INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
(Approved by AICTE | NAAC Accreditation with 'A' Grade | Accredited by NBA | Affiliated to JNTUH)
Dundigal, Hyderabad - 500 043, Telangana

OUTCOME BASED EDUCATION
WITH
CHOICE BASED CREDIT SYSTEM

BACHELOR OF TECHNOLOGY
AERONAUTICAL ENGINEERING

ACADEMIC REGULATIONS, COURSE STRUCTURE AND SYLLABI
UG20

B.Tech Regular Four Year Degree Program
(for the batches admitted from the academic year 2020 - 2021)

&

B.Tech (Lateral Entry Scheme)
(for the batches admitted from the academic year 2021 - 2022)

These rules and regulations may be altered/changed from time to time by the academic council
FAILURE TO READ AND UNDERSTAND THE RULES IS NOT AN EXCUSE

VISION

To bring forth professionally competent and socially sensitive engineers, capable of working across cultures meeting the global standards ethically.

MISSION

To provide students with an extensive and exceptional education that prepares them to excel in their profession, guided by dynamic intellectual community and be able to face the technically complex world with creative leadership qualities.

Further, be instrumental in emanating new knowledge through innovative research that emboldens entrepreneurship and economic development for the benefit of wide spread community.

QUALITY POLICY

Our policy is to nurture and build diligent and dedicated community of engineers providing a professional and unprejudiced environment, thus justifying the purpose of teaching and satisfying the stake holders.

A team of well qualified and experienced professionals ensure quality education with its practical application in all areas of the Institute.

PROGRAM OUTCOMES (PO's)

Engineering Graduates will be able to:

PO1: **Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.

PO2: **Problem Analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.

PO3: **Design/Development of Solutions:** Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: **Conduct Investigations of Complex Problems:** Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.

PO5: **Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.

PO6: **The Engineer and Society:** Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.

PO7: **Environment and Sustainability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: **Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO9: **Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

PO10: **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

PO11: **Project Management and Finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

PO12: **Life-Long Learning:** Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

CONTENTS

"Take up one idea.
Make that one idea your life-think of it, dream of it, live on that idea.
Let the brain muscles, nerves, every part of your body be full of that idea and just leave every other idea alone. This is the way to success"

Swami Vivekananda

PRELIMINARY DEFINITIONS AND NOMENCLATURES

AICTE: Means All India Council for Technical Education, New Delhi.

Autonomous Institute: Means an institute designated as Autonomous by University Grants Commission (UGC), New Delhi in concurrence with affiliating University (Jawaharlal Nehru Technological University, Hyderabad) and State Government.

Academic Autonomy: Means freedom to an institute in all aspects of conducting its academic programs, granted by UGC for Promoting Excellence.

Academic Council: The Academic Council is the highest academic body of the institute and is responsible for the maintenance of standards of instruction, education and examination within the institute. Academic Council is an authority as per UGC regulations and it has the right to take decisions on all academic matters including academic research.

Academic Year: It is the period necessary to complete an actual course of study within a year. It comprises two main semesters i.e., (one odd + one even) and one supplementary semester.

Branch: Means specialization in a program like B.Tech degree program in Aeronautical Engineering, B.Tech degree program in Computer Science and Engineering etc.

Board of Studies (BOS): BOS is an authority as defined in UGC regulations, constituted by Head of the Organization for each of the departments separately. They are responsible for curriculum design and updation in respect of all the programs offered by a department.

Backlog Course: A course is considered to be a backlog course, if the student has obtained a failure grade (F) in that course.

Basic Sciences: The courses offered in the areas of Mathematics, Physics, Chemistry etc., are considered to be foundational in nature.

Betterment: Betterment is a way that contributes towards improvement of the students' grade in any course(s). It can be done by either (a) re-appearing or (b) re-registering for the course.

Commission: Means University Grants Commission (UGC), New Delhi.

Choice Based Credit System: The credit based semester system is one which provides flexibility in designing curriculum and assigning credits based on the course content and hours of teaching along with provision of choice for the student in the course selection.

Certificate Course: It is a course that makes a student to have hands-on expertise and skills required for holistic development in a specific area/field.

Compulsory course: Course required to be undertaken for the award of the degree as per the program.

Continuous Internal Examination: It is an examination conducted towards sessional assessment.

Core: The courses that are essential constituents of each engineering discipline are categorized as professional core courses for that discipline.

Course: A course is a subject offered by a department for learning in a particular semester.

Course Outcomes: The essential skills that need to be acquired by every student through a course.

Credit: A credit is a unit that gives weight to the value, level or time requirements of an academic course. The number of 'Contact Hours' in a week of a particular course determines its credit value. One credit is equivalent to one lecture/tutorial hour per week.

Credit point: It is the product of grade point and number of credits for a course.

Cumulative Grade Point Average (CGPA): It is a measure of cumulative performance of a student over all the completed semesters. The CGPA is the ratio of total credit points secured by a student in various courses in all semesters and the sum of the total credits of all courses in all the semesters. It is expressed up to two decimal places.

Curriculum: Curriculum incorporates the planned interaction of students with instructional content, materials, resources, and processes for evaluating the attainment of Program Educational Objectives.

Department: An academic entity that conducts relevant curricular and co-curricular activities, involving both teaching and non-teaching staff, and other resources in the process of study for a degree.

Detention in a Course: Student who does not obtain minimum prescribed attendance in a course shall be detained in that particular course.

Dropping from Semester: Student who doesn't want to register for any semester can apply in writing in prescribed format before the commencement of that semester.

Elective Course: A course that can be chosen from a set of courses. An elective can be Professional Elective and / or Open Elective.

Evaluation: Evaluation is the process of judging the academic performance of the student in her/his courses. It is done through a combination of continuous internal assessment and semester end examinations.

Experiential Engineering Education (ExEEd): Engineering entrepreneurship requires strong technical skills in engineering design and computation with key business skills from marketing to business model generation. Our students require sufficient skills to innovate in existing companies or create their own.

Grade: It is an index of the performance of the students in a said course. Grades are indicated by alphabets.

Grade Point: It is a numerical weight allotted to each letter grade on a 10 - point scale.

Honours: An Honours degree typically refers to a higher level of academic achievement at an undergraduate level.

Institute: Means Institute of Aeronautical Engineering, Hyderabad unless indicated otherwise by the context.

Massive Open Online Courses (MOOC): MOOC courses inculcate the habit of self learning. MOOC courses would be additional choices in all the elective group courses.

Minor: Minor are coherent sequences of courses which may be taken in addition to the courses required for the B.Tech degree.

Pre-requisite: A specific course or subject, the knowledge of which is required to complete before student register another course at the next grade level.

Professional Elective: It indicates a course that is discipline centric. An appropriate choice of minimum number of such electives as specified in the program will lead to a degree with specialization.

Program: Means, UG degree program: Bachelor of Technology (B.Tech); PG degree program: Master of Technology (M.Tech) / Master of Business Administration (MBA).

Program Educational Objectives: The broad career, professional and personal goals that every student will achieve through a strategic and sequential action plan.

Project work: It is a design or research based work to be taken up by a student during his/her final year to achieve a particular aim. It is a credit based course and is to be planned carefully by the student.

Re-Appearing: A student can reappear only in the semester end examination for theory component of a course, subject to the regulations contained herein.

Registration: Process of enrolling into a set of courses in a semester of a program.

Regulations: The regulations, common to all B.Tech programs offered by Institute, are designated as "IARE Regulations – R20" and are binding on all the stakeholders.

Semester: It is a period of study consisting of 15 to 18 weeks of academic work equivalent to normally 90 working days. Odd semester commences usually in July and even semester in December of every year.

Semester End Examinations: It is an examination conducted for all courses offered in a semester at the end of the semester.

S/he: Means "she" and "he" both.

Student Outcomes: The essential skill sets that need to be acquired by every student during her/his program of study. These skill sets are in the areas of employability, entrepreneurial, social and behavioral.

University: Means Jawaharlal Nehru Technological University Hyderabad (JNTUH), Hyderabad, is an affiliating University.

Withdraw from a Course: Withdrawing from a course means that a student can drop from a course within the first two weeks of odd or even semester (deadlines are different for summer sessions). However, s/he can choose a substitute course in place of it, by exercising the option within 5 working days from the date of withdrawal.

FOREWORD

The autonomy is conferred to Institute of Aeronautical Engineering (IARE), Hyderabad by University Grants Commission (UGC), New Delhi based on its performance as well as future commitment and competency to impart quality education. It is a mark of its ability to function independently in accordance with the set norms of the monitoring bodies including J N T University Hyderabad (JNTUH), Hyderabad and AICTE, New Delhi. It reflects the confidence of the affiliating University in the autonomous institution to uphold and maintain standards it expects to deliver on its own behalf. Thus, an autonomous institution is given the freedom to have its own **curriculum, examination system** and **monitoring mechanism**, independent of the affiliating University but under its observance.

IARE is proud to win the credence of all the above bodies monitoring the quality in education and has gladly accepted the responsibility of sustaining, if not improving upon the standards and ethics for which it has been striving for more than a decade in reaching its present standing in the arena of contemporary technical education. As a follow up, statutory bodies such as Academic Council and Board of Studies (BOS) are constituted with the guidance of the Governing Body of the institute and recommendations of the JNTUH to frame the regulations, course structure, and syllabi under autonomous status.

The autonomous regulations, course structure, and syllabi have been prepared after prolonged and detailed interaction with several expertise solicited from academics, industry and research, in accordance with the vision and mission of the institute in order to produce a quality engineering graduate to the society.

All the faculty, parents, and students are requested to go through all the rules and regulations carefully. Any clarifications needed are to be sought at appropriate time and from the principal of the institute, without presumptions, to avoid unwanted subsequent inconveniences and embarrassments. The cooperation of all the stake holders is requested for the successful implementation of the autonomous system in the larger interests of the institute and brighter prospects of engineering graduates.

PRINCIPAL

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

ACADEMIC REGULATIONS – UG20

B.Tech. Regular Four Year Degree Program
(for the batches admitted from the academic year 2020 - 2021)
&
B.Tech. (Lateral Entry Scheme)
(for the batches admitted from the academic year 2021 - 2022)

For pursuing four year undergraduate Bachelor of Technology (B.Tech) degree program of study in engineering offered by Institute of Aeronautical Engineering under Autonomous status.

A student shall undergo the prescribed courses as given in the program curriculum to obtain his/her degree in major in which he/she is admitted with 160 credits in the entire program of 4 years. Additional 20 credits can be acquired for the degree of B.Tech with **Honours or additional Minor in Engineering**. These additional 20 credits will have to be acquired with massive open online courses (MOOCs), to tap the zeal and excitement of learning beyond the classrooms. This creates an excellent opportunity for students to acquire the necessary skill set for employability through massive open online courses where the rare expertise of world famous experts from academics and industry are available.

Separate certificate will be issued in addition to major degree program mentioning that the student has cleared Honours / Minor specialization in respective courses.

1. CHOICE BASED CREDIT SYSTEM

The credit based semester system provides flexibility in designing program curriculum and assigning credits based on the course content and hours of teaching. The Choice Based Credit System (CBCS) provides a 'cafeteria' type approach in which the students can take courses of their choice, learn at their own pace, undergo additional courses and acquire more than the required credits, and adopt an interdisciplinary approach to learning.

A course defines learning objectives and learning outcomes and comprises lectures / tutorials / laboratory work / field work / project work / comprehensive examination / seminars / assignments / MOOCs / alternative assessment tools / presentations / self-study etc., or a combination of some of these. Under the CBCS, the requirement for awarding a degree is prescribed in terms of number of credits to be completed by the students.

2. MEDIUM OF INSTRUCTION

The medium of instruction shall be **English** for all courses, examinations, seminar presentations and project work. The program curriculum will comprise courses of study as given in course structure, in accordance with the prescribed syllabi.

3. PROGRAMS OFFERED

Presently, the institute is offering Bachelor of Technology (B.Tech) degree programs in eleven disciplines. The various programs and their two-letter unique codes are given in Table 1.

Table 1: B.Tech Programs offered

S. No	Name of the Program	Title	Code
1	Aeronautical Engineering	AE	07
2	Computer Science and Engineering	CS	05
3	Computer Science and Engineering (AI & ML)	CA	34
4	Computer Science and Engineering (Data Science)	CD	35
5	Computer Science and Engineering (Cyber Security)	CC	36
6	Computer Science and Information Technology	CI	37
7	Information Technology	IT	06
8	Electronics and Communication Engineering	EC	04
9	Electrical and Electronics Engineering	EE	02
10	Mechanical Engineering	ME	03
11	Civil Engineering	CE	01

4. SEMESTER STRUCTURE

Each academic year is divided into three semesters, TWO being **MAIN SEMESTERS** (one odd + one even) and ONE being a **SUPPLEMENTARY SEMESTER**. Main semesters are for regular class work. Supplementary Semester is primarily for failed students i.e. registration for a course for the first time is generally not permitted in the supplementary semester.

4.1 Each main semester shall be of 21 weeks (Table 1) duration and this period includes time for registration of courses, course work, examination preparation, and conduct of examinations.

4.2 Each main semester shall have a minimum of 90 working days.

4.3 The supplementary semester shall be a fast track semester consisting of eight weeks and this period includes time for registration of courses, course work, and examination preparation, conduct of examinations, assessment, and declaration of final results.

4.4 All subjects may not be offered in the supplementary semester. The student has to pay a stipulated fee prescribed by the institute to register for a course in the supplementary semester. The supplementary semester is provided to help the student in not losing an academic year. It is optional for a student to make use of supplementary semester. **Supplementary semester is a special semester and the student cannot demand it as a matter of right** and will be offered based on availability of faculty and other institute resources.

4.5 The institute may use **supplementary semester** to arrange add-on courses for regular students and / or for deputing them for practical training / FSI model. A student can register for a maximum number of 15 credits during a supplementary semester.

The registration for the supplementary semester (during May – July, every year) provides an opportunity to students to clear their backlogs (‘F’ grade) or who are prevented from appearing for SEE examinations due to shortage of attendance less than 65% in each course (‘SA’ Grade) in the earlier semesters or the courses which he / she could not register (Drop / Withdraw) due to any reason.

Students will not be permitted to register for more than 15 credits (both I and II semester) in the supplementary semester. Students required to register for supplementary semester courses are to pay a nominal fee within the stipulated time. A separate circular shall be issued at the time of supplementary semester.

It will be optional for a student to get registered in the course(s) of supplementary semester; otherwise, he / she can opt to appear directly in supplementary examination. However, if a student gets registered in a course of supplementary semester, then it will be compulsory for a student to fulfill attendance criterion (≥90%) of supplementary semester and he / she will lose option to appear in immediate supplementary examination.

The students who have earlier taken SEE examination and register afresh for the supplementary semester may revoke the CIA marks secured by them in their regular/earlier attempts in the same course. Once revoked, the students shall not seek restoration of the CIA marks.

Supplementary semester will be at an accelerated pace e.g. one credit of a course shall require two hours/week so that the total number of contact hours can be maintained same as in normal semester.

Instructions and guidelines for the supplementary semester course:

- A minimum of 36 to 40 hours will be taught by the faculty for every course.
- Only the students registered and having sufficient percentage of attendance for the course will be permitted to write the examination.
- The assessment procedure in a supplementary semester course will be similar to the procedure for a regular semester course.
- Student shall register for the supplementary semester as per the schedule given in academic calendar.
- Once registered, students will not be allowed to withdraw from supplementary semester.

4.6 The academic calendar shown in Table 2 is declared at the beginning of the academic year.

Table 2: Academic Calendar

<table>
<tr><td rowspan="6">FIRST SEMESTER (21 weeks)</td><td>I Spell Instruction Period</td><td>8 weeks</td><td rowspan="5">19 weeks</td></tr>
<tr><td>I Continuous Internal Assessment Examinations (Mid-term)</td><td>1 week</td></tr>
<tr><td>II Spell Instruction Period</td><td>8 weeks</td></tr>
<tr><td>II Continuous Internal Assessment Examinations (Mid-term)</td><td>1 week</td></tr>
<tr><td>Preparation and Practical Examinations</td><td>1 week</td></tr>
<tr><td colspan="2">Semester End Examinations</td><td>2 weeks</td></tr>
<tr><td colspan="3">Semester Break and Supplementary Exams</td><td>2 weeks</td></tr>
<tr><td rowspan="6">SECOND SEMESTER (21 weeks)</td><td>I Spell Instruction Period</td><td>8 weeks</td><td rowspan="5">19 weeks</td></tr>
<tr><td>I Continuous Internal Assessment Examinations (Mid-term)</td><td>1 week</td></tr>
<tr><td>II Spell Instruction Period</td><td>8 weeks</td></tr>
<tr><td>II Continuous Internal Assessment Examinations (Mid-term)</td><td>1 week</td></tr>
<tr><td>Preparation & Practical Examinations</td><td>1 week</td></tr>
<tr><td colspan="2">Semester End Examinations</td><td>2 weeks</td></tr>
<tr><td colspan="3">Summer Vacation, Supplementary Semester and Remedial Exams</td><td>8 weeks</td></tr>
</table>

4.7 Students admitted on transfer from JNTUH affiliated institutes, Universities and other institutes in the subjects in which they are required to earn credits so as to be on par with regular students as prescribed by concerned 'Board of Studies'.

5.0 REGISTRATION / DROPPING / WITHDRAWAL

The academic calendar includes important academic activities to assist the students and the faculty. These include, dates assigned for registration of courses, dropping of courses and withdrawal from courses. This enables the students to be well prepared and take full advantage of the flexibility provided by the credit system.

5.1. Each student has to compulsorily register for course work at the beginning of each semester as per the schedule mentioned in the Academic Calendar. It is compulsory for the student to register for courses in time. The registration will be organized departmentally under the supervision of the Head of the Department.

5.2. In ABSENTIA, registration will not be permitted under any circumstances.

5.3. At the time of registration, students should have cleared all the dues of Institute and Hostel for the previous semesters, paid the prescribed fees for the current semester and not been debarred from the institute for a specified period on disciplinary or any other ground.

5.4. In the first two semesters, the prescribed course load per semester is fixed and is mandated to registered all courses. Withdrawal / dropping of courses in the first and second semester is not allowed.

5.5. In higher semesters, the average load is 22 credits / semester, with its minimum and maximum limits being set at 16 and 28 credits. This flexibility enables students (**from IV semester onwards**) to cope-up with the course work considering the academic strength and capability of student.

5.6. Dropping of Courses:

Within one week after the last date of first internal assessment test or by the date notified in the academic calendar, the student may in consultation with his / her faculty mentor/adviser, drop one or more courses without prejudice to the minimum number of credits as specified in clause 5.4. The dropped courses are not recorded in the memorandum of grades. Student must complete the dropped subject by registering in the supplementary semester / forthcoming semester in order to earn the required credits. Student must complete the dropped subject by registering in the supplementary semester / forthcoming semester in order to earn the required credits.

5.7. Withdrawal from Courses:

A student is permitted to withdraw from a course by the date notified in the academic calendar. Such withdrawals will be permitted without prejudice to the minimum number of credits as specified in clause 5.4. A student cannot withdraw a course more than once and withdrawal of reregistered courses is not permitted.

6.0 CREDIT SYSTEM

The B.Tech Program shall consist of a number of courses and each course shall be assigned with credits. The curriculum shall comprise Theory Courses, Elective Courses, Laboratory Courses, Value Added Courses, Mandatory Courses, Experiential Engineering Education (ExEEd), Internship and Project work.

Depending on the complexity and volume of the course, the number of contact periods per week will be assigned. Each theory and laboratory course carries credits based on the number of hours / week.

- Contact classes (Theory): 1 credit per lecture hour per week, 1 credit per tutorial hour per week.
- Laboratory hours (Practical): 1 credit for 2 practical hours per week.
- Project work: 1 credit for 2 hours of project work per week.
- Mandatory Courses: No credit is awarded.
- Value Added Courses: No credit is awarded.
- Experiential Engineering Education (ExEEd): 1 credit for two per hours.

Credit distribution for courses offered is given in Table 5.

Table 5: Credit distribution

S. No	Course	Hours	Credits
1	Theory Course	2 / 3 / 4	2 / 3 / 4
2	Elective Courses	3	3
3	Laboratory Courses	2 / 3 / 4	1 / 1.5 / 2
4	Mandatory Course / Value Added Course	-	0
5	Project Work	-	10
6	Full Semester Internship (FSI) Project work	-	10

Major benefits of adopting the credit system are listed below:

- Quantification and uniformity in the listing of courses for all programs at College, like core, electives and project work.
- Ease of allocation of courses under different heads by using their credits to meet national /international practices in technical education.
- Convenience to specify the minimum / maximum limits of course load and its average per semester in the form of credits to be earned by a student.
- Flexibility in program duration for students by enabling them to pace their course load within minimum/maximum limits based on their preparation and capabilities.
- Wider choice of courses available from any department of the same College or even from other similar Colleges, either for credit or for audit.
- Improved facility for students to optimize their learning by availing of transfer of credits earned by them from one College to another.

7.0 CURRICULAR COMPONENTS

Courses in a curriculum may be of three kinds: **Foundation / Skill, Core and Elective Courses.**

Foundation / Skill Course:

Foundation courses are the courses based upon the content leads to enhancement of skill and knowledge as well as value based and are aimed at man making education. Skill subjects are those areas in which one needs to develop a set of skills to learn anything at all. They are fundamental to learning any subject.

Professional Core Courses:

There may be a core course in every semester. This is the course which is to be compulsorily studied by a student as a core requirement to complete the requirement of a program in the said discipline of study.

Elective Course:

Electives provide breadth of experience in respective branch and application areas. Elective course is a course which can be chosen from a pool of courses. It may be:

- Supportive to the discipline of study
- Providing an expanded scope
- Enabling an exposure to some other discipline / domain
- Nurturing student's proficiency / skill.

An elective may be Professional Elective, is a discipline centric focusing on those courses which add generic proficiency to the students or may be Open Elective, chosen from unrelated disciplines.

There are six professional elective tracks; students can choose not more than two courses from each track. Overall, students can opt for six professional elective courses which suit their project work in consultation with the faculty advisor/mentor. Nevertheless, one course from each of the four open electives has to be selected. A student may also opt for more elective courses in his/her area of interest.

Every course of the B.Tech program will be placed in one of the eight categories with minimum credits as listed in the Table 6.

Table 6: Category Wise Distribution of Credits

S. No	Category	Breakup of Credits
1	Humanities and Social Sciences (HSMC), including Management.	6
2	Basic Science Courses (BSC) including Mathematics, Physics and Chemistry.	18.5
3	Engineering Science Courses (ESC), including Workshop, Drawing, ExEEd, Basics of Electrical / Electronics / Mechanical / Computer Engineering.	20.5
4	Professional Core Courses (PCC), relevant to the chosen specialization / branch.	78
5	Professional Electives Courses (PEC), relevant to the chosen specialization / branch.	18
6	Open Elective Courses (OEC), from other technical and/or emerging subject areas.	09
7	Project work (PROJ) / Full Semester Internship (FSI) Project work	10
8	Mandatory Courses (MC) / Value Added Courses (VAC).	Non-Credit
TOTAL		**160**

Semester wise course break-up

Following are the **TWO** models of course structure out of which any student shall choose or will be allotted with one model based on their academic performance.

i. Full Semester Internship (FSI) Model and

ii. Non Full Semester Internship (NFSI) Model

In the FSI Model, out of the selected students - half of students shall undergo Full Semester Internship in VII semester and the remaining students in VIII semester. In the Non-FSI Model, all the selected students shall carry out the course work and Project work as specified in the course structure. A student who secures a minimum CGPA of 7.5 upto IV semester with **no current arrears** and maintains the CGPA of 7.5 till VI Semester shall be eligible to opt for FSI.

8. EVALUATION METHODOLOGY

Each theory course will be evaluated for a total of 100 marks, with 30 marks for Continuous Internal Assessment (CIA) and 70 marks for Semester End Examination (SEE). Student's performance in a course shall be judged by taking into account the results of CIA and SEE together. Table-7 shows the typical distribution of weightage for CIA and SEE.

Table 7: Assessment pattern for Theory Courses

Component		Marks	Total Marks
CIA	Continuous Internal Examination – 1 (Mid-term)	10	30
	Continuous Internal Examination – 2 (End-term)	10	
	Tech talk / Quiz – 1 and Quiz – 2	5	
	Concept video / Alternative Assessment Tool (AAT)	5	
SEE	Semester End Examination (SEE)	70	70
Total Marks			**100**

8.1. Semester End Examination (SEE):

The SEE is conducted for 70 marks of 3 hours duration. The syllabus for the theory courses is divided into FIVE modules and each modules carries equal weightage in terms of marks distribution. The question paper pattern is as follows.

Two full questions with 'either' 'or' choice will be drawn from each module. Each question carries 14 marks. There could be a maximum of two sub divisions in a question.

The emphasis on the questions is broadly based on the following criteria:

50 %	To test the objectiveness of the concept
50 %	To test the analytical skill of the concept OR to test the application skill of the concept

8.1. Continuous Internal Assessment (CIA):

For each theory course the CIA shall be conducted by the faculty / teacher handling the course. CIA is conducted for a total of 30 marks, with 20 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (AAT). **Two CIE Tests are Compulsory** and sum of the two tests, along with the scores obtained in the quizzes (average of Quiz – 1 and Quiz – 2) / AAT shall be considered for computing the final CIA of a student in a given course.

The CIE Tests/quizzes/AAT shall be conducted by the course faculty with due approval from the HOD. Advance notification for the conduction of Quiz/AAT is mandatory and the responsibility lies with the concerned course faculty.

8.1.1. Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively for 10 marks each of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered. The valuation and verification of answer scripts of CIE exams shall be completed within a week after the conduct of the Examination.

8.1.2. Quiz – Online Examination

Two Quiz exams shall be conducted along with CIE in online mode for 5 marks each, consisting of 10 short answers questions (Definitions and Terminology) and 10 multiple choice questions (having each question to be answered by tick marking the correct answer from the choices (commonly four) given against it. Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Average of two quiz examinations shall be considered.

8.1.3. Alternative Assessment Tool (AAT)

In order to encourage innovative methods while delivering a course, the faculty members are encouraged to use the Alternative Assessment Tool (AAT). This AAT enables faculty to design own assessment patterns during the CIA. The AAT enhances the autonomy (freedom and flexibility) of individual faculty and enables them to create innovative pedagogical practices. If properly applied, the AAT converts the classroom into an effective learning centre.

The AAT may include tech talk, tutorial hours/classes, seminars, assignments, term paper, open ended experiments, concept videos, partial reproduction of research work, oral presentation of research work, developing a generic tool-box for problem solving, report based on participation in create-a-thon, make-a-thon, code-a-thon, hack-a-thon conducted by reputed organizations / any other. etc.

However, it is mandatory for a faculty to obtain prior permission from the concerned HOD and spell out the teaching/assessment pattern of the AAT prior to commencement of the classes.

8.2 Laboratory Course

Each laboratory will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end lab examination. Out of 30 marks of internal assessment, continuous lab assessment will be done for 20 marks for the day to day performance and 10 marks for the final internal lab assessment. The semester end laboratory examination for 70 marks shall be conducted internally by the respective department with at least two faculty members as examiners, both nominated by the Principal from the panel of experts recommended by the Chairman, BOS.

All the drawing related courses are evaluated in line with laboratory courses. The distribution shall be 30 marks for internal evaluation (20 marks for day–to–day work, and 10 marks for internal tests) and 70 marks for semester end laboratory examination. There shall be ONE internal test of 10 marks in each semester.

8.3 Audit Courses

In Addition, a student can register for courses for audit only with a view to supplement his/her knowledge and/or skills. Here also, the student's grades shall have to be reflected in the Memorandum of Grades. But, these shall not be taken into account in determining the student's academic performance in the semester. In view of this, it shall not be necessary for the institute to issue any separate transcript covering the audit courses to the registrants at these courses. Its result shall be declared as "Satisfactory" or "Not Satisfactory" performance.

8.4 Mandatory Courses (MC)

These courses are among the compulsory courses but will not carry any credits. However, a pass in each such course during the program shall be necessary requirement for the student to qualify for the award of Degree. Its result shall be declared as "Satisfactory" or "Not Satisfactory" performance.

8.5 Additional Mandatory Courses for lateral entry B.Tech students

In addition to the non-credit mandatory courses for regular B.Tech students, the lateral entry students shall take up the following three non-credit mandatory bridge courses (one in III semester, one in IV semester and one in V semester) as listed in Table 8. The student shall pass the following non-credit mandatory courses for the award of the degree and must clear these bridge courses before advancing to the VII semester of the program.

Table-8: Additional Mandatory Courses for lateral entry

S. No	Additional mandatory courses for lateral entry students
1	Dip-Mathematics
2	Dip-Programming for Problem Solving
3	Dip-English Communication Skills

8.6 Value Added Courses

The value added courses are audit courses offered through joint ventures with various organizations providing ample scope for the students as well as faculty to keep pace with the latest technologies pertaining to their chosen fields of study. A plenty of value added programs will be proposed by the departments one week before the commencement of class work. The students are given the option to choose the courses according to their desires and inclinations as they choose the desired items in a cafeteria. The expertise gained through the value added programs should enable them to face the formidable challenges of the future and also assist them in exploring new opportunities. Its result shall be declared with "Satisfactory" or "Not Satisfactory" performance.

8.7 Experiential Engineering Education (ExEED)

Engineering entrepreneurship requires strong technical skills in engineering design and computation with key business skills from marketing to business model generation. Students require sufficient skills to innovate in existing companies or create their own.

This course will be evaluated for a total of 100 marks consisting of 30 marks for internal assessment and 70 marks for semester end Examination. Out of 30 marks of internal assessment, The Student has to submit Innovative Idea in a team of four members in the given format. The semester end examination for 70 marks shall be conducted internally, students has to present the Innovative Idea and it will be evaluated by internal ExEEd faculty with at least one faculty member as examiner from the industry, both nominated by the Principal from the panel of experts recommended by the Dean-CLET.

8.8 Project Work / FSI Project Work

This gives students a platform to experience a research driven career in engineering, while developing a device / systems and publishing in reputed SCI / SCOPUS indexed journals and/or filing an **Intellectual Property** (IPR-Patent/Copyright) to aid communities around the world. Students should work individually as per the guidelines issued by head of the department concerned. The benefits to students of this mode of learning include increased engagement, fostering of critical thinking and greater independence.

The topic should be so selected that the students are enabled to complete the work in the stipulated time with the available resources in the respective laboratories. The scope of the work be handling part of the consultancy work, maintenance of the existing equipment, development of new experiment setup or can be a prelude to the main project with a specific outcome.

Project report will be evaluated for 100 marks in total. Assessment will be done for 100 marks out of which, the supervisor / guide will evaluate for 30 marks based on the work and presentation / execution of the work. Subdivision for the remaining 70 marks is based on publication, report, presentation, execution and viva-voce. Evaluation shall be done by a committee comprising the supervisor, Head of the department and an examiner nominated by the Principal from the panel of experts recommended by Chairman, BOS in consultation with Head of the department.

8.8.1 Project work

The student's project activity is spread over in VII semester and in VIII semesters. A student shall carry out the project work under the supervision of a faculty member or in collaboration with an Industry, R&D organization or another academic institution/University where sufficient facilities exist to carry out the project work.

Project work (phase-I) starts in VII semester as it takes a vital role in campus hiring process. Students shall select project titles from their respective logins uploaded by the supervisors at the beginning of VII semester. Three reviews are conducted by department review committee (DRC) for 10 marks each. Student must submit a project report summarizing the work done up to design phase/prototype by the end of VII semester. The semester end examination for project work (phase-I) is evaluated based on the project report submitted and a viva-voce exam for 70 marks by a committee comprising the head of the department, the project supervisor and an external examiner nominated by the Principal.

Project Work (phase-II) starts in VIII semester, shall be evaluated for 100 marks out of which 30 marks towards continuous internal assessment and 70 marks for semester end examination. Three reviews are to be conducted by DRC on the progress of the project for 30 marks. The semester end examination shall be based on the final report submitted and a viva-voce exam for 70 marks by a committee comprising the head of the department, the project supervisor and an external examiner nominated by the Principal.

A minimum of 40% of maximum marks shall be obtained to earn the corresponding credits.

8.8.2 Full Semester Internship (FSI)

FSI is a full semester internship program carry 10 credits. The FSI shall be opted in VII semester or in VIII semester. During the FSI, student has to spend one full semester in an identified industry / firm / R&D organization or another academic institution/University where sufficient facilities exist to carry out the project work.

Following are the evaluation guidelines:

- Quizzes: 2 times
- Quiz #1 - About the industry profile, weightage: 5%
- Quiz #2 - Technical-project related, weightage: 5%
- Seminars - 2 times (once in six weeks), weightage: 7.5% + 7.5%
- Viva-voce: 2 times (once in six weeks), weightage: 7.5% + 7.5%
- Project Report, weightage: 15%
- Internship Diary, weightage: 5 %
- Final Presentation, weightage: 40%

FSI shall be open to all the branches with a ceiling of maximum 10% distributed in both semesters. The selection procedure is:

- Choice of the students.
- CGPA (> 7.5) upto IV semester having no credit arrears.
- Competency Mapping / Allotment.

It is recommended that the FSI Project work leads to a research publication in a reputed Journal/Conference or the filing of patent/design with the patent office, or, the start-up initiative with a sustainable and viable business model accepted by the incubation center of the institute together with the formal registration of the startup.

8.9 Plagiarism index for Project Report:

All project reports shall go through the plagiarism check and the plagiarism index has to be less than 20%. Project reports with plagiarism more than 20% and less than 60% shall be asked for resubmission within a stipulated period of six months. Project reports with plagiarism more than 60% shall be rejected.

9. MAKEUP EXAMINATION

The make-up examination facility shall be available to students who may have missed to attend **CIE/Quiz** of one or more courses in a semester for valid reasons. The CIE make-up examination shall have comprehensive online objective type questions for 20 marks and Quiz for 5 marks. The content for the make-up examination shall be on the whole syllabus. The Makeup examination shall be conducted at the end of the respective semester.

10. SUPPLEMENTARY EXAMINATIONS

In addition to the Regular Semester End Examinations held at the end of each semester, Supplementary Semester End Examinations will be conducted within three weeks of the commencement of the teaching of the next semester. Candidates taking the Regular / Supplementary examinations as Supplementary candidates may have to take more than one Semester End Examination per day. A student can appear for any number of supplementary examinations till he/she clears all courses which he/she could not clear in the first attempt. However the maximum stipulated period for the course shall not be relaxed under any circumstances.

11. ATTENDANCE REQUIREMENTS AND DETENTION POLICY

11.1 It is desirable for a candidate to have 100% attendance in each course. In every course (theory/laboratory), student has to maintain a minimum of 75% attendance including the days of attendance in sports, games, NCC and NSS activities to be eligible for appearing in Semester End Examination of the course.

11.2 In case of medical issues, deficiency of attendance in each course to the extent of 10% may be condoned by the College Academic Committee (CAC) on the recommendation of the Head of the Department if the attendance is between 75% and 65% in every course, subjected to the submission of medical certificates, medical case file, and other needful documents to the concerned departments.

11.3 The basis for the calculation of the attendance shall be the period prescribed by the institute by its calendar of events. For late admission, attendance is reckoned from the date of admission to the program. However, in case of a student having less than 65% attendance in any course, s/he shall be detained in the course and in no case such process will be relaxed.

11.4 A candidate shall put in a minimum required attendance in atleast 60% of (rounded to the next highest integer) theory courses for getting promoted to next higher class / semester. Otherwise, s/he shall be declared detained and has to repeat semester.

11.5 Students whose shortage of attendance is not condoned in any subject are not eligible to write their semester end examination of that courses and their registration shall stand cancelled.

11.6 A prescribed fee shall be payable towards condonation of shortage of attendance.

11.7 A student shall not be promoted to the next semester unless he satisfies the attendance requirement of the present semester, as applicable. They may seek readmission into that semester when offered next. If any candidate fails to fulfill the attendance requirement in the present semester, he shall not be eligible for readmission into the same class.

11.8 Any student against whom any disciplinary action by the institute is pending shall not be permitted to attend any SEE in that semester.

12. CONDUCT OF SEMESTER END EXAMINATIONS AND EVALUATION

12.1 Semester end examination shall be conducted by the Controller of Examinations (COE) by inviting Question Papers from the External Examiners.

12.2 Question papers may be moderated for the coverage of syllabus, pattern of questions by a Semester End Examination Committee chaired by Head of the Department one day before the commencement of semester end examinations. Internal Examiner shall prepare a detailed scheme of valuation.

12.3 The answer papers of semester end examination should be evaluated by the internal examiner immediately after the completion of exam and the award sheet should be submitted to COE in a sealed cover.

12.4 COE shall invite 3 - 9 internal/external examiners to evaluate all the semester end examination answer books on a prescribed date(s). Practical laboratory exams are conducted involving external examiners.

12.5 Examinations Control Committee shall consolidate the marks awarded by examiner/s and award grades.

13. SCHEME FOR THE AWARD OF GRADE

13.1 A student shall be deemed to have satisfied the minimum academic requirements and earn the credits for each theory course, if s/he secures

a) Not less than 35% marks for each theory course in the semester end examination, and

b) A minimum of 40% marks for each theory course considering Continuous Internal Assessment (CIA) and Semester End Examination (SEE).

13.2 A student shall be deemed to have satisfied the minimum academic requirements and earn the credits for each Laboratory / Project work / FSI Project work, if s/he secures

a) Not less than 40% marks for each Laboratory / Project work / FSI Project work course in the semester end examination,

b) A minimum of 40% marks for each Laboratory / Project work / FSI Project work course considering both internal and semester end examination.

13.3 If a candidate fails to secure a pass in a particular course, it is mandatory that s/he shall register and reappear for the examination in that course during the next semester when examination is conducted in that course. It is mandatory that s/he should continue to register and reappear for the examination till s/he secures a pass.

13.4 A student shall be declared successful or ‘passed’ in a semester, if he secures a Grade Point ≥ 5 (‘C’ grade or above) in every course in that semester (i.e. when the student gets an SGPA ≥5.0 at the end of that particular semester); and he shall be declared successful or ‘passed’ in the entire under graduate programme, only when gets a CGPA ≥5.0 for the award of the degree as required.

14. LETTER GRADES AND GRADE POINTS

14.1 Performances of students in each course are expressed in terms of marks as well as in Letter Grades based on absolute grading system. The UGC recommends a 10-point grading system with the following letter grades as given in the Table-9.

Table-9: Grade Points Scale (Absolute Grading)

Range of Marks	Grade Point	Letter Grade
100 – 90	10	S (Superior)
89 – 80	9	A+ (Excellent)
79 – 70	8	A (Very Good)
69 – 60	7	B+ (Good)
59 – 50	6	B (Average)
49 – 40	5	C (Pass)
Below 40	0	F (Fail)
Absent	0	AB (Absent)
Authorized Break of Study	0	ABS

14.2 A student is deemed to have passed and acquired to correspondent credits in particular course if s/he obtains any one of the following grades: “S”, “A+”, “A”, “B+”, “B”, “C”.

14.3 A student obtaining Grade F shall be considered Failed and will be required to reappear in the examination.

14.4 For non credit courses, ‘Satisfactory’ or “Not Satisfactory” is indicated instead of the letter grade and this will not be counted for the computation of SGPA/CGPA.

14.5 “SA” denotes shortage of attendance (as per item 11) and hence prevention from writing Semester End Examination.

14.6 “W” denotes **withdrawal** from the exam for the particular course.

14.7 At the end of each semester, the institute issues grade sheet indicating the SGPA and CGPA of the student. However, grade sheet will not be issued to the student if s/he has any outstanding dues.

14.8 **Award of Class:**

Sometimes, it is necessary to provide equivalence of these averages, viz., SGPA and CGPA with the percentages and/or Class awarded as in the conventional system of declaring the results of University examinations. This shall be done by Autonomous Colleges under the University only at one stage by prescribing certain specific thresholds in these averages for First Class with Distinction, First Class and Second Class, at the time of Degree Award. This provision given in Table-10 follows the approach of the Council for this purpose as reproduced from the AICTE Approval Process Handbook:

Table 10: Percentage Equivalence of Grade Points (for a 10 – Point Scale)

Grade Point	Percentage of Marks / Class
5.5	50
6.0	55
6.5	60
7.0	65
7.5	70
8.0	75

Note:

(1) The following Formula for Conversion of CGPA to percentage of marks to be used only after a student has successfully completed the program:
Percentage of Marks = $(CGPA - 0.5) \times 10$

(2) Class designation:
≥75% (First Class with Distinction),
≥ 60% and <75 % (First Class),
≥ 50 % and <60% (Second Class),
≥45% and <50% (Pass Class).

(3) The SGPA will be computed and printed on the Memorandum of Grades only if the candidate passes in all the courses offered and gets minimum B grade in all the courses.

(4) CGPA is calculated only when the candidate passes in all the courses offered in all the semesters.

15. COMPUTATION OF SGPA AND CGPA

The UGC recommends to compute the Semester Grade Point Average (SGPA) and Cumulative Grade Point Average (CGPA). The credit points earned by a student are used for calculating the Semester Grade Point Average (SGPA) and the Cumulative Grade Point Average (CGPA), both of which are important performance indices of the student. SGPA is equal to the sum of all the total points earned by the student in a given semester divided by the number of credits registered by the student in that semester. CGPA gives the sum of all the total points earned in all the previous semesters and the current semester divided by the number of credits registered in all these semesters. Thus,

$$SGPA = \sum_{i=1}^{n} (C_i G_i) / \sum_{i=1}^{n} C_i$$

Where, C_i is the number of credits of the i^{th} course and G_i is the grade point scored by the student in the i^{th} course and n represent the number of courses in which a student is registered in the concerned semester.

$$CGPA = \sum_{j=1}^{m} (C_j S_j) / \sum_{j=1}^{m} C_j$$

Where, S_j is the SGPA of the j^{th} semester and C_j is the total number of credits upto the semester and m represent the number of semesters completed in which a student registered upto the semester.

The SGPA and CGPA shall be rounded off to 2 decimal points and reported in the transcripts.

16. ILLUSTRATION OF COMPUTATION OF SGPA AND CGPA

16.1 Illustration for SGPA

Course Name	Course Credits	Grade letter	Grade point	Credit Point (Credit x Grade)
Course 1	3	A	8	3 x 8 = 24
Course 2	4	B+	7	4 x 7 = 28
Course 3	3	B	6	3 x 6 = 18

Course 4	3	S	10	3 x 10 = 30
Course 5	3	C	5	3 x 5 = 15
Course 6	4	B	6	4 x 6 = 24
	20			**139**

Thus, SGPA = 139 / 20 = 6.95

16.2 Illustration for CGPA

Semester 1	Semester 2	Semester 3	Semester 4
Credit: 20 SGPA: 6.9	Credit: 22 SGPA: 7.8	Credit: 25 SGPA: 5.6	Credit: 26 SGPA: 6.0
Semester 5	**Semester 6**		
Credit: 26 SGPA: 6.3	Credit: 25 SGPA: 8.0		

$$Thus,\ CGPA = \frac{20x6.9 + 22x7.8 + 25x5.6 + 26x6.0 + 26x6.3 + 25x8.0}{144} = 6.73$$

17. REVIEW OF SEE THEORY ANSWER BOOKS

Semester end examination answer books are made available online in CMS portal on the day of publication of results. A student, who is not satisfied with the assessment, is directed to apply for the review of his/her semester end examination answer book(s) in the theory course(s), within 2 working days from the publication of results in the prescribed format to the Controller of Examinations through the Head of the department with prescribed fee.

The Controller of Examinations shall appoint two examiners (chief examiner of original exam and a new examiner) for the review of the semester end examination (theory) answer book. Both examiners shall jointly review and marks awarded in the previous assessment shall be kept open.

The marks obtained by the candidate after the review shall be considered for grading, only if, the change in mark is more than or equal to 10% of total mark of semester end examination (theory). Marks obtained after re-evaluation shall stand final even if it is less than the original marks. Review is not permitted to the courses other than theory courses.

18. PROMOTION POLICIES

The following academic requirements have to be satisfied in addition to the attendance requirements mentioned in item no. 11.

18.1 For students admitted into B.Tech (Regular) program

18.1.1 A student will not be promoted from II semester to III semester unless s/he fulfills the academic requirement of securing 50% of the total credits (rounded to the next lowest integer) from I and II semester examinations, whether the candidate takes the examination(s) or not.

18.1.2 A student will not be promoted from IV semester to V semester unless s/he fulfills the academic requirement of securing 60% of the total credits (rounded to the next lowest integer) upto III semester **or** 60% of the total credits (rounded to the next lowest integer) up to IV semester, from all the examinations, whether the candidate takes the examination(s) or not.

18.1.3 A student shall be promoted from VI semester to VII semester only if s/he fulfills the academic requirements of securing 60% of the total credits (rounded to the next lowest integer) up to V semester **or** 60% of the total credits (rounded to the next lowest integer) up to VI semester from all the examinations, whether the candidate takes the examination(s) or not.

18.1.4 A student shall register for all the 160 credits and earn all the 160 credits. Marks obtained in all the 160 credits shall be considered for the award of the Grade.

18.2 For students admitted into B.Tech (lateral entry students)

18.2.1 A student will not be promoted from IV semester to V semester unless s/he fulfills the academic requirement of securing 60% of the total credits (rounded to the next lowest integer) up to IV semester, from all the examinations, whether the candidate takes the examination(s) or not.

18.2.2 A student shall be promoted from VI semester to VII semester only if s/he fulfills the academic requirements of securing 60% of the total credits (rounded to the next lowest integer) up to V semester **or** 60% of the total credits (rounded to the next lowest integer) up to VI semester from all the examinations, whether the candidate takes the examination(s) or not.

18.2.3 A student shall register for all the 126 credits and earn all the 126 credits. Marks obtained in all the 126 credits shall be considered for the award of the Grade.

19. GRADUATION REQUIREMENTS

The following academic requirements shall be met for the award of the B.Tech degree.

19.1 Student shall register and acquire minimum attendance in all courses and secure 160 credits (with minimum CGPA of 5.0), for regular program and 126 credits (with minimum CGPA of 5.0), for lateral entry program.

19.2 A student of a regular program, who fails to earn 160 credits within eight consecutive academic years from the year of his/her admission with a minimum CGPA of 5.0, shall forfeit his/her degree and his/her admission stands cancelled.

19.3 A student of a lateral entry program who fails to earn 126 credits within six consecutive academic years from the year of his/her admission with a minimum CGPA of 5.0, shall forfeit his/her degree and his/her admission stands cancelled.

20. BETTERMENT OF MARKS IN THE COURSES ALREADY PASSED

Students who clear all the courses in their first attempt and wish to improve their CGPA shall register and appear for betterment of marks for one course of any theory courses within a period of subsequent two semesters. The improved marks shall be considered for classification / distinction but not for ranking. If there is no improvement, there shall not be any change in the original marks already awarded.

21. AWARD OF DEGREE

21.1 Classification of degree will be as follows:

CGPA $\geq$ 8.0	CGPA $\geq$ 6.5 and < 8.0	CGPA $\geq$ 5.5 and < 6.5	CGPA $\geq$ 5.0 and < 5.5	CGPA < 5.0
First Class with Distinction	**First Class**	**Second Class**	**Pass Class**	**Fail**

21.2 A student with final CGPA (at the end of the under graduate programme) $\geq$8.00, and fulfilling the following conditions - shall be placed in '**first class with distinction**'. However,

(a) Should have passed all the courses in '**first appearance'** within the first 4 academic years (or 8 sequential semesters) from the date of commencement of first year first semester.

(b) Should have secured a CGPA $\geq$8.00, at the end of each of the 8 sequential semesters, starting from I year I semester onwards.

(c) Should not have been detained or prevented from writing the semester end examinations in any semester due to shortage of attendance or any other reason.

A student not fulfilling any of the above conditions with final CGPA >8 shall be placed in **'first class'.**

21.3 Students with final CGPA (at the end of the B.Tech program) ≥6.50 but <8.00 shall be placed in **'first class'.**

21.4 Students with final CGPA (at the end of the B.Tech program) ≥5.50 but <6.50, shall be placed in '**second class**'.

21.5 All other students who qualify for the award of the degree (as per item 19), with final CGPA (at the end of the B.Tech program) ≥5.0 but <5.50, shall be placed in '**pass class**'.

21.6 A student with final CGPA (at the end of the B.Tech program) < 5.00 will not be eligible for the award of the degree.

21.7 Students fulfilling the conditions listed under item 21.2 alone will be eligible for award of '**Gold Medal**'.

21.8. In order to extend the benefit to the students with one/two backlogs after either VI semester or VIII semester, GRAFTING option is provided to the students enabling their placements and fulfilling graduation requirements. Following are the guidelines for the Grafting:

(a) Grafting will be done among the courses within the semester shall draw a maximum of 7 marks from the any one of the cleared courses in the semester and will be grafted to the failed course in the same semester.

(b) Students shall be given a choice of grafting only once in the 4 years program, either after VI semester (Option #1) or after VIII semester (Option #2).

(c) Option#1: Applicable to students who have maximum of TWO theory courses in V and / or VI semesters.

Option#2: Applicable to students who have maximum of TWO theory courses in VII and / or VIII semesters.

(d) Eligibility for grafting:

i. Prior to the conduct of the supplementary examination after the declaration of VI or VIII semester results.

ii. S/he must appear in all regular or supplementary examinations as per the provisions laid down in regulations for the courses s/he appeals for grafting.

iii. The marks obtained by her/him in latest attempt shall be taken into account for grafting of marks in the failed course(s).

21.9 Student, who clears all the courses upto VII semester, shall have a chance to appear for Quick Supplementary Examination to clear the failed courses of VIII semester.

21.10 By the end of VI semester, all the students (regular and lateral entry students) shall complete one of the Value added course and mandatory course with acceptable performance.

21.11 In case, a student takes more than one attempt in clearing a course, the final marks secured shall be indicated by * mark in the grade sheet.

All the candidates who register for the semester end examination will be issued a memorandum of grades sheet by the institute. Apart from the semester wise memorandum of grades sheet, the institute will issue the provisional certificate and consolidated grades memorandum subject to the fulfillment of all the academic requirements.

22. B.TECH WITH HONOURS OR ADDITIONAL MINORS IN ENGINEERING

Students acquiring 160 credits are eligible to get B.Tech degree in Engineering. A student will be eligible to get B.Tech degree with Honours or additional Minors in Engineering, if s/he completes an additional 20 credits (3/4 credits per course). These could be acquired through MOOCs from SWAYAM / NPTEL / edX / Coursera / Udacity / PurdueNext / Khan Academy / QEEE etc. The list for MOOCs will be a dynamic one, as new courses are added from time to time. Few essential skill sets required for employability are also identified year wise. Students interested in doing MOOC courses shall register the course title at their department office at the start of the semester against the courses that are announced by the department. Any expense incurred for the MOOC course / summer program should be met by the students.

Only students having no credit arrears and a CGPA of 7.5 or above at the end of the fourth semester are eligible to register for B.Tech (Honours / Minor). After registering for the B.Tech (Honours / Minor) program, if a student fails in any course, s/he will not be eligible for B.Tech (Honours / Minor).

Every Department to develop and submit a Honours / Minors – courses list of 5 - 6 theory courses.

Honours Certificate for Vertical in his/her OWN Branch for Research orientation; Minor in any other branch for Improving Employability.

For the MOOCs platforms, where examination or assessment is absent (like SWAYAM) or where certification is costly (like Coursera or edX), faculty members of the institute prepare the examination question papers, for the courses undertaken by the students of respective Institutes, so that examinations Control Office (ECO) can conduct examination for the course. There shall be one Continuous Internal Examination (Quiz exam for 30 marks) after 8 weeks of the commencement of the course and semester end examination (Descriptive exam for 70 marks) shall be done along with the other regular courses.

A student can enroll for both Minor & Honours or for two Minors. The final grade sheet will only show the basic CGPA corresponding to the minimum requirement for the degree. The Minors/Honours will be indicated by a separate CGPA. The additional courses taken will also find separate mention in the grade sheet.

If a student drops (or terminated) from the Minor/Honours program, they cannot convert the earned credits into free or core electives; they will remain extra. These additional courses will find mention in the grade sheet (but not in the degree certificate). In such cases, the student may choose between the actual grade or a “Pass (P)” grade and also choose to omit the mention of the course as for the following:

- All the courses done under the dropped Minor/Honours will be shown in the grade sheet
- None of the courses done under the dropped Minor/Honours will be shown in the grade sheet.

Honours will be reflected in the degree certificate as “B.Tech (Honours) in XYZ Engineering”. Similarly, Minor as “B.Tech in XYZ Engineering with Minor in ABC”. If a student has done both Honours & Minor, it will be acknowledged as “B.Tech (Honours) in XYZ Engineering with Minor in ABC”. And two minors will be reflected as “B.Tech in XYZ Engineering with Minor in ABC and Minor in DEF”.

22.1. B.Tech with Honours

The total of 20 credits required to be attained for B.Tech Honours degree is distributed from V semester to VII semester in the following way:

For V semester	:	4 – 8 credits
For VI semester	:	4 – 8 credits
For VII semester	:	4 – 8 credits

Following are the details of such Honours which include some of the most interesting areas in the profession today:

S. No	Department	Honours scheme
1	Aeronautical Engineering	Aerospace Engineering / Space Science etc.
2	Computer Science and Engineering / Information Technology	Big data and Analytics / Cyber Physical Systems, Information Security / Cognitive Science / Artificial Intelligence/ Machine Learning / Data Science / Internet of Things (IoT) etc.
3	Electronics and Communication Engineering	Digital Communication / Signal Processing / Communication Networks / VLSI Design / Embedded Systems etc.

4	Electrical and Electronics Engineering	Renewable Energy systems / Energy and Sustainability / IoT Applications in Green Energy Systems etc.
5	Mechanical Engineering	Industrial Automation and Robotics / Manufacturing Sciences and Computation Techniques etc.
6	Civil Engineering	Structural Engineering / Environmental Engineering etc.

22.2 B.Tech with additional Minor in Engineering

Every department to develop and submit Minor courses list of 5 - 6 Theory courses. Student from any department is eligible to apply for Minor from any other department. The total of 20 credits to complete the B.Tech (Minor) program by registering for MOOC courses each having a minimum of 3/4 credits offered by reputed institutions / organization with the approval of the department. Registration of the student for B.Tech (Minor), is from V Semester to VII Semester of the program in the following way:

For V semester	:	4 – 8 credits
For VI semester	:	4 – 8 credits
For VII semester	:	4 – 8 credits

Only students having no credit arrears and a CGPA of 7.5 or above at the end of the fourth semester are eligible to register for B.Tech (Minor). After registering for the B.Tech (Minor) program, if a student fails in any course, s/he will not be eligible for B.Tech (Minor).

Every student shall also have the option to do a minor in engineering. A major is a primary focus of study and a minor is a secondary focus of study. The minor has to be a subject offered by a department other than the department that offers the major of the student or it can be a different major offered by the same department. For example, a student with the declared major in Computer Science and Engineering (CSE) may opt to do a minor in Physics; in which case, the student shall receive the degree B.Tech, Computer Science and Engineering with a minor in Physics. A student can do Majors in chosen filed as per the career goal, and a minor may be chosen to enhance the major thus adding the diversity, breadth and enhanced skills in the field.

22.3 Advantages of Minor in Engineering:

The minors mentioned above are having lots of advantages and a few are listed below:

1. To apply the inter-disciplinary knowledge gained through a Major (Stream) + Minor.
2. To enable students to pursue allied academic interest in contemporary areas.
3. To provide an academic mechanism for fulfilling multidisciplinary demands of industries.
4. To provide effective yet flexible options for students to achieve basic to intermediate level competence in the Minor area.
5. Provides an opportunity to students to become entrepreneurs and leaders by taking business/ management minor.
6. Combination in the diverse fields of engineering e.g., CSE (Major) + Electronics (Minor) combination increases placement prospects in chip designing companies.
7. Provides an opportunity to Applicants to pursue higher studies in an inter-disciplinary field of study.
8. Provides opportunity to the Applicants to pursue interdisciplinary research.
9. To increase the overall scope of the undergraduate degrees.

22.4 Following are the details of such Minor / Honours which include some of the most interesting areas in the profession today:

1. Aerospace Engineering
2. Space Science
3. Industrial Automation and Robotics
4. Computer Science and Engineering
5. Data Analytics
6. Machine Learning
7. Data Science

8. Artificial Intelligence
9. Information Security
10. Internet of Things
11. Cyber Physical Systems
12. Electronic System Design
13. Renewable Energy Sources
14. Energy and Sustainability
15. Manufacturing Sciences and Computation Techniques
16. Structural Engineering
17. Environmental Engineering
18. Technological Entrepreneurship
19. Materials Engineering
20. Physics (Materials / Nuclear / Optical / Medical)
21. Mathematics (Combinatorics / Logic / Number theory / Dynamical systems and differential equations/ Mathematical physics / Statistics and Probability).

23.0 TEMPORARY BREAK OF STUDY FROM THE PROGRAM

23.1 A candidate is normally not permitted to take a break from the study. However, if a candidate intends to temporarily discontinue the program in the middle for valid reasons (such as accident or hospitalization due to prolonged ill health) and to rejoin the program in a later respective semester, s/he shall seek the approval from the Principal in advance. Such application shall be submitted before the last date for payment of examination fee of the semester in question and forwarded through the Head of the Department stating the reasons for such withdrawal together with supporting documents and endorsement of his / her parent / guardian.

23.2 The institute shall examine such an application and if it finds the case to be genuine, it may permit the student to temporarily withdraw from the program. Such permission is accorded only to those who do not have any outstanding dues / demand at the College / University level including tuition fees, any other fees, library materials etc.

23.3 The candidate has to rejoin the program after the break from the commencement of the respective semester as and when it is offered.

23.4 The total period for completion of the program reckoned from the commencement of the semester to which the candidate was first admitted shall not exceed the maximum period specified in clause 19. The maximum period includes the break period.

23.5 If any candidate is detained for any reason, the period of detention shall not be considered as 'Break of Study'.

24. TERMINATION FROM THE PROGRAM

The admission of a student to the program may be terminated and the student is asked to leave the institute in the following circumstances:

a. The student fails to satisfy the requirements of the program within the maximum period stipulated for that program.
b. A student shall not be permitted to study any semester more than three times during the entire program of study.
c. The student fails to satisfy the norms of discipline specified by the institute from time to time.

25. TRANSCRIPT

The Transcript will be issued to the student as and when required and will contain a consolidated record of all the courses undergone by him/her, grades obtained and CGPA upto the date of issue of transcript. Only last letter grade obtained in a course by the student upto the date of issue of transcript will be shown in the Transcript.

26. WITH-HOLDING OF RESULTS

If the candidate has not paid any dues to the institute / if any case of indiscipline / malpractice is pending against him, the results and the degree of the candidate will be withheld.

27. GRADUATION DAY

The institute shall have its own annual Graduation Day for the award of degrees to the students completing the prescribed academic requirements in each case, in consultation with the University and by following the provisions in the Statute. The college shall institute prizes and medals to meritorious students and award them annually at the Graduation Day. This will greatly encourage the students to strive for excellence in their academic work.

28. DISCIPLINE

Every student is required to observe discipline and decorum both inside and outside the institute and are expected not to indulge in any activity which will tend to bring down the honour of the institute. If a student indulges in malpractice in any of the theory / practical examination, continuous assessment examinations, he/she shall be liable for punitive action as prescribed by the institute from time to time.

29. GRIEVANCE REDRESSAL COMMITTEE

The institute shall form a Grievance Redressal Committee for each course in each department with the Course Teacher and the HOD as the members. This Committee shall solve all grievances related to the course under consideration.

30. TRANSITORY REGULATIONS

A candidate, who is detained or has discontinued a semester, on readmission shall be required to do all the courses in the curriculum prescribed for the batch of students in which the student joins subsequently. However, exemption will be given to those candidates who have already passed such courses in the earlier semester(s) he was originally admitted into and substitute subjects are offered in place of them as decided by the Board of Studies. However, the decision of the Board of Studies will be final.

a) Four Year B.Tech Regular course:

A student who is following Jawaharlal Nehru Technological University (JNTUH) curriculum and detained due to the shortage of attendance at the end of the first semester shall join the autonomous batch of first semester. Such students shall study all the courses prescribed for the batch in which the student joins and considered on par with regular candidates of Autonomous stream and will be governed by the autonomous regulations.

A student who is following JNTUH curriculum, detained due to lack of credits or shortage of attendance at the end of the second semester or at the subsequent semesters shall join with the autonomous batch in the appropriate semester. Such candidates shall be required to pass in all the courses in the program prescribed by the Board of Studies concerned for that batch of students from that semester onwards to be eligible for the award of degree. However, exemption will be given in the courses of the semester(s) of the batch which he had passed earlier and substitute courses will be offered in place of them as decided by the Board of Studies. The student has to clear all his backlog courses up to previous semester by appearing for the supplementary examinations conducted by JNTUH for the award of degree. The total number of credits to be secured for the award of the degree will be sum of the credits up to previous semester under JNTUH regulations and the credits prescribed for the semester in which a candidate seeks readmission and subsequent semesters under the autonomous stream. The class will be awarded based on the academic performance of a student in the autonomous pattern.

b) Three Year B.Tech program under Lateral Entry Scheme:

A student who is following JNTUH curriculum and detained due to the shortage of attendance at the end of the first semester of second year shall join the autonomous batch of third semester. Such students shall study all the courses prescribed for the batch in which the student joins and considered on par with Lateral Entry regular candidates of Autonomous stream and will be governed by the autonomous regulations.

A student who is following JNTUH curriculum, if detained due to lack of credits or shortage of attendance at the end of the second semester of second year or at the subsequent semesters shall join with the autonomous batch in the appropriate semester. Such candidates shall be required to pass in all the courses in the program prescribed by the Board of Studies concerned for that batch of students from that semester onwards to be eligible for the award of degree. However, exemption will be given in the courses of the semester(s) of the batch which he had passed earlier and substitute courses are offered in place of them as decided by the Board of Studies. The student has to clear all his backlog courses up to previous semester by appearing for the supplementary examinations conducted by JNTUH for the award of degree. The total number of credits to be secured for the award of the degree will be sum of the credits up to previous semester under JNTUH regulations and the credits prescribed for the semester in which a candidate seeks readmission and subsequent semesters under the autonomous status. The class will be awarded based on the academic performance of a student in the autonomous pattern.

c) Transfer candidates (from non-autonomous college affiliated to JNTUH):

A student who is following JNTUH curriculum, transferred from other college to this institute in third semester or subsequent semesters shall join with the autonomous batch in the appropriate semester. Such candidates shall be required to pass in all the courses in the program prescribed by the Board of Studies concerned for that batch of students from that semester onwards to be eligible for the award of degree. However, exemption will be given in the courses of the semester(s) of the batch which he had passed earlier and substitute courses are offered in their place as decided by the Board of Studies. The student has to clear all his backlog courses up to previous semester by appearing for the supplementary examinations conducted by JNTUH for the award of degree. The total number of credits to be secured for the award of the degree will be the sum of the credits up to the previous semester under JNTUH regulations and the credits prescribed for the semester in which a candidate joined after transfer and subsequent semesters under the autonomous status. The class will be awarded based on the academic performance of a student in the autonomous pattern.

d) Transfer candidates (from an autonomous college affiliated to JNTUH):

A student who has secured the required credits up to previous semesters as per the regulations of other autonomous institutions shall also be permitted to be transferred to this institute. A student who is transferred from the other autonomous colleges to this institute in third semester or subsequent semesters shall join with the autonomous batch in the appropriate semester. Such candidates shall be required to pass in all the courses in the program prescribed by the Board of Studies concerned for that batch of students from that semester onwards to be eligible for the award of degree. However, exemption will be given in the courses of the semester(s) of the batch which he had passed earlier and substitute subjects are offered in their place as decided by the Board of Studies. The total number of credits to be secured for the award of the degree will be the sum of the credits up to previous semester as per the regulations of the college from which he is transferred and the credits prescribed for the semester in which a candidate joined after transfer and subsequent semesters under the autonomous status. The class will be awarded based on the academic performance of a student in the autonomous pattern.

e) Readmission from IARE-R16/R18 to IARE-UG.20 regulations

A student took admission in IARE-R18 Regulations, detained due to lack of required number of credits or percentage of attendance at the end of any semester is permitted to take re-admission at appropriate level under any regulations prevailing in the institute subject to the following rules and regulations.

1. Student shall pass all the courses in the earlier scheme of regulations (IARE - R18). However, in case of having backlog courses, they shall be cleared by appearing for supplementary examinations conducted under IARE - R18 regulations from time to time.
2. After rejoining, the student is required to study the courses as prescribed in the new regulations for the re-admitted program at that level and thereafter.
3. If the student has already passed any course(s) of readmitted program in the earlier regulation / semester of study, such courses are exempted in the new scheme to appear for the course(s).
4. The courses that are not done in the earlier regulations / semester as compared with readmitted program need to be cleared after readmission by appearing for the examinations conducted time to time under the new regulations.
5. In general, after transition, course composition and number of credits / semester shall be balanced between earlier and new regulations on case to case basis.
6. In case, the students who do not have option of acquiring required credits with the existing courses offered as per the new curriculum, credit balance can be achieved by clearing the additional courses offered by the respective departments (approved in Academic Council meeting). The additional courses that are offered can be of theory or laboratory courses and shall be offered during semester.
7. Students re-joined in III semester shall be treated on par with "Lateral Entry" students for credits and graduation requirements. However, the student shall clear all the courses in B.Tech I Semester and B.Tech II Semester as per IARE-R18 regulations.

31. REVISION OF REGULATIONS AND CURRICULUM

The Institute from time to time may revise, amend or change the regulations, scheme of examinations and syllabi if found necessary and on approval by the Academic Council and the Governing Body and shall be binding on the students, faculty, staff, all authorities of the Institute and others concerned.

FREQUENTLY ASKED QUESTIONS AND ANSWERS ABOUT AUTONOMY

1. **Who grants Autonomy? UGC, Govt., AICTE or University**
   In case of Colleges affiliated to a university and where statutes for grant of autonomy are ready, it is the respective University that finally grants autonomy but only after concurrence from the respective state Government as well as UGC. The State Government has its own powers to grant autonomy directly to Govt. and Govt. aided Colleges.

2 **Shall IARE award its own Degrees?**
No. Degree will be awarded by Jawaharlal Nehru Technological University, Hyderabad with a mention of the name IARE on the Degree Certificate.

3 **What is the difference between a Deemed University and an Autonomy College?**
A Deemed University is fully autonomous to the extent of awarding its own Degree. A Deemed University is usually a Non-Affiliating version of a University and has similar responsibilities like any University. An Autonomous College enjoys Academic Autonomy alone. The University to which an autonomous college is affiliated will have checks on the performance of the autonomous college.

4 **How will the Foreign Universities or other stake – holders know that we are an Autonomous College?**
Autonomous status, once declared, shall be accepted by all the stake holders. The Govt. of Telangana mentions autonomous status during the First Year admission procedure. Foreign Universities and Indian Industries will know our status through our website.

5 **What is the change of Status for Students and Teachers if we become Autonomous?**
An autonomous college carries a prestigious image. Autonomy is actually earned out of our continued past efforts on academic performances, our capability of self- governance and the kind of quality education we offer.

6 **Who will check whether the academic standard is maintained / improved after Autonomy? How will it be checked?**
There is a built in mechanism in the autonomous working for this purpose. An Internal Committee called Academic Program Evaluation Committee, which will keep a watch on the academics and keep its reports and recommendations every year. In addition the highest academic council also supervises the academic matters. The standards of our question papers, the regularity of academic calendar, attendance of students, speed and transparency of result declaration and such other parameters are involved in this process.

7 **Will the students of IARE as an Autonomous College qualify for University Medals and Prizes for academic excellence?**
No. IARE has instituted its own awards, medals, etc. for the academic performance of the students. However for all other events like sports, cultural on co-curricular organized by the University the students shall qualify.

8 **Can IARE have its own Convocation?**
No. Since the University awards the Degree the Convocation will be that of the University, but there will be Graduation Day at IARE.

9 **Can IARE give a provisional degree certificate?**
Since the examinations are conducted by IARE and the results are also declared by IARE, the college sends a list of successful candidates with their final Grades and Grade Point Averages including CGPA to the University. Therefore with the prior permission of the University the college will be entitled to give the provisional certificate.

10 **Will Academic Autonomy make a positive impact on the Placements or Employability?**
Certainly. The number of students qualifying for placement interviews is expected to improve, due to

rigorous and repetitive classroom teaching and continuous assessment. Also the autonomous status is more responsive to the needs of the industry. As a result therefore, there will be a lot of scope for industry oriented skill development built-in into the system. The graduates from an autonomous college will therefore represent better employability.

11 What is the proportion of Internal and External Assessment as an Autonomous College?

Presently, it is 60% external and 40% internal. As the autonomy matures the internal assessment component shall be increased at the cost of external assessment.

12 Is it possible to have complete Internal Assessment for Theory or Practicals?

Yes indeed. We define our own system. We have the freedom to keep the proportion of external and internal assessment component to choose.

13 Why Credit based Grade System?

The credit based grade system is an accepted standard of academic performance the world over in all Universities. The acceptability of our graduates in the world market shall improve.

14 What exactly is a Credit based Grade System?

The credit based grade system defines a much better statistical way of judging the academic performance. One Lecture Hour per week of Teaching Learning process is assigned One Credit. One hour of laboratory work is assigned half credit. Letter Grades like A, B,C,D, etc. are assigned for a Range of Marks. (e.g. 91% and above is A+, 80 to 90 % could be A etc.) in Absolute Grading System while grades are awarded by statistical analysis in relative grading system. We thus dispense with sharp numerical boundaries. Secondly, the grades are associated with defined Grade Points in the scale of 1 to 10. Weighted Average of Grade Points is also defined Grade Points are weighted by Credits and averaged over total credits in a Semester. This process is repeated for all Semesters and a CGPA defines the Final Academic Performance

15 What are the norms for the number of Credits per Semester and total number of Credits for UG/PG program?

These norms are usually defined by UGC or AICTE. Usually around 25 Credits per semester is the accepted norm.

16 What is a Semester Grade Point Average (SGPA)?

The performance of a student in a semester is indicated by a number called SGPA. The SGPA is the weighted average of the grade points obtained in all the courses registered by the student during the semester.

$$SGPA = \sum_{i=1}^{n} (C_i G_i) / \sum_{i=1}^{n} C_i$$

Where, C_i is the number of credits of the i^{th} course and G_i is the grade point scored by the student in the i^{th} course and i represent the number of courses in which a student registered in the concerned semester. SGPA is rounded to two decimal places.

17 What is a Cumulative Grade Point Average (CGPA)?

An up-to-date assessment of overall performance of a student from the time of his first registration is obtained by calculating a number called CGPA, which is weighted average of the grade points obtained in all the courses registered by the students since he entered the Institute.

$$CGPA = \sum_{j=1}^{m} (C_j S_j) / \sum_{j=1}^{m} C_j$$

Where, S_j is the SGPA of the j^{th} semester and C_j is the total number of credits upto the semester and m represent the number of semesters completed in which a student registered upto the semester. CGPA is rounded to two decimal places.

18 Is there any Software available for calculating Grade point averages and converting the same into Grades?

Yes, The institute has its own MIS software for calculation of SGPA, CGPA, etc.

19 Will the teacher be required to do the job of calculating SGPAs etc. and convert the same into Grades?

No. The teacher has to give marks obtained out of whatever maximum marks as it is. Rest is all done by the computer.

20 Will there be any Revaluation or Re-Examination System?

No. There will double valuation of answer scripts. There will be a makeup Examination after a reasonable preparation time after the End Semester Examination for specific cases mentioned in the Rules and Regulations. In addition to this, there shall be a ‘summer term’ (compressed term) followed by the End Semester Exam, to save the precious time of students.

21 How fast Syllabi can be and should be changed?

Autonomy allows us the freedom to change the syllabi as often as we need.

22 Will the Degree be awarded on the basis of only final year performance?

No. The CGPA will reflect the average performance of all the semester taken together.

23 What are Statutory Academic Bodies?

Governing Body, Academic Council, Examination Committee and Board of Studies are the different statutory bodies. The participation of external members in everybody is compulsory. The institute has nominated professors from IIT, NIT, University (the officers of the rank of Pro-vice Chancellor, Deans and Controller of Examinations) and also the reputed industrialist and industry experts on these bodies.

24 Who takes Decisions on Academic matters?

The Governing Body of institute is the top academic body and is responsible for all the academic decisions. Many decisions are also taken at the lower level like Boards of Studies. Decisions taken at the Boared of Studies level are to be ratified at the Academic Council and Governing Body.

25 What is the role of Examination committee?

The Examinations Committee is responsible for the smooth conduct of internal, End Semester and make up Examinations. All matters involving the conduct of examinations spot valuations, tabulations preparation of Grade Sheet etc fall within the duties of the Examination Committee.

26 Is there any mechanism for Grievance Redressal?

The institute has grievance redressal committee, headed by Dean - Student affairs and Dean - IQAC.

27 How many attempts are permitted for obtaining a Degree?

All such matters are defined in Rules & Regulation

28 Who declares the result?

The result declaration process is also defined. After tabulation work wherein the SGPA, CGPA and final Grades are ready, the entire result is reviewed by the Moderation Committee. Any unusual deviations or gross level discrepancies are deliberated and removed. The entire result is discussed in the Examinations and Result Committee for its approval. The result is then declared on the institute notice boards as well put on the web site and Students Corner. It is eventually sent to the University.

29 Who will keep the Student Academic Records, University or IARE?

It is the responsibility of the Dean, Academics of the Autonomous College to keep and preserve all the records.

30 What is our relationship with the JNT University?

We remain an affiliated college of the JNT University. The University has the right to nominate its members on the academic bodies of the college.

31 Shall we require University approval if we want to start any New Courses?

Yes, It is expected that approvals or such other matters from an autonomous college will receive priority.

32 Shall we get autonomy for PG and Doctoral Programs also?

Yes, presently our PG programs also enjoying autonomous status.

MALPRACTICE RULES

DISCIPLINARY ACTION FOR / IMPROPER CONDUCT IN EXAMINATIONS

S. No	Nature of Malpractices/Improper conduct	Punishment
	If the candidate:	
1. (a)	Possesses or keeps accessible in examination hall, any paper, note book, programmable calculator, cell phone, pager, palm computer or any other form of material concerned with or related to the subject of the examination (theory or practical) in which he is appearing but has not made use of (material shall include any marks on the body of the candidate which can be used as an aid in the subject of the examination)	Expulsion from the examination hall and cancellation of the performance in that subject only.
(b)	Gives assistance or guidance or receives it from any other candidate orally or by any other body language methods or communicates through cell phones with any candidate or persons in or outside the exam hall in respect of any matter.	Expulsion from the examination hall and cancellation of the performance in that subject only of all the candidates involved. In case of an outsider, he will be handed over to the police and a case is registered against him.
2.	Has copied in the examination hall from any paper, book, programmable calculators, palm computers or any other form of material relevant to the subject of the examination (theory or practical) in which the candidate is appearing.	Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted to appear for the remaining examinations of the subjects of that Semester/year. The Hall Ticket of the candidate is to be cancelled and sent to the Controller of Examinations.
3.	Impersonates any other candidate in connection with the examination.	The candidate who has impersonated shall be expelled from examination hall. The candidate is also debarred and forfeits the seat. The performance of the original candidate, who has been impersonated, shall be cancelled in all the subjects of the examination (including practicals and project work) already appeared and shall not be allowed to appear for examinations of the remaining subjects of that semester/year. The candidate is also debarred for two consecutive semesters from class work and all semester end examinations. The continuation of the course by the candidate is subject to the academic regulations in connection with forfeiture of seat. If the imposter is an outsider, he will be handed over to the police and a case is registered against him.
4.	Smuggles in the Answer book or additional sheet or takes out or arranges to send out the question paper during the examination or answer book or additional sheet, during or after the examination.	Expulsion from the examination hall and cancellation of performance in that subject and all the other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the

		remaining examinations of the subjects of that semester/year. The candidate is also debarred for two consecutive semesters from class work and all semester end examinations. The continuation of the course by the candidate is subject to the academic regulations in connection with forfeiture of seat.
5.	Uses objectionable, abusive or offensive language in the answer paper or in letters to the examiners or writes to the examiner requesting him to award pass marks.	Cancellation of the performance in that subject.
6.	Refuses to obey the orders of the Controller of Examinations /Additional Controller of Examinations/any officer on duty or misbehaves or creates disturbance of any kind in and around the examination hall or organizes a walk out or instigates others to walk out, or threatens the COE or any person on duty in or outside the examination hall of any injury to his person or to any of his relations whether by words, either spoken or written or by signs or by visible representation, assaults the COE or any person on duty in or outside the examination hall or any of his relations, or indulges in any other act of misconduct or mischief which result in damage to or destruction of property in the examination hall or any part of the Institute premises or engages in any other act which in the opinion of the officer on duty amounts to use of unfair means or misconduct or has the tendency to disrupt the orderly conduct of the examination.	In case of students of the college, they shall be expelled from examination halls and cancellation of their performance in that subject and all other subjects the candidate(s) has (have) already appeared and shall not be permitted to appear for the remaining examinations of the subjects of that semester/year. The candidates also are debarred and forfeit their seats. In case of outsiders, they will be handed over to the police and a police case is registered against them.
7.	Leaves the exam hall taking away answer script or intentionally tears off the script or any part thereof inside or outside the examination hall.	Expulsion from the examination hall and cancellation of performance in that subject and all the other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester/year. The candidate is also debarred for two consecutive semesters from class work and all semester end examinations. The continuation of the course by the candidate is subject to the academic regulations in connection with forfeiture of seat.
8.	Possess any lethal weapon or firearm in the examination hall.	Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester/year. The candidate is also debarred and forfeits the seat.
9.	If student of the college, who is not a candidate for the particular examination or any person not	Student of the colleges expulsion from the examination hall and cancellation of the

	connected with the college indulges in any malpractice or improper conduct mentioned in clause 6 to 8.	performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester/year. The candidate is also debarred and forfeits the seat. Person(s) who do not belong to the College will be handed over to police and, a police case will be registered against them.
10.	Comes in a drunken condition to the examination hall.	Expulsion from the examination hall and cancellation of the performance in that subject and all other subjects the candidate has already appeared including practical examinations and project work and shall not be permitted for the remaining examinations of the subjects of that semester/year.
11.	Copying detected on the basis of internal evidence, such as, during valuation or during special scrutiny.	Cancellation of the performance in that subject and all other subjects the candidate has appeared including practical examinations and project work of that semester/year examinations.
12.	If any malpractice is detected which is not covered in the above clauses 1 to 11 shall be reported to the University for further action to award suitable punishment.	

FAILURE TO READ AND UNDERSTAND THE REGULATIONS IS NOT AN EXCUSE

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad – 500043

COURSE CATALOG

(AERONAUTICAL ENGINEERING)

I SEMESTER

Course Code	Course Name	Subject Area	Category	Periods per week			Credits	Scheme of Examination Max. Marks		
				L	T	P		CIA	SEE	Total
THEORY										
AHSC01	English	HSMC	Foundation	3	0	0	3	30	70	100
AHSC02	Linear Algebra and Calculus	BSC	Foundation	3	1	0	4	30	70	100
AHSC03	Engineering Physics	BSC	Foundation	3	0	0	3	30	70	100
ACSC01	Python Programming	ESC	Foundation	3	0	0	3	30	70	100
PRACTICAL										
AHSC04	English Language and Communication Skills Laboratory	HSMC	Foundation	0	0	2	1	30	70	100
AHSC05	Physics Laboratory	BSC	Foundation	0	0	3	1.5	30	70	100
ACSC02	Python Programming Laboratory	ESC	Foundation	0	0	3	1.5	30	70	100
TOTAL				**12**	**01**	**08**	**17**	**210**	**490**	**700**

II SEMESTER

Course Code	Course Name	Subject Area	Category	Periods per week			Credits	Scheme of Examination Max. Marks		
				L	T	P		CIA	SEE	Total
THEORY										
AHSC06	Chemistry	BSC	Foundation	2	0	0	2	30	70	100
AHSC07	Mathematical Transform Techniques	BSC	Foundation	3	1	0	4	30	70	100
AMEC01	Engineering Mechanics	ESC	Foundation	3	0	0	3	30	70	100
AEEC01	Basic Electrical Engineering	ESC	Foundation	3	0	0	3	30	70	100
ACSC06	Experiential Engineering Education (ExEEd) – Academic Sucess	ESC	Foundation	2	0	0	1	30	70	100
PRACTICAL										
AMEC02	Manufacturing Practice	ESC	Foundation	0	0	2	1	30	70	100
AMEC03	Computer Aided Engineering Drawing	ESC	Foundation	1	0	2	1.5	30	70	100
ACSC03	Programming for Problem Solving Laboratory	ESC	Foundation	0	0	3	1.5	30	70	100
TOTAL				**14**	**01**	**07**	**17**	**240**	**560**	**800**

III SEMESTER

Course Code	Course Name	Subject Area	Category	Periods per week			Credits	Scheme of Examination Max. Marks		
				L	T	P		CIA	SEE	Total
THEORY										
AHSC08	Probability and Statistics	BSC	Foundation	3	1	0	4	30	70	100
AAEC01	Mechanics of Solids	PCC	Core	3	0	0	3	30	70	100
AAEC02	Engineering Thermodynamics	PCC	Core	3	0	0	3	30	70	100
AAEC03	Fluid Dynamics	PCC	Core	3	1	0	4	30	70	100
ACSC08	Data Structures	PCC	Core	3	0	0	3	30	70	100
ACSC09	ExEEd - Prototype / Design Building	ESC	Foundation	2	0	0	1	30	70	100
PRACTICALS										
AAEC04	Fluid Dynamics Laboratory	PCC	Core	0	0	2	1	30	70	100
AAEC05	Mechanics of Solids Laboratory	PCC	Core	0	0	3	1.5	30	70	100
ACSC10	Data Structures Laboratory	PCC	Core	0	0	3	1.5	30	70	100
MANDATORY / VALUE ADDED COURSES										
AHSC10	Essence of Indian Traditional Knowledge	MC-I	MC	Ref: 8.4 Academic Regulations, UG.20						
TOTAL				**17**	**02**	**08**	**22**	**270**	**630**	**900**

IV SEMESTER

Course Code	Course Name	Subject Area	Category	Periods per week			Credits	Scheme of Examination Max. Marks		
				L	T	P		CIA	SEE	Total
THEORY										
AAEC06	Aerospace Structures	PCC	Core	3	1	0	4	30	70	100
AAEC07	Aircraft Propulsion	PCC	Core	3	1	0	4	30	70	100
AAEC08	Aerodynamics	PCC	Core	3	0	0	3	30	70	100
AAEC09	Flight Mechanics	PCC	Core	3	0	0	3	30	70	100
AAEC10	Aircraft Production Technology	PCC	Core	3	0	0	3	30	70	100
ACSC14	ExEEd - Fabrication / Model Development	ESC	Foundation	2	0	0	1	30	70	100
PRACTICALS										
AAEC11	Aerospace Structures Laboratory	PCC	Core	0	0	3	1.5	30	70	100
AAEC12	Aerodynamics and Propulsion Laboratory	PCC	Core	0	0	3	1.5	30	70	100
AAEC13	Aircraft Production Technology Laboratory	PCC	Core	0	0	2	1	30	70	100
MANDATORY / VALUE ADDED COURSES										
ACSC18	Fundamentals of Database Systems	VAC-I	Skill	Ref: 8.6, Academic Regulations-UG.20						
	TOTAL			**17**	**02**	**08**	**22**	**270**	**630**	**900**

V SEMESTER

Course Code	Course Name	Subject Area	Category	Periods per week			Credits	Scheme of Examination Max. Marks		
				L	T	P		CIA	SEE	Total
THEORY										
AHSC13	Business Economics and Financial Analysis	HSMC	Foundation	3	0	0	3	30	70	100
AAEC14	Aerospace Propulsion	PCC	Core	3	1	0	4	30	70	100
AAEC15	Analysis of Aircraft Structures	PCC	Core	3	1	0	4	30	70	100
AAEC16	High Speed Aerodynamics	PCC	Core	3	1	0	4	30	70	100
	Professional Elective – I	PEC	Elective	3	0	0	3	30	70	100
ACSC20	ExEEd - Project Based Learning	ESC	Foundation	2	0	0	1	30	70	100
PRACTICALS										
AAEC21	Computer Aided Aircraft Production Drawing Laboratory	PCC	Core	0	0	3	1.5	30	70	100
AAEC22	Computational Structure Laboratory	PCC	Core	0	0	3	1.5	30	70	100
MANDATORY / VALUE ADDED COURSES										
ACSC23	Object Oriented Programming Development and Languages	VAC-II	Skill	Ref: 8.6, Academic Regulations-UG.20						
TOTAL				**17**	**03**	**06**	**22**	**240**	**560**	**800**

VI SEMESTER

Course Code	Course Name	Subject Area	Category	Periods per week			Credits	Scheme of Examination Max. Marks		
				L	T	P		CIA	SEE	Total
THEORY										
AAEC23	Finite Element Analysis	PCC	Core	3	1	0	4	30	70	100
AAEC24	Aircraft Stability and Control	PCC	Core	3	1	0	4	30	70	100
AAEC25	Computational Aerodynamics	PCC	Core	3	1	0	4	30	70	100
	Professional Elective – II	PEC	Elective	3	0	0	3	30	70	100
	Open Elective – I	OEC	Elective	3	0	0	3	30	70	100
ACSC27	ExEEd - Research Based Learning	ESC	Foundation	2	0	0	1	30	70	100
PRACTICALS										
AAEC32	Computational Aerodynamics Laboratory	PCC	Core	0	0	3	1.5	30	70	100
AAEC33	Computer Aided Manufacturing (CAM) Laboratory	PCC	Core	0	0	3	1.5	30	70	100
MANDATORY / VALUE ADDED COURSES										
ACSC29	Design of Algorithms	VAC-III	Skill	Ref: 8.6, Academic Regulations-UG.20						
TOTAL				**17**	**03**	**06**	**22**	**240**	**560**	**800**

VII SEMESTER

Course Code	Course Name	Subject Area	Category	Periods per week			Credits	Scheme of Examination Max. Marks		
				L	T	P		CIA	SEE	Total
THEORY										
AAEC34	Flight Vehicle Design	PCC	Core	3	0	0	3	30	70	100
AAEC35	Aerospace Structural Dynamics	PCC	Core	3	1	0	4	30	70	100
	Professional Elective – III	PEC	Elective	3	0	0	3	30	70	100
	Professional Elective – IV	PEC	Elective	3	0	0	3	30	70	100
	Open Elective – II	OEC	Elective	3	0	0	3	30	70	100
PRACTICALS										
AAEC44	Flight Vehicle Design Laboratory	PCC	Core	0	0	3	1.5	30	70	100
AAEC45	Aerospace Structural Dynamics Laboratory	PCC	Core	0	0	3	1.5	30	70	100
AAEC46	Project Work (Phase - I)	PROJ	Project	0	0	4	2	30	70	100
TOTAL				**15**	**01**	**10**	**21**	**240**	**560**	**800**

VIII SEMESTER

Course Code	Course Name	Subject Area	Category	Periods per week			Credits	Scheme of Examination Max. Marks		
				L	T	P		CIA	SEE	Total
THEORY										
	Professional Elective – V	PEC	Elective	3	0	0	3	30	70	100
	Professional Elective – VI	PEC	Elective	3	0	0	3	30	70	100
	Open Elective – III	OEC	Elective	3	0	0	3	30	70	100
PRACTICALS										
AAEC55	Project Work (Phase - II)	PCC	Project	0	0	16	8	30	70	100
TOTAL				**09**	**00**	**16**	**17**	**120**	**280**	**400**

PROFESSIONAL ELECTIVES COURSES

Course code	PE - I Dynamics and Design of Elements	Course code	PE - II Aerodynamics and Manufacturing	Course code	PE - III Materials and Mechanics
AAEC17	Heat and Mass Transfer	AAEC26	Airport Planning and Management	AAEC36	Techniques in Wind Tunnel Testing
AAEC18	Air Transportation System	AAEC27	Rocket and Missile Technology	AAEC37	Fatigue and Fracture of Materials
AAEC19	Space Dynamics	AAEC28	Hypersonic Aerodynamics	AAEC38	Orbital Mechanics
AAEC20	Mechanism and Machine Design	AAEC29	CAE/CAM	AAEC39	Introduction to Composite Materials

Course code	PE - IV Design of UAV's	Course code	PE - V Structures and Instrumentation	Course code	PE - VI Optimization of Propulsion Systems
AAEC40	Turbo Machinery	AAEC47	Ground Vehicle Aerodynamics	AAEC51	Non Destructive Testing
AAEC41	Theory of Stress Strain Measurements	AAEC48	Theory of Aeroelasticity	AAEC52	Automatic Control of Aircraft
AAEC42	Unmanned Air Vehicles	AAEC49	Flight Scheduling and Operations	AAEC53	Gas Turbines and Jet Propulsion Technology
AAEC43	Computational Gas Dynamics	AAEC50	Avionics and Instrumentation	AAEC54	Engineering Optimization Techniques

OPEN ELECTIVES COURSES

OPEN ELECTIVE - I

Course Code	Course Title
AAEC30	Flight Control Theory
AAEC31	Airframe Structural Design
AMEC34	Industrial Management
AMEC35	Elements of Mechanical Engineering
ACEC30	Modern Construction Materials
ACEC31	Disaster Management

OPEN ELECTIVES – II

Course Code	Course Title
ACSC24	Computer Architecture
ACSC25	Advanced Data Structures
ACSC26	Artificial Intelligence
AITC19	Cyber Crime and Computer Forensics
AITC20	Ethical Hacking
AITC21	Mobile Computing

OPEN ELECTIVE - III

Course Code	Course Title
AHSC15	Soft Skills and Interpersonal Communication
AHSC16	Cyber Law and Ethics
AHSC17	Economic Policies in India
AHSC18	Global Warming and Climate Change
AHSC19	Intellectual Property Rights
AHSC20	Entrepreneurship

MANDATORY / VALUE ADDED COURSES

Course Code	Course Title
AHSC10	Essence of Indian Traditional Knowledge (MC)
ACSC18	Fundamentals of Database Systems (VAC)
ACSC23	Object Oriented Programming Development and Languages (VAC)
ACSC29	Design of Algorithms (VAC)

SYLLABUS
(I - VIII SEMESTERS)

ENGLISH

I Semester: AE / ECE / EEE / ME / CE II Semester : CSE / CSE (AI & ML) / CSE (DS) / CSE (CS) / CSIT / IT								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AHSC01	**Foundation**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		2	-	-	2	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		
Prerequisite: Standard applicability of vocabulary and Grammer								

I. COURSE OVERVIEW:

The sole aim of the course is to enhance the communication skills of upcoming engineering graduates to meet the requirements and challenges in a competitive global world. This course is designed to provide a well-rounded introduction to English language learning. Moreover, the course pays special attention to the typical problems and challenges confronted by the Indian learners of English like mispronunciation, spellings, and structures of English due to their mother tongue influence. This course includes General Introduction to Listening Skills, Speaking Skills, Vocabulary and Grammar, Reading Skills, and Writing Skills.

II. COURSE OBJECTIVES:

The Students will try to learn:

I. The theoretical and fundamental inputs to communicate intelligibly in English through standard Pronunciation.
II. The four language skills i.e., Listening, Speaking, Reading and Writing effectively and their application in real-life situations.
III. The Writing strategies of English using correct spelling, grammar, punctuation and appropriate vocabulary.
IV. Different mechanics of writing styles forms of writing emails, reports, formal and informal letters.

III. COURSE SYLLABUS:

MODULE-I: GENERAL INTRODUCTION AND LISTENING SKILLS (09)

Introduction to communication skills; Communication process; Elements of communication; Soft skills vs hard skills; Listening skills; Significance; Stages of listening; Barriers to listening and effectiveness of listening; Listening comprehension.

MODULE –II: SPEAKING SKILLS (09)

Significance; Essentials; Barriers and effectiveness of speaking; Verbal and non-verbal communication; Generating talks based on visual prompts; Public speaking; Exposure to structured talks; Addressing a small group or a large formal gathering; Oral presentation.

MODULE –III: VOCABULARY & GRAMMAR (09)

Vocabulary: The concept of Word Formation; Root words from foreign languages and their use in English; Acquaintance with prefixes and suffixes from foreign languages in English to form derivatives; Idioms and phrases; One-word substitutes.

Grammar: Sentence structure; Uses of phrases and clauses; Punctuation; Subject verb agreement; Modifiers; Articles; Prepositions.

MODULE –IV: READING SKILLS (09)

Significance; Techniques of reading; Skimming-Reading for the gist of a text; Scanning - Reading for specific information; Intensive; Extensive reading; Reading comprehension; Reading for information transfer; Text to diagram; Diagram to text.

MODULE –V: WRITING SKILLS (09)

Significance; Effectiveness of writing; Organizing principles of Paragraphs in documents; Techniques for writing precisely; Letter writing; Formal and Informal letter writing; E-mail writing, Report Writing.

IV. TEXT BOOKS:

1. Handbook of English for Communication (Prepared by Faculty of English, IARE).

V. REFERENCE BOOKS:

1. Sanjay Kumar and Pushp Lata. "Communications Skills". Oxford University Press. 2011.
2. Michael Swan. "Practical English Usage", Oxford University Press, 1995.
3. F.T. Wood. "Remedial English Grammar". Macmillan. 2007.
4. William Zinsser. "On Writing Well". Harper Resource Book, 2001.
5. Raymond Murphy, "Essential English Grammar with Answers", Cambridge University Press 2nd Edition, 2011.

VI. WEB REFERENCES:

1. www.edufind.com
2. www.myenglishpages.com
3. http:grammar.ccc.comment.edu
4. http:owl.english.prudue.edu

VII. E-TEXT BOOKS:

1. http://bookboon.com/en/communication-ebooks-zip
2. http://www.bloomsbury-international.com/images/ezone/ebook/writing-skills-pdf.pdf
3. https://americanenglish.state.gov/files/ae/resource_files/developing_writing.pdf
4. http://learningenglishvocabularygrammar.com/files/idiomsandphraseswithmeaningsandexamplespdf
5. http://www.robinwood.com/Democracy/GeneralEssays/CriticalThinking.pdf

LINEAR ALGEBRA AND CALCULUS

I Semester: Common for All Branches

Course Code	Category	Hours / Week			Credits	Maximum Marks		
AHSC02	Foundation	L	T	P	C	CIA	SEE	Total
		3	1	-	4	30	70	100
Contact Classes: 45	**Tutorial Classes: 15**	**Practical Classes: Nil**				**Total Classes: 60**		

Prerequisite: Basic principles of algebra and calculus

I. COURSE OVERVIEW:

Linear algebra is a sub-field of mathematics concerned with vectors, matrices, and linear transforms. Calculus is the branch of mathematics which majorly deals with derivatives and integrals. Linear algebra is a key foundation to the field of machine learning. Matrices are used in computer animations, color image processing. Eigenvalues are used by engineers to discover new and better designs for the future. Differential equations have wide applications in various engineering and science disciplines as the laws of physics are generally written down as differential equations.The Fourier series has many applications in electrical engineering, image processing etc.The course includes types of Matrices, Rank, methods of finding rank, eigen values and eigen vectors, maxima and minima of functions of several variables, solutions of higher order ordinary differential equations and Fourier series.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The principles of Eigen value analysis and linear transformations, Matrix rank finding methods
II. The calculus of functions of several variables and the concept of maxima-minima for a three-dimensional surface.
III. The analytical methods for solving higher order differential equations with constant coefficients.
IV. Fourier series expansions in standard intervals as well as arbitrary intervals.

III. COURSE SYLLABUS:

MODULE-I: THEORY OF MATRICES (09)

Real matrices: Symmetric, skew-symmetric and orthogonal matrices; Complex matrices: Hermitian, Skew- Hermitian and unitary matrices; Elementary row and column transformations, finding rank of a matrix by reducing to Echelon form and Normal form; Finding the inverse of a matrix using Gauss-Jordan method;

MODULE –II: LINEAR TRANSFORMATIONS (09)

Cayley-Hamilton theorem: Statement, verification, finding inverse and powers of a matrix; Linear dependence and independence of vectors; Linear transformation; Eigen values and Eigen vectors of a matrix; Diagonalization of matrix by linear transformation.

MODULE –III: FUNCTIONS OF SINGLE AND SEVERAL VARIABLES (09)

Mean value theorems: Rolle’s theorem, Lagrange’s theorem, Cauchy’s theorem-without proof.

Functions of several variables: Partial differentiation, Jacobian, functional dependence, maxima and minima of functions with two variables and three variables. Method of Lagrange multipliers.

MODULE –IV: HIGHER ORDER LINEAR DIFFERENTIAL EQUATIONS (09)

Linear differential equations of second and higher order with constant coefficients.

Non-homogeneous term of the type $f(x) = e^{ax}, \sin ax, \cos ax$ and $f(x) = x^n, e^{ax}v(x)$, Method of variation of parameters.

MODULE –V: FOURIER SERIES (09)

Fourier expansion of periodic function in a given interval of length 2π; Fourier series of even and odd functions; Fourier series in an arbitrary interval, Half- range Fourier sine and cosine expansions.

IV. TEXT BOOKS

1. B.S. Grewal, Higher Engineering Mathematics, Khanna Publishers, 36th Edition, 2010.
2. N.P. Bali and Manish Goyal, A text book of Engineering Mathematics, Laxmi Publications, Reprint, 2008.
3. Ramana B.V., Higher Engineering Mathematics, Tata McGraw Hill New Delhi, 11th Reprint 2010.

V. REFERENCE BOOKS:

1. Erwin Kreyszig, Advanced Engineering Mathematics, 9th Edition, John Wiley & Sons, 2006.
2. Veerarajan T., Engineering Mathematics for first year, Tata McGraw-Hill, New Delhi, 2008.
3. D. Poole, Linear Algebra: A Modern Introduction, 2nd Edition, Brooks/Cole, 2005.

VI. WEB REFERENCES:

1. http://www.efunda.com/math/math_home/math.cfm
2. http://www.ocw.mit.edu/resourcs/#Mathematics
3. http://www.sosmath.com
4. http://www.mathworld.wolfram.com

VII. E-TEXT BOOKS:

1. http://www.e-booksdirectory.com/details.php?ebook=10166
2. http://www.e-booksdirectory.com/details.php?ebook=7400re

ENGINEERING PHYSICS

<table>
<tr><td colspan="8">I Semester: AE / ME / CE / EEE / ECE</td></tr>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Category</th><th colspan="3">Hours / Week</th><th>Credits</th><th colspan="3">Maximum Marks</th></tr>
<tr><th>L</th><th>T</th><th>P</th><th>C</th><th>CIA</th><th>SEE</th><th>Total</th></tr>
<tr><td>AHSC03</td><td>Foundation</td><td>3</td><td>-</td><td>-</td><td>3</td><td>30</td><td>70</td><td>100</td></tr>
<tr><td>Contact Classes: 45</td><td>Tutorial Classes: Nil</td><td colspan="4">Practical Classes: Nil</td><td colspan="3">Total Classes: 45</td></tr>
<tr><td colspan="9">Prerequisite: Basic principles of waves</td></tr>
</table>

I. COURSE OVERVIEW:

This course develops abstract and critical reasoning by studying mathematical and logical proofs and assumptions as applied in basic physics and to make connections between physics and other branches of sciences and technology. The topics covered include waves, non-dispersive transverse and longitudinal waves, light and optics, wave optics, lasers, introduction to quantum mechanics, solution of wave equation and introduction to solids and semiconductors. The course helps students to gain knowledge of basic principles and appreciate the diverse applications in technological fields in respective branches.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The basic formulations in wave mechanics for the evolution of energy levels and quantization of energies for a particle in a potential box with the help of mathematical description
II. The fundamental properties of semiconductors including the band gap, charge carrier concentration, doping and charge carrier transport mechanisms
III. The simple optical setups and experimental approaches of Light and Laser using its interaction with matter
IV. The basic studies between different harmonic oscillators and different waves for using those relationships on practical problems.

III. COURSE OBJECTIVES:

MODULE-I: QUANTUM MECHANICS (09)

Introduction to quantum physics, de-broglie's hypothesis, Wave-particle duality, Davisson and Germer experiment, Time-independent Schrodinger equation for wave function, Physical significance of the wave function, Schrodinger equation for one dimensional problems–particle in a box.

MODULE –II: INTRODUCTION TO SOLIDS AND SEMICONDUCTORS (09)

Introduction to classical free electron theory and quantum theory, Bloch's theorem for particles in a periodic potential (Qualitative treatment), Kronig-Penney model (Qualitative treatment), classification: metals, semiconductors, and insulators. Intrinsic and extrinsic semiconductors, Carrier concentration, Dependence of Fermi level on carrier-concentration and temperature, Hall effect.

MODULE –III: LASERS AND FIBER OPTICS (09)

Characteristics of lasers, Spontaneous and stimulated emission of radiation, Metastable state, Population inversion, Lasing action, Ruby laser, He-Ne laser and applications of lasers.

Principle and construction of an optical fiber, Acceptance angle, Numerical aperture, Types of optical fibers (Single mode, multimode, step index, graded index), Optical fiber communication system with block diagram and Applications of optical fibers.

MODULE –IV: LIGHT AND OPTICS (09)

Principle of superposition of waves, Young's double slit experiment, Fringe width, Newton's rings.
Fraunhofer diffraction from a single slit, double slit (extension to N slits) and diffraction grating experiment.

MODULE –V: HARMONIC OSCILLATIONS AND WAVES IN ONE DIMENSION (09)

Simple harmonic oscillator, Damped harmonic oscillator, Forced harmonic oscillator. Transverse waves and Longitudinal wave equation, Reflection and transmission of waves at a boundary, Harmonic waves.

IV. TEXT BOOKS:

1. G. Main, “Vibrations and Waves in Physics”, Cambridge University Press, 1993.
2. R. K. Gaur, S. L. Gupta, “Engineering Physics”, Dhanpat Rai Publications, 8^{th} Edition, 2001.
3. Dr. K. Vijaya Kumar, Dr. S. Chandralingam, “Modern Engineering Physics”, Chand & Co. New Delhi, 1^{st} Edition, 2010.

V. REFERENCE BOOKS:

1. H.J. Pain, “The Physics of Vibrations and Waves”, Wiley, 2006.
2. Ghatak, “Optics”, McGraw Hill Education, 2012.
3. O. Svelto, “Principles of Lasers”, Springer Science & Business Media, 2010.

VI. WEB REFERENCES:

1. http://link.springer.com/book
2. http://www.thphys.physics.ox.ac.uk
3. http://www.sciencedirect.com/science
4. http://www.e-booksdirectory.com

VII. E-TEXT BOOKS:

1. http://www.peaceone.net/basic/Feynman/
2. http://physicsdatabase.com/free-physics-books/
3. http://www.damtp.cam.ac.uk/user/tong/statphys/sp.pdf
4. www.freebookcentre.net/Physics/Solid-State-Physics-Books.html

PYTHON PROGRAMMING

I Semester: **Common for all branches**

Course Code	Category	Hours / Week			Credits	Maximum Marks		
ACSC01	Foundation	L	T	P	C	CIA	SEE	Total
		3	0	0	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		

Prerequisites: **There are no prerequisites to take this course.**

I. COURSE OVERVIEW:

This course introduces students to writing computer programs. This course presents the principles of structured programming using the Python language, one of the most increasingly preferred languages for programming today. Because of its ease of use, it is ideal as a first programming language and runs on both the PC and Macintosh platforms. However, the knowledge gained in the course can be applied later to other languages such as C and Java. The course uses iPython Notebook to afford a more interactive experience. Topics include fundamentals of computer programming in Python, object-oriented programming and graphical user interfaces.

II. COURSE OBJECTIVES:

The students will try to learn:

I. Acquire programming skills in core Python.
II. Acquire Object-oriented programming skills in Python.
III. Develop the skill of designing graphical-user interfaces (GUI) in Python.
IV. Develop the ability to write database applications in Python.
V. Acquire Python programming skills to move into specific branches - Internet of Things (IoT), Data Science, Machine Learning (ML), Artificial Intelligence (AI) etc.

III. SYLLABUS:

MODULE – I: INTRODUCTION TO PYTHON (09)

Introduction to Python: Features of Python, History and Future of Python, Working with Python – interactive and script mode, Identifiers and Keywords, Comments, Indentation and Multi-lining, Data types – built-in data types, Operators and Expressions, Console Input/Output, Formatted printing, Built-in Functions, Library Functions.

MODULE – II: DECISION CONTROL STATEMENTS (09)

Selection/Conditional Branching Statements: if, if-else, nested if, if-elif-else statement(s), Basic Loop Structures/ Iterative Statements – while and for loop, Nested loops, break and continue statement, pass Statement, else Statement used with loops.

MODULE – III: CONTAINER DATA TYPES (09)

Lists: Accessing List elements, List operations, List methods, List comprehension; Tuples: Accessing Tuple elements, Tuple operations, Tuple methods, Tuple comprehension, Conversion of List comprehension to Tuple, Iterators and Iterables, zip() function.

Sets: Accessing Set elements, Set operations, Set functions, Set comprehension; Dictionaries: Accessing Dictionary elements, Dictionary operations, Dictionary Functions, Nested Dictionary, Dictionary comprehension.

MODULE - IV STRINGS AND FUNCTIONS (09)

Strings: Accessing String elements, String properties, String operations.
Functions: Communicating with functions, Variable Scope and lifetime, return statement, Types of arguments, Lambda functions, Recursive functions.

MODULE - V CLASSES AND OBJECTS (09)

Classes and Objects – Defining Classes, Creating Objects, Data Abstraction and Hiding through Classes, Class Method and self Argument, Class variables and Object variables, __init()__ and __del__() method, Public and private data members, Built-in Class Attributes, Garbage Collection. OOPs Features: Abstraction, Encapsulation, Inheritance, and Polymorphism

IV. TEXT BOOKS:

1. Reema Thareja, "Python Programming - Using Problem Solving Approach", Oxford Press, 1st Edition, 2017.
2. Dusty Philips, "Python 3 Object Oriented Programming", PACKT Publishing, 2nd Edition, 2015.

V. REFERENCE BOOKS:

1. Yashavant Kanetkar, Aditya Kanetkar, "Let Us Python", BPB Publications, 2nd Edition, 2019.
2. Martin C. Brown, "Python: The Complete Reference", Mc. Graw Hill, Indian Edition, 2018.
3. Michael H.Goldwasser, David Letscher, "Object Oriented Programming in Python", Prentice Hall, 1st Edition, 2007.
4. Taneja Sheetal, Kumar Naveen, "Python Programming – A Modular Approach", Pearson, 1st Edition, 2017.
   R Nageswar Rao, "Core Python Programming", Dreamtech Press, 2018.

VI. WEB REFERENCES:

1. https://realPython.com/Python3-object-oriented-programming/
2. https://Python.swaroopch.com/oop.html
3. https://Python-textbok.readthedocs.io/en/1.0/Object_Oriented_Programming.html
4. https://www.programiz.com/Python-programming/

ENGLISH LANGUAGE AND COMMUNICATION SKILLS LABORATORY

I SEMESTER: AE / ECE / EEE / ME / CE

II SEMESTER: CSE / CSE (AI & ML) / CSE (DS) / CSE (CS) / CSIT / IT

Course Code	Category	Hours / Week			Credits	Maximum Marks		
AHSC04	Foundation	L	T	P	C	CIA	SEE	Total
		-	-	2	1	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: 45				Total Classes: 45		

Prerequisite: There are no prerequisites to take this course.

I. COURSE OVERVIEW

The sole aim of the course is to enhance the communication skills of upcoming engineering graduates to meet the requirements and challenges in a competitive global world. This course includes General Introduction to Listening Skills, Speaking Skills, Vocabulary and Grammar, Reading Skills, and Writing Skills.

II. COURSE OBJECTIVES:

The students will try to:

I. Improve their ability to listen and comprehend a given text.
II. Upgrade the fluency and acquire a functional knowledge of English Language.
III. Enrich thought process by viewing a problem through multiple angles.

III. COURSE SYLLABUS:

Week-l: LISTENING SKILL

a. Listening to conversations and interviews of famous personalities in various fields; Listening practice related to the TV talk shows and news.
b. Listening for specific information; Listening for summarizing information – Testing.

Week-2: LISTENING SKILL

a. Listening to films of short duration and monologues for taking notes; Listening to answer multiple choice questions.
b. Listening to telephonic conversations; Listening to native Indian: Abdul Kalam, British: Helen Keller and American: Barrack Obama speakers to analyze intercultural differences – Testing.

Week-3: SPEAKING SKILL

a. Functions of English Language; Introduction to pronunciation; Vowels and Consonants
b. Tips on how to develop fluency, body language and communication; Introducing oneself: Talking about yourself, others, leave taking.

Week-4: SPEAKING SKILL

a. Sounds - Speaking exercises involving the use of Vowels and Consonant sounds in different contexts; Exercises on Homophones and Homographs
b. Just a minute (JAM) session.

Week-5: SPEAKING SKILL

a. Stress patterns.
b. Situational Conversations: common everyday situations; Acting as a compare and newsreader; Greetings for different occasions with feedback preferably through video recording.

Week-6: READING SKILL

a. Intonation.
b. Reading newspaper and magazine articles; Reading selective autobiographies for critical commentary.

Week-7: READING SKILL

a. Improving pronunciation through tongue twisters.
b. Reading advertisements, pamphlets; Reading comprehension exercises with critical and analytical questions based on context.

Week-8: WRITING SKILL

a. Listening to inspirational short stories and Writing messages

b. Writing leaflets, Notice; Writing tasks; Flashcards – Exercises

Week-9: WRITING SKILL

a. Write the review on a video clipping of short duration (5 to 10minutes).
b. Write a slogan related to the image; Write a short story of 6-10 lines based on the hints given.

Week-10: WRITING SKILL

a. Minimizing Mother Tongue interference to improve fluency through watching educational videos.
b. Writing practices – précis writing; Essay writing

Week-11: THINKING SKILL

a. Correcting common errors in day to day conversations.

Practice in preparing thinking blocks to decode diagrammatical representations into English words, expressions, idioms, proverbs.

IV. TEXT BOOK:

1. "English Language and Communication Skills" Lab Manual - Prepared by the faculty of English, IARE.

V. REFERENCE BOOKS:

1. Meenakshi Raman, Sangeetha Sharma, "Technical Communication Principles and Practices", Oxford University Press, New Delhi, 3rd Edition, 2015.
2. Rhirdion, Daniel, "Technical Communication", Cengage Learning, New Delhi, 1st Edition, 2009.

PHYSICS LABORATORY

<table>
<tr><td colspan="9">I Semester: AE / ME / CE / ECE / EEE
II Semester: CSE / CSE (AI & ML) / CSE (DS) / CSE (CS) / CSIT / IT</td></tr>
<tr><th>Course Code</th><th>Category</th><th colspan="3">Hours / Week</th><th>Credits</th><th colspan="3">Maximum Marks</th></tr>
<tr><td rowspan="2">AHSC05</td><td rowspan="2">Foundation</td><td>L</td><td>T</td><td>P</td><td>C</td><td>CIA</td><td>SEE</td><td>Total</td></tr>
<tr><td>-</td><td>-</td><td>3</td><td>1.5</td><td>30</td><td>70</td><td>100</td></tr>
<tr><td>Contact Classes: Nil</td><td>Tutorial Classes: Nil</td><td colspan="4">Practical Classes: 36</td><td colspan="3">Total Classes: 36</td></tr>
<tr><td colspan="9">Pre-Requisites: Basic principles of Physics</td></tr>
</table>

I. COURSE OVERVIEW:

This course is designed to lay a strong foundation in Engineering Physics that forms a basis to various branches of Engineering. It helps the students to perform experiments, to correlate theory with experimental data, analyse using graphical representations and present them as part of a clear, well-organized lab report. At the end of the course, students will be able to demonstrate a working knowledge of fundamentals of Physics and communicate their ideas effectively, both orally and in writing.

II. COURSE OBJECTIVES:

The students will try to learn:

1. Experimental skills in using optical instruments to determine physical constants.
2. The real time applications of electromagnetic theory.
3. The working principles of various electronic devices.

III. COURSE SYLLABUS:

Week-1: HALL EFFECT (LORENTZ FORCE)
Determination of charge carrier density.

Week-2: MELDE'E EXPERIMENT
Determination of frequency of a given tuning fork.

Week-3: STEWART GEE'S APPARATUS
Magnetic field along the axis of current carrying coil-Stewart and Gee's method.

Week-4: B-H CURVE WITH CRO
To determine the energy loss per unit volume of a given magnetic material per cycle by tracing the Hysteresis loop (B-H curve).

Week-5: ENERGY GAP OF A SEMICONDUCTOR DIODE
Determination of energy gap of a semiconductor diode.

Week-6: PHOTO DIODE
Studying V-I characteristics of photo diode.

Week-7: OPTICAL FIBER
Evaluation of numerical aperture of a given optical fiber.

Week-8: WAVE LENGTH OF LASER LIGHT
Determination of wavelength of a given laser light using diffraction grating.

Week-9: PLANCK'S CONSTANT
Determination of Planck's constant using LED.

Week-10: LIGHT EMITTING DIODE
Studying V-I characteristics of LED

Week-11: NEWTONS RINGS
Determination of radius of curvature of a given plano-convex lens.

Week-12: SINGLE SLIT DIFFRACTION

Determination of width of a given single slit.

IV. MANUALS:

1. C. L. Arora, “Practical Physics”, S. Chand & Co., New Delhi, 3rd Edition, 2012.
2. VijayKumar, Dr.T.Radhakrishna, “Practical Physics for Engineering Students”, SM Enterprises, 2nd Edition, 2014.

V. WEB REFERENCE:

http://www.iare.ac.in

PYTHON PROGRAMMING LABORATORY

I Semester: Common from all branches								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
ACSC02	Foundation	L	T	P	C	CIA	SEE	Total
		0	0	3	1.5	30	70	100
Contact Classes: Nil	Tutorial Classes: Nil	Practical Classes: 36				Total Classes:36		
Prerequisite: There are no prerequisites to take this course.								

I. COURSE OVERVIEW:

This course introduces students to writing computer programs. This course presents the principles of structured programming using the Python language, one of the most increasingly preferred languages for programming today. Because of its ease of use, it is ideal as a first programming language and runs on both the PC and Macintosh platforms. However, the knowledge gained in the course can be applied later to other languages such as C and Java. The course uses iPython Notebook to afford a more interactive experience. Topics include fundamentals of computer programming in Python, object-oriented programming and graphical user interfaces.

II. COURSE OBJECTIVES:

The students will try to learn:

VI. Acquire programming skills in core Python.
VII. Acquire Object-oriented programming skills in Python.
VIII. Develop the skill of designing graphical-user interfaces (GUI) in Python.
IX. Develop the ability to write database applications in Python.
X. Acquire Python programming skills to move into specific branches - Internet of Things (IoT), Data Science, Machine Learning (ML), Artificial Intelligence (AI) etc.

III. COURSE SYLLABUS:

Week – 1: OPERATORS

a. Read a list of numbers and write a program to check whether a particular element is present or not using membership operators.
b. Read your name and age and write a program to display the year in which you will turn 100 years old.
c. Read radius and height of a cone and write a program to find the volume of a cone.
d. Write a program to compute distance between two points taking input from the user (Hint: use Pythagorean theorem)

Week – 2: CONTROL STRUCTURES

a. Read your email id and write a program to display the no of vowels, consonants, digits and white spaces in it using if…elif…else statement.
b. Write a program to create and display a dictionary by storing the antonyms of words. Find the antonym of a particular word given by the user from the dictionary using while loop.
c. Write a Program to find the sum of a Series 1/1! + 2/2! + 3/3! + 4/4! +…….+ n/n!. (Input :n = 5, Output : 2.70833)
d. In number theory, an abundant number or excessive number is a number for which the sum of its proper divisors is greater than the number itself. Write a program to find out, if the given number is abundant. (Input: 12, Sum of divisors of 12 = 1 + 2 + 3 + 4 + 6 = 16, sum of divisors 16 > original number 12)

Week – 3: LIST

a. Read a list of numbers and print the numbers divisible by x but not by y (Assume x = 4 and y = 5).
b. Read a list of numbers and print the sum of odd integers and even integers from the list.(Ex: [23, 10, 15, 14, 63], odd numbers sum = 101, even numbers sum = 24)
c. Read a list of numbers and print numbers present in odd index position. (Ex: [10, 25, 30, 47, 56, 84, 96], The numbers in odd index position: 25 47 84).
d. Read a list of numbers and remove the duplicate numbers from it. (Ex: Enter a list with duplicate elements: 10 20 40 10 50 30 20 10 80, The unique list is: [10, 20, 30, 40, 50, 80])

Week – 4: TUPLE

a. Given a list of tuples. Write a program to find tuples which have all elements divisible by K from a list of tuples. test_list = [(6, 24, 12), (60, 12, 6), (12, 18, 21)], K = 6, Output : [(6, 24, 12), (60, 12, 6)]
b. Given a list of tuples. Write a program to filter all uppercase characters tuples from given list of tuples. (Input: test_list = [("GFG", "IS", "BEST"), ("GFg", "AVERAGE"), ("GfG",), ("Gfg", "CS")], Output : [('GFG', 'IS', 'BEST')]).
c. Given a tuple and a list as input, write a program to count the occurrences of all items of the list in the tuple. (Input : tuple = ('a', 'a', 'c', 'b', 'd'), list = ['a', 'b'], Output : 3)

Week – 5: SET

a. Write a program to generate and print a dictionary that contains a number (between 1 and n) in the form (x, x*x).
b. Write a program to perform union, intersection and difference using Set A and Set B.
c. Write a program to count number of vowels using sets in given string (Input : "Hello World", Output: No. of vowels : 3)
d. Write a program to form concatenated string by taking uncommon characters from two strings using set concept (Input : S1 = "aacdb", S2 = "gafd", Output : "cbgf").

Week – 6: DICTIONARY

a. Write a program to do the following operations:
   i. Create a empty dictionary with dict() method
   ii. Add elements one at a time
   iii. Update existing key's value
   iv. Access an element using a key and also get() method
   v. Deleting a key value using del() method
b. Write a program to create a dictionary and apply the following methods:
   i. pop() method
   ii. popitem() method
   iii. clear() method
c. Given a dictionary, write a program to find the sum of all items in the dictionary.
d. Write a program to merge two dictionaries using update() method.

Week – 7: STRINGS

a. Given a string, write a program to check if the string is symmetrical and palindrome or not. A string is said to be symmetrical if both the halves of the string are the same and a string is said to be a palindrome string if one half of the string is the reverse of the other half or if a string appears same when read forward or backward.
b. Write a program to read a string and count the number of vowel letters and print all letters except 'e' and 's'.
c. Write a program to read a line of text and remove the initial word from given text. (Hint: Use split() method, Input : India is my country. Output : is my country)
d. Write a program to read a string and count how many times each letter appears. (Histogram).

Week – 8: USER DEFINED FUNCTIONS

a. A generator is a function that produces a sequence of results instead of a single value. Write a generator function for Fibonacci numbers up to n.
b. Write a function merge_dict(dict1, dict2) to merge two Python dictionaries.
c. Write a fact() function to compute the factorial of a given positive number.
d. Given a list of n elements, write a linear_search() function to search a given element x in a list.

Week – 9: BUILT-IN FUNCTIONS

a. Write a program to demonstrate the working of built-in statistical functions mean(), mode(), median() by importing statistics library.
b. Write a program to demonstrate the working of built-in trignometric functions sin(), cos(), tan(), hypot(), degrees(), radians() by importing math module.
c. Write a program to demonstrate the working of built-in Logarithmic and Power functions exp(), log(), log2(), log10(), pow() by importing math module.
d. Write a program to demonstrate the working of built-in numeric functions ceil(), floor(), fabs(), factorial(), gcd()

by importing math module.

Week – 10: CLASS AND OBJECTS

a. Write a program to create a BankAccount class. Your class should support the following methods for
   i) Deposit
   ii) Withdraw
   iii) GetBalanace
   iv) PinChange
b. Create a SavingsAccount class that behaves just like a BankAccount, but also has an interest rate and a method that increases the balance by the appropriate amount of interest (Hint:use Inheritance).
c. Write a program to create an employee class and store the employee name, id, age, and salary using the constructor. Display the employee details by invoking employee_info() method and also using dictionary (__dict__).
d. Access modifiers in Python are used to modify the default scope of variables. Write a program to demonstrate the 3 types of access modifiers: public, private and protected.

Week – 11: MISCELLANEOUS PROGRAMS

a. Write a program to find the maximum and minimum K elements in Tuple using slicing and sorted() method (Input: test_tup = (3, 7, 1, 18, 9), k = 2, Output: (3, 1, 9, 18))
b. Write a program to find the size of a tuple using getsizeof() method from sys module and built-in __sizeof__() method.
c. Write a program to check if a substring is present in a given string or not.
d. Write a program to find the length of a string using various methods:
   i. Using len() method
   ii. Using for loop and in operator
   iii. Using while loop and slicing

Week – 12: ADDITIONAL PROGRAMS - FILE HANDLING

1. Write a program to read a filename from the user, open the file (say firstFile.txt) and then perform the following operations:
   i. Count the sentences in the file.
   ii. Count the words in the file.
   iii. Count the characters in the file.
2. Create a new file (Hello.txt) and copy the text to other file called target.txt. The target.txt file should store only lower case alphabets and display the number of lines copied.
3. Write a Python program to store N student's records containing name, roll number and branch. Print the given branch student's details only.

IV. REFERENCE BOOKS:

1. Michael H Goldwasser, David Letscher, "Object Oriented Programming in Python", Prentice Hall, 1st Edition, 2007.
2. Yashavant Kanetkar, Aditya Kanetkar, "Let us Python", BPB publication, 1st Edition, 2019.
3. Ashok Kamthane, Amit Kamthane, "Programming and Problem Solving with Python", McGraw Hill Education (India) Private Limited, 2018.
4. Taneja Sheetal, Kumar Naveen, "Python Programming – A modular approach", Pearson, 2017.
5. R Nageswara Rao, "Core Python Programming", Dreamtech press, 2017 Edition.

V. WEB REFERENCES:

1. https://realpython.com/python3-object-oriented-programming/
2. https://python.swaroopch.com/oop.html
3. https://python-textbok.readthedocs.io/en/1.0/Object_Oriented_Programming.html
4. https://www.programiz.com/python-programming/
5. https://www.geeksforgeeks.org/python-programming-language/

CHEMISTRY

I Semester: CSE / CSE (AI&ML) / CSE (DS) / CSE (CS) / / CSIT / IT II Semester: AE / ME / CE / ECE / EEE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AHSC06	**Foundation**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		2	-	-	2	30	70	100
Contact Classes: 45	**Tutorial Classes: 0**	**Practical Classes: Nil**				**Total Classes: 45**		
Prerequisite: There are no prerequisites to take this course.								

I. COURSE OVERVIEW:

The concepts developed in this course involve elements and compounds and their applied industrial applications. It deals with topics such as batteries, corrosion and control of metallic materials, water and its treatment for different purposes, engineering materials such as plastics, elastomers and biodegradable polymers, their preparation, properties and applications, energy sources and environmental science. Sustainable chemistry that focuses on the design of the products and processes that minimize or eliminate the use and generation of hazardous substances is also included.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The concepts of electrochemical principles and causes of corrosion in the new developments and breakthroughs efficiently in engineering and technology.
II. The different parameters to remove causes of hardness of water and their reactions towards complexometric method.
III. The polymerization reactions with respect to mechanisms and its significance in industrial applications.
IV. The Significance of Green chemistry to reduce pollution in environment by using natural resources.

III. COURSE SYLLABUS

MODULE-I: ELECTROCHEMISTRY AND CORROSION (09)

Electro chemical cells: Electrode potential, standard electrode potential, Calomel electrode and Nernst equation; Electrochemical series and its applications; Numerical problems; Batteries: Primary (Dry cell) and secondary batteries (Lead-acid storage battery, Li-ion battery). Corrosion: Causes and effects of corrosion: Theories of chemical and electrochemical corrosion, mechanism of electrochemical corrosion; Corrosion control methods: Cathodic protection, sacrificial anode and impressed current Cathodic protection; Surface coatings: Metallic coatings- Methods of coating- Hot dipping- galvanization and tinning, electroplating.

MODULE –II: WATER TECHNOLOGY (09)

Introduction: Hardness of water, causes of hardness; types of hardness: temporary and permanent hardness, expression and units of hardness; estimation of hardness of water by complexometric method; potable water and its specifications, Steps involved in the treatment of water, disinfection of water by chlorination and ozonization; External treatment of water; Ion-exchange process; Desalination of water: Reverse osmosis, numerical problems.

MODULE-III: ENGINEERING MATERIALS (09)

Polymers-classification with examples, polymerization-addition, condensation and co-polymerization;
Plastics: Thermoplastics and thermosetting plastics; Compounding of plastics; Preparation, properties and applications of polyvinyl chloride, Teflon, Bakelite and Nylon-6, 6; Elastomers: Natural rubber, processing of natural rubber, vulcanization; Buna-s and Thiokol rubber; Biodegradable polymers.

Lubricants: characteristics of lubricants, mechanism of lubrication – thick film, thin film, extreme pressure lubrication, properties – flash and fire point, cloud and pour point, viscosity and oiliness of lubricants.

MODULE –IV: GREEN CHEMISTRY AND FUELS (09)

Introduction: Definition of green chemistry, methods of green synthesis: aqueous phase, microwave method, phase transfer catalyst and ultra sound method. Fuels: definition, classification of fuels ; Solid fuels: coal; analysis of coal: proximate and ultimate analysis; Liquid fuels: Petroleum and its refining; Gaseous fuels: Composition, characteristics and applications of LPG and CNG; Calorific value: Gross Calorific value(GCV) and Net Calorific value(NCV), numerical problems.

MODULE –V: NATURAL RESOURCES AND ENVIRONMENTAL POLLUTION (09)

Natural resources: Classification of resources, living and nonliving resources; Water resources: Use and over utilization of surface and ground water, floods and droughts, dams, benefits and problems; Land resources; Energy resources: renewable and non-renewable energy sources, use of alternate energy source. Environmental pollution: Causes, effects and control measures of air pollution, water pollution, soil pollution and noise pollution.

IV. TEXT BOOKS:

1. P. C. Jain and Monica Jain, "Engineering Chemistry", DhanpatRai Publishing Company, 16th Edition, 2017.
2. ShashiChawla, "Text Book of Engineering Chemistry" DhanatRai and Company, 2017.
3. Prashanthrath, B.Rama Devi, Ch.VenkataRamana Reddy, Subhendu Chakroborty, Cengage Learning Publishers, 1st Edition, 2018.

V. REFERENCE BOOKS:

1. Bharathi Kumari, "Engineering Chemistry", VGS Book Links, 10th Edition, 2018.
2. B. Siva Shankar, "Engineering Chemistry", Tata McGraw Hill Publishing Limited, 3rd Edition, 2015.
3. S. S. Dara, Mukkanti, "Text of Engineering Chemistry", S. Chand & Co, New Delhi, 12th Edition, 2006.

VI. WEB REFERENCES:

1. Engineering chemistry (NPTEL Web-book), by B.L.Tembe, Kamaluddin and M.S.Krishnan.
   http://www.cdeep.iitb.ac.in/webpage_data/nptel/Core%20Science/Engineering%20Chemistry%201/About-Faculty.html
2. Polymer Science (NPTEL Web-book), by Prof. Dibakar Dhara
   https://onlinecourses.nptel.ac.in/noc20_cy21/preview
3. Environmental Chemistry and Analysis(NPTEL Web-book), by Prof. M.S.Subramanian
   https://nptel.ac.in/courses/122/106/122106030/

MATHEMATICAL TRANSFORM TECHNIQUES

II Semester: AE / ME / CE / ECE / EEE

Course Code	Category	Hours / Week			Credits	Maximum Marks		
AHSC07	Foundation	L	T	P	C	CIA	SEE	Total
		3	1	-	4	30	70	100
Contact Classes: 45	Tutorial Classes: 15	Practical Classes: Nil			Total Classes: 60			
Prerequisite: Basic principles of calculus								

I. COURSE OVERVIEW:

This course focuses on transformations from theoretical based mathematical laws to its practical applications in the domain of various branches of engineering field. The course includes the transformations such as Laplace, Fourier, applications of scalar and vector field over surface, volume and multiple integrals. The course is designed to extract the mathematical developments, skills, from basic concepts to advance level of engineering problems to meet the technological challenges.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The transformation of ordinary differential equations in Laplace field and its applications.
II. The operation of the non-periodic functions by Fourier transforms.
III. The concepts of *multiple integration for finding* areas and volumes of physical quantities.
IV. The Integration of the several functions by transforming the co-ordinate system in scalar and vector fields.

III. COURSE SYLLABUS

MODULE-I: LAPLACE TRANSFORMS (09)

Definition of Laplace transform, linearity property, piecewise continuous function, existence of Laplace transform, function of exponential order, first and second shifting theorems, change of scale property, Laplace transforms of derivatives and integrals, multiplied by t, divided by t, Laplace transform of periodic functions.

Inverse Laplace transform: Definition of Inverse Laplace transform, linearity property, first and second shifting theorems, change of scale property, multiplied by s, divided by s; Convolution theorem and applications to ordinary differential equations.

MODULE –II: FOURIER TRANSFORMS (09)

Fourier integral theorem, Fourier sine and cosine integrals; Fourier transforms; Fourier sine and cosine transform, properties, inverse transforms, finite Fourier transforms. .

MODULE –III: MULTIPLE INTEGRALS (09)

Double Integrals: Evaluation of double integrals in Cartesian coordinates and Polar coordinates; Change of order of integration; Area as a double integral; Transformation of coordinate system.

Triple Integrals: Evaluation of triple integrals in Cartesian coordinates; volume of a region using triple integration.

MODULE –IV: VECTOR DIFFERENTIAL CALCULUS (09)

Scalar and vector point functions; Definitions of Gradient, divergent and curl with examples; Solenoidal and irrotational vector point functions; Scalar potential function. Line integral, surface integral and volume integral, Green‘s theorem in a plane, Stoke‘s theorem and Gauss divergence theorem without proofs.

MODULE –V: PARTIAL DIFFERENTIAL EQUATIONS (09)

Formation of partial differential equations by elimination of arbitrary constants and arbitrary functions, solutions of first order linear equations; Charpit's method.

IV. TEXT BOOKS:

1. B.S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 36th Edition, 2010.
2. N.P. Bali and Manish Goyal, "A text book of Engineering Mathematics", Laxmi Publications, Reprint, 2008.
3. Ramana B.V., "Higher Engineering Mathematics", Tata McGraw Hill New Delhi, 11th Reprint, 2010

V. REFERENCE BOOKS:

1. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons, 9th Edition, 2006.
2. Veerarajan T., "Engineering Mathematics for first year", Tata McGraw-Hill, New Delhi, 2008.
3. D. Poole, "Linear Algebra: A Modern Introduction", Brooks/Cole, 2nd Edition, 2005.
4. Dr. M Anita, "Engineering Mathematics-I", Everest Publishing House, Pune, First Edition, 2016.

VI. WEB REFERENCES:

1. http://www.efunda.com/math/math_home/math.cfm
2. http://www.ocw.mit.edu/resourcs/#Mathematics
3. http://www.sosmath.com
4. http://www.mathworld.wolfram.com.

VII. E-TEXT BOOKS:

1. http://www.e-booksdirectory.com/details.php?ebook=10166
2. http://www.e-booksdirectory.com/details.php?ebook=7400re

ENGINEERING MECHANICS

<table>
<tr><td colspan="10">II Semester: AE / ME / CE</td></tr>
<tr><th>Course Code</th><th>Category</th><th colspan="3">Hours / Week</th><th>Credits</th><th colspan="3">Maximum Marks</th></tr>
<tr><td rowspan="2">AMEC01</td><td rowspan="2">Foundation</td><td>L</td><td>T</td><td>P</td><td>C</td><td>CIA</td><td>SEE</td><td>Total</td></tr>
<tr><td>3</td><td>-</td><td>-</td><td>3</td><td>30</td><td>70</td><td>100</td></tr>
<tr><td>Contact Classes: 45</td><td>Tutorial Classes: Nil</td><td colspan="4">Practical Classes: Nil</td><td colspan="3">Total Classes: 45</td></tr>
<tr><td colspan="9">Prerequisite: Knowledge of Linear Algebra and Calculus</td></tr>
</table>

I. COURSE OVERVIEW:

Engineering Mechanics is a branch of Physics that deals with the study of the system of forces acting on a particle which is at rest or in motion. The course emphasizes thorough understanding of theories and principles related to static and dynamic equilibrium of rigid bodies to acquire the analytical capability required for solving engineering problems and is one of the foundation courses that forms the basis of many of the traditional branches of engineering such as aerospace, civil and mechanical engineering.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The application of mathematics and science principles to represent the free body diagrams in the area of rigid body mechanics.
II. The conditions of static and dynamic equilibrium of bodies subjected to a particular force system for solving the field problems.
III. The effects of force and motion while carrying out the innovative design functions of engineering.

III. COURSE SYLLABUS:

MODULE-I: INTRODUCTION TO ENGINEERING MECHANICS (10)

Classification of Engineering Mechanics, Basic Terminologies in Mechanics, Laws of Mechanics, Derived Laws, Characteristics of a Force, System of Forces, Composition of Forces, Resolution of Forces, Composition of Forces by Method of Resolution, Resultant of Non-Concurrent Force System, Supports and Reactions, Free Body Diagrams, Equilibrium of Bodies, Equilibrant, Equilibrium of Connected Bodies, Moment of a Force, Varignon's Theorem, Couple, Resolution of a Force into a Force and a Couple.

MODULE –II: FRICTION (08)

Frictional Force, Laws of Friction, Angle of Friction, Angle of Repose and Cone of Friction, Types of friction, Limiting friction, Static and Dynamic Friction; Ladder friction, wedge friction, screw jack & differential screw jack.

MODULE –III: CENTROID, CENTRE OF GRAVITY AND MOMENT OF INERTIA (10)

Centre of Gravity, Centroid, Difference between Centre of gravity and Centroid, Determination of Centroid of Simple Figures from First Principle, Centroid of Composite Sections, Centre of Gravity from First Principles, Centre of Gravity of Composite Bodies.

Moment of Inertia, Polar Moment of Inertia, Radius of Gyration, Theorems of Moment of Inertia, Moment of Inertia from First Principle, Moment of Inertia of Standard Sections and Composite sections, Mass Moment of Inertia, Determination of Mass Moment of Inertia from First Principles, Parallel Axis Theorem/Transfer Formula, Mass Moment of Inertia of Composite Bodies.

MODULE –IV: PARTICLE DYNAMICS AND WORK ENERGY PRINCIPLE (09)

Kinetics of Rigid Bodies – Newton's II law, D'Alembert's principle and its applications in plane motion and connected bodies. Work, Work Done by a Varying Force, Energy, Power, Work Energy Equation for Translation, Work Done by a Spring.

MODULE –V: IMPULSE MOMENTUM AND MECHANICAL VIBRATIONS (08)

Linear Impulse and Momentum, Connected Bodies, Conservation of Momentum, Coefficient of restitution, Types of Impact. Vibrations - Basic terminology, free and forced vibrations, types of pendulum, Derivation for frequency and time period of simple, compound and torsion pendulums.

IV. TEXT BOOKS:

1. Irving H. Shames (2006), “Engineering Mechanics”, Prentice Hall, 4th Edition, 2013
2. S.Bhavikatti, “A Text Book of Engineering Mechanics”, New Age International, 1st Edition, 2012.
3. R. C. Hibbler (2006), “Engineering Mechanics: Principles of Statics and Dynamics”, Pearson Press.

V. REFERENCE BOOKS:

1. F. P. Beer and E. R. Johnston (2011), “Vector Mechanics for Engineers”, Vol I - Statics, Vol II, – Dynamics, Tata McGraw Hill, 9th Edition, 2013.
2. A.K.Tayal, “Engineering Mechanics”, Uma Publications, 14th Edition, 2013.
3. R. K. Bansal “Engineering Mechanics”, Laxmi Publication, 8th Edition, 2013.
4. Basudeb Bhattacharya, “Engineering Mechanics”, Oxford University Press, 2nd Edition, 2014.
5. K.Vijay Reddy, J. Suresh Kumar, “Singer’s Engineering Mechanics Statics and Dynamics”, B S Publishers, 1st Edition, 2013.

VI. WEB REFERENCES:

1. https://en.wikipedia.org/wiki/Dynamics_(mechanics)
2. https://www.youtube.com/playlist?list=PLUl4u3cNGP62esZEwffjMAsEMW_YArxYC

VII. E-TEXT BOOKS:

1. http://www.freeengineeringbooks.com/Civil/Engineering-Mechanics-Books.php
2. http://www.textbooksonline.tn.nic.in/books/11/stdxi-voc-ema-em-2.pdf
3. http://www.faadooengineers.com/threads/17024-Engineering-mechanics-pdf-Free-Download

BASIC ELECTRICAL ENGINEERING

I Semester : CSE / CSE (AI & ML) / CSE (DS) / CSE (CS) / CSIT / IT

II Semester : AE / ME / CE

Course Code	Category	Hours / Week			Credits	Maximum Marks		
AEEC01	Foundation	L	T	P	C	CIA	SEE	Total
		3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil			Total Classes: 45			

Prerequisites: Linear Algebra and Calculus

I. COURSE OVERVIEW:

The Basic Electrical Engineering enables knowledge on electrical quantities such as current, voltage, power, energy to know the impact of technology in global and societal context, provides knowledge on basic DC and AC circuits used in electrical and electronic devices, highlights the importance of transformers, electrical machines in generation, transmission and distribution of electric power, identify the types of electrical machines suitable for particular applications.

II. COURSE OBJECTIVES:

The students will try to learn:

Understand the basic electrical circuits and circuit laws to study the behavior AC and DC circuits.
Analyze electrical circuits with the help of network theorems.
Outline the concepts of network topology to reduce complexity of network and study its behavior.
Demonstrate the working principle of AC and DC machines.
Analyse single phase transformers circuits.

III.COURSE SYLLABUS:

MODULE – I: INTRODUCTION TO ELECTRICAL CIRCUITS (09)

Circuit concept: Ohm's law, Kirchhoff's laws, equivalent resistance of networks, Source transformation, Star to delta transformation, mesh and nodal analysis; Single phase AC circuits: Representation of alternating quantities, RMS, average, form and peak factor, concept of impedance and admittance.

MODULE – II: NETWORK THEOREMS AND NETWORK TOPOLOGY (09)

Network Theorems: Superposition, Reciprocity, Thevenin's, Norton's, Maximum power transfer for DC excitations circuits. Network Topology: Definitions, Graph, Tree, Incidence matrix, Basic Cut Set and Basic Tie Set Matrices for planar networks.

MODULE – III: DC MACHINES (09)

DC generators: Principle of operation, construction, EMF equation, types of DC generators. Losses and efficiency. **Critical field resistance, speed control.**

DC motors: Principle of operation, back EMF, torque equation, types of DC motors, Losses and efficiency, **condition for maximum efficiency**, numerical problems.

MODULE –IV: SINGLE PHASE TRANSFORMERS (08)

Single Phase Transformers: Principle of operation, construction, types of transformers, EMF equation, operation of transformer under no load and on load, Phasor diagrams, equivalent circuit, efficiency, regulation and numerical problems.

MODULE – V: AC MACHINES (09)

Three Phase Induction motor: Principle of operation, slip, slip -torque characteristics, efficiency and applications; Alternators: Introduction, principle of operation, constructional features, calculation of regulation by synchronous impedance method and numerical problems.

IV. TEXT BOOKS:

1. A Chakrabarthy, "Electric Circuits", DhanipatRai& Sons, 6th Edition, 2010.
2. A Sudhakar, Shyammohan S Palli, "Circuits and Networks", Tata McGraw-Hill, 4th Edition, 2010.
3. A E Fitzgerald and C Kingsley, "Electric Machinery", McGraw Hill Education, 2013.
4. I JNagrath, DP Kothari, "Electrical Machines", Tata McGraw-Hill publication, 3rd Edition, 2010.

V. REFERENCE BOOKS:

1. John Bird, "Electrical Circuit Theory and Technology", Newnes, 2nd Edition, 2003.
2. C L Wadhwa, "Electrical Circuit Analysis including Passive Network Synthesis", International, 2nd Edition, 2009.
3. David A Bell, "Electric circuits", Oxford University Press, 7th Edition, 2009.
4. PS Bimbra, "Electrical Machines", Khanna Publishers, 2nd Edition, 2008.

VI. WEB REFERENCES:

1. https://www.igniteengineers.com
2. https://www.ocw.nthu.edu.tw
3. https://www.uotechnology.edu.iq
4. https://www.iare.ac.in

VII. E-TEXT BOOKS

1. https://www.bookboon.com/en/concepts-in-electric-circuits-ebook
2. https://www.www.jntubook.com
3. https://www.allaboutcircuits.com
4. https://www.freeengineeringbooks.com

EXPERIENTIAL ENGINEERING EDUCATION (ExEEd) - ACADEMIC SUCCESS

I Semester: CSE / CSE (AI&ML) / CSE (DS) / CSE(CS) / IT / CSIT

II Semester: AE / ME / CE / ECE / EEE

Course Code	Category	Hours / Week			Credits	Maximum Marks		
ACSC06	Foundation	L	T	P	C	CIA	SEE	Total
		2	-	-	1	30	70	100
Contact Classes: Nil	**Tutorial Classes: Nil**	**Practical Classes: 36**				**Total Classes: 36**		

Prerequisite: There are no prerequisites to take this course

I.COURSE OVERVIEW:

The course aims to provide students with an understating of the different learning –coding platforms, role of the entrepreneur, innovation and technology in customer centric engineering.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The different ways in engaging continuous learning process through the interaction with peers in related topics.
II. The skills and potential opportunities using well know frameworks and analytical tools.
III. The attitudes, values, characteristics, behavior and processes with processing an entrepreneurial mindset.

III. COURSE CONTENT:

WEEK – I

Introduction to ExEED - Dr. Ch. Srinivasulu

WEEK – II:

Skill Development - Dr. G Ramu

WEEK – III:

Skill Development - Dr. G Ramu

WEEK – IV:

Open Source platforms for Learning , Practice and Excel in their field - Dr. M MadhuBala

WEEK – V:

Opportunities and challenges - Respective Department HOD's

WEEK – VI:

Skill Development - Dr. G Ramu

WEEK – VII:

Skill Development - Dr. G Ramu

WEEK –VIII:

Entrepreneurial Mindset - Dr. J Sirisha Devi

WEEK – IX:

Entrepreneurial Mindset - Dr. J Sirisha Devi

WEEK – X:

Innovation Culture - Dr. M Pala Prasad Reddy

WEEK – XI:

Support & Funding from various organizations - Dr. M Pala Prasad Reddy

WEEK – XII:

Rapid Prototyping - Prof. V V S H Prasad

WEEK – XIII:
Intellectual Property Rights - Mr. K Aditya Nag

WEEK – XIV:
Story Telling by Students - Dr. Ch. Srinivasulu

MANUFACTURING PRACTICE

II Semester: AE / ME / CE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AMEC02	**Foundation**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		0	0	2	1	30	70	100
Contact Classes: Nil	**Tutorial Classes: Nil**	**Practical Classes: 36**				**Total Classes: 36**		
Prerequisite: There are no prerequisites to take this course.								

I. COURSE OVERVIEW:

The course is intended to provide the basic concepts about Engineering tools for cutting and measuring used in a workshop. The students will be benefited from hands on training process as well as knowledge to carry out a particular process for making a product. This course provides wider perspective of manufacturing, processes to learn and introduces major trades as well as digital manufacturing facilities.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The application of jigs and fixtures, measuring, marking and cutting tools in various types of manufacturing processes.
II. The preparation of different joints in carpentry and fitting and also familiarizes wood working machinery.
III. The concepts of forming processes by forging, black-smithy and tin-smithy with an application extracts of Engineering Drawing.
IV. The standard electrical wiring practices for domestic and industrial appliances.
V. The current advancements in developing the prototype models through digital manufacturing facilities.

III. COURSE SYLLABUS:

Week-1: CARPENTRY-I
Batch I: Preparation of lap joint as per given dimensions.
Batch II: Preparation of dove tail joint as per given taperangle.

Week-2: CARPENTRY-II
Batch I: Preparation of dove tail joint as per given taper angle.
Batch II: Preparation of lap joint as per given dimensions.

Week-3: FITTING
Batch I & II: Make a straight fit and straight fit for given dimensions.
Make a square fit for straight fit for given sizes.

Week-4: ELECTRICAL AND ELECTRONICS
Batch I & II: Make an electrical connection to demonstrate domestic voltage and current sharing.
Make an electrical connection to control one bulb with two switches-stair case connection.

Week-5: BLACKSMITHY- I, TINSMITHY- I
Batch I: Prepare S-bend & J-bend for given MS rod using open hearth furnace.
Batch II: Prepare the development of a surface and make a rectangular tray and a round tin.

Week-6: TINSMITHY- I, BLACKSMITHY- I
Batch I: Prepare the development of a surface and make a rectangular tray and a round tin.
Batch II: Prepare S-bend & J-bend of given MS rod using open hearth furnace.

Week-7: MOULD PREPARATION
Batch I: Prepare a wheel flange mould using a given wooden pattern.
Batch II: Prepare a bearing housing using an aluminum pattern.

Week-8: MOULD PREPARATION

Batch I: Prepare a bearing housing using an aluminum pattern.
Batch II: Prepare a wheel flange mould using a given wooden pattern.

Week-09: WELDING
Batch I: Arc welding & Gas Welding.
Batch II: Gas welding & Arc Welding.

Week-10: INJECTION MOULDING
Batch I & II: Injection moulding.

Week-11: BLOW MOULDING
Batch I & II: Blow moulding.

Week-12: MACHINE SHOP-Turning and Milling
Batch I & II: Working on central lathe and shaping machine.
Working on milling machine.

Week-13: **ADVANCED MACHINE SHOP-I**
Batch I & II: Working on CNC Turning machines.
Working on CNC Vertical Drill Tap Center.

Week-14: **ADVANCED MACHINE SHOP-II**
Batch I & II: Working on CNC Laser Engraving Machine.
Working on 5 Axis CNC Routing Machine.

IV. REFERENCE BOOKS:

1. Hajra Choudhury S.K., Hajra Choudhury A.K. and NirjharRoy S.K., "Elements of Workshop Technology", Media promoters and publishers private limited, Mumbai, Vol. I 2008 and Vol. II 2010.
2. Kalpakjian S, Steven S. Schmid, "Manufacturing Engineering and Technology", Pearson Education India Edition, 4^{th} Edition, 2002.
3. Gowri P. Hariharan, A. Suresh Babu," Manufacturing Technology – I", Pearson Education, 2008.
4. Roy A. Lindberg, "Processes and Materials of Manufacture", Prentice Hall India, 4^{th} Edition, 1998.
5. Rao P.N., "Manufacturing Technology", Vol. I and Vol. II, Tata McGraw-Hill House, 2017.

V. WEB REFERENCES:

http://www.iare.ac.in

COMPUTER AIDED ENGINEERING DRAWING

II Semester: AE / ME / CE							
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AMEC03	Foundation	L	T	P	C	CIA	SEE	Total
		1	-	2	1.5	30	70	100
Contact Classes: 15	Tutorial Classes: Nil	Practical Classes: 45				Total Classes: 60		
Prerequisite: There are no prerequisites to take this course.								

I. COURSE OVERVIEW:

One of the best ways to communicate one's idea is through some form of picture or drawing. Engineering Drawing is the accurate technique that develops the ability to visualize any object with all physical and dimensional configurations. During the process of design, the designer may have to carry out a large amount of computations to generate optimum design and develops engineering drawings for manufacturing a product using interactive computer graphics. The computer aided engineering drawing assists in preparation of 3D and 2D drawings to carry out sophisticated design and analysis. This course forms the foundation for the development of computer graphics and CAD/CAM technologies in the era of digital manufacturing.

II. COURSE OBJECTIVES:

The students will try to learn:

VI. The basic knowledge about engineering drawing as a communicative language of engineers in ideation.

VII. The ability to visualize, create and edit any object with all the physical and dimensional configurations using computer aided drawing tools.

VIII. The code of engineering drawing practice as per the Bureau of Indian Standards and International practices.

III. COURSE OBJECTIVES:

MODULE – I: INTRODUCTION TO ENGINEERING DRAWING AND OVERVIEW OF COMPUTER GRAPHICS

Principles of Engineering Graphics and their significance, usage of Drawing instruments, lettering.

Listing the computer technologies that impact on graphical communication, Demonstrating knowledge of the theory of CAD software.

MODULE – II: CONIC SECTIONS AND SCALES

Conic sections including the Rectangular Hyperbola (General method only); Cycloid, Epicycloid, Hypocycloid and Involute; Scales-Plain, Diagonal and Vernier Scales.

MODULE – III: PROJECTION OF POINTS AND LINES

Principles of Orthographic Projections-Conventions-Projections of Points and lines inclined to both planes.

Projections of planes, Planes inclined to both the planes.

MODULE – IV: PROJECTION OF REGULAR SOLIDS

Draw the orthographic views of geometrical solids of Prism, Pyramid, Cylinder and Cone.

MODULE – V: ISOMETRIC AND ORTHOGRAPHIC PROJECTIONS

Principles of Isometric projection–Isometric Scale, Isometric Views, Conventions; Isometric Views of lines, Planes, Simple and compound Solids; Conversion of Isometric Views to Orthographic Views and Vice-versa.

IV. TEXT BOOKS:

1. N. D. Bhatt, "Engineering Drawing", Charotar Publications, New Delhi, 49th Edition, 2010.
2. C.M. Agarwal, Basant Agarwal, "Engineering Drawing", Tata McGraw Hill, 2nd Edition, 2013.

V. REFERENCE BOOKS:

1. K. Venugopal, "Engineering Drawing and Graphics". New Age Publications, 2nd Edition, 2010.
2. Dhananjay. A. Johle, "Engineering Drawing", Tata McGraw Hill, 1st Edition, 2008.
3. S.Trymbaka Murthy, "Computer Aided Engineering Drawing", I.K. International Publishers, 3rd Edition, 2011.

4. A.K.Sarkar, A.P Rastogi, “Engineering graphics with Auto CAD”, PHI Learning, 1st Edition, 2010.

VI. WEB REFERENCES:

1. http://nptel.ac.in/courses/112103019
2. http://www.autocadtutorials.net/
3. http://gradcab.com/questions/tutorial-16-for-beginner-engineering-drawing-I

PROGRAMMING FOR PROBLEM SOLVING LABORATORY

II Semester: AERO / MECH / CIVIL								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
ACSC03	Foundation	L	T	P	C	CIA	SEE	Total
		0	0	3	1.5	30	70	100
Contact Classes: Nil	Tutorial Classes: Nil	Practical Classes: 36				Total Classes:36		
Prerequisite: Knowledge of Python programming								

I.COURSE OVERVIEW:

This course introduces students to writing computer programs. This course presents the principles of structured programming using the Python language, one of the most increasingly preferred languages for programming today. Because of its ease of use, it is ideal as a first programming language and runs on both the PC and Macintosh platforms. However, the knowledge gained in the course can be applied later to other languages such as C and Java. The course uses iPython Notebook to afford a more interactive experience. Topics include fundamentals of computer programming in Python, object-oriented programming and graphical user interfaces.

II.COURSE OBJECTIVES:

The students will try to learn:

I. The programming skills of core Python.
II. The Object-oriented programming skills of Python.
III. Designing skills required to develop graphical-user interfaces (GUI) in Python.
IV. To write database applications in Python.
V. Python programming to move into specific branches like- Internet of Things (IoT), Data Science, Machine Learning (ML), Artificial Intelligence (AI) etc.

III.COURSE SYLLABUS

Week – 1: STUDENTS IN A COLLEGE

1. There are D departments in a college and each department has A_i number of students. Your task is to find the total number of students in the college.

   Input Format:
   The first line of input contains an integer D , the number of departments
   The second line of input contains D space-separated integers denoting number of students in each department.

   Output Format:
   A single integer(the total number of students in the college)

   Example:
   Input:
   3
   1 2 3

   Output:
   6

2. In Statistics, range is defined as the difference between highest and lowest values. Given marks of students in a class, find the range.

   Input Format:
   The first line of input contains an integer N, the number of students
   The second line of input contains N space-separated integers denoting the marks of each student in the class.

   Output Format:
   A single integer(the range)

   Example:

Input:
5
10 20 40 20 30

Output:
30

Week – 2: TRIANGLES

1. What is the maximum number of squares of size **2x2** that can be fit in a right angled isosceles triangle of base **B**. One side of the square must be parallel to the base of the isosceles triangle. Base is the shortest side of the triangle.

Input Format:
The first line of input contains an integer T , denoting number of test cases.
Each of the next T lines contain a single integer , B (base)

Output Format:
For each test case , print a single integer, the number of squares.

Example:
Input:
3
1
1
4
11
Output:
0
0
1
10

2. Given 3 sides of a triangle, check whether the given three sides form a triangle and if so , check if it is an equilateral , isosceles or scalene triangle, also print its area.

Input Format:
The first line of input contains an integer T , denoting number of test cases.
Each of the next T lines contain 3 space separated integers , the 3 sides

Output Format:
For each test case , if the given 3 sides form a triangle ,
Print "EQUILATERAL" / "ISOSCELES" /"SCALENE" followed by the area (up to 2 decimal places)
If they do not form a triangle , print "NOT A TRIANGLE"

Example:
Input:
5
3 3 3
3 5 3
3 7 3
4 2 3
1 2 3

Output:
EQUILATERAL 3.89
ISOSCELES 4.14
NOT A TRIANGLE
SCALENE 2.90
NOT A TRIANGLE

Week – 3: MAGIC SQUARE

1. A magic square of size N is a square matrix of order NxN that satisfies these conditions.
   a. It should contain all elements from 1 to N^2 without repetitions.
   b. The sum of the numbers in any row,column or diagonal should be equal.

   Write a Python program to check whether a given matrix is a magic square or not

   Input Format:
   The first line of input contains an integer N, the order of the square matrix
   Each of the next N lines contain N-space separated integers denoting the elements of the matrix

   Output Format:
   Print "YES" if it is a magic square, else print "NO".

   Example:
   Input:
   3
   8 1 6
   3 5 7
   4 9 2

   Output:
   YES

Week – 4: RUNNING RACE

1. The scores of participants in a running race are given, find the runner up.

   Input Format:
   The first line of input contains an integer T, the number of test cases
   Each of the next T lines contain some space separated integers denoting the participant's scores

   Output Format:
   For each test case, print a single integer denoting the score of the runner up. If there is no runner up, print "NONE".

   Example:
   Input:
   5
   1 2 3 4 5
   5 5 5 5 2 5 5 2
   5 5 5 5 5 5
   10 20 30 40 50
   19 76 89 12 34 78 90 90 76 89 90
   Output:
   4
   2
   NONE
   40
   89

2. The scores of participants in a running race were recorded but the person recording the scores made some errors and added some duplicate entries. Remove all duplicate entries and print the count of the errors made.

   Input Format:
   The first line of input contains an integer N, the number of scores that were recorded
   The second line of input contains N space-separated integers denoting the recorded scores.

   Output Format:
   The first line of output should contain the distinct scores after removing duplicate entries.
   The second line of output should contain an integer denoting the number of errors made.

Example:
Input:
10
1 2 3 1 1 3 4 2 8 9

Output:
1 2 3 4 8 9
4

Week – 5: PANGRAM

1. Given a string check if it is Pangram or not. A pangram is a sentence containing every letter in the English Alphabet. Ignore case and special characters.

Input Format:
The first line of input contains an integer T, the number of test cases.
Each of the following T lines contain a string

Output Format:
For each test case, print "PANGRAM" or "NOT PANGRAM".

Example:
Input:
3
The quick brown fox jumps over the lazy dog
$!#@ ABC DEF ghi jkl mnop qrst uvw XYZ @#!$
Institute of Aeronautical Engineering

Output:
PANGRAM
PANGRAM
NOT PANGRAM

Week – 6: FREQUENCY OF LETTERS

1. Given a sentence, print the frequency of each English letter present in the sentence, in alphabetic order. Consider all characters to be lowercase.

Input Format:
A sentence

Output Format:
For every character, print the character followed by a hyphen and then the frequency (in alphabetic order). Ignore digits and special characters and consider uppercase letters also as lowercase.

Example:
Input:
12345 This is a sentence @IARE
Output:
a-2
c-1
e-4
h-1
i-3
n-2
r-1
s-3
t-2

Week – 7: BINARY NUMBERS

1. Write a program to convert a given decimal number into binary.

   Input Format:
   The first line of input contains an integer T denoting the number of test cases.
   Each of the next T lines contains decimal integers.

   Output Format:
   For each test case, print the binary equivalent.

   Example:
   Input:
   4
   1
   3
   5
   10

   Output:
   1
   11
   101
   1010

2. Write a program to convert a given binary number into decimal form.

   Input Format:
   The first line of input contains an integer T denoting the number of test cases.
   Each of the next T lines contains binary integers.

   Output Format:
   For each test case, print the decimal equivalent.

   Example:
   Input:
   4
   1
   11
   101
   1001

   Output:
   1
   3
   5
   9

Week – 8: PATTERNS

1. Write a Python program to print the following pattern.

```
N=5
  *
 ***
*****
 ***
  *
```

2. Write a Python program to print the following pattern.

```
S= SCHOOL
   IIIIII
   IAAAAAI
   IARRRAI
```

IARERAI
IARRRAI
IAAAAAI
IIIIII

Week – 9: COMBINATIONS

1. Given an array of size n, generate and print all possible combinations of r elements in array.

Input Format:
First line contains Space-separated integers denoting array elements.
Second line contains r , size of each combination

Output Format:
Print each combination in a separate line and every combination should have comma separated integers.

Example:
Input:
1 2 3 4
2

Output:
1,2
1,3
1,4
2,3
2,4
3,4

Week – 10: CLASS AND OBJECTS

1. Create a Temperature class. Make two methods.
   i. Convert Fahrenheit - It will take Celsius and will print it into Fahrenheit.
   ii. Convert Celsius - It will take Fahrenheit and will convert it into Celsius.

2. Create a Time class and initialize it with hours and minutes.
   i. Make a method add Time which should take two time object and add them. E.g.- (2 hour and 50 min) + (1 hr and 20 min) is (4 hr and 10 min)
   ii. Make a method display Time which should print the time.
   iii. Make a method Display Minute which should display the total minutes in the Time. E.g.- (1 hr 2 min) should display 62 minute.

Week – 11: ROMAN NUMERAL

1. Write a Python program to convert a decimal number into its roman numeral form.

Input Format:
The first line of input contains an integer T denoting the number of test cases.
Each of the next T lines contains decimal integers.

Output Format:
For each test case, print the roman numeral equivalent.

Example:
Input:
4

10
100
999
2020

Output:
X
C
CMXCIX
MMXX

2. Write a Python program to convert a roman numeral into its decimal form.

Input Format:
The first line of input contains an integer T denoting the number of test cases.
Each of the next T lines contains roman numbers.

Output Format:
For each test case, print the decimal equivalent.

Example:
Input:
4
XII
C
DXCVII
MMXX

Output:
12
100
597
2020

Week – 12: FILE HANDLING

1. Write a Python program to count the number of characters, words, lines in a file.

Example:

Input File:
First line
Second line
Third line

Output:
Characters:31
Words:6
Lines:3

2. Write a Python program to add line numbers to a file.

Example:

Input File:
First line
Second line
Third line

Output:

1. First line
2. Second line
3. Third line

IV. REFERENCE BOOKS:

1. Michael H Goldwasser, David Letscher, "Object Oriented Programming in Python", Prentice Hall, 1st Edition, 2007.
2. Yashavant Kanetkar, Aditya Kanetkar, "Let us Python", BPB publication, 1st Edition, 2019.
3. Ashok Kamthane, Amit Kamthane, "Programming and Problem Solving with Python", McGraw Hill Education (India) Private Limited, 2018.
4. Taneja Sheetal, Kumar Naveen, "Python Programming – A modular approach", Pearson, 2017.
5. R Nageswara Rao, "Core Python Programming", Dreamtech Press, 2017 Edition.

V. WEB REFERENCES:

1. https://www.codesdope.com/practice/python-your-class/
2. https://www.geeksforgeeks.org/python-programming-language/
3. https://www.hackerrank.com/
4. https://www.codechef.com/

PROBABILITY AND STATISTICS

II Semester: CSE / CSE (AI & ML) / CSE (DS) / CSE (CS) / CSIT / IT **III Semester:** AE | ME | **IV Semester:** CE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AHSC08	**Foundation**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	1	-	4	30	70	100
Contact Classes: 45	**Tutorial Classes: 15**	**Practical Classes: Nil**				**Total Classes: 60**		
Prerequisite: **Fundamentals of statistics**								

I. COURSE OVERVIEW:

Probability theory is the branch of mathematics that deals with modelling uncertainty. Inferential Statistics and regression analysis together with random variate distributions are playing an exceptional role in designing data driven technology which is familiarly known as data centric engineering. They also have wide variety applications in telecommunications and other engineering disciplines. The course covers advanced topics of probability and statistics with applications. The course includes: random variables, probability distributions, hypothesis testing, confidence intervals, and linear regression. There is an emphasis placed on real-world applications to engineering problems.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The theory of random variables, basic random variate distributions and their applications.

II. The Methods and techniques for quantifying the degree of closeness among two or more variables and linear regression analysis.

III. The Estimation statistics and Hypothesis testing which play a vital role in the assessment of the quality of the materials, products and ensuring the standards of the engineering process.

IV. The statistical tools which are essential for translating an engineering problem into probability model.

III. COURSE SYLLABUS:

MODULE-I: RANDOM VARIABLES (09)

Random variables: Basic definitions, discrete and continuous random variables; Probability distribution: Probability mass function and probability density functions.

MODULE –II: PROBABILITY DISTRIBUTION (09)

Binomial distribution; Mean and variances of Binomial distribution, Poisson distribution: Poisson distribution as a limiting case of Binomial distribution, mean and variance of Poisson distribution, Normal distribution; Mean, Variance, Mode, Median of Normal distribution.

MODULE –III: CORRELATIONS AND REGRESSION (09)

Correlation: Karl Pearson's Coefficient of correlation, Rank correlation, Repeated Ranks.

Regression: Lines of regression, Regression coefficient, Angle between two lines of regression.

MODULE –IV: TEST OF HYPOTHESIS - I (09)

Sampling: Population, Sampling, standard error; Test of significance: Null hypothesis, alternate hypothesis; Large sample tests: Test of hypothesis for single mean, difference between means, single proportion and difference between proportions.

MODULE –V: TEST OF HYPOTHESIS - II (09)

Small sample tests: Student t-distribution, F-distribution and Chi-square distribution.

IV. TEXT BOOKS:

1. Erwin Kreyszig, "Advanced Engineering Mathematics", John Wiley & Sons Publishers, 9th Edition, 2014.
2. B. S. Grewal, "Higher Engineering Mathematics", Khanna Publishers, 42nd Edition, 2012.

V. REFERENCE BOOKS:

1. S. C. Gupta, V. K. Kapoor, "Fundamentals of Mathematical Statistics", S. Chand & Co., 10th Edition, 2000.
2. N. P. Bali, "Engineering Mathematics", Laxmi Publications, 9th Edition, 2016.
3. Richard Arnold Johnson, Irwin Miller and John E. Freund, "Probability and Statistics for Engineers", Prentice

Hall, 8th Edition, 2013.

VI. WEB REFERENCES:

1. http://www.efunda.com/math/math_home/math.cfm
2. http://www.ocw.mit.edu/resourcs/#Mathematics
3. http://www.sosmath.com
4. http://www.mathworld.wolfram.com

VII. E-TEXT BOOKS:

1. http://www.keralatechnologicaluniversity.blogspot.in/2015/06/erwin-kreyszig-advanced-engineering- mathematics-ktu-ebook-download.html
2. http://www.faadooengineers.com/threads/13449-Engineering-Maths-II-eBooks

MECHANICS OF SOLIDS

III Semester: AE

Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAEC01	Core	L	T	P	C	CIA	SEE	Total
		3	0-	0	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil			Total Classes: 45			

Prerequisite: Engineering Mechanics

I. COURSE OVERVIEW:

The primary objectives of mechanics of solids is to enable students to acquire the fundamentals for understanding the behavior of structural components commonly used in engineering and machines subjected to various loading and support conditions based on principles of equilibrium and material constitutional relationship. In day-to-day work, an engineer comes across certain materials, i.e., steel girders, angle irons, circular bars, etc., which are used in designing all types of structures and machines. An in-depth understanding of material properties under various loading conditions including temperature and their effects is essential to take suitable protective measures for safe working of designed and fabricated product.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The concepts of mechanics of deformable solids and their constitutive relations (including stress – strain relations), principal stresses and strains and resilience produced under various loading conditions for determining the strength of aircraft structures.

II. The methods of determining shear force - bending moment, twisting moment, flexural Stresses, shear stresses, deflection of beams subjected to various loadings and boundary conditions, for designing the shape, size and material of aircraft components.

III. The mechanism of buckling behavior of the columns under different end conditions along with Eigen modes, effect of direct and eccentric loading in designing long columns

IV. The equilibrium and compatibility conditions for two-dimensional and three dimensional elastic bodies for analysis of aircraft structures.

III. COURSE SYLLABUS:

MODULE-I: SIMPLE STRESSES & STRAINS (09)

Elasticity and plasticity, types of stresses and strains, Saint Venant's principle, Hooke's law, stress, strain diagram for mild steel, working stress, factor of safety, lateral strain, Poisson's ratio & volumetric strain, Elastic moduli & the relationship between them, bars of varying section, composite bars, temperature stresses; Strain energy and resilience, gradual, sudden, impact loadings.

MODULE –II: SHEAR FORCE AND BENDING MOMENT (09)

Definition of beam, types of beams, concept of shear force and bending moment, S.F and B.M diagrams for cantilever, simply supported and overhanging beams subjected to point loads, u.d.l., uniformly varying loads and combination of these loads, point of contra flexure, relation between S.F., B.M.

MODULE –III: FLEXURAL, SHEAR STRESSES (10)

Flexural Stresses: Theory of simple bending, assumptions, derivation of bending equation, neutral axis, determination bending stresses, section modulus of rectangular and circular sections (Solid and Hollow), I, T, angle and channel sections, design of simple beam sections, beams of uniform strength.

Shear Stresses: Derivation of formula, shear stress distribution across various beams sections like rectangular, circular, triangular, I, T and angle sections.

MODULE –IV: DEFLECTION OF BEAMS(09)

Bending into a circular arc, slope, deflection and radius of curvature, differential equation for the elastic line of a beam, double integration and Macaulay's methods, determination of slope and deflection for cantilever and simply supported beams, over hanging beams, propped beams and cantilevers subjected to point loads, U.D.L and uniformly varying load. Beams of variable cross-sections.

MODULE –V: TORSION OF CIRCULAR SHAFTS, PRINCIPAL STRESS AND STRAINS(09)

Torsion of circular Shafts: Introduction, relation between twisting moment twist and shear stress, torque, power, rotational speed, polar moment of inertia, torsional shear stress and polar moment of inertia for solid and hollow circular shafts, design of shafts, combined bending and torsion.

Principal Stress and Strains: Stress components of inclined planes, Biaxial stress with state of simple shear, circular diagram of stress, Mohr circle, principal strains: Computation of principal stresses form principal strains, strain in an inclined direction, Mohr circle of strain, strain measurement, strain Rosettes.

IV. TEXT BOOKS

1. B C Punmia, "Mechanics of Materials", Laxmi publications (P) Ltd, 2006
2. T. H. G. Megson, "Aircraft Structures for Engineering Students", Butterworth-Heinemann Ltd, 5th Edition, 2012
3. Gere, Timoshenko, "Mechanics of Materials", McGraw Hill, 3rd Edition, 1993.

V. REFERENCE BOOKS:

1. Stephen Timoshenko, "Strength of Materials", Vol I & II, CBS Publishers and Distributors, 3rd Edition, 2004.
2. Timoshenko, S, Young, D. H. "Elements of Strength of Materials", T. Van Nostrand Co. Inc., Princeton N.J, 4th Edition, 1977.
3. Russell C. Hibbeler, "Mechanics of Materials", Pearson, 9th Edition, 2014.
4. Robert L Mott "Applied strength of materials", PHI, 5th Edition, 2009
5. Ferdinand P. Beer, E. Russell Johnston, John T. Dewolf, David F. Mazurek ,"Mechanics of Materials", 6th Edition, McGraw-Hill, 2012

VI. WEB REFERENCES:

1. www.nptel.ac.in/courses/112107147
2. www.vssut.ac.in/lecture_notes/lecture1423904647.pdf
3. www.web.mit.edu/emech/dontindex-build/

VII. E-TEXT BOOKS:

1. www.e-booksdirectory.com/listing.php?category=456
2. www.esag.harvard.edu/rice/e0_Solid_Mechanics_94_10.pdf
3. www.itiomar.it/pubblica/dispense/MECHANICAL%20ENGINEERING%20HANDBOOK/

ENGINEERING THERMODYNAMICS

III Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC02	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	0	0	3	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		
Prerequisite: Basic principles of waves								

I. COURSE OVERVIEW:

Engineering Thermodynamics is the field of physics which deals with the relationship between heat and mechanical work, and the properties of systems that bear relation to heat and work. General laws of energy transformations concerning all types of systems, mechanical, electrical and chemical may fall within the purview of this science.

It is a science based on a number of empirical laws formed by experimentation from which all predictions concerning the physical behavior of the system may be deduced by logical reasoning. The findings have been formalized into certain basic laws, which are known as Zeroth law, First, Second and third laws of thermodynamics. Power cycles and refrigeration cycle based on thermodynamic system are analyzed for determination of their efficiencies and applications. This course emphasis on the groundwork for subsequent studies in the fields of fluid mechanics, heat transfer and to prepare the cohorts for effective use of thermodynamics in the real-world applications..

II. COURSE OBJECTIVES:

The students will try to learn:

I. The concepts of thermodynamics, gas properties and the thermodynamic disorderness in the real time physical systems in heat engines, heat pumps and refrigerators for measure of their performance.
II. The characteristics of pure substances, mixtures, usage of steam tables, mollier' chart and psychometric charts for solving thermal problems.
III. The characteristics and performance of open and closed systems of thermodynamic cycles for effective delineation of real time applications.
IV. The methods of heat transfer and the suitability of heat exchangers and gas compressors in power plants and aircraft propulsion system.

III. COURSE OBJECTIVES:

MODULE-I: BASIC CONCEPTS AND FIRST LAW OF THERMODYNAMICS (09)

Basic concepts*:* System, control volume, surrounding, boundaries, universe, types of systems, macroscopic and microscopic viewpoints, concept of continuum, thermodynamic equilibrium, state, property, process, cycle, reversibility, quasi static process, irreversible process, causes of irreversibility, various flow and non-flow processes, energy in state and in transition, types-work and heat, point and path function, Zeroth law of thermodynamics, concept of quality of temperature, Principles of thermometry, reference points, constant volume gas thermometer, ideal gas scale, PMMI Joule's experiments, first law of thermodynamics, corollaries first law applied to a process, applied to a flow system, steady flow energy equation.

MODULE –II: SECOND LAW OF THERMODYNAMICS(09)

Limitations of the first law: thermal reservoir, heat engine, heat pump, parameters of performance, second Law of thermodynamics, Kelvin Planck and Clausius statements and their equivalence, Corollaries, PMM of second kind, Carnot's principle, Carnot cycle and its specialties, thermodynamic scale of temperature, Clausius inequality, Entropy, principle of Entropy increase, availability and irreversibility, thermodynamic potentials, Gibbs and Helmholtz functions, Maxwell relations, Third Law of thermodynamics.

MODULE –III: PURE SUBSTANCES AND MIXTURES OF PERFECT GASES (09)

Pure substances: Phase transformations, T-S and H-S diagrams, P-V-T surfaces, triple point at critical state properties during change of phase, dryness fraction, Mollier charts, psychometric properties, dry bulb temperature, wet bulb temperature, dew point temperature, thermodynamic wet bulb temperature, specific humidity, relative humidity, saturated air, vapour pressure, degree of saturation, adiabatic saturation, Carrier's equation, Psychometric chart.

MODULE –IV: POWER CYCLES(09)

Power cycles: Otto, Diesel, Dual combustion cycles, description and representation on P-V and T-S diagram, thermal efficiency, mean effective pressures on air standard basis, comparison of cycles, introduction to Brayton cycle and Bell

Coleman cycle.

MODULE –V: ELEMENTS OF HEAT TRANSFER AND GAS COMPRESSORS (09)

Basic concepts of Heat Transfer: Conduction, Convection and Radiation, Heat Exchangers, Types of Heat Exchangers. Basic concepts of: Gas Compressors, Types of Air Compressors, Single-Stage compression, Multi-Stage Compression, Volumetric Efficiency, Rotary Compressors.

IV. TEXT BOOKS:

1. P. K. Nag, "Engineering Thermodynamics", Tata McGraw-Hill, 4th Edition, 2008.
2. YunusCengel, Michael A. Boles, "Thermodynamics-An Engineering Approach", Tata McGraw-Hill, 7th Edition, 2011.
3. R.K.Rajput, "Engineering Thermodynamics", Laxmi Publications (P) Ltd, Third Edition, 2007.

V. REFERENCE BOOKS:

1. J. B. Jones, R. E. Dugan, "Engineering Thermodynamics", Prentice Hall of India Learning, 1st Edition, 2009.
2. Y. V. C. Rao, "An Introduction to Thermodynamics", Universities Press, 3rd Edition, 2013.
3. K. Ramakrishna, "Engineering Thermodynamics", Anuradha Publishers, 2nd Edition, 2011.
4. Holman. J.P, "Thermodynamics", Tata McGraw-Hill, 4th Edition, 2013

VI. WEB REFERENCES:

1. https://en.wikipedia.org/wiki/Thermodynamics
2. https://en.wikipedia.org/wiki/Laws_of_thermodynamics
3. http://www.livescience.com/50776-thermodynamics.html
4. https://www3.nd.edu/~powers/ame.20231/planckdover.pdf

VII.E-TEXT BOOKS:

1. https://www3.nd.edu/~powers/ame.20231/planckdover.pdf
2. http://www.ebookdownloadz.net/2014/08/engineering-thermodynamics-by-pknag.html

FLUID DYNAMICS

III Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC03	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	1	0	4	30	70	100
Contact Classes: 45	**Tutorial Classes: 15**	**Practical Classes: Nil**				**Total Classes:60**		
Prerequisites: Linear Algebra and Calculus								

I. COURSE OVERVIEW:

This course will provide with the terminology associated with fluid mechanics and the use of fluid properties in solving problems. It also emphasizes on mathematical description of fluid flows. The basic conservation equations of a fluid flow are derived for different fluid flows. It introduces the concept of a boundary layer, boundary layer thickness and basic aspects of bluff body aerodynamics. Compare and contrast various fluid machinery based on flow properties and its applications. The course discusses the concept of dimensional analysis and its importance, and open-channel flows which are widely applicable in engineering.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The fundamental knowledge of types of fluids, properties and behavior under static and dynamic conditions of closed conduit and external flow systems.

II. The analysis of prototype models based on geometric, kinematic, and dynamic similarities for the evaluation of performance of designed hydraulic machines.

III. The importance of formation of boundary layer when fluid flows over the solid bodies and effect in reduction of displacement, momentum, energy and pressure gradient.

IV. The operating principle of various turbo machinery and analyze their characteristics for their suitability in engineering application using governing equations.

III. SYLLABUS:

MODULE – I: FLUID PROPERTIES AND FLUID STATICS(10)

Density, specific weight, specific gravity, surface tension and capillarity, Newton's law of viscosity, incompressible and compressible fluid, numerical problems; Hydrostatic forces on submerged bodies - Pressure at a point, Pascal's law, pressure variation with temperature and height, center of pressure plane, vertical and inclined surfaces; Manometers - simple and differential Manometers, inverted manometers, micro manometers, pressure gauges and numerical problems. Buoyancy - Archimedes principle, metacenter, Meta centric height calculations; Stability.

MODULE – II: DIMENSIONAL ANALYSIS(10)

Fundamental and secondary quantities, Dimensional homogeneity, Methods of dimensional Analysis- Rayleigh's method, Buckingham's π- theorem, method of selecting repeating variables, similarity parameters - Reynolds number, Froude number, Euler's number, Weber's number, Mach number concepts of geometric, kinematic and dynamic similarity.

MODULE – III: KINEMATICS AND DYNAMICS OF FLUIDS(10)

Methods of describing fluid motion, types of fluid flows, differential form of continuity equation- Cartesian, cylindrical and polar coordinate system, Numerical problems

Euler's equation of Motion; Bernoulli's equation, Application of Bernoulli's equation in flow measurements: velocity and mass flow rate, pitot-static tube, venturi meter, orifice meter and V-Notch

MODULE - IV BOUNDARY LAYER THEORY (09)

Introduction and classification of boundary layer, boundary layer properties- Displacement, momentum and energy thickness, idea of boundary layer separation, streamlined and bluff bodies, drag force on flat due to boundary layer.

MODULE - V TURBO MACHINERY(09)

Introduction and classification of fluid machines: Turbo machinery analysis; The angular momentum principle;
Euler turbo machine equation; Application to fluid systems, working principle overview of turbines, fans, pumps and compressors.

IV. TEXT BOOKS:

1. D.J Tritton, “Physical Fluid Dynamics”, Oxford university press, 2nd Edition 2016.
2. R. K Bansal, “Fluid mechanics and hydraulic machines”, Laxmi publications ltd, 9th Edition, 2011.
3. Robert W Fox, Alan T McDonald, “Introduction to fluid Mechanics”, John Wiley and Sons, 6th Edition, 1995.
4. Streeter V. L, Wylie, E.B., “Fluid Mechanics”, McGraw-Hill, 9th Edition, 1983.

V. REFERENCE BOOKS:

1. Yuan S W, “Foundations of fluid Mechanics”, Prentice-Hall, 2nd Edition, 1987.
2. Milne Thompson L M, “Theoretical Hydrodynamics”, MacMillan, 5th Edition, 1968.
3. Rathakrishnan. E, “Fundamentals of Fluid Mechanics”, Prentice-Hall, 5th Edition, 2007.
4. Som S. K, Biswas. G, “Introduction to fluid mechanics and fluid machines”, Tata McGraw-Hill, 2nd Edition, 2004.

VI. WEB REFERENCES:

1. https://nptel.ac.in/courses/112105171/1
2. https://textofvideo.nptel.iitm.ac.in/112105171/lec1.pdf
3. https://www.fkm.utm.my/~syahruls/3-teaching/2-fluid-II/fluid-II-enote/32-pump-2.pdf
4. https://www.scribd.com/doc/16605891/Fluid-Mechanics

DATA STRUCTURES

III Semester: Common for all branches								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
ACSC08	Core	L	T	P	C	CIA	SEE	Total
		3	0	0	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		
Prerequisites: Python Programming								

I. COURSE OVERVIEW:

The course covers some of the general-purpose data structures and algorithms, and software development. Topics covered include managing complexity, analysis, static data structures, dynamic data structures and hashing mechanisms. The main objective of the course is to teach the students how to select and design data structures and algorithms that are appropriate for problems that they might encounter in real life. This course reaches to student by power point presentations, lecture notes, and lab which involve the problem solving in mathematical and engineering areas.

II. COURSE OBJECTIVES:

The students will try to learn:

I. To provide students with skills needed to understand and analyze performance trade-offs of different algorithms / implementations and asymptotic analysis of their running time and memory usage.
II. To provide knowledge of basic abstract data types (ADT) and associated algorithms: stacks, queues, lists, tree, graphs, hashing and sorting, selection and searching.
III. The fundamentals of how to store, retrieve, and process data efficiently.
IV. To provide practice by specifying and implementing these data structures and algorithms in Python.
V. Understand essential for future programming and software engineering courses.

III. SYLLABUS:

MODULE – I: INTRODUCTION TO DATA STRUCTURES, SEARCHING AND SORTING (09)

Basic concepts: Introduction to data structures, classification of data structures, operations on data structures; Algorithm Specification, Recursive algorithms, Data Abstraction, Performance analysis- time complexity and space complexity, Asymptotic Notation-Big O, Omega, and Theta notations. Introduction to Linear and Non Linear data structures, Searching techniques: Linear and Binary search; Sorting techniques: Bubble, Selection, Insertion, Quick and Merge Sort and comparison of sorting algorithms.

MODULE – II: LINEAR DATA STRUCTURES (09)

Stacks: Stack ADT, definition and operations, Implementations of stacks using array, applications of stacks, Arithmetic expression conversion and evaluation; Queues: Primitive operations; Implementation of queues using Arrays, applications of linear queue, circular queue and double ended queue (deque).

MODULE – III: LINKED LISTS (09)

Linked lists: Introduction, singly linked list, representation of a linked list in memory, operations on a single linked list; Applications of linked lists: Polynomial representation and sparse matrix manipulation.

Types of linked lists: Circular linked lists, doubly linked lists; Linked list representation and operations of Stack, linked list representation and operations of queue.

MODULE - IV NON LINEAR DATA STRUCTURES (09)

Trees: Basic concept, binary tree, binary tree representation, array and linked representations, binary tree traversal, binary tree variants, threaded binary trees, application of trees, Graphs: Basic concept, graph terminology, Graph Representations - Adjacency matrix, Adjacency lists, graph implementation, Graph traversals – BFS, DFS, Application of graphs, Minimum spanning trees – Prims and Kruskal algorithms.

MODULE - V BINARY TREES AND HASHING (09)
Binary search trees: Binary search trees, properties and operations; Balanced search trees: AVL trees; Introduction to M-Way search trees, B trees; Hashing and collision: Introduction, hash tables, hash functions, collisions, applications of hashing.

IV. TEXT BOOKS:

1. Rance D. Necaise, “Data Structures and Algorithms using Python”, Wiley Student Edition.
2. Benjamin Baka, David Julian, “Python Data Structures and Algorithms”, Packt Publishers, 2017.

V. REFERENCE BOOKS:

1. S. Lipschutz, “Data Structures”, Tata McGraw Hill Education, 1st Edition, 2008.
2. D. Samanta, “Classic Data Structures”, PHI Learning, 2nd Edition, 2004.

VI. WEB REFERENCES:

1. https://www.tutorialspoint.com/data_structures_algorithms/algorithms_basics.htm
2. https://www.codechef.com/certification/data-structures-and-algorithms/prepare
3. https://www.cs.auckland.ac.nz/software/AlgAnim/dsToC.html
4. https://online-learning.harvard.edu/course/data-structures-and-algorithms

EXPERIENTIAL ENGINEERING EDUCATION (EXEED) – PROTOTYPE / DESIGN BUILDING

III Semester: Common for all branches								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
ACSC09	Foundation	L	T	P	C	CIA	SEE	Total
		2	0	0	1	30	70	100
Contact Classes: 28	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 28		
Prerequisite: There are no prerequisites to take this course								

I. COURSE OVERVIEW:

This course provides an overall exposure to the various methods and tools of prototyping. This course discusses Low-Fidelity, paper, wireframing and tool based prototyping techniques along with design principles and patterns.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The basic principles and design aspect of prototyping.
II. The various techniques, design guidelines and patterns.
III. The applications of prototyping using various tools and platforms.

WEEK NO	TOPIC
WEEK – I	An introduction to Prototyping
WEEK – II	Low - Fidelity Prototyping and Paper Prototyping
WEEK – III	Wireframing and Tool based Prototyping
WEEK – IV	Physical Low- Fidelity Prototyping
WEEK – V	Tool based prototyping
WEEK – VI	Design Principles and Patterns- Graphic Design
WEEK – VII	Design Principles and Patterns- Interaction Design
WEEK –VIII	Commercial design guidelines and standards.
WEEK - IX	Universal design: Sensory and cognitive impairments
WEEK - X	Universal design: Tools, Limitations and standards
WEEK - XI	Introduction platforms and context : Mobile UI design, Wearable
WEEK - XII	Introduction platforms and context : Automotive user interface
WEEK - XIII	Introduction platforms and context : IoT and Physical Computing
WEEK - XIV	Assessment

FLUID DYNAMICS LABORATORY

<table>
<tr><td colspan="10">III Semester: AE</td></tr>
<tr><th>Course Code</th><th>Category</th><th colspan="3">Hours / Week</th><th>Credits</th><th colspan="3">Maximum Marks</th></tr>
<tr><td rowspan="2">AAEC04</td><td rowspan="2">Core</td><td>L</td><td>T</td><td>P</td><td>C</td><td>CIA</td><td>SEE</td><td>Total</td></tr>
<tr><td>0</td><td>0</td><td>2</td><td>1</td><td>30</td><td>70</td><td>100</td></tr>
<tr><td>Contact Classes: Nil</td><td>Tutorial Classes: Nil</td><td colspan="4">Practical Classes: 45</td><td colspan="3">Total Classes: 45</td></tr>
<tr><td colspan="10">Pre-Requisites: Basic principles of Physics</td></tr>
</table>

I. COURSE OVERVIEW:

The Fluid Dynamics laboratory is designed to explore the properties of fluids and conduct experiments involving both incompressible flow. This course aims to provide fundamental knowledge of basic measurements and devices utilized in fluid dynamic applications. It serves as an introductory course, introducing concepts related to flow behavior, fluid forces, and analytical tools. Additionally, the course covers various flow measurement devices, pumps, turbines commonly employed in fluid dynamic applications, and how to assess their performance characteristics. You will gain hands-on experience investigating the principles of fluid statics, as well as the kinematics and kinetics of fluid flow, along with the operation of turbo machinery.

II. COURSE OBJECTIVES:

The students will try to learn:

I. Gain knowledge on working of centrifugal pumps, positive displacement pumps, hydraulic turbines centrifugal blowers and steam turbines.
II. Compare performance of various machines at different operating points.
III. Knowledge of various flow meters and the concept of fluid mechanics.

III. COURSE OUTCOMES:

At the end of the course students should be able to:

CO 1	Infer the concept of calibrating orifice and venturi meter to minimize uncertainty in the discharge coefficient.
CO 2	Utilize the pipe friction test apparatus to measure the friction factor under a range of flow rates and flow regimes for calculating major loses in closed pipes.
CO 3	Demonstrate the validation of Bernoulli's theorem for incompressible, steady, continuous flow in order to regulate pipe flow across a cross-section and datum.
CO 4	Illustrate the critical Reynolds number using Reynolds apparatus for transition of laminar flow into turbulent flow.
CO 5	Make use of the jet impact apparatus to investigate the reaction forces generated due to changes in momentum.
CO 6	Distinguish the performance characteristics of turbo machinery to various operating conditions for calculating efficiency of turbines under specific applications.

EXERCISES FOR FLUID DYNAMICS LABORATORY

Note: Students are encouraged to bring their own laptops for laboratory practice session

1. Getting Started Exercises

1.1 Introduction to Fluid Dynamics Laboratory

1. Understand the working principle of venturimeter, and orifice meter used in the laboratory.
2. Become familiar with the operation and usage of fluid flow through pipes.
3. Learn to take readings of fluid level readings in manometer.

Try

1. Calculate the coefficient of discharge using venturimeter experimental setup
2. Calculate the efficiency of the centrifugal pump, using the experimental setup

2. Exercises on Calibration of Venturimeter

2.1 Venturimeter

Start the pump, operate the valves, measure the variations in manometer readings (h1 & h2), note down the time (t), and calculate the coefficient of discharge using the experimental setup, shown in Figure 1.

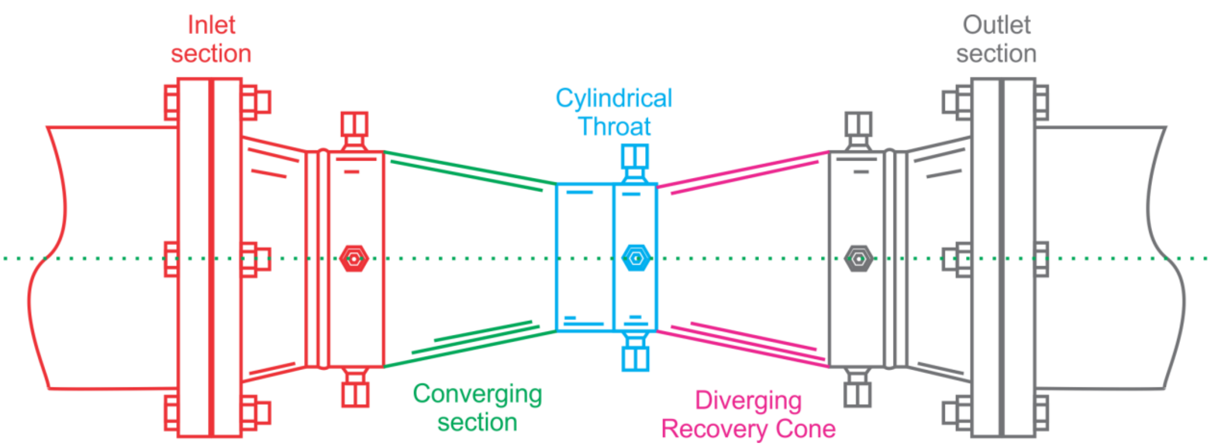


Figure 1. Venturimeter

Try

1. Change the rate of convergence and divergence of venturi and repeat the same experiment.
2. Open the valves half only and repeat the experiment and compare the results with full open condition.
3. Open the valves to 2/3 and repeat the experiment and compare the results with full open condition.

3. Exercises on Calibration of Orifice Meter

3.1 Orifice Meter

Start the pump, operate the valves, measure the variations in manometer readings (h1 &h2), note down the time (t), and calculate the coefficient of discharge the experimental setup, shown in Figures 1 & 2.

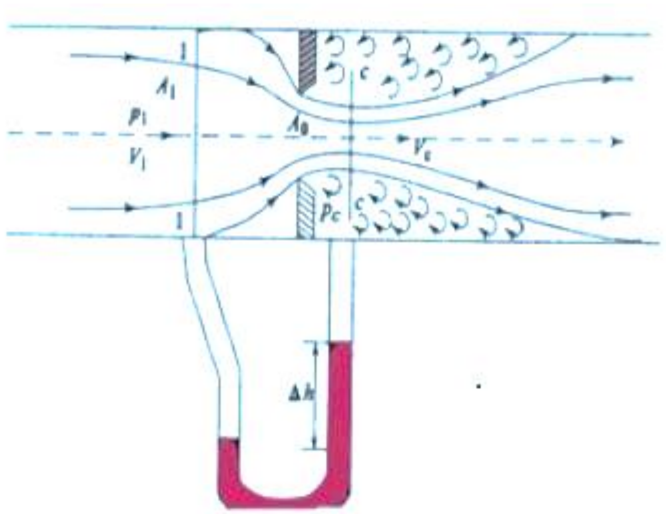


Figure 2. Orifice meter

Try

1. Change the height of wedge for orifice and find the discharge coefficient.
2. Open the valves half only and repeat the experiment and compare the results with full open condition.
3. Change the height of the wedge for orifice, and find the discharge coefficient.

4. Exercises on Pipe Flow Losses in Rectangular Pipe

4.1 Pipe Flow

Start the pump, operate the valves, measure the variations in manometer readings (h1 &h2), note down the time (t), and calculate the discharge, velocity and friction factor using the formula for given circular and rectangular pipes the experimental setup, shown in figure 3.

Try

1. Change the roughness of a pipe and find the friction loses for a square pipe with full valves open
2. Change the dimensions of a pipe, open the valves half only and repeat the experiment for a square pipe and compare the results with full open condition

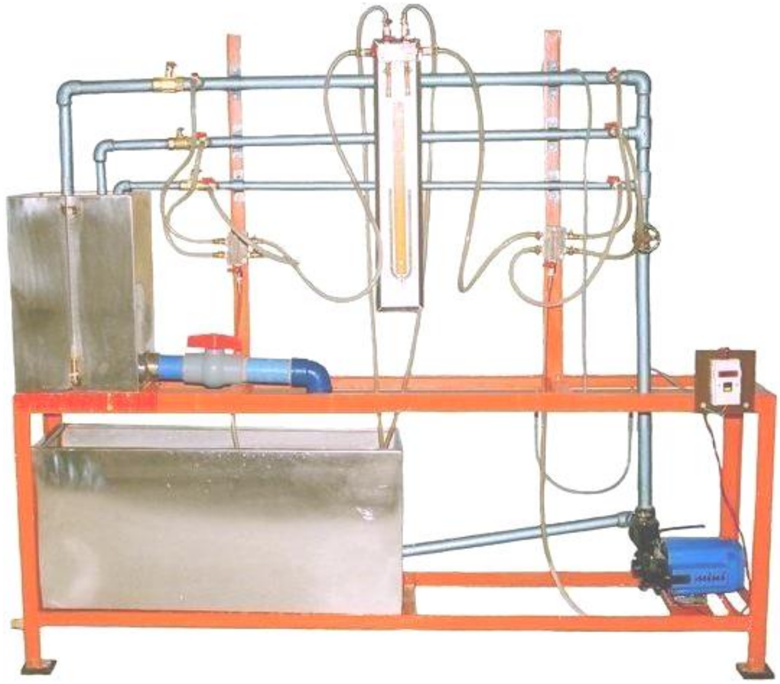


Figure 3. Flow through pipe experiment setup

5. Exercises on Pipe Flow Losses in Circular Pipe

5.1 Pipe Flow

Start the pump, operate the valves, measure the variations in manometer readings (h1 &h2), note down the time (t), and calculate the discharge, velocity and friction factor using the formula for given circular and rectangular pipes the experimental setup, shown in figure 3.

Try

1. Change the roughness of a pipe and find the friction loses for a circular pipe with full valves open.
2. Change the dimensions of a pipe, open the valves half only and repeat the experiment for a circular pipe and compare the results with full open condition.

6. Exercises on Verification of Bernoulli's theorem.

6.1 Bernoulli's theorem

Start the pump, adjust the flow, note down the piezometer readings and time (t), calculate the pressure head, velocity head, and datum head, and verify the Bernoulli's Theorem, using the experimental setup, shown in Figure 4.

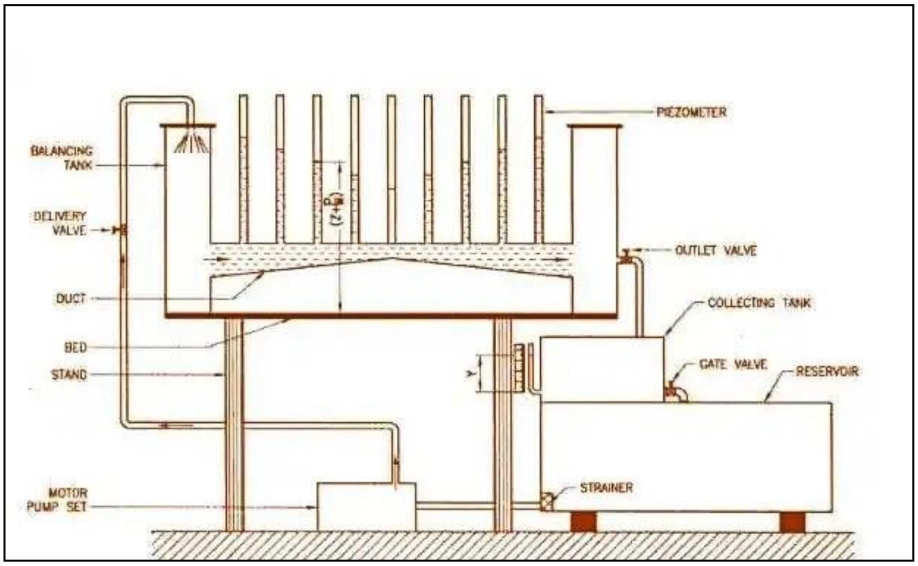


Figure 4: Bernoulli experiment setup

Try

1. Vary the mass flow rate and verify Bernoulli's theorem
2. Change the fluid type and verify Bernoulli's theorem

7. Exercises on Impact of Jets on Vanes

7.1 Jets on Vanes

1. Fix the given vane and add dead weight, note down the forces, note down the time, calculate the flow speed, discharge, and coefficient of impact vanes, shown in Figure 5.

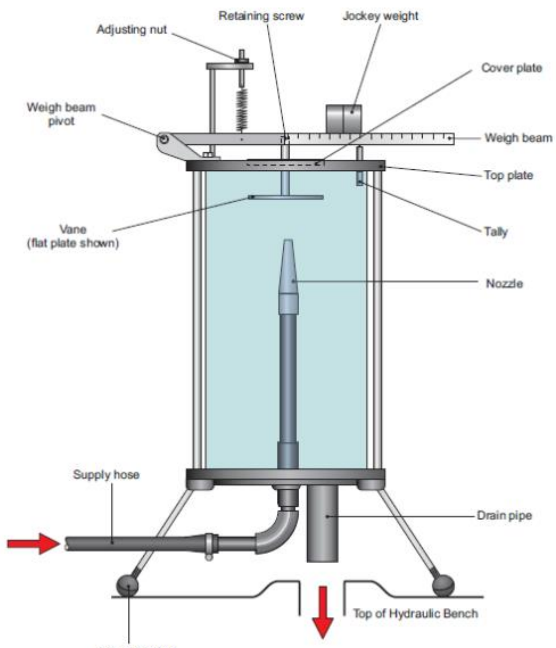


Figure 5: Jet on Vanes

Try

1. Change the vane angle to 45^0 and repeat the same experiment.
2. Change the vane angle to 60^0 and repeat the same experiment.
3. Change the orifice geometry and find the coefficient of impact vanes.

8. Exercises on Performance of Centrifugal Pumps

8.1 Centrifugal Pump

Start the pump, operate the valves, note down the readings for pressure head, time (t), calculate the actual discharge, input power, output power, and calculate the efficiency of the centrifugal pump, using the experimental setup, shown in Figure 6.

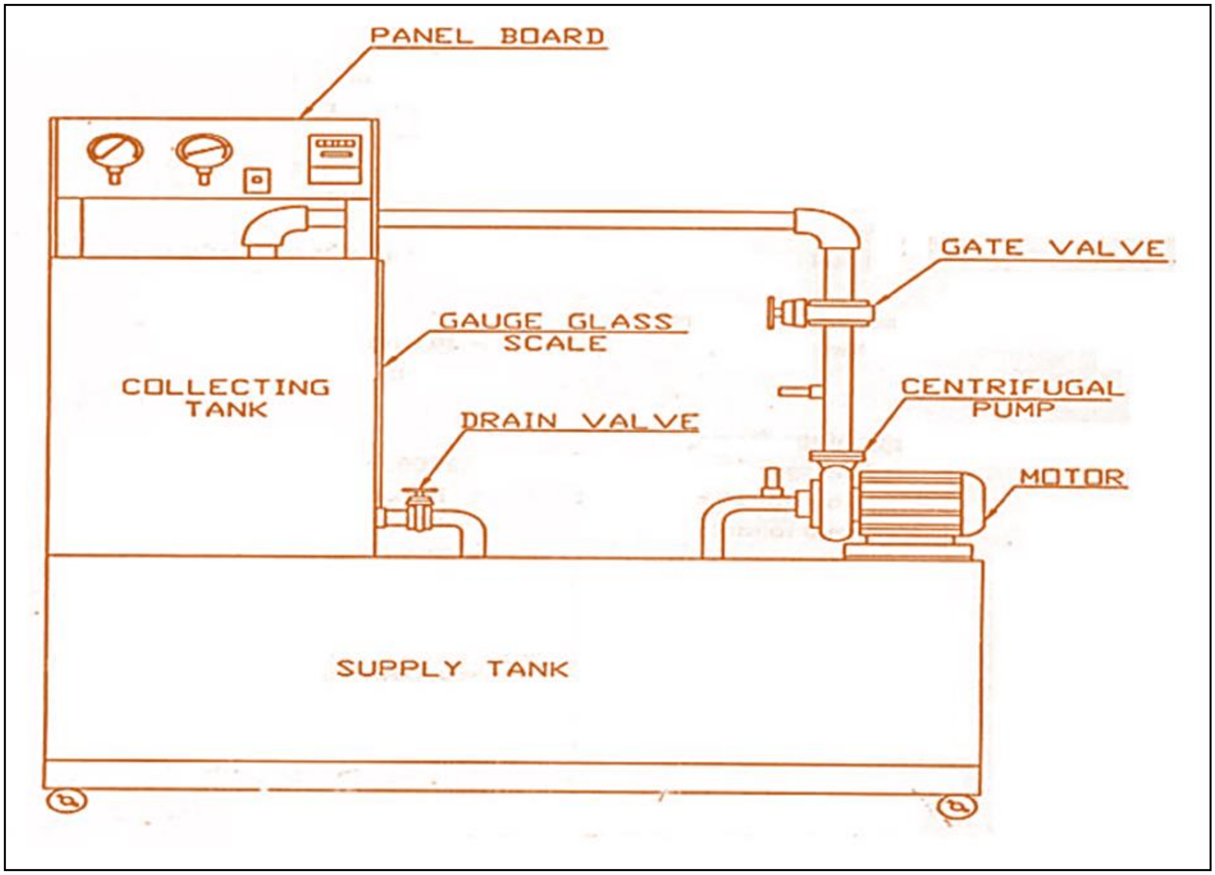


Figure 6: Centrifugal pump experiment setup

Try

1. Note down the time for 15 cm rise of water and calculate the efficiency of the centrifugal pump.
2. Note down the time for 30 cm rise of water and calculate the efficiency of the centrifugal pump.

9. Exercise on Performance of Reciprocating Pump

9.1 Reciprocating Pump

Start the pump, operate the valves, note down the readings for delivery valve, pressure head reading, time (t), calculate the actual discharge, input power, output power, and calculate the efficiency of the centrifugal pump, using the experimental setup, shown in Figure 7.

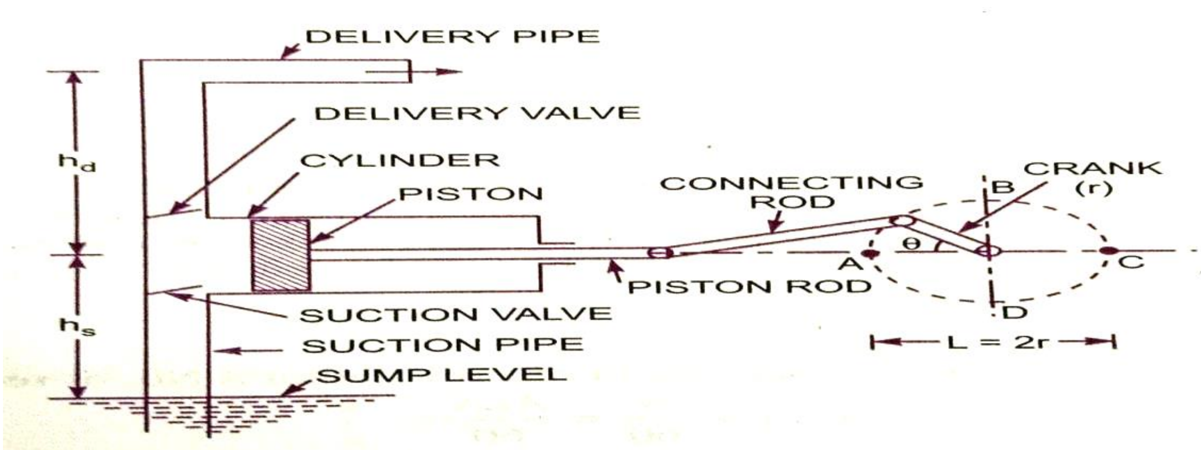


Figure 7: Reciprocating pump setup

Try

1. Note down the time for 15 cm rise of water and calculate the efficiency of the centrifugal pump
2. Note down the time for 30 cm rise of water and calculate the efficiency of the centrifugal pump

10. Exercise on Pelton Wheel Turbine

1. Start the pump, adjust the nozzle opening about half, note down the pressure gauge, vacuum gauge readings, speed of the turbine, manometer readings (h1 & h2), and calculate output power, input power, and efficiency of the Pelton wheel turbine, using the experimental setup, shown in Figure 8.

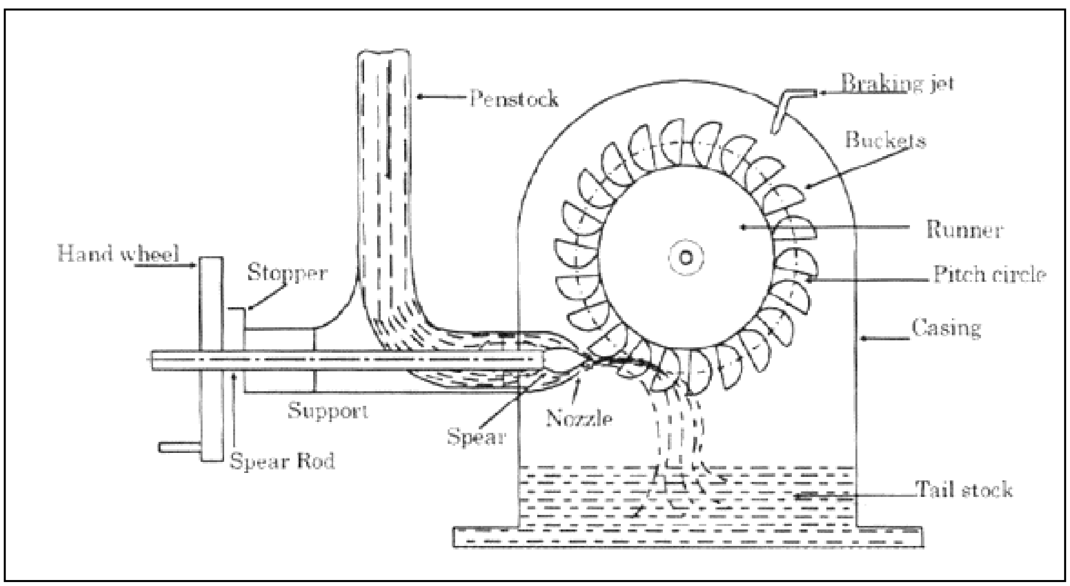


Figure 8: Schematic diagram of a Pelton turbine

Try

1. Adjust the nozzle opening for full, and calculate the efficiency of the Pelton wheel turbine
2. Note down the time for 30 cm rise of water and calculate the efficiency of the centrifugal pump
3. Performance characteristics of Pelton wheel turbine for change in the bucket design
4. Performance characteristics of Pelton wheel turbine for change in datum head

11. Exercise on Francis Turbine

Start the pump, adjust the nozzle opening about half, note down the pressure gauge, vacuum gauge readings, speed of the turbine, manometer readings (h1 & h2), and calculate output power, input power, and efficiency of the Francis Turbine, using the experimental setup, shown in Figure 9.

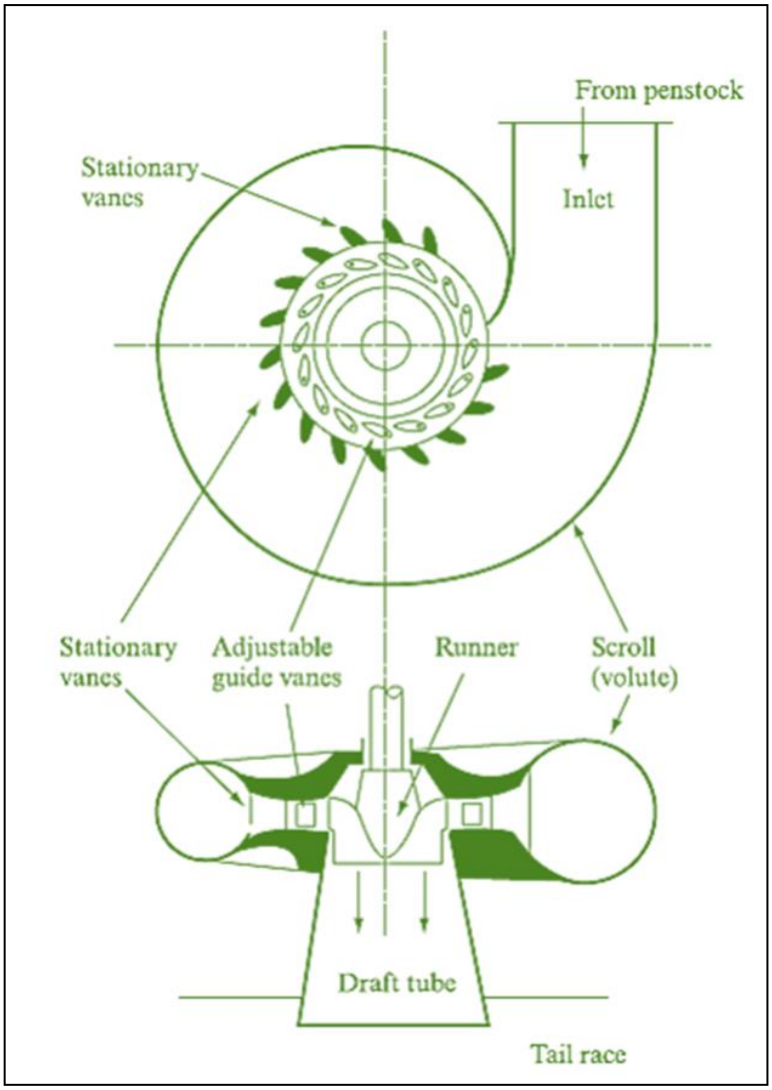


Figure 9: Schematic diagram of a Francis turbine

Try

1. Adjust the nozzle opening for 2/3, and calculate the efficiency of the Pelton wheel turbine
2. Adjust the nozzle opening for full, and calculate the efficiency of the Pelton wheel turbine
3. Performance characteristics of Francis wheel turbine for change in the vane angle
4. Performance characteristics of Francis wheel turbine for change in datum head

12. Exercise on Flow through Notch-I

Fix the plate with V notch in the hydraulic bench, start the pump, note down h1, h2 readings in the notch, calculate actual, theoretical discharge, and find the coefficient of discharge, using the experimental setup, shown in Figure 10.

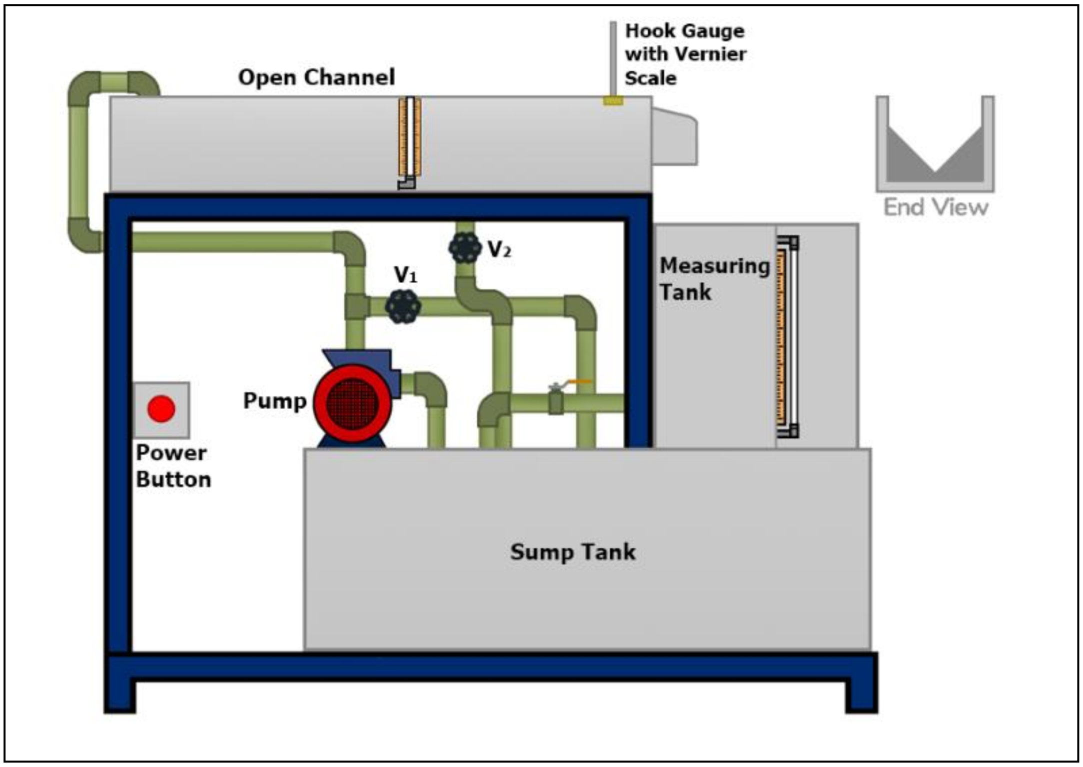


Figure 10: Schematic diagram of a flow through notches experiment.

Try

1. Use trapezoidal weir and find the coefficient of discharge
2. Use sharp-crested weir and find the coefficient of discharge

13. Exercise on Flow through Notch-II

Fix the plate with rectangular notch (figure 11) in the hydraulic bench, start the pump, note down h1, h2 readings in the notch, calculate actual, theoretical discharge, and find the coefficient of discharge, using the experimental setup, shown in Figure 10 &11.

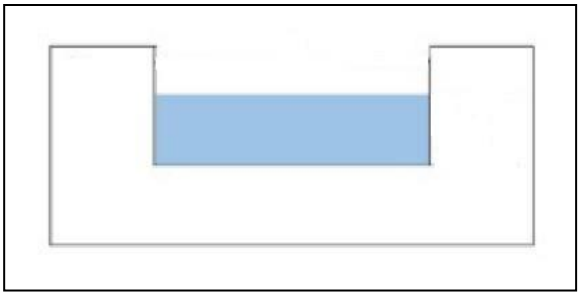


Figure 11: Schematic diagram of a flow through rectangular notch

Try

1. Use Ogee-shaped weir and find the coefficient of discharge
2. Use Broad crested weir and find the coefficient of discharge

14. Exercise on Flow though Orifice Mouth Piece

Fill the sump tank with water, place the given mouth piece, operate the valve, measure the discharge, note down the time (t), and find out the coefficient of discharge

Try

1. Change the height of mouth piece and find the discharge coefficient
2. Change the shape of mouth piece and find the discharge coefficient

V. TEXT BOOKS:

1. Frank M. White, "Fluid Mechanics ", McGraw Hill Education Private Ltd, 9th edition, 2022.
2. R. K Bansal, "Fluid Mechanics and Hydraulic Machines", Laxmi Publications Ltd, Revised 9th edition, 2019.

VI. REFERENCE BOOKS:

1. Rathakrishnan. E, "Fluid Mechanics, an introduction", PHI Learning Pvt. Ltd, 2022.

VII. ELECTRONICS RESOURCES:

1. https://archive.nptel.ac.in/courses/112/105/112105171/
2. https://akanksha.iare.ac.in/index?route=course/details&course_id=522

VIII. MATERIALS ONLINE

1. Course template
2. Lab manual

MECHANICS OF SOLIDS LABORATORY

<table>
<tr><td colspan="10">III SEMESTER: AE</td></tr>
<tr><td>Course Code</td><td>Category</td><td colspan="3">Hours / Week</td><td>Credits</td><td colspan="3">Maximum Marks</td></tr>
<tr><td rowspan="2">AAEC05</td><td rowspan="2">Core</td><td>L</td><td>T</td><td>P</td><td>C</td><td>CIA</td><td>SEE</td><td>Total</td></tr>
<tr><td>0</td><td>0</td><td>3</td><td>1.5</td><td>30</td><td>70</td><td>100</td></tr>
<tr><td>Contact Classes: Nil</td><td>Tutorial Classes: Nil</td><td colspan="4">Practical Classes: 45</td><td colspan="3">Total Classes: 45</td></tr>
<tr><td colspan="9">Prerequisite: There are no prerequisites to take this course.</td></tr>
</table>

I. COURSEOVERVIEW:

The objective of the Mechanics of Solids lab is to demonstrate the basic principles in the area of strength and mechanics of materials and structural analysis to the undergraduate students through a series of experiments. In this lab the experiments are performed to measure the properties of the materials such as impact strength, tensile strength, compressive strength, hardness, ductility etc.

This lab also used in project works for testing of various materials like composite materials, ferrous and nonferrous alloys, etc. It also useful to identify suitable materials for aero structures based on mechanical properties and its characterization.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The mechanics of materials and structural analysis through a series of experiments using appropriate codes and standards.
II. The behaviour and failure modes of the materials under different mechanical loading conditions
III. The writing process and evaluation of the experimental results materials based on characterization.

III. COURSE OUTCOMES

CO1	Compare the hardness of ferrous and nonferrous materials using Rockwell and Brinell's hardness testing machines.
CO2	Choose the regions of elasticity and plasticity, stress-strain relationships using universal testing machine for determining the safety factor.
CO3	Summarize performance of a material or product using torsion tests, when undergoes rotational motion when in service
CO4	Identify the quality performance of springs or structural elements for specified requirements such as energy storage and energy conversion.
CO5	Demonstrate toughness and capacity to resist the energy of a product subjected to shock loading by adopting Charpy and Izod test
CO6	Make use of shear force and bending moment distribution along the length of beams under various loads for design of structural members

Do's

1) For safety purpose the students should compulsorily wear shoes.
2) Enter laboratory with appropriate laboratory uniform and shoes.
   i. For boys, half sleeve shirts, tucked in trousers
   ii. For ladies, half sleeve overcoat, hair put inside the overcoat
3) Don't use mobile phones during laboratory hours

4) Bring the laboratory manual, observation and record without fail.
5) Keep all your belongings in the book rack or at the place suggested by lab instructor
6) Be punctual to the classes.
7) To come prepared with procedure relevant to the experiment.

Don’t

1) Don’t operate any machine without permission of the lab uncharged
2) Don’t unplug any machine from power supply.
3) Don’t remove any parts of the machine.

IV. COURE CONTENT:

EXERCISES ON MECHANICS OF SOLIDS LABORATORY

1. Getting Started Exercises

1.1 Introduction to Laboratory

The solid Mechanics of Solids (MoS) Laboratory is well equipped with destructive testing machineries. Students will be able to understand the basic concepts of Mechanics of Solids and enable to apply them to practical problems in this laboratory. Different types of tests are conducted in this laboratory as per standards (ASTM and IS) for the estimation of mechanical properties of various materials such as Young's Modulus, Shear Modulus, Hardness, Toughness, Stiffness, etc. Many students of Final year are utilizing this laboratory for testing of various materials like composite materials, ferrous and nonferrous alloys for the design of components of aircraft and machine elements.

- To familiarize students with lab equipments
- Inform the students on lab evaluation process
- Inform the students about laboratory precautions
- To familiarize students sample preparations
- Learning outcomes of the lab

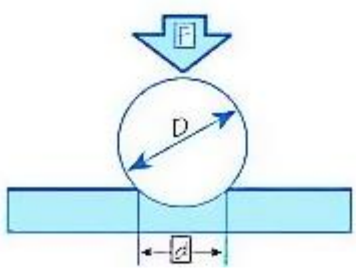
2. Brinell Hardness test

2.1. Introduction

Hardness is defined as a material's ability to resist permanent indentation (that is plastic deformation). Typically, the harder the material, the better it resists wear or deformation. The term hardness, thus, also refers to local surface stiffness of a material or its resistance to scratching, abrasion, or cutting.

2.2. Objectives

1. To determine the hardness number from Brinell hardness test.
2. To measure the ultimate tensile strength of the specimen from the Brinell hardness test.
3. The specimen prepared as per the given dimensions in fig.2.1

 fig.2.1: Brinell hardness test	Where D = Ball diameter d = impression diameter F = load HB = Brinell result

2.3 Further Probing Experiments

1. Measure the hardness values for different conventional materials.
2. Compare the hardness values same material with different loads and comment on the results.

3. Rockwell Hardness test

3.1. Introduction

Hardness is defined as a material's ability to resist permanent indentation (that is plastic deformation). Typically, the harder the material, the better it resists wear or deformation. The term hardness, thus, also refers to local surface stiffness of a material or its resistance to scratching, abrasion, or cutting.

3.2. Procedure

1. To determine the Brinell hardness number from the Rockwell hardness test
2. To find the ultimate tensile strength of the metal specimens from the Brinell hardness number by using empirical relationships as shown in fig.3.1

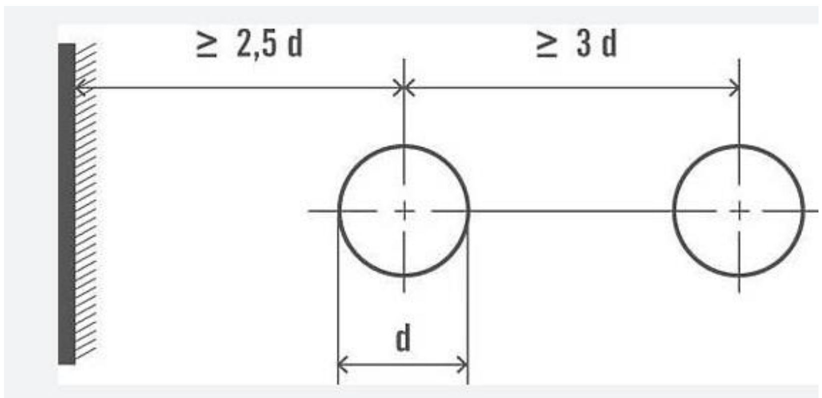


fig.3.1: Rockwell Hardness test specimen as per ISO 6508

3.3 Further Probing Experiments

1. Measure the hardness values for different materials which needs unusual scales.
2. Compare the hardness values same material with different loads and comment on the results.

4. Tension test of Mild Steel

4.1. Introduction

The objective of this experiment is to evaluate the mechanical (tensile) properties of selected metallic materials using the tensile test method. These mechanical properties include modulus of elasticity, yield strength, ultimate tensile strength, failure strength, ductility, and strain to failure.

4.2. Procedure

1. Measure the original length and diameter of the specimen. The length may either be length of gauge section which is marked on the specimen with a preset punch or the total length of the specimen.
2. Insert the specimen into grips of the test machine and attach strain-measuring device to it.
3. Begin the load application and record load versus elongation data.
4. Take readings more frequently as yield point is approached.
5. Measure elongation values with the help of dividers and a ruler.
6. Continue the test till Fracture occurs.
7. By joining the two broken halves of the specimen together, measure the final length and diameter of specimen as shown in fig.4.1.

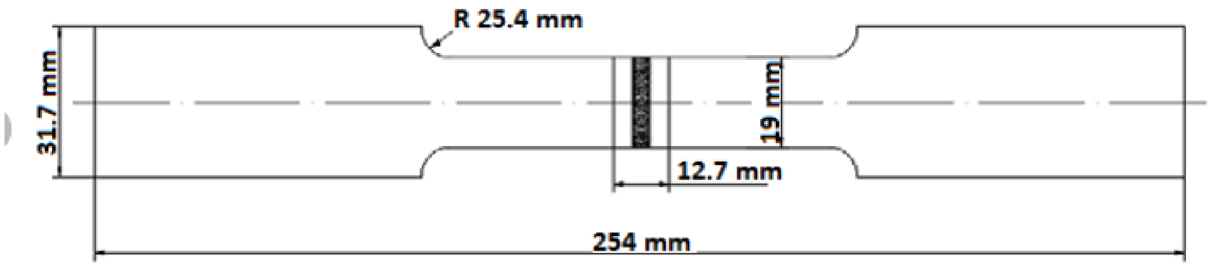


fig.4.1: Tension test specimen preparation

4.3. Further Probing Experiments

1. Calculate the Young's Modulus for ductile materials.
2. Generate stress Vs strain diagram for different materials using servo driven Universal Testing Machine.

5. Torsion test of Mild Steel

5.1. Introduction

The stress resulting from torsion load can be determined by means of the torsion test. This test resembles the tension test in that a load deflection curve is also development (which is transformed to a shear-strain curve).In a torsion test, a solid or hollow cylindrical specimen is twisted and the resultant deformation, measured as the angle through which the bar is twisted. The test then consists of measuring the angle of twist, Φ(rad) at selected increments of torque, T (N.m). Expressing Φ as the angular deflection curve per unit gage length.

5.2. Procedure

1. Measure the original length and diameter of the specimen. The length may either be length of gauge section which is marked on the specimen with a preset punch or the total length of the specimen.
2. Insert the specimen into grips of the test machine and attach strain-measuring device to it.
3. Begin the load application and record load versus elongation data.
4. Take readings more frequently as yield point is approached.
5. Measure elongation values with the help of dividers and a ruler.
6. Continue the test till Fracture occurs.
7. By joining the two broken halves of the specimen together, measure the final length and diameter of specimen as shown in fig.7.1. (All dimensions are in mm).

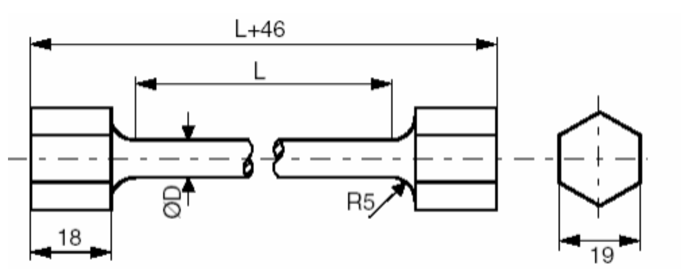


fig.5.1: Torsion test specimen dimensions

5.3. Precautions

1. Wear tight overalls and shoe for safety.
2. If the strain measuring device is an extensometer it should be removed before necking begins.
3. Measure deflection on scale accurately and carefully.

5.4. Further Probing Experiments

1. Calculate the Young's Modulus for various ductile materials.
2. Generate stress Vs strain diagram for different materials using servo driven Universal Testing Machine.

6. Izod impact test

6.1. Introduction

Impact test determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's toughness and acts as a tool to study temperature-dependent brittle-ductile transition.

6.2. Procedure

1. With the striking hammer (pendulum) in safe test position, firmly hold the steel specimen in impact testing machines vice in such a way that the notch faces the hammer and is half inside and half above the top surface of the vice.
2. Bring the striking hammer to its top most striking position unless it is already there, and lock it at that position.
3. Bring indicator of the machine to zero, or follow the instructions of the operating manual supplied with the machine.
4. Release the hammer. It will fall due to gravity and break the specimen through its momentum, the total energy is not absorbed by the specimen. Then it continues to swing.
5. At its topmost height after breaking the specimen, the indicator stops moving, while the pendulum falls back. Note the indicator at that topmost final position as shown in fig.6.1

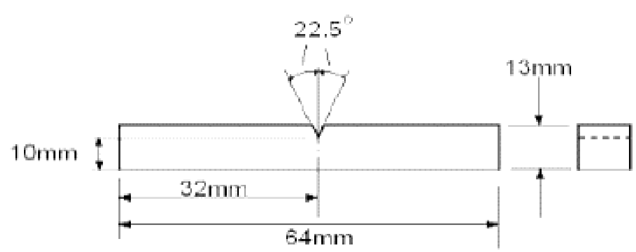


fig.6.1: Izod impact test specimen dimensions

6.3 Further Probing Experiments

1. Calculate the impact strength of unnotched specimens.
2. Determine the impact strength of U-Notched specimens.

7. Charpy impact test

7.1. Introduction

Impact test determines the amount of energy absorbed by a material during fracture. This absorbed energy is a measure of a given material's toughness and acts as a tool to study temperature-dependent brittle-ductile transition.

7.2. Procedure

1. With the striking hammer (pendulum) in safe test position, firmly hold the steel specimen in impact testing machines vice in such a way that the notch faces the hammer and is half inside and half above the top surface of the vice.
2. Bring the striking hammer to its top most striking position unless it is already there, and lock it at that position.
3. Bring indicator of the machine to zero, or follow the instructions of the operating manual supplied with the machine as shown in figure below.

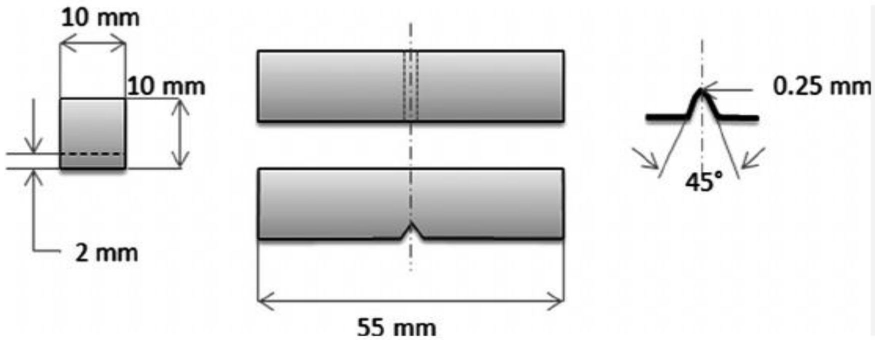


fig.7.1: Charpy Impact Test Specimen Dimensions

7.3 Further Probing Experiments

1. Calculate the impact strength of a unnotched specimens.
2. Determine the impact strength of a U-Notched specimens.

8 Compression test for short columns

8.1 Introduction

Compression tests on short columns are used to determine a material's behaviour under applied crushing loads, and are typically conducted by applying compressive pressure using a universal testing machine. By using this experiment the load corresponding to the crushing stress, is called crushing load will be determined for the short columns.

During the test, various properties of the material are calculated and plotted as a stress-strain diagram which is used to determine qualities such as elastic limit, proportional limit, yield point, yield strength and, for some materials, compressive strength.

8.2 Objectives

Compressive strength of the long columns.

8.3 Further Probing Experiments

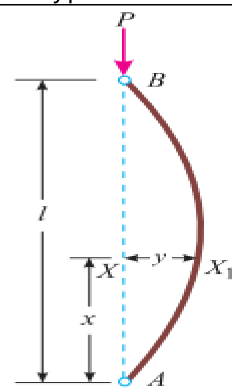
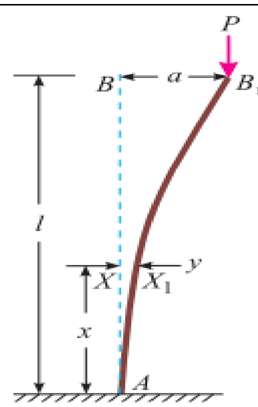
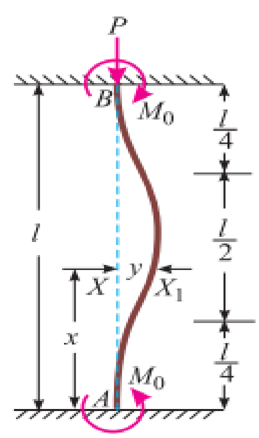
1. Calculate the compressive strength of a non ferrous metal cube.
2. Determine the compressive strength of a metallic columns

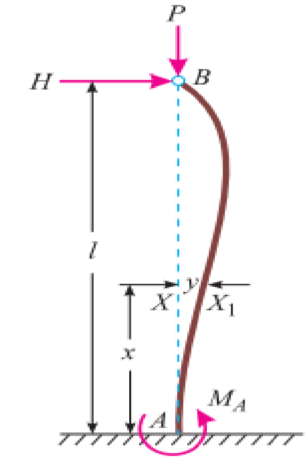
9 Compression test for long columns

9.1 Introduction

Compression tests on long columns are used to determine a material's behaviour under applied buckling loads, and are typically conducted by applying compressive pressure using a universal testing machine. The column will fail due to buckling before the yield strength of the member is reached. Buckling occurs suddenly, and is characterized by large deflections perpendicular to the axis of the column. The stability of long columns also effects end conditions, which are 1. Both ends hinged, 2. Both ends fixed, 3. One end is fixed and the other hinged, and 4. One end is fixed and the other free.

During the test, various properties of the material are calculated and plotted as a stress-strain diagram which is used to determine qualities such as elastic limit, proportional limit, yield point, yield strength and, for some materials, compressive strength.

S,No	Columns	Types of end conditions,
1	Columns with Both Ends Hinged	
2	Columns with One End Fixed and the Other Free	
3	Columns with Both Ends Fixed	

4	Columns with One End Fixed and the Other Hinged	

9.2 Objectives

1. Buckling strength of the long columns.
2. Compressive strength of the long columns.

9.3 Further Probing Experiments

1. Calculate the compressive strength of a non ferrous metal cube.
2. Determine the compressive strength of a metallic columns

10 Spring test

10.1 Introduction

Spring test is used to determine the stiffness of helical spring. Stiffness is the ability of a material withstand load per unit deflection. The modulus of rigidity of a spring material varies as a function of chemical composition, cold working, and degree of aging,

10.2 Procedure

1. Measure the diameter of the wire of the spring by using the micrometre.
2. Measure the diameter of spring coils by using the Vernier calliper
3. Count the number of turns.
4. Insert the spring in the spring testing machine and load the spring by a suitable weight and note the corresponding axial deflection in tension or compression.
5. Increase the load and take the corresponding axial deflection readings.
6. Plot a curve between load and deflection. The shape of the curve gives the stiffness of the spring.

10.3 Further Probing Experiments

1. Measure the hardness values for different materials which needs unusual scales.
2. Compare the hardness values same material with different loads and comment on the results.

11 Deflection test for simple supported beam

11.1 Introduction

In Designing of beams two design criteria ate important, one Strength which is resist to shear force and bending moment, and other is the stiffness, which is resistance to deflection under different types of loads. There are many methods to find out the slope and deflection at a section in a loaded beam, but 1. Double integration method and 2. Macaulay's methods are the important.

11.2 Procedure

In this experiment Macaulay's method shown in fig. 11.2, and using out the slopes and deflection of beams with the following rules

a. Always take origin on the extreme left of the beam.
b. Take left clockwise moment as negative and left anticlockwise moment as positive.
c. While calculating the slopes and deflections, it is convenient to use the values first in terms of kN and metres.

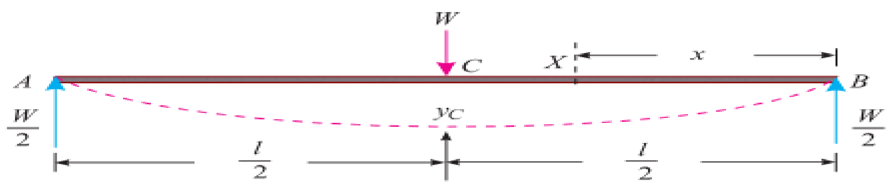


fig.11.2: Deflection of simple supported beam

11.3 Further Probing Experiments

1. Measure the slope and deflection values for simple supported beam with different loads.
2. Repeat the experiment, by changing the point of applications of loads.

12 Deflection test for cantilever beam

12.1 Introduction

In Designing of beams two design criteria ate important, one Strength which is resist to shear force and bending moment, and other is the stiffness, which is resistance to deflection under different types of loads. There are many methods to find out the slope and deflection at a section in a loaded beam, but 1. Double integration method and 2. Macaulay's methods are the important.

12.2 Procedure

In this experiment Macaulay's method shown in fig. 12.2, using out the slopes and deflection of beams with the following rules

Always take origin on the extreme left of the beam.
Take left clockwise moment as negative and left anticlockwise moment as positive.
While calculating the slopes and deflections, it is convenient to use the values first in terms of kN and metres.

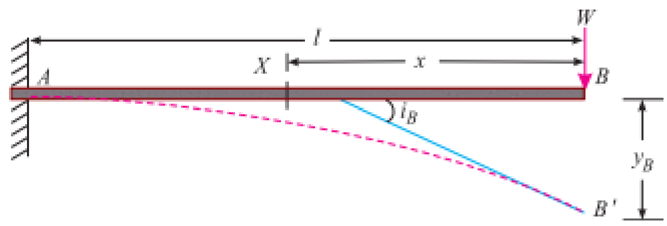


fig.12.2: Charpy Impact Test Specimen Dimensions

Further Probing Experiments

1. Measure the slope and deflection values for cantilever beam with different loads.
2. Repeat the same experiment, by changing the point of applications of loads.

13. Microstructure of Steels

Metallic materials, when considered in a broad sense, may be divided into two large groups, ferrous and nonferrous. The ferrous materials are iron-based, and the nonferrous materials have some element other than iron as the principal constituent. The bulk of the nonferrous materials is made up of the alloys of copper, aluminium, magnesium, nickel, tin, lead, and zinc. The temperature at which the allotropic changes take place in iron is influenced by alloying elements, the most important of which is carbon. This is the part between pure iron and an interstitial compound, iron carbide, Fe,C, containing 6.67 percent carbon by weight.

13.1 Study of microstructure of steels

- Introduction
- Procedure
- Observations
- Further probing experiments

13.2 Observations

The microstructure of low carbon steels as shown in fig. 13.2

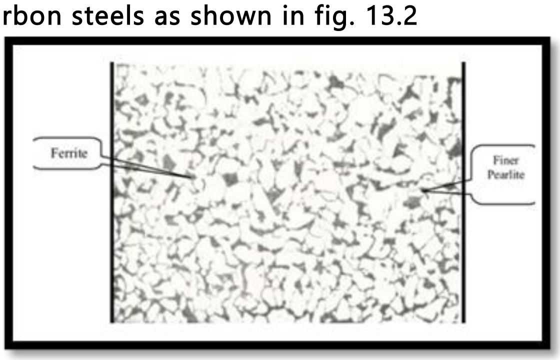


fig. 13.2: Microstructure of low carbon steels

The microstructure of medium carbon steels as shown in fig. 13.3

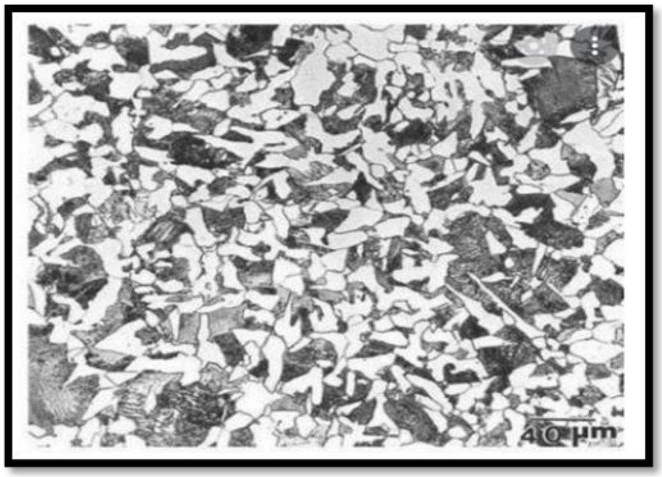


fig. 13.3: Microstructure of medium carbon steels

13.3 Precautions

- Wear tight overalls and shoe for safety.
- Be aware about mounting press and the time of etching process.
- Don't touch the specimen when it is so hot and use tongs for hold it.
- Be away at the time of belt polishing and disc polishing.

The microstructure of medium carbon steels as shown in fig. 13.3

13.4 Further Probing Experiments

1. Change the values of magnification lens and obtain the microstructures.
2. Obtain the microstructures of LCS, MCS and HCS using trinocular.

14 Microstructure of Cast Iron

14.1 Introduction

Cast irons are a class of ferrous alloys with carbon contents above 2.14 % by weightage; in practice, however, most cast irons contain between 3.0 and 4.5 % of Carbon and, in addition, other alloying elements. A re-examination of the iron–iron carbide phase diagram reveals that alloys within this composition range become completely liquid at temperatures between approximately 1150 and

13000C (2100 and 2350F), which is considerably lower than for steels. Thus, they are easily melted and amenable to casting. Furthermore, some cast irons are very brittle, and casting is the most convenient fabrication technique.

14.2 Procedure

1. Cut the specimen into required shape by using cutoff machine.
2. Mount the specimen in mounting press by adding 2 spoons of Bakelite powder.
3. Polish the specimen on belt polisher to make the surface even.
4. Then polish the specimen again by using sand and emery papers.
5. After polishing the specimen is again polish on the belt polisher by adding 2-3 drops of water.
6. Observe the micro-structure of specimen under microscope and note it down.
7. Apply approximate etchant to the specimen.
8. Observe the micro scope structure and note it down.

14.3 Observation

The microstructure of medium Grey Cast Iron as shown in fig.14.3

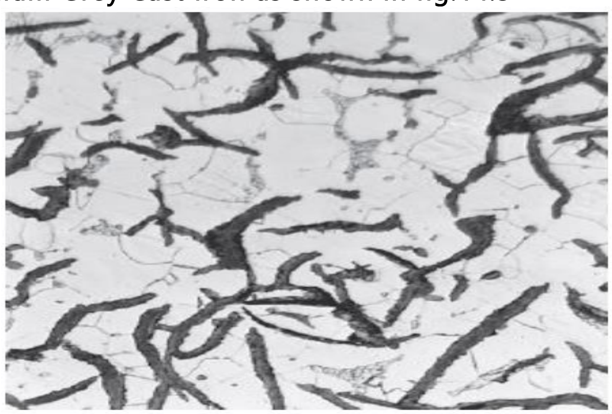


fig. 14.3: Microstructure of Grey Cast Iron

14.4 Further Probing Experiments

1. Change the values of magnification lens and obtain the microstructures.
2. Obtain the microstructures of different cast irons using trinocular.

V. TEXT BOOKS:

1. Engineering Mechanics of Solids by Popov, Egor P, 2nd edition 2013.
2. James M. Gere, Stephen Timoshenko, “Mechanics of materials". 2nd edition 2016.

VI. WEB REFERENCES:

1. https://www.labtesting.com/about/capabilities/metal-and-material-analysis/metallurgical-analysis/

VII. Electronics References

1. https://onlinecourses.nptel.ac.in/noc23_me140/preview
2. https://archive.nptel.ac.in/courses/105/105/105105108/
3. https://nptel.ac.in/courses/112107146

VIII. Materials Online

1. Course template
2. Lab manual

DATA STRUCTURES LABORATORY

III Semester: Common for all branches								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
ACSC10	Core	L	T	P	C	CIA	SEE	Total
		0	0	3	1.5	30	70	100
Contact Classes: Nil	Tutorial Classes: Nil	Practical Classes: 45				Total Classes: 45		
Prerequisite: Programming for Problem Solving using C and Python Programming								

I. COURSE OVERVIEW:

The course covers some of the general-purpose data structures and algorithms, and software development. Topics covered include managing complexity, analysis, static data structures, dynamic data structures and hashing mechanisms. The main objective of the course is to teach the students how to select and design data structures and algorithms that are appropriate for problems that they might encounter in real life. This course reaches to student by power point presentations, lecture notes, and lab which involve the problem solving in mathematical and engineering areas.

II. COURSES OBJECTIVES:

The students will try to learn

I. The skills needed to understand and analyze performance trade-offs of different algorithms / implementations and asymptotic analysis of their running time and memory usage.

II. The basic abstract data types (ADT) and associated algorithms: stacks, queues, lists, tree, graphs, hashing and sorting, selection and searching.

III. The fundamentals of how to store, retrieve, and process data efficiently.

III. COURSE OUTCOMES:

At the end of the course students should be able to:

CO 1	Interpret the complexity of algorithm using the asymptotic notations.
CO 2	Select appropriate searching and sorting technique for a given problem.
CO 3	Construct programs on performing operations on linear and nonlinear data structures for organization of a data
CO 4	Make use of linear data structures and nonlinear data structures solving real time applications.
CO 5	Describe hashing techniques and collision resolution methods for efficiently accessing data with respect to performance.
CO 6	Compare various types of data structures; in terms of implementation, operations and performance.

IV. COURSE CONTENT:

EXERCISES FOR DATA STRUCTURES LABORATORY

Note: Students are encouraged to bring their own laptops for laboratory practice sessions.

1. Getting Started Exercises

1.1 Implicit Recursion

A specific type of recursion called **implicit recursion** occurs when a function calls itself without making an explicit recursive call. This can occur when a function calls another function, which then calls the original code once again and starts a recursive execution of the original function.

Using implicit recursion find the second-largest elements from the array.

In this case, the **find_second_largest** method calls the **find_largest()** function via implicit recursion to locate the second-largest number in a provided list of numbers. Implicit recursion can be used in this way to get the second-largest integer without having to write any more code

Input: nums = [1, 2, 3, 4, 5]

Output: 4

```
def find_largest(numbers):
     # Write code here
     …

def find_second_largest(numbers):
    # Write code here
     …

# Driver code
numbers = [1, 2, 3, 4, 5]

# Function call
second_largest = find_second_largest(numbers)
print(second_largest)
```

1.2 Towers of Hanoi

Tower of Hanoi is a mathematical puzzle where we have three rods (A, B, and C) and N disks. Initially, all the disks are stacked in decreasing value of diameter i.e., the smallest disk is placed on the top and they are on rod A. The objective of the puzzle is to move the entire stack to another rod (here considered C), obeying the following simple rules:

- Only one disk can be moved at a time.
- Each move consists of taking the upper disk from one of the stacks and placing it on top of another stack i.e. a disk can only be moved if it is the uppermost disk on a stack.
- No disk may be placed on top of a smaller disk.

Input: 2

Output: Disk 1 moved from A to B

Disk 2 moved from A to C
Disk 1 moved from B to C

Input: 3

Output: Disk 1 moved from A to C

Disk 2 moved from A to B
Disk 1 moved from C to B

Disk 3 moved from A to C

Disk 1 moved from B to A

Disk 2 moved from B to C

Disk 1 moved from A to C

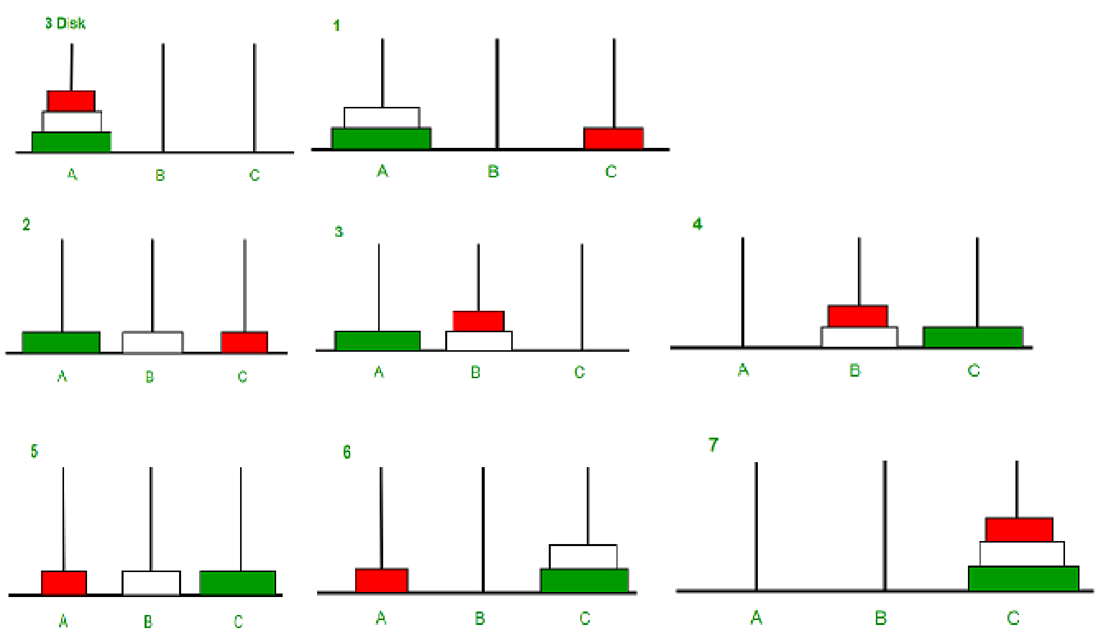
Tower of Hanoi using Recursion:

The idea is to use the helper node to reach the destination using recursion. Below is the pattern for this problem:

- Shift 'N-1' disks from 'A' to 'B', using C.
- Shift last disk from 'A' to 'C'.
- Shift 'N-1' disks from 'B' to 'C', using A.

Follow the steps below to solve the problem:

- Create a function towerOfHanoi where pass the N (current number of disk), from_rod, to_rod, aux_rod.
- Make a function call for N – 1 th disk.
- Then print the current the disk along with from_rod and to_rod
- Again make a function call for N – 1 th disk.




```
# Recursive Python function to solve Tower of Hanoi
def TowerOfHanoi(n, from_rod, to_rod, aux_rod):
    if n == 0:
        return
    # Write code here
```

```
    …

# Driver code
N = 3

# A, C, B are the name of rods
TowerOfHanoi(N, 'A', 'C', 'B')
```

1.3 Recursively Remove all Adjacent Duplicates

Given a string, recursively remove adjacent duplicate characters from the string. The output string should not have any adjacent duplicates.

Input: s = “azxxzy”

Output: “ay”

Explanation:

- First “azxxzy” is reduced to “azzy”.
- The string “azzy” contains duplicates
- So it is further reduced to “ay”

Input: “caaabbbaacdddd”

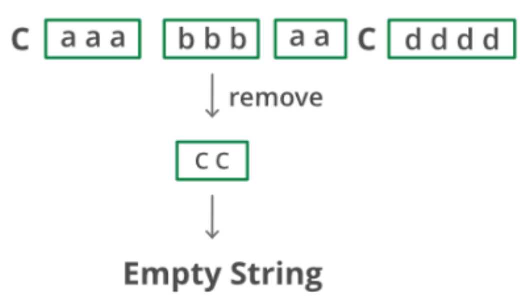
Output: Empty String

Input: “acaaabbbacdddd”

Output: “acac”

Procedure to remove duplicates:

- Start from the leftmost character and remove duplicates at left corner if there are any.
- The first character must be different from its adjacent now. Recur for string of length n-1 (string without first character).
- Let the string obtained after reducing right substring of length n-1 be rem_str. There are three possible cases
    - If first character of rem_str matches with the first character of original string, remove the first character from rem_str.
    - If remaining string becomes empty and last removed character is same as first character of original string. Return empty string.
    - Else, append the first character of the original string at the beginning of rem_str.
- Return rem_str.



```
# Program to remove all adjacent duplicates from a string

# Recursively removes adjacent duplicates from str and returns
# new string. last_removed is a pointer to last_removed character

def removeUtil(string, last_removed):

      # Write code here
        …
def remove(string):
    # Write code here
    …
# Utility functions
def toList(string):
    x = []
    for i in string:
        x.append(i)
    return x

def toString(x):
    return ''.join(x)

# Driver program
string1 = "azxxxzy"
print remove(string1)

string2 = "caaabbbaac"
print remove(string2)

string3 = "gghhg"
print remove(string3)

string4 = "aaaacddddcappp"
print remove(string4)

string5 = "aaaaaaaaaa"
print remove(string5)
```

1.4 Product of Two Numbers using Recursion

Given two numbers x and y find the product using recursion.

Input: x = 5, y = 2

Output: 10

Input: x = 100, y = 5

Output: 500

Procedure

1. If x is less than y, swap the two variables value
2. Recursively find y times the sum of x
3. If any of them become zero, return 0

```
# Find Product of two Numbers using Recursion

# recursive function to calculate multiplication of two numbers
def product( x , y ):
    # Write code here
    …
# Driver code
x = 5
y = 2
print( product(x, y))
```

1.5 Binary to Gray Code using Recursion

Given the Binary code of a number as a decimal number, we need to convert this into its equivalent Gray Code. Assume that the binary number is in the range of integers. For the larger value, we can take a binary number as string.

In gray code, only one bit is changed in 2 consecutive numbers.

Input: 1001

Output: 1101

Explanation: 1001 -> 1101 -> 1101 -> 1101

Input: 11

Output: 10

Explanation: 11 -> 10

Procedure:

The idea is to check whether the last bit and second last bit are same or not, if it is same then move ahead otherwise add 1.

Follow the steps to solve the given problem:

binary_to_grey(n)
if n == 0
    grey = 0;
else if last two bits are opposite to each other
    grey = 1 + 10 * binary_to_gray(n/10))
else if last two bits are same
    grey = 10 * binary_to_gray(n/10))

```
# Convert Binary to Gray code using recursion
# Function to change Binary to Gray using recursion
def binary_to_gray(n):
    # write code here
    …
# Driver Code
binary_number = 1011101
print(binary_to_gray(binary_number), end='')
```

1.6 Count Set-bits of a number using Recursion

Given a number N. The task is to find the number of set bits in its binary representation using recursion.

Input: 21

Output: 3

Explanation: 21 represented as 10101 in binary representation

Input: 16

Output: 1

Explanation: 16 represented as 10000 in binary representation

Procedure:

1. First, check the LSB of the number.
2. If the LSB is 1, then we add 1 to our answer and divide the number by 2.
3. If the LSB is 0, we add 0 to our answer and divide the number by 2.
4. Then we recursively follow step 1 until the number is greater than 0.

```
# Find number of set bits in a number
# Recursive function to find number of set bits in a number
def CountSetBits(n):
    # write code here
    …
# Driver code
n = 21;
# Function call
print(CountSetBits(n));
```

1.7 Fibonacci Series in Reverse Order using Recursion

Given an integer N, the task is to print the first N terms of the Fibonacci series in reverse order using Recursion.

Input: N = 5

Output: 3 2 1 1 0

Explanation: First five terms are – 0 1 1 2 3

Input: N = 10

Output: 34 21 13 8 5 3 2 1 1 0

The idea is to use recursion in a way that keeps calling the same function again till N is greater than 0 and keeps on adding the terms and after that starts printing the terms.

Follow the steps below to solve the problem:

1. Define a function fibo (int N, int a, int b) where
   i. N is the number of terms and
   ii. a and b are the initial terms with values 0 and 1.
2. If N is greater than 0, then call the function again with values N-1, b, a+b.
3. After the function call, print a as the answer.

```python
# Function to print the Fibonacci series in reverse order.
def fibo(n, a, b):
    # write code here
    …
# Driver Code
N = 10
fibo(N, 0, 1)
```

1.8 Length of Longest Palindromic Sub-string using Recursion

Given a string S, the task is to find the length longest sub-string which is a palindrome.

Input: S = "aaaabbaa"

Output: 6

Explanation: Sub-string "aabbaa" is the longest palindromic sub-string.

Input: S = "banana"

Output: 5

Explanation: Sub-string "anana" is the longest palindromic sub-string.

The idea is to use recursion to break the problem into smaller sub-problems. In order to break the problem into two smaller sub-problems, compare the start and end characters of the string and recursively call the function for the middle substring.

```python
# Find the length of longest palindromic sub-string using Recursion
# Function to find maximum of the two variables
def maxi(x, y):
    if x > y:
        return x
    else:
        return y
 # Function to find the longest palindromic substring: Recursion
def longestPalindromic(strn, i, j, count):
    # write code here
    …
# Function to find the longest palindromic sub-string
def longest_palindromic_substr(strn):
    # write code here
    …
strn = "aaaabbaa"
# Function Call
print(longest_palindromic_substr(strn))
```

1.9 Find the Value of a Number Raised to its Reverse

Given a number N and its reverse R. The task is to find the number obtained when the number is raised to the power of its own reverse

Input : N = 2, R = 2

Output: 4

Explanation: Number 2 raised to the power of its reverse 2 gives 4 which gives 4 as a result after performing modulo 10^9+7

Input: N = 57, R = 75

Output: 262042770

Explanation: 57^{75} modulo 10^9+7 gives us the result as 262042770

```
# Function to return ans with modulo
def PowerOfNum(N, R):
    # write code here
     …
# Driver code
N = 57
R = 75
# Function call
print(int(PowerOfNum(N, R)))
```

1.10 Mean of Array using Recursion

Find the mean of the elements of the array.

Mean = (Sum of elements of the Array) / (Total no of elements in Array)

Input: 1 2 3 4 5

Output: 3

Input: 1 2 3

Output: 2

To find the mean using recursion assume that the problem is already solved for N-1 i.e. you have to find for n

Sum of first N-1 elements = (Mean of N-1 elements) * (N-1)

Mean of N elements = (Sum of first N-1 elements + N-th elements) / (N)

```
# Program to find mean of array
# Function definition of findMean function
def findMean(A, N):
    # write code here
    …
```

```python
# Driver Code
Mean = 0
A = [1, 2, 3, 4, 5]
N = len(A)
print(findMean(A, N))
```

Try:

1. Given two numbers **N** and **r**, find the value of $^{N}C_{r}$ using recursion.

$$C(n,r) = C(n-1,r-1) + C(n-1,r)$$

Input: N = 5, r = 2

Output: 10

Explanation: The value of 5C2 is 10

2. Predict the output of the following program. What does the following fun() do in general?

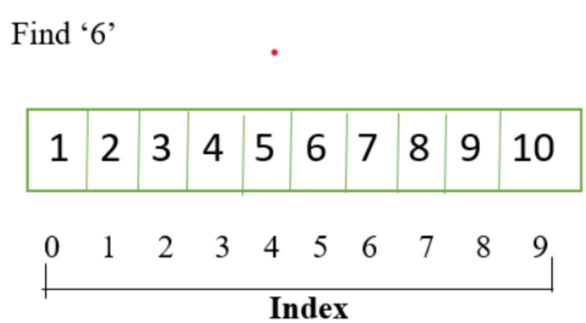
```python
fp = 15
def fun(n):
    global fp
    if (n <= 2):
        fp = 1
        return 1

    t = fun(n - 1)
    f = t + fp
    fp = t
    return f

# Driver code
print(fun(5))
```

3. **Tail recursion:** Calculate factorial of a number using a Tail-Recursive function.

2. Searching

2.1 Linear / Sequential Search

Linear search is defined as the searching algorithm where the list or data set is traversed from one end to find the desired value. Given an array arr[] of n elements, write a recursive function to search a given element x in arr[].



Note : We find '6' at index '5' through linear search

Linear search procedure:

1. Start from the leftmost element of arr[] and one by one compare x with each element of arr[]

2. If x matches with an element, return the index.

3. If x doesn't match with any of the elements, return -1.

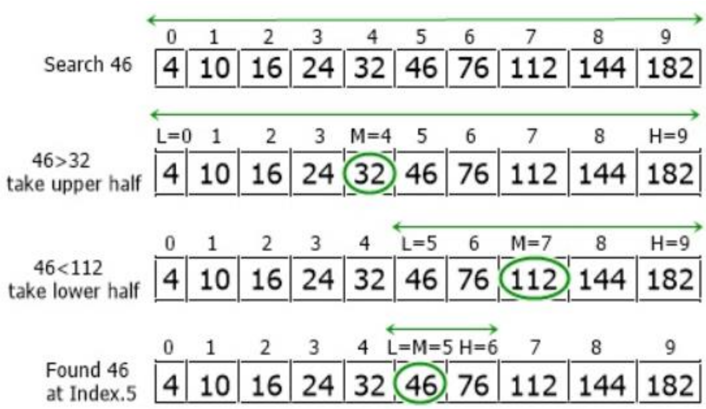
Input: arr[] = {10, 20, 80, 30, 60, 50, 110, 100, 130, 170}
x = 110;
Output: 6
Element x is present at index 6

Input: arr[] = {10, 20, 80, 30, 60, 50, 110, 100, 130, 170}
x = 175;
Output: -1
Element x is not present in arr[].

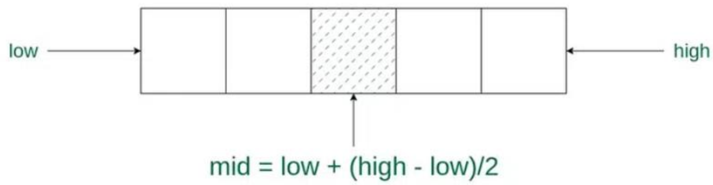
```
# Recursive linear search
def linear_search(arr, curr_index, key):
    # write code here
    …

# Driver code
arr = [10, 20, 80, 30, 60, 50, 110, 100, 130, 170]
x = 110
linear_search(arr, 0, x)
```

2.2 Binary Search

Binary Search is defined as a searching algorithm used in a sorted array by repeatedly dividing the search interval in half. The idea of binary search is to use the information that the array is sorted and reduce the time complexity to O(log N).



Conditions for Binary Search algorithm:
1. The data structure must be sorted.
2. Access to any element of the data structure takes constant time.



Binary Search Procedure:
1. Divide the search space into two halves by finding the middle index “mid”.
2. Compare the middle element of the search space with the key.
3. If the key is found at middle element, the process is terminated.
4. If the key is not found at middle element, choose which half will be used as the next search space.
    a. If the key is smaller than the middle element, then the left side is used for next search.
    b. If the key is larger than the middle element, then the right side is used for next search.
5. This process is continued until the key is found or the total search space is exhausted.

Input: arr = [2, 5, 8, 12, 16, 23, 38, 56, 72, 91]
Output: target = 23
Element 23 is present at index 5

```
# Program for recursive binary search.

# Returns index of x in arr if present, else -1
def binarySearch(arr, l, r, x):
    # write code here
    …

# Driver Code
arr = [2, 3, 4, 10, 40]
x = 10
result = binarySearch(arr, 0, len(arr)-1, x)

if result != -1:
    print("Element is present at index", result)
else:
    print("Element is not present in array")
```

2.3 Uniform Binary Search

Uniform Binary Search is an optimization of Binary Search algorithm when many searches are made on same array or many arrays of same size. In normal binary search, we do arithmetic operations to find the mid points. Here we precompute mid points and fills them in lookup table. The array look-up generally works faster than arithmetic done (addition and shift) to find the mid-point.

Input: array = {1, 3, 5, 6, 7, 8, 9}, v=3

Output: Position of 3 in array = 2

Input: array = {1, 3, 5, 6, 7, 8, 9}, v=7

Output: Position of 7 in array = 5

The algorithm is very similar to Binary Search algorithm, the only difference is a lookup table is created for an array and the lookup table is used to modify the index of the pointer in the array which makes the search faster. Instead of maintaining lower and upper bound the algorithm maintains an index and the index is modified using the lookup table.

```
# Implementation of above approach

MAX_SIZE = 1000

# lookup table
lookup_table = [0] * MAX_SIZE

# create the lookup table for an array of length n
def create_table(n):
    # write code here
    …
# binary search

def binary(arr, v):
    # write code here
    …

# Driver code
arr = [1, 3, 5, 6, 7, 8, 9]
n = len(arr)

# create the lookup table
create_table(n)

# print the position of the array
print("Position of 3 in array = ", binary(arr, 3))
```

2.4 Interpolation Search

Interpolation search works better than Binary Search for a Sorted and Uniformly Distributed array. Binary search goes to the middle element to check irrespective of search-key. On the other hand, Interpolation search may go to different locations according to search-key. If the value of the search-key is close to the last element, Interpolation Search is likely to start search toward the end side. Interpolation search is more efficient than binary search when the elements in the list are uniformly distributed, while binary search is more efficient when the elements in the list are not uniformly distributed.

Interpolation search can take longer to implement than binary search, as it requires the use of additional calculations to estimate the position of the target element.

Input: arr = [1, 2, 3, 4, 5, 6, 7, 8, 9]
Output: target = 5

```
# Interpolation search
def interpolation_search(arr, target):
    # write code here
    …


# Driver code
arr = [1, 2, 3, 4, 5, 6, 7, 8, 9]
target = 5

index = interpolation_search(arr, target)
```

```
if index == -1:
    print(f"{target} not found in the list")
else:
    print(f"{target} found at index {index}")
```

2.5 Fibonacci Search

Given a sorted array arr[] of size n and an element x to be searched in it. Return index of x if it is present in array else return -1.

Input: arr[] = {2, 3, 4, 10, 40}, x = 10
Output: 3
Element x is present at index 3.

Input: arr[] = {2, 3, 4, 10, 40}, x = 11
Output: -1
Element x is not present.

Fibonacci Search is a comparison-based technique that uses Fibonacci numbers to search an element in a sorted array.
Fibonacci Numbers are recursively defined as F(n) = F(n-1) + F(n-2), F(0) = 0, F(1) = 1. First few Fibonacci Numbers are 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, …

Fibonacci Search Procedure:

Let the searched element be x. The idea is to first find the smallest Fibonacci number that is greater than or equal to the length of the given array. Let the found Fibonacci number be fib (m'th Fibonacci number). We use (m-2)'th Fibonacci number as the index (If it is a valid index). Let (m-2)'th Fibonacci Number be i, we compare arr[i] with x, if x is same, we return i. Else if x is greater, we recur for subarray after i, else we recur for subarray before i.

Let arr[0..n-1] be the input array and the element to be searched be x.

1. Find the smallest Fibonacci number greater than or equal to n. Let this number be fibM [m'th Fibonacci number]. Let the two Fibonacci numbers preceding it be fibMm1 [(m-1)'th Fibonacci Number] and fibMm2 [(m-2)'th Fibonacci Number].
2. While the array has elements to be inspected:
   i. Compare x with the last element of the range covered by fibMm2
   ii. If x matches, return index
   iii. Else If x is less than the element, move the three Fibonacci variables two Fibonacci down, indicating elimination of approximately rear two-third of the remaining array.
   iv. Else x is greater than the element, move the three Fibonacci variables one Fibonacci down. Reset offset to index. Together these indicate the elimination of approximately front one-third of the remaining array.
3. Since there might be a single element remaining for comparison, check if fibMm1 is 1. If Yes, compare x with that remaining element. If match, return index.

```
# Fibonacci search
from bisect import bisect_left

# Returns index of x if present, else returns -1

def fibMonaccianSearch(arr, x, n):
    # write code here
    …

# Driver Code
arr = [10, 22, 35, 40, 45, 50, 80, 82, 85, 90, 100,235]
n = len(arr)
x = 235
ind = fibMonaccianSearch(arr, x, n)
if ind>=0:
  print("Found at index:",ind)
else:
  print(x,"isn't present in the array");
```

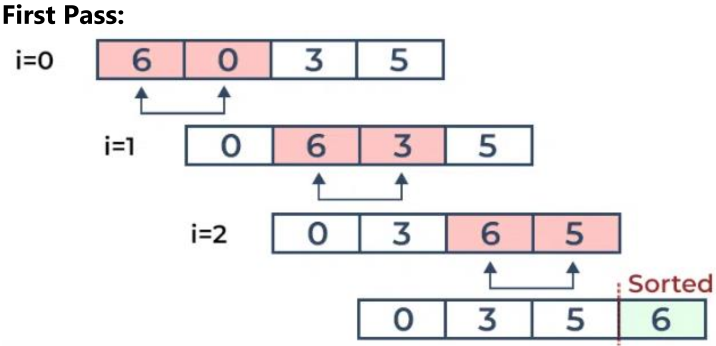
3. Sorting

3.1 Bubble Sort

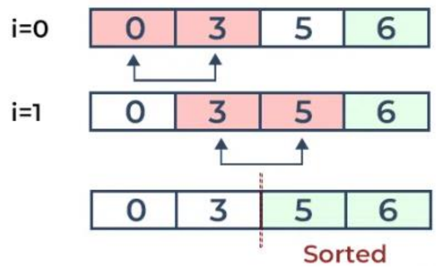
Bubble Sort is the simplest sorting algorithm that works by repeatedly swapping the adjacent elements if they are in the wrong order. This algorithm is not suitable for large data sets as its average and worst-case time complexity is quite high.

Bubble Sort Procedure:
1. Traverse from left and compare adjacent elements and the higher one is placed at right side.
2. In this way, the largest element is moved to the rightmost end at first.
3. This process is then continued to find the second largest and place it and so on until the data is sorted.

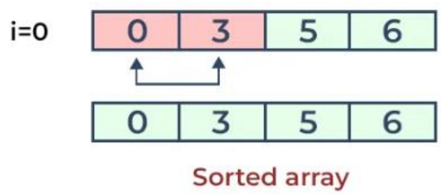
Input: arr = [6, 3, 0, 5]
Output:
First Pass:



Second Pass:



Third Pass:




```
# Implementation of Bubble Sort

def bubbleSort(arr):
      # write code here
      …

# Driver code to test above
arr = [64, 34, 25, 12, 22, 11, 90]

bubbleSort(arr)

print("Sorted array:")
for i in range(len(arr)):
    print("%d" % arr[i], end=" ")
```

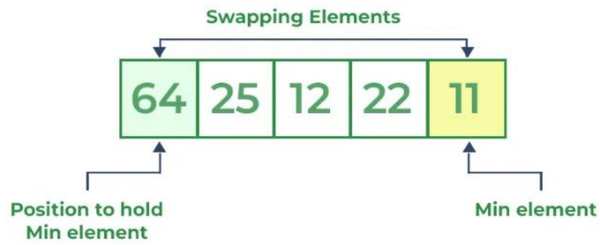
3.2 Selection Sort

Selection sort is a simple and efficient sorting algorithm that works by repeatedly selecting the smallest (or largest) element from the unsorted portion of the list and moving it to the sorted portion of the list. The algorithm repeatedly selects the smallest (or largest) element from the unsorted portion of the list and swaps it with the first element of the unsorted part. This process is repeated for the remaining unsorted portion until the entire list is sorted.

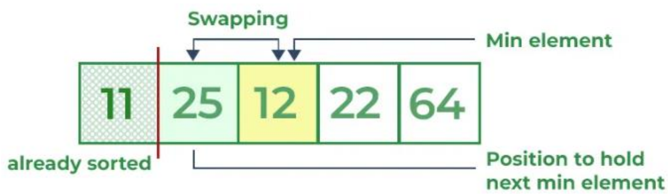
Input: arr = [64, 25, 12, 22, 11]

Output: arr = [11, 12, 22, 25, 64]

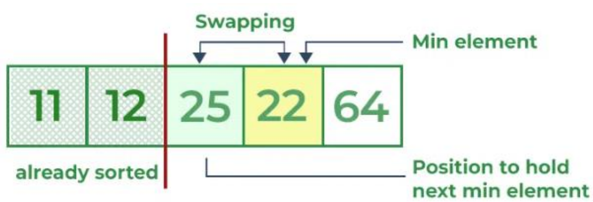
First Pass: For the first position in the sorted array, the whole array is traversed from index 0 to 4 sequentially. The first position where 64 is stored presently, after traversing whole array it is clear that 11 is the lowest value. Thus, replace 64 with 11. After one iteration 11, which happens to be the least value in the array, tends to appear in the first position of the sorted list.



Second Pass: For the second position, where 25 is present, again traverse the rest of the array in a sequential manner. After traversing, we found that 12 is the second lowest value in the array and it should appear at the second place in the array, thus swap these values.

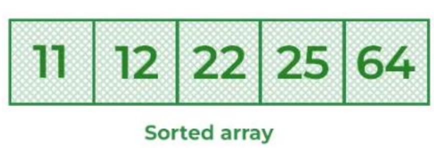


Third Pass: Now, for third place, where 25 is present again traverse the rest of the array and find the third least value present in the array. While traversing, 22 came out to be the third least value and it should appear at the third place in the array, thus swap 22 with element present at third position.



Fourth Pass: Similarly, for fourth position traverse the rest of the array and find the fourth least element in the array. As 25 is the 4th lowest value hence, it will place at the fourth position.

Fifth Pass: At last the largest value present in the array automatically get placed at the last position in the array. The resulted array is the sorted array.




```
# Implementation of selection sort
import sys
A = [64, 25, 12, 22, 11]

# Traverse through all array elements
for i in range(len(A)):
```

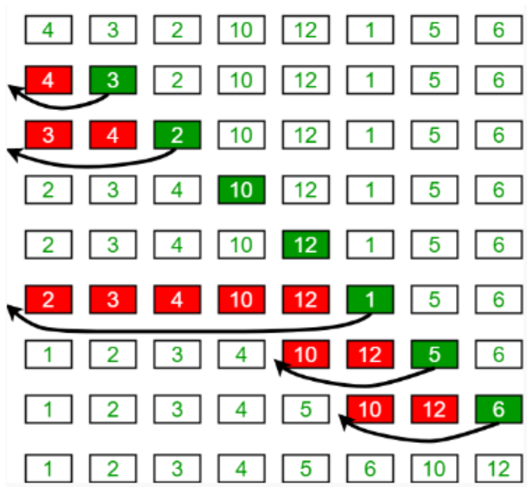
```
    # write code here
    …
# Driver code
print ("Sorted array")
for i in range(len(A)):
    print("%d" %A[i],end=" , ")
```

3.3 Insertion Sort

Insertion sort is a simple sorting algorithm that works similar to the way you sort playing cards in your hands. The array is virtually split into a sorted and an unsorted part. Values from the unsorted part are picked and placed at the correct position in the sorted part.

Insertion Sort Procedure:

1. To sort an array of size N in ascending order iterate over the array and compare the current element (key) to its predecessor, if the key element is smaller than its predecessor, compare it to the elements before.
2. Move the greater elements one position up to make space for the swapped element.



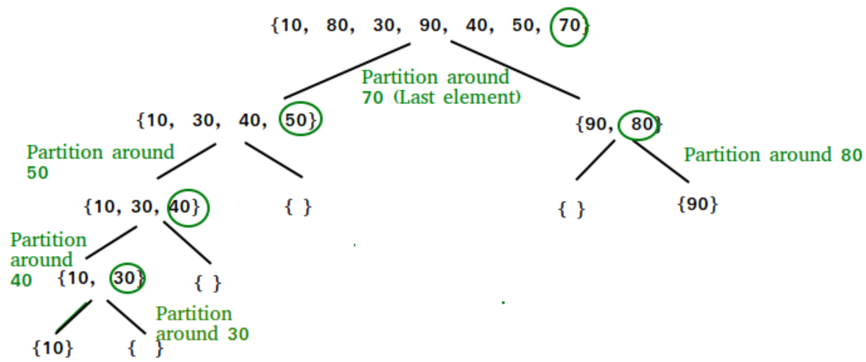
Input: arr = [4, 3, 2, 10, 12, 1, 5, 6]
Output: arr = [1, 2, 3, 4, 5, 6, 10, 12]

```
# Implementation of Insertion Sort

# Function to do insertion sort
def insertionSort(arr):
    # write code here
    …

# Driver code
arr = [12, 11, 13, 5, 6]
insertionSort(arr)
for i in range(len(arr)):
    print ("% d" % arr[i])
```

4. Divide and Conquer

4.1 Quick Sort

QuickSort is a sorting algorithm based on the Divide and Conquer algorithm that picks an element as a pivot and partitions the given array around the picked pivot by placing the pivot in its correct position in the sorted array. The key process in quickSort is a partition(). The target of partitions is to place the pivot (any element can be chosen to be a pivot) at its correct position in the sorted array and put all smaller elements to the left of the pivot, and all greater elements to the right of the pivot. Partition is done recursively on each side of the pivot after the pivot is placed in its correct position and this finally sorts the array.



The quick sort method can be summarized in three steps:

1. **Pick:** Select a pivot element.
2. **Divide:** Split the problem set, move smaller parts to the left of the pivot and larger items to the right.
3. **Repeat and combine:** Repeat the steps and combine the arrays that have previously been sorted.

Algorithm for Quick Sort Function:

```
//start –> Starting index,  end --> Ending index
Quicksort(array, start, end)
{
        if (start < end)
        {
                pIndex = Partition(A, start, end)
                Quicksort(A,start,pIndex-1)
                Quicksort(A,pIndex+1, end)
        }
}
```

Algorithm for Partition Function:

```
partition (array, start, end)
{
        // Setting rightmost Index as pivot
        pivot = arr[end];

        i = (start - 1)  // Index of smaller element and indicates the
            // right position of pivot found so far
        for (j = start; j <= end- 1; j++)
        {
                // If current element is smaller than the pivot
                if (arr[j] < pivot)
                {
```

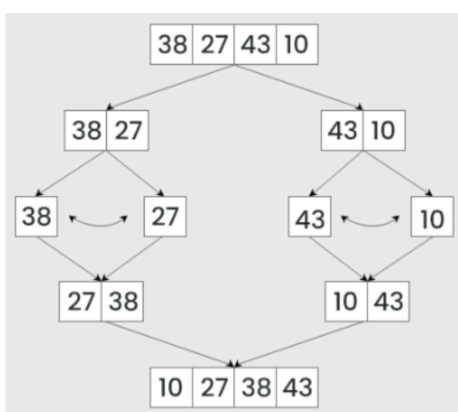
```
                        i++;    // increment index of smaller element
                        swap arr[i] and arr[j]
                }
        }
        swap arr[i + 1] and arr[end])
        return (i + 1)
}
```

Input: arr = [10, 80, 30, 90, 40, 50, 70]
Output: arr = [10, 30, 40, 50, 70, 80, 90]

```python
# Implementation of QuickSort

# Function to find the partition position
def partition(array, low, high):
    # write code here
    …

# Function to perform quicksort
def quicksort(array, low, high):
    # write code here
    …

# Driver code
array = [10, 7, 8, 9, 1, 5]
N = len(array)

# Function call
quicksort(array, 0, N - 1)
print('Sorted array:')
for x in array:
    print(x, end=" ")
```

4.2 Merge Sort

Merge sort is defined as a sorting algorithm that works by dividing an array into smaller subarrays, sorting each subarray, and then merging the sorted subarrays back together to form the final sorted array. In simple terms, we can say that the process of merge sort is to divide the array into two halves, sort each half, and then merge the sorted halves back together. This process is repeated until the entire array is sorted.



Input: arr = [12, 11, 13, 5, 6, 7]
Output: arr = [5, 6, 7, 11, 12, 13]

```
# Implementation of MergeSort

def mergeSort(arr):
    # write code here
    …

# print the list
def printList(arr):
    for i in range(len(arr)):
        print(arr[i], end=" ")
    print()


# Driver Code
arr = [12, 11, 13, 5, 6, 7]
print("Given array is")
printList(arr)
mergeSort(arr)
print("\nSorted array is ")
printList(arr)
```

4.3 Heap Sort

Heap sort is a comparison-based sorting technique based on Binary Heap data structure. It is similar to the selection sort where we first find the minimum element and place the minimum element at the beginning. Repeat the same process for the remaining elements.

Heap Sort Procedure:

First convert the array into heap data structure using heapify, then one by one delete the root node of the Max-heap and replace it with the last node in the heap and then heapify the root of the heap. Repeat this process until size of heap is greater than 1.

- Build a heap from the given input array.
- Repeat the following steps until the heap contains only one element:
    - Swap the root element of the heap (which is the largest element) with the last element of the heap.
    - Remove the last element of the heap (which is now in the correct position).
    - Heapify the remaining elements of the heap.
    - The sorted array is obtained by reversing the order of the elements in the input array.

Input: arr = [12, 11, 13, 5, 6, 7]
Output: Sorted array is 5 6 7 11 12 13

```
# Implementation of heap Sort
# To heapify subtree rooted at index i.
# n is size of heap
```

```python
def heapify(arr, N, i):
    # write code here
    …

# The main function to sort an array of given size
def heapSort(arr):
    # write code here
    …

# Driver code
arr = [12, 11, 13, 5, 6, 7]

# Function call
heapSort(arr)
N = len(arr)
print("Sorted array is")
for i in range(N):
    print("%d" % arr[i], end=" ")
```

4.4 Radix Sort

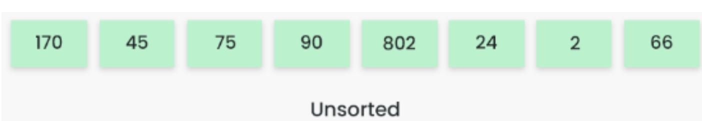
Radix Sort is a linear sorting algorithm that sorts elements by processing them digit by digit. It is an efficient sorting algorithm for integers or strings with fixed-size keys. Rather than comparing elements directly, Radix Sort distributes the elements into buckets based on each digit's value. By repeatedly sorting the elements by their significant digits, from the least significant to the most significant, Radix Sort achieves the final sorted order.

Radix Sort Procedure:

The key idea behind Radix Sort is to exploit the concept of place value.

1. It assumes that sorting numbers digit by digit will eventually result in a fully sorted list.
2. Radix Sort can be performed using different variations, such as Least Significant Digit (LSD) Radix Sort or Most Significant Digit (MSD) Radix Sort.

To perform radix sort on the array [170, 45, 75, 90, 802, 24, 2, 66], we follow these steps:



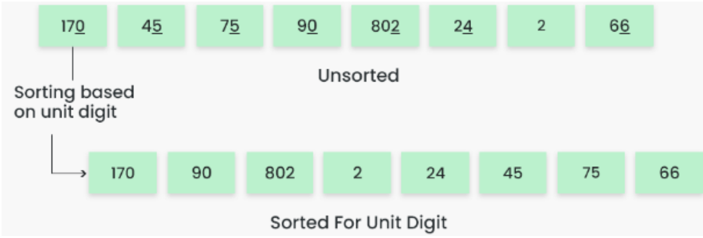
Step 1: Find the largest element in the array, which is 802. It has three digits, so we will iterate three times, once for each significant place.

Step 2: Sort the elements based on the unit place digits (X=0). We use a stable sorting technique, such as counting sort, to sort the digits at each significant place.

Sorting based on the unit place:

Perform counting sort on the array based on the unit place digits.

The sorted array based on the unit place is [170, 90, 802, 2, 24, 45, 75, 66]

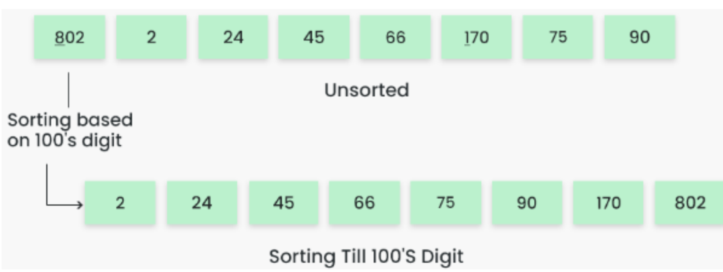


Step 3: Sort the elements based on the tens place digits.

Sorting based on the tens place:
Perform counting sort on the array based on the tens place digits.
The sorted array based on the tens place is [802, 2, 24, 45, 66, 170, 75, 90]

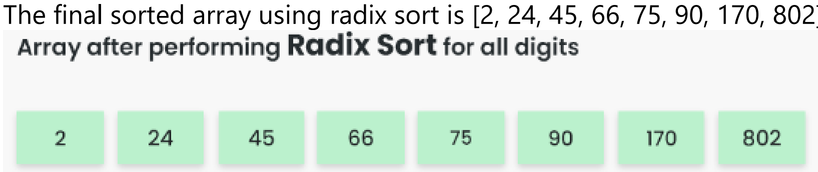
Step 4: Sort the elements based on the hundreds place digits.

Sorting based on the hundreds place:
Perform counting sort on the array based on the hundreds place digits.
The sorted array based on the hundreds place is [2, 24, 45, 66, 75, 90, 170, 802]



Step 5: The array is now sorted in ascending order.

The final sorted array using radix sort is [2, 24, 45, 66, 75, 90, 170, 802]




```
# Implementation of Radix Sort
# A function to do counting sort of arr[] according to the digit represented by exp.

def countingSort(arr, exp1):
    # write code here
    …
```

```python
# Method to do Radix Sort
def radixSort(arr):
    # write code here
    …

# Driver code
arr = [170, 45, 75, 90, 802, 24, 2, 66]

# Function Call
radixSort(arr)

for i in range(len(arr)):
    print(arr[i],end=" ")
```

4.5 Shell Sort

Shell sort is mainly a variation of Insertion Sort. In insertion sort, we move elements only one position ahead. When an element has to be moved far ahead, many movements are involved. The idea of ShellSort is to allow the exchange of far items. In Shell sort, we make the array h-sorted for a large value of h. We keep reducing the value of h until it becomes 1. An array is said to be h-sorted if all sublists of every h'th element are sorted.

Shell Sort Procedure:

1. Initialize the value of gap size h
2. Divide the list into smaller sub-part. Each must have equal intervals to h
3. Sort these sub-lists using insertion sort
4. Repeat this step 1 until the list is sorted.
5. Print a sorted list.

```
Procedure Shell_Sort(Array, N)
  While Gap < Length(Array) /3 :
            Gap = ( Interval * 3 ) + 1
  End While Loop
  While Gap > 0 :
     For (Outer = Gap; Outer < Length(Array); Outer++):
        Insertion_Value = Array[Outer]
            Inner = Outer;
        While Inner > Gap-1 And Array[Inner – Gap] >= Insertion_Value:
            Array[Inner] = Array[Inner – Gap]
            Inner = Inner – Gap
         End While Loop
           Array[Inner] = Insertion_Value
     End For Loop
     Gap = (Gap -1) /3;
  End While Loop
End Shell_Sort
```

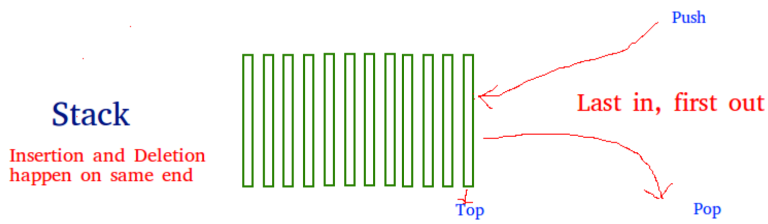
```python
# Implementation of Shell Sort

def shellSort(arr, n):
    # write code here
    …

# Driver code
arr = [12, 34, 54, 2, 3]
```

```
print("input array:",arr)

shellSort(arr,len(arr))
print("sorted array",arr)
```

5. Stack

5.1 Stack implementation using List

A stack is a linear data structure that stores items in a Last-In/First-Out (LIFO) or First-In/Last-Out (FILO) manner. In stack, a new element is added at one end and an element is removed from that end only. The insert and delete operations are often called push and pop.



The functions associated with stack are:

- **empty()** – Returns whether the stack is empty
- **size()** – Returns the size of the stack
- **top() / peek()** – Returns a reference to the topmost element of the stack
- **push(a)** – Inserts the element 'a' at the top of the stack
- **pop()** – Deletes the topmost element of the stack

```
# Stack implementation using list
top=0
mymax=5
def createStack():
    stack=[]
    return stack
def isEmpty(stack):
    # write code here
    …
def Push(stack,item):
    # write code here
    …
def Pop(stack):
    # write code here
    …
# create a stack object
stack = createStack()
while True:
    print("1.Push")
    print("2.Pop")
```

```
    print("3.Display")
    print("4.Quit")
    # write code here
    …
```

5.2 Balanced Parenthesis Checking

Given an expression string, write a python program to find whether a given string has balanced parentheses or not.

Input: {[]{()}}

Output: Balanced

Input: [{}{}(]

Output: Unbalanced

Using stack One approach to check balanced parentheses is to use stack. Each time, when an open parentheses is encountered push it in the stack, and when closed parenthesis is encountered, match it with the top of stack and pop it. If stack is empty at the end, return Balanced otherwise, Unbalanced.

```
# Check for balanced parentheses in an expression
open_list = ["[","{","("]
close_list = ["]","}",")"]

# Function to check parentheses
def check(myStr):
    # write code here
    …
```

5.3 Evaluation of Postfix Expression

Given a postfix expression, the task is to evaluate the postfix expression. Postfix expression: The expression of the form "a b operator" (ab+) i.e., when a pair of operands is followed by an operator.

Input: str = "2 3 1 * + 9 -"

Output: -4

Explanation: If the expression is converted into an infix expression, it will be 2 + (3 * 1) – 9 = 5 – 9 = -4.

Input: str = "100 200 + 2 / 5 * 7 +"

Output: 757

Procedure for evaluation postfix expression using stack:

- Create a stack to store operands (or values).
- Scan the given expression from left to right and do the following for every scanned element.
    - If the element is a number, push it into the stack.
    - If the element is an operator, pop operands for the operator from the stack. Evaluate the operator and push the result back to the stack.
- When the expression is ended, the number in the stack is the final answer.

```
# Evaluate value of a postfix expression

# Class to convert the expression
class Evaluate:

    # Constructor to initialize the class variables
    def __init__(self, capacity):
        self.top = -1
        self.capacity = capacity

        # This array is used a stack
        self.array = []

    # Check if the stack is empty
    def isEmpty(self):
        # write code here
        …

    def peek(self):
        # write code here
        …

    def pop(self):
        # write code here
        …

    def push(self, op):
        # write code here
        …

    def evaluatePostfix(self, exp):
        # write code here
        …

# Driver code
exp = "231*+9-"
obj = Evaluate(len(exp))

# Function call
print("postfix evaluation: %d" % (obj.evaluatePostfix(exp)))
```

5.4 Infix to Postfix Expression Conversion

For a given Infix expression, convert it into Postfix form.
Infix expression: The expression of the form “a operator b” (a + b) i.e., when an operator is in-between every pair of operands.
Postfix expression: The expression of the form “a b operator” (ab+) i.e., When every pair of operands is followed by an operator.

Infix to postfix expression conversion procedure:

1. Scan the infix expression from left to right.

2. If the scanned character is an operand, put it in the postfix expression.

3. Otherwise, do the following

- If the precedence and associativity of the scanned operator are greater than the precedence and associativity of the operator in the stack [or the stack is empty or the stack contains a '('], then push it in the stack. ['^' operator is right associative and other operators like '+','–','*' and '/' are left-associative].

- Check especially for a condition when the operator at the top of the stack and the scanned operator both are '^'. In this condition, the precedence of the scanned operator is higher due to its right associativity. So it will be pushed into the operator stack.

- In all the other cases when the top of the operator stack is the same as the scanned operator, then pop the operator from the stack because of left associativity due to which the scanned operator has less precedence.

- Else, Pop all the operators from the stack which are greater than or equal to in precedence than that of the scanned operator.

- After doing that Push the scanned operator to the stack. (If you encounter parenthesis while popping then stop there and push the scanned operator in the stack.)

4. If the scanned character is a '(', push it to the stack.

5. If the scanned character is a ')', pop the stack and output it until a '(' is encountered, and discard both the parenthesis.

6. Repeat steps 2-5 until the infix expression is scanned.

7. Once the scanning is over, Pop the stack and add the operators in the postfix expression until it is not empty.

8. Finally, print the postfix expression.

Input: A + B * C + D
Output: A B C * + D +

Input: ((A + B) – C * (D / E)) + F
Output: A B + C D E / * - F +

```
# Convert infix expression to postfix
# Class to convert the expression

class Conversion:

    # Constructor to initialize the class variables
    def __init__(self, capacity):
        self.top = -1
        self.capacity = capacity

        # This array is used a stack
        self.array = []


        # Precedence setting
```

```
        self.output = []
        self.precedence = {'+': 1, '-': 1, '*': 2, '/': 2, '^': 3}

    # Check if the stack is empty
    def isEmpty(self):
        # write code here
        …

    # Return the value of the top of the stack
    def peek(self):
        # write code here
        …

    # Pop the element from the stack
    def pop(self):
        # write code here
        …

    # Push the element to the stack
    def push(self, op):
        # write code here
        …

    # A utility function to check is the given character is operand
    def isOperand(self, ch):
        # write code here
        …

    # Check if the precedence of operator is strictly less than top of stack or not
    def notGreater(self, i):
        # write code here
        …

    # The main function that converts given infix expression
    # to postfix expression
    def infixToPostfix(self, exp):
       # write code here
        …

# Driver code
exp = "a+b*(c^d-e)^(f+g*h)-i"
obj = Conversion(len(exp))

# Function call
obj.infixToPostfix(exp)
```

5.5 Reverse a Stack

The stack is a linear data structure which works on the LIFO concept. LIFO stands for last in first out. In the stack, the insertion and deletion are possible at one end the end is called the top of the stack. Define two recursive functions BottomInsertion() and Reverse() to reverse a stack using Python. Define some basic function of the stack like push(), pop(), show(), empty(), for basic operation like respectively append an item in stack, remove an item in stack, display the stack, check the given stack is empty or not.

BottomInsertion(): this method append element at the bottom of the stack and BottomInsertion accept two values as an argument first is stack and the second is elements, this is a recursive method.

Reverse(): the method is reverse elements of the stack, this method accept stack as an argument Reverse() is also a Recursive() function. Reverse() is invoked BottomInsertion() method for completing the reverse operation on the stack.

Input: Elements = [1, 2, 3, 4, 5]
Output: Original Stack
5
4
3
2
1
Stack after Reversing
1
2
3
4
5

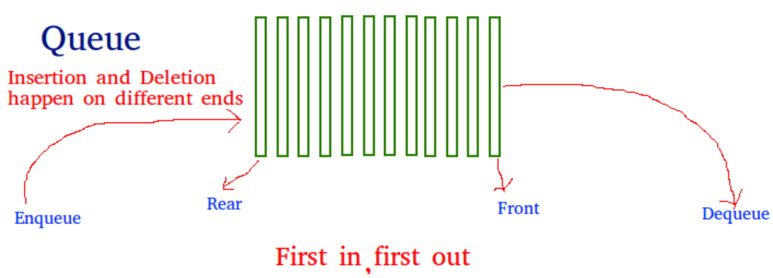
```
# create class for stack
class Stack:

    # create empty list
    def __init__(self):
        self.Elements = []

    # push() for insert an element
    def push(self, value):
        self.Elements.append(value)

    # pop() for remove an element
    def pop(self):
        return self.Elements.pop()

    # empty() check the stack is empty of not
    def empty(self):
        return self.Elements == []

    # show() display stack
    def show(self):
        for value in reversed(self.Elements):
            print(value)
 # Insert_Bottom() insert value at bottom
def BottomInsert(s, value):
   # write code here
```

```
   …
# Reverse() reverse the stack
def Reverse(s):
   # write code here

   …
# create object of stack class
stk = Stack()

stk.push(1)
stk.push(2)
stk.push(3)
stk.push(4)
stk.push(5)

print("Original Stack")
stk.show()

print("\nStack after Reversing")
Reverse(stk)
stk.show()
```

6. Queue

6.1 Linear Queue

Linear queue is a linear data structure that stores items in First in First out (FIFO) manner. With a queue the least recently added item is removed first. A good example of queue is any queue of consumers for a resource where the consumer that came first is served first.




```
# Static implementation of linear queue
front=0
rear=0
mymax=5
def createQueue():
    queue=[]   #empty list
    return queue
def isEmpty(queue):
    # write code here
    …
def enqueue(queue,item):  # insert an element into the queue
```

```
    # write code here
    …
def dequeue(queue):  #remove an element from the queue
    # write code here
    …
# Driver code
queue = createQueue()
while True:
    print("1.Enqueue")
    print("2.Dequeue")
    print("3.Display")
    print("4.Quit")
    # write code here
    …
```

6.2 Stack using Queues

Implement a last-in-first-out (LIFO) stack using only two queues. The implemented stack should support all the functions of a normal stack (push, top, pop, and empty).

- void push(int x) Pushes element x to the top of the stack.
- int pop() Removes the element on the top of the stack and returns it.
- int top() Returns the element on the top of the stack.
- boolean empty() Returns true if the stack is empty, false otherwise.

Input:

["MyStack", "push", "push", "top", "pop", "empty"]

[[], [1], [2], [], [], []]

Output:

[null, null, null, 2, 2, false]

```
class MyStack:

    def __init__(self):
       # write code here
       …
    def push(self, x: int) -> None:
       # write code here
       …
    def pop(self) -> int:
       # write code here
       …
    def top(self) -> int:
       # write code here
       …
```

```
    def empty(self) -> bool:
       # write code here
       …
# Your MyStack object will be instantiated and called as such:
# obj = MyStack()
# obj.push(x)
# param_2 = obj.pop()
# param_3 = obj.top()
# param_4 = obj.empty()
```

6.3 Queue using Stacks

Implement a first in first out (FIFO) queue using only two stacks. The implemented queue should support all the functions of a normal queue (push, peek, pop, and empty).

- void push(int x) Pushes element x to the back of the queue.
- int pop() Removes the element from the front of the queue and returns it.
- int peek() Returns the element at the front of the queue.
- boolean empty() Returns true if the queue is empty, false otherwise.

Input:

["MyQueue", "push", "push", "peek", "pop", "empty"]

[[], [1], [2], [], [], []]

Output:

[null, null, null, 1, 1, false]

```
class MyQueue:

    def __init__(self):
       # write code here
       …
    def push(self, x: int) -> None:
       # write code here
       …
    def pop(self) -> int:
       # write code here
       …
    def peek(self) -> int:
       # write code here
       …
    def empty(self) -> bool:
       # write code here
       …
# Your MyQueue object will be instantiated and called as such:
# obj = MyQueue()
# obj.push(x)
```

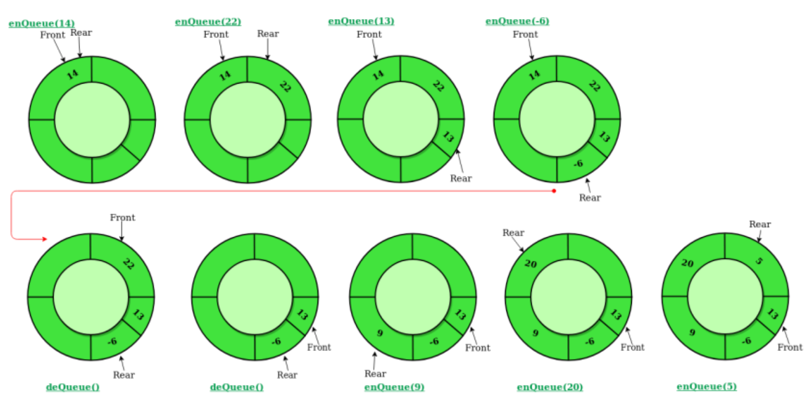
```
# param_2 = obj.pop()
# param_3 = obj.peek()
# param_4 = obj.empty()
```

6.4 Circular Queue

A Circular Queue is an extended version of a normal queue where the last element of the queue is connected to the first element of the queue forming a circle. The operations are performed based on FIFO (First In First Out) principle. It is also called 'Ring Buffer'.

Operations on Circular Queue:

- **Front:** Get the front item from the queue.
- **Rear:** Get the last item from the queue.
- **enQueue(value)** This function is used to insert an element into the circular queue. In a circular queue, the new element is always inserted at the rear position.
    - Check whether the queue is full – [i.e., the rear end is in just before the front end in a circular manner].
    - If it is full then display Queue is full.
        - If the queue is not full then, insert an element at the end of the queue.
- **deQueue()** This function is used to delete an element from the circular queue. In a circular queue, the element is always deleted from the front position.
    - Check whether the queue is Empty.
    - If it is empty then display Queue is empty.
        - If the queue is not empty, then get the last element and remove it from the queue.



Implement Circular Queue using Array:

1. Initialize an array queue of size **n**, where n is the maximum number of elements that the queue can hold.
2. Initialize two variables front and rear to -1.
3. **Enqueue:** To enqueue an element **x** into the queue, do the following:

- Increment rear by 1.
- If **rear** is equal to n, set **rear** to 0.
- If **front** is -1, set **front** to 0.
- Set queue[rear] to x.

4. **Dequeue:** To dequeue an element from the queue, do the following:
    - Check if the queue is empty by checking if **front** is -1.
    - If it is, return an error message indicating that the queue is empty.
    - Set **x** to queue [front].
    - If **front** is equal to **rear**, set **front** and **rear** to -1.
    - Otherwise, increment **front** by 1 and if **front** is equal to n, set **front** to 0.
    - Return x.

```
class CircularQueue():

    # constructor
    def __init__(self, size): # initializing the class
        self.size = size

        # initializing queue with none
        self.queue = [None for i in range(size)]
        self.front = self.rear = -1

    def enqueue(self, data):
         # Write code here
         …

    def dequeue(self):
         # Write code here
         …

    def display(self):
        # Write code here
        …
# Driver Code
ob = CircularQueue(5)
ob.enqueue(14)
ob.enqueue(22)
ob.enqueue(13)
ob.enqueue(-6)
ob.display()
print ("Deleted value = ", ob.dequeue())
print ("Deleted value = ", ob.dequeue())
ob.display()
ob.enqueue(9)
ob.enqueue(20)
ob.enqueue(5)
```

```
ob.display()
```

6.5 Deque (Doubly Ended Queue)

In a Deque (Doubly Ended Queue), one can perform insert (append) and delete (pop) operations from both the ends of the container. There are two types of Deque:

1. **Input Restricted Deque:** Input is limited at one end while deletion is permitted at both ends.
2. **Output Restricted Deque:** Output is limited at one end but insertion is permitted at both ends.

Operations on Deque:

1. **append():** This function is used to insert the value in its argument to the right end of the deque.
2. **appendleft():** This function is used to insert the value in its argument to the left end of the deque.
3. **pop():** This function is used to delete an argument from the right end of the deque.
4. **popleft():** This function is used to delete an argument from the left end of the deque.
5. **index(ele, beg, end):** This function returns the first index of the value mentioned in arguments, starting searching from beg till end index.
6. **insert(i, a):** This function inserts the value mentioned in arguments(a) at index(i) specified in arguments.
7. **remove():** This function removes the first occurrence of the value mentioned in arguments.
8. **count():** This function counts the number of occurrences of value mentioned in arguments.
9. **len(dequeue):** Return the current size of the dequeue.
10. **Deque[0]:** We can access the front element of the deque using indexing with de[0].
11. **Deque[-1]:** We can access the back element of the deque using indexing with de[-1].
12. **extend(iterable):** This function is used to add multiple values at the right end of the deque. The argument passed is iterable.
13. **extendleft(iterable):** This function is used to add multiple values at the left end of the deque. The argument passed is iterable. Order is reversed as a result of left appends.
14. **reverse():** This function is used to reverse the order of deque elements.
15. **rotate():** This function rotates the deque by the number specified in arguments. If the number specified is negative, rotation occurs to the left. Else rotation is to right.

```
# importing "collections" for deque operations
import collections

# initializing deque
de = collections.deque([1, 2, 3])
print("deque: ", de)

# using append() to insert 4 at the end of deque
# Write code here

# Printing modified deque
# Write code here

# using appendleft() to insert 6 at the beginning of deque
# Write code here
```

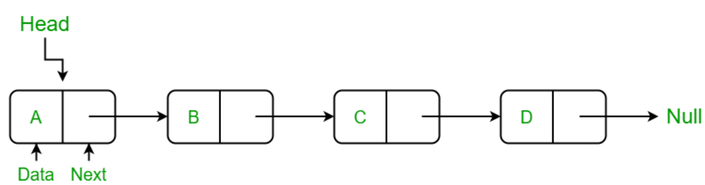
```
# Printing modified deque
# Write code here

# using pop() to delete 4 from the right end of deque
# Write code here

# Printing modified deque
# Write code here

# using popleft() to delete 6 from the left end of deque
# Write code here

# Printing modified deque
# Write code here

# using insert() to insert the value 3 at 5th position
# Write code here

# printing modified deque
# Write code here

# using count() to count the occurrences of 3
# Write code here

# using remove() to remove the first occurrence of 3
# Write code here

# Printing modified deque
# Write code here

# Printing current size of deque
# Write code here

# using pop() to delete 6 from the right end of deque
# Write code here

# Printing modified deque
# Write code here

# Printing current size of deque
# Write code here

# Accessing the front element of the deque
# Write code here

# Accessing the back element of the deque
# Write code here

# using extend() to add 4,5,6 to right end
# Write code here
```

```
# Printing modified deque
# Write code here

# using extendleft() to add 7,8,9 to left end
# Write code here

# Printing modified deque
# Write code here

# using rotate() to rotate the deque rotates by 3 to left
# Write code here

# Printing modified deque
# Write code here

# using reverse() to reverse the deque
# Write code here

# Printing modified deque
# Write code here
```

7. Linked List

7.1 Singly Linked List

A singly linked list is a linear data structure in which the elements are not stored in contiguous memory locations and each element is connected only to its next element using a pointer.



Creating a linked list involves the following operations:

1. Creating a Node class:
2. Insertion at beginning:
3. Insertion at end
4. Insertion at middle
5. Update the node
6. Deletion at beginning
7. Deletion at end
8. Deletion at middle
9. Remove last node
10. Linked list traversal
11. Get length

```python
# Create a Node class to create a node
class Node:
    def __init__(self, data):
        self.data = data
        self.next = None

# Create a LinkedList class
class LinkedList:
    def __init__(self):
        self.head = None

    # Method to add a node at begin of LL
    def insertAtBegin(self, data):
        # Write code here
        …
    # Method to add a node at any index, Indexing starts from 0.
    def insertAtIndex(self, data, index):
        # Write code here
        …
     # Method to add a node at the end of LL
    def insertAtEnd(self, data):
        # Write code here
        …
     # Update node of a linked list at given position
    def updateNode(self, val, index):
        # Write code here
        …
    # Method to remove first node of linked list
    def remove_first_node(self):
        # Write code here
        …
    # Method to remove last node of linked list
    def remove_last_node(self):
       # Write code here
        …
    # Method to remove at given index
    def remove_at_index(self, index):
        # Write code here
        …
     # Method to remove a node from linked list
```

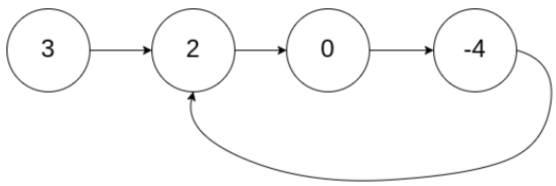
```
    def remove_node(self, data):
        # Write code here
        …
     # Print the size of linked list
    def sizeOfLL(self):
        # Write code here
        …
    # print method for the linked list
    def printLL(self):
        # Write code here
        …
# create a new linked list
llist = LinkedList()

# add nodes to the linked list
llist.insertAtEnd('a')
llist.insertAtEnd('b')
llist.insertAtBegin('c')
llist.insertAtEnd('d')
llist.insertAtIndex('g', 2)
# print the linked list
print("Node Data")
llist.printLL()
# remove a nodes from the linked list
print("\nRemove First Node")
llist.remove_first_node()
print("Remove Last Node")
llist.remove_last_node()
print("Remove Node at Index 1")
llist.remove_at_index(1)
# print the linked list again
print("\nLinked list after removing a node:")
llist.printLL()
print("\nUpdate node Value")
llist.updateNode('z', 0)
llist.printLL()
print("\nSize of linked list :", end=" ")
print(llist.sizeOfLL())
```

7.2 Linked List Cycle

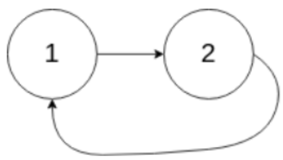
Given head, the head of a linked list, determine if the linked list has a cycle in it. There is a cycle in a linked list if there is some node in the list that can be reached again by continuously following the next pointer. Internally, pos is used to denote the index of the node that tail's next pointer is connected to.

Note that pos is not passed as a parameter.

Return true if there is a cycle in the linked list. Otherwise, return false.



Input: head = [3, 2, 0, -4], pos = 1
Output: true
Explanation: There is a cycle in the linked list, where the tail connects to the 1st node (0-indexed).



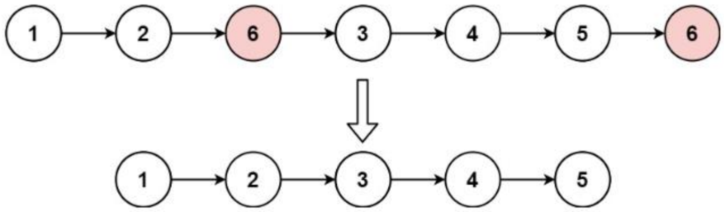
Input: head = [1, 2], pos = 0
Output: true
Explanation: There is a cycle in the linked list, where the tail connects to the 0th node.

Input: head = [1], pos = -1
Output: false
Explanation: There is no cycle in the linked list.

```
# Definition for singly-linked list.
class ListNode:
    def __init__(self, x):
        self.val = x
        self.next = None

class Solution:
    def hasCycle(self, head):
        # Write code here
        …
```

7.3 Remove Linked List Elements

Given the head of a linked list and an integer val, remove all the nodes of the linked list that has Node.val == val, and return the new head.



Input: head = [1, 2, 6, 3, 4, 5, 6], val = 6

Output: [1, 2, 3, 4, 5]

Input: head = [ ], val = 1

Output: [ ]

Input: head = [7, 7, 7, 7], val = 7

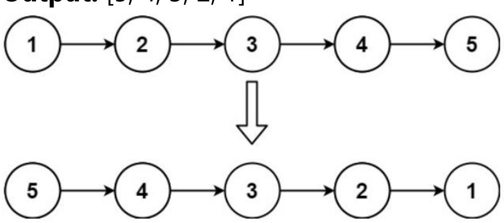
Output: [ ]

```
# Definition for singly-linked list.
class ListNode:
   def __init__(self, val=0, next=None):
       self.val = val
       self.next = next

class Solution:
    def removeElements(self, head, val):
        # Write code here
        …
```

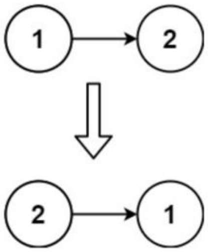
7.4 Reverse Linked List

Given the head of a singly linked list, reverse the list, and return the reversed list.

Input: head = [1, 2, 3, 4, 5]
Output: [5, 4, 3, 2, 1]



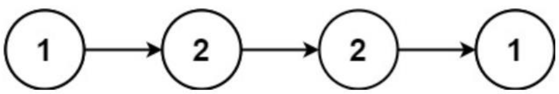
Input: head = [1, 2]
Output: [2, 1]




```python
# Definition for singly-linked list.
class ListNode:
   def __init__(self, val=0, next=None):
       self.val = val
       self.next = next

class Solution:
    def reverseList(self, head):
        # Write code here
         …
```

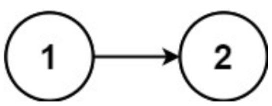
7.5 Palindrome Linked List

Given the head of a singly linked list, return true if it is a palindrome or false otherwise.



Input: head = [1, 2, 2, 1]

Output: true



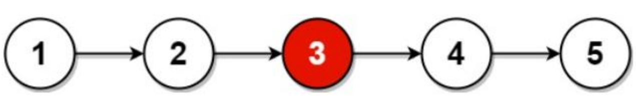
Input: head = [1, 2]

Output: false

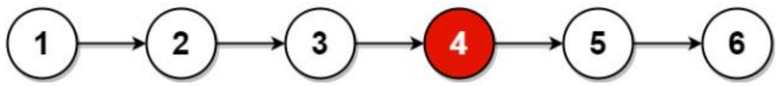
```python
# Definition for singly-linked list.
class ListNode:
   def __init__(self, val=0, next=None):
       self.val = val
       self.next = next

class Solution:
    def isPalindrome(self, head):
        # Write code here
         …
```

7.6 Middle of the Linked List

Given the head of a singly linked list, return the middle node of the linked list. If there are two middle nodes, return the second middle node.



Input: head = [1, 2, 3, 4, 5]
Output: [3, 4, 5]
Explanation: The middle node of the list is node 3.



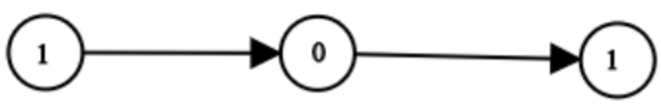
Input: head = [1, 2, 3, 4, 5, 6]
Output: [4, 5, 6]
Explanation: Since the list has two middle nodes with values 3 and 4, we return the second one.

```
# Definition for singly-linked list.
class ListNode:
   def __init__(self, val=0, next=None):
       self.val = val
       self.next = next

class Solution:
    def middleNode(self, head):
        # Write code here
         …
```

7.7 Convert Binary Number in a Linked List to Integer

Given head which is a reference node to a singly-linked list. The value of each node in the linked list is either 0 or 1. The linked list holds the binary representation of a number.

Return the decimal value of the number in the linked list. The most significant bit is at the head of the linked list.



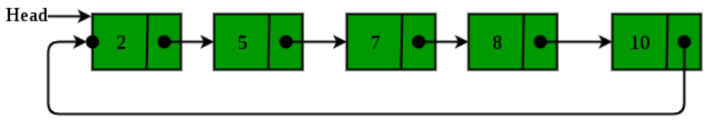
Input: head = [1, 0, 1]
Output: 5
Explanation: (101) in base 2 = (5) in base 10
Input: head = [0]
Output: 0

```
# Definition for singly-linked list.
class ListNode:
   def __init__(self, val=0, next=None):
       self.val = val
       self.next = next

class Solution:
    def getDecimalValue(self, head):
        # Write code here
         …
```

8. Circular Single Linked List and Doubly Linked List

8.1 Circular Linked List

The circular linked list is a linked list where all nodes are connected to form a circle. In a circular linked list, the first node and the last node are connected to each other which forms a circle. There is no NULL at the end.



Operations on the circular linked list:

1. Insertion at the beginning
2. Insertion at the end
3. Insertion in between the nodes
4. Deletion at the beginning
5. Deletion at the end
6. Deletion in between the nodes
7. Traversal

```
# Circular linked list operations

class Node:
    def __init__(self, data):
        self.data = data
        self.next = None

class CircularLinkedList:
    def __init__(self):
        self.last = None
    def addToEmpty(self, data):
        # Write code here
        …

    # add node to the front
    def addFront(self, data):
        # Write code here
        …

    # add node to the end
    def addEnd(self, data):
        # Write code here
        …

    # insert node after a specific node
    def addAfter(self, data, item):
        # Write code here
        …

    # delete a node
    def deleteNode(self, last, key):
        # Write code here
        …

    def traverse(self):
```

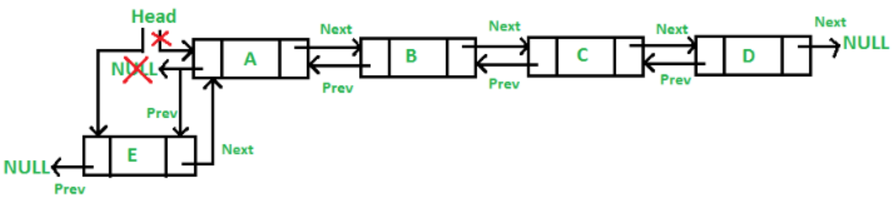
```
        # Write code here
        …
# Driver Code
cll = CircularLinkedList()

last = cll.addToEmpty(6)
last = cll.addEnd(8)
last = cll.addFront(2)
last = cll.addAfter(10, 2)

cll.traverse()
last = cll.deleteNode(last, 8)
print()
cll.traverse()
```

8.2 Doubly Linked List

The A doubly linked list is a type of linked list in which each node consists of 3 components:

1. *prev - address of the previous node
2. data - data item
3. *next - address of next node.

Double Linked List Node



Operations on the Double Linked List:

1. Insertion at the beginning
2. Insertion at the end
3. Insertion in between the nodes
4. Deletion at the beginning
5. Deletion at the end
6. Deletion in between the nodes
7. Traversal

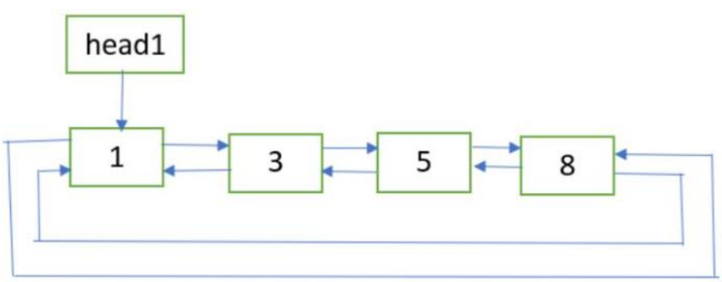
```
# Implementation of doubly linked list
class Node:
    def __init__(self,data):
        self.data=data
        self.next=self.prev=None

class DLinkedList:
    def __init__(self):
        self.head=None
        self.ctr=0
    def insert_beg(self,data):
        # Write code here
        …
    def insert_end(self,data):
        # Write code here
        …
    def delete_beg(self):
        # Write code here
        …
    def delete_end(self):
        # Write code here
        …
    def insert_pos(self,pos,data):
        # Write code here
        …
    def delete_pos(self,pos):
        # Write code here
        …
    def traverse_f(self):
        # Write code here
        …
    def traverse_r(self):
        # Write code here
        …

def menu():
    print("1.Insert at beginning")
    print("2.Insert at position")
    print("3.Insert at end")
    print("4.Delete at beginning")
    print("5.Delete at position")
    print("6.Delete at end")
    print("7.Count no of nodes")
    print("8.Traverse forward")
    print("9.Traverse reverse")
    print("10.Quit")
    ch=eval(input("Enter choice:"))
    return ch

print("******************Double linked list**************")
d=DLinkedList()
while True :
    ch=menu()
    if ch==1:
        data=eval(input("Enter data:"))
        d.insert_beg(data)

    elif ch==2:
        data=eval(input("Enter data:"))
```

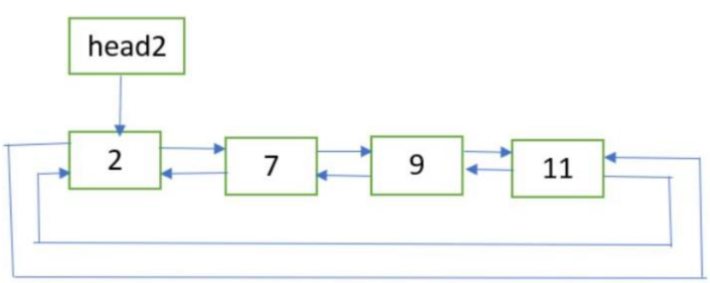
```
        pos=int(input("Enter position:"))
        d.insert_pos(pos,data)

    elif ch==3:
        data=eval(input("Enter data:"))
        d.insert_end(data)

    elif ch==4:
        d.delete_beg()

    elif ch==5:
        pos=int(input("Enter position:"))
        d.delete_pos(pos)

    elif ch==6:
        d.delete_end()

    elif ch==7:
        print("Number of nodes",d.ctr)

    elif ch==8:
        d.traverse_f()
    elif ch==9:
        d.traverse_r()

    else:
        print("Exit")
        break
```

8.3 Sorted Merge of Two Sorted Doubly Circular Linked Lists

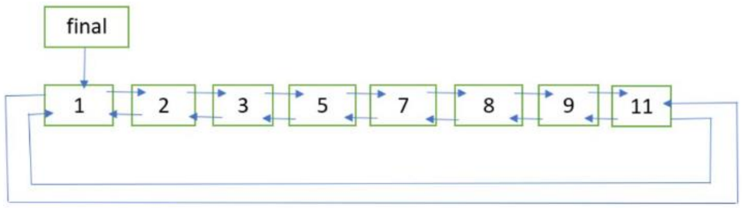
Given two sorted Doubly circular Linked List containing n1 and n2 nodes respectively. The problem is to merge the two lists such that resultant list is also in sorted order.

Input: List 1 and List 2





Output: Merged List



Procedure for Merging Doubly Linked List:

1. If head1 == NULL, return head2.
2. If head2 == NULL, return head1.
3. Let **last1** and **last2** be the last nodes of the two lists respectively. They can be obtained with the help of the previous links of the first nodes.
4. Get pointer to the node which will be the last node of the final list. If last1.data < last2.data, then **last_node** = last2, Else **last_node** = last1.
5. Update last1.next = last2.next = NULL.
6. Now merge the two lists as two sorted doubly linked list are being merged. Refer **merge** procedure of this post. Let the first node of the final list be **finalHead**.
7. Update finalHead.prev = last_node and last_node.next = finalHead.
8. Return **finalHead**.

```
# Implementation for Sorted merge of two sorted doubly circular linked list

import math

class Node:
    def __init__(self, data):
        self.data = data
        self.next = None
        self.prev = None

# A utility function to insert a new node at the beginning
# of doubly circular linked list
def insert(head_ref, data):
     # Write code here
     …
# function for Sorted merge of two sorted doubly linked list
def merge(first, second):
    # Write code here
    …
# function for Sorted merge of two sorted doubly circular linked list
def mergeUtil(head1, head2):
    # Write code here
    …
# function to print the list
def printList(head):
```

```
    # Write code here
    …
# Driver Code
head1 = None
head2 = None
# list 1:
head1 = insert(head1, 8)
head1 = insert(head1, 5)
head1 = insert(head1, 3)
head1 = insert(head1, 1)
# list 2:
head2 = insert(head2, 11)
head2 = insert(head2, 9)
head2 = insert(head2, 7)
head2 = insert(head2, 2)

newHead = mergeUtil(head1, head2)

print("Final Sorted List: ", end = "")
printList(newHead)
```

8.4 Delete all occurrences of a given key in a Doubly Linked List

Given a doubly linked list and a key x. The problem is to delete all occurrences of the given key x from the doubly linked list.

Input: 2 <-> 2 <-> 10 <-> 8 <-> 4 <-> 2 <-> 5 <-> 2
x = 2
Output: 10 <-> 8 <-> 4 <-> 5

Algorithm:
delAllOccurOfGivenKey (head_ref, x)

```
if head_ref == NULL
   return
Initialize current = head_ref
Declare next
while current != NULL
     if current->data == x
        next = current->next
        deleteNode(head_ref, current)
        current = next
     else
        current = current->next
```

```
# Implementation to delete all occurrences of a given key in a doubly linked list
import math

# a node of the doubly linked list
class Node:
    def __init__(self,data):
        self.data = data
        self.next = None
        self.prev = None

# Function to delete a node in a Doubly Linked List.
# head_ref --> pointer to head node pointer.
# del --> pointer to node to be deleted.
```

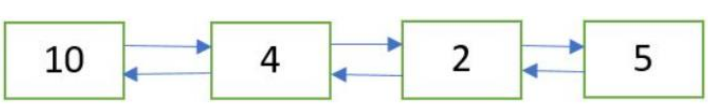
```python
def deleteNode(head, delete):
    # Write code here
    …

# function to delete all occurrences of the given key 'x'
def deleteAllOccurOfX(head, x):
    # Write code here
    …

# Function to insert a node at the beginning of the Doubly Linked List
def push(head,new_data):
    # Write code here
    …

# Function to print nodes in a given doubly linked list
def printList(head):
    # Write code here
    …

# Driver Code
# Start with the empty list
head = None
# Create the doubly linked list:
head = push(head, 2)
head = push(head, 5)
head = push(head, 2)
head = push(head, 4)
head = push(head, 8)
head = push(head, 10)
head = push(head, 2)
head = push(head, 2)
print("Original Doubly linked list:")
printList(head)
x = 2
# delete all occurrences of 'x'
head = deleteAllOccurOfX(head, x)
print("\nDoubly linked list after deletion of ",x,":")
printList(head)
```

8.5 Delete a Doubly Linked List Node at a Given Position

Given a doubly linked list and a position n. The task is to delete the node at the given position n from the beginning.

Input: Initial doubly linked list

Output: Doubly Linked List after deletion of node at position n = 2



Procedure:

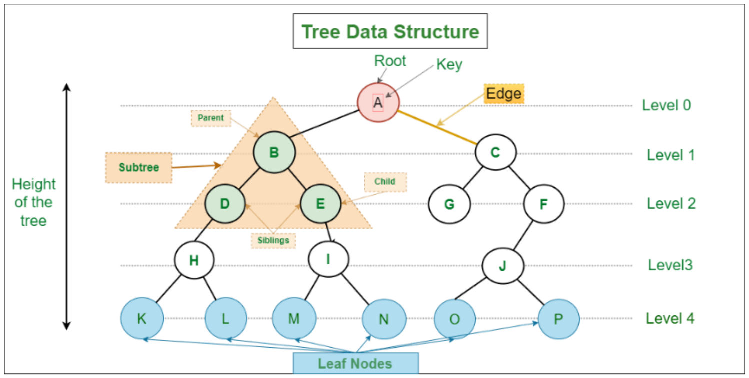
1. Get the pointer to the node at position n by traversing the doubly linked list up to the nth node from the beginning.
2. Delete the node using the pointer obtained in Step 1.

```
# Python implementation to delete a doubly Linked List node
# at the given position

# A node of the doubly linked list
class Node:

    # Constructor to create a new node
    def __init__(self, data):
        self.data = data
        self.next = None
        self.prev = None

# Function to delete a node in a Doubly Linked List.
# head_ref -. pointer to head node pointer.
# del -. pointer to node to be deleted.
def deleteNode(head_ref, del_):
    # Write code here
    …

# Function to delete the node at the given position
# in the doubly linked list
def deleteNodeAtGivenPos(head_ref, n):
    # Write code here
    …

# Function to insert a node at the beginning of the Doubly Linked List
def push(head_ref, new_data):
    # Write code here
    …

# Function to print nodes in a given doubly linked list
def printList(head):
    # Write code here
    …
# Driver Code
# Start with the empty list
head = None
head = push(head, 5)
head = push(head, 2)
head = push(head, 4)
head = push(head, 8)
head = push(head, 10)
print("Doubly linked list before deletion:")
printList(head)

n = 2

# delete node at the given position 'n'
head = deleteNodeAtGivenPos(head, n)
print("\nDoubly linked list after deletion:")
printList(head)
```

9. Trees

9.1 Tree Creation and Basic Tree Terminologies

A tree data structure is a hierarchical structure that is used to represent and organize data in a way that is easy to navigate and search. It is a collection of nodes that are connected by edges and has a hierarchical relationship between the nodes.



Basic Terminologies in Tree:

1. **Parent Node:** The node which is a predecessor of a node is called the parent node of that node. {B} is the parent node of {D, E}.
2. **Child Node:** The node which is the immediate successor of a node is called the child node of that node. Examples: {D, E} are the child nodes of {B}.
3. **Root Node:** The topmost node of a tree or the node which does not have any parent node is called the root node. {A} is the root node of the tree. A non-empty tree must contain exactly one root node and exactly one path from the root to all other nodes of the tree.
4. **Leaf Node or External Node:** The nodes which do not have any child nodes are called leaf nodes. {K, L, M, N, O, P} are the leaf nodes of the tree.
5. **Ancestor of a Node:** Any predecessor nodes on the path of the root to that node are called Ancestors of that node. {A, B} are the ancestor nodes of the node {E}
6. **Descendant:** Any successor node on the path from the leaf node to that node. {E, I} are the descendants of the node {B}.
7. **Sibling:** Children of the same parent node are called siblings. {D, E} are called siblings.
8. **Level of a node:** The count of edges on the path from the root node to that node. The root node has level 0.
9. **Internal node:** A node with at least one child is called Internal Node.
10. **Neighbour of a Node:** Parent or child nodes of that node are called neighbors of that node.
11. **Subtree:** Any node of the tree along with its descendant.

```
# Demonstration of Tree Basic Terminologies
# Function to add an edge between vertices x and y

# Function to print the parent of each node
def printParents(node, adj, parent):
```

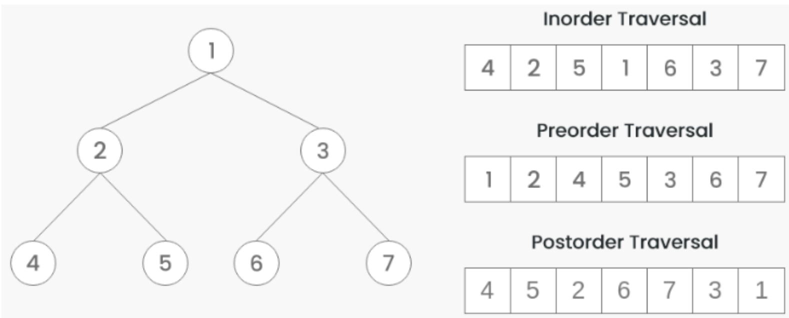
```
    # Write code here
    …

# Function to print the children of each node
def printChildren(Root, adj):
    # Write code here
    …

# Function to print the leaf nodes
def printLeafNodes(Root, adj):
    # Write code here
    …

# Function to print the degrees of each node
def printDegrees(Root, adj):
    # Write code here
    …

# Driver code
# Number of nodes
N = 7
Root = 1

# Adjacency list to store the tree
adj = []
for i in range(0, N+1):
    adj.append([])

# Creating the tree
adj[1].append(2)
adj[2].append(1)

adj[1].append(3)
adj[3].append(1)

adj[1].append(4)
adj[4].append(1)

adj[2].append(5)
adj[5].append(2)

adj[2].append(6)
adj[6].append(2)

adj[4].append(7)
adj[7].append(4)

# Printing the parents of each node
print("The parents of each node are:")
printParents(Root, adj, 0)
# Printing the children of each node
print("The children of each node are:")
printChildren(Root, adj)

# Printing the leaf nodes in the tree
print("The leaf nodes of the tree are:")
printLeafNodes(Root, adj)

# Printing the degrees of each node
```

```
print("The degrees of each node are:")
printDegrees(Root, adj)
```

9.2 Binary Tree Traversal Techniques

A binary tree data structure can be traversed in following ways:

1. Inorder Traversal
2. Preorder Traversal
3. Postorder Traversal
4. Level Order Traversal



Algorithm Inorder (tree)

1. Traverse the left subtree, i.e., call Inorder(left->subtree)
2. Visit the root.
3. Traverse the right subtree, i.e., call Inorder(right->subtree)

Algorithm Preorder (tree)

1. Visit the root.
2. Traverse the left subtree, i.e., call Preorder(left->subtree)
3. Traverse the right subtree, i.e., call Preorder(right->subtree)

Algorithm Postorder (tree)

1. Traverse the left subtree, i.e., call Postorder(left->subtree)
2. Traverse the right subtree, i.e., call Postorder(right->subtree)
3. Visit the root.

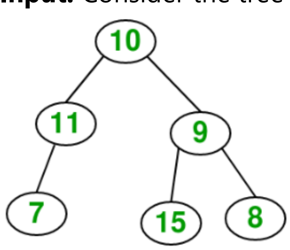
```
# Program to create a binary tree and print traversal orders
class Node:
    def __init__(self,data):
        self.data=data
        self.l=None
        self.r=None

class BT:
    def __init__(self):
        self.root=None

    def insert(self,n):
        # Write code here
        …


      def postorder(self,root):
```

```
        # Write code here
        …

    def preorder(self,root):
        # Write code here
        …

    def inorder(self,root):
        # Write code here
        …

# Driver code
b=BT()
print("*****************TREE USING DOUBLE LINKED LIST************************")
while True:
    print("1.Insert data to tree")
    print("2.Post Order Traversal")
    print("3.Pre Order Traversal")
    print("4.In Order Traversal")
    print("5.Exit")
    ch=int(input("Enter choice:"))
    if ch==1:
        n=int(input("Enter number of nodes:"))
        b.insert(n)
    elif ch==2:
        b.postorder(b.root)
    elif ch==3:
        b.preorder(b.root)
    elif ch==4:
        b.inorder(b.root)
    else:
        print("Exit")
        break
```

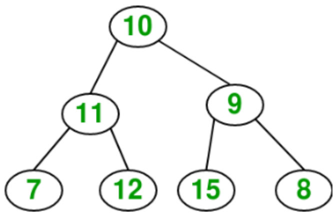
9.3 Insertion in a Binary Tree in Level Order

Given a binary tree and a key, insert the key into the binary tree at the first position available in level order.

Input: Consider the tree given below



Output:



After inserting 12

The idea is to do an iterative level order traversal of the given tree using queue. If we find a node whose left child is empty, we make a new key as the left child of the node. Else if we find a node whose right child is empty, we make the new key as the right child. We keep traversing the tree until we find a node whose either left or right child is empty.

```
# Insert element in binary tree
class newNode():
    def __init__(self, data):
        self.key = data
        self.left = None
        self.right = None

# Inorder traversal of a binary tree
def inorder(temp):
    # Write code here
    …
```

```
# function to insert element in binary tree
def insert(temp,key):
   # Write code here
   …
```

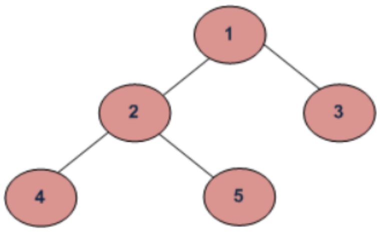
```
# Driver code
root = newNode(10)
root.left = newNode(11)
root.left.left = newNode(7)
root.right = newNode(9)
root.right.left = newNode(15)
root.right.right = newNode(8)
print("Inorder traversal before insertion:", end = " ")
inorder(root)

key = 12
insert(root, key)

print()
print("Inorder traversal after insertion:", end = " ")
inorder(root)
```

9.4 Finding the Maximum Height or Depth of a Binary Tree

Given a binary tree, the task is to find the height of the tree. The height of the tree is the number of edges in the tree from the root to the deepest node.

Note: The height of an empty tree is 0.

Input: Consider the tree below



Recursively calculate the height of the left and the right subtrees of a node and assign height to the node as max of the heights of two children plus 1.

maxDepth('1') = max(maxDepth('2'), maxDepth('3')) + 1 = 2 + 1
because recursively
maxDepth('2') = max (maxDepth('4'), maxDepth('5')) + 1 = 1 + 1 and (as height of both '4' and '5' are 1)
maxDepth('3') = 1

Procedure:

- Recursively do a Depth-first search.
- If the tree is empty then return 0
- Otherwise, do the following
  - Get the max depth of the left subtree recursively i.e. call maxDepth(tree->left-subtree)
  - Get the max depth of the right subtree recursively i.e. call maxDepth(tree->right-subtree)
  - Get the max of max depths of left and right subtrees and add 1 to it for the current node.

$$max_depth = max(maxdeptofleftsubtree, maxdepthofrightsubtree) + 1$$

  - Return max_depth.

```
# Find the maximum depth of tree
# A binary tree node
class Node:
    # Constructor to create a new node
    def __init__(self, data):
        self.data = data
        self.left = None
        self.right = None

# Compute the "maxDepth" of a tree -- the number of nodes
# along the longest path from the root node down to the farthest leaf node

def maxDepth(node):
    # Write code here
    …

# Driver program to test above function
root = Node(1)
```

```
root.left = Node(2)
root.right = Node(3)
root.left.left = Node(4)
root.left.right = Node(5)
print("Height of tree is %d" % (maxDepth(root)))
```

9.5 Deletion in a Binary Tree

Given a binary tree, delete a node from it by making sure that the tree shrinks from the bottom (i.e. the deleted node is replaced by the bottom-most and rightmost node).

Input: Delete 10 in below tree

```
     10
   /    \
 20     30
```

Output:

```
     30
   /
 20
```

Input: Delete 20 in below tree

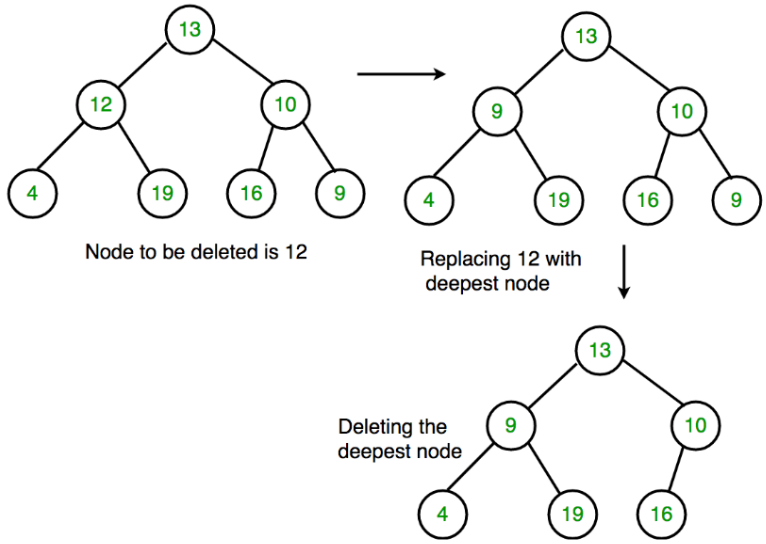
```
     10
   /    \
 20     30
          \
          40
```

Output:

```
     10
  /     \
40       30
```

Algorithm:

1. Starting at the root, find the deepest and rightmost node in the binary tree and the node which we want to delete.
2. Replace the deepest rightmost node's data with the node to be deleted.
3. Then delete the deepest rightmost node.




```
# Deletion in a Binary Tree

# Create a node with data, left child and right child.

class Node:
    def __init__(self, data):
        self.data = data
        self.left = None
        self.right = None

# Inorder traversal of a binary tree
def inorder(temp):
    # Write code here
    …

# function to delete the given deepest node (d_node) in binary tree
def deleteDeepest(root, d_node):
    # Write code here
    …

# function to delete element in binary tree
def deletion(root, key):
    # Write code here
    …

# Driver code
root = Node(10)
root.left = Node(11)
root.left.left = Node(7)
root.left.right = Node(12)
root.right = Node(9)
root.right.left = Node(15)
root.right.right = Node(8)
print("The tree before the deletion: ", end = "")
inorder(root)
key = 11
root = deletion(root, key)
print();
print("The tree after the deletion: ", end = "")
inorder(root)
```

10. Binary Search Tree (BST)

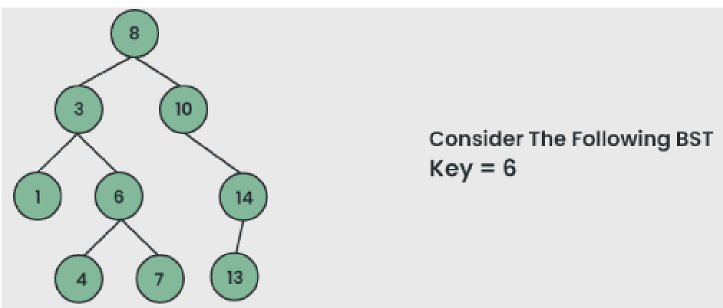
10.1 Searching in Binary Search Tree

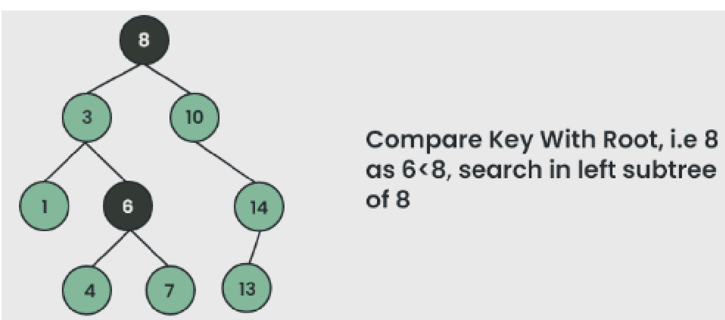
Given a BST, the task is to delete a node in this BST. For searching a value in BST, consider it as a sorted array. Perform search operation in BST using Binary Search Algorithm.

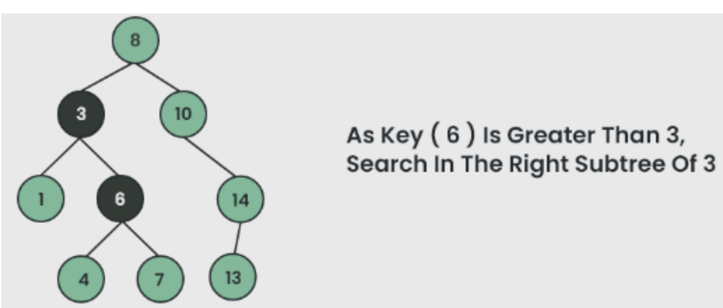
Algorithm to search for a key in a given Binary Search Tree:

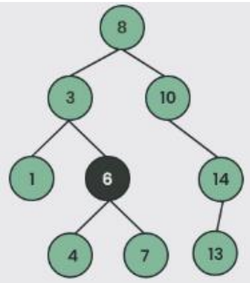
Let's say we want to search for the number **X,** We start at the root. Then:

- We compare the value to be searched with the value of the root.
- If it's equal we are done with the search if it's smaller we know that we need to go to the left subtree because in a binary search tree all the elements in the left subtree are smaller and all the elements in the right subtree are larger.
- Repeat the above step till no more traversal is possible
- If at any iteration, key is found, return True. Else False.









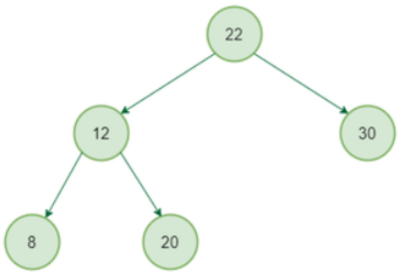
As 6 Is Equal To Key (6), So We Have Found The Key

```
# Search a given key in a given BST

class Node:
    # Constructor to create a new node
    def __init__(self, key):
        self.key = key
        self.left = None
        self.right = None

# A utility function to insert
# a new node with the given key in BST
def insert(node, key):
    # Write code here
    …

# Utility function to search a key in a BST
def search(root, key):
    # Write code here
    …

# Driver Code
root = None
root = insert(root, 50)
insert(root, 30)
insert(root, 20)
insert(root, 40)
insert(root, 70)
insert(root, 60)
insert(root, 80)
# Key to be found
key = 6

# Searching in a BST
if search(root, key) is None:
    print(key, "not found")

else:
    print(key, "found")

key = 60

# Searching in a BST
if search(root, key) is None:
    print(key, "not found")
else:
    print(key, "found")
```

10.2 Find the node with Minimum Value in a BST

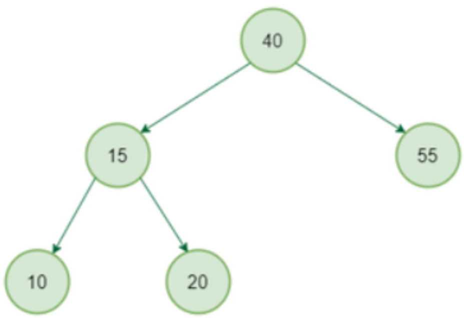
Write a function to find the node with minimum value in a Binary Search Tree.

Input: Consider the tree given below



Output: 8

Input: Consider the tree given below



Output: 10

```
from typing import List
class Node:
    def __init__(self, data):
        self.data = data
        self.left = None
        self.right = None

# Give a binary search tree and a number, inserts a new node with the given number
# in the correct place in the tree. Returns the new root pointer
def insert(node: Node, data: int) -> Node:
    # Write code here
    …
# Given a non-empty binary search tree, inorder traversal for
# the tree is stored in the list sorted_inorder. Inorder is LEFT, ROOT, RIGHT.

def inorder(node: Node, sorted_inorder: List[int]) -> None:
    # Write code here
    …
# Driver Code
root = None
root = insert(root, 4)
insert(root, 2)
insert(root, 1)
insert(root, 3)
insert(root, 6)
```

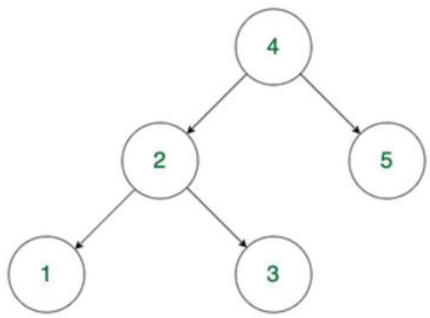
```
insert(root, 4)
insert(root, 5)
sorted_inorder = []
inorder(root, sorted_inorder)  # calling the recursive function

# Values of all nodes will appear in sorted order in the list sorted_inorder
print(f"Minimum value in BST is {sorted_inorder[0]}")
```

10.3 Check if a Binary Tree is BST or not

A binary search tree (BST) is a node-based binary tree data structure that has the following properties.

1. The left subtree of a node contains only nodes with keys less than the node's key.
2. The right subtree of a node contains only nodes with keys greater than the node's key.
3. Both the left and right subtrees must also be binary search trees.
4. Each node (item in the tree) has a distinct key.

Input: Consider the tree given below



Output: Check if max value in left subtree is smaller than the node and min value in right subtree greater than the node, then print it "Is BST" otherwise "Not a BST"

Procedure:

1. If the current node is null then return true
2. If the value of the left child of the node is greater than or equal to the current node then return false
3. If the value of the right child of the node is less than or equal to the current node then return false
4. If the left subtree or the right subtree is not a BST then return false
5. Else return true

```
# Program to check if a binary tree is BST or not
# A binary tree node has data, pointer to left child and a pointer to right child

class Node:
     def __init__(self, data):
        self.data = data
        self.left = None
        self.right = None

def maxValue(node):
    # Write code here
    …

def minValue(node):
    # Write code here
    …
```

```
# Returns true if a binary tree is a binary search tree
def isBST(node):
    # Write code here
    …

# Driver code
root = Node(4)
root.left = Node(2)
root.right = Node(5)
# root.right.left = Node(7)
root.left.left = Node(1)
root.left.right = Node(3)

# Function call
if isBST(root) is True:
    print("Is BST")
else:
    print("Not a BST")
```

10.4 Second Largest Element in BST

Given a Binary search tree (BST), find the second largest element.

Input: Root of below BST

```
     10
    /
   5
```

Output: 5

Input: Root of below BST

```
     10

    /  \

   5    20

          \

           30
```

Output: 20

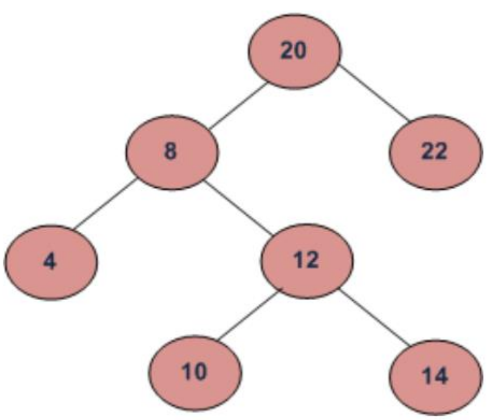
Procedure: The second largest element is second last element in inorder traversal and second element in reverse inorder traversal. We traverse given Binary Search Tree in reverse inorder and keep track of counts of nodes visited. Once the count becomes 2, we print the node.

```
# Find the second largest element in
class Node:

    # Constructor to create a new node
    def __init__(self, data):
        self.key = data
```

```
        self.left = None
        self.right = None

# A function to find 2nd largest element in a given tree.
def secondLargestUtil(root, c):
    # Write code here
    …
# Function to find 2nd largest element
def secondLargest(root):
    # Write code here
    …

# A utility function to insert a new node with given key in BST
def insert(node, key):

# Driver Code
# Let us create following BST
#       50
#     /    \
#    30     70
#   / \     / \
#  20  40  60  80

root = None
root = insert(root, 50)
insert(root, 30)
insert(root, 20)
insert(root, 40)
insert(root, 70)
insert(root, 60)
insert(root, 80)
secondLargest(root)
```

Try:

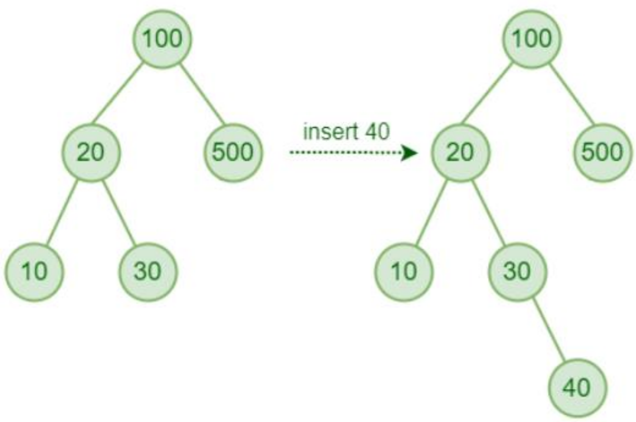
1. **Kth largest element in BST when modification to BST is not allowed:** Given a Binary Search Tree (BST) and a positive integer k, find the k'th largest element in the Binary Search Tree. For a given BST, if k = 3, then output should be 14, and if k = 5, then output should be 10.



10.5 Insertion in Binary Search Tree (BST)

Given a Binary search tree (BST), the task is to insert a new node in this BST.

Input: Consider a BST and insert the element 40 into it.



Procedure for inserting a value in a BST:

A new key is always inserted at the leaf by maintaining the property of the binary search tree. We start searching for a key from the root until we hit a leaf node. Once a leaf node is found, the new node is added as a child of the leaf node. The below steps are followed while we try to insert a node into a binary search tree:

- Check the value to be inserted (say X) with the value of the current node (say val) we are in:
    - If X is less than val move to the left subtree.
    - Otherwise, move to the right subtree.
    - Once the leaf node is reached, insert X to its right or left based on the relation between X and the leaf node's value.

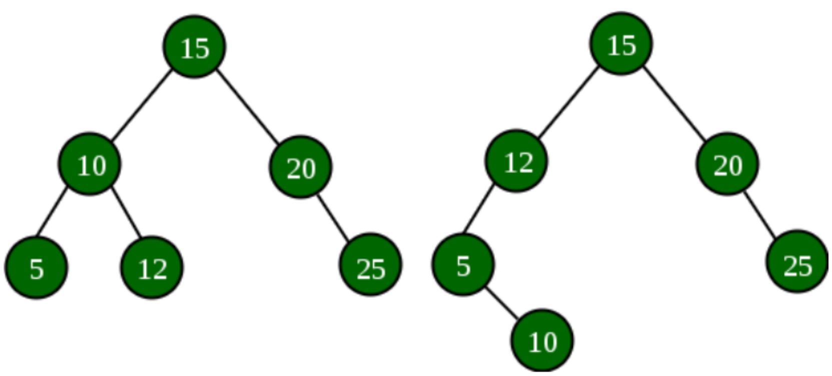
```
# insert operation in binary search tree
# A utility class that represents an individual node in a BST
class Node:
    def __init__(self, key):
        self.left = None
        self.right = None
        self.val = key

 # A utility function to insert a new node with the given key
def insert(root, key):
    # Write code here
    …

 # A utility function to do inorder tree traversal
def inorder(root):
    # Write code here
    …

# Driver code
# Let us create the following BST
```

```
#       50
#     /     \
#    30     70
#   / \     / \
#  20 40   60 80
r = Node(50)
r = insert(r, 30)
r = insert(r, 20)
r = insert(r, 40)
r = insert(r, 70)
r = insert(r, 60)
r = insert(r, 80)

# Print inorder traversal of the BST
inorder(r)
```

Try:

1. **Check if two BSTs contain same set of elements:** Given two Binary Search Trees consisting of unique positive elements, we have to check whether the two BSTs contain the same set of elements or not.

Input: Consider two BSTs which contains same set of elements {5, 10, 12, 15, 20, 25}, but the structure of the two given BSTs can be different.



11. AVL Tree

11.1 Insertion in an AVL Tree

AVL tree is a self-balancing Binary Search Tree (BST) where the difference between heights of left and right subtrees cannot be more than one for all nodes. To make sure that the given tree remains AVL after every insertion, we must augment the standard BST insert operation to perform some re-balancing. Following are two basic operations that can be performed to balance a BST without violating the BST property (keys(left) < key(root) < keys(right)).

- Left Rotation
- Right Rotation

T1, T2 and T3 are subtrees of the tree, rooted with y (on the left side) or x (on the right side)

```
    y                                    x
   / \     Right Rotation              /   \
  x    T3  - - - - - - - >           T1     y
 / \       < - - - - - - -                 / \
T1  T2     Left Rotation                  T2  T3
```

Keys in both of the above trees follow the following order

keys(T1) < key(x) < keys(T2) < key(y) < keys(T3)

So BST property is not violated anywhere.

Procedure for inserting a node into an AVL tree
Let the newly inserted node be w

- Perform standard BST insert for w.
- Starting from w, travel up and find the first unbalanced node. Let z be the first unbalanced node, y be the child of z that comes on the path from w to z and x be the grandchild of z that comes on the path from w to z.
- Re-balance the tree by performing appropriate rotations on the subtree rooted with z. There can be 4 possible cases that need to be handled as x, y and z can be arranged in 4 ways.
- Following are the possible 4 arrangements:
    - y is the left child of z and x is the left child of y (Left Left Case)
    - y is the left child of z and x is the right child of y (Left Right Case)
    - y is the right child of z and x is the right child of y (Right Right Case)
    - y is the right child of z and x is the left child of y (Right Left Case)

```
# Insert a node in AVL tree

# Generic tree node class
class TreeNode(object):
    def __init__(self, val):
        self.val = val
        self.left = None
        self.right = None
        self.height = 1

# AVL tree class which supports the insert operation
class AVL_Tree(object):

    # Recursive function to insert key in subtree rooted with node and returns
    # new root of subtree.
    def insert(self, root, key):
        # Write code here
        …
```

```
    def leftRotate(self, z):
        # Write code here
        …

    def rightRotate(self, z):
        # Write code here
        …

    def getHeight(self, root):
        # Write code here
        …

    def getBalance(self, root):
        # Write code here
        …

    def preOrder(self, root):
        # Write code here
        …

# Driver code
myTree = AVL_Tree()
root = None

root = myTree.insert(root, 10)
root = myTree.insert(root, 20)
root = myTree.insert(root, 30)
root = myTree.insert(root, 40)
root = myTree.insert(root, 50)
root = myTree.insert(root, 25)

"""The constructed AVL Tree would be
            30
           /  \
         20   40
        /  \     \
       10  25    50"""

# Preorder Traversal
print("Preorder traversal of the",
      "constructed AVL tree is")
myTree.preOrder(root)
print()
```

11.2 Deletion in an AVL Tree

Given an AVL tree, make sure that the given tree remains AVL after every deletion, we must augment the standard BST delete operation to perform some re-balancing. Following are two basic operations that can be performed to re-balance a BST without violating the BST property (keys(left) < key(root) < keys(right)).

1. Left Rotation
2. Right Rotation

T1, T2 and T3 are subtrees of the tree rooted with y (on left side)
or x (on right side)

```
     y                               x
    / \     Right Rotation          /  \
   x   T3   - - - - - - - >        T1   y
  / \       < - - - - - - -            / \
 T1  T2     Left Rotation            T2  T3
```

Keys in both of the above trees follow the following order
keys(T1) < key(x) < keys(T2) < key(y) < keys(T3)
So BST property is not violated anywhere.

Procedure to delete a node from AVL tree:

Let w be the node to be deleted

1. Perform standard BST delete for w.

2. Starting from w, travel up and find the first unbalanced node. Let z be the first unbalanced node, y be the larger height child of z, and x be the larger height child of y. Note that the definitions of x and y are different from insertion here.

3. Re-balance the tree by performing appropriate rotations on the subtree rooted with z. There can be 4 possible cases that needs to be handled as x, y and z can be arranged in 4 ways. Following are the possible 4 arrangements:

   i. y is left child of z and x is left child of y (Left Left Case)

   ii. y is left child of z and x is right child of y (Left Right Case)

   iii. y is right child of z and x is right child of y (Right Right Case)

   iv. y is right child of z and x is left child of y (Right Left Case)

```
# delete a node in AVL tree

class TreeNode(object):
    def __init__(self, val):
        self.val = val
        self.left = None
        self.right = None
        self.height = 1

# AVL tree class which supports insertion, deletion operations
class AVL_Tree(object):

    def insert(self, root, key):
        # Write code here
        …

    # Recursive function to delete a node with given key from subtree
    # with given root. It returns root of the modified subtree.
    def delete(self, root, key):
        # Write code here
        …
```

```
    def leftRotate(self, z):
        # Write code here
        …

    def rightRotate(self, z):
        # Write code here
        …

    def getHeight(self, root):
        # Write code here
        …

    def getBalance(self, root):
        # Write code here
        …

    def getMinValueNode(self, root):
        # Write code here
        …

    def preOrder(self, root):
        # Write code here
        …

myTree = AVL_Tree()
root = None
nums = [9, 5, 10, 0, 6, 11, -1, 1, 2]

for num in nums:
    root = myTree.insert(root, num)


# Preorder Traversal
print("Preorder Traversal after insertion -")
myTree.preOrder(root)
print()

# Delete
key = 10
root = myTree.delete(root, key)

# Preorder Traversal
print("Preorder Traversal after deletion -")
myTree.preOrder(root)
print()
```

11.3 Count Greater Nodes in AVL Tree

Given an AVL tree, calculate number of elements which are greater than given value in AVL tree.

Input: x = 5

Root of below AVL tree

```
  9
 / \
1   10
```

```
   / \   \
  0   5   11
 /   / \
-1   2   6
```

Output: 4

Explanation: There are 4 values which are greater than 5 in AVL tree which are 6, 9, 10 and 11.

```
# Count greater nodes in an AVL tree

class Node:
    def __init__(self, key):
        self.key = key
        self.left = None
        self.right = None
        self.height = 1
        self.desc = 0

 def height(N):
    if N is None:
        return 0
    return N.height

# A utility function to get maximum of two integers

def max(a, b):
    if a > b:
        return a
    return b

def newNode(key):
    # Write code here
    …

# A utility function to right rotate subtree rooted with y

def rightRotate(y):
    # Write code here
    …

def leftRotate(x):
    # Write code here
    …
def getBalance(N):
    # Write code here
    …

def insert(root, key):
    # Write code here
    …

def minValueNode(node):
    # Write code here
    …
```

```
# Recursive function to delete a node with given key # from subtree with given root. It returns root of the modified subtree.

def deleteNode(root, key):
    # Write code here
    …

def preOrder(root):
    # Write code here
    …

def CountGreater(root, x):
    # Write code here
    …

# Driver program to test above function
root = None
root = insert(root, 9)
root = insert(root, 5)
root = insert(root, 10)
root = insert(root, 0)
root = insert(root, 6)
root = insert(root, 11)
root = insert(root, -1)
root = insert(root, 1)
root = insert(root, 2)

print("Preorder traversal of the constructed AVL tree is")
preOrder(root)

print("Number of elements greater than 9 are")
print(CountGreater(root, 9))

root = deleteNode(root, 10)

print("Preorder traversal after deletion of 10")
preOrder(root)
print('Number of elements greater than 9 are')
print(CountGreater(root, 9))
```

11.4 Minimum Number of Nodes in an AVL Tree with given Height

Given the height of an AVL tree 'h', the task is to find the minimum number of nodes the tree can have.

Input: H = 0

Output: N = 1

Only '1' node is possible if the height
of the tree is '0' which is the root node.

Input: H = 3

Output: N = 7

Recursive approach:
In an AVL tree, we have to maintain the height balance property, i.e. difference in the height of the left and the right subtrees cannot be other than -1, 0 or 1 for each node.

We will try to create a recurrence relation to find minimum number of nodes for a given height, n(h).

- For height = 0, we can only have a single node in an AVL tree, i.e. n(0) = 1
- For height = 1, we can have a minimum of two nodes in an AVL tree, i.e. n(1) = 2
- Now for any height 'h', root will have two subtrees (left and right). Out of which one has to be of height h-1 and other of h-2. [root node excluded]
- So, n(h) = 1 + n(h-1) + n(h-2) is the required recurrence relation for h>=2 [1 is added for the root node]

```
# Function to find minimum number of nodes

def AVLnodes(height):
    # Write code here
    …
# Driver Code
H = 3
print(AVLnodes(H))
```

12. Graph Traversal

12.1 Breadth First Search

The **Breadth First Search (BFS)** algorithm is used to search a graph data structure for a node that meets a set of criteria. It starts at the root of the graph and visits all nodes at the current depth level before moving on to the nodes at the next depth level.
For a given graph G, print BFS traversal from a given source vertex.

```
# BFS traversal from a given source vertex.

from collections import defaultdict
 # This class represents a directed graph using adjacency list representation
class Graph:

    # Constructor
    def __init__(self):
        # Default dictionary to store graph
        self.graph = defaultdict(list)

    # Function to add an edge to graph
    def addEdge(self, u, v):
        self.graph[u].append(v)

    # Function to print a BFS of graph
    def BFS(self, s):
       # Write code here
       …

# Create a graph given in the above diagram
g = Graph()
g.addEdge(0, 1)
g.addEdge(0, 2)
g.addEdge(1, 2)
g.addEdge(2, 0)
g.addEdge(2, 3)
```

```
g.addEdge(3, 3)

print("Following is Breadth First Traversal" " (starting from vertex 2)")
g.BFS(2)
```

Output: Following is Breadth First Traversal (starting from vertex 2)
2 0 3 1

12.2 Depth First Search

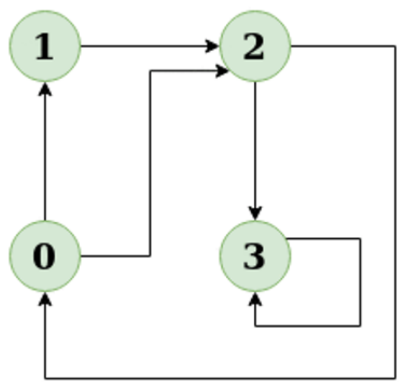
Depth First Traversal (or DFS) for a graph is similar to Depth First Traversal of a tree. The only catch here is, that, unlike trees, graphs may contain cycles (a node may be visited twice). To avoid processing a node more than once, use a boolean visited array. A graph can have more than one DFS traversal.

For a given graph G, print DFS traversal from a given source vertex.

Input: n = 4, e = 6
0 -> 1, 0 -> 2, 1 -> 2, 2 -> 0, 2 -> 3, 3 -> 3

Output: DFS from vertex 1: 1 2 0 3

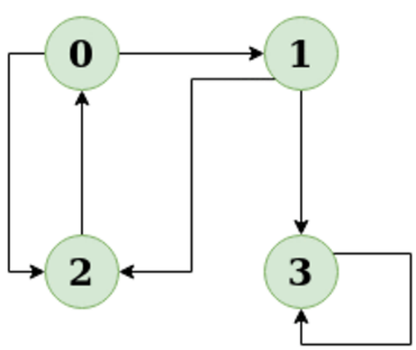
Explanation:
DFS Diagram:



Input: n = 4, e = 6
2 -> 0, 0 -> 2, 1 -> 2, 0 -> 1, 3 -> 3, 1 -> 3

Output: DFS from vertex 2: 2 0 1 3

Explanation:
DFS Diagram:



```python
# DFS traversal from a given graph
from collections import defaultdict

# This class represents a directed graph using adjacency list representation
class Graph:
    # Constructor
    def __init__(self):
        # Default dictionary to store graph
        self.graph = defaultdict(list)

    # Function to add an edge to graph
    def addEdge(self, u, v):
        self.graph[u].append(v)
    # A function used by DFS
    def DFSUtil(self, v, visited):
        # Write code here
        …

    # The function to do DFS traversal. It uses recursive DFSUtil()

    def DFS(self, v):
      # Write code here
      …
# Driver's code
g = Graph()
g.addEdge(0, 1)
g.addEdge(0, 2)
g.addEdge(1, 2)
g.addEdge(2, 0)
g.addEdge(2, 3)
g.addEdge(3, 3)
print("Following is Depth First Traversal (starting from vertex 2)")
# Function call
g.DFS(2)
```

12.3 Best First Search (Informed Search)

The idea of Best First Search is to use an evaluation function to decide which adjacent is most promising and then explore. Best First Search falls under the category of Heuristic Search or Informed Search.

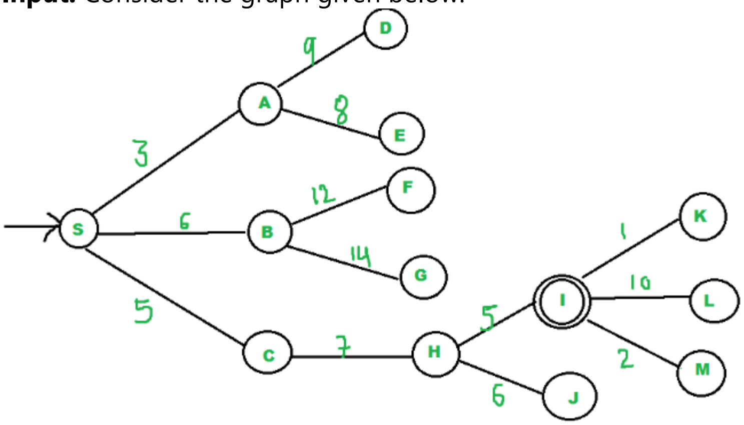
Implementation of Best First Search:
We use a priority queue or heap to store the costs of nodes that have the lowest evaluation function value. So the implementation is a variation of BFS, we just need to change Queue to PriorityQueue.

Algorithm:
Best-First-Search(Graph g, Node start)

```
1) Create an empty PriorityQueue
   PriorityQueue pq;
2) Insert "start" in pq.
   pq.insert(start)
3) Until PriorityQueue is empty
     u = PriorityQueue.DeleteMin
     If u is the goal
        Exit
     Else
        Foreach neighbor v of u
           If v "Unvisited"
```

Mark v "Visited"
pq.insert(v)
Mark u "Examined"
End procedure

Input: Consider the graph given below.



- We start from source “S” and search for goal “I” using given costs and Best First search.
- pq initially contains S
    - We remove S from pq and process unvisited neighbors of S to pq.
    - pq now contains {A, C, B} (C is put before B because C has lesser cost)
- We remove A from pq and process unvisited neighbors of A to pq.
    - pq now contains {C, B, E, D}
- We remove C from pq and process unvisited neighbors of C to pq.
    - pq now contains {B, H, E, D}
- We remove B from pq and process unvisited neighbors of B to pq.
    - pq now contains {H, E, D, F, G}
- We remove H from pq.
- Since our goal “I” is a neighbor of H, we return.

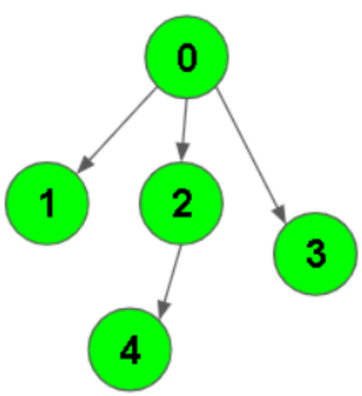
```
from queue import PriorityQueue
v = 14
graph = [[] for i in range(v)]

# Function For Implementing Best First Search
# Gives output path having lowest cost

def best_first_search(actual_Src, target, n):
```

```
    # Write code here
    …
# Function for adding edges to graph
def addedge(x, y, cost):
    # Write code here
    …
# The nodes shown in above example(by alphabets) are
# implemented using integers addedge(x,y,cost);
addedge(0, 1, 3)
addedge(0, 2, 6)
addedge(0, 3, 5)
addedge(1, 4, 9)
addedge(1, 5, 8)
addedge(2, 6, 12)
addedge(2, 7, 14)
addedge(3, 8, 7)
addedge(8, 9, 5)
addedge(8, 10, 6)
addedge(9, 11, 1)
addedge(9, 12, 10)
addedge(9, 13, 2)

source = 0
target = 9
best_first_search(source, target, v)
```

12.4 Breadth First Traversal of a Graph

Given a directed graph. The task is to do Breadth First Traversal of this graph starting from 0.
One can move from node u to node v only if there's an edge from u to v. Find the BFS traversal of the graph starting from the 0th vertex, from left to right according to the input graph. Also, you should only take nodes directly or indirectly connected from Node 0 in consideration.

Input: Consider the graph given below where V = 5, E = 4, edges = {(0,1), (0,2), (0,3), (2,4)}



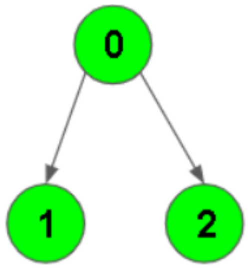
Output: 0 1 2 3 4

Explanation:

0 is connected to 1, 2, and 3.

2 is connected to 4.
So starting from 0, it will go to 1 then 2 then 3. After this 2 to 4, thus BFS will be 0 1 2 3 4.

Input: Consider the graph given below where V = 3, E = 2, edges = {(0, 1), (0, 2)}



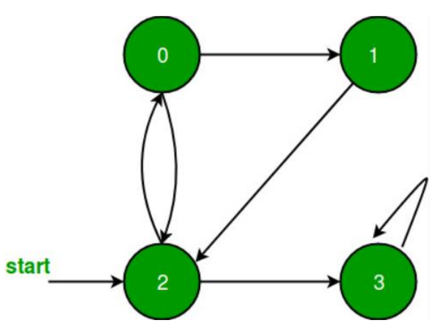
Output: 0 1 2
Explanation:
0 is connected to 1, 2. So starting from 0, it will go to 1 then 2, thus BFS will be 0 1 2.
Your task is to complete the function **bfsOfGraph()** which takes the integer V denoting the number of vertices and adjacency list as input parameters and returns a list containing the BFS traversal of the graph starting from the 0th vertex from left to right.

```
from typing import List
from queue import Queue
class Solution:

    # Function to return Breadth First Traversal of given graph.
    def bfsOfGraph(self, V: int, adj: List[List[int]]) -> List[int]:
        # Write code here
         …
# Driver Code
T=int(input())
for i in range(T):
      V, E = map(int, input().split())
      adj = [[] for i in range(V)]
      for _ in range(E):
            u, v = map(int, input().split())
            adj[u].append(v)
      ob = Solution()
      ans = ob.bfsOfGraph(V, adj)
      for i in range(len(ans)):
               print(ans[i], end = " ")
      print()
```

12.5 Depth First Search (DFS) for Disconnected Graph

Given a Disconnected Graph, the task is to implement DFS or Depth First Search Algorithm for this Disconnected Graph.

Input: Consider the graph given below.



Output: 0 1 2 3

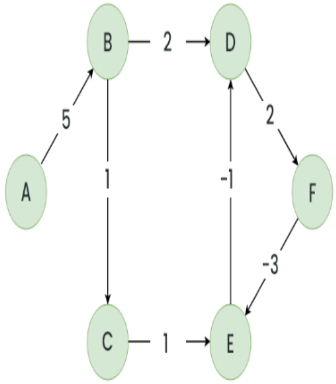
Procedure for DFS on Disconnected Graph:
Iterate over all the vertices of the graph and for any unvisited vertex, run a DFS from that vertex.

```
# DFS traversal for complete graph
from collections import defaultdict

# This class represents a directed graph using adjacency list representation
class Graph:
    # Constructor
    def __init__(self):
        # Default dictionary to store graph
        self.graph = defaultdict(list)

    # Function to add an edge to graph
    def addEdge(self, u, v):
        # Write code here
        …

    # A function used by DFS
    def DFSUtil(self, v, visited):
        # Write code here
        …

    # The function to do DFS traversal.
    # It uses recursive DFSUtil
    def DFS(self):
        # Write code here
        …
# Driver's code
print("Following is Depth First Traversal")
g = Graph()
g.addEdge(0, 1)
g.addEdge(0, 2)
g.addEdge(1, 2)
g.addEdge(2, 0)
g.addEdge(2, 3)
g.addEdge(3, 3)

# Function call
g.DFS()
```

Try:

1. **Detect a negative cycle in a Graph (Bellman Ford):** A Bellman-Ford algorithm is also guaranteed to find the shortest path in a graph, similar to Dijkstra's algorithm. Although Bellman-Ford is slower than Dijkstra's algorithm, it is capable of handling graphs with negative edge weights, which makes it more versatile. The shortest path cannot be found if there exists a negative cycle in the graph. If we continue to go around the negative cycle an infinite number of times, then the cost of the path will continue to decrease (even though the length of the path is increasing).

Consider a graph G and detect a negative cycle in the graph using Bellman Ford algorithm.



13. Minimum Spanning Tree (MST)

13.1 Kruskal's Algorithm

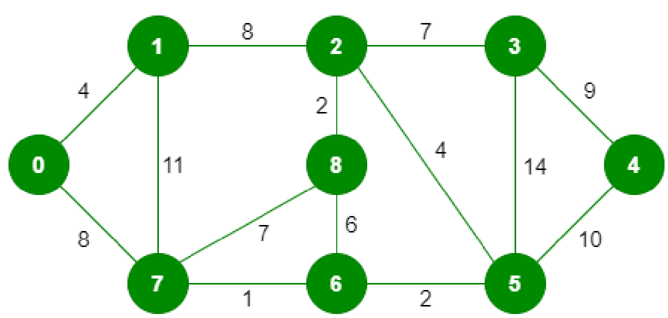
In Kruskal's algorithm, sort all edges of the given graph in increasing order. Then it keeps on adding new edges and nodes in the MST if the newly added edge does not form a cycle. It picks the minimum weighted edge at first and the maximum weighted edge at last.

MST using Kruskal's algorithm:

1. Sort all the edges in non-decreasing order of their weight.
2. Pick the smallest edge. Check if it forms a cycle with the spanning tree formed so far. If the cycle is not formed, include this edge. Else, discard it.
3. Repeat step#2 until there are (V-1) edges in the spanning tree.

Kruskal's algorithm to find the minimum cost spanning tree uses the greedy approach. The Greedy Choice is to pick the smallest weight edge that does not cause a cycle in the MST constructed so far.

Input: For the given graph G find the minimum cost spanning tree.



The graph contains 9 vertices and 14 edges. So, the minimum spanning tree formed will be having (9 – 1) = 8 edges.

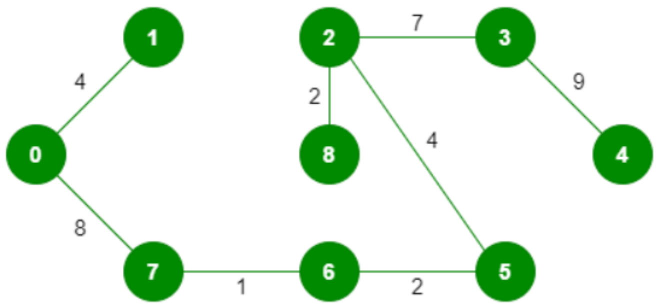
After sorting:

Weight	Source	Destination
1	7	6
2	8	2
2	6	5

4	0	1
4	2	5
6	8	6
7	2	3
7	7	8
8	0	7
8	1	2
9	3	4
10	5	4
11	1	7
14	3	5

Now pick all edges one by one from the sorted list of edges.

Output:




```
# Kruskal's algorithm to find minimum Spanning Tree of a given connected,
# undirected and weighted graph

# Class to represent a graph
class Graph:
    def __init__(self, vertices):
        self.V = vertices
        self.graph = []

    # Function to add an edge to graph
    def addEdge(self, u, v, w):
        self.graph.append([u, v, w])

    def find(self, parent, i):
        …

    def union(self, parent, rank, x, y):
        …

    def KruskalMST(self):
      # write your code here
      …

# Driver code
g = Graph(4)
g.addEdge(0, 1, 10)
g.addEdge(0, 2, 6)
g.addEdge(0, 3, 5)
g.addEdge(1, 3, 15)
```

```
g.addEdge(2, 3, 4)

# Function call
g.KruskalMST()
```

Output: Following are the edges in the constructed MST
2 -- 3 == 4

0 -- 3 == 5

0 -- 1 == 10

Minimum Cost Spanning Tree: 19

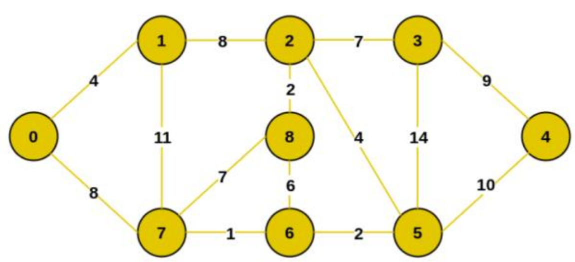
13.2 Prim's Algorithm

The Prim's algorithm starts with an empty spanning tree. The idea is to maintain two sets of vertices. The first set contains the vertices already included in the MST, and the other set contains the vertices not yet included. At every step, it considers all the edges that connect the two sets and picks the minimum weight edge from these edges. After picking the edge, it moves the other endpoint of the edge to the set containing MST.

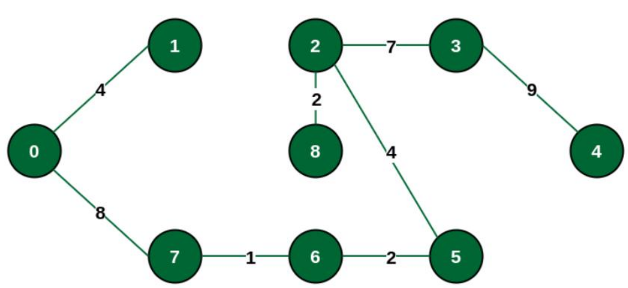
Prim's Algorithm:
The working of Prim's algorithm can be described by using the following steps:

1. Determine an arbitrary vertex as the starting vertex of the MST.
2. Follow steps 3 to 5 till there are vertices that are not included in the MST (known as fringe vertex).
3. Find edges connecting any tree vertex with the fringe vertices.
4. Find the minimum among these edges.
5. Add the chosen edge to the MST if it does not form any cycle.
6. Return the MST and exit

Input: For the given graph G find the minimum cost spanning tree.



Output: The final structure of the MST is as follows and the weight of the edges of the MST is (4 + 8 + 1 + 2 + 4 + 2 + 7 + 9) = 37.




```
# Prim's Minimum Spanning Tree (MST) algorithm.
# The program is for adjacency matrix representation of the graph
```

```python
# Library for INT_MAX
import sys

class Graph():
    def __init__(self, vertices):
        self.V = vertices
        self.graph = [[0 for column in range(vertices)]
                      for row in range(vertices)]

    # A utility function to print
    # the constructed MST stored in parent[]
    def printMST(self, parent):
        print("Edge \tWeight")
        for i in range(1, self.V):
            print(parent[i], "-", i, "\t", self.graph[i][parent[i]])

    # A utility function to find the vertex with
    # minimum distance value, from the set of vertices
    # not yet included in shortest path tree
    def minKey(self, key, mstSet):
       # write your code here
       …

    def primMST(self):
       # write your code here
       …


# Driver's code
g = Graph(5)
g.graph = [[0, 2, 0, 6, 0],
           [2, 0, 3, 8, 5],
           [0, 3, 0, 0, 7],
           [6, 8, 0, 0, 9],
           [0, 5, 7, 9, 0]]

g.primMST()
```

Output:

Edge   Weight

0 - 1   2

1 - 2   3

0 - 3   6

1 - 4   5

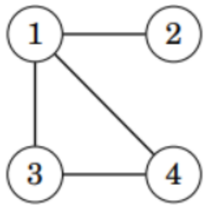
13.3 Total Number of Spanning Trees in a Graph

If a graph is a complete graph with n vertices, then total number of spanning trees is $n^{(n-2)}$ where n is the number of nodes in the graph. In complete graph, the task is equal to counting different labeled trees with n nodes for which have Cayley's formula.

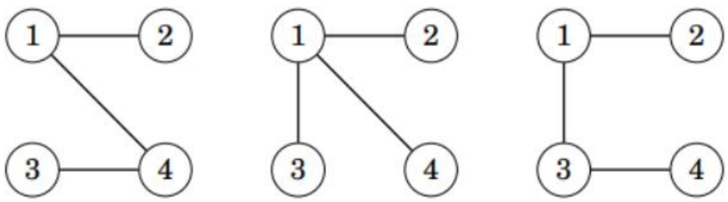
Laplacian matrix:

A Laplacian matrix L, where L[i, i] is the degree of node i and L[i, j] = −1 if there is an edge between nodes i and j, and otherwise L[i, j] = 0.

Kirchhoff's theorem provides a way to calculate the number of spanning trees for a given graph as a determinant of a special matrix. Consider the following graph,



All possible spanning trees are as follows:



In order to calculate the number of spanning trees, construct a Laplacian matrix L, where L[i, i] is the degree of node i and L[i, j] = −1 if there is an edge between nodes i and j, and otherwise L[i, j] = 0.
for the above graph, The Laplacian matrix will look like this

$$L = \begin{bmatrix} 3 & -1 & -1 & -1 \\ -1 & 1 & 0 & 0 \\ -1 & 0 & 2 & -1 \\ -1 & 0 & -1 & 2 \end{bmatrix}$$

The number of spanning trees equals the determinant of a matrix.

The Determinant of a matrix that can be obtained when we remove any row and any column from L.
For example, if we remove the first row and column, the result will be,

$$\det(\begin{bmatrix} 1 & 0 & 0 \\ 0 & 2 & -1 \\ 0 & -1 & 2 \end{bmatrix}) = 3.$$

The determinant is always the same, regardless of which row and column we remove from L.

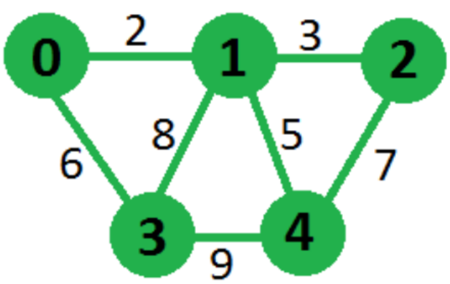
```
# Finds the number of spanning trees in a graph using Matrix Chain Multiplication.
MAX = 100
MOD = 1000000007

# Matrix Multiplication
def multiply(A, B, C):
    # write your code here
    …

# Function to find Nth power of A
def power(A, N, result):
    # write your code here
    …
# Function to find number of Spanning Trees in a Graph
# using Matrix Chain Multiplication.
```

```
def numOfSpanningTree(graph, V):
    # write your code here
    …

# Driver program
V = 4 # Number of vertices in graph
E = 5 # Number of edges in graph
graph = [[0, 1, 1, 1],
         [1, 0, 1, 1],
         [1, 1, 0, 1],
         [1, 1, 1, 0]]
print(numOfSpanningTree(graph, V))
```

13.4 Minimum Product Spanning Tree

A minimum product spanning tree for a weighted, connected, and undirected graph is a spanning tree with a weight product less than or equal to the weight product of every other spanning tree. The weight product of a spanning tree is the product of weights corresponding to each edge of the spanning tree. All weights of the given graph will be positive for simplicity.

Input:



Output: Minimum Product that we can obtain is 180 for above graph by choosing edges 0-1, 1-2, 0-3 and 1-4

This problem can be solved using standard minimum spanning tree algorithms like Kruskal and prim's algorithm, but we need to modify our graph to use these algorithms. Minimum spanning tree algorithms tries to minimize the total sum of weights, here we need to minimize the total product of weights. We can use the property of logarithms to overcome this problem.

log(w1* w2 * w3 * …. * wN) = log(w1) + log(w2) + log(w3) ….. + log(wN)

We can replace each weight of the graph by its log value, then we apply any minimum spanning tree algorithm which will try to minimize the sum of log(wi) which in turn minimizes the weight product.

```
# Minimum product spanning tree
import math

# Number of vertices in the graph
V = 5

# A utility function to find the vertex with minimum key value, from the set
# of vertices not yet included in MST
def minKey(key, mstSet):
    # write your code here
    …

# A utility function to print the constructed MST stored in parent[] and
# print Minimum Obtainable product
```

```
def printMST(parent, n, graph):
    # write your code here
    …

# Function to construct and print MST for a graph represented using adjacency
# matrix representation inputGraph is sent for printing actual edges and
# logGraph is sent for actual MST operations
def primMST(inputGraph, logGraph):
    # write your code here
    …

# Method to get minimum product spanning tree
def minimumProductMST(graph):
    # write your code here
    …

# Driver code
graph = [ [ 0, 2, 0, 6, 0 ],
          [ 2, 0, 3, 8, 5 ],
          [ 0, 3, 0, 0, 7 ],
          [ 6, 8, 0, 0, 9 ],
          [ 0, 5, 7, 9, 0 ], ]

# Print the solution
minimumProductMST(graph)
```

13.5 Reverse Delete Algorithm for Minimum Spanning Tree

In Reverse Delete algorithm, we sort all edges in decreasing order of their weights. After sorting, we one by one pick edges in decreasing order. We include current picked edge if excluding current edge causes disconnection in current graph. The main idea is delete edge if its deletion does not lead to disconnection of graph.

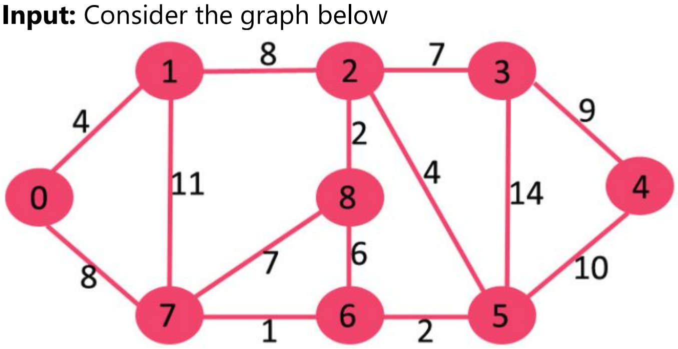
Algorithm:

1. Sort all edges of graph in non-increasing order of edge weights.

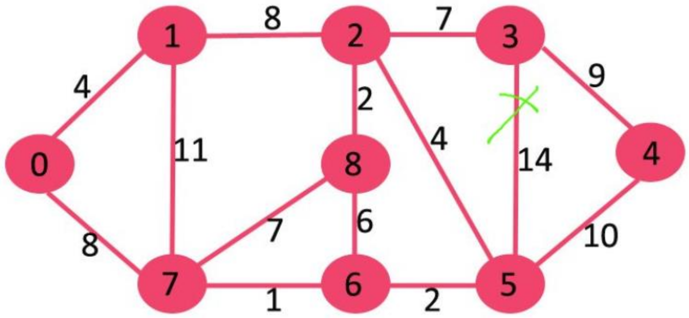
2. Initialize MST as original graph and remove extra edges using step 3.

3. Pick highest weight edge from remaining edges and check if deleting the edge disconnects the graph or not.
   If disconnects, then we don't delete the edge.
   Else we delete the edge and continue.

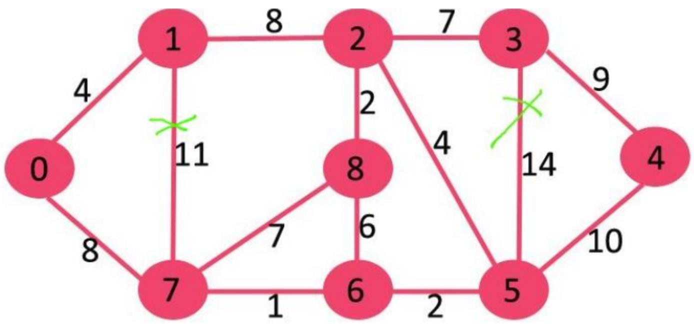
Input: Consider the graph below



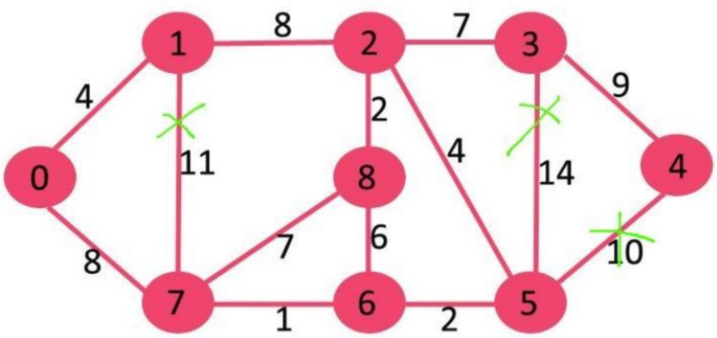
If we delete highest weight edge of weight 14, graph doesn't become disconnected, so we remove it.



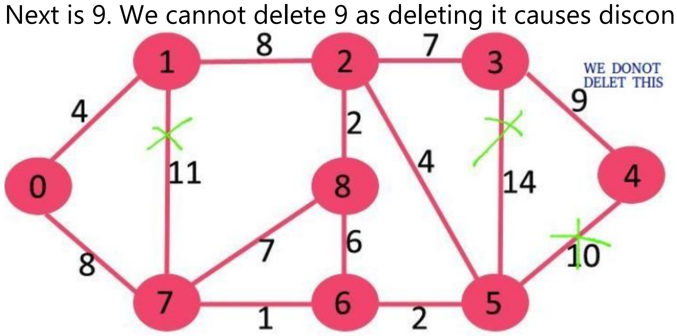
Next we delete 11 as deleting it doesn't disconnect the graph.



Next we delete 10 as deleting it doesn't disconnect the graph.



Next is 9. We cannot delete 9 as deleting it causes disconnection.



We continue this way and following edges remain in final MST.

Edges in MST

(3, 4)

(0, 7)

(2, 3)
(2, 5)
(0, 1)
(5, 6)
(2, 8)
(6, 7)

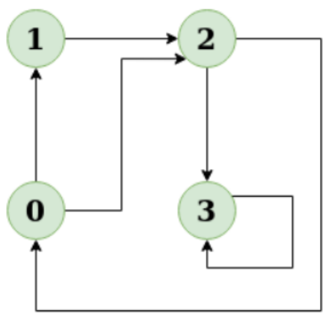
```
# Find Minimum Spanning Tree of a graph using Reverse Delete Algorithm

# Graph class represents a directed graph using adjacency list representation
class Graph:
    def __init__(self, v):

        # No. of vertices
        self.v = v
        self.adj = [0] * v
        self.edges = []
        for i in range(v):
            self.adj[i] = []

    # function to add an edge to graph
    def addEdge(self, u: int, v: int, w: int):
        # write code here
        …

    def dfs(self, v: int, visited: list):
       # write code here
        …

    # Returns true if graph is connected
    # Returns true if given graph is connected, else false
    def connected(self):
       # write code here
       …

    # This function assumes that edge (u, v) exists in graph or not
    def reverseDeleteMST(self):
        # write code here
        …

# Driver Code
# create the graph given in above figure
V = 9
g = Graph(V)

# making above shown graph
g.addEdge(0, 1, 4)
g.addEdge(0, 7, 8)
g.addEdge(1, 2, 8)
g.addEdge(1, 7, 11)
g.addEdge(2, 3, 7)
g.addEdge(2, 8, 2)
g.addEdge(2, 5, 4)
g.addEdge(3, 4, 9)
g.addEdge(3, 5, 14)
g.addEdge(4, 5, 10)
g.addEdge(5, 6, 2)
g.addEdge(6, 7, 1)
```

```
g.addEdge(6, 8, 6)
g.addEdge(7, 8, 7)

g.reverseDeleteMST()
```

Try:

1. **Detect Cycle in a Directed Graph:** Given the root of a Directed graph, The task is to check whether the graph contains a cycle or not.

Input: N = 4, E = 6



Output: Yes

Explanation: The diagram clearly shows a cycle 0 -> 2 -> 0

14. Final Notes

The only way to learn programming is program, program and program on challenging problems. The problems in this tutorial are certainly NOT challenging. There are tens of thousands of challenging problems available – used in training for various programming contests (such as International Collegiate Programming Contest (ICPC), International Olympiad in Informatics (IOI)). Check out these sites:

- The ACM - ICPC International collegiate programming contest (https://icpc.global/)
- The Topcoder Open (TCO) annual programming and design contest (https://www.topcoder.com/)
- Universidad de Valladolid's online judge (https://uva.onlinejudge.org/).
- Peking University's online judge (http://poj.org/).
- USA Computing Olympiad (USACO) Training Program @ http://train.usaco.org/usacogate.
- Google's coding competitions (https://codingcompetitions.withgoogle.com/codejam, https://codingcompetitions.withgoogle.com/hashcode)
- The ICFP programming contest (https://www.icfpconference.org/)
- BME International 24-hours programming contest (https://www.challenge24.org/)
- The International Obfuscated C Code Contest (https://www0.us.ioccc.org/main.html)
- Internet Problem Solving Contest (https://ipsc.ksp.sk/)
- Microsoft Imagine Cup (https://imaginecup.microsoft.com/en-us)
- Hewlett Packard Enterprise (HPE) Codewars (https://hpecodewars.org/)
- OpenChallenge (https://www.openchallenge.org/)

Coding Contests Scores

Students must solve problems and attain scores in the following coding contests:

	Name of the contest	Minimum number of problems to solve	Required score
•	CodeChef	20	200
•	Leetcode	20	200
•	GeeksforGeeks	20	200
•	SPOJ	5	50
•	InterviewBit	10	1000
•	Hackerrank	25	250
•	Codeforces	10	100
•	BuildIT	50	500
		Total score need to obtain	2500

Student must have any one of the following certifications:

1. HackerRank - Problem Solving Skills Certification (Basic and Intermediate)
2. GeeksforGeeks – Data Structures and Algorithms Certification
3. CodeChef - Learn Data Structures and Algorithms Certification
4. Interviewbit – DSA pro / Python pro
5. Edx – Data Structures and Algorithms
5. NPTEL – Programming, Data Structures and Algorithms
6. NPTEL – Introduction to Data Structures and Algorithms
7. NPTEL – Data Structures and Algorithms
8. NPTEL – Programming and Data Structure

V. TEXT BOOKS:

1. Rance D. Necaise, “Data Structures and Algorithms using Python”, Wiley Student Edition.
2. Benjamin Baka, David Julian, “Python Data Structures and Algorithms”, Packt Publishers, 2017.

VI. REFERENCE BOOKS:

1. S. Lipschutz, “Data Structures”, Tata McGraw Hill Education, 1st edition, 2008.
2. D. Samanta, “Classic Data Structures”, PHI Learning, 2nd edition, 2004.

VII. ELECTRONICS RESOURCES:

1. https://www.tutorialspoint.com/data_structures_algorithms/algorithms_basics.htm
2. https://www.codechef.com/certification/data-structures-and-algorithms/prepare
3. https://www.cs.auckland.ac.nz/software/AlgAnim/dsToC.html
4. https://online-learning.harvard.edu/course/data-structures-and-algorithms

VIII. MATERIALS ONLINE

1. Course Content
2. Lab manual

ESSENCE OF INDIAN TRADITIONAL KNOWLEDGE

III Semester: Common for all branches

Course Code	Category	Hours / Week			Credits	Maximum Marks		
		L	T	P	C	CIA	SEE	Total
AHSC10	Mandatory	-	-	-	-	-	-	-
Contact Classes: Nil	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: Nil		

Prerequisite: No Prerequisites

COURSE OBJECTIVES:

The course should enable the students to:

I. Understand the concept of Traditional knowledge and its importance
II. Know the need and importance of protecting traditional knowledge.
III. Know the various enactments related to the protection of traditional knowledge.
IV. Understand the concepts of Intellectual property to protect the traditional knowledge

MODULE-I INTRODUCTION TO TRADITIONAL KNOWLEDGE

Define traditional knowledge, nature and characteristics, scope and importance, kinds of traditional knowledge, the physical and social contexts in which traditional knowledge develop, the historical impact of social change on traditional knowledge systems. Indigenous Knowledge (IK), characteristics, traditional knowledge vis-à-vis indigenous knowledge, traditional knowledge Vs western knowledge traditional knowledge vis-à-vis formal knowledge

MODULE-II PROTECTION OF TRADITIONAL KNOWLEDGE

Protection of traditional knowledge: The need for protecting traditional knowledge Significance of TK Protection, value of TK in global economy, Role of Government to harness TK.

MODULE-III LEGAL FRAMEWORK AND TK

A: The Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006, Plant Varieties Protection and Farmer's Rights Act, 2001 (PPVFR Act);

B: The Biological Diversity Act 2002 and Rules 2004, the protection of traditional knowledge bill, 2016. Geographical indicators act 2003.

MODULE-IV TRADITIONAL KNOWLEDGE AND INTELLECTUAL PROPERTY

Systems of traditional knowledge protection, Legal concepts for the protection of traditional knowledge, Certain non IPR mechanisms of traditional knowledge protection, Patents and traditional knowledge, Strategies to increase protection of traditional knowledge, global legal FORA for increasing protection of Indian Traditional Knowledge.

MODULE-V TRADITIONAL KNOWLEDGE IN DIFFERENT SECTORS:

Traditional knowledge and engineering, Traditional medicine system, TK and biotechnology, TK in agriculture, Traditional societies depend on it for their food and healthcare needs, Importance of conservation and sustainable development of environment, Management of biodiversity, Food security of the country and protection of TK. 139.

Text Books:

1. Traditional Knowledge System in India, by Amit Jha, 2009.
2. Traditional Knowledge System and Technology in India by Basanta Kumar Mohanta and Vipin Kumar Singh Pratibha Prakashan 2012.

Reference Books:

1. Traditional Knowledge System in India by Amit Jha Atlantic publishers, 2002.
2. "Knowledge Traditions and Practices of India" Kapil Kapoor1, Michel Danino2

AEROSPACE STRUCUTRES

IV Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC06	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	1	0	4	30	70	100
Contact Classes: 45	**Tutorial Classes: 15**	**Practical Classes: Nil**				**Total Classes: 60**		
Prerequisite: Knowledgwe of Mechanics of Solids								

I. COURSE OVERVIEW:

This course is designed to study the behavior of aircraft structural elements subjected to inertial, aerodynamic, and maneuver loads. Thin walled beams, thin plates analysis are being conducted by energy methods. Structural idealization and load analysis on wing, fuselage, and landing gears are integral part of this course. The ultimate goal is to design and development of the new generation aircraft components. This course is a prerequisite for Analysis of Aircraft structures and Finite Element Methods/Analysis.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The application of mathematical principles to aircraft components to determine deflections and stresses under various loading conditions.

II. The bending of thin walled structures and the concept of structural idealization to transform complex structures to simple structures.

III. The behaviour of wing, fuselage and landing gears under various loading conditions.

III. COURSE SYLLABUS

MODULE-I: INTRODUCTION TO AIRCRAFT STRUCTURAL COMPONENTSAND ENERGY METHODS (10)

Aircraft Structural components and loads, functions of structural components, airframe loads; Types of structural joints, type of loads on structural joints; Aircraft inertia loads; Symmetric manoeuvre loads, gust loads. Monocoque and semi monocoque structures, stress in thinshells; Introductions to energy principles, castiglianos theorems, maxiwells reciprocal theorem, unit load method, Rayleigh Ritz method, total potential energy method, flexibility method.

MODULE –II: THIN PLATE THEORY, STRUCTURAL INSTABILITY(09)

Analysis of thin rectangular plates subject to bending, twisting, distributed transverse load, combined bending and in-plane loading: Thin plates having small initial curvature, energy methods of analysis.
Buckling of thin plates: Elastic, inelastic, experimental determination of critical load for a flat plate, local instability, instability of stiffened panels, failure stresses in plates and stiffened panels. Tension field beams- complete diagonal tension, incomplete diagonal tension, post buckling behavior.

MODULE-III: BENDING, SHEAR AND TORSION OF THIN WALLED BEAMS(09)

Unsymmetrical bending: Resolution of bending moments, direct stress distribution, position of neutral axis; Deflections due to bending: Approximations for thin walled sections, temperature effects; Shear loaded thin walled beams: General stress, strain and displacement relationships, direct stress and shear flow system, shear centre, twist and warping.

Torsion of beams of closed section: Displacements associated with Bredt-Batho shear flow; Torsion of open section beams; Warping of cross section, conditions for zero warping; Bending, shear, torsion of combined open and closed section beams.

MODULE –IV: STRUCTURAL IDEALIZATION(09)

Structural idealization: Principal assumptions, idealization of panel, effect on the analysis of thin walled beams under bending, shear, torsion loading- application to determining deflection of open and closed section beams. Fuselage frames - bending, shear and torsion.

MODULE –V: ANALYSIS OF FUSELAGE, WING AND LANDING GEAR(09)

Wing spar and box beams, tapered wing spar, open and closed sections beams, beams having variable stringer areas; wings – three boom shell in bending, torsion and shear, tapered wings, deflections, cutouts in wings; Cutouts in fuselages; Fuselage frame and wing rib; principle of stiffener, web constructions. Landing gear and types; Analysis of landing gear.

IV. TEXT BOOKS:

1. T. H. G. Megson, "Aircraft Structures for Engineering Students", Butterworth-Heinemann Ltd, 5th Edition, 2012.
2. E. H. Bruhn, "Analysis and Design of Flight vehicles Structures", Tri-state off set company, USA, 4th Edition, 1965.

V. REFERENCE BOOKS:

1. B. K. Donaldson, "Analysis of Aircraft Structures - An Introduction", McGraw Hill, 3rd Edition, 1993.
2. S. Timoshenko, "Strength of Materials, Vols I and II", Princeton D. Von Nostrand Co., Reprint, 1977.

VI. WEB REFERENCES:

1. https://nptel.ac.in/courses/112101095/
2. https://www.scribd.com/doc/244154727/theory-of-structures-timoshenko-pdf

VII. E-TEXT BOOKS:

1. https://www.freeengineeringbooks.com/AeroSpace/Aircraft-Structures-Books.php
2. https://docs.google.com/file/d/0Bw8MfqmgWLS4RlNqaE1oUzdOajQ/view?pref=2&pli=1

AIRCRAFT PROPULSION

IV Semester: AE

Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAEC07	Core	L	T	P	C	CIA	SEE	Total
		3	1	-	4	30	70	100
Contact Classes: 45	Tutorial Classes: 15	Practical Classes: Nil			Total Classes: 60			
Prerequisite: Knowledge of Engineering Thermodynamics								

I. COURSE OVERVIEW:

An aerospace propulsion system is a machine that produces thrust to push an aircraft forward. This course introduces various aircraft propulsion systems, and their performance analysis. The course discusses the operating principles of the aircraft engine's major components such as inlets, compressors, turbines, and nozzles. The design parameters, performance characteristics, and the factors influencing them are also addressed. This course is a prerequisite to the next level course, Turbomachinery.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The fundamentals of air-breathing propulsion system, their operating principles, and function of an individual component.
II. The geometry off low inlets, combustion chambers, and factors affecting their performance.
III. The establishment of flow through various inlets and nozzles under different operating conditions.
IV. The operating principles of various compressors, turbines and performance characteristics under different flight conditions.

III. COURSE SYLLABUS

MODULE-I: AIR-BREATHING ENGINES(09)

Classification, operational envelopes; Description and function of gas generator, turbojet, turbofan, turboprop, turbo shaft, ramjet, scramjet, turbojet/ramjet combined cycle engine, thrust equation; Engine performance parameters, specific thrust, specific fuel consumption and specific impulse, thermal efficiency, propulsive efficiency, engine overall efficiency and its impact on aircraft range and endurance; Ideal cycle analysis , a turbojet, turbojet with afterburner, turbofan engine.

MODULE –II: INLETS AND COMBUSTION CHAMBERS(09)

Internal flow and stall in subsonic inlets, relation between minimum area ratio and external deceleration ratio, diffuser performance, supersonic inlets, operating conditions of supersonic inlet, starting problem on supersonic inlets, shock swallowing by area variation; Classification of combustion chambers, Combustion mechanism and important combustion parameters. Pressure losses; combustion efficiency; combustion intensity. Factors affecting combustion chamber design, and operation, flame stabilization

MODULE –III: NOZZLES(09)

heory of flow in isentropic nozzles, nozzles and choking, nozzle throat conditions, nozzle efficiency, losses in nozzles.

Over expanded and under expanded nozzles, Nozzle design considerations: fixed and variable geometry nozzles, thrust vectoring, thrust reversal.

MODULE –IV: COMPRESSORS(09)

Principle of operation of centrifugal compressor and axial flow compressor, work done and pressure rise, velocity triangles, degree of reaction, free vortex and constant reaction designs of axial flow compressor, performance characteristics of centrifugal and axial flow compressors, stage efficiency calculations, cascade testing.

MODULE –V: TURBINES(09)

Principle of operation of axial flow turbines, limitations of radial flow turbines, work done and pressure rise, velocity triangles, degree of reaction, free vortex and constant angle designs, performance characteristics, turbine blade cooling.

IV. TEXT BOOKS:

1. Hill, P.G. & Peterson, C.R. "Mechanics & Thermodynamics of Propulsion" Addison Wesley Longman INC, 1999.
2. Mattingly J.D., "Elements of Propulsion: Gas Turbines and Rocket", AIAA, 1991.

V. REFERENCE BOOKS:

1. Cohen, H.Rogers, G.F.C. and Saravanamuttoo, H.I.H. “Gas Turbine Theory”, Longman, 1989.
2. Oates, G.C., “Aero thermodynamics of Aircraft Engine Components”, AIAA Education Series, New York, 1985.

VI. WEB REFERENCES:

1. https://nptel.ac.in/courses/101101002/
2. https://nptel.ac.in/courses/112106073/

VII. E-TEXT BOOKS:

1. https://as.wiley.com/WileyCDA/WileyTitle/productCd-1118806778.html
2. https://www.scribd.com/document/63588270/Aerospace-Propulsion-Systems
3. https://www.crcpress.com/Aircraft-Propulsion-and-Gas-Turbine-Engines/ElSayed/p/book/9780849391965

AERODYNAMICS

IV Semester: AE									
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAEC08	Core	L	T	P	C	CIA	SEE	Total
		3	0	0	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		
Prerequisite: Knowledge of Engineering Thermodynamics								

I. COURSE OVERVIEW:

Aerodynamics course focuses on the study of the flow of air about a body, and the body can be an airplane, but many of the concepts explored are relevant to a wide variety of applications from sailboats, automobiles and birds. This course will enable learners to gain a fundamental understanding of concepts and models used to aerodynamically analyze and some classical theories which are useful for design of aircraft components. As this course is an introduction to aerodynamics, it is prerequisite course for high speed aerodynamics as well as can be an advanced subject for students with aerodynamics as specialization.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The fundamental knowledge on basics of aerodynamics and aerodynamic characteristics of wings, airfoils.
II. The mathematical model for lift and drag coefficient of finite wing and wing of infinite aspect ratio.
III. The flow over non-lifting bodies from method of singularities and investigate the interference effect.
IV. The effect of viscosity and boundary layer growth over various shaped geometry and its control.

COURSE SYLLABUS

MODULE-I: INTRODUCTORY TOPICS FOR AERODYNAMICS (09)

Potential flow, velocity potential, stream function, Laplace equation, flow singularities-Uniform flow, source, sink, doublet, Vortex, Non lifting and lifting flow over a cylinder Kutta-Joukowski theorem.

MODULE –II: THIN AEROFOIL THEORY(09)

Aerofoil nomenclature, aerodynamic characteristics, centre of pressure and aerodynamic centre; Wing of infinite aspect ratio, C_L-α- diagram for a wing of infinite aspect ratio, generation of lift, starting Vortex, Kutta's trailing edge condition; Thin aerofoil theory; High lift airfoils, High lift devices.

MODULE –III: FINITE WING THEORY (12)

Vortex motions, vortex line, vortex tube, vortex sheet; Circulation; Kelvin and Helmhotz theorem; Biot-Savart's law, applications, Rankine's vortex; Flow past finite wings, vortex model of the wing and bound vortices; Induced drag; Prandtl's lifting line theory; Elliptic wing.

Influence of taper and twist applied to wings, effect of sweep back wings; Delta wings, primary and secondary vortex; Elements of lifting surface theory. Source Panel Vortex panel and Vortex lattice methods.

MODULE –IV: FLOW PAST NON-LIFTING BODIES AND CONFORMAL TRANSFORMATION (08)

Flow past non lifting bodies, method of singularities; Wing-body interference; Effect of propeller on wings and bodies and tail unit; Flow over airplane as a whole.

Potential, Cauchy-Reiman relations, Complex conformal transformation, Kutta-Joukowski transformation

MODULE –V: BOUNDARY LAYERTHEORY (07)

Introduction to boundary layer, laminar and turbulent boundary layer, transition, boundary layer on flat plate, displacement thickness, momentum thickness, energy thickness, effect of curvature, temperature boundary layer.

IV. TEXT BOOKS:

1. E. L. Houghton and P. W. Carpenter, "Aerodynamics for Engineering Students", Edward Arnold Publishers Ltd., London, 5th Edition, 1982,

2. J. D. Anderson, "Fundamentals of Aerodynamics", McGraw Hill Book Co., New York, 5th Edition, 1985.
3. John J. Bertin and Russell M. Cummings, "Aerodynamics for Engineering Students", Pearson, 5th Edition, 2009.

V. REFERENCE BOOKS:

1. L. J. Clancy, "Aerodynamics", Pitman, 1st Edition, 1986.
2. L. H. Milne, S. Thomson, "Theoretical Aerodynamics", Dover, 2nd Edition, 1985.
3. K. Karamcheti, "Principles of Ideal-Fluid Aerodynamics", Krieger Pub Co; 2nd edition, 1980.

VI. WEB REFERENCES:

1. https://www.loc.gov/rr/scitech/tracer-bullets/aerodynamicstb.html
2. https://www.myopencourses.com/subject/aerodynamics-2
3. https://tocs.ulb.tu-darmstadt.de/211658790.pdf
4. https://www.princeton.edu/~stengel/MAE331Lecture3.pdf

VII. E-TEXT BOOKS:

1. https://bookboon.com/en/a-first-course-on-aerodynamics-ebook
2. https://airspot.ru/book/file/22/houghton_aerodynamics_for_engineering_students.pdf
3. https://www.adl.gatech.edu/extrovert/Ebooks/ebook_Lowspeed.pdf
4. https://rahauav.com/Library/Aerodynamic/Aerodynamics%20for%20engineering%20students_6th_www.rahauav.com.pdf

FLIGHT MECHANICS

IV Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC09	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	0	0	3	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		
Prerequisite: **Knowledge of Engineering Mechanics**								

I. COURSE OVERVIEW:

Flight mechanics is the science that investigates the performance of the aircraft as applied to flight vehicles and to provide a clear understanding of related topics, specifically on aerodynamics, propulsion, performance, stability and flight controls. The course introduces the fundamental principles of aerodynamics and propulsion for aircraft performance in classical flying stages. This course is the point of confluence of other disciplines with aeronautical engineering and the gateway to aircraft design.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The fundamental principles of aerodynamics and propulsion for aircraft performance in classical flying stages.
II. The different regimes of aircraft and performance requirements at various atmospheric conditions.
III. The mathematical models for various types of maneuvers, safety requirements during takeoff, landing for better performance and stability.

III. COURSE SYLLABUS:

MODULE-I: INTRODUCTION TO AIRCRAFT PERFORMANCE(10)

The role and design mission of an aircraft; Performance requirements and mission profile; Aircraft design performance, the standard atmosphere; Off-standard and design atmosphere; Measurement of air data; Air data computers; Equations of motion for performance - the aircraft force system; Total airplane drag- estimation, drag reduction methods; The propulsive forces, the thrust production engines, power producing engines, variation of thrust, propulsive power and specific fuel consumption with altitude and flight speed; The minimum drag speed, minimum power speed; Aerodynamic relationships for a parabolic drag polar.

MODULE –II: CRUISE PERFORMANCE (08)

Maximum and minimum speeds in level flight; Range and endurance with thrust production, and power producing engines; Cruise techniques: constant angle of attack, constant mach number; constant altitude, methods- comparison of performance. The effect of weight, altitude and temperature on cruise performance; Cruise performance with mixed power-Plants.

MODULE –III: CLIMB AND DECENT PERFORMANCE (10)

Importance of Climb and descent performance, Climb and descent technique generalized performance analysis for thrust producing, power producing and mixed power plants, maximum climb gradient, and climb rate.

Energy height and specific excess power, energy methods for optimal climbs - minimum time, minimum fuel climbs. Measurement of best climb performance. Descent performance in Aircraft operations. Effect of wind on climb and decent performance.

MODULE –IV: AIRCRAFT MANOEUVRE PERFORMANCE(09)

Lateral maneuvers- turn performance- turn rates, turn radius- limiting factors for turning performance. Instantaneous turn and sustained turns, specific excess power, energy turns. Longitudinal aircraft maneuvers, the pull-up, maneuvers. The maneuver envelope (V-n diagram), Significance. Maneuver boundaries and limitations, Maneuver performance of military Aircraft, transport Aircraft.

MODULE –V: SAFETY REQUIREMENTS -TAKEOFF AND LANDING PERFORMANCE AND FLIGHT PLANNING(08)

Estimation of takeoff distances. The effect on the takeoff distance of weight wind, runway conditions, ground effect. Takeoff performance safety factors. Estimation of landing distances. The discontinued landing, Baulk landing, air safety procedures and requirements on performance. Fuel planning fuel requirement, trip fuel, Environment effects, reserve, and tinkering**.**

IV. TEXT BOOKS:

1. Anderson, J.D. Jr., "Aircraft Performance and Design", International edition McGraw Hill, 1st Edition, 1999, ISBN: 0-07-001971-1.
2. Eshelby, M.E., "Aircraft Performance theory and Practice", AIAA Education Series, AIAA, 2nd Edition, 2000, ISBN: 1-56347-398-4.

V. REFERENCE BOOKS:

1. McCormick, B.W, "Aerodynamics, Aeronautics and Flight Mechanics", John Wiley, 2nd Edition, 1995, ISBN: 0-471-57506-2.
2. Yechout, T.R. et al., "Introduction to Aircraft Flight Mechanics", AIAA Education Series, AIAA, 1st Edition, 2003, ISBN: 1-56347-577-4.
3. Shevel, R.S., "Fundamentals of Flight", Pearson Education, 2nd Edition, 1989, ISBN: 81-297-0514-1.

VI. WEB REFERENCES:

1. www.myopencourses.com/subject/flight-dynamics-i-airplane-performance.
2. www.scribd.com/doc/185026212/Introduction-to-Flight-Third-Edition-by-John-D-Anderson-Jr
3. www.scribd.com/book/282507871/Performance-and-Stability-of-Aircraft
4. www.scribd.com/doc/203462287/Aircraft-Performance-NPTEL
5. www.nptel.ac.in/courses/101106041

VII. E-TEXT BOOKS:

1. www.scribd.com/doc/97544751/Anderson-Aircraft-Performance-and-Design

AIRCRAFT PRODUCTION TECHNOLOGY

IV Semester : AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC10	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	0	0	3	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		
Prerequisites: **Knowledge of Manufacturing Practice**								

I. COURSE OVERVIEW:

The subject aircraft Production Technology encompasses on providing good theoretical background and a sound practical knowledge of automation and computer integrated manufacturing to the engineering students. Hence production technology plays a vital role for design the components and producing it with minimum cost and with longer service. The subject deals with combination of materials and heat treatment process, methods of prevention of corrosion, fabrication of composite materials, manufacturing process such as casting, welding, sheet metal forming, riveting process, machining process, automation and jigs and fixtures widely employed in industries.

It also includes instruction in safety, testing methods, selecting feeds and speeds of machines using precision measuring instruments. Manufacturing is becoming important to the developed and developing nations technologically and economically.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The methods of improving the mechanical properties of aerospace materials and their alloys using heat treatment processes and corrosion prevention methods.

II. The concepts of welding, casting, forming, riveting process and quality inspection techniques used in manufacturing the aerospace components at low cost with minimum wastage.

III. The working principles, advantages and disadvantages of conventional and unconventional machining process used in aerospace industries.

IV. The characteristics and applications of aircraft materials including composites used in aerospace industry.

III.COURSE SYLLABUS:

MODULE – I: AIRCRAFT ENGINEERING MATERIALS(09)

Engineering materials: Classification of Engineering materials, study of Steels and Iron, Iron carbon phase diagram, heat treatment-annealing, normalizing, hardening and tempering of Aluminum and steel, Non-Ferrous metals and Alloys: Structure and properties of copper and its alloys, Aluminum and its alloys, Titanium and its alloys, Corrosion - Types of Corrosions - Prevention - Protective Treatments.

MODULE – II: CASTING, WELDING AND INSPECTION TECHNIQUES (09)

General principles of various casting processes Sand casting, die-casting, centrifugal casting, investment casting, Shell molding types; Principles and equipment used in arc welding, gas welding, resistance welding, solid, laser welding, and electron beam welding, soldering and brazing techniques. Need for NDT, ultrasonic testing and Radiographic testing.

MODULE – III: SHEET METAL PROCESSES IN AIRCRAFT INDUSTRY (09)

Sheet metal operations: shearing, punching, super plastic forming; operations in bending like stretch forming spinning drawing.

Riveting, types and techniques, equipment, fasteners, integral tanks, final assembly of aircraft, Jigs and Fixtures, stages of assembly, aircraft tooling concepts.

MODULE –IV: CONVENTIONAL AND UNCONVENTIONAL MACHINING PROCESSES(09)

General working principles, applications and operations of lathe, shaper, milling machines, grinding, drilling machine, computer numeric control machining; Working principles and applications of abrasive jet machining, ultrasonic machining, Electric discharge machining and electro chemical machining, laser beam, electron beam, plasma arc machining.

MODULE – V: AIRCRAFT COMPOSITES (09)

Production of semi-fabricated forms, Introduction to fiber reinforced plastics, glass and carbon composites; Fibers, resins and their Characteristics, Classification of aircraft materials; Application of composite materials, Super alloys, indigenized alloys, emerging trends in aerospace materials.

IV. TEXT BOOKS:

1. S. Kalpakjian, Steven R. Schmid, “Manufacturing Engineering and Technology”, Addison Wesley 5th Edition, 1991.
2. S. C. Keshu, K. K Ganapathy, “Aircraft production technology and management”, Interline Publishing House, Bangalore, 3rd Edition, 1993.
3. Douglas F. Horne, “Aircraft production technology”, Cambridge University Press, 1st Edition, 1986.

V. REFERENCE BOOKS:

1. S. C. Keshu, K. K Ganapathy, “Air craft production techniques”, Interline Publishing House, Bangalore, 3rd Edition, 1993.
2. R. K. Jain, “Production technology”, McGraw Hill, 1st Edition, 2002.
3. O. P. Khanna, M. Lal, “Production technology”, DhanpatRai Publications, 5th Edition, 1997.

VI. WEB REFERENCES:

1. https://nptel.ac.in/courses/112107145/
2. https://nptel.ac.in/courses/112105126/

VII. E-TEXT BOOKS

1. https://books.google.co.in/books?id=6wFuw6wufTMC&redir_esc
2. https://royalmechanicalbuzz.blogspot.in/2015/04/manufacturing-engineering-by-kalpakjian.html

EXPERIENTIAL ENGINEERING EDUCATION (EXEED) – FABRICATION / MODEL DEVELOPMENT

IV Semester: Common for all branches									
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
ACSC14	Foundation	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		2	-	-	1	30	70	100
Contact Classes: 28	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 28**		
Prerequisite: There are no prerequisites to take this course								

COURSE OVERVIEW:

This course provide the environment to develop high-tech, ecological and socially responsible products from concept and design to production. The course covers hands-on learning in product and industrial design and product development with product lifecycle management.

OBJECTIVES:

The students will try to learn:

I. The design thinking process and Identify opportunities through customer needs analysis.
II. Product specifications based on customer needs that are desirable, feasible, and viable through applied creativity.
III. The Implementation techniques for planning and executing a prototype design services.

WEEK NO	TOPIC
WEEK – I	Introduction To Product Design
WEEK – II	Design Thinking Skills
WEEK – III	Identifying Customer Needs
WEEK – IV	Product Specifications
WEEK – V	Applied Creativity
WEEK – VI	Prototyping
WEEK – VII	Design Of Services
WEEK –VIII	Product Architecture
WEEK - IX	Financial Analysis
WEEK - X	Design For Environment
WEEK - XI	Product Development Process
WEEK - XII	Reverse Engineering
WEEK - XIII	Value Engineering
WEEK - XIV	Assessment

AEROSPACE STRUCTURES LABORATORY

IV Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC11	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		-	-	3	1.5	30	70	100
Contact Classes: Nil	**Tutorial Classes: Nil**	**Practical Classes: 36**				**Total Classes: 36**		
Prerequisite: There are no prerequisites to take this course								

I. COURSE OVERVIEW:

Aircraft structural laboratory is used to enhance the learning of the undergraduate student by encouraging them to undertake the projects in the area of structural analysis of thin walled structural components, wings, fuselage and landing gears.

II. COURSE OBJECTIVES:

The students will try to learn:

I. Provide basic knowledge on the mechanical behavior of materials like aluminum, mild steel, and cast iron.
II. Visualize the crack detection using various NDT methods and also discuss the changing strength due to these defects.
III. Understand the concept of locating the shear centre for open and closed section of beams.
IV. Obtain buckling strength of both long and short columns using different elastic supports

III. COURSE SYLLABUS:

Week – 1: DEFLECTION TEST

Stress and deflections of beams for various end conditions, verification of Maxwell's theorem

Week – 2: BUCKLING TEST

Compression tests on long columns, Critical buckling loads.

Week – 3: COMPRESSION TEST

Compression tests on short columns, Critical buckling loads, south well plot

Week – 4: BENDING TEST

Unsymmetrical Bending of a Beam

Week – 5: SHEAR CENTRE FOR OPEN SECTION

Shear Centre of an open Section beam.

Week – 6: SHEAR CENTRE FOR CLOSED SECTION

Shear Centre of a closed Section beam.

Week – 7: SHEAR STRESS OF RIVETED JOINTS

Shear strength of riveted joints using UTM

Week – 8: SANDWICH PANEL TENSION TEST

Fabrication and determine the young's modulus of a sandwich structures.

Week – 9: NON-DESTRUCTIVE TESTING-I

Study of non-destructive testing procedures using dye penetration.

Week – 10: NON-DESTRUCTIVE TESTING-II

Non-destructive testing procedures - Magnetic particle inspection.

Week – 11: NON-DESTRUCTIVE TESTING-III

Non-destructive testing procedure - Ultrasonic techniques.

Week – 12: VIBRATION TEST

Determination of natural frequency of beams under free and forced vibration using.

IV.TEXT BOOKS:

1. T. H. G. Megson, "Aircraft Structures for Engineering Students", Butterworth-Heinemann Ltd, 5th Edition, 2012.
2. E. H. Bruhn, "Analysis and Design of Flight vehicles Structures", Tri-state off set company, USA, 4th Edition, 1965.

V. REFERENCE BOOKS:

1. B. K. Donaldson, "Analysis of Aircraft Structures - An Introduction", McGraw Hill, 3rd Edition, 1993.
2. S. Timoshenko, "Strength of Materials, Vols I and II", Princeton D. Von Nostrand Co., Reprint, 1977.

VI. WEB REFERENCES:

1. https://nptel.ac.in/courses/112101095/
2. https://www.scribd.com/doc/244154727/theory-of-structures-timoshenko-pdf

AERODYNAMICS AND PROPULSION LABORATORY

IV Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC12	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		0	0	3	1.5	30	70	100
Contact Classes: Nil	**Tutorial Classes: Nil**	**Practical Classes: 36**				**Total Classes: 36**		
Prerequisite: Knowledge of Fluid Dynamics and Engineering Thermodynamics								

I. COURSE OVERVIEW:

The course is intended to provide the basic understanding of flow around different airfoil sections to calculate lift, drag, and moments by using low speed wind tunnel. Propulsion lab deals to understand the performance and efficiency of different compressors, nozzles, propeller and turbines.

II. COURSE OBJECTIVES:

The students will try to learn:

I. Understand the behavior of flow properties over different models using subsonic wind tunnel.
II. Demonstrate experimentally the pressure distribution over circular, symmetric and cambered airfoils and evaluate lift and drag.
III. Illustrate flow visualization studies at low speeds over different aerodynamic bodies.
IV. Demonstrate the performance of blower, turbines, nozzles and propellers.
V. Understand the thermodynamic behavior of gas turbine engines and to calculate different performance parameters.

III. COURSE SYLLABUS:

Week-1: CALIBRATION AND PRESSURE DISTRIBUTION-CYLINDER

Calibration of subsonic wind tunnel, Pressure distribution over cylinder.

Week-2: PRESSURE DISTRIBUTION AND FLOW VISUALIZATION -SYMMETRIC, CAMBERED AIRFOIL

Pressure distribution and flow visualization over symmetric, cambered airfoil

Week-3: FORCE MEASUREMENT

Force measurement using wind tunnel balance.

Week-4: WAKE ANALYSIS

Force measurement using wind tunnel balance.

Week-5: FLOW OVER A FLAT PLATE

Flow over a flat plate

Week-6: BLOWER TEST RIG

Efficiency of blower test rig for 3 different vane settings.

Week-7: GAS TURBINE PARAMETERS CALCULATION

Calculation of work, power and Thrust requirement in gas turbine- combustion power input, work heat relationship.

Week-8: GAS TURBINE EFFICIENCY AND PERFORMANCE DIAGRAMS

Elucidate T-S, H-S diagrams for the gas turbine and compare efficiencies of non-ideal engine components.

Week-09: GAS TURBINE EFFICIENCY CALCULATIONS

Calculation of thermal, propulsive and overall efficiency of turbo jet cycle.

Week-10: NOZZEL PERFORMECE

Calculation of various nozzle performance with airflow

Week-11: CALORIFIC VALUE OF DIFFERENT FUELS
Calculation of calorific value of different fuels and materials using digital bomb calorimeter and optimizing astute fuels.

Week-12: PROPELLER TEST RIG
Calculation of propeller efficiency and thrust availability using propeller test rig at various blade pitch angles.

IV. REFERENCE BOOKS:

1. L. J. Clancy, "Aerodynamics", Pitman, 1st Edition, 1986.
2. Alan pope, "Low Speed Wind Tunnel Testing", John Wiley, 2nd Edition, 1999.
3. N. M. Komerath, "Low Speed Aerodynamics", Extrovert, 1st Edition, 2012.
4. https://www.cast-safety.org/pdf/3_engine_fundamentals.pdf
5. https://en.wikipedia.org/wiki/Reciprocating_engine

V. WEB REFERENCES:

1. www.loc.gov/rr/scitech/tracer-bullets/aerodynamicstb.html
2. www.myopencourses.com/subject/aerodynamics-2
3. www.tocs.ulb.tu-darmstadt.de/211658790.pdf
4. www.princeton.edu/~stengel/MAE331Lecture3.pdf

AIRCRAFT PRODUCTION TECHNOLOGY LABORATORY

IV Semester: AE								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAEC13	Core	L	T	P	C	CIA	SEE	Total
		0	0	2	1	30	70	100
Contact Classes: Nil	Tutorial Classes: Nil	Practical Classes: 24				Total Classes: 24		
Prerequisite: Knowledge of Manufacturing Practice.								

I. COURSE OVERVIEW:

The Aircraft Production Technology lab encompasses on providing sound practical knowledge on testing of engineering material and conventional machining process which plays a vital role in designing the components with minimum cost and with longer service.

II. COURSE OBJECTIVES:

The students will try to learn:

I. Understand the basic material properties to identify the suitable applications in aerospace industries.
II. Illustrate other conventional machining techniques required for aircraft production.
III. Learn the tooling and material joining technique used in aircraft assembly.

III. COURSE SYLLABUS:

Week-1: BASIC METALLURGY -I

Preparation and study of microstructure of pure materials like Cu and Al.

Week-2: BASIC METALLURGY -II

a. Study of microstructures of non-ferrous alloys.
b. Study of microstructure of heat treated steel.

Week-3: LATHE OPERATIONS -I

Introduction- lathe machine, plain turning, Step turning & grooving.

Week-4: LATHE OPERATIONS -II

Taper turning-compound rest/offset method & Drilling using lathe, External threading-Single start

Week-5: SHAPING

Shaping-V-Block

Week-6: SLOTTING

Slotting-Keyways

Week-7: MILLING

Milling-Face milling, End milling and Side milling

Week-8: GRINDING

Grinding-Cylindrical /Surface/Tool & cutter.

Week-09: DRILLING

Drilling, reaming, counter boring, Counter sinking and Taping.

Week-10: WELDING PROCESS-I

Gas Welding, Brazing and Soldering.

Week-11: WELDING PROCESS-II

Arc welding and Spot welding

Week-12: BASIC CASTING
Preparation of casting with simple patterns.

IV. TEXT BOOKS:

1. S. Kalpakjian, Steven R. Schmid, "Manufacturing Engineering and Technology", Addison Wesley 5th Edition, 1991.
2. S. C. Keshu, K. K Ganapathy, "Aircraft production technology and management", Interline Publishing House, Bangalore, 3rd Edition, 1993.
3. Douglas F. Horne, "Aircraft production technology", Cambridge University Press, 1st Edition, 1986.

V. REFERENCE BOOKS:

1. S. C. Keshu, K. K Ganapathy, "Air craft production techniques", Interline Publishing House, Bangalore, 3rd Edition, 1993.
2. R. K. Jain, "Production technology", McGraw Hill, 1st Edition, 2002.
3. O. P. Khanna, M. Lal, "Production technology", DhanpatRai Publications, 5th Edition, 1997.

VI. WEB REFERENCES:

1. https://nptel.ac.in/courses/112107145/
2. https://nptel.ac.in/courses/112105126/

VII. E-TEXT BOOKS

1. https://books.google.co.in/books?id=6wFuw6wufTMC&redir_esc
2. https://royalmechanicalbuzz.blogspot.in/2015/04/manufacturing-engineering-by-kalpakjian.html

FUNDAMENTALS OF DATABASE SYSTEMS

IV Semester: CE / EEE / ME / ECE / AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
ACSC18	**SKILL**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		-	-	-	-	-	-	-
Contact Classes: Nil	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: Nil**		

I. COURSE OVERVIEW

The fundamentals of Database systems are vital components of modern information systems. Database applications all pervasive and range in size from small in-memory databases to terabytes or even larger in various applications domains. The course focuses and the fundamentals of knowledgebase and relational database management systems, and the current developments in database theory and their practices.

II. COURSE OBJECTIVES:

The course should enable the students to:

I. Understand the role of database management system in an organization and learn the database concepts.
II. Design databases using data modeling and data normalization techniques.
III. Construct database queries using relational algebra and calculus.
IV. Understand the concept of a database transaction and related database facilities.
V. Learn how to evaluate set of queries in query processing.

III. COURSE SYLLABUS:

MODULE: I CONCEPTUAL MODELING (10)

Introduction to file and database systems: Database system structure, data models: entity relationship model, relational model.

MODULE: II RELATIONAL APPROACH (08)

Relational algebra and calculus: Relational algebra, selection and projection, set operations, renaming, joins, division, examples of algebra queries, relational calculus, tuple relational calculus.

MODULE : III BASIC SQL QUERY AND NORMALIZATION (10)

SQL data definition; Queries in SQL: updates, views, integrity and security, relational database design.

Normal Forms: 1NF, 2NF, 3NF and BCNF.

MODULE : IV TRANSACTION MANAGEMENT (09)

Transaction processing: Introduction, need for concurrency control, desirable properties of transaction, schedule and recoverability, Serializability and schedules

MODULE : V CONCURRENCY CONTROL (08)

Concurrency control; Types of locks: Two phases locking, deadlock, timestamp based concurrency control, recovery techniques, concepts, immediate update, deferred update, shadow paging.

IV. TEXT BOOKS:

Abraham Silberschatz, Henry F. Korth, S. Sudarshan, "Database System Concepts", McGraw-Hill, 4thEdition, 2002.

V. REFERENCE BOOKS:

1. Ramez Elmasri, Shamkant B. Navathe, "Fundamental Database Systems", Pearson Education, 3rd Edition, 2003.
2. Raghu Ramakrishnan, "Database Management System", Tata McGraw-Hill Publishing Company, 3rd Edition, 2003.
3. Hector Garcia Molina, Jeffrey D. Ullman, Jennifer Widom, "Database System Implementation", Pearson Education, United States, 1st Edition, 2000.
4. Peter Rob, Corlos Coronel, "Database System, Design, Implementation and Management", Thompson Learning Course Technology, 5th Edition, 2003.

VI. WEB REFERENCES:

1. https://www.youtube.com/results?search_query=DBMS+onluine+classes
2. http://www.w3schools.in/dbms/
3. http://beginnersbook.com/2015/04/dbms-tutorial/

VII. E-TEXT BOOKS

1. http://www.e-booksdirectory.com/details.php?ebook=10166
2. http://www.e-booksdirectory.com/details.php?ebook=7400re

BUSINESS ECONOMICS AND FINANCIAL ANALYSIS

IV Semester: **CSE / CSIT / CSE(DS), CSE(CS)**

V Semester: **AE / CE / EEE | VI Semester: ECE / ME / IT / CSE(AI&ML)**

Course Code	Category	Hours / Week			Credits	Maximum Marks		
		L	T	P	C	CIA	SEE	Total
AHSC13	Foundation	3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil			Total Classes: 45			

Prerequisite: **There is no prerequisite is required to this course**

I. COURSE OVERVIEW:

The course is designed in such a way that it gives an overview of concepts of Economics. Managerial Economics enables students to understand micro environment in which markets operate how price determination is done under different kinds of competitions. Financial Analysis gives clear idea about concepts, conventions and accounting procedures along with introducing students to fundamentals of ratio analysis and interpretation of financial statements. Break Even Analysis is very helpful to the Business Concern for Decision Making, controlling and forward Strategic Planning. Ratio analysis gives an idea about financial forecasting, financial planning, controlling the business and decision making.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The concepts of business economics and demand analysist o helps in optimal decision making in business environment**.**

II. The functional relationship between Production and factors of production and able to compute breakeven point to illustrate the various uses of breakeven analysis.

III. The features, merits and demerits of different forms of business organizations existing in the modern business environment and market structures.

IV. The concept of capital budgeting and allocations of the resources through capital budgeting methods and compute simple problems for project management.

V. Various accounting concepts and different types of financial ratios for knowing financial positions of business concern.

III. COURSE OBJECTIVES:

MODULE – I: INTRODUCTION AND DEMAND ANALYSIS (07)

Definition, nature and scope of business economics; Demand analysis; Demand determinants, law of demand and its exceptions; Elasticity of demand: Definition, types, measurement and significance of elasticity of demand, demand forecasting, factors governing demand forecasting.

MODULE – II: PRODUCTION AND COST ANALYSIS (10)

Production function; Isoquants and isocosts, MRTS, least cost combination of inputs, Cobb-Dougles production function, internal and external economies of scale, cost analysis; Cost concepts: Break even analysis (BEA), determination of break-even point (simple problems), managerial significance.

MODULE – III: MARKETS AND NEW ECONOMIC ENVIRONMENT (08)

Types of competition and markets, features of perfect competition, monopoly and monopolistic competition, price-output determination in case of perfect competition and monopoly business.

Features and evaluation of different forms of business organizations: Sole proprietorship, partnership, joint stock company, public enterprises and their types.

MODULE – IV: CAPITAL BUDGETING (10)

Capital and its significance, types of capital, estimation of fixed and working capital requirements, methods and sources of raising capital, capital budgeting: features of capital budgeting proposals; Methods of capital budgeting: Payback period, accounting rate of return(ARR), net present value method and internal rate of return method (simple problems).

MODULE – V: INTRODUCTION TO FINANCIAL ACCOUNTING AND FINANCIAL ANALYSIS (10)

Financial accounting objectives, functions, importance; Accounting concepts and accounting conventions -double-entry book keeping, journal, ledger, trial balance; Final accounts: Trading account, profit and loss account and balance sheet with simple adjustments; Financial analysis: Analysis and interpretation of liquidity ratios, activity ratios, capital structure ratios and profitability ratios (simple problems), Du Pont chart.

IV. TEXT BOOKS:

1. Aryasri, "Managerial Economics and Financial Analysis", TMH publications, 4th Edition, 2012.
2. M. Kasi Reddy, Saraswathi, "Managerial Economics and Financial Analysis", PHI Publications, New Delhi, 2nd Edition, 2012.
3. Varshney, Maheswari, "Managerial Economics", Sultan Chand Publications, 11th Edition, 2009.

V. REFERENCE BOOKS:

1. S. A. Siddiqual, A. S. Siddiqual, "Managerial Economics and Financial Analysis", New Age International Publishers, Hyderabad, Revised 1st Edition, 2013.
2. S. N. Maheswari, S. K. Maheswari, "Financial Accounting", Vikas publications, 3rd Edition, 2012.
3. J. V. Prabhakar Rao, P. V. Rao, "Managerial Economics and Financial Analysis", Maruthi Publishers, Reprinted Edition, 2011.
4. Vijay Kumar, Appa Rao, "Managerial Economics and Financial Analysis", Cengage Publications, 1st Edition, Paperback, 2011.

VI. WEB REFERENCES:

1. https:// www.slideshare.net/glory1988/managerial-economics-and- financial analysis
2. https:// thenthata.web4kurd.net/mypdf/managerial-economics-and- financial analysis
3. https:// bookshallcold.link/pdfread/managerial-economics-and-financial analysis
4. https:// www.gvpce.ac.in/syllabi/Managerial Economics and financial analysis

AEROSPACE PROPULSION

V Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC14	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	1	-	4	30	70	100
Contact Classes: 45	**Tutorial Classes: 15**	**Practical Classes: Nil**				**Total Classes: 60**		
Prerequisite: Aircraft Propulsion								

I. COURSE OVERVIEW:

This course deals with the basic principles of rocket propulsion and presents an overview of the space missions followed by the system requirements. It includes an overview of different types of propulsion like solid, liquid and hybrid propulsion. Solid propulsion grain design and estimates for the mission will be evaluated by gaining knowledge. In addition to solid, liquid and hybrid propulsion techniques will be detailed in the current course and this also tries to forecast the future development of propulsion technologies, identifying some futuristic propulsion systems, which will need to use new space propulsion technologies. It includes an overview of the relevant propulsion technologies (e.g., cold gas, chemical, electric), propulsion technology selection, system design, and component evaluation.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The fundamental knowledge and basic working principle of rocket propulsion
II. The salient features of different chemical rocket propulsion systems and combustion processes
III. The advanced space propulsion systems using electric, ion and nuclear propulsion techniques
IV. The application of rocket propulsion technology in design and development of modern and efficient space propulsion system

III. COURSE SYLLABUS:

MODULE-I: PRINCIPLES OF ROCKET PROPULSION (09)

History of rockets, Newton's third law, orbits and space flight, types of orbits, basic orbital equations, elliptical transfer orbits, launch trajectories, the velocity increment needed the thermal rocket engine, SSTO and TSTO, launch assists.

MODULE –II: FUNDAMENTALS OF ROCKET PROPULSION (09)

Operating principle, rocket equation, specific impulse of a rocket, rocket nozzle classification, performance characteristics of rockets, air augmented rockets, pulse rocket motors, static testing of rockets and instrumentation, safety considerations.

MODULE –III: SOLID ROCKET PROPULSION (09)

Salient features of solid propellant rockets, selection criteria of solid propellants, propellant grain design considerations. Types of igniters.

Erosive burning in solid propellant rockets, combustion instability, strand burner and T-burner, applications and advantages of solid propellant rockets.

MODULE –IV: LIQUID AND HYBRID ROCKET PROPULSION (09)

Salient features of liquid propellant rockets, selection of liquid propellants, various feed systems and injectors for liquid propellant rockets, thrust control, cooling in liquid propellant rockets and the associated heat transfer problems, combustion instability in liquid propellant rockets, peculiar problems associated with operation of cryogenic engines, introduction to hybrid rocket propulsion, standard and reverse hybrid systems, combustion process in hybrid propellant rockets, applications and limitations.

MODULE –V: ADVANCED PROPULSION TECHNIQUES (09)

Electric rocket propulsion, types of electric propulsion techniques, Ion propulsion, Nuclear rocket, comparison of performance of these propulsion systems with chemical rocket propulsion systems, future applications of electric propulsion systems, Solar sail.

IV. TEXT BOOKS:

1. Turner, M.J.L., “Rocket and Spacecraft Propulsion”, MIT Press, 2nd Edition, 1922.
2. Sutton, G.P., “Rocket Propulsion Elements” John Wiley & Sons Inc., New York, 5th Edition, 1993.
3. P Hill, P.G. and Peterson, C.R., Mechanics and Thermodynamics of Propulsion, Addison Wesley, 2nd Edition, 1992.

V. REFERENCE BOOKS:

1. Mathur, M.L., and Sharma, R.P., “Gas Turbine, Jet and Rocket Propulsion”, Standard Publishers and Distributors, Delhi, 1988.
2. Tajmar, M., “Advanced Space Propulsion Systems”, Springer, 2003.
3. Hieter and Pratt, “Hypersonic Air Breathing Propulsion”, 4th Edition, 1993.

VI. WEB REFERENCES:

1. https://nptel.ac.in/courses/101/106/101106082/
2. https://nptel.ac.in/courses/101/104/101104078/
3. https://www.grc.nasa.gov/www/k-12/airplane/shortp.html

VII. E-TEXT BOOKS:

1. https://www.springer.com/gp/book/9783540692027
2. https://books.google.co.in/books/about/Rocket_Propulsion_Elements.html?id=1Sf6eV6CgtEC&redir_esc=y
3. https://www.pearson.com/store/p/mechanics-and-thermodynamics-of-propulsion / P100000432806 /9780201146592

ANALYSIS OF AIRCRAFT STRUCTURES

V Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC15	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	1	-	4	30	70	100
Contact Classes: 45	**Tutorial Classes: 15**	**Practical Classes: Nil**				**Total Classes: 60**		
Prerequisite: **Engineering Mechanics, Solid Mechanics, Aerospace Structures, Mathematics**								

I. COURSE OVERVIEW:

The major emphasis of this course is to apply the concept of solid mechanics to aircraft structural components to determine deflections and stresses acting on components. Analysis and design of thin walled beams, thin plates analysis by using energy methods is dealt.Further the design concepts of structural idealization, structural discontinuities in open and closed section beams have been introduced to analyze, design and development of flight vehicles structural components.

II.COURSE OBJECTIVES:

The student will try to learn:

I. The concepts of fatigue and energy methods in aircraft components construction.
II. The properties and analysis of composite structures for replacement of aluminum structures with composites for high strength to weight ratio.
III. The mechanism involved in thin walled closed and rectangular section beam subjected to torsion and Shear loads for design of modern aircrafts.
IV. The concepts of Stresses and deflections of various open and closed section aircraft beam structures.

III.COURSE SYLLABUS:

MODULE-I: FATIGUE OF AIRCRAFT STRUCTURE (10)

Impact Strength: Introduction, Impact stresses due to axial, bending and torsional loads, effect of inertia. Fatigue Strength: Introduction, S-N Diagram, Low cycle fatigue, High cycle fatigue, Endurance limit, modifying factors: size effect, surface effect, Stress concentration effects, Fluctuating stresses, Goodman and Soderberg relationship, stresses due to combined loading, cumulative fatigue damage.

MODULE –II: ENERGY METHODS: Strain Energy due to axial, bending and Torsional loads. Composite beam, Clapeyron's Three Moment Equation

Columns: Columns with various end conditions, Euler's Column curve, Rankine's formula, Column with initial curvature, Eccentric loading, south-well plot, Beam-column.

MODULE –III: LAMINATED AIRCRAFT COMPOSITE STRUCTURES (10)

Classification and characteristics of composite materials, Combinations of composite materials, Mechanical Behavior. Basic terminology-laminae, laminates, Manufacture – Initial form of constituent Materials, Layup, Curing, Strength and stiffness Advantages, Cost Advantages, and Weight Advantages.

Applications- Military, Civil Aircraft, Space and Automotive. Elastic constants of a simple lamina, Stress–strain relationships for an orthotropic ply(macro- approach), Thin-walled composite beams.

MODULE –IV: STRUCTURAL AND LOADING DISCONTINUITIES-CLOSED SECTION BEAMS (09)

General aspects, Shear stress distribution at a built-in end of a closed section beam, Thin-walled rectangular section beam subjected to torsion.

MODULE –V: STRUCTURAL AND LOADING DISCONTINUITIES -OPEN SECTION BEAMS (08)

I-section beam subjected to torsion, Torsion of an arbitrary section beam, Distributed torque loading, Extension of the theory to allow for general systems of loading, Moment couple (bimoment).

IV. TEXT BOOKS:

1. T. H. G. Megson, "Aircraft Structures for Engineering Students", Butterworth-Heinemann Ltd, 5th Edition, 2012.
2. David J Perry, J J Azar , "Aircraft Structures" McGraw-Hill Book Company, 2nd Edition, 2012.

V. REFERENCE BOOKS:

1. B. K. Donaldson, "Analysis of Aircraft Structures - An Introduction", McGraw Hill, 3rd Edition, 1993.
2. E. H. Bruhn, "Analysis and Design of Flight Vehicles Structures", Tri-state off set company, USA, 4th Edition, 1965.
3. S. Timoshenko, "Strength of Materials, Vols I and II", Princeton D. Von Nostrand Co., Reprint, 1977.

HIGH SPEED AERODYNAMICS

V Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC16	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	1	-	4	30	70	100
Contact Classes: 45	**Tutorial Classes: 15**	**Practical Classes: Nil**				**Total Classes: 60**		
Prerequisite: Aerodynamics								

I. COURSE OVERVIEW:

High speed aerodynamics is a branch of science deals with compressible flows in which density and temperature change are significant with variation in flow speed. The course is designed as a core course for the undergraduate students of Aerospace engineering and contains the basic material essential for a foundation of compressible flow aerodynamics. The course introduces the fundamental concepts and principles of compressible flow and intends to provide the necessary background for advanced studies on the subject. A number of application problems are incorporated to illustrate the concepts. The course covers the general principles and essentials of compressible flow, the flow equations, one-dimensional gas dynamics, wave motion and waves in supersonic flow, flow in ducts, small-perturbation theory, method of characteristics and similarity rules. Even though the course is prepared mainly for the use of undergraduate students in aerospace engineering, it will also be useful to graduate students, teachers and practicing engineers and scientists.

II. COURSE OBJECTIVES:

The student will try to learn:

I. Basic concepts of compressible flow, governing equations of compressible flow, compressibility effect at high speeds and their importance on the design of high-speed vehicles
II. The wave formations, propagation in supersonic flow field and their resultant effect on flow properties variations.
III. The Method of characteristics, compatibility equations and method of solutions for isentropic and non-isentropic flows
IV. The various experimental methods and measurement techniques utilized in compressible flow regimes.

III. COURSE SYLLABUS:

MODULE-I: INTRODUCTION TO COMPRESSIBLE FLOWS (10)

Basic concepts: Introduction to compressible flow, brief review of thermodynamics and fluid mechanics, integral forms of conservation equations, differential conservation equations, continuum postulates, acoustic speed and Mach number, governing equations for compressible flows.

MODULE –II: SHOCK AND EXPANSION WAVES (12)

Shocks and expansion waves: Development of governing equations for normal shock, stationery and moving normal shock waves, applications to aircrafts, supersonic wind tunnel, shock tubes, shock polars, supersonic pitot-probes; oblique shocks, governing equations, reflection of shock, Prandtl-Meyer expansion flow, shock expansion method for flow over airfoil, introduction to shock wave boundary layer interaction.

MODULE –III: ONE DIMENSIONAL AND QUASI ONE DIMENSINAL FLOW (9)

Quasi one-dimensional flow: Isentropic flow in nozzles, area Mach relations, choked flow, under and over expanded nozzles, slip streamline.

One dimensional flow: Flow in constant area duct with friction and heat transfer, Fanno flow and Rayleigh flow, flow tables and charts for Fanno flow and Rayleigh flow.

MODULE –IV: APPLICATIONS OF COMPRESSIBLE FLOWS AND NUMERICAL TECHNIQUES (9)

Small perturbation equations for subsonic, transonic, supersonic and hypersonic flow; Experimental characteristics of airfoils in compressible flow, supercritical airfoils, area rule; Theory of characteristics, determination of the characteristic lines and compatibility equations, supersonic nozzle design using method of characteristics.

MODULE –V: EXPERIMENTAL METHODS IN COMPRESSIBLE FLOWS (08)

Experimental methods: Subsonic wind tunnels, supersonic wind tunnels, shock tunnels, free-piston shock tunnel, detonation-driven shock tunnels, and expansion tubes and characteristic features, their operation and performance, flow visualization techniques for compressible flows.

IV. TEXT BOOKS:

1. Radhakrishnan Ethirajan, "Gas Dynamics", John Wiley & Sons, 7th Edition, 2020.
2. John D. Anderson, "Modern Compressible flow with historical perspective", McGraw-Hill Education, 3rd Edition, 2002.

V. REFERENCE BOOKS:

1. Ascher H. Shapiro, "The Dynamics and Thermodynamics of Compressible Fluid Flow", John Wiley & Sons; Volume 1, 4th Edition, 1977.
2. John D. Anderson, "Fundamentals of Aerodynamics", McGraw-Hill Education, 6th Edition, 2016.

VI. WEB REFERENCES:

1. https://www.slideshare.net/lccmechanics/high-speed-aerodynamics
2. https://en.wikipedia.org/wiki/High-speed_flight

VII. E-TEXT BOOKS:

1. https://www.ebooksdirectory.com/details.php?ebook=8565

HEAT AND MASS TRANSFER

V Semester: AE									
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAEC17	Elective	L	T	P	C	CIA	SEE	Total
		3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		
Prerequisite: Knowledge of Engineering Thermodynamics and Fluid dynamics								

I. COURSE OVERVIEW:

Heat transfer is the flow of thermal energy due to temperature difference and the subsequent temperature distribution changes commonly measured as heat flux. This course focuses on heat transfer modes such as conduction, convection and radiation, boundary conditions, one dimensional steady and unsteady state condition, heat exchangers and mass transfer mechanisms applied to modern aero-thermal systems for designing higher thermal efficient systems. Thus there is great relevance for this course in modeling heat exchangers, heat treatment of fins and complex mechanical systems and creates a scope for further graduate studies.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The governing equations and performance relations of various modes of heat transfer using the three types of coordinate systems.

II. The concepts for validating heat transfer parameters during internal and external flows based on non-dimensional numbers and convective mode heat transfer.

III. The performance and analysis of heat exchangers for real-time applications using various methods and indicators (such as LMTD and NTU etc).

IV. The design methodologies for enhancing heat and mass transfer among a wide variety of practical engineering problems.

III. COURSE SYLLABUS:

MODULE-I: INTRODUCTION TO HEAT TRANSFER, CONDUCTION (10)

Modes and mechanisms of heat transfer, Basic laws of heat transfer. Conduction heat transfer: Fourier rate equation, Steady, unsteady and periodic heat transfer -Initial and boundary conditions, Overall heat transfer coefficient, Electrical analogy, Critical radius of insulation, Extended surfaces (Fins) Long, Short and insulated tips. Application to error measurement of temperature. Significance of Biot and Fourier numbers, Chart solutions of transient conduction systems –concept of Functional Body.

MODULE –II: FREE AND FORCED CONVECTION (08)

Free and Forced Convection – Hydrodynamic and Thermal Boundary Layer. Free and Forced Convection during external flow over Plates and Cylinders and Internal flow through tubes.

MODULE –III: PHASE CHANGE HEAT TRANSFER, HEAT EXCHANGERS (10)

Film boiling, Regimes of pool boiling and flow boiling. Film wise and drop wise condensation, Nusselt's theory of condensation on a vertical plate.

Classification of heat exchangers, overall heat transfer Coefficient and fouling factor, Concepts of LMTD and NTU methods, Problems using LMTD and NTU Methods, Application in Aero engines.

MODULE –IV: RADIATION HEAT TRANSFER (08)

Emission characteristics, Laws of black-body radiation, Irradiation, Total and Monochromatic quantities, Heat exchange between two black bodies, concepts of shape factor, Emissivity, heat exchange between grey bodies, radiation shields, electrical analogy for radiation networks.

MODULE –V: MASS TRANSFER (09)

Basic Concepts, Diffusion Mass Transfer, Fick's Law of Diffusion, Steady state Molecular Diffusion, Convective Mass Transfer, Momentum, Heat and Mass Transfer Analogy, Convective Mass Transfer Correlations.

IV. TEXT BOOKS:

1. Yunus A. Cengel, "Heat Transfer A Practical Approach", Tata McGraw hill Education (P) Ltd, New Delhi, India. 4th Edition, 2012.
2. R. C. Sachdeva, "Fundamentals of Engineering, Heat and Mass Transfer", New Age, New Delhi, India, 3rd Edition 2012.

V. REFERENCE BOOKS:

1. Holman, "Heat Transfer" Tata McGraw Hill education (P) Ltd, New Delhi, India. 10th Edition, 2012.
2. C. P. Kothandaraman, "Heat and Mass Transfer Data Book", New Age International Publishers, New Delhi, India, 9th Edition 2018.
3. P. S. Ghoshdastidar, "Heat Transfer", Oxford University Press, 2nd Edition, 2012.
4. D. S. Kumar, "Heat and Mass Transfer", S.K. Kataria& sons, 9th Edition 2015.

VI. WEB REFERENCES:

1. https://nptel.ac.in/courses/112101097/
2. https://hyperphysics.phy-astr.gsu.edu/hbase/thermo/heatra.html

VII. E-TEXT BOOKS:

1. https://bookzz.org/book/2556672/5ef6f5
2. https://bookzz.org/book/533930/66495a
3. https://bookzz.org/book/495953/61bfa5

AIR TRANSPORTATION SYSTEM

V Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC18	**Elective**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	-	-	3	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		
Prerequisite: Introduction to Aerospace Engineering								

I. COURSE OVERVIEW:

This course presents air transport system considers route structure options in terms of operational impacts and describes the context and boundaries of the industry – the natural, regulatory and operational environments 'Systems' perspectives are introduced to integrate the discussion of aircraft, airlines, airports and airspace issues. Examines major operational elements of the world's air transport system Considers route structure options in terms of operational impacts the natural, regulatory and operational boundaries of the industry.

II. COURSE OBJECTIVES:

The Students will try to learn:

I. The characteristics of aircraft, airlines and airport and air transport systems.
II. The various authorities involved in airport management airport planning, airport operations
III. The environmental regulation and airport fee, rates taxes and charges meteorological services.
IV. The safety regulation followed according to the rules with the economic regulation and aviation security.

III. COURSE SYLLABUS:

MODULE-I: AVIATION INDUSTRY & ITS REGULATORY AUTHORITIES (9)

Introduction, history of aviation-evolution, development, growth, challenges. Aerospace industry, air transportation industry-economic impact- types and causes. Airline Industry-structure and economic characteristics The breadth of regulation- ICAO, IATA, national authorities (DGCA, FAA). Safety regulations-risk assessment human factors and safety, security regulations, environmental regulations.

MODULE –II: AIRPORT PLANNING (9)

Categories of airspace-separation minima, airspace sectors-capacity, demand and delay. Evolution of air traffic control system-procedural ATC system, procedural ATC with radar assistance, first generation 'automated' ATC system, current generation radar and computer-based ATC systems. Aerodrome air traffic control equipment and Operation-ICAO future air-navigation system service provides as businesses. Communication, navigation and surveillance systems (CNSS). Radio communications-VHF, HF, ACARS, SSR, ADS. Navigation- NDB, VOR, DME, area-navigation systems (R-Nav), ILS, MLS, GPS, INS.

MODULE –III: AIRCRAFT (9)

Costs-project cash-flow, aircraft price. Compatibility with the operational infrastructure. Direct and indirect operating costs.

Balancing efficiency and effectiveness-payload-range, fuel efficiency, technical contribution to performance, operating speed and altitude, aircraft field length performance, typical operating costs. Effectiveness-wake-vortices, cabin dimensions, flight deck.

MODULE –IV: AIRPORTS (9)

Setting up an airport-airport demand, airport sitting, runway characteristics-length, declared distances, aerodrome areas, obstacle safeguarding. Runway capacity- evaluating runway capacity -sustainable runway capacity. Runway pavement length, Maneuvering area- airfield lighting, aprons, Passenger terminals-terminal sizing and configuration. Airport demand, capacity and delay.

MODULE –V: AIRLINES (9)

Setting up an airline-modern airline objectives. Route selection and development, airline objectives. Route selection and development, airline fleet planning, annual utilization and aircraft size, seating arrangements. Indirect operating costs. Aircraft- buy or lease. Revenue generation, Computerized reservation systems, yield management. Integrating service quality into the revenue-generation process. Marketing the seats. Airline scheduling, Evaluating success financial viability, regularity compliance, efficient use of resources, effective service.

IV. TEXT BOOKS:

1. Hirst, M., "The Air Transport System", Wood head Publishing Ltd, Cambridge, England, 2008.

V. REFERENCE BOOKS:

1. Wensven, J.G, "Air Transportion: A Management Perspective", Ashgate, 2007.
2. Belobaba, P, Odoni, A. and Barnhart, C, "Global Airline Industry", Wiley, 2009.
3. M.Bazargan, M, "Airline Operations and Scheduling", Ashgate, 2004.
4. Nolan,M.s, "Fundamentals of Air Traffic Control", Thomson Learning, 4th Edition, 2004.
5. Wells, A. and young, S., "Airport Planning and Management", McGraw-Hill, 5th Edition, 1986.

SPACE DYNAMICS

V Semester: AE								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAEC19	Elective	L	T	P	C	CIA	SEE	Total
		3	0	0	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		
Prerequisite: Knowledge of Mathematics								

I. COURSE OVERVIEW:

Space dynamics is a branch of physics that deals with the study of the system of forces acting on a celestial body motion under the influence of several celestial bodies. The course emphasizes the theories and principles related to Orbital mechanics application of celestial mechanics to the practical problems concerning the motion of artificial spacecraft and rockets. Broadly, the orbital dynamics of systems under the influence of gravity, including both spacecraft and natural astronomical bodies such as star systems, planets, moons, and comets. Orbital mechanics focuses on spacecraft trajectories, including orbital maneuvers, orbital plane changes, and interplanetary transfers, and is used by mission planners to predict the results of propulsive maneuvers.

II. COURSE OBJECTIVES:

The student will try to learn:

IV. The application of mathematics and science principles to represent the free body diagrams in the area of rigid body mechanics.

V. The conditions of static and dynamic equilibrium of bodies subjected to a particular force system for solving the field problems.

VI. The effects of force and motion while carrying out the innovative design functions of engineering.

III. COURSE SYLLABUS:

MODULE-I: INTRODUCTION TO SPACE MECHANICS. (10)

Basic concepts: The solar system, Reference frames and coordinate systems, The celestial sphere, The ecliptic, Motion of vernal equinox, Sidereal time, Solar Time, Standard Time, The earth‘s atmosphere. The many body problem, Lagrange-Jacobi identity. The circular restricted three body problem, Liberation points, Relative Motion in the N-body problem.

MODULE-II: SPACE DYNAMICS (10)

Particle Dynamics, Conic Section, Central Force Motion: Two Body Problem Equation of Relative Motion. Integrals of the Two Body Problem. Kepler's Equation. Kepler's Problem, Orbital Elements and Coordinate Systems and orbit Determination, Restricted Three Body Problem: Equation of Motion. Inertial, Relative, and Bary centric Formulas. General Three Body problem.

MODULE –III: ORBIT TRANSFER AND ORBITAL PURTURBATION (08)

Coplanar Transfer: Hohmann and Bielliptic transfer. Orbital Change due to Impulsive Thrust. Non-coplanar Transfer. Interception and Rendezvous. Continuous Thrust Transfer.

Special and general perturbations- Cowell‘s Method, Encke‘s method. Method of variations of orbital elements, General perturbations approach.

MODULE –IV: ATTITUDE DYNAMICS AND LAUNCH VEHICLE PARAMETER (10)

Rigid Body Dynamics, Attitude Control, Gravity Gradient Satellite, Dual Spin Satellite, Dependence of orbital parameters on in-plane injection parameters, Launch vehicle performances, Orbit deviations due to injection errors.

MODULE –V: BALLISTIC MISSILE TRAJECTORIES (09)

The boost phase, the ballistic phase, Trajectory geometry, optimal flights. Time of flight, Re-entry phase. The position of the impact point, Influence coefficients.

IV. TEXT BOOKS:

1. Vallado, David A, “Fundamentals of Astrodynamics and Applications”, Kluwer Academic Publishers, London.
2. Roy, Archie E, “The Foundation of Astrodynamics”, The Macmillan Company, Collier Macmillan Limited, London.

3. Battin, Richard H, “An Introduction to the Mathematics and Methods of Astrodynamics”, Dover Publication, New York.
4. Kaplan, Marshall H, “Modern Spacecraft Dynamics and Control”, John Wiely & Sons, New York.
5. Wiesel, William E, “Spaceflight Dynamics”, Tata McGraw Hill Publishing Company Limited, New Delhi.
6. Thomson, William T, “Introduction to Space Dynamics”, Dover Publication, New York.
7. Sidi, Marcel J, “Spacecraft Dynamics and Control”, Cambridge University Press, U.K.

V. E-TEXT BOOKS:

1. https://nptel.ac.in/courses/101/105/101105030/

MECHANISM AND MACHINE DESIGN

V Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC20	**Elective**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	-	-	3	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		
Prerequisite: Engineering Mechanics								

I. COURSE OVERVIEW:

This is a basic course on modeling, design, integration and best practices for use of machine elements such as bearings, springs, gears, cams and mechanisms. Modeling and analysis of these elements is based upon extensive application of physics, mathematics and core mechanical engineering principles (solid mechanics, fluid mechanics, manufacturing, estimation, computer simulation, etc.). These principles are reinforced via (1) hands-on laboratory experiences wherein students conduct experiments and disassemble machines and (2) a substantial design project wherein students model, design, fabricate and characterize a mechanical system that is relevant to a real world application.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The basic mechanism involved in machine design and basic relative kinematics relations of two moving point.
II. The individual links and categorize the type of the connection of the links (joints) for the mechanism of machines.
III. The fundamentals of specific link and joint combinations such as gyroscopic motion, followers, cam and gear systems.
IV. The kinematic analysis and develop analytical equations describing the relative position, velocity and acceleration of all moving links.

III. COURSE SYLLABUS:

MODULE-I: MECHANISMS & MACHINES (08)

Elements of links, classification, rigid link, flexible and fluid link, types of kinematic pairs, sliding, turning, rolling, screw and spherical pairs, lower and higher pairs, closed and open pairs, constrained motion, completely, partially or successfully constrained, and incompletely constrained, mechanism and machines, classification, kinematic chain, inversion of mechanism, inversion of quadratic cycle, chain, single and double slider crank chains.

MODULE –II: KINEMATIC ANALYSIS OF MECHANISMS (10)

Instantaneous centre of rotation, centroids and axodes, relative motion between two bodies, three centres in line theorem, graphical determination of instantaneous centre, diagrams for simple mechanisms and determination of angular velocity of points and links. Velocity and acceleration, motion of link in machine, determination of velocity and acceleration diagrams, graphical method, application of relative velocity method for four bar chain, analysis of slider crank chain for displacement, velocity and acceleration.

MODULE –III: BELT DRIVES, AND CAMS AND FOLLOWERS (10)

Belt Drives: Types of belts, material used for belts, types of flat belt drives, and velocity ratio of belt drive. Length of open belt drive. Power transmitted by a belt. Ratio of driving tensions for flat belt drive.

Centrifugal Tension. Maximum Tension in the Belt. Initial Tension in the Belt. Cams and followers, definition uses, types, terminology, types of follower motion, uniform velocity, simple harmonic motion and uniform acceleration, maximum velocity and acceleration during outward and return strokes.

MODULE –IV: GEARS AND GEAR TRAINS (09)

Gears And Gear Trains: friction wheels and toothed gears, types, law of gearing, condition for constant velocity ratio for transmission of motion, velocity of sliding, form of teeth, cycloidal and involute profiles, phenomena of interferences. Gear trains: Introduction, types, simple and reverted gear trains, epicyclic gear train; Methods of finding train value or velocity ratio of epicyclic gear trains.

MODULE –V: GYROSCOPIC COUPLE AND PRECESSION MOTION AND BALANCING OF ROTATING MASSES (08)

Angular Motion: Gyroscopes - Processional Angular Motion; Gyroscopic Couple; effect of precession motion on the stability of moving vehicles such as motorcycle - motorcar - aero planes and ships. Balancing of Rotating Masses;. Balancing of a Single Rotating Mass By a Single Mass Rotating in the same plane; Balancing of a Single rotating mass by two masses rotating in different planes; Balancing of several masses rotating in the same plane; Balancing of several masses rotating in different planes.

IV. TEXT BOOKS:

1. Amithab Ghosh, Asok Kumar Malik, "Theory of Mechanisms and Machines", East West Press Pvt Ltd, 2001.
2. S.S Ratan, "Theory of Machines", Tata McGraw-Hill, 4th Edition, 2014.
3. J. S. Rao, R.V. Dukkipati, "Mechanism and Machine Theory", New Age Publications, 1996.
4. P. L. Ballaney, "Theory of Machines", Khanna Publishers, 3rd Edition, 2003

V. REFERENCE BOOKS:

1. Dr.Jagdish Lal, J. M. Shaw, "Theory of Machines", 1st Edition, 1985.
2. Abdulla Sharif, Dhanpat Rai, "Theory of Machines", 5th Edition, 1987.
3. Neil Sclater, P. Nicholas, Chironis, "Mechanisms and Mechanical Devices Sourcebook", New York McGraw-Hill, publications, 3rd Edition.1963.
4. J. E. Shigley, R. Charles, Mischke, "Mechanical Engineering and Design", TMH, 1st Edition, 2003.

VI. WEB REFERENCES:

1. https://en, wikipedia.org/wiki/Mechanism_(engineering)
2. https://en, wikipedia.org/wiki/Machine_(mechanical)
3. https://en, wikipedia.org/wiki/Crank_(mechanism)

VII. E-TEXT BOOKS:

1. https://engineeringstudymaterial.net/ebook/mechanisms-and-mechanical-devices-sourcebook/
2. https://accessengineeringlibrary.com/browse/mechanisms-and-mechanical-devices-sourcebook-fifth-edition.
3. https://www,amazon,com/Mechanisms-Mechanical-Devices-Sourcebook-Fourth-ebook/dp/B0062Y 79H0#navbar

EXPERIENTIAL ENGINEERING EDUCATION (ExEEd) – PROJECT BASED LEARNING

V Semester: **Common for all branches**

Course Code	Category	Hours / Week			Credits	Maximum Marks		
ACSC20	Foundation	L	T	P	C	CIA	SEE	Total
		2	-	-	1	30	70	100
Contact Classes: 36	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 36		

Prerequisite: **There are no prerequisites to take this course**

I. COURSE OVERVIEW:

Project-based learning (PBL) is collaborative, learner-centered instructional approach where students work in groups to construct their knowledge using modern tools. It often requires students to collaborate, design, revise, and share their ideas and experiences with authentic audiences and supportive peer groups rather than collect resources, organize work, and manage long-term activities. Project-Based Learning begins with the assignment of tasks that will lead to the problem identification, modeling, simulation and analyzing the results.

II. COURSE OBJECTIVES:

The students will try to learn:

I. To emphasize learning activities that is long-term, interdisciplinary and student-centric.
II. To inculcate independent learning by problem solving with social context.
III. To engages students in rich and authentic learning experiences.
IV. To provide every student the opportunity to get involved either individually or as a group so as to develop team skills and learn professionalism.

III. COURSE SYLLABUS

I. Defining the Problem
II. Gathering requirements
III. Design / *Mode*ling
IV. Implementation
V. Testing
VI. Report

COMPUTER AIDED AIRCRAFT PRODUCTION DRAWING LABORATORY

<table>
<tr><td colspan="10">V Semester: AE</td></tr>
<tr><th>Course Code</th><th>Category</th><th colspan="3">Hours / Week</th><th>Credits</th><th colspan="3">Maximum Marks</th></tr>
<tr><td rowspan="2">AAEC21</td><td rowspan="2">Core</td><td>L</td><td>T</td><td>P</td><td>C</td><td>CIA</td><td>SEE</td><td>Total</td></tr>
<tr><td>-</td><td>-</td><td>3</td><td>1.5</td><td>30</td><td>70</td><td>100</td></tr>
<tr><td>Contact Classes: Nil</td><td>Tutorial Classes: Nil</td><td colspan="4">Practical Classes: 36</td><td colspan="3">Total Classes: 36</td></tr>
<tr><td colspan="9">Prerequisite: Basic Engineering Drawing with Auto CAD</td></tr>
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I. COURSE OVERVIEW:

Computer aided design laboratory provides a strong foundations of computer aided designing tool and students will learn the implementation of solid modeling using CATIA. It enables students to master the fundamentals of advanced modeling techniques, sketcher tools, base features, drafting, sheet metal and surface design workbenches. This course focuses on giving the foundations of engineering design and making it very useful for getting the student ready for product manufacturing industry.

II. COURSE OBJECTIVES:

The student will try to learn:

I. Methods to create and save various types of CATIA V5 documents.
II. Selection of workbenches based on the product that has to be designed.
III. Fundamentals of geometric dimensioning and tolerances and representing those using designing software's
IV. Design various aircraft components in CATIA.

III. COURSE SYLLABUS:

Week-1: SKETCHER
Interface, Sketch Tools, View Tool bar, Profile Tool bar, Operation Tool bar, Tools , Constrain tool bar, Transformation Tool bar, User Selection Filter, Standards, Visualizations.

Week-2: PART DESIGN
Sketch Based Features, Dress up Features, Transformation Features, Reference Elements, Measure, Thickness,

Week-3: BOOLEAN OPERATIONS
Boolean Operations.

Week-4: SHEET METAL DESIGN
Walls, Cutting and Stamping, Bending, Rolled Walls,

Week-5: SURFACE DESIGN
Surfaces, Operations, Wireframe, Replication.

Week-6: ASSEMBLY
Product Structure Tools, Constrains.

Week-7: GD&T
Introduction to Geometric Dimensioning and Tolerance, Weld Symbols, GD&T Symbols, Types of Tolerances, Types of views, Roughness Symbols.

Week-8: DRAFTING
Views, Annotations, Sheet Background

Week-9: DESIGN OF AIRCRAFT WING
Design of any two types of Aircraft structures

Week-10: DESIGN OF FUSELAGE
Design of fuselage with internal components

Week-11: DESIGN OF NOSE CONE
Design of Nose cone structures

Week-12: DESIGN OF LANDING GEAR
Design of Main landing gear and nose landing gear

VI. REFERENCE BOOKS:

1. http://www.ehu.eus/asignaturasKO/DibujoInd/Manuales/R12_manual_catia_v5.pdf
2. http://www.engr.psu.edu/xinli/edsgn497k/TeaPotAssignment.pdf

V. WEB REFERENCES:

1. www.ebooks directory.com

COMPUTATIONAL STRUCTURE LABORATORY

<table>
<tr><td colspan="10">V Semester: AE</td></tr>
<tr><th>Course Code</th><th>Category</th><th colspan="3">Hours / Week</th><th>Credits</th><th colspan="3">Maximum Marks</th></tr>
<tr><td rowspan="2">AAEC22</td><td rowspan="2">Core</td><td>L</td><td>T</td><td>P</td><td>C</td><td>CIA</td><td>SEE</td><td>Total</td></tr>
<tr><td>0</td><td>0</td><td>3</td><td>1.5</td><td>30</td><td>70</td><td>100</td></tr>
<tr><td>Contact Classes: Nil</td><td>Tutorial Classes: Nil</td><td colspan="4">Practical Classes: 36</td><td colspan="3">Total Classes: 36</td></tr>
<tr><td colspan="9">Prerequisite: Mechanics of Solids and Aerospace Structures</td></tr>
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I. COURSE OVERVIEW:

Computational Structural Analysis Laboratory sessions focus on the creation of geometry, meshing (Discretization) and the physics behind the stress strain variation on a continuum. It will also cover the different solvers available in a FEA package and their applications based on the problem type. This course offers a wide range of applications in aircraft structural analysis such as deflection of truss, frames, beams, stress and strain distributions in a plate as well as a solid continuum. Apart from these, it will also address the nonlinear stress problems alongside vibration and flutter analysis.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The latest computational techniques and software used for structural analysis.
II. The how real-life structures behave under static and dynamic loads.
III. The professional and contemporary issues in the design and fabrication of aerospace structures.

III. COURSE SYLLABUS:

Week-1: INTRODUCTION AND BASIC FUNCTIONS
Batch I: Starting up of ANSYS/Nastran
Batch II: Description of user interface

Week-2: STATIC ANALYSIS: TRUSS AND FRAME STRUCTURES
Batch I: 2D truss structures
Batch II: 3D truss structures

Week-3: STATIC ANALYSIS: BEAMS
Batch I: Straight beams
Batch II: Tapered beams

Week-4: STATIC ANALYSIS: TWO DIMENSIONAL PROBLEMS
Batch I: 2D-structure with various loadings
Batch II: 2D-structure with different materials
Batch I & Batch II: Plate with a hole

Week-5: DYNAMIC ANALYSIS: MODAL AND TRANSIENT ANALYSES
Batch I: Modal analysis
Batch II: Transient Response of spring mass system

Week-6: THERMAL ANALYSIS
Batch I: Bars and Beams
Batch II: 2D structures

Week-7: NON-LINEAR ANALYSIS
Batch I: Non-linear behavior with large deflections
Batch II: Non-linear behavior with materials

Week-8: **HARMONIC RESPONSE ANALYSIS**
Batch I: Random Vibration Analysis of a deep simply-supported beam
Batch II: Harmonic response of a spring-mass system

Week-09: ANALYSIS OF AIRCRAFT STRUCTURE: WING
Batch I: Static analysis of Aircraft wing structure
Batch II: Modal analysis of Aircraft wing structure

Week-10: ANALYSIS OF AIRCRAFT STRUCTURE: FUSELAGE
Batch I: Static analysis of Aircraft Semi monocoque fuselage structure
Batch II: Modal analysis of Aircraft Semi monocoque fuselage structure

Week-11: ANALYSIS OF AIRCRAFT STRUCTURE: LANDING GEAR
Batch I: Static analysis of main landing gear
Batch II: Modal analysis of main landing gear

Week-12: ANALYSIS OF COMPOSITE STRUCTURES
Batch I: Static analysis of main landing gear
Batch II: Modal analysis of main landing gear

IV. REFERENCE BOOKS:

1. Huei-Huang Lee, "Finite Element Simulations with ANSYS Workbench 16", SDC publications, 2nd Edition, 2016.
2. Anderson, William J, "MSC/Nastran: Interactive Training Program", Wiley, 1st Edition 2015.

V. WEB REFERENCES:

1. https://www.scribd.com/doc/311680146/eBook-PDF-Cfd-Fluent.
2. https://cfd.ninja/tutorials/ansys-fluent
3. https://confluence.cornell.edu/display/SIMULATION/FLUENT+Learning+Modules

OBJECT ORIENTED PROGRAMMING DEVELOPMENT AND LANGUAGES

V Semester: AE / ECE / EEE / ME / CE							
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
ACSC23	**Skill**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		-	-	-	-	-	-	-
Contact Classes: Nil	**Total Tutorials: Nil**	**Total Practical Classes: Nil**				**Total Classes: Nil**		

I.COURSE OVERVIEW:

Java's unique architecture enables programmers to develop a single application that can run across multiple platforms seamlessly and reliably. This course, enable the students to gain extensive experience with Java and its object oriented features to create robust console and GUI applications and store and retrieve data from relational databases.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The basic object-oriented programming concepts and apply them in problem solving.
II. The inheritance concepts for reusing the program.
III. The programs to implement event handling, user interfaces and graphical interfaces with the help of Java.

III. COURSE SYLLABUS

MODULE-I: FUNDAMENTALS OF OBJECT-ORIENTED PROGRAMMING

Object oriented paradigm: Basic concepts of Object-Oriented Programming, Benefits of OOP, Applications of OOP; Java Evolution: Java Features, How Java differs from C and C++, Java and Internet,Java and World Wide Web, Web Browsers, Hardware and Software Requirements, Java Environment. Overview of Java Language: Simple Java Program, Java Program Structure, Java Tokens, Java Statements, Implementing a Java Program, Java Virtual Machine, Constants, Variables, Data types, Scope of Variables, Symbolic Constants, Type Casting and type promotions, Operators, Operator Precedence and Associativity, Control Statements, break, continue, Arrays-Multi dimensional arrays, Wrapper Classes, Simple examples.

MODULE-II: CLASSES AND OBJECTS

Classes and Objects, constructors, methods, this keyword, garbage collection, finalize, overloading methods and constructors, access control, static members, nested and inner classes, command line arguments, variable length arguments. Inheritance: Forms of inheritance, specialization, specification, construction, extension, limitation, combination, benefits and costs of inheritance. Super uses- final - polymorphism, method overriding - dynamic method dispatch, abstract classes, exploring String class.

MODULE-III: PACKAGES AND INTERFACES

Defining and accessing a package, understanding CLASSPATH, access protection importing packages, Interfaces: Defining and implementing an interface, Applying interfaces, Variables in interfaces and extended interfaces. Exploring java.lang and java.util packages.

Exception Handling: Fundamentals, usage of try, catch, multiple catch clauses, throw, throws and finally. Java Built in Exceptions and creating own exception subclasses.

MODULE- IV: MULTITHREADED PROGRAMMING

Java Thread life cycle model: Thread creation, Thread Exceptions, Thread Priority, Synchronization ,Messaging, Runnable Interface - Interthread Communication - Deadlock - Suspending, Resuming and stopping threads.
I/O Streams: File, Streams, Advantages, The stream classes, Byte streams, Character streams.

MODULE- V APPLET PROGRAMMING

Event handling: basics of event handling, Event classes, Event Listeners, delegation event model, handling mouse and keyboard events, adapter classes, AWT Class hierarchy, AWT Controls, Layout Managers and Menus, limitations of AWT. How Applets differ from Applications: Applet Life Cycle, Creating an Applet, Running the AppletDesigning a Webpage, Applet Tag, Adding Applet to HTML file, More about Applet Tag, Passing parameters to Applets, Aligning the display.

IV. TEXTBOOKS:

1. Herbert Schildt, "The Complete Reference Java J2SE", TMH Publishing Company Ltd, New Delhi, 5th Edition, 2008.
2. Cay Horstmann, "Big Java", John Wiley and Sons, 2nd Edition, 2006.

V. REFERENCES BOOKS:

1. H.M.Dietel and P.J.Dietel, "Java How to Program", Pearson Education/PHI, 6th Edition 2008.
2. Cay.S.Horstmann and Gary Cornell, "Core Java 2" Vol 1, Fundamentals", Pearson Education, 7th Edition, 2007.
3. Cay.S.Horstmann and Gary Cornell, "Core Java 2, Vol 2, Advanced Features", Pearson Education. 7th Edition, 2008.

VI. WEB REFERENCES:

1. http://www.javatpoint.com/java-tutorial
2. http://www.javatutorialpoint.com/introduction-to-java/

VII. E-Text Books:

1. http://bookboon.com/en/java-programming-language-ebooks
2. https://en.wikibooks.org/wiki/Java_Programming

FINITE ELEMENT ANALYSIS

VI Semester: AE								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAEC23	Core	L	T	P	C	CIA	SEE	Total
		3	1	-	4	30	70	100
Contact Classes: 45	Tutorial Classes: 15	Practical Classes: Nil				Total Classes: 60		
Prerequisite: Mechanics of solids								

I. COURSE OVERVIEW:

The finite element analysis (FEA) is a numerical method widely used for modeling and analyzing structures. This course introduces the mathematical modeling concepts of the Finite Element Method for solving structural, thermal and dynamics problems that are too complicated to be solved by analytical methods.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The theoretical basics of governing equations and convergence criteria of finite element method.
II. The commercial Finite Element packages to build Finite Element models and solve a selected range of engineering problems.
III. The approximate Finite Element Solutions for the various field problems.

III. COURSE SYLLABUS:

MODULE-I: INTRODUCTION (10)

Introduction to Finite Element Method for solving field problems. Stress and Equilibrium. Boundary conditions. Strain - displacement relations. Stress-strain relations for 2-D and3-D elastic problems. One Dimensional Problem: Finite element modeling coordinates and shape functions. Assembly of Global stiffness matrix and load vector. Finite element equations – Treatment of boundary conditions, Quadratic shape functions.

MODULE –II: ANALYSIS OF TRUSSES AND BEAMS (10)

Analysis of Trusses: Stiffness matrix for plane Truss Elements, stress calculations and problems. Analysis of beams: Element stiffness matrix for two noded, two degrees of freedom per node beam element and simple problems.

MODULE –III: CONTINUUM ELEMENTS (09)

Finite element modeling of two dimensional stress analysis with constant strain triangles and treatment of boundary conditions. Estimation of load vector and stresses.

Finite element modeling of Axi-symmetric solids subjected to Axi-symmetric loading with triangular elements Two dimensional four noded isoparametric elements and problems.

MODULE –IV: STEADY STATE HEAT TRANSFER ANALYSIS (09)

Steady state Heat Transfer Analysis: one dimensional analysis of slab, fin and two dimensional analysis of thin plate.

MODULE –V: DYNAMIC ANALYSIS (07)

Dynamic Analysis: Formulation of finite element model, element –Mass matrices, evaluation of Eigen values and Eigen Vectors for a stepped bar, convergence requirements, mesh generation, techniques such as semi-automatic and fully automatic use of software such as ANSYS, NISA, NASTRAN etc.

IV. TEXT BOOKS:

1. Tirupathi. R. Chandrapatla, Ashok D. Belegundu, “Introduction to Finite Elements in Engineering”, Prentice Hall India, 3rd Edition, 2003.
2. Rao. S.S., “Finite Element Methods in Engineering”, Butterworth and Heinemann, 2000.
3. Reddy J.N., “An Introduction to Finite Element Method”, McGraw Hill, 2000

V. REFERENCE BOOKS:

1. Krishnamurthy, C.S., “Finite Element Analysis”, Tata McGraw Hill, 2000.
2. K. J. Bathe, E. L. Wilson, “Numerical Methods in Finite Elements Analysis”, Prentice Hall of India, 1985.
3. Robert D Cook, David S Malkus, Michael E Plesha, “Concepts and Applications of Finite Element Analysis”, John Wiley and Sons, 4th Edition, 2003.
4. Larry J Segerlind, "Applied Finite Element Analysis", John Wiley and Sons, 2nd Edition, 1984.

VI. WEB REFERENCES:

1. www.home.iitk.ac.in/~sbasu/me623_2006/fem_notes_me623.pdf
2. www.nptel.ac.in/courses/112104116/
3. www.me.berkeley.edu/~lwlin/me128/FEMNotes.pdf

VII. E-TEXT BOOKS:

1. www.civilenggforall.com/2015/09/finite-element-analysis-by-ss-bhavikatti-free-download-pdfcivilenggforall.com.html
2. www.books.google.co.in/books/about/Finite_Element_Analysis_For_Engineering.html

AIRCRAFT STABILITY AND CONTROL

VI Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC24	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	1	-	4	30	70	100
Contact Classes: 40	**Tutorial Classes: 15**	**Practical Classes: Nil**				**Total Classes: 60**		
Prerequisite: Knowledge of Aerodynamics/ Propulsion and Flight Mechanics								

I. COURSE OVERVIEW:

Aircraft Stability and Control is the science that investigates the stability and control of aircrafts and all other flying vehicles. From the advent of the first flight by the Wright Brothers, it was observed that flight without knowledge of stability and control was not viable. Since then, several different concepts for controlling aircraft flight have been devised including control surfaces, deformable surfaces, morphing of wings etc. This course introduces some of these concepts and describes their operation, as well as the degree of stability that these devices can provide. Modern aircraft control is ensured through automatic control systems known as autopilot. Their role is to increase safety, facilitate the pilot's task and improve flight qualities. The course will introduce modern aircraft stability and control and discuss some of its objectives and applications.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The concept of stability and application to dynamic systems like Aircraft, and the role of primary controls and secondary controls in longitudinal stability.
II. The concept of slide slip angle, roll angle and yaw angle their concepts related to lateral-directional stability.
III. Mathematical modeling of an aircraft in longitudinal, lateral and directional cases.
IV. Longitudinal and directional parameters with the help of the linearzed equations of aircraft motion.
V. Different type of modes in longitudinal, lateral and directional motion of aircraft, and recovery from those modes.

III. COURSE SYLLABUS:

MODULE-I: INTRODUCTION AND LONGITUDINAL STABILITY-I (11)

Aircraft axes system, Definition: Equilibrium, stability, controllability, & maneuverability. Examples from simple mechanical systems for stability. Longitudinal static stability and dynamic stability for un- accelerated flight. Criteria for longitudinal static stability and trim condition. Contribution of principle components on longitudinal stability. Equations of equilibrium- stick fixed neutral point, elevator angle required to trim. Definition-static margin. Equations of motion in steady state, symmetric pull-up maneuver. Elevator effectiveness, elevator hinge moment, neutral point, maneuver point, static margin for stick fixed and stick free conditions, control force and control gradient. Trim tabs and types of trim tabs, aerodynamic and mass balancing of control surfaces, Most forward and aft limits of CG and neutral point. Numerical.

MODULE –II: LATERAL-DIRECTIONAL STATIC STABILITY (07)

Introduction to lateral-direction stability- aerodynamic forces and moments, aircraft side force due to side slip, aircraft rolling moment due to side slip, and aircraft yawing moment due to side slip. Aircraft component contribution for directional static stability, aircraft component contribution for lateral-directional stability, rudder requirements. Numerical.

MODULE –III: AIRCRAFT EQUATION OF MOTION (10)

Description of motion of flight vehicle - systems of reference frames - earth, body, wind, stability axes system, relative merits. Euler angles, angles of attack and sideslip angle - definitions - Earth to body axis transformation, stability axis to body axis transformation. Rotating axis system - expressions for linear and angular moment of rigid body, time derivatives-inertia tensor, components of linear and angular velocities, accelerations.

Components of aerodynamic, gravity forces, moments applied on flight vehicle. Equations of motion- longitudinal and lateral-directional (No derivation**).** Relation between angular velocity components and Euler angle rates. Determination of velocities of airplane in earth axis system. Numerical.

MODULE –IV: LINEARIZATION OF EQUATIONS OF MOTION AND AERODYNAMIC FORCES AND MOMENTS DERIVATIVES (09)

Description of state of motion of vehicle, forces and moments as perturbations over prescribed reference flight condition. Equation of motion in perturbation variables. Assumption of small perturbations, first order approximations-linearization equations of motion. Linearized of force and moment equation of motion**,** Linearized longitudinal and lateral-directional equations of perturbed motion. Significance of aerodynamic derivatives. Derivatives of axial, normal force components and pitching moment with respect to the velocity, angle of attack, angle of attack rate, pitch rate, elevator angle (No derivation only concept). Numerical.

MODULE –V: AIRCRAFT DYNAMIC STABILITY (09)

Principle modes of motion characteristics, mode shapes and significance, time constant, un-damped natural frequency and damping ratio- mode shapes- significance. One degree of freedom, two degree of freedom approximations- constant speed (short period), constant angle of attack (long period) approximations- solutions. Determination of longitudinal and lateral stability from coefficients of characteristic equation- stability and lateral stability from coefficients of characteristics equation- stability criteria, Aircraft spin- entry, balance of forces in steady spin, recovery, pilot techniques. Numerical.

IV. TEXT BOOKS:

1. Nelson, R.C, "Flight Stability and Automatic Control", Tata McGraw Hill, 2nd Edition, 2007, ISBN 0-07-066110-3.
2. Yechout, T.R. etal., "Introduction to Aircraft Flight Mechanics", AIAA Education Series, 2003, ISBN 1-56347-577-4.
3. Etkin, B and Reid, L.D., "Dynamics of Flight", Pearson Press, John Wiley, 3rd Edition, 1998, ISBN0-47103418-5.

V. REFERENCE BOOKS:

1. Schmidt, L.V., "Introduction to Aircraft Flight Dynamics", AIAA Education Series, 1st Edition, 1998, ISBN A-56347-226-0.
2. McCormick, B.W., "Aerodynamics, Aeronautics, and Flight Mechanics", Wiley India, 2nd Edition, 1995, ISBN 97.

VI. WEB REFERENCES:

1. www.scribd.com/book/282507871/Performance-and-Stability-of-Aircraft
2. www.nptel.ac.in/courses/101106043/
3. www.nptel.ac.in/courses/101106042/
4. www.scribd.com/document/174035182/Flight-mechanics

VII. E-TEXT BOOKS:

1. www.csobeech.com/files/AirplanePerformanceStabilityandControl.pdf
2. www.books.google.co.in/books?isbn=1600860788

COMPUTATIONAL AERODYNAMICS

VI Semester: AE								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAEC25	Core	L	T	P	C	CIA	SEE	Total
		3	1	-	4	30	70	100
Contact Classes: 45	Tutorial Classes: 15	Practical Classes: Nil				Total Classes: 60		
Prerequisite: Knowledge of Fluid Dynamics and Aerodynamics								

I. COURSE OVERVIEW:

This course deals with the basic aspects of Computational Fluid Dynamics, emphasizing on the governing equations of fluid dynamics and their numerical discretization techniques using finite volume and finite difference methods. This course also describes the methods of grid generation techniques for both structured and unstructured grid in 2D as well as 3D. It describes the mathematical behavior of the different classes of partial differential equations. Alongside aforementioned techniques, this course also deals with pressure based solvers for incompressible viscous flow. Having said that, all basic stability conditions, errors and convergence efficiency of numerical solutions is also discussed.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The concepts of grid generation techniques for simple and complex domains to model fluid flow problems.
II. The aspects of numerical discretization techniques such as finite volume and finite difference methods.
III. The mathematical modeling of different classes of partial differential equations to show their impact on computational fluid dynamics.

III. COURSE SYLLABUS:

MODULE-I: INTRODUCTION (09)

Need of computational fluid dynamics, philosophy of CFD, CFD as a research tool as a design tool, applications in various branches of engineering, models of fluid flow finite control volume, infinitesimal fluid element, substantial derivative physical meaning of divergence of velocity, derivation of continuity, momentum and energy equations, physical boundary conditions significance of conservation and non-conservation forms and their implication on CFD applications strong and weak conservation forms shock capturing and shock fitting approaches

MODULE –II: MATHEMATICAL BEHAVIOR OF PARTIAL DIFFERENTIAL EQUATIONS AND THEIR IMPACT ON COMPUTATIONAL AERODYNAMICS (08)

Classification of quasi-linear partial differential equations by Cramer‘s rule and Eigen value method, general behavior of different classes of partial differential equations and their importance in understanding physical and CFD aspects of aerodynamic problems at different Mach numbers involving hyperbolic, parabolic and elliptic equations: domain of dependence and range of influence for hyperbolic equations, well-posed problems.

MODULE –III: BASIC ASPECTS OF DISCRETIZATION (10)

Introduction to finite difference: finite difference approximation for first order, second order and mixed derivatives, explicit and implicit approaches, truncation and round-off errors, consistency, stability, accuracy, convergence, efficiency of numerical solutions. Von Neumann stability analysis, physical significance of CFL stability condition.

Need for grid generation, structured grids artesian grids, stretched (compressed) grids, body fitted structured grids, H-mesh, C-mesh, O-mesh, I-mesh, multi-block grids, C-H mesh, H-O-H mesh, overset grids, adaptive grids, unstructured grids: triangular, tetrahedral cells, hybrid grids, quadrilateral, hexahedral cells.

MODULE –IV: CFD TECHNIQUES (09)

Lax-Wendroff technique, MacCormack‘s technique, Crank Nicholson technique, Relaxation technique, aspects of numerical dissipation and dispersion. Alternating-Direction-Implicit (ADI) Technique, pressure correction technique: application to incompressible viscous flow, need for staggered grid. Philosophy of pressure correction method, pressure correction formula. Numerical procedures: SIMPLE, SIMPLER, SIMPLEC and PISO algorithms, boundary conditions for the pressure correction method.

MODULE –V:FINITE VOLUME METHODS (09)

Linear Impulse and Momentum, Connected Bodies, Conservation of Momentum, Coefficient of restitution, Types of Impact. Vibrations - Basic terminology, free and forced vibrations, types of pendulum, Derivation for frequency and time period of simple, compound and torsion pendulums.

IV. TEXT BOOKS:

1. J. D. Anderson, Jr., “Computational Fluid Dynamics- The Basics with Applications”, McGraw Hill, 2012.
2. D A Anderson, J C Tannehill, R H Pletcher, “Computational Fluid Mechanics and Heat Transfer”, 1st Edition, 1997.

V. REFERENCE BOOKS:

1. Hirsch, C., “Numerical Computation of Internal and External Flows: The Fundamentals of Computational Fluid Dynamics”, Vol. I, Butter worth-Heinemann, 2nd Edition, 2007.
2. H K Varsteeg, W Malalasekera, “An Introduction to Computational Fluid Dynamics – The Finite Volume Method”, Longman Scientific and Technical, 1st Edition, 1995.
3. Patankar, S.V., “Numerical Heat Transfer and Fluid Flow”, Hemisphere Pub. Corporation, 1st Edition, 1980.

VI. WEB REFERENCES:

1. https://www.mathematik.uni-dortmund.de/~kuzmin/cfdintro/lecture1.pdf
2. https://bookboon.com/en/computational-fluid-dynamics-ebook
3. https://www.sciencedirect.com/science/book/9780080445069
4. https://cg.informatik.uni-freiburg.de/course_notes/cfd.pdf

VII. E-TEXT BOOKS:

1. https://www.leka.lt/sites/default/files/dokumentai/computational-fluid-dynamics.pdf
2. https://www.topajka-shaw.co.nz/UCFD.htm
3. https://www.grc.nasa.gov/WWW/wind/valid/tutorial/tutorial.html
4. https://www.scribd.com/doc/311680146/eBook-PDF-Cfd-Fluent

AIRPORT PLANNING AND MANAGEMENT

VI Semester: AE								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAEC26	Elective	L	T	P	C	CIA	SEE	Total
		3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		
Prerequisite: Introduction to Aerospace Engineering								

I. COURSE OVERVIEW:

This course presents an overall introduction to the field of airline operations and management. The course will cover such topics as airline industry and history, airline finance and economics, airline organization, airline business and low-cost carriers' strategy, management structure, pricing strategy, revenue management technology, financial analysis, demand forecasting models, aircraft fleet selection, marketing strategy, sales and distribution, capacity planning, routing network, cost analysis, business alliance, international business, labor relationship, cargo business, safety and security measure, public relations, aviation law, government regulations, daily operations, emerging and future development.

II. COURSE OBJECTIVES:

The Students will try to learn:

I. The structure of private airports and public use airports, commercial service airports and primary commercial service airports.
II. The air cargo market-expanding the movement governmental requirements non-passenger Related airport authority functions
III. The scope of technical services-air traffic control, passenger handling, ramp handling-aircraft ramp servicing, ramp layout.
IV. The airport system planning, airport master plan, airport lay out plan, cargo apron operation.

III. COURSE SYLLABUS:

MODULE-I:AIRPORTASANOPERATIONALSYSTEM (9)

Private airports and public use airports, commercial service airports and primary commercial service airports, general aviation airports, reliever airports. Hub classification-large hubs, medium hubs, small hubs, non-hubs. Components of an airport-airside, landside. Airport as a system-function of the airport-complexity of airport operation.

MODULE –II: AIRPORT PLANNING (9)

Airport system planning, airport master plan, airport layout plan – forecasting, facilities requirements, design alternatives, financial plans, land use planning, environmental planning.

MODULE –III: GROUND HANDLING AND BAGGAGE HANDLING (9)

Passenger handling, ramp handling-aircraft ramp servicing, ramp lay out. Departure control. Division of ground handling responsibility.

Control of groundling handling efficiency. Baggage handling baggage operations –operating characteristics of baggage handling systems-inbound baggage systems, outbound baggage system-operating performance-organizing for the task.

MODULE –IV:PASSENGER TERMINAL OPERATIONS AND CARGO OPERATIONS: (9)

Function of the passenger terminal, philosophies of terminal management. Direct passenger services, airline related passenger services .airline related operations functions. Governmental requirements-non-passenger related airport authority functions, processing very important person's .passenger information system. Space components adjacencies-aids to circulation hubbing considerations. Air cargo market –expanding the movement. Flow through the cargo terminal unit loading devices. Handling within the terminal-cargo apron operations-computerization of facilitation-example of modern cargo design-freight operations for the integrated carrier.

MODULE –V: AIRPORTTECHNICALSERVICES AND ACCESS (9)

Scope of technical services-air traffic control telecommunications-meteorology-aeronautical information. Access as part of airport system access users and modal choice, access interaction with passenger terminal operation, access modes-in-town and off-airport terminals. Factors affecting access mode choice

IV. TEXT BOOKS:

1. A.T. Wells, and S.B. Young, “Airport Planning and Management”, McGraw-Hill, 5th Edition, 2004.
2. N. Ashford, H.P.M. Stanton, and C.A. Moore, “Airport Operations”, McGraw-Hill, 5th Edition, 1997.

V. REFERENCE BOOKS:

1. A. Kazda and R.E Caves, “Airport Design and Operation”, Elsevier, 2nd Edition, 2007.
2. R. Horonjeff, F.X. McKelvey, W.J. Sproule, and S.B. Young, “Planning and Design of Airports”, McGraw-Hill, 5th Edition, 2010.

ROCKET AND MISSILE TECHNOLOGY

VI Semester: AE

Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAEC27	Elective	L	T	P	C	CIA	SEE	Total
		3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		

Prerequisite: Knowledge of Aerodynamics and Aerospace propulsion

I. COURSE OVERVIEW:

This course deals with fundamental aspects of rockets and the current trends in rocket propulsion. It includes the combustion process, propellants and various components of chemical rocket propulsion systems and their applications. The course compares and contrasts various thrust vector control mechanisms of nozzle and cooling systems of combustion chamber. It discusses on various materials and its properties that are used for manufacturing of rocket and missiles. This course also covers the basic concepts of guidance of missile and various types of tactical guidance systems and techniques.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The fundamental concepts of various rocket propulsion systems, combustion process and forces/moments acting on the rocket under static and dynamic conditions.
II. The Various components and propellants of a chemical rocket propulsion system with its characteristics and applications.
III. The operating principle of guided missile, and the guidance, control and instrumentation needed to acquire the target.
IV. The Properties of different materials that are used in manufacturing of various rocket and missile components.

III. COURSE SYLLABUS:

MODULE-I: ROCKET DYNAMICS (10)

Classification and application of rocket propulsion, rocket systems, airframe components, rocket principle and its equation, forces and moments acting on a rocket, inertial and non-inertial frames, Propulsive efficiency and performance parameters of a rocket, rocket nozzle and flow separation, Multistage of rockets, numerical problems.

MODULE –II: SOLID PROPULSION AND PYROTECHNICS (10)

Solid propellant rockets, classification, components and their characteristics, criteria for choice of propellants, propellant grain configuration, grain mechanical properties, factors influencing the ballistics and burn rate, Ignition of solid rocket motor, types of nozzles, thrust vector control, design problems in rocket systems.

MODULE –III: LIQUID PROPULSION AND CONTROL SYSTEMS (8)

Liquid propellant rockets, classification and components, thrust chamber, propellant feed system and engine cycles for pump feed system, types of valves, injectors and applications.

Liquid monopropellant and different bipropellant systems, cryogenic propellants, cooling of thrust chamber, pogo and slosh combustion instability and thrusters for control and numerical problems.

MODULE –IV: MISSILE AERODYNAMICS AND GUIDANCE SYSTEMS (09)

Guided missile systems, Indian missile program, structure of the missile and its aerodynamics, aerodynamic characteristics of complete structure, wing design, warheads and fuzzes, Guidance phases during flight, standard terminologies in missile guidance, classification of guidance systems in missiles.

MODULE –V: DESIGN, MATERIALS AND TESTING OF ROCKETS (08)

Design requirements and selection, performance evaluation and assessment, space environment on the selection of materials for rockets and spacecraft, material selection for specific requirements, advance materials, super alloys and composite materials, qualification of rocket and missile systems, types of testing and evaluation of design and function.

IV. TEXT BOOKS:

1. Sutton, G.P., et al., “Rocket Propulsion Elements”, John Wiley & Sons, New York, 1993.
2. Martin J.L Turner, “Rocket & Spacecraft Propulsion”, Springers Oraxis Publishing, 2001.
3. T V Karthikeyan, “Guided Missiles”, Defence Scientific information and Documentation Centre, 1990.

V. REFERENCE BOOKS:

1. Mathur, M., and Sharma, R.P, “Gas Turbines and Jet and Rocket Propulsion”, Standard Publishers, New Delhi, 1998.
2. Cornelisse, J.W, “Rocket Propulsion and Space Dynamics”, J.W, Freeman & Co. Ltd, London, 1982.
3. Parker, E.R, “Materials for Missiles and Spacecraft”, McGraw-Hill Book, 1982.

HYPERSONIC AERODYNAMICS

VI Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC28	**Elective**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	-	-	3	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		
Prerequisite: Knowledge of High Speed Aerodynamics								

I. COURSE OVERVIEW:

Hypersonic aerodynamics is a special branch of the study of aeronautics. The chief characteristic of hypersonic aerodynamics is that the temperature of the flow around the aircraft is so great that the chemistry of the gas must be considered. At low hypersonic speeds, the molecular bonds vibrate, which changes the magnitude of the forces generated by the air on the aircraft. At higher hypersonic speeds, the molecules break apart producing electrically charged plasma around the aircraft. Large variations in air density and pressure occur because of shock waves, and expansions. Hypersonic aircraft typically have very thick boundary layers along the surface and high heat transfer to the surface. All of these high-speed flow phenomena lead to a vehicle design unlike the typical airliner or fighter aircraft.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The basics of aerodynamics to know the boundary layer and variation of properties at different velocities.
II. The aerodynamic forces and moments on different aerodynamic bodies at different conditions.
III. The aerodynamic heating for bodies travelling at hypersonic speeds and importance of high entropy layer.
IV. The complementary role of experiments and numerical computations in handling hypersonic flows.

III. COURSE SYLLABUS:

MODULE-I: GENERAL CHARACTERIZATION OF HYPERSONIC FLOWS (10)

Defining hypersonic flow, characterizing hypersonic flow using fluid dynamic phenomena, basic equations of motion, equilibrium and non-equilibrium flows, equilibrium conditions, dependent variables, transport properties, continuity, momentum and energy equations, general form of the equations of motion in conservation form.

MODULE –II: DEFINING THE AEROTHERMODYNAMIC ENVIRONMENT, EXPERIMENTAL MEASUREMENTS OF HYPERSONIC FLOWS (08)

Empirical correlations complemented by analytical techniques, general comments about computational fluid dynamics, computations based on a two layer flow model, techniques treating entire shock layer in a unified fashion, calibration and validation of the computational fluid dynamics codes, experimental measurements of hypersonic flows: ground-based simulation of hypersonic flows, ground-based hypersonic facilities, experimental data and model design considerations, flight tests, importance of interrelating computational fluid dynamics, ground test data and flight test data.

MODULE –III: STAGNATION-REGION FLOW FIELD AND PRESSURE DISTRIBUTION (10)

Stagnating streamline, stagnation-point convective heat transfer, radiative heat flux; pressure distribution, Newtonian flow models, departure from the Newtonian flow field.

Shock wave boundary layer (viscous) interaction for two dimensional compression ramps, tangent cone and tangent wedge approximations, need for more sophisticated models, pressure distributions for a reacting gas, pressures in separated regions.

MODULE –IV: BOUNDARY LAYER AND CONVECTIVE HEAT TRANSFER, VISCOUS INTERACTIONS (09)

Boundary conditions, metricor equivalent cross section radius, convective heat transfer and skin friction, effects of surface catalycity, base heat transfer in separated flow; viscous interactions: compression ramp flows, shock interactions, flow field perturbations around swept fins, corner flows, examples of viscous interactions for hypersonic vehicles: X-15, space shuttle orbiter, hypersonic air-breathing aircraft.

MODULE –V: AERODYNAMIC FORCES AND MOMENTS AEROTHERMODYNAMICS AND DESIGN CONSIDERATIONS OF HYPERSONIC VEHICLES (08)

Newtonian aerodynamic coefficients, reentry capsule aerodynamics, shuttle orbiter aerodynamics, X-15 aerodynamics, hypersonic aerodynamics of research plane, dynamic stability considerations. Design considerations: re-entry vehicles, design philosophy, design considerations for rocket-launched glide reentry vehicles, air breathing vehicles, combined rocket and air breathing powered vehicles, design of a new vehicle.

IV. TEXT BOOKS:

1. John J Bertin, "Hypersonic Aerothermodynamics", AIAA Education Series, 1st Edition, 1994.
2. Mikhailov G K& Parton V Z, "Super and Hypersonic Aerodynamics and Heat Transfer", CRC publishers, 1st Edition, 1992.

V. REFERENCE BOOKS:

1. John D Anderson, "Hypersonic and High Temperature Gas Dynamics", AIAA Education Series, 2nd Edition, 2006.
2. Ernst H Hirshchel, "Basics of Aerothermodynamics", Springer-Verlag, 1st Edition, 2005.

VI. WEB REFERENCES:

1. https://nptel.ac.in/courses/101103003/
2. https://www.grc.nasa.gov/www/BGH/

VII. E-TEXT BOOKS:

1. https://bookzz.org/book/678872/21935f
2. https://bookzz.org/book/1201615/e314e1
3. https://bookzz.org/book/592471/7e27f3

CAE/CAM

<table>
<tr><td colspan="9">VI Semester: AE</td></tr>
<tr><th>Course Code</th><th>Category</th><th colspan="3">Hours / Week</th><th>Credits</th><th colspan="3">Maximum Marks</th></tr>
<tr><td rowspan="2">AAEC29</td><td rowspan="2">Elective</td><td>L</td><td>T</td><td>P</td><td>C</td><td>CIA</td><td>SEE</td><td>Total</td></tr>
<tr><td>3</td><td>-</td><td>-</td><td>3</td><td>30</td><td>70</td><td>100</td></tr>
<tr><td>Contact Classes: 45</td><td>Tutorial Classes: Nil</td><td colspan="4">Practical Classes: Nil</td><td colspan="3">Total Classes: 45</td></tr>
<tr><td colspan="9">Prerequisite: Knowledge of GD &T</td></tr>
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I. COURSE OVERVIEW:

The goal of the course is to provide the students with an opportunity to conceive, design, and implement products quickly and effectively, using the latest rapid prototyping methods and CAD/CAE/CAM technology. Computer-Aided-Engineering tools are the broad usage of computer software to aid in engineering analysis tasks.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The basics of computer aided designing, computer aided manufacturing and computer integrated manufacturing.
II. The group technology, computer aided process planning, material requirement planning (MRP) Enterprise resource planning (ERP).
III. The knowledge about shop floor control and Flexible manufacturing systems (F.M.S).
IV. The integration of manufacturing enterprise using computer integrated manufacturing (CIM) technologies.

III. COURSE SYLLABUS:

MODULE-I: INTRODUCTION (08)

Computers in industrial manufacturing, product cycle, CAD/CAM hardware, basic structure, CPU, memory types, input devices, display devices, hardcopy devices, and storage devices, computer graphics, rasters can graphics coordinate system, database structure for graphics modeling, transformation of geometry, three dimensional transformations, mathematics of projections, clipping, hidden surface removal.

MODULE –II: GEOMETRIC MODELLING (10)

Requirements, geometric models, geometric construction models, curve representation methods, surface representation methods, modeling facilities desired, drafting and modeling systems, basic geometric commands, layers, display control commands, editing, dimensioning and solid modeling.

MODULE –III: GROUP TECHNOLGY COMPUTER AIDED PROCESS PLANNING (10)

History of group technology, role of G.T in CAD/CAM integration, part families, classification and coding, DCLASS and MCLASS and OPTIZ coding systems, facility design using G.T, benefits of G.T, cellular manufacturing.

Process planning, role of process planning in CAD/CAM integration, approaches to computer aided process planning, variant approach and generative approaches, CAPP and CMPP systems.

MODULE –IV: COMPUTER AIDED PLANNING AND CONTROL, SHOP FLOOR CONTROL AND INTRODUCTION TO FMS (09)

Production planning and control, cost planning and control, inventory management, material requirements planning (ERP), control, phases, factory data collection system, automatic identification methods, bar code technology, automated data collection system; FMS, components of FMS, types, FMS workstation, material handling and storage system, FMS layout, computer control systems, applications and benefits.

MODULE –V: COMPUTER AIDED PLANNING AND CONTROL AND COMPUTER MONITORING (08)

Production planning and control, cost planning and control, inventory management, material requirements planning (MRP), shop floor control, lean and agile manufacturing, types of production monitoring systems, structure model of manufacturing, process control and strategies, direct digital control.

IV. TEXT BOOKS:

1. A. Zimmers, P. Groover, "CAD/CAM", Prentice-Hall India, 3rd Edition, 2008.
2. Zeid, Ibrahim, "CAD/CAM Theory and Practice", Tata McGraw-Hill, 4th Edition, 1997.
3. Mikell. P.Groover "Automation, Production Systems and Computer Integrated Manufacturing", Pearson Education, 2001.
4. Ranky, Paul G., "Computer Integrated Manufacturing", Prentice hall of India Pvt. Ltd, 2005
5. Yorem Koren, "Computer Integrated Manufacturing", McGraw Hill, 2005.

V. REFERENCE BOOKS:

1. P. Groover, Automation, "Production Systems & Computer Integrated Manufacturing", Pearson Education. 2nd Edition 1989.
2. Lalit Narayan, "Computer Aided Design and Manufacturing", Prentice-Hall India, 3rd Edition 2002.
3. Radhakrishnan, Subramanian, "CAD/CAM/CIM", New Age, 4th Edition 2016.
4. Jami J Shah, Martti Mantyla, "Parametric and Feature-Based CAD/CAM: Concepts, Techniques, and Applications", John Wiley & Sons Inc, 1995.
5. Alavala, "CAD/CAM: Concepts and Applications", PHI Publications, 4th Edition, 2016.
6. W. S. Seames, "Computer Numerical Control Concepts and Programming", 4th Edition 1999.

VI. WEB REFERENCES:

1. https://en.wikipedia.org/wiki/CAD/CAM_dentistry
2. https://en.wikipedia.org/wiki/Computer-aided_manufacturing
3. https://en.wikipedia.org/wiki/Computer-integrated_manufacturing

VII. E-TEXT BOOKS:

1. https://books.google.co.in/books?id=8W0E9eK2raMC
2. https://books.google.co.in/books?id=mzm9WuuI4mQC
3. https://books.google.co.in/books?id=F5d6CwAAQBAJ

FLIGHT CONTROL THEORY

OE –I: VI Semester: AERO / MECH / CIVIL OE – III: VIII Semester: CSE / CSE (AI & ML) / CSE (DS) / CSE (CS) / CSIT / IT / ECE / EEE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC30	**Elective**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	-	-	3	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		

I. COURSE OVERVIEW:

Flight control system of an aircraft is instrumental in establishing stability of the aircraft through control surfaces. This course introduces the concepts of the control system theory such as transfer functions, step response and impulse response. This course covers stability, feedback and different techniques used for control systems analysis. The course emphasizes on the flight control systems, response analysis for control surface inputs and control augmentation systems such as autopilots.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The stability criteria to determine the stability of an aircraft, and specify the aircraft time-domain and frequency-domain response specifications.

II. The classical control theory in the frequency domain and modern control theory in the state- space are effectively mixed to provide the student with a modern view of systems theory.

III. The various control techniques for aircraft control systems, and study some feedback control applications.

IV. The controllability and observability of aerospace systems, and apply the modern control techniques to design enhanced flight control systems.

III. COURSE SYLLABUS:

MODULE-I: INTRODUCTION TO CONTROL SYSTEM (10)

Dynamical systems-principal constituents-input, output-process (plant)-block diagram representation. Inputs- control input, noise. Function of controls regulation (hold), tracking (command)-examples. Measure of effectiveness. Sensitivity of output to control input, noise and system parameters- robustness. Deterministic and stochastic control. Control in everyday life. The pervasiveness of control in nature, engineering and societal systems. The importance of study of control system. Need for stable, effective (responsive), robust control system. Modeling of dynamical systems by differential equations-system parameters. Examples from diverse fields. First and second order systems, higher order systems, single input single output systems, and multiple-input multiple-output.

MODULE –II: MATHEMATICAL MODELING OF DYNAMICAL SYSTEMS (10)

Control system performance- time domain description- output response to control inputs-- impulse and indicial response- characteristic parameters- significance- relation to system parameters- examples- first and second order linear systems, higher order systems. Synthesis of response to arbitrary input functions from impulse and indicial response. Review of Fourier transforms and Laplace transforms- inverse transforms- significance, applications to differential equations. 's' (Laplace) domain description of input- output relations- transfer function representation- system parameters- gain, poles and zeroes. Characteristic equation- significance- examples. Frequency and damping ratio of dominant poles. Relation of transfer functions to impulse response. Partial fraction decomposition of transfer functions- significance.

MODULE –III: STEADY STATE RESPONSE ANALYSIS (10)

System type, steady state error, error constants- overall system stability. Application of feedback in stability augmentation, control augmentation, automatic control-examples. Composition, reduction of block diagrams of complex systems-rules and conventions. Control system components - sensors, transducers, servomotors, actuators, filters-modeling, transfer functions. Single-input single-output systems. Multiple input-multiple output systems, matrix transfer functions-examples. Types of control problems- the problem of analysis, control synthesis, system synthesis- examples- static control of aircraft.

Extension to dynamic control. System identification from input output measurements importance. Flight path stabilization, longitudinal control law design using back stepping algorithm. Experimental determination of system transfer functions by frequency response measurements. Example. Frequency domain description- frequency response- gain and phase shift- significance- representation asymptotic (Bode) plots, polar (Nyquist) plots, frequency transfer functions. Characteristic parameters corner frequencies, resonant frequencies, peak gain, and bandwidth- significance. First and second order systems- extension to higher order systems.

MODULE –IV: AIRCRAFT RESPONSE TO CONTROL (07)
Approximations to aircraft transfer functions, control surface actuators-review. Response of aircraft to elevator input, Response of aircraft to rudder input and Response of aircraft to aileron input to atmosphere. Need for automatic control. Auto pilots Stability augmentation systems-pitch damper and yaw damper.

MODULE –V: FLYING QUALITIES OF AIRCRAFT (08)
Reversible and irreversible flight control systems. Flying qualities of aircraft-relation to airframe transfer function. Pilot's opinion ratings. Flying quality requirements- pole-zero, frequency response and time-response specifications. Displacement and rate feedback determination of gains conflict with pilot input s resolution-control augmentation systems- Full authority fly-by-wire. Auto Pilot-Normal acceleration, Turn rate, Pitch rate Commands-Applications.

IV. TEXT BOOKS:

1. Kuo, B.C., “Automatic control of Aircraft and Missiles”, John Wiley Sons, New York, 1990.
2. Stevens B.L & Lewis F.L, “Aircraft control & Simulation”, John Wiley Sons, New York, 1992.

V. REFERENCE BOOKS:

1. Mc Lean, D., “Automatic Flight Control Systems”, Prentice Hall, 1990.
2. Bryson, A.E., “Control of Aircraft and Spacecraft”, Princeton University Press, 1994.
3. E H J Pallett, Shawn Coyle, “Automatic Flight Control”, 4th Edition, 2002.

VI. WEB REFERENCES:

1. https://www.e-booksdirectory.com/
2. https://www.aerospaceengineering.es/book/

VII. E-TEXT BOOKS:

1. https://books.google.co.in/books?isbn=1118870972
2. https://books.google.co.in/books?isbn=0387007261

AIRFRAME STRUCTURAL DESIGN

OE –I: VI Semester: AERO / MECH / CIVIL OE – III: VIII Semester: CSE / CSE (AI & ML) / CSE (DS) / CSE (CS) / CSIT / IT / ECE / EEE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC31	**Elective**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	-	-	3	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		

I. COURSE OVERVIEW:

This course deals with fundamental aspects of an anatomy of aircraft and the current trends in airframe design. It includes the evolution of the aircraft and space industry, aerodynamics and performance of the aircraft with their applications. It compares and contrasts various thrust vector control mechanisms of different aircraft propulsion systems. It discusses various materials and its properties that are used for manufacturing different parts of an aircraft. This course enriches the knowledge of connection between theoretical and practical methods for performing the airframe design exercises

II. COURSE OBJECTIVES:

The student will try to learn:

I. The fundamental concepts of various airframe designs, aircraft propulsion systems and aerodynamic forces/moments acting on the aircraft and spacecraft under static and dynamic load conditions

II. The characteristics of stability and performance of an aircraft and the role of primary and secondary controls in longitudinal and lateral stability

III. The properties of different materials that are used in industries for manufacturing various components of an aircraft and spacecraft achieving specified stability requirements.

IV. The mathematical modeling of tailless aircraft, flapping wing aircraft and innovative designs in modern aircraft for future requirements.

II. COURSE SYLLABUS:

MODULE-I: HISTORY OF FLIGHT AND SPACE ENVIRONMENT (10)

Balloons and dirigibles, heavier than air aircraft, commercial air transport; Introduction of jet aircraft, helicopters, missiles; Conquest of space, commercial use of space; Different types of flight vehicles, classifications exploring solar system and beyond, a permanent presence of humans in space; Earth‘s atmosphere, the standard atmosphere; The temperature extremes of space, laws of gravitation, low earth orbit, microgravity, benefits of microgravity; Environmental impact on spacecraft, space debris; Planetary environments.

MODULE –II: INTRODUCTION TO AERODYNAMICS (10)

Anatomy of the airplane, helicopter; Understanding engineering models; Aerodynamic forces on a wing, force coefficients; Generating lift, moment coefficients; Aerodynamic forces on aircraft – classification of NACA airfoils, aspect ratio, wing loading, mach number, centre of pressure and aerodynamic centre, aerofoil characteristics-lift, drag curves; Different types of drag.

MODULE –III: FLIGHT VEHICLE PERFORMANCE AND STABILITY (09)

Performance parameters, performance in steady flight, cruise, climb, range, endurance, accelerated flight symmetric maneuvers, turns, sideslips, takeoff and landing.

Flight vehicle Stability, static stability, dynamic stability; Longitudinal and lateral stability; Handling qualities of the airplanes.

MODULE –IV: INTRODUCTION TO AIRPLANE STRUCTURES AND MATERIAL,POWERPLANT (08)

General types of construction, monocoque, semi-monocoque; Typical wing and fuselage structure; Metallic & non-metallic materials, use of aluminum alloy, titanium, stainless steel and composite materials; Basic ideas about engines, use of propellers and jets for thrust production; Principles of operation of rocket, types of rockets.

MODULE –V: SATELLITE SYSTEMS ENGINEERING HUMAN SPACE EXPLORATION (08)

Satellite missions, an operational satellite system, elements of satellite, satellite bus subsystems; Satellite structures, mechanisms and materials; Power systems; Communication and telemetry; Propulsion and station keeping; Space missions, mission objectives. Goals of human space flight missions, historical background, the Soviet and US missions; The mercury, Gemini, Apollo (manned flight to the moon), Skylab, apollo-soyuz, space Shuttle; International space station, extravehicular activity; The space suit; The US and Russian designs; Life support systems, flight safety; Indian effort in aviation, missile and space technology.

IV. TEXT BOOKS:

1. Newman D, “Interactive Aerospace Engineering and Design”, McGraw-Hill, 1st Edition, 2002.
2. Anderson J. D, “Introduction To Flight”, McGraw-Hill Education, 5th Edition, 2002.

V. REFERENCE BOOKS:

1. Kermode. A. C, “Flight without Formulae”, McGraw Hill, 4th Edition, 1997.
2. Barnard R.H and Philpot. D.R, “Aircraft Flight”, Pearson, 3rd Edition, 2004.
3. SwattonP.J, “Flight Planning”, Blackwell Publisher, 6th Edition, 2002.

VI. WEB REFERENCES:

1. http://ase.sbu.ac.ir/FA/Staff/abbasrahi/Lists/Dars/Attachments/11/Vibrations%20of%20Continuous%20Systems.pdf
2. http://arc-test.aiaa.org/doi/book/10.2514/4.862458
3. http://arc-test.aiaa.org/doi/abs/10.2514/5.9781600862373.0719.0728

VII. E-TEXT BOOKS:

1. http://www.gregorypaulblog.com/structural-dynamics-in-aeronautical-engineering-aiaa-education-series.pdf
2. https://aerocastle.files.wordpress.com/2012/10/mechanical_vibrations_5th-edition_s-s-rao.pdf

INDUSTRIAL MANAGEMENT

OE –I: VI Semester: AERO / MECH / CIVIL OE – III: VIII Semester: CSE / CSE (AI & ML) / CSE (DS) / CSE (CS) / CSIT / IT / ECE / EEE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AMEC34	**Elective**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	0	0	3	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		

I.COURSE OVERVIEW:

The industrial management prepares engineers to design, improve, install, and operate the integrated systems of people, materials, and facilities needed by industry, commerce, and society. Industrial engineers solve problems that arise in the management of systems, applying the principles of engineering science, product/service and process design, work analysis, human factors principles, and operations research.The focus of this course is how to improve processes or design things that are more efficient and waste less money, time, raw resources, man-power and energy while following safety standards and regulations

II. COURSE OBJECTIVES:

The students will try to learn:

I. The production planning and control procedures to handle industrial disputes.
II. The Work study procedures and quality concepts to enhance more productivity
III. The significant exposure on some maintenance practices in industry for consistent productivity.

III.COURSE SYLLABUS:

MODULE-I: CONCEPTS OF INDUSTRIAL MANAGEMENT (9)

Principles of management- Growth of management thought, Functions of management, Principles of organization, Types of organization and committees.

MODULE –II: WORK STUDY (9)

Concept of productivity, Method Study - Basic steps in method study, Process charts, Diagrams, Principles of motion economy, Micro motionstudy, Therbligs, SIMO chart. Work Measurement - Stop watch procedure of time study, Performance rating, allowances, Work sampling, Simple problems.

MODULE –III: INVENTORY CONTROL (9)

Inventory Control: Inventory, Cost, Deterministic Models and Introduction to Supply Chain Management.

MODULE –IV: QUALITY CONTROL (9)

Quality Control: Process control, SQC, Control charts, Single, Double and Sequential Sampling, Introduction to TQM.

MODULE –V: DEMAND FORECASTING AND COST ESTIMATION (9)

Demand Forecasting and cost Estimation: Characteristics of Forecasts, Forecasting Horizons, Steps to Forecasting, Forecasting Methods, Seasonal Adjustments, Forecasting Performance Measures, Cost Estimation, Elements of cost, Computation of Material Variances Break-Even Analysis.

IV. TEXT BOOKS:

1. O.P. Khanna, “Industrial Engineering and Management”, Khanna Publishers.
2. T.R. Banga and S.C.Sarma, “Industrial Engineering and Management Science”, Khanna Publishers.

V. REFERENCE BOOKS:

1. Ralph M Barnes, “Motion and Time Study”, John Willey & Sons Work Study lLO.

2. Ernest J McCormick, “Human factors in Engineering & Design”, TMH.
3. Paneer Selvam, “Production & Operation Management”, PHI.
4. NVS Raju, “Industrial Engineering Management”, Cengage Learning.

VI. REFERENCE BOOKS:

1. https://nptel.ac.in/courses/112/107/112107142/#
2. https://nptel.ac.in/courses/112/107/112107143/#

ELEMENTS OF MECHANICAL ENGINEERING

OE –I: VI Semester: AERO / MECH / CIVIL OE – III: VIII Semester: CSE / CSE (AI & ML) / CSE (DS) / CSE (CS) / CSIT / IT / ECE / EEE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AMEC35	**Elective**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	0	0	3	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		

I.COURSE OVERVIEW:

The main aim of this course to impart mechanical engineering fundamental basics to allied engineering students so that they have minimum understanding of mechanical system, equipment and process.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The fundamentals of mechanical systems.
II. The significance of mechanical engineering and apply in different fields of engineering.
III. The various applications of engineering materials for designing different engineering components.

III. COURSE SYLLABUS:

MODULE-I: SOURCES OF ENERGY, BASIC CONCEPTS OF THERMODYNAMICS (9)

Sources of Energy : Introduction and application of energy sources like fossil fuels, hydel, solar, wind, nuclear fuels and bio-fuels; environmental issues like global warming and ozone depletion.

Basic concepts of Thermodynamics: Introduction, states, concept of work, heat, temperature; Zeroth, 1st, 2nd and 3rd laws of thermodynamics. Concept of internal energy, enthalpy and entropy (simple numericals).

MODULE –II: BOILER AND TURBINES(9)

Boilers: Introduction to boilers, classification, Lancashire boiler, Babcock and Wilcox boiler. Introduction to boiler mountings and accessories (no sketches).

Turbines: Hydraulic Turbines-Classification and specification, Principles and operation of Pelton wheel turbine, Francis turbine and Kaplan turbine (elementary treatment only).

Hydraulic Pumps: Introduction, classification and specification of pumps, reciprocating pump and centrifugal pump, concept of cavitations and priming.

MODULE –III: PROPERTIES, COMPOSITION AND INDUSTRIAL APPLICATIONS OF ENGINEERING MATERIALS(9)

Metals-Ferrous: cast iron, tool steels and stainless steels and nonferrous: aluminum, brass, bronze. Polymers -Thermoplastics and thermosetting polymers. Ceramics -Glass, optical fiber glass, cermets. Composites -Fiber reinforced composites, Metal Matrix Composites, Smart materials -Piezoelectric materials, shape memory alloys, semiconductors and insulators.

Joining Processes: Soldering, Brazing and Welding Definitions. Classification and methods of soldering, brazing and welding. Brief description of arc welding, oxy-acetylene welding, TIG welding, and MIG welding.

MODULE –IV: MACHINE TOOLS(9)

Lathe -Principle of working of a center lathe. Parts of a lathe. Operations on lathe –Turning, Facing, Knurling, Thread Cutting, Drilling, Taper turning by Tailstock offset method and Compound slide swiveling method, Specification of Lathe.

Milling Machine-Principle of milling, types of milling machines. Working of horizontal and vertical milling machines. Milling processes -plane milling, end milling, slot milling, angular milling, form milling, straddle milling, and gang milling.

MODULE –V: INTRODUCTION TO ADVANCED MANUFACTURING SYSTEMS (9)

Computer Numerical Control (CNC): Introduction. Components of CNC, open loop and closed loop systems, advantages of CNC, CNC Machining centers and Turning centers.

Robots: Robot anatomy, joints and links, common robot configurations. Applications of Robots in material handling, processing and assembly and inspection

.TEXT BOOKS

V. K. Manglik, "Elements of Mechanical Engineering", Prentice Hall, 1st Edition, 2013.

Mikell P. Groover, "Automation, Production Systems and CIM", Prentice Hall, 4th Edition, 2013

REFERENCE BOOKS:

S. Trymbaka Murthy, "A Text Book of Elements of Mechanical Engineering", University Press, 4th Edition, 2006.

K. P. Roy, S. K. Hajra Choudary, Nirjhar Roy, "Element of Mechanical Engineering", Media Promoters & Publishers, 7th Edition, 2012.

Pravin Kumar, "Basic Mechanical Engineering", Pearson, 1st Edition, 2013

.WEB REFERENCES:

http://www.nptel.ac.in/courses/112107144/

http://www.nptel.ac.in/courses/112101098/download/lecture-37.pdf

MODERN CONSTRUCTION MATERIALS

OE –I: VI Semester: AERO / MECH / CIVIL OE – III: VIII Semester: CSE / CSE (AI & ML) / CSE (DS) / CSE (CS) / CSIT / IT / ECE / EEE								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
ACEC30	Elective	L	T	P	C	CIA	SEE	Total
		3	0	0	3	30	70	100
Contact Classes: 45	Total Tutorials: Nil	Total Practical Classes: Nil				Total Classes: 45		

I. COURSE OVERVIEW:

This course provides the scientific basis for the understanding and development of construction materials. It serves as a foundation course for post-graduate students interested in careers involving research, teaching and/or construction engineering, as well as marketing, decision making, innovation and specification related to construction materials.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The concept of modern water proofing and insulating materials in constructions.
II. Importance of composites and chemicals in production of modern concrete.
III. The types of concrete and their constituents and properties.
IV. The impact of building construction on society and demonstrate awareness of contemporary issues.

III.COURSE SYLLABUS:

MODULE-I: STONES – BRICKS – CONCRETE BLOCKS (09)

Stone as building material, Criteria for selection, Tests on stones, Deterioration and Preservation of stone work, Bricks, Classification, Manufacturing of clay bricks, Tests on bricks Compressive Strength, Water Absorption, Efflorescence, Bricks for special use, Refractory bricks, Cement, Concrete blocks, Light-weight concrete blocks.

MODULE-II: LIME – CEMENT – AGGREGATES – MORTAR (09)

Lime, Preparation of lime mortar, Cement, Ingredients, Manufacturing process, Types and Grades, Properties of cement and Cement mortar, Hydration, Compressive strength, Tensile strength, Fineness, Soundness and consistency, Setting time, Industrial byproducts, Fly ash, Aggregates, Natural stone aggregates, Crushing strength, Impact strength, Flakiness Index, Elongation Index, Abrasion Resistance, Grading, Sand Bulking.

MODULE-III: CONCRETE (09)

Concrete, Ingredients, Manufacturing Process, Batching plants, RMC, Properties of fresh concrete, Slump, Flow and compaction Factor, Properties of hardened concrete, Compressive, Tensile and shear strength.

Modulus of rupture, Tests, Mix specification, Mix proportioning, BIS method, High Strength Concrete and HPC, Self compacting Concrete, Other types of Concrete, Durability of Concrete.

MODULE-IV: TIMBER AND OTHER MATERIALS (09)

Timber, Market forms, Industrial timber, Plywood, Veneer, Thermacole, Panels of Laminates, Steel, Aluminum and Other Metallic Materials, Composition, Aluminium composite panel, Uses: Market forms, Mechanical treatment, Paints, Varnishes, Distempers, Bitumens.

MODULE-V: MODERN MATERIALS (09)

Glass, Ceramics, Sealants for joints, Fibre glass reinforced plastic, Clay products, Refractories, Composite materials, Types, Applications of laminar composites, Fibre textiles, Geomembranes and Geotextiles for earth reinforcement.

IV.TEXT BOOKS:

1. W.D. Callister, John Wiley, “Materials Science and Engineering: An Introduction”, John Wiley & Sons, Inc. 1994.
2. P.C. Varghese, “Building Materials”, Prentice-Hall India, 2005.

V. REFERENCE BOOKS:

1. V. Raghavan, “Materials Science and Engineering”, Prentice Hall, 1990.
2. R.A. Higgins, “Properties of Engineering Materials”, Industrial Press, 1994.
3. Eds. J.M. Illston and P.L.J. Domone, “Construction Materials: Their nature and behaviour”, Spon Press, 3rd Edition, 2002

VI.WEB REFERENCES:

1. https://www.scribd.com/document/394619658/Material-Science-and-Engineering-V-Raghavan-pdf
2. https://files.isec.pt/DOCUMENTOS/SERVICOS/BIBLIO/INFORMA%C3%87%C3%95ES%20ADICIONAIS/Materials-for-engineers-5ed_Higgins.pdf

VII. E-TEXT BOOKS:

1. https://onlinecourses.nptel.ac.in/noc20_ce05/preview
2. http://kaizenha.com/wp-content/uploads/2016/04/Materials-Textbook-8th-Edition.pdf

DISASTER MANAGEMENT

<table>
<tr><td colspan="10">OE –I: VI Semester: AERO / MECH / CIVIL
OE – III: VIII Semester: CSE / CSE (AI & ML) / CSE (DS) / CSE (CS) / CSIT / IT / ECE / EEE</td></tr>
<tr><td>Course Code</td><td>Category</td><td colspan="3">Hours / Week</td><td>Credits</td><td colspan="3">Maximum Marks</td></tr>
<tr><td rowspan="2">ACEC31</td><td rowspan="2">Elective</td><td>L</td><td>T</td><td>P</td><td>C</td><td>CIA</td><td>SEE</td><td>Total</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td><td>30</td><td>70</td><td>100</td></tr>
<tr><td>Contact Classes: 45</td><td>Total Tutorials: Nil</td><td colspan="4">Total Practical Classes: Nil</td><td colspan="3">Total Classes: 45</td></tr>
</table>

I. COURSE OVERVIEW:

The Disaster management provides a fundamental understanding of different aspects. It deals with the concepts and functions of disaster management to build competencies of professionals and development practitioners. It provides effective supporting environment by the governmental locating substantial resources for effective mitigation of disasters. It helps learners to apply the disaster mitigation strategies, preparedness for reducing damage intensity, loss of life and property.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The concept of environmental hazards, disasters and various approaches dealing with the mitigation of disasters.
II. The knowledge on various types of environmental disasters and their impacts on human beings and nature.
III. The Different types of endogenous and exogenous hazards and their influence on human life and nature.
IV. The immediate response and damage assessment with information reporting and monitoring tools.

III.COURSE SYLLABUS:

MODULE-I: ENVIRONMENTAL HAZARDS AND DISASTERS (09)

Environmental hazards and disasters: meaning of environmental hazards, environmental disasters and environmental stress; concept of environmental hazards, environmental stress and environmental disasters, different approaches and relation with human ecology, landscape approach, ecosystem approach, perception approach, human ecology and its application in geographical researches.

MODULE-II: TYPES OF ENVIRONMENTAL HAZARDS AND DISASTERS (09)

Types of environmental hazards and disasters: Natural hazards and disasters, man induced hazards and disasters, natural hazards, planetary hazards/ disasters, extra planetary hazards/ disasters, planetary hazards, endogenous hazards, exogenous hazards.

MODULE-III: ENDOGENOUS HAZARDS (09)

Endogenous hazards, volcanic eruption, earthquakes, landslides, volcanic hazards/ disasters, causes and distribution of volcanoes, hazardous effects of volcanic eruptions, environmental impacts of volcanic eruptions.

Earthquake hazards/ disasters, causes of earthquakes, distribution of earthquakes, hazardous effects of, earthquakes, earthquake hazards in India, human adjustment, perception and mitigation of earthquake

MODULE-IV: EXOGENOUS HAZARDS (09)

Exogenous hazards/ disasters, infrequent events, cumulative atmospheric hazards/ disasters; Infrequent events: Cyclones , lightning , hailstorms; Cyclones: Tropical cyclones and local storms, destruction by tropical cyclones and local storms (causes, distribution human adjustment, perception and mitigation); Cumulative atmospheric hazards/ disasters: Floods, droughts, cold waves, heat waves floods; Causes of floods, flood hazards India, flood control measures (human adjustment, perception and mitigation); Droughts: Impacts of droughts, drought hazards in India, drought control measures, extra planetary hazards/

disasters, man induced hazards /disasters, physical hazards/ disasters, soil erosion, Soil erosion: Mechanics and forms of soil erosion, factors and causes of soil erosion, conservation measures of soil erosion; Chemical hazards/ disasters: Release of toxic chemicals, nuclear explosion, sedimentation processes; Sedimentation processes: Global sedimentation problems regional sedimentation problems, sedimentation and environmental problems, corrective measures of erosion and sedimentation, biological hazards/ disasters, population explosion.

MODULE-V: EMERGING APPROACHES IN DISASTER MANAGEMENT (09)
Emerging approaches in Disaster Management, Three Stages
1. Pre, disaster stage(preparedness)
2. Emergency Stage
3. Post Disaster stage, Rehabilitation.

IV.TEXT BOOKS:

1. Pardeep Sahni, "Disaster Mitigation: Experiences and Reflections", PHI Learning Pvt. Ltd., 1st Edition, 2001.
2. J.Glynn,Gary W.HeinKe, "Environmental Science and Engineering", Prentice Hall Publishers, 2nd Edition, 1996.

V. REFERENCE BOOKS:

1. B. C. Punmia, Ashok K Jain and Arun K Jain, "Mechanics of Materials", Laxmi Publications Pvt. Ltd., New Delhi, 12th Edition, 2007.
2. R. Subramanian, "Strength of Materials", Oxford University Press, 2nd Edition, 2010.
3. D. S. Prakash Rao, "Strength of Materials A Practical Approach Vol.1", Universities Press (India) Pvt. Ltd., India, 3rd Edition, 2007.
4. J. M. Gere, S.P. Timoshenko, "Mechanics of Materials, SI units edition", CL Engineering, USA, 5th Edition, 2000.

VI. Web References:

1. https://www.google.co.in/?gfe_rd=cr&ei=,iAwWLiDIazv8we8_5LADA#q=disater+mangement
2. http://ndma.gov.in/images/policyplan/dmplan/National%20Disaster%20Management%20Plan%20May%202016.pdf
3. http://www.eib.europa.eu/attachments/pipeline/20080021_eia_en.pdf
4. http://www.ndmindia.nic.in/

VII. E-Text Books:

1. http://cbse.nic.in/natural%20hazards%20&%20disaster%20management.pdf\
2. http://www.digitalbookindex.org/_search/search010emergencydisastera.asp
3. http://www.icbse.com/books/cbse,ebooks,download

EXPERIENTIAL ENGINEERING EDUCATION (ExEEd) – RESEARCH BASED LEARNING

VI Semester: Common for all branches							
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
ACSC27	Foundation	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		2	-	-	1	30	70	100
Contact Classes: 36	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 36**		
Prerequisite: There are no prerequisites to take this course								

I. COURSE OVERVIEW:

Research-based learning (RBL) presents as an alternative learning model that can develop the critical thinking skills. The research-based learning is conducted under constructivism which covers four aspects: learning which constructs student's understanding, learning through developing prior knowledge, learning which involves social interaction process, and meaningful learning which is achieved through real-world experience. The major focus is to engage students in the inquiry process where they formulate questions, conduct investigations, apply information and media to learning, and generate products that illustrate learning. The 5E learning cycle adopted for RBL leads students through five phases: Engage, Explore, Explain, Elaborate, and Evaluate which results in greater benefits concerning student's ability for scientific inquiry.

II. COURSE OBJECTIVES:

The students will try to learn:

I. To provide an opportunity for the students to engage in solving the real-world problems.
II. To introduce the overall process of research from its inception to the report.
III. To create the environment for multi-disciplinary research.
IV. Comprehend the role of ethics in research

III. COURSE SYLLABUS

I. What is Research?
II. Identifying Problem Statement
III. Overview of research-literature
IV. Planning activities, clarifying methods/methodologies
V. Experimentation
VI. Hypothesis testing
VII. Undertaking investigation and analyzing the data
VIII. Interpretation and consideration of results
IX. Presentation of replication studies

COMPUTATIONAL AERODYNAMICS LABORATORY

VI Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC32	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		0	0	3	1.5	30	70	100
Contact Classes: Nil	**Tutorial Classes: Nil**	**Practical Classes: 36**				**Total Classes: 36**		
Prerequisite: **Low Speed Aerodynamics, High speed Aerodynamics.**								

I. COURSE OVERVIEW:

Computational Aerodynamics laboratory sessions focus on the creation of geometry, meshing (Discretization) and the physics applied to aerodynamics in order to visualize fluid flow and temperature distribution, and estimating the flow parameters around the aerodynamic body. Computational Aerodynamics laboratory also covers the usage of finite difference methods and necessary coding techniques. In this lab course, the students are trained on conducting simulations using the numerical methods analysis tool of CAD systems. The simulations include fluid, structural, thermal systems in the emerging technologies of interdisciplinary applications such as mechanical, aerospace, and refrigeration systems.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The formulation of the problem, discretization and suitable boundary conditions by using numerical methods.
II. The basic computational coding techniques that provides the data and contours in the predicting the performance of fluid systems.
III. The environment and usage of commercial computational fluid dynamics packages.

III. COURSE SYLLABUS:

Week-1: INTRODUCTION

Introduction to computational aerodynamics, the major theories, approaches and methodologies used in computational aerodynamics. Applications of computational aerodynamics for classical aerodynamic's problems.

Week-2: INTRODUCTION TO ANSYS CFX

Introduction to ANSYS CFX, geometry creation, suitable meshing types and boundary conditions.

Week-3: INTRODUCTION TO FLUENT

Introduction to fluent, boundary conditions, solver conditions and post processing results.

Week-4: FLOW OVER A FLAT PLATE

Flow over a flat plate at low Reynolds numbers, observe the boundary layer phenomena, no slip condition and velocity profile inside the boundary layer.

Week-5: FLOW THROUGH PIPE

Flow through pipe at different Reynolds numbers; observe the velocity changes for laminar and turbulent flows.

Week-6: FLOW OVER A CIRCULAR CYLINDER

Flow over a circular cylinder at different Reynolds numbers, observe the properties at separation region and wake region.

Week-7: FLOW OVER A CAMBERED AEROFOIL

Flow over a cambered aerofoil at different Reynolds number, observe flow properties and compare the computation results with experimental results (consider the model from aerodynamics laboratory).

Week-8: **FLOW OVER A SYMMETRIC AEROFOIL**

Flow over a symmetric aerofoil at different Reynolds number, observe flow properties and compare the computation results with experimental results (consider the model from aerodynamics laboratory).

Week-09: FLOW OVER WEDGE
Flow over wedge body at supersonic Mach number; observe the shock wave phenomena and change of properties across the shock wave.

Week-10: FLOW OVER A CONE
Flow over a cone at supersonic Mach number; observe the shock waves and 3D relieving effect.

Week-11: CODE DEVELOPEMENT
Solution for the following equations using finite difference method
One dimensional wave equation using explicit method of lax.
One dimensional heat conduction equation using explicit method.

Week-12: CODE DEVELOPEMENT
Generation of the following grids
Algebraic grids.
Elliptic grids.

IV. REFERENCE BOOKS:

1. Anderson, J.D, Jr, "Computational Fluid Dynamics the Basics with Applications", McGraw-Hill, 1st Edition 1998.
2. Hoffmann, K. A. and Chiang, S. T, "Computational Fluid Dynamics for Engineers", Engineering Education Systems, 4th Edition, 2000.

V. WEB REFERENCES:

1. https://www.scribd.com/doc/311680146/eBook-PDF-Cfd-Fluent.
2. https://cfd.ninja/tutorials/ansys-fluent
3. https://confluence.cornell.edu/display/SIMULATION/FLUENT+Learning+Modules

COMPUTER AIDED MANUFACTURING (CAM) LABORATORY

VI Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC33	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		-	-	3	1.5	30	70	100
Contact Classes: Nil	**Tutorial Classes: Nil**	**Practical Classes: 36**				**Total Classes: 36**		
Prerequisite: **Knowledge of Engineering Drawing**								

I. COURSE OVERVIEW:

Computer-aided manufacturing (CAM) is an application technology that uses computer software and machinery to facilitate and automate manufacturing processes. Overview of CNC machines, component identification, safety features and precautions, setting home positions, offsets and works settings, part programming with G codes, program execution, controlling dimensional accuracy and surface finish.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The various fields of engineering where these tools can be effectively used to improve the output of a product.
II. How the tools are used in industries by solving some real time problems.
III. Various stages of product development and their management.
IV. The programming and operating skills for computer numerical control (CNC) machines.

III. COURSE SYLLABUS:

Week-1: INTRODUCTION TO COMPUTER NUMERICAL CONTROL

Numerical control, functions of a machine tool, concept of numerical control, historical development, definition, advantages of CNC machine tools. Features of CNC, machine control MODULE (MCU) for CNC, classification of CNC machine tools. Features of CNC, machine control MODULE (MCU) for CNC, classification of CNC machine tools.

Week-2: CNC PLAIN TURNING

To perform the Plain Turning operation using CNC turning machine.

Week-3: CNC STEP TURNING

To perform Step turning operation using CNC turning machine.

Week-4: GROOVING AND THREADING

To perform grooving and threading operation using CNC turning machine.

Week-5: DRILLING AND BORING

To perform drilling and boring operation using CNC turning machine.

Week-6: CNC MILLING : PLAIN MILLING AND STEP MILLING

To perform plain milling and step milling operation using CNC milling machine.

Week-7: DRILLING OPERATION

To perform drilling operation using CNC milling machine.

Week-8: PROFILE MILLING AND HELICAL MILLING

To perform profile milling and helical milling operation using CNC milling machine.

Week-09: TAPPING AND SLOTTING

To perform tapping and slotting operation using CNC milling machine.

Week-10: CNC CYLINDRICAL GRINDING

To perform cylindrical grinding operation using CNC cylindrical grinding machine.

Week-11: LASER CUTTING
To perform aerofoil profile cutting using Laser cutting machine.

Week-12: RAPID DRILLING
To perform rapid drilling using Electrical Discharge machine.

IV. REFERENCE BOOKS:

1. K.L. Narayana, P. Kannaiah, "Production Drawing", New Age publishers, 3rd Edition, 2009.
2. GouthamPohit, GouthamGhosh, "Machine Drawing with Auto CAD", Pearson, 1st Edition, 2004.
3. James D. Meadows, "Geometric Dimensioning and Tolerancing", CRC Press, 1st Edition, 1995.

V. WEB REFERENCES:

1.https://mech.iitm.ac.in/Production%20Drawing.pdf

DESIGN OF ALGORITHMS

VI Semester: AE / ECE / EEE / ME / CE								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
ACSC29	Skill	L	T	P	C	CIA	SEE	Total
		-	-	-	-	-	-	-
Contact Classes: Nil	Total Tutorials: Nil	Total Practical Classes: Nil				Total Classes: Nil		

I. COURSE OVERVIEW:

Design and analysis of algorithms is the process of finding the computational complexity of algorithms. It helps to design and analyze the logic on how the algorithm will work before developing the actual code for a program. It focuses on introduction to algorithm, asymptotic complexity, sorting and searching using divide and conquer, greedy method, dynamic programming, backtracking, branch and bound. NP-hard and NP-complete problems. The applications of algorithm design are used for information storage, retrieval, transportation through networks, and presentation to users.

II. COURSE OBJECTIVES:

The students will try to learn:

I. Assess how the choice of data structures and algorithm design methods impacts the performance of programs.
II. Solve problems using data structures such as binary search trees, and graphs and writing programs for these solutions.
III. Choose the appropriate data structure and algorithm design method for a specified application.
IV. Solve problems using algorithm design methods such as the greedy method, divide and conquer, dynamic programming, backtracking, and branch and bound and writing programs for these solutions.

III. SYLLABUS

MODULE –IINTRODUCTION

Algorithm: Pseudo code for expressing algorithms; Performance analysis: Space complexity, time complexity; Asymptotic notations: Big O notation, omega notation, theta notation and little o notation, amortized complexity; Divide and Conquer: General method, binary search, quick sort, merge sort, Strassen‘s matrix multiplication.

MODULE -IISEARCHING AND TRAVERSAL TECHNIQUES

Disjoint set operations, union and find algorithms; Efficient non recursive binary tree traversal algorithms, spanning trees; Graph traversals: Breadth first search, depth first search, connected components, biconnected components.

MODULE -IIIGREEDY METHOD AND DYNAMIC PROGRAMMING

Greedy method: The general method, job sequencing with deadlines, knapsack problem, minimum cost spanning trees, single source shortest paths.

Dynamic programming: The general method, matrix chain multiplication optimal binary search trees, 0/1 knapsack problem, single source shortest paths, all pairs shortest paths problem, the travelling salesperson problem.

MODULE -IVBACKTRACKING AND BRANCH AND BOUND

Backtracking: The general method, the 8 queens problem, sum of subsets problem, graph coloring, Hamiltonian cycles; Branch and bound: The general method, 0/1 knapsack problem, least cost branch and bound solution, first in first out branch and bound solution, travelling salesperson problem.

MODULE -VNP-HARD AND NP-COMPLETE PROBLEMS

Basic Concepts: Non-deterministic algorithms, the classes NP-Hard and NP-NP Hard problems, clique decision problem, chromatic number decision problem, Cook's theorem.

IV. TEXT BOOKS:

1. Ellis Horowitz, SatrajSahni, SanguthevarRajasekharan, “Fundamentals of Computer Algorithms”, Universities Press, 2nd Edition, 2015.
2. Alfred V. Aho, John E. Hopcroft, Jeffrey D, “The Design And Analysis Of Computer Algorithms”, Pearson India, 1st Edition, 2013.

V. REFERENCE BOOKS:

1. Levitin A, "Introduction to the Design and Analysis of Algorithms", Pearson Education, 3rd Edition, 2012.
2. Goodrich, M. T. R Tamassia, "Algorithm Design Foundations Analysis and Internet Examples", John Wileyn and Sons, 1st Edition, 2001.
3. Base Sara Allen Vangelder, "Computer Algorithms Introduction to Design and Analysis", Pearson, 3rd Edition, 1999.

VI. WEB REFERENCES:

1. http://www.personal.kent.edu/~rmuhamma/Algorithms/algorithm.html
2. http://openclassroom.stanford.edu/MainFolder/CoursePage.php?course=IntroToAlgorithms
3. http://www.facweb.iitkgp.ernet.in/~sourav/daa.html

VII. E-TEXT BOOKS:

1. https://kailash392.files.wordpress.com/2019/02/fundamentalsof-computer-algorithms-by-ellis-horowitz.pdf.

FLIGHT VEHICLE DESIGN

VII Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC34	**Core**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	-	-	3	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		
Prerequisite: Basic knowledge of Flight Dynamics and Design								

I. COURSE OVERVIEW:

This course is designed to provide students an understanding of procedure followed in conceptual design of an aircraft, meeting the user-specified design requirements and safety considerations specified by the aircraft certification agencies. The course introduces theoretical basics of methods and models that are used in the conceptual airplane design and discusses the theoretical problem solving skills related to analysis and design of flight vehicle structures. This course explains re-sizing and of a baseline civil transport aircraft to meet a specified market requirement.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The fundamental concepts of various aerofoil characteristics and blend the best suitable requirements for various applications designing in various applications.

II. Initial sizing of fuselage and tail plane design; static stability; structural loading; cost analysis; takeoff and landing; and specification of (T/W) ratio and wing loading (W/S).

III. The characteristics of stability and performance of an aircraft and the role of primary and secondary controls in longitudinal and lateral stability.

IV. The Conceptual designs of aerospace vehicles, components, missions, or systems that incorporate realistic constraints/applicable engineering standards.

III. COURSE SYLLABUS:

MODULE-I:OVERVIEW OF THE DESIGN PROCESS (9)

Phases of aircraft design, aircraft conceptual design process, project brief / request for proposal, problem definition, information retrieval, integrated product development and aircraft design. initial conceptual sketches, takeoff gross weight estimation, airfoil selection, airfoil design, airfoil design considerations, wing geometry and wing vertical location, wing tip shapes, tail geometry and arrangements, thrust to weight ratio, thrust matching, wing loading performance, constraint analysis.

MODULE –II: INITIAL SIZING & CONFIGURATION LAYOUT (9)

Sizing with fixed engine and with rubber engine. Geometry sizing of fuselage, wing, tail, control surfaces, and development of configuration lay out from conceptual sketch. the inboard profile drawing, lofting definition, significance and methods, flat wrap lofting, special consideration in configuration lay out, Isobar tailoring, structural load paths, radar, IR, fuselage design, crew station, passengers and payload.

MODULE –III: PROPULSION, FUEL SYSTEM INTEGRATION, LANDING GEAR AND BASELINE DESIGN ANALYSIS – I (9)

Propulsion selection, jet engine integration, propeller engine integration, engine design considerations, engine size estimation, fuel system design and integration, landing gear and sub systems arrangements, guidelines and significance of design layout, report of initial specifications.

Estimation of lift curve slope, maximum lift coefficient, complete drag build up, installed performance of an engine, aircraft structures and loads categories, air load distribution on lifting surfaces, review of methods of structural analysis, material selection, weights and moments statistical group estimation method.

MODULE –IV: BASELINE DESIGN ANALYSIS – II (9)

Estimation of static pitch stability, velocity stability and trim, estimation of stability and control derivatives, static lateral, directional stability and trim. estimation of aircraft dynamical characteristics, handling qualities, relation to aircraft dynamic characteristics, steady level flight, minimum thrust required for level flight, range and loiter endurance, steady climbing and descending flight, best angle and rate of climb, time to climb and fuel to climb, level turning flight, gliding flight, energy maneuverability methods of optimal climb trajectories and turns, the aircraft operating envelope, take off analysis, landing analysis, effects of wind on aircraft performance.

MODULE –V: COST ESTIMATION, PARAMETRIC ANALYSIS, OPTIMISATION, REFINED SIZING AND TRADE STUDIES (9)

Elements of life cycle cost, cost estimating method, operation and maintenance costs, aircraft and airline economics, airline revenue, investment cost analysis, improved conceptual sizing methods, trade studies, requirement trades, growth sensitivities, multivariable design optimization methods, determination of final baseline design configuration, preparation of type specification report. Case studies on design of DC-3 and Boeing B-707&747; General dynamics F-16, SR-71 Blackbird, Northrop-Grumman B-2 Stealth Bomber.

IV. TEXT BOOKS:

1. Raymer, D.P, “Aircraft Design: A Conceptual Approach”, AIAA Education Series, AIAA, 3rd Edition, 1999, ISBN: 1-56347-281-0.
2. Howe, D, “Aircraft Conceptual Design Synthesis”, Professional Engineering Publishing, London, 2000, ISBN: 1-86058-301-6.
3. Fielding, J.P, “Introduction to Aircraft Design”, Cambridge University Press, 2005, ISBN: 0-521- 657222-9

V. REFERENCE BOOKS:

1. Krishnamurthy, C.S., "Finite Element Analysis", Tata McGraw Hill, 2000.
2. K. J. Bathe, E. L. Wilson, "Numerical Methods in Finite Elements Analysis", Prentice Hall of India, 1985.
3. Robert D Cook, David S Malkus, Michael E Plesha, "Concepts and Applications of Finite Element Analysis", John Wiley and Sons, 4th Edition, 2003.
4. Larry J Segerlind, "Applied Finite Element Analysis", John Wiley and Sons, 2nd Edition, 1984.

AEROSPACE STRUCTURAL DYNAMICS

VII SEMESTER: AE

Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAEC35	Core	L	T	P	C	CIA	SEE	Total
		3	1	-	4	30	70	100
Contact Classes: 45	Tutorial Classes: 15	Practical Classes: Nil				Total Classes: 60		

Prerequisite: Aircraft Structures

I. COURSE OVERVIEW:

Aerospace Structural Dynamics subject focuses on the vibration analysis of different structural components. It provides the students with basic knowledge of mechanical vibrations of single and multiple degrees of freedom systems. These concepts are then extended to vibrations of continuum elastic bodies. Moreover, this course will also provide the required knowledge on aeroelasticity, which is one of the emerging fields of research in aerospace / aeronautical engineering. The theoretical knowledge gained through this course serves as a complement for the aerospace structural dynamics laboratory. Altogether, will be a good addition to the student's curriculum.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The knowledge of mathematics, science, and engineering by developing the equations of motion for vibratory systems and solving for the free and forced response.
II. The identification, formulation and solve engineering problems. This will be accomplished by having students model, analyze and modify a vibratory structure order to achieve specified requirements.
III. The structural vibrations which may affect safety and reliability of engineering systems.
IV. The structural dynamic and steady and unsteady aerodynamics aspects of airframe and its components of space structures.

III. COURSE OBJECTIVES:

MODULE-I: SINGLE-DEGREE-OF-FREEDOM LINEAR SYSTEMS (10)

Introduction to theory of vibration, equation of motion, free vibration, response to harmonic excitation, response to an impulsive excitation, response to a step excitation, response to periodic excitation (Fourier series), response to a periodic excitation (Fourier transform), Laplace transform (Transfer Function).

MODULE-II: TWO-DEGREE-OF-FREEDOM SYSTEMS (10)

Introduction, Equations of Motion for Forced Vibration, Free Vibration Analysis of an Undamped System, Torsional System, Coordinate Coupling and Principal Coordinates, Forced-Vibration Analysis, Semi definite Systems, Self-Excitation and Stability Analysis, Transfer- Function Approach, Solutions Using Laplace Transform, Solutions Using Frequency Transfer Functions.

MODULE-III: MULTI-DEGREE-OF-FREEDOM LINEAR SYSTEMS (08)

Matrix formulation, stiffness and flexibility influence coefficients; Eigen value problem; normal modes and their properties; Free and forced vibration by Modal analysis;

Method of matrix inversion; Torsional vibrations of multi- rotor systems and geared systems; Discrete- Time systems.

MODULE-IV: DYNAMICS OF CONTINUOUS ELASTIC BODIES (09)

Introduction, transverse vibration of a string or cable, longitudinal vibration of a bar or rod, torsional vibration of shaft or rod, lateral vibration of beams, the Rayleigh-Ritz method.

MODULE-V: INTRODUCTION TO AEROELASTICITY (08)

Static Aeroelasticity; Typical Section Model of an Airfoil: Typical Section Model with Control Surface, Typical Section Model—Nonlinear Effects. One Dimensional Aeroelastic Model of Airfoils: Beam-Rod Representation of Large Aspect Ratio Wing, Eigen value and Eigen function Approach, Galerkin's Method.
Dynamic Aeroelasticity; Hamilton's Principle: Single Particle, Many Particles, Continuous Body, Potential Energy, Non potential Forces, Lagrange's Equations.

IV. TEXT BOOKS:

1. Bismarck-Nasr, M.N., “Structural Dynamics in Aeronautical Engineering”, AIAA Education Series, 2nd Edition, 1999.
2. Rao, S.S., “Mechanical Vibrations”, Prentice-Hall, 5th Edition, 2011.
3. Earl H. Dowell, “A Modern Course in Aeroelasticity” Volume 217, Duke University, Durham, NC, USA.

V. REFERENCE BOOKS:

1. R.L. Bisplinghoff, H. Ashley, and R.L. Halfmann, “Aeroelasticity”, Addison Wesley Publishing Co, 2nd Edition, 1996.
2. Leissa, A.W., “Vibration of continuous system”, The McGraw-Hill Company, 2nd Edition, 2011.
3. Inman, D.J, “Vibration Engineering”, Prentice Hall Int., Inc., 3rd Edition, 2001.

VI. WEB REFERENCES:

1. http://ase.sbu.ac.ir/FA/Staff/abbasrahi/Lists/Dars/Attachments/11/Vibrations%20of%20Continuous%20Systems.pdf
2. http://arc-test.aiaa.org/doi/book/10.2514/4.862458
3. http://arc-test.aiaa.org/doi/abs/10.2514/5.9781600862373.0719.0728

VII. E-TEXT BOOKS:

1. http://www.gregorypaulblog.com/structural-dynamics-in-aeronautical-engineering-aiaa-education-series.pdf
   https://aerocastle.files.wordpress.com/2012/10/mechanical_vibrations_5th-edition_s-s-rao.pdf

TECHNIQUES IN WIND TUNNEL TESTING

VII Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC36	**Elective**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	-	-	3	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		
Prerequisite: Aerodynamics								

I. COURSE OVERVIEW:

The experimental aerodynamics is the first course for graduate and undergraduate students in Aerospace Engineering. The testing methodology employed in low and high-speed aerodynamics is a new techniques through which the students will learn various types of wind tunnels, tools and techniques. The experimental aerodynamics will be helpful to industrial aerodynamics study in various engineering branches like, environmental engineering, civil engineering, Automobile engineering etc., so that students get exposure to the various aspects of the subject related issues to measuring techniques, wind tunnel design, method and practical applications used. This subject will help the students to develop the tool by using multidisciplinary techniques. A number of problems/examples will be cited to enhance the understanding of the subject matter and besides, many unsolved problems will be provided with answers to further test the student's learning.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The basic fundamentals of Aerodynamics experiments, their need in comparison with numerical computation and theoretical studies.
II. The concepts of flow similarity and evaluate the loss coefficients of wind tunnel components.
III. The concept of force and moment measurements using wind tunnel balance and extrapolate it to new balance development.
IV. The various techniques for pressure, velocity, temperature measurement and flow visualization.

III. COURSE SYLLABUS:

MODULE-I: FUNDAMENTALS OF EXPERIMENTS IN AERODYNAMICS (10)

Forms of aerodynamic experiments, observations, measurement objectives. History: Wright Brother‘s wind tunnel, model testing, wind tunnel principles, scaling laws, scale parameters, geometric similarity, kinematic similarity& dynamic similarity. Wind tunnels: low speed tunnel, high speed tunnels, transonic, supersonic and hypersonic tunnels, shock tubes. Special tunnels: low turbulence tunnels, high Reynolds number tunnels, environmental tunnels, automobile tunnels, distinctive features, application.

MODULE –II: WIND TUNNEL EXPERIMENTATION CONSIDERATIONS (08)

Low speed wind tunnels, principal components. Function, description, design requirements, constraints and loss coefficients. Wind tunnel performance flow quality, power losses, wind tunnel corrections, sources of inaccuracies: buoyancy, solid blockage, wake blockage, streamline curvature causes, estimation and correction.

MODULE –III: WIND TUNNEL BALANCE (10)

Load measurement: low speed wind tunnel balances, mechanical & Strain gauge types, null displacement methods & strain method, sensitivity, weigh beams, steel yard type and current balance type, balance linkages, levers and pivots.

Model support three point wire support, three point strut support, platform balance, yoke balance, strain gauge, 3component strain gauge balance, description, application.

MODULE –IV: PRESSURE, VELOCITY & TEMPERATURE MEASUREMETNS (09)

Pressure: static pressure, surface pressure orifice, static probes, pitot probe for total pressure, static pressure and flow angularity, pressure sensitive paints, steady and unsteady pressure measurement and various types of pressure probes and transducers, errors in pressure measurement. Temperature: measurement of temperature using thermocouples, resistance thermometers, temperature sensitive paints and liquid crystals. Velocity: measurement of airspeed, Mach number from pressure measurements, flow direction, boundary layer profile using pitot static probe, 5 hole probe yaw meter, total head rake, hot wire anemometry, laser doppler anemometry, particle image velocimetry, working principle description of equipment, settings, calibration, measurement, data processing, applications.

MODULE –V: FLOW VISUALIZATION TECHNIQUES (08)

Flow visualization: necessity, streamlines, streak lines, path lines, time lines, tufts, china clay, oil film, smoke, hydrogen bubble. Optical methods: density and refractive index, schlieren system, convex lenses, concave mirrors, shadowgraph, interferometry, working principle, description, setting up, operation, observation, recording, interpretation of imagery, relative merits and applications

IV. TEXT BOOKS:

1. Jewel B Barlow, William H Rae Jr. & Alan Pope, "Low Speed Wind Tunnel Testing", John Wiley & Sons, Re-Print, 1999.
2. Alan Pope, Kennith L Goin, "High Speed Wind Tunnel Testing", John Wiley & Sons, Reprint, 1965.

V. REFERENCE BOOKS:

1. Gorlin S M & Slezinger I I, "Wind tunnels & Their Instrumentations", NASA publications, Translated version, 1966.
2. Jorge C Lerner & Ulfilas Boldes, "Wind Tunnels and Experimental Fluid Dynamics Research", InTech, 1st Edition, 2011.
3. Liepmann H W and Roshko A, "Elements of Gas Dynamics", John Wiley & Sons, 4th Edition, 2003.

FATIGUE AND FRACTURE OF MATERIALS

VII SEMESTER : AE								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAEC37	Elective	L	T	P	C	CIA	SEE	Total
		3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		
Prerequisite: Engineering Mechanics, Solid Mechanics, Aerospace Structures, Mathematics								

I. COURSE OVERVIEW:

The major emphasis of this course is to apply the concept of solid mechanics to predict the failure and strength of a structure under fluctuating loads and under cracked conditions. Various theories related to fatigue were discussed. Mechanism and conditions of crack growth are included which is used for design of structure against crack growth. Testing techniques in fatigue and fracture gives clear insights of realistic methods adopted in industries and able to test the materials.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The phenomena and theories of materials subjected to fatigue.
II. The orientation on classical and modern methods and design criteria against fatigue loads.
III. The numerical methods of design for crack analysis.
IV. The factor under which the crack grows under various loading conditions.

III. COURSE SYLLABUS:

MODULE-I: FATIGUE OF STRUCTURES (10)

S.N. curves, Endurance limit, Effect of mean stress, Goodman, Gerber and Soderberg relations and diagrams, Notches and stress concentrations, Neuber‟s stress concentration factors, plastic stress concentration factors, Notched S-N curves.

MODULE –II: STATISTICAL ASPECTS OF FATIGUE BEHAVIOUR (08)

Low cycle and high cycle fatigue, Coffin-Manson's relation, Transition life, Cyclic Strain hardening and softening, Analysis of load histories, Cycle counting techniques, Cumulative damage, Miner's theory, other theories.

MODULE –III: PHYSICAL ASPECTS OF FATIGUE (10)

Phase in fatigue life, Crack initiation, Crack growth.

Final fracture, Dislocations, Fatigue fracture surfaces.

MODULE –IV: FRACTURE MECHANICS (09)

Strength of cracked bodies, potential energy and surface energy, Griffith‟s theory, Irwin, Orwin extension of Griffith‟s theory to ductile materials, Stress analysis of cracked bodies, Effect of thickness on fracture toughness, Stress intensity factors for typical geometries.

MODULE –V: FATIGUE DESIGN AND TESTING (08)

Safe life and fail safe design philosophies, Importance of Fracture Mechanics in aerospace structure, Application to composite materials and structures.

IV. TEXT BOOKS:

1. D. Brock, "Elementary Engineering Fracture Mechanics", Noordh off International Publishing Co., London, 1994.
2. J. F. Knott, "Fundamentals of Fracture Mechanics", Butterworth & Co., (Publishers) Ltd., London, 1983.

V. REFERENCE BOOKS:

1. W. Barrois and L. Ripley, "Fatigue of Aircraft Structures", S Pergamon Press, Oxford, 1983.
2. C. G. Sih, "Mechanics of Fracture", Vol.1 Sijthoff and Noordhoff International Publishing Co., Netherland, 1989.

VI. WEB REFERENCES:

1. https://ocw.mit.edu/courses/materials-science-and-engineering/3-35-fracture-and-fatigue-fall-2003/

ORBITAL MECHANICS

VII Semester: AE								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAEC38	Elective	L	T	P	C	CIA	SEE	Total
		3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		
Prerequisite: Space Dynamics								

I. COURSE OVERVIEW:

Orbital mechanics or astrodynamics is the application of ballistics and celestial mechanics to the practical problems concerning the motion of rockets and other spacecraft. The motion of these objects is usually calculated from Newton's laws of motion and law of universal gravitation.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The knowledge in two-body, restricted three-body and n-body problem, Hamiltonian dynamics, canonical transformations, Poincare surface sections.

II. The rigorous vector analysis of rotational kinematics, Review of the basic Newtonian dynamics and Analysis of spacecraft altitude dynamics..

III. The necessary knowledge to study the satellite and interplanetary trajectories and Formal approaches for handling coordinate transformations..

IV. The orbital problems related to Earth satellite orbits using Hamilton‘s and generate interplanetary orbits in the frame work of restricted three-body problem..

V. The rendezvous problems in orbital transfer problems, to provide the knowledge about link between two spacecrafts.

III. COURSE SYLLABUS:

MODULE-I: INTRODUCTION TO ORBITAL MECHANICS (10)

Fundamental principles and definitions, problem of two bodies, Kepler‘s equation; Equation of motion in inertial frame, equations of relative motion, angular momentum and the orbit formulas; Central orbits, circular orbits, elliptical orbits.

MODULE –II: ORBITAL POSITION AND ORBITS IN THREE DIMENSIONS (10)

Time since periapsis, parabolic trajectories, hyperbolic trajectories, geocentric right ascension-declination frame, state vector and the geocentric equatorial frame, orbital elements and the state vector; Coordinate transformation, transformation between geocentric equatorial and perifocal frames; Effects of the Earth‘s oblateness.

MODULE –III: PRELIMAMINARY ORBIT DETERMINATION (09)

Gibbs method of orbit determination from three position Lambert‘s problem, sidereal time top centric coordinate system, top centric equatorial coordinate system, top centric horizon coordinate system.

Orbit determination from angle and range measurements angles only, preliminary orbit determination; Gauss method of preliminary orbit determination...

MODULE –IV: ORBITAL MANEUVERS (08)

Introduction, Impulsive maneuver, Kepler‘s equation and Lambert‘s theorem, force model, fundamentals of perturbation theory, perturbation in the elements, Lagrange‘s and Hamilton's equations, the method of canonical transformations, the general integrals of the problem of n-bodies, the problem of three bodies, restricted three-body problem, periodic and quasi-periodic orbits, Poincare surface sections..

MODULE –V: RELATIVE MOTION AND RENDEZVOUS (08)

Approximations to Relative motion in orbit Linearization of the equations of relative motion in orbit Clohessy-Wiltshire equations two-impulse rendezvous maneuvers Relative motion in close-proximity circular orbits.

IV. TEXT BOOKS:

1. Curtis, Howard D, "Orbital Mechanics for Engineering Students", Butterworth Heinemann, Elsevier series, 3rd Edition, 2010.
2. Bate, Roger R.; Mueller, Donald D.; White, Jerry E. "Fundamentals of Astrodynamics". Dover Publications, 1st Edition 1971.

V. REFERENCE BOOKS:

1. Sellers, Jerry J.; Astore, William J, Giffen, Robert B, Larson, Wiley J. Kirkpatrick, Douglas H, "Understanding Space An Introduction to Astronautics", McGraw Hill, 2nd Edition,2004.
2. Bryson, A.E, "Control of Aircraft and Spacecraft", Princeton University Press, 1994.
3. Thomson, William T, "Introduction to Space Dynamics", New York: Wiley, 3rd Edition, 1963.

VI. WEB REFERENCES:

1. https://soaneemrana.org/onewebmedia/INTRODUCTION%20TO%20SPACE%20DYNAMICS1
2. https://projectehermes.upc.edu/Enginyeria_Aeroespacial/4A/Enginyeria%20espacial/Teoria/Extra/Orbital%20Mechanics%20for%20Engineering%20Students.pdf

VII. E-TEXT BOOKS:

1. https://store.doverpublications.com/0486651134.html
2. https://worldcat.org/title/introduction-to-space-dynamics/oclc/867680515

INTRODUCTION TO COMPOSITE MATERIALS

VII Semester: AE

Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAEC39	Elective	L	T	P	C	CIA	SEE	Total
		3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		

Prerequisite: Aerospace Structures

I. COURSE OVERVIEW:

Design and analysis of composite structures discusses about different requirements of composite structures will be discussed within the framework of the course and associated design concepts will be introduced. In particular, the requirements associated with production, assembly and loads occurring during operation will be considered.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The fabrication, analysis and design of composite materials & structures.
II. The basic composites technology, including materials and processes, manufacturing, structural design, maintenance, proof of structures and other considerations.
III. The static testing procedure and repairing methodology of composite structural members and joints.
IV. The structural designs using composite materials

III. COURSE SYLLABUS:

MODULE-I: STRESS STRAIN RELATION (10)

Introduction- Advantages and application of composite materials, reinforcements and matrices; Generalized Hooke's Law; Elastic constants for anisotropic, orthotropic and isotropic materials.

MODULE –II: METHODS OF ANALYSIS (08)

Micro mechanics: Mechanics of materials approach, elasticity approach to determine material properties; Macro Mechanics; Stress-strain relations with respect to natural axis, arbitrary axis; Determination of material properties; Experimental characterization of lamina.

MODULE –III: LAMINATED PLATES, SANDWICH CONSTRUCTIONS AND FABRICATION PROCESS (10)

Governing differential equation for a general laminate, angle ply and cross ply laminates; Failure criteria for composites.

Basic design concepts of sandwich construction ; Materials used for sandwich construction ; Failure modes of sandwich panels; Various open and closed mould processes; Manufacture of fibers; Types of resins and properties and applications; Netting analysis.

MODULE –IV: DAMAGE TOLERANCE IN COMPOSITES (09)

Introduction, sources of damage, types of damage, FAR requirements and advisory circulars, building block approach; Impact damages: Damage growth under fatigue loads; residual strength: Tests and analytical methods; Detailed design: Basics of projections, drawing standards and conventions, introduction to CADD, design of composite parts and assembly design; Optimization: Fundamentals of optimization, mathematical concepts in optimization, Optimization of composite plates.

MODULE –V: TESTING OF COMPOSITE STRUCTURES (08)

Factors influencing testing, test environment, test methods and standards, introduction to static testing of composite structures and examples; Repair of composite aircraft structures: Introduction to repair, repair philosophy, repair sequence, repair criteria, damage assessment, classification of repair, selection of repair joints, repair procedures, certification of repair.

IV. TEXT BOOKS:

1. Gibson, R.F, "Principles of Composite Material Mechanics", CRC Press, 2nd Edition, 2007.
2. Jones, R.M, "Mechanics of Composite Materials", Taylor & Francis, 2nd Edition, 2010 (Indian Print)

3. Reddy, J.N., “Mechanics of Laminated Composite Plates and Shells – Theory and Analysis”, CRC Press, 2nd Edition, 2004.

V. REFERENCE BOOKS:

1. Agarwal, B.D., and Broutman, L.J, “Analysis and Performance of Fibre Composites”, John Wiley and sons, New York, 1995
2. Lubin, G., “Handbook on Advanced Plastics and Fibre Glass”, Von Nostrand Reinhold Co, New York, 1989.
3. AutarK. Kaw “Mechanics of Composite Materials”, CRC Press, 2nd Edition, 2005.

VI. WEB REFERENCES:

1. www.nptel.ac.in/courses/101104010/
2. www.freevideolectures.com/Course/94/Prestressed-Concrete-Structures/35
3. www.adturtle.biz/LP_TA/index.cfm?T=436857.

VII. E-TEXT BOOKS:

1. www.samples.sainsburysebooks.co.uk/9781118536957_sample_413689.pdf
2. www.samples.sainsburysebooks.co.uk/9780470972717_sample_386378.pdf
3. www.safaribooksonline.com/library/view/design-and-analysis/9781118536940/
4. https://www.amazon.com/Data-Structures-C-Noel-Kalicharan/dp/1438253273.

TURBO MACHINERY

VII SEMISTER : AE/ME								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC40	**Elective**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	-	-	3	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		
Prerequisite: Knowledge of Thermal Engineering, Heat Transfer								

I. COURSE OVERVIEW:

Turbo machinery describes machines that transfer energy between a rotor and a fluid like centrifugal pumps, including both turbines and compressors usually work with a gas. Indulgent in application of aerospace jet engines, turbines and Centrifugal Compressors and Radial flow turbines relationships like Newton's second law of motion and Euler's pump and turbine equation for compressible fluids are also turbo machines.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The basic concepts of turbo machinery, hydraulic pumps and effects of flow parameters on the performance of the machine.
II. The geometrical conditions and description of the main components in Centrifugal pumps, Pelton, Francis, Kaplan and gas-turbines.
III. The energy transfer and losses in centrifugal compressors, axial fans and steam turbines.
IV. The Basic design of Wind turbines, Reversible Pump turbines, multi-phase pumps and wet gas compressors.

III. COURSE SLLABUS:

MODULE-I: INTRODUCTION TO TURBOMACHINERY (10)

Classification of turbo machines, second law of thermodynamics applied to turbine and compressors work, nozzle, diffuser work, fluid equation, continuity, Euler's, Bernoulli's, equation and its applications, expansion and compression process, reheat factor, preheat factor.

MODULE-II: FUNDAMENTAL CONCEPTS OF AXIAL AND RADIAL MACHINES (10)

Euler's equation of energy transfer, vane congruent flow, influence of relative circulation, thickness of vanes, number of vanes on velocity triangles, slip factor, Stodola, Stanitz and Balje's slip factor, suction pressure and net positive suction head, phenomena of cavitation in pumps, concept of specific speed, shape number, axial, radial and mixed flow machines, similarity laws.

MODULE-III: AXIAL COMPRESSOR AND FANS (9)

Flow through axial flow fans, principle of axial fan and propeller, application of fan for circulation and ventilation, stage pressure rise and work done.

Slip stream and blade element theory for propellers, performance and characteristics of axial fans, effects of cascading, degree of reaction, blade loading coefficient and blade loss.

MODULE-IV: CENTRIFUGAL COMPRESSORS (8)

Flow through centrifugal compressors, stage velocity triangles, specific work, forward, radial and backward swept vanes, enthalpy entropy diagrams, degree of reaction, slip factor, efficiency, vaneless and vane diffuser system, volute as spiral casing, surge and stall in compressors.

MODULE-V: AXIAL TURBINES (8)

Stage velocity triangles, work, efficiency, blade loading, flow coefficient, single stage impulse and reaction turbines, degree of reaction, 50% reaction turbine stage, radial equilibrium and actuator disc approach for design of turbine blades, partial admission problems in turbines, losses in turbo machines

IV. TEXT BOOKS:

1. Yahya S.M, "Turbines, Compressor and Fans", TMH, 4th Edition, 2010.
2. Shepherd D.G., "Principles of Turbo machinery", Collier Macmillan, 2nd Edition, 1961.
3. Venkanna B.K., "Fundamentals of Turbo machinery", PHI, 3rd Edition, 2009.

V. REFERENCE BOOKS:

4. Peng W.W., "Fundamentals of Turbo machinery", Wiley, 2nd Edition, 2007.
5. Korpela S.A., "Principles of Turbo machinery", Wiley, 2nd Edition, 2011.
6. Turton R.K., "Principles of Turbo machinery", Springer, 3rd Edition, 1994.

VI. WEB REFERENCES:

1. https://www.cfd-online.com/Wiki/Turbomachinery
2. https://www.leka.lt/sites/default/files/dokumentai/key-concepts-in-turbo-machinery_1.pdf
3. https://www.sciencedirect.com/science/book/9781856177931

VII. E-TEXT BOOKS:

7. https://elearning.vtu.ac.in/newvtuelc/courses/15/E-Notes/turbomachines/MODULE-I%20&%20MODULE-II_GRS.pdf
8. https://engineering-e-book.blogspot.com/2008/01/turbomachinery-books.html
9. https://myopencourses.com/subject/computational-fluid-dynamics-for-turbomachinery

THEORY OF STRESS STRAIN MEASUREMENTS

VII Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC41	**Elective**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	-	-	3	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		
Prerequisite: Aerospace Structures								

I. COURSE OVERVIEW:

Experimental stress analysis overs the primary components of experimental pressure evaluation that consists of exhaustive remedy of the maximum flexible strategies like photoelasticity and stress gauges and additionally a short advent to the rising strategies like virtual photograph correlation. In addition it additionally affords the essential components of six specific experimental strategies

II. COURSE OBJECTIVES:

The student will try to learn:

I. The effects of force and motion while carrying out the innovative design functions of engineering. Bring awareness on experimental method of finding the response of the structure to different types of load.

II. The relation between the mechanics theory, experimental stress analysis, and the mechanical, optical, pneumatic and electrical strain gauges for strain measurement.

III. The fundamental concepts and newly experimental techniques and able to use the experimental techniques on the practical problems.

IV. The fine presentation related to the experimental paper.

III. COURSE SYLLABUS:

MODULE-I: MEASUREMENTS & EXTENSOMETER (10)

Principles of measurements, accuracy, sensitivity and range of measurements; Mechanical, optical acoustical and electrical extensometers and their uses, advantages and disadvantages.

MODULE –II: ELECTRICAL RESISTANCE STRAIN GAGES (08)

Strain sensitivity in metallic alloys, gage construction, adhesives and mounting techniques, gage sensitivity and gage factor, performance characteristics, environmental effects, strain gage circuits; Potentiometer, wheat stone's bridges, constant current circuits.

MODULE –III: TWO AND THREE DIMENSIONAL PHOTO-ELASTICITY (10)

Two dimensional photoelasticity; Concepts of light-photo-elastic effects, stress optic law-interpretation of fringe pattern-compensation and separation techniques; Photoelastic materials; Introduction to three dimensional photoelasticity.

Photoelastic (Bi-refringent) coatings, effects of coating thickness, brittle coatings, types of brittle coatings, advantages and brittle coating applications, crack detection methods and Moire methods: Applications and advantages.

MODULE –IV: PHOTO-ELASTICITY (09)

Nature of light, wave theory of light, optical interference, stress optic law , effect of stressed model in plane and circular polariscopes, isoclinics and iso-chromatics, fringe order determination fringe multiplication techniques, calibration photoelastic model materials.

MODULE –V: STRAIN ANALYSIS METHODS (08)

Two element, three element rectangular and delta rosettes, correction for transverse strain effects, stress gauge, plane shear gauge, and stress intensity factor gauge.

IV. TEXT BOOKS:

1. Dally and Riley, "Experimental Stress Analysis", McGraw-Hill, New York, 1978.
2. Sadhu Singh, "Experimental Stress Analysis", Khanna Publisher, 4th Edition, 2009.
3. Srinath L.S tata , "Experimental stress Analysis", McGraw-Hill, 3rd Edition, 2012.

V. REFERENCE BOOKS:

1. M.M. Frocht, John Wiley & sons, "Photoelasticity Vol I and Vol II", McGraw Hill, 2nd Edition, 1969.
2. Perry and Lissner, "Strain Gauge Primer", McGraw Hill, 2nd Edition, 1969.

VI. WEB REFERENCES:

1. https://www.youtube.com/playlist?list=PLUl4u3cNGP62esZEwffjMAsEMW_YArxYC
2. www.nptel.ac.in/syllabus/syllabus.php?subjectId=112106068www.textofvideo.nptel.iitm.ac.in/112106068/lec1.pdf

VII. E-TEXT BOOKS:

1. www.scribd.com/doc/241582542/Experimental-Stress-Analysis-by-Dally-and-Riley-P-1554n
2. www.apm.iitm.ac.in/smlab/kramesh/book_5.html
3. www.myopencourses.com/subject/experimental-stress-analysis-1
4. https://www.amazon.com/Data-Structures-C-Noel-Kalicharan/dp/1438253273

UNMANNED AIR VEHICLES

VII Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC42	**Elective**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	-	-	3	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**			**Total Classes: 45**			
Prerequisite: Basic Aerodynamics, Propulsion and Flight Dynamics								

I. COURSE OVERVIEW:

The course focuses on fundamentals related to powered, aerial vehicle systems that do not carry a human operator, including the terminology related to unmanned air vehicles (UAV), subsystems, basic design phases, aerodynamics, and also provides insight into different types of airframes and power-plants. It imparts knowledge about navigation, communications, control, and stability of UAVs. The course is aimed to obtain the knowledge also in commercial, private, public, and educational interest in UAS applications.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The major subsystems and the fundamental design phases of Unmanned Air Vehicle Systems (UAS).
II. The basic drags and airframe configurations of Unmanned Air Vehicles (UAVs).
III. The various communication media and navigation systems of UAVs.
IV. The different techniques used to achieve the control and stability of UAVs.

III. COURSE SYLLABUS:

MODULE-I: INTRODUCTION TO UNMANNED AIRCRAFT SYSTEMS (09)

UAS; Categories of systems; The systemic basis of UAS-system composition; Conceptual phase; Preliminary design; Detail design; Selection of the system; Some applications of UAS.

MODULE –II: AERODYNAMICS AND AIRFRAME CONFIGURATIONS (09)

Lift-induced Drag; Parasitic Drag; Rotary-wing aerodynamics; Response to air turbulence; Airframe configurations, scale effects; Packaging density ; Aerodynamics; Structures and mechanisms; Selection of power-plants; Modular construction; Ancillary equipment.

MODULE –III: CHARACTERISTICS OF AIRCRAFT TYPES (09)

Long-endurance, long-range role aircraft; Medium-range, tactical aircraft; Close-range / battlefield aircraft;

MUAV types; MAV and NAV types; UCAV; Novel hybrid aircraft configurations; Research UAV.

MODULE –IV: COMMUNICATIONS NAVIGATION (09)

Communication media; Radio communication; Mid-air collision (MAC) avoidance; Communications data rate and bandwidth usage; Antenna types; NAVSTAR global positioning system (GPS) - TACAN -LORAN C - Inertial navigation - Radio tracking - Way-point navigation.

MODULE –V: CONTROL AND STABILITY (09)

HTOL Aircraft: Aero-stable configuration, Spatially stabilized configuration – Helicopters: SMR, CHR – Convertible rotor aircraft - Payload control -Sensors –Autonomy.

IV. TEXT BOOKS:

1. Reg Austin, “Unmanned Aircraft Systems”, John Wiley and Sons, 2010.

V. REFERENCE BOOKS:

1. Paul Gerin Fahlstrom, “Introduction to UAV Systems”, John Wiley & Sons, 2012.
2. Collinson R.P.G, “Introduction to Avionics Systems”, Springer, 2011.
3. Bernad Etikin, “Dynamic of Flight: Stability and Control, John Wiley & Sons, 1995.

VI. WEB REFERENCES:

1. www.nasa.gov/centers/armstrong/images/UAV/index.html
2. www.drdo.gov.in/unmanned-aerial-systems-uas

VII. E-TEXT BOOKS:

1. www.springer.com/gp/book/9789048197064.

COMPUTATIONAL GAS DYNAMICS

<table>
<tr><td colspan="11">VII Semester: AE</td></tr>
<tr><th>Course Code</th><th>Category</th><th colspan="3">Hours / Week</th><th>Credits</th><th colspan="3">Maximum Marks</th></tr>
<tr><td rowspan="2">AAEC43</td><td rowspan="2">Elective</td><td>L</td><td>T</td><td>P</td><td>C</td><td>CIA</td><td>SEE</td><td>Total</td></tr>
<tr><td>3</td><td>-</td><td>-</td><td>3</td><td>30</td><td>70</td><td>100</td></tr>
<tr><td>Contact Classes: 45</td><td>Tutorial Classes: Nil</td><td colspan="4">Practical Classes: Nil</td><td colspan="3">Total Classes: 45</td></tr>
<tr><td colspan="9">Prerequisite: Knowledge of Aerodynamics and Computational Aerodynamics</td></tr>
</table>

I. COURSE OVERVIEW:

This course deals with the advanced aspects of Computational Fluid Dynamics, emphasizing on the governing equations of fluid dynamics and their numerical discretization techniques using panel methods, finite volume and finite difference methods. This course also describes the methods of grid generation techniques for both structured and unstructured grid with panel methods. It describes the mathematical behavior of the different classes of partial differential equations. Alongside aforementioned techniques, this course also deals with pressure based solvers for incompressible viscous flow. Having said that, all basic stability conditions, errors and convergence efficiency of numerical solutions is also discussed

II. COURSE OBJECTIVES:

The student will try to learn:

I. The concept of panel methods, analyze various boundary conditions applied and demonstrate several searching and sorting algorithms.

II. The initial methods applied in the process of CFD tools development their advantages and disadvantages over modern developed methods.

III. The different methods evolved in analyzing numerical stability of solutions and evaluate the parameters over which the stability depends and their range of values.

IV. The advanced techniques and methods in time marching steps and identify different boundary conditions for different cases in CFD techniques.

III. COURSE SYLLABUS:

MODULE-I: NUMERICAL SOLUTIONS (10)

Euler equations: Flux approach, Lax-Wendroff method, basic principles of upwind schemes, flux vector splitting, Steger Warming flux vector splitting, Van Leer flux vector splitting, Upwind reconstruction, evolution, Godunov's first order upwind method, Roe's first order upwind method.

MODULE –II: TIME DEPENDENT METHODS (10)

Stability of solution, explicit methods, FTFS, FTCS, FTBS, Leapfrog method, Lax method. Implicit methods: Euler's FTCS, Crank Nicolson method, description of Lax- Wendroff scheme, McCormack two step predictor-corrector method, description of time split methods, approximate factorization schemes.

MODULE –III: BOUNDARY CONDITIONS (09)

Boundary Layer Equations: Setting up the boundary layer equations, flat plate boundary layer solution, boundary layer transformations, explicit and implicit discretization, solution of the implicit difference equations, integration of the continuity equation, boundary layer edge and wall shear stress, Keller-box scheme.

Concept of dummy cells, solid wall inviscid flow, viscous flow, farfield concept of characteristic variables, modifications for lifting bodies inlet outlet boundary, injection boundary, symmetry plane, coordinate cut, periodic boundaries, interface between grid blocks, flow gradients at boundaries of unstructured grids.

MODULE –IV: METHOD OF CHARACTERISTICS (08)

Philosophy of method of characteristics, determination of characteristic lines, two dimensional irrotational flow, determination of compatibility equations, MODULE processes, supersonic nozzle design by the method of characteristics, supersonic wind tunnel nozzle, minimum length nozzles, domain of dependence and range of influence.

MODULE –V: PANEL METHODS (08)

Basic formulation, boundary conditions, physical considerations, reduction of a problem to a set of linear algebraic equations, aerodynamic loads, preliminary considerations prior to establishing numerical solution, steps toward constructing a numerical solution, solution of thin airfoil with lumped vortex filament, accounting for effects of compressibility and viscosity.

IV. TEXT BOOKS:

1. Tannehill John C, Anderson Dale A, Pletcher Richard H, "Computational Fluid Mechanics and Heat Transfer", Taylor & Francis, 2nd Edition, 1997.
2. Chung T G, "Computational Fluid Dynamics", Cambridge University Press, 2nd Edition, 2010.
3. Katz Joseph and Plotkin Allen, "Low-Speed Aerodynamics", Cambridge University Press, 2nd Edition, 2006.

V. REFERENCE BOOKS:

1. Anderson J D, "Modern Compressible Fluid Flow", McGraw Hill, 2nd Edition, 1990.
2. Anderson J D, "Fundamentals of Aerodynamics", Tata McGraw Hill, 5th Edition, 2010.
3. Anderson J D, "Computational Fluid Dynamics", McGraw Hill, 1995.

VI. WEB REFERENCES:

1. https://s6.aeromech.usyd.edu.au/aerodynamics/index.php/sample-page/subsonic-aerofoil-and-wing-theory/2d-panel-methods/
2. www.wind.civil.aau.dk/lecture/8sem_CFD/Lecture1/Lecture1.pdf
3. personalpages.manchester.ac.uk/staff/david.d.apsley/lectures/comphydr/timedep.pdf

VII. E-TEXT BOOKS:

1. https://books.google.co.in/books/about/Advanced_Computational_Fluid_and_Aerodyn.html?id=dWS4jgEACAAJ&redir_esc=y.
2. https://www.scribd.com/doc/159468983/Low-Speed-Aerodynamics-Joseph-Katz-Alen-Plotkin
3. https://www.crcpress.com/Computational-Fluid-Mechanics-and-Heat-Transfer-Third-edition/Pletcher-Tannehill-Anderson/p/book/9781591690375.
4. https://www.faadooengineers.com/threads/8482-Computational-Fluid-Dynamics-Ebook-Ppt-Pdf-Download.

COMPUTER ARCHITECTURE

OE – I: VI Semester: ECE / EEE OE –II: VII Semester: AERO / MECH / CIVIL								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
ACSC24	Elective	L	T	P	C	CIA	SEE	Total
		3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		

I. COURSE OVERVIEW:

This course introduces the principles of computer organization and the basic architecture concepts. The main objective of this course is to give students to a clear understanding of the modern computer architecture. It also helps the students to know about hardware and software implementation of (ALU) arithmetic and logic unit to solve addition, subtraction, multiplication and division. It also defines the constituent parts of the system, how they are interconnected, and how they interoperate in order to implement the architectural specification. In this course, students will learn the basics of hardware components from basic gates to memory and I/O devices, instruction set architectures and designs to improve the performance.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The organization and architecture of computer systems and electronic computers.
II. The assembly language program execution, instruction format and instruction cycle.
III. How to design a simple computer using hardwired and micro programmed control methods.
IV. The basic components of computer systems besides the computer arithmetic.
V. The input-output organization, memory organization and management, and pipelining.

III. SYLLABUS

MODULE – I: INTRODUCTION TO COMPUTER ORGANIZATION (09)

Basic computer organization, CPU organization, memory subsystem organization and interfacing, input or output subsystem organization and interfacing, simple computer levels of programming languages, assembly language instructions, a simple instruction set architecture.

MODULE –II: ORGANIZATION OF A COMPUTER (09)

Register transfer: Register transfer language, register transfer, bus and memory transfers, arithmetic micro operations, logic micro operations, shift micro operations; Control memory.

MODULE –III: CPU AND COMPUTER ARITHMETIC (09)

CPU design: Instruction cycle, data representation, memory reference instructions, input-output, and interrupt, addressing modes, data transfer and manipulation, program control.

Computer arithmetic: Addition and subtraction, floating point arithmetic operations, decimal arithmetic unit.

MODULE –IV: INPUT-OUTPUT ORGANIZATION (09)

Input or output organization: Input or output Interface, asynchronous data transfer, modes of transfer, priority interrupt, direct memory access.

MODULE –V: MEMORY ORGANIZATION (09)

Memory organization: Memory hierarchy, main memory, auxiliary memory, associative memory, cache memory, virtual memory; Pipeline: Parallel processing, Instruction pipeline.

IV. TEXT BOOKS:

1. M. Morris Mano, "Computer Systems Architecture", Pearson, 3rd Edition, 2015.
2. Patterson, Hennessy, "Computer Organization and Design: The Hardware/Software Interface", Morgan Kaufmann, 5th Edition, 2013.

V. REFERENCE BOOKS:

1. John. P. Hayes, "Computer System Architecture", McGraw-Hill, 3rd Edition, 1998.
2. Carl Hamacher, Zvonko G Vranesic, Safwat G Zaky, "Computer Organization", McGraw-Hill, 5th Edition, 2002.
3. William Stallings, "Computer Organization and Architecture", Pearson Edition, 8th Edition, 2010.

VI. WEB REFERENCES:

1. https://www.tutorialspoint.com/computer_logical_organization/
2. https://www.courseera.org/learn/comparch
3. https://www.cssimplified.com/.../computer-organization-and-assembly-language-programming

VI. E-TEXT BOOKS:

1. https://www.groupes.polymtl.ca/inf2610/.../ComputerSystemBook.pdf
2. https://www.cse.hcmut.edu.vn/~vtphuong/KTMT/Slides/TextBookFull.pdf

ADVANCED DATA STRUCTURES

OE – I: VI Semester: ECE / EEE OE –II: VII Semester: AERO / MECH / CIVIL							
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
ACSC25	Elective	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	-	-	3	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		

I. COURSE OVERVIEW:

The course is intended to provide the foundations of the practical implementation and usage of Advanced Data Structures. It also covers some classical results and recent advancements on data structures, and the algorithms acting upon them. Typical topics include in sorting and searching, reorganizing lists and search trees based on the online sequence of queries to speed up searches, improving efficiency based on the distribution of queries, performing fast text retrieval by constructing indexes, and improving space efficiency of data structures for large data sets. The main objective of this course is to ensure that the student evolves into a competent programmer capable of designing and analyzing the implementations of different data structures for different kinds of problems.

II.COURSE OBJECTIVES:

The students will try to learn:

I. The basic data structures and techniques of algorithm analysis.
II. The dictionaries, hashing mechanisms and skip lists for faster data retrieval.
III. The comprehension of heaps, priority queues and its operations.
IV. Briefly about balanced trees and their operations.
V. The tries and pattern matching algorithms.

III. SYLLABUS:

MODULE – I: OVERVIEW OF DATA STRUCTURES (09)

Algorithms; Performance analysis: Time complexity and Space complexity, Asymptotic notation. Review of basic data structures - The list ADT, Stack ADT, Queue ADT, Linked list – Single linked list, Double linked list, Circular linked list.

MODULE – II: DICTIONARIES, HASH TABLES (09)

Dictionaries: Linear list representation, Skip list representation, operations - insertion, deletion and searching, Hash table representation, hash functions, collision resolution - separate chaining, open addressing - linear probing, quadratic probing, double hashing, rehashing, extendible hashing, comparison of hashing and skip lists.

MODULE – III: PRIORITY QUEUES (09)

Priority Queues – Definition, ADT, Realizing a Priority Queue using Heaps, Insertion, Deletion,.

Application-Heap Sort, External Sorting- Model for external sorting, Multiway merge, Polyphase merge.

MODULE – IV: SEARCH TREES (09)

Binary Search Trees - Definition, ADT, Operations - Searching, Insertion, Deletion, AVL Trees - Definition, ADT, Balance factor, Operations – Insertion, Deletion, Searching, Introduction to Red – Black and Splay Trees, B-Trees, B-Tree operations - insertion, deletion, searching, Comparison of Search Trees.

MODULE – V: PATTERN MATCHING AND TRIES (09)

Pattern matching algorithms - the Boyer - Moore algorithm, the Knuth – Morris - Pratt algorithm. Tries – Definition, concepts of digital search tree, Binary trie, Patricia, Multi-way trie.

IV. TEXT BOOKS:

1. Ellis Horowitz, Sartaj Sahni, Sanguthevar Rajasekaran, "Fundamentals of Computer Algorithms", Universities Press Private Limited, India, 2nd Edition, 2008.
2. G.A. V.Pai, "Data Structures and Algorithms", Tata McGraw Hill, New Delhi, 1st Edition, 2008.
3. Richard F Gilberg, Behrouz A Forouzan, "Data Structures - A Pseudocode Approach with C", Cengage Learning, Thomson Press (India) Ltd, 2nd Edition, 2006.

V. REFERENCE BOOKS:

1. D. Samanta, "Classic Data Structures", Prentice Hall of India Private Limited, 2nd Edition, 2003.
2. Aho, Hop craft, Ullman, "Design and Analysis of Computer Algorithms", Pearson Education India, 1st Edition, 1998.
3. Goodman, Hedetniemi, "Introduction to Design and Analysis of Algorithms", Tata McGraw Hill, New Delhi, India, 1st Edition, 2002.
4. Adam Drozdek, "Data Structures and Algorithms in C++", Thomson Course Technology, 3rd Edition, 2005.
5. M. T. Goodrich, R. Tomassia, "Data structures and Algorithms in Java", Wiley India, 3rd Edition, 2011.

VI. WEB REFERENCE:

1. https://www.tutorialspoint.com/data_structures_algorithms/data_structures_basics.htm
2. https://www.geeksforgeeks.org/data-structures/
3. http://www.nptelvideos.in/2012/11/data-structures-and-algorithms.html

VII. E-TEXT BOOKS:

1. https://pdfs.semanticscholar.org/19ec/55ed703eb24e1d98a4abd1a15387281cc0f8.pdf
2. https://www.academia.edu/35961658/Data.Structures.A.Pseudocode.Approach.with.C.2nd.edition_1_.pdf
3. https://sonucgn.files.wordpress.com/2018/01/data-structures-by-d-samantha.pdf

ARTIFICIAL INTELLIGENCE

OE – I: VI Semester: ECE / EEE OE –II: VII Semester: AERO / MECH / CIVIL								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
ACSC26	Elective	L	T	P	C	CIA	SEE	Total
		3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		

I. COURSE OVERVIEW:

Artificial Intelligence has emerged as an increasingly impactful discipline in science and technology. AI applications are embedded in the infrastructure of many products and industries search engines, medical diagnoses, speech recognition, robot control, web search advertising and even toys. This course provides a broad overview of modern artificial Intelligence, learn how machines can engage in problem solving, reasoning, learning, and interaction design, test and implement algorithms.

II.COURSE OBJECTIVES:

The students will try to learn:

I. Gain a historical perspective of AI and its foundations.
II. Become familiar with basic principles of AI toward problem solving, inference, knowledge representation, and learning.
III. Explore the current scope, potential, limitations, and implications of intelligent systems.

III. SYLLABUS:

MODULE – I: INTRODUCTION (09)

Introduction: AI problems, Intelligent agents: Agents and Environments, the concept of rationality, the nature of environments, Structure of agents, Problem solving agents, Problem formulation.

MODULE – II: KNOWLEDGE REPRESENTATION & REASONS (09)

Knowledge – Based Agents, the Wumpus world.
Propositional Logic: Reasoning patterns in propositional logic - Resolution, Forward & Backward Chaining. Inference in First order logic: Propositional vs. first order inference.

MODULE – III: SEARCHING: (09)

Searching for solutions, uniformed search strategies – Depth limited search, bi-direction search, Comparing uninformed search strategies.

Search with partial information (Heuristic search), TSP problem, best first search, A* search, Hill climbing, Simulated annealing search.

MODULE – IV: CONSTRAIN SATISFACTION PROBLEMS (09)

Backtracking search for CSPs local search for constraint satisfaction problems. Game Playing: Games, Min - Max algorithm, Optimal decisions in multiplayer games, Alpha-Beta pruning.

MODULE – V: PLANNING: (09)

Classical planning problem, Language of planning problem, planning with state – space search, forward state spare search, backward state space search, Heuristics for state space search, Partial order planning Graphs, Planning graphs.

IV. TEXT BOOKS:

1. Stuart Russel, Peter Norvig, “Artificial Intelligence – A Modern Approach”, Pearson Education. 3rd Edition, 2009.

V. REFERENCE BOOKS:

1. E.Rich and K.Knight, “Artificial Intelligence”, Tata McGraw Hill, 3rd Edition, 2008.
2. Patterson, “Artificial Intelligence and Expert Systems”, PHI, 2nd Edition, 2009.
3. Giarrantana/ Riley, “Expert Systems: Principles and Programming”, Thomson, 4th Edition, 2004.
4. Ivan Bratka, “PROLOG Programming for Artificial Intelligence, Pearson Education, 3rd Edition, 2000.

CYBER CRIME AND COMPUTER FORENSICS

OE – I: VI Semester: ECE / EEE OE –II: VII Semester: AERO / MECH / CIVIL							
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AITC19	Elective	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	-	-	3	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		

I. COURSE OVERVIEW:

This course is designed to introduce the participant to the cybercrime prevention, detection and incident management processes, policies, procedures and cybercrime governance activities. The course is focus on cybercrime management standards, guidelines and procedures as well as the implementation and governance of these activities. In addition, it also provides the students an understanding of the new and advanced digital investigation techniques for machines, systems and networks since new technologies are opening today the door to new criminal approaches.

II.COURSE OBJECTIVES:

The students will try to learn:

I. The fundamental concepts of computer forensics and different types of forensics systems.
II. The methodologies to analyze and validate the forensics data.
III. The different tools and tactics that is associated with cyber forensics.

III. SYLLABUS:

MODULE – I: INTRODUCTION (09)

Introduction: Computer forensics fundamentals, types of computer forensics technology, types of computer forensics systems, vendor and computer forensics services.

MODULE – II: COMPUTER FORENSICS EVIDENCE AND CAPTURE (09)

Data recovery, evidence collection and data seizure, duplication and preservation of digital evidence, computer image verification and authentication.

MODULE – III: COMPUTER FORENSIC ANALYSIS (09)

Discover of electronic evidence, identification of data, reconstructing past events, fighting against macro threats.

Information warfare arsenal, tactics of the military, tactics of terrorist and rogues, tactics of private companies.

MODULE – IV: INFORMATION WARFARE (09)

Arsenal, surveillance tools, hackers and theft of components, contemporary computer crime, identity theft and identity fraud, organized crime &terrorism, avenues prosecution and government efforts, applying the first amendment to computer related crime, the fourth amendment and other legal issues.

MODULE – V: COMPUTER FORENSIC CASES (09)

Developing forensic capabilities, searching and seizing computer related evidence, processing evidence and report preparation, future issues.

IV. TEXT BOOKS:

1. John R. Vacca, “Computer Forensics: Computer Crime Scene Investigation”, Cengage Learning, 2nd Edition, 2005. (UNIT I – IV)
2. Marjie T Britz, “Computer Forensics and Cyber Crime: An Introduction”, Pearson Education, 2nd Edition, 2008. (UNIT IV – V)

V. REFERENCE BOOKS:

1. MariE-Helen Maras, "Computer Forensics: Cybercriminals, Laws, and Evidence", Jones & Bartlett Learning; 2nd Edition, 2014.
2. Chad Steel, "Windows Forensics", Wiley, 1st Edition, 2006.
3. Majid Yar, "Cybercrime and Society", SAGE Publications Ltd, Hardcover, 2nd Edition, 2013.
4. Robert M Slade, "Software Forensics: Collecting Evidence from the Scene of a Digital Crime", Tata McGraw Hill, Paperback, 1st Edition, 2004.

ETHICAL HACKING

OE – I: VI Semester: ECE / EEE OE –II: VII Semester: AERO / MECH / CIVIL								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AITC20	Elective	L	T	P	C	CIA	SEE	Total
		3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		

I. COURSE OVERVIEW:

This course will provide fundamentals of the tools and techniques used by hackers and information security professionals alike to break into an organization. This course will immerse you into the Hacker Mindset so that you will be able to defend against future attacks. It puts you in the driver's seat of a hands-on environment with a systematic ethical hacking process. It will give an overview of how to scan, test, hack and secure own systems thought the different phases of ethical hacking include reconnaissance, gaining access, enumeration, maintaining access, and covering various tracks.

II.COURSE OBJECTIVES:

The students will try to learn:

I. The concepts of security testing and the knowledge required to protect against the hacker and attackers.
II. The reconnaissance and the publicly available tools used to gather information on potential targets.
III. The scanning techniques used to identify network systems open ports.
IV. The network system vulnerabilities and confirm their exploitability.
V. The techniques for identifying web application vulnerabilities and attacks.

III. SYLLABUS:

MODULE – I: INTRODUCTION TO HACKING (09)

Introduction to hacking, important terminologies, penetration test, vulnerability assessments versus penetration test, pre-engagement, rules of engagement, penetration testing methodologies, osstmm, nist, owasp, categories of penetration test, types of penetration tests, vulnerability assessment summary, reports.

MODULE – II: INFORMATION GATHERING AND SCANNING (09)

information gathering techniques, active information gathering, passive information gathering, sources of information gathering, tracing the location, traceroute, icmp traceroute, tcp traceroute, usage, udp traceroute, enumerating and fingerprinting the webservers, google hacking, dns enumeration, enumerating snmp, smtp enumeration, target enumeration and port scanning techniques, advanced firewall/ids evading techniques.

MODULE – III: NETWORK ATTACKS (09)

Vulnerability data resources, exploit databases, network sniffing, types of sniffing, promiscuous versus nonpromiscuous mode, mitm attacks, arp attacks, denial of service attacks.

Stripping https, traffic dns spoofing, arp spoofing attack manipulating the dns records, dhcp spoofing,
remote exploitation, attacking network remote services, overview of brute force attacks, traditional brute force.

MODULE – IV: EXPLOITATION (09)

Introduction to metasploit, reconnaissance with metasploit, port scanning with metasploit, compromising a windows host with metasploit, client side exploitation methods, e–mails with malicious attachments, creating a custom executable, creating a backdoor with set, pdf hacking, social engineering toolkit, browser exploitation, post, exploitation, acquiring situation awareness, hashing algorithms, windows hashing methods.

MODULE – V: WIRELESS AND WEB HACKING (09)

Wireless hacking, introducing aircrack, cracking the wep, cracking a wpa/wpa2 wireless network using aircrack, ng – evil twin attack, causing denial of service on the original ap, web hacking, attacking the authentication, brute force and dictionary attacks, types of authentication.

IV. TEXT BOOKS:

1. Rafay Baloch, "Ethical Hacking and Penetration Testing Guide", CRC Press, 2014.

V. REFERENCE BOOKS:

1. Kevin Beaver, "Ethical Hacking for Dummies", Wiley, 6th Edition, 2018.
2. Jon Erickson , "Hacking: The Art of Exploitation", Rogunix, 2nd Edition, 2007.

MOBILE COMPUTING

OE – I: VI Semester: ECE / EEE OE –II: VII Semester: AERO / MECH / CIVIL								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AITC21	**Elective**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	-	-	3	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		

I. COURE OVERVIEW:

With the increasing popularity of mobile devices, mobile computing has become part of our daily life. This course will cover the nomenclature and implementation of mobile computing and mobile communication. It also provide a systematic explanation of mobile computing as a discrete discipline and will provide an in-depth coverage of mobile systems and devices used for application development, mobile databases, client-server computing agents, application servers, security protocols, mobile Internet, and ad-hoc and sensor networks.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The concept of wireless transmission protocols.
II. The typical mobile networking infrastructure through a popular GSM protocol architecture.
III. The various layers of mobile networks for location management.
IV. The database issues in mobile environments and data delivery models.
V. The platforms and protocols used in mobile environment.

III. SYLLABUS:

MODULE-I: INTRODUCTION (08)

Mobile computing – Paradigm, promises/Novel applications and impediments and architecture; Mobile and handheld devices, limitations of mobile and handheld devices. GSM – Services, system architecture, radio interfaces, protocols, localization, calling, handover, security, new data services, GPRS.

MODULE-II: MEDIA ACCESS LAYER AND MOBILE NETWORK LAYER (08)

Motivation for a specialized MAC (Hidden and exposed terminals. Near and far terminals), SDMA, FDMA, TDMA, CDMA, wireless LAN (IEEE802.11) system and protocol architecture; Mobile network layer: Packet delivery and handover management, location management, registration, tunneling and encapsulation, route optimization, DHCP.

MODULE-III: MOBILE TRANSPORT LAYER (08)

Conventional TCP/IP protocols, indirect TCP, snooping TCP, mobile TCP, other transport layers protocols for mobile networks;

Database issues: Database hoarding & caching techniques, C-S computing and adaptation, transactional models, query processing, data recovery process and QoS issues.

MODULE-IV: DATA DISSEMINATION AND SYNCHRONIZATION (10)

Communications asymmetry, classification of data delivery mechanisms, data dissemination, broadcast models, selective tuning and indexing methods.

MODULE-V: MOBILE ADHOC NETWORKS(MANET'S) (09)

Introduction, applications and challenges of a MANET, routing, classification of routing algorithms, algorithms such as DSR, AODV, DSDV; Mobile Agents, Service Discovery.

IV. TEXT BOOKS:

1. Jochen Schiller, "Mobile Communications", Pearson Education, 2nd Edition, 2009.
2. Raj Kamal, "Mobile Computing", Oxford University Press, Illustrated, 2nd Edition, 2012.

V. REFERENCE BOOKS:

1. Adelstein, Frank, Gupta, Sandeep KS, Richard III, Golden, Schwiebert, Loren, "Fundamentals of Mobile and Pervasive Computing", McGraw-Hill Professional, 2005.
2. Hansmann, Merk, Nicklous, Stober, "Principles of Mobile Computing", Springer, 2nd Edition, 2003.
3. Martyn Mallick, "Mobile and Wireless Design Essentials", Wiley Dream Tech, 1st Edition, 2003.

VI. WEB REFERENCE:

1. https://en.wikipedia.org/wiki/Mobile_computing
2. https://www.tutorialspoint.com/mobile_computing/mobile_computing_quick_guide.h
3. https://media.techtarget.com/searchMobileComputing/downloads/Mobile_and_pervasive_computing_Ch06 pdf

VII. E-TEXT BOOKS:

1. https://books.google.co.in/books?id=HoFdSmH77wsC&printsec=frontcover&source=gbs_ge_summary_r&cad=0#v=onepage&q&false
2. https://books.google.co.in/books?id=LSqPLwEACAAJ&source=gbs_book_other_versions

FLIGHT VEHICLE DESIGN LABORATORY

VII Semester: AE							
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAEC44	Core	L	T	P	C	CIA	SEE	Total
		0	0	3	1.5	30	70	100
Contact Classes: Nil	Tutorial Classes: Nil	Practical Classes: 36				Total Classes: 36		
Prerequisite: Basic knowledge of Excel and MAT Lab.								

I. COURSE OVERVIEW:

This course is designed to provide students an understanding of procedure followed in conceptual design of an aircraft, meeting the user-specified design requirements and safety considerations specified by the aircraft certification agencies. The course introduces theoretical basics of methods and models that are used in the conceptual airplane design and discusses the theoretical problem solving skills related to analysis and design of flight vehicle structures. This course explains re-sizing and of a baseline civil transport aircraft to meet a specified market requirement.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The conceptual sketch of aircrafts based on client requirements such as type, role, payload, mission, aerodynamic & performance requirements.

II. The Estimation total takeoff gross weight, thrust-weight ratio, wing loading parameters using data sheets.

III. The Development of initial layouts for major components such as fuselage, empennage, landing gears and wings.

III. COURSE SYLLABUS:

Week-1: OBJECTIVES AND REQUIREMENTS OF THE VEHICLE

Data collection for conceptual sketch from existing aircraft includes :
Batch I: Type of aircraft, Role, Mission.
Batch II: Payload, Aerodynamic & performance requirements.

Week-2: CONCEPTUAL SKETCH AND WEIGHT ESTIMATION

Batch I: Conceptual sketch of candidate aircraft (3-view).
Batch II: First estimation of gross take-off weight with trade-off studies

Week-3: AIRFOIL DESIGN AND CONSTRAINT ANALYSIS

Batch I: Air foil selection
Batch II: Wing geometry selection

Week-4: CONSTRAINT ANALYSIS

Batch I: Determination of Thrust-to-Weight ratio.
Batch II: Determination of Wing Loading.

Week-5: INITIAL SIZING-I

Batch I: Rubber engine
Batch II: Fixed engine sizing

Week-6: INITIAL SIZING-II

Batch I: Configuration layouts.
Batch II: Crew station, passengers and payload

Week-7: PREPARATION PERFORMANCE ESTIMATIONS

Batch I: Performance constraint analysis
Batch II: constraint analysis

Week-8: **LOAD ESTIMATIONS-I**
Batch I: Types of gear loads
Batch II: Landing gear loads
Week-09: LOAD ESTIMATIONS-II
Batch I: Types of propulsion systems
Batch II: Propulsion system load.

Week-10: COST ESTIMATION
Batch I: Cost estimation and parametric analysis
Batch II: Optimization and trade studies

Week-11: DESIGN CASE STUDY-I
Batch I: Design study of DC-3
Batch II: Design study B-747

Week-12: DESIGN CASE STUDY-II
Batch I:Dynamics of F-16
Batch II :Dynamics of SR-71

IV. REFERENCE BOOKS:

1. Daniel P. Raymer "Aircraft Design a Conceptual Approach", 5th Edition 1999.

AEROSPACE STRUCTURAL DYNAMICS LABORATORY

VII Semester: AE

Course Code	Category	Hours / Week			Credits	Maximum Marks		
		L	T	P	C	CIA	SEE	Total
AAEC45	Core	0	0	3	1.5	30	70	100
Contact Classes: Nil	Tutorial Classes: Nil	Practical Classes: 36				Total Classes: 36		

Prerequisite: Aerospace Structural Dynamics

I. COURSE OVERVIEW:

This course focuses on mechanical devices that are designed to have mobility to perform certain functions. In this process they are subjected to some forces. This course will provide the knowledge on how to analyze the motions of mechanisms and design mechanisms to give required strength. This includes relative static and dynamic force analysis and consideration of gyroscopic effects on aero planes, ships, automobiles like two wheelers and four wheelers. Balancing of rotating and reciprocating masses, friction effect in brakes clutches and dynamometers are also studied. Mechanical vibrations give an insight into the various disturbances while designing vibratory systems.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The basic principles of kinematics and there lated terminology of machines.
II. The Discriminate mobility; enumerate links and joints in the mechanisms.
III. The concept of analysis and formulation of different mechanisms.

III. COURSE SYLLABUS:

Week-1: GOVERNORS

To study the function of a Governor.

Week-2: GYROSCOPE

To determine the Gyroscope couple.

Week-3: STATIC FORCE ANALYSIS

To draw free body diagram and determine forces under static condition.

Week-4: DYNAMIC FORCE ANALYSIS

To draw free body diagram and determine forces under dynamic condition.

Week-5: BALANCING

To determine balancing forces and reciprocating masses.

Week-6: BEARINGS

To determine the bearing life.

Week-7: LONGITUDINAL AND LATERAL VIBRATIONS

To determine the longitudinal and transfer vibration.

Week-8: VIBRATION ANALYSIS OF SHAFT

To determine critical speed of a shaft.

Week-09: MECHANISMS

To design various mechanism and their inversions.

Week-10: DIFFERENTIAL GEAR BOX

To study automobile differential gear box.

Week-11: FREE VIBRATION OF CANTIEVER BEAM
To study Vibrations in beam Structures

Week-12: FORCED VIBRATION OF CANTIEVER BEAM
To study Vibrations in beam Structures

IV. REFERENCE BOOKS:

1. Joseph E. Shigley, "Theory of Machines and Mechanisms", Oxford University Press, 4th Edition, 2010.
2. Thomas Bevan, "Theory of Machines", Pearson, 3rd Edition, 2009.

V. WEB REFERENCES:

1. http://www.e-booksdirectory.com

PROJECT WORK - I

VII Semester: Common for all branches								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC46	**Project**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		0	0	4	2	30	70	100
Contact Classes: Nil	**Tutorial Classes: Nil**	**Practical Classes: 36**				**Total Classes: 36**		

The object of Project Work I is to enable the student to take up investigative study in the broad field of Aeronautical Engineering, either fully theoretical/practical or involving both theoretical and practical work to be assigned by the Department on an individual basis or two/three students in a group, under the guidance of a Supervisor. This is expected to provide a good initiation for the student(s) in R&D work. The assignment to normally include:

1. Survey and study of published literature on the assigned topic;
2. Working out a preliminary Approach to the Problem relating to the assigned topic;
3. Conducting preliminary Analysis / Modeling / Simulation/Experiment/Design/Feasibility;
4. Preparing a Written Report on the Study conducted for presentation to the Department;
5. Final Seminar, as oral Presentation before a departmental committee.

GROUND VEHICLE AERODYNAMICS

VIII Semester: AE								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAEC47	Elective	L	T	P	C	CIA	SEE	Total
		3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		
Prerequisite: Knowledge of Aerodynamics								

I. COURSE OVERVIEW:

Automotive aerodynamics is the study of the aerodynamics of road vehicles. Its main goals are reducing drag and wind noise, minimizing noise emission, and preventing undesired lift forces and other causes of aerodynamic instability at high speeds. Air is also considered a fluid in this case. For some classes of racing vehicles, it may also be important to produce down force to improve traction and thus cornering abilities.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The basics of vehicle aerodynamics, history of developments and apply the concepts of fluid mechanics to automobiles.
II. The estimation of drag on ground vehicles and analyze the effects of various configurations of cars on drag.
III. The stability and handling qualities based of ground vehicles due to side wind loads and dirt accumulation.
IV. The above concepts to race car design and understand various experimental techniques applied in automotive aerodynamics.

III. COURSE SYLLABUS:

MODULE-I: OVERVIEW AND INTRODUCTION (10)

Historical developments and trends, fundamentals of fluid mechanics, flow phenomenon related to vehicles, external and internal flow problem, resistance to vehicle motion, mechanics of air flow around a vehicle, pressure distribution, aerodynamic forces, vehicle drag and types, side and lift forces, performance potential of vehicle aerodynamics.

MODULE –II: AERODYNAMIC DRAG AND SHAPE OPTMIZATION OF CARS (08)

Cars as a bluff body, flow field around a car, analysis of aerodynamic drag, drag coefficient of cars, strategies for aerodynamic development, low drag profiles. Front end modification, front and rear wind shield angle, boat tailing, hatch back, fast back and square back, dust flow patterns at the rear, effect of rear configuration, effect of fasteners

MODULE –III: VEHICLE HANDLING AND STABILITY (10)

Origin, characteristics and effects of forces and moments on a vehicle, lateral stability problems.

Vehicle dynamics under side winds, dirt accumulation on the vehicle, wind noise: Mechanisms and generation design features, measurement and techniques.

MODULE –IV: RACE CAR AERODYNAMICS (09)

Basic vehicle body concepts, aerodynamics of the complete vehicle, flow over wheels, sliding seal and skirts, under body channels, simple add on: spoilers, strakes and wickers, internal flow, race car wings, most current examples in detail design.

MODULE –V: MEASUREMENT AND TEST TECHNIQUES (08)

Wind tunnel scope, fundamental techniques, simulation limitations, prototype tests, wind tunnel types and testing methods, test techniques: scope, measuring equipment and transducers, road testing methods.

IV. TEXT BOOKS:

1. Wolf- Heinrich Hucho, “Aerodynamics of Road vehicles”, SAE International 1998.
2. Joseph Katz, “Race Car Aerodynamics Designing for Speed”, Bentley Publishers, 2nd Edition, 1996.

V. REFERENCE BOOKS:

1. Alan Pope, “Wind Tunnel Testing”, John Wiley & Sons, 2nd Edition, 1974.

VI. WEB REFERENCES:

1. https://www.buildyourownracecar.com/race-car-aerodynamics-basics-and-design/
2. https://www.ara.bme.hu/oktatas/letolt/Vehicleaerodyn/Vehicleaerodyn.pdf
3. https://auto.howstuffworks.com/fuel-efficiency/fuel-economy/aerodynamics.html
4. https://www.slideshare.net/friendsrtg/vehicle-body-engineering-aerodynamics

VII. E-TEXT BOOKS:

1. https://dlx.bookzz.org/genesis/1111000/58a5c1c372f8f523a0c58e26c3c531eb/_as/[Wolf-Heinrich_Hucho_(Eds.)]_Aerodynamics_of_Road_(BookZZ.org).pdf
2. https://dlx.bookzz.org/genesis/555000/2c09a10c7a7c0f3deaeeb9ddc4251c26/_as/[Joseph_Katz]_Race_Car_Aerodynamics_Designing_for(BookZZ.org).pdf

THEORY OF AEROELASTICITY

VIII Semester: AE								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAEC48	Elective	L	T	P	C	CIA	SEE	Total
		3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		
Prerequisite: Aerospace Structures, Mathematics, Structural Dynamics, and Aerodynamics.								

I. COURSE OVERVIEW:

The major emphasis of this course is to apply the concept of solid mechanics, aerodynamics and theory of vibrations to predict the effect of aircraft vibrations. Lifting surface divergence and steady state aeroelastic problems are used to analyze the vibrations of control surfaces and wings. Applications of flutter in other fields are explored for real world problems like flutter of transmission lines.

II. COURSE OBJECTIVES:s

The student will try to learn:

I. The importance of aeroelasticity in flight vehicle design and classify static and dynamic aeroelastic problems.
II. The structural dynamic and steady and unsteady aerodynamics aspects of airframe and its components and their role in aeroelasticity.
III. The theoretical basis for the solution of static aeroelastic problems an estimate loads and other critical speeds
IV. The mathematical basis for the solution of flutter problems and estimate of flutter speeds.

III. COURSE SYLLABUS:

MODULE-I: AEROELASTIC PHENOMENA (10)

Stability versus response problems; The aeroelastic triangle of forces; Aero elasticity in aircraft design; Prevention of aero elastic instabilities; Influence and stiffness coefficients; Coupled oscillations.

MODULE –II: DIVERGENCE OF A LIFTING SURFACE (08)

Simple two dimensional idealizations; Strip theory, integral equation of the second kind exact solutions for simple rectangular wings, _Semi rigid 'assumption and approximate solutions; Generalized coordinates, successive approximations, numerical approximations using matrix equations.

MODULE –III: STEADY STATE AEROLASTIC PROBLEMS (10)

Loss and reversal of aileron control, critical aileron reversal speed, aileron efficiency, semi rigid theory and successive approximations.

Lift distribution, rigid and elastic wings; Tail efficiency, effect of elastic deformation on static longitudinal stability

MODULE –IV: FLUTTER PHENOMENON (09)

Non-dimensional parameters, stiffness criteria, dynamic mass balancing, dimensional similarity; Flutter analysis, two dimensional thin airfoils in steady incompressible flow, quasi steady aerodynamic derivatives; Galerkin method for critical flutter speed, stability of disturbed motion, solution of the flutter determinant, methods of determining the critical flutter speeds, flutter prevention and control.

MODULE –V: EXAMPLES OF AEROELASTIC PROBLEMS (08)

Galloping of transmission lines and Flow induced vibrations of transmission lines, tall slender structures and suspension bridges.

IV. TEXT BOOKS:

1. Y.C. Fung, "An Introduction to the Theory of Aeroelasticity", John Wiley & Sons, New York, 2008.
2. E.G. Broadbent, "Elementary Theory of Aeroelasticity", Bun Hill Publications Ltd, 1986.

V. REFERENCE BOOKS:

1. R.L. Bisplinghoff, H.Ashley, and R.L. Halfmann, "Aeroelasticity", Addison Wesley Publishing, 2nd Edition, 1996.
2. R.H. Scanlan and R. Rosenbaum, "Introduction to the study of Aircraft Vibration and Flutter", Macmillan, New York, 1981.

FLIGHT SCHEDULING AND OPERATIONS

VIII Semester: AE								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAEC49	Elective	L	T	P	C	CIA	SEE	Total
		3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil			Total Classes: 45			
Prerequisite: Air transportation system								

I. COURSE OVERVIEW:

This course is designed to Explores a variety of models and optimization techniques for the solution of airline Schedule planning and operations problems. Schedule design, fleet assignment, aircraft maintenance routing, crew, Scheduling, passenger mix, and other topics are covered. Recent models and algorithms addressing issues of model. Integration, robustness, and operations recovery are introduced. Modeling and solution techniques designed specifically for large-scale problems, and state-of-the-art applications of these techniques to airline problems are detailed. After completion of the course the student gains adequate knowledge to compare different sources of energy for selection and applying economically.

II. COURSE OBJECTIVES:

The Students will try to learn:

I. The fundamental concepts of various airline network flows and blend the best suitable requirements for various applications.
II. The mathematical formulation-decision variables, objective function, constraints and methods of solution for airline scheduling.
III. The characteristics of stability and performance of an aircraft significance of flight scheduling
IV. The Concept of aircraft boarding strategy and common strategies for aircraft boarding.

III. COURSE SYLLABUS:

MODULE-I: NETWORK FLOWS AND INTEGER PROGRAMMING MODELS (9)

Complexity of airline planning, operations and dispatch- need for optimization- role of operations research and simulation. Networks- definitions, network flow models- shortest path problem, minimum cost flow problem, maximum flow problem, multi-commodity problem. Integer programming models- set covering/ partitioning problems, traveling salesman problem- mathematical formulation- decision variables, objective function, constraints, and methods of solution, Solution by simulation.

MODULE –II: AIRCRAFT ROUTING AND MANAGEMENT OF IRREGULAR OPERATIONS (9)

Goal of aircraft routing- maintenance requirements, other constraints. Routing cycles, route generators. Mathematical models of routing- decision variables, objective functions, alternatives, constraints- flight coverage and aircraft available. Example problems and solutions. The problem statement, the time band approximation model-formulation of the problem-the scenarios- solution.

MODULE –III: FLIGHT SCHEDULING (9)

Significance of flight scheduling. The route system of the airlines- point-to-point flights, hub and spoke flights. Schedule construction-operational feasibility, economic viability. Route development and flight scheduling process- load factor and frequency- case study.

MODULE –IV: FLEET ASSIGNMENT AND CREW AND MANPOWER SCHEDULING (9)

Purpose of fleet assignment. Fleet types, fleet diversity, fleet availability-performance measures, formulation of the fleet assignment problem- decision variables, objective function, constraints, solution. Scenario analysis, fleet Assignment models. Crew scheduling process-significance. Development of crew pairing- pairing generators- mathematical formulation of crew pairing problem- methods of solution. Crew rostering- rostering practices. Solutions. Man power scheduling- modeling, formulation of the problem, solutions.

MODULE –V: GATE ASSIGNMENT AND AIRCRAFT BOARDING STRATEGY (9)

Gate assignment-significance- the problem-levels of handling-passenger flow, distance matrix- mathematical formulation, solution. Common strategies for aircraft boarding process, mathematical model, interferences, model description, aisle interferences.

IV. TEXT BOOKS:

1. Bazargan M, "Airline Operations and Scheduling", 2nd Edition, Ash gate Publishing Ltd, 2010.

V. REFERENCE BOOKS:

1. Belobaba Podoni, A., Barnhart, C. "The Global Airline Industry", Wiley, 2009.
2. Wu, Cheng-Lung, "Airline Operations and Delay Management", Ashgate Publishing Ltd, 2010.
3. Wensveen, J.G. "Air Transportation: A Management Perspective", Ashgate Publishing Ltd, 6th Edition, 2007.
4. Ahuja, R. et al, "Network Flows-Theory, Algorithms and Applications", Prentice-Hall, 1993.
5. Yu. G, "Operations Research in Airlines Industry", Academic Publishers, 1998.

AVIONICS AND INSTRUMENTATION

VIII Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC50	**Elective**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	-	-	3	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		
Prerequisite: **Aircraft systems and control**								

I. COURSE OVERVIEW:

Avionics deals with electronic systems which are used on aircraft, satellites and spacecraft's. This course covers the major phases of avionics from navigation, guidance, and communication to sophisticated system using state of art sensors and radars used in aerospace systems. Various electronic instrument systems, numbering systems, data buses, data conversion and logic gates are also covered. The course provides an understanding of the sensors, display system and communication system for various aerospace applications. This course introduces the electronic flight instrument systems available with advanced avionics. The course includes different adaptations involved in a military aircraft.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The working principle and classification of sensors, radars, radio communication and navigation systems with respect to their application.
II. Concept of microelectronic devices along with their evolution and applications, with the emphasis on digital data buses.
III. Different adaptations, avionics systems, and its application in military aircraft when compared to civilian aircraft.

III. COURSE SYLLABUS:

MODULE-I: AVIONICS TECHNOLOGY (10)

Evolution of electronics; The nature of microelectronic devices, processors, memory devices; Introduction to avionics, systems integration, need - data bus systems, MIL STD 1553 bus system, ARINC 429/ARINC 629 bus systems, optical data bus systems; Integrated modular avionics architectures , commercial off the shelf systems; Avionics packaging.

MODULE-II: AIRCRAFT INSTRUMENTATION - SENSORS AND DISPLAYS (10)

Air data sensors, magnetic sensing, inertial sensing, and radar sensors. The electromechanical instrumented flight deck, early flight deck instruments, attitude direction indicator, horizontal situation indicator, altimeter, airspeed indicator; Advanced flight deck display system architectures, display systems, display media, future flight deck displays.

MODULE-III: COMMUNICATION AND NAVIGATION AIDS (10)

Radio frequency spectrum, communication systems, HF, VHF, satellite communications; ATC transponder, traffic collision avoidance system; Navigational aids; Automatic direction finding, VHF Omni range, distance measuring equipment; TACAN, VORTAC; Satellite navigation systems, the GPS.

Basic navigation, radio, inertial navigations, satellite navigation; GPS, differential GPS, wide area augmentation systems, local area augmentation system, and GPS overlay program; Integrated navigation, sensor usage; Flight management system (FMS); FMS control and display MODULE; Lateral navigation.

MODULE-IV: MILITARY AIRCRAFT ADAPTATION (10)

Avionic and mission system interface, navigation and flight management; Navigation aids, flight deck displays, communications, aircraft systems; Applications, personnel, material and vehicle transport, air-to-air refueling, maritime patrol, airborne early warning, ground surveillance; Electronic warfare, the EW spectrum, electronic support measures, electronic countermeasures, electro-optics and the infra-red.

MODULE-V: AIRBORNE RADAR, ASTRIONICS - AVIONICS FOR SPACECRAFT (10)

Propagation of Radar waves, functional elements of radar, antenna- transmitter; Types of radar- pulse Doppler, civil aviation applications, military applications; Attitude determination and control of spacecraft, magnetometers, sun sensors, star trackers, earth and horizon sensors; Command and telemetry.

IV. TEXT BOOKS:

1. Moir, I. and Seabridge, A, "Civil Avionics Systems", AIAA Education Series, AIAA, 2002.
2. Collinson, R.P.G, "Introduction to Avionics Systems", 2nd Edition, Springer, 2003.

V. REFERENCE BOOKS:

1. Helfrick, A, "Principles of Avionics", Avionics Communications, Leesburg, 3rd Edition, 2000.
2. Henderson, M. F, "Aircraft Instruments & Avionics for A &P Technicians", Jeppesen Sanderson Training Products, 1993.

NON DESTRUCTIVE TESTING

VIII Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC51	**Elective**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	-	-	3	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		
Prerequisite: **Knowledge of Materials and Processes**								

I. COURSE OVERVIEW:

Nondestructive testing (NDT) is the process of inspecting, testing, or evaluating materials, components or Assemblies for Discontinuities or differences in characteristics without destroying the serviceability of the part or system. This includes understanding the basic principles of various NDT methods, fundamentals, discontinuities in different product form, Importance of NDT, applications, limitations of NDT methods and techniques. Nondestructive tests are used in manufacturing, fabrication and in-service inspections to ensure product integrity and Reliability, to control manufacturing Processes, lower production costs and to maintain a uniform quality level.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The basic principles of various non-destructive testing methods, fundamentals, discontinuities in different product forms.
II. The various defect types and select the appropriate nondestructive testing methods for better evaluation of the specimen.
III. The Implementation and documention to written procedure paving the way for further training in specific techniques of non-destructive inspection of the experimental subject.
IV. The principles and operational techniques of the radiographic testing followed by its interpretation and evaluation.

III. COURSE SYLLABUS:

MODULE-I: OVERVIEW OF NON DESTRUCTIVE TESTING (09)

NDT versus mechanical testing, overview of the non-destructive testing methods for the detection of manufacturing defects as well as material characterization; Relative merits and limitations, various physical characteristics of materials and their applications in NDT, visual inspection, v unaided and aided.

MODULE –II: SURFACE NON DESTRUCTIVE EXAMINATION METHODS (09)

Liquid Penetrant Testing: Principles, types and properties of liquid penetrants, developers, advantages and limitations of various methods, Testing Procedure, Interpretation of results; Magnetic particle testing; Theory of magnetism, inspection materials magnetisation methods, interpretation and evaluation of test indications, principles and methods of demagnetization, residual magnetism.

MODULE –III: THERMOGRAPHY AND EDDY CURRENT TESTING (ET) (09)

Thermography: Principles, contact and non contact inspection methods, techniques for applying liquid crystals.
Advantages and limitation, infrared radiation and infrared detectors, instrumentations and methods, applications; Eddy Current Testing; Generation of eddy currents, properties of eddy currents, Eddy current sensing elements, probes, instrumentation, types of arrangement, applications, advantages, limitations, interpretation/evaluation.

MODULE –IV: ULTRASONIC TESTING (UT) AND ACOUSTIC EMISSION (AE) (09)

Ultrasonic Testing: Principle, transducers, transmission and pulse-echo method, straight beam and angle beam, instrumentation, data representation, A-scan, B-scan, C-scan; Phased array ultrasound, time of flight diffraction; Acoustic emission technique, V principle, AE parameters, applications.

MODULE –V: EXPERIMENTAL METHODS AND INDUSTRIAL APPLICATIONS (09)

Principle, interaction of X-Ray with matter, imaging, film and film less techniques. Fluoroscopy; Xerox; Radiography, computed radiography, computed tomography. Span of NDE Activities: Railways, Nuclear, Non-nuclear and Chemical Industries, Aircraft and Aerospace Industries, Automotive Industries, Offshore Gas and Petroleum Projects, Coal Mining Industry, NDE of pressure vessels, castings, welded constructions

IV. TEXT BOOKS:

1. Baldev Raj, T. Jayakumar, M. Thavasimuthu "Practical Non-Destructive Testing", Narosa Publishing House, 2009.
2. Ravi Prakash, "Non-Destructive Testing Techniques", New Age International Publishers, 1st revised Edition, 2010.

V. REFERENCE BOOKS:

1. Paul E Mix, "Introduction to Non-destructive testing: a training guide", Wiley, New Jersey, 2nd Edition, 2005.
2. Charles, J. Hellier, "Handbook of Non-destructive evaluation", McGraw Hill, New York 2001.

VI. WEB REFERENCES:

1. https://nptel.ac.in/syllabus/syllabus_pdf/113106070.pdf
2. https://nptel.ac.in/courses/113106070/24

VII. E-TEXT BOOKS:

1. https://www.springer.com/la/book/9780412625008
2. https://eprints.nmlindia.org/1850/1/177-193.PDF
3. https://www.tower.com/non-destructive-test-evaluation-materials-prof-j-prasadpaperback/wapi/124712958

AUTOMATIC CONTROL OF AIRCRAFT

VIII Semester: AE							
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAEC52	Elective	L	T	P	C	CIA	SEE	Total
		3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		

Prerequisite: Knowledge of Mathematics/ Aircraft stability and control

I. COURSE OVERVIEW:

The system that is used to control the flight is called the flight control system (FCS). In the early days of flying, the FCS was mechanical. By means of cables and pulleys, the control surfaces of the aircraft were given the necessary deflections to control the aircraft. However, new technologies brought with it the fly-by-wire FCS. In this system electrical signals are sent to the control surfaces. The signals are sent by the flight (control) computer (FC/FCC)

II. COURSE OBJECTIVES:

The student will try to learn:

I. The guidance and control of aircraft and explain different augmentation system and concepts.
II. The different auto pilot systems, flight path stabilization and automatic flare control.
III. The fly by wire flight control systems and different flight control law design using back stepping algorithm.
IV. The operating principles and design of guidance laws, launch vehicle and mission requirements.

III. COURSE SYLLABUS:

MODULE-I: INTRODUCTION (05)

Introduction to Guidance and control: Definition, historical background.

MODULE –II: AUGMENTATION SYSTEMS (07)

Need for automatic flight control systems, stability augmentation systems, control augmentation systems, gain scheduling concepts.

MODULE –III: LONGITUDINAL AUTOPILOT (10)

Displacement Autopilot: Pitch orientation control system, acceleration control system, glide slope coupler and automatic flare control.

Flight path stabilization, longitudinal control law design using back stepping algorithm.

MODULE –IV: LATERAL AUTOPILOT (11)

Damping of the Dutch roll, methods of obtaining coordination, yaw orientation control system, turn compensation, automatic lateral beam guidance.

MODULE –V: FLY BY WIRE FLIGHT CONTROL (12)

Introduction to Fly-by-wire flight control systems, fly-by-wire flight control features and advantages, control laws, redundancy and failure survival, digital implementation, fly-by-light flight control.

IV. TEXT BOOKS:

1. Blake Lock, J.H, “Automatic control of Aircraft and missiles”, John Wiley Sons, New York, 1990.
2. Stevens B.L & Lewis F.L, “Aircraft control & simulation”, John Wiley Sons, New York, 1992.
3. Collinson R.P.G, “Introduction to Avionics”, Chapman and Hall, 1st Edition India, 1996.

V. REFERENCE BOOKS:

1. Garnel. P. & East. D.J, “Guided Weapon control systems”, Pergamon Press, Oxford, 1st Edition 1977.
2. Bernad Etikin, “Dynamic of flight stability and control”, John Wiley, 1st Edition 1972.
3. Nelson R.C, “Flight stability & Automatic Control”, McGraw Hill, 1st Edition 1989.

VI. WEB REFERENCES:

1. https://ocw.mit.edu/courses/aeronautics-and-astronautics/16...aircraft.../lecture-16
2. www.fsd.mw.tum.de/research/flight-control/
3. nptel.ac.in/courses/101108056/

VII. E-TEXT BOOKS:

1. https://books.google.co.in/books?isbn=1118870972
2. https://books.google.co.in/books?isbn=0387007261

GAS TURBINES AND JET PROPULSION TECHNOLOGY

VIII Semester: AE								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AAEC53	**Elective**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	-	-	3	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		
Prerequisite: Thermodynamics and Aerospace Propulsion								

I. COURSE OVERVIEW:

The course will deal about the fundamentals of gas turbines, classifications, thermodynamic analysis, gas turbine parts, and performance of the components of the gas turbine. It also incorporates efficiency and specific impulse for gas turbine. The course deals with testing engines for different parameters for optimized performance and safety.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The Fundamentals of gas turbine and jet propulsion using laws of thermodynamics.
II. The Parametric cyclic analysis, performance parameters, efficiency and specific impulse for gas turbine components.
III. The types of testing of engines and engine performance trends of aircraft for improved engine performance.

III. COURSE SYLLABUS:

MODULE-I: GAS TURBINE (9)

Introduction to Gas Turbines, Development, Classification and Application of Gas Turbines, Ideal and Actual Cycles; Effect of Inter cooling, Reheating, Regeneration, Combined cycle, and Cogeneration. Criteria of performance, Simple Turbojet Cycle, The turboprop engine, Types of engines showing arrangement of parts. Operating parameters. Energy distribution of turbojet, turboprop and turbofan engines.

MODULE –II: ENGINE PARTS-I (9)

Compressor assembly, Compressor MAP. Surge margin, Inlet distortions. Testing and Performance Evaluation.
Combustor: Combustor MAP, Pressure loss, combustion light up test. Testing and Performance Evaluation. Performance requirements of combustion chambers. Comparison of thrust and specific fuel consumption. Types of burners: advantages and disadvantages. Influence of design factors on burner performance. Effect of operating variables on burner performance.

MODULE –III: ENGINE PARTS-II (9)

Thrust, pressure and velocity diagrams. Gas Turbine Emissions. Impulse turbine and reaction turbine. Exhaust system, sound suppression. Thrust reversal: types, design & systems. Methods of thrust augmentation, after burner system. Turbines: Turbine MAP. Turbine Testing and Performance Evaluation.

Construction of nozzles. Inlet duct &nozzles: Ram pressure recovery of inlet duct. Propelling nozzles, after burner, maximum mass flow conditions. Testing and Performance Evaluation. Intake, and propelling nozzle efficiencies

MODULE –IV: ENGINE TESTING (9)

Proof of Concepts: Design Evaluation tests. Structural Integrity. Environmental Ingestion Capability. Preliminary Flight Rating Test, Qualification Test, Acceptance Test. Reliability figure of merit. Durability and Life Assessment Tests, Reliability Tests. Engine testing with simulated inlet distortions and, surge test. Estimating engine-operating limits. Methods of displacing equilibrium lines.

MODULE –V:TYPES OF ENGINE TESTING'S (9)

Normally Aspirated Testing, Open Air Test Bed, Ram Air Testing, Altitude Testing, Altitude test facility, Flying Test Bed, Ground Testing of Engine Installed in Aircraft, Flight testing. Jet thrust measurements in flight. Measurements and Instrumentation. Data Acquisition system, Measurement of Shaft speed, Torque, Thrust, Pressure, Temperature, Vibration, Stress, Temperature of turbine blading etc. Engine performance trends: Mass and CUSUM plots. Accuracy and Uncertainty in Measurements. Uncertainty analysis. Performance Reduction Methodology.

IV. TEXT BOOKS:

1. V. Ganesan, "I.C. Engines Gas Turbines", McGraw Hill,
2. Irwin E. Treager, "Gas Turbine Engine Technology", McGraw Hill Education, 3rd Edition, 2013.

V. REFERENCE BOOKS:

1. Saravanamuttoo, Cohen, Rogers, "Gas Turbine Theory", Pearson publications.
2. P. P Walshand P. Peletcher, "Gas Turbine Performance" Blackwell Science, 1998.

VI. WEB REFERENCES:

1. https://www.grc.nasa.gov/www/k-12/airplane/turbine.html
2. https://onlinecourses.nptel.ac.in/noc20_me42
3. https://nptel.ac.in/courses/101/101/101101002/

VII. E-TEXT BOOKS:

1. https://arc.aiaa.org/doi/book/10.2514/4.105173

ENGINEERING OPTIMIZATION TECHNIQUES

VIII Semester: AE

Course Code	Category	Hours / Week			Credits	Maximum Marks		
AAEC54	Elective	L	T	P	C	CIA	SEE	Total
		3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		

Prerequisite: Mathematics, Numerical Methods

I. COURSE OVERVIEW:

The major emphasis of this course is to apply the concept of mathematical principles to obtain the required performance of systems. Various techniques in optimizations which include simplex methods and classical methods are discussed. Constrained and Un constrained techniques which are the part of engineering problems are addressed.

II. COURSE OBJECTIVES:

The student will try to learn:

I. The concepts of optimization and various methods for obtaining best performance of systems.
II. The concept of classical methods and its applications for better design.
III. The methods involved in nonlinear programming and simplex methods for efficient programming.
IV. The concepts linear and nonlinear programming for obtaining better solutions under constraints and unconstraint conditions.

III. COURSE SYLLABUS:

MODULE-I: INTRODUCTION TO OPTIMIZATION (10)

Introduction, Historical Development , Engineering Applications of Optimization, Statement of an Optimization Problem, Design Vector, Design Constraints, Constraint Surface, Objective Function, Objective Function Surfaces, Classification of Optimization Problems, Classification Based on the Existence of Constraints, Classification Based on the Nature of the Design Variables, Classification Based on the Physical Structure of the Problem, Classification Based on the Nature of the Equations Involved, Classification Based on the Permissible Values of the Design Variables, Classification Based on the Deterministic Nature of the Variables, Classification Based on the Separability of the Functions, Classification Based on the Number of Objective Functions, Optimization Techniques

MODULE –II: CLASSICAL OPTIMIZATION TECHNIQUES (08)

Introduction, Single-Variable Optimization, Multivariable Optimization with No Constraints, Semi definite Case, Saddle Point, Multivariable Optimization with Equality Constraints, Solution by Direct Substitution, Solution by the Method of Constrained Variation, Solution by the Method of Lagrange Multipliers, Multivariable Optimization with Inequality Constraints, Kuhn–Tucker Conditions, Constraint Qualification, Convex Programming Problem

MODULE –III: LINEAR PROGRAMMING : SIMPLEX METHOD (10)

Introduction, Applications of Linear Programming, Standard Form of a Linear Programming Problem, Geometry of Linear Programming Problems.

Pivotal Reduction of a General System of Equations, Motivation of the Simplex Method, Simplex Algorithm, Identifying an Optimal Point, Improving a non optimal Basic Feasible Solution, Two Phases of the Simplex Method

MODULE –IV: NONLINEAR PROGRAMMING:ONE-DIMENSIONAL MINIMIZATION METHODS (09)

Introduction, Unimodal Function, ELIMINATION METHODS, Unrestricted Search, Search with Fixed Step Size, Search with Accelerated Step Size, Exhaustive Search, Dichotomous Search, Interval Halving Method, Fibonacci Method, Golden Section Method, Comparison of Elimination Methods

MODULE –V: NONLINEAR PROGRAMMING II: UNCONSTRAINED OPTIMIZATION TECHNIQUES (08)

Introduction, Classification of Unconstrained Minimization Methods, General Approach, Rate of Convergence, Scaling of Design Variables, DIRECT SEARCH METHODS -Random Search Methods, Random Jumping Method, Random Walk Method, Random Walk Method with Direction Exploitation, Advantages of Random Search Methods, Grid Search Method, Univariate Method, Pattern Directions, Powell's Method, Conjugate Directions, Algorithm, Simplex Method, Reflection, Expansion, Contraction, INDIRECT SEARCH (DESCENT) METHODS, Gradient of a Function, Evaluation of the Gradient, Rate of Change of a Function along a Direction, Steepest Descent (Cauchy) Method, Conjugate Gradient

(Fletcher–Reeves) Method, Development of the Fletcher–Reeves Method, Fletcher–Reeves Method, Newton's Method, Marquardt Method, Quasi-Newton Methods, Rank 1 Updates, Rank 2 Updates, Davidon–Fletcher–Powell Method, Broyden–Fletcher–Goldfarb–Shanno Method

IV. TEXT BOOKS:

1. Singiresu S. Rao, "Engineering Optimization Theory and Practice", John Wiley Sons, 4th Edition, 2009.
2. Kalyanmoy Deb, "Optimization for Engineering Design" PHI Learning private limited, 2nd Edition, 2012

V. REFERENCE BOOKS:

1. Kaushik Kumar, Supriyo Roy, J. Paulo Davim "Soft Computing Techniques for Engineering Optimization", CRC Press, 1st Edition, 2021.
2. Xin-She Yang "Optimization Techniques and Applications with Examples" John Wiley & Sons, 2018

SOFT SKILLS AND INTERPERSONAL COMMUNICATION

OE – I: VI Semester: CSE / CSE (AI & ML) / CSE (DS) / CSE (CS) / CSIT / IT
OE –II: VII Semester: ECE / EEE
OE – III: VIII Semester: AERO / MECH / CIVIL

Course Code	Category	Hours / Week			Credits	Maximum Marks		
		L	T	P	C	CIA	SEE	Total
AHSC15	Elective	3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		

I. COURSE OVERVIEW:

The objectives of the Soft Skills and Interpersonal Communication are to give each student a realistic perspective of work and work expectations, to help formulate problem solving skills, to guide students in making appropriate and responsible decisions, to create a desire to fulfill individual goals, and to educate students about unproductive thinking, self-defeating emotional impulses, and self- defeating behaviors.

II. COURSE OBJECTIVES:

The students will try to learn:

I. How to communicate in a comprehensible English accent and pronunciation.
II. The four language skills i.e., Listening, Speaking, Reading and Writing effectively.
III. The art of interpersonal communication skills to avail the global opportunities.
IV. The understanding of soft skills resulting in an overall grooming of the skills.

III. SYLLABUS

MODULE-I: SOFT SKILLS (09)

Soft Skills: An Introduction – Definition and Significance of Soft Skills; Process, Importance and Application of Soft Skills, Discovering the Self; Setting Goals; Positivity and Motivation: Developing Positive Thinking and Attitude.

MODULE –II: EFFECTIVENESS OF SOFT SKILLS (09)

Developing interpersonal relationships through effective soft skills; Define Listening, Speaking, Reading and Writng skills; Barriers to Listening, Speaking, Reading and Writing; Essential formal writing skills; Public Speaking: Skills, Methods, Strategies and Essential tips for effective public speaking.

MODULE-III: ORAL AND AURAL SKILLS (09)

Vocabulary:
Sounds of English vowels sounds and constant sounds, Word Accent and connected speech- contractions, questions tags, Listening for information, Taking notes while listening to lectures (use of Dictionary).

Group Discussion: Importance, Planning, Elements, Skills, Effectively disagreeing, Initiating.

MODULE-IV: VERBAL AND NON-VERBAL COMMUNICATION (09)

Interpersonal communication-verbal and nonverbal etiquette; Body language, grapevine, Postures, Gestures, Facial expressions, Proximity; Conversation skills, Critical thinking, Teamwork, Group Discussion, Impact of Stress; Measurement and Management of Stress.

MODULE-V: INTERPERSONAL COMMUNICATION (09)

Significance; Effectiveness of writing; Organizing principles of Paragraphs in documents; Writing introduction and conclusion; Techniques for writing precisely; Letter writing; Formal and Informal letter writing; E-mail writing, Report Writing.

IV. TEXT BOOKS:

Handbook of English for Communication (Prepared by Faculty of English, IARE)

V. REFERENCE BOOKS:

1. Dorch, Patricia. What Are Soft Skills? New York: Execu Dress Publisher, 2013.
2. Kamin, Maxine. Soft Skills Revolution: A Guide for Connecting with Compassion for Trainers, Teams, and Leaders.

Washington, DC: Pfeiffer & Company, 2013.
3. Klaus, Peggy, Jane Rohman & Molly Hamaker. “The Hard Truth about Soft Skills”, London: HarperCollins E-books, 2007.
4. Stein, Steven J. & Howard E. Book. “The EQ Edge: Emotional Intelligence and Your Success” Canada: Wiley & Sons, 2006
5. Suresh Kumar. English for Success. Cambridge University Press IndiaPvt.Ltd.2010.
6. Dorling Kindersley. Communication Skills & Soft Skills - An Integrated Approach. India Pvt. Ltd. 2013.

VI. WEB REFERENCES:

1. www.edufind.com
2. www.myenglishpages.com
3. http://grammar.ccc.comment.edu
4. http://owl.english.prudue.edu

VII. E-Text Books:

1. http://bookboon.com/en/communication-ebooks-zip
2. http://www.bloomsbury-international.com/images/ezone/ebook/writing-skills-pdf.pdf
3. https://americanenglish.state.gov/files/ae/resource_files/developing_writing.pdf
4. http://learningenglishvocabularygrammar.com/files/idiomsandphraseswithmeaningsandexamplespdf.pdf
5. http://www.robinwood.com/Democracy/General Essays/CriticalThinking.pdf

CYBER LAW AND ETHICS

<table>
<tr><td colspan="10">OE – I: VI Semester: CSE / CSE (AI & ML) / CSE (DS) / CSE (CS) / CSIT / IT
OE –II: VII Semester: ECE / EEE
OE –III: VIII Semester: AERO / MECH / CIVIL</td></tr>
<tr><th rowspan="1">Course Code</th><th>Category</th><th colspan="3">Hours / Week</th><th>Credits</th><th colspan="3">Maximum Marks</th></tr>
<tr><td rowspan="2">AHSC16</td><td rowspan="2">Elective</td><td>L</td><td>T</td><td>P</td><td>C</td><td>CIA</td><td>SEE</td><td>Total</td></tr>
<tr><td>3</td><td>-</td><td>-</td><td>3</td><td>30</td><td>70</td><td>100</td></tr>
<tr><td>Contact Classes: 45</td><td>Tutorial Classes: Nil</td><td colspan="4">Practical Classes: Nil</td><td colspan="3">Total Classes: 45</td></tr>
</table>

I. COUSRE OVERVIEW

This course consists of a sustained study of ethical and legal issues that arise in relation to employment in the public and private sectors, including allocation of resources, corporate and social responsibility, relationships, and discrimination. The main focus of this course will be on the ethical and legal standards governing information technology. New technology creates ethical challenges for individuals around the globe, and applies to most persons regardless of whether they are employed in the information technology field or a more traditional occupation. The study of this course provides a framework for making ethical decisions that professionals are likely to encounter in the workplace. This course will not only focus on ethics but on the legal, economic, social, cultural and global impacts of decisions that are made in the context of professional occupations.

II. COUSRE OBJECTIVES:

The students will try to learn:

I. The key terms and concepts in cyber society, cyber ethics.
II. The fundamentals of Cyber Law
III. The importance of nine P's in ethics.
IV. The artificial intelligence and Blockchain ethics.

III. SYLLABUS

MODULE-I: CYBER SOCIETY (09)

Definitions, Specificities of the Cyberspace, Dimensions of Cyber Ethics in Cyber Society, Fourth Industrial Revolution, Users' Motivations in Cyber-Space, Core Values and Virtues, Old Values or Eschatological Vision?, Cyber Ethics by Norms, Laws and Relations Artificial Intelligence Ethics: "AI for Good", Cyber-Capitalism: Cyber-Ethics as Business Ethics.

MODULE-II: CYBER LAW AND CYBER ETHICS (09)

Cyber Law and Cyber Ethics

The importance of cyber law, the significance of cyber ethics, cyber crime is unethical and illegal, ethics education has positive impact, the need for cyber regulation based on cyber ethics, very dangerous times.

MODULE-III: ETHICS IN THE INFORMATION SOCIETY, THE NINE P'S (09)

Principles: ethical values, participation: access to knowledge for all, people: community, identity, gender, generation, education, profession: ethics of information professions, privacy: dignity, data mining, security.

Piracy: intellectual property, cybercrime, protection: children and young people, power: Economic power of technology, media and consumers, policy: ethics of regulation and freedom.

MODULE-IV: DISRUPTIVE CYBER TECHNOLOGIES AND AI ETHICS (09)

Disruptive Cyber Technologies and Ethics -I

Artificial: negative moral judgment?, artificial: ethically positive innovation?, intelligence: action-oriented ability, creation story: human beings responsibility, the commandment to love and artificial intelligence;

Artificial Intelligence Ethics: Top nine ethical issues in artificial intelligence, five core principles to keep AI ethical, ethics should inform AI, but which ethics?

MODULE-V: DISRUPTIVE CYBER TECHNOLOGIES AND ETHICS –II (09)
Disruptive Cyber Technologies and Ethics -II
BLOCKCHAIN ETHICS:
Blockchain definition and description, Blockchain anonymity and privacy: ethical, no possibility to be forgotten, Blockchain for voting, Blockchain for transparent trade tracing, Blockchain energy: environmental impact, decentralized or majority-owned, ethically more benefits or dangers, future jobs in cyber society.

IV. TEXT BOOKS:

1. Christoph Stuckelberger, Pavan Duggal, "Cyber Ethics 4.0 Serving Humanity with Values", Globethics.net Global Series, 2018.

V. REFERENCE BOOKS:

1. Dr. Farooq Ahmad, Cyber Law in India, Allahbad Law Agency- Faridabad.
2. J.P. Sharma, SunainaKanojia, Cyber Laws
3. Harish Chander , Cyber Laws and IT Protection.

VI. E-REFERENCE:

https://www.globethics.net/documents/4289936/13403236/Ge_Global_17_web_isbn9782889312641.pdf/

ECONOMIC POLICIES IN INDIA

OE – I: VI Semester: CSE / CSE (AI & ML) / CSE (DS) / CSE (CS) / CSIT / IT OE –II: VII Semester: ECE / EEE OE –III: VIII Semester: AERO / MECH / CIVIL								
Course Code	**Category**	**Hours / Week**			**Credits**	**Maximum Marks**		
AHSC17	**Elective**	**L**	**T**	**P**	**C**	**CIA**	**SEE**	**Total**
		3	-	-	3	30	70	100
Contact Classes: 45	**Tutorial Classes: Nil**	**Practical Classes: Nil**				**Total Classes: 45**		

I. COURSE OVERVIEW

The objective of this course is to provide a broad sweep of the concept, structure and trends in the Indian economy in a roughly chronological manner. It begins with a review of the evolution of the Indian economy during colonial rule and introduces the roots of Indian underdevelopment. This course is designed to acquaint the students in a comprehensive manner with different aspects of Indian economy. The policy issues and measure to understand economic initiatives for improving economic development and growth, agriculture and industry, planning of the different sectors of the economy and the place of Indian economy in the international level particularly after economic reforms and covered.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The economic development elements and its measures
II. The inside knowledge on monetary policy and its importance in economic development
III. The importance of fiscal policies in promoting the economy
IV. The policies and practices in resource base infrastructure
V. The industrial and exit policies related to the industries

III. SYLLABUS

MODULE-I: INTRODUCTION ECONOMIC DEVELOPMENT AND ITS DETERMINANTS (09)

Approaches to economic development and its measurement – sustainable development; Role of State, market and other institutions; Indicators of development – PQLI, Human Development Index (HDI), gender development indices.

MODULE-II: MONEY, BANKING AND PRICES (09)

Analysis of price behavior in India; Financial sector reforms; Interest rate policy; Review of monetary policy of RBI; Money and capital markets; Working of SEBI in India.

MODULE-III: FISCAL POLICY AND PUBLIC FINANCES (09)

Fiscal federalism – Centre-State financial relations; Finances of central government; Finances of state governments; Parallel economy; Problems relating to fiscal policy; Fiscal sector reforms in India.

MODULE-IV: RESOURCE BASE AND INFRASTRUCTURE (09)

Energy; social infrastructure – education and health; Environment; Regional imbalance; Issues and policies in financing infrastructure development. Policies and Performance in Industry Growth; productivity; diversification; small scale industries; public sector; competition policy; foreign investment.

MODULE-V: THE INDUSTRIAL AND EXIT POLICIES (09)

Industrial policy; Public Sector enterprises and their performance; Problem of sick units in India; Privatization and disinvestment debate; Growth and pattern of industrialization; Small-scale sector; Productivity in industrial sector; Exit policy – issues in labour market reforms; approaches for employment generation.

IV. TEXT BOOKS:

1. The Wealth of Nations-Adam Smith, introduction by Alan B Krueger.
2. The Strength of Economic Development by Albert Hirschman.
3. Money, Banking and Public Finance by Dr. V.C.Sinha
4. Government of India, Economic Survey (Annual), Ministry of Finance, New Delhi.
5. Jain, a. K. (1986), Economic Planning in India, Ashish Publishing House, New Delhi.

V. REFERENCE BOOKS:

1. Ahluwalia, I. J. and I. M. D Little (Eds.) (1999), India's Economic Reforms and Development (Essays in honour of Manmohan Singh), Oxford University Press, New Delhi.
2. Bardhan, P. K. (9th Edition) (1999), The Political Economy of Development in India, Oxford University Press, New Delhi.
3. Bawa, R. s. and P. S. Raikhy (Ed.) (1997), Structural Changes in Indian Economy, Guru Nanak Dev University Press, Amritsar.
4. Brahmananda, P. R. and V. R. Panchmukhi (Eds.) (2001), Development Experience in the Indian Economy: Inter-State Perspectives, Book well, Delhi.
5. Chakravarty, S. (1987), Development Planning: The Indian Experience, Oxford University Press, New Delhi.
6. Dantwala, M. L. (1996), Dilemmas of Growth: The Indian Experience, Sage Publications, New Delhi.
7. Datt, R. (Ed.) (2001), Second Generation Economic Reforms in India, Deep & Deep Publications, New Delhi.

VI. WEB REFERENCE:

1. Parikh, K. S. (1999), India Development Report – 1999-2000, Oxford University Press, New Delhi8.
2. Reserve Bank of India, Report on Currency and Finance, (Annual).
3. Sandesara, J. c. (1992), Industrial Policy and Planning, 1947-19919 : Tendencies, Interpretations and Issues, Sage Publications, New Delhi.

GLOBAL WARMING AND CLIMATE CHANGE

OE – I: **VI Semester: CSE / CSE (AI & ML) / CSE (DS) / CSE (CS) / CSIT / IT**
OE –II: **VII Semester: ECE / EEE**
OE –III: **VIII Semester: AERO / MECH / CIVIL**

Course Code	Category	Hours / Week			Credits	Maximum Marks		
AHSC18	Elective	L	T	P	C	CIA	SEE	Total
		3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		

I. COURSE OVERVIEW

This course aims to address the whole complexity of climate change as an issue, by bringing together the science, impacts, economics, abatement technologies, and policy solutions. The course will address several important questions like what is the scientific basis for our understanding of climate change, and in what ways is that scientific basis uncertain. What changes in climate might we expect over the coming centuries? What would be the impacts of these changes in climate for human well-being and the natural world? What are the sources of emissions of greenhouse gases? What technologies exist or might be developed to allow us to slow climate change, and what international policy solutions might be necessary or preferred?

II. COURSE OBJECTIVES:

The students will try to learn:

I. The importance of Ozone layer in the atmosphere.
II. The comprehend composition of atmosphere.
III. The impacts of climate change on ecosystem.
IV. The initiatives taken by different countries to reduce emission of greenhouse gases.

III. SYLLABUS:

MODULE – I: EARTH'S CLIMATE SYSTEM (09)

Role of ozone in environment, Ozone layer – Ozone depleting gases, Green House Effect – Radioactive effects of Greenhouse gases, The Hydrological cycle, Green House Gases and Global Warming, Carbon Cycle.

MODULE –II: ATMOSPHERE AND ITS COMPONENTS (09)

Importance of Atmosphere – Physical and chemical characteristics of Atmosphere, Vertical structure of the atmosphere, Composition of the atmosphere, Atmospheric stability, Temperature profile of the atmosphere, Lapse rates, Temperature inversion, Effects of inversion on pollution dispersion.

MODULE – III: IMPACTS OF CLIMATE CHANGE (09)

Causes of Climate change: Changes of Temperature in the environment, Melting of ice pole, sea level rise, Impacts of Climate Change on various sectors – Agriculture, Forestry and Ecosystem, Water Resources, Human Health, Industry, Settlement and Society.

Methods and Scenarios, Projected Impacts for different regions, Uncertainties in the projected impacts of Climate Change, Risk of Irreversible Changes.

MODULE – IV: OBSERVED CHANGES AND ITS CAUSES (09)

Climate change and Carbon credits, CDM – Initiatives in India-Kyoto Protocol, Paris Convention - Intergovernmental Panel on Climate change, Climate Sensitivity and Feedbacks. The Montreal Protocol – UNFCCC – IPCC – Global Climate Models (GCM) - Evidences of Changes in Climate and Environment- on a Global scale and in India.

MODULE – V: CLIMATE CHANGE AND MITIGATION MEASURES (09)

Clean Development Mechanism, Carbon Trading – Examples of future clean technology, Biodiesel – Natural Compost, Eco-friendly plastic, Alternate Energy –Hydrogen, Bio-fules, Solar Energy, Wind and Hydroelectric Power. Mitigation Efforts in India and Adaptation funding. Key Mitigation Technologies and Practices –

Energy Supply, Transport, Buildings, Industry, Agriculture, Forestry – Carbon sequestration, Carbon capture and storage (CCS), Waste (MSW & Bio-waste, Biomedical, Industrial waste) – International and Regional cooperation.

IV. TEXT BOOKS:

1. Dr. Sushil Kumar Dash, "Climate Change: An Indian Perspective (Environment and Development)", Cambridge University Press India Pvt Ltd, 2007.
2. Adaptation and mitigation of climate change – Scientific Technical Analysis, Cambridge University Press, Cambridge, 2006.

V. REFERENCE BOOKS:

1. Atmospheric Science, J.M. Wallace and P.V Hobbs, Elsevier/ Academic Press, 2006.
2. "Climate Change and Climate Variability on Hydrological Regimes", Jan C. Van Dam, Cambridge University Press, 2003.

VI. E-TEXT BOOKS

1. https://www.worldcat.org/title/encyclopedia-of-global-warming-climate-change/oclc/805580328
2. https://libguides.nus.edu.sg/c.php?g=433566&p=2955835

INTELLECTUAL PROPERTY RIGHTS

<table>
<tr><td colspan="9">OE – I: VI Semester: CSE / CSE (AI & ML) / CSE (DS) / CSE (CS) / CSIT / IT
OE –II: VII Semester: ECE / EEE
OE –III: VIII Semester: AERO / MECH / CIVIL</td></tr>
<tr><th rowspan="1">Course Code</th><th>Category</th><th colspan="3">Hours / Week</th><th>Credits</th><th colspan="3">Maximum Marks</th></tr>
<tr><td rowspan="2">AHSC19</td><td rowspan="2">Elective</td><td>L</td><td>T</td><td>P</td><td>C</td><td>CIA</td><td>SEE</td><td>Total</td></tr>
<tr><td>3</td><td>-</td><td>-</td><td>3</td><td>30</td><td>70</td><td>100</td></tr>
<tr><td>Contact Classes: 45</td><td>Tutorial Classes: Nil</td><td colspan="4">Practical Classes: Nil</td><td colspan="3">Total Classes: 45</td></tr>
</table>

I. COUSRE OVERVIEW:

The course will cover the philosophy of intellectual property rights, various technical and legal dimensions of IPR, and implications of IPR for growth and development of science, along with the various socio-economic and ethico-legal consequences of IPR on economic development. Students can also get disseminate knowledge on Design, Geographical Indication (GI), Plant Variety and Layout Design Protection and their registration aspects and also aware about current trends in IPR and Govt. steps in fostering IPR.

II. COURSE OBJECTIVES:

The students will try to learn:

I. The knowledge in world trade organization and agreements between nations.
II. The intellectual property with international trade agreements.
III. The different types of intellectual property rights.
IV. The different laws in protection of intellectual property rights and its implementation.

III. SYLLABUS:

MODULE- I: INTRODUCTION (10)

General agreement on tariffs and trade (GATT) eight rounds: Uruguay round, world trade organization: structure, technology transfer, dispute resolution mechanism, Doha declaration world trade organization agreements including trade related intellectual properties rights and trade related investment measures.

MODULE- II: WORLD INTELLECTUAL PROPERTY ORGANIZATION (08)

Paris convention, Bern convention, Budapest treaty, Madrid agreement, huge agreement.

MODULE- III: PATENTS (09)

Historical background of intellectual property rights, introduction, definition and classification of intellectual property, patents, patentable and non-patentable inventions. Legal requirements for patents, types of patent applications.

Patent document: specification and claims, important procedural aspects, management of intellectual property rights assets and intellectual property portfolio, commercial exploitation of intellectual property.

MODULE- IV: DESIGNS AND GEOGRAPHICAL INDICATIONS (10)

Designs: basic requirements, procedure, convention application term, date, geographical indication: definition, what can be registered, who can apply, rights, term, restrictions.

MODULE- V: TRADEMARK AND COPYRIGHTS (08)

Definition, classification of trademarks, classifications of goods and services, Vienna classification, trademarks procedure, trademarks enforcement: infringement and passing off, remedies, copyrights, term of copyrights, and procedure of copyright assignment of copyright, copyright infringement remedies.

IV. TEXT BOOKS:

1. P. K. Vasudeva,World Trade Organization: Implications on Indian Economy, Pearson Education,2015.
2. P.KrishnaRao, WTO, Text and cases, Excel Books, 2015.
3. Carlos M.Correa- Intellectual property rights, The WTO and Developing countries-Zed books.

V. REFERENCE BOOKS:

1. Caves, Frankel, Jones, World Trade and Payments-An Introduction, Pearson4. Education, 2015.

2. Carlos M.Correa- Intellectual property rights, The WTO and Developing countries-Zed books.
3. Peter-Tobias stoll, Jan busche, Katrianarend- WTO- Trade –related aspects of IPR- Library of Congress.

VI. WEB REFERENCES:

1. http://www.ebooks directory.com
2. http://Campus guides.lib.utah.edu

VII. E-Text Books:

1. http://www.bookboon.com
2. http://www.freemagagement.com
3. http://www.emeraldinsight.com

ENTREPRENEURSHIP

OE – I: VI Semester: CSE / CSE (AI & ML) / CSE (DS) / CSE (CS) / CSIT / IT OE –II: VII Semester: ECE / EEE OE –III: VIII Semester: AERO / MECH / CIVIL								
Course Code	Category	Hours / Week			Credits	Maximum Marks		
AHSC20	Elective	L	T	P	C	CIA	SEE	Total
		3	-	-	3	30	70	100
Contact Classes: 45	Tutorial Classes: Nil	Practical Classes: Nil				Total Classes: 45		

I. COURSE OVERVIEW:

This course aims to provide students with an understanding of the nature of enterprise and entrepreneurship and introduces the role of the entrepreneur, will inculcate the knowledge of government supporting programs. Apart from this, students learn about the women entrepreneurs and success stories of women entrepreneurs, gain the knowledge of project management and profitability appraisal, focus on importance of training the new entrepreneurs as well as existing entrepreneurs. The students can also acquire necessary knowledge and skills required for organizing and carrying out entrepreneurial activities, for analysing and understanding business situations in entrepreneurs act and to master the knowledge necessary to plan entrepreneurial activities. The objective of the course is, to develop the ability of analysing various aspects of entrepreneurship – especially of taking over the risk, and the specificities as well as the pattern of entrepreneurship development and, finally, to contribute to their entrepreneurial and managerial potentials.

II. COUSRE OBJECTIVES:

The students will try to learn:

I. The Entrepreneurial process and also inspire them to be Entrepreneurs.
II. The key steps in the elaboration of business idea.
III. The stages of the entrepreneurial process and the resources needed for the successful development of entrepreneurial ventures.

III. SYLLABUS:

MODULE-I: UNDERSTANDING ENTREPRENEURIAL MINDSET (09)

The revolution impact of entrepreneurship- The evolution of entrepreneurship - Functions of Entrepreneurs – types of entrepreneurs -Approaches to entrepreneurship- Process approach- Role of entrepreneurship in economic development- Twenty first century trends in entrepreneurship.

MODULE-II: INDIVIDUAL ENTREPRENEURIAL MIND-SET AND PERSONALITY (09)

The entrepreneurial journey Stress and the entrepreneur - the entrepreneurial ego - Entrepreneurial motivations- Motivational cycle – Entrepreneurial motivational behavior – Entrepreneurial competencies. Corporate Entrepreneurial Mindset, the nature of corporate entrepreneur- conceptualization of corporate entrepreneurship Strategy-sustaining corporate entrepreneurship.

MODULE-III: LAUNCHING ENTREPRENEURIAL VENTURES (09)

Opportunities identification- Finding gaps in the market place – techniques for generating ideas- entrepreneurial Imagination and Creativity- the nature of the creativity process - Innovation and entrepreneurship.

Methods to initiate Ventures- Creating new ventures-Acquiring an Established entrepreneurial venture- Franchising- advantage and disadvantages of Franchising.

MODULE-IV: LEGAL CHALLENGES OF ENTREPRENEURSHIP (09)
Intellectual property protection - Patents, Copyrights - Trademarks and Trade secrets - Avoiding trademark pitfalls. Feasibility Analysis - Industry and competitor analysis - Formulation of the entrepreneurial Plan- The challenges of new venture start-ups, developing an effective business model – Sources of finance - Critical factors for new venture development - The Evaluation process.

MODULE-V: STRATEGIC PERSPECTIVES IN ENTREPRENEURSHIP (09)
Strategic planning - Strategic actions strategic positioning- Business stabilization - Building the adaptive firms - Understanding the growth stage – Internal growth strategies and external growth strategies, Unique managerial concern of growing ventures. Initiatives by the Government of India to promote entrepreneurship, Social and women entrepreneurship.

IV. TEXT BOOKS:

1. D F Kuratko and T V Rao, "Entrepreneurship- A South-Asian Perspective", Cengage Learning, 2012.
2. Bruce R. Barringer/ R.Duane Ireland, "Entrepreneurship Successfully Launching New Ventures", Pearson, 4th Edition, 2015.
3. S.S.Khanka, Entrepreneurship Development, S. Chand Publications, 2015.

V. REFERENCE BOOKS:

1. Stuart Read, Effectual Entrepreneurship, Routledge, 2013.
2. Rajeev Roy, Entrepreneurship, Oxford publications, 2nd Edition, 2012.
3. Nandan .H, Fundamentals of Entrepreneurship, PHI, 2013.

PROJECT WORK - II

<table>
<tr><td colspan="9">VIII Semester: Common for all branches</td></tr>
<tr><th>Course Code</th><th>Category</th><th colspan="3">Hours / Week</th><th>Credits</th><th colspan="3">Maximum Marks</th></tr>
<tr><td rowspan="2">AAEC55</td><td rowspan="2">Project</td><td>L</td><td>T</td><td>P</td><td>C</td><td>CIA</td><td>SEE</td><td>Total</td></tr>
<tr><td>0</td><td>0</td><td>16</td><td>8</td><td>30</td><td>70</td><td>100</td></tr>
<tr><td>Contact Classes: Nil</td><td>Tutorial Classes: Nil</td><td colspan="4">Practical Classes: 180</td><td colspan="3">Total Classes: 180</td></tr>
<tr><td colspan="9">The object of Project Work II & Dissertation is to enable the student to extend further the investigative study taken up under AE P1, either fully theoretical/practical or involving both theoretical and practical work, under the guidance of a Supervisor from the Department alone or jointly with a Supervisor drawn from R&D laboratory/Industry. This is expected to provide a good training for the student(s) in R&D work and technical leadership. The assignment to normally include:

1. In depth study of the topic assigned in the light of the Report prepared under AE P1;
2. Review and finalization of the Approach to the Problem relating to the assigned topic;
3. Preparing an Action Plan for conducting the investigation, including team work;
4. Detailed Analysis / Modeling / Simulation / Design / Problem Solving / Experiment as needed;
5. Final development of product/process, testing, results, conclusions and future directions;
6. Preparing a paper for Conference presentation/Publication in Journals, if possible;
7. Preparing a Dissertation in the standard format for being evaluated by the Department.
8. Final Seminar Presentation before a Departmental Committee.</td></tr>
</table>

INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad - 500 043

UNDERTAKING BY STUDENT / PARENT

"To make the students attend the classes regularly from the first day of starting of classes and be aware of the College regulations, the following undertaking form is introduced which should be signed by both student and parent. The same should be submitted to the Dean of Academic".

I, Mr. / Ms. -- joining I Semester / III Semester for the academic year 20 - 20 / 20 - 20 in Institute of Aeronautical Engineering, Hyderabad, do hereby undertake and abide by the following terms, and I will bring the ACKNOWLEDGEMENT duly signed by me and my parent and submit it to the Dean of Academic.

1. I will attend all the classes as per the timetable from the starting day of the semester specified in the institute Academic Calendar. In case, I do not turn up even after two weeks of starting of classes, I shall be ineligible to continue for the current academic year.
2. I will be regular and punctual to all the classes (theory/laboratory/project) and secure attendance of not less than 75% in every course as stipulated by Institute. I am fully aware that an attendance of less than 65% in more than 60% of theory courses in a semester will make me lose one year.
3. I will compulsorily follow the dress code prescribed by the college.
4. I will conduct myself in a highly disciplined and decent manner both inside the classroom and on campus, failing which suitable action may be taken against me as per the rules and regulations of the institute.
5. I will concentrate on my studies without wasting time in the Campus/Hostel/Residence and attend all the tests to secure more than the minimum prescribed Class/Sessional Marks in each course. I will submit the assignments given in time to improve my performance.
6. I will not use Mobile Phone in the institute premises and also, I will not involve in any form of ragging inside or outside the campus. I am fully aware that using mobile phone to the institute premises is not permissible and involving in Ragging is an offence and punishable as per JNTUH/UGC rules and the law.
7. I declare that I shall not indulge in ragging, eve-teasing, smoking, consuming alcohol drug abuse or any other anti-social activity in the college premises, hostel, on educational tours, industrial visits or elsewhere.
8. I will pay tuition fees, examination fees and any other dues within the stipulated time as required by the Institution / authorities, failing which I will not be permitted to attend the classes.
9. I will not cause or involve in any sort of violence or disturbance both within and outside the college campus.
10. If I absent myself continuously for 3 days, my parents will have to meet the HOD concerned/ Principal.
11. I hereby acknowledge that I have received a copy of IARE – UG20 Academic Rules and Regulations, Syllabus copy and hence, I shall abide by all the rules specified in it.

ACKNOWLEDGEMENT

I have carefully gone through the terms of the undertaking mentioned above and I understand that following these are for my/his/her own benefit and improvement. I also understand that if I/he/she fail to comply with these terms, shall be liable for suitable action as per Institute/JNTUH/AICTE/UGC rules and the law. I undertake that I/he/she will strictly follow the above terms.

Signature of Student with Date

Signature of Parent with Date
Name & Address with Phone Number