D Y Patil College of Engineering and Technology,
Kasaba Bawada, Kolhapur
Department of Mechanical Engineering

D. Y. Patil College of Engineering and Technology

Kasaba Bawada, Kolhapur

(An Autonomous Institute)

Accredited by NAAC with 'A' Grade

T. Y. B. Tech Programme Structure

B. Tech.

(Mechanical Engineering)

(To be implemented from academic year **2024-25**)

D Y PATIL COLLEGE OF ENGINEERING AND TECHNOLOGY, KOLHAPUR

Teaching and Evaluation Scheme from Year 2024-25 (asper NEP-2020)

Third Year B.Tech Mechanical Engineering

SEMESTER -V

Sr. No.	Course Code	Course Type	Course Name	Teaching Scheme				Theory			Practical/ Tutorial		Total Marks
				Credits	Contact Hrs			ISE	MSE	ESE			
					L	P	T				INT	OE/PoE	
01	231MEPCCL301	PCC	Design of Machine Elements	3	3	-	-	20	30	50	-	-	100
02	231MEPCCL302	PCC	Energy & Power Engineering	3	3	-	-	20	30	50	-	-	100
03	231MEPCCL303	PCC	Industrial Metallurgy	3	3	-	-	20	30	50	-	-	100
04	231MEMDML301	MDM	Operation Research & Management	4	3	2	-	20	30	50	25	-	125
05	231MEOECL301	OEC	Computer Integrated Manufacturing System	2	2	-	-	-	-	50	-	-	50
06	231MEPECL301-304	PEC	Program Elective Course-I*	3	3	-	-	20	30	50	-	-	100
07	231MEPCCP301	PCC	Design of Machine Elements Lab	1	-	2	-	-	-	-	25	25	50
08	231MEPCCP302	PCC	Energy & Power Engineering Lab	1	-	2	-	-	-	-	25	-	25
09	231MEPCCP303	PCC	Industrial Metallurgy lab	1	-	2	-	-	-	-	25	25	50
10	231MEPECP301-304	PEC	Program Elective Courses-I Lab*	1	-	2	-	-	-	-	25	-	25
11	231MEMCL301	MC	Finishing School Training V	Audit	3*	-	-	-	-	-	50	-	Grade
12	231MECCA301	CCA	Liberal Learning	Audit	2*	-	-	-	-	-	50	-	Grade
Total				22	17	10	-	100	150	300	125	50	725

Program Elective Courses -I*	
Industrial Hydraulics and Pneumatics (231MEPEC301)	Advanced Manufacturing Technology-I (231MEPEC303)
Instrumentation and Control Engineering (231MEPEC302)	Safety and Maintenance Engineering (231MEPEC304)

MECHANICAL ENGG. DEPT. K. BAWADA, KOP.

PRINCIPAL, D.Y. Patil College of Engine... And Technology, Kasaba Bawada, Kolhap... (An Autonomous Institu...

Professor & Head
Mechanical Engg. Dept.,
D. Y. Patil College of Engg. & Tech.
Kolhapur

D Y PATIL COLLEGE OF ENGINEERING AND TECHNOLOGY, KOLHAPUR

Teaching and Evaluation Scheme from Year 2024-25 (asper NEP-2020)

Third Year B.Tech Mechanical Engineering

SEMESTER -VI

Sr. No.	Course Code	Course Type	Course Name	Teaching Scheme				Theory			Practical/ Tutorial		Total Marks
				Credits	Contact Hrs			ISE	MSE	ESE	INT	OE/PoE	
					L	P	T						
01	231MEPCCL304	PCC	Metrology and Quality Control	3	3	-	-	20	30	50	-	-	100
02	231MEPCCL305	PCC	Operation Research	2	2	-	-	-	-	50	-	-	50
03	231MEPCCL306	PCC	Mechatronics	3	3	-	-	20	30	50	-	-	100
04	231MEMDML302	MDM	Production & Material Management Lab	2	1	2	-	-	-	50	-	-	50
05	231MEPECL305-308	PEC	Program Elective Course-II*	4	4	-	-	20	30	50	25	-	125
06	231MEPECL309-312	PEC	Program Elective Course-III*	3	3	-	-	20	30	50	-	-	100
07	231MEVSECL301	VSEC	Computer Aided Manufacturing	1	1	-	-	-	-	-	25	-	25
08	231MEPCCP304	PCC	Metrology and Quality Control Lab	1	-	2	-	-	-	-	25	25	50
09	231MEPCCP306	PCC	Mechatronics Lab	1	-	2	-	-	-	-	25	25	50
10	231MEPECP309-312	PEC	Program Elective Courses-III Lab*	1	-	2	-	-	-	-	25	-	25
11	231MEVSECP301	VSEC	Computer Aided Manufacturing Lab	1	-	2	-	-	-	-	25	-	25
12	231MEMCL302	MC	Finishing School Training VI	Audit	3*	-	-	-	-	-	50	-	Grade
	231MECCA302	CCA	Liberal Learning	Audit	2*	-	-	-	-	-	50	-	Grade
Total				22	17	10	-	80	120	300	150	50	700

Program Elective Courses -II*	Program Elective Courses -III*
Machine Design (231MEPEC305)	Tool Engineering (231MEPEC309)
Thermal Energy Systems (231MEPEC306)	Refrigeration and Air Conditioning (231MEPEC310)
Logistics and Supply Chain Management(231MEPEC307)	Electric Vehicle (231MEPEC311)
Enterprise Resource Planning (231MEPEC308)	Rapid Prototyping (231MEPEC312)

MECHANICAL ENGG. DEPT. * K. BAVADA, KOP. *

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Kolhapur

Course Plan

Course Title: **Design of Machine Elements**	
Course Code: **231MEPCCL301**	**Semester: V**
Teaching Scheme: L-T-P: **3-0-0**	Credits: 3
Evaluation Scheme: ISE + MSE Marks: 20 + 30	ESE Marks: **50**
Prerequisite:	Strength of Materials, Kinematics Mechanism and Machines and Dynamics of Machines
Course Description:	
Design of Machine Elements is the application of mathematics, kinematics, statics, dynamics, mechanics of materials, engineering materials, manufacturing process and engineering drawing. It deals with understanding of basic concepts of machine design, phases of design. It involves designing of various machine elements and creative combining of these elements into a component or assembly that satisfy need.	

Course Objectives:

1	To study basic concepts of machine design and design procedure of machine element.
2	To study the design of various mechanical elements against static loading such as knuckle joint couplings, screws, springs and bolted and welded joints
3	To study use of design data book for design of machine elements
4	To study selection of machine elements from manufacturer's catalogue

Course Outcomes (COs):

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

CO	Statement	BTL
301.1	**Understand** basic concepts of machine design and design procedure of machine element.	L2
301.2	**Apply** the principles of static loading to design the mechanical elements such as a Knuckle joint, levers and screws.	L3
301.3	**Implement** the design procedure for finding the parameters of the mechanical elements such as shaft, key and couplings.	L3
301.4	**Execute** the principles of static loading to design of springs, bolted and welded joints.	L3
301.5	**Use** of design data book for design of machine elements	L3
301.6	**Select** the Flat belt and V belt from Manufactures catalogue	L2

Course Content

Content	Hours
Unit 1: Introduction to Machine Design	7
Concept of Machine design, Types of loads, Factor of safety, Theories of failures, Phases of design, Review and selection of various engineering material properties and I.S. coding for ferrous materials, standardization, preferred series, use of design data book.	
Unit No. 02: Design of Machine Elements under Static Loading	7
A) Knuckle joint, turn buckle and bell crank Lever. B) Design of Power screw: - Forms of threads, terminology of threads, friction in threads, multiple start screws, torque analysis for lifting and lowering load, design of power screws and nut with square, trapezoidal threads, self-locking & overhauling of screw, stresses in power screws	
Unit No. 03: Design of Shafts, Keys and Coupling: -	6
Design of solid and hollow shafts, splined shafts, ASME code for shaft design, Types and design of Keys, Types of Couplings, Design of Rigid Coupling, flexible bushed pin type flanged coupling	
Unit No. 04: Design of Joints:	7
A) Design of Bolted Joints Subjected to Eccentric Loading- 1) In a plane containing bolts, 2) Parallel to axis of bolt, 3) Perpendicular to the axis of bolt. B) Design of welded joints: - 1) Strength of transverse and parallel fillet welds 2) Eccentric load in the plane of weld 3) Welded joint subjected to bending moment	
Unit No. 05: Design of springs: -	7
Types of springs, materials and their applications, Styles of end, Stress and deflection equations for helical compression Springs, Design of Helical Compression Spring subjected to static loading.	
Unit–06: Design of Power Transmission Systems: -	6
Design of Pulley- flat and V belt pulley, Selection of flat belt, V belt as per the standard manufacturer's catalogue.	

Text Books:

01 Bhandari V.B. - "Design of Machine Elements" - McGraw Hill Education (India) Ltd.
02 Shigley J.E. and Mischke C.R. - "Mechanical Engineering Design" McGraw Hill Publ. Co. Ltd.
03 Ballaney, P.L., "Theory if Machines and Mechanisms", 2005, ISBN 9788174091222
04 Hannah and Stephens, "Mechanics of Machines: Advanced Theory and Examples", 1970, ISBN 0713132329 Edward Arnold London

Reference Books

1 Spotts M.F. - "Design of Machine Elements" - Prentice Hall International.
2 Black P.H. and O. Eugene Adams - "Machine Design" - McGraw Hill Book Co. Ltd.
3 "Design Data" - P.S.G. College of Technology, Coimbatore.
4 Hall A.S.; Holowenko A.R. and Laughlin H.G. - "Theory and Problems of Machine Design" - Schaum's outline series.
5 Ulicker Jr. J.J., Penock G.R. & Shigley J.E. "Theory of Machines and Mechanisms" Tata McGraw Hills
6 Ghosh Amitabha & Mallik Asok Kumar, "Theory of Mechanisms and Machines" east-West Press Pvt. Ltd. New Delhi

NPTEL Swayam Course List

1. Course Name: Design, Technology and Innovation
By Prof. B. K. Chakravarthy | IIT Bombay
Link: https://onlinecourses.swayam2.ac.in/aic20_ed02/preview

2. Course Name: Functional and Conceptual Design
By Prof. Asokan T | IIT Madras
Link: https://onlinecourses.nptel.ac.in/noc22_de10/preview

3. Course Name: Understanding Design
By Prof. Nina Sabnani | Industrial Design Centre, IIT Bombay
Link: https://onlinecourses.swayam2.ac.in/aic19_de04/preview

4. Course Name: Work System Design
By Prof. Inderdeep Singh | IIT Roorkee
Link: https://onlinecourses.nptel.ac.in/noc22_me133/preview

Course Plan

Course Title: **ENERGY & POWER ENGINEERING**	
Course Code: **231MEPCCL302**	Semester: **V**
Teaching Scheme: L-T-P: **3-0-0**	Credits: **3**
Evaluation Scheme: ISE +MSE Marks: **20+ 30**	ESE Marks: **50**

Prerequisite:	Basic mechanical Engineering, Thermodynamics, Heat and Mass Transfer,

Course Description:

This subject enables the student to understand basic principle of different type of renewable sources. Students will also learn new trends in power and energy sectors. Understand and the working principles & concept of various power stations, Performance and economic analysis.

Course Objectives:

1	To understand basic principles of solar Energy & solar photovoltaic system.
2	To understand basic principles and working of wind energy.
3	To understand the different types of power plant, & power scenario in India
4	To understand concept of different type of Instrumentation use for power plants and Load Curves and Load duration curves
5	To understand the Energy Marketing and Management.

Course Outcomes (COs):

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

CO	Statement	BTL
CO302.1	Describe the basic details of solar energy & equipment's used for the measurement of solar irradiation.	L2
CO302.2	Demonstrate working of solar photovoltaic system.	L2
CO302.3	Demonstrate working of wind energy.	L2
CO302.4	Explain the basic working principles of steam, hybrid, diesel, as turbine power plant and boilers.	L2
CO302.5	Demonstrate basics of Load Curves and Load duration curves & know the costs Associated with power generation.	L3
CO302.6	Understand the Energy Marketing and Management.	L2

Course Content

Unit-1 Introduction of Energy and Power plant:	
Introduction to Renewable and non-Renewable Energy sources. Different types of power plants – Solar, wind, Gas, Tidal. Geothermal Thermal, Hydro, IC Engine, Gas Turbine, Nuclear and their characteristics, Comparison of Power plants with respect to various parameters, Issues in Power plants power scenario in India and world, NTPC, NHPC and their role in Power development in India, Power Generation in Private sector, Power distribution, Power grid corporation of India, State grids, Railway grids and International grids.	**8.00 hrs**
Unit-2 Solar energy	
Introduction Solar energy, Solar potential, Solar radiation spectrum, Solar radiation geometry, Solar radiation data, Solar Collectors – flat plate, evacuated tube, Cylindrical parabolic, Concentrating parabolic, various Collectors, Modern thermal energy storage - Ultra capacitors/ Super capacitors, Super conducting materials, new generation batteries.	**8.00 hrs**
Unit-3 Solar photo voltaic system	
Operating Principle of Photovoltaic cell concepts, Photo-cell materials, Cell module array, Series and parallel connections, Maximum power point tracking, Study of standalone system with battery and AC or DC load, Hybrid systems (Diesel-PV, Wind-PV, Biomass-Diesel systems), Applications,	**7.00 hrs**
Unit-4 Wind energy	
Wind parameters and wind data, Power from wind, Site selection, Wind energy conversion systems and their classification, Construction and working of typical wind mill, Introduction to OTEC.	**6.00 hrs**
Unit-5 Instrumentation & Load Curves	
Flow measurement of feed water, fuel, air, steam with correction factor for temperature, Speed measurement, Level recorders, Radiation detectors, Smoke density measurement, Dust monitor, Flue gas oxygen analyzer – Analysis of impurities in feed water and steam – Dissolved oxygen analyzer – Chromatography – PH meter – fuel analyzer – Pollution monitoring instruments, Integration of instrumentation system. Load Curves and Load duration curves (Numerical treatments), Performance and operational characteristics of power plants, Peak load, Intermediate load and Base load plants and their characteristics, Input output characteristics of power plants, Economic division of between Base load plant and peak load plants, Tariff methods.	**9.00 hrs**

Unit-6 Energy Marketing and Management	
Energy Management, Energy Marketing: Selling and marketing in India, Creating supply chain in India, successfully working with business and virtual teams in India, Navigating the financial, legal and accounting environment, Human Resources issues , India's business culture in energy sector, Conservation of energy.	**7.00 hrs**

Textbook:

1 "Solar Energy", S.P.SukhatmeandJ.K.Nayak,TataMcGraw-Hill,3rd Edition,(2008).
2 "Non-ConventionalEnergySources",G.D.Rai.-KhannaPublisher,4 th Edition
3 "PowerPlantTechnology",M.M.ElWakil,TataMcGraw-Hill.Int,2ndEdition.Reprint,(2010).
4 "Power Plant Engineering" ,Domkundwar and Arora ,Dhanpatrai and Sons.

Reference Books:

1 "Solar Photovoltaic Fundamentals, Technologies and Applications", Chetan Singh Solanki, Prentice Hall of India Publications.
2 "Modern Power Station Practice", Vol.6, Instrumentation, Controls and Testing, by Pergamon Press, Oxford,(1971).
3 "PowerSystemAnalysis",GraingerJohnJ,andStevensonJr..W.D.,TataMcGrawHill,(2003).
4 "Economic Operation of Power Systems",L.K. Kirchmeyer,John Wiley and Sons,(1993).

NPTEL Swayam Course List

1. . Course Name: **Introduction of Energy and Power plant.**
   By Prof Ravi Kumar. | IIT Rookre
   http://kcl.digimat.in/nptel/courses/video/112107291/L31.html
2. Course Name: **Solar energy.**
   By Prof Ashish Garg | IIT Kanpur .
   http:playlist?list=PLFW6IRTa1g83uUSWpXcu-jXS32_RSXfVc
3. Course Name: **Wind energy**
   By Prof Dr. Pankaj Kalita | IIT Guwahati
   https://onlinecourses.nptel.ac.in/noc23_ge47/preview

Course Plan

Course Title: **Industrial Metallurgy**	
Course Code: **201MEPCCL303**	Semester: **V**
Teaching Scheme: L-T-P: **3-0-0**	Credits: **3**
Evaluation Scheme: ISE + MSE Marks: **20 + 30**	ESE Marks: **50**
Prerequisite:	Engineering Physics, Engineering Chemistry & Manufacturing Processes
Course Description:	
Metallurgy plays an important role in today's world of science and technology. This course is to provide a physical basis that links the structure of materials with their properties, focusing on ferrous and nonferrous metals. The concepts of micro structural changes during cooling are also discussed, Heat treating is a group of industrial and metalworking processes as hardening, normalizing and annealing etc. are used to alter the physical properties of a material	

Course Objectives:

1	To acquaint students with the basic concepts of Metals and alloy systems.
2	To understand fundamental knowledge of Steel & its alloys along with its applications.
3	To understand fundamental knowledge of Cast Iron & its alloys along with its applications.
4	To understand basic concepts of non-ferrous alloys and advanced materials.
5	To understand basic concepts and its application of Heat treatment processes.

Course Outcomes (COs):

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

CO	Statement	BTL
302.1	**Classify** basic concept of metals and alloy systems.	L2
302.2	**Select** different grades of steel for engineering application using fundamental knowledge of Steel & its alloys	L3
302.3	**Describe** fundamental knowledge of Cast Iron.	L2
302.4	**Explain** basic concepts of non-ferrous alloys and advanced materials	L2
302.5	**Understand** basic concepts and its application of heat treatment processes	L2
302.6	**Select** appropriate heat & surface treatment processes for industrial applications	L3

Course Content

Content	Hours
Unit 1: Introduction to Metals and alloy systems	8
Introduction to Metallic and Non-metallic materials and its classification (metals/alloys, polymers and composites) a) Imperfections in crystals, Defects- Point, Line, Planar, Volume- Slip planes and slip systems b) Alloy formation by crystallization, Nucleation and growth, Cooling curves, Dendritic structure and coring. c) Solid solutions and intermediate phases d) Phases and Gibbs phase rule e) Construction of equilibrium diagrams from cooling curves, Isomorphous (Solid Solution), Eutectic, Partial solubility Peritectic and Intermetallic Compounds Lever arm principles.	
Unit No. 02: Steel and its Alloys	7
With respect to typical compositions, Properties and Applications for the following alloys.) a) Fe- Fe3C equilibrium diagram - b) Alloy steels- Free cutting steels, HSLA high carbon low alloy steels, managing steels. creep resisting steels, Stainless steels- different types. Tool steels- types, c) Selection of materials and Specifications based on -IS, BS, SAE, AISI, DIN, JIS) Miscellaneous alloys such as super alloys.	
Unit No. 03: Cast Iron and Types of Cast Iron	5
Classification of Cast irons Gray cast irons, nodular cast irons, white cast irons, malleable cast irons, chilled. Effect of various parameters on structure and properties of cast irons. Applications of cast irons for different components of machine tools, automobiles, pumps, etc.	
Unit No. 04: Non-Ferrous Alloys and Advances in Materials	8
I. Copper based alloys brasses Cu- Zn, Bronzes Cu- Sn, Cu- Be, Cu-Ni. b) Aluminum based alloys Al-Cu (Duralumin), Precipitation Hardening, Al-Si (Modification), c) Lead Alloys-Pb- Sn (Solders and fusible alloys), g) Tin Alloys- Sn-Sb alloys (Babbits) ,h) Ti and its alloys II. Polymers, Composites, Nano-Materials.	
Unit No. 05: Principles of Heat & Surface treatment	5
a) Transformation of Pearlite into austenite upon heating, b) Transformation of austenite into Pearlite, Bainite and Martensite on cooling. c) TTT –Diagram and CCT - Diagrams - significance, Effect of alloying elements on TTT diagram and its significance. d) Heat treatment furnaces and equipment's, controlled atmosphere. Surface Treatment: Electrolytic Polishing, Electroplating, Galvanizing, All types of surface hardening processes.	

Unit–06: Heat Treatment Processes	
a)Heat Treatment of Steels I. Annealing – Types-Full, Partial and Sub critical annealing (Various types) and purposes II. Normalising- Purposes III. Hardening (Hardening types), Purposes, Austempering and Martempering, Mechanism of quenching and Quenching media, Hardenability- Concept and methods of determination of hardenability- Grossmans critical diameter method and Jominy end quench test. IV. Tempering Types, Structural transformations during tempering, purposes subzero treatment V Heat treatment defects and remedies.	7

Text Books:

01 "Material Science and Metallurgy for Engineers", V.D.Kodgire, Everest Publishers Pune, 39th Edition, 2017.

02 "Heat Treatments Principles and Practices", T.V. Rajan , C.P. Sharma and Ashok Sharma Prentice Hall of India Pvt Ltd, New Delhi, 2nd Edition 2011.

03 Ballaney, P.L., "Theory if Machines and Mechanisms", 2005, ISBN 9788174091222

04 Hannah and Stephens, "Mechanics of Machines: Advanced Theory and Examples", 1970, ISBN 0713132329 Edward Arnold London

Reference Books

1 "Material Science and Engineering", V.Raghwan. Prentice Hall of India Pvt. Ltd., New Delhi ,3rd Edition, 1995.

2 "Introduction to Physical Metallurgy", S.H.Avner, Mcgraw Hill Book Company Inc, Edition, 2nd. 1974

3 "Material Science and Engineering", W.D Callister, Wiley India Pvt.Ltd., 5th Edition 2013.

Online Resources:

Unit No	Online Resource Link	Source
1	https://nptel.ac.in/courses/113105024	NPTEL
2	https://nptel.ac.in/courses/113104068	NPTEL
3	https://nptel.ac.in/courses/113104068	NPTEL
4	https://nptel.ac.in/courses/113105021/ https://nptel.ac.in/courses/113105081	NPTEL
5	https://nptel.ac.in/courses/113104074	NPTEL
6	https://nptel.ac.in/courses/113104074	NPTEL

Course Plan

Course Title: **Operation Research & Management**	
Course Code: **231MEMDML301**	Semester: **V**
Teaching Scheme: L-T-P: **3-0-2**	Credits: **4**
Evaluation Scheme: ISE + MSE Marks: **20+ 30**	ESE Marks: **50** INT Marks: **25**

Prerequisite:	Mathematics, probability distributions and statistics
Course Description:	
This course will teach operational researchers to use their analytical and creative skills to develop better systems and operational procedures to solve manufacturing, production, development related problem	

Course Objectives:

1	To analyze different situations in the industrial scenario involving limited resources and finding the optimal solution within constraints.
2	To understand the quantitative techniques in management decision-making and its applications by using Linear Programming Model, Assignment Model, Transportation Model, Network Model and Sequencing Model to solve manufacturing problem.

Course Outcomes (COs):

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

CO	Statement	BTL
301.1	Understand the formulation of Linear programming problems	L 2
301.2	Solve Linear programming problems by using Operations Research techniques	L 3
301.3	Solve Transportation and Assignment problems	L 3
301.4	Understand project planning process	L 2
301.5	Apply the various techniques of Project Management such as CPM/PERT networks	L 3
301.6	Understand role of project manager	L 2

Course Content

Course Content

Content	Hours
Unit 1: Introduction To Operation Research	7
Birth of O.R., Methodology, Scope and Limitations. Types of O.R. Models, Applications in Production Management, Use of computers in O.R, Linear Programming: Formulation, graphical method.	
Unit2 : LLP by Simplex Method	8
Formulating maximization / minimization problems, Graphical solution, simplex methods, Special cases of LP, Duality of LP and its interpretation, Dual simplex methods,	
Unit 3:Operation Research Models	8
Transportation model- Mathematical formulation, methods to obtain initial basic feasible solution (IBFS)- NWCR , LCM and VAM, Conditions for testing optimality, MODI method for testing optimality of solution of balanced problems and unbalanced problems Assignment Model- Mathematical statement, Methods to solve balanced assignment problems, unbalanced assignment problems, Maximization problems. Sequencing- Sequencing of n jobs & 2 machines, Sequencing of n jobs & 3 machines	
Unit 4 : Project Planning	7
Project Planning – Importance of Project Planning, Steps of Project Planning, Project Scope, Work Breakdown Structure (WBS) and Organization Breakdown Structure (OBS), Phased Project Planning	
Unit 5 : Project Scheduling and Costing	9
Project Scheduling and Costing – Gantt chart, CPM and PERT Analysis, Identification of the Critical Path and its Significance, Calculation of Floats and Slacks	
Unit 6 : Project Monitoring and Control	6
Project Monitoring and Control – Role of Project Manager, MIS in Project Monitoring, Project Audit	

Textbook:

1 "Operations Research", Hira and Gupta, S.Chand and Co. New Delhi.

2 "Operations Research", Mandhar Mahajan, Dhanpat Rai & Co.

3 "Entrepreneurship Development" by S.S. Khanka - Published by S. Chand Publishing.

4 "Entrepreneurship: Theory and Practice" by Vasant Desai - Published by Himalaya Publishing House.

Reference Books:

1. "Operation Research an Introduction", Hamdy A. Taha, Pearson,10 th Edition

2. "Introduction to Operation Research", Paneer-Selvam, Prentice Hall of India publication,
2nd Edition

3. "Operation Research", Pradeep J. Jha, Tata McGraw Hill Publication.

4. "Entrepreneurship Development" by Dr. S.S. Khanka - Published by S. Chand Publishing, volume I.

5. "Entrepreneurship: Theory and Practice" by Dr. B.S. Bodla - Published by Kalyani Publishers, volume I

6. "Entrepreneurial Development" by Dr. Rajeev Roy - Published by Excel Books, volumeI

7. "Entrepreneurship Development and Management" by Dr. S. Anil Kumar - Published by Himalaya Publishing House, volume I.

Online Resources:

Unit No	Online Resource Link	Source
1	https://nptel.ac.in/courses/110/106/110106062/	NPTEL
2	https://nptel.ac.in/courses/110/106/110106059/	NPTEL
3	https://nptel.ac.in/courses/112/106/112106134/	NPTEL

Course Plan

Course Title: **Computer Integrated Manufacturing Systems**	
Course Code: **231MEOECL301**	Semester: **V**
Teaching Scheme: L-T-P: **2-0-0**	Credits:**02**
Evaluation Scheme:	ESE Marks: **50**

Prerequisite:	Basic Mechanical Engineering, Basic Computer Science and Engineering.

Course Description:

Computer-integrated manufacturing system (CIMS) is the manufacturing approach of using computers to control the entire production process. Computer Integrated Manufacturing, known as CIM, is the phrase used to describe the complete automation of a manufacturing plant, with all processes functioning under computer control and digital information tying them together. This is the complete automation of a manufacturing facility such as a factory. All functions are under computer control. This starts with computer-aided design, followed by computer-aided manufacture, inspection followed by automated storage and distribution.

Course Objectives:

1	Elaborate the principle/s of Automation, CIM, CAD, CAM and study the differences between these concepts.
2	To acquaint student with the use computerized manufacturing planning and control system.
3	Study the fundamentals of Group technology, flexible manufacturing system
4	Study application of robotics technology in the field of manufacturing and inspection.
5	Understand modern trends in Manufacturing like Industry 4.0 and applications of Internet of Things leading to Smart Manufacturing.

Course Outcomes (COs): At the end of the course the student should be able to:

CO	Statement	BTL
301.1	Able to define Automation, CIM, CAD, CAM and explain the differences between these concepts.	**L2**
301.2	Discuss different computerized manufacturing Planning and control systems used in Industry and understand their output and benefits	**L2**
301.3	Understand fundamentals of Group Technology and Flexible Manufacturing Systems	**L2**
301.4	Recognize applications of robotics in the field of manufacturing.	**L2**

Course Content

Content	Hours
Unit 1: Introduction to CIM and Automation.	7
Meaning, Scope, Evolution, Architecture, Elements, Benefits, Limitations, traditional product cycle diagram, disadvantages and limitation of traditional product cycle, current production needs-production, accuracy, quality, repeatability, flexibility, survival etc. Role of Computers in design and manufacturing, integration. Automation in Production Systems, automated manufacturing systems- types of automation, reasons for automating etc.	
Unit No. 02: Computerized Manufacture Planning and Control System	8
Computer Aided Process Planning, Retrieval and Generative Systems, benefits of CAPP, Production Planning and Control Systems, typical activities of PPC System, computer integrated production management system, Material Requirement Planning, inputs to MRP system, working of MRP, outputs and benefits, Capacity Planning, Computer Aided Quality Control, Shop floor control.	
Unit No. 03: Flexible Manufacturing Systems	8
Fundamentals of Group Technology and Flexible Manufacturing Systems, types of FMS, FMS components, Material handling and storage system, applications, benefits, computer control systems, FMS planning and design issues, Automated Storage and Retrieval Systems, AS/RS and Automatic parts identification systems and data capture.	
Unit No. 04: Robot Technology	7
Brief History, Basic Concepts of Robotics such as Definition, three laws, Robot anatomy, DOF, Robot anatomy, joints and links, common robot configurations, robot control systems, accuracy and repeatability, end effectors, sensors in robotics. Types of robots. Application of Robots in various stages of manufacturing and inspection.	

Text Books:

01 CAD/CAM Principles and Applications, P N Rao, McGraw Hill Education.
02 CAD/CAM/CIM, P. Radhakrishnan, S. Subramanyan, V. Raju, New Age International

Reference Books

1 Automation, Production Systems, and Computer Aided Manufacturing, Mikell P. Groover, Prentice-Hall International publication.
2 Industrial Robotics, Groover, McGraw Hill Education.

3 Mechatronics, HMT limited, McGraw Hill Education
4 Principles of computer integrated manufacturing, Kant.S.,PHI Learning,New Delhi,(1995),ISBN10:812031476X.
5 CIM: Principles of computer-integrated manufacturing, Waldner.J.B., John Wiley & Sons Inc.UK,(1992),IBSN-9780471934509

NPTEL Swayam Course List

1. http://nptel.ac.in/courses/112102103/17
2. http://nptel.ac.in/courses/112107077/module5/1ecture2/lecture2.pdf
3. https://nptel.ac.in/courses/112103174/module1/lec2/3.html
4. https://3dp-dei.vlabs.ac.in/exp/simulation-anatomy-fdm/
5. https://3dp-dei.vlabs.ac.in/exp/simulation-anatomy-fdm/
6. https://3dp-dei.vlabs.ac.in/exp/simulation-anatomy-fdm/

Course Plan

Course Title: **Industrial Hydraulics and Pneumatics**	
Course Code: **231MEPECL301**	Semester: **V**
Teaching Scheme: L-T-P: **3-0-0**	Credits: **3**
Evaluation Scheme: ISE + MSE Marks: **20 + 30**	ESE Marks: **50**

Prerequisite:	Basic Mechanical Engineering, Fluid Mechanics, Manufacturing Processes.

Course Description:

Fluid power systems are now extensively used in machine tools, material handling devices, transports and other mobile equipment. This course will provide the students the knowledge of fundamentals of fluid systems, working principles of various fluid system components and its applications in industry.

Course Objectives:

1	To study fundamentals of hydraulic and pneumatic system
2	To study construction and working principle of various elements of hydraulic system.
3	To study construction and working principle of control elements of hydraulic system.
4	To study construction and working principle of various elements of pneumatic system.
5	To understand working of hydraulic and pneumatic circuits.
6	To understand selection and sizing of fluid system elements.

Course Outcomes (COs):

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

CO	Statement	BTL
301.1	**Understand** fundamentals of hydraulic and pneumatic systems.	**L2**
301.2	**Explain** construction and working principle of various elements of hydraulic system.	**L2**
301.3	**Understand** construction and working principle of various control valves of hydraulic system.	**L2**
301.4	**Discuss** construction and working principle of various elements of pneumatic system.	**L2**
301.5	**Illustrate** the working hydraulic and pneumatic circuits.	**L3**
301.6	**Apply** knowledge of hydraulic and pneumatic system to select and design various fluid system components	**L3**

Course Content

Content	Hours
Unit 1: Introduction to Fluid Power	08
a) Classification, general features, applications in various fields of engineering, various hydraulic and pneumatic ISO/JIC Symbols, transmission of power at static and dynamic states, advantages and disadvantages b) Principle of hydraulic system, Types of hydraulic fluids and their properties, selection of fluid, effect of temperature on fluids. c) Introduction and Application of pneumatics, Physical properties, Principles, basic requirement of pneumatic system, comparison with hydraulic system.	
Unit No. 02: Hydraulic System Elements	08
a) Classification, types of seals, sealing material, pipes, hoses, compatibility of seal with fluid, sources of contamination and its control, strainer, filter, heat-exchanger, reservoir. b) Pumps-types, selection of pumps from Gear, vane, piston, screw, ball pump etc. for various applications. c) Actuators-linear and rotary, hydraulic motors, types of hydraulic cylinders and their mountings. Accumulators, intensifier and their applications.	
Unit No. 03: Control of Fluid Power Elements	08
a) Requirements of Pressure control, direction control and flow control valves. b) Principle of pressure control valves directly operated and pilot operated pressure relief valve, pressure reducing valve, sequence valves, counter balance valve. c) Principles and types of direction control valves-2/2, 3/2, 4/2, 4/3, 5/2. Open center, close center, tandem center, manual operated, mechanical operated solenoid, pilot operated direction control valves, check valves.	
Unit No. 04: Elements of Pneumatic System	07
a) Air compressor- Types, selection criteria, capacity control, piping layout, fitting and connectors, Pneumatic controls, Direction control valves (two-way, three way, four way), check valves, flow control valves, pressure control valves, speed regulators, quick exhaust valves, time delay valve, shuttle valve and twin pressure valve. Solenoid operated, pilot operated valves, Pneumatic actuators, Rotary and reciprocating cylinders–types and their mountings, Air motor – types, Comparison with hydraulic and electric motor. b) Serving of compressed air–types of filters, regulators, lubricators (FRL unit), mufflers, and dryers. Maintenance, trouble shooting and safety of hydraulic and pneumatic system.	
Unit No. 05: Hydraulic and Pneumatic Circuits and its Application-	07

a) Hydraulic Circuits i. Speed control circuits– Meter-in, Meter-out, Bleed off, Regenerative, Fast approach and slow traverse ii. Sequence circuits– Travel dependent and Pressure dependent iii. Synchronizing circuit. iv. Regenerative circuit. b) Pneumatic circuits i. Speed control circuits ii. Impulse operation circuit. iii. Sequence circuits. iv. Time delay circuit. Note:5 circuits will be taught in practical session	
Unit–06: Selecting and Sizing of Fluid System Elements	**07**
a) Power and pump efficiencies of hydraulic pump b) cylinder force and losses c) Oil flow velocity d) Cylinder efficiency e) Sizing of cylinder tubes f) Piston rod design	

Text Books:

01 "Oil hydraulics Systems", S. R. Mujumdar, Tata McGraw Hill Publication.
02 "Pneumatic Systems", S. R. Mujumdar-Tata McGraw Hill Publication

Reference Books

1 "Hydraulic and Pneumatic", H. L. Stewart, Industrial Press.
2 "Industrial Hydraulic", J. J. Pipenger, Tata McGrawHill.
3 "Power Hydraulics", Goodwin 1st Edition.
4 "Introduction to Hydraulic and Pneumatic", S. Ilangoand, V. Soundararajan, Prentice Hall of India, 2nd Edition.

NPTEL Swayam Course List

1. Course Name: Oil Hydraulics and Pneumatics,
   By Prof. Somashekhar S | IIT Madras
   https://nptel.ac.in/courses/112106300
2. Course Name: Fundamentals of Industrial Oil Hydraulics and Pneumatics
   Prof. R.N. Maiti , IIT Kharagpur
   https://nptel.ac.in/courses/112105047

Course Plan

Course Title: **Instrumentation and Control Engineering**	
Course Code: **231MEPECL302**	Semester: **V**
Teaching Scheme: L-T-P: **3-0-0**	Credits: **3**
Evaluation Scheme: ISE + MSE Marks: 20 + 30	ESE Marks: **50**

Prerequisite:	Fundaments of mechanical and electrical systems
Course Description:	
"Instrumentation and Control" is an important subject which aims to teach students about measurement and control systems used in machines. It covers sensors, signal processing, and data collection, and their industrial applications such as robotics, cars, and automation. It will also teach students fundamentals of control engineering which will help them design and understand control system architecture for any mechanical system	

Course Objectives:

1	To introduce students to the fundamental principles of measurement, instrumentation, and sensor technologies.
2	To develop an understanding of signal conditioning, data acquisition systems, and their applications in various industries.
3	To equip students with the knowledge of sensors and their industrial applications for measuring mechanical entities.
4	To provide a strong foundation in control system concepts, including modeling and analysis techniques.
5	To enable students to analyze the stability of control systems using time-domain and frequency-domain methods.

Course Outcomes (COs):

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

CO	Statement	BTL
C302.1	Understand measurement errors and select suitable sensor calibration technique.	L3
C302.2	demonstrate signal conditioning circuits data acquisition system	L3
C302.3	select suitable sensors or instrumentation system for industrial applications	L3
C302.4	explain control system types and interpret mechanical systems using block diagrams.	L4

C302.5	determine stability using Routh's criterion and interpret root locus for mechanical systems.	L4
C302.6	analyze Bode diagrams for gain/phase margins and assess stability in mechanical systems.	L4

Course Content

Content	Hours
Unit 1: Introduction to Instrumentation	6
Basics of Measurement, Classification of Errors, Error Analysis, Number Systems – Binary, Decimal, Octal and Hexadecimal, Static and Dynamic Characteristics of transducers, Performance measures of sensors, Classifications of Sensors, Sensor Calibration techniques, Sensor Output Signal Types.	
Unit 2: Signal Conditioning and DAQ systems	7
Operational Amplifiers, Amplifiers, Bridges, Filters, Analog to Digital and Digital to Analog Conversions, Signal Processing, Elements of Data Acquisition Systems, basic of virtual instrumentation system, data logging. Applications – Automobile, Aerospace, Home Appliances, Manufacturing, Environmental Monitoring.	
Unit 3: Sensors and Industrial Instrumentation	8
Measurement of Mechanical Entities: Fluid Flow, Displacement, Angular Speed, Temperature, Force and Torque etc. **Industrial Applications of Sensors and Instrumentation systems** – Vibration measurement in Machine Tools, Position measurement of end effectors in robotics, speed measurement of road wheels in Automotive Systems, Localization, Mapping and path planning of Mobile Robots and AGVs, Automatic Inspection in Industrial Automation system.	
Unit 4: Fundamentals of Control Systems	9
Concepts of Control System: Open Loop and Closed Loop control systems and their differences, Different examples of control systems, classification of control systems, Feed-back characteristics, Effect of feedback, Mathematical Models, Differential Equations, Impulse Response and Transfer functions. Transfer Function Representation: Block Diagram representation of systems, Block diagram algebra, Representation by signal flow graph, Reduction using Mason's gain formula.	
Unit 5: Stability Analysis and Root Locus Technique	9
Concept of Stability, Routh's Stability criterion, qualitative stability and conditional stability, limitations of Routh's stability.	

Root Locus Technique: Root locus Concept, construction of root loci effect of adding poles and zeros to G(s) H(s) of the root loci.	
Unit 6: Frequency Response Analysis	6
Introduction, Frequency domain specifications, Bode diagrams, Determination of frequency domain specifications and phase margin and Gain margin. Stability Analysis from Bode Plots.	

Textbook:

1. J. Nagrath, M.Gopal, "Control System Engineering", New Age International Publishers
2. M. Gopal, "Control Systems - Principals and Design", Tata McGraw Hill.
3. "Mechanical Measurements", Shirohi and Radha Krishnan H.C., New Age International, New Delhi, 3rd Edition,2007.
4. "Mechanical Measurement and Control" D.S. Kumar, Metropolitan Book Co. Pvt. Ltd., New Delhi, 4th Edition, 2007.

Reference Books:

1. Benjamin C. Kuo "Automatic Control Systems", Prentice Hall of India.
2. Schaum's Outline Series, "Feedback and Control Systems", Tata McGraw-Hill.
3. "Measurement Systems", Doebelin Ernesto, McGraw Hill International Publication Co. New York, 4th Edition, 1990
4. "Mechanical Measurement and Control", A.K. Sawhney and P. Sawhney, Dhanpat Rai and Company Pvt. Ltd., New Delhi, 12th Edition, 2010.
5. "Theory and design for mechanical measurements", Richard S. Figliola, Donald E. Beasley, Wiley India Edition

Online Resources:

Sr. No	Online Resource Link	Source
1.	https://nptel.ac.in/courses/108102191	NPTEL
2.	https://nptel.ac.in/courses/108101037	NPTEL
3	https://nptel.ac.in/courses/108106098	NPTEL

Course Plan

Course Title: **Safety and Maintenance Engineering**	
Course Code: **231MEPECL304**	Semester: **V**
Teaching Scheme: **L-T-P : 3-0-0**	Credits: **3**
Evaluation Scheme : ISE + MSE Marks : 20 + 30	ESE Marks: **50**

Prerequisite:	Preliminary knowledge of various types of Safety measures and maintenance basics
Course Description:	
This course focuses on industrial safety and maintenance strategies to enhance equipment reliability and workplace safety. It covers accident prevention, industrial safety laws, preventive and predictive maintenance, and modern condition monitoring techniques. Students will gain practical insights into maintenance planning, fault diagnosis, and emerging technologies in Industry 4.0	

Course Objectives:

1	To understand the importance of safety engineering in industrial environments.
2	To educate students on accident prevention methods and cost analysis.
3	To study various industrial safety acts, hazard identification, and risk management.
4	To analyze maintenance planning and strategies for industrial equipment.
5	To evaluate condition monitoring techniques for predictive maintenance.
6	To explore modern trends in safety and maintenance, including AI and IoT applications.

Course Outcomes (COs):

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

CO	Statement	BTL
304.1	Explain the importance of safety and accident prevention.	L2
304.2	Interpret and apply various safety laws and regulations.	L3
304.3	Implement preventive maintenance techniques in industrial scenarios.	L3
304.4	Identify potential hazards and propose mitigation strategies.	L4
304.5	Evaluate different maintenance methodologies and select suitable strategies.	L5
304.6	Utilize condition monitoring tools for effective maintenance.	L3

Course Content

Content	Hours
Unit 1: Fundamentals of Industrial Safety and Accident Prevention: • Introduction to Industrial Safety • History and Development of Safety Regulations • Safety Terminology: Hazard, Risk, Unsafe Acts & Conditions • Accident Causation Theories and Safety Policies • Role of Safety Officers, Management, and Workers in Safety • Hazard Identification and Risk Assessment (HAZOP, PHA)	7
Unit 2: Industrial Safety Laws and Regulations: • Overview of the Factories Act, Workmen's Compensation Act • Indian Boiler Act, Explosives Act, Pesticides Act • Occupational Safety and Health Administration (OSHA) Regulations • Hazardous Waste Management and E-waste Rules • Industrial Hygiene, Ergonomics, and Workplace Health • Fire Prevention and Emergency Response Planning	7
Unit 3: Maintenance Planning and Strategies: • Introduction to Maintenance Engineering • Objectives and Benefits of Planned Maintenance • Types of Maintenance: Breakdown, Preventive, Predictive, and Corrective • Reliability and Availability of Machines • Maintenance Economics and Cost Analysis • Maintenance Scheduling and Resource Planning	7
Unit 4: Preventive Maintenance and Fault Diagnosis: • Importance of Preventive Maintenance • Lubrication Principles and Methods • Failure Analysis and Root Cause Analysis (RCA) • Fault Tree Analysis and Risk Mitigation • Applications of Total Productive Maintenance (TPM) • Role of IoT in Predictive Maintenance	8
Unit 5: Condition Monitoring and Non-Destructive Testing (NDT) • Introduction to Condition Monitoring Techniques • Vibration Analysis, Infrared Thermography • Lubrication Oil Analysis and Wear Debris Analysis • Noise, Vibration, and Harshness (NVH) Testing • On-load vs. Off-load Condition Monitoring • Case Studies on Real-time Condition Monitoring	8

Unit 6: Modern Trends in Safety and Maintenance Engineering	
• AI and Machine Learning in Predictive Maintenance • Digital Twin Technology for Maintenance Optimization • Automated Fault Detection Systems and Smart Sensors • Industry 4.0 and Smart Maintenance Systems • Sustainability and Green Manufacturing in Maintenance • Future Trends in Industrial Safety and Maintenance	8

Text Books:

1) Srivastava, S.K., Industrial Maintenance Management, S. Chand and Co.
2) Bhattacharya, S.N., Installation, Servicing, and Maintenance, S. Chand and Co.
3) Willie Hammer, Occupational Safety Management and Engineering, Prentice Hall.

Reference Books:

1) Higgins, L.R., Maintenance Engineering Handbook, McGraw Hill.
2) Armstrong, Condition Monitoring, BSIRSA.
3) Ray Asfahl, C., Industrial Safety and Health Management, Prentice Hall.
4) S.C. Mishra, Reliability and Maintenance Engineering, New Age Publishing.
5) B.S. Dhillon, Engineering Systems Reliability, Safety, and Maintenance, CRC Press.

Online Resources:

Sr. No	Online Resource Link	Source
1.	https://onlinecourses.nptel.ac.in/noc20_mg43/preview	NPTEL
2.	https://onlinecourses.swayam2.ac.in/nou25_me05/preview	NPTEL
3.	https://onlinecourses.swayam2.ac.in/nou25_ge32/preview	NPTEL

Lab Course Plan

Course Title: **Design of Machine Elements Lab**	
Course Code: **231MEPCCP301**	Semester: **V**
Teaching Scheme: L-T-P: **0-0-2**	Credits: **1**
Evaluation Scheme: INT Marks: **25**	OE Marks: **25**
Prerequisite:	Engineering Mechanics and Strength of Materials, Familiarity with CAD software for engineering drawing and modelling.
Course Description:	
Design of Machine Elements is the application of mathematics, kinematics, statics, dynamics, mechanics of materials, engineering materials, manufacturing process and engineering drawing. It deals with understanding of basic concepts of machine design, phases of design. It involves designing of various machine elements and creative combining of these elements into a component or assembly that satisfy need.	

Course Objectives:

1	To develop an understanding of the design procedures and calculations for machine elements like joints, couplings, and springs.
2	To enhance the ability to prepare detailed and assembly drawings of mechanical components using CAD software.
3	To apply material selection principles in mechanical design based on IS codes and material properties.
4	To enable students to select appropriate power transmission elements such as belts based on manufacturer catalogs.

Course Outcomes (COs):

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

CO	Statement	BTL
301.1	Demonstrate the ability to design and analyze machine elements such as joints, couplings, and springs through detailed reports and calculations.	**L3**
301.2	Create accurate detail and assembly drawings of mechanical components using both manual drafting and CAD software.	**L6**
301.3	Apply knowledge of material selection and IS codes for designing machine components with the use of design data book.	**L3**
301.4	Select appropriate power transmission elements such as flat belts and V-belts for given engineering applications using manufacturer catalogs.	**L4**

Lab Course Content

Sr. No.	Details	Type	Hrs.
1	Prepare a detail report of design procedure showing calculations and sketches of Knuckle joint /Lever.	O	2.00
2	Draw a details and assembly drawing of Knuckle joint /Lever on A2 size drawing sheet.	O	2.00
3	Prepare a detail report of design procedure showing calculations and sketches of flexible bushed pin type flanged coupling.	O	2.00
4	Draw a details and assembly drawing of flexible bushed pin type flanged coupling on A2 size drawing sheet.	O	2.00
5	Case study of components (include selection of materials for various components showing their IS codes, composition and properties).	S	1.00
6	Problems on design of helical compression spring subjected to static load	S	1.00
7	Problems on design of Power Screw subjected to static load	S	1.00
8	Selection of Flat belts as per the manufacturer's catalogue	S	2.00
9	Selection of V- belts as per the manufacturer's catalogue	S	1.00
10	Cad drawing of Knuckle joint/flexible bushed pin type flanged coupling using any modeling software.	O	1.00

S – Study, O – Operational

Text Books:

1. Bhandari V.B. - "Design of Machine Elements" - McGraw Hill Education (India) Ltd.
2. Shigley J.E. and Mischke C.R. - "Mechanical Engineering Design" McGraw Hill Publ. Co.Ltd.
3. Ballaney, P.L., "Theory if Machines and Mechanisms", 2005, ISBN 9788174091222
4. Hannah and Stephens, "Mechanics of Machines: Advanced Theory and Examples", 1970, ISBN 0713132329 Edward Arnold London

Reference Books

1. Spotts M.F. - "Design of Machine Elements" - Prentice HallInternational.
2. Black P.H. and O. Eugene Adams - "Machine Design" - McGraw Hill BookCo.Ltd.
3. "Design Data" - P.S.G. College of Technology,Coimbatore.
4. Hall A.S.; Holowenko A.R. and Laughlin H.G. - "Theory and Problems of Machine Design" - Schaum's outlineseries.
5. Ulicker Jr. J.J., Penock G.R. & Shigley J.E. "Theory of Machines and Mechanisms" Tata McGraw Hills
6. Ghosh Amitabha & Mallik Asok Kumar, "Theory of Mechanisms and Machines" east-West Press Pvt. Ltd. New Delhi

NPTEL Swayam Course List

1. Course Name: Design, Technology and Innovation
By Prof. B. K. Chakravarthy | IIT Bombay
Link: https://onlinecourses.swayam2.ac.in/aic20_ed02/preview

2. Course Name: Functional and Conceptual Design
By Prof. Asokan T | IIT Madras
Link: https://onlinecourses.nptel.ac.in/noc22_de10/preview

3. Course Name: Understanding Design
By Prof. Nina Sabnani | Industrial Design Centre, IIT Bombay
Link: https://onlinecourses.swayam2.ac.in/aic19_de04/preview

4. Course Name: Work System Design
By Prof. Inderdeep Singh | IIT Roorkee
Link: https://onlinecourses.nptel.ac.in/noc22_me133/preview

B. Tech. Curriculum
w.e.f. 2024-25

ENERGY AND POWER ENGINEERING LAB
COURSECODE: 201MEPCCL302

Course Title: **ENERGY & POWER ENGINEERING LAB**	
Course Code: **201MEPCCP302**	**Semester: V**
Teaching Scheme: L-T-P: **0-0-2**	Credits: **1**
Evaluation Scheme:	INT Marks: **25**

Prerequisite:	Basic mechanical Engineering, Thermodynamics, Heat and Mass Transfer,

Course Description:

This subject enables the student to understand basic principle of different type of renewable sources. Students will also learn new trends in power and energy sectors. Understand and the working principles & concept of various power stations, Performance and economic analysis.

Course Objectives:

1	To understand basic principles of solar Energy & solar photovoltaic system.
2	To understand basic principles and working of wind energy.
3	To understand the different types of power plant,& power scenario in India
4	TounderstandconceptofdifferenttypeoflnstrumentationuseforpowerplantsandLoadCurves and Load duration curves
5	To understand the Energy Marketing and Management.

Course Outcomes (COs):

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

CO	Statement	BTL
302.1	Describe the basic details of solar energy & equipment's used for the measurement of solar irradiation.	L2
302.2	Demonstrate working of solar photovoltaic system.	L2
302.3	Demonstrate working of wind energy.	L2
302.4	Explain the basic working principles of steam, hybrid, diesel, as turbine power plant and boilers.	L2
302.5	Demonstrate basics of Load Curves and Load duration curves & Know the costs Associated with power generation.	L3
302.6	Understand the Energy Marketing and Management.	L2

Third Year. B. Tech. Curriculum
As per NEP

List of Assignments/Experiments			
Sr. No.	**Details**	**Type**	**Hrs.**
1	Study of various renewable and nonrenewable power plants	S	2.00
2	Study of solar power plants and collectors.	S	2.00
3	Study of solar photovoltaic system	S	2.00
4	Study wind energy	S	2.00
5	Study of Instrumentation used in power plants Load Curves	S	2.00
6	Study of Load Curves and Load duration curves	S	2.00
7	Study of Energy Marketing and Management	S	2.00
8	Study of Indian electricity grid code.	S	2.00
9	Industrial visit to any power plant / Survey based / Project based industrial visit.	S	2.00
10	Energy Audit - Case study of an organization and report	S	2.00
11	Market survey of various renewable and nonrenewable systems which include the equipment's with related specifications, manufacturers, cost and comparison with respect to tonnage, coat and presentation of report in the laboratory.	S	2.00

Textbook:

1 "Solar Energy", S.P.SukhatmeandJ.K.Nayak,TataMcGraw-Hill,3rd Edition,(2008).
2 "Non-ConventionalEnergySources",G.D.Rai.-KhannaPublisher,4 th Edition
3 "PowerPlantTechnology",M.M.ElWakil,TataMcGraw-Hill.Int,2ndEdition.Reprint,(2010).
4 "Power Plant Engineering" ,Domkundwar and Arora ,Dhanpatrai and Sons.

Reference Books:

1 "Solar Photovoltaic Fundamentals, Technologies and Applications", Chetan Singh Solanki, Prentice Hall of India Publications.

2 "Modern Power Station Practice", Vol.6, Instrumentation, Controls and Testing, by Pergamon Press, Oxford,(1971).

3 "PowerSystemAnalysis",GraingerJohnJ,andStevensonJr..W.D.,TataMcGrawHill,(2003).

4 "Economic Operation of Power Systems",L.K. Kirchmeyer,John Wiley and Sons,(1993).

NPTEL Swayam Course List

1. . Course Name: **Introduction of Energy and Power plant.**
   By Prof Ravi Kumar. | IIT Rookre
   http://kcl.digimat.in/nptel/courses/video/112107291/L31.html
2. Course Name: **Solar energy.**
   By Prof Ashish Garg | IIT Kanpur .
   http:playlist?list=PLFW6lRTa1g83uUSWpXcu-jXS32_RSXfVc
3. Course Name: **Wind energy**
   By Prof Dr. Pankaj Kalita | IIT Guwahati
   https://onlinecourses.nptel.ac.in/noc23_ge47/preview

Lab Course Plan

Course Title: **Industrial Metallurgy Lab**	
Course Code: 21MEPCCP303	Semester: **V**
Teaching Scheme: L-T-P: **0-0-2**	Credit: **1**
Evaluation Scheme: INT Marks: **25**	OE Marks: **25**
Prerequisite:	Engineering Physics, Engineering Chemistry & Manufacturing Process.
Course Description:	
This course student will able to understand various mechanical properties by conducting mechanical testing. Students will get acquaint with microstructure and composition of metals and its alloys.	

Course Objectives:

1	To acquaint students with the basic concepts of Metallurgical Microscope and study microstructure of Ferrous and Non- Ferrous alloys.
2	To understand fundamental knowledge of Destructive testing.
3	To understand fundamental knowledge of Non Destructive testing.
4	To understand basic concepts of Hardenability and Heat treatment processes.

Course Outcomes (COs):

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

CO	Statement	BTL
302.1	**Classify** phases in microstructure of ferrous and Non -ferrous alloys.	L2
302.2	**Analyze** result obtained from Destructive testing.	L3
302.3	**Analyze** result obtained from Non Destructive testing.	L3
302.4	**Select** appropriate heat treatment processes for industrial applications.	L3

Lab Course Content

Sr. No.	Details	Type	Hrs.
1	Introduction to Metallurgical Microscope	S	2
2	Destructive Testing: -. Introduction to Tensile, Compressive, Impact, Hardness (Rockwell, Brinell and Vickers Hardness testing (Rockwell and Brinell)	S & O	4
3	Destructive Testing: -. Impact testing (Izod and Charpy) of M.S, Brass and Al Alloy.	S & O	2
4	Non- Destructive Testing: Introduction to Non-destructive testing. Dye Penetrant,	S &O	4
5	Non- Destructive Testing: Magnetic particle Test	S &O	2
6	Macroscopic Examinations Spark Test.	O	2
7	Sample preparation and study of microstructure of ferrous Alloy (Steel and Cast Iron)	O	2
8	Sample preparation and study of microstructure of ferrous Alloy (copper, Brass and aluminum)	O	2
9	Heat treatment of steels (Annealing, Normalizing, Hardening on medium/ high carbon steels)	S	2
10	Jominy end - quench test for hardenability	O	2

S – Study, O – Operational

Text Books:

1 "Material science and Engineering",W.D Callister, Wiley India Pvt.Ltd., 5th Edition".

2 "Testing of Materials" Vernon John Springer Link 1992".

Reference Books

1. ASM Handbook Volume 9: Metallographic and Microstructures

2. ASM Handbook Volume 8: Mechanical Testing and Evaluation

3. ASM Handbook Volumes 4A, 4B, 4C, 4D, 4E Heat Treating Set

Online Resources:

Unit No	Online Resource Link	Source
1	https://onlinecourses.nptel.ac.in/noc22_mm05/preview	NPTEL
2	https://archive.nptel.ac.in/courses/113/102/113102080/	NPTEL

B. Tech. Mechanical Curriculum
w.e.f. 2024-25

Lab Course Plan

Course Title: **Industrial Hydraulics and Pneumatics Lab**	
Course Code: **231MEPECP301**	**Semester: V**
Teaching Scheme: L-T-P: **0-0-2**	Credits: **1**
Evaluation Scheme:	INT Marks: **25**

Prerequisite:	Basic Mechanical Engineering, Fluid Mechanics, Manufacturing Processes..

Course Description:

Fluid power systems are now extensively used in machine tools, material handling devices, transports and other mobile equipment. This course will provide the students the knowledge of fundamentals of fluid systems, working principles of various fluid system components and its applications in industry.

Course Objectives:

1	To study and demonstrate fundamentals of hydraulic and pneumatic system
2	To demonstrate construction and working principle of various components of hydraulic and pneumatic system.
3	To prepare and execute hydraulic and pneumatic circuit.
4	To use software to simulate hydraulic and pneumatic circuit.
5	To select fluid system components using manufacturer catalogue.

Course Outcomes (COs):

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

CO	Statement	BTL
301.1	**Demonstrate** fundamentals of hydraulic and pneumatic system.	**L2**
301.2	**Demonstrate** construction and working of various components of hydraulic and pneumatic system	**L2**
301.3	**Prepare and execute** hydraulic and pneumatic circuit	**L2**
301.4	**Prepare and execute** hydraulic and pneumatic circuit using simulation software	**L2**
301.5	**Apply** knowledge of hydraulic and pneumatic system to select and design various fluid system elements	**L3**

Lab Course Content

Sr. No.	Details	Type	Hrs.
1	Study and Demonstration of basic hydraulic and pneumatic system.	S/O	2.00
2	Study of ISO/JIC Symbols for hydraulic and pneumatic systems.	S	2.00
3	Circuit preparations on meter in and meter out on hydraulic trainer kit.	O	2.00
4	Circuit preparations on Sequencing circuits on hydraulic trainer kit.	O	2.00
5	Circuit preparations on Synchronizing circuit on hydraulic trainer kit.	O	2.00
6	Circuit preparations on Sequencing circuits on pneumatic trainer kit.	O	2.00
7	Circuit preparations on Synchronizing circuit on pneumatic trainer kit.	O	2.00
8	At least two Circuit preparations using Fluid Simulation Software.	O	2.00
9	Study of manufacturer catalogue to select fluid system components	S	2.00
10	Industrial visits are recommended for applications of pneumatic and hydraulic system and their reports.	S	4.00

Text Books:

1. "Pneumatic Systems", S. R. Mujumdar-Tata McGraw Hill Publication.
2. "Industrial Fluid Power", D. S. Pawaskar, Nishant Prakashan.
3. "Hydraulics and Pneumatics", Shaikh and Khan, R. K. Publication

Reference Books

1. "Hydraulic and Pneumatic", H. L. Stewart, Industrial Press.
2. "Industrial Hydraulic", J. J. Pipenger, Tata McGrawHill.
3. "Power Hydraulics", Goodwin 1st Edition.
4. "Introduction to Hydraulic and Pneumatic", S. Ilangoand, V. Soundararajan, Prentice Hall of India, 2nd Edition.

NPTEL Swayam Course List

1. Course Name: Oil Hydraulics and Pneumatics,
By Prof. Somashekhar S | IIT Madras
https://nptel.ac.in/courses/112106300
2. Course Name: Fundamentals of Industrial Oil Hydraulics and Pneumatics
Prof. R.N. Maiti , IIT Kharagpur
https://nptel.ac.in/courses/112105047

Course Plan

Course Title: **Instrumentation and Control Engineering Lab**	
Course Code: **231MEPECP302**	Semester: **V**
Teaching Scheme: L-T-P: **0-0-2**	Credits: **01**
Evaluation Scheme:	INT Marks: **25**

Prerequisite:	Fundaments of mechanical and electrical systems.

Course Description:

"Instrumentation and Control" is an important subject which aims to teach students about measurement and control systems used in machines. It covers sensors, signal processing, and data collection, and their industrial applications such as robotics, cars, and automation. It will also teach students fundamentals of control engineering which will help them design and understand control system architecture for any mechanical system;

Course Objectives:

1	To introduce students to the fundamental principles of measurement, instrumentation, and sensor technologies.
2	To develop an understanding of signal conditioning, data acquisition systems, and their applications in various industries.
3	To equip students with the knowledge of sensors and their industrial applications for measuring mechanical entities.
4	To provide a strong foundation in control system concepts, including modeling and analysis techniques.
5	To enable students to analyze the stability of control systems using time-domain and frequency-domain methods.

Course Outcomes (COs):

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

CO	Statement	BTL
C302.1	Understand fundamentals of measurement systems	L2
C302.2	Demonstrate Operations of Measuring Instruments	L3
C302.3	Demonstrate the Control Modes for Temperature control system	L3
C302.4	Analyze transfer functions for various control systems	L3

Lab Course Content

Sr. No.	Experiment/Assignment List	Type	Hrs.
1	Study and assignment on generalized measurement system and characteristics of instruments.	S	2
2	Study and assignment on sensing elements and transducers.	S	2
3	Study and Measurement of Angular speed by using Magnetic Pickup and Photoelectric Pickup	O	2
4	Study and Measurement of Temperature by using Thermocouple, RTD, Thermistor	O	2
5	Study and Measurement of Displacement by using LVDT	O	2
6	Study of Vibrations testing by using Vibrometer	O	2
7	Case study on measuring system for Pressure, flow, temperature etc.	S	2
8	Case Study on Industrial Instrumentation systems	S	2
9	Study of Components of Control Systems	S	2
10	Study of On-Off Controller for Temperature	O	2
11	Study of Control Modes like P, PD for Temperature	O	2
12	Study of Control Modes like PI, PID for Temperature	O	2
13	Introduction to Different software for control system simulation	O	2
14	Determination of transfer function in block diagram representation	O	2
15	Plot Root locus of given transfer function, locate closed loop poles for different values of K.	O	2

S-STUDY, O-OPERATIONAL

Textbook:

1. J. Nagrath, M.Gopal, "Control System Engineering", New Age International Publishers
2. M. Gopal, "Control Systems - Principals and Design", Tata McGraw Hill.
3. "Mechanical Measurements", Shirohi and Radha Krishnan H.C., New Age International, New Delhi, 3rd Edition,2007.
4. "Mechanical Measurement and Control" D.S. Kumar, Metropolitan Book Co. Pvt. Ltd., New Delhi, 4th Edition, 2007.

Reference Books:

1. Benjamin C. Kuo "Automatic Control Systems", Prentice Hall of India.
2. Schaum's Outline Series, "Feedback and Control Systems", Tata McGraw-Hill.
3. "Measurement Systems", Doebelin Ernesto, McGraw Hill International Publication Co. New York, 4th Edition, 1990
4. "Mechanical Measurement and Control", A.K. Sawhney and P. Sawhney, Dhanpat Rai and Company Pvt. Ltd., New Delhi, 12th Edition, 2010.
5. "Theory and design for mechanical measurements", Richard S. Figliola, Donald E. Beasley, Wiley India Edition

Online Resources:

Sr. No	Online Resource Link	Source
1.	https://nptel.ac.in/courses/108102191	NPTEL
2.	https://nptel.ac.in/courses/108101037	NPTEL
3	https://nptel.ac.in/courses/108106098	NPTEL

Lab Course Plan

Course Title: **Safety and Maintenance Engineering lab**	
Course Code: **231MEPECP304**	Semester: **V**
Teaching Scheme: **L-T-P : 0-0-2**	Credits: **1**
Evaluation Scheme:	INT Marks: **25**

Prerequisite:	Basic knowledge of industrial safety measures, hazard identification, maintenance fundamentals, and engineering equipment operation

Course Description:

This course provides hands-on training in safety assessment, preventive and predictive maintenance, fault diagnosis, and modern condition monitoring techniques. Students will learn through practical assignments and case studies, gaining experience in real-world maintenance and safety management.

Course Objectives:

1	Learn practical safety assessment techniques and accident prevention measures.
2	Apply safety regulations and industrial safety laws in a workplace environment.
3	Conduct maintenance planning and scheduling for industrial machinery.
4	Implement preventive and predictive maintenance techniques.
5	Utilize condition monitoring tools such as vibration analysis and thermography.
6	Explore modern safety and maintenance technologies like IoT, AI, and digital twins.

Course Outcomes (COs):

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

CO	Statement	BTL
304.1	Identify and assess workplace hazards using industry-standard techniques.	L2
304.2	Implement safety measures in compliance with industrial safety laws.	L3
304.3	Demonstrate different types of maintenance strategies for equipment reliability.	L3
304.4	Apply fault diagnosis techniques such as root cause analysis and fault tree analysis.	L4
304.5	Perform condition monitoring using non-destructive testing (NDT) methods.	L5
304.6	Analyze modern predictive maintenance techniques using AI and IoT.	L3

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Lab Course Content

Sr. No.	Details	Type	Hrs.
1	Study of Hazard Identification and Risk Assessment (HIRA) technique	S/O	2.00
2	Study case laws on industrial accidents and analyze their implications.	S	2.00
3	Hands-on training on fire prevention, extinguisher operation, and evacuation planning.	O	2.00
4	Application of LOTO procedures for machine safety during maintenance.	O	2.00
5	Develop a maintenance plan for industrial machines using a case study.	S	2.00
6	Study different lubrication methods and their impact on machinery lifespan.	S	2.00
7	Conduct FMEA on a machine component and propose mitigation strategies.	O	2.00
8	Investigate failure cases using RCA and construct a fault tree for a real-world failure.	S	2.00
9	Perform a vibration analysis experiment on rotating machinery.	O	2.00
10	Explore digital twin technology for real-time asset tracking and fault prediction.	S	2.00
11	Study green manufacturing practices and their role in sustainable maintenance.	S	2.00
12	Study AI-driven safety and maintenance applications in modern industries.	S	2.00
13	Industrial visits are recommended for applications of Safety and Maintenance and their reports.	S	4.00

Text Books:

1) Srivastava, S.K., Industrial Maintenance Management, S. Chand and Co.
2) Bhattacharya, S.N., Installation, Servicing, and Maintenance, S. Chand and Co.
3) Willie Hammer, Occupational Safety Management and Engineering, Prentice Hall.

Reference Books:

1) Higgins, L.R., Maintenance Engineering Handbook, McGraw Hill.
2) Armstrong, Condition Monitoring, BSIRSA.
3) Ray Asfahl, C., Industrial Safety and Health Management, Prentice Hall.
4) S.C. Mishra, Reliability and Maintenance Engineering, New Age Publishing.
5) B.S. Dhillon, Engineering Systems Reliability, Safety, and Maintenance, CRC Press.

Online Resources:

Sr. No	Online Resource Link	Source
1.	https://onlinecourses.nptel.ac.in/noc20_mg43/preview	NPTEL
2.	https://onlinecourses.swayam2.ac.in/nou25_me05/preview	NPTEL
3.	https://onlinecourses.swayam2.ac.in/nou25_ge32/preview	NPTEL

Course Plan

Course Title: **Metrology and Quality Control**	
Course Code: **231MEPCCL304**	**Semester: VI**
Teaching Scheme: L-T-P: **3-0-0**	Credits: **3**
Evaluation Scheme: ISE + MSE Marks: **20 + 30**	ESE Marks: **50**

Prerequisite:	Engineering Physics, Machine Drawing, Manufacturing Processes, Machine tools and Processes

Course Description:

The course Metrology and Quality Control is designed to impart the knowledge to develop measurement procedures, conduct metrological experiments, and obtain and interpret the results. The different methods and instruments which can be used for linear and angular measurements, geometrical parameters (like surface finish, Squareness, Parallelism, Roundness etc.) and the use of gauges and system of limits, Fits, Tolerances etc. are often required to be studied and used by Mechanical Engineer on the shop floor. He/she is also required to analyze, Interpret and present the data collected, graphically & statistically for ensuring the quality. The knowledge of the subject also forms the basis for the design of mechanical measurements systems, design & drawing of mechanical components. The course would be useful in many areas in the traditional and modern high technology viz. manufacturing, industrial, scientific research and many others.

Course Objectives:

1	Understand the principle/s, construction, working and use of linear, angle measuring instruments and comparator.
2	Understand the use of standards in measurement, limits, fits and tolerances.
3	Study the methods used for the measurement of screw threads and gears
4	Study the measurement of geometrical forms and surface roughness and Advances in metrology.
5	Understand the concept of quality and various SQC techniques.

Course Outcomes (COs):

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

CO	Statement	BTL
CO304.1	Understand use of measuring tools for linear and angular measurements.	**L2**
CO304.2	Discuss the basics of Limits, fits, tolerances and their role and importance in manufacturing.	**L1**
CO304.3	Select proper measuring instrument for screw thread and gear measurement.	**L2**
CO304.4	Learn advanced techniques of metrology in various industrial applications.	**L2**

CO304.5	Understand Quality Control and Quality assurance concepts.	L2
CO304.6	Analyze use of control charts and sampling plans.	L4

Course Content

Content	Hours
Unit 1: Introduction to Metrology, study of Linear and Angular measurements	8
Unit 1:Need of Metrology, Precision, accuracy, methods and errors in measurement, Introduction to calibration process. Linear Measurements International standards of length, line standard and end standard measurements, wavelength standard characteristics of measuring instruments for linear measurement, slip gauges. Angular Measurements Bevel Protractor, spirit level, angle gauges, sine bar, sin center, angle dekkor, auto collimator etc.	
Unit No. 02: Study of Limits, Fits, Tolerance and Comparators	8
Limits, Fits and Tolerances Importance of limits system in mass production, IS specifications of limits, unilateral and bilateral tolerances, types of fits (including Numerical) Limit Gauges Importance of limit gauges, Types, Taylors principle, design of plug and ring limit gauges (Including numerical) Comparators Need of comparators, Principle of operation, its uses in inspection and characteristics of I. Mechanical (dial indicator, bore dial gauge, Johnsons Mickrokator, Sigma Comparator. II. Optical (Optical profile projector, Tool makers microscope) III. Electrical and Electronic Comparator IV. Pneumatics Comparator (Solex comparator)	
Unit No. 03: Measurement of Screw thread and Gear	7
Screw thread terminology, thread form error, measurement of minor, major and effective diameter (two-three wire method), pitch measurement, floating carriage micrometer, screw thread micrometer. Gear measurement Measurement of tooth thickness, run-out checking, pitch checking, profile checking, alignment checking, Parkinson gear tester, errors in measurement.	
Unit No. 04: Surface finish measurement and Advances in Metrology Surface finish measurement	7
Types of textures obtained during machining operations, CLA, Ra, RMS, Rz values and their interpretation, direction of lays, texture symbols, symbols for designating surface finish, straightness, flatness, square, roundness on drawing, various instruments used in surface roughness assessment Advances in Metrology Principle of Coordinate measuring Machine(CMM), Types of CMM, Laser in Metrology, Machine Vision for inspection, Robotics inspection.	

Unit No. 05: Introduction to Quality Control and Quality Assurance	
Concept of quality and Quality Control, role of Quality, dimension of quality, quality control and quality assurance. Quality of design and conformance, Cost of quality and value of quality, balance between cost and value of quality. Quality Assurance 7 QC tools (new), Quality Circles, Introduction to 6 Sigma and 5S system.	7
Unit–06: Statistical Quality control and Acceptance Sampling	
Importance of statistical method in quality control, ND curve, types of control charts (numerical treatments on X bar, R,P and C charts)their construction and applications, process capability. Acceptance Sampling Basic concept of sampling inspection, Single sampling and double sampling plan, Operating characteristics curves.	8

Text Books

01 "Engineering Metrology", I.C. Gupta, Dhanpat Rai Publications.
02 "Engineering Metrology", R.K.Jain, Khanna Publisher.

Reference Books

1 "Practical Engineering Metrology", Sharp K.W.B. Pitman, London.
2 "Statistical Quality Control", A.L. Grant, Tata McGraw Hill International, New York. 6th Edition.
3 "Statistical Quality Control", R.C. Gupta,9th Edition.
4 "Engineering Metrology", Hume K.G., MC Donald, Technical and Scientific, London ,2nd Edition.
5 "Quality Control and Indl Statistics", Duncon A.J., D.B. Taraporevela and Co. Bombay.
6 "Fundamentals of Quality Control and Improvement", Amitva Mitra, 3rd Edition.
7 "Statistical Quality Control", Douglas Montgomery, Wiley India Pvt. Ltd., 6th Edition.

NPTEL Swayam Course List

1. https://www.digimat.in/nptel/courses/video/112106179/L01.html
2. https://www.digimat.in/nptel/courses/video/112104250/L19.html
3. https://nptel.ac.in/courses/112/104/112104250
4. https://nptel.ac.in/courses/110/105/110105088/
5. https://nptel.ac.in/courses/112/107/112107259/

Course Plan

Course Title: **Operation Research & Management**	
Course Code: **231MEPCCL305**	Semester: **VI**
Teaching Scheme: L-T-P: **2-0-0**	Credits: **2**
Evaluation Scheme:	ESE Marks: **50**

Prerequisite: Mathematics, probability distributions and statistics
Course Description:
This course will teach operational researchers to use their analytical and creative skills to develop better systems and operational procedures to solve manufacturing, production, development related problem

Course Objectives:

1	To analyze different situations in the industrial scenario involving limited resources and finding the optimal solution within constraints.
2	To understand the quantitative techniques in management decision-making and its applications by using Linear Programming Model, Assignment Model, Transportation Model, Network Model and Sequencing Model to solve manufacturing problem.

Course Outcomes (COs):

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

CO	Statement	BTL
305.1	Understand the formulation of Linear programming problems	L 2
305.2	Solve Linear programming problems by using Operations Research techniques	L 3
305.3	Solve Transportation and Assignment problems	L 3
305.4	Apply the various techniques of Project Management such as CPM/PERT networks	L 3
305.5	Understand role of project manager	L 2

Course Content

Content	Hours
Unit 1: Introduction to Operation Research	7
Birth of O.R., Methodology, Scope and Limitations. Types of O.R. Models, Applications in Production Management, Use of computers in O.R, Linear Programming: Formulation, graphical method.	
Unit2 : Linear Programming Problems	8
Formulating maximization / minimization problems, Graphical solution, simplex methods, Special cases of LP, Duality of LP and its interpretation, Dual simplex methods,	
Unit 3: Transportation , Assignment and Sequencing Model	7
Transportation model- Mathematical formulation, methods to obtain initial basic feasible solution (IBFS)- NWCR , LCM and VAM, Conditions for testing optimality, MODI method for testing optimality of solution of balanced problems and unbalanced problems Assignment Model- Mathematical statement, Methods to solve balanced assignment problems, unbalanced assignment problems, Maximization problems. Sequencing- Sequencing of n jobs & 2 machines, Sequencing of n jobs & 3 machines	
Unit 4 : Fundamentals of CPM / PERT and Decision Theory	8
CPM & PERT – Gantt chart, CPM and PERT Analysis, Identification of the Critical Path and its Significance, Calculation of Floats and Slacks Decision Theory: pay off and regret tables, decision rules, decisions under uncertainty and risk, decision tree	

Textbook:

1. "Operations Research", Hira and Gupta, S.Chand and Co. New Delhi.
2. "Operations Research", Mandhar Mahajan, Dhanpat Rai & Co.

Reference Books:

1. "Operation Research an Introduction", Hamdy A. Taha, Pearson,10 th Edition
2. "Introduction to Operation Research", Paneer-Selvam, Prentice Hall of India publication,
   2nd Edition
3. "Operation Research", Pradeep J. Jha, Tata McGraw Hill Publication.
4. "Operation Research", Mariappan, Pearson Education.
5. "Operation Research – Principle and Applications", G. Shriniwasan, Prentice Hall of India
   Publication, 3rd Edition

Online Resources:

Unit No	Online Resource Link	Source
1	https://nptel.ac.in/courses/110/106/110106062/	NPTEL
2	https://nptel.ac.in/courses/110/106/110106059/	NPTEL
3	https://nptel.ac.in/courses/112/106/112106134/	NPTEL

Course Plan

Course Title: **Mechatronics**	
Course Code: **231MEPCCL306**	Semester: **VI**
Teaching Scheme: L-T-P: **3-0-0**	Credits: **3**
Evaluation Scheme: ISE + MSE Marks: **20 + 30**	ESE Marks: **50**

Prerequisite:	Essentials of Electrical & Electronics Technology

Course Description:

Mechatronics course is of importance due to the global demand and developments in Mechatronics system, Industrial Automation & Robotics, Industry 4.0 automated manufacturing systems, planning and controlling activities etc. For designing and developing mechatronics systems students of mechanical engineering must understand basic elements of mechatronics systems such as sensors, microcontrollers, microprocessors, logic and programs for automating the processes.

Course Objectives:

1	To prepare Mechanical Engineering students for advanced graduate studies in Mechatronics, Manufacturing engineering, Industrial automation and related field
2	To introduce graduate of mechanical engineering with working principle of Microprocessor and Microcontroller
3	To provide the fundamentals of PLC programming, ladder diagram and significance of PLC systems in industrial application
4	To make students aware about graphical representation and simulation of mechatronics systems.

Course Outcomes (COs):

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

CO	Statement	BTL
C306.1	Explain the construction, working principles of key elements used in mechatronics.	L2
C306.2	Understand construction and working of various sensors and Actuators	L2
C306.3	Understand principle of Electric drives, and various controllers	L2
C306.4	Write simple PLC Programs using Timers and Counters	L3
C306.5	Solve PLC Ladder diagrams for different applications	L3
C306.6	Demonstrate suitable tool or graphical representation of mechatronic system	L3

Course Content

Content	Hours
Unit 1 : Introduction to Mechatronics	6
Introduction to Mechatronics, Evolution of Mechatronics, Advantages, disadvantages and applications of Mechatronics, Mechatronics systems, multi discipline scenario, Mechatronics key elements, Control Systems, Open and Closed Loops Systems	
Unit 2 : Sensors	8
Transducers: Introduction, Performance Terminology. Sensors: Classification, Displacement, Position, proximity, Force measurement, liquid flow, level and pressure measurement, temperature measurement, Optical sensors, Digital Encoders, Strain Guage, Vibration Sensor, Vision Sensors, Selection of Sensors.	
Unit 3 : Electric Drives and Controllers	8
Introduction, Electromagnetic principle, solenoids, Relays, Drives of Stepper Motor, DC Geared Motors, Servo Motors. Op-Amps, A/D & D/A Converters, Signal Processing, Proportional, Integral, Derivative Controller, PD Controller, PID Controller **Microcontroller:** Introduction to 8085 microprocessor and 8051 microcontrollers, microcontroller families: ATMEGA and PIC microcontrollers, Introduction to Advanced Controllers: Arduino, Raspberry Pi	
Unit 4 : Programmable Logic Controller	8
Introduction to Digital logic gates, Boolean algebra, application of logic gates, Introduction, Basic Structure, Programming units and Memory Units of PLC Input & Output Models. Ladder diagram & PLC programming fundamentals, machine control terminology, physical components Vs. program components, Latching, Internal Relays, Timers, Counters, Shift Registers. Applications: Light Control, Disagreement and Majority Circuit, Fail Safe Circuits.	
Unit 5 : Mechatronics System Design:	9
Mechatronics in Engineering Design, Traditional and Mechatronics Design, Mechatronics Design Process, Case Studies- Automatic liquid filling system, liquid mixture, traffic control light, liquid mixer, pick & place robot, washing machine, vending machine, sorting machine, conveyor system, robotic arm, water heating	
Unit 6 : Interfacing and Graphical Programming	6
Data Acquisition- Interfacing and Communication Standards, User Interfaces in Automation- HMI, Fundamentals of Graphical Software packages- SCADA, LabVIEW. System Design and Modelling using SCADA, System Simulation using SCADA, Interfacing of SCADA simulation to Physical System	

Textbook:

1. Mechatronics", W. Bolton, Pearson Education , 4th Edition,
2. "Mechatronics: Principles & applications", Godfrey Onwubolu Elsevier (2005)3
3. "Introduction to PLC Programming" NIIT.
4. "Programmable Logical Controller", Hackworth, Pearson Education, (2008).

Reference Books:

1. "Introduction to Mechatronics" AppuKuttam, Oxford Publications, 1st Edition.
2. Introduction to Mechatronics & Measurment Systems", David G AlciatoreMichel Histand, Tata McGraw Hill Pub. Co.New Delhi 4th Edition
3. "Automated Manufacturing Systems" ,S. Brain Morris, Tata McGraw Hill
4. "Mechatronics and Microprocessor", Ramchandran, Willey India, (2009).
5. "Mechatronics: Integrated Mechanical Electronic System", Ramchandran, Willey India,1stEdition.

Online Resources:

Sr. No	Online Resource Link	Source
1.	https://nptel.ac.in/courses/112107298	NPTEL
2.	https://nptel.ac.in/courses/112103174	NPTEL

Course Plan

Course Title: **Production & Material Management Lab**	
Course Code: **231MEMDML302**	Semester: **VI**
Teaching Scheme: L-T-P: **1-0-2**	Credits: **2**
Evaluation Scheme:	ESE Marks: **50**

Prerequisite:	Basic knowledge of Manufacturing Processes, Fundamental concepts of Engineering Economics
Course Description:	
This course introduces the principles of Production and Material Management, covering topics such as production systems, planning, control, inventory techniques, and material handling. It equips students with skills to optimize resources and enhance productivity	

Course Objectives:

1	To understand the fundamentals of production and material management.
2	To learn various production systems and capacity planning methods.
3	To explore inventory management, purchasing techniques, and material handling systems.

Course Outcomes (COs):

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

CO	Statement	BTL
C302.1	Understand and apply production planning and control techniques to optimize manufacturing operations.	L 2
C302.2	Demonstrate knowledge of material management strategies, including inventory control and procurement processes.	L 2

Course Content

Content	Hours
Unit 1: Introduction to Production Management	**10**
Introduction to Production Management: Definition and Scope, Objectives and Importance, Production Planning and Control (PPC), Functions of PPC, Stages: Planning, Scheduling, Routing, and Dispatching, Types of Production Systems- Job Production, Batch Production, Mass Production, Continuous Production, Capacity Planning - Definition and Importance, Techniques of Capacity Planning (Short-Term and Long-Term), Plant Layout and Facility Location, Types of Plant Layout: Product, Process, Fixed, and Cellular Layout, Factors Affecting Plant Location	
Unit 2: Introduction to Material Management	**10**
Introduction to Material Management, Definition, Objectives, and Importance, Functions of Material Management, Inventory Control Techniques- Economic Order Quantity (EOQ), ABC, VED, and FSN Analysis, Just-In-Time (JIT) and Kanban, Purchasing and Procurement-Types of Purchasing Methods, Vendor Selection and Evaluation, Stores and Warehouse Management -Functions of Stores Management, Warehouse Layout and Storage Systems, Material Handling Systems-Types of Material Handling Equipment, Factors for Selection of Handling Equipment, Waste Management and Control-Types of Industrial Waste, Techniques for Waste Reduction	

Textbook:

1. Industrial Engineering and Management by T.R. Banga and SC Sharma; Khanna Publishers, Delhi.
2. Industrial Engineering and Management by O.P. Khanna; Dhanpat Rai and Sons, New Delhi.
3. Production Management by C.L. Mahajan; Satya Parkashan Company Limited, New Delhi.
4. Mechanical Costing, Estimation and Project Planning by CK Singh; Standard Publishers, New Delhi.

Reference Books:

1. "Production and Operations Management" by K. Aswathappa and K. Shridhara Bhat, Willey, India Publications
2. "Materials Management" by P. Gopalakrishnan and Abid Haleem, PHI Publication
3. Introduction to Management Science Operations Research, by Mohan Man, Gupta P. K., Swarup Kanti, 19th ed. Sultan Chand & Sons.
4. "Production Management and Material Management" by Mr. K. Shridhara Bhat, Himalaya Publishing House

Online Resources:

Unit No	Online Resource Link	Source
1	https://nptel.ac.in/courses/110107141	NPTEL
2	https://nptel.ac.in/courses/112107143	NPTEL
3	https://onlinecourses.swayam2.ac.in/imb24_mg119/preview	NPTEL
4	https://onlinecourses.swayam2.ac.in/nou20_cs07/preview	NPTEL

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Course Plan

Course Title: **Machine Design**	
Course Code: **231MEPECL305**	**Semester: VI**
Teaching Scheme: L-T-P :**4-0-0**	Credits: **4**
Evaluation Scheme: ISE + MSE Marks: **20 + 30**	ESE Marks: **50** INT Marks: **25**

Prerequisite:	Strength of Material, Dynamics of machines, Design of Machine Elements

Course Description:

This course is in continuation with design of Machine element. The Machine design course deals with design of the mechanical components against fluctuating load. It aims to acquire knowledge of designing procedures of transmission elements such as gears, rolling contact bearings and sliding contact bearings and pressure vessels. This course is also concerned with consideration involved in selection various elements of all machine tools.

Course Objectives:

01	To study machine elements subjected to fluctuating loading
02	To study rolling contact bearings used and hydrodynamic bearing for mechanical systems
03	To understand theories and principles used in design of pressure vessels.
04	To design various types of gears using strength and wear considerations
05	To study the concept of machine tool structures design.
06	To study machine elements subjected to fluctuating loading

Course Outcomes (COs):

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

CO	Statement	BTL
CO310.1	**Apply** fundamental principles of fatigue and stress concentration while designing various components subjected to fluctuating loading.	L3
CO310.2	**Select** rolling contact bearings from manufacturer's catalogue and solve the problems on hydrodynamic bearing.	L3
CO310.3	**Apply** theories and principles used in design of pressure vessels.	L3
CO310.4	**Execute** design procedure for spur and helical gears	L3

CO310.5	**Execute** design procedure for bevel and worm gears	L3
CO310.6	**Understand** the concept of machine tool structures design	L2

Course Content

Content	Hours
Unit 1: Design for Fluctuating Loads Stress concentration - causes and remedies, Fluctuating stresses, S-N. diagram under fatigue load, Endurance limit, Notch sensitivity, Endurance strength modifying factors, Design for finite and infinite life under reversed stresses, Cumulative damage in fatigue failure, Goodman diagram, Modified Goodman diagram, Fatigue design for components under combined stresses	06
Unit 2: Design of Bearings **Introduction to Tribological consideration in design** Friction, Wear, Lubrication **Rolling Contact Bearing** Types, Static and dynamic load capacities, Steinbeck's equation, Equivalent bearing load, Load-life relationship, Bearing life, Load factor, Selection of bearing from manufactures catalogue, Design for variable load and speed, Bearings with probability of survival other than 90 %. Mountings, Dismounting and preloading of bearings. **Sliding contact bearing** Types of sliding contact bearing, Basic theory, thick and thin film lubrication, Reynolds's equation (No equation), Raimondi and Boyd method relating bearing variables, Somerfield Number, Design consideration in hydrodynamic bearings, Temperature rise, Introduction to hydrostatic bearings	08
Unit 3: Pressure Vessel Design Types of pressure vessels, Thin and thick cylinders; Failure criteria of vessels; Lame's equation; Clavarino's and Birnie's equation; Autofrettage and compound cylinders; Classification of pressure vessel as per IS2825, 1969, Shell and end closures, Types of pressure vessel support	06
Unit 4: Design of Spur Gear and Helical Gear Introduction to Gears: Material selection, Types of gear failure. Methods of gear lubrication. **Spur Gear:** Force analysis, Static beam strength (Lewis equation) Barth equation, Dynamic tooth load (spot's equation and Buckingham equation), Wear strength (Buckingham's equation), design of spur gear.	08

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Helical Gears: Formative number of teeth, Force analysis, Beam and wear strength, Effective load and design of helical gear.	
Unit 5: Design of Bevel Gear and Worm Gear **Bevel Gear:** Straight tooth bevel gear terminology, Force analysis, Beam and wear strength, Dynamic tooth load, Design of straight tooth bevel gears based on beam and wear strength. **Worm Gears:** Terminology, force analysis, friction, efficiency of worm gear drive, design of worm drive as per IS 7443-1974 based on beam strength and wear strength rating, thermal consideration in worm drive)	06
Unit 6: Design of Machine Structures Introduction, Functions of Machine Tool Structure, Design Criteria for Machine Tool Structure, Design of Beds, Design of Columns, Design of Housing, Design of Spindle	06

Sr. No.	Name of Assignments
1	Prepare a detail report of design procedure showing calculations and sketches of i) Spur gear/ Helical gear box or ii) Bevel gear/ Worm and Worm wheel box.
2	Draw a details and assembly drawing of i) Spur gear/ Helical gear box or ii) Bevel gear/ Worm and Worm wheel box on A2 size drawing sheet.
3	Assignments based on Study of Ball bearing mountings and its selection of bearings
4	Assignments on selection of bearings using Manufactures catalogue
5	Prepare a detail report of design procedure showing calculations and sketches of pressure vessel.
6	Draw a details and assembly drawing of pressure vessel
7	Industrial visit based on above syllabus
8	Design criteria for machine tool structures
9	Design of Machine tool components such as spindle, bed, column and housing
10	Draw cad drawing of assembly of any one of the followings: Spur gear/ Helical gear or Bevel gear/ Worm and Worm wheel

	or pressure vessel.

❖ **S-STUDY, O-OPERATIONAL**

Text Books:

1. "Design of Machine Elements", V.B. Bhandari., Tata McGraw Hill Publication, 3rd edition.
2. "Mechanical Engineering Design" Shigley J.E. and Mischke C.R , McGraw Hill Publication. Co. Ltd
3. "Machine tool design", N K Mehta, Tata McGraw Hill Publication, 3rd Edition.

Reference Books:

1. "Design of Machine Element" M.F.Spotts, Prentice Hall Publication, 6th Edition.
2. "Design Data" – P.S.G. College of Technology, Coimbatore
3. "Machine Component Design",Robert C. Juvniall, Willey Ltd, 5th Edition.
4. "Machine Design", Black P.H. and O.EugeneAdams, Tata McGraw Hill International.
5. "Bearing Manufacturers Catalogue".
6. "Machine Design" U.C.Jindal, Pearson Publication
7. "Machine Tool Desdign Data Book", CMTI Publication.

Online Resources:

1. https://onlinecourses.swayam2.ac.in/aic20_ed02/preview
2. https://onlinecourses.nptel.ac.in/noc22_de10/preview
3. https://onlinecourses.nptel.ac.in/noc22_de14/preview
4. https://onlinecourses.nptel.ac.in/noc22_me134/preview
5. https://onlinecourses.swayam2.ac.in/aic19_de04/preview
6. https://onlinecourses.nptel.ac.in/noc22_me133/preview

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Course Plan

Course Title: **Thermal Energy Systems**	
Course Code: **231MEPECL306**	**Semester: VI**
Teaching Scheme: L-T-P:**4-0-0**	Credits: **4**
Evaluation Scheme: ISE + MSE Marks: 20 + 30	ESE Marks:**50** INT Marks: **25**

Prerequisite:	Applied Thermodynamics
Course Description:	
It deals with study of different thermal energy systems and its environmental sustainability along with the advanced technology in these systems. It Also covers Thermoelectric and solar thermal systems.	

Course Objectives:

1	To Study basic components of thermal energy systems including boilers, turbines, compressors, and heat exchangers.
2	to study Different Thermodynamic cycles, including their processes, assumptions, and performance characteristics.
3	To Study feasibility and benefits of integrating thermoelectric and solar thermal systems for renewable energy generation.
4	To Study emerging technologies and future trends in thermal energy systems with a focus on innovation and sustainability.
5	To Study practical techniques and engineering methods to reduce the environmental footprint of thermal systems.
6	To study feedback control mechanisms used in thermal systems such as power plants and refrigeration systems.

Course Outcomes (COs):

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

CO	Statement	BTL
306.1	Identify and describe the basic components of thermal energy systems including boilers, turbines, compressors, and heat exchangers.	**L2**
306.2	Analyze the Different Thermodynamic cycles, including their processes, assumptions, and performance characteristics.	**L3**
306.3	Evaluate the feasibility and benefits of integrating thermoelectric and solar thermal systems for renewable energy generation.	**L3**
306.4	Explore emerging technologies and future trends in thermal energy systems with a focus on innovation and sustainability.	**L3**

306.5	Explore emerging technologies and future trends in thermal energy systems with a focus on innovation and sustainability.	**L3**
306.6	It deals with study of different thermal energy systems and its environmental sustainability along with the advanced technology in these systems. It Also covers Thermoelectric and solar thermal systems	**L2**

Course Content

Content	Hours
Unit 1: Introduction to Thermal Energy Systems	7
Overview of thermal energy systems. Components of thermal energy systems: boilers, turbines, compressors, heat exchangers. Introduction to thermodynamics as applied to energy systems. Classification of thermal systems: Heat engines, refrigeration systems, and power generation systems. Applications in power plants, HVAC, and industrial systems.	
Unit No. 02: Thermodynamic Cycles	7
Introduction to thermodynamic cycles. Ideal Rankine Cycle: Process and performance. Ideal Brayton Cycle: Thermodynamic analysis and applications. Comparison of Rankine and Brayton cycles. Refrigeration Cycle: Vapour-compression and absorption refrigeration systems. Performance parameters of thermodynamic cycles. Detailed analysis of the Brayton cycle. Gas turbine systems: Open-cycle and closed-cycle systems.	
Unit No. 03: Introduction to thermoelectric energy conversion.	6
Principles of thermoelectric generators. Solar thermal energy systems: Solar collectors, storage, and applications. Design of solar thermal power plants. Integration of thermoelectric and solar systems for renewable energy generation.	
Unit No. 04: Advanced Topics in Thermal Energy Systems	7
Supercritical and subcritical cycles. Advanced cooling technologies: Heat pipes, thermosyphons, and phase-change materials. Thermodynamic and environmental challenges in modern thermal systems. Hybrid systems combining multiple energy sources. Emerging technologies in thermal energy systems and future trends.	
Unit No. 05: Environmental Impact and Sustainability in Thermal Systems	7
Environmental concerns related to thermal energy systems. Emissions from power plants, engines, and refrigeration systems. Greenhouse gases and environmental regulations. Sustainable energy systems: Energy conservation and renewable energy integration. Techniques for reducing environmental impact of thermal systems.	

Unit–06: Control of Thermal Systems	6
Control strategies for thermal systems. Feedback systems in power plants and refrigeration. Automation and control in heat exchangers and boilers.	

Text Books:

01 J. P. Holman, "Thermodynamics", McGraw Hill, London
02 "Thermal System Design",Stoecker, Tata McGrew Hill Publication, 3rd Edition
03 : "HVAC System Design Handbook" ASHRAE.

Reference Books

1 refrigeration and Air conditioning
2 Thermal Design & Optimization - Bejan
3 Design of Thermal Systems - Stoecker
4 refrigeration and Air conditioning
5 Ulicker Jr. J.J., Penock G.R. & Shigley J.E. "Theory of Machines and Mechanisms" Tata McGraw Hills

NPTEL Swayam Course List

1. Heat Exchangers fundamentals and design
   http://www.digimat.in/nptel/courses/video/112105248/L12.html
2. Heat Transfer and Combustion in Multiphase Systems
   https://onlinecourses.nptel.ac.in/noc25_me35/preview
3. Thermal Engineering: Basic and Applied
   https://onlinecourses.nptel.ac.in/noc25_me77/preview?user_email=abhijeetpaatil699@gmail.com

Course Plan

Course Title: **Logistics and Supply Chain Management**	
Course Code: **231MEPECL307**	Semester: **VI**
Teaching Scheme: L-T-P: **4-0-0**	Credits: **4**
Evaluation Scheme: ISE + MSE Marks: **20 + 30**	ESE Marks: **50** INT Marks: **25**

Prerequisite:	Industrial Management and Operational Research
Course Description:	
There is a great deal of confusion regarding exactly what Supply Chain Management involves. In fact, most people using the name Supply Chain Management treat it as a synonym for logistics or as logistics that includes customers and suppliers. However, successful SCM requires cross functional integration of key business processes within the firm and across the network of firms that comprise the supply chain. This course introduces the concepts of Logistics and Supply Chain Management. It also provides an understanding of Logistics while underlining the importance of Supply Chain Management in different kinds of Industries. This course provides an integrated view of purchasing, production, inventory, transportation, warehousing and administration	

Course Objectives:

1	An understanding of the primary differences between logistics and Supply Chain Management
2	An understanding of the individual processes of Supply Chain Management and their interrelationships within individual companies and across the supply chain
3	An understanding of the management components of Supply Chain Management
4	An understanding of the tools and techniques useful in implementing Supply Chain Management
5	Knowledge about the professional opportunities in Supply Chain Management.

Course Outcomes (COs):

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

CO	Statement	BTL
307.1	Identify different kinds of supply chain relationship operations associated with the business organizations for maintaining effective	L 2

	supply chain relations.	
307.2	Organize the sourcing and transporting decisions for the propose minimizing the transporting cost and cost of purchase.	L 2
307.3	Create awareness of warehouse, packaging and material handling decisions in Supply Chain Management.	L 2
307.4	Design transportation network & analyze factors affecting transportation decisions.	L 3
307.5	Understand the relationship development management and explore operational, social and financial performance.	L 2

Course Content

Content	Hours
Unit 1: 21st Century Supply Chains:	4
Introduction and Concepts, Generalized Supply Chain Model, Financial Sophistication, Logistics Value Proposition, the Work of Logistics, Logistical Operations, Logistical Operating Arrangements, Flexible Structure, Supply Chain Synchronization.	
Unit 2: Customer Accommodation:	9
Customer-focused Marketing, Customer Service, Customer Satisfaction, Customer Success, Forecasting, CPFR, Procurement and Manufacturing. **Information Technology Framework:** Comprehensive Information System Integration, Communication Technology, Rationale for ERP Implementation, ERP System Design, SC Information System Design.	
Unit 3: Inventory: Functionality and Definitions, Inventory Carrying Cost, Planning Inventory, Managing Uncertainly, Inventory Management Policies and Practices. **Transportation:** Transportation Infrastructure; Transport Functionality, Principles & Participants, Regulations, Transport Structure, Transport Service, Transport Operations; Transport Economics and Pricing, Transportation Administration, Documentation	09
Unit 4: Warehousing: Strategic Warehousing, Warehouse Operations, Ownership arrangements, Warehouse Decisions, Warehouse Management Systems.	09

Packaging and Material Handling: Packaging Perspectives, Packaging for Material Handling Efficiency, Materials Handling, Supply Chain Logistics Design: Global Strategic Positioning; Global SC Integration, SC Security, International Sourcing.	
Unit 5: Network Integration: Enterprise Facility Network, Warehouse Requirements, Total Cost Integration, Formulating Logistical Strategy. **Logistics Design and Operational Planning:** Planning Methodology Phase-I, II and III, SC Analysis Methods and Techniques.	**09**
Unit 6: Supply Chain Logistics Administration: Relationship Development and Management, Operational, Financial and Social Performance.	**04**

Text book :

1. "Supply Chain Management -Strategy, Planning & Operation" by Sunil Chopra & Peter Mcindl, Pearson Education Inc, 11th Edition, 2003.
2. "Logistics and Supply Chain Management" by K. Shridhara Bhat, Himalaya Publishing House, 1st Edition, 2016.

Reference Books:

1. Supply Chain Management by Rahul V Altekar, PHI Learning Ltd, New Delhi, 2009.
2. "Strategic Logistics Management" by Douglas Lanibert & James Stock, McGraw Hill, 4th Edition, 2004.

Online Resources:

Unit No	Online Resource Link	Source
1	https://nptel.ac.in/courses/110107141	NPTEL
2	https://nptel.ac.in/courses/112107143	NPTEL
3	https://onlinecourses.swayam2.ac.in/imb24_mg119/preview	NPTEL
4	https://onlinecourses.swayam2.ac.in/nou20_cs07/preview	NPTEL

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Course Plan

Course Title: **Enterprise Resource Planning**	
Course Code: **231MEPECL308**	**Semester: VI**
Teaching Scheme: L-T-P: **4-0-0**	Credits: 4
Evaluation Scheme: ISE + MSE Marks: 20 + 30	ESE Marks: **50** INT Marks: **25**

Prerequisite:	Clear Business Objectives, Comprehensive Business Process Review, Data Quality and Integrity, Customization vs. Standardization.

Course Description:

The course provides an overview of Enterprise Resource Planning (ERP) software systems and their role within an organization. It introduces key concepts of integrated information systems and explains why such systems are valuable to businesses. In addition to the lecture, students will be guided through several hands-on activities of various business processes in SAP S/4HANA software products. The course will also provide a discussion of various business cases in which ERP concepts can be applied.

Course Objectives:

1	Know the basics, evolution , importance of ERP, Correlate ERP and related technology.
2	Understand manufacturing perspectives of ERP.
3	Know business modules of ERP also Understand the key implementation issues and some popular products in ERP.
4	Understand implementation of ERP package.

Course Outcomes (COs):

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

CO	Statement	BTL
308.1	Understand the structure of an ERP system and know how process chains in Materials management, production, controlling and sales are implemented in an ERP system.	**L2**
308.2	Implementation and customize an ERP system using the appropriate modeling methods, that are Entity Relationship Modeling (ERM) and Event-Driven Process Chains (EPC).	**L2**
308.3	Understand the customization of an ERP system and customize essential parts of materials management, production, controlling and sales in SAP ECC.	**L2**
308.4	Understand software design issues in state-of-the-art business software and realize the importance of project management in an ERP implementation project.	**L2**
308.5	Understand what to expect, and not to expect, from a consultant implementing an ERP system.	**L2**
308.6	Understand the importance of IT governance in long-term relationships with a software vendor, such as SAP.	**L2**

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Course Content

Content	Hours
Unit 1: **Introduction to ERP**	10
Introduction, Evolution, Reasons for the growth of ERP market, Advantages, Reasons for failure of ERP. Benefits of ERP-Reduction of lead time, On time shipment, Reduction in cycle time, Improved resource utilization, Better customer satisfaction, Input supplier performance, Increased flexibility, Three-Tier Architecture of ERP system & Case studies.	
Unit No. 02: **ERP and Related Technologies.**	10
Business Processing Reengineering(BPR), Data Warehousing, Data Mining, On-line Analytical Processing(OLAP), Supply Chain Management (SCM), Customer Relationship Management(CRM), Electronic Data Interchange (EDI)	
Unit No. 03: **A Manufacturing Perspective**	10
MRP - Material Requirement Planning, BOM - Bill Of Material, MRP - Manufacturing Resource Planning, DRP - Distributed Requirement Planning, PDM - Product Data Management, CAD/CAM & Case studies	
Unit No. 04: **ERP Modules**	10
Introduction and study of Business modules like Finance, Mfg. and Production, HR, Plant maintenance, Quality and Material Management, Sales and Distribution.	
Unit No. 05: **ERP Implementation Life Cycle**	10
Project Preparation, Initial Costing, Requirement Engineering, ERP Solution Selection, Technical Planning, Change Management and Training Plan, Implementation and Deployment Planning, Configuration, Custom Coding, Final Preparation, Go-live	
Unit–06: **ERP Market & Benefits of ERP**	10
Brief account of ERP market, various ERP packages like SAPAG, Oracle, PeopleSoft, etc. Indian scenario for ERP implementation. Reduction of Lead-Time, On-time Shipment, Reduction in Cycle Time, Improved Resource Utilization, Better Customer Satisfaction, Improved Supplier Performance, Increased Flexibility, Reduced Quality, Costs, Improved Information Accuracy and Design-making Capability.	

Text Books:

01 "Enterprise Resource Planning", Alexis Leon, Tata McGraw Hill Publication, ISBN 0- 07-463712-6

02 "Enterprise Resource Planning", Bret Wagner, Delmar Learning, International Edition, ISBN 10: 1439081085, ISBN–13: 978-1439081082.

03 "Enterprises Resource Planning", Venkateshswara, Scitech Publication

04 "Entrepreneurship", Chris Boulton, Patric Turner, Willey India

05 "Management Information System" S. Sadagopan, PHI, New Delhi, 2nd Edition.

Reference Books:

1 "Modern ERP: Select Implement and Use", Marianne Bradford, Hand M Books, ISBN: 978-0-557-01291-6.

2 "Enterprises Resource Planning", E.F. Monk, B.J. Wagner, Cengage Learning

3 "Enterprises Resource Planning", A. R Singla, Cengage Learning.

4 "Enterprises Resource Planning-Concepts and Practices", Vinod Kumar Garg and Venkitakrishnan N. K. , PHI, New Delhi.

NPTEL SWAYAM Course List :

1. Course Name: Management Information system
By Prof. G.K.Ghose| IIT kharagpur
Link: https://nptel.ac.in/courses/110105148

2. Course Name: Enterprise Resource Planning
By Mr. Prakash Soni, Industry Expert
Link : https://elearn.nptel.ac.in/shop/completed-courses/partnering

3. Course Name: E- Business
By Prof. Mamata Jenamani | IIT kharagpur
Link: https://nptel.ac.in/courses/110105083

Course Plan

Course Title: **Tool Engineering**	
Course Code: **231MEPEC309**	Semester: **VI**
Teaching Scheme: L-T-P: **3-0-0**	Credits: **3**
Evaluation Scheme: ISE + MSE Marks: **20+30**	ESE Marks: **50**

Prerequisite:	Manufacturing processes, Machine Tools and Processes, Production Drawing,

Course Description:

Tool Engineering is mainly focused on metal cutting principles and tool design. It includes machinability aspects, cutting tool geometries and other aspects of machining like surface finish, heat generation and cutting forces. Design of jigs, fixtures and dies is main focus of the course, wherein student will design and prepare manufacturing drawings of jigs and fixtures. Design of progressive and drawing die are also included to study sheet metal operations in details.

Course Objectives:

1	To study metal cutting technology
2	To understand the principles of locating, clamping and tool guiding devices
3	To understand the principles of clamping devices
4	To understand the sheet metal operations and its tools.
5	To Understand Drawing and progressive die design.

Course Outcomes (COs):

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

CO	Statement	BTL
CO309.1	Understand metal cutting principles.	**L2**
CO309.2	Discuss machinability and tool life aspects for various machining processes	**L2**
CO309.3	Understand important elements of Jigs, Fixtures	**L2**
CO309.4	Design drilling jig and milling fixture	**L3**
CO309.5	Design drawing die.	**L3**
CO309.6	Design Progressive die.	**L3**

Course Content

Content	Hours
Unit 1: Theory of Metal Cutting	7
Wedge action, Concept of speed, Feed and depth of cut, orthogonal and oblique cutting. Mechanics of metal cutting-Chip formation, Types of chips-continues, continues with built up edges, discontinues/segmented, non-homogenous, cutting ratio, shear plane and shear angle, velocity relationships, force measurement by tool dynamometers. Numerical problems on orthogonal cutting operation.	
Unit No. 02: Tool Life and Machinability	8
Cutting tool materials and their properties, Advanced cutting tools. ISO specification of turning tool holders. Machinability of Metals- Factors affecting,.improvement and machinability index. Tool life - Types of wear, relationship with cutting parameters, Taylor's equation, improvement measures. Surface finish- various factors affecting, effect of cutting parameters, improvements. Heat generation in machining, its effect on cutting force, tool life and surface finish, types and selection criteria of cutting fluids. Numerical problems on tool life.	
Unit No. 03: Introduction to Jigs and Fixtures	7
Basic concept of jigs and fixtures for different manufacturing processes. Necessity of jig and fixture in mass production, applications, difference between jig and fixture,Degrees of freedom and its importance, 3-2-1 principle, Materials for manufacturing jig and fixture. Locating elements-types, construction and applications. Clamping elements- types, construction and applications. Tool guiding elements- types, construction and applications. Ejection devices and full proofing.	
Unit No. 04: Design of Jigs and Fixture	8
Design consideration and procedure for jig and fixture. Design of Jig- Principles of Jig design, types of jigs- plate, template, box, channel, sandwich, latch, turn-over, tumble jig their construction, working and its application. Design of Fixture- Principles of fixture design, types of fixtures- gang, straddle, string milling fixture etc, selection of the suitable cutting tool and machine tool for different milling operations, design of different elements of milling fixtures like setting block, tenon, T-bolt and T nut etc, Introduction to different fixtures like turning/lathe fixture, construction, working and its application.	

Unit No. 05: Bending, drawing and forging die	
Bending dies -a) Types and Parts and functions of bending die.b) Definition, calculations and factors affecting bend radii, bend allowance and spring back.c) Method to compute bending pressure.: Types, sketch, working and applications of bending dies. Drawing dies-types and method to determine blank size for drawing operation, Types, sketch, working and applications of drawing dies (embossing, curling, bulging, coining, swaging and hole flanging). Forging dies- terminology, types, sketch, working and application	7
Unit–06: Press tool design	
Press working processes-types, sketches and Applications, Press tools: types, working, components and their Functions. Concept, meaning, definitions and calculations of press tonnage and shut height of press tool. Shear action in die cutting operation. Centre of pressure: Concept, meaning, definition, Methods of finding and importance. Die clearance: Concept, meaning, definition, Reasons, effects and methods of application. Cutting force: Methods to calculate and methods of reducing. Scrap strip layout: Concept, importance, method to prepare, and determining percentage stock utilization. Types, working, and applications of stock stop, pilots, strippers and knockouts. Cutting dies-types and applications. Design of progressive cutting die a) Sketch the component. b) Prepare scrap strip layout c) Calculate tonnage. d) Determine centre of pressure. e) Determine dimensions of punches, die block and die shoe.	8

Text Books:

01 Manufacturing Technology, Volume-2, P.N. Rao, TMH
02 Jigs and Fixture, P. H. Joshi, Tata Mc-Graw Hill Pub. Co
03 A Text Book of Prod. Engineering, P. C. Sharma, S. Chand

Reference Books

1 Metal cutting theory and cutting tool design, V. Arshinov, G. Alekseev, MIR Publisher
2 Tool Design, Donaldson, TMH
3 An Introduction to Jig & Tool Design, M.H.A. Kempster, ELBS
4 Jigs and Fixture Design Manual, Henrikson, Industrial Press, NY
5 Fundamentals of Tool Design, Ed. Frank Wilson, ASTME, TMH
6 Techniques of Press Working of Metals by Eary and Reed
7 CMTI Machine Tool Design Handbook, TMH

NPTEL Swayam Course List

1. https://nptel.ac.in/courses/112105127
2. https://archive.nptel.ac.in/courses/112/105/112105306/
3. https://archive.nptel.ac.in/courses/112/105/112105233/

Course Plan

Course Title: **REFRIGERATION AND AIR CONDITIONING**	
Course Code: **231MEPEC310**	Semester: **VI**
Teaching Scheme: L-T-P: **3-0-0**	Credits: **3**
Evaluation Scheme: ISE + MSE Marks: **20 + 30**	ESE Marks: **50**

Prerequisite:	Applied thermodynamics, Heat Transfer
Course Description:	
This subject enables the student to understand Basic of Refrigeration system, Refrigeration Cycles, their analysis and performance evaluation. Students will also learn different refrigerants, their properties and Various parts of Vapor compression cycle. Understand the working principles & concept of Psychometric and Human Comfort. To understand Basic of Heating and Cooling Load Calculation & Air Distribution System	

Course Objectives:

1	To understand Basic of Refrigeration system, Refrigeration Cycles
2	To evaluate refrigeration systems under different conditions.
3	To understand the properties of refrigerants, & various parts of Vapor compression cycle.
4	To study selection of machine elements from manufacturer's catalogue
5	To understand & evaluate Heating and Cooling Load Calculation & Air Distribution System

CO	Statement	BLT
CO310.1	**Understand** Basic of Refrigeration system, Refrigeration Cycles,	L2
CO310.2	**Aanalysis** refrigeration systems under different conditions.	L3
CO310.3	**Uunderstand** the properties of refrigerants, & various parts of Vapor compression cycle	L2
CO310.4	**Understand** concept of Psychometric and Human Comfort	L3
CO310.5	**Understand** & evaluate Heating and Cooling Load Calculation	L3
CO310.6	**Understand** & evaluate & Air Distribution System	L3

Course Content

Unit-1 Basic of Thermodynamics & vapor compression cycle	7.00 hrs
Basic of A Refrigerating Machine – The Second Law Interpretation, Introduction to Heat pump, Heat Engine and Refrigerator (with Numerical treatment), Energy Ratios (EER), BEE star rating COP, Power Consumption of a Refrigerating Machine, Refrigeration Cycle, vapour as a Refrigerant Reversed Carnot Cycle Limitations of Carnot Cycle with Gas as a Refrigerant, Reversed Brayton or Jouleor Bell Coleman Cycle,	
Unit-2 Vapour Compression System	8.00 hrs
Limitations of Reversed Carnot Cycle with vapour as a Refrigerant, Dry versus Wet Compression, Throttling versus Isentropic Expansion, Introduction to Vapour Compression Cycle and Vapour Absorption cycle. Pressure Enthalpy Diagram and Calculations (Numerical on VCR Cycle) and effect of Operating Conditions, effect of Evaporator Pressure Effect of Condenser Pressure, effect of Suction Vapour Superheat, effect of Liquid Sub cooling, Using Liquid- Vapour Regenerative Heat Exchanger, and Actual Vapour Compression Cycle. Removal of flash gas, Flash intercooling, Introduction to cryogenic Engineering and applications,	
Unit-3 Refrigerants and Refrigeration Equipment	8.00 hrs
Classification, Desirable Properties like Thermodynamic, physical, and chemical. Comparison among commonly used refrigerants, Selection of Refrigerants, Effect on Ozone depletion and global warming, Alternative Refrigerants. Environmental Protection protocol and India's commitment. Introduction to role of ASHRAE &ISHRAE in refrigeration and air conditioning area, ASHRA Nomenclatures. Insulation, types and different applications, properties of ideal insulations. Introduction to Equipment such as Compressor, Condenser, Evaporator, Expansion devices.	
Unit-4 Psychrometry and Human Comfort	7.00 hrs
Moist air as a working substance, Psychrometric properties of air, Use of Psychrometric tables and charts, Processes, Combinations and Calculations (Numerical on Psychrometry), ADP, Coil Condition lime, Sensible heat factor, Bypass factor, Air washer and its applications. Thermal exchange between human body and environment, factors affecting comfort, effective temperature comfort chart, ventilation requirements	

Unit-5 Heating and Cooling Load Calculation:	8.00 hrs
Representation of actual air conditioning process by layouts and on Psychometric charts, load analysis, RSHF, GSHF, ESHF, Enumeration and brief explanation of the factors forming the load on refrigeration and air conditioning systems, Energy requirements of different types of air conditioning systems, Energy conservation in air conditioning. Inside and Outside Design condition. Cooling Load estimation Introduction to Inverter technology and its use in power failure, Introduction to Phase change material used for temperature retention in refrigerator	
Unit-6 Air Distribution System	7.00 hrs
Re-circulated air, Ventilation air, Duct work, Use of friction loss and rectangular equivalent of round duct chart, duct system, principle of duct sizing, and air distribution it's norms, diffusers, dampers, layout, duct systems for theaters, auditorium, hospitals, assembly shop etc. Energy Conservations and Green Buildings, Freeze drying, Pharmaceutical and hospital air conditioning, textile, car air conditioning (plant layout, system components and design conditioning	

Textbook:

01 "Refrigeration and Air Conditioning",C. P. Arora, Tata McGraw-Hill Publishing Company Ltd., New Delhi,1981,2ndEdition.

02 "Refrigeration and Air Conditioning", by Er. R. K. Rajput.(3 rd Edition,Katsonbook.)

03 Dr. S.N. Sapali "Refrigeration and Air-conditioning", PHI (Second Edition) 2011

Reference Books:

01 "Basic Refrigeration And Air Conditioning", PN Ananthanarayan Tata McGraw Hill Publishing Company Ltd., New Delhi, 3rd Edition,(1981).

02 "Refrigeration and Air Conditioning", Arora Domkundwar, Pearson Education,3 rd Edition.

03 "Refrigeration and Air Conditioning", Stoker.

04 Roy J. Dossat "Principles of Refrigeration", Pearson, fourth edition, 2007.

NPTEL Swayam Course List

1. Course Name: Basic of Thermodynamics.
   By Prof. Som IIT Khargapur
   http://nptel.ac.in
2. Course Name: vapor compression cycle.
   By By Prof. Som IIT Khargapur
   https://archive.nptel.ac.in/courses/112/105/112105129/
3. Course Name: Refrigerants and Refrigeration Equipment.
   By Prof. Ravi Kumar | IIT Roorkee
   https://onlinecourses.nptel.ac.in/noc22_me135/preview
4. Course Name: Psychometric and Human Comfort
   By By Prof. Ravi Kumar | IIT Roorkee
   https://onlinecourses.nptel.ac.in/noc24_me90/preview
5. Course Name :Air Distribution System.
   By Prof. Ravi Kumar | IIT Roorkee
   https://archive.nptel.ac.in/courses/112/105/112105129/

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T. Y. B. Tech. Curriculum
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Course Plan

Course Title: **Electric Vehicle**	
Course Code: **231MEPEC311**	**Semester: VI**
Teaching Scheme: L-T-P: **3-0-0**	Credits: **3**
Evaluation Scheme: ISE + MSE Marks: **20 + 30**	ESE Marks: **50**

Prerequisite:	Basic Mechanical Engineering, Basic Electronics and Electrical Engineering

Course Description:

This course will be a first level course on electric vehicle. Students will be able to understand the operation of battery driven electric vehicle. The introduction section will enable the students to understand the architect of electric vehicles and its important components. Then the course will cover vehicle dynamics, electric motors, power electronics, batteries and it's charging.

Course Objectives:

1	To impart the basic knowledge of Electric Vehicle.
2	To make the student conversant with power sources of todays and future EV.
3	To prepare the students for a career in the drastically changing automotive industry.
4	To acquaint the student with prerequisite for higher studies in Electric Vehicle.
5	To make the students aware with different areas of research in the field of Electric Vehicle.

Course Outcomes (COs):

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

CO	Statement	BTL
311.1	**Understand** the basic knowledge of electric vehicle.	**L2**
311.2	**Describe** the various types of batteries used in electric vehicles.	**L2**
311.3	**Understand** various battery charging methods for electric vehicles.	**L2**
311.4	**Determine the various types of motors used in electric vehicles.**	**L3**
311.5	**Explain** motor control technology in electric vehicles.	**L3**
311.6	**Discuss** safety, norms of electric vehicles.	**L1**

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Course Content

Content	Hours
Unit 1: **Introduction**	6
Energy crises, Need of future transportation, Introduction and overview of Electric Drive layouts and its configurations, Traction power requirement for vehicle propulsion under different road and speed condition, EV – Indian policies (FAME I and FAME II), R&D and Collaboration.	
Unit No. 02: **Batteries for electric vehicle**	8
Electrochemical Batteries – Fundamental reactions and thermodynamics, Voltage, Specific power and Energy, Working of Pb-Acid batteries, Ni-Fe, Ni- Cd, Ni-MH Batteries, Li- Polymer, Li-ion, Battery selection for Electric Vehicle, Regenerative Braking for battery charging. Battery Storage, Battery Pack Design.	
Unit No. 03: **Battery charging technology for electric vehicle**	6
Types of battery charging, Normal charging, Opportunity charging, Fast charging, Constant current and constant voltage Charging, Multistage charging (MSC), Pulse Charging, Trickle Charging (TC), Wire and Wireless charging, Charging station infrastructure. Battery swapping. Battery Charging algorithms.	
Unit No. 04: **Motors in electric vehicles**	6
Types of Electric Motors used in electric vehicles, DC motors, Induction motors, Permanent Magnet motors, Switched Reluctance motors, BLDC motor, Torque – speed characteristics of above-mentioned motors, Comparison and its layout in EV, Selection of motor for EV, Motor location and drive from motor to wheels.	
Unit No. 05: **Motor control in electric vehicle**	9
Power conversion required in EV, Principle of operation of power electronics devices like: SCR, TRIAC, DIAC, GTO, MOSFET, IGBT and power BJT, Battery to Motor with speed control, Regenerative Braking requirements, Bi-directional and multiple input to single output power conversion in EV. Power conversion required for DC charging and AC charging on board and off board.	
Unit No. 06: **Safety, Norms of Electric Vehicle**	5
Type approval procedure for electric and hybrid electric vehicles, V2X technology like V2 home, V2Grid, Self-driving from level 1 to level 5, Autonomous driving.	

Text Books:

01	M. Ehsani, Y. Gao, S.E. Gay and Ali Emadi, Modern Electric, Hybrid Electric and Fuel Cell Vehicles: Fundamentals, Theory and Design, CRC Press. 2005
02	Sheldon Williamsom, Energy Management Strategies for Electric and Plug-in Hybrid Vehicles, Springer 2013
03	J. Larminie and J. Lowry, Electric Vehicle Technology Explained, Wiley, 2003

Reference Books

1	James Larmine and John Lowry, Electrical Vehicle Technology Explained,John Wiely and Sons Ltd.,2nd Edition WSE 2020.
2	Iqbal Husain, Electric and Hybrid Vehicles: Design Fundamental. CRC Press, 2nd Edition, e-library 2017
3	C.C. Chan, K.T. Chau, Modern Elèctric Vehicle Technology, Oxford Publication, New York, 1st edition 2011

NPTEL Swayam Course List

1. Electric Vehicle Part I: https://onlinecourses.nptel.ac.in/noc22_ee53/preview
2. Fundamentals of Electric vehicles: https://nptel.ac.in/courses/108106170
3. Electric Vehicle Part I :https://nptel.ac.in/courses/108102121

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Course Plan

Course Title: **Rapid Prototyping**	
Course Code: **231MEPECL312**	**Semester: VI**
Teaching Scheme: L-T-P :**3-0-0**	Credits: **3**
Evaluation Scheme: ISE + MSE Marks: **20 + 30**	ESE Marks: **50**

Prerequisite:	Manufacturing Processes, CAD

Course Description:

Rapid Prototyping is a course that covers the basics of modern 3D printing technology. In this course, students will learn about the different types of additive manufacturing processes, including Fused Deposition Modeling (FDM), Stereolithography (SLA), Selective Laser Sintering (SLS), and others. They will also learn about the materials used in additive manufacturing, such as plastics, metals, and ceramics, and the properties that make them suitable for different applications. The course will cover the principles of design for additive manufacturing, including the use of CAD software to create 3D models and the optimization of part orientation and support structures. Students will also learn about the post-processing techniques used to finish and refine parts after they have been printed. Additionally, the course will discuss the applications of additive manufacturing in various industries, such as aerospace, automotive, medical, and consumer products. Students will explore case studies of successful applications of 3D printing technology, as well as emerging trends and future possibilities. By the end of the course, students will have a solid understanding of additive manufacturing and its potential applications, as well as hands-on experience with 3D printing technology. They will be equipped with the skills and knowledge necessary to design and manufacture their own parts using additive manufacturing techniques.

Course Objectives:

01	To provide comprehensive knowledge of the wide range of additive manufacturing processes, capabilities and materials
02	To understand the software tools and techniques used for additive manufacturing.
03	To create physical objects that facilitates product development/prototyping requirements.
04	To study various post processing techniques of AM

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Course Outcomes (COs):

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

CO	Statement	BTL
CO312.1	Elaborate the fundamental concepts of Rapid Prototyping	L2
CO312.2	Discuss Principles and different materials used in FDM and SLA printing.	L4
CO312.3	Discuss Principles and different materials used in Directed Energy Deposition, Material Jetting, Binder Jetting, Powder Bed Fusion, and Sheet Lamination.	L4
CO312.4	Describe the process of 3D modeling for additive manufacturing, including the use of CAD software.	L2
CO312.5	Identify specific parts used in different applications that can be produced using additive manufacturing.	L3
CO312.6	Explore various techniques used to enhance the properties of additive manufacturing parts.	L4

Course Content

Content	Hours
Unit 1: Introduction to Rapid Prototyping/Additive Manufacturing Definition of Additive Manufacturing (3D Printing), Additive vs Subtractive Manufacturing, Rapid prototyping (RP), Historical development of Rapid Prototyping, Areas of Application (Basic Introduction) Advantages and Limitations of Additive Manufacturing, commonly used Terms, Classification of Additive Manufacturing Processes, Process overviews, Steps Involved	06
UNIT 2: Additive Manufacturing Processes I: Fused Deposition Modelling and Stereo lithography Fused Deposition Modelling (FDM): FDM Technology, Various FDM Printers and Specifications, Process Parameters of Models and specifications, Process, Materials for FDM,Their Application areas and Caparison, Applications, Advantages and Disadvantages. Stereo lithography (SLA): Specifications of SLA Printers, Process, working principle, photopolymers, photo polymerization, Layering technology, laser and laser scanning, Applications, Advantages and Disadvantages.	10

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UNIT 3: Additive Manufacturing Processes II: Directed Energy Deposition, Material Jetting, Binder Jetting, Powder Bed Fusion, Sheet Lamination etc.: Specifications, Process Parameters of Models and specifications, Process, Materials, Application areas and Comparison, Applications, Advantages and Disadvantages	08
UNIT 4 : Design Potential of Rapid Prototyping: Aspects of CAD for Additive Manufacturing (3D Modelling, Slicing, STL file Generation etc.) Conventional design for manufacturing and assembly (DFM, DFMA), Geometrical freedom, design complexity/ optimization, parts consolidation, body fitting customization and multiple assemblies manufactured as one, Customer input and customization. 3D Scanning and digitization, AM Software: data formats and standardization, Slicing algorithms, Advanced Slicing	08
UNIT 5 : Applications of Additive Manufacturing Form and fit checking, Ergonomic Studies, Functional testing, Automotive applications- Parts of racing cars, Applications in Aerospace industry, Construction industry, Applications in Medical field , Rapid Tooling: Mold making, Rapid tooling for die, permanent mold casting, Rapid manufacturing of sheet metal forming tools, casting pattern plates by rapid tooling, RP for series production investment casting, Advances in Additive Manufacturing	06
UNIT 6: Post Processing of AM Parts: Support Material Removal, Surface Texture Improvement, Accuracy Improvement, Aesthetic Improvement, and Preparation for use as a Pattern, Property Enhancements using Non-thermal and Thermal Techniques. Details of Sanding, Vapor Smoothing, Priming & Painting, Polishing, Coating, Electroplating, Welding etc.	06

Text Books:

1. Gibson, I., Rosen, D.W. and Stucker, B., "Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2015.
2. Chua, C.K., Leong K.F. and Lim C.S., "Rapid prototyping: Principles and applications", Third edition, World Scientific Publishers, 2010.

Reference Books:

1. Liou, L.W. and Liou, F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2011.
2. Kamrani, A.K. and Nasr, E.A., "Rapid Prototyping: Theory and practice", Springer, 2006.
3. Hilton, P.D. and Jacobs, P.F., Rapid Tooling: Technologies and Industrial Applications, CRC Press, 2000

Online Resources:

1. Additive Manufacturing Industry News: A website dedicated to news and updates on the additive manufacturing industry. (https://www.additivemanufacturing.media/)
2. 3D Printing Industry: An online publication covering the latest news, trends, and developments in the 3D printing and additive manufacturing industry. (https://3dprintingindustry.com/)
3. All3DP: An online platform that provides news, reviews, and resources on 3D printing and additive manufacturing. (https://all3dp.com/)
4. TCT Magazine: A leading source of news and insights on additive manufacturing, 3D printing, and related technologies. (https://www.tctmagazine.com/)
5. Virtual Labs : https://3dp-dei.vlabs.ac.in/

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Course Plan

Course Title: **Computer Aided Manufacturing**	
Course Code: **231MEVSECL301**	Semester: **VI**
Teaching Scheme: L-T-P: **1-0-0**	Credits: **01**
Evaluation Scheme:	INT Marks: **25**

Prerequisite:	3D modelling, basic knowledge of turning, milling and other machining processes

Course Description:

Computer Aided Manufacturing is aimed at providing basic understanding of the CNC technology with industrial practices to make them fit in industries. This course enables students to understand CNC programming and use CAM software in order to produce mechanical components

Course Objectives:

1	To introduce the fundamentals of Computer-Aided Manufacturing (CAM) and its integration with modern industrial processes.
2	To develop an understanding of CNC programming, including G-code and M-code, for machining operations.
3	To provide knowledge of rapid prototyping techniques and their applications in product development

Course Outcomes (COs):

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

CO	Statement	BTL
301.1	Demonstrate a comprehensive understanding of CAM principles and its role in modern manufacturing.	**L2**
301.2	Develop CNC programs using manual part programming techniques with G-code and M-code.	**L3**
301.3	Apply knowledge of rapid prototyping processes to generate computer program for models using additive manufacturing.	**L3**

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Course Content

Content	Hours
Unit 1: Introduction to CAM & Manual Part Programming	11
Brief Introduction to Computer-aided Manufacturing, The History of Computer Numerical Control (CNC), Applications of Computer-aided Manufacturing, Benefits of CAD-CAM in Manufacturing. Co-ordinate System and Programming Methods. Introduction to CNC Programming – G-Code and M-Code. Program Format for Machining Operations. Tool Radius Compensation & Cutter Compensation. Canned Cycles in CNC Programming. Manual Part Programming. Case Studies of turning and milling.	
Unit No. 02: Rapid Prototyping	04
Introduction to Rapid Prototyping. Process of Rapid Prototyping. Techniques of Rapid Prototyping. Generation and Slicing of CAD Models. 3D Printing & Post-Processing Technique	

List of Assignments

Sr. No.	Name of assignment
1	Assignment on introduction to CAM, benefits and applications
2	Manual part programming for CNC turning (part with steps)
3	Manual part programming for CNC turning (part with steps, radii and chamfers)
4	Manual part programming for CNC turning part using canned cycle.
5	Manual part programming for CNC milling for profile cutting- 1
6	Manual part programming for CNC milling for profile cutting- 2
7	Manual part programming for CNC milling for drilling of different diameter holes.
8	Assignment on rapid prototyping .

Text Books:

1. "CAD/CAM- Principals and Applications", P.N. Rao, Tata McGraw Hill, 2ndEdition.
2."CAD/CAM/CAE", N.K. Chougule, SciTech Publication, Revised Edition.

Reference Books:

1. CAD/CAM by M.P.Grover and E.W.Zimmer, Prentice Hall of India Pvt. Ltd.
2. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Kamrani A. K., Nasr E. A., Springer

Online Resources:

1. Course Name: Introduction to computer control
By Prof. A. R. Choudhury | IIT Kharagpur
Link:https://youtube.com/playlist?list=PLSGws_74K01KX9YtVZACpOoFYv6oaJIC&si=IO5H8-8pECR_VcqP
2. Course Name: CNC programming
By Prof. S. N. Joshi| IIT Guwahati
Link: https://youtu.be/_5r2XR1h1aQ?si=foA_K2zoXilcwlSX

Lab Course Plan

Course Title: **Metrology and Quality Control Lab**	
Course Code: **231MEPCCP304**	Semester: **VI**
Teaching Scheme: L-T-P: **0-0-2**	Credits: **1**
Evaluation Scheme: INT Marks: **25**	OE Marks: **25**

Prerequisite:	Engineering Physics, Machine Drawing, Manufacturing Processes, Machine tools and Processes
Course Description:	
This course deals with the study, use, demonstration and hands on practice of different types of measuring instruments, equipment's and machines used for measurement of various features/measurands of industrial parts and also apply knowledge of measuring instruments in actual industry practice.	

Course Objectives:

1	To elaborate basic concepts of metrology, various standards and methods of dimensional measurement.
2	To explain importance of measurement of various parameters of screw threads, gears and surface quality by using different tools.
3	To make the students to identify quality aspects at various stages of product development.
4	To train the students to apply knowledge of statistical tools for analysis of quality.

Course Outcomes (COs):

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

CO	Statement	BTL
CO304.1	Select and use an appropriate linear, angular measuring instrument and comparator for inspection.	L3
CO304.2	Measure surface roughness, screw thread parameter and gear tooth parameter using appropriate instrument.	L3
CO304.3	Demonstration on CMM for dimensional and geometrical features.	L3
CO304.4	Plot normal distribution curve and control charts for a given manufacturing process.	L4

Lab Course Content

Sr. No.	Details	Type	Hrs.
1	Perform linear measurement experiment using Vernier caliper, Vernier height gauge, and vernier depth gauge.	O	4
2	Perform linear measurement experiment using Outside Micrometer, Inside Micrometer and Depth Micrometer.	O	2
3	To check the bore diameter using Bore Dial Gauge	O	-
4	Perform angle measurement using Bevel protractor.	O	1
5	Perform angle measurement using Sine bar.	O	2
6	Use of comparators to inspect various dimensional and geometrical features.	O	1
7	Use of optical profile projector for Screw thread measurement and gear tooth profile inspection.	O	1
8	Use of Tool maker's microscope for profile inspection of various industrial parts.	O	1
9	Use of gear tooth vernier caliper for measuring Chordal thickness of gear tooth.	O	1
10	Measurement of surface roughness with portable surface roughness tester	O	1
11	Screw thread measurement (major, minor and effective diameter) with the help of floating carriage Micrometer.	O	-
12	Study and use of variable (Xbar and R chart) and attribute(P) chart using Mini tab.	S	1
	A group of 5 students can select any one group activity given below- Students should collect drawing of a component from industry and suggest a measuring instrument / method to measure various dimension and geometric parameters in it.		
	Industrial Visits for studying Coordinate measuring machine (CMM), different comparators, various special measuring instruments and calibration process.		

Text Books:

1. "Engineering Metrology", I. C. Gupta, Dhanpat Rai Publications, 7th Edition
2. "Engineering Metrology", R. K. Jain, Khanna Publications, 17th Edition
3. "Statistical Methods", S. P. Gupta, Danpat Rai and Sons, New Delhi, 2007

Reference Books

1. "Engineering Metrology and Measurements", N. V. Raghavendra and L. Krishnamurthy, Oxford publication,2013 Edition.
2. "Practical Engineering Metrology", Sharp K.W.B., Pitman, London, 1966
3. "Statistical Quality Control", A. L. Grant, Tata McGraw Hill International, New York, 6th Edition
4. "Statistical Quality Control", R. C. Gupta, 9th Edition
5. "Engineering Metrology", Hume K. G., M. C. Donald, Technical and Scientific, London, 2nd Edition.
6. "Quality Control and Industrial Statistics", Duncon A. J., Publisher- R. D. Irwin, 4th Edition.

NPTEL Swayam Course List

1. https://www.digimat.in/nptel/courses/video/112106179/L01.html
2. https://www.digimat.in/nptel/courses/video/112104250/L19.html
3. https://nptel.ac.in/courses/112/104/112104250
4. https://nptel.ac.in/courses/110/105/110105088/
5. https://nptel.ac.in/courses/112/107/112107259/

Course Plan

Course Title: **Mechatronics Lab**	
Course Code: **231MEPCCP306**	Semester: **VI**
Teaching Scheme: L-T-P: **0-0-2**	Credits: **01**
Evaluation Scheme: INT Marks: **25**	POE Marks: **25**

Prerequisite:	Essentials of Electrical & Electronics Technology

Course Description:

Mechatronics course is of importance due to the global demand and developments in Mechatronics system, Industrial Automation & Robotics, Industry 4.0 automated manufacturing systems, planning and controlling activities etc. For designing and developing mechatronics systems students of mechanical engineering must understand basic elements of mechatronics systems such as sensors, microcontrollers, microprocessors, logic and programs for automating the processes.

Course Objectives:

1	To prepare Mechanical Engineering students for advanced graduate studies in Mechatronics, Manufacturing engineering, Industrial automation and related field
2	To introduce graduate of mechanical engineering with working principle of Microprocessor and Microcontroller
3	To provide the fundamentals of PLC programming, ladder diagram and significance of PLC systems in industrial application
4	To make students aware about graphical representation and simulation of mechatronics systems.

Course Outcomes (COs):

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

CO	Statement	BTL
C306.1	Demonstrate Operations of Sensors and Actuators.	L2
C306.2	Understand the principle of Microprocessor and Microcontroller	L2
C306.3	Demonstrate the working of sensor by making the connection with PLC.	L2
C306.4	Write & Demonstrate the PLC programming	L3

Course Content

Sr. No.	Experiment/Assignment List	Type	Hrs.
1	Demonstration of Various types of Sensors	O	2
2	Demonstration of various types of Actuators	O	2
3	Programming of Microprocessor	O	2
4	Introduction to Programmable Logic Controller	S	2
5	Demonstration of truth tables using PLC Programming.	O	2
6	Demonstration of PLC Program using Timers	O	2
7	Demonstration of PLC Program using Counters	O	2
8	Demonstration of Pneumatic circuit using PLC	O	2
9	Demonstration of Industrial Applications using PLC	O	2
10	Simulation of Mechatronics System using SCADA	O	4
11	Development of Micro Project to demonstrate Mechatronics System	O	6
12	Industrial visit to study Mechatronic system, application and submission of visit report.	S	2

S-STUDY, O-OPERATIONAL

Textbook:

1. Mechatronics", W. Bolton, Pearson Education , 4th Edition,
2. "Mechatronics: Principles & applications", Godfrey Onwubolu Elsevier (2005)3
3. "Introduction to PLC Programming" NIIT.
4. "Programmable Logical Controller", Hackworth, Pearson Education, (2008).

Reference Books:

1. "Introduction to Mechatronics" AppuKuttam, Oxford Publications, 1st Edition.
2. Introduction to Mechatronics & Measurment Systems", David G AlciatoreMichel Histand, Tata McGraw Hill Pub. Co.New Delhi 4th Edition
3. "Automated Manufacturing Systems" ,S. Brain Morris, Tata McGraw Hill
4. "Mechatronics and Microprocessor", Ramchandran , Willey India, (2009).
5. "Mechatronics: Integrated Mechanical Electronic System", Ramchandran , Willey India,1stEdition.

Online Resources:

Sr. No	Online Resource Link	Source
1.	https://nptel.ac.in/courses/112107298	NPTEL
2.	https://nptel.ac.in/courses/112103174	NPTEL

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Lab Course Plan

Course Title: **Tool Engineering Lab**	
Course Code: 21MEPECP309	**Semester: VI**
Teaching Scheme: L-T-P: **0-0-2**	Credits: **1**
Evaluation Scheme:	INT Marks: 25

Prerequisite:	Manufacturing processes, Production Drawing, Limits and Fits, Metallurgy

Course Description:

Tool Engineering is mainly focused on metal cutting principles and tool design. It includes machinability aspects, cutting tool geometries and other aspects of machining like surface finish, heat generation and cutting forces. Design of jigs, fixtures and dies is main focus of the course, wherein student will design and prepare manufacturing drawings of jigs and fixtures. Design of progressive and drawing die are also included to study sheet metal operations in details.

Course Objectives:

1	To study metal cutting technology
2	To understand the locating principles of locating devices
3	To understand the principles of clamping devices
4	To understand the principles of designing locating and clamping devices
5	To understand the function of Jigs, fixtures and dies
6	To understand the design practices of Jigs, fixtures and dies

Course Outcomes (COs):

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

CO	Statement	BTL
CO303.1	Discuss machinability and tool-life aspects for various machining processes	L2
CO303.2	Understand important elements of Jigs, Fixtures	L2
CO303.3	Design drilling jig and milling fixture	L3
CO303.4	Prepare 3D model of Jigs and Fixtures.	L3

Sr. No.	Details	Type	Hrs.
1	Selection of turning tool holders with ISO specification	S	1
2	Demonstration and measurement of effect of speed, feed data on surface finish (Tuning/milling operation)	O	1
3	Force measurement by tool dynamometers for lathe/drilling/milling operation	O	1
4	Study of various elements of jigs and fixture (clamping, locating ,tool guiding etc)	S	1
5	Design and drawing of jig for drilling / reaming/ tapping operation. (Assembly & Details on A2 size sheet showing manufacturing drawing with tolerances, material specification and heat treatments, standard components like screw, nut, bolt, pins etc)	S	2
6	Design and drawing of jig for drilling / reaming/ tapping operation (Only assembly drawing on A2 size sheet mentioning the fits)	S	2
7	Design and drawing of milling fixtures. (Assembly and Details on A2 size sheet showing manufacturing drawing with tolerances, material specification and heat treatments, standard components like screw, nut, bolt, pins etc.)	S	2
8	Design and drawing of milling fixtures. (Only assembly drawing on A2 size sheet mentioning the fits)	S	2
9	Demonstration of drilling jig/milling fixture setting on actual machine table	O	1
10	Design and drafting using any CAD software for above any one Jig, fixture or die showing assembly	O	2
11	Industrial visit to study the actual use of Jigs, Fixture and dies	-	
12	Case study-Students in a team of 5 should design(using CAD software) and manufacture (using different wood working/metal cutting tools) a Jig or fixture prototype (Wooden/metal/thermocol or any suitable material) and submit a report.	-	

Textbooks:

1. Manufacturing Technology, Volume-2, P.N. Rao, TMH
2. Jigs and Fixture, P. H. Joshi, Tata Mc-Graw Hill Pub. Co
3. A Text Book of Prod. Engineering, P. C. Sharma, S. Chand

Reference Books:

1. Metal cutting theory and cutting tool design, V. Arshinov, G. Alekseev, MIR Publisher
2. Tool Design, Donaldson, TMH
3. An Introduction to Jig & Tool Design, M.H.A. Kempster, ELBS
4. Jigs and Fixture Design Manual, Henrikson, Industrial Press, NY
5. Fundamentals of Tool Design, Ed. Frank Wilson, ASTME, TMH
6. Techniques of Press Working of Metals by Eary and Reed
7. CMTI Machine Tool Design Handbook, TMH

NPTEL Swayam Course List

1. https://nptel.ac.in/courses/112105127
2. https://archive.nptel.ac.in/courses/112/105/112105306/
3. https://archive.nptel.ac.in/courses/112/105/112105233/

Course Plan

Course Title: **REFRIGERATION AND AIR CONDITIONING**	
Course Code: **231MEPEC310**	**Semester: VI**
Teaching Scheme: L-T-P: **0-0-2**	Credits: **3**
Evaluation Scheme:	INT Marks: **25**

Prerequisite:	Applied thermodynamics, Heat Transfer

Course Description:

This subject enables the student to understand Basic of Refrigeration system, Refrigeration Cycles, their analysis and performance evaluation. Students will also learn different refrigerants, their properties and Vvarious parts of Vapor compression cycle. Understand the working principles & concept of Psychometric and Human Comfort. To understand Basic of Heating and Cooling Load Calculation & Air Distribution System

Course Objectives:

1	To understand Basic of Refrigeration system, Refrigeration Cycles
2	To evaluate refrigeration systems under different conditions.
3	To understand the properties of refrigerants, & various parts of Vapor compression cycle.
4	To study selection of machine elements from manufacturer's catalogue
5	To understand & evaluate Heating and Cooling Load Calculation & Air Distribution System

CO	Statement	BLT
CO310.1	**Understand** Basic of Refrigeration system, Refrigeration Cycles,	L2
CO310.2	**Aanalysis** refrigeration systems under different conditions.	L3
CO310.3	**Uunderstand** the properties of refrigerants, & various parts of Vapor compression cycle	L2
CO310.4	**Understand** concept of Psychometric and Human Comfort	L3
CO310.5	**Understand** & evaluate Heating and Cooling Load Calculation	L3
CO310.6	**Understand** & evaluate & Air Distribution System	L3

List of Assignments/Experiments			
Sr. No.	Details	Type	Hrs.
1	Study of various conventional and Nonconventional methods of refrigeration	O	2.00
2	Study and demonstration on Compressor, Condenser, Evaporator, Expansion, devices, Types, selection. Component balancing, safety devices and refrigeration controls	O	2.00
3	Study and demonstration of controls and safety devices in refrigeration and air conditioning.	O	2.00
4	Study and demonstration of dehydration, charging leak testing and testing of refrigeration system with trouble shooting.	O	2.00
5	Study and trail on vapour absorption system	O	2.00
6	Trail on Vapor compression cycle.	O	2.00
7	Trial on ice plant test rig	O	2.00
8	Trial on heat pump test rig.	O	2.00
9	Study and demonstration on air conditioning systems. (Unitary viz Room/Split and Packaged Air Conditioners and central air conditioning/system)	O	2.00
10	Trial on window Air Conditioning Test Rig	O	2.00
11	Market survey of various refrigeration and air conditioning systems which include the equipment's with related specifications, manufacturers, cost and comparison with respect to tonnage, coat and presentation of report in the laboratory.	O	2.00
12	Visit to central air conditioning or cold storage or dairy plant to ice plant related with refrigeration and air conditioning system.	O	2.00

Minimum 9 experiments should be carried out to cover the entire curriculum of course.

- **S-STUDY, O-OPERATIONAL**

Textbook:

01 "Refrigeration and Air Conditioning",C. P. Arora, Tata McGraw-Hill Publishing Company Ltd., New Delhi,1981,2ndEdition.

02 "Refrigeration and Air Conditioning", by Er. R. K. Rajput.(3 rd Edition,Katsonbook.)

03 Dr. S.N. Sapali "Refrigeration and Air-conditioning", PHI (Second Edition) 2011

Reference:

01 "Basic Refrigeration And Air Conditioning", PN Ananthanarayan Tata McGraw Hill Publishing Company Ltd., New Delhi, 3rd Edition,(1981).

02 "Refrigeration and Air Conditioning", Arora Domkundwar, Pearson Education,3 rd Edition.

03 "Refrigeration and Air Conditioning", Stoker.

04 Roy J. Dossat "Principles of Refrigeration", Pearson, fourth edition, 2007.

NPTEL Swayam Course List

1. Course Name: Basic of Thermodynamics.
   By Prof. Som IIT Khargapur
   http://nptel.ac.in
2. Course Name: vapor compression cycle.
   By By Prof. Som IIT Khargapur
   https://archive.nptel.ac.in/courses/112/105/112105129/
3. Course Name: Refrigerants and Refrigeration Equipment.
   By Prof. Ravi Kumar | IIT Roorkee
   https://onlinecourses.nptel.ac.in/noc22_me135/preview
4. Course Name: Psychometric and Human Comfort
   By By Prof. Ravi Kumar | IIT Roorkee
   https://onlinecourses.nptel.ac.in/noc24_me90/preview
5. Course Name :Air Distribution System.
   By Prof. Ravi Kumar | IIT Roorkee
   https://archive.nptel.ac.in/courses/112/105/112105129/

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w.e.f. 2024-25

Course Plan

Course Title: **Rapid Prototyping Lab**	
Course Code: **231MEPECP312**	**Semester: VI**
Teaching Scheme: L-T-P :**0-0-2**	Credits: **1**
Evaluation Scheme:	INT Marks: **25**

Prerequisite:	Manufacturing Processes, CAD

Course Description:

The Additive Manufacturing Lab provides students with a hands-on experience in modern 3D printing technology. This lab complements the theoretical knowledge gained in the Additive Manufacturing course by focusing on practical applications and techniques. Students will have the opportunity to work with different types of additive manufacturing processes, including Fused Deposition Modeling (FDM), Stereolithography (SLA), Selective Laser Sintering (SLS), and more. They will gain proficiency in using additive manufacturing equipment and software to create functional 3D printed objects.

Course Objectives:

01	To study discretization techniques.
02	To calculate the stress, temperature and other related parameters in Structural Analysis & heat transfer
03	To use commercial software for Structural Analysis & heat transfer

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Course Outcomes (COs):

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

CO	Statement	BTL
312.1	**Understand** different discretization techniques.	L2
312.2	Solve 1 D and 2D Structural Analysis problems to **evaluate** deformation, stress, strain and reaction	L5
312.3	Solve 1 D Heat transfer problem to **evaluate** temperature distribution and heat flux	L5

Course Content

List of Experiment / Assignments			
Sr. No.	**Name of Experiment / Assignments**	**Type**	**Hrs.**
1	Study of a FDM 3 D Printer and its various elements and a Virtual lab on FDM Printer	S	2
2	Study of Slicing Software Ultimaker Cura and other Software	O	2
3	Build Time Assessment: Evaluate effect of various process parameters on Build Time	O	2
4	Print Quality Assessment: Evaluate the impact of different print settings, such as layer height, print speed, and infill density, on the quality of FDM prints. Measure and compare factors like dimensional accuracy, surface finish.	O	2
5	Design and Development / Selection of a Product using FDM Technology (Design)	O	2
6	Design and Development / Selection of a Product using FDM Technology (Design)	O	2
7	Design and Development / Selection of a Product using FDM Technology (Design)	O	2
8	Design and Development / Selection of a Product using FDM Technology (Slicing and Priting)	O	2
9	Design and Development / Selection of a Product using FDM Technology (Printing)	O	2
10	Study of a SLA 3 D Printer and its various elements and a Virtual lab on SLA Printer	O	2
11	Investigate the effect of varying exposure times print quality and curing depth. Print test specimens using different exposure times and measure the dimensional accuracy and surface finish.	O	2

12	Comparison of FDM ad SLA Technologies		2
13	Advanced Slicing Options		2
14	Industrial or Lab Visit Report on various 3D Printing Technologies		2
15	Industrial or Lab Visit Report on various 3D Printing Technologies		2

Text Books:

1. Gibson, I., Rosen, D.W. and Stucker, B., "Additive Manufacturing Methodologies: Rapid Prototyping to Direct Digital Manufacturing", Springer, 2015.
2. Chua, C.K., Leong K.F. and Lim C.S., "Rapid prototyping: Principles and applications", Third edition, World Scientific Publishers, 2010.

Reference Books:

1. Liou, L.W. and Liou, F.W., "Rapid Prototyping and Engineering applications: A tool box for prototype development", CRC Press, 2011.
2. Kamrani, A.K. and Nasr, E.A., "Rapid Prototyping: Theory and practice", Springer, 2006.
3. Hilton, P.D. and Jacobs, P.F., Rapid Tooling: Technologies and Industrial Applications, CRC Press, 2000

Online Resources:

1. Additive Manufacturing Industry News: A website dedicated to news and updates on the additive manufacturing industry. (https://www.additivemanufacturing.media/)
2. 3D Printing Industry: An online publication covering the latest news, trends, and developments in the 3D printing and additive manufacturing industry. (https://3dprintingindustry.com/)
3. All3DP: An online platform that provides news, reviews, and resources on 3D printing and additive manufacturing. (https://all3dp.com/)
4. TCT Magazine: A leading source of news and insights on additive manufacturing, 3D printing, and related technologies. (https://www.tctmagazine.com/)
5. Virtual Labs : https://3dp-dei.vlabs.ac.in/

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Lab Course Plan

Course Title: **Computer Aided Manufacturing Lab**	
Course Code: **231MEVSECP301**	Semester: **VI**
Teaching Scheme: L-T-P: **0-0-2**	Credits: **01**
Evaluation Scheme:	INT Marks: **25**

Prerequisite:	3D modelling, basic knowledge of turning, milling and other machining processes

Course Description:

Computer Aided Manufacturing is aimed at providing basic understanding of the CNC technology with industrial practices to make them fit in industries. This course enables students to understand CNC programming and use CAM software in order to produce mechanical components

Course Objectives:

1	To enable them to understand the use of CNC technology for efficient manufacturing.
2	To prepare CNC part programs using appropriate CAM software.
3	To carry out the machining of component as per the generated part program.

Course Outcomes (COs):

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

CO	Statement	BTL
301.1	Use the CAM software and prepare CNC part programs.	**L2**
301.2	Execute the part program and manufacture the component.	**L6**
301.3	Develop a 3D printed object from CAD Model.	**L6**

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Course Content

Sr. No.	Name of practical
1	Introduction to CAM
2	Introduction to manufacturing environment in CAM software
3	Generation of Part Program using software- CNC turning
4	Generation of Part Program using software- CNC turning – Job 1
5	Machining on CNC turning – Job 1
6	Generation of Part Program using software- CNC turning – Job 2
7	Machining on CNC turning – Job 2
8	Generation of Part Program using software- CNC Milling (Hole making)
9	Generation of Part Program using software- CNC Milling (Cavity making)
10	Generation of Part Program using software- CNC Milling – Job 1
11	Machining on CNC Milling – Job 1
12	Generation of Part Program using software- CNC Milling – Job 2
13	Machining on CNC Milling – Job 2
14	3D modelling and slicing of Mechanical component using slicing software
15	Printing of Mechanical component using additive manufacturing technique.

Text Books:

1. "CAD/CAM- Principals and Applications", P.N. Rao, Tata McGraw Hill, 2ndEdition.
2."CAD/CAM/CAE", N.K. Chougule, SciTech Publication, Revised Edition.

Reference Books:

1. CAD/CAM by M.P.Grover and E.W.Zimmer, Prentice Hall of India Pvt. Ltd.
2. Additive Manufacturing Technologies: Rapid Prototyping to Direct Digital Manufacturing, Kamrani A. K., Nasr E. A., Springer

Online Resources:

1. Course Name: Introduction to computer control
By Prof. A. R. Choudhury | IIT Kharagpur
Link:https://youtube.com/playlist?list=PLSGws_74K01KX9YtVZACpOoFYv6oaJIC&si=IO5H8-8pECR_VcqP
2. Course Name: CNC programming
By Prof. S. N. Joshi| IIT Guwahati
Link: https://youtu.be/_5r2XR1h1aQ?si=foA_K2zoXilcwlSX

Course Plan

Course Title : 3D'iots: 3D Printing Student Club	
Course Code: Course Code: 231MECCAC301 and 231MECCAC302	**Semester: V & VI**
Teaching Scheme: L-T-P: 2-0-0	Credits: Audit
Evaluation Scheme:	Marks: **Grade**

Overview:

3Diot is a dynamic student-run club within the mechanical engineering department, dedicated to exploring and advancing the field of 3D printing. The club provides a platform for students to learn, innovate, and compete in the realm of additive manufacturing. Through a series of structured activities including bootcamps, awareness sessions, and competitions, 3D'iots aims to cultivate a deep understanding and practical expertise in 3D printing technologies among its members.

Aims:

1. To foster interest and enthusiasm for 3D printing among students.
2. To provide hands-on experience with 3D printing technologies.
3. To promote innovation and creativity in the design and manufacturing processes.
4. To bridge the gap between theoretical knowledge and practical application in 3D printing.
5. To build a community of like-minded individuals passionate about 3D printing.

Objectives:

1. Conduct regular 3D printing boot-camps to train students in the basics and advanced techniques of 3D printing.
2. Facilitate mentorship programs where experienced members can guide beginners in their learning journey
3. Encourage students to undertake innovative projects and research work in the field of 3D printing.
4. Organize hackathons and challenges to stimulate problem-solving and creative thinking.
5. Create partnerships with industry professionals and academic experts to enhance learning opportunities.
6. Offer rewards and recognition for outstanding achievements in various 3D printing challenges.

Outcomes:

1. Members will gain a comprehensive understanding of 3D printing technologies and their applications.
2. Students will develop practical skills in designing, prototyping, and manufacturing using 3D printers.
3. Members will be better prepared for careers in engineering and manufacturing, with a strong portfolio of 3D printing projects.
4. Networking opportunities with industry professionals will enhance career prospects.
5. A strong, supportive community of 3D printing enthusiasts will be established, fostering collaboration and continuous learning.

Evaluation Guidelines

- **Attendance:** Regular attendance in bootcamps, workshops, and club meetings.
- **Engagement:** Active participation in discussions, Q&A sessions, and group activities.
- **Teamwork:** Collaboration with peers on projects and challenges.
- **Technical Proficiency:** Ability to operate 3D printers, use relevant software (e.g., CAD, slicing tools), and troubleshoot common issues.
- **Project Execution:** Successful completion of assigned projects and tasks within the given timeframe.
- **Innovation:** Demonstration of creativity and innovative thinking in project design and implementation.
- **Event Participation:** Involvement in organizing and participating in competitions, workshops, and awareness campaigns.
- **Community Building:** Contribution to building a supportive and collaborative club environment.
- **Competition Performance:** Participation and performance in internal and external 3D printing competitions.
- **Project Showcase:** Presentation of completed projects during club meetings or events.
- **Awards and Accolades:** Recognition received for outstanding work and contributions.

Certification Levels

1. Beginner Level Certification:

- Attend at least 75% of the bootcamps and workshops.
- Complete a basic 3D printing project (e.g., designing and printing a simple object).
- Demonstrate understanding of basic 3D printing concepts and machine operation.

2. Intermediate Level Certification:

- Successfully complete multiple 3D printing projects, including a complex design.
- Participate in at least one internal competition or challenge.

- Show proficiency in troubleshooting and maintaining 3D printers.

3. Advanced Level Certification:

- Lead a team in a major 3D printing project or competition.
- Organize or contribute significantly to a club event or workshop.
- Conduct a presentation or seminar on a specialized 3D printing topic.
- Publish a Research Article in Journal or Conference

Course Plan

Course Title: Waste to Best Student Club	
Course Code: Course Code: 231MECCAC301 and 231MECCAC302	**Semester: V & VI**
Teaching Scheme: L-T-P: 2-0-0	Credits: Audit
Evaluation Scheme:	Marks: **Grade**

Overview:

The "Waste to Best" student club aims to promote environmental sustainability through creative recycling and waste management initiatives within the community. Waste to Best club play an important role in creating environmental awareness amongst the future generation. It is the means by which students can be empowered to participate and take up meaningful environmental activities and projects.

Many activities, projects, competitions are arranged to make a frame work of Waste to best club. Preparation of Eco-friendly product out of waste material forms an important part of this club, as it enables us to make the useless things more useful.

Aims:

1. To educate students and the community about the importance of waste reduction, recycling, and upcycling to minimize environmental impact.
2. To encourage the adoption of sustainable behaviors among students.
3. To Providing opportunities for students to take leadership roles in environmental stewardship through practical initiatives and projects.
4. Inspiring creativity by exploring innovative ways to repurpose waste materials into useful or artistic items.

Objectives:

1. To Organise regular drives to collect recyclable materials like paper, plastic, and electronics from students and faculty.
2. To host workshops and different activities where members learn to transform waste materials into useful items such as crafts, artwork.
3. Initiating campaigns to educate people about the importance of waste reduction, recycling, and upcycling in preserving the environment.
4. Partnering with local businesses or environmental organizations for resources, guest speakers, or field trips related to waste management and sustainability.
5. To encourage students to undertake innovative projects and research work in the field of environmental sustainability through creative recycling and waste management.
6. To provide hands-on learning experiences in recycling and upcycling, fostering creativity and environmental stewardship among students.
7. To organize competitions for produce useful products from waste materials through their creative thinking.

Outcomes:

□ **Environmental:** Reducing the carbon footprint by diverting waste from landfills and promoting sustainable practices.

□ **Educational:** Providing hands-on learning experiences in recycling and upcycling, fostering creativity and environmental stewardship among students.

□ **Community:** Building a sense of community and responsibility towards the environment among club members and the broader college population.

Evaluation Guidelines

- **Attendance:** Regular attendance in activities, workshops, and club meetings.
- **Engagement:** Active participation in discussions, Q&A sessions, and group activities.
- **Teamwork:** Collaboration with peers on projects and challenges.
- **Project Execution:** Successful completion of assigned projects and tasks within the given timeframe.
- **Innovation:** Demonstration of creativity and innovative thinking in project design and implementation.
- **Event Participation:** Involvement in organizing and participating in competitions, workshops, and awareness campaigns.
- **Community Building:** Contribution to building a supportive and collaborative club environment.
- **Competition Performance:** Participation and performance in internal and external Waste to best competitions.

- **Project Showcase:** Presentation of completed projects during club meetings or events.
- **Awards and Accolades:** Recognition received for outstanding work and contributions.

Certification Levels

1. Beginner Level Certification:

- Regular organization of recycling drives within the college community.
- Completion of at least two upcycling workshops or projects.
- Participation in local environmental awareness campaigns or events.

2. Intermediate Level Certification:

□ Expansion of recycling initiatives to include more types of materials (e.g., electronics, organic waste).
□ Implementation of a sustainable practice campaign (e.g., promoting reusable water bottles or reducing paper waste).

□ Collaboration with at least one external organization or business on a sustainability project.

3. Advanced Level Certification:

- Development and implementation of a comprehensive waste audit and reduction plan for the school, colleges and industries.
- Creation of an ongoing sustainability education program involving multiple college grades or departments.
- Establishment of long-term partnerships with multiple external stakeholders (e.g., local government, NGOs, businesses).

Course Plan

Course Title: Lean Club	
Course Code: Course Code: 231MECCAC301 and 231MECCAC302	**Semester: V & VI**
Teaching Scheme: L-T-P: 2-0-0	Credits: Audit
Evaluation Scheme:	Marks: **Grade**

Overview:

Lean Manufacturing Clubs (LMCs) serve as platforms for students to cultivate proficiency in lean manufacturing principles. lean manufacturing prioritizes waste minimization and process optimization for enhanced efficiency. LMCs offer a multifaceted learning experience. Workshops, guest lectures by industry professionals, and interactive discussions equip students with core lean concepts such as value stream mapping and the 5S methodology. By engaging with these principles, students bridge the theory-practice gap, gaining practical insights applicable to real-world manufacturing scenarios. LMCs play a vital role in equipping students with theoretical knowledge and practical application of lean manufacturing principles. This exposure prepares them for future careers in manufacturing, engineering, and supply chain management.

Aims:

1. To equip students with a foundational understanding of lean manufacturing principles and methodologies (e.g., value stream mapping, Kanban, 5S).
2. To bridge the gap between theoretical classroom learning and practical application in manufacturing environments.
3. To develop problem-solving skills by applying lean principles to real-world manufacturing scenarios through case studies and simulations.
4. To foster critical thinking and analytical abilities to identify and eliminate waste within production processes.

Objectives:

1. Knowledge Acquisition: Equip students with a foundational understanding of lean manufacturing principles and methodologies (e.g., value stream mapping, Kanban, 5S).
2. Skill Development: Foster critical thinking, problem-solving, and analytical abilities to identify and eliminate waste within production processes.
3. Practical Application: Bridge the gap between theoretical classroom learning and practical application in manufacturing environments through case studies and simulations.
4. Networking: Create a community for engineering students interested in manufacturing and operations.
5. Industry Exposure: Facilitate interaction with industry professionals through guest lectures, plant visits, or mentorship programs.
6. Career Development: Enhance student resumes by showcasing their involvement with the LMSC and their acquired lean manufacturing knowledge.
7. Job Market Readiness: Increase students' competitiveness in the job market, particularly in manufacturing, engineering, and supply chain fields.
8. Process Improvement Mindset: Cultivate a process-oriented mindset that prioritizes efficiency and continuous improvement.

Outcomes:

1. **Strong Foundation in Lean Manufacturing:** LMSC participation equips students with in-demand knowledge of lean principles and methodologies, making them proficient in a core industry skill.
2. **Enhanced Problem-Solving and Critical Thinking:** Through applying lean concepts to real-world scenarios with case studies and simulations, students develop strong problem-solving and analytical abilities.
3. **Improved Job Market Readiness and Career Prospects:** Understanding lean manufacturing principles gives students a significant advantage in manufacturing, engineering, and supply chain careers, making them more competitive and opening doors to potential job opportunities through industry connections fostered by the club.

Evaluation Guidelines

- **Attendance:** Regular attendance in activities, workshops, and club meetings.
- **Engagement:** Active participation in discussions, Q&A sessions, and group activities.
- **Teamwork:** Collaboration with peers on projects and challenges.
- **Event Participation:** Involvement in organizing and participating in competitions, workshops, and awareness campaigns.
- **Community Building:** Contribution to building a supportive and collaborative club environment.
- **Competition Performance:** Participation and performance in internal and external Waste to best competitions.

Certification Levels

1. Beginner Level Certification: (Lean Manufacturing Fundamentals)

- Target Audience: New members or students with minimal lean manufacturing knowledge.
- Focus: Develop a foundational understanding of core lean concepts like value stream mapping, 5S, Kanban, and Kaizen through workshops, guest lectures, and introductory activities.
- Activities: Attend introductory workshops, participate in basic simulations or case studies applying lean principles to simple scenarios

2. Intermediate Level Certification: (Lean Manufacturing Applications with Six Sigma Yellow Belt Certification)

- Target Audience: Students with a basic understanding of lean principles who want to deepen their knowledge and explore Six Sigma methodology.
- Focus: Build upon foundational lean concepts and explore the introduction of Six Sigma Yellow Belt principles for problem-solving within manufacturing environments.
- Attend workshops or training sessions on the DMAIC methodology (Define, Measure, Analyze, Improve, Control) used in Six Sigma.
- Analyze case studies that integrate lean and Six Sigma principles for process improvement.
- Participate in group projects or simulations focused on applying both lean and Six Sigma Yellow Belt tools to identify and eliminate waste in a manufacturing scenario.

3. Advanced Level Certification: (Lean Manufacturing Leadership and Industry Engagement with Six Sigma Green Belt Certification)

- Target Audience: Advanced members with a strong understanding of lean principles seeking leadership experience, industry exposure, and potential exploration of Six Sigma Green Belt certification.
- Focus: Develop leadership skills, engage with industry professionals, mentor new members, and delve deeper into Six Sigma methodology. Students can explore pursuing a Six Sigma Green Belt certification to further enhance their skillset.
- Attend workshops or training courses on Six Sigma Green Belt methodology, focusing on a deeper understanding of DMAIC (Define, Measure, Analyze, Improve, Control) and its application in conjunction with lean principles.
- Participate in case studies that integrate advanced lean and Six Sigma Green Belt tools for complex process improvement scenarios.

Course Plan

Course Title: जिज्ञासा: Curious for Robots (Robotics and Automation Student Club)	
Course Code: Course Code: 231MECCAC301 and 231MECCAC302	**Semester: V & VI**
Teaching Scheme: L-T-P: 2-0-0	Credits: Audit
Evaluation Scheme:	Marks: **Grade**

Overview: The Robotics and Automation Club to explore the field of Robotics from its basics. Robotics and Automation is ever blooming and upcoming field with tremendous scope and opportunities for Mechanical Engineers. The club aims to open horizon of knowledge and opportunities in the field of Robotics and Automation through various events, competitions and workshops.

- **Aims:**
  - To foster interest and enthusiasm for Robotics and Automation among students.
  - To provide hands-on experience with Robotics Development and Automation Systems..
  - To promote innovation and creativity in the design and manufacturing processes.
  - To bridge the gap between theoretical knowledge and practical application in Robotics and Automation
  - To build a community of like-minded individuals passionate about Robotics and Automation.
- **Objectives: -**
  1. To facilitate students to learn Automation and Robotics
  2. To provide students a platform to design robots and provide smart solutions in automation
  3. To enable students to learn programming for robots and automation systems
- **Outcomes: -**

  Through the club students will be able to
  1. Understand basic robot anatomy, design principles of robots and automation systems
  2. Design and develop robots for different applications
  3. Provide solutions for automation related problems to society and industry

Evaluation Guidelines

- **Attendance:** Regular attendance in bootcamps, workshops, and club meetings.
- **Engagement:** Active participation in discussions, Q&A sessions, and group activities.
- **Teamwork:** Collaboration with peers on projects and challenges.
- **Technical Proficiency:** Ability to build Arduino circuits, use relevant software (e.g., Arduino IDE etc.), and troubleshoot common issues.

- **Project Execution:** Successful completion of assigned projects and tasks within the given timeframe.
- **Innovation:** Demonstration of creativity and innovative thinking in project design and implementation.
- **Event Participation:** Involvement in organizing and participating in competitions, workshops, and awareness campaigns.
- **Community Building:** Contribution to building a supportive and collaborative club environment.
- **Competition Performance:** Participation and performance in internal and external Robotics competitions such as RoboRace, RoboWar, RoboMaze, RoboSoccer etc..
- **Project Showcase:** Presentation of completed projects during club meetings or events.
- **Awards and Accolades:** Recognition received for outstanding work and contributions

Certification Levels

1. Beginner Level Certification (Level 1):

- Attend at least 75% of the bootcamps and workshops.
- Develop a wire Controlled robot with basic components.
- Demonstrate understanding of basic robotics concepts and types of robots.

2. Intermediate Level Certification (Level 2):

- Successfully develop robot with wireless remote control.
- Participate in at least one internal competition or challenge.
- Show proficiency in developing innovative ideas for robots development.

3. Advanced Level Certification (Level 3):

- Lead a team in a reputed Robotics project or competition.
- Organize or contribute significantly to a club event or workshop.
- Conduct a presentation or seminar specialized in Robotics or IoT domain.
- Publish a Research Article in Journal or Conference.

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