IEM Salt Lake Campus, IEM Newtown Campus & IEM Jaipur Campus

New Syllabus Outline Structure

For
6th SEMESTER
(B.Tech in Mechanical Engineering)

Effective for Academic Year 2026-2027

DEPARTMENT OF MECHANICAL ENGINEERING

B.Tech ME 6th Semester

SL NO	Category	Paper Code	Paper Name	L	T	P	Contact (Hrs)	Credits
Theory Papers								
1	PCC	PCCME601	Computer-Aided Design & Analysis	2	0	0	2	2
2	PCC	PCCME602	Manufacturing Automation	3	0	0	3	3
3	PCC	PCCME603	Production & Operation Management	2	1	0	3	3
4	PEC	PEME601	Professional Elective- II	3	0	0	3	3
5	HSMC	HSME601	HSS/Management Elective-1	3	0	0	3	3
6	HSMC	ESP(ME)601	Essentials Studies for Professionals (ME) – VI	2	0	0	2	0.5
Practical / Sessional Papers								
7	PCC	PCCME681	Product Innovation & Entrepreneurship	0	1	1	2	1.5
8	PCC	PCCME691	Mechanical Engg Lab IIC (Advanced Manufacturing & Automation)	0	0	3	3	1.5
9	PCC	PCCME692	Mechanical Engg Lab ID (Computer Aided Design & Analysis)	0	0	2	2	1
10	PCC	PCCME693	Mechanical Engg Lab IIID (Refrigeration and Air Conditioning)	0	0	2	2	1
11	ESC	ESCME681	Database Management System	0	0	2	2	1
12	PRJ	PRJME681	Project-IV (Minor)	0	0	4	4	2
13	HSMC	SDP681	Skill Development for Professionals -VI	0	0	2	2	0.5
TOTAL							**33**	**23**
For B.Tech with Minor Degree (Robotics/ Sustainable Energy Engineering/ Artificial intelligence and Machine learning/Additive manufacturing)								
14	MD	MINOR601R	Control of Robotic Systems	3	0	0	3	3
15	MD	MINOR601S	Electronics for Renewables	1	1	2	3	3

16	MD	MINOR601A	Special topics in Artificial Intelligence	3	0	0	3	3
17	MD	MINOR601M	Material, Processing & Application of 3D Printing	4	0	0	4	4
Mandatory Courses								
18	MC	IFC	Industry and Foreign Certification (IFC)	0	0	0	0	0
19	MC	MAR	Mandatory Additional Requirements (MAR)	0	0	0	0	0
For B.Tech Honours Degree								
20	MOOCs	MOOCS	MOOCs Certificate Courses (NPTEL/SWAYAM)	-	-	-	-	-

List of Professional Electives for Elective-II (PEME601)

A. Refrigeration and Air Conditioning (PEME601A)
B. Additive Manufacturing (PEME601B)
C. Turbo Machinery (PEME601C)
D. Finite Element Analysis (PEME601D)
E. Tribology (PEME601E)
F. Composite Materials (PEME601F)
G. Design for Manufacturing & Assembly (PEME601G)

List of HSS/Management Elective-1 (HSME601)

A. Project Management (HSME601A)
B. Operations Research (HSME601B)

Subject Name: Computer Aided Design & Analysis

Subject Code: PCCME601 Credit: 2 Lecture Hours: 24
Pre-Requisites: Machine Element & System Design, Mathematics

Relevant Links: STUDY MATERIAL COURSERA

Objectives:

1. To understand the role of computer-based tools in the design, analysis, and manufacturing processes.
2. To develop a thorough understanding of geometric transformations and their applications in 2D and 3D modeling.
3. To gain proficiency in creating, representing, and modifying curves and surfaces using computer-aided tools.
4. To acquire knowledge of solid modeling techniques and standards for model exchange between software platforms.
5. To apply finite element analysis and optimization techniques to solve engineering problems using popular CAE software.

Contents

Module number	Topic	Sub-topics	Mapping with Industry and International Academia	Textbook & Chapter No.	Lecture Hours	Corresponding Lab Assignment
Module I	**Introduction**	Role of computers in design process; Computer aided design, analysis and manufacturing; Computer integrated manufacturing; Popular CAD software used in industry	***National Standard:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard*** https://ocw.mit.edu/courses/mechanical-engineering/2-158j-computational-geometry-spring-2003/ ***Industry Mapping:*** *AUTO-CAD, SOLIDWORKS*	P.N. Rao, "CAD/CAM Principles and Applications, " Chapter 1	**2**	1.Implement and apply 2D transformation matrices (translation, scaling, rotation) on a set of points, and visualize both original and transformed shapes. 2. Generate and use equation-driven curves in SolidWorks for designing machine elements like sinusoidal or parabolic cams. 3. Model and simulate robotic arm motion using a cubic Bezier curve in MATLAB-SIMULINK, visualize the trajectory, and compare it with a linear path. 4. Create a 3D object
Module II	**Transformations**	Matrix representation of points, lines and planes; 2D transformation for translation, scaling, rotation and reflection; Homogeneous representation & concatenation; 3D transformations.	***National Standard:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard*** https://ocw.mit.edu/courses/mechanical-engineering/2-158j-computational-geometry-spring-2003/ ***Industry Mapping:*** *MATLAB*	P.N. Rao, "CAD/CAM Principles and Applications, " Chapter 3	**4**	
Module III	**Curves and Surfaces**	Representation of curves; Hermite curves, Bezier curves, Bspline curves,	***National Standard:*** https://www.aicte-	P.N. Rao, "CAD/CAM Principles and	**6**	

		Rational curves; Surface modelling – parametric representation, planar surface, surface of revolution, Coons and bicubic patches, Bezier and B-spline surfaces.	india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard*** https://ocw.mit.edu/courses/mechanical-engineering/2-158j-computational-geometry-spring-2003/ ***Industry Mapping:*** *AUTO-CAD, SOLIDWORKS*	Applications, " Chapter 4		in SolidWorks, export it as IGES or STL, and import it into a CAE tool. 5. Perform FEA in ANSYS to simulate stress and deformation of a bar element under load, and analyze the dynamic results. 6. Determine the theoretical stress-concentration factor (Kt) for a notched specimen using ANSYS Mechanical. 7. Develop a basic 2D beam model in STAAD.Pro, apply boundary conditions and loads, and analyze displacement and stress distribution using FEA. 8. Optimize a design using AI based
Module IV	**Solid Modelling**	Solid modelling techniques – sweep (linear and curved), Boolean (constructive solid geometry) and other techniques; Solid model representation (Boundary and Constructive Solid Geometry); Medical modelling (pixels, scans and voxels); Exchange standards (IGES, DXF, STEP, STL etc.).	***National Standard:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard*** https://ocw.mit.edu/courses/mechanical-engineering/2-158j-computational-geometry-spring-2003/ ***Industry Mapping:*** *AUTO-CAD, SOLIDWORKS*	P.N. Rao, "CAD/CAM Principles and Applications, " Chapter 4	**4**	
Module V	**Engineering Analysis**	Introduction to finite element method; Principle of potential energy; FE analysis of 1D element problems (spring, bar, truss elements); Development	***National Standard:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf	David Hutton, "Fundamentals of Finite Element Analysis" Chapter 1, 2	**8**	

		of element stiffness equation and their assembly; Plain strain and plain stress problems	***International Standard*** https://ocw.mit.edu/courses/mechanical-engineering/2-158j-computational-geometry-spring-2003/ ***Industry Mapping:*** *ANSYS*			Topology Optimization tool of SolidWorks

Text Book:

1. Ibrahim Zeid, "Mastering CAD CAM," Tata McGraw Hill Publishing Co. 2007.
2. David Hutton, "Fundamentals of Finite Element Analysis", Tata McGraw Hill Publishing Co. 2004 edition (Chapters 1, 2)
3. John J Craig, "Introduction to Robotics: Mechanics and Control", Pearson (Chapter 2)

Reference Books

1. P N Rao, "CAD/CAM Principles and Applications", McGraw Hill Education (India) Private Limited, 3rd Edition, 2010 (Chapters 1, 3 ,4)
2. C. McMohan and J. Browne, "CAD/CAM Principles," Pearson Education, 2nd Edition, 1999.
4. Geometric Modeling, Michael E. Mortenson, Tata McGraw Hill, 2013.
5. W. M. Neumann and R.F. Sproul, "Principles of Computer Graphics," McGraw Hill, 1989.
6. D. Hearn and M.P. Baker, "Computer Graphics," Prentice Hall Inc., 1992.

Online Resources:

1 NPTEL Lecture Series:

- https://nptel.ac.in/courses/112/102/112102101/,
- https://nptel.ac.in/courses/112/104/112104031/

2 MIT OCW:
https://ocw.mit.edu/courses/mechanical-engineering/2-158j-computational-geometry-spring-2003/

Course Outcomes:

At the end of this course students will demonstrate the ability to

1) Demonstrate the ability to create 2D and 3D models using CAD tools and apply geometric transformations for design manipulation.
2) Develop and analyze parametric curves and surfaces to model complex engineering geometries.
3) Perform solid modeling and effectively utilize Boolean operations to construct advanced shapes in CAD software.
4) Conduct finite element analysis in CAE software for practical engineering applications and validate the results.

CO-PO Mapping:

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

Subject Name: Manufacturing Automation
Subject Code: PCCME602 **Credit: 3** **Lecture Hours: 36**

Pre-Requisites: Manufacturing Process II, Basic Electronics Engineering, Mechatronics, Robotics & Control

Relevant Links: Study Material **NPTEL (1, 2, 3)** **Coursera (1, 2)**

Objectives:

1. To understand the importance of automation in the of field machine tool-based manufacturing
2. To get the knowledge of various elements of manufacturing automation – CAD/CAM, sensors, pneumatics, hydraulics and CNC
3. To understand the basics of product design and the role of manufacturing automation

Contents

Module number	Topic	Sub-topics	Mapping with Industry and International Academia	Textbook & Chapter No.	Lecture Hours	Corresponding Lab Assignment
1	**Machine and Process Automation**	Automated flow lines (types, selection); Work part transport and transfer mechanisms; Feedback systems and control; Modular and reconfigurable machines, adaptive machine controls.	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard*** https://ocw.mit.edu/courses/2-007-design-and-manufacturing-i-spring-2009/pages/lecture-notes/ ***Industry Mapping:*** *MATLAB/Simulink,* LabVIEW	M. P. Groover, Automation, Production Systems and Computer-integrated Manufacturing Chapter 10, 11, 16	**5**	1. Design and simulate a basic CNC machine control system using MATLAB/Simulink. 2. Design and simulate an automated flow line using LabVIEW, focusing on flow line types and part transfer mechanisms.
2	**Automated Assembly Systems**	Historical developments; Choice of assembly methods; Design for automated assembly; Transfer systems; Vibratory and non-vibratory feeders; Feed tracks, part orienting and placing mechanisms.	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf **National Standard** https://www.iitk.ac.in/me/me765a ***International Standard*** https://ocw.mit.edu/courses/mas-836-sensor-technologies-for-interactive-environments-	M. P. Groover, Automation, Production Systems and Computer-integrated Manufacturing Chapter 17, 18	**5**	1. Model and simulate an automated assembly system focusing on the choice of assembly methods and transfer systems using SolidWorks. 2. Design a part feeding system, including part orientation mechanisms for an automated assembly process using SolidWorks.

			spring-2011/pages/lecture-notes/ https://ocw.mit.edu/courses/2-875-mechanical-assembly-and-its-role-in-product-development-fall-2004/ ***Industry Mapping:*** *Solidworks*			
3	**Factory Automation**	Lean manufacturing, Automation scalability (fixed, programmable, flexible and reconfigurable); Design and analysis of automated flow lines; Average production time, production rate, line efficiency; Analysis of transfer lines without storage; Partial and full automation.	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard*** https://ocw.mit.edu/courses/15-763j-manufacturing-system-and-supply-chain-design-spring-2005/pages/lecture-notes/ https://ocw.mit.edu/courses/16-852j-integrating-the-lean-enterprise-fall-2005/ ***Industry Mapping:*** *PTC Creo, Siemens NX, Minitab*	M. P. Groover, Automation, Production Systems and Computer-integrated Manufacturing Chapter 1, 3, 26	**7**	1. Design a product for lean manufacturing using PTC Creo, and analyze scalability options for automation (fixed, programmable, flexible, and reconfigurable). 2. Use Minitab to analyze the performance of transfer lines without storage, comparing partial and full automation, and evaluating line efficiency and production rate.

4	**Automation Tools and Techniques**	Mechanical, electro-mechanical, pneumatic and hydraulic systems; electro-pneumatic, Sensors integration; Process monitoring, data analysis, and control using actuators; Robots (pick, place, assembly, welding, painting, etc.); Automatic Guided Vehicles; Automated inspection and measurement (CMM and 3D Scanning); Machine vision, AI and machine learning; Human machine interfaces; Examples and case studies.	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard*** https://ocw.mit.edu/courses/2-007-design-and-manufacturing-i-spring-2009/pages/lecture-notes/ ***Industry Mapping:*** *MATLAB, Labview, python*	M. P. Groover, Automation, Production Systems and Computer-integrated Manufacturing Chapter 6, 8, 10, 22	**9**	1. Simulate a hybrid system combining pneumatic and electro-mechanical components, incorporating sensor integration for process monitoring and control using MATLAB. 2. Design and implement an automated inspection system using machine vision, integrating AI for defect detection, and process monitoring in MATLAB and LabVIEW.
5	**Advanced Automation Trends**	Digital, inclusive, smart and distributed manufacturing; Industry 4.0; Digital transformations in shop-floors (CIM to Smart factory; Intelligent machines to Smart Machines; Factory automation to Distributed automation; Human sense to system sensed).	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard*** https://ocw.mit.edu/courses/2-854-introduction-to-manufacturing-systems-fall-2016/pages/syllabus/ ***Industry Mapping:*** *MATLAB. SolidWorks*	Chapter 23	5	1. Design a digital and smart manufacturing system using SolidWorks and simulate its control and monitoring using MATLAB, implementing key Industry 4.0 principles. 2. Explore the digital transformation of shop floors, focusing on transitioning from Computer Integrated Manufacturing (CIM) to

						Smart Factories using MATLAB for process automation and real-time analytics.
6	**Examples and Case Studies**	Pick and place robots, testing and sorting based systems, etc; Orientation of parts: in-bowl and out-of-bowl toolings; Manufacturing equipment embedded with digital data and driven by adoptive controls; Manufacturing automation with autonomous decisions taken by computers based on the realistic process/machines (production conditions) data acquired from the resources.	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard*** https://ocw.mit.edu/courses/2-12-introduction-to-robotics-fall-2005/ Introduction to Robotics | Mechanical Engineering | MIT OpenCourseWare ***Industry Mapping:*** *Minitab, RobotStudio*	M. P. Groover, Automation, Production Systems and Computer-integrated Manufacturing Chapter 8	**5**	1. Use RobotStudio to design, simulate, and optimize a pick-and-place robot for an automated testing and sorting system. Analyze the system's performance and efficiency using Minitab for data analysis.

Text Books:

1. M. P. Groover, Automation, Production Systems and Computer-integrated Manufacturing, Prentice Hall, 2018. (Chapter 8,10,11,17,18,26)

Reference Books:

2. S. Kalpakjian and S. R. Schmid, Manufacturing – Engineering and Technology, Pearson.
3. Yoram Koren, Computer Control of Manufacturing Systems, McGraw Hill, 2005
4. Frank Lamb - Industrial Automation, Mc Graw Hill,2013

5. W. Buekinsham, Automation, 3rd edition, PHI Publications, 2004.
6. CAD/CAM Principles and Applications, P.N. Rao, Tata McGraw Hill, 2010.

Online Resources:

1. https://archive.nptel.ac.in/courses/112/104/112104288/
2. https://www.coursera.org/learn/factory-automation-shaping-the-future-of-manufacturing
3. https://www.coursera.org/specializations/digital-technology-in-manufacturing

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. Understand and apply automated flow line principles, including transport, transfer mechanisms, and feedback control, in product design and manufacturing.
2. Analyze the impact of fixed, programmable, flexible, and reconfigurable automation on manufacturing efficiency and production rates.
3. Identify and implement automation tools and technologies in designing, monitoring, and controlling manufacturing processes.
4. Evaluate emerging trends in smart manufacturing, including Industry 4.0 and the shift to data-driven, smart factory environments.

CO-PO Mapping:

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

Subject Name: Production & Operation Management

Subject Code: PCCME603 **Credit: 3** **Lecture Hours: 36**

Pre-Requisites: Mathematics

Relevant Links: Study material **NPTEL** **Coursera (1, 2, 3)**

Objectives:

1. To provide knowledge on machines and related tools for manufacturing various components.
2. To understand the relationship between process and system in the manufacturing domain.
3. To identify the techniques for the quality assurance of the products and the optimality of the process in terms of resources and time management.
4. This course is designed to address the key operations and logistical issues in service and manufacturing organizations that have strategic as well as tactical implications.

Contents

Module number	Topic	Sub-topics	Mapping with Industry and International Academia	Text Book mapping	Lecture Hours	Corresponding Lab Assignment
	Introduction	Scope of production management. Production system and resources (machines, tooling, etc.); Types of production (batch, flow and unit), Roles of line supervisors and production managers.	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard*** https://ocw.mit.edu/courses/15-764-the-theory-of-operations-management-spring-2004/ ***Industry Mapping:*** Enterprise Resource Planning (ERP), Manufacturing execution system (MES), NetSuite, Asana, ClickUp	Chapter 1 Production And Operations Management By R. Panneerselvam	**7**	1. Follow some case study based on production management
	Project Management	Project life cycle: concept phase (RFQ, Quotations, Proposals), Project initiations, DPR preparation (project value, business case development and feasibility study); Project planning (obtaining resources, acquiring financing and procuring required materials); Project team, producing quality outputs, acceptance criteria; Project closure: acceptance of project deliverable; Analytics: Performance, capability	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard*** https://ocw.mit.edu/courses/15-351-managing-innovation-and-entrepreneurship-spring-2008/ ***Industry Mapping:*** Enterprise Resource Planning (ERP), Manufacturing execution system (MES), NetSuite, Asana, ClickUp	Chapter 2 Production And Operations Management By R. Panneerselvam	**6**	1. Solve some practical problems product life Cycle

		aggregation, variability analysis, Output-outcome analysis, project documentation, best practices, and depository.				
	Production Planning and Control	Production planning, Process planning, Resource planning, demand-utility mapping (production capability index, forecasting models, aggregate production planning, materials requirement planning); Inventory Management: Economic order Quantity, discount models, stochastic inventory models, practical inventory control models, JIT; Supply chain and management.	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard*** https://ocw.mit.edu/courses/mas-666-developmental-entrepreneurship-fall-2003/ ***Industry Mapping:*** Enterprise Resource Planning (ERP), Manufacturing execution system (MES), NetSuite, Asana, ClickUp	Chapter 3 Production And Operations Management By R. Panneerselvam	**8**	1. Solve some database management problem by using software
	Factory Management	Factory layout: line balancing, material flow and handling, Lean and green manufacturing, Human resource management, Training need analysis, Advantage and opportunities for Digitalization, Advanced factory systems: TQM; Important acts, regularities and safety norms, Reliability assessment of processes, Block	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard*** https://ocw.mit.edu/courses/15-351-managing-innovation-and-entrepreneurship-spring-2008/	Chapter 4 Production And Operations Management By R. Panneerselvam	**7**	**1.** By using software solve supply chain related issues

		chain, Energy management, Efficiency & throughput, Overall equipment effectiveness. Process capability, lean manufacturing.	***Industry Mapping:*** Enterprise Resource Planning (ERP), Manufacturing execution system (MES), NetSuite, Asana, ClickUp			
	Operation Management	Linear programming, objective function and constraints, graphical method, Simplex and duplex algorithms, transportation assignment; Simple queuing theory models; Traveling Salesman problem; Network models: shortest route, minimal spanning tree, maximum flow model.	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard*** https://ocw.mit.edu/courses/15-351-managing-innovation-and-entrepreneurship-spring-2008/ ***Industry Mapping:*** Enterprise Resource Planning (ERP), Manufacturing execution system (MES), NetSuite, Asana, ClickUp	Chapter 2 to 5 Taha H. A., Operations Research, 6th Edition	**8**	1. By using LPP solve problems of Operation management

Text Book:

1. R. Panneerselvam, Production and Operations Management, PHI. (Chapter 1,2,3,4,5)
2. Taha H. A., Operations Research, 6th Edition, PHI India, 2003. (Chapter 2,3,4,5)

Reference Books:

1. L.J. Krajewski and L.P Ritzmen, Operations Management: Strategy and Analysis, Pearson, 2010.
2. R.B. Chase, F.R. Jacobs and N.J. Aquilano, Operations Management for Competitive Advantage, Tata McGraw Hill, 2011.
3. W. J. Hopp and M. L. Spearman, Factory Physics: Foundations of Manufacturing Management, McGraw Hill International Edition, 2008.
4. Mahadevan. B., Operations Management: Theory and Practice, Pearson, 2015.
5. M.P. Poonia, Total Quality Management, Khanna Publishing House, 2022.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc20_mg06/preview
2. https://www.coursera.org/learn/wharton-operations
3. https://www.coursera.org/specializations/supply-chain-management
4. https://www.coursera.org/learn/principles-of-management
5. https://www.coursera.org/learn/operations-research-modeling

Course Outcomes:

At the end of this course, students will demonstrate the ability to

1. To provide knowledge on production management techniques that develop and establish relationship between market demand and production capability.
2. To understand the operation management: Resource planning and their utility
3. To understand the scientific approach and tools and techniques that assure market competitiveness by ensuring the quality, cost and time.
4. To understand the concept of production operations viz. Product design, Process design, Layout planning, Capacity planning, Quality management, Purchasing management.

CO-PO Mapping:

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

Subject Name: Product Innovation & Entrepreneurship

Subject Code: PCCME681 **Credit: 3** **Lecture Hours: 36**

Pre-Requisites:

Relevant Links: Study Material **NPTEL** **Coursera (1, 2)**

Objectives:

To expose aspiring student entrepreneurs to various elements of a technology venture starting from market need identification to innovative solution development and its commercialization through business planning and start-up company incubation.

Contents

Module number	Topic	Sub-topics	Mapping with Industry and International Academia	Text Book & Chapter	Lecture Hours	Corresponding Lab Assignment
1	**Entrepreneurship**	Role of entrepreneurship in economic development; Entrepreneurial mindset, motivation, and competencies; Market pull and technology push factors; New product development lifecycle; Technology readiness levels; Product-market fit validation; Commercialization pathways; Business vision & leadership; Team composition & management.	***AICTE prescribed syllabus*** - https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard -*** https://ocw.mit.edu/courses/15-351-managing-innovation-and-entrepreneurship-spring-2008/ ***Industry Mapping:*** *MATLAB. MS-Excel, Crunchbase*	Peter F. Drucker, "Innovation and Entrepreneurship Chapter 1&2	**7**	Identify a product idea, outline its target market, list potential competitors, and brainstorm customer needs and value propositions and develop a product.
2	**Product Innovation**	Opportunity scanning, market survey, need identification and problem definition; Creative design thinking for concept generation; Detailed design & prototyping; Functionality & manufacturability; Bill of materials &	***AICTE prescribed syllabus*** - https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard -*** https://ocw.mit.edu/courses/15-351-managing-innovation-and-entrepreneurship-spring-2008/	Innovation Management and New Product Development Paul Trott Chapter 13 & 14	**8**	Select a product idea, define the need it addresses, and outline its concept generation. Create a rough sketch of the design, list key materials, and propose a simple assembly plan.

		components supply chain; Manufacturing & assembly plan; Product testing & quality assurance; Intellectual property rights management.	***Industry Mapping:*** *SolidWorks, MATLAB. MS-Excel*			
3	**Marketing & Finance**	Market segmentation & market sizing; Customer persona & value proposition; Marketing (Go-to-market) strategy; Distribution channels and sales network; Funding requirement (based on stage); Source of funding for startup ventures; Financial projections and accounting; Startup to scale up financing.	***AICTE prescribed syllabus*** - https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard -*** https://ocw.mit.edu/courses/15-351-managing-innovation-and-entrepreneurship-spring-2008/ ***Industry Mapping:*** *MATLAB. MS-Excel, Hubspot*	Innovation Management and New Product Development Paul Trott Chapter 16	**7**	Choose a product idea, define target market segments, and create a customer persona. Outline a basic go-to-market strategy, identify distribution channels, and estimate initial funding needs.
4	**Venture Creation**	Sustainable business options & pathways; Business model & business canvas; Startup team & business partners; Startup ecosystem and stakeholders; Technology business incubators & parks; Proposal pitching	***AICTE prescribed syllabus*** - https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard -*** https://ocw.mit.edu/courses/15-351-managing-innovation-and-	New Venture Creation: Jeffry A Timmons and Stephen Spinelli Chapter 2	**7**	Define a sustainable business idea, outline its business model using a simple canvas, and identify key partners and stakeholders.

		& agreements; Startup company incorporation; Social impact & responsibility.	entrepreneurship-spring-2008/ ***Industry Mapping:*** *B-Plans. MS-Excel*			
5	**Course Project**	Need identification, innovative solution, business plan, go-to-market strategy.	***AICTE prescribed syllabus*** - https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard -*** https://ocw.mit.edu/courses/15-351-managing-innovation-and-entrepreneurship-spring-2008/ ***Industry Mapping:*** *MATLAB. MS-Excel,*	Innovation Management and New Product Development Paul Trott Chapter 12	**7**	Identify customer needs and rank them in an Excel sheet. Design an innovative solution with estimated costs. Create a basic financial plan with cost and revenue projections. Outline a simple go-to-market strategy (sales channels, target segments). Based on all develop a product.

Text Books:

1. Innovation Management and New Product Development: Paul Trott, Pearson Education Limited (Chapter 1,2,12,13,14,16)
2. Peter F. Drucker, "Innovation and Entrepreneurship", 1st ed., Harper Business, 2006.

Reference Books:

1. Chelat Bhuvanachandran, Innovision, Khanna Book Publishing, 2022.
2. New Venture Creation: Jeffry A Timmons and Stephen Spinelli, 1st edition Publisher: McGraw-Hill
3. Byers, Dorf, and Nelson, Technology Ventures: From Ideas to Enterprise, McGraw Hill, 2010
4. Steve Blank, "The Startup Owner's Manual"
5. T.V. Rao, "Entrepreneurship - A South Asian Perspective"

6. Bill Aulet, "Technology Entrepreneurship", 4th ed., Tata McGraw Hill, 2014

Online Resources:

https://onlinecourses.nptel.ac.in/noc22_ge03/preview

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Identify opportunities, foster innovation, and build core competencies for growth.
2. Manage ideation, prototyping, testing, and market readiness.
3. Develop entry, engagement, and commercialization approaches.
4. Plan finances, secure funding, and create sustainable business models.

CO-PO Mapping:

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

Subject Name: Finance & Accounting

Subject Code: HSMME601B **Credit: 3** **Lecture Hours: 36**

Pre-Requisites: Mathematics

Relevant Links: Study Material **NPTEL (1, 2)** **Coursera (1, 2, 3)**

Course Content:

Module number	Topic	Sub-topics	Mapping with Industry and International Academia	Text Book & Chapter	Lecture Hours	Corresponding Lab Assignment
1	**Economic Decisions Making-**	Overview, Problems, Role, Decision making process.	***International Standard -*** https://global.oup.com/us/companion.websites/9780190296902/sr/interactive/ecce/engineering costs/ ***Industry Mapping:*** *MATLAB, MS Project:*	**5)** R. Paneer Seelvan: Engineering Economics, PHI **Chapter-**1,2 & 20	**3**	**1. Fixed, Variable, and Marginal Costs Analysis:** Using MS Excel, create a model to analyze fixed, variable, marginal, and average costs, applying the per-unit and segmenting estimation methods for different production scenarios. **2. Present Worth Analysis & Inflation Adjustment:** In MS Project, implement present worth techniques for a project's cash flow analysis, adjusting for
2	**Engineering Costs & Estimation-**	Fixed, Variable, Marginal & Average Costs, Sunk Costs, Opportunity Costs, Recurring and Nonrecurring Costs, Incremental Costs, Cash Costs vs Book Costs, Life-Cycle Costs; Types of Estimates, Estimating Models - Per- Unit Model, Segmenting Model, Cost Indexes, Power- Sizing Model, Improvement & Learning Curve, Benefits.		**5)** R. Paneer Seelvan: Engineering Economics, PHI **Chapter-** 3,4 & 5 **7)** Premvir Kapoor, Sociology & Economics for Engineers, Khanna Publishing House **Chapter-** 5 & 6	**5**	
3	**Present Worth Analysis**	End-of-Year Convention, Viewpoint of Economic Analysis Studies,	***International Standard -*** https://ocw.mit.edu/courses/15-	**1)** James L.Riggs,David D. Bedworth, Sabah U.	**5**	

		Borrowed Money Viewpoint, Effect of Inflation & Deflation, Taxes, Economic Criteria, Applying Present Worth Techniques, Multiple Alternatives.	511-financial-accounting-summer-2004/ ***Industry Mapping:*** MS Excel, MATLAB,	Randhawa : Economics for Engineers 4e , Tata McGraw-Hill **Chapter-**3 & 4 **5)** R. Paneer Seelvan: Engineering Economics, PHI **Chapter-** 4		inflation, taxes, and evaluating multiple alternatives based on economic criteria. **3. Internal Rate of Return & Break-Even Analysis:** Use MATLAB to calculate the internal rate of return (IRR) and perform sensitivity and break-even analysis on different capital investment alternatives for a project. **4. Depreciation Methods & Capital Allowances:** Using MS Excel, create a model to calculate
4	**Cash Flow & Rate of Return Analysis**	Calculations, Treatment of Salvage Value, Annual Cash Flow Analysis, Analysis Periods; Internal Rate of Return, Calculating Rate of Return, Incremental Analysis; Best Alternative Choosing an Analysis Method, Future Worth Analysis, Benefit Cost Ratio Analysis, Sensitivity and Break-Even Analysis. Economic Analysis in the Public Sector- Quantifying and Valuing Benefits & drawbacks.	***International Standard -*** https://ocw.mit.edu/courses/15-501-introduction-to-financial-and-managerial-accounting-spring-2004/ ***Industry Mapping:*** MS Excel, MS Project, MATLAB,	**7)** Premvir Kapoor, Sociology & Economics for Engineers, Khanna Publishing House **Chapter-7 &** 8 **5)** R. Paneer Seelvan: Engineering Economics, PHI **Chapter- 5 &7**	**7**	

5	**Depreciation-**	Basic Aspects, Deterioration & Obsolescence, Depreciation and Expenses, Types of Property, Depreciation Calculation Fundamentals, Depreciation and Capital Allowance Methods, Straight Line Depreciation Declining Balance Depreciation, Common Elements of Tax Regulations for Depreciation and Capital Allowances	***International Standard -*** https://ocw.mit.edu/courses/15-514-financial-and-managerial-accounting-summer-2003/ ***Industry Mapping:*** MS Excel, Google Sheets:	**1)** James L.Riggs,David D. Bedworth, Sabah U. Randhawa : Economics for Engineers 4e , Tata McGraw-Hill **Chapter-** 6 & 7 **5)** R. Paneer Seelvan: Engineering Economics, PHI **Chapter-**9 & 10	**6**	depreciation using straight-line and declining balance methods, and incorporate tax regulations for capital allowances. **5. Cost Accounting & Indirect Cost Allocation:** In MS Project, build a cost tracking system to monitor direct and indirect costs, applying methods for cost allocation and generating income statements and balance sheets for project evaluation.
6	**Inflation and Price Change**	Definition, Effects, Causes, Price Change with Indexes, Types of Index, Composite vs Commodity Indexes, Use of Price Indexes in Engineering Economic Analysis, Cash Flows that inflate at different Rates.	***International Standard -*** https://global.oup.com/us/companion.websites/9780190296902/sr/interactive/ecce/engineering costs/ ***Industry Mapping:*** MS Excel, R, MATLAB,	**7)** Premvir Kapoor, Sociology & Economics for Engineers, Khanna Publishing House **Chapter-** 10 **5)** R. Paneer Seelvan: Engineering Economics, PHI	**5**	

				Chapter- 11		
7	**Accounting-.**	Function, Balance Sheet, Income Statement, Financial Ratios Capital Transactions, Cost Accounting, Direct and Indirect Costs, Indirect Cost Allocation	***International Standard -*** https://global.oup.com/us/companion.websites/9780190296902/sr/interactive/ecce/engineering costs/ ***Industry Mapping:*** Microsoft Dynamics 365 Finance	**5)** R. Paneer Seelvan: Engineering Economics, PHI **Chapter-** 20 &11 **7)** Premvir Kapoor, Sociology & Economics for Engineers, Khanna Publishing House **Chapter-** 13 & 11	**5**	

Text Book

1. R. Paneer Seelvan: Engineering Economics, PHI (Chapter 1,2,3,4,5,7,9,10,11,13,20)
2. James L.Riggs,David D. Bedworth, Sabah U. Randhawa : Economics for Engineers 4e , Tata McGraw-Hill (Chapter 3,4,6,7)
3. Premvir Kapoor, Sociology & Economics for Engineers, Khanna Publishing House (Chapter 5,6,7,8,10)

Reference Book

1. Donald Newnan, Ted Eschembach, Jerome Lavelle : Engineering Economics Analysis, OUP
2. John A. White, Kenneth E.Case, David B.Pratt : Principle of Engineering Economic Analysis, John Wiley
3. Sullivan and Wicks: Engineering Economy, Pearson

4. Michael R Lindeburg : Engineering Economics Analysis, Professional Pub

Online resources

1. https://onlinecourses.nptel.ac.in/noc20_mg52/preview
2. https://onlinecourses.nptel.ac.in/noc24_ec01/preview

Course Outcomes

1. EXPLAIN and APPLY principles of cost estimation and financial analysis, including fixed and variable costs, life cycle costing, improvement models, and learning curves.
2. ANALYZE economic and financial indicators such as inflation, deflation, economic criteria, present worth, and cash flow to support decision-making.
3. EVALUATE financial performance using tools like rate of return, cost ratio, break-even analysis, depreciation methods, and tax regulations.
4. UNDERSTAND and INTERPRET accounting concepts, including balance sheets, income statements, cost accounting, and the impact of price changes using price indices.

CO-PO Mapping:

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

Subject Name: Refrigeration & Air Conditioning **Credit: 3**

Subject Code: PEME601A **Lecture Hours: 36**

Pre-Requisites: Thermodynamics, Heat Transfer

Relevant Links: Study Material **NPTEL (1)** **Coursera (1)**

Course Objective:

Objectives: 1. To familiarize with the terminology associated with refrigeration systems and air conditioning

2. To understand basic refrigeration processes

3. To understand the basics of psychrometry and practice of applied psychrometrics

4. To acquire the skills required to model, analyse and design different refrigeration as well as air conditioning processes and components

Course Content:

Module number	Topic	Sub-topics	Mapping with Industry and International Academia	Text Book & Chapter	Lecture Hours	Corresponding Lab Assignment
1	**Introduction**	Basic Definitions of Refrigeration and Air-Conditioning; History of Refrigeration; Natural and Artificial Refrigeration Methods; Techniques to produce low temperatures; Applications of Refrigeration; Refrigerants-Classification, Nomenclature, Desirable Properties, Selection.	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard:*** ASHARE and ISHRAE Handbook ***Industry Mapping:*** Basics of Air Conditioning & Heat Load Calculation by L&T EduTech	Refrigeration and Airconditioning,C P Aroa Chapter 1	02	Study of a Domestic Refrigerator.
2	**Air Refrigeration**	Air Refrigeration Cycles - reversed Carnot cycle; Bell-Coleman cycle analysis; various methods of Aircraft Refrigeration: Analysis, Merits and demerits.	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard:*** ASHARE and ISHRAE Handbook ***Industry Mapping:*** Basics of Air Conditioning & Heat Load Calculation by L&T EduTech	Refrigeration and Airconditioning, P L Ballaaney, Chapter 2	02	Study of a room (window type) Air Conditioner.

3	**Vapor Compression Refrigeration System**	Ideal VCR cycle (Working, Analysis and Limitations); Standard VCRS (Working and Analysis); Methods to improve performance of VCR; Multi-Stage VCRS; Cascade Refrigeration.	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard:*** ASHARE and ISHRAE Handbook ***Industry Mapping:*** Basics of Air Conditioning & Heat Load Calculation by L&T EduTech	Refrigeration and Airconditioning, P L Ballaaney, Chapter 3	06	Determination of C.O.P of a vapour compression refrigeration system.
4	**Components of Refrigeration Systems**	Compressors: Positive Displacement (Reciprocating and Rotary); Dynamic (Centrifugal and Axial) Compressors; Condensers and Evaporators (Both Natural and Forced Convection type); Expansion Devices and other components of the system.	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard*** ASHARE and ISHRAE Handbook ***Industry Mapping:*** Basics of Air Conditioning & Heat Load Calculation by L&T EduTech	A Text book of Refrigeration and Airconditioning,R S Khurmi and J K Gupta Chapter 15	04	Experiment in an Air Conditioning Test Unit; Determination of bypass factor and plotting of the cooling – dehumidification process on a psychometric chart.
5	**Vapor Absorption Systems**	Working and Analysis; Absorbent - Refrigerant combinations; Water Ammonia Systems;	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20En	Refrigeration and Airconditioning, P L Ballaaney, Chapter 20	04	

		Water-Lithium Bromide System; Modified Version of Aqua-Ammonia System with Rectifier and Analyzer Assembly.	gg.pdf ***International Standard*** ASHARE and ISHRAE Handbook ***Industry Mapping:*** Basics of Air Conditioning & Heat Load Calculation by L&T EduTech			
6	**Other Refrigeration systems**	Brief Discussion on (i) Steam-Jet refrigeration system; (ii) Vortex tube refrigeration; (iii) Thermoelectric refrigeration system; and (iv) Magnetic refrigeration.	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard*** ASHARE and ISHRAE Handbook ***Industry Mapping:*** Basics of Air Conditioning & Heat Load Calculation by L&T EduTech	Refrigeration and Airconditioning, P L Ballaaney, Chapter 20	02	Performance test of thermoelectric refrigeration system.
7	**Psychrometry**	Classification of Air-Conditioning Systems; ASHRAE Nomenclature; Applications of Air-Conditioning; Psychrometry - Air-water vapor mixtures; Psychrometric Properties;	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard:*** ASHARE and ISHRAE Handbook ***Industry Mapping:***	Refrigeration and Airconditioning, P L Ballaaney, Chapter 20, 21	08	Assignment on CBE Thermal Comfort Tool

		Psychrometric or Air-Conditioning processes; Psychrometric Chart.	https://comfort.cbe.berkeley.edu/			
8	**Air-Conditioning Systems**	Classification of Air-Conditioning Systems; Psychrometry of Air Conditioning Systems; Thermal Comfort (Definition and Psychrometric Properties for Thermal Comfort); Mathematical Analysis of Air-Conditioning Systems; Cooling and Heating Load Estimation; a brief discussion on Ventilation.	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard:*** ASHARE, ISHRAE Handbook, NBA 2016, ECBC 2017 and ENS 2018. ***Industry Mapping:*** Basics of Air Conditioning & Heat Load Calculation by L&T EduTech	Refrigeration and Airconditioning, P L Ballaaney, Chapter 22-26	12	Assignment on Heat load calculation and Air-Conditioning Systems sizing

Course Outcomes:

After completing this course, the students will

CO1 Understand the working principles of refrigeration and air-conditioning systems.
CO2 Design refrigeration systems that can produce low temperatures required in many industrial applications.
CO3 Acquire enough knowledge to size the air conditioning systems for various application.
CO4 Acquire expertise and develop confidence to design HVAC system.

Text Books:

1. C.P. Arora, Refrigeration and Air Conditioning, McGraw Hill India, 2017. (Chapter 1)
2. P.L. Ballaney, Refrigeration and Air Conditioning, Khanna Publication, New Delhi, 1972. (Chapter 2,3,20,21,22,23,24,25,26)
3. S Khurmi and J K Gupta, A Text book of Refrigeration and Airconditioning, S. Chand Publication. (Chapter 15)

Reference Books:

1. W.F. Stocker and J.W. Jones, Refrigeration and Air Conditioning, McGraw Hill, 2014.
2. Arora and Domkundwar, Refrigeration and Air Conditioning, Dhanpat Rai Publication.
3. P N Ananthanarayanan, Basic Refrigeration and Air Conditioning, McGraw Hill Fourth Edition, 2016.

Online Resources: 1 https://onlinecourses.nptel.ac.in/noc22_me135/preview

CO-PO Mapping:

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

Subject Name: Additive Manufacturing

Subject Code: PEME601B **Credit: 3** **Lecture Hours: 3**

Pre-Requisites: Manufacturing Process I, II

Relevant Links: Study Material **NPTEL (1 , 2, 3)** **Coursera (1 , 2, 3)**

Objectives: To provide an overview of Additive Manufacturing processes, systems, and applications.

Course Content:

Module number	Topic	Sub-topics	Mapping with Industry and International Academia	Text Book & Chapter	Lecture Hours	Corresponding Lab Assignment
1	**Introduction to Additive Manufacturing (AM):**	Evolution of AM/3D printing; Comparison with subtractive and forming processes; Advantages of AM; Classification of AM processes; Key steps in AM.	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard:*** ***Industry Mapping:*** *AutoCAD, SolidWorks*	Ian Gibson, David W Rosen, Brent Stucker, "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping and Direct Digital Manufacturing Chapter 1	4	Using SolidWorks, create a 3D model of a part and simulate the advantages of additive manufacturing (AM) compared to traditional subtractive and forming processes, highlighting key steps in the AM process.
2	**CAD for Additive Manufacturing:**	CAD Data formats, Data translation, Data loss, STL format	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard:***	Ian Gibson, David W Rosen, Brent Stucker, "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping and	3	In AutoCAD, convert a 3D model into STL format, explore data loss issues during translation, and demonstrate the

			Industry Mapping: AutoCAD, *Ultimaker Cura*	Direct Digital Manufacturing Chapter 2, 15, 17		process of preparing a model for 3D printing using AM.
3	**Liquid State-based AM Processes:**	Stereo lithography – Process and working principle; Photopolymers; Photo polymerization, layering technology, Laser and Laser scanning; Micro stereolithography; Equipment and specifications; Applications, advantages, disadvantages, examples; Solid ground curing: Process, Working principle; Equipment and specifications; Applications, advantages, disadvantages, examples.	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard:*** ***Industry Mapping:*** ANSYS, *SolidWorks, PrusaSlicer*	Ian Gibson, David W Rosen, Brent Stucker, "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping and Direct Digital Manufacturing Chapter 1, 3, 4 3D Printing and Additive Manufacturing: Principles & Applications, Chua Chee Kai, Leong Kah Fai. Chapter 3	8	Use MATLAB to simulate the stereolithography process and solid ground curing, analyzing the working principles, equipment specifications, and potential applications and advantages of each method. Using PrusaSlicer, prepare models for FDM and LOM processes, compare the materials and equipment specifications, and discuss the advantages and disadvantages of each process.
4	**Solid State-based AM Processes:**	Fused Deposition Modeling – Process, working principle and materials; Equipment and specifications; Laminated object manufacturing – Process and working principle; Equipment and	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard:***	Ian Gibson, David W Rosen, Brent Stucker, "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping and Direct Digital	8	

		specifications; Applications, advantages, disadvantages, examples; Other solid-state processes – Ultrasonic consolidation, Gluing, Thermal bonding; Demonstration of equipment.	***Industry Mapping:*** ANSYS, MATLAB, *Ultimaker Cura*	Manufacturing Chapter 3, 7, 10		
5	**Powder Based AM Processes:**	Powder Bed Fusion Processes – Working principle and materials; Powder fusion mechanism and powder handling; Various LBF processes (principle, materials, applications and examples) – Selective laser Sintering, Electron Beam Melting, Laser Engineered Net Shaping, Binder Jetting and Direct Metal Deposition; Comparison between LBF processes; Materials-process-structure-property relationships; relative advantages and limitations.	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard:*** ***Industry Mapping:*** *SolidWorks, 3D Sprint*	Ian Gibson, David W Rosen, Brent Stucker, "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping and Direct Digital Manufacturing Chapter 2, 3, 5, 10 3D Printing and Additive Manufacturing: Principles & Applications, Chua Chee Kai, Leong Kah Fai. Chapter 5	8	In SolidWorks, model parts suited for various Powder Bed Fusion (PBF) processes like Selective Laser Sintering (SLS) and Electron Beam Melting (EBM), and compare the material-process relationships, advantages, and limitations of each PBF technique. Design and Develop a AI-Driven 3D Printing Workflow for Automated Quality
6	**Applications of AM:**	Product development lifecycle applications – Rapid prototyping, ML	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/M	Ian Gibson, David W Rosen, Brent Stucker, "Additive	5	

		based 3D printing Characterization, concept models, visualization aids, replacement parts, tooling, jigs and fixtures, moulds and casting; Application sectors – aerospace, automobile, medical, jewelry, sports, electronics, food, architecture, construction and others.	odel_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard:*** ***Industry Mapping:*** MATLAB	Manufacturing Technologies: 3D Printing, Rapid Prototyping and Direct Digital Manufacturing Chapter 19 3D Printing and Additive Manufacturing: Principles & Applications, Chua Chee Kai, Leong Kah Fai. Chapter 7		Enhancement and Defect Detection.

Text Books:

1. Ian Gibson, David W Rosen, Brent Stucker, "Additive Manufacturing Technologies: 3D Printing, Rapid Prototyping and Direct Digital Manufacturing", Springer, 2015 (Chapter 1,2,3,4,5,7,10,15,17,19))
2. Chua Chee Kai, Leong Kah Fai, "3D Printing and Additive Manufacturing: Principles & Applications," World Scientific, 2015. (Chapter 7)

Reference Books:

1. C.P Paul, A.N Junoop, "Additive Manufacturing: Principles, Technologies and Applications," McGrawHill, 2021.
2. Frank W. Liou, Rapid Prototyping and Engineering Applications: A Toolbox for Prototype Development, CRC Press, Taylor and Francis Group, 2007.
3. Duc Pham, S.S. Dimov, "Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling", Springer-Verlag London, 2001.

4. Sabrie Soloman, 3D Printing & Design, Khanna Book Publishing Company, New Delhi, 2020.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc21_me115/preview
2. https://onlinecourses.nptel.ac.in/noc20_mg70/preview
3. https://onlinecourses.nptel.ac.in/noc24_me130/preview
4. https://www.coursera.org/learn/introduction-to-additive-manufacturing-processes
5. https://www.coursera.org/learn/additive-manufacturing-3d-printing
6. https://www.coursera.org/specializations/additive-manufacturing

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Understand the overall principle and various processes for additive manufacturing.
2. Describe the CAD and data format for 3D printing purpose.
3. Select a particular additive manufacturing process based on the end application.
4. Plan the steps in fabricating a given part using additive manufacturing.

CO-PO Mapping:

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

Subject Name: Turbo Machinery

Subject Code: PEME601C **Credit: 3** **Lecture Hours:36**

Pre-Requisites: Fluid Mechanics and Fluid Machinery

Relevant Links: STUDY MATERIAL **NPTEL**

COURSE OBJECTIVES:

1. To know about the basic characteristics of compressible and incompressible flow machines.
2. To learn about deriving dimensionless numbers through dimensional analysis.
3. To know about the system of testing and performance analysis of turbo machines.

COURSE CONTENT:

Module number	Topic	Sub-topics	Textbook & Chapter No.	Mapping with Industry and International Academia	Lecture Hours	Corresponding Lab Assignment
1	**Introduction**	Classification: Incompressible and compressible flow machines; Radial, axial and mixed flow machines;	Mechanics of Fluids, B. Massey, Chapter - 13	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf	**2**	Make a simple model of a Pelton turbine's blade and design an appropriate fluid domain of the jet that flows out from the nozzle

		Turbines vs pumps, fans and compressors. Applications: Water supply, ventilation, power generation, propulsion		***International Standard:*** https://ocw.mit.edu/courses/2-25-advanced-fluid-mechanics-fall-2013/ ***Industry Mapping:*** ANSYS AHEC/MNRE/SHP Standards/E & M Works entitled "Guidelines for Selection of Turbine and Governing System for Hydroelectric Projects		to impinge the blade. Validate the flow velocity at the inlet and outlet using Continuity equation.
2	**Incompressible- Flow Machines**	Hydraulic Turbines: Headrace, penstock, nozzle, runner, draft tube and tail race; Gross head and net head; Velocity diagrams for impulse and reaction turbines; Discharge, head, power and efficiencies	Power Plant Engineering, P. K. Nag, Chapter – 10 Fluid Mechanics and Hydraulic Machines, R. K. Bansal, Chapter - 18	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard:*** https://ocw.mit.edu/courses/2-25-advanced-fluid-mechanics-fall-2013/pages/syllabus/ ***Industry Mapping:*** ANSYS AHEC/MNRE/SHP Standards/E & M Works entitled "Guidelines for Selection of Turbine and Governing System for Hydroelectric Projects	**8**	Make a simple model of a Francis turbine's blade. Identify the relation between changing area and fluid velocity through the casing using Continuity equation. Show the same in Workbench.
3	**Pumps**	Reservoir, foot valve,	Fluid	***AICTE prescribed syllabus:***	**8**	Create a working model of

		suction line, pump, delivery line and overhead tank; Static head and losses; Velocity diagrams; Discharge, head, power and efficiencies	Mechanics and Hydraulic Machines, R. K. Bansal, Chapters – 19 and 20	https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard:*** https://ocw.mit.edu/courses/2-000-how-and-why-machines-work-spring-2002/pages/study-materials/ ***Industry Mapping:*** ANSYS, MATLAB Fundamentals of external gear pump design, Logan T. Williams		a gear pump using MATLAB. Replicate the same using the same input parameters in ANSYS to compare the results obtained from the two approaches.
4	**Compressible-Flow Machines**	Static and stagnation states; Isentropic and adiabatic expansion and compression processes; Nozzle, diffuser and rows of stationary and moving blades; Efficiencies	Power Plant Engineering, P. K. Nag, Chapter – 7	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard:*** https://ocw.mit.edu/courses/16-01-unified-engineering-i-ii-iii-iv-fall-2005-spring-2006/pages/fluid-mechanics/ ***Industry Mapping:*** ANSYS	**8**	Make a simple model of a subsonic nozzle. Compare the flow of air and hydraulic oil (of your choice) through the nozzle. Note the difference in velocity at the exit of the nozzle to help visualize the effect of compressibility on flow.
5	**Dimensional**	Similarity laws, volume-	Fluid	***AICTE prescribed syllabus:***	**4**	Create a MATLAB script

	Analysis	flow, mass-flow head and power coefficients, pressure ratio, enthalpy ratio, Reynolds number, Mach number; Specific speed and machine selection	Mechanics and Hydraulic Machines, R. K. Bansal, Chapter - 12	https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard:*** https://ocw.mit.edu/courses/2-25-advanced-fluid-mechanics-fall-2013/pages/syllabus/ ***Industry Mapping:*** MATLAB		that calculates the dimensionless numbers (Reynold's number, Mach number, Weber number and Froude number) for the same input values. Create a plot in MATLAB to visualize the relationship between Reynold's number and fluid velocity.
6	**Testing and Performance Analysis**	Measurement devices; affinity laws and unit quantities. Set up and operating characteristics of pumps, turbines, fans and turbo-compressors. Cavitation– cause of cavitation and definition of Thoma's cavitation parameter, surge and choking	Mechanics of Fluids, B. Massey, Chapter - 13	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard:*** https://ocw.mit.edu/courses/2-016-hydrodynamics-13-012-fall-2005/pages/syllabus/ ***Industry Mapping:*** ANSYS	**6**	Create a condition in a simple 2D model (a rectangle, say) to ensure cavitation. Hint: Use Bernoulli's equation and its application in siphons to identify the required pressure.

COURSE OUTCOMES:

After completing this course, the students will

CO1: know basic characteristics of incompressible flow machines.

CO2: know basic characteristics of compressible flow machines.
CO3: learn how to derive dimensionless numbers using dimensional analysis.
CO4: know about the method of testing and performance analysis of turbo machines.

Textbooks:
1. R. K. Bansal, Fluid Mechanics & Machinery, Laxmi Publications, 2018. (Chapters – 12, 18, 19, 20)
2. P. K. Nag, Power Plant Engineering, McGraw Hill Education (India) Private Limited, 2014. (Chapters – 7, 10)
3. Bernard S. Massey, Mechanics of Fluids, Taylor & Francis, 2012. (Chapter - 13)

Reference Books:
1. S.K. Som, G. Biswas and S. Chakraborty, Introduction to Fluid Mechanics & Fluid Machines, McGraw Hill, 2017.
2. S.C. Gupta, Fluid Mechanics and Hydraulic Machines, Pearson Publication, 2006.
3. A.T. Sayers, Hydraulic and Compressible Flow Turbomachines, McGraw-Hill, 1990.

CO-PO Mapping:

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

Subject Name: Finite Element Analysis

Subject Code: PEME601D **Credit: 3** **Lecture Hours: 36**

Pre-Requisites: Engineering Mechanics, Strength of Materials, Mathematics

Relevant Links: STUDY MATERIALS **NPTEL**

Module number	Topic	Sub-topics	Mapping with Industry and International Academia	Text Book & Chapter	Lecture Hours	Corresponding Lab Assignment
Module I	**Introduction**	Historical background, Relevance of FEA/FEM to design problems, Mathematical modeling of field problems in engineering, governing equations, discrete and continuous models, boundary and initial value problems, Weighted Residual Methods, Variational formulation of boundary value problems, Ritz technique, Galerkin method, Basic concept of Finite Element Method.	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard*** https://ocw.mit.edu/courses/mechanical-engineering/2-158j-computational-geometry-spring-2003/ ***Industry Mapping: ANSYS, MATLAB***	D. Hutton, Fundamentals of Finite Element Analysis Chapter 1,5	**3**	Use MATLAB to implement the Galerkin method for solving a 1D heat conduction problem and compare the results with the analytical solution.

Module II	**One dimensional problems**	One dimensional second order equation, discretization, linear and higher order elements, derivation of shape functions, Stiffness matrix and force vectors, assembly of elemental matrices, solution of problems from solid mechanics, Applications to axial loadings of rods– Extension to plane trusses, Bending of beams– Finite element formulation of stiffness matrix and load vectors, Assembly to Global equations, boundary conditions.	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard*** https://ocw.mit.edu/courses/mechanical-engineering/2-158j-computational-geometry-spring-2003/ ***Industry Mapping: MATLAB***	D. Hutton, Fundamentals of Finite Element Analysis Chapter 2	**4**	Discretize a rod under axial loading into finite elements in MATLAB, compute the stiffness matrix and force vector, and solve for nodal displacements.
Module III	**Two dimensional problems– scalar variable problems**	Two dimensional equations, variational formulation, finite element formulation, triangular elements- shape functions, elemental matrices and RHS vectors; Finite element modeling– CST element, Element	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard***	D. Hutton, Fundamentals of Finite Element Analysis Chapter 5,7	**6**	Use MATLAB to model steady-state heat conduction in a 2D rectangular plate using triangular (CST) elements. Plot

		equations, Load vectors and boundary conditions, Assembly, Application to heat transfer, application to thermal problems, torsion of non-circular shafts, quadrilateral and higher order elements. Plane stresses and plane strain problems, body forces and thermal loads, plate and shell elements.	https://ocw.mit.edu/courses/mechanical-engineering/2-158j-computational-geometry-spring-2003/ ***Industry Mapping: ANSYS, MATLAB***			temperature distribution.
Module IV	**Two dimensional problems–vector variable problems**	Vector Variable problems, Elasticity equations–Plane Stress, Plane Strain and Axisymmetric problems, Formulation, element matrices, Assembly, boundary conditions and solutions Examples	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard*** https://ocw.mit.edu/courses/mechanical-engineering/2-158j-computational-geometry-spring-2003/ ***Industry Mapping: ANSYS, MATLAB***	D. Hutton, Fundamentals of Finite Element Analysis Chapter 9	**4**	Perform finite element analysis in ANSYS to determine the stress distribution in a plate with a hole under uniaxial tension.

Module V	**Isoperimetric elements for two dimensional problems**	Natural coordinates, Isoparametric elements, Four node quadrilateral element, Shape functions, Element stiffness matrix and force vector, Numerical integration, Stiffness integration, Displacement and Stress calculations, application to plane stress problems, matrix solution techniques, solution of dynamic problems, introduction to FE software.	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standard*** https://ocw.mit.edu/courses/mechanical-engineering/2-158j-computational-geometry-spring-2003/ ***Industry Mapping: ANSYS, MATLAB***	D. Hutton, Fundamentals of Finite Element Analysis Chapter 6	**4**	Use MATLAB to formulate and solve a plane stress problem with four-node quadrilateral elements. Validate results with numerical integration.

Text Books:

1. D. Hutton, Fundamentals of Finite Element Analysis, McGraw Hill. (Chapter 1,2,5,6,7,9)

Reference Books

1. J. N. Reddy, Finite Element Method in Engineering, McGraw Hill.
2. Rao S.S., The Finite Element Method in Engineering, 3rd ed., Butterworth Heinemann.
3. T.R. Chandrupatla and A.D. Belegundu, Introduction to Finite Elements in Engineering, Pearson.
4. C.S. Krishnamoorthy, Finite Element Analysis, McGraw Hill.
5. P. Seshu, Textbook of Finite Element Analysis, Prentice Hall of India.
6. Klaus - Jurgen Bathe, Finite Element Procedures, PHI Learning Pvt. Ltd.

Course Outcomes:

1. Enhance understanding of finite element techniques for problem evaluation.
2. Formulate and solve problems related to one-dimensional structural elements.
3. Utilize finite element methods to address challenges in solid mechanics and heat transfer.
4. Develop FE characteristic equations for two-dimensional elements and analyze plain stress, plain strain, axi-symmetric, and plate bending scenarios.

CO-PO Mapping:

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

Subject Name: Tribology

Subject Code: PEME601E **Credit: 3** **Lecture Hours: 36**

Pre-Requisites: Machine Design, Fluid Mechanics

Relevant Links: STUDY MATERIAL **NPTEL**

Module No	Topic	Sub-topics	Mapping with Industry and International Academia	Mapping with Textbooks	Lecture Hours	Corresponding Lab Assignment
1	**Introduction to tribology and engineering surface**	History, Industrial Importance. Engineering Surfaces: Properties and Measurement: Measurement Methods, Surface Profilometry, Statistical Description of Roughness.	***National Standard:*** *https://people.iitism.ac.in/~academics/assets/course_structure/new/cat/mech/MED519.pdf* ***International Standard:*** *https://ocw.mit.edu/courses/2-800-tribology-fall-2004/* ***Industry Mapping:*** *ANSYS, Surface Profilometer*	Engineering Tribology, Prasanta Sahoo, Chapter 1, 2	**5**	1. Carrying out contact analysis in ANSYS and verify Hertz contact model 2. Measuring coefficient of friction of different machined surfaces 3. Measuring coefficient of friction of
2	**Surface contact**	Hertz contact theory, Greenwood-Williamson model, Elastic-plastic contact Basic Models of adhesion, Factors influencing	***National Standard:*** *https://people.iitism.ac.in/~academics/assets/course_structure/new/cat/mech/MED519.pdf* ***International Standard:***	Engineering Tribology, Prasanta Sahoo, Chapter 3	**6**	

		adhesion.	https://ocw.mit.edu/courses/2-800-tribology-fall-2004/ ***Industry Mapping:*** *ANSYS*			different surface pairs with varying materials
3	**Friction**	Measurement methods, Origin of friction, Friction theories, stick-slip, Rolling friction, Friction of metals and non-metals.	***IIT Syllabus:*** https://people.iitism.ac.in/~academics/assets/course_structure/new/cat/mech/MED519.pdf ***International Standard:*** https://ocw.mit.edu/courses/2-800-tribology-fall-2004/ ***Industry Mapping:*** *ANSYS, Tribometer*	Engineering Tribology, Prasanta Sahoo, Chapter 5	**5**	4. Solving lubrication problems using MATLAB
4	**Wear**	Types of wear: adhesive, abrasive, corrosive, fatigue, fretting, erosion, percussion, Delamination theory, Wear debris analysis, Wear testing methods, Wear of metals, ceramics, polymers.	***National Standard:*** https://people.iitism.ac.in/~academics/assets/course_structure/new/cat/mech/MED519.pdf ***International Standard:*** https://ocw.mit.edu/courses/2-800-tribology-fall-2004/ ***Industry Mapping:*** *Tribometer*	Engineering Tribology, Prasanta Sahoo, Chapter 6	**5**	
5	**Surface engineering**	Surface treatments: Microstructural and thermochemical treatments, Surface coatings: Hard Facing, Vapour Deposition	***National Standard:*** https://people.iitism.ac.in/~academics/assets/course_structure/new/cat/mech/MED519.pdf	Engineering Tribology, Prasanta Sahoo, Chapter 8	**4**	

		Processes: PVD, CVD, PECVD etc.	***International Standard:*** *https://ocw.mit.edu/courses/2-800-tribology-fall-2004/* ***Industry Mapping:*** *Tribometer*			
6	**Liquid lubricants**	Liquid lubricants-classifications, Properties – viscosity, thermal behaviour, chemical stability, Additives, Applications	***National Standard:*** *https://people.iitism.ac.in/~academics/assets/course_structure/new/cat/mech/MED519.pdf* ***International Standard:*** *https://ocw.mit.edu/courses/2-800-tribology-fall-2004/* ***Industry Mapping:*** *Tribometer*	Engineering Tribology, Prasanta Sahoo, Chapter 10	**2**	
7	**Lubrication in bearings**	Basic Equations for Fluid Film Lubrication, Hydrodynamic lubrication -Thrust and Journal bearings, Hydrostatic lubrication	***National Standard:*** *https://people.iitism.ac.in/~academics/assets/course_structure/new/cat/mech/MED519.pdf* ***International Standard:*** *https://ocw.mit.edu/courses/2-800-tribology-fall-2004/* ***Industry Mapping:*** *MATLAB*	Design of Machine Elements, V.B. Bhandari, Chapter 16	**7**	
8	**Nanotribology**	Measurement Tools: Surface force apparatus,	***National Standard:*** *https://people.iitism.ac.in/~academics/ass*	Engineering Tribology,	**2**	

		Scanning tunnelling microscope, Atomic / Friction Force Microscope.	ets/course_structure/new/cat/mech/MED519.pdf ***International Standard:*** https://ocw.mit.edu/courses/2-800-tribology-fall-2004/ ***Industry Mapping:*** *AFM*	Prasanta Sahoo, Chapter 19		

Course Outcomes:

After the completion of the course, student will be able to

2. Understand and analyze surface properties and surface roughness of solid surfaces
3. Apply contact mechanics theories and assess adhesion between surfaces.
4. Identify and analyze friction and wear behavior in machine elements.
5. Apply lubrication principles, select appropriate lubrication systems for different applications

Text Books:

1. Engineering Tribology, Prasanta Sahoo, Prentice Hall India Learning Private Limited (Chapters – 1,2,3,5,6,8,10).
2. Design of Machine Element, V.B. Bhandari, McGraw Hill (Chapter 16)

Reference Books:

1. Fundamentals of Engineering Tribology with Applications, Harish Hirani, Cambridge University Press.
2. Contact Mechanics and Friction: Physical Principles and Applications, V.L. Popov, Springer.
3. Introduction to Tribology, Bharat Bhushan, Wiley.

Online Recourses:

NPTEL: https://nptel.ac.in/courses/112102015

CO-PO Mapping:

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

Subject Name: Composite Materials

Subject Code: PEME601 **Credit: 3** **Lecture Hours: 36**

Pre-Requisites: Engineering Mechanics, Strength of Materials, Engineering Materials

Relevant Link: Study material **NPTEL** **Coursera (1, 2)**

Course Content:

Module	Topic	Sub-topics	Mapping with Industry and International Academia	Lecture Hours	Mapping with Text Book	Assignments
I	**Chapter 1**	Review of engineering materials and their properties, Definition and applications of composite materials, Fibres-glass, carbon, ceramic, and aramid fibres; Matrices-polymer, graphite, ceramic, and metal matrices; characteristics of fibres and matrices. Types of reinforcement and matrix; carbon and glass fibres; PMCs, MMCs, and CMCs; aligned fibre composites	***AICTE/National level prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf Composite Materials syllabus JU Material Engineering.pdf ***International Standard*** https://ocw.mit.edu/courses/3-40j-physical-metallurgy-fall-2009/pages/lecture-notes/ ***Industry Mapping:*** ANSYS/ MINITAB	7	Gibson R.F. Principles of Composite Material Mechanics, second edition, McGraw Hill, 1994. Chapter 1, W. D. Callister, 2006, "Materials Science and Engineering-An Introduction", 6th Edition, Wiley India, Chapter 16	Design a Metal Matrix Composite for a high-performance aerospace application that requires a combination of high strength, low weight, and thermal stability. Discuss the selection of matrix material, reinforcement material, and manufacturing method, justifying your choices based on the specific needs of the application.

II	**Chapter 2**	Axial and transverse Young's moduli for an aligned long fibre composite; short fibre and particulate composites – stiffness behavior, Fracture strength of composites: axial tensile strength of long fibre composites, transverse and shear strength.	***AICTE/National level prescribed syllabus:*** https://makautexam.net/aicte_details/aicteugdetails.html Composite Materials syllabus JU Material Engineering.pdf ***International Standard*** https://ocw.mit.edu/courses/3-40j-physical-metallurgy-fall-2009/pages/lecture-notes/ ***Industry Mapping:*** ANSYS/ MINITAB	8	Gibson R.F. Principles of Composite Material Mechanics, second edition, McGraw Hill, 1994. Chapter 4,9,10. W. D. Callister, 2006, "Materials Science and Engineering-An Introduction", 6th Edition, Wiley India, Chapter 16	Analyze how different fiber types and fiber orientations influence the axial tensile strength of long fiber composites. Discuss the role of the matrix material in the composite's overall tensile performance.
III	**Chapter 3**	Manufacturing of composite materials, bag moulding, compression moulding, pultrusion, filament welding, other manufacturing processes, demand, and future applications	***AICTE/National level prescribed syllabus:*** https://makautexam.net/aicte_details/aicteugdetails.html Composite Materials syllabus JU Material Engineering.pdf ***International Standard*** https://ocw.mit.edu/courses/3-40j-physical-metallurgy-fall-2009/pages/lecture-notes/ ***Industry Mapping:*** ANSYS/ MINITAB	7	Gibson R.F. Principles of Composite Material Mechanics, second edition, McGraw Hill, 1994. Chapter 1, W. D. Callister, 2006, "Materials Science and Engineering-An Introduction", 6th Edition, Wiley India,	Analyze the factors that influence the quality of a composite part produced through compression molding. How do variables such as temperature, pressure, material properties, and mold design affect the final product's mechanical properties and surface finish?

					Chapter 16	
IV	**Chapter 4**	Fracture toughness of composites: energies absorbed by crack deflection and by fibre pull-out, crack deflection, toughness of different types of composite, constraints on matrix plasticity in MMCs, metal fibre reinforced ceramics. Compressive loading of fiber composites; thermal expansion of composites	***AICTE/National level prescribed syllabus:*** https://makautexam.net/aicte_details/aicteugdetails.html Composite Materials syllabus JU Material Engineering.pdf ***International Standard*** https://ocw.mit.edu/courses/3-40j-physical-metallurgy-fall-2009/pages/lecture-notes/ ***Industry Mapping:*** ANSYS/ MINITAB	6	Gibson R.F. Principles of Composite Material Mechanics, second edition, McGraw Hill, 1994. Chapter 9,	Analyze how the fiber-matrix interface, fiber volume fraction, and fiber orientation affect the fracture toughness of composite materials. Discuss the role of toughening mechanisms in improving fracture resistance.
V	**Chapter 5**	Mechanical Testing of composites and their constituents: Measurement of Constituent material properties: Fiber test, Matrix test. Measurement of Basic Composite properties: Tensile tests, compressive tests, shear tests. Measurement of Visco Elastic and Dynamic Tests.	***AICTE/National level prescribed syllabus:*** https://makautexam.net/aicte_details/aicteugdetails.html Composite Materials syllabus JU Material Engineering.pdf ***International Standard*** https://ocw.mit.edu/courses/3-40j-physical-metallurgy-fall-2009/pages/lecture-notes/ ***Industry Mapping:*** ANSYS/ MINITAB	8	Gibson R.F. Principles of Composite Material Mechanics, second edition, McGraw Hill, 1994. Chapter 10	Analyze the differences in mechanical properties such as tensile strength, compression strength, and shear strength of composite materials based on the type of testing performed.

Course Outcomes:

1. Understand basics of composite materials and its use.
2. Understand basics of fiber and particulate composite.
3. Understand manufacturing processes of composite materials.
4. Understand the mechanical behavior of composites due to variation in temperature and moisture.

Text Books:

1. Gibson R.F. Principles of Composite Material Mechanics, second edition, McGraw Hill, 1994. (Chapter 1,4,9,10)
2. W. D. Callister, 2006, "Materials Science and Engineering-An Introduction", 6th Edition, Wiley India (Chapter 16)

Reference books:

1. Hyer M.W., Stress Analysis of Fiber- Reinforced Composite Materials, McGraw Hill, 1998.
2. 2.K.K. Chawla, Composite Materials- Science and Engineering, Springer International Publishing, 2019.
3. M. Mukhopadhyay, Mechanics of Composite Materials and Structures, University Press, 2013

CO-PO Mapping:

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

Subject Name: Project Management

Subject Code: HSME601A **Credit: 3** **Lecture Hours: 36**

Pre-Requisites: Mathematics

Relevant Links: Study Material **NPTEL (1, 2)** **Coursera (1, 2, 3)**

Module number	Topic	Sub-topics	Mapping with Industry and International Academia	Text Book & Chapter	Lecture Hours	Corresponding Lab Assignment
1	**Overview of Project Management**	Project Definition: Project study techniques: Project management features; Management information and control systems for projects; Project organization design: Plant location analysis models;	**IIT Syllabus** https://www.ieor.iitb.ac.in/acad/courses/ie705 ***International Standard*** - https://ocw.mit.edu/courses/1-011-project-evaluation-spring-2011/ ***Industry Mapping:*** *MS excel, MS project*	K Nagarajan, Project Management, Chapter 1 R. Panneerselvam, P Senthilkumar, Project Management, Chapter 1	**3**	**1.** Using MATLAB, simulate a project planning and monitoring framework for a developmental project, focusing on stakeholder analysis and key project phases (planning, execution, and closure). **2.** Complement this with MS Project to create a detailed Gantt chart and resource allocation for the same project, ensuring alignment with Business Project Management principles. **3.** Social Cost Benefit Analysis, and the `OpenProj' or `Open Workbench'
2	**Project Lifecycle**	Project Design, Project Planning and Scheduling, Project Monitoring, Control, Analysis and Appraisal and Closure & Dissemination. emphasis would be on developmental projects while drawing heavily from the advances in the field of `Business Project Management'. Framework for conceiving, planning, executing and closing projects; Project views of the stakeholders.	**IIT Syllabus** https://www.ieor.iitb.ac.in/acad/courses/ie705 ***International Standard*** - https://ocw.mit.edu/courses/1-040-project-management-spring-2004/ ***Industry Mapping:*** *MATLAB,* OpenProject, MS project	Panneerselvam, P Senthilkumar, Project Management, Chapter 2	**5**	

3	**Anatomy of projects**	Objectives and success criteria- both financial and non-financial measures; Project evaluation and selection methods using multiple attributes -economic and operation analysis; Decision tree, AHP and Utility theory.	**IIT Syllabus** https://www.ieor.iitb.ac.in/acad/courses/ie705 ***International Standard -*** https://ocw.mit.edu/courses/1-040-project-management-spring-2004/ ***Industry Mapping:*** *MS Project*	K Nagarajan, Project Management, Chapter 3 Panneerselvam, P Senthilkumar, Project Management, Chapter 14	**5**	software tool will be introduced for project scheduling and management. 4. Develop a comprehensive framework for evaluating project anatomy, incorporating objectives, financial/non-financial success criteria, and selection methodologies such as economic analysis, decision trees, AHP, and utility theory using MS project. 5. Create a detailed Work Breakdown Structure (WBS) and project schedule using Microsoft Project to manage a hypothetical project effectively.
4	**Scheduling Optimization**	Concepts and applications of Work Breakdown Structure (WBS), Project scheduling; Network analysis for time management (Gantt charts, PERT, CPM, RAMPS, multi-project control; Project cost optimization time cost Trade off: Crashing and Simulation);	**IIT Syllabus** https://www.ieor.iitb.ac.in/acad/courses/ie705 ***International Standard -*** https://ocw.mit.edu/courses/1-040-project-management-spring-2004/ https://ocw.mit.edu/courses/esd-36-system-project-management-fall-2012/pages/syllabus/ ***Industry Mapping:*** Microsoft Project, Open Workbench, excel,	K Nagarajan, Project Management, Chapter 8 Sitagshu Khatua, Project Management and Appraisal Chapter 5 Panneerselvam, P Senthilkumar, Project Management, Chapter 17&18	**6**	

5	**Project Resource Management** :	Allocation, Leveling and Smoothing methods; Multi project and multi resource, multi-mode scheduling under various constraints- limited resources, limited budget, non-split, start / end lag; Application of Heuristics, Mathematical programming, Evolutionary algorithms such as GA, Application of knowledge-based systems.	**IIT Syllabus** https://www.ieor.iitb.ac.in/acad/courses/ie705 ***International Standard -*** https://ocw.mit.edu/courses/1-040-project-management-spring-2004/ ***Industry Mapping:*** OpenProject, MATLAB	Panneerselvam, P Senthilkumar, Project Management, Chapter 20 &21	**6**	6. Analyze project scheduling and optimize time-cost trade-offs using techniques like CPM, PERT, and crashing in Microsoft Project.
6	**Managing Project Risks**	Decision making theories in management under certainty, Application of the methodologies and formation in project decision making problem solutions: risk, uncertainty and competitive situations; Identification, Assessment and Mitigation.	**IIT Syllabus** https://www.ieor.iitb.ac.in/acad/courses/ie705 ***International Standard -*** https://ocw.mit.edu/courses/1-040-project-management-spring-2004/ https://ocw.mit.edu/courses/esd-36-system-project-management-fall-2012/pages/syllabus/ ***Industry Mapping:*** *MS project*	Panneerselvam, P Senthilkumar, Project Management, Chapter 2 K Nagarajan, Project Management, Chapter 3	**5**	

7	**Earned value concept in project control**	Calculation of Schedule and Cost Variances; Managing Human resources, conflicts, quality, reliability, IT and Life cycle costs in projects. Project capital, cost estimation: Breakeven analysis, Cost-benefit analysis: Profitability analysis, commercial and notional profitability; Management and human factor analysis,	**IIT Syllabus** https://www.ieor.iitb.ac.in/acad/courses/ie705 ***International Standard -*** https://ocw.mit.edu/courses/1-040-project-management-spring-2004/ ***Industry Mapping:*** *MS Project*	K Nagarajan, Project Management, Chapter 3 &4 Panneerselvam, P Senthilkumar, Project Management, Chapter 5 &6	**6**	

Course Outcomes

1. Students will understand project management frameworks, focusing on design, planning, scheduling, and closure for developmental projects.
2. Students will master project scheduling techniques and resource management methods under various constraints.
3. Students will apply evaluation and decision-making tools like AHP, Decision Trees, and Utility Theory in project selection.
4. Students will manage project risks, costs, and control using earned value concepts, cost estimation, and profitability analysis.

Online Resources:

7. https://onlinecourses.nptel.ac.in/noc19_cs70/preview
8. https://archive.nptel.ac.in/courses/110/104/110104073/
9. https://www.coursera.org/professional-certificates/google-project-management
10. https://www.coursera.org/specializations/meem-project-management
11. https://www.coursera.org/professional-certificates/google-project-management

12. https://ocw.mit.edu/courses/esd-36-system-project-management-fall-2012/pages/syllabus/
13. https://www.linkedin.com/learning/project-management-foundations-15528659/deliver-successful-projects?contextUrn=urn%3Ali%3AlyndaLearningPath%3A56db2d113dd5596be4e4989d&u=229219690

Text Book

1. R. Panneerselvam, P Senthilkumar, Project Management, PHI Learning Private Limited (Chapter 1,2,5,6,14,17,18,20,21)
2. K Nagarajan, Project Management, 8th edition, New Age int. Ltd. (Chapter 1,3,4,5)
3. Sitagshu Khatua, Project Management and Appraisal, Oxford University Press

References

1. Shtub, A., Bard, J. F. and Globerson, S. (1994), Project Management: Engineering, Technology and Implementation, Prentice Hall, Englewood Cliffs, USA.
2. Goodpasture, J. C. (2003), Quantitative Methods in Project Management, J Ross Publishing, Boca Raton, Florida, USA.
3. Meredith, J. R. and Mantel Jr., S. J. (2004), Project Management: A Managerial Approach, John Wiley, New York.
4. Berkun, S. (2005), Art of Project Management, O'Reilly Media, Cambridge, MA, USA.
5. Kolisch, R. (2001), Make-To-Order Assembly Management, Springer, Berlin.
6. Marchewka, J. T. (2006), Information Technology Project Management, John Wiley, New York, USA.
7. Project Management Institute (2000). A Guide to the Project Management Body of Knowledge, Project Management Institute, Newtown Square, Pennsylvania, USA.
8. Kerzner, H., (1998), Project Management: A Systems approach to Planning, Scheduling and Controlling, John Wiley, New York.
9. Nicholas, J. M. (2001), Project Management for Business and Technology: Principles and Practice, Prentice Hall India, New Delhi.
10. Bruke, R. (2004), Project Management Planning and Control Techniques, Wiley, Chichester.
11. Goldratt, E. M., (1997), Critical Chain, North River Press, Great Barrington, MA, USA.

CO-PO Mapping:

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

Subject Name: Operation Research **Credit: 3**

Subject Code: HSME601B **Lecture Hours: 36**

Pre-requisite: Basic Engineering Knowledge

Relevant Links: OR - Study Materials.pdf **NPTEL**

Objectives:

- To study the various Operations Research tools
- To study to apply an appropriate model to the given situation
- To formulate the problems of Operation research and Supply chain system
- To solve and analyze the problems on Operations Research

Course Content

Module number	Topic	Sub-topics	Mapping with Industry and International Academia	Lecture Hours	Corresponding Lab Assignment	Mapping with Text Books

1	**Introduction to Operations Research:**	Introduction, Historical Background, Scope of Operations Research, Features of Operations Research, Phases of Operations Research, Types of Operations Research Models, Operations Research Methodology, Operations Research Techniques and Tools, Structure of the Mathematical Model, Limitations of Operations Research.	***IIT Roorkee Syllabus:*** IITRoorkee.pdf ***International Standard:*** Philadelphia University _OR.pdf	**2**	NA	H.A. Taha, Operations Research - An Introduction, 7th Edition, Prentice Hall, 2002
2	**Linear Programming:**	Introduction, Linear Programming Problem, Requirements of LPP, Mathematical Formulation of LPP, Case Studies of LPP, Graphical Methods to Solve Linear Programming Problems, Applications, Advantages, Limitations. Graphical Analysis of Linear Programming Problems: Introduction, Graphical Analysis, Some Basic Definitions, Graphical Methods to Solve LPP, Some Exceptional Cases, Important Geometric Properties of LPP. Simplex Method: Introduction, Standard Form of LPP, Fundamental theorem of LPP, Solution of LPP - Simplex Method, The Simplex Algorithm, Penalty Cost	***IIT Roorkee Syllabus:*** IITRoorkee.pdf ***International Standard:*** Philadelphia University _OR.pdf	**8**	NA	H.A. Taha, Operations Research - An Introduction, 7th Edition, Prentice Hall, 2002

		Method or Big M-method, Two Phase Method, Solved Problems on Minimisation. Duality in Linear Programming Problem: Introduction, Importance of Duality Concepts, Formulation of Dual Problem, Economic Interpretation of Duality, Sensitivity Analysis.				
3	**Transportation Problem:**	Introduction, Formulation of Transportation Problem (TP), Transportation Algorithm (MODI Method), the Initial Basic Feasible Solution, Moving Towards Optimality.	***IIT Roorkee Syllabus:*** IITRoorkee.pdf ***International Standard:*** Philadelphia University _OR.pdf	**3**	NA	H.A. Taha, Operations Research - An Introduction, 7th Edition, Prentice Hall, 2002
4	**Assignment Problem:**	Introduction, Mathematical Formulation of the Problem, Hungarian Method Algorithm, Travelling Salesman Problem.	***IIT Roorkee Syllabus:*** IITRoorkee.pdf ***International Standard:*** Philadelphia University _OR.pdf	**3**	NA	H.A. Taha, Operations Research - An Introduction, 7th Edition, Prentice Hall, 2002
5	**Project Management Using CPM-PERT:**	Project Scheduling and PERT-CPM: Introduction, Basic Difference between PERT and CPM, PERT/CPM Network Components and Precedence Relationship, Project Management – PERT, Float calculation and its	***IIT Roorkee Syllabus:*** IITRoorkee.pdf ***International Standard:*** Philadelphia	**5**	NA	H.A. Taha, Operations Research - An Introduction, 7th Edition, Prentice Hall, 2002

		importance. Cost reduction by Crashing of activity.	University _OR.pdf			
6	**Queuing Theory:**	Basis of Queuing theory, elements of queuing theory, Operating characteristics of a queuing system, Queue discipline, Service Mechanism, Classification of Queuing models, [M/M/1]:{//FCFS} Queue System, numerical.	***IIT Roorkee Syllabus:*** IITRoorkee.pdf ***International Standard:*** Philadelphia University _OR.pdf	**3**	NA	H.A. Taha, Operations Research - An Introduction, 7th Edition, Prentice Hall, 2002
7	**Inventory Management:**	Inventory classification, Different costs associated with Inventory, Inventory models with deterministic demands (EOQ, EPQ and price discount models), inventory classification systems.	***IIT Roorkee Syllabus:*** IITRoorkee.pdf ***International Standard:*** Philadelphia University _OR.pdf	**4**	NA	H.A. Taha, Operations Research - An Introduction, 7th Edition, Prentice Hall, 2002
8	**Job Sequencing:**	Introduction to sequencing and scheduling models: n job two machines problem, n job 3 machines problem.	***IIT Roorkee Syllabus:*** IITRoorkee.pdf ***International Standard:*** Philadelphia University _OR.pdf	**2**	NA	H.A. Taha, Operations Research - An Introduction, 7th Edition, Prentice Hall, 2002

9	**Decision Theory:**	Introduction, Decision under certainty, Decision under risk, Decision under uncertainty: Laplace criterion, MaxiMin criterion, MiniMax criterion, savage MiniMax regret criterion, Hurwicz criterion, Decision tree.	***IIT Roorkee Syllabus:*** IITRoorkee.pdf ***International Standard:*** Philadelphia University _OR.pdf	**3**	NA	H.A. Taha, Operations Research - An Introduction, 7th Edition, Prentice Hall, 2002
10	**Replacement Theory:**	Introduction, Replacement of capital equipment which depreciated with time, replacement by alternative equipment, Group and individual replacement policy.	***IIT Roorkee Syllabus:*** IITRoorkee.pdf ***International Standard:*** Philadelphia University _OR.pdf	3	NA	H.A. Taha, Operations Research - An Introduction, 7th Edition, Prentice Hall, 2002

Text /Reference Books:

1. H.A. Taha, Operations Research - An Introduction, 7th Edition, Prentice Hall, 2002.
2. F.S. Hillier, G.J. Lieberman, B. Nag and P. Basu, Introduction to Operation Research, 10th Edition, McGraw Hill, 2017.
3. C. Mohan and K. Deep, Optimization Techniques, New Age, 2009.
4. N.D. Vohra, Quantitative Techniques in Management, 5th Edition, McGraw-Hill.
5. K.V. Mittal and C. Mohan, Optimization Methods in Operations Research and Systems Analysis, New Age, 2003.
6. A. Ravindran, D.T. Phillips and J.J. Solberg, Operations Research: Principles and Practice, 2nd Edition, John Willey and Sons, 2009.
7. K. Bedi, Production and Operations Management, Oxford University Press, 2004.
8. S.J. Chandra and A. Mehra, Numerical Optimization with Applications, Narosa, 2009.
9. J.K. Sharma, Operation Research: Theory and Applications, 5th Edition, Macmillan Pub., 2013.

10. Research Applications and Algorithms, 4th Edition, Brooks/Cole, USA.

Online Resources:

1. https://onlinecourses.nptel.ac.in/noc19_ma29/preview
2. https://onlinecourses.swayam2.ac.in/cec20_ma10/preview

Course Outcomes:

At the end of this course students will demonstrate the ability to

CO1	Develop a model that describes the real-life problem and solve them using optimization technique.
CO2	Use the basic methodology to find the solution of linear problems.
CO3	Introduce the students to the basic concepts of decision science, inventory management and project management.
CO4	To formulate complex mathematical models in management science, industrial engineering and transportation science.

CO-PO Mapping:

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

Subject Name: Mechanical Engg Lab IIC (Advanced Manufacturing & Automation)

Subject Code: PCCME691 **Credit: 1** **Lecture Hours: 24**

Pre-Requisites: Manufacturing Process II

Course Objectives:

- To equip students with hands-on expertise in advanced manufacturing technologies, including CNC machining, additive manufacturing, and robotics.
- To provide comprehensive knowledge of both conventional and unconventional machining techniques, fostering the ability to select appropriate tools and processes for diverse manufacturing needs.

Course Contents

Exp. number	Topic	Mapping with Industry and International Academia	Corresponding Lab Assignment
	1. CNC Programming on CNC Lathe using G and M Codes and using APT: Taper turning and external thread cutting. 2. CNC Programming on CNC vertical Milling Machine using G and M Codes and using APT: Contour milling. 3. Programming on CNC machine Simulator and observing virtual machining 4. Experiments on AJM/ USM/ WEDM/ EDM/ ECM/ LBM	**International Academia:** https://professional.mit.edu/course-catalog/additive-manufacturing-3d-printing-factory-floor https://ocw.mit.edu/courses/2-12-introduction-to-robotics-fall-2005/	1. Validate the CNC programs by simulating the machining operations in the CAM software and analyzing the toolpaths and simulated results. 2. Utilize simulation software like ANSYS Simulate material removal rate, surface finish, accuracy, tool wear, and energy consumption using appropriate parameters and materials. 3. Use simulation software tools such as Materialize Magics or Ultimaker Cura

5. Design and manufacture of Engineering components using Additive Manufacturing (3D printing). 6. Conversion of STL format, Slicing of STL file, and study of the effect of process parameters like layer thickness, Orientation, and infill on build time using software. 7. 3D Printing of modelled component by varying layer thickness, varying orientation, and varying infill. 8. Microprocessor-controlled pick-and-place robot: write simple Robot Programming 9. Study and solve problems on the geometry of robot manipulators, actuators, and grippers 10. Laboratory modules of pneumatics and/or electro-pneumatics actuation systems. 11. Laboratory modules of hydraulics and/or electro-hydraulics actuation systems. 12. Simulation of designed pneumatics/hydraulics systems	**AICTE-prescribed syllabus:** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf **Industry Mapping:** Solid CAM, Fanuc CNC simulator, SIEMENS Sinutrain Solidworks, Fusion 360, NX 8, MasterCAM, CURA, ThinkerCAD, MATLAB, LabVIEW, Python, fluidsim	to optimize the design and printing parameters for the selected additive manufacturing process. Optimize process parameters such as layer thickness, build orientation, infill density, and support structures to achieve desired outcomes such as part strength, dimensional accuracy, and surface finish. 4. Design and control a robotic arm for pick-and-place operations, integrating sensors for process monitoring and using LabVIEW/Python for visualization and control.

Online Learning Resources:

1. https://ocw.mit.edu/courses/2-008-design-and-manufacturing-ii-spring-2004/pages/labs/
2. https://www.coursera.org/specializations/3d-printing-additive-manufacturing
3. https://onlinecourses.nptel.ac.in/noc21_me04/preview
4. https://www.coursera.org/specializations/autodesk-cad-cam-manufacturing
5. https://www.coursera.org/specializations/cad-design-digital-manufacturing
6. https://ocw.mit.edu/courses/2-008-design-and-manufacturing-ii-spring-2003/resources/labs13/

Course Outcomes:

1. Develop skills in CNC lathe and milling machine programming, operation, and techniques.
2. Understand unconventional machining processes and tools used in manufacturing.
3. Learn additive manufacturing processes and their applications in modern industry.
4. Operate a robot arm and design basic pneumatic and hydraulic circuits.

Learning Resources:

1. P.N. Rao, Manufacturing technology Volume II Metal Cutting and Machine Tools, McGraw Hill, 4th edition
2. S. Kalpakjian and S.R. Schmid, Manufacturing Processes for Engineering Materials, 5th Edition, Pearson India, 2014.
3. M.P. Grover, Fundamentals of Modern Manufacturing, 3rd Edition, Wiley.

CO-PO Mapping:

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

Subject Name: Mechanical Engg Lab ID (Computer Aided Design and Analysis)

Subject Code: PCCME692 **Credit: 1** **Lecture Hours: 24**

Pre-requisite: Computer Aided Design and Analysis

Course Objectives:

- Develop proficiency in 2D and 3D geometric modeling and apply various transformations (translation, scaling, rotation) to shapes.
- Utilize solid modeling techniques to create complex 3D objects and conduct basic finite element analyses to simulate structural behavior.

Course Contents (experiments/ problems/ studies are to perform):

Topic	Mapping with Industry and International Academia	Corresponding Lab Assignment
1. Develop MATLAB code to implement 2D transformation matrices for translation, scaling, and rotation. Apply these matrices to a given set of points and graphically display both the original and transformed shapes 2. Generate equation driven curves in SolidWorks and implement them in designing machine elements e.g. sinusoidal or parabolic profile cams. 3. Generate a smooth trajectory of a robotic arm motion with a cubic Bezier curve with pre-defined control points. Visualize this trajectory in a MATLAB-	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standards:*** https://ocw.mit.edu/courses/2-008-design-	1. Implement MATLAB for 2D transformation matrices on translation, scaling, and rotation. Apply these matrices to a specified set of points and visually represent both the original and transformed shapes. 2. Generate equation driven curves in SolidWorks and implement them in designing machine elements e.g. sinusoidal or parabolic profile cams. 3. Implement a MATLAB SIMULINK model to simulate the motion of a robotic arm along a smooth path using a cubic Bezier curve, where the

SIMULINK environment and compare it with a linear path 4. Utilize solid modeling techniques to create a 3D object in SolidWorks. Save the model and export it in a commonly accepted file format like IGES or STL and import to a CAE tool. 5. Conduct a one-dimensional finite element analysis (FEA) using ANSYS to simulate the stress and deformation of a bar element subjected to a specified load. Utilize post-processing capabilities to visually represent the results and compare them with theoretical predictions based on classical mechanics 6. Determine the theoretical stress-concentration factor (K_t) for a notched specimen using ANSYS Mechanical. 7. Create a simple 2D frame model in STAAD.Pro, apply loads and boundary conditions, and analyze the internal forces (axial, shear, bending) using post-processing tools.	and-manufacturing-ii-spring-2003/pages/labs/ ***Industry Mapping:*** AUTOCAD, SOLIDWORKS, ANSYS, MATLAB-SIMULINK, STAAD Pro	arm moves between two specified coordinates with the help of pre-defined control points. Visualize the trajectory in the Scope block and compare the smooth motion provided by the cubic Bezier curve to a linear path. 4. Utilize solid modeling techniques to create a 3D object in SolidWorks. Save the model and export it in a commonly accepted file format like IGES or STL and import to a CAE tool. 5. Perform a finite element analysis using ANSYS to simulate the stress and deformation of a bar element subjected to a specified load. Learn the postprocessing technique and analyse the dynamic result obtained. 6. Determine the theoretical stress-concentration factor (K_t) for a notched specimen using ANSYS Mechanical.

Course Outcomes:

After completing this course,

1. Demonstrate proficiency in using CAD software to create and manipulate 2D and 3D geometric shapes.
2. Apply mathematical concepts to implement 2D transformations and understand their effects on shapes.
3. Utilize solid modeling techniques to create complex 3D objects and understand their manufacturing implications.
4. Apply FEA principles to analyze the stress and deformation of simple structures and interpret the results.

Learning Resources:

1. Ibrahim Zeid, “Mastering CAD CAM,” Tata McGraw Hill Publishing Co. 2007.
2. C. McMohan and J. Browne, “CAD/CAM Principles,” Pearson Education, 2nd Edition, 1999.
3. Geometric Modeling, Michael E. Mortenson, Tata McGraw Hill, 2013.

CO-PO Mapping:

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

Subject Name: Mechanical Engineering Laboratory IIID (Refrigeration and Air Conditioning)

Subject Code: PCCME693 **Credit: 1** **Lecture Hours: 24**

Pre-Requisites: Heat transfer

Course Content:

S. No.	Topic	Mapping with Industry and International Academia	Corresponding Lab Assignment
1	Analyzing different components of a domestic refrigerator and enhancing the efficiency through simulation.	***AICTE prescribed syllabus:*** https://www.aicte-india.org/sites/default/files/Model_Curriculum/Final_Mechanical%20Engg.pdf ***International Standards:*** https://ocw.mit.edu/courses/4-42j-fundamentals-of-energy-in-buildings-fall-2010/pages/readings/ ***Industry Mapping:*** MATLAB, ANSYS	Create a MATLAB Simulink model of the various parts of a simple domestic refrigerator (compressor, condenser, expansion valve and evaporator).
2	Evaluate the C.O.P. and air-conditioning capacity of a window-type-air conditioner via thermodynamic data collection from different sensors and analyzing the same through plotting *p-h* and *T-s* diagrams at different ambient conditions on a psychrometric chart of R-22.		Create a MATLAB Simulink model of an air conditioning system (compressor, condenser, expansion valve, evaporator, thermostat control unit and power meter), define the system parameters (room temperature, ambient temperature, compressor power, thermostat set points), run the simulation for 2 hours and observe the fluctuation of room temperature.
3	Evaluate the C.O.P. of a vapour compression refrigeration system based on the thermodynamic data collected from the setup (based on LabVIEW software) and analyzing the same through plotting the *p-h* diagram on a psychrometric chart of R-134a. Also, comparing the theoretical and actual results.		For a CAD model of a VCRS, define the boundary conditions of the system in ANSYS, consider refrigerant R-22 as the fluid and check the heat flow along the system for a 2-hour simulation. Calculate the C.O.P. of the system based on the generated results.
4	Evaluate the C.O.P. of a centralized-air conditioner		For the MATLAB Simulink model of a VCRS, use

	(setup – based on LabVIEW software) via thermodynamic data collection from different sensors and analyzing the same through plotting *p-h* and *T-s* diagrams on a psychrometric chart of R-134a. Also, comparing the theoretical and actual results.	Basics of Air Conditioning & Heat Load Calculation by L&T EduTech NBA 2016, ECBC 2017 and ENS 2018	**psychrometric.m** (from MATLAB File Exchange) to track the change in air properties (such as dry bulb temperature, wet bulb temperature, relative humidity, and enthalpy) as the air moves through the evaporator and condenser. Calculation of heat load of a room through real-life data collection using simulation tool.
5	Performance analysis of a thermoelectric refrigeration system and its correlation with thermodynamic cycle to understand the Peltier effect and calculating the effectiveness of the semi-conductor diode of the setup.		Make a 2D geometry of a block of ice (at -10°C) surrounded by ambient air and assess the flow of heat with respect to time. Tabulate the transient results.
Mini Project: Create a MATLAB script titled "refrigerationCycleSimulator.m" that simulates the performance of a VCRS that uses input parameters like refrigerant type, compressor efficiency, condenser and evaporator temperatures, and the script calculates important thermodynamic properties (enthalpy, pressure, entropy, etc.) at various points in the cycle. The tool should also help visualize the cycle on a *T-s* diagram and *P-h* diagram.			

Course outcomes:

CO1: Understand the basic operating principles and working of a refrigeration system's components.
CO2: Analyze the operation and performance of refrigeration systems.
CO3: Evaluate the performance characteristics and energy efficiency of air conditioning systems.
CO4: Investigate the psychrometric behavior of air conditioning systems.

Learning Resources:

Ramesh Chandra Arora, "Refrigeration and Air Conditioning", PHI Learning Pvt. Ltd., 2010.

R. S. Khurmi and J. K. Gupta, "A Textbook of Refrigeration and Air Conditioning" S. Chand Publishing.

CO-PO Mapping:

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

Subject Name: Database Management Systems **Credit: 1**

Subject Code: ESCME681 **Lecture Hours: 24**

Pre-requisite: Basic knowledge of computer fundamentals, programming in C/C++, Data Structure & Algorithms and basic understanding of algorithms and problem-solving concepts.

Objectives:

To develop the ability to efficiently organize, manage, and process data using appropriate data structures and algorithms through programming.

Contents

Module & Topic	Sub-topics	Mapping with Industry and International Academia
Module I	Data base System Applications, Purpose of Database Systems, View of Data – Data Abstraction Instances and Schemas – data Models – the ER Model – Relational Model – Other Models – Database Languages – DDL – DML – database Access for applications Programs – data base Users and Administrator – Transaction Management – data base Architecture – Storage Manager – the Query Processor Data base design and ER diagrams – ER Model - Entities, Attributes and Entity sets – Relationships and Relationship sets – ER Design Issues – Concept Design – Conceptual Design for University Enterprise. Introduction to the Relational Model – Structure – Database Schema, Keys – Schema Diagrams	**NPTEL** https://onlinecourses.nptel.ac.in/noc22_cs91/preview **Linkedin** https://www.linkedin.com/learning/topics/database-management **Coursera** https://www.coursera.org/learn/database-management

Module II	Relational Query Languages, Relational Operations. Relational Algebra – Selection and projection set operations – renaming – Joins – Division – Examples of Algebra overviews – Relational calculus – Tuple relational Calculus – Domain relational calculus. Overview of the SQL Query Language – Basic Structure of SQL Queries, Set Operations, Aggregate Functions – GROUPBY – HAVING, Nested Sub queries, Views, Triggers.	**NPTEL** https://onlinecourses.nptel.ac.in/noc22_cs91/preview **Linkedin** https://www.linkedin.com/learning/topics/database-management **Coursera** https://www.coursera.org/learn/database-management
Module III	Normalization – Introduction, Non loss decomposition and functional dependencies, First, Second, and third normal forms – dependency preservation, Boyee/Codd normal form. Higher Normal Forms - Introduction, Multi-valued dependencies and Fourth normal form, Join dependencies and Fifth normal form	**NPTEL** https://onlinecourses.nptel.ac.in/noc22_cs91/preview **Linkedin** https://www.linkedin.com/learning/topics/database-management **Coursera** https://www.coursera.org/learn/database-management
Module IV	Transaction Concept- Transaction State- Implementation of Atomicity and Durability – Concurrent – Executions – Serializability- Recoverability – Implementation of Isolation – Testing for serializability- Lock –Based Protocols – Timestamp Based Protocols- Validation- Based Protocols – Multiple Granularity. Recovery and Atomicity – Log – Based Recovery – Recovery with Concurrent Transactions – Buffer Management – Failure with loss of nonvolatile storage-Advance Recovery systems- Remote Backup systems.	**NPTEL** https://onlinecourses.nptel.ac.in/noc22_cs91/preview **Linkedin** https://www.linkedin.com/learning/topics/database-management **Coursera** https://www.coursera.org/learn/database-management

Module V	File organization– File organization – various kinds of indexes. Query Processing – Measures of query cost - Selection operation – Projection operation, - Join operation – set operation and aggregate operation – Relational Query Optimization – Transacting SQL queries – Estimating the cost – Equivalence Rules.	**NPTEL** https://onlinecourses.nptel.ac.in/noc22_cs91/preview **Linkedin** https://www.linkedin.com/learning/topics/database-management **Coursera** https://www.coursera.org/learn/database-management

Text Books:

1. Data base System Concepts, Silberschatz, Korth, McGraw hill, Sixth Edition.(All UNITS except III th)
2. Data base Management Systems, Raghurama Krishnan, Johannes Gehrke, TATA McGrawHill 3rd Edition.

Reference Books:

1. Fundamentals of Database Systems, Elmasri Navathe Pearson Education.
2. An Introduction to Database systems, C.J. Date, A.Kannan, S.Swami Nadhan, Pearson, Eight Edition for UNIT III.

Course Outcomes:

At the end of this course students will demonstrate the ability to

1. Understand the fundamentals, architecture, and applications of database systems and their components.
2. Design and model databases using ER diagrams and relational models with appropriate keys and constraints.
3. Analyze and execute queries using relational algebra, relational calculus, and SQL.
4. Apply normalization techniques for efficient and consistent database design.
5. Illustrate transaction management, concurrency control, recovery mechanisms, and query optimization in database systems.

Subject Name: Project-IV (Minor)

Subject Code: PRJME681 **Credit: 1** **Lecture Hours: 24**

Pre-Requisites: No pre-requisites

Course Objectives:

This course is aimed to provide more weightage for project work. The project work could be done in the form of a summer project or internship in the industry or even a minor practical project in the college. Participation in any technical event/ competition to fabricate and demonstrate an innovative machine or product could be encouraged under this course.

Course Outcomes:

Students will be able to understand

1. Background work related to project idea.
2. the procedure to carry out practical projects related to any technical event
3. fabrication process of a product
4. demonstrate an innovative machine or product, etc.

CO-PO Mapping:

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

Subject Code: ESP(ME)601	**Category**: Mandatory & Industry Value Added Course
Subject Name: Essential Studies for Professionals (ME)-VI	**Semester:** 6th
L-T-P : 2-0-0 (Total Contact Hrs. 2)	**Credit: 2**
Pre-Requisites: Thermodynamics, Fluid Mechanics, Strength of Material	

Course Objective:

1. To learn about modes of heat transfer and related laws for professional exams
2. To learn about fundamentals of fluid mechanics for various exams
3. To learn about basic of Structure and properties of mechanics of materials forprofessional exams
4. To learn about fundamentals of Hydraulics for various exams

Course Outcomes:

At the end of the course the students will be able-

1. To develop an understanding of heat transfer correlations and their laws and factors.
2. To apply the knowledge of turbo machinery.
3. To understand fluid statistics and fluid properties.
4. To learn and understand the Structure and properties of Hydraulic machines.

Course Content:

Module No.	Description	Hour	BloomsLevel	PO (1.1.2) Mapping
1.	**Heat-Transfer:** Modes of heat transfer; one dimensional heat conduction, resistance concept and electrical analogy, heat transfer through fins; unsteady heat conduction, lumped parameter system, Heisler's charts;thermal boundary layer, dimensionless parameters in free and forced convective heat transfer, heat transfer correlations for flow over flat plates and through pipes, effect of turbulence; heat exchanger performance,LMTD and NTU methods; radiative heattransfer, Stefan-Boltzmann law, Wien's displacement law, black and grey surfaces, view factors, radiation network analysis	12	L1 (Remember) L2 (Understand)L4 (Analyze)	PO1,PO2,PO3
2.	**Application: Turbomachinery:** Impulse andreaction principles, velocity diagrams, Pelton-wheel, Francis and Kaplan turbine Fluid Mechanics: Fluid properties; fluid statics, manometry **Mechanics of Materials**: Stress and strain, elastic constants, Poisson's ratio; Mohr's circle for plane stress and plane strain; thin cylinders; shear force and bendingmoment diagrams; bending and shear stresses; deflection of beams; torsion of circular shafts; Euler's theory of columns; energy methods; thermal stresses; straingauges and rosettes; testing of materials with universal testing machine; testing of hardness and impact strength	12	L1 (Remember) L2 (Understand) L3 (Apply) L4 (Analyze)	PO1,PO2,PO3
3.	**Fluid Mechanics:** Properties of fluids, fluid statics; Continuity, momentum, energy and corresponding equations; Potential flow, applications of momentum and energy equations; Laminar and turbulent	12	L1 (Remember) L2 (Understand) L3 (Apply) L4 (Analyze)	PO1,PO2,PO3

	flow; Flow in pipes, pipe networks; Concept of boundarylayer and its growth. **Hydraulics:** Forces on immersed bodies; Flow measurement in channels and pipes; Dimensional analysis and hydraulic similitude; Kinematics of flow, velocity triangles; Basics of hydraulic machines, specific speed of pumps and turbines; Channel Hydraulics - Energy-depth relationships, specific energy, critical flow,slope profile, hydraulic jump, uniform flow and gradually varied flow			

Ref Books:

G.K publishers GATE Mechanical Engineering, Mcgraw hill GATE 2017 Mechanical Engineering,Wiley GATE 2017 Mechanical Engineering,

Subject Code: SDP681	**Category** : Mandatory& Industry ValueAdded Course
Subject Name: SKILL DEVELOPMENT FOR PROFESSIONALS-VI	**Semester** : 6th
L-T-P : 2-0-0 (Total Contact Hrs. 2)	**Credit:** 1
Pre-Requisites: Fundamental knowledge of Mathematics, English language till class 10th standard and basic aptitude for Reasoning ability	

Course Objective:

1. To learn about basic of Mathematics to apply for Engineering problems as well as in daily life.
2. To learn about the Basics Grammatical English and Vocabulary.
3. To sharpen and develop the basic Aptitude skill.

Course Outcomes:

At the end of the course the students will be able to

1. The ability to communicate effectively with a range of audiences.
2. The ability to face the test and interview conducted by different companies and succeed. And also, preparation to appear different competitive exams starts
3. The ability to recognize the need for continuing professional development.
4. The ability to succeed in competitive exams (BANK/IBPS/SSC/GATE / GRE / PSU's/Placement Aptitude etc.).

Course Content:

Module No.	Description	Hours	BloomsLevel	PO(1..12) Mapping

1.	**Revision and Advanced Problems in Quantitative Aptitude** 1) Numbers (+, -, x, etc.), Percentages, Ratio, Partnership, Linear Equations, Profit & Loss 2) Averages, Mixtures & Allegations, Number System, Time and Work 3) Simple & Compound Interest, Other / Misc. Quantitative Apt., Indices and Surds, Quadratic Equations 4) Permutations & Combinations, Probability, Geometry, Mensuration 5) Data Interpretation, Various Charts, Diagrams, Tables	15	L2 (Understand) L3 (Apply) L4 (Analyze)	PO1, PO2, PO10
2.	**Revision and Advanced Problems in Reasoning** **1)** Coding, Series & Numbers, Blood Relations, Analogy **2)** Cubes, Data Sufficiency, Non-Verbal Reasoning **3)** Syllogisms, Puzzles, Machine I/O, Inequality **4)** Seating Arrangement, Calendar / Clock **5)** Statements, Other / Misc Logical Reasoning, Decision Making (Ethics)	15	L2 (Understand) L3 (Apply) L4 (Analyze)	PO1, PO2, PO10
3.	Revision and Advanced Questions in Verbal English 1) Grammar, 2) Clauses, 3) Spotting errors, 4) Sentence Correction, 5) Blanks, 6) Reading Comprehensions, 7) Vocabulary	18	L1 (Remember) L2 (Understand) L3 (Apply) L4 (Analyze)	PO1, PO2, PO10

Learning Resources:

Text Books:

1. Objective General English- S.P Bakshi

2. English Grammar and Competition-S.C Gupta
3. Fast Track Objective Arithmetic- Rajesh Verma
4. Quantitative Aptitude– S.Chand

Reference Books:

1. Advance Maths- Rakesh Yadav
2. Verbal and Non-Verbal Reasoning- R.S Agarwal
3. 3.A new approach to Reasoning- BS Sijwali
4. Quantitative Aptitude-R. S Agar

Minor Degree in Sustainable Energy Engineering (SEE)- IEM_UEM

Electronics for Renewables

Course Code	MINOR601S
Course Title	Electronics for Renewables
Number of credits	03(L:1;P:2;S:1)
Course category	SEE
Pre-requisites	Basic Electronics, Energy resources

Course Objective:

This course will offer

- An understanding of basic components used in electronics application in renewable energy
- Operation of rectifiers
- Description and design of DC to DC convertors and their role in renewable energy technologies
- Description and design of DC to AC convertors and their role in renewable energy technologies
- Understanding and functionality of simple, PWM and MPPT charge controllers, their input and output parameters
- Understanding and functionality of off-grid, grid-tied and hybrid solar inverters
- Details of the efficient solar products available commercially for domestic and commercial application

Course Content

A. Theoretical Learning

Lecture No.	Contents
1	**Electronic components-1**: Components of electronic circuits used in renewable energy like diode, MOSFETs, IGBTs, etc. their functionalities and I-V characteristics
2	**Electronic components-2**: Components of electronic circuits used in renewable energy like diode, MOSFETs, IGBTs, etc. their functionalities and I-V characteristics
3	Rectifier: Half bridge and full-bridge converters, Power circuit and steady state analysis
4	DC – DC controller -1: Need of DC-DC conversion in renewable energy technologies, basics of DC-DC conversion, design of circuits, input and output parameters
5	DC – DC controller -2: Need of DC-DC conversion in renewable energy technologies, basics of DC-DC conversion, design of circuits, input and output parameters
6	DC – AC conversion-1: Need of DC-AC conversion in renewable energy technologies, basics of DC-AC conversion, design of circuits, input and output parameters
7	DC – AC conversion-2: Need of DC-AC conversion in renewable energy technologies, basics of DC-AC conversion, design of circuits, input and output parameters
8	Application of DC-DC controllers to solar energy-1: functionality and design of simple charge controller, input and output parameters
9	Application of DC-DC controllers to solar energy-2: functionality and design of PWM charge controller, input and output parameters

10	Application of DC-DC controllers to solar energy-3: functionality and design of MPPT charge controller
11	Application of DC-AC inverter to solar energy-1: functionality and design of off-grid inverter, input and output parameters
12	Application of DC-AC inverter to solar energy-2: functionality and design of grid-connected inverter, input and output parameters
13	Application of DC-AC inverter to solar energy-3: functionality and design of hybrid inverter, input and output parameters
14	Efficient solar operated products-1: Solar based DC products for domestic and industrial appliances
15	Efficient solar operated products-2: Solar based DC products for domestic and industrial appliances

B. Practical Learning

In contents please provide as detailed titled of the experiments as possible, also break down experiments in sub experiments to give clear indication on what are the concepts/observations students are expected to learn in each experiments

Experiment No.	Contents
1	Learn to make a PCB, design of PCB, fabrication of PCB
2	Experiment with an Half Bridge & Full bridge rectifiers & observer their characterisation, note down input and output parameters
3	Various firing circuits for IGBTs & their characterisation
4	Open up a hybrid / MPPT solar inverter, look at each and every block inside the inverter, write down the function of each block and match it with the theory that you have learned, note down the input and output parameters, using oscilloscope observe the shape of output waveform
5	Make a PCB with DC-DC conversion ICs and create a DC-DC converte

6	Make a simple inverter on a PCB, observe the input and output parameters, observe the output waveform shape

C. Social Learning

This activity would be most crucial and needs careful design. This includes activities outside the classroom and outside the laboratory. Students must do something to apply their knowledge. This can also be exercise to apply the knowledge learned in classroom and laboratory and gather more information/data from society on a topic.

Social experiment No.	Contents
1	Use the DC-DC charge controller that you have made and installed it for someone or some shop (like Paan shop, or any other shop) as device for their mobile charging. Make a brief report on it, possibly with photo of installation and small interview.
2	Use DC-DC charge controller that you have made, coupleit withbatteryand solar panel to run a 2 W LED light, install the light at someone's place who may need such light e.g. vegetable / fruit vendor, a hut, etc. Make a brief report on it possibly with photo of installation and small interview.
3	Based on your understanding of electronics used for solar energy applications, give one or two talks to junior classes or in a school
4	Visit a solar system installation in institution or any other location, small or big, observe the electronics used in the installation, prepare a report on it.

Text books and other references

● Power Electronics, P.S. Bimbhra, Khanna Book Publishing Co., New Delhi.
● Electrical Machines – I & II, P.S. Bimbhra, Khanna Book Publishing Co., New Delhi.
● Rashid.M. H "power electronics Hand book", Academic press, 2001.
● Mohan, Undeland and Robins, "Power Electronics – Concepts, applications and Design,

John Wiley and Sons, Singapore.
● Ned Mohan, T.M. Undeland and William P.Robbins, Power Electronics: Converters, Applications, 3rd Edition, John Wiley & Sons, 2009.
● Industrial Electronics and control /Biswanath Paul.
● Renewable Energy Technologies /Ramesh & Kumar /Narosa
● Electrical power systems quality-Roger C.Dugan- McGraw- Hills
● Energy Technology, O.P. Gupta, Khanna Publishing House, New Delhi, 2020.
● Khandelwal, K. C. and Mahdi, Biogas Technology - A Practical Hand Book, Tata McGraw.
● A. Chakrabarti, Energy Engineering and Management, PHI.

Expected outcome of course:

● Ability to understand the role of various electronic components in renewable energy technologies
● Ability to theoretically design DC to DC and DC to AC converters
● Ability to describe various charge controller and inverters used in solar energy technologies
● Ability to understand various solar DC efficient products available in the market
● Ability to fabricate simple DC to DC converters using ICs and deploy in the field

Course Code	:	MINOR601A
Course Title	:	Special topics in Artificial Intelligence
Number of Credits	:	3 (L: 3; T: 0; P: 0)
Semester	:	6th Semester

Course Objective: To give fundamental knowledge to the students so that they can understand what the AI is and study important topics related to the field.

Course Contents: **[Total Theory Duration: 42 Lectures]**

Module 1: [Duration: 9 Lectures]
Bayesian Filtering; Recurrent Neural Networks, Deep Neural Networks, Deep Reinforcement Learning.

Module 2: [Duration: 7 Lectures]
Self-Play Networks, Generative Adversarial Networks, Learning from Concept-Drifting Data Streams.

Module 3: [Duration: 9 Lectures]
Audio Signal Processing Basics, mirtoolbox contains many useful audio processing library functions, VOICEBOX: Speech Processing Toolbox for MATLAB, Audio processing in Matlab.

Module 4: [Duration: 10 Lectures]
Architectures for second generation knowledge based systems, Distributed AI and its applications.

Module 5: [Duration: 7 Lectures]
An introduction to neurocomputing and its possible role in AI, The role of uncertainty measures and principles in AI.

Text Books/References:

1. Dr. Nilakshi Jain, Artificial Intelligence: Making a System Intelligent, John Wiley & Sons.
2. Artificial Intelligence & Soft Computing for Beginners, 3rd Edition-2018, by Anindita Das, Shroff Publisher Publisher.
3. Artificial Intelligence: A Modern Approach, 3rd Edition, by Stuart Russell and Peter Norvig, Pearson Publisher.
4. New Artificial Intelligence (Advanced), Takashi Maeda and Fumio Aoki, Ohmsha Publisher.

Course Outcomes: After completion of course, students would be able:

1. To understand various AI techniques.
2. To decide when to use which type of AI technique.

Course Code: MINOR601R

Course Title: Control of Robotic Systems

Credits: 3 (L: 3; T: 0; P: 0)

Course Category: MINOR

Course Objective

This course aims to develop the understanding of control systems, its designing and application.

Course Contents

Module 1: Basics of Control

Differential Equation, Transfer function, Frequency response, Routh-Hurwitz test, relative stability, Root locus design, construction of root loci, Phase lead and phase-lag design, lag-lead design, Bode, polar, Nyquist plot

Module 2: Linear Control

Concept of states, state space model, different form, Controllability, observability, Pole placement by state feedback, observer design, P, PI & PID Controller, Control law partitioning, Modelling and control of a single joint

Module 3: Non-Linear Control System

Common physical non-linear system, Phase plane method, system analysis by phase plane method, Stability of non-linear system, Stability analysis by describing function method, Liapunov's stability criterion, The control problems for manipulators

Module 4: Motion Control

Point to Point Control, trajectory generation, Continuous Path Control, Joint based control, Cartesian Control, Force Control, hybrid position/force control system

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Text Books / References

1. M. Gopal, *Control Systems*, McGraw-Hill (2012)
2. K. Ogata, *Modern Control Engineering*, Prentice Hall India (2009)
3. M. Spong, M. Vidyasagar, S. Hutchinson, *Robot Modeling and Control*, Wiley & Sons (2005)
4. J. J. Craig, *Introduction to Robotics: Mechanics and Control*, 3rd Edition, Addison-Wesley (2003)
5. S. K. Saha, *Introduction to Robotics 2e*, Tata McGraw-Hill Education (2014)
6. Thomas Kailath, *Linear Systems*, Prentice Hall (1980)
7. Alok Sinha, *Linear Systems: Optimal and Robust Control*, Taylor & Francis (2007)

Alternative SWAYAM/NPTEL Course

NPTEL Course Name	Instructor	Host Institute
Robotics and Control: Theory and Practice	Prof. N. Sukavanam, Prof. M. Felix Orlando	IIT Roorkee
Control systems	Prof. C. S. Shankar Ram	IIT Madras

Course Outcomes (COs)

After successful completion of this course, students will be able to:

CO1: Analyze and model dynamic systems using differential equations, transfer functions, and state-space representations.

CO2: Design and evaluate classical and state-space control strategies, including P, PI, PID controllers and state feedback/observer systems.

CO3: Examine stability and behavior of non-linear systems using phase-plane analysis, Lyapunov methods, and describing functions.

CO4: Apply motion control techniques for robotic manipulators including trajectory planning, joint-space and Cartesian control, and hybrid position/force control.