# INSTITUTE OF AERONAUTICAL ENGINEERING

**(Autonomous)**
Dundigal, Hyderabad -500 043

## MECHANICAL ENGINEERING

## COURSE DESCRIPTOR

| | | | | | |
|---|---|---|---|---|---|
| **Course Title** | **MANUFACTURING PROCESS** | | | | |
| **Course Code** | AMEB05 | | | | |
| **Programme** | B.Tech | | | | |
| **Semester** | THREE | | | | |
| **Course Type** | Core | | | | |
| **Regulation** | IARE - R18 | | | | |
| **Course Structure** | **Theory** | | | **Practical** | |
| | **Lectures** | **Tutorials** | **Credits** | **Laboratory** | **Credits** |
| | 3 | 0 | 4 | 2 | 1 |
| **Course Faculty** | Dr. Ch Sandeep, Associate Professor | | | | |

## I. COURSE OVERVIEW:

The primary objective of this course is to introduce the concept of manufacturing technology with the help of various processes widely employed in industries. The course consists of casting, welding, sheet metal forming, extrusion and forging processes with the related details of equipment and applications. Introduces the different manufacturing processes and breakeven analysis. Engineering materials, laying emphasis on ferrous and non-ferrous materials along with the heat treatment of metals. Discusses the special casting processes and metal-forming processes respectively.

## II. COURSE PRE-REQUISITES:

| Level | Course Code | Semester | Prerequisites | Credits |
|---|---|---|---|---|
| UG | AMEB01 | II | Workshop Manufacturing Practices Laboratory | 1.5 |

## III. MARKS DISTRIBUTION:

| Subject | SEE Examination | CIA Examination | Total Marks |
|---|---|---|---|
| Manufacturing Process | 70 Marks | 30 Marks | 100 |

## IV. DELIVERY / INSTRUCTIONALMETHODOLOGIES:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| ✘ | 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 3 hours 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 module. 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 |
|---|---|
| 10 % | Remember |
| 50 % | Understand |
| 25 % | Apply |
| 15 % | Analyze |
| 0 % | Evaluate |
| 0 % | Create |

**Continuous Internal Assessment (CIA):**

CIA is conducted for a total of 30 marks (Table 2), with 20 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 - Online Examination**

Two Quiz exams shall be online examination consisting of 25 multiple choice questions and are to be answered by choosing the correct answer from a given set of choices (commonly four). Such a question paper shall be useful in testing of knowledge, skills, application, analysis, evaluation and understanding of the students. Marks shall be awarded considering the average of two quiz examinations for every course.

**Alternative Assessment Tool (AAT)**

This AAT enables faculty to design own assessment patterns during the CIA. The AAT converts the classroom into an effective learning centre. The AAT may include tutorial hours/classes, seminars, assignments, term paper, open ended experiments, METE (Modeling and Experimental Tools in Engineering), five minutes video, MOOCs etc.

Table 3: Assessment pattern for AAT

| 5 Minutes Video | Assignment | Tech-talk | Seminar | Open Ended Experiment |
|---|---|---|---|---|
| 20% | 30% | 30% | 10% | 10% |

## VI. COURSE OBJECTIVES:

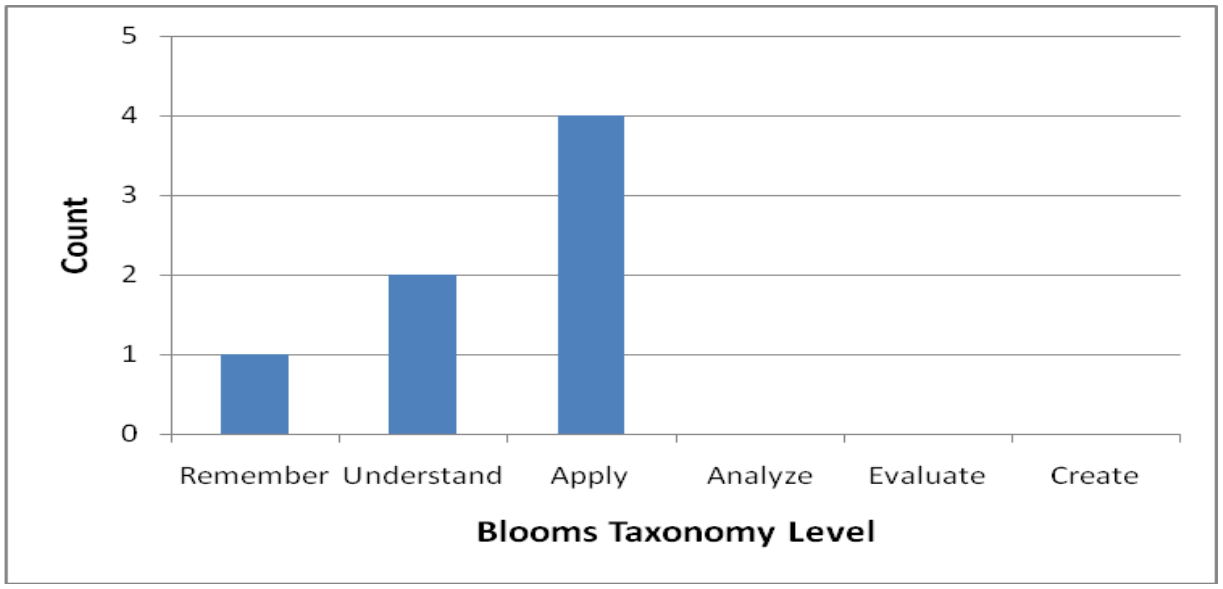
| The students will try to learn: | |
|---|---|
| I | The Importance of manufacturing sciences in the day-to-day life, and study the basic manufacturing processes and tools used. |
| II | The knowledge in thermal, metallurgical aspects during casting and welding for defect free manufacturing components. |
| III | Design features that make each of these manufacturing process both harder, easier, assess design and manufacturing features on real products |

## VII. COURSE OUTCOMES:

| At the end of the course students are able to: | | |
|---|---|---|
| | **Course Outcomes** | **Knowledge Level (Bloom's Taxonomy)** |
| CO1 | **Outline** the steps involved in making a casting the desired pattern for automotive industry components cylinder heads, engine blocks etc. | Remember |
| CO2 | **Design** the gating and riser system needed for casting requirements to achieve defect/error free components | Apply |
| CO3 | **Categorize** various defects and shortcomings during gas welding operation such as TIG, MIG and Spot welding etc. for real time applications. | Understand |
| CO4 | **Illustrate** the properties and bonding techniques of plastics and various plastic molding techniques. | Understand |

| | | |
|---|---|---|
| CO5 | **Apply** the appropriate metal forming techniques, for producing components like hexagonal bolt, nut etc., | Apply |
| CO6 | **Explain** the working principle of hot and cold extrusion processes and their application in industries for making of pipes and tubes. | Apply |
| CO7 | **Analyze** the manufacturing defects as well as material characterization and its application. | Apply |
| CO8 | **Classify** the various forging techniques based on functionality, cost and time in development of critical products. | Understand |
| CO9 | **Evaluate** the appropriate manufacturing process parameters, for effective optimization of prototype / products. | Apply |

## COURSE KNOWLEDGE COMPETENCY LEVELS




## VIII. HOW PROGRAM OUTCOMES ARE ASSESSED:

| Program Outcomes | | Strength | Proficiency Assessed by |
|---|---|---|---|
| PO 1 | **Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems. | 3 | CIE/Quiz/AAT |
| PO 2 | **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. | 3 | CIE/Quiz/AAT |
| PO 3 | **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. | 2 | Seminar/ conferences/ Research papers |
| PO 4 | **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. | 2 | Discussion on Innovations/ Presentation |

**3 = High; 2 = Medium; 1 = Low**

## IX. HOW PROGRAM SPECIFIC OUTCOMES ARE ASSESSED:

| Program Specific Outcomes | | Strength | Proficiency assessed by |
|---|---|---|---|
| PSO 1 | Formulate and evaluate engineering concepts of design, thermal and production to provide solutions for technology aspects in digital manufacturing. | 2 | Research papers/ Industry exposure |
| PSO 2 | Focus on ideation and research towards product development using additive manufacturing, CNC simulation and high speed machining. | 2 | Research papers/ Group discussion/ Short term courses |
| PSO 3 | Make use of computational and experimental tools for creating innovative career paths, to be an entrepreneur and desire for higher studies. | 2 | Research papers / Industry exposure |

**3 = High; 2 = Medium; 1 = Low**

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

| Course Outcomes | Program Outcomes | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO 1 | √ | | | | | | | | | | | | | | |
| CO 2 | √ | √ | | | | | | | | | | | | | |
| CO 3 | | | | √ | | | | | | | | | | | |
| CO 4 | | | √ | | | | | | | | | | | | |
| CO 5 | | √ | √ | | | | | | | | | | | | √ |
| CO 6 | √ | √ | √ | | | | | | | | | | | | √ |
| CO 7 | √ | √ | √ | | | | | | | | | | | | √ |
| CO 8 | √ | √ | | | | | | | | | | | | | |
| CO 9 | √ | √ | | | | | | | | | | | | | |

## XI. JUSTIFICATIONS FOR CO – (PO, PSO) MAPPING –DIRECT:

| Course Outcomes | POs / PSOs | Justification for mapping (Students will be able to) | No. of key competencies |
|---|---|---|---|
| CO 1 | PO 1 | Recall (knowledge) the basic steps involved in design and manufacturing and identify the importance of system by (apply), implementing (complex) various techniques using **Scientific Principles** of Methodology using mathematics and **engineering fundamentals.** | 2 |
| CO 2 | PO 1 | Identify (knowledge) in suitable methods involved in design, casting to achieve error free components using in *solving (complex) engineering problems* by applying the principles of **mathematics and engineering fundamentals**. | 2 |
| | PO 2 | Understand the given **problem statement** and **apply data validation techniques** to **solve** *(complex) specific engineering problems related* to design**.** | 3 |

| | | | |
|---|---|---|---|
| **CO 3** | **PO 4** | Investigate prototype models based on constraint including **Environmental sustainability**, **Health and safety risks assessment issues** and define specific problem | **2** |
| **CO 4** | **PO 3** | **Identify** the various properties of Bonding techniques using **analytical and mathematical process**. | **3** |
| **CO 5** | **PO 2** | Make use of the metal forming techniques used in **Design, Model Creation** and **Validation of component** Parts *by* **Problem Analysis.** | **4** |
| | **PO 3** | Understand the given **problem statement** related to their working principle and based upon type of **manufacturing process**. | **2** |
| | **PSO 3** | Build practical experience in building the real time products, using **industry standard tools and collaboration technique** in the field of Manufacturing System. | **2** |
| **CO 6** | **PO 1** | Apply the basic **mathematical principles** used in formulation of **engineering problems** | **2** |
| | **PO 2** | Understand the working principle used in Hot & Cold Working Process by **Natural Science and Engineering Sciences.** | **2** |
| | **PSO 3** | Identify the principle involved in Hot & Cold Extrusion process by **Qualitative & Quantitative methods** to their engineering problems. | **2** |
| **CO 7** | **PO 1** | Develop (knowledge, understand and apply) the basic tools used for *engineering problems* by applying the principles of **mathematics and engineering fundamentals**. | **2** |
| | **PO 2** | Identify the manufacturing defects as well as material characterization of **model & validating the data results**. | **2** |
| | **PO 3** | **Understand the user needs** of user-defined problems, **use creativity** in building prototype applying the methods of model analyses **for innovative solutions, evaluate the outcomes to achieve engineering objectives**. | **5** |
| | **PSO 3** | Build practical experience in designing Prototype model, using **industry standard tools and collaboration technique** in the field of Manufacturing. | **2** |
| **CO 8** | **PO 1** | Explain (understand) the process parameter using *(complex) the functions of engineering problems* by applying the principles of **mathematics and engineering fundamentals.** | **2** |
| | **PO 2** | Categorise the concept of Forging Techniques based upon the information and data collection in *engineering problems.* | **4** |
| **CO 9** | **PO 1** | Make use of the process parameters used in Manufacturing for solving the errors in real time *engineering problems* by applying the principles of **mathematics and engineering fundamentals.** | **2** |
| | **PO 2** | Develop a prototype model for real time scenario using **industry standard tools and collaboration technique**s. | **4** |

## XII. TOTAL COUNT OF KEY COMPETENCIES FOR CO – (PO, PSO) MAPPING:

| **Course Outcomes** | **Program Outcomes / No. of Key Competencies Matched** | | | | | | | | | | | | **PSO/ No. of key competencies** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **1** | **2** | **3** |
| | **3** | **10** | **10** | **11** | **1** | **5** | **3** | **3** | **12** | **5** | **12** | **12** | **6** | **2** | **2** |

| | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **CO 1** | 2 | | | | | | | | | | | | | | |
| **CO 2** | 2 | 3 | | | | | | | | | | | | | |
| **CO 3** | | | | 2 | | | | | | | | | | | |
| **CO 4** | | | 3 | | | | | | | | | | | | |
| **CO 5** | | 4 | 2 | | | | | | | | | | | | 2 |
| **CO 6** | 2 | 2 | | | | | | | | | | | | | 2 |
| **CO 7** | 2 | 2 | | | | | | | | | | | | | 2 |
| **CO 8** | 2 | 4 | | | | | | | | | | | | | |
| **CO 9** | 2 | 4 | | | | | | | | | | | | | |

## XIII. PERCENTAGE FOR KEY COMPETENCIES FOR CO-(PO, PSO):

| **Course Outcomes** | **Program Outcomes /No. of key competencies** | | | | | | | | | | | | **PSO / No. of key competencies** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** | **9** | **10** | **11** | **12** | **1** | **2** | **3** |
| | **3** | **10** | **10** | **11** | **1** | **5** | **3** | **3** | **12** | **5** | **12** | **12** | **6** | **2** | **2** |
| **CO 1** | 66.7 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **CO 2** | 66.7 | 30.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **CO 3** | 0.0 | 0.0 | 0.0 | 18.18 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **CO 4** | 0.0 | 0.0 | 30.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **CO 5** | 0.0 | 40.0 | 20.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 |
| **CO 6** | 66.7 | 20.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 |
| **CO 7** | 66.7 | 20.0 | 50.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 100.0 |
| **CO 8** | 66.7 | 40.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| **CO 9** | 66.7 | 40.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |

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

COs and POs and COs and PSOs on the scale of 0 to 3, **0** being **no correlation**, **1** being the **low correlation**, **2** being **medium correlation** and **3** being **high correlation**.

**0** – **0**≤ ***C***≤ 5%–No correlation;
**1** – 5 <***C***≤ 40%– Low/ Slight;
**2** − 40 % <***C***< 60% –Moderate.
**3** – 60% ≤ ***C***< 100% – Substantial /High

| Course Outcomes | Program Outcomes | | | | | | | | | | | | Program Specific Outcomes | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 1 | 2 | 3 |
| CO 1 | 3 | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| CO 2 | 3 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| CO 3 | - | - | - | 1 | - | - | - | - | - | - | - | - | - | - | - |
| CO 4 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| CO 5 | - | 1 | - | - | - | - | - | - | - | - | - | - | - | - | 3 |
| CO 6 | 3 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | 3 |
| CO 7 | 3 | 1 | 2 | - | - | - | - | - | - | - | - | - | - | - | 3 |
| CO 8 | 3 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| CO 9 | 3 | 1 | - | - | - | - | - | - | - | - | - | - | - | - | - |
| TOTAL | 18 | 6 | 2 | 1 | | | | | | | | | | | 9 |
| AVERAGE | **3.0** | **1.0** | **2.0** | **1.0** | | | | | | | | | | | **3.0** |

## XV. ASSESSMENT METHODOLOGY –DIRECT

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CIE Exams | PO 1,PO 2 | SEE Exams | PO 1,PO 2 PO 4 | Assignments | PO 1,PO 2, PO 5 | Seminars | PO 9, PO 10, PO 12 |
| Laboratory Practices | - | Student Viva | - | Mini Project | - | Certification | - |
| Term Paper | PO 4 | 5 Minutes Video | PO 5 | Tech talk | PO 10 | Open Ended Experiments | PO 12 |

## XVI. ASSESSMENT METHODOLOGY -INDIRECT

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

## XVII. SYLLABUS

| MODULE-I | CASTING |
|---|---|
| Casting: Steps involved in making a casting, its applications, patterns and types of patterns, pattern allowances and their construction, types of casting processes, solidification of casting. | |
| **MODULE-II** | **WELDING** |
| Welding: Welding types, Oxy-fuel gas welding, cutting, standard time and cost calculations, arc welding Process, forge welding, resistance welding, thermit welding. Inert gas welding, TIG welding, MIG welding, friction welding, induction pressure welding, explosive welding, electron beam welding, laser welding, soldering and brazing. Heat affected zone in welding, welding defects, causes and remedies, destructive and non-destructive testing of welds. | |

| Module-III | METAL FORMING |
|---|---|
| Forming: Hot working, cold working, strain hardening, recovery, re-crystallization and grain growth, comparison of properties of cold and hot worked parts, rolling fundamentals, theory of rolling, types of rolling mills and products; Forces in rolling and power requirements, stamping, forming and other cold.<br><br>Working processes: Blanking and piercing, bending and forming, drawing and its types, wire drawing and tube drawing; coining; hot and cold spinning, types of presses and press tools, forces and power requirements for the above operations. | |
| **MODULE-IV** | **EXTRUSION AND RAPID PROTOTYPING** |
| Extrusion of Metals: Basic extrusion process and its characteristics, hot extrusion and cold extrusion, forward extrusion and backward extrusion, impact extrusion, extruding equipment, tube extrusion and Pipe making, hydrostatic extrusion, forces in extrusion; Additive manufacturing: Rapid prototyping and rapid tooling. | |
| **MODULE-V** | **FORGING** |
| Forging processes: Forging operations and principles, tools, forging methods, Smith forging, drop forging, roll forging, forging hammers: Rotary forging, forging defects, cold forging, swaging, forces in forging operations. | |
| **Text Books:** | |
| 1. Kalpakjian and Schmid, Manufacturing processes for engineering materials -Pearson India, 5th Edition 2014. | |
| **Reference Books:** | |
| 1. Mikell P. Groover, Fundamentals of Modern Manufacturing: Materials, Processes, and Systems John Wiley & Sons Inc., 4th Edition, 2008.<br>2. Degarmo, Black &Kohser, Materials and Processes in Manufacturing (9th Edition) John Wiley & Sons Inc., 7th Edition, 2012. | |

## XVIII. COURSEPLAN:

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

| Lecture No | Topics to be covered | Course Outcomes | Reference |
|---|---|---|---|
| 1 | Introduction to manufacturing processes. | CO 1 | T2:2.3 |
| 2 | Review on casting and pattern | CO 1 | R1:2.6 |
| 3 | Discuss the casting processes and their types | CO 2 | T1:2.6 |
| 4 | Describe the solidification of casting | CO 2 | T2:2.7<br>R1:2.18 |
| 5 | Describe the welding techniques | CO 3 | T2:2.22 |
| 6 | Discuss the effect of TIG and MIG welding | CO 3 | T2:2.25 |
| 7 | Discuss the effect of Heat affected zone in welding | CO 3 | T2:2.26<br>R1:2.55 |
| 8 | Discuss the welding defects | CO 3 | T2:2.16<br>R1:2.61 |
| 9 | Discuss the causes and remedies | CO 4 | T2:2.30<br>R1:2.58 |
| 10 | Introduction to destructive and non-destructive testing of welds. | CO 4 | T2:3.6<br>R1:4.29 |

| Lecture No | Topics to be covered | Course Outcomes | Reference |
|---|---|---|---|
| 11 | Classifying and Demonstration of metal forming | CO 5 | T2:3.14<br>R1:4.31 |
| 12 | Discuss the hot and cold working. | CO 5 | T2:3.14<br>R1:4.33 |
| 13 | Discuss the strain hardening recovery & recrystallization | CO 5 | R1:4.36 |
| 14 | Comparison of properties of cold and hot worked parts | CO 5 | T2:3.18<br>R1:4.64 |
| 15 | Introduction to rolling | CO 6 | T2:3.22 |
| 16 | Demonstration of working of rolling operations | CO 6 | T2:3.28<br>R1:4.67 |
| 17 | Classifying rolling types. | CO 6 | T2:4.2 |
| 18 | Demonstration of rolling theory | CO 6 | T2:4.3<br>R1:4.71 |
| 19 | Introduction to mills and products and stamping | CO 7 | T1:4.8<br>R2:4.68 |
| 20-21 | Demonstration of forces in rolling and their calculations | CO 7 | T2:4.15<br>R1:5.74 |
| 22 | Discuss stamping forming and other cold operations. | CO 7 | T1:4.12<br>R2:5.75 |
| 23-24 | Explanation of blanking and piercing operations | CO 7 | T1:4.8<br>R1:5.72 |
| 25 | Introduction to drawing and its types. | CO 7 | T1:5.8<br>R1:5.73 |
| 26-27 | Discuss the wire and tube drawing techniques | CO 7 | T1:5.14<br>R1:6.78 |
| 28 | Explain extrusion of metals | CO 7 | T2:5.19<br>R1:6.81 |
| 29-30 | Discuss the characteristics of extrusion types | CO 7 | T1:6.4<br>R2:6.8 |
| 31 | Describe the importance of impact and extruding equipment. | CO 8 | T2:7.7<br>R1:7.74 |
| 32-33 | Describe hydrostatic extrusion, forces in extrusion | CO 8 | T1:7.12<br>R2:8.75 |
| 34 | Introduction to Additive manufacturing | CO 8 | T1:7.8<br>R1:8.72 |
| 35 | Draw & Describe Forging operations and principles | CO 8 | T1:8.8<br>R1:8.73 |
| 36 | Discuss the tools, forging methods. | CO 9 | T1:9.14<br>R1:10.78 |
| 37-38 | Describe the Smith forging, drop forging | CO 9 | T2:9.19<br>R1:10.814 |
| 39-40 | Describe the importance of roll forging, forging hammers. | CO 9 | T1:10.4<br>R2:11.68 |
| 41-43 | Discuss the rotary forging, forging defects | CO 9 | T2:10.7<br>R1:12.74 |
| 44-45 | Describe the cold forging, swaging, forces in forging operations. | CO 9 | T1:11.12<br>R2:12.75 |

**Prepared by:**
Dr. Ch. Sandeep, Associate Professor **HOD, ME**