

**Curriculum for
Third Year, B.Tech. Programme
w.e.f.
Academic Year 2025-2026
(NEP-2020 Compliant)**

Department of Production Engineering



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Table of Contents

Sr. No.	Particulars	Page No.
1)	Abbreviations	04
2)	Department Vision, Mission, PEOs, POs and PSOs.	05 to 08
3)	Curriculum Structure for Third Year, B.Tech. Production Engineering.	09
4)	List of Multidisciplinary Minor (MDM) Courses to be offered by the Department of Production Engineering (Department Level).	11
5)	List of Multidisciplinary Minor (MDM) Courses to be offered by Production Engineering (Institute Level)	-
6)	List of Double Minor Courses to be offered by Production Engineering	12
7)	List of Honour Courses to be offered by Production Engineering	13
8)	List of Open Elective (OE) Courses to be offered by Production Engineering (Department Level)	14
9)	List of Open Elective (OE) Courses to be offered by Production Engineering (Institute Level)	-
10)	List of Exit options after Third Year B. Tech. to qualify for B. Vocational	15
11)	Syllabus of fifth Semester Courses	16 to 41
12)	Syllabus of Sixth Semester Courses.	42 to 75
13)	Syllabus of Multidisciplinary Minor (MDM) Courses to be Offered by Production Engineering at Third Year B. Tech. level (Department level)	76 to 81
14)	Syllabus of Multidisciplinary Minor (MDM) Courses to be Offered by Production Engineering at Third Year B. Tech. level (Institute level)	-
15)	Syllabus of Open Elective Courses (OE) to be offered by Production Engineering at Third Year B. Tech. level (Department level)	82 to 84
16)	Syllabus of Open Elective Courses (OE) to be offered by Production Engineering at Third Year B. Tech. level (Institute level)	-

17)	Syllabus of Exit Options after Third Year, B. Tech. to qualify for B. Vocational	85 to 93
18)	Syllabus of Double Minor (DM) Courses to be offered by Production Engineering at Third Year B. Tech. level	94 to 99
19)	Syllabus of Honour Courses (HON) to be offered by Production Engineering at Third Year B. Tech. level	100 to 110

Abbreviations

A. Course code and definition

Abbreviation	Definition
L	Lecture
P	Practical
T	Tutorial
BSC	Basic Science Course
PCC	Programme Core Course
PEC	Programme Elective Course
MDM	Multidisciplinary Minor
HON	Honor Course
OE	Open Electives
HSSM	Humanities, Social Science, and Management Course
VEC	Value Education Courses
VSEC	Vocational Skill and Skill Enhancement Courses
FP	Field Project
DM	Double Minor
EX	Exit Course

B. Definition of Credit

1 Hour Lecture (L) per week	1 Credit
1 Hour Tutorial (T) per week	1 Credit
1 Hour Practical (P) per week	0.5 Credit

Department of Production Engineering

Bachelor of Technology (B. Tech.) in Production Engineering

Vision

Provide an environment for quality education, pro-industry research and innovation with industry partnership to meet global standards with the sense of 'Make in India' philosophy.

Mission

M 1	Provide up to date knowledge in the fields of manufacturing and management.
M 2	Continual up-gradation of curriculum in the context of global standards, peer feedback, in consultation with stakeholders.
M 3	Establish and maintain state-of-the-art research facilities and develop linkages with Industries and other educational institutions.
M 4	Encourage students for research and development activities, innovation and entrepreneurship.
M 5	Continuing education programme to develop skilled human power.

Programme Educational Objectives (PEOs)

The Production Engineering graduates will be able to:

PEO 1	Provide knowledge and skills of broad spectrum in domain of Mechanical Engineering.
PEO 2	Cater the needs of Indian as well as multinational industries and other organisations.
PEO 3	Be competent with a strong technological background, to formulate, analyse the societal, industrial and environmental challenges to obtain the economically viable solutions.
PEO 4	Foundation for higher studies, research, entrepreneurship and administrative services.

PEO 5	Inculcate the attitude of self and lifelong learning, out of box thinking, ethics and integrity, professional and managerial competencies to work on the multidisciplinary projects.
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Programme Outcomes (POs)

On successful completion of B. Tech. Program, Production Engineering graduates will be able to:

PO 1	Engineering Knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO 2	Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
PO 3	Design/Development of Solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO 4	Conduct Investigations of Complex Problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions for complex problems
PO 5	Modern Tool Usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
PO 6	The Engineer and Society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO 7	Environment and Sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO 8	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.

PO 9	Individual and Teamwork: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO 10	Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO 11	Project Management and Finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO 12	Recognize the need for and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Specific Outcomes (PSOs)

PSO 1	Apply principles of engineering, basic science and mathematics to model, analyse, design production systems and processes.
PSO 2	Plan, operate, control, maintain and improve production systems, components and processes.
PSO 3	Be prepared to work professionally as a Production / Mechanical Engineer.

Correlation Matrix (Correlation between the PEOs and the POs)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO 11	PO 12	PSO1	PSO2	PSO3
PE01	✓	✓	✓	✓	✓			✓			✓	✓	✓	✓	
PE02	✓	✓	✓	✓	✓						✓	✓	✓	✓	
PE03	✓	✓	✓	✓	✓						✓	✓	✓		
PE04	✓	✓	✓	✓	✓		✓	✓			✓	✓	✓	✓	
PE05	✓	✓		✓	✓	✓		✓			✓	✓	✓	✓	✓

The cells filled in with the ✓ indicate the fulfilment/correlation of the concerned PEO with the PO.

Curriculum Structure for Third Year, B.Tech. (Production Engineering)

Semester - V									
Sr. No.	Course code	Course Name	Hours				Credits		
			L	T	P	Total	Theory	Practical	Total
1	PCC-PE301	Metallurgy and Metal Forming	03	00	02	05	03	01	04
2	PCC-PE303	Machine Design	03	00	02	05	03	01	04
3	PCC-PE305	Metal Cutting Theory	03	00	02	05	03	01	04
4	PEC-PE3**	Program Elective Course-1	03	00	02	05	03	01	04
5	MDM-PE301	Multidisciplinary Minor - III	02	00	02	04	02	01	03
6	OE-PE301	Renewable Energy Resources	02	00	00	02	02	00	02
7	VSEC-PE301	CAD Modelling	00	00	04	04	00	02	02
Total			16	00	14	30	16	07	23

Semester - VI									
Sr. No.	Course code	Course Name	Hours				Credits		
			L	T	P	Total	Theory	Practical	Total
1	PCC-PE302	Design of Jigs, Fixtures and Dies	03	00	02	05	03	01	04
2	PCC-PE304	Metrology and Quality Control	03	00	02	04	03	01	04
3	PCC-PE306	Introduction to FEA and CAD	02	00	02	03	02	01	03
4	PEC-PE3**	Program Elective Course-2	03	00	00	03	03	00	03
5	PEC-PE3**	Program Elective Course-3	02	00	02	03	02	01	03
6	MDM-PE302	Multidisciplinary Minor - IV	03	00	00	03	03	00	03
7	VSEC-PE302	Industrial Robotics Lab.	00	00	04	02	00	02	02
Total			16	01	10	23	16	06	22

List of Programme Elective Courses to be offered by Department of Production Engineering

Programme Elective Course-I

Sr. No.	Course Code	Semester	Name of the Course	Credits		
				Theory	Practical	Total
1	PEC-PE301	Sem-V	Industrial Engineering	03	01	04
2	PEC-PE303	Sem-V	Computer Integrated Manufacturing System	03	01	04
3	PEC-PE305	Sem-V	Smart Materials	03	01	04
4	PEC-PE307	Sem-V	Object Oriented Programming with C++	03	01	04

Programme Elective Course-II

Sr. No.	Course Code	Semester	Name of the Course	Credits		
				Theory	Practical	Total
1	PEC-PE302	Sem-VI	Artificial Intelligence and Machine Learning	03	00	03
2	PEC-PE304	Sem-VI	Product Design and Development	03	00	03
3	PEC-PE306	Sem-VI	Supply Chain Management	03	00	03
4	PEC-PE308	Sem-VI	Maintenance Engineering	03	00	03

Programme Elective Course-III

Sr. No.	Course Code	Semester	Name of the Course	Credits		
				Theory	Practical	Total
1	PEC-PE310	Sem-VI	Machine Tool Design	02	01	03
2	PEC-PE312	Sem-VI	Mechatronics and Automation	02	01	03
3	PEC- PE314	Sem-VI	Optimisation Techniques	02	01	03
4	PEC- PE316	Sem-VI	Hydraulics and Pneumatics	02	01	03

List of Multidisciplinary Minor (MDM) Courses to be offered by Department of Production Engineering (Department Level)

Sr. No.	Course Code	Semester	Name of the Course	Credits		
				Theory	Practical	Total
1	MDM-PE201	Sem-III	Fundamentals of Metal Cutting	02	01	03
2	MDM-PE202	Sem-IV	Fundamentals of Manufacturing Processes	02	01	03
3	MDM-PE301	Sem-V	Production Management	02	01	03
4	MDM-PE302	Sem-VI	Industrial Engineering	03	00	03
5	MDM-PE401	Sem-VII	Industrial Safety	03	00	03
Total				12	03	15

Note: <<<Name of Department>>> Students will choose a Multidisciplinary Minor (MDM) Bucket (a Set of Courses to be learnt from 2nd Year to Third/Final Year) offered by the other departments.

List of Double Minor Courses to be offered by Department of Production Engineering

Sr. No.	Course Code	Semester	Name of the course	Credits		
				Theory	Practical	Total
1	DM-PE201	Sem-III	Fundamentals of Metal Cutting	02	01	03
2	DM-PE202	Sem-IV	Fundamentals of Manufacturing Processes	02	01	03
3	DM-PE301	Sem-V	Production Management	02	01	03
4	DM-PE302	Sem-VI	Industrial Engineering	03	00	03
5	DM-PE401	Sem-VII	Industrial Safety	03	00	03
6	DM-PE402	Sem-VIII	Fundamentals of Robotics and Industrial Automation	03	00	03
	Total			15	03	18

Note: Students are required to select a double minor program from a department other than their major programme and it must be different from the Multidisciplinary Minor programme. For instance, students can pursue a double minor in Electronics and Telecommunication Engineering from any department within the institution, except for those already majoring¹ in Electronics and Telecommunication Engineering and have not chosen it as their Multidisciplinary Minor programme.

¹Major Programme: Students who enrolled in their first year of engineering is the major programme.

List of Honour Courses to be offered by Department of Production Engineering

A. Specialization: Honors in Manufacturing Engineering

Sr. No.	Course Code	Semester	Name of the course	Credits		
				Theory	Practical	Total
1	HON-MF201	Sem-III	Sheet Metal Modelling and Manufacturing	03	01	04
2	HON-PEMF202	Sem-IV	Micro and Nano Fabrication Techniques	03	01	04
3	HON-PEMF301	Sem-V	Smart Manufacturing	02	01	03
4	HON-PEMF302	Sem-VI	Product Lifecycle Management	03	00	03
5	HON-PEMF401	Sem-VII	Digital Manufacturing	03	01	04
	Total			14	04	18

B. Specialization: Honors in Industrial Engineering

Sr. No.	Course Code	Semester	Name of the course	Credits		
				Theory	Practical	Total
1	HON-PEIE203	Sem-III	Enterprise Resource Planning	03	00	03
2	HON-PEIE204	Sem-IV	Industrial Project Management	03	01	04
3	HON-PEIE303	Sem-V	Industrial Waste Management and Recycling	03	01	04
4	HON-PEIE304	Sem-VI	Production Planning and Control	02	01	03
5	HON-PEIE403	Sem-VII	Materials Management	03	01	04
	Total			14	04	18

Note: Students shall select either option A or B

**List of Open Elective (OE) Courses to be offered by
Department of Production Engineering (Department Level)**

Sr. No.	Course Code	Semester	Name of the course	Credits		
				Theory	Practical	Total
1	OE-PE201	Sem-III	World Class Manufacturing	03	00	03
2	OE-PE202	Sem-IV	Robust Design of Products and Processes	03	00	03
3	OE-PE301	Sem-V	Renewable Energy Resources	02	00	02
Total				08	00	08

Note: It is essential for students to choose these courses from disciplines other than their major programme for which they initially enrolled in during their first year.

List of Exit Options after Third Year, B. Tech (Department of Production Engineering)

Exit Option - to qualify for B. Voc:									
Sr. No.	Course code	Course Name	Hours				Credits		
			L	T	P	Total	Theory	Practical	Total
1	EX-PE302	Minor Project	0	0	8	8	0	4	4
In-house Lab sessions (Any Two of the following 4 Labs)									
2	EX-PE304	Computer Aided drafting Lab.	0	0	4	4	0	2	2
3	EX-PE306	CAD- Lab.	0	0	4	4	0	2	2
4	EX-PE308	CNC Lab.	0	0	4	4	0	2	2
5	EX-PE310	Industrial Robotics Lab.	0	0	4	4	0	2	2
Total			0	0	16	16	0	8	8

Syllabus of SEMESTER-V Courses

Metallurgy and Metal Forming

Course Code	PCC-PE301				
Category	Program Core Course				
Course Title	Metallurgy and Metal Forming				
Scheme and Credits	L	T	P	No. of Credits	Semester
	3	0	2	4	V

Course Objectives:

1. To make student aware of methods of manufacturing Pig Iron from Iron ore and making of steel by Basic oxygen and Electric arc melting processes.
2. To study the phase diagrams of ferrous and non-ferrous metals alloys help students to understand how to make various engineering alloys and modify their structures and properties by heat treatments to suit a particular application.
3. To study different non-destructive testing methods for inspecting the components.
4. To study the press working terminology and equipment, press tool operations, Press selection and rating, Principle of metal cutting, working of cutting die, die clearance and its effect, types of die construction and design of piercing, blanking, compound and progressive.
5. To study the types of forging processes, rolling processes and extrusion processes with equipment and machines used, design analysis of dies.

Course Outcomes:

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

CO1: Classify the cast irons and their applications and heat treatment processes.

CO2: Describe powder metallurgy, its processes and applications.

CO3: Select the suitable non-destructive testing method for inspecting components.

CO4: Classify different metal forming processes.

CO5: Design dies for cutting, forging, bending, drawing, piercing, and blanking.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	1	-	2	-	-	-	-	-	-	-	-	3	-	2
CO2	2	1	-	1	-	-	-	-	-	-	-	-	3	2	1
CO3	2	2	1	-	3	-	-	-	-	1	-	-	2	2	3
CO4	2	-	2	1	3	-	-	-	-	1	-	-	2	2	1
CO5	3	2	1	3	2	2	-	-	-	-	-	-	3	3	3

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Introduction: Pig iron Production, Manufacture of steel, by Basic oxygen steel making, Electric Arc steel making, introduction to phase diagram	08

	Steel as an Engineering Alloy: Iron-Iron carbide equilibrium diagram, non-equilibrium cooling of steels, classification and applications of steel, specifications of steel, transformation products of austenite, time Temperature transformation (TTT) diagrams. Cast Irons: White C.I. Gray C.I. malleable C.I., Nodular cast iron, Alloy cast irons and heat treatment of cast irons.		
2	Heat Treatment of Steel: Conventional annealing, Bright annealing, box annealing, Isothermal (cycle) annealing, Normalizing, Hardening, Tempering, Secondary hardening, Temper brittleness, Quench cracks, Hardenability, Carburizing, Selective carburizing, heat treatment after carburizing, Nitriding, Carbonitriding, flame hardening, Induction hardening. Engineering Non-Ferrous Metals: Copper and copper alloys, Brasses, Aluminium and Aluminium alloys, Nickel and Nickel alloys, Tin and tin alloys and Bearing materials	09	
3	Powder Metallurgy: Introduction, characterization and testing of metal powders, powder manufacture, powder conditioning, Oil impregnated bearings, cemented carbide, cermet, advantages and limitations of powder metallurgy. Study of Non-Destructive Methods: Dye penetrant test, Magnetic particle test, Ultrasonic test, Radiography, Eddy current test, significance & comparison of these tests.	07	
4	Metal Forming Introduction: Principle of metal forming, classification of metal-forming process, plastic deformation, cold working, Hot working, materials for cold and hot working. Dies For Sheet Metal Cutting and Shaping: Press working terminology and equipment; Press tool operations, Principle of metal cutting, working of cutting die, die clearance and its effect, types of die construction. Design of dies: Piercing, Blanking, Compound and progressive.	08	
5	Metal Forming Processes Forging: Types of forging dies, advantages and limitations; forging equipment and machines, press forging, drop forging, open die forging, close forging, dogging defects.	06	
6	Rolling: Classification of rolling processes, rolling mills, hot rolling, cold rolling, rolling of bars and shapes, Forces and geometrical relationships in rolling, problems and defects in rolled products, process Analysis. Extrusion: Classification of extrusion processes, Extrusion equipment, hot extrusion, cold extrusion, Deformation.	06	
Textbooks:			

1. Mechanical Metallurgy by George E. Dieter, McGraw-Hill Book Company, 3rd edition 2017.
2. Rao PN, Manufacturing Technology-Foundry, Forming and welding Tata McGraw Hill, 5th edition 2018.
3. Sharma P. C. – Production Engineering, (S. Chand and co. Ltd. New Delhi 10th edition 2005) Swarup O., “Elements and Metallurgy”, Rastogi Publication, Meerut, 1983.

References:

1. Naik S.P., “Engineering Metallurgy and Material Science”, Charotar Publication House, New Delhi, 1985.
2. Jain R.K., “Production Technology”, Khanna Publication, New Delhi, 2012.
3. Kodgire V. D., “Material Science and Metallurgy for Engineers”, Everest Publishing House, Pune, 2008, ISBN 81-86314-00-8.
4. Khanna O.P. “Materials Science and Metallurgy”, Dhanpat Rai & Sons, New Delhi, 2010, ISBN-97-88189-92-831-5.
5. William D. Callister, “Materials Science and Engineering: An Introduction, 8th Edition, Wiley India (P) Ltd (2010).
6. T.V. Rajan, C.P. Sharma, “Heat Treatment principles and Techniques”, PHI Learning Pvt. Ltd., 1994.
7. Manufacturing Science, Amitabha Ghosh and Ashok Kumar Mallik, 1985, Affiliated East West Press Pvt.Ltd., New Delhi. 6. Metal Forming Handbook by Schuler, Springer, 1998.
8. Materials and Processes in manufacturing, by E. Paul Degarmo, Prentice-Hall of India, 2005. Primer course on sheet metal forming- by Prof. K. Narasimhan, IIT Bombay.

List of Experiments:

Sr.	Experiment Name
1.	Study of Metallurgical Microscope.
2.	Preparation of Specimen for microscopic examination.
3.	Study of microstructure of plain carbon steels of various compositions.
4.	Surface hardening and study of microstructure (study expt.)
5.	Study of I.S. codes of steels and selection procedure.
6.	Study and demonstration of the NDT processes.
7.	Study of Sheet Metal Forming Operation.
8.	Journal based on Study of Metal Forming Processes Forging Process.
9.	Journal based on Study of Metal Forming Processes Rolling Process.
10.	Journal based on Study of Metal Forming Processes Extrusion Process.

Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify the list as necessary.

Alternative NPTEL/SWAYAM Course

Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Phase Diagrams in Materials Science and Engineering	Dr. Krishanu Biswas	IIT Kanpur
2	Non-ferrous Extractive Metallurgy	Prof. H.S. Ray	IIT Kharagpur

		Mr. L Pugazhenthay	
3	Principles of Physical Metallurgy	Prof. R.N. Ghosh	IIT Kharagpur
4	Powder Metallurgy	Dr. Ranjit Bauri	IIT Madras
5	Theory and Practice of Non-Destructive Testing	Dr. Ranjit Bauri	IIT Madras
6	Principles of Metal Forming Technology	Dr. Pradeep K. Jha	IIT Roorkee
7	Plastic Working of Metallic Materials	Prof. P.S. Robi	IIT Guwahati

Experiments That May Be Performed Through Virtual Labs:

Sr. No.	Experiment Name	Experiment Link (s)
1	Extrusion Process	https://msvs-dei.vlabs.ac.in/Extrusion.php
2	Rolling Process	https://msvs-dei.vlabs.ac.in/Rolling_process.php
3	Sheet Metal Working	https://msvs-dei.vlabs.ac.in/SheetMetal.php

Machine Design

Course Code	PCC-PE303				
Category	Program Core Course				
Course Title	Machine Design				
Scheme and Credits	L	T	P	No. of Credits	Semester
	3	0	2	4	V

Course Objectives:

1. To understand the basics of design procedure.
2. To study the fundamentals of theories of failure.
3. To analyse and design the machine elements subject to static and fluctuating load.
4. To design and optimize machine elements for real-life applications.
5. To develop problem-solving and critical thinking skills in designing machine components and analysing their performance under real-life operating conditions.

Course Outcomes:

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

CO1: Understand basic design procedure and the necessary design considerations.

CO2: Define and distinguish static and fluctuating loads/stresses.

CO3: Apply relevant theories of failure to derive empirical relations for various machine elements.

CO4: Analyse and interpret the behaviour of machine components under static and fluctuating loads/stresses using computational tools and programming.

CO5: Design shafts, gears, clutches, brakes, power screws etc. for real life applications when subjected to static loading using generative design.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO2	1	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO3	-	2	2	-	-	-	-	-	-	-	-	-	2	-	2
CO4	2	2	3	2	3	1	1	-	-	-	-	-	3	3	2
CO5	3	2	3	-	3	1	-	-	-	-	-	2	3	3	2

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Introduction Mechanical Engineering design, Traditional design methods, Design synthesis, Aesthetic considerations in design, Ergonomic considerations in design, Use of standard in design, Selection of preferred sizes, value analysis, Engineering	06

	materials, Selection of materials, manufacturing considerations in design, statistical considerations in design.	
2	Design of Machine Part Subjected to Static Load Modes of failure, F. O. S., Stress due to B. M., stress due to torsional moment, Eccentric axial loading, combined stress direct and bending e. g. C- clamp, frame, screw press etc. Design of Machine Parts Subjected to Fluctuating Load Stress concentration, stress concentration factors, methods to reduce stress concentration effects, fluctuating stresses, fatigue failure, notch sensitivity, endurance limit, Rotating beam test, Fatigue strength, factor affecting fatigue strength, Soderberg and Goodman diagram, S. N. diagram, cumulative damage in fatigue: - Miner's equation.	8
3	Design of Temporary Joints Types of temporary joints- key and cotter joints, knuckle joint and fasteners, Design of cotter and knuckle joint. Power Screws Forms of threads, Nomenclature of screw thread, Thread series and its designation, Power screws and their advantages over v-threads, force analysis of square threads and trapezoidal threads, self-locking in power screws, collar friction, stresses in screw, Differential and compound screws, Recirculating type ball screws. Design of Permanent Joints Types of permanent joints-Riveted and Welded Joints, Rivet heads, Terminology, Caulking and fullering, Efficiency of a riveted joint, eccentrically loaded riveted joints, welding process, merits and demerits of welded joint over riveted joints, weld symbols, eccentrically loaded welded joints.	8
4	Shafts, Keys and Couplings Transmission shafting, Design against static load and torsional rigidity, keys: Design of various types of keys, couplings: design of rigidity and flexible couplings.	06
5	Springs Types of springs, terminology of springs, spring materials, design of different types of springs, optimum design of helical springs, multi leaf springs. Friction Clutches Torque transmitting capacity, single disc and multiple disc clutches, friction materials, cone clutches, and centrifugal clutches.	08

	Design of Brakes Design and working of different types of brakes: Shoe Brake, Band Brake, Internal Expanding brake.	
6	Gears and Belt Drives Types of gears, V. R. for each type, selection of types of gear, modes of failure, gear design for maximum power transmitting capacity, Design of spur and helical gear, Lewis's equation, Buckingham's Equation, Wear strength of spur & helical gears, gear lubrication. Flat and V- belts, geometrical relationships, ratio of belt tension, selection of V belt and flat belts, condition for maximum power transmission. Advances in Design Introduction to Computational Tools for Design Automation, Basics of C++ Programming, implementing mechanical design formulas using C++ programming (e.g., Stress, Strain, Factor of Safety), Introduction to Generative Design and its Applications. Overview of Topology Optimization and Introduction to Generative Design Tools.	08
Textbooks:		
1. Design of Machine Elements, 5th Edition 2020 - Mcgraw Hill Education V. B. Bhandari.		
References:		
1. Design of Machine elements, 8th Edition 2004 -M. F. Spotts (Prentice Hall of India Ltd.) 2. Mechanical Engineering Design, 12th Edition 2024 -J. E. Shigley (McGraw- Hill Int. Ltd.) 3. Machine Design -Pandey and Shah, Charotar Publishing House Pvt. Ltd.; 21st Edition 2022. 4. Machine Elements in Mechanical Design Robert Mott, Edward Vavrek, Jyhwen Wang Pearson; 6th edition (10 May 2017) ASIN: B071SDVF6B. 5. Machine Design -Schaum's series (McGraw Hill Co - Ltd.). 6. Programming with C++ - E. Balagurusamy (for basic C++ programming). 7. Fusion 360 for Generative Design (Autodesk Help Resource). 8. Generative AI for Mechanical Engineering - Dr. Suresh Namboothiri and Dipali Patil.		
List of Experiments:		
Conduct of following laboratory experiments based on numerical/ assignments on above syllabus and drawing/CAD sheets for design of following machine components.		
Sr.	Experiment Name	
1.	Design different forms of screw threads.	
2	Design different types of forms and proportions of rivet-heads.	
3.	Design different types of forms and proportions of rivet-heads. a. Lap joint (single-riveted, double riveted (chain), double riveted (zigzag)) b. Butt joint (single strap, double straps)	
4.	Design of shafts.	
5.	Design different types of keys.	

6.	Design of Joints: cotter joints, knuckle joint.
7.	Design of Couplings: flanged coupling, universal coupling etc.
8.	Design of springs.
9.	Design of clutches.
10.	C++ Programming on mechanical design calculations (E.g. Stress, FoS (Factor of Safety), Shaft design calculations, etc.).
11.	Generative Design of Mechanical Components: Brakes, Gears, Belt Drives.

Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify it, as necessary.

Alternative NPTEL/SWAYAM Course

Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Design of Machine Elements	Prof. B Maiti and Prof. G. Chakraborty	IIT Kharagpur

Metal Cutting Theory

Course Code	PCC-PE305				
Category	Program Core Course				
Course Title	Metal Cutting Theory				
Scheme and Credits	L	T	P	No. of Credits	Semester
	3	0	2	4	V

Course Objectives:

1. To study the metal cutting technology including the process, measurements, design and selection of various cutting tools and their industrial specifications.
2. To select suitable cutting tool for performing identified machining operation.
3. To design form tool for given application and conditions.
4. To Design single and multiple point cutting tools for given conditions and applications
5. To study cutting forces during different cutting operations.

Course Outcomes:

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

CO1: The students shall have the knowledge of fundamentals of metal cutting technology including the process, measurements, design and selection of various cutting tools and their industrial specifications.

CO2: Select suitable cutting tool for performing identified machining operation.

CO3: Design form tool for given application and conditions.

CO4: Design single and multiple point cutting tools for given conditions and applications.

CO5: Understand cutting forces generated during different cutting operations.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2	-	-	-	-	-	-	-	-	2	2	-	-
CO2	2	2	3	-	-	-	-	-	-	-	-	2	2	-	2
CO3	2	2	3	-	-	-	-	-	-	-	-	2	-	-	2
CO4	2	2	3	-	-	-	-	-	-	-	-	2	-	-	2
CO5	2	2	2	-	-	-	-	-	-	-	-	2	-	-	-

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Theory of Metal Cutting Speed, Feed, Depth of Cut, Orthogonal Cutting and Oblique Cutting, Geometry of single point cutting tool, Mechanism of chip formation, Chip Breaker, Strain in Chip, Shear plane angle, Cutting ratio, Force relationship, Velocity relationship, Merchant circle, Ernst Merchant theory, dynamometer.	08

2	Machinability: Concept of Machinability, i) Cutting force: Effect of speed, feed, depth of cut, tool materials, angles and work material on cutting forces, specific cutting force, specific power consumption. ii) Tool life: Flank and Crater wear, Mechanism of wear, effect of cutting parameter on tool life, Taylor's tool life equation. iii) Surface Roughness: Effect of speed, feed, depth of cut, tool materials, angles and work material on surface roughness, built up edge, chatter and its elimination.	08
3	Sources of Heat Generation and Economics of Machining: Sources of heat generation, Types of cutting fluids, Selection of cutting fluids. Economics of machining; criteria for minimum cost and maximum production.	07
4	Cutting Tool Materials: Single point tools - Definition of angles as per ASA system and ORS system, tool signature, Study of modern tool materials such as uncoated / coated carbides, Ceramics, cermet's, cubic boron nitride, diamond etc., Desirable properties of tool material, Selection of tool grades and styles including specifications from commercial catalogues for different processes like turning, milling, drilling, grinding for different operations	08
5	Design of Form Tool: Design of flat form tool and circular form tool. Geometry, nomenclature, types, selection and applications of drills, reamers, milling cutters and broach	07
6	Design of single Point Cutting Tool: Design procedure of single point turning tool, High speed machining, Minimum Quantity Lubrication.	06

Textbooks:

1. Cutting tools - P.H. Joshi - Tata McGraw Hill Publishing Co. Ltd. 1st edition 1991.
2. Metal Cutting Theory and Cutting Tool Design - Arshinov V. and Alekseev G., Mir Publication.
3. Metal Cutting and Tool Design - Dr. Ranganath 2nd revised edition 1999 - Vikas Publishing House.

References:

1. Production Technology - HMT Handbook (TMH) McGraw Hill Education (1 July 2017)
2. Metal cutting Theory and Practice- A. Bhattacharya, New Central Book Agency.
3. Metals Handbook, Vol. 16 Machining, A.S.M., Metals Park, Ohio.
4. Metal Cutting Principals - Shaw M.C. - Oxford Calrendon Press, 2002.
5. Theory of Metal Forming and Metal cutting by Sinha, Prasad (DhanpatRai).
6. Machine Tool Engineering: K. R. Nagpal, Khanna Publication.
7. Tool Engineering handbook - ASTME, Frank Wilson (Editor) (TMH)
8. Textbook of Production Engineering (Tool Design) by K. Surendar and Umesh Chandra.
9. Commercial catalogues of tool manufacturers like SANDVIK, KENNAMETAL, TAEGUTECH, ISCAR, MITSUBISHI, Grindwell Norton, Carborundum Universal etc.
10. Fundamentals of Metal Cutting and Machine Tools B. L. Juneja, Nitin Seth. New Age Publication 2017.

List of Experiments:

Sr.	Experiment Name
1.	Measurement of Cutting force with the help of lathe tool dynamometer.
2.	Measurement of twisting force with the help of drill tool dynamometer.
3.	Measurement of cutting force with the help of milling tool dynamometer.
4.	Machining one job of C.I., and measurement of surface roughness to study the effect of parameters such as feed, tool nose radius, depth of cut on the surface roughness.
5.	Machining one job of Steel and measurement of surface roughness to study the effect of parameters such as feed, tool nose radius, depth of cut on the surface roughness.
6.	Machining one job of Aluminium and measurement of surface roughness to study the effect of parameters such as feed, tool nose radius, depth of cut on the surface roughness.
7.	Design of form tool for given components.
8.	Design of broach for given components.
9.	Experimental Investigation of process parameters in CNC (or any conventional machine tool) machining of any hard material.
10.	Industrial visit to study applications of tools for different metal cutting processes.

Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify it, as necessary.

Alternative NPTEL/SWAYAM Course			
Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Metal Cutting and Machine Tools	Prof. Asimava Roy Choudhury	IIT Kharagpur

Industrial Engineering

Course Code	PEC-PE301				
Category	Program Elective Course				
Course Title	Industrial Engineering				
Scheme and Credits	L	T	P	No. of Credits	Semester
	3	0	2	4	V

Course Objectives:

1. To introduce the concepts, principles, and framework of Industrial Engineering and Productivity enhancement approaches.
2. To familiarize the students with different time study and work measurement techniques for productivity improvement.
3. To introduce various aspects of facility design.
4. To acquaint the students with various components and functions of Production Planning and Control.
5. To acquaint the student about inventory management and approaches to control.

Course Outcomes:

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

CO1: Evaluate the productivity and implement various productivity improvement techniques.

CO2: Apply work study techniques and understand its importance for better productivity.

CO3: Demonstrate the ability to select plant location, appropriate layout and material handling equipment.

CO4: Use of Production planning and control tools for effective planning, scheduling and managing the shop floor control.

CO5: Plan inventory requirements and exercise effective control on manufacturing requirements.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	-	-	-	-	-	-	-	3	-	-
CO2	3	3	2	-	2	-	-	-	-	-	-	-	3	-	-
CO3	2	1	-		-	2	-	3	2	3	-	-	3	-	-
CO4	2	2	-		2	3	1	2	-	2	3	-	3	-	-
CO5	3	3	3	-	3	-	-	1	-	2	2	2	3	1	-

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Introduction to Industrial Engineering and Productivity Introduction to Industrial Engineering, Historical background and scope, Contribution of Taylor, Gilbreth, Gantt, Maynard, Ford, Deming and Ohno. Importance of Industrial engineering. Introduction to Work system design Productivity: Definition of productivity, Measures of Productivity, Total Productivity Model, Need for Productivity Evaluation, Productivity measurement models, Productivity improvement Work Study approaches, Principles, Productivity Improvement techniques – Technology based, Material based, Employee based, Product based techniques.	08
2	Work Study Method Study: Introduction and objectives, Areas of application of work study in industry, Selection and Basic procedure. Recording techniques, Operations Process Chart, Flow Process Chart (Man, Machine & Material) Multiple Activity Chart, Two Handed process chart, Flow Diagram, String Diagram and Travel Chart, SIMO chart, Therbligs, Micro motion and macro-motion study: Principles of motion economy, Normal work areas and workplace design. Work Measurement: Techniques, time study, steps, work sampling, Determination of time standards. Observed time, basic time, normal time, rating factors, allowances, standard time, and standard time determination.	08
3	Production Facility Design Plant Location: Introduction, Factors affecting location decisions, Multi-facility location Plant Layout: Principles of Plant layout and Types, factors affecting layout, methods, factors governing flow pattern, travel chart for flow analysis, analytical tools of plant layout, layout of manufacturing shop floor, repair shop, services sectors, and process plant. Layout planning, Quantitative methods of Plant layout and relationship diagrams. Dynamic plant layout. Material Handling: Objectives and benefits of Material handling, Relationship between layout and Material handling, Equipment selection.	06
4	Production Planning and Control Types and methods of Production, and their Characteristics, functions and objectives of Production Planning and Control, Steps: Process planning, Loading, Scheduling, Dispatching and Expediting with illustrative examples, Capacity Planning, Aggregate production planning and Master production scheduling. Introduction to a line of balance, assembly line balancing, and progress control. Forecasting Techniques: Causal and time series models, Moving average, Exponential smoothing, Trend and Seasonality.	08
5	Inventory and Inventory Control	08

	Inventory: Functions, Costs, Classifications, Deterministic inventory models and Quantity discount Inventory Control: EOQ (Numerical), concepts, type of Inventory models-deterministic and probabilistic, Selective inventory control, Fundamental of Material Requirement Planning (MRP-I), Manufacturing Resource Planning (MRP-II), Enterprise Resource Planning (ERP), Just-in-Time system (JIT) and Supply Chain Management (SCM)	
6	Value Engineering and Job Evaluation Value Engineering: VE concepts, Principles, Methodologies and standards, methods of functional analysis. Job Evaluation and Wage Plan: Objective, Methods of job evaluation, job evaluation procedure, merit rating (Performance appraisal), method of merit rating, wage and wage incentive plans, Performance appraisal, concept of KRA (Key Result Areas), Introduction to industrial legislation.	06

Textbooks:

1. O. P. Khanna, Industrial engineering and management, Dhanpat Rai Publications (P) Ltd.-New D 2018.
2. M Mahajan, Industrial Engineering and Production Management, Dhanpat Rai & Co. (P) Limited 2015.
3. Industrial Engineering and Production Management by Martand Telsang, published by S. Chand, is the Third Edition. This edition was published on January 1, 2018

References:

1. Banga and Sharma, Industrial Organization & Engineering Economics, Khanna publication
2. Askin, Design and Analysis of Lean Production System, Wiley, India
3. Introduction to Work Study by ILO, ISBN 978-81-204-1718-2, Oxford & IBH Publishing Company, New Delhi, Second Indian Adaptation, 2008.
4. H. B. Maynard, K. Jell, Maynard's Industrial Engineering Handbook, McGraw Hill Education.
5. Zandin K.B., Most Work Measurement Systems, ISBN 0824709535, CRC Press, 2002
6. Martin Murry, SAP ERP: Functionality and Technical Configuration, SAP Press.
7. Barnes, Motion and time Study design and Measurement of Work, Wiley India
8. Sumanth, D.J., "Productivity Engineering and Management", TMH, New Delhi, 1990.
9. Edosomwan, J.A., "Organizational Transformation and Process re- Engineering", British Cataloging in publications, 1996.
10. Prem Vrat, Sardana, G.D. and Sahay, B.S., "Productivity Management - A systems approach", Narosa Publications, New Delhi, 1998.
11. Francis, R.L., and White, J.A., "Facilities layout and Location", Prentice Hall of India, 2002.
12. James A. Tompkins, John A. White, "Facilities Planning", Wiley, 2013

List of Experiments:

The term - work shall consist of a journal based on the below mentioned laboratory Experiments/study (at least 8).

Sr.	Experiment Name
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1.	Apply method study approach to analyse the motions involved in machining operation of the given job.
2.	Apply work measurement technique to analyse the time components involved machining operation of given job using stopwatch.
3.	Prepare flow process chart by considering any job
4.	Prepare flow diagram and string diagram by considering any job/example.
5.	Prepare travel chart and SIMO chart by considering any job/example.
6.	Prepare and analyse factor affecting on plant location by considering any plant.
7.	Prepare layout of any manufacturing plant.
8.	Prepare case study report on Material Requirement Planning, Manufacturing Resources Planning and Enterprise Resource Planning.
9.	Prepare supply chain management chart for online purchase of goods/products.
10.	Prepare case study report on job evaluation and wages plan by considering any plant.
11.	Study of value engineering and value analysis.

Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify the list as necessary.

Alternative NPTEL/SWAYAM Course

Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Principles of Industrial Engineering	Prof. D K Dwivedi	IIT Roorkee

Computer Integrated Manufacturing Systems

Course Code	PEC-PE303				
Category	Program Elective Course				
Course Title	Computer Integrated Manufacturing Systems				
Scheme and Credits	L	T	P	No. of Credits	Semester
	3	0	2	4	V

Course Objectives:

1. To understand the concepts of computer integrated manufacturing system and its applications.
2. To study various computer integrated manufacturing systems with respect to its actual applications in manufacturing.
3. To study various Flexible manufacturing systems, transfer lines in CIMS.
4. To elaborate the role of DAS in CIMS.
5. To elaborate the role of DBMS in CIMS.

Course Outcomes:

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

CO1: Demonstrate the knowledge of the concepts of computer integrated manufacturing system and its applications

CO2: Explain the various computer integrated manufacturing systems with respect to its actual applications in manufacturing

CO3: Explain various Flexible manufacturing systems, transfer lines in CIMS

CO4: Illustrate the role of DAS in CIMS.

CO5: Illustrate the role of DBMS in CIMS.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	-	-	-	-	-	-	-	-	-	2	2	-	2
CO2	2	2	-	-	-	-	-	-	-	-	-	2	2	-	2
CO3	2	2	-	-	-	-	-	-	-	-	-	2	-	-	2
CO4	2	2	-	-	-	-	-	-	-	-	-	2	-	-	2
CO5	2	2	-	-	-	-	-	-	-	-	-	2	-	-	2

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Basic Concept of CIMS: -Scope, islands of automation, architecture of CIM, information flow in CIM, elements of CIM, benefits, limitations, obstacles in implementation Planning for CIMS, need for planning, Phases of CIM implementation, incremental implementation and one time implementation, CIM benchmarking, Economic and social justification of CIM.	07

2	Product Design and CAD, application of computers in design, CAM – manufacturing planning and control, scope of CAD / CAM and CIM, Concurrent engineering, Design for manufacturing and assembly, Case studies on Concurrent engineering, Design for manufacturing and assembly.	07
3	a) Group Technology: Concept, design and manufacturing attributes, part families, composite part, methods of grouping, PFA, classification and coding system- OPITZ, Relevance of GT in CIM, GT and CAD, benefits and limitations of GT. b) Computer Aided Process Planning and Control: need, retrieval and generative type CAPP, role of CAPP in CIM. c) Computer Aided Production Planning and Control: Computer integrated production management system, Role of computers in aggregate planning, master production schedule, shop floor control, materials requirement planning, and capacity planning, manufacturing resource planning and enterprise resource planning.	08
4	Flexible Manufacturing Systems, Transfer lines, Assembly Lines in CIMS: Concept, flexible & rigid manufacturing, manufacturing cell and FMS structure, types, components of FMS, Distributed Numerical Control (DNC), Building Blocks of FMS, Flexible Assembly System, Transfer Lines, concept, applications, benefits, Automates assembly lines, Design for assembly.	07
5	Production Support Machines and Systems in CIM: Robots, types, joint configurations, Industrial robots for load/unload, automated material handling, automatic guided vehicles, Types, Vehicle guidance, Management and safety, automated storage and retrieval system	07
6	a) Data Acquisition and Database Management Systems: (a) Data acquisition system, type of data, automatic data identification methods, bar code technology, machine vision. (b) Data and database management system, database design requirements, types of DBMS models- hierarchical, network and relational models and their applications. b) Communication in CIMS: Role of communication in CIMS, requirements of shop floor communication, types and components of communication systems in CIM, Networking concepts, network topology, access methods, ISO-OSI reference model for protocols, MAP/TOP, TCP/IP.	08
Textbooks:		
1. Automation, Production systems and Computer Integrated Manufacturing, 3/e - M. PGroover Pearson Education; Fourth edition 2016. 2. Computer Integrated Design and Manufacturing - Bedworth, Henderson & Wolfe, McGraw-Hill Inc.,US 1991. 3. Performance Modelling of Automated Manufacturing Systems, 2/e - Viswanadham, N & Narahari, Y. Prentice-Hall 1992.		
References:		
1. Principles of Computer Integrated Manufacturing - S. Kant Vajpayee, Prentice Hall India Learning Private Limited 1998. 2. CAD / CAM Principles and Applications - P.N. Rao McGraw Hill Education; 3rd edition 2017.		

3. CAD/CAM/CIM – Radhakrishnan, Subramanayam & Raju New Age International Pvt Ltd; Fourth edition 2018.
4. Computer Integrated Manufacturing, - James A. Rehg, H. W. Kraebber, Pearson; 2nd edition 2000.
5. MAP/TOP Networking: Foundation of CIM – Vincent Jones (McGraw Hill)

List of Experiments:

Sr.	Experiment Name
1.	Exercise on classification and coding of components using GT Techniques, related to Design Attributes.
2.	Exercise on classification and coding of components using GT Techniques, related to Manufacturing attributes.
3.	A. Exercise on building MRP system for a company manufacturing approximately 3 – 5 assembly products involving total about 15 components.
4.	B. Exercise on building MRP system for a company manufacturing approximately 3 – 5 assembly products involving total about 15 components.
5.	C. Exercise on building MRP system for a company manufacturing approximately 3 – 5 assembly products involving total about 15 components.
6.	A. Exercise on capacity planning for a turning shop with 5 – 10 lathes, 15 turned components with average 3 to 4 turning operations each, for given batch sizes.
7.	B. Exercise on capacity planning for a turning shop with 5 – 10 lathes, 15 turned components with average 3 to 4 turning operations each, for given batch sizes.
8.	Study of co-ordinate measuring machine involving study of dimensions and geometrical features of components, accessories of C.M.M.s and programming aspects, through an industrial visit and its report.
9.	Exercise on Database Management- Creation of a simple manufacturing database using MS Access or similar software involving query, sorting.
10.	Case study on data acquisition systems, LAN structure & communication interface.

Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify the list as necessary.

Alternative NPTEL/SWAYAM Course			
Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Computer Integrated manufacturing System	Prof. J. Ramkumar, Prof. Amandeep Singh	IIT Kanpur

Smart Materials

Course Code	PEC-PE305				
Category	Program Elective Course				
Course Title	Smart Materials				
Scheme and Credits	L	T	P	No. of Credits	Semester
	3	0	2	4	V

Course Objectives:

1. To study the working principles of various materials.
2. To identify applicability of various smart materials as actuators and sensors.
3. To study advances in smart materials.
4. To Synthesis, sensing and actuation of Ferrofluids and Magneto rheological Fluids, Soft Matter, arbon Nanotubes and Carbon nanostructures, Thermoelectric Materials.
5. To classify and select Smart Materials for Energy Applications: Materials used for energy storage.

Course Outcomes:

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

CO1: Classify and select different types of smart materials.

CO2: Comprehend Important Concepts and principles of Smart Materials.

CO3: Synthesis, sensing and actuation of Piezoelectric Materials, Magneto strictive Materials, Shape Memory Alloys, Electroactive Polymers.

CO4: Synthesis, sensing and actuation of Ferrofluids and Magneto rheological Fluids, Soft Matter, Carbon Nanotubes and Carbon nanostructures, Thermoelectric Materials

CO5: Classify and select Smart Materials for Energy Applications: Materials used for energy storage.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	-	-	-	1	-	1	-	-	-	-	-	-	-	-
CO2	2	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO3	-	-	2	-	-	-	-	-	-	-	-	-	-	-	-
CO4	-	-	2	2	-	-	-	-	-	-	-	-	-	1	-
CO5	-	-	3	2	-	-	-	-	-	-	-	-	-	-	-

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Introduction to smart materials Overview of the different types of Smart Materials, Smart materials used in structures, smart material for sensors, actuators controls, memory and energy storage and their inter- relationships, concept of High bandwidth- low strain	07

	generating materials (HBLS), and Low Bandwidth High Strain Generating Materials (LBHS), Nano Composite Materials.	
2	Important Concepts of Smart Materials Artificial skins, artificial muscles, biomimetic materials, materials with tuneable responses, non- linear properties, self-healing materials, adaptive structures, self-replicating materials/structures, self-assembly, inch worm devices, hysteresis, integrated sensing and actuation.	08
3	Overview of the following materials with focus on synthesis, constitutive/governing relationships, strengths and weaknesses, and applications (both sensing and actuation etc). 1. Piezoelectric Materials 2. Magneto strictive Materials 3. Shape Memory Alloys 4. Electroactive Polymers	07
4	Overview of the following materials with focus on synthesis, strengths and weaknesses, and applications 1. Ferrofluids and Magneto rheological Fluids and applications in dampers 2. Soft Matter and its applications as smart skins, smart textiles etc 3. Carbon Nanotubes and Carbon nanostructures and its applications 4. Thermoelectric Materials and Peltier devices.	07
5	Smart Materials for Energy Applications Materials used for energy storage, Hydrogen Storage Materials, Energy harvesting, Energy scavenging from vibrations.	07
6	Manufacturing techniques for smart materials Micromanufacturing, high resolution lithography, LIGA process, Generative manufacturing processes such as STL, SLS, SPB, BPM, LOM, SGC, FDM, BIS, BPM, Self-assembly process, Ion beam processes.	08

Textbooks:

1. V.K. Varadan, K.J. Vinay, and S. Gopalakrishnan, Smart Materials Systems and MEMS Design and Development Methodologies, John Wiley & Sons Inc; 1st edition 2006.
2. G. K. Narula, K. S. Narula, V. K. Gupta, "Material Science", McGraw Hill Education 2017.
3. Pradeep T, "Nano: The Essentials", McGraw Hill Education; 1st edition 2017.
4. Callister's Materials Science and Engineering.

References:

1. Inderjit Chopra and Jayant Sirohi, Smart Structures Theory, Cambridge Press.
2. William D. Callister, Jr. "Materials Science and Engineering An Introduction", John Wiley & Sons, Inc. 7th Edition
3. G. Gautschi, "Piezoelectric Sensorics: Force, Strain, Pressure, Acceleration and Acoustic Emission Sensors, Materials and Amplifiers", Springer, Berlin; New York, 2002 (ISBN:3540422595)
4. K. Uchino, "Piezoelectric Actuators and Ultrasonic Motors", Kluwer Academic Publishers, Boston, 1997 (ISBN: 0792398114)
5. A.V. Srinivasan, "Smart Structures: Analysis and Design", Cambridge University Press, Cambridge; New York, 2001 (ISBN: 0521650267)

6. G. Engdahl, "Handbook of Giant Magneto strictive Materials", Academic Press, San Diego, Calif.; London, 2000 (ISBN: 012238640X)
7. K. Otsuka and C.M. Wayman, "Shape Memory Materials", Cambridge University Press, Cambridge; New York, 1998 (ISBN: 052144487X)
8. Eric Udd, "Fibre Optic Sensors: An Introduction for Engineers and Scientists", John Wiley & Sons, New York, 1991 (ISBN: 0471830070)
9. André Preumont, "Vibration Control of Active Structures: An Introduction", 2nd Edition, Kluwer Academic Publishers, Dordrecht; Boston, 2002 (ISBN: 1402004966).

List of Experiments:

Sr.	Experiment Name
1.	To observe phase transformation and actuation behavior in NiTi SMA wires.
2.	To demonstrate generation of voltage across a piezoelectric crystal under mechanical stress.
3.	To investigate the healing capability of a polymer composite.
4.	To model and visualize hysteresis in a smart actuator system.
5.	To measure applied force or pressure using a piezo sensor.
6.	To demonstrate strain generation under a magnetic field.
7.	To observe viscosity, change of MR fluid under magnetic field.
8.	To observe basic mechanical/thermal or electrical property assessment of CNT sheets.
9.	To harvest energy from vibrations using a piezoelectric patch and to observe Seebeck and Peltier effects.
10.	To manufacture a smart component using FDM 3D printing and to understand the process of photolithography or microfabrication.

Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify the list as necessary.

Alternative NPTEL/SWAYAM Course

Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Advanced Materials and Processes	Prof. Jayant Das	IIT Kharagpur
2	Introduction to Smart Material	Prof. Nachiketa Tiwari, Prof. Bishakh Bhattacharya	IIT Kanpur

Object Oriented Programming with C++

Course Code	PEC-PE307				
Category	Program Elective Course				
Course Title	Object oriented Programming with C++				
Scheme and Credits	L	T	P	No. of Credits	Semester
	3	0	2	4	V

Course Objectives:

- CO1: To understand basic concepts of C++ language.
 CO2: To develop programming skills using object-oriented programming with C++.
 CO3: To utilize pointers, templates, and exception handling.
 CO4: To implement file handling and fundamental data structures.
 CO5: To gain hands-on proficiency in office automation tasks using spreadsheet tools.

Course Outcomes:

- At the end of the course, students will be able to:
 CO1: Create program using C++ language.
 CO2: Design software using object-oriented features such as classes, inheritance, operator overloading, and polymorphism.
 CO3: Implement advanced C++ programming constructs including pointers, templates, exception handling, and demonstrate basic usage of STL.
 CO4: Apply file handling techniques and develop basic data structures like stack, queue, and list.
 CO5: Create, format, and analyze spreadsheets using Excel functions, formulas, charts, and filters.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	1	-	-	-	-	-	1	2	-	1	-	-	-
CO2	3	1	1	1	-	-	-	-	1	2	-	1	1	-	-
CO3	3	1	1	1	1	-	-	-	1	2	1	1	1	-	-
CO4	3	1	1	1	1	-	-	-	1	2	1	1	1	-	-
CO5	3	1	1	1	2	-	-	-	2	2	1	1	2	-	1

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Basics of C++ Programming: Introduction to C++ and its applications, program structure, tokens, keywords, identifiers, constants, data types (basic, derived, user-defined), variables, operators, control structures, arrays (1D and 2D).	08
2	Functions and Classes: Function types, recursion, default arguments, function overloading, class and object basics, constructors, destructors, static data members and functions.	08
3	Advanced OOP Concepts:	08

	Inheritance (types, access specifiers), polymorphism (compile-time and run-time), virtual and pure virtual functions, operator overloading, abstract classes.	
4	Pointers, Templates, and Exception Handling: Pointers and pointer arithmetic, pointers with arrays and functions, function and class templates, standard template library (STL) introduction, basics of exception handling (try, catch, throw)	07
5	File Handling and Data Structures: File operations (open, read, write, close), file modes, file copying, introduction to basic data structures: stack, queue, linked list using C++.	07
6	Office Automation Using MS Excel: Spreadsheet creation, using formulas and functions, applying filters, creating charts and graphs, basic data analysis in Excel.	07
Textbooks:		
1. Let Us C++, Yashavant Kanetkar, BPB Publications, 2020 (3rd Edition). 2. Mastering C++, K. R. Venugopal, Tata McGraw-Hill, 2006. 3. Object-Oriented Programming with C++, E. Balagurusamy, McGraw Hill Education, 2017 (7th Edition).		
References:		
1. Programming with C++ -Ravichandran (Tata McGraw Hill). 2. Help Manuals of MS-EXCEL.		
List of Experiments:		
Sr.	Experiment Name	
1.	Write a program to demonstrate basic input/output, variables, and operators.	
2.	Implement control structures (if-else, switch, loops) to solve simple problems.	
3.	Create a 1D and 2D array and perform basic operations like sum, max, transpose.	
4.	Write user-defined functions.	
5.	Demonstrate recursion with a factorial or Fibonacci number generator.	
6.	Create a class with data members and member functions.	
7.	Implement constructors, destructors, and static members in a class.	
8.	Demonstrate single and multiple inheritance using suitable class hierarchy.	
9.	Implement function overriding and use of virtual functions and pointers.	
10.	Overload operators (like +, -, or ==) in user-defined classes.	
11.	Create function and class templates with basic examples (like swap, sort).	
12.	Implement file handling: open, read, write and copy contents from a file.	
13.	Implement basic stack and queue operations using classes.	
14.	Create and format a simple spreadsheet (MS Excel) with formulas and charts.	
15.	Mini projects.	
Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify the list as necessary.		

CAD Modelling

Course Code	VSEC-PE301				
Category	Vocational Skill and Skill Enhancement Courses				
Course Title	CAD Modelling				
Scheme and Credits	L	T	P	No. of Credits	Semester
	0	0	4	2	V

Course Objectives:

1. To introduce students to computer-aided design (CAD) software tools and user interface.
2. To develop proficiency in 2D sketching and 3D modelling of mechanical components.
3. To understand assembly design, drafting, and documentation practices.
4. To apply CAD techniques in sheet metal design, surface modelling, and basic motion simulation.
5. To prepare students for industrial applications of CAD in product design and manufacturing.

Course Outcomes:

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

CO1: Demonstrate understanding of CAD software tools for 2D and 3D modelling.

CO2: Create accurate 3D models of machine components and assemblies.

CO3: Apply dimensioning, constraints, and drafting techniques to generate engineering drawings.

CO4: Model sheet metal and surface-based parts for design and analysis.

CO5: Develop and present a mini project simulating real-world mechanical design using CAD.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO2	2	3	2	-	2	-	-	-	-	-	-	-	2	-	-
CO3	2	2	2	-	2	-	-	-	-	2	-	-	-	-	-
CO4	2	-	-	-	2	-	1	-	-	-	2	-	-	-	-
CO5	3	-	-	1	3	1	1	-	-	-	-	-	1	1	1

Textbooks:

1. Engineering Drawing and Design, David A. Madsen, David P. Madsen, Cengage Learning, 2022 (6th Edition).
2. Computer Aided Design: A Conceptual Approach, M. M. Maheta, Mahajan Publishing House, 2017.
3. Fundamentals of Computer Aided Manufacturing, T. R. Banga, N. Singh, Khanna Publishers, 2013.

References:

1. Computer-Aided Design and Manufacturing, Mikell P. Groover, Emory W. Zimmers Jr., Pearson Education, 2013.
2. Help manuals of CAD software.

List of Experiments:

Sr.	Experiment Name
1.	Introduction to CAD software interface and basic sketching tools
2.	Create 2D sketches of mechanical components using constraints and dimensions
3.	Create 3D solid models of simple machine parts (e.g., nut, bolt, bush)
4.	Perform parametric modelling of a machine component
5.	Create assembly of at least three parts (e.g., shaft with key and gear)
6.	Create exploded view and animation of a mechanical assembly
7.	Generate 2D orthographic views and section views from 3D model
8.	Perform drafting and annotation on engineering drawings
9.	Model and simulate sheet metal parts (bending, drawing etc.)
10.	Create and simulate simple mechanisms (e.g., slider-crank or 4-bar linkage)
11.	Surface modelling of aesthetically designed product (e.g., mouse, bottle)
12.	Create a CAD model using reverse engineering approach from physical component
13.	Import and export part files in different CAD formats (e.g., STEP, IGES)
14.	Generate Bill of Materials (BOM) from an assembly
15.	Mini projects.

Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify the list as necessary.

Syllabus of SEMESTER-VI

Courses

Design of Jigs, Fixtures and Dies

Course Code	PCC-PE302				
Category	Program Core Course				
Course Title	Design of Jigs, Fixtures and Dies				
Scheme and Credits	L	T	P	No. of Credits	Semester
	3	0	2	4	VI

Course Objectives:

1. To study the design principle of jigs, fixtures and dies.
2. To study the turning and milling fixtures for simple components
3. To design press tools and cutting/punching dies for simple components
4. To design drawing dies and blanks for simple component
5. To design different miscellaneous dies.

Course Outcomes:

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

CO1: Select drilling and reaming jigs for simple components.

CO2: Design turning and milling fixtures for simple components.

CO3: Design press tools and cutting/punching dies for simple components.

CO4: Design drawing dies and blanks for simple component.

CO5: Design different miscellaneous dies.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	-	-	-	1	-	-	-	-	-	-	-	1	-	2
CO2	2	-	3	-	-	-	-	-	-	-	-	-	-	-	2
CO3	2	-	3	-	-	-	-	-	-	-	-	-	-	-	2
CO4	2	-	3	-	-	-	-	-	-	-	-	-	-	-	2
CO5	2	-	3	-	-	-	-	-	-	-	-	-	-	-	2

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Introduction to Jigs and Fixtures: Necessity, applications and types, basic concept of jigs and fixtures for different manufacturing processes, dependency of jig and fixture design on operation sequence.	06
2	Location and clamping system: Principles, types, applications, locating pins, pads, diamond pins, adjustable supports, Vee and post locators, clamping system -principle, types, screw clamp, strap, lever, hinge type, cam operated, toggle clamps, centralizer and equalizer clamp, multiple clamping, quick acting clamps, pneumatically operated clamps.	06
3	Design of Jigs & fixtures: A) Design of jigs: Principles of jig design, types of jigs-plate, template, box, channel, sandwich, latch, turn-over, tumble jig etc., types	09

	of bushes, selection of bushes and liners, construction of jig and fixture bodies, use of standard parts. B) Design of fixtures: Principles of fixture design, types of fixtures- gang, straddle, vertical, slot, string milling fixture etc, selection of the suitable type, design of milling fixtures, use of setting block, tenons, T-bolts etc, design of turning fixture for lathe. Indexing System: Necessity, different indexing systems for jigs and fixtures. Concept of Modular Fixtures.	
4	Introduction to press tools: Dies, punches, types of presses, types of dies, simple, compound, combination and progressive dies, press tools for operations like blanking, piercing, drawing, shaving, trimming, etc.	06
5	Design of die set for cutting operations: Theory of metal cutting, cutting force and blank holding force estimation, punch and die clearance, scrap strip layout, design of punches, design of dies, pilots, strippers, stock stops, finger stops, auto stops, center of pressure, selection of die set.	08
6	Design of drawing die: blank size determination, no. of draws, stage wise achievement of drawn component, stage wise component drawings, drawing radii and clearance, drawing forces, defects in drawing, Miscellaneous dies like-cut off dies, trimming, shaving, bulging, rubber, lancing, slitting, horn type, side cam dies, bending, forming, curling dies etc. (theoretical treatment only)	09
Textbooks:		
1. Tool Design, Donaldson McGraw Hill Education; Fifth edition 2017. 2. Tool Design, Pollock, Prentice-Hall; 2nd edition 1988. 3. A Textbook of Prod. Engineering, P. C. Sharma, S Chand; 8th edition 1999.		
References:		
1. An Introduction to Jig & Tool Design, M.H.A. Kempster, (ELBS). 2. Fundamentals of Tool Design, Ed. Frank Wilson, ASTME Prentice-Hall, 1962. 3. Jigs and Fixture Design Manual, Henrikson (Industrial Press, NY). 4. Handbook of Die Design- Suchy, (McGraw Hill) 2005. 5. Die Design Fundamentals, J. R. Paquin, R. E. Crowley, Industrial Press Inc. 6. Jigs and Fixture, P. H. Joshi, McGraw Hill Education; 3rd edition 2017. 7. Techniques of Press Working of Metals by Eary and Reed. 8. CMTI Machine Tool Design Handbook, Kojo Press 2024; Kojo Press 9. Design Data Handbook –PSG College of Tech., Coimbatore.		
List of Experiments:		
Sr.	Experiment Name	
1.	Study of various elements of jigs and fixtures.	
2.	A. Design and drawing a jig for given component. (drilling)	
3.	B. Design and drawing a jig for given component. (reaming)	
4.	C. Design and drawing a jig for given component. (Drilling/reaming) (Flanged/rectangular job)	
5.	A. Design and drawing a fixture for given component. (Milling)	
6.	B. Design and drawing a fixture for given component. (Slotting: Set screw)	

7.	C. Design and drawing a fixture for given component. (Slotting: Set screw) (Mass production)
8.	A. Design and drawing of one progressive die.
7	B. Design and drawing of one progressive die.
8	A. Design and drawing of one drawing die.
9	B. Design and drawing of one drawing die.
10	At least one industrial visit to study industrial practices related to the subject and submission of the visit report.

Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify the list as necessary.

Alternative NPTEL/SWAYAM Course

Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Manufacturing Processes-II	Prof. A.B. Chattopadhyay Prof. S. Paul Prof. A.K. Chattopadhyay	IIT Kharagpur

Metrology and Quality Control

Course Code	PCC-PE304				
Category	Program Core Course				
Course Title	Metrology and Quality Control				
Scheme and Credits	L	T	P	No. of Credits	Semester
	3	0	2	4	VI

Course Objectives:

1. To study need of metrology and basic terminology of metrology.
2. To learn the basics of limit, fit, tolerances and gauge designing.
3. To study the principles of measurement of various mechanical properties such as geometrical, dimensional, surface finish, etc.
4. To learn the use of various measuring instruments with different setups for accurate measurements.
5. To study the identify suitable quality control tool for given application.

Course Outcomes:

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

CO1: Use linear and angular measuring instruments.

CO2. Design tolerances and fits for selected product quality.

CO3. Identify suitable comparator and light waves for different measurements.

CO4. Understanding of basic concepts of mechanical measurement and errors in measurements.

CO5. Implement statistical quality control methods, including control charts, process capability analysis, and acceptance sampling, while understanding TQM principles.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	1	-	-	-	-	-	-	-	-	-	2	1	1	1
CO2	2	-	-	2	-	-	-	-	-	-	-	-	1	1	1
CO3	3	-	1	-	1	-	-	-	-	-	-	-	1	1	1
CO4	2	1	2	1	-	-	-	-	-	-	-	1	1	1	-
CO5	1	-	-	2	1	-	-	-	-	-	-	1	-	-	-

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Introduction: Need, Precision, Accuracy, Errors, Linearity, Repeatability, Methods of Measurement. Linear Measurement: Vernier Callipers, Height Gauge, Depth Gauges, Feeler Gauges, Micrometre, Slip Gauges. Measurement Standards: Line Standard, End Standard, Wavelength Standard, Classification of Standards, GD&T.	07

2	Limits, Fits and Gauges: Tolerances, Interchangeability, Selective Assembly Terminology, Limits of Size, Allowances, Clearances, Interference, Fits, Selection of Fits, Numerical Problems on Limits of Size and Tolerances, Gauges (Ring, Snap), Taylor's Principle, Gauge Design, Tolerance and Geometry, Geometric Dimensioning and Tolerance.	07
3	Comparators: Definition, Types, Characteristics, Applications, Construction and Working of Different Mechanical, Electrical, Optical, and Pneumatic Comparators.	06
4	Mechanical Measurement: Principle and Applications of Measuring Instruments Like Protractor (Optical and Bevel), Sine Bar, Angle Gauges, Spirit Level, Clinometers, Autocollimator, Angle Dekker, Constant Deviation Prism, and Miscellaneous Measurement of Angle, Profile Projector, Toolmaker's Microscope and CMM.	08
5	Pressure Measurement: Introduction to SQC and statistical background. System of Chance Causes, Patterns of Variations, Interpretation of Lack of Statistical Control. Interpretation of Patterns of Variation on X & R Charts, Control Charts for Variables, and attributes. Process Capability Analysis - Estimation of Process Capability using Process Capability Indices, Viz: Cp, Cpk, Cpm, and Their Interpretation.	08
6	Temperature Measurement: Background including normal, poisson and binomial distribution. Different sampling plans. Lot-by-lot acceptance using single sampling plan, OC curves, sampling risk, AQL, LTPD, alpha and beta risk, construction of OC curve for given sampling plan and estimation of different parameters. Total Quality Management (TQM)	08

Textbooks:

1. R.K. Jain, "Engineering Metrology", Khanna Publishers; Special Edition 2022.
2. K.J.Hume, "Engineering Metrology", Kalyani publication ISBN8170290015
3. I. C. Gupta, "A Textbook of Engineering Metrology", Dhanpat Rai Publications 2018.

References:

1. R.K. Jain, "Engineering Metrology", Khanna Publication, New Delhi 1997.
2. K.J.Hume, "Engineering Metrology", Kalyani publication ISBN8170290015.
3. Textbook Of Metrology, M.Mahajan Dhanpat Rai & Co.[P] Ltd.; 1st edition 2012.
4. Beckwith, T. G. and W.L. Buck: "Mechanical Measurements", 2nd Edition, Addison Wisely Publishing Company, Reading, Mass, 2000 ISBN8131702073.
5. D. S. Kumar, "Mechanical Measurement & Control", Metropolitan Book Co. (P) Ltd., ISBN 81 200 0214-8.
6. Statistical Quality Control: M. Mahajan, Dhanpat Rai & Co. (P) Limited 2016.
7. Total Quality Management: Bester field Dale and others, Pearson Education 2018.

List of Experiments:

Sr.	Experiment Name
1.	Use of precision measuring instruments for linear measurements.
2.	Experiment on mechanical comparator and study of different types of comparators.
3.	Experiment on sine bar for measurement of taper angle.
4.	Study of auto collimator / angle dekkor.
5.	Experiment on pitch errors of screw threads.
6.	Assignment on the design of gauges.
7.	Experiment on profile projector/ Tool maker's Microscope.
8.	Experiment on Coordinate Measuring Machine.
9.	Experiment on Height master
10.	Experiment on pressure and temperature measurements.

Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify it as necessary.

Alternative NPTEL/SWAYAM Course

Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Mechanical Measurement and Metrology	Prof. Shunmugam M. S Prof. S.P. Venkateshan	IIT Madras
2	Inspection and Quality Control in Manufacturing	Prof. Kaushik Pal	IIT Roorkee

Introduction to FEA and CFD

Course Code	PCC-PE306				
Category	Program Core Course				
Course Title	Introduction to FEA and CFD				
Scheme and Credits	L	T	P	No. of Credits	Semester
	2	0	2	3	VI

Course Objectives:

1. To acquire basic knowledge of static structural and governing equations.
2. To understand the concept and procedure of Finite Element method.
3. To understand the concept and procedure of Computational Fluid Dynamics.
4. To learn about steps used in finite element method such as drafting, meshing, application of different boundary conditions, and problem solution.
5. To acquire knowledge about digital twins.

Course Outcomes:

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

CO1: Understand the procedures used for problem analysis using numerical methods.

CO2: Obtain a solution to static structural and thermal problems analytically.

CO3: Discretise the governing equations using the finite volume method.

CO4: Model different static structural problems using commercial software.

CO5: Understand the fundamentals of digital transformation and digital twins.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	2	3	-	-	-	-	-	-	3	2	-	1
CO2	3	2	2	2	3	-	-	-	-	-	-	3	2	-	1
CO3	3	3	2	2	3	-	-	-	-	-	-	3	2	-	1
CO4	3	3	3	2	3	-	-	-	-	-	-	3	2	-	1
CO5	3	3	3	2	3	-	-	-	-	-	-	3	2	-	1

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Introduction to FEA Introduction, History background, Concept of stress, strain in terms of partial derivatives, Stresses & equilibrium boundary conditions, Strain displacement relations, Stress – strain relations	05
2	FEA Analytical solution	07

	Different steps in FEA, Matrix formation, and solution, Step wise procedure of Finite element method, Variational techniques for derivation of finite element equations, Assembly procedure, Numerical on equilibrium problems, Numerical on equilibrium problems, Solution methods, Stiffness matrix, properties, numerical.	
3	Introduction to computational fluid dynamics Computational approach to Fluid Dynamics and its comparison with experimental and analytical methods, Governing Equations, finite volume method.	07
4	CFD Analytical Methodology Different steps in computational fluid dynamics, Problem formation, and solution, steps involved, control volume approach, assembly procedure, Numerical on heat transfer and fluid flow, Numerical on steady and unsteady problem.	07
5	Introduction to digital twins Overview of Digital Twins Historical context and evolution; Digital Twins maturity models; Significance in digital transformation and modern industries. Introduction to different Digital Twin frameworks; Industry applications; Problem identification and digital transformation roadmap.	04

Textbooks:

1. Introduction to finite elements in Engineering, Chandrupatla and Belegundu, Prentice Hall of India Pvt. Ltd. New Delhi, 2001.

References:

1. A First Course in Finite Element Method, Logan Deryl L., Thomson Brook/Cole, 3rd ed. 2002
2. An Introduction to Computational Fluid Flow (Finite Volume Method), by H.K. Versteeg, W.Malalasekera, Printice Hall
3. Finite Element Procedures in Engineering Analysis, Bathe K.J., Cliffs, N.J., Englewood, Prentice Hall, 1981.
4. Computational Methods for Fluid Dynamics, Ferziger and Peric, Springer International Publishing AG; 4th ed. 2020.
5. Fluid Mechanics, Dr. R.K. Bansal, Laxmi Publications; Tenth edition 2019.

List of Experiments:

Sr.	Experiment Name
1.	Introduction to simulation software. a. Overview of the software tool. b. Introduction to commercial software workbench, geometry, meshing, fluent. solver, problem set up, post-processing module.
2.	Grid generation using suitable software. a. Meshing of simple and complex geometries. b. Quality of Mesh. c. Named selection.

	d. Grid Independence Test.
3.	Modeling and simulation for deformation, strain, and stress distribution over three-dimensional static structural problems—uniform cross-section rod.
4	Modeling and simulation for deformation, strain, and stress distribution over three-dimensional static structural problems—stepped rod.
5	Modeling and simulation for fatigue loading over three-dimensional plate with internal holes.
6.	Modeling and simulation for tensile / compressive loading over three-dimensional square rod.
7.	Modeling and simulation for tensile / compressive loading over three-dimensional circular rod.
8.	Modeling and simulation for thermal analysis for temperature, and heat flux distribution over three-dimensional cylinder for different boundary conditions.
9.	Modeling and simulation for thermal analysis of flow through a circular tube for various inlet boundary conditions, laminar and turbulent.
10.	Modeling and simulation for pressure loss analysis of flow through a circular tube for various inlet boundary conditions, laminar and turbulent.

Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify it as necessary.

Alternative NPTEL/SWAYAM Course

Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Basics of FEA	Prof. Nachiketa Tiwari	IIT Kanpur
2	Finite Element Method	Prof. Amit Shaw	IIT Kharagpur
3	Computational Fluid Dynamics	Prof. Suman Chakraborty	IIT Kharagpur

Artificial Intelligence and Machine Learning

Course Code	PEC-PE302				
Category	Program Elective Course				
Course Title	Artificial Intelligence and Machine Learning				
Scheme and Credits	L	T	P	No. of Credits	Semester
	3	0	0	3	VI

Course Objectives:

1. Acquaint with fundamentals of artificial intelligence and machine learning.
2. Learn feature extraction and selection techniques for processing data set.
3. Understand basic algorithms used in classification and regression problems.
4. Outline steps involved in development of machine learning model.
5. Implement and analyse machine learning model in mechanical engineering problems.

Course Outcomes:

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

CO1: Explain the elements of Industry 4.0 and smart machines and manufacturing systems.

CO2: Explain the basics concepts in AIML and types of AIML systems.

CO3: Apply machine learning algorithms for classification and regression problems.

CO4: Explain the steps in development of ML model and types of ANN.

CO5: Explain applications of AIML in mechanical engineering

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	-	-	-	-	-	-	-	-	-	2	-	-	-
CO2	2	2	-	-	-	-	-	-	-	-	-	2	-	-	-
CO3	2	2	-	-	-	-	-	-	-	-	-	2	-	-	-
CO4	2	2	2	-	-	-	-	-	-	-	-	2	2	2	2
CO5	2	-	-	-	-	-	-	-	-	-	-	2	2	2	2

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Introduction to Industry 4.0 Concept of Industry 4.0, The Fourth Revolution, LEAN manufacturing, Smart factories, Potential manufacturing for Industry 4.0, smart manufacturing system for Industry 4.0, Timeline of Industry 1.0–4.0, Demand dimensions for Industry 4.0, Design prerequisites for Industry 4.0, Benefits of Industry 4.0, Limitations of Industry 4.0.	07
2	Smart factories and smart machines	08

	The Smart Factory of the Industry 4.0: Cyber-Physical Systems, Internet of Services, Steps to implement industry 4.0 in manufacturing industry. Concept of smart machines, sensors and transducers used in smart machines, Selection of parameters on the manufacturing machines to be monitored for monitoring-machine health, quality of output of the machine, machine data collections, storing, retrieving and analyzing, time intervals for these measurements, applications, benefits.	
3	Introduction to AI & ML History of AI, Comparison of AI with Data Science, Need of AI in Mechanical Engineering, Introduction to Machine Learning. Basics of artificial intelligence: Reasoning, problem solving, Knowledge representation, Planning, Learning, Perception, Motion and manipulation. Types of AI: Cybernetics and brain simulation, Symbolic, Sub-symbolic, Statistical. Types of ML: Supervised learning, Unsupervised learning, Reinforcement learning.	08
4	Classification & Regression algorithms in Machine Learning Difference between feature extraction and feature selection Classification: Decision tree, Random Forest, Naive Bayes, Support vector machine. Regression: Logistic Regression, Support Vector Regression. Regression trees: Decision tree, random forest, K-Means, K-Nearest Neighbor (KNN). Applications of classification and regression algorithms in Mechanical Engineering.	08
5	Development of ML Model and Artificial neural network Problem identification: classification, clustering, regression, ranking. Steps in ML modeling, Data Collection, Data pre-processing, Model Selection, Model training (Training, Testing, K-fold Cross Validation), Model evaluation (understanding and interpretation of confusion matrix, Accuracy, Precision, Recall, True positive, false positive etc.), Hyper parameter Tuning, Predictions. Characteristics of Deep Learning, Artificial Neural Network types.	07
6	Applications of AIML in Mechanical Manufacturing Industries Human Machine Interaction, Predictive Maintenance and Health Management, Fault Detection, Image based part classification, Process Optimization, Material Inspection, tuning of control algorithms, Fault diagnosis- Quality inspection-Improving the safety of working places, Machine learning in Machine Tools and Manufacturing Industries.	07

Textbooks:

1. Deisenroth, Faisal, Ong, Mathematics for Machine Learning, Cambridge University Press, 2020.
2. B Joshi, Machine Learning and Artificial Intelligence, Springer, 2020.

References:

1. Parag Kulkarni and Prachi Joshi, "Artificial Intelligence – Building Intelligent Systems", PHI learning Pvt. Ltd., ISBN – 978-81-203-5046-5, 2015
2. Stuart Russell and Peter Norvig (1995), "Artificial Intelligence: A Modern Approach," Third edition, Pearson, 2003.
3. Industry 4.0: Managing The Digital Transformation by Alp Ustundag, Springer Publication.

4. Solanki, Kumar, Nayyar, Emerging Trends and Applications of Machine Learning, IGI Global, 2018.
5. Mohri, Rostamizdeh, Talwalkar, Foundations of Machine Learning, MIT Press, 2018.
6. Kumar, Zindani, Davim, Artificial Intelligence in Mechanical and Industrial Engineering, CRC Press, 2021.
7. Zsolt Nagy - Artificial Intelligence and Machine Learning Fundamentals-press (2018)
8. Artificial Intelligence by Elaine Rich, Kevin Knight and Nair, TMH.

Alternative NPTEL/SWAYAM Course

Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	An Introduction to Artificial Intelligence.	Prof. Mausam	IIT Delhi
2	Machine learning for engineering and science applications.	Prof. Balaji Srinivasan	IIT Madras

Product Design and Development

Course Code	PEC-PE304				
Category	Program Elective Course				
Course Title	Product Design and Development				
Scheme and Credits	L	T	P	No. of Credits	Semester
	3	0	0	3	VI

Course Objectives:

1. To provide the realistic understanding of the design process.
2. To develop the attitude and approaches towards product development than merely presenting design techniques.
3. To understand the material and manufacturing processes selection in product design.
4. To develop cost estimation technique in product design.
5. To understand modern tools and methods like collaborative practices, internet-based design, PLM in context of product development.

Course Outcomes:

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

CO1: Employ engineering principles to execute a design from concept to finished product.

CO2: Select the optimum material and manufacturing process for a given component under a set of given working condition.

CO3: Recommend a substitute material and/or a process for making a component to improve its performance, cost or other attributes under a given set of service conditions.

CO4: Demonstrate design and development of the product, the associated manufacturing equipment and processes, and the repair tools and processes using concurrent engineering.

CO5: Realize concept of PDM and PLM.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	3	2	-	-	2	-	-	-	-	3	3	2
CO2	2	-	-	2	2	-	-	1	-	-	-	-	3	2	2
CO3	2	2	3	-	2	-	1	1	1	1	-	-	2	2	2
CO4	3	3	2	2	-	1	1	-	1	1	-	-	3	2	2
CO5	3	-	2	2	2	-	-	-	-	-	-	-	2	1	2

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Introduction: Engineering design, Process and purpose of design, Types of design, importance of design, morphology of design, design considerations.	07

2	Product Design Process: Steps in design: need identification & problem definition, Functional requirement analysis, defining a product development team, gathering information, concept generation & evaluation, organization for design, product specification and detailed design.	08
3	Material And Manufacturing Process Selection In Design: Factors influencing material and process selection, approaches, tools and software used in selection.	07
4	Development of Design: Concept to product, design for: function, manufacture/production, shipping, handling, installation, use, maintenance etc.	08
5	Design Cost Evaluation: Need, methods, design to cost and life cycle, economics and financial feasibility, costing and use of software for estimation.	07
6	Product Development Approaches: Concurrent engineering, partnership with supplier, collaborative and Internet based design. Design Project Management: PDM, PLM and related software tools. Case studies based on Concurrent and collaborative product development approaches, Modular product design, mechanical and electronic products design.	07

Textbooks:

1. Product design and development by Ulrich Karl T and Eppinger Steven D., McGraw Hill; Seventh edition 2020.
2. Product Design and Manufacture by Chitale AK and Gupta RC, Prentice Hall India Learning Private Limited; 5th edition 2011.

References:

1. Engineering Design by Dieter George E. McGraw Hill; Standard Edition 2022.
2. Fundamentals of Design and manufacturing, GK Lal, Vijay Gupta, N Venkata Reddy, Narosa Publications, 2006
3. Handbook of Product Design for Manufacturing, Bralla, James G., McGraw Hill Pub 1986
4. Design for X, G. Q. Huang, Chapman & Hall, Springer; Softcover reprint of the original 1st ed. 1996 edition (5 December 2012).

Alternative NPTEL/SWAYAM Course

Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Product Design and Development	Prof. Inderdeep Singh	IIT Roorkee

Supply Chain Management

Course Code	PEC-PE306				
Category	Program Elective Course				
Course Title	Supply Chain Management				
Scheme and Credits	L	T	P	No. of Credits	Semester
	3	0	0	3	VI

Course Objectives:

1. Understand the fundamentals of supply chain management.
2. Know the various strategies and models of supply chain management.
3. Understand the collaboration and integration of other technology.
4. Apply principles of material management.
5. Understand the global supply chain management.

Course Outcomes:

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

CO1: Understand the fundamental concepts of supply chain management.

CO2: Recognize the importance of supply chain management in business operations.

CO3: Identify key components and processes within a supply chain.

CO4: Estimate scope in material management.

CO5: Comprehend the role of technology in enhancing supply chain management.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	1	1	-	2	-	-	-	3	-	-
CO2	3	-	-	-	-	2	1	-	2	-	-	-	2	1	-
CO3	3	2	2	1	-	-	1	-	2	-	-	-	3	-	3
CO4	3	2	2	2	-	-	1	-	1	-	3	-	2	-	-
CO5	3	2	-	-	-	-	2	-	-	-	-	-	2	-	1

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Fundamentals of Supply Chain Management Understanding Supply Chain concepts, Role and Importance of Supply Chain Management, Historical Evolution of Supply Chains, Key Supply Chain Processes and Components, Supply Chain Stakeholders and Their Roles	07
2	Supply Chain Strategies and Models Supply Chain Strategy Development, Supply Chain Design Models, Lean vs. Agile Supply Chains, Risk Management in Supply Chains, Sustainability in Supply Chain Strategies.	07

3	Supply Chain Integration Cross-Functional Collaboration, Information Sharing in Supply Chains, Technology and Supply Chain Integration, Supply Chain Performance Measurement	07
4	Demand and Supply Management Demand Forecasting Methods, Supply Chain Planning and Coordination, Inventory in Demand and Supply Management, Managing Demand Variability, JIT and MRP in Supply Chain Operations	08
5	Digital Twin SCM Introduction, digital twin, types of digital twin SCM, digital twin enablers, SCM digital.	08
6	Global Supply Chain Management Globalization and Its Impact on Supply chains, Global Sourcing and Procurement, International Transportation and Trade Regulations, Cultural and Legal Aspects in Global Supply Chain, Supply Chain Resilience in a Global Context	07

Textbooks:

1. "Supply Chain Management: Strategy, Planning, and Operation" by Sunil Chopra and Peter Meindl, Publishers- Person, Delhi

References:

1. "Introduction to Materials Management" by J. R. Tony Arnold, Stephen N. Chapman, and Lloyd M. Clive, Publishers- Pearson Education; Eighth edition 2017.
2. "Logistics Management and Strategy: Competing through the Supply Chain" by Alan Harrison and Remko van Hoek, Publishers- Pearson Education, 2019
3. "Principles of Supply Chain Management a Balanced Approach, Wisner, Keong Leong and Keah-Choon Tan, Thomson Press-2006
4. "Modeling the Supply Chain", Jeremy F Shapiro, Thomson duxbury 2002

Alternative NPTEL/SWAYAM Course

Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Operations and supply chain management	Prof. G. Srinivasan	IIT Madras
2	Logistics & Supply Chain Management	Prof. Vikas Thakur	IIT Kharagpur

Maintenance Engineering

Course Code	PEC-PE308				
Category	Program Elective Course				
Course Title	Maintenance Engineering				
Scheme and Credits	L	T	P	No. of Credits	Semester
	3	0	0	3	VI

Course Objectives:

1. To make students aware of various basic aspects related to maintenance and its management in the industry.
2. To understand problem-based techniques related with maintenance, replacement of machines, etc.
3. To Study life cycle costing and condition-based monitoring.
4. To impart practical knowledge.
5. To study various types of defects in working of different types of machines.

Course Outcomes:

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

CO1: Discuss wear and theories of failure.

CO2: Suggest maintenance schemes.

CO3: Demonstrate the skills related to life cycle costing and condition-based monitoring.

CO4: Understand various aspects of maintenance in practical situations.

CO5: Identify various types of defects in working of different types of machines.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	2	-	-	-	-	-	-	-	-	-	-	-	2	-
CO2	1	-	-	-	2	-	-	-	-	-	-	-	1	-	-
CO3	1	-	3	-	-	-	-	-	-	-	-	-	-	2	-
CO4	-	-	3	2	-	-	-	-	-	-	-	-	1	-	-
CO5	-	2	-	3	-	-	-	-	-	-	-	-	-	3	-

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Introduction: Objectives, economic aspect of maintenance, planning of maintenance work optimum degree of maintenance efforts, types of failure probability distribution and their significance in formation of maintenance policy. Lubrication: Introduction to lubrication engineering, type, classification of lubricants with their properties and characteristics. Science of friction and wear; theories of lubrication; Bearing lubrication technique for minimization of friction and wear.	08

2	Wear: Theories of wear – Wear –fundamentals, Different types of wear, such as abrasive, corrosive, seizure, scoring, scuffing, pitting, spalling, adhesive, etc. and techniques for minimization of wear with examples.	05
3	Maintenance Systems: Break down maintenance, routine maintenance, planned maintenance, preventive maintenance, predictive maintenance, corrective maintenance, design out maintenance, proactive maintenance, and Reliability Centered Maintenance. Total Productive Maintenance: Organization, merits and demerits.	05
4	Defect/failure generation and analysis Basics of failure: failure generation, and fault tree analysis, ETA, RCA, failure mode and effects analysis. Reliability: Definition and basic concepts; Failure data, failure modes, and reliability in terms of hazard rate and failure density function; Hazard models and bath tub curve.	08
5	Condition monitoring Condition signals and monitoring: condition monitoring techniques like performance, visual, temperature, vibration, lubricant, leakage, crack, corrosion, noise/sound monitoring, SOAP, etc. Non-destructive testing as an aid to maintenance, principle methods, such as dye-penetrant, magnetic particle testing and ultrasonic tests, use of AI ML in diagnostic maintenance.	10
6	Replacement analysis: Introduction, reasons for replacement, factors affecting replacement methods used for selecting alternatives, cost comparison for replacement analysis considering inflation and technological advancements, present worth method, Annual cost method, rate of return method, depreciation method, life average method etc.	08

Textbooks:

1. Production, Planning Control & Industrial Management. - K.C.Jain & L.N. Aggarwal. Khanna Publishers; Latest edition 1999.
2. Maintenance engineering and management –sushil kumar srivastav (chand)
3. Maintenance Engineering and Management, Mishra R.C Prentice Hall India Learning Private Limited; 2nd edition 2012.

References:

1. Production and operation Management - Nair McGraw Hill Education 2002.
2. Production and operation Management – S N chary (TMH)
3. Production handbook - IVth Edition (Willey)
4. Fundamentals of Production Systems and Engineering. - Sekhan & A.S.Sachdeva.
5. Production Management - Lallan Prasad & A.M. Banerjee
6. Singh and C.S. Dhillon, "Engineering Reliability-New Techniques and Applications", John Wiley and Sons, Tata McGraw Hill Publishing Company Limited, New Delhi.
7. Industrial Engineering and Management - O.P. Khanna 2020.
8. Industrial Organization and Engineering Economics-T.R.Banga & S.C.Sharma. Khanna Publishers; Latest edition 2006.

Alternative NPTEL/SWAYAM Course			
Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Machinery fault diagnosis and signal processing	Prof. A.R.Mohanty	IIT Kharagpur

Machine Tool Design

Course Code	PEC-PE310				
Category	Program Elective Course				
Course Title	Machine Tool Design				
Scheme and Credits	L	T	P	No. of Credits	Semester
	2	0	2	3	VI

Course Objectives:

1. To understand core concepts of Machine Tool & Product Design.
2. To understand the basic approach for designing machine tool components and implement the appropriate method.
3. To compute the power requirements of various machine tools.
4. To learn to design quality-based manufacturing system.
5. To learn to design a product using innovative concepts of Product Design.

Course Outcomes:

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

CO1: Apply the concepts of machine tool design.

CO2: Select the correct design approach & design the important components of machine tools.

CO3: Calculate the forces acting and the subsequent power requirements of machine tools.

CO4: Design the critical components comprising a manufacturing system & emphasize on the quality of the system.

CO5: Analyse the various phases of the design cycle sequentially and envision the concept of Scratch to Market with respect to a product.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	2	-	-	-	-	-	-	-	-	2	-	-	2
CO2	2	2	3	-	-	-	-	-	-	-	-	2	2	-	2
CO3	2	2	3	-	-	-	-	-	-	-	-	2	2	2	2
CO4	2	2	3	-	-	-	-	-	-	-	-	2	2	-	2
CO5	2	2	3	-	-	-	-	-	-	-	-	2	-	-	2

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Introduction to Machine & Machine Tool Types, capabilities, features of construction like working & auxiliary motions in machine tools, parameters defining the working motions of a machine tool, machine tool drives, general requirements of machine tool design, methodology for machine tools design considering quality, quantity of production and economic aspects. Principle of Machine Tool Design from the point of view of quality, production rate,	06

	strength, rigidity, assembly, ergonomics, aesthetics, maintenance and interchangeability	
2	Analysis of forces Forces affecting machine tool elements, determination of motive power for different operating conditions, use of handbooks. b) Design considerations and selection of standard components Drive systems with pulleys, belts, ropes and chains; selection of oil seals, gaskets and electric motors from standard catalogues.	06
3	Kinematics of Machine Tools Classification of various driving systems, basic considerations in the design of drives, aims of speed & feed regulation, stepped regulation of speeds, design of gear box, laws of stepped regulations, selection of range ratio, G.P. ratio, break up of speed steps, structural diagram, Ray diagram & speed chart, design of feed box, machine tool drives using multiple speed motors, general recommendations for developing gearing diagram, determining the number of teeth on gears, stepless regulation of speed and feed rates.	06
4	a) Design of Spindle & Spindle Support Functions of spindle unit and requirements, materials and construction, spindle ends, spindle support, design calculations, mounting arrangements of spindle bearings, spindle bearing lubrication. b) Selection of Machine Tool Bearing Journal, rolling and hydrostatic bearings, basic principles, assembly, mounting and maintenance, procedure for selection of bearings from manufacturer's catalogue based on load and life considerations.	06
5	a) Design of Machine Tool Structures Functions of machine tool structures and their requirements, design criteria, materials, static and dynamic stiffness, profiles of machine tool structures, basic design procedure, design of beds, columns, housings, rams etc, Causes of vibrations in machine tools and methods of elimination. b) Design of Guide ways Functions and types of guideways, materials, design criteria and calculations of slide-ways based on wear and accuracy, design of anti-friction guideways, hydrostatic and hydrodynamic lubrication of guideways.	06
Textbooks:		
1. Machine tool design by N.K. Mehta McGraw hill Exclusive (E); 3rd Edition 2017. 2. Principles of machine tools by Gopal Chandra Sen and Amitabh Bhattacharya New Central Book Agency; 2nd edition 2009. 3. Design of Machine Elements, V. B. Bhandari, Tata McGraw-Hill Publishing Company Ltd.		
References:		
1. Machine Tool Design Handbook, C.M.T.I, Bangalore, (TMH). 2. Design Data Handbook, PSG College of Tech., Coimbatore. 3. Design of Machine Tool, Dr. S. K. Basu Oxford & IBH Publishing Co Pvt. Ltd; 6th edition 2018. 4. Design of Machine Elements, Pearson Education; Eighth edition 2019. 5. Elements of Machine Design, N. C. Pandya and C. S. Shaha, Charotkar Publishing House 6. Design Data Handbook, K. Mahadevan and Balveera Reddy, C.B.S Publishers & Distributors. 7. Engineering Design, a Materials and Processing Approach, G. Dieter, Tata McGraw-Hill		

Publishing Company Ltd.

8. Product Design and Manufacturing, (3/e), A. K. Chitale and R. C. Gupta, Prentice Hall of India Pvt. Ltd. 2007.

9. Catalogues of Bearing Manufacturers, example, S.K.F, NACHI, TIMKEN, NRB etc.

List of Experiments:

Sr.	Experiment Name
1.	Design of a gear box for speed and feed drive, design of shafts and gears with assembly drawing
2.	A. Selection of bearings from manufacturer's catalogue.
3.	B. Selection of bearings from manufacturer's catalogue
4.	Study of different machine tools from the point of view of types of machine parts.
5.	A. Exercise on design of machine tools from ergonomic aspects suitable in India.
6.	B. Exercise on design of machine tools from ergonomic aspects suitable in India.
7.	Design of Guide ways
8.	Design of Machine Tool Structures
9.	Design of Spindle & Spindle Support
10.	Case Study on design of machine tool components.

Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify it as necessary.

Mechatronics and Automation

Course Code	PEC-PE312				
Category	Program Elective Course				
Course Title	Mechatronics and Automation				
Scheme and Credits	L	T	P	No. of Credits	Semester
	2	0	2	3	VI

Course Objectives:

1. To provide students with a comprehensive understanding of Mechatronics systems.
2. To provide students with the knowledge of various autonomous systems.
3. To enable students to explore the integration of Mechatronics in modern automation systems.
4. To study techniques involved in Mechatronics systems which are very much essential to understand the emerging field of automation.
5. To study the hydraulic, pneumatic and other actuation systems employed in manufacturing industry.

Course Outcomes:

On successful completion of this module, students should be able to:

CO1: Analyse and differentiate between traditional and Mechatronics-based approaches.

CO2: Dissect and comprehend the working principles of diverse Mechatronics products.

CO3: Understand and categorize different types of autonomous systems.

CO4: Develop the ability to design and implement basic automation and material handling systems.

CO5: Critically evaluate and apply communication protocols and automation technologies.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	1	-	-	-	1	-	-	-	-	-	-	2	-	2
CO2	1	-	2	1	-	-	-	-	-	-	-	-	1	2	-
CO3	-	2	-	2	-	-	-	-	1	-	-	-	-	3	2
CO4	-	-	2	-	1	-	-	-	-	-	1	-	1	2	2
CO5	-	2	-	-	1	-	-	-	-	1	-	-	-	1	1

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Introduction to Mechatronics, Sensors & Actuators: -Mechatronics, Examples of Mechatronics systems. Sensors: Types of sensors; Motion Sensors – Encoder (Absolute & incremental), Lidar, Eddy Current, Proximity (Optical, Inductive, Capacitive), MEMS Accelerometer; Temperature sensor –Pyrometer, Infrared Thermometer; Force / Pressure Sensors – Strain gauges, Piezoelectric sensor;	07

	Flow sensors – Electromagnetic, Ultrasonic, Hot-wire anemometer; Colour sensor – RGB type; Biosensors – Enzyme, ECG, EMG Actuators: Servo motor; Hydraulic and Pneumatic; linear electrical actuators Selection of Sensor & Actuator.	
2	Programmable Logic Controller and Signal Conditioning: - Introduction to PLC; Architecture of PLC; Selection of PLC; Ladder Logic programming for different types of logic gates, logic functions, Sequencing. Cascading. Signal Conditioning: Introduction, operational amplifier, protection, filtering, Wheatstone bridge, digital signals, multiplexers.	07
3	Introduction to Autonomous Systems: Definition and history of autonomous systems, Types of autonomous systems: ground, aerial, and underwater, Components of autonomous systems: sensors, actuators, controllers, and communication devices, Benefits and challenges of autonomous systems Robot - Definition - Robot Anatomy, Coordinate Systems, Work Envelope Types, Classification of Robots, Specifications, Robot Parts, and their Functions, Need for Robots, and Different Applications. End Effectors or Grippers- Selection and Design Considerations Mobile Robot: Principle of locomotion and types of locomotion. Types of mobile robots: ground robots (wheeled and legged robots), aerial robots, underwater robots and water surface robots	08
5	Introduction to Automation Systems: Definition, importance, and historical evolution. Types of Automation: Fixed automation, programmable automation, and flexible automation. Components of Automation Systems: Sensors, actuators, controllers, and communication networks.	03
6	Communication Systems for Autonomous Systems: Communication protocols and standards: Ethernet, Modbus, Profibus, CAN, and others, Wireless communication: Wi-Fi, Bluetooth, Zigbee, and others, Communication in autonomous vehicle networks Case study: Communication systems in autonomous vehicles	05

Textbooks:

1. Bolton, W. (2015). Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering. Pearson.
2. Mahalik, Mechatronics – Principles, concepts and applications, Tata Mc-Graw Hill publication, New Delhi.

References:

1. Siciliano, Bruno, and Oussama Khatib, eds. Springer Handbook of Robotics. 2nd ed. Cham: Springer, 2016.
2. Spong, Mark W., Seth Hutchinson, and M. Vidyasagar. Robot Modelling and Control. 2nd ed. Hoboken, NJ: Wiley, 2020.
3. Deb, S. R. Robotics Technology and Flexible Automation. 2nd ed. New Delhi: Tata McGraw-Hill, 2009.

4. "Introduction to Autonomous Mobile Robots" by Roland Siegwart, Illah Reza Nourbakhsh, and Davide Scaramuzza.
5. "Handbook of Unmanned Aerial Vehicles" by Kimon P. Valavanis and George J. Vachtsevanos

List of Experiments:

Sr.	Experiment Name
1.	Experiment on measurement of temperature using suitable sensor.
2.	Experiment on measurement of displacement using suitable sensor.
3.	Study and use of direction control of Servo motor using PLC.
4.	Demonstration of PLC controlled electrohydraulic / elector pneumatic circuit.
5.	Study about Automation of industrial processes using PLC or SCADA
6.	To dissect and analyse the components and functioning of a robotic toy, exploring its design, actuation, and control mechanisms
7.	To explore the principles of locomotion and navigation in mobile robots by programming a robot to navigate a predefined path while avoiding obstacles.
8.	Study and perform an experiment to measure the unknown Resistance by Wheatstone's bridge
9.	Study about Design and Implementation of a Communication Network for Automation
10.	Industrial visit to understand integration and application of Mechatronics and automation.

Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify it as necessary.

Alternative NPTEL/SWAYAM Course

Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Mechatronics and Manufacturing Automation.	Dr. Shrikrishna N. Joshi	IIT Guwahati

Optimisation Techniques

Course Code	PEC-PE314				
Category	Program Elective Course				
Course Title	Optimisation Techniques				
Scheme and Credits	L	T	P	No. of Credits	Semester
	2	0	2	3	VI

Course Objectives:

1. To learn about defining the problem.
2. To formulate the objective function.
3. To choose the correct optimization techniques.
4. To find the correct decision.
5. To study optimization problems.

Course Outcomes:

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

CO1: Explain the need of optimization of engineering systems.

CO2: Apply classical optimization techniques, linear programming, simplex algorithm, transportation problem.

CO3: Apply unconstrained optimization and constrained linear programming.

CO4: Generate optimal solutions for various queuing, transportation, and assignment problems.

CO5: Formulate optimization problems.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	-	2	-	-	-	-	-	-	1	1	-	1
CO2	2	2	1	1	-	-	-	-	-	-	-	1	1	-	-
CO3	3	-	1	-	1	-	-	-	-	-	-	-	-	1	-
CO4	2	1	2	1	-	1	-	1	-	2	-	1	1	-	-
CO5	3	3	-	2	2	1	-	-	1	1	-	3	1	1	1

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Introduction And Classical Optimization Techniques: Introduction and Classical Optimization Techniques: Statement of an Optimization problem, design vector, design constraints, constraint surface, objective function, objective function surfaces, classification of Optimization problems.	06

	Classical Optimization Techniques: Single variable Optimization, multi variable Optimization without constraints, necessary and sufficient conditions for minimum/maximum multivariable.	
2	Linear Programming: Analysis and model formulation various real-life problems, Canonical and standard form of LPP, Assumptions in LP, Graphical, Simplex, Dual Simplex, Big M method, Concept of Duality, Advantages and Limitations of LP models.	06
3	Transportation and Assignment Models: Formulation of Transportation problem. Finding basic feasible solutions, Northwest corner rule, least cost method, and Vogel's approximation method. Mathematical Formulation of the Problem, Hungarian Method Algorithm.	06
4	Introduction to Queuing Theory: Introduction and applications of queuing models, Basic structure and characteristics of queuing models, single channel queuing theory, birth-death process, finite queue variation, finite calling population variation further above model.	04
5	Simulation: Introduction, Methodology of Simulation, Basic Concepts, Simulation Procedure, Application of Simulation Monte-Carlo Method, Introduction, Monte-Carlo Simulation, Numerical	04
6	Inventory Models: Classical EOQ Models, EOQ Model with Price Breaks, EOQ with Shortage, Probabilistic EOQ Model.	04

Textbooks:

1. Prem Kumar Gupta, D. S. Hira, Problems in Operations Research: Principles and Solutions, S. Chand, 2010.

References:

1. Singiresu S. Rao, Engineering Optimization: Theory and Practice by John Wiley and Sons, 4th edition, 2009.
2. H. S. Kasene & K. D. Kumar, Introductory Operations Research, Springer (India), Pvt. Ltd., 2004
3. George Bernard Dantzig, Mukund Narain Thapa, "Linear programming", Springer series in operations research 3rd edition, 2003.
4. H.A. Taha, "Operations Research: An Introduction", 8th Edition, Pearson/Prentice Hall, 2007.
5. Kalyanmoy Deb, "Optimization for Engineering Design – Algorithms and Examples", PHI Learning Pvt. Ltd, New Delhi, 2005.

List of Experiments:

Sr.	Experiment Name
1	Numerical based on the above syllabus.
2	At least 2 assignments using Microsoft Solver for LPP.
3	Solve a single-variable optimization problem using first and second derivative tests.

4	Assignments - Case study: Optimization in mechanical design (e.g., minimizing material in a beam).
5	Assignments - Interpret primal and dual problems and their solutions.
6	Solve complete transportation problem using MODI method.
7	Solve a single-channel queuing model (M/M/1).
8	Simulate a production line or inventory model using Excel.
9	Derive and solve Classical EOQ model.
10	Solve EOQ with Price Breaks.

Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify it as necessary.

Alternative NPTEL/SWAYAM Course			
Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Fundamental of Operations Research	Prof. G. Srinivasan	IIT Madras
2	Operations Research	Prof. Kusum Deep	IIT Roorkee

Hydraulics and Pneumatics

Course Code	PEC-PE316				
Category	Program Elective Course				
Course Title	Hydraulics and Pneumatics				
Scheme and Credits	L	T	P	No. of Credits	Semester
	2	0	2	3	VI

Course Objectives:

1. To acquire basic knowledge of fluid systems and processes.
2. To understand the working principles of various components of hydraulic & pneumatic systems.
3. To acquire the knowledge of a selection of appropriate hydraulic and pneumatic systems.
4. To understand industrial applications of hydraulic and pneumatic systems.
5. To design hydraulic and pneumatic systems for industrial applications.

Course Outcomes:

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

CO1: Understand the principles of operation of various processes and fluid systems.

CO2: Identify various components of hydraulic & pneumatic systems.

CO3: Select appropriate components required for hydraulic and pneumatic systems.

CO4: Design hydraulic and pneumatic systems for industrial applications.

CO5: Troubleshoot hydraulic & pneumatic circuits.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	2	-	-	-	-	-	-	-	-	1	2	1	1
CO2	2	2	2	-	-	-	-	-	-	-	-	1	2	1	1
CO3	2	3	2	-	2	-	-	-	-	-	-	1	2	1	1
CO4	3	3	3	2	2	-	-	-	-	-	-	1	2	1	1
CO5	2	3	-	2	2	-	-	-	-	-	-	1	2	1	1

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Introduction to Hydraulics and Pneumatics Introduction to Hydraulics and Pneumatics, Introduction to oil hydraulics and pneumatics, their structure, advantages and limitations. Properties of fluids, Fluids for hydraulic systems, governing laws. Distribution of fluid power, ISO symbols, and energy losses in hydraulic systems.	07

2	Hydraulic Pumps and Power Units Types, classification, principle of working and constructional details of vane pumps, gear pumps, radial and axial plunger pumps, screw pumps, power and efficiency calculations, characteristics curves, and selection of pumps for hydraulic Power transmission. Power units and accessories: Types of power units, reservoir assembly, constructional details, pressure switches, temperature switches.	08
3	Hydraulic Actuators Linear and Rotary, Hydraulic motors - Types- Vane, Gear, Piston types, radial piston, Methods of control of acceleration and deceleration, Types of cylinders and mountings, Calculation of piston velocity and thrust under static and dynamic applications, considering friction and inertia loads, Design considerations for cylinders, Cushioning of cylinders. (Numerical analysis).	08
4	Hydraulic circuit design and analysis Definition of hydraulic circuits, control of a single-acting Hydraulic cylinder, regenerative cylinder circuit, pump-unloading circuit, hydraulic cylinder sequencing circuits, cylinder synchronising circuits, speed control of a hydraulic cylinder, speed control of a hydraulic motor, hydrostatic transmission system, analysis of hydraulic system with frictional losses.	07

Textbooks:

1. Fluid Power with Applications, Anthony Esposito, Seventh Edition, Pearson Education India; 7th edition 2013.
2. Oil Hydraulic System- Principle and Maintenance, S.R. Majumdar, McGraw Hill Education; 1st edition 2017.
3. Pneumatics Systems Principles and Maintenance, S.R. Majumdar, Tata McGraw Hill 2017.

References:

1. Industrial Hydraulics, J. J. Pipenger, Tata McGraw Hill 1980.
2. Power Hydraulics, Michael J, Princes and Ashby J. G, Longman Higher Education 1988.
3. Fluid Mechanics, Dr. R.K. Bansal, Laxmi Publications; Tenth edition 2019.

List of Experiments:

The laboratory work shall consist of assignments on the syllabus and the following laboratory tests on the material's mechanical properties.

Sr.	Experiment Name
1.	Test on Gear/Vane/Piston pump and plotting of performance characteristics.
2.	Experiments on a hydraulic trainer: a. Regenerative circuit b. Speed control circuit c. Sequencing circuit
3.	Experiments on a pneumatic trainer: a. Automatic reciprocating circuit b. Speed control circuit c. Pneumatic circuit involving shuttle valve/ quick exhaust valve
4	Test on filters.

5	Design of accumulators and intensifiers in hydraulic system.
6.	Design of air distribution in a pneumatic system.
7.	Design of simple hydraulic systems used in practice such as hydraulic clamps, jack, dumper, press etc.
8.	Assignment on ISO symbols for different components of Hydraulic and Pneumatic system.
9.	Assignment on different types of actuators used in Pneumatic and Hydraulic system.
10.	Assignment on troubleshooting procedures of various hydraulic and pneumatic systems.
11.	Assignment on the selection of circuit components for simple hydraulic and pneumatic systems.

Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify it as necessary.

Alternative NPTEL/SWAYAM Course			
Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Oil Hydraulics and Pneumatics	Prof. Somashekhar S.	IIT Madras
2	Fundamentals of Oil Hydraulics and Pneumatics	Prof. R.N. Maiti	IIT Kharagpur
3	Industrial Hydraulics and Automation	Prof. Niranjana Kumar	IIT Dhanbad

Industrial Robotic Lab.

Course Code	VSEC-PE302				
Category	Vocational Skill and Skill Enhancement Course				
Course Title	Industrial Robotic Lab.				
Scheme and Credits	L	T	P	No. of Credits	Semester
	0	0	4	2	VI

Course Objectives:

1. To familiarize with subtractive Industrial processes in particular Robotic systems.
2. To acquaint with the basic part programming process for specific operations.
3. To familiarize with the industrial manufacturing process in mainly robotic line.
4. To acquaint with the process of industrial production line using robotic systems.
5. To understand the advances factory process to automatically perform it.

Course Outcomes:

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

CO1: Familiarize with subtractive Industrial processes in particular robotic systems.

CO2: Build any given condition's using various robotic system.

CO3: Build any given real-life program using robotic system.

CO4: Develop a different condition program using robotic system.

CO5: Understand the factory process and convert into advance automation process.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	-	-	-	-	-	-	1	3	2	-
CO2	3	2	2	2	2	-	-	-	-	-	-	1	3	2	-
CO3	3	3	2	2	2	-	-	-	-	-	-	1	3	2	1
CO4	3	3	2	2	2	-	-	-	-	-	-	1	3	2	1
CO5	3	3		2	2	-	-	-	-	-	-	1	3	2	-

List of Experiments:

Sr.	Experiment Name
1.	Introduction of Machine Tending, Sand Core Drilling, Deburring, MIG Welding Robotic Systems.
2.	Study the 6-AXIS Yaskawa (GP12) industrial robot and jogging coordinate.
3.	Study the robotic programming and perform tasks with the robot.
4.	Program the Yaskawa robot to the given drawing.
5.	Program the Yaskawa robot to pick the components from AXB matrix of the fixture and place it in the output conveyor one by one with 2 Seconds of time delay each. (Machine tending robotic system)
6.	Program the Yaskawa robot to drill the given job as per the drawing attached. (Sand core drilling robotic system)
7.	Program the Yaskawa robot to arrange the components from AXB Matrix to CXD matrix using palletizing concept with vision inspection. (Vision Based robotic system)

8.	Program the Yaskawa robot to deburr the rectangular & Circular job. (Deburring robotic system)	
9.	Program the Yaskawa robot to pick the component from the in-feed conveyor and place it in the machine canopy for machining process. After machining, the robot must pick the component from the machine canopy and place it in the output conveyor. Repeat the cycle for 3 times with 2 seconds time delay.	
10.	Program the Yaskawa robot to weld the T joint for the given MS component. (Mig welding robotic system)	

Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify the list as necessary.

Textbooks:

1. Industrial Automation and Robotics 1st Edition 2022 Hardbound by Kumar, Kaushik, Taylor and Francis Ltd. Author: Kumar, Kaushik, Publisher: Taylor and Francis Ltd.
2. Essentials of Robotics Process Automation Author: S. Mukherjee.

References:

1. Robot Operating System (Ros): The Complete Reference (Volume 2), By: Anis Koubaa (Edited) | Publisher: Springer | Publisher Imprint: Springer.
2. Robotic Process Automation: Guide To Building Software Robots, Automate Repetitive Tasks & Become An RPA.
3. Intelligent Control of Robotic Systems, Author: Samrat Dutta Laxmidhar Behera & Swagat Kumar.
4. Programming Robots with ROS: A Practical Introduction to the Robot Operating System (Greyscale Indian Edition) 01/01/2016 Author: Morgan Quigley, Brian Gerkey, William D. Smart.

Alternative NPTEL/SWAYAM Course			
Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Automation in Manufacturing	Prof. S. N. Joshi	IIT Guwahati

Production Management

Course Code:	MDM-PE301				
Category:	Multidisciplinary Minor Course				
Course Title:	Production Management				
Scheme and Credits:	L	T	P	No. of Credits	Semester
	2	0	2	3	V

Course Objectives:

1. Understand the basic concepts, scope, and functions of production and operations management.
2. Analyze plant location and layout strategies for effective production systems.
3. Apply forecasting, production planning, and scheduling techniques in manufacturing systems.
4. Evaluate inventory control models and MRP systems for production optimization.
5. Understand modern practices like JIT, Lean, and Six Sigma to improve productivity.
6. Examine the impact of Industry 4.0 and digital technologies on production management.

Course Outcomes:

At the end of Course Students will be able to:

- CO1. Explain the functions and importance of production and operations management.
 CO2. Analyze factors influencing plant location and evaluate different layout types.
 CO3. Apply forecasting and production planning techniques in industrial scenarios.
 CO4. Evaluate inventory control systems and scheduling methods for efficient operations.
 CO5. Describe and apply Lean, JIT, and Six Sigma practices for process improvement.
 CO6. Analyze the role of smart technologies and Industry 4.0 in modern production systems.

CO-PO Mapping:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	-	-	-	-	-	-	-	-	-	-	1	-	-	1
CO2	3	3	1	-	-	-	-	-	-	-	-	-	-	-	-
CO3	1	1	1	2	-	-	-	-	-	-	-	1	1	-	-
CO4	1	-	2	3	2	-	-	-	-	-	-	-	-	-	-
CO5	1	-	2	-	2	-	-	-	1	-	-	1	-	-	-
CO6	1	3	2	-	2	2	-	-	1	1	1	1	-	-	-

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Introduction to Production Management: Definition, scope, and objectives of production management, Difference between production and operations management, Types of production	05

	systems (job, batch, mass, continuous), Productivity measurement and improvement techniques.	
2	Plant Location and Layout: Factors affecting plant location, Location selection methods, Plant layout objectives and types: process, product, fixed, cellular, Line balancing and layout optimization.	07
3	Forecasting and Production Planning: Importance of demand forecasting, Qualitative and quantitative methods (Moving average, Exponential smoothing, Regression), Production Planning and Control (PPC): objectives and functions, Aggregate planning strategies.	07
4	Capacity Planning and Scheduling: Capacity planning: types, measures, and factors, Master production schedule (MPS), Job sequencing and priority rules, Gantt charts, Johnson's rule, and scheduling techniques.	08
5	Inventory Management and Modern Practices: Inventory types and costs, Inventory control models: EOQ, ABC, VED, Material Requirement Planning (MRP), Introduction to ERP, JIT, Kanban, Lean manufacturing, and Six Sigma.	08
6	Emerging Trends in Production Management: Smart manufacturing and Industry 4.0, Role of AI, IoT, and robotics in production, Sustainable production and green manufacturing, Overview of digital twins and cyber-physical systems.	08

Textbooks:

1. "Production and Operations Management" S.N. Chary, McGraw Hill Education, Latest Edition.
2. "Operations Management" Jay Heizer and Barry Render, Pearson Education, 12th Edition, 2025.

References:

1. "Modern Production/Operations Management" Elwood S. Buffa & Rakesh K. Sarin, Wiley 2025.
2. "Operations Management for Competitive Advantage" Richard B. Chase, McGraw Hill.
3. "Production and Operations Management" K. Aswathappa, Himalaya Publishing.

List of Experiments:

Sr.	Experiment Name
1.	To design and compare different plant layouts (process, product, and cellular) using simulation software such as FlexSim / AutoCAD.
2.	To apply quantitative forecasting methods (e.g., moving average, exponential smoothing, regression) to historical demand data.
3.	To perform line balancing using heuristics like the Ranked Positional Weight method.
4.	To prepare MRP tables based on a bill of materials (BOM), lead times, and inventory data.

5.	To construct Gantt charts and sequence jobs using rules like FCFS, SPT, EDD.
6.	To implement EOQ, reorder point, and safety stock models using spreadsheet tools.
7.	To develop an aggregate production plan for a given demand pattern using level, chase, and mixed strategies.
8.	To simulate a manufacturing system and apply lean tools such as 5S, value stream mapping (VSM), and Kaizen.
9.	To apply DMAIC methodology to a simple process and use tools like cause-effect diagrams and control charts.
10.	To explore Industry 4.0 technologies (IoT, data analytics, digital twin) through virtual labs or case studies.

Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify the list as necessary.

Alternative NPTEL/SWAYAM Course			
Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Production and Operation Management	Prof. Rajat Agrawal	IIT Kharagpur

Industrial Engineering

Course Code	MDM-PE302				
Category	Multidisciplinary Minor				
Course Title	Industrial Engineering				
Scheme and Credits	L	T	P	No. of Credits	Semester
	3	0	0	3	VI

Course Objectives:

1. To introduce the concepts, principles, and framework of Industrial Engineering and Productivity enhancement approaches.
2. To familiarize the students with different time study and work measurement techniques for productivity improvement.
3. To introduce various aspects of facility design.
4. To acquaint the students with various components and functions of Production Planning and Control.
5. To acquaint the student about inventory management and approaches to control.

Course Outcomes:

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

CO1: Evaluate the productivity and implement various productivity improvement techniques.

CO2: Apply work study techniques and understand its importance for better productivity.

CO3: Demonstrate the ability to select plant location, appropriate layout and material handling equipment.

CO4: Use of Production planning and control tools for effective planning, scheduling and managing the shop floor control.

CO5: Plan inventory requirements and exercise effective control on manufacturing requirements.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	-	-	-	-	-	-	-	3	-	-
CO2	3	3	2	-	2	-	-	-	-	-	-	-	3	-	-
CO3	2	1	-		-	2	-	3	2	3	-	-	3	-	-
CO4	2	2	-		2	3	1	2	-	2	3	-	3	-	-
CO5	3	3	3	-	3	-	-	1	-	2	2	2	3	1	-

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Introduction to Industrial Engineering and Productivity Introduction to Industrial Engineering, Historical background and scope, Contribution of Taylor, Gilbreth, Gantt, Maynard, Ford, Deming and Ohno. Importance of Industrial engineering. Introduction to Work system design Productivity: Definition of productivity, Measures of Productivity, Total Productivity Model, Need for Productivity Evaluation, Productivity measurement models, Productivity improvement Work Study approaches, Principles, Productivity Improvement techniques – Technology based, Material based, Employee based, Product based techniques.	08
2	Work Study Method Study: Introduction and objectives, Areas of application of work study in industry, Selection and Basic procedure. Recording techniques, Operations Process Chart, Flow Process Chart (Man, Machine & Material) Multiple Activity Chart, Two Handed process chart, Flow Diagram, String Diagram and Travel Chart, SIMO chart, Therbligs, Micro motion and macro-motion study: Principles of motion economy, Normal work areas and workplace design. Work Measurement: Techniques, time study, steps, work sampling, Determination of time standards. Observed time, basic time, normal time, rating factors, allowances, standard time, and standard time determination.	08
3	Production Facility Design Plant Location: Introduction, Factors affecting location decisions, Multi-facility location Plant Layout: Principles of Plant layout and Types, factors affecting layout, methods, factors governing flow pattern, travel chart for flow analysis, analytical tools of plant layout, layout of manufacturing shop floor, repair shop, services sectors, and process plant. Layout planning, Quantitative methods of Plant layout and relationship diagrams. Dynamic plant layout. Material Handling: Objectives and benefits of Material handling, Relationship between layout and Material handling, Equipment selection.	06
4	Production Planning and Control Types and methods of Production, and their Characteristics, functions and objectives of Production Planning and Control, Steps: Process planning, Loading, Scheduling, Dispatching and Expediting with illustrative examples, Capacity Planning, Aggregate production planning and Master production scheduling. Introduction to a line of balance, assembly line balancing, and progress control. Forecasting Techniques: Causal and time series models, Moving average, Exponential smoothing, Trend and Seasonality.	08
5	Inventory and Inventory Control	08

	Inventory: Functions, Costs, Classifications, Deterministic inventory models and Quantity discount Inventory Control: EOQ (Numerical), concepts, type of Inventory models-deterministic and probabilistic, Selective inventory control, Fundamental of Material Requirement Planning (MRP-I), Manufacturing Resource Planning (MRP-II), Enterprise Resource Planning (ERP), Just-in-Time system (JIT) and Supply Chain Management (SCM)	
6	Value Engineering and Job Evaluation Value Engineering: VE concepts, Principles, Methodologies and standards, methods of functional analysis. Job Evaluation and Wage Plan: Objective, Methods of job evaluation, job evaluation procedure, merit rating (Performance appraisal), method of merit rating, wage and wage incentive plans, Performance appraisal, concept of KRA (Key Result Areas), Introduction to industrial legislation.	06

Textbooks:

4. O. P. Khanna, Industrial engineering and management, Dhanpat Rai Publications (P) Ltd.-New D 2018.
5. M Mahajan, Industrial Engineering and Production Management, Dhanpat Rai & Co. (P) Limited 2015.
6. Industrial Engineering and Production Management by Martand Telsang, published by S. Chand, is the Third Edition. This edition was published on January 1, 2018

References:

1. Banga and Sharma, Industrial Organization & Engineering Economics, Khanna publication
2. Askin, Design and Analysis of Lean Production System, Wiley, India
3. Introduction to Work Study by ILO, ISBN 978-81-204-1718-2, Oxford & IBH Publishing Company, New Delhi, Second Indian Adaptation, 2008.
4. H. B. Maynard, K Jell, Maynard's Industrial Engineering Handbook, McGraw Hill Education.
5. Zandin K.B., Most Work Measurement Systems, ISBN 0824709535, CRC Press, 2002
6. Martin Murry, SAP ERP: Functionality and Technical Configuration, SAP Press.
7. Barnes, Motion and time Study design and Measurement of Work, Wiley India
8. Sumanth, D.J, "Productivity Engineering and Management", TMH, New Delhi, 1990.
9. Edosomwan, J.A, "Organizational Transformation and Process re- Engineering", British Cataloging in publications, 1996.
10. Prem Vrat, Sardana, G.D. and Sahay, B.S, "Productivity Management - A systems approach", Narosa Publications, New Delhi, 1998.

Alternative NPTEL/SWAYAM Course			
Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Principles of Industrial Engineering	Prof. D K Dwivedi	IIT Roorkee

Renewable Energy Resources

Course Code	OE-PE301				
Category	Open Elective				
Course Title	Renewable Energy Resources				
Scheme and Credits	L	T	P	No. of Credits	Semester
	2	0	0	2	V

Course Objectives:

1. To study energy generation, different energy sources, and their utilization and environmental impact.
2. To gain knowledge of solar radiation and its applications
3. To understand the wind energy and its nature.
4. To analyze the performance of solar collectors and wind turbines.
5. To learn about fuel cells and their efficiency.

Course Outcomes:

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

CO1: Interpret the energy reserves of India and the potential of different energy sources.

CO2: Measure the solar radiation parameters and performance of different solar collectors.

CO3: Calculate different parameters of the wind turbine rotor.

CO4: Implicit the importance and applications of geothermal and ocean energy.

CO5: Demonstrate knowledge in the field of fuel cells and potential for power generation.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	-	-	-	1	-	-	-	-	-	-	-	1	-	-
CO2	2	-	3	-	-	-	-	-	-	-	-	1	-	-	-
CO3	-	-	3	2	-	-	-	-	-	-	-	-	-	2	-
CO4	1	-	-	-	2	-	-	-	-	-	-	-	1	-	-
CO5	1	-	-	-	3	-	-	-	-	-	-	-	1	-	-

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Energy Resources and Utilization Conservation and forms of energy, energy reserves in India, nuclear power, hydroelectric power potential, India's power scene, renewable energy sources, energy parameters, cogeneration, rational energy use of energy, energy efficiency and conservation, new technologies, distributed energy systems, and dispersed generation.	03
2	Solar Energy Solar constant, spectral distribution of extraterrestrial radiation, terrestrial	06

	solar radiation, solar radiation geometry, computation of $\cos\theta$, sunrise, sunset, day length, LAT, Empirical equation for estimating the availability of solar radiation, solar radiation measurement, and Solar radiation data for India. Solar Thermal energy collectors, design parameters, analysis, performance, Solar Thermal energy storage. solar photovoltaic system, materials for solar cells, characteristics, efficiency, applications PV system	
3	Wind Energy Classification, types of rotors, terminology, operation of wind turbines, wind energy extraction, wind characteristics, wind speed, energy estimation, power density duration curve, density function, field data analysis, direction and wind speed, variation of wind speed, wind scale, energy pattern factor in wind power studies, land for wind energy, design of wind turbine rotor, regulating system, wind power generation curve, horizontal axis wind turbine generator, modes of wind power generation, advantages and disadvantages. Wind energy farms.	06
4	Ocean Energy and Geothermal Energy Ocean Energy: Tidal Energy, Tidal characteristics, Tidal Energy estimation, Development of a tidal power scheme, Yearly power generation from Tidal Plants, Economics of Tidal Power, Wave characteristics energy and power from the waves, wave energy conversion devices.	06
5	Geothermal Energy: Structure of earth's interior, sites, field, gradient, resources, power generation, geothermal resources in India, utilization, global status of electricity generation from geothermal resources, advantages of geothermal energy.	06
6	Fuel Cells Principle of operation of an acidic Fuel Cell, Technical parameter, Fuel Processor, methanol fuel cell, fuel cell types, Advantages of fuel cell power plants, fuel cell battery-powered bus system, comparison between acidic and alkaline hydrogen-oxygen fuel cells, state-of-the-art fuel cells, energy output of a fuel cell, efficiency and EMF of a fuel cell, Gibbs Helmholtz equation, hydrogen fuel cell analysis with thermodynamic potentials, comparison of electrolysis and the fuel cell process, operating characteristics of fuel cells, thermal efficiency, future potential.	06
Textbooks:		
1. G. D. Rai, "Non- conventional Energy Sources", Khanna publishers, New Delhi, 2011. 2. Chetan Singh Solanki, "Renewable Energy Technologies", Prentice Hall of India, New Delhi, 2009.		
References:		
1. D.P. Kothari, K.C. Singal and Rakesh Ranjan, "Renewable Energy Sources and Emerging Technologies", Prentice Hall of India, New Delhi, 2009 2. Malti Goel, "Energy Sources and Global Warming", allied publishers Pvt Ltd. New Delhi, 2005. 3. S.P. Sukhatme, "Solar Energy: Principles of Thermal Collection and Storage", TMH, New Delhi.		

Alternative NPTEL/SWAYAM Course			
Sr.	NPTEL Courses Name	Instructor	Host Institute
1	Renewable Energy Engineering: Solar, Wind, and Biomass Energy Systems	Prof. Vaibhav Goud	IIT Guwahati
2	Solar Energy Engineering and Technology	Prof. Pankaj kalita	IIT Guwahati

Minor Project

Course Code	EX-PE302				
Category	Exit Course				
Course Title	Minor Project				
Scheme and Credits	L	T	P	No. of credits	Semester
	0	0	8	4	NA

Course Objectives:

1. To develop the ability in the students to apply some of the techniques/principles that have been taught, in real life engineering problems.
2. To study and conduct mini project / case studies.
3. To study different types of recent techniques.
4. To conduct literature survey using research papers.
5. To enhance presentation skills.

Course Outcomes:

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

1. Identify an open-ended problem in area of mechanical engineering which requires further investigation.
2. Identify the methods and materials required for the project work.
3. Formulate and implement innovative ideas for social and environmental benefits.
4. Analyse the results to come out with concrete solutions.
5. Write technical report of the project apart from developing a presentation.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	-	-	-	-	-	-	1	3	2	-
CO2	3	2	2	2	2	-	-	-	-	-	-	1	3	2	-
CO3	3	3	2	2	2	-	-	-	-	-	-	1	3	2	1
CO4	3	3	2	2	2	-	-	-	-	-	-	1	3	2	1
CO5	3	3		2	2	-	-	-	-	-	-	1	3	2	-

Course Contents:

A student is required to carry out the project work related to Mechanical/Production Engineering, under the guidance of a faculty member and/or the supervisor of the concerned industry/institute/organization. The student can undertake the project individually or in a group of not more than four students. The project must cover at least any one area suggested below:

- Design, analysis and/or fabrication
- Experimentation, Product design and development
- Design and development of laboratory equipment's/test rigs.
- Industry needs based basic survey or Testing or Analysis etc.

Computer Aided Drafting Lab.

Course Code	EX-PE304				
Category	Exit Course				
Course Title	Computer Aided Drafting Lab.				
Scheme and Credits	L	T	P	No. of Credits	Semester
	0	0	4	2	NA

Course Objectives:

1. To know about file management techniques in a CAD software.
2. To Draw complex 2D geometric figures using CAD software.
3. To Modify complex 2D geometric figures using CAD software.
4. To dimensions and write text on existing 2D geometric entities
5. To plot existing drawing with desired parameters.

Course Outcomes:

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

CO1: Use file management techniques in a CAD software.

CO2: Draw complex 2D geometric figures using CAD software.

CO3: Modify complex 2D geometric figures using CAD software.

CO4: Use software to dimensions and write text on existing 2D geometric entities.

CO5: Use software to plot existing drawing with desired parameters.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	-	-	-	-	-	-	1	3	2	-
CO2	3	2	2	2	2	-	-	-	-	-	-	1	3	2	-
CO3	3	3	2	2	2	-	-	-	-	-	-	1	3	2	1
CO4	3	3	2	2	2	-	-	-	-	-	-	1	3	2	1
CO5	3	3		2	2	-	-	-	-	-	-	1	3	2	-

List of Experiments:

Sr.	Experiment Name
1.	Initiate the Graphics Package; Setting the paper size, space; setting the limits, units etc.
2.	A. Initiate the Graphics Package- use of snap and grid commands.
3.	B. Initiate the Graphics Package- use of snap and grid commands.
4.	A. Draw the basic sketch of the solid model.
5.	B. Draw the basic sketch of the solid model.
6.	A. Draw the basic sketch for the revolved solid model.
7.	B. Draw the basic sketch for the revolved solid model.
8.	A. Draw the sketch for the 3D modeling of solid work given dimension.
9.	B. Draw the sketch for the 3D modeling of solid work given dimension.

10.	A. Operating model of edge cam part modeling.
11.	B. Operating model of edge cam part modeling.
12.	A. Draw the sketch of the given model.
13.	B. Draw the sketch of the given model.
Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify the list as necessary.	
Textbooks:	
1. Computer-Aided Drafting Laboratory Manual by Dr. Y. Rameswara Reddy & K. Pavan Kumar Reddy (2023). 2. Computer-Aided Engineering Drawing, 7th Edition by Subrata Pal & Madhusudan Bhattacharyya (2015). 3. Technical Drawing 101 with AutoCAD 2025 by Ashleigh Congdon-Fuller, Antonio Ramirez, and Douglas Smith (2024). 4. Introduction to AutoCAD 2025 for Civil Engineering Applications by Nighat Yasmin (2024).	
References:	
1. Principles and Practice: An Integrated Approach to Engineering Graphics and AutoCAD 2024. 2. Technical Drawing 101 with AutoCAD 2025. 3. Engineering Graphics Essentials with AutoCAD 2025 Instruction. 4. AutoCAD 2024 Tutorial First Level 2D Fundamentals. 5. Introduction to AutoCAD 2024 for Civil Engineering Applications. 6. AutoCAD 2024: A Power Guide for Beginners and Intermediate Users. 7. AutoCAD 2024 Beginning and Intermediate.	

CAD- Lab.

Course Code	EX-PE306				
Category	Exit Course				
Course Title	CAD-ANSYS Lab.				
Scheme and Credits	L	T	P	No. of Credits	Semester
	0	0	4	2	NA

Course Objectives:

1. To study the force and stress in mechanical components.
2. To study deflection in mechanical components.
3. To study thermal stress of mechanical components.
4. To know heat transfer in mechanical components.
5. To study the vibration of mechanical components.

Course Outcomes:

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

- CO1: Analyse the effect of force and impact of stress on the mechanical components.
CO2: Calculate the deflection occurring on the mechanical components.
CO3: Get a detailed understanding of the thermal stress creation and its mechanism of spreading in mechanical components.
CO4: Gain knowledge regarding the mechanism of heat transfer in mechanical components.
CO5: Find out the vibration effects on mechanical components.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	-	-	-	-	-	-	1	3	2	-
CO2	3	2	2	2	2	-	-	-	-	-	-	1	3	2	-
CO3	3	3	2	2	2	-	-	-	-	-	-	1	3	2	1
CO4	3	3	2	2	2	-	-	-	-	-	-	1	3	2	1
CO5	3	3		2	2	-	-	-	-	-	-	1	3	2	-

List of Experiments:

Sr.	Experiment Name
1	Study of Basics in ANSYS.
2	Stress analysis of a plate with a circular hole.
3	Stress analysis of rectangular L bracket.
4	Stress analysis of cantilever beam.
5	Stress analysis of simply supported beam.
6	Stress analysis of fixed beam.
7	Stress analysis of an axi-symmetric component.
8	Thermal stress analysis of a 2D component.

9	Conductive heat transfer analysis of a 2D component.
10	Convective heat transfer analysis of a 2D component.
11	Mode frequency analysis of cantilever beam.
12	Mode frequency analysis of simply supported beam.
Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify the list as necessary.	
Textbooks:	
1. Automation, Production systems and Computer Integrated Manufacturing, 3/e - M. PGroover Pearson Education; Fourth edition 2016.	
2. Computer Integrated Design and Manufacturing - Bedworth, Henderson & Wolfe, McGraw-Hill Inc.,US 1991.	
3. Performance Modelling of Automated Manufacturing Systems, 2/e - Viswanadham, N & Narahari, Y. Prentice-Hall 1992.	
References:	
1. Principles of Computer Integrated Manufacturing - S. Kant Vajpayee, Prentice Hall India Learning Private Limited 1998.	
2. CAD / CAM Principles and Applications - P.N. Rao McGraw Hill Education; 3rd edition 2017.	
3. CAD/CAM/CIM – Radhakrishnan, Subramanayam & Raju New Age International Pvt Ltd. Fourth edition 2018.	
4. Computer Integrated Manufacturing, - James A. Rehg, H. W. Kraebber, Pearson; 2nd edition 2000.	
5. MAP/TOP Networking: Foundation of CIM – Vincent Jones (McGraw Hill).	

CNC Lab.

Course Code	EX-PE308				
Category	Exit Course				
Course Title	CNC Lab.				
Scheme and Credits	L	T	P	No. of Credits	Semester
	0	0	4	2	NA

Course Objectives:

- 1: To study the part programming and operations of CNC machines.
- 2: To study program of various jobs on CNC turning center.
- 3: To study program of various jobs on CNC machining center.
- 4: To study CNC programming skills for milling applications.
5. To study various jobs on CNC lathe and milling machine.

Course Outcomes:

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

- CO1: Understand the part programming and operations of CNC machines.
 CO2: Write program of various jobs on CNC turning center.
 CO3: Write program of various jobs on CNC machining center.
 CO4: Learn CNC programming skills for milling applications.
 CO5: Learn various jobs on CNC lathe and milling machine.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	-	2	1	1	-	-	-	-	-	-	1	3	2	-
CO2	3	-	2	2	2	-	-	-	-	-	-	1	3	2	-
CO3	3	2	2	2	2	-	-	-	-	-	-	1	3	2	1
CO4	3	2	2	2	2	-	-	-	-	-	-	1	3	2	1
CO5	3	2		2	2	-	-	-	-	-	-	1	3	2	-

List of Experiments:

Sr.	Experiment Name
1	Study of constructional detail of CNC lathe.
2	Creating a simple cylindrical profile (facing, turning, parting).
3	Creating grooves using appropriate tool paths.
4	Machining external threads using CNC programming.
5	Study of constructional detail of CNC milling machine.
6	Study the constructional details and working of Automatic tool changer and Multiple pallets.
7	Creating a flat surface using a face mill.
8	Machining external profiles of a given shape.
9	Develop a part programme for following lathe operations and make the job on CNC lathe: Plain turning and facing operation Taper turning operation Circular interpolation

10	Develop a part programme for the following milling operation and make the job on CNC milling: Plain milling Slot milling Contouring Pocket milling.
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Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify the list as necessary.

Industrial Robotic Lab.

Course Code	EX-PE310				
Category	Exit course				
Course Title	Robotic Lab.				
Scheme and Credits	L	T	P	No. of Credits	Semester
	0	0	4	2	NA

Course Objectives:

1. To familiarize with subtractive Industrial processes in particular Robotic systems.
2. To acquaint with the basic part programming process for specific operations.
3. To familiarize with the industrial manufacturing process in mainly robotic line.
4. To acquaint with the process of industrial production line using robotic systems.
5. To understand the advances factory process to automatically perform it.

Course Outcomes:

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

CO1: Familiarize with subtractive Industrial processes in particular robotic systems.

CO2: Build any given condition's using various robotic system.

CO3: Build any given real-life program using robotic system.

CO4: Develop a different condition program using robotic system.

CO5: Understand the factory process and convert into advance automation process.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	-	-	-	-	-	-	1	3	2	-
CO2	3	2	2	2	2	-	-	-	-	-	-	1	3	2	-
CO3	3	3	2	2	2	-	-	-	-	-	-	1	3	2	1
CO4	3	3	2	2	2	-	-	-	-	-	-	1	3	2	1
CO5	3	3		2	2	-	-	-	-	-	-	1	3	2	-

List of Experiments:

Sr.	Experiment Name
1.	Introduction of Machine Tending, Sand Core Drilling, Deburring, MIG Welding Robotic Systems.
2.	Study the 6-AXIS Yaskawa (GP12) industrial robot and jogging coordinate.
3.	Study the robotic programming and perform tasks with the robot.
4.	Program the Yaskawa robot to the given drawing.
5.	Program the Yaskawa robot to pick the components from AXB matrix of the fixture and place it in the output conveyor one by one with 2 Seconds of time delay each. (Machine tending robotic system)
6.	Program the Yaskawa robot to drill the given job as per the drawing attached. (Sand core drilling robotic system).

7.	Program the Yaskawa robot to arrange the components from AXB Matrix to CXD matrix using palletizing concept with vision inspection. (Vision Based robotic system)
8.	Program the Yaskawa robot to deburr the rectangular & Circular job. (Deburring robotic system).
9.	Program the Yaskawa robot to pick the component from the in-feed conveyor and place it in the machine canopy for machining process. After machining, the robot must pick the component from the machine canopy and place it in the output conveyor. Repeat the cycle for 3 times with 2 seconds time delay.
10.	Program the Yaskawa robot to weld the T joint for the given MS component. (Mig welding robotic system).

Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify the list as necessary.

Textbooks:

1. Industrial Automation and Robotics 1st Edition 2022 Hardbound by Kumar, Kaushik, Taylor and Francis Ltd. Author: Kumar, Kaushik, Publisher: Taylor and Francis Ltd.
2. Essentials of Robotics Process Automation Author: S. Mukherjee.

References:

1. Robot Operating System (Ros): The Complete Reference (Volume 2), By: Anis Koubaa (Edited) | Publisher: Springer | Publisher Imprint: Springer.
2. Robotic Process Automation: Guide To Building Software Robots, Automate Repetitive Tasks & Become An RPA.
3. Intelligent Control of Robotic Systems, Author: Samrat Dutta Laxmidhar Behera & Swagat Kumar.
4. Programming Robots with ROS: A Practical Introduction to the Robot Operating System (Greyscale Indian Edition) 01/01/2016 Author: Morgan Quigley, Brian Gerkey, William D. Smart.

Alternative NPTEL/SWAYAM Course			
Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Automation in Manufacturing	Prof. S. N. Joshi	IIT Guwahati

Production Management

Course Code:	DM-PE301				
Category:	Double Minor Course				
Course Title:	Production Management				
Scheme and Credits:	L	T	P	No. of Credits	Semester
	2	0	2	3	V

Course Objectives:

1. Understand the basic concepts, scope, and functions of production and operations management.
2. Analyze plant location and layout strategies for effective production systems.
3. Apply forecasting, production planning, and scheduling techniques in manufacturing systems.
4. Evaluate inventory control models and MRP systems for production optimization.
5. Understand modern practices like JIT, Lean, and Six Sigma to improve productivity.
6. Examine the impact of Industry 4.0 and digital technologies on production management.

Course Outcomes:

At the end of Course Students will be able to:

- CO1. Explain the functions and importance of production and operations management.
 CO2. Analyze factors influencing plant location and evaluate different layout types.
 CO3. Apply forecasting and production planning techniques in industrial scenarios.
 CO4. Evaluate inventory control systems and scheduling methods for efficient operations.
 CO5. Describe and apply Lean, JIT, and Six Sigma practices for process improvement.
 CO6. Analyze the role of smart technologies and Industry 4.0 in modern production systems.

CO-PO Mapping:

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	1	-	-	-	-	-	-	-	-	-	-	1	-	-	1
CO2	3	3	1	-	-	-	-	-	-	-	-	-	-	-	-
CO3	1	1	1	2	-	-	-	-	-	-	-	1	1	-	-
CO4	1	-	2	3	2	-	-	-	-	-	-	-	-	-	-
CO5	1	-	2	-	2	-	-	-	1	-	-	1	-	-	-
CO6	1	3	2	-	2	2	-	-	1	1	1	1	-	-	-

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Introduction to Production Management: Definition, scope, and objectives of production management, Difference between production and operations management, Types of production	05

	systems (job, batch, mass, continuous), Productivity measurement and improvement techniques.	
2	Plant Location and Layout: Factors affecting plant location, Location selection methods, Plant layout objectives and types: process, product, fixed, cellular, Line balancing and layout optimization.	07
3	Forecasting and Production Planning: Importance of demand forecasting, Qualitative and quantitative methods (Moving average, Exponential smoothing, Regression), Production Planning and Control (PPC): objectives and functions, Aggregate planning strategies.	07
4	Capacity Planning and Scheduling: Capacity planning: types, measures, and factors, Master production schedule (MPS), Job sequencing and priority rules, Gantt charts, Johnson's rule, and scheduling techniques.	08
5	Inventory Management and Modern Practices: Inventory types and costs, Inventory control models: EOQ, ABC, VED, Material Requirement Planning (MRP), Introduction to ERP, JIT, Kanban, Lean manufacturing, and Six Sigma.	08
6	Emerging Trends in Production Management: Smart manufacturing and Industry 4.0, Role of AI, IoT, and robotics in production, Sustainable production and green manufacturing, Overview of digital twins and cyber-physical systems.	08

Textbooks:

1. "Production and Operations Management" S.N. Chary, McGraw Hill Education, Latest Edition.
2. "Operations Management" Jay Heizer and Barry Render, Pearson Education, 12th Edition, 2025.

References:

1. "Modern Production/Operations Management" Elwood S. Buffa & Rakesh K. Sarin, Wiley 2025.
2. "Operations Management for Competitive Advantage" Richard B. Chase, McGraw Hill.
3. "Production and Operations Management" K. Aswathappa, Himalaya Publishing.

List of Experiments:

Sr.	Experiment Name
1.	To design and compare different plant layouts (process, product, and cellular) using simulation software such as FlexSim / AutoCAD.
2.	To apply quantitative forecasting methods (e.g., moving average, exponential smoothing, regression) to historical demand data.
3.	To perform line balancing using heuristics like the Ranked Positional Weight method.
4.	To prepare MRP tables based on a bill of materials (BOM), lead times, and inventory data.

5.	To construct Gantt charts and sequence jobs using rules like FCFS, SPT, EDD.
6.	To implement EOQ, reorder point, and safety stock models using spreadsheet tools.
7.	To develop an aggregate production plan for a given demand pattern using level, chase, and mixed strategies.
8.	To simulate a manufacturing system and apply lean tools such as 5S, value stream mapping (VSM), and Kaizen.
9.	To apply DMAIC methodology to a simple process and use tools like cause-effect diagrams and control charts.
10.	To explore Industry 4.0 technologies (IoT, data analytics, digital twin) through virtual labs or case studies.

Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify the list as necessary.

Alternative NPTEL/SWAYAM Course			
Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Production and Operation Management	Prof. Rajat Agrawal	IIT Kharagpur

Industrial Engineering

Course Code	DM-PE302				
Category	Double Minor course				
Course Title	Industrial Engineering				
Scheme and Credits	L	T	P	No. of Credits	Semester
	3	0	0	3	VI

Course Objectives:

1. To introduce the concepts, principles, and framework of Industrial Engineering and Productivity enhancement approaches.
2. To familiarize the students with different time study and work measurement techniques for productivity improvement.
3. To introduce various aspects of facility design.
4. To acquaint the students with various components and functions of Production Planning and Control.
5. To acquaint the student about inventory management and approaches to control.

Course Outcomes:

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

CO1: Evaluate the productivity and implement various productivity improvement techniques.

CO2: Apply work study techniques and understand its importance for better productivity.

CO3: Demonstrate the ability to select plant location, appropriate layout and material handling equipment.

CO4: Use of Production planning and control tools for effective planning, scheduling and managing the shop floor control.

CO5: Plan inventory requirements and exercise effective control on manufacturing requirements.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	1	-	-	-	-	-	-	-	-	-	3	-	-
CO2	3	3	2	-	2	-	-	-	-	-	-	-	3	-	-
CO3	2	1	-		-	2	-	3	2	3	-	-	3	-	-
CO4	2	2	-		2	3	1	2	-	2	3	-	3	-	-
CO5	3	3	3	-	3	-	-	1	-	2	2	2	3	1	-

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Introduction to Industrial Engineering and Productivity Introduction to Industrial Engineering, Historical background and scope, Contribution of Taylor, Gilbreth, Gantt, Maynard, Ford, Deming and Ohno. Importance of Industrial engineering. Introduction to Work system design Productivity: Definition of productivity, Measures of Productivity, Total Productivity Model, Need for Productivity Evaluation, Productivity measurement models, Productivity improvement Work Study approaches, Principles, Productivity Improvement techniques – Technology based, Material based, Employee based, Product based techniques.	08
2	Work Study Method Study: Introduction and objectives, Areas of application of work study in industry, Selection and Basic procedure. Recording techniques, Operations Process Chart, Flow Process Chart (Man, Machine & Material) Multiple Activity Chart, Two Handed process chart, Flow Diagram, String Diagram and Travel Chart, SIMO chart, Therbligs, Micro motion and macro-motion study: Principles of motion economy, Normal work areas and workplace design. Work Measurement: Techniques, time study, steps, work sampling, Determination of time standards. Observed time, basic time, normal time, rating factors, allowances, standard time, and standard time determination.	08
3	Production Facility Design Plant Location: Introduction, Factors affecting location decisions, Multi-facility location Plant Layout: Principles of Plant layout and Types, factors affecting layout, methods, factors governing flow pattern, travel chart for flow analysis, analytical tools of plant layout, layout of manufacturing shop floor, repair shop, services sectors, and process plant. Layout planning, Quantitative methods of Plant layout and relationship diagrams. Dynamic plant layout. Material Handling: Objectives and benefits of Material handling, Relationship between layout and Material handling, Equipment selection.	06
4	Production Planning and Control Types and methods of Production, and their Characteristics, functions and objectives of Production Planning and Control, Steps: Process planning, Loading, Scheduling, Dispatching and Expediting with illustrative examples, Capacity Planning, Aggregate production planning and Master production scheduling. Introduction to a line of balance, assembly line balancing, and progress control. Forecasting Techniques: Causal and time series models, Moving average, Exponential smoothing, Trend and Seasonality.	08
5	Inventory and Inventory Control	08

	Inventory: Functions, Costs, Classifications, Deterministic inventory models and Quantity discount Inventory Control: EOQ (Numerical), concepts, type of Inventory models-deterministic and probabilistic, Selective inventory control, Fundamental of Material Requirement Planning (MRP-I), Manufacturing Resource Planning (MRP-II), Enterprise Resource Planning (ERP), Just-in-Time system (JIT) and Supply Chain Management (SCM)	
6	Value Engineering and Job Evaluation Value Engineering: VE concepts, Principles, Methodologies and standards, methods of functional analysis. Job Evaluation and Wage Plan: Objective, Methods of job evaluation, job evaluation procedure, merit rating (Performance appraisal), method of merit rating, wage and wage incentive plans, Performance appraisal, concept of KRA (Key Result Areas), Introduction to industrial legislation.	06

Textbooks:

7. O. P. Khanna, Industrial engineering and management, Dhanpat Rai Publications (P) Ltd.-New D 2018.
8. M Mahajan, Industrial Engineering and Production Management, Dhanpat Rai & Co. (P) Limited 2015.
9. Industrial Engineering and Production Management by Martand Telsang, published by S. Chand, is the Third Edition. This edition was published on January 1, 2018

References:

11. Banga and Sharma, Industrial Organization & Engineering Economics, Khanna publication
12. Askin, Design and Analysis of Lean Production System, Wiley, India
13. Introduction to Work Study by ILO, ISBN 978-81-204-1718-2, Oxford & IBH Publishing Company, New Delhi, Second Indian Adaptation, 2008.
14. H. B. Maynard, K Jell, Maynard's Industrial Engineering Handbook, McGraw Hill Education.
15. Zandin K.B., Most Work Measurement Systems, ISBN 0824709535, CRC Press, 2002
16. Martin Murry, SAP ERP: Functionality and Technical Configuration, SAP Press.
17. Barnes, Motion and time Study design and Measurement of Work, Wiley India
18. Sumanth, D.J, "Productivity Engineering and Management", TMH, New Delhi, 1990.
19. Edosomwan, J.A, "Organizational Transformation and Process re- Engineering", British Cataloging in publications, 1996.
20. Prem Vrat, Sardana, G.D. and Sahay, B.S, "Productivity Management - A systems approach", Narosa Publications, New Delhi, 1998.

Alternative NPTEL/SWAYAM Course			
Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Principles of Industrial Engineering	Prof. D K Dwivedi	IIT Roorkee

Smart Manufacturing

Course Code	HON-PEMF301				
Category	Honor Course- Manufacturing Engineering				
Course Title	Smart Manufacturing				
Scheme and Credits	L	T	P	No. of Credits	Semester
	2	0	2	3	V

Course Objectives:

1. To impart knowledge on the fundamentals of manufacturing and Industry 4.0.
2. To provide a comprehensive understanding of Smart Manufacturing, its relevance in the modern industrial landscape, and practical application knowledge for effective implementation of Smart Manufacturing solutions.
3. To explore the key technologies, tools, and data acquisition techniques employed in Smart Manufacturing, enabling students to understand the implementation of advanced technologies and data-driven decision-making processes in manufacturing environments.
4. To examine the challenges and opportunities associated with implementing Smart Manufacturing systems.
5. To give the exposure on ML algorithms in manufacturing and data analytics.

Course Outcomes:

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

CO1: Gain knowledge on the fundamentals of manufacturing and Industry 4.0.

CO2: Understanding of Smart Manufacturing, its relevance in the modern industrial landscape, and practical application knowledge for effective implementation of Smart Manufacturing solutions.

CO3: Understand the implementation of advanced technologies and data-driven decision-making processes in manufacturing environments.

CO4: Solve challenges and gain opportunities associated with implementing Smart Manufacturing systems.

CO5: Understand ML algorithms in manufacturing and data analytics.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	-	-	-	-	-	-	-	-	-	-	2	2	-	-
CO2	2	2	2	1	-	-	-	-	2	1	-	1	2	-	1
CO3	2	2	2	2	1	-	-	-	2	1	-	1	2	1	2
CO4	2	2	2	1	1	1	1	-	-	1	-	2	2	1	1
CO5	2	2	2	1	1	1	1	-	-	1	-	2	2	1	1

Course Content:

Unit No.	Unit Title and Contents	Hours
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1	Introduction to Smart Manufacturing - Definition, objectives, benefits of Smart Manufacturing, Evolution of manufacturing systems, Key components and technologies in Smart Manufacturing, Industrial Automation and Control Systems. Basic principles and technologies of a Smart manufacturing, Digitalization and the Networked Economy, Globalization and Emerging Issues. Cyber-Physical Systems and Cyber-Physical Production Systems, smart work piece, Digital Twins in production, Assistance systems for production.	05
2	Smart Design & Fabrication Smart Design/Fabrication - Digital Tools, Product Representation and Exchange Technologies and Standards, Agile (Additive) Manufacturing Systems and Standards. Mass Customization, Smart Machine Tools, Robotics and Automation (perception, manipulation, mobility, autonomy), Smart Perception – Sensor networks and Devices. Online Predictive modelling, Monitoring and Intelligent Control of Machining/Manufacturing and Logistics/Supply Chain Processes; Smart Energy Management of manufacturing processes and facilities.	08
3	ML in Manufacturing - ML - Concept of AI, Conceptual Learning, AI & Augmented reality in Manufacturing. ANN in Manufacturing-Biological Neuron, Artificial Neuron, Types NNs, ML Applications in Manufacturing. Human-Robot Collaboration. Communication Systems in Cloud Manufacturing, Cloud Applications in Manufacturing, and allied factory.	08
4	Application Factories and Assembly Line, Food Industry, Medical, Power Plants, Inventory Management & Quality. Data Acquisition and Analysis.	04
5	Sustainability and environmental considerations in Smart Manufacturing, Energy efficiency, Waste Reduction and Recycling, resource optimization, Ethical and social implications of automation and AI, Emerging trends in Smart Manufacturing.	05
Textbooks:		
1. Masoud Soroush, McKetta Michael Baldea, & Thomas Edgar (2020). “Smart Manufacturing: Concepts and Methods”, Elsevier, 2020. 2. Smart Manufacturing Innovation and Transformation: Interconnection and Intelligence Luo, Z. ed., 2014 IGI Global.		
References:		
1. Smart Manufacturing: Integrating Transformational Technologies for Competitiveness and Sustainability. Shemwell, S.M. and Quazi, H.A., CRC press 2. Gilchrist, A., “Industry 4.0: the industrial internet of things”, A press, 2016 3. Automation, Production Systems and CIM/Groover M.P./PHI/2007 4. Rawat, D. B., Brecher, C., Song, H., & Jeschke, S. (2017)., “Industrial Internet of Things: Cybermanufacturing Systems”, Springer, 2017. 5. M. Kuniavsky, Smart Things: Ubiquitous Computing User Experience Design, 1st edition, Morgan Kaufmann, 2010\ ISBN-10: 0123748992.		
List of Experiments/Assignments:		

Sr.	Experiment Name
1.	Simulation of Manufacturing System Evolution using software.
2.	Case Study Analysis: Evaluate benefits of Smart Manufacturing in real industries.
3.	Demonstration of Industrial Control Systems (PLC-based control lab).
4.	PLC Programming for basic industrial automation tasks (e.g., motor control, sensors).
5.	SCADA/HMI Lab: Creating simple Human-Machine Interfaces.
6.	Hands-on with Sensors and Actuators: Integration and testing.
7.	Introduction to Cyber-Physical Production System Simulation (e.g., Siemens Tecnomatix).
8.	IoT Lab: Sensor data acquisition using Arduino/Raspberry Pi with cloud dashboards.
9.	3D CAD Modelling and Export to STL/STEP formats.
10.	3D Printing/Additive Manufacturing: Printing a prototype using smart design principles.
11.	Robotics Lab: Basic pick-and-place operation using a robotic arm.
12.	Smart Sensor Integration Lab: Implementing sensor networks in a model production line.
13.	Basic Machine Learning Model Implementation using Python/Google Colab for predictive maintenance.
14.	Image Recognition in Manufacturing using OpenCV/TensorFlow (e.g., quality inspection).

Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify the list as necessary.

Alternative NPTEL/SWAYAM Course			
Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	The Future of Manufacturing Business: Role of Digital Technologies	Prof. R. K. Amit, Prof. U. Chandrasekhar	IIT Madras

Product Lifecycle Management

Course Code	HON-PEMF302				
Category	Honors Course- Manufacturing Engineering				
Course Title	Product Lifecycle Management				
Scheme and Credits	L	T	P	No. of Credits	Semester
	3	0	0	3	VI

Course Objectives:

1. To impart the latest knowledge, principles, strategies, practices, and applications in PLM domain.
2. To provide an in-depth understanding of various applications and solutions of PLM.
3. To build conceptual foundation of PLM, along with the latest industry views on PLM applications.
4. To present frameworks which provide economic justifications for PLM projects.
5. To understand the proper PLM system as per the need of organization.

Course Outcomes:

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

CO1: Justify importance and need of various components/elements of PLM.

CO2: Able to demonstrate the benefits of PLM implementation/deployment.

CO3: Distinguish various tasks terminologies used in domain of PLM.

CO4: Apply and design the various strategies for process and product data management.

CO5: Evaluate and select the proper PLM system as per the need of organization.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	-	2	-	1	1	-	3	-	-	-	3	-	2
CO2	3	1	-	-	1	1	1	-	3	-	-	-	3	-	1
CO3	3	-	-	-	1	-	-	-	-	-	-	-	3	-	-
CO4	3	2	2	1	-	1	1	-	3	-	-	-	3	2	2
CO5	3	2	1	1	1	1	2	-	3	-	-	-	3	-	2

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Introduction: Overview, Need, Benefits, Concepts of Product Life Cycle, Components/Elements of PLM.	08
2	PLM Strategy and Vision: Company's PLM vision, PLM strategy, Principles of PLM strategy, preparing for the PLM strategy, Developing a PLM strategy, Strategy identification and selection, PLM business goals.	08

3	PLM Tools & Technique: Information, Tools, Information system and people involved in PLM, Product data and processes like New Product Development, Change management, Concurrent Design and Process Management, Product data linkages across the domain.	08
4	PLM-ERP: Introduction, characteristics, evolution of ERP Systems, Business Functions Supported by ERP, products, benefits of using ERP, case Studies on ERP Implementation	06
5	SAP: SAP history, SAP product line, new products of SAP, types of SAP projects, architecture of SAP.	06
6	PLM Project: Human resources in product lifecycle, methods, Techniques, Practices, Methodologies, Processes, System components in lifecycle, Slicing and dicing the systems, Interfaces, Information Standards, Vendors of PLM system and components.	08

Textbooks:

1. Product Lifecycle Management by Grieves, Michael, McGraw-Hill publication 2005.
2. Product Lifecycle Management by Antti Saaksvuori, Anselmilmmonen, Springer-Verlag Berlin and Heidelberg GmbH & Co. K; Softcover reprint of hardcover 3rd ed. 2008 edition.

References:

1. Product Lifecycle Management: 21st Century Paradigm for Product Realisation by Stark, John, Springer Publication 2008.
2. Product design and development by Ulrich Karl T and Eppinger Steven D., McGraw Hill Pub. Company 2020.
3. Fundamentals of Design and manufacturing, GK Lal, Vijay Gupta, N Venkata Reddy, Narosa Publications 2010.
4. Handbook of Product Design for Manufacturing, Bralla, James G., McGraw Hill Pub. 1986.

Alternative NPTEL/SWAYAM Course			
Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Product Design and Development	Prof. Inderdeep Singh	IIT Roorkee
2	NOC: Carbon Accounting and Sustainable Designs in Product Lifecycle Management	Prof. Amandeep Singh Oberoi, Prof. Deepu Philip, Prof. Prabal Pratap Singh	IIT Kanpur

Industrial Waste Management and Recycling

Course Code	HON-PEIE303				
Category	Honours Course- Industrial Engineering				
Course Title	Industrial Waste Management and Recycling				
Scheme and Credits	L	T	P	No. of Credits	Semester
	3	0	2	4	V

Course Objectives:

1. To understand the fundamentals of industrial waste generation and its environmental implications.
2. To explore various techniques and technologies for industrial waste management and recycling.
3. To analyze the regulatory frameworks governing industrial waste disposal and recycling.
4. To develop skills for designing sustainable waste management and recycling strategies for industrial applications.
5. To foster an understanding of the economic and environmental benefits of recycling in industrial processes.

Course Outcomes:

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

CO1: Apply the basics of solid waste management towards sustainable development.

CO2: Apply technologies to process waste and dispose the same.

CO3: Identify and classify hazardous waste and manage the hazard.

CO4: Classify hazardous waste and manage the hazard.

CO5: Design working models to convert waste to energy.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	2	2	-	-	-	-	3	-	-	-	-	2	2	-	2
CO2	2	2	-	-	-	-	3	-	-	-	-	2	2	-	2
CO3	2	2	-	-	-	-	3	-	-	-	-	2	2	2	2
CO4	2	2	-	-	-	-	3	-	-	-	-	2	-	2	-
CO5	2	2	-	-	-	-	3	-	-	-	-	2	-	2	-

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Introduction to Industrial Waste Introduction, Sources of Industrial Waste, Characteristics of the Industrial Wastes, Effects on Sewage Treatment Plants, Waste Reduction Alternatives, Classification of Wastes, Factors influencing waste generation and health hazards, Industries Producing Wastes Origin, Characteristics and Treatment.	06
2	Solid Waste Management	07

	Key components of solid waste management, Generation, storage (containers), collection, transportation (human powered, animal powered and motorized) and disposal (Landfills, composting, incineration and pyrolysis), Recycling and resource recovery, layout of routes. Methods of handling and processing of solid wastes: separation, screening, size reduction, densification, baling, cubing, compaction, and pelleting.	
3	Steel Plant Wastes Characterization of Steel Plant Waste: Classification of steel plant waste based on its composition, physical properties, and hazardous characteristics. Techniques for analysing and characterizing different types of steel plant waste, including chemical analysis, physical testing, and waste sampling methods. Identification of hazardous components in steel plant waste and their potential environmental and health risks	08
4	Industrial Wastewater treatment Sources and characteristics of industrial wastewater & effect on environment, Management- volume reduction, neutralization, equalization and proportioning (SKG). Treatment and disposal of sludge (SKG) & Industrial Complexing for Zero Pollution Attainment (AS). Treatment of wastewater produced from a) Sugar Industry. b) Distillery Industry c) Dairy Industry d) Paper and pulp industry e) Textile industry	07
5	Recycling Industrial Waste Introduction to Recycling in Industrial Context: Definition of industrial waste recycling. Importance of recycling in reducing environmental impact and resource conservation. Comparison of recycling practices in industrial settings versus household or municipal recycling. Recycling Methods and Technologies: Overview of recycling methods applicable to industrial waste streams. Explanation of mechanical, chemical, and thermal recycling processes. Discussion on advanced recycling technologies such as pyrolysis, gasification, and liquefaction.	08
6	Challenges and Opportunities in Industrial Recycling: Identification of challenges associated with industrial waste recycling, such as contamination, logistics, and economics. Exploration of opportunities for improving recycling rates and efficiency in industrial sectors. Discussion on innovative solutions and emerging technologies addressing challenges in industrial recycling. Review of case studies showcasing successful industrial waste recycling programs.	08
Textbooks:		
1. Dr. H.S. Bhatia, "A Comprehensive Book on Industrial Waste and its Management", Misha Books Publisher, First Edition 1 January 2019 2. Syed E. Hasan, "Introduction to Waste Management: A Textbook", Wiley books publisher ISBN: 978-1-119-43393-4, August 2022.		
References:		
1. Environmental Pollution by Chemicals - Walker, Hulchiason. 2. Biochemistry and Microbiology of Pollution - Higgins and Burns. 3. Environmental Pollution - Laurent Hodge, Holt.		

4. Waste Water Treatment - Datta and Rao (Oxford and IBH).
5. Sewage and waste treatment - Hammer
6. Environment and Metal Pollution - Khan (ABD Pub. Jaipur).
7. Environment Pollution - Timmy Katyal (Satke Anmol Pub. New Delhi).
8. "Hazardous Waste Management" by Michael D. LaGrega, Phillip L. Buckingham, and Jeffrey C. Evans.
9. "Waste Treatment and Disposal" by Paul T. Williams
10. "Recycling of Solid Waste for Biofuels and Bio-chemicals" edited by ObulisamyParthiba Karthikeyan, Kirsten Heimann, and Subramanian Senthilkannan Muthu.

List of Experiments:

Sr.	Experiment Name
1.	To collect and analyze samples from local industries (or simulated samples) for pH, BOD, COD, and heavy metals.
2.	Conduct a mini-survey or case study of nearby industries to classify waste types and sources.
3.	Analyze sample slag for pH, heavy metals, and particle size distribution.
4.	Conduct Toxicity Characteristic Leaching Procedure (simulated, if actual lab not equipped).
5.	Adjust pH of simulated industrial effluent using acid/base.
6.	Treat colored/disturbed water using alum/ferric chloride and observe settling.
7.	Measure BOD/COD for simulated effluent from industries like dairy or distillery.
8.	Demonstrate mechanical size reduction of plastic for reuse or repurposing.
9.	Demonstrate pyrolysis using a small organic sample (e.g., biomass or plastic) in a safe lab setup.
10.	Research and present a report on any successful local/national recycling initiative.
11.	Analyze a mixed waste sample to detect contaminants that hinder recycling.

Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify the list as necessary.

Production Planning and Control

Course Code	HON-PEIE304				
Category	Honors Course- Industrial Engineering				
Course Title	Production Planning and Control				
Scheme and Credits	L	T	P	No. of Credits	Semester
	2	0	2	3	VI

Course Objectives:

1. To gain an understanding and appreciation of the fundamental principles and methodologies relevant to planning, design, operation, and control of Production Systems.
2. To reinforce analytical skills already learned and build on these skills to further increase one's "portfolio" of useful analytical tools.
3. To gain the ability to recognize situations in a production system environment those suggest the use of certain quantitative methods to assist in decision making.
4. To learn how to think about, approach, analyse, and solve production system problems using both technology and people skills.
5. To increase knowledge and broaden perspective of the "industrial world" in which one will contribute his / her talent and leadership as an Industrial Engineer.

Course Outcomes:

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

CO1: Discuss the different types of production systems.

CO2: Analyse the product development and design technique.

CO3: Use forecasting techniques to forecast the demand.

CO4: Construct and model Aggregate production plans.

CO5: Gain the knowledge of different inventory control systems and inventory models.

CO-PO Mapping:

CO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	1	-	-	-	-	-	-	-	-	-	-	-	1	-	-
CO2	-	2	-	-	-	-	-	-	-	-	-	-	1	2	-
CO3	1	-	-	-	2	-	-	-	-	-	-	-	1	-	-
CO4	-	-	3	-	2	-	-	-	-	-	-	-	-	2	-
CO5	1	-	3	-	-	-	-	-	-	-	-	-	-	-	3

Course Content:

Unit No.	Unit Title and Contents	Hours
1	Introduction Functions of PPC, types of production, production consumption cycle, coordination of production decisions. Product Development and Design:	05

	Product Design and Company Policy, Product Analysis: Marketing Aspect, Product Characteristics, Economic Analysis, production Aspect.	
2	Forecasting Introduction, Time Series Methods, Casual Methods, Forecast Errors. Facility Layout: Introduction, Flow Systems, Types of Layouts: Product, Process, Group Layout, Computerized Layout Planning.	05
3	Batch Production Quantities in batch production, criteria for batch size determination, minimum cost batch size, production range, maximum profit batch size, maximum return and maximum rate of return economic batch size.	05
4	Production And Operations Planning Aggregate Planning, Strategies and techniques for Aggregate Planning, Production Planning in Mass Production Systems and Assembly Line Balancing, Sequencing problems such as 1 machine n jobs, 2 machines n jobs & its extension, m machines 2 jobs, scheduling jobs with random arrivals.	05
5	Inventory Control Inventory and its purpose, the relevant costs, selective inventory analysis (ABC analysis), Classical Inventory Model, EOQ with quantity discounts, EOQ for multiple items with constraints on resources, Safety Stock, determining safety stock when usage and lead time vary, Fixed Order Period Inventory Control System.	05
6	Material Requirement Planning (MRP) and Inventory Control Bill of Materials (BOM), MRP Structure and Logic, Lot Sizing Techniques: EOQ, LFL, POQ, etc., MRP II and ERP Integration, Inventory Types, Functions, and Costs, ABC, VED, and FSN Analysis, Inventory Models: EOQ, EOQ with Discounts, Reorder Point, Safety Stock	05
Textbooks:		
1. Simuel Eilon, Elements of Production Planning and Control, Macmillan Publications 2015. 2. Martend Telsang, Industrial Engineering, S. Chand Publication 2006.		
References:		
1. James L. Riggs, Production Systems Planning and Analysis & Control. Wiley India Pvt Ltd; Third edition 2009. 2. Narasimhan, Mcleavey, Billington, Production Planning & Inventory Control, Pearson Education (US); 2nd edition 1995. 3. Chary S. N., Theory and Problems in Production and Operation Management, Tata McGraw Hill, Edition 1995.		
List of Experiments:		
Sr.	Experiment Name	
1.	Choose an existing product from any industry (e.g., consumer electronics, furniture, tools, etc.) that you believe could be improved or redesigned. Justify why you chose this product for redesign. Discuss any limitations or problems associated with the current design.	

2.	A PowerPoint presentation on company policies.
3.	Analyse historical data for seasonal trends and adjust production plans accordingly also Plan for demand fluctuations and capacity adjustments during peak seasons.
4	Use historical data to predict future demand and apply methods like moving averages or exponential smoothing. Develop a demand forecast for production planning.
5	Prepare a set of batch production requirements (e.g., for a food product or pharmaceuticals), calculate the optimal batch sizes and production schedules to minimize downtime and optimize resource utilization.
6.	Choose a product or service that could benefit from batch production. Explain why this product is suitable for batch production.
7.	Create and interpret Gantt charts to visualize job scheduling on different machines.
8.	Arrange the jobs according to the rule (FCFS, SPT, EDD, CR). (Any One)
9.	Calculate safety stock, reorder points, and economic order quantity (EOQ). Manage raw materials, work-in-progress, and finished goods inventory.
10.	Prepare a PowerPoint presentation on inventory control techniques.

Note: The list provided above is merely illustrative. The course coordinator reserves the right to modify it as necessary.

Alternative NPTEL/SWAYAM Course			
Sr. No.	NPTEL Courses Name	Instructor	Host Institute
1	Production and Operation Management	Prof. Rajat Agrawal	IIT Roorkee
2	Principle of Industrial Engineering	Prof. D.K. Dwivedi	IIT Roorkee
3	Operations Management	Dr. Inderdeep Singh	IIT Roorkee