SEMESTER 8

MECHANICAL ENGINEERING

SEMESTER S8

CRYOGENIC ENGINEERING

Course Code	PEMET861	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	PCMET403 Engineering Thermodynamics	Course Type	Theory

Course Objectives:

1. Understand the Fundamental Principles and Applications of Cryogenic Engineering
2. Analyse and Evaluate the Performance of Cryogenic Systems and Components

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to cryogenic engineering - Historical background - Major events in the development of cryogenic engineering. Low Temperature Properties of Engineering Materials - Mechanical properties, Thermal properties, Electric and magnetic properties. Cryogenic fluids (N_2, O_2, H_2, He, Ar, Ne, CH_4) and their properties. Applications of cryogenics - Applications in space, food processing, superconductivity, electrical power, biology, medicine, electronics, quantum computing, and manufacturing industry.	9
2	Cryogenic Liquefaction systems – System performance parameters, ideal liquefaction system, Joule-Thomson expansion, Adiabatic expansion. Liquefaction systems for gases other than Neon, Hydrogen and Helium- Simple Linde - Hampson system, Claude, Cascade System, and Auto-cascade system.	9

	Liquefaction systems for Neon, Hydrogen and Helium – LN_2 precooled Linde Hampson and Claude systems, Ortho to Para conversion arrangement in hydrogen liquefaction system, Simon Helium liquefaction system, Collins Helium liquefaction system. Critical components of Liquefaction systems – critical components, types of heat exchanger used in cryogenic systems and their effect on system performance.	
3	Cryogenic Refrigeration systems- Ideal isothermal and isobaric refrigeration systems, Refrigeration using liquids as refrigerant- Linde-Hampson refrigerator, Claude refrigerator. Refrigeration using gases as refrigerant- Stirling cycle cryocoolers, Philips refrigerator, Effect of regenerator effectiveness on performance of the Philips refrigerator, Gifford McMahon refrigerators, Pulse tube cryocoolers. Refrigerators using solids as working media-Magnetic refrigerators – Thermodynamics of magnetic refrigerators, dilution refrigerators.	**9**
4	Cryogenic fluid storage and transfer systems-Cryogenic fluid storage vessel, Thermal insulations and their performance at cryogenic temperatures, Super Insulations, Vacuum insulation, Powder insulation, Cryogenic fluid transfer systems, Cryo pumping. Cryogenic instrumentation, Pressure measurement – Mc Leod gauge, Pirani gauge, and Penning gauge, Flow measurement – Orifice meter, Venturi meter, and Turbine flow meter. Liquid level gauges-hydrostatic, resistance gauge, capacitance gauge, and thermodynamic gauge, Temperature measurements- ITS-90, Thermocouple, RTD, magnetic thermometers, and vapor pressure thermometers, Safety in cryogenic fluid handling, storage and use.	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Describe and analyse the mechanical, thermal, electrical, and magnetic properties of engineering materials at cryogenic temperatures and determine their suitability for various applications.	**K1, K2**
CO2	Identify and explain the properties of common cryogenic fluids and evaluate their applications in various industries	**K1, K2**
CO3	Analyse and compare different cryogenic liquefaction systems	**K2, K3**
CO4	Analyse and compare different cryogenic refrigeration systems	**K2, K3**
CO5	Demonstrate knowledge of cryogenic instrumentation techniques for pressure, flow, and temperature measurement and safety protocols for the handling, storage, and use of cryogenic fluids	**K1, K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	3	2	-	-	-	-	-	-	-	-	-	-
CO3	3	3	3	-	-	-	-	-	-	-	-	-
CO4	3	3	3	-	-	-	-	-	-	-	-	-
CO5	3	2	-	-	-	-	-	-	-	-	-	-

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Cryogenic systems	Randal F. Barron	McGraw Hill	1986
2	Fundamentals of Cryogenic Engineering	M Mukhopadhyay	PHI Learning	2010
3	Cryogenic Process Engineering	K. D. Timmerhaus and T.M. Flynn	Springer	2013
4	Cryogenics	S.S Thipse	Narrosa	2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Cryogenic Mixed Refrigerant Processes	G Venkatarathnam	International Cryogenics Monograph Series, Springer International Publishing	2007
2	Cryocoolers: Theory and Applications	M. D. Atrey (Ed)	International Cryogenics Monograph Series, Springer International Publishing	2020
3	Cryogenic Technology and applications,	A. R. Jha,	Elsevier Science	2011

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1-IV	Cryogenic Engineering, Prof. M D Atrey, IIT Bombay https://nptel.ac.in/courses/112101004

SEMESTER S8

PRESSURE VESSEL AND PIPING DESIGN

Course Code	PEMET862	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. To present the industrial related problems, procedures and design principles for pressure vessels and enhance the understanding of design procedure of pressure vessel and Design of piping layout.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Pressure vessel – Terminology – Types of loads – Types of pressure- Types of supports. Stresses in pressure vessels – Dilation of pressure vessels. Membrane stress analysis of vessel shell components- cylindrical shells, spherical shells, torus, conical head, elliptical head, (Familiarisation of corresponding ASME section 8 codes for membrane stress equations)) Discontinuity stress analysis in pressure vessels.	9
2	Stresses in thick-walled cylinders –Lame's equation for internal and external pressure, Shrink-fit stresses in Built up cylinders, auto frettage of thick cylinders. Theory of reinforced opening (Familiarisation of corresponding ASME section 8 codes for reinforcement analysis)	9
3	Design of tall vessel under wind and seismic load. Design of leg, lug and saddle supports. Buckling -Analysis of Elastic buckling of cylinders or pipes under external pressure- Design of Stiffeners for pressure vessel (Use relevant ASME codes and standard practices in pressure vessel	9

	design for the entire third module)	
4	Pipes- Size and wall thickness specification, Type of pipes based on manufacturing technique. Piping components - bends, tees, elbows, reducers, bellows, flanges and valves. Stress Analysis, sizing and thickness calculation of pipes (Familiarise with ASME B31.3). Allowable and displacement stress range for expected cyclic life-stress intensification factor- Flexibility Analysis (Analysis as per clause 119.7.1 in Code ASME B31.1/clause 319.4.1 in ASME B31.3 only)	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain the design considerations of various shell type pressure vessels	**K2**
CO2	Explain the design considerations of thick cylinders under various kind of loadings	**K2**
CO3	Apply design concepts in the design of shell and supports of vertical and horizontal pressure vessels and solve problems involving the thickness and stiffener support requirements of cylinders under buckling loads	**K3**
CO4	Solve problems involving pipe stress and flexibility analysis and also understand the fracture based design concepts of pressure vessels	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	3	-	-	-	-	-	-	-	-	-	-	-
CO3	3	3	3	-	-	-	-	-	-	-	-	-
CO4	3	3	3	-	-	-	-	-	-	-	-	-

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Theory and Design of Pressure Vessels	John F. Harvey	CBS Publisher and Distributors	
2	Process Equipment Design	Brownell, L. E., and Young, E. H.,	John Wiley and Sons	
3	Pressure Vessels Design and practice	SomnathChathopadhyay	C. R. C Press	
4	Pressure vessel design handbook	Eugene F megyesy	Pressure vessel publishing Inc	

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Pressure Vessel Design Manual	Dennis R. Moss,	Elsevier Inc	

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc23_ch69/preview
2	https://onlinecourses.nptel.ac.in/noc23_ch69/preview
3	https://onlinecourses.nptel.ac.in/noc23_ch69/preview
4	https://onlinecourses.nptel.ac.in/noc23_ch69/preview

SEMESTER S8

HYBRID AND ELECTRIC VEHICLES

Course Code	**PEMET863**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None/ (Course code)	**Course Type**	Theory

Course Objectives:

1. To understand the basic concepts of hybrid and electric vehicles.
2. To study the various energy storage and propulsion systems of hybrid and electric vehicles.
3. To study the various motor drives and controllers of hybrid and electric vehicles.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Vehicle fundamentals – general description, vehicle resistances, tractive effort, vehicle performance - maximum speed, power, gradability, etc. Electric vehicles – introduction, history, social and environmental importance of hybrid and electric vehicles, Types of EVs. EV transmission – configurations – front wheel drive and rear-wheel drive. Traction motor characteristics and comparison with IC engine characteristics. Hybrid electric vehicles – concept, architecture, classification, series, parallel, series-parallel and complex, hybrid drivetrains, the configuration of the series hybrid electric drive train, the configuration of the parallel hybrid electric drive train.	9

2	Energy storage – Battery basics, battery parameters, battery technologies - Lead-Acid Battery, Nickel-Cadmium Battery, Nickel-Metal-Hydride (NiMH) Battery, Li-Ion Battery, Li-Polymer Battery. Alternative energy sources – fuel cell, supercapacitors and ultracapacitors, flywheel (Overview only). Battery pack design, battery management system (BMS), sensors used in BMS, thermal management systems of battery, battery safety standards in India, AIS 156 (2020) and AIS 038 Rev (2020). EV charging – types, layout of AC and DC chargers, different charging protocols-CHAdeMO, CCS2, GB/T, battery swapping.	**9**
3	Electric propulsion system – electric motors, classification, induction motors, basic principles and construction, torque–slip characteristics. Permanent magnets, ferrite, SmCo and NdFeB types, PM motors-BLDC, PMSM, basic principles and construction, switched reluctance motors (SRM), basic principles and construction. Regenerative braking – principle, block diagram. Gearbox, selection of gear ratio, Different kinds of gearboxes. EV motor sizing – need of gearbox.	**9**
4	Motor controllers – motor drive components, power electronic switches, MOSFET and IGBT, bidirectional switch. Induction motor controls – constant speed/frequency control, variable DC/AC inverter with sinusoidal PWM, field orientation control. BLDC motor controls – torque control and speed control methods, principles and block diagrams. SRM drive converter - classical half-bridge converter. Vehicle Sensors specific to EV sensors interfaced to the ECU's in the vehicle network. Controller Area Networking (CAN) – frame types of CAN, layered architecture of CAN.	**9**

	Vehicle Validation - 6 levels of EV validations. Advances in electric and hybrid vehicle technology – autonomous driving, connected vehicles (overview only).	

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub-divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain the general architecture of Electric vehicles.	**K2**
CO2	Describe various battery, charging types and battery management of Electric vehicles.	**K2**
CO3	Describe various motors and drives of Electric vehicles.	**K2**
CO4	Explain details of power transmission of Electric vehicles and select the appropriate components based on requirement.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3					2	2					3
CO2	3	1				1						3
CO3	3					1						3
CO4	3					1						2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Electric and Hybrid Vehicles": Design Fundamentals	Iqbal Husain	CRC press	2nd edition, 2010
2	Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design	Mehrdad Ehsani, YimiGao, Sebastian E. Gay, Ali Emadi	CRC press	3rd edition, 2018
3	Electric Vehicle Technology Explained	James Larminie, John Lowry	Wiley-Blackwell	2nd edition, 2012

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Electric and hybrid vehicles	Denton T.	CBS Publishers & Distributors Pvt. Ltd.	2nd edition, 2020
2	Electric Vehicle Battery Systems	Dhameja S.	Newnes (an imprint of Butterworth-Heinemann Ltd)	2001

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/108106170
2	https://nptel.ac.in/courses/108106170
3	https://onlinecourses.swayam2.ac.in/ntr24_ed54/preview
4	https://onlinecourses.swayam2.ac.in/ntr24_ed54/preview

SEMESTER S8

MICRO AND NANO MANUFACTURING

Course Code	PEMET864	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Nil	Course Type	Theory

Course Objectives:

1. To give awareness of different techniques used in micro and nano manufacturing
2. To give in-depth idea of the conventional techniques used in micro manufacturing
3. To introduce Non-conventional micro-nano manufacturing and finishing approaches
4. To introduce Micro and Nanofabrication Techniques and other processing routes in
5. Micro and nano manufacturing
6. To know different techniques used in Micro Joining and the metrology tools in micro and nano manufacturing.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Precision engineering, Introduction to macro, meso, micro, and nano manufacturing - Classification —**Traditional Mechanical Micromachining Process**: Micro Turning, Micro Drilling, Micro Grinding, High-Speed Machining – Micro tools**.** Diamond micro turning- principle, process, description and applications. **Mechanical type micromachining processes** - Abrasive based nano finishing process Introduction to **beam energy based micro machining processes**- Ultrasonic micro machining, Focused Ion Beam machining, Laser Beam micro machining.	**10**

	Thermo-Electric type micromachining processes - Chemical and Electro-Chemical Type Advanced Machining Processes	
2	**Micro forming techniques**: laser micro-bending, micro-deep drawing, and micro-extrusion, Micro moulding processes: Injection moulding, hot embossing - micromolding tools-applications. Micro welding and joining techniques: Laser micro welding- Electron Beam Micro welding. **Micro/ Nano finishing processes**- Abrasive Flow Machining, Magnetic Abrasive Finishing, Magneto Rheological Abrasive Flow Machining, Magneto Rheological Finishing. Elastic Emission machining (EEM), IonBeam Machining (IBM), Chemical Mechanical Polishing (CMP)-principle, equipment and applications **Hybrid micro/nano machining** – Electro Chemical Spark Micro Machining, Electro Discharge Grinding, Electrolytic in Process Dressing Grinding. **Laser technology in micro manufacturing**- Practical Lasers, application of technology fundamentals.	**10**
3	**Characterizing etching processes in bulk micromachining**; basics of micro-fabrication, integrated circuit fabrication; crystallography and its effects, silicon as substrate and structural material, stress and strain, crystal plane effects on etching, wet etching process, reaction phenomena, anisotropic etching, isotropic etch curves, masking for anisotropic etchants, etching control, fusion bonding of silicon on an insulator, deep reactive ion etching, fabrication of a cantilever probe, manufacture, microprocessors and applications; problems with etching in bulk micromachining. **Micro fabrication Techniques:** Lithography, Thin Film Deposition and Doping, Etching and Substrate Removal, Substrate Bonding, MEMS Fabrication Techniques, Micro-fabrication using deposition techniques: epitaxial, sputtering, chemical vapour deposition (CVD) techniques. Bulk Micromachining, Surface Micromachining, High- Aspect- Ratio Micromachining, Photolithography, LIGA process.	**12**
4	**Introduction to Nanofabrication**, Nanofabrication using soft lithography – principle, applications – Examples (Field Effect Transistor, Elastic Stamp) e-Beam Nanolithography – important techniques, Introduction to Nanotechnology. **Principle of the soft lithography** and applications; principle of micro	**12**

	contact printing and applications; characterizing the surface micromachining process, isolation layer, sacrificial layer, structural material, selective etching – properties, stress, stress measurement, friction; wafer bonding: anodic and fusion, bonding. **Manipulative techniques** – process principle, applications. **Introduction toCarbon nano materials** — properties and applications, Carbon Nanotubes Transistors – (Description only) Diamond - Properties and applications, CVD Diamond Technology. **Introduction to micro-nano inspection and metrology**- Scanning electron microscopy- principle and description, Scanning white light interferometry- principle and description. Optical microscopy- principle and description. Scanning probe microscopy, Scanning tunnelling microscopy- principle, description and applications. Confocal microscopy, Atomic force microscopy- principle and description. Introduction to On-machine metrology.	

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Micro project	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Explain different techniques used in micro and nano manufacturing	**K2**
CO2	Describe conventional techniques and non-conventional micro-nano manufacturing approaches	**K2**
CO3	Outline the working principle and applications of micro and nano finishing processes	**K2**
CO4	Explain the basics of micro and nano fabrication techniques	**K2**
CO5	Select a suitable Metrology for measurement of dimensional, form, and surface integrity of components manufacturing using micro and nano Manufacturing	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	1	-	2	1	1	-
CO2	3	-	-	-	-	-	1	-	2	1	1	-
CO3	3	-	-	-	-	-	1	-	2	1	1	-
CO4	3	-	-	-	-	-	1	-	2	1	1	-
CO5	3	-	-	-	1	-	2	-	2	1	1	1

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Microfabrication and Nano manufacturing	Mark J. Jackson	Taylor and Francis-CRC press	2006
2	Micro manufacturing Processes	Jain V.K	CRC Press	2012
3	Nano Materials	Bandyopadhyay A.K	New Age International Publishers, New Delhi	2008

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Micro and Nano manufacturing	Mark. J. Jackson	Springer	2007
2	Introduction to Micromachining First edition	Jain V.K	Narosa publishing house	2017
3	MEMS and microsystems: design, manufacture, and nanoscale engineering	Hsu, Tai-Ran	John Wiley & Sons	2008

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://youtube.com/playlist?list=PLB8BC0AB0AD5DA4E2&si=5K0kjXdseqlVUSxq
2	https://youtu.be/YJ5OhYLbeSE?si=uzqWytqgjRbI5I1i
3	https://youtube.com/playlist?list=PLgMDNELGJ1CbHti4HN0BuagtoD06H78YT&si=R-34kA6jB8QL-bKN
4	https://youtu.be/TbYU8df53V4?si=vck_ULHZL908ZmHK

SEMESTER S8

ADVANCED NUMERICAL CONTROL IN MANUFACTURING

Course Code	PEMET866	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None/ (Course code)	Course Type	Theory

Course Objectives:

1. To know the operational difference between NC and CNC systems
2. To understand the controlling elements in CNC machines
3. To learn the programming used in CNC machines

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Principles of Numerical Control Structure of NC systems, Applications of CNC machines in manufacturing, Advantages of CNC machines. Historical developments and future trends. Future of NC Machines, Difference between ordinary and NC Machine tools, Machining Capabilities of a CNC Machine, Methods for improving accuracy and productivity. Control of NC Systems: Classification of CNC control systems Open and Closed loop systems, Types of CNC Machine Tools systems devices.	9
2	Encoders and interpolators, Features of CNC Systems, Direct Numerical Control (DNC), Standard Controllers and General Programming features available in CNC Systems, Computer Process monitoring and Control. Adaptive control systems.	8
3	NC Part Programming: Axis identification and coordinate systems, Structure of CNC part program, Programming codes, Programming for 2 and 3 axis control systems, Manual part programming for a turning center, Programming using tool nose radius compensation, Tools offsets, Do loops,	10

	sub routines and fixed cycles. Manual Programming for simple parts.	
4	Computer aided part programming; Tools for computer aided part programming, Computer aided NC Programming in APT language, use of canned cycles, Generation of NC Programmes through CAD/CAM systems, Design and implementation of post processors. Constructional Details of CNC Machines: Machine structure, Slide –ways , Motion transmission elements , Swarf removal and safety considerations , Automatic tool changers and multiple pallet systems, Sensors and feedback devices in CNC machines.	**9**

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the working of NC and CNC systems	**K2**
CO2	Understand feedback mechanisms in CNC machines	**K2**
CO3	Create programming code in CNC	**K6**
CO4	Understand the construction details of CNC machines	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	-
CO2	3-	-	-	-	-	-	-	-	-	-	-	-
CO3	3	2	2	-	2	-	-	-	1	-	-	-
CO4	3	2	2	-	-	-	-	-	1	-	-	-

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Numerical Controls in Manufacturing	Frank W Wilson	McGraw-Hill	1963
2	Introduction to Numerical Control in Manufacturing	American Society of Tool and Manufacturing Engineers, Chester Joseph Kishel	American Society of Tool and Manufacturing Engineers,	1969

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Computer Control of Manufacturing Systems	Yoram Koren	McGraw-Hill Inc.,US	

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1-4	https://archive.nptel.ac.in/courses/112/105/112105211/

SEMESTER S8

METAL ADDITIVE MANUFACTURING

Course Code	PEMET867	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Nil	Course Type	Theory

Course Objectives:

1. To understand IoT and digital manufacturing demands for quicker and modular manufacturing solutions
2. To familiarise the current status of metal AM basics, materials, processes, and major important related aspects.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction to Additive Manufacturing (AM)– Process, Materials, Applications- Modular Design and Topology–Customization, Efficiency, Scalability - Design freedom in AM– Complex Geometries, Lightweight Structures, Material Efficiency -Benefits of Topology Design Freedom– Performance Enhancement, Innovation, Sustainability	9
2	CAD for AM, Integration of CAD with Additive Manufacturing, Design for AM, Topology Optimization, Metal AM physics and processes – PBF, DED, Binder Jetting, Sheet Lamination. Laser and Extrusion – SLS, SLM, DMLS, FDM, Robocasting. Metal AM processes, Filament, Powder and Sheet Systems, Metal AM as an Extension of Welding Techniques (GTAW/GMAW).	9
3	Metal AM physics and processes, Directed Energy, Binder and Material Jetting Feedstocks, Metallurgy and properties of materials– Microstructure, Mechanical, Thermal and Chemical Properties, Post processing and testing –	9

	Heat Treatment, Hot Isostatic Pressing, Machining, Surface Treatment and NDT Methods.	
4	Reverse Engineering for metal AM, Data Handling, Simulation and Analysis, Modelling for AM –Support Structures, Functional Integration, Value analysis – Cost, Time, Performance and Sustainability -Future of metal AM	**9**

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	To study the basic Metal Additive Manufacturing Techniques	**K2**
CO2	To understand the features and control of various MAM Methods	**K2**
CO3	To familiarize the metallurgy of MAM Processes.	**K3**
CO4	To study the relation between reverse engineering and additive manufacturing.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	2	-	2	-	-	-	-	-	-	-	-	2
CO2	2	-	-	-	3	-	-	-	-	-	-	2
CO3	3	-	-	-	-	-	-	-	-	-	-	2
CO4	3	-	-	-	-	2	-	-	-	-	-	2

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Additive Manufacturing of Metals: The Technology, Materials, Design and Production	Li Yang, Pan Michaleris	Springer	

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Additive Manufacturing of High-Performance Metals and Alloys	Robert Pederson, Matthew S. Sokolov, Chao Ma	IntechOpen	
2	Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping, and Direct Digital Manufacturing	Ian Gibson, David W. Rosen, Brent Stucker, MahyarKhorasani	Springer	

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://youtu.be/hOkV4Uo_w2Y
2	https://youtu.be/G9T9MkbjB68
3	https://youtu.be/_V_CUDPSzJE
4	https://youtu.be/EyEg57tlS1k

SEMESTER S8

NANOTECHNOLOGY

Course Code	PEMET868	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)		Course Type	Theory

Course Objectives:

1. Develop an understanding of nanomaterials and properties
2. Apply nanomaterials and engineering solutions to new technologies

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Nanoscience and technology: Introduction, brief history, Discussion on Fayman's talk, size effect, anomalous behavior of materials at nanoscale, impact of nanoscale on various properties of materials (structural, mechanical, thermal, optical, electronic), applications, examples from nature	9
2	Fabrication of Nanomaterials, Top-down and Bottom-up approaches Top-down fabrication: Mechanical methods, thermal methods, High energy methods, Chemical and lithographic methods Bottom-up methods: gaseous phase methods, liquid phase methods, solid bottom-up methods, Template synthesis	9
3	Carbon-based nanomaterials: Bonding in C materials, Synthesis and properties of fullerene, graphene, and CNT. Diamondoid nanomaterials,, Carbon dots, Pyrolyzed nanocarbon materials. Emerging 2D materials: Transition metal dichalcogenides, Hexagonal Boron nitride, M-Xenes synthesis, properties, and applications.	9

4	Nanomaterials for Energy and Environment: Electrochemical energy storage, hydrogen storage, solar cells, organic solar cells, photocatalysis, water purifications, desalination, solid waste removal Nanobiotechnology: micro and nanofluidics, biochips, lab-on chips and integrated systems. Nanoparticle-based drug delivery,nanostructures in diagnostics Nanocomposites, biodegradable nanocomposites	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand anomalous behavior of material at nanoscale dimensions	**K3**
CO2	Get an introduction to the nanoscale properties of materials	**K3**
CO3	Understand nanomaterial synthesis methods	**K3**
CO4	Explore the properties and application of C-based nanomaterials and other emerging 2D nanomaterials	**K3**
CO5	Get exposure to nanomaterials for energy and nanobiotechnology	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	3	2	-	-	-	-	-	-	-	-	-
CO2	3	3	2	-	-	-	-	-	-	-	-	-
CO3	3	3	2	-	-	-	-	-	-	-	-	-
CO4	3	3	2	-	-	-	-	-	-	-	-	-
CO5	3	3	2	-	-	-	2	-	-	-	-	-

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to nanoscience and technology	Gabor L Hornyak	CRC Press	2009
2	Fundamentals of nanotechnology	Gabor L Hornyak	CRC press	2009

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Introduction to nanotechnology	Charles P Poole, Frank J Owens	Wiley	2003
2	Introduction to nanoscience and nanotechnology	K K Chattopadhyay, A N Banerjee	PHI	2009
3	Basic Principles of Nanotechnology	Wesley C. Sanders	CRC Press	2019

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://nptel.ac.in/courses/118102003
2	https://nptel.ac.in/courses/118102003
3	https://nptel.ac.in/courses/118102003
4	https://onlinecourses.nptel.ac.in/noc23_ge21/preview

SEMESTER S8

AIRCRAFT DESIGN

Course Code	**PEMET865**	**CIE Marks**	60
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	40
Credits	5/3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	None	**Course Type**	Theory

Course Objectives:

1. Calculate jet and propeller driven airplane performance(take-off/landing distance, endurance, climb, manoeuvre)
2. Perform conceptual airplane and propulsion sizing estimate to meet specified operational and performance requirements
3. To develop problem solving skills i.e. identifying main issues in aeronautical problems, simplify the problem and solve it using standard tools

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Phases of the design process, conceptual design, preliminary design, detailed design. Typical program organization and personnel responsibilities. Role of aircraft design engineer. Major difference between manned and unmanned air vehicle design.	**8**
2	Basic aircraft terminology and conventions. Coordinate systems, forces and moments, aerodynamic coefficient. Significance of aerodynamic center. Aircraft weight breakdown and definition. Basic aircraft performance terminology(flight in the horizontal and vertical planes). Aircraft sizing. Factors influencing the aircraft configuration, size, weight. Weight breakdown. Historical weight data. The lift curve and parabolic drag polar.	**10**

3	Aircraft performance and fuel fraction estimates. Range, Endurance, Manoeuvring flight in the vertical and horizontal planes, Climbing flight, Descend/ Glide, Field Performance- Take-off and Landing. Special performance requirements like accelerated flight.	**8**
4	Propulsion system selection. Flight regimes, Refined performance estimating methods, Installation factors. Configuration trade studies- Configuration types(tailless, canard, conventional), wing location design, Empennage configurations(cruciform, T, H, V, cathedral). Engine placements(single or multi engine). Landing gear type and placement(tail dragger, tricycle, tandem). Airofoil selection,packaging for storage/transport	**10**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	To make the required decisions during the total design cycle of an aircraft including conceptual, preliminary and detailed design	**K2**
CO2	To distinguish and understand the design phases of an aircraft.	**K2**
CO3	To be able to calculate the performance characteristics of aircraft	**K2**
CO4	To evaluate and understand layout design of different aircrafts	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	3	2	-	-	-	-	-	-	-	-	-	-
CO3	3	2	-	-	-	-	-	-	-	-	-	-
CO4	3	2	-	-	-	-	-	-	-	-	-	-

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Aircraft Design: A conceptual Approach	Daniel P. Raymer	AIAA	2012
2	Introduction to Aircraft Design	John P Fielding	Cambridge Aerospace Series	2 2017
3	Aircraft Performance	Martin E. Eshelby	Elsevier	2000

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Aircraft Engineering Design, Structures and Systems	Ian Booth	NY research press	2018

SEMESTER S8

INDUSTRIAL HYDRAULICS AND AUTOMATION

Course Code	OEMET831	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	Nil	Course Type	Theory

Course Objectives:

1. To know about the basic elements of closed loop hydraulic system
2. To do the sizing and system design of typical hydraulic systems
3. To design and develop low-cost automation circuits for industrial problems

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Hydraulic Power Generators – Selection and specification of pumps, pump characteristics. Linear and Rotary Actuators –election, specification and characteristics	8
2	Control and regulation elements: Pressure - direction and flow control valves -relief valves, non-return and safety valves - actuation systems.	8
3	Hydraulic system for industrial equipment. e.g. Counter balance circuit, sequencing circuit, the tandem actuator of hydraulic actuators, steering circuit used in automobiles, Hydraulic press circuit operation, closed-circuit and open-circuit hydrostatic transmission, Accumulator circuit for intermittent operation of actuators	10
4	Circuits: sequential circuits - cascade methods - mapping methods – step counter method, compound circuit design - combination circuit design. -fault finding of circuits - use of microprocessors for sequencing Introduction to different types of industrial controllers- Types of automation system ,PLC, Low cost automation	10

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the various components in industrial hydraulic system	**K2**
CO2	Understand the various hydraulic circuits used in industries	**K2**
CO3	To design simple hydraulic circuits	**K3**
CO4	Understand the industrial controllers and automation systems	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	-	1	1	-	-	-	-	-	-	-
CO2	3	3	-	1	1	-	-	-	-	-	-	-
CO3	3	3	-	1	1	-	-	-	-	-	-	-
CO4	3	3	-	1	1	-	-	-	-	-	-	-

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Hydraulic and Pneumatics	Andrew Parr	Jaico Publishing House,	1,1999
2	Hydraulic systems: Principles and maintenance	Majumdar, S. R.	. Tata McGraw-Hill Education	1,2013
3	Fluid power circuits and controls: fundamentals and applications.	Cundiff, J. S.	CRC Press.	1,2001

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Pneumatic systems: Principles and maintenance.	Majumdar, S. R.	. Tata McGraw-Hill Education	1,2010
2	Hydraulic control systems.	Herbert E. Merritt.	John Wiley & Sons.	1,1967
3	Fundamentals of fluid power control	Watton, J	University Press	1,2009

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://onlinecourses.nptel.ac.in/noc24_me69/preview
2	https://onlinecourses.nptel.ac.in/noc24_me69/preview
3	https://onlinecourses.nptel.ac.in/noc24_me69/preview
4	https://onlinecourses.nptel.ac.in/noc24_me69/preview

SEMESTER S8

3D PRINTING AND TOOLING

Course Code	OEMET832	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	NONE	Course Type	Theory

Course Objectives:

1. To demonstrate appropriate level of understanding on principles of additive manufacturing
2. To understand the different additive manufacturing technologies.
3. To choose appropriate materials for additive manufacturing processes.

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**Introduction to Additive Manufacturing (AM) –**Basic principle of AM- Procedure of product development in AM process chain. Classification of additive manufacturing processes, Basic concept, Digitization techniques, Benefits and challenges in AM. **Data processing for AM-** CAD model preparation, Part orientation and support generation, Slicing methods, Tool path generation, STL Formats. Demonstration of slicing software packages.	**8**
2	**Common AM technologies:** Principle, materials, process parameters, advantages and applications of: Stereo Lithography (SLA), Digital Light Processing (DLP), Continuous Liquid Interface Production (CLIP), Laminated Object Manufacturing (LOM), Ultrasonic AM (UAM), 3D printing, Binder Jetting, Material Jetting, Fused Deposition Modelling (FDM), Direct Ink Writing (DIW).	**10**

3	**Common AM technologies:** Principle, materials, process parameters, advantages and applications of: Selective Laser Sintering (SLS), Selection Laser Melting (SLM), Electron Beam Melting (EBM), Wire Arc Additive Manufacturing (WAAM), Laser Engineering Net Shaping (LENS).	**10**
4	**Indirect methods for Rapid Tool Production-** Role of indirect methods in tool production, Metal deposition Tools, RTV Tools, Eoxy Tools, Ceramic Tools, Cast Metal Tools, Investment Casting, Fusible Metallic Core and Sand casting. **Direct Methods for Rapid Tool Production-** Classification of Direct Rapid Tool Methods, Laminated Object Manufactured Tools, Vacuum Forming Tools, Paper Pulp Molding Tools, Framework for Composite Manufacture.	**8**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the development of AM from conventional manufacturing systems.	**K2**
CO2	Understand the data processing techniques in AM process	**K2**
CO3	Understand the principles of AM processes.	**K2**
CO4	Understand the RP tooling applications of AM processes.	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-		-	-	-	-	-	-	-
CO2	2	2	2	-	3	-	-	-	-	-	-	-
CO3	2	-	-	-		-	-	-	-	-	-	-
CO4	2	-	-	-		-	-	-	-	-	-	-
CO5	2	-	-	-		-	-	-	-	-	-	-

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Additive Manufacturing Technologies-3D Printing, Rapid Prototyping, and Direct Digital Manufacturing.	Gibson l D. W. Rosen l and B. Stucker	Springer	Second Edition, 2015
2	Rapid prototyping: Principles and applications	Chua, C.K., Leong K.F. and Lim C.S.	World Scientific Publishers	Third edition, 2010.
3	Rapid Manufacturing The Technologies and Applications of Rapid Prototyping and Rapid Tooling	D.T. Pham and S.S. Dimov	Springer London Ltd	Reprint of the original 1st ed. 2001, 2011

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Additive Manufacturing: Principles, technologies and Application	C.P. Paul , A.N. Jinoop	McGraw Hill	First Edition, 2021
2	Additive Manufacturing Technologies	S. Shiva, Anuj K. Shukla	Wiley	First Edition, 2024
3	Additive Manufacturing: Fundamentals and Advancements	Manu Srivastava, SandeepRathee, Sachin Maheshwari	CRC Press	First Edition, 2019

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1,2,3 and 4	NOC: Fundamentals of Additive Manufacturing Technologies, IIT Guwahati by Prof. Sajan Kapil Link: https://nptel.ac.in/courses/112103306

SEMESTER S8

NUMERICAL TECHNIQUES ENGINEERING

Course Code	**OEMET833**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Nil	**Course Type**	Theory

Course Objectives:

1. To get an awareness about the usefulness of numerical methods in solving different engineering problems
2. To understand the error involved in numerical analysis

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Motivation and Applications of numerical methods, Significant digits, Accuracy and precision; Truncation and round-off errors. Roots of nonlinear equations-Bisection method, Newton Raphson method Solution of system of linear equations-Gauss elimination, Gauss Jordan, Gauss Siedel, LU decomposition Curve fitting:Least square regression-Linear regression, linearization of nonlinear relationships, Polynomial and multiple linear regression	**8**
2	Curve fitting: Interpolation-Newton's forward, backward, divided difference, Lagrange's interpolation, cubic spline Numerical differentiation-Difference formula, Newton's forward, backward and divided difference method, Sterling's formula Numerical integration-Trapezoidal, Simpson's one-third rule, Simpson's three-eight rule, Gauss Quadrature	**10**

3	Numerical solution of ordinary differential equations-Initial value and boundary value problems Taylor's method, Euler method, Modified Euler method, Runge Kutta fourth order method for first order, second order and simultaneous first order differential equations, Predictor corrector method, Shooting method, finite difference method	**9**
4	Numerical solution of partial differential equation-Types, Difference equations Elliptic equation-Laplace equation, Poisson's equation, Liebmann's iterative method, Parabolic equation-explicit and implicit method, convergence and stability, Crank Nicolson method, Hyperbolic equation	**9**

Course Assessment Method

(CIE: 40marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Apply numerical methods to solve linear and nonlinear equations	**K3**
CO2	Implement numerical schemes to fit data	**K3**
CO3	Solve differentiation and integration numerically	**K3**
CO4	Execute numerical procedures to solve ordinary and partial differential equations	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO11**	**PO12**
CO1	3	2	-	-	3	-	-	-	-	-	-	2
CO2	3	2	-	2	3	-	-	-	-	-	-	2
CO3	3	2	-	-	3	-	-	-	-	-	-	2
CO4	3	2	-	-	3	-	-	-	-	-	-	2

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Numerical methods for Engineers	Steven C Chapra, Reymond P Canale	Mc Graw Hill	6th Edition, 2010
2	Numerical Methods for Engineers	Gupta S.K.	New Age International	1995
3	Numerical methods	E Balagurusamy	Mc Graw Hill Education	2017

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Applied Numerical Analysis	Gerald, C. F. and Wheatly P O	Wesley	6th Edition
2	Numerical Methods for Scientific and Engineering Computation	Jain, M. K., Iyengar, S. R. K. and Jain, R. K.	New Age Pvt. Pub, New Delhi	
3	Elementary Numerical Analysis	Conte, S. D. and De Boor, C.	Mc Graw Hill Publisher	
4	Applied Numerical Analysis	Krishnamurthy, E. V. & Sen, S. K.	East West Publication	
5	An introduction to numerical analysis	Suli & Mayers	Cambridge University Press	

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1-4	https://archive.nptel.ac.in/courses/127/106/127106019/

SEMESTER S8

BUSINESS ORGANIZATION AND DEVELOPMENT

Course Code	**OEMET834**	**CIE Marks**	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	**ESE Marks**	60
Credits	3	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)		**Course Type**	Theory

Course Objectives:

1. To understand the Business organisation and Enterprises.

2. To acquire knowledge about Development & Establishment of Enterprises

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**INTRODUCTION**:-Business-Concept-Objectives-Characteristics .Business plan- Structure of Business plan-Major Financial decisions in Business-External and Internal factors affecting. Distinction of Business, Commerce and Trade. Industrialization- Globalization and Modern day Business. Need of Business Ethics and Business Responsibility.	**9**
2	**BUSINESS ORGANIZATIONS:-** Forms of Business Organizations- Sole proprietor – Partnership- Types- One person Company- Joint stock Company- Private & Public limited Companies. Limited liability Partnership (LLP). Co-operative Organizations, Multi National Companies (MNC)**.**Entrepreneurship -Forms of Entrepreneurship -Indian Scenario-Skill India- Make in India-Start up India**.**	**9**
3	**DEVELOPMENT & ESTABLISHMENT OF BUSINESS:-**Business Formation stages- Promotion- Incorporation and registration -Capital-Sources of Capital-Commencement-Documentation- Memorandum and articles of association-Prospectus. Establishing- Alternative identification -expansion-Market feasibility -Market Assessment-Technology in Business-Financial allocation- HR upgradation.Supporting Organisations-Chamber of Commerce.	**9**

4	**BUSINESS CHANNELS** : - Distribution Channels- Functions- Types- Internal and external trades. Import and export.Whole sale and retail system. Theory of retailing. Business channel Intermediaries. Franchising – Branding. Business Insurance system. Business Combination systems- Needs- Acquisition-Merging- Takeover.	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand the fundamentals of Business organisation.	**K1**
CO2	To acquire the knowledge on distinction of different organisations.	**K2**
CO3	To familiarize the stages of development and establishment of Business.	**K2**
CO4	To identify different Business channels	**K1**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	-	-	-	-	1	-	1	-	-	1
CO2	2	1	-	-	-	1	-	-	-	-	-	1
CO3	1	1	-	-	1	-	-	-	-	-	1	1
CO4	1	1	-	-	-	1	-	-	-	-	-	1

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Business Organisation & Management	T.N Chhabra	Sun India	2021
2	Modern Business Organisation & Management	S. A Sherlekar	Himalaya publishing	2016

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Business Organisation and Management	Basu C R	Tata McGraw-Hill	2017
2	Essentials of Management	Singh B P & Singh A K	Excel Books	2002
3	Business Organisation& Management	Vasishth N&Rajput N	Kitab Mahal	2019

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/110/107/110101146/
2	https://archive.nptel.ac.in/courses/110/107/110101146/
3	https://archive.nptel.ac.in/courses/110/107/110101146/
4	https://archive.nptel.ac.in/courses/110/107/110101146/

SEMESTER S8

WORLD CLASS MANUFACTURING

Course Code	OEMET835	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3-0-0-0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	GCPHT121	Course Type	Theory

Course Objectives:

1. Understand the Industrial practices adopted in World class manufacturing.
2. To familiarise the strategic planning for WCM.
3. To familiarise WCM tools.
4. Acquire the knowledge about Recent trends in WCM

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	**INTRODUCTION:** World class manufacturing-Definition-Historic Journey- Five levels led to WCM -characteristics of WCM-Pillars of WCM-Control Techniques of World class Manufactures- Principles of WCM- JIT-Zero waste Concept- TQM- TPM.	9
2	**PLANNING& HRD PRACTICES IN WCM:** Manufacturing strategy – Strategy Procedure- Types of strategy -Competitive priorities-Aggregate planning-Master Production schedule. Employee Morale-Team work- Employee Involvement-Cross functional teams-Motivation &Appraisal. Work study methods	9
3	**WCM CONCEPTS & TOOLS :** concepts –AMBITE- MRP II-TOPP-Automation systems- Types-Modern Manufacturing systems- Flexible Manufacturing- Lean Mnufacturing-5S-Agile Manufacturing Six Sigma-Automated Material Handling systems. Process Design & Process design tools. Bar code systems. IOT in manufacturing.	9
4	**WORLD CLASS MANUFACTURING -RECENT TRENDS &INDIA**: World class manufacturing Companies in INDIA-Production 4.0-Industry 4.0-Digitalization process in India-AI-Robotics-3D Printing-Extended Realities- VR& AR –Digital Twins .Automation in Industries-Case studies. Reshoring-Make in INDIA-Sustainable Manufacturing.	9

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	To familiarise with the basic concepts in World class Manufacturing.	**K1**
CO2	To understand the Strategy planning in WCM	**K1**
CO3	To Identify the employee involvement in WCM	**K1**
CO4	To Examine & Categorize different tools in WCM	**K2**
CO5	Learn different concepts in Modern day Manufacturing	**K1**
CO6	Analyse Indian scenario & WCM	**K2**
CO7	Identify various modern day trends and terminologies in WCM	**K1**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1						1		1			1
CO2	2	1				1						1
CO3	1							1	1			1
CO4	2	1			1	1	1	1				1
CO5	1	1				1						1
CO6	1						1				1	2
CO7	1				1			1				1

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	World class Manufacturing, The lessons of simplicity applied.	Richard J Schonberger	The FREE PRESS	(2013)
2	World class Manufacturing	B.S. Sahay, K B C Saxena, Ashish Kumar	Infinity Publishers	Ist Edition (2018)
3	Strategic Decision making in Modern Manufacturing	Harinder Sing Jagdev,Attracta Brennan,J.Browne	Springer	Reprint Edition (2013)

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	World class Manufacturing	Adeel Hejaji	Lambert	2015
2	World class Manufacturing and Material Handling	Edward H Frazelle	Mc GrawHill	2nd Edition 2016

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/110/107/110107116/
2	https://archive.nptel.ac.in/courses/110/107/110107116/
3	https://archive.nptel.ac.in/courses/110/107/110107116/
4	https://archive.nptel.ac.in/courses/110/107/110107116/

SEMESTER S8

MICRO ELECTRO MECHANICAL SYSTEMS

Course Code	OEMET836	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None/ (Course code)	Course Type	Theory

Course Objectives:

1. To Understand micro electromechanical systems and components
2. To understand the science of microsystems design in detail
3. To understand MEMS Fabrication technologies and the importance of CAD in MEMS Fabrication

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Definition of MEMS. MEMS devices. Silicon as a MEMS material – mechanical properties of silicon. Mechanical components in MEMS. Design concepts of mechanical components. Working Principles of Microsystems.	9
2	Engineering Science for Microsystems design and Fabrication. Scaling laws – Scaling in geometry, rigid body dynamics, electrostatic forces, electromagnetic forces, electricity-fluid mechanics and heat transfer	9
3	Materials for MEMS and Microsystems. Fabrication technologies – Photolithography – Ion implantation – diffusion – oxidation – CVD – Physical Vapour Deposition – Etching. Micro manufacturing – Bulk and surface micro machining – LIGA	9
4	Microsystems Design – Design considerations – Process design – Mechanical Design – CAD – Micro system packaging – Levels – Bonding – Interfaces – Assembly – Selection of Packaging Materials.	9

Course Assessment Method

(CIE: 40 marks, ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	15	10	10	40

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Understand micro electromechanical systems, MEMS components, MEMS design concepts and working principles.	**K2**
CO2	Understand the engineering and physics of MEMS Fabrication Process	**K2**
CO3	Understand the various processes in MEMS Fabrication	**K2**
CO4	Understand the interface between MEMS and CAD	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table (Mapping of Course Outcomes to Program Outcomes)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	-	-	-	-	-	-	-	-	-	-	2
CO2	3	-	-	-	-	-	2	-	-	-	-	-
CO3	3	-	-	-	-	-	-	-	-	-	-	-
CO4	3	-	2	-	-	-	-	-	-	-	-	3

Note: *1: Slight (Low), 2: Moderate (Medium), 3: Substantial (High), -: No Correlation*

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Mems & Microsystems Design and Manufacturing	Tai–Ran Hsu	John Wiley & Sons	2008 2nd Edition

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Fundamentals of Microfabrication	Marc J Madou	CRC Press	2002 2nd Edition
2	The MEMS Handbook	Mohamed Gad-el-Hak	CRC Press	2002

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1-2	https://onlinecourses.nptel.ac.in/noc24_ee108/unit?unit=16&lesson=17 https://onlinecourses.nptel.ac.in/noc24_ee108/unit?unit=16&lesson=18 https://onlinecourses.nptel.ac.in/noc24_ee108/unit?unit=16&lesson=19
3-4	https://onlinecourses.nptel.ac.in/noc24_ee108/unit?unit=22&lesson=23 https://onlinecourses.nptel.ac.in/noc24_ee108/unit?unit=22&lesson=24 https://onlinecourses.nptel.ac.in/noc24_ee108/unit?unit=22&lesson=25 https://onlinecourses.nptel.ac.in/noc24_ee108/unit?unit=22&lesson=26 https://onlinecourses.nptel.ac.in/noc24_ee108/unit?unit=22&lesson=27 https://onlinecourses.nptel.ac.in/noc24_ee108/unit?unit=30&lesson=33

SEMESTER S8

PRODUCT DESIGN AND INNOVATION

Course Code	PEMET837	CIE Marks	40
Teaching Hours/Week (L: T:P: R)	3:0:0:0	ESE Marks	60
Credits	3	Exam Hours	2 Hrs. 30 Min.
Prerequisites (if any)	None	Course Type	Theory

Course Objectives:

1. To create confidence in developing new products.
2. To acquaint with methods and tools for product design and development.
3. To equip with practical knowledge in conceptualization, design and development of new product

SYLLABUS

Module No.	Syllabus Description	Contact Hours
1	Introduction: Classification/ Specifications of Products, Product life cycle, product mix. Introduction to product design, Modern product development process Design by evolution, Design by innovation, Morphology of design Ethics in product design, legal factors and social issues	9
2	Creativity Techniques: Creative thinking, conceptualization, brain storming, primary design, drawing, simulation, detail design. Conceptual Design: Generation, selection & embodiment of concept, Product architecture. Industrial design: process, need. Robust Design: Taguchi Designs, Design of experiments	9
3	Design for Manufacturing and Assembly: Methods of designing for Manufacturing and Assembly. Design for Maintenance. Design for Environment. Ergonomics in product design. Aesthetics in product design. Concepts of size and texture colour. Value Engineering - Definition. Methodology, Case studies.	9

4	Product costing. Economic analysis: Qualitative & Quantitative. Psychological and Physiological considerations Concurrent Engineering - Elements of concurrent engineering, Benefits Rapid prototyping: concepts, processes and advantages. Reverse engineering: steps in reverse engineering- hardware and software in reverse engineering. Tools for product design – Drafting / Modelling software. Patents & IP Acts- Overview, Disclosure preparation	**9**

Course Assessment Method

(CIE: 40 marks , ESE: 60 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Assignment/ Microproject	Internal Examination-1 (Written)	Internal Examination- 2 (Written)	Total
5	**15**	**10**	**10**	**40**

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 3 marks **(8x3 =24marks)**	• Each question carries 9 marks. • Two questions will be given from each module, out of which 1 question should be answered. • Each question can have a maximum of 3 sub divisions. **(4x9 = 36 marks)**	**60**

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Determine the life cycle of a product and product development process	**K2**
CO2	Develop knowledge of robust design and conceptual design	**K2**
CO3	Introduce the concept of Design for Manufacturing and Assembly in product design	**K2**
CO4	Use value engineering in the development of product	**K2**
CO5	Incorporate ergonomics and rapid prototyping in product development	**K2**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	2	-	-	-	-	-	-	-	-	-	-
CO2	3	2	-	-	-	-	-	-	-	-	-	-
CO3	3	2	-	-	-	-	-	-	-	-	-	-
CO4	3	2	-	-	-	-	-	-	-	-	-	-
CO5	3	2	-	-	-	-	-	-	-	-	-	-

Text Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Product Design & Development.	Karl T Ulrich, Steven D Eppinger	Tata McGraw Hill	2003

Reference Books				
Sl. No	**Title of the Book**	**Name of the Author/s**	**Name of the Publisher**	**Edition and Year**
1	Product Design: "Techniques in Reverse Engineering and new Product Development.",	Kevin Otto & Kristin Wood	Pearson Education New Delhi	2000

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1-4	https://archive.nptel.ac.in/courses/107/103/107103082/