IARE

INSTITUTE OF
AERONAUTICAL ENGINEERING

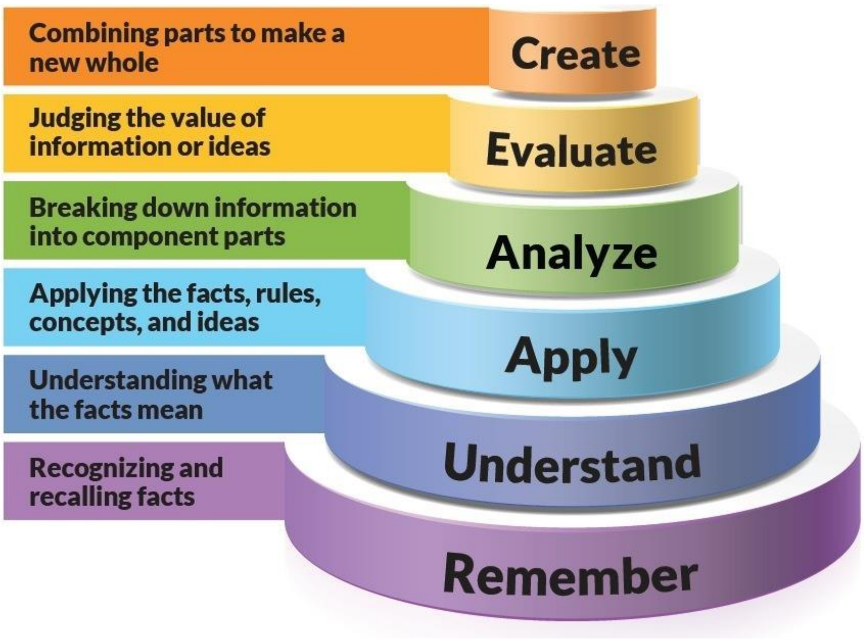
Outcome Based Education (OBE) Manual (PG21)

Department of Mechanical Engineering

OUTCOME BASED EDUCATION BOOKLET

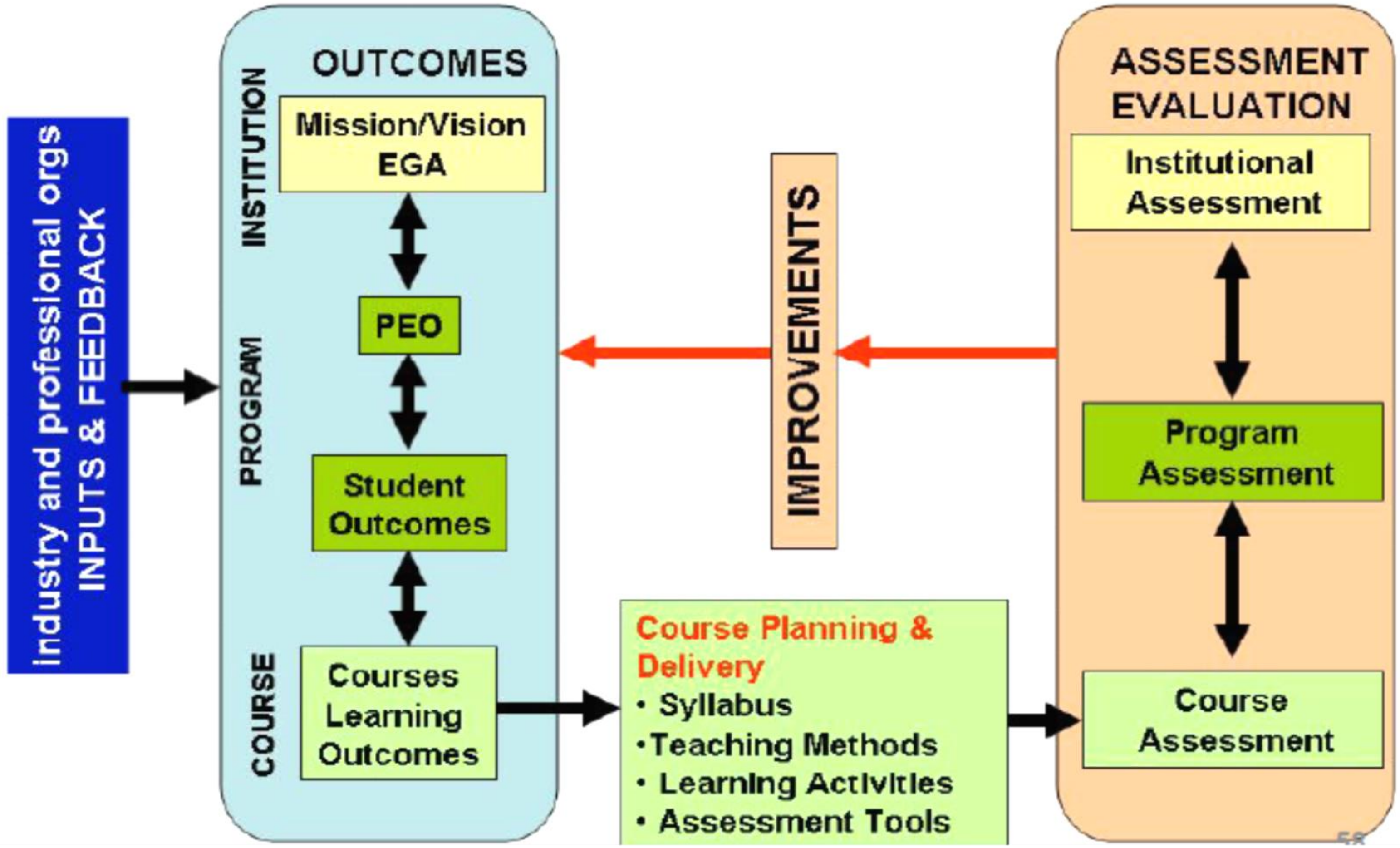
M.Tech CAD/CAM
Mechanical Engineering

For the batch of students admitted during
Academic Year 2021 – 2022



INSTITUTE OF AERONAUTICAL ENGINEERING
(Autonomous)
Approved by AICTE; Affiliated to JNTUH and Accredited by NAAC with 'A' Grade
Dundigal, Hyderabad – 500 043

The OBE Framework



Vision

The Department of Mechanical Engineering envisions value based education, research and development in the areas of Manufacturing and Computer Aided Engineering as an advanced center for Mechanical Engineering, producing graduates of world-class competence to face the challenges of global market with confidence, creating effective interface with various organizations.

Mission

The mission of the Mechanical Engineering Department is to prepare effective and responsible engineers for global requirements by providing quality education and to improve pedagogical methods employed in delivering the academic programs to the needs of the industry and changing world by conducting basic and applied research and to generate intellectual property.

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Part – I

I. Program Educational Objectives and Assessment Criteria:

Program Educational Objectives, Program Outcomes and Assessment Criteria (Approved by DAC MECH on 30/01/2018):

Mechanical Engineering Department Advisory Council: The Mechanical Engineering Department Advisory Council (MECHDAC) includes a diverse group of experts from academic and industry, as well as alumni representation. The Advisory Board meets annually, or as needed, for a comprehensive review of the Mechanical Engineering Department strategic planning and programs. The Advisory Council meets with administration, faculty and students and prepares a report, which is presented to principal. In each visit, the Department of Mechanical Engineering responds to the report indicating improvements and amendments to the program.

Program educational objectives are broad statements that describe the career and professional accomplishments that the program is preparing graduates to achieve.
Outcomes — Program outcomes are narrower statements that describe what students are expected to know and be able to do by the time of graduation. These relate to the skills, knowledge, and behaviors that students acquire in their matriculation through the program.

II. Program Educational Objectives (PEO'S)

A graduate of Institute of Aeronautical Engineering College, Mechanical Engineering should enjoy a successful career in Mechanical Engineering or a related field after graduation. The program aims to:

Program Educational Objective 1

Impart essential knowledge in the latest technological topics on computer aided engineering and to prepare them for taking up further **research** in the areas

Program Educational Objective 2

Create congenial environment that promotes learning, growth and imparts ability to work with **inter-disciplinary** groups

Program Educational Objective 3

Broaden and deepen the capabilities in **analytical and experimental methods**, analysis of data, and draw relevant conclusions for scholarly writing and presentation

These Program Educational Objectives are broad by intention, permitting the Mechanical Engineering CAD/CAM post graduates to seek further research or work in diverse areas. To make these objectives meaningful, they may be demonstrated by performance, actions, or achievements.

1. To impart essential knowledge in the latest technological topics on computer aided engineering and to prepare them for taking up further research in the areas:
   - Impart knowledge of various computerized tools for performing geometry and dimensional tolerance in different technical drawings.
   - Impart knowledge of software for modeling and analysis of various systems and sub systems.
   - Develop the knowledge of using multi physics tools to gain research knowledge and develop further mathematical and experimental models in engineering

2. To create congenial environment that promotes learning, growth and imparts ability to work with inter-disciplinary groups:
    - Knowledge of robotic systems and subsystems to work with electronic engineers in development of new products and assembly lines.
    - Knowledge of research methodology to work in any of the inter-disciplinary group to develop standard research.
    - Factual reporting in engineering journals which may further lead to publishing inter-departmental white papers for technology transfer.
3. To broaden and deepen the capabilities in analytical and experimental methods, analysis of data and draw relevant conclusions for scholarly writing and presentations:
    - Broad spectrum of project work included in two phases encompasses the importance of raw data collection from previous scholarly articles, conversion of raw data to scientific data by numerical, mathematical and experimental analysis.
    - Specified subjects for writing technical reports and publishing research and scholarly articles in renowned journals.
    - Encouragement to publish scholarly articles in journals in hand with the faculty and mentoring for overall improvement.

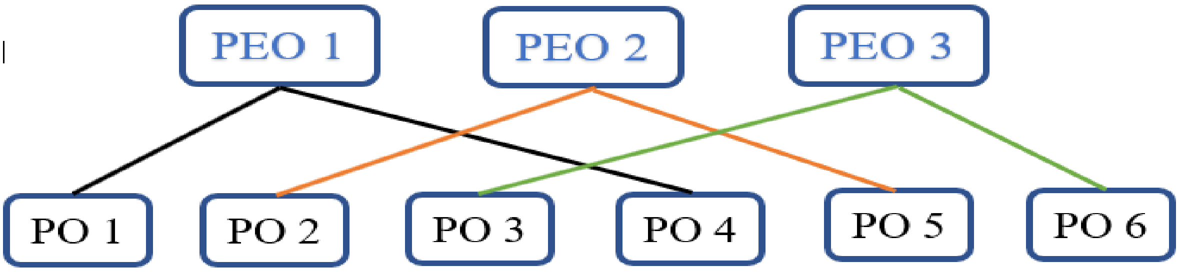
III. Program Outcomes (PO'S):

1. Apply advanced level knowledge, techniques, skills and modern tools in the field of computer aided engineering to critically assess the emerging technological issues.
2. Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.
3. Conduct experimental, and analytical studies, analyzing results with scientific methods and use of software.
4. Write and present a substantial technical report/document.
5. Independently carry out research/investigation and development work to solve practical problems.
6. Design and validate technological solutions to improve the defined problems as well as engage in lifelong learning through continuing education.

IV. PEO's Vs PO's

S. No	Program Educational Objectives	Program Outcomes
PEO - I	To impart essential knowledge in the latest technological topics on computer aided engineering and to prepare them for taking up further research in the areas.	1. Apply advanced level knowledge, techniques, skills and modern tools in the field of computer aided engineering to critically assess the emerging technological issues. 4. Write and present a substantial technical report/document
PEO - II	To create congenial environment that promotes learning, growth and imparts ability to work with inter-disciplinary groups.	2. Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team. 5.Independently carry out research/investigation and development work to solve practical problems.
PEO - III	To broaden and deepen the capabilities in analytical and experimental methods, analysis of data and draw relevant conclusions for scholarly writing and presentations.	3. Conduct experimental, and analytical studies, analyzing results with scientific methods and use of software. 6. Design and validate technological solutions to improve the defined problems as well as engage in lifelong learning through continuing education.

V. Mapping of Program Outcomes to Program Educational Objectives



VI. MAPPING OF PO's Vs PEO's

Program Outcomes	PEO-I	PEO-II	PEO-III
1. Apply advanced level knowledge, techniques, skills and modern tools in the field of computer aided engineering to critically assess the emerging technological issues.	✔		
2. Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.		✔	
3. Conduct experimental, and analytical studies, analyzing results with scientific methods and use of software			✔
4. Write and present a substantial technical report/document.	✔		
5. Independently carry out research/investigation and development work to solve practical problems.		✔	
6. Design and validate technological solutions to improve the defined problems as well as engage in lifelong learning through continuing education.			✔

Note:

- The assessment process can be direct or indirect.
- The direct assessment will be through interim assessment by the faculty or by industry / technology experts.
- The indirect assessment on the other hand could be by students through course outcomes, lab evaluation, department associations, exit interviews, engineering services, GATE examination etc.
- Frequency of assessment can be once in a semester and justified by the programme coordinator.

VII. Table-1 Relation between the Program Educational Objectives and Program Outcomes:

A broad relation between the program objective and the outcomes is given in the following table:

	(PEO-I) Research	(PEO-II) Inter-disciplinary groups	(PEO-III) Analytical and Research Skills
1. Apply advanced level knowledge, techniques, skills and modern tools in the field of computer aided engineering to critically assess the emerging technological issues.	3	2	3

2. Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.	3	3	3
3. Conduct experimental, and analytical studies, analyzing results with scientific methods and use of software	3	3	3
4. Write and present a substantial technical report/document.	3	2	2
5. Independently carry out research/investigation and development work to solve practical problems.	2	3	3
6. Design and validate technological solutions to improve the defined problems as well as engage in lifelong learning through continuing education.	2	2	2

Table - Relationships between program objectives and program outcomes
Key: 3 = Strong relationship; 2 = Moderate relationship

Note:

- The assessment process can be direct or indirect.
- The direct assessment will be through interim assessment by the faculty or by industry / technology experts.
- The indirect assessment on the other hand could be by students through course outcomes, lab evaluation, department associations, exit interviews, engineering services, GATE examination etc.
- Frequency of assessment can be once in a semester and justified by the programme coordinator.

VIII. A LIST OF COURSES OFFERED IN MECHANICAL ENGINEERING CURRICULUM (IARE-PG21): FOR THE BATCHES ADMITTED DURING 2021-2023
MAPPING OF COURSES TO PROGRAM OUTCOMES AND PROGRAM SPECIFIC OUTCOMES

M. Tech CAD/CAM (PG21)

I Semester		POS					
CODE	**Subject**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
BCCC01	Advanced CAD	✔	✔		✔		✔
BCCC02	Numerical Methods and Partial Differential Equations	✔		✔	✔	✔	✔
BCCC03	Design for Manufacturing and Assembly	✔	✔	✔	✔	✔	✔
BCCC09	Stress Analysis and Vibration	✔	✔	✔	✔	✔	✔
BHSCO2	Disaster Management						
PRACTICAL							

BCCC11	Computer Aided Design Laboratory	✔		✔	✔		✔
BCCC12	Computational Techniques Laboratory	✔	✔		✔	✔	
II Semester		**POs**					
CODE	**Subject**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
BCCC13	Advanced Finite Element Method		✔	✔	✔		
BCCC14	Computer Integrated Manufacturing		✔	✔	✔	✔	✔
BCCC15	Computer Aided Process Planning	✔	✔	✔	✔		✔
BCCC22	Intelligent Manufacturing Systems	✔	✔	✔	✔	✔	✔
BHSC08	Personality Development through Life Enlightenment Skills		✔	✔			✔
PRACTICALS							
BCCC23	Computer Aided Machining and Robotics Laboratory		✔			✔	
BCCC24	Simulation and Analysis Lab			✔	✔		✔
BCCC25	Mini Project with Seminar	✔	✔	✔	✔	✔	✔
III Semester		**POs**					
CODE	**Subject**	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**
BHSC11	Research Methodology and IPR		✔	✔	✔		
BCCC28	Design and Analysis of Experiments	✔		✔		✔	
BPSC30	Waste to Energy	✔				✔	
PRACTICALS							
BCCC31	Phase I - Dissertation	✔	✔	✔	✔	✔	✔
IV Semester		**POs**					

CODE	Subject	PO1	PO2	PO3	PO4	PO5	PO6
PRACTICALS							
BCCC32	Phase II - Dissertation	✔	✔	✔	✔	✔	✔

IX. Outcome Delivery and Assessment (PG21) (For batches admitted during PG21)

The categorization of outcomes of the above Mechanical Engineering courses is grouped as follows:

Program Outcome (1): Apply advanced level knowledge, techniques, skills and modern tools in the field of computer aided engineering to critically assess the emerging technological issues.			
BCCC01	Advanced CAD	BCCC22	Intelligent Manufacturing Systems
BCCC02	Numerical Methods and Partial Differential Equations	BCCC25	Mini Project with Seminar
BCCC03	Design for Manufacturing and Assembly	BCCC28	Design and Analysis of Experiments
BCCC09	Stress Analysis and Vibration	BPSC30	Waste to Energy
BCCC11	Computer Aided Design Laboratory	BCCC31	Phase I - Dissertation
BCCC12	Computational Techniques Laboratory	BCCC32	Phase II - Dissertation
BCCC15	Computer Aided Process Planning		
Program Outcome (2): Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.			
BCCC01	Advanced CAD	BHSC08	Personality Development through Life Enlightenment Skills
BCCC03	Design for Manufacturing and Assembly	BCCC23	Computer Aided Machining and Robotics Laboratory
BCCC09	I Stress Analysis and Vibration	BCCC25	Mini Project with Seminar
BCCC12	Computational Techniques Laboratory	BHSC11	Research Methodology and IPR
BCCC13	Advanced Finite Element Method	BCCC31	Phase I - Dissertation
BCCC14	Computer Integrated Manufacturing	BCCC32	Phase II - Dissertation
BCCC15	Computer Aided Process Planning		
BCCC22	Intelligent Manufacturing Systems		
Program Outcome (3): Conduct experimental, and analytical studies, analyzing results with scientific methods and use of software			
BCCC02	Numerical Methods and Partial Differential Equations	BCCC24	Simulation and Analysis Lab
BCCC03	Design for Manufacturing and Assembly	BCCC25	Mini Project with Seminar
BCCC09	Professional Elective – I Stress Analysis and Vibration	BHSC11	Research Methodology and IPR
BCCC11	Computer Aided Design Laboratory	BCCC28	Design and Analysis of Experiments
BCCC13	Advanced Finite Element Method	BCCC31	Phase I - Dissertation
BCCC14	Computer Integrated	BCCC32	Phase II - Dissertation

	Manufacturing		
BCCC15	Computer Aided Process Planning		
BCCC22	Intelligent Manufacturing Systems		
BHSC08	Personality Development through Life Enlightenment Skills		
Program Outcome (4): Write and present a substantial technical report/document.			
BCCC01	Advanced CAD	BCCC15	Computer Aided Process Planning
BCCC02	Numerical Methods and Partial Differential Equations	BCCC22	Intelligent Manufacturing Systems
BCCC03	Design for Manufacturing and Assembly	BCCC24	Simulation and Analysis Lab
BCCC09	Stress Analysis and Vibration	BCCC25	Mini Project with Seminar
BCCC11	Computer Aided Design Laboratory	BHSC11	Research Methodology and IPR
BCCC12	Computational Techniques Laboratory	BCCC31	Phase I - Dissertation
BCCC13	Advanced Finite Element Method	BCCC32	Phase II - Dissertation
BCCC14	Computer Integrated Manufacturing		
Program Outcome (5): Independently carry out research/investigation and development work to solve practical problems.			
BCCC02	Numerical Methods and Partial Differential Equations	BCCC23	Computer Aided Machining and Robotics Laboratory
BCCC03	Design for Manufacturing and Assembly	BCCC25	Mini Project with Seminar
BCCC09	Stress Analysis and Vibration	BCCC28	Design and Analysis of Experiments
BCCC12	Computational Techniques Laboratory	BPSC30	Waste to Energy
BCCC14	Computer Integrated Manufacturing	BCCC31	Phase I - Dissertation
BCCC22	Intelligent Manufacturing Systems	BCCC32	Phase II - Dissertation
Program Outcome (6): Design and validate technological solutions to improve the defined problems as well as engage in lifelong learning through continuing education			
BCCC01	Advanced CAD	BCCC01	Advanced CAD
BCCC02	Numerical Methods and Partial Differential Equations	BCCC02	Numerical Methods and Partial Differential Equations
BCCC03	Design for Manufacturing and Assembly	BCCC03	Design for Manufacturing and Assembly
BCCC09	Stress Analysis and Vibration	BCCC09	Stress Analysis and Vibration
BCCC11	Computer Aided Design Laboratory	BCCC11	Computer Aided Design Laboratory
BCCC14	Computer Integrated Manufacturing	BCCC14	Computer Integrated Manufacturing
BCCC15	Computer Aided Process Planning		

X. Methods of Measuring Program Outcomes

Methodologies that are used to measure student learning each have their own limitations and biases, and no method can be counted on to be completely error free. That is why best practice in educational research dictates triangulating the data. If several different sources of data are used, it increases the probability that the findings present an accurate picture. We employ the following formal assessment procedures:

1. End-of-semester course evaluations
2. Departmental mid-semester course evaluations
3. Departmental course objective surveys
4. Course portfolio evaluations
5. Exit Interviews
6. Alumni feedback
7. Employer surveys
8. Department academic council meetings
9. Faculty meetings
10. Project work
11. Job Placements
12. Professional societies

Each is described in more detail below:

1. End-of-semester course evaluations:

College being autonomous conducts end-of-semester examination for all courses. Summary results for each course are distributed to the appropriate instructor and the HOD, summarizing the course-specific results and comparing them to the average across the university. Students are encouraged to write specific comments about the positive and negative aspects of the course. The statistical summary and student comments are presented are also submitted to the principal and department academic council for review.

2. Departmental mid-semester course evaluations:

Mechanical Engineering department conducts mid-semester reviews for all courses. All departmental students are encouraged to fill out a brief survey on the state of the courses they are currently taking, and space is provided for a written comment. Faculty are strongly encouraged to review these evaluations, and draft a brief response on how they will react to correct any deficiencies noted by the students. The results are reviewed by departmental faculty (all faculty have permission to read results for all courses).

3. Departmental course objective surveys:

Mechanical Engineering department conducts end-of-semester course objective surveys for all of our courses. All departmental students are encouraged to fill out a brief survey on the state of the courses they are currently taking, and space is provided for a written comment. Faculty are strongly encouraged to review these evaluations, and draft a brief response on how they will react to correct any deficiencies noted by the students. The results are reviewed by departmental faculty (all faculty have permission to read results for all courses). The results of how courses satisfy their objectives are discussed at a faculty meeting. Based on this feedback for certain courses, alterations or changes to the course objectives can be done.

4. Course portfolio evaluations:

We collect course portfolios from the instructor of each course offered in the given semester. They remain on file for our entire faculty to study. These portfolios help the course coordinator monitor how the course is being taught, and help new faculty understand how more experienced colleagues teach the given course. With respect to assessment, each portfolio contains two surveys to be filled out by the instructor of the course. The beginning-of-semester survey encourages faculty members to think about what they can do to improve the teaching and administration of their course, compared with the last time they taught it. The end-of-semester survey encourages faculty to record what did and did not work well during this course offering and what changes should be made for the future.

5 Exit Interviews:

Inputs from final year students are solicited annually through Computer Science and Engineering Exit Survey. The results are disseminated to the faculty and department advisory council for analysis and discussion. The questioner is designed to survey program outcomes, solicit about program experiences, career choices as well as suggestions and comments. This instrument seeks to assess how students view the department's program in retrospect.

6 Alumni feedback:

The alumni survey is a written questionnaire which alumni are asked to complete. We use this survey seeking input on the Program Objectives and Learning Outcomes based on their experience after graduation and after they have spent time in the working world. Alumni are an excellent resource with perspective on the value and advantages of their education. They are also resource for current students for potential networking and employment. The data will be analyzed and used in continuous improvement.

7 Employer surveys:

The employer survey is a written questionnaire which employers of the program's graduates are asked to complete. We review the effectiveness of our curriculum and how well the student is prepared in the department of Mechanical Engineering, IARE. To do this, we survey Employers and Advisors of alumni who graduated four years ago. We ask about several categories of preparation, and for each category, how well do you think he or she was prepared, and how important you think preparation in that area is to him or her in the current position. This survey will greatly assist us in determining the college overall level of achievement of our Program Educational Objectives.

8 Department academic council meetings:

Mechanical Engineering Department Advisory Council (MEDAC) includes a diverse group of experts from academe and industry, as well as alumni representation. The Advisory Board meets annually, or as needed, for a comprehensive review of the Mechanical Engineering Department strategic planning and programs. The Advisory Council meets with administration, faculty and students and prepares a report, which is presented to principal. In each visit, the Department of Mechanical Engineering responds to the report indicating improvements and amendments to the program.

9 Faculty meetings:

The state of undergraduate program is always on the agenda at the monthly meeting of faculty. The faculty devotes a substantial amount of time to formal and informal discussions assessing the state of program and searching for improvements.

10 Project work:

The final project reports, must demonstrate that students produced solutions to research/industry problems involving contemporary issues. There is no scale for this tool as the reports provide qualitative data.

11 Job Placements:

Data from the Placement and Training Centre on graduates' job placement reflects how successful our graduates are in securing a job in a related field.

12 Professional societies:

The role of professional societies in introducing our students to technical, entrepreneurial and Societal aspects of the field and in providing outstanding opportunities for lifelong learning makes them important constituents.

Part – II

METHODOLOGY FOR PREPARATION AND ASSESSMENT OF COURSE LEVEL STUDENT LEARNING OUTCOMES

Although the term "Expected Learning Outcome" may be new, the process of identifying the key concepts or skills that students are expected to learn during specific courses is not. Many people are more familiar with the terms "course objective" or "course competency". Expected learning outcomes are really very similar to both of these concepts, so if you already have course objectives or competencies, you are close to having expected learning outcomes for class.

This will provide information on exactly what expected learning outcomes are and what methods can be used to assess them. This is designed to assist faculty with the process of developing expected learning outcomes and methods for assessing those outcomes in their courses. This provides basic information related to (1) course purpose; (2) expected learning outcomes; (3) methods for assessing expected learning outcomes; (4) criteria for grade determination; and (5) a course outline.

I. **Expected Course Outcomes:**
After reading and completing this, individuals will be able to :

- Prepare a description of the course as well as a written statement regarding the course's purpose;
- Construct/develop expected learning outcomes for the course;
- Create an assessment plan that outlines the specific methods that will be used to assess the expected student learning outcomes for a course;
- Describe how grades will be determined in a process that is separate and distinct from assessing the expected learning outcomes;
- Identify the common components of a course outline
- Revise their course syllabi to incorporate a course purpose, expected learning outcomes, methods to assess those outcomes, the criteria for grade determination, and a course outline.
- This process uses some terminology related to expect learning outcomes and assessment. A brief glossary of terms has been provided below for reference purposes.

Assessment of expected learning outcomes:

The process of investigating (1) what students are learning and (2) how well they are learning it in relation to the stated expected learning outcomes for the course.

Assessment plan: The proposed methods and timeline for assessment-related activities in a given course (e.g., when are you going to check what/how well the students are learning and how are you going to do that?).

Classroom Assessment Technique (CAT): Angelo and Cross (1993) developed a variety of techniques/activities than can be used to assess students' learning. These CATs are often done anonymously and are not graded. These activities check on the class's learning while students are still engaged in the learning process. An example of a CAT is a non-graded quiz given a few weeks before the first exam.

Course description: A formal description of the material to be covered in the course.

Course purpose: The course purpose describes the intent of the course and how it contributes to the program. The course purpose goes beyond the course description.

Expected teaming outcome: A formal statement of what students are expected to learn in a course (synonyms for "expected learning outcome" include learning outcome, learning outcome statement, and student learning outcome).

Evaluation: Making a judgment about the quality of student's learning/work and assigning marks based on that judgment. Evaluation activities (such as exams, papers, etc.) are often seen as formal ways to assess the expected learning outcomes for a course.

Methods for assessing student learning outcomes: This term refers to any technique or activity that is used to identify what students are learning or how well they are learning. Formal methods for evaluating student learning outcomes include Continuous Assessment Tests, Mid Semester Test, Tutorials, End Semester Examination etc. The assessment methods are used to identify how the well students have acquired the learning outcomes for the course.

II. COURSE PURPOSE

One of the first steps in identifying the expected learning outcomes for a course is identifying the purpose of teaching in the course. By clarifying the purpose of the course, faculty can help discover the main topics or themes related to students' learning. These themes help to outline the expected learning outcomes for the course.

The course purpose involves the following:

1. What role does this course play within the program?
2. How is the course unique or different from other courses?
3. Why should/do students take this course? What essential knowledge or skills should they gain from this experience?
4. What knowledge or skills from this course will students need to have mastered to perform well in future classes or jobs?
5. Why is this course important for students to take?

The "Course Description" provides general information regarding the topics and content addressed in the course, the "Course Purpose" goes beyond that to describe how this course fits in to the students' educational experience in the program.

III EXPECTED LEARNING OUTCOMES

Expected Learning Outcome (definition)

An expected learning outcome is a formal statement of what students are expected to learn in a course. Expected learning outcome statements refer to specific knowledge, practical skills, areas of professional development, attitudes, higher-order thinking skills, etc. that faculty members expect students to develop, learn, or master during a course (Suskie, 2004). Expected learning outcomes are also often referred to as "learning outcomes", "student learning outcomes", or "learning outcome statements".

Simply stated, expected learning outcome statements describe:

1. What faculty members want students to *know* at the end of the course and
2. What faculty members want students *to be able to do* at the end of the course?

Learning outcomes have three major characteristics

1) They specify an action by the students/learners that is *observable*
2) They specify an action by the students/learners that is *measurable*
3) They specify an action that is done by the *students/learners* (rather than the faculty members)
   Effectively developed expected learning outcome statements should possess all three of these characteristics. When this is done, the expected learning outcomes for a course are designed so that they can be assessed (Suskie, 2004).

IV. WRITING EFFECTIVE LEARNING OUTCOMES STATEMENTS

When stating expected learning outcomes, it is important to use verbs that describe exactly what the learner(s) will be able to *do* upon completion of the course.

Examples of good action words to include in expected learning outcome

Statements: Compile, identify, create, plan, revise, analyze, design, select, utilize, apply, demonstrate, prepare, use, compute, discuss, explain, predict, assess, compare, rate, critique, outline, or evaluate
There are some verbs that are unclear in the context of an expected learning outcome statement (e.g., know, be aware of, appreciate, learn, understand, comprehend, become familiar with). These words are often vague, have multiple interpretations, or are simply difficult to observe or measure (American Association of Law Libraries, 2005). As such, it is best to avoid using these terms when creating expected learning outcome statements.

For example, please look at the following learning outcomes statements:

- The students will understand basic Thermal system.
- The students will appreciate knowledge discovery from Design of Machine members.
- Both of these learning outcomes are stated in a manner that will make them difficult to assess. Consider the following:
- How do you observe someone "understanding" a theory or "appreciating" Design of Machine members and Thermal systems?
- How easy will it be to measure "understanding" or "appreciation"?

These expected learning outcomes are more effectively stated the following way:

- The students will be able to identify and describe what techniques are used to extract knowledge from Thermal systems.
- The students will be able to identify the characteristics of Classification techniques from other Design of machine members.

Incorporating Critical Thinking Skills into Expected Learning Outcomes Statements

Many faculty members choose to incorporate words that reflect critical or higher-order thinking into their learning outcome statements. Bloom (1956) developed a taxonomy outlining the different types of thinking skills people use in the learning process. Bloom argued that people use different levels of thinking skills to process different types of information and situations. Some of these are basic cognitive skills (such as memorization) while others are complex skills (such as creating new ways to apply information). These skills are often referred to as critical thinking skills or higher-order thinking skills.

Bloom proposed the following taxonomy of thinking skills. All levels of Bloom's taxonomy of thinking skills can be incorporated into expected learning outcome statements. Recently, Anderson and Krathwohl (2001) adapted Bloom's model to include language that is oriented towards the language used in expected learning outcome statements. A summary of Anderson and Krathwohl's revised version of Bloom's taxonomy of critical thinking is provided below.

Definitions of the different levels of thinking skills in Bloom's taxonomy

1. **Remember —**recalling relevant terminology, specific facts, or different procedures related to information and/or course topics. At this level, a student can remember something, but may not really understand it.
2. **Understand —** the ability to grasp the meaning of information (facts, definitions, concepts, etc.) that has been presented.
3. **Apply —** being able to use previously learned information in different situations or in problem solving.
4. **Analyze —** the ability to break information down into its component parts. Analysis also refers to the process of examining information in order to make conclusions regarding cause and effect, interpreting motives, making inferences, or finding evidence to support statements/arguments.
5. **Evaluate —** being able to judge the value of information and/or sources of information based on personal values or opinions.
6. **Create -** the ability to creatively or uniquely apply prior knowledge and/or skills to produce new and original thoughts, ideas, processes, etc. At this level, students are involved in creating their own thoughts and ideas.

V. Table of Blooms Taxonomy
List of Action Words Related to Critical Thinking Skills

Here is a list of action words that can be used when creating the expected student learning outcomes related to critical thinking skills in a course. These terms are organized according to the different levels of higher-order thinking skills contained in Anderson and Krathwohl's (2001) revised version of Bloom's taxonomy

REMEMBER	UNDERSTAND	APPLY	ANALYZE	EVALUATE	CREATE
Count	Associate	Add	Analyze	Appraise	Categorize
Define	Compute	Apply	Arrange	Assess	Combine
Describe	Convert	Calculate	Breakdown	Compare	Compile
Draw	Defend	Change	Combine	Conclude	Compose
Identify	Discuss	Classify	Design Detect	Contrast	Create
Label	Distinguish	Complete	Develop	Criticize	Drive
List	Estimate	Compute	Diagram	Critique	Design
Match	Explain	Demonstrate	Differentiate	Determine	Devise
Name	Extend	Discover	Discriminate	Grade	Explain
Outline	Extrapolate	Divide	Illustrate Infer	Interpret	Generate
Point	Generalize	Examine	Outline Point	Judge	Group

Quote	Give examples	Graph	out Relate	Justify	Integrate
Read	Infer	Interpolate	Select	Measure	Modify
Recall	Paraphrase	Manipulate	Separate	Rank	Order
Recite	Predict	Modify	Subdivide	Rate	Organize
Recognize	Rewrite	Operate	Utilize	Support	Plan
Record	Summarize	Prepare		Test	Prescribe
Repeat		Produce			Propose
Reproduce		Show			Rearrange
Select		Solve			Reconstruct
State Write		Subtract			Related
		Translate			Reorganize
		Use			Revise
					Rewrite
					Summarize
					Transform
					Specify

VI. TIPS FOR DEVELOPING COURSE LEVEL EXPECTED LEARNING OUTCOMES STATEMENTS

- Limit the course-level expected learning outcomes to 5 - 10 statements for the entire course (more detailed outcomes can be developed for individual units, assignments, chapters, etc.)
- Focus on overarching or general knowledge and/or skills (rather than small or trivial details).
- Focus on knowledge and skills that are central to the course topic and/or discipline.
- Focus on the learning that results from the course rather than describing activities or lessons in the course.
- Incorporate or reflect the institutional and departmental missions.
- Incorporate various ways for students to show success (outlining, describing, modeling, depicting, etc.) rather than using a single statement such as "at the end of the course, students will know" as the stem for each expected outcome statement.

VII. EXPECTED LEARNING OUTCOMES STATEMENTS (PG21)

The following depict some sample expected learning outcome statements from selected courses.

Design for Manufacturing and Assembly		
Course Objectives	**Course Outcomes**	
The students will try to learn: 1. The techniques of Design for Manufacturing and Assembly applied for minimizing product cost through design and process improvements. 2. The selection of material and process used in the prototype design in the early stages of product development for cost effectiveness. 3. The pattern movement in assembly process, assembly errors and minimization steps by considering logical sub-assemblies and re-orientation of parts during machining .	**CO Code**	**At the end of the course students are able to:**
	CO 1	**Interpret the specific materials compatible with existing production processes that will minimize processing time and functional requirements.**
	CO 2	**Identify the concepts of Design for Manufacture and Assembly (DFMA) for product development which minimizes part count in manufacturing process.**
	CO 3	**Make use of the suitable materials for product manufacturing in engineering applications to eliminate expensive and complex features.**
	CO 4	**Identify various defects and shortcomings during permanent joining operations such as TIG, MIG and Spot welding for real time applications.**
	CO 5	**Analyze the manufacturing defects as well as material characterization and its application.**
	CO 6	**Examine the appropriate manufacturing process parameters, for effective optimization of prototype / products.**

VIII. AN OVERVIEW OF ASSESSMENT

What is assessment?

According to Palomba and Banta (1999) assessment involves the systematic collection, review, and use of evidence or information related to student learning. Assessment helps faculty understand how well their students understand course topics/lessons. Assessment exercises are often anonymous. This anonymity allows students to respond freely, rather than trying to get the "right" answer or look good. Assessment exercise attempt to gauge students' understanding in order to see what areas need to be re-addressed in order to increase the students' learning.

In other words, assessment is the process of investigating (1) what students are learning and (2) how well they are learning it in relation to the stated expected learning outcomes for the course. This process also involves providing feedback to the students about their learning and providing new learning opportunities/strategies to increase student learning.

For example, Dr. KGK Murti initiates a class discussion on material from Chapter One and determines that most students are confused about Topic X. This class discussion served as a method for assessing student learning and helped determine the fact that student learning related to Topic X is somewhat lacking. Dr. KGK Murti now has the opportunity to (1) inform the students that there is some confusion and (2) make clarification to address this confusion (e.g., ask student to re-read Chapter One, re-lecture over Topic X, etc.). This assessment process helps increase students' learning.

What is the difference between "evaluation" and "assessment"?

Evaluation focuses on making a judgment about student work to be used in assigning marks that express the level of student performance. Evaluation is usually used in the process of determining marks. Evaluation typically occurs after student learning is assumed to have taken place (e.g., a final exam). Evaluation is part of the assessment process. Course assignments that are evaluated/graded (e.g., exams, papers, tutorials, etc.) are often seen as formal assessment techniques.

While evaluation is an important component of most classrooms, it does have some limitations. For example, if the class average on an exam is a 45%, it seems pretty clear that something went wrong along the way. When one has only evaluated the final learning product, it can be challenging to go back and discover what happened. It can also be difficult to address the situation or provide opportunities for students to learn from their mistakes. Yes, a curve on an exam can help address a low dass average, but does it help the students learn? Engaging in informal assessment activities throughout the course can help avoid this situation.

What is involved in the assessment process?

1. Establishing expected learning outcomes for the course;
2. Systematically gathering, analyzing, and interpreting evidence (through formal assessment activities such as exams or papers and informal assessment activities such as in-class discussions exercises) to determine how well the students' learning matches:
   - faculty expectations for what students will learn and
   - the stated expected learning outcomes for the course
3. Faculty members should use this evidence/assessment of student learning to:
   - provide questionary to students about their learning (or lack thereof) and
   - adjust their teaching methods and/or students' learning behaviors to ensure greater student learning (Maki, 2006).

The Best Practice in a Classroom Assessment and is an example of a method that can be used to assess learning outcomes. At the end of a class period or major topic, faculty ask students to anonymously write down what point(s) were the most unclear to them. After class, faculty members review these responses and then re-teach or re-address any confusing topics, thus increasing student learning (Angelo & Cross, 1993).

IX. WRITING A COURSE PURPOSE

Determining the PURPOSE of teaching the course

When planning a course and determining the Learning Outcomes for that course, it is important to examine the course's purpose within the context of the college, and/or the department/program. This process will assist faculty in determining the intent of the course as well as how the course fits into the curriculum. This will help identify the essential knowledge, skills, etc. that should be incorporated into the course and the stated expected learning outcomes for the course. The course purpose section should clarify the course's standing within the programme (e.g., is the course required or an elective?, does this class have a pre-requisite?, etc.). It should also describe the course's role in the departmental/programmatic curriculum by addressing the intent (importance, main contribution, intrinsic value, etc.) of the class.

STEP ONE: Determine if the course is part of the ASME / I Mech E / AICTE Model Curriculum

The earliest curriculum was published in 1970 for CAD-CAM in American Universities like MIT, Leigh University and it was introduced in the late 1990s in Indian Universities. MHRD, Govt. of India has funded towards the establishment of National Institutes (CITD) and Indo German Collaboration and this helped promoting of CAD-CAM in India. The core curriculum covers basics of CAD-CAM and followed by AICTE model curriculum. This course was introduced at under graduate level and also Laboratory exercises were framed with the advent of introduction of CAD-CAM software in India.

STEP TWO: Determine how the course fits into the departmental curriculum

Here are some questions to ask to help determine how a course fits in the departmental curriculum:

What role does the course play in the departmental/programmatic curriculum?

- Is this course required?
- Is this course an elective?
- Is this course required for some students and an elective for others?
- Does this class have a pre-requisite?
- Is this class a pre-requisite for another class in the department?
- Is this course part of ASME / IMechE / AICTE Model Curriculum?

How advanced is this course?

- Is this course an undergraduate or graduate course?
- Where does this course fall in students' degree plan - as an introductory course or an advanced course?
- Can I expect the students taking this course to know anything about the course topic?
- Are other faculty members counting on students who have taken this course to have mastered certain knowledge or skills?

When students leave this course, what do they need to know or be able to do?

- Is there specific knowledge that the students will need to know in the future?
- Are there certain practical or professional skills that students will need to apply in the future?
- Five years from now, what do you hope students will remember from this course?

What is it about this course that makes it unique or special?

- Why does the program or department offer this course?
- Why can't this course be "covered" as a sub-section of another course?
- What unique contributions to students' learning experience does this course make?

- What is the value of taking this course? How exactly does it enrich the program or department?

X. WRITING EXPECTED LEARNING OUTCOMES FOR A COURSE

The following pages should be of assistance in developing several broad, effectively stated expected learning outcomes for a course. When beginning to construct expected learning outcome statements, it is always good to think about the learners.
Please take a moment to think about the student learners in the course. Please consider the following questions:

- What are the most essential things the students need to know or be able to do at the end of this course?
- What knowledge and skills will they bring with them?
- What knowledge and skills should they learn from the course?
  When you begin thinking about the expected learning outcomes for a course, it is a good idea to think broadly. Course-level expected learning outcomes do not need to focus on small details; rather, they address entire classes of theories, skill sets, topics, etc.

The "Course Description" contains the following contents: **(Annexure - A)**

- Course Overview
- Prerequisite(s)
- Marks Distribution
- Evaluation Scheme
- Course Objectives
- Course Outcomes
- How Course Outcomes are assessed
- Syllabus
- List of Text Books / References / Websites /Journals / Others
- Course Plan
- Mapping course objectives leading to the achievement of the programme outcomes
- Mapping course outcomes leading to the achievement of the programme outcomes

XI. REFERENCES

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INSTITUTE OF AERONAUTICAL ENGINEERING

(Autonomous)

Dundigal, Hyderabad -500 043

MECHANICAL ENGINEERING

COURSE DESCRIPTOR

Course Title	**DESIGN FOR MANUFACTURING AND ASSEMBLY**				
Course Code	BCCC04				
Programme	M. Tech				
Semester	I	ME-CAD/CAM			
Course Type	Foundation				
Regulation	IARE – PG21				
Course Structure	**Theory**			**Practical**	
	Lectures	**Tutorials**	**Credits**	**Laboratory**	**Credits**
	3	-	3	-	-
Chief Coordinator	Dr. K. China Apparao, Associate Professor, ME				

I. COURSEPRE-REQUISITES:

Level	Course Code	Semester	Prerequisites	Credits
UG	AMEB06	IV	PRODUCTION ENGINEERING	3

II. COURSE OVER VIEW:

To provide an overview of Design for Manufacturing and Assembly (DFMA) techniques, which are used to minimize product cost through design and process improvements. Design for Manufacturing (DFM) and Design for Assembly (DFA) are now commonly referred to as a single methodology, Design for Manufacturing and Assembly (DFMA). This course bridges gap between design and manufacturing, it introduces the principles of design for developing the product, which includes design considerations in casting, forging, metal forming and in welding.

III. MARKS DISTRIBUTION:

Subject	SEE Examination	CIA Examination	Total Marks
DESIGN FOR MANUFACTURING AND ASSEMBLY	70 Marks	30 Marks	100

IV. DELIVERY / INSTRUCTIONAL METHODOLOGIES:

✔	Chalk & Talk	✔	Quiz	✔	Assignments	✗	MOOCs
✔	LCD / PPT	✔	Seminars	✗	Mini Project	✔	Videos
✔	Open Ended Experiments						

V. EVALUATION METHODOLOGY:

The 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). Out of 30 marks allotted for CIA during the semester, marks are awarded by taking average of two CIA examinations or the marks scored in the make-up examination.

Semester End Examination (SEE): The SEE is conducted for 70 marks of 3hours duration. The syllabus for the theory courses is divided into five modules and each module 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 unit. Each question carries 14 marks. **There could be a maximum of two sub divisions in a question.**

The expected percentage of cognitive level of the questions is broadly based on the criteria given in Table: 1.

Table 1: The expected percentage of cognitive level of questions in SEE

Percentage of Cognitive Level	Blooms Taxonomy Level
20 %	Remember
70 %	Understand
10 %	Apply
00 %	Analyze

Continuous Internal Assessment (CIA):

CIA is conducted for a total of 30 marks (Table 2), with 25 marks for Continuous Internal Examination (CIE), 05 marks for Quiz and 05 marks for Alternative Assessment Tool (Table 3).

Table 2: Assessment pattern for CIA

Component	**Theory**			**Total Marks**
Type of Assessment	**CIE Exam**	**Quiz**	**AAT**	
CIA Marks	20	05	05	30

Continuous Internal Examination (CIE):

Two CIE exams shall be conducted at the end of the 8th and 16th week of the semester respectively. The CIE exam is conducted for 20 marks of 2 hours duration consisting of five descriptive type questions out of which four questions have to be answered where, each question carries 5 marks. Marks are awarded by taking average of marks scored in two CIE exams.

Quiz/Alternative Assessment Tool (AAT):

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are be answered by choosing the correct answer from a given set of choices (commonly four). Marks shall be awarded considering the average of two quizzes for every course. The AAT may include seminars, assignments, term paper, open ended experiments, five minutes video and MOOCs.

VI. COURSE OBJECTIVES:

The students will try to learn:	
I	The techniques of Design for Manufacturing and Assembly applied for minimizing product cost through design and process improvements.
II	The selection of material and process used in the prototype design in the early stages of product development for cost effectiveness.
III	The pattern movement in assembly process, assembly errors and minimization steps by considering logical sub-assemblies and re-orientation of parts during machining.

VII. COURSE OUTCOMES:

At the end of the course students are able to:		
	Course Outcomes	**KnowledgeLevel (Bloom's Taxonomy)**
CO 1	**Interpret the specific materials compatible with existing production processes that will minimize processing time and functional requirements.**	Understand
CO 2	**Identify the concepts of Design for Manufacture and Assembly (DFMA) for product development which minimizes part count in manufacturing process.**	Apply
CO 3	**Make use of the suitable materials for product manufacturing in engineering applications to eliminate expensive and complex features.**	Apply
CO 4	**Identify various defects and shortcomings during permanent joining operations such as TIG, MIG and Spot welding for real time applications.**	Apply
CO 5	**Analyze the manufacturing defects as well as material characterization and its application.**	Analyze
CO 6	**Examine the appropriate manufacturing process parameters, for effective optimization of prototype / products.**	Analyze

VIII. PROGRAM OUTCOMES

Program Outcomes (POs)	
PO 1	Apply advanced level knowledge, techniques, skills and modern tools in the field of computer aided engineering to critically assess the emerging technological issues.
PO 2	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.
PO 3	Conduct experimental, and analytical studies, analyzing results with scientific methods and use of software
PO 4	Write and present a substantial technical report/document.

PO 5	Independently carry out research/investigation and development work to solve practical problems.
PO 6	Design and validate technological solutions to improve the defined problems as well as engage in lifelong learning through continuing education.

IX. HOW PROGRAM OUTCOMES AREASSESSED:

Program Outcomes (POs)		Strength	Proficiency assessed by
PO 1	Apply advanced level knowledge, techniques, skills and modern tools in the field of computer aided engineering to critically assess the emerging technological issues.	2	SEE/CIA
PO 2	Function on multidisciplinary environments by working cooperatively, creatively and responsibly as a member of a team.	1	SEE/CIA
PO 4	Write and present a substantial technical report/document.	1	SEE/CIA

3 = High; 2 = Medium; 1 = Low

X. MAPPING OF EACH CO WITH PO(s),

Course Outcomes	Program Outcomes					
	1	2	3	4	5	6
CO 1	√	√				
CO 2	√	√				
CO 3		√				
CO 4		√				
CO 5		√				
CO 6				√		

XI. COURSE ARTICULATION MATRIX (CO-PO/PSO MAPPING)

Course Outcomes	Program Outcomes					
	1	2	3	4	5	6
CO 1	3	1	-	-	-	-
CO 2	3	1	-	-	-	-
CO 3	-	1	-	-	-	-
CO 4	-	2	-	-	-	-
CO 5	-	1	-	-	-	-
CO 6	-	-	-	1	-	-
TOTAL	6	6		1		
AVERAGE	**2.0**	**1.0**		**1.0**		

XII. ASSESSMENTMETHODOLOGIES–DIRECT

CIE Exams	✔	SEE Exams	✔	Assignments	✔	Seminars	✔
Laboratory Practices	✔	Student Viva	✔	Mini Project	✔	Certification	-

XIII. ASSESSMENTMETHODOLOGIES-INDIRECT

✔	Early Semester Feedback	✔	End Semester OBE Feedback
✔	Assessment of Mini Projects by Experts		

XIV. SYLLABUS

UNIT-I	**INTRODUCTION TO DESIGN**	**Classes:09**
Introduction: Design philosophy steps in design process, general design rules for manufacturability, basic principles of design Ling for economical production, creativity in design; Materials selection of materials for design developments in material technology, criteria for material selection, material selection interrelationship with process selection process selection charts.		
UNIT-II	**MACHINING PROCESS**	**Classes:09**
Machining process: Overview of various machining processes, general design rules for machining, dimensional tolerance and surface roughness, design for machining, ease of redesigning of components for machining ease with suitable examples. General design recommendations for machined parts; Metal casting: Appraisal of various casting processes, selection of casting processes, general design considerations for casting, casting tolerances, use of solidification simulation in casting design, product design rules for sand casting.		
UNIT- III	**METAL JOINING**	**Classes:09**
Metal joining: Appraisal of various welding processes, factors in design of weldments, general design guidelines, pre and post treatment of welds, effects of thermal stresses in weld joints, design of brazed joints; Forging, design factors for forging, closed dies forging design, parting lines of die drop forging die design general design recommendations. Extrusion and sheet metal work: Design guidelines for extruded sections, design principles for punching, blanking, bending, deep drawing, Keeler Goodman forming line diagram, component design for blanking.		
UNIT- IV	**ASSEMBLY ADVANTAGES**	**Classes:09**
Assembly advantages: Development of the assemble process, choice of assemble method assemble advantages social effects of automation, automatic assembly transfer systems: Continuous transfer, intermittent transfer, indexing mechanisms, and operator, paced free, transfer machine.		
UNIT-V	**DESIGN OF MANUAL ASSEMBLY**	**Classes:09**
Design of manual assembly: Design for assembly fits in the design process, general design guidelines for manual assembly, development of the systematic DFA methodology, assembly efficiency, classification system for manual handling, classification system for manual insertion and fastening, effect of part symmetry on handling time, effect of part thickness and size on handling time, effect of weight on handling time, parts requiring two hands for manipulation, effects of combinations of factors, effect of symmetry effect of chamfer design on insertion operations, estimation of insertion time.		
Text Books:		
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Reference Books:		

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XV. COURSEPLAN

The course plan is meant as a guideline. Probably there may be changes.

Lecture No	Topics to be covered	Course Learning Outcomes	Reference
OBE DISCUSSION			
1	Course Description on Outcome Based Education (OBE): Course Objectives, Course Outcomes (CO), Program Outcomes (PO) and CO-PO Mapping	-	
CONTENT DELIVERY (THEORY)			
2	Introduction: Design philosophy steps in design process.	CLO 1	T1:1.7 R1:3.7
3	General design rules for manufacturability	CLO 1	T1:1.7 R1:3.8
4	General design rules for manufacturability	CLO 1	T1:1.7 R1:3.8
5	Basic principles of design Ling for economical production	CLO 2	T1:1.8 R1:3.12
6	Basic principles of design Ling for economical production	CLO 2	T1:1.8 R1:3.12
7	Creativity in Design	CLO 2	T1:1.8 R1:3.13
8	Materials selection of materials for design developments	CLO 3	T1:3.1 R1:3.13
9	Materials selection for design developments in material technology	CLO 3	T1:3.1 R1:3.14
10	Materials selection for design developments in material technology	CLO 3	T1:3.1 R1:3.14
11	Criteria for material selection	CLO 3	T1:2.1 R1:4.2
12	Material selection interrelationship with process selection	CLO 3	T1:3.1 R1:3.14
13	Material selection interrelationship with process selection charts.	CLO 3	T1:2.1 R1:4.3
14	Material selection interrelationship with process selection charts.	CLO 3	T1:2.1 R1:4.3
15	Machining process: Overview of various machining processes.	CLO 4	T1:3.3 R1:3.14
16	Machining process: Overview of various machining processes.	CLO 4	T1:3.3 R1:3.15
17	General Design rules for machining	CLO 4	T1:4.1 R1:4.4
18	General Design rules for dimensional tolerance	CLO 4	T1:4.1 R1:4.5
19	General Design rules for surface roughness	CLO 4	T1:4.1 R1:4.6

20	General Design rules for dimensional tolerance and surface roughness	CLO 4	T1:4.1 R1:4.6
21	Metal casting: Appraisal of various casting processes.	CLO 5	T1:5.1 R1:5.2
22	Metal casting: Appraisal of various casting processes	CLO 5	T1:5.1 R1:5.2
23	Metal casting: selection of casting process	CLO 5	T1:5.1 R1:5.3
24	General design considerations for casting and casting tolerances	CLO 6	T1:6.1 R1:7.2
25	Use of solidification simulation in casting design.	CLO 6	T1:6.1 R1:7.3
26	Product design rules for sand casting.	CLO 6	T1:6.1 R1:7.4
27	Metal joining: Appraisal of various welding processes.	CLO 7	T1:6.6 R:7.4
28	Factors in design of weldments, general design guideline.	CLO 7	T1:6.7 R:7.4
29	Pre and post treatment of welds.	CLO 7	T1:6.11 R1:8.5
30	Effects of thermal stresses in weld joints, design of brazed joints.	CLO 7	T1:6.11 R1:8.6
31	Forging, design factors for forging	CLO 8	T1:7.1 R1:6.5
32	Closed dies forging design,	CLO 8	T1:7.1 R1:6.5
33	Parting lines of die drop forging	CLO 8	T1:8.1 R3:3.2
34	Die design general design recommendations	CLO 8	T1:8.1 R3:3.3
35	Extrusion and sheet metal work: Design guidelines for extruded sections.	CLO 9	T1:9.1 R3:3.4
36	Design principles for punching, blanking	CLO 9	T1:9.5 R3:4.4
37	Design principles for punching, blanking	CLO 9	T1:9.5 R3:4.4
38	Bending, deep drawing, Keeler Goodman forming line diagram,	CLO 10	T1:10.1 R3:5.3
39	Component design for blanking.	CLO 10	T1:10.4 R3:7.2
40	Assembly advantages: Development of the assemble process	CLO 11	T1:10.8 R3:7.6
41	Assembly advantages: Development of the assemble process	CLO 11	T1:10.8 R3:7.6
42	Choice of assemble method assemble, advantages social effects of automation	CLO 12	T1:10.9 R3:7.7
43	Indexing mechanisms, and operator, paced free, transfer machine.	CLO 13	T1:10.10 R3:7.8
44	Indexing mechanisms, and operator, paced free, transfer machine.	CLO 13	T1:10.10 R3:7.8
45	Design of manual assembly: Design for assembly fits in the design	CLO 13	T1:15.1

	process		R3:7.9
46	Design for assembly fits in the design process	CLO 13	T1:15.1 R3:7.10
47	Design for assembly fits in the design process	CLO 13	T1:15.1 R3:7.10
48	General design guidelines for manual assembly	CLO 14	T1:13.5 R3:9.2
49	development of the systematic DFA methodology	CLO 14	T1:13.5 R3:9.2
50	Assembly efficiency,	CLO 14	T1:13.7 R3:9.4
51	Classification system for manual handling.	CLO 14	T1:13.7 R3:9.4
52	Classification system for manual handling,	CLO 14	T1:13.7 R3:9.4
53	Classification system for manual insertion	CLO 15	T1:13.8
54	Classification system for fastening.	CLO 15	T1:13.9
55	Effect of part symmetry on handling time.	CLO 15	T1:13.9
56	Effect of part thickness and size on handling time.	CLO 14	T1:13.6 R3:10.3
57	Effect of weight on handling time	CLO 14	T1:13.6 R3:10.3
58	Parts requiring two hands for manipulation.	CLO 15	T1:13.9 R3:12.3
59	Effects of combinations of factors.	CLO 15	T1:13.9 R3:12.3
59	Effect of symmetry effect of chamfer design on insertion operations,	CLO 16	T1:14.8 R3:12.6
60	Estimation of insertion time.	CLO 16	T1:14.8 R3:12.6

XVI. GAPS IN THE SYLLABUS - TO MEET INDUSTRY / PROFESSIONREQUIREMENTS:

S No	Description	Proposed actions	Relevance with POs
1	Assembly efficiency, classification system for manual handling	Industrial visits	PO1, PO2, PO4
2	Design of manual assembly	Seminar/ industrial visit	PO4
3	CAD application in design for manufacturing and assembly	Seminar	PO3

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