25UMET303	PRINCIPLES OF MANUFACTURING	Category	L	T	P	R	Credit	Year of Introduction
		PBL	3	0	0	1	4	2025

Preamble: The objective of this course is to provide students with a comprehensive understanding of the fundamental principles and processes involved in manufacturing. It introduces the concepts of casting, metal forming, joining processes, powder metallurgy, sheet metal operations, and additive manufacturing.

Prerequisite: Nil

Course Outcomes:

CO	Course Outcomes	Knowledge Level
CO1	Explain the principles of casting, metal forming, joining, powder metallurgy, and additive manufacturing processes.	K2 Understand
CO2	Apply manufacturing process principles to select suitable casting, forming, joining, and additive manufacturing methods for engineering components.	K3 Apply
CO3	Apply manufacturing concepts to identify defects, analyze failures, and recommend process improvements in engineering products.	K3 Apply
CO4	Demonstrate reverse engineering, process mapping, and manufacturing documentation to solve real-world manufacturing problems.	K3 Apply

Mapping of course outcomes with program outcomes and program specific outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	3	2	1	1	1	–	1	–	–	–	–	2	1
CO2	3	3	3	2	2	–	1	–	–	1	–	3	2
CO3	3	3	3	3	2	1	2	–	2	2	–	3	3
CO4	2	2	3	3	3	1	2	–	3	3	–	3	3
Avg	2.75	2.5	2.5	2.25	2.0	1.0	1.5	–	2.5	2.0	–	2.75	2.25

Mapping of course outcomes with Knowledge and Attitude Profile (WK)

	WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9
CO1	*	*	*	*	*	_	_	*	_
CO2	*	*	*	*	*	*	_	*	_
CO3	*	*	*	*	*	*	_	*	_
CO4	*	*	*	*	*	*	*	*	_

WKs Mapped with the course

WK1	WK2	WK3	WK4	WK5	WK6	WK7	WK8	WK9
*	*	*	*	*	*	*	*	-

Mark Distribution:

Total Marks	CIE Marks	ESE Marks	ESE Duration
100	60	40	2.5 hrs

Continuous Internal Evaluation Pattern:

Attendance : 5 marks
Continuous Assessment Test : 25 marks
Experiential Evaluation : 30 marks

SYLLABUS

Module 1 (14 hrs)

Introduction to casting, Patterns: Types and Materials-Types of Allowances; Moulding sand – gating system design, riser design; special casting process - Die casting, Precision Investment casting, Centrifugal casting, Continuous casting and Squeeze casting; defects in castings.

Plastic deformation of metals, stress-strain relationships, Yield criteria. Introduction to hot and cold working.

Module 2 (14 hrs)

Forging: Open die forging and closed die forging, Various Forging Operations, Forging machines, Forging defects – Residual stresses in forging

Rolling: Various Rolling Processes and Mills, rolling force and power, numerical problems, Defects in rolled product.

Extrusion: Hot and Cold extrusion; Extrusion equipment's; Defects in extrusion; Hydrostatic extrusion; Extrusion of tubes & seamless pipes

Drawing: Drawing process; Drawing forces, Die design and die materials; Drawing defects and residual stresses; Drawing equipment.

Module 3 (14 hrs)

Metal Joining: Classifications of Welding Processes.

Gas welding; Oxyfuel-gas Welding, Flame types and filler metals, Applications

Arc welding: Non-consumable Electrode Arc Welding processes - Gas Tungsten-arc Welding, Plasma-arc Welding; Consumable Electrode Arc Welding processes: Shielded Metal-arc Welding,

Submerged-arc Welding, Gas Metal-arc Welding, Flux-cored Arc Welding.
Electron beam Welding and Laser beam welding
Solid-State Welding Processes: Ultrasonic Welding, Friction Welding, Thermit Welding, Resistance welding.
Solidification of the Weld Metal and Heat Affected Zone, Residual Stresses, Weldability of ferrous and non-ferrous metals, Defects in welding.
Brazing - soldering - adhesive bonding

Module 4 (14 hrs)

Powder Metallurgy: Methods of Powder Production, Blending Metal Powders, Compaction of Metal Powders, Sintering, Secondary and Finishing Operations
Sheet metal operations: Shearing operations – punching and blanking, Type of Shearing Dies, Clearance and Punch and Die Shape of shearing dies.
Bending: Bending of Sheets, Plates, and Tubes, Minimum Bend Radius, Springback, Bending force.
Additive Manufacturing: Classification of AM technologies, Fused deposition Modelling (FDM), Laminated Object Manufacturing (LOM), Selective Laser Sintering (SLS) and Laser Engineered Net Shaping (LENS)

Text Books:

1. Kalpakjian, S., & Schmid, S. R., *Manufacturing engineering and technology* (6th ed.). Prentice Hall, 2009.
2. Jain, R. K*., Production technology* (17th ed.). Khanna Publishers, 2001.
3. Gibson, I., Rosen, D., Stucker, B., & Khorasani, M., *Additive manufacturing technologies* (3rd ed.). Springer, 2021.
4. American Welding Society, *Welding handbook: Welding science and technology* (Vol. 1, 9th ed.). American Welding Society, 2001.

Reference Books:

1. Beddoes, J., & Bibby, M. J., *Principles of metal manufacturing processes.* Elsevier, 2003.
2. *The Welding Institute of Metals, Metals handbook* (Vol. 5). The Welding Institute of Metals, 1977.
3. Heine, R., Loper, C., & Rosenthal, P., *Principles of metal casting*. Tata McGraw Hill, 2004.
4. Flemings, M. C., *Solidification processes*. McGraw Hill, 1974.

Project/Experiential Evaluation (30 marks)

1. **The Field Audit & Problem Identification (10 Marks) – Team Activity (group of 3-4)**

   Task: Each student must visit a local industry (e.g., local workshop / fabrication unit / foundry / sheet metal shop / welding shop) in their vicinity.

   They must identify a specific manufacturing defect or inefficiency related to the syllabus (e.g., casting defects in a local foundry, improper welding in a gate, springback issues in a bending shop, or a forging crack in a hand tool).

   Deliverables:

   Technical Diagnosis Report

   3-minute video documentation

   Evaluation Rubrics (10 marks)

Criteria	Marks

Technical Understanding	3
Defect Analysis	3
Practical Insight	2
Presentation quality	2

2. **Reverse Engineering & Process Mapping Challenge**

Task: Teams need to select a common household or industrial object (e.g. a wrench, a soda can, Bicycle rim, Spanner, Welded chair, 3D printed part).

They must "deconstruct" the manufacturing history. They will create a Process Flow Map identifying whether it was forged, rolled, or extruded, and why that specific method was chosen over others.

Deliverables:

Technical Report including product photographs, Process Flow Map (hand-drawn or software-generated) and Process selection justification

Evaluation Rubrics (10 marks)

Criteria	**Marks**
Correct process identification	3
Flow clarity	3
Process reasoning	2
Technical report	2

3. **Manufacturing Failure Analysis & Public Awareness Project**

Task: Students investigate a real-life product failure from society and analyze it using manufacturing principles learned in the course.

Each group must select a failed or defective product from real life:

Examples:

- Cracked welded gate
- Broken forged spanner
- Bent sheet metal roofing
- Leaking cast pump housing
- Failed bicycle rim
- Cracked aluminum utensil
- Worn-out powder metallurgy bush
- 3D printed component failure

Students must do the following activities

Identify

- Manufacturing process used
- Material involved
- Type of failure (fracture, porosity, distortion, residual stress, etc.)

Diagnose

- Root cause of failure
- Link to theory (gating defect, improper rolling, weld HAZ issue, springback, etc.)

Recommend

- Process improvement
- Design modification
- Alternative manufacturing method
- Sustainability consideration

Public awareness output

Students must prepare:

- A 1-page illustrated awareness poster and
  - A 2-minute awareness video explaining:
    "Why this failure happened and how to prevent it."

The awareness poster or video can be exhibited to non-department students during college exhibitions, shared with workshop owners or local technicians for practical feedback, and presented as part of NSS or community engagement activities to create public awareness about manufacturing quality and failure prevention etc.

Evaluation Rubric (10 Marks)

Criteria	**Marks**
Correct process identification	2
Root cause technical analysis	2
Link to manufacturing theory	2
Improvement suggestion quality	2
Awareness material quality	2

END SEMESTER EXAMINATION – MODEL QUESTION PAPER

Course Code	**25UMET303**
Course Name	**PRINCIPLES OF MANUFACTURING**
Max. Marks: 40	**Duration: 2.5 Hours**

Part A (Answer all questions. Each question carries 2 marks)				
Qn	**Question**	**Marks**	**CO**	**BL**

No.				
1	Explain the various types of pattern allowances provided in casting process.	2	CO 1	L2
2	Explain the working principle of centrifugal casting process.	2	CO 1	L2
3	Explain the different types of rolling mills used in metal forming operations.	2	CO 2	L2
4	Describe the various defects that occur in extrusion process.	2	CO 2	L2
5	Explain the working principle of Gas Tungsten-Arc Welding process with a neat sketch.	2	CO 3	L2
6	Describe the process of brazing and differentiate it from soldering.	2	CO 3	L2
7	Explain the various steps involved in the powder metallurgy process.	2	CO 4	L2
8	Describe the working principle of Fused Deposition Modelling process.	2	CO 4	L2
Part B (Answer any one full question from each Module. Each carries 6 marks)				
Module I				
Qn No.	**Question**	**Marks**	**CO**	**BL**
9	Explain the design considerations for gating system and riser design in a casting process, with the help of neat sketches.	6	CO 1	L2
OR				
10	Discuss the plastic deformation behaviour of metals and explain the yield criteria along with the stress-strain relationship.	6	CO 1	L2
Module II				
Qn No.	**Question**	**Marks**	**CO**	**BL**
11	A steel strip of initial thickness 25 mm is to be rolled to a final thickness of 20 mm using rolls of diameter 500 mm. Apply the principles of rolling to calculate the rolling force required, given that the average flow stress of the material is 240 MPa and the width of the strip is 300 mm. Also discuss the defects observed in rolled products.	6	CO 2	L3
OR				
12	Apply the concept of extrusion to explain the die design considerations for tube extrusion, and calculate the extrusion	6	CO 2	L3

	force required for a billet of diameter 100 mm being extruded through a die of diameter 50 mm, given the flow stress of the material as 300 MPa.			
Module III				
Qn No.	**Question**	**Marks**	**CO**	**BL**
13	Apply the principles of arc welding to select a suitable welding process for joining two austenitic stainless steel plates of 10 mm thickness, justifying your choice based on weldability and heat-affected zone considerations.	6	CO 3	L3
OR				
14	Demonstrate, with suitable sketches, how residual stresses develop during solidification of the weld metal, and apply this understanding to suggest suitable methods to minimize distortion in welded structures.	6	CO 3	L3
Module IV				
Qn No.	**Question**	**Marks**	**CO**	**BL**
15	A circular blank of diameter 40 mm is to be punched from a sheet metal of thickness 2 mm having shear strength 350 MPa. Calculate the punching force required, and apply the concept of clearance to determine the clearance to be provided between the punch and die.	6	CO 4	L3
OR				
16	Apply the concept of bending to calculate the minimum bend radius and springback for a sheet metal of thickness 3 mm, yield strength 250 MPa and modulus of elasticity 200 GPa, given that the bend angle is 90°.	6	CO 4	L3