2024 - 25

CURRICULUM FRAMEWORK FOR UG PROGRAMMES

NATIONAL INSTITUTE OF TECHNOLOGY
TIRUCHIRAPPALLI

VISION OF THE INSTITUTE

- To be a university globally trusted for technical excellence where learning and research integrate to sustain society and industry.

MISSION OF THE INSTITUTE

- To offer undergraduate, postgraduate, doctoral and modular programmes in multi-disciplinary / inter-disciplinary and emerging areas.
- To create a converging learning environment to serve a dynamically evolving society.
- To promote innovation for sustainable solutions by forging global collaborations with academia and industry in cutting-edge research.
- To be an intellectual ecosystem where human capabilities can develop holistically.

VISION OF THE DEPARTMENT

To establish a world class academy for Manufacturing and Industrial Engineering.

MISSION OF THE DEPARTMENT

- Curriculum development with state-of-the-art technologies.
- Pursue research interests of manufacturing and industrial engineering.
- Consultancy in design, manufacturing and industrial engineering.
- Industry-Institute interaction.
- Equipping Laboratories with state-of-the-art equipment.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

PEO1	**Graduates formulate, analyze and solve Manufacturing and Industrial engineering problems.**
PEO2	**Graduates take gainful employment for manufacturing functions.**
PEO3	**Graduates become product and process design professionals for sustainable manufacturing.**
PEO4	**Graduates become entrepreneurs in Manufacturing Engineering sector.**

PROGRAMME OUTCOMES (POs)

PO1	Engineering Knowledge	Graduates will apply knowledge acquired in mathematics, science, engineering and humanities to production engineering problems.
PO2	Problem Analysis	Graduates will have the ability to define the problems and provide solutions by designing and conducting experiments, interpreting and analysing data for manufacturing.
PO3	Design/ development of solutions	Graduates will design manufacturing systems that would encompass machining technology, welding technology, metal forming, foundry technology and thermal engineering infrastructure and would meet specifications and requirements as demanded by the customers.
PO4	Conduct investigations of complex problems	Graduates will apply design and tooling for manufacturing, finite element methods, modelling of manufacturing systems to solve production engineering problems.
PO5	Modern tool usage	Graduates understand manufacturing technologies like computer controlled processes and management information systems, production management, SCM, ERP and new manufacturing concepts like TPS, agile manufacturing, pull & push system.
PO6	Engineer & society	Graduates will have the confidence to apply engineering solutions in global and societal contexts.
PO7	Environment & sustainability	Graduates will understand quantitative modelling and analysis of a broad array of systems-level decision problems concerned with economic efficiency, work design, productivity and quality with environmental focus.
PO8	Ethics	Graduates should be capable of self-education and clearly understand the value of achieving perfection in their professional endeavours.
PO9	Individual & team work	Graduates will participate as members of engineering and science laboratory teams, as well as members of multidisciplinary design teams.
PO10	Communication	Graduates will be proficient in English language in both verbal and written forms which will enable them to compete with graduates of international engineering institutions.
PO11	Project & finance management	Graduates will exhibit competency in choosing and applying appropriate resource management technique(s) so as to optimally utilize resources in manufacturing systems.
PO12	Life-long learning	Graduates will be broadly educated and will have an understanding of the impact of engineering on society and confront contemporary issues.

PROGRAMME SPECIFIC OUTCOMES (PSOs)

PSO1	Design and deploy relevant manufacturing technologies for industrial applications to comply with quality standards and requirements.
PSO2	Establish competence for designing experiments, interpretation and data analysis through the application of mathematical, statistical, optimization, simulation tools and methods.

CURRICULUM FRAMEWORK AND CREDIT SYSTEM FOR THE FOUR-YEAR B.Tech. and 3 Year B.Sc. (Engineering) PROGRAMME

COURSE STRUCTURE

Course Category	Courses	No. of Credits	Weightage (%)
GIR (General Institute Requirements)	23	56	34.7
PC (Programme Core)	15	52 – 55**	33.1
Programme Elective (PE) / Open Elective (OE)	12	36	22.3
Essential Laboratory Requirements (ELR)	8 Maximum 2 per session up to 6th semester	16	9.9
Total	**58**	**160+3**	**100**
Minor (Optional)	Courses for 15 credits	15 Additional credits	-
Honors (Optional)	Courses for 15 credits	15 Additional credits	-

1. A minimum of seven Programme Core, each carrying 4 credits (II, III, IV, V, VI Semester).
2. Out of the 12 elective courses (PE / OE), students must complete at least eight Programme Electives (PE).
3. For a Minor Degree (MI), students must earn 15 credits in addition to the credit specified by the departments (160 credits), with the details of the Minor only mentioned on the transcript, not the degree certificate.
4. To qualify for an Honours Degree (HO), students must: (a) register for at least 12 theory courses and 2 ELRs in their second year, (b) consistently maintain a minimum CGPA of 8.5 during the first four sessions, (c) maintain a minimum CGPA of 8.5 in all sessions excluding honours courses, (d) successfully completed additional courses totaling 15 credits (3 numbers of 4 credit course and 1 number of 3 credit course), and (e) achieve at least a B grade in Honours courses, which must be distinct and at a higher level than PC and PE courses, preferably M. Tech. courses. Honours courses cannot be treated as programme electives and grades from these courses do not factor into CGPA calculations.
5. Project work is compulsory for B. Tech. programme. However, those students wish to carry out the intern outside the institute (8th semester) can opt for two electives courses equivalent to 6 credits. But the project work is compulsory for B. Tech. (Honours) degree

CURRICULUM FRAME WORK / FLEXIBLE CURRICULUM / NEP 2020 / NCrF / B.Tech.

Semester	GIR		PC		ELR		PE/OE		Total Credits	Credit Distribution
	Course	Credit	Course	Credit	Course	Credit	Course	Credit		
I	7	19	-	-	-	-	-	-	**19**	**40**
II	8	17	1	4	-	-	-	-	**21**	
III	-	-	4	14	2	4	2	6	**24**	**48**
IV	1	4	3	10	2	4	2	6	**24**	
V	1	3	4	14	2	4	1	3	**24**	**48**
VI	2	4	3	10	2	4	2	6	**24**	
VII	2	3	-	-	-	-	4	12	**15**	**24**
VIII	1	6	-	-	-	-	1	3	**9**	
Total	**22**	**56**	**15**	**52**	**8**	**16**	**12**	**36**	**160**	**160**

CURRICULUM FRAME WORK / FLEXIBLE CURRICULUM / NEP 2020 / NCrF / B.Sc. (Engineering)

	Sem	GIR		PC		ELR		PE/OE		Total Credits	Credit Distri-bution
		Course	Credit	Course	Credit	Course	Credit	Course	Credit		
Same as B.Tech.	I	7	19	-	-	-	-	-	-	**19**	**40**
	II	8	17	1	4	-	-	-	-	**21**	
	III	-	-	4	14	2	4	2	6	**24**	**48**
	IV	1	4	3	10	2	4	2	6	**24**	
B.Sc. Exit	V	1	3	2	8	2	4	2	6	**21**	**37**
	VI	4@	12	-	-	2	4	-	-	**16***	
After B.Sc. exit and join back for B. Tech.	VII	-	-	3	10	-	-	3	9	**19**	**35**
	VIII	1	1	2	6	-	-	3	9	**16**	
	Total	**22**	**56**	**15**	**52**	**8**	**16**	**12**	**36**	**160**	**160**

@(Summer internship (2), Project Work (6) and Industrial Lecture (1))

CURRICULUM FRAME WORK / FLEXIBLE CURRICULUM / NEP 2020 / NCrF / B.Tech.

Semester	GIR		PC		ELR		PE/OE		Total Credits	Credit Distribution
	Course	Credit	Course	Credit	Course	Credit	Course	Credit		
I	7	19	-	-	-	-	-	-	**19**	**40**
II	8	17	1	4	-	-	-	-	**21**	
III	1	4	4	14	2	4	1	3	**25**	**50**
IV	-	-	3	12	2	4	3	9	**25**	
V	1	3	4	15	2	4	1	3	**25**	**49**
VI	2	4	3	10	2	4	2	6	**24**	
VII	2	3	-	-	-	-	4	12	**15**	**24**
VIII	1	6	-	-	-	-	1	3	**9**	
Total	**22**	**56**	**15**	**55**	**8**	**16**	**12**	**36**	**163**	**163**

CURRICULUM FRAME WORK / FLEXIBLE CURRICULUM / NEP 2020 / NCrF / B.Sc. (Engineering)

	Sem	GIR		PC		ELR		PE/OE		Total Credits	Credit Distri-bution
		Course	Credit	Course	Credit	Course	Credit	Course	Credit		
Same as B.Tech.	**I**	7	19	-	-	-	-	-	-	**19**	**40**
	II	8	17	1	4	-	-	-	-	**21**	
	III	1	4	4	14	2	4	1	3	**25**	**50**
	IV	-	-	3	12	2	4	3	9	**25**	
B.Sc. Exit	**V**	1	3	2	8	2	4	1	3	**18**	**34**
	VI	4[#]	12	-	-	2	4	-	-	**16***	
After B.Sc. exit and join back for B. Tech.	**VII**	-	-	3	10	-	-	4	12	**22**	**39**
	VIII	1	1	2	7	-	-	3	9	**17**	
	Total	**22**	**56**	**15**	**55**	**8**	**16**	**12**	**36**	**163**	**163**

[#](Summer internship (2), Project Work (6), Professional Ethics (3), and Industrial Lecture (1))

GENERAL INSTITUTE REQUIREMENTS (GIR) COURSES

Sl. No.	Course	Number of Courses	Max. Credits
1.	Mathematics	3	10
2.	Physics	1	3
	Physics Laboratory	1	2
3.	Chemistry	1	3
	Chemistry Laboratory	1	2
4.	Industrial Economics and Foreign Trade	1	3
5.	English for Communication	1	4
6.	Energy and Environmental Engineering	1	2
7.	Professional Ethics	1	3
8.	Engineering Graphics	1	3
9.	Engineering Practice	1	2
10.	Basic Engineering	2	4
11.	Introduction to computer Programming	1	3
12.	Branch Specific Course (Introduction to the Branch of study)	1	2
13.	Summer Internship	1	2
14.	Project work	1	6
15.	Comprehensive viva	1	1
16.	Industrial Lecture	1	1
17.	NSS/NCC/NSO	1	Pass / Fail
Total		**22**	**56**

Curriculum Framework and Credit System / 160

Semester I (July Session)

Sl. No.	Course Code	Course	Credits	Category
1.	HSIR11	English for Communication (Theory & Laboratory)	4	GIR
2.	MAIR11	Matrices and Calculus	3	GIR
3.	CHIR11	Chemistry	3	GIR
4.	PRIR15	Introduction to Production Engineering	2	GIR
5.	EEIR11	Basics of Electrical and Electronics Engineering	2	GIR
6.	MEIR12	Engineering Graphics	3	GIR
7.	CHIR12	Chemistry Laboratory	2	GIR
		Total	**19**	

Semester II (January Session)

Sl. No.	Course Code	Course	Credits	Category
1.	MAIR21	Complex Analysis and Differential Equations	3	GIR
2.	PHIR11	Physics	3	GIR
3.	CSIR12	Introduction to Computer Programming	3	GIR
4.	CEIR11	Basics of Civil Engineering	2	GIR
5.	ENIR11	Energy and Environmental Engineering	2	GIR
6.	PRIR11	Engineering Practice	2	GIR
7.	PHIR12	Physics Laboratory	2	GIR
8.	SWIR11	NSS/NCC/NSO	0	GIR
9.	PRPC10	Applied Mechanics	4	PC
		Total	**21**	

Semester III (July Session)

Sl. No.	Course Code	Course	Credits	Category
1.	PRPC11	Casting and Welding Technology	4	PC
2.	PRPC12	Metallurgy and Materials Engineering	3	PC
3.	PRPC13	Fluid Mechanics and Thermal Engineering	4	PC
4.	PRPC14	Forming and Machining Technology	4	PC
5.	PRPEXX	Programme Elective – I	3	PE
6.	PRPEXX	Programme Elective – II	3	PE
7.	PRLR10	Manufacturing Processes Laboratory	2	ELR
8.	PRLR11	Weldability, Foundry and Formability Laboratory	2	ELR
		Total	**25**	

Note: Department(s) to offer Minor (MI) Course and Online Course (OC) to those willing students in addition to 24 credits.

Semester IV (January Session)

Sl. No.	Course Code	Course	Credits	Category
1.	MAIR45	Probability and Statistics	4	GIR
2.	PRPC15	Kinematics and Dynamics of Machines	4	PC
3.	PRPC16	Metrology, Quality and Safety	3	PC
4.	PRPC17	Computer Numerical Control (CNC) Systems	3	PC
5.	PRPEXX	Programme Elective – III	3	PE
6.	PRXXXX	Programme Elective – IV / Open Elective – I	3	PE/OE
7.	PRLR12	Metrology and Computer Numerical Control Machines	2	ELR
8.	PRLR13	Machine Drawing (CAD) and Cost Estimation	2	ELR
		Total	**24**	

Semester V (July Session) / Continuing B.Tech.

Sl. No.	Course Code	Course	Credits	Category
1.	HSIR14	Professional Ethics	3	GIR
2.	PRPC18	Industrial Automation and Mechatronics	3	PC
3.	PRPC19	Design of Machine Elements	4	PC
4.	PRPC20	Manufacturing System Simulation	3	PC
5.	PRPC21	Manufacturing Tooling and Automated Inspection	4	PC
6.	PRXXXX	Programme Elective – V / Open Elective – II	3	PE/OE
7.	PRLR14	Manufacturing System Simulation Laboratory	2	ELR
8.	PRLR15	Industrial Automation and Mechatronics Laboratory	2	ELR
		Total	**24**	

Semester V (July Session) / B.Sc. (Engineering) Exit

Sl. No.	Course Code	Course	Credits	Category
1.	HSIR14	Professional Ethics	3	GIR
2.	PRPC18	Industrial Automation and Mechatronics	3	PC
3.	PRPC19	Design of Machine Elements	4	PC
4.	PRPEXX	Programme Elective – V	3	PE
5.	PRXXXX	Programme Elective - VI / Open Elective – II	3	PE/OE
6.	PRLR14	Manufacturing System Simulation Laboratory	2	ELR
7.	PRLR15	Industrial Automation and Mechatronics Laboratory	2	ELR
		Total	**20**	

Semester VI (January Session)

Sl. No.	Course Code	Course	Credits	Category
1.	PRIR17	Industrial Lecture	1	GIR
2.	HSIR13	Industrial Economics and Foreign Trades	3	GIR
3.	PRPC22	Operations Research	4	PC
4.	PRPC23	Analysis of Production Systems	3	PC
5.	PRPC24	Computer Aided Design and Rapid Prototyping	3	PC
6.	PRPEXX	Programme Elective – VI	3	PE
7.	PRXXXX	Programme Elective – VII / Open Elective – III	3	PE/OE
8.	PRLR16	Advanced Manufacturing Laboratory	2	ELR
9.	PRLR17	Industrial Engineering Laboratory	2	ELR
		Total	**24**	

Semester VI (January Session) / B.Sc. (Engineering) Exit

Sl. No.	Course Code	Course	Credits	Category
1.	PRIR19	Project Work	6	GIR
2.	PRIR20	Winter Internship	2	GIR
3.	PRIR17	Industrial Lecture	1	GIR
4.	HSIR13	Industrial Economics and Foreign Trades	3	GIR
5.	PRLR16	Advanced Manufacturing Laboratory	2	ELR
6.	PRLR17	Industrial Engineering Laboratory	2	ELR
		Total	**16**	

Semester VII (July Session)

Sl. No.	Course Code	Course	Credits	Category
1.	PRIR16	Summer Internship*	2	GIR
2.	PRIR18	Comprehensive Viva Voce	1	GIR
3.	PRPEXX	Programme Elective – VIII	3	PE
4.	PRPEXX	Programme Elective – IX	3	PE
5.	PRXXXX	Programme Elective – X / Open Elective – IV	3	PE/OE
6.	PRXXXX	Programme Elective – XI / Open Elective – V	3	PE/OE
		Total	**15**	

** Evaluation for Summer Internship*

Semester VII (July Session) / Rejoins B.Tech. after B.Sc. (Engineering) exit

Sl. No.	Course Code	Course	Credits	Category
1.	PRPC20	Manufacturing System Simulation	3	PC
2.	PRPC21	Manufacturing Tooling and Automated Inspection	4	PC
3.	PRPC22	Operations Research	4	PC
4.	PRPEXX	Programme Elective – VII	3	PE
5.	PRPEXX	Programme Elective – VIII	3	PE
6.	PRXXXX	Programme Elective – IX / Open Elective – III	3	PE/OE
		Total	**20**	

Semester VIII (January Session)

Sl. No.	Course Code	Course	Credits	Category
1.	PRXXXX	Programme Elective – XII / Open Elective – IV	3	PE/OE
2.	PRIR19	Project Work	6	GIR
		Total	**9**	

Semester VIII (January Session) / Rejoins B.Tech. after B.Sc. (Engineering) exit

Sl. No.	Course Code	Course	Credits	Category
1.	PRIR18	Comprehensive Viva Voce	1	GIR
2.	PRPC23	Analysis of Production Systems	3	PC
3.	PRPC24	Computer Aided Design and Rapid Prototyping	3	PC
4.	PRPEXX	Programme Elective – X	3	PE
5.	PRPEXX	Programme Elective – XI	3	PE
6.	PRXXXX	Programme Elective – XII / Open Elective – IV	3	PE/OE
		Total	**16**	

Semester	I	II	III	IV	V	VI	VII	VIII	Total
B.Tech.	19	21	25	24	24	24	15	9	**161**
B.Sc.	19	21	25	24	20	16	20	16	**161**

Note:

1. Curriculum should have 7 Programme Core courses shall be of 4 credits each.
2. Out of 12 elective courses (PE/OE), the students should study at least eight programme elective courses (PE).
3. Minor (MI): 15 credits over and above the minimum credit as specified by the departments (160). The details of MINOR will be mentioned in the transcript and in the Degree certificate.
4. Honours (HO): 15 credits over and above the minimum credit as specified by the departments (160).

ELECTIVES CHOICES

Option 1 / Regular B.Tech.

To get a B.Tech. degree in Production Engineering, possible choices of electives in Programme Electives and Open Electives are,

Program Electives	Open Electives	Total
8	4	12
9	3	12
10	2	12
11	1	12
12	0	12

Option 2 / B.Sc. (Engineering) Exit (at end of 3rd year)

Program Electives	Open Electives	Total
3	2	5
4	1	5
5	0	5

Option 3 / B.Tech. with Minor

To get a B.Tech. degree in Production Engineering, and minor in other programmes, possible choices of electives in Programme Electives, Open Electives and Minor Electives are,

Program Electives	Open Electives	Minor Electives	Total
8	4	5	12 + 5
9	3	5	12 + 5
10	2	5	12 + 5
11	1	5	12 + 5
12	0	5	12 + 5

Option 4 / B.Tech. with Honours

To get a B.Tech. Honors degree in Production Engineering, possible choices of electives in Programme Electives, Open Electives, and Honors electives are,

Program Electives	Open Electives	Honors Electives	Total
8	4	4	12 + 4
9	3	4	12 + 4
10	2	4	12 + 4
11	1	4	12 + 4
12	0	4	12 + 4

Option 5 / B.Tech. with Honours and Minor

To get a B.Tech. Honors degree in Production Engineering, and minor in other programmes possible choices of electives in Programme Electives, Open Electives, and Honors electives are,

Program Electives	Open Electives	Honors Electives	Minor Electives	Total
8	4	4	5	12 + 4 + 5
9	3	4	5	12 + 4 + 5
10	2	4	5	12 + 4 + 5
11	1	4	5	12 + 4 + 5
12	0	4	5	12 + 4 + 5

Note: No Minor or Honours will be awarded for B.Sc. But student can credit minors and honours during the 6 semesters, and redeem it to obtain a minor or honours after rejoining and completing B.Tech. Also, B.Sc. students shall only do programme electives in place of their project work in 6^{th} semester.

LIST OF COURSES

(I) PROGRAMME CORE (PC)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	PRPC10	Applied Mechanics	---	4
2.	PRPC11	Casting and Welding Technology	---	4
3.	PRPC12	Metallurgy and Materials Engineering	CHIR11	3
4.	PRPC13	Fluid Mechanics and Thermal Engineering	---	4
5.	PRPC14	Forming and Machining Technology	PRPC12	4
6.	PRPC15	Kinematics and Dynamics of Machines	PRPC10	4
7.	PRPC16	Metrology, Quality and Safety	---	3
8.	PRPC17	Computer Numerical Control (CNC) Systems	PRPC14	3
9.	PRPC18	Industrial Automation and Mechatronics	EEIR11	3
10.	PRPC19	Design of Machine Elements	PRPC10	4
11.	PRPC20	Manufacturing System Simulation	---	3
12.	PRPC21	Manufacturing Tooling and Automated Inspection	PRPC14	4
13.	PRPC22	Operations Research	---	4
14.	PRPC23	Analysis of Production Systems	---	3
15.	PRPC24	Computer Aided Design and Rapid Prototyping	---	3

(II) ELECTIVES

a. PROGRAMME ELECTIVES

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	PRPE10	Rapid Product Development	PRPC11, PRPC14	3
2.	PRPE11	Product Development Strategies	---	3
3.	PRPE12	Design for Manufacture and Assembly	PRPC19	3
4.	PRPE13	Finite Element Methods for Engineers	PRPC10	3
5.	PRPE14	Concepts of Engineering Design	PRPC19	3
6.	PRPE15	Engineering Optimization	---	3
7.	PRPE16	Computational Fluid Dynamics	PRPC13	3
8.	PRPE17	Experimental Stress Analysis	PRPC10	3
9.	PRPE18	Supply Chain Management	PRPC22	3
10.	PRPE19	Plant Engineering	---	3
11.	PRPE20	Design and Analysis of Experiments	---	3
12.	PRPE21	Lean Manufacturing	---	3
13.	PRPE22	Material Handling and Storage	---	3
14.	PRPE23	Sustainable Manufacturing	---	3
15.	PRPE24	Industry 4.0	---	3
16.	PRPE25	Integrated Materials Management	---	3
17.	PRPE26	Agile Manufacturing	---	3
18.	PRPE27	Industrial Robotics	---	3
19.	PRPE28	Unconventional Machining Processes	PRPC14	3
20.	PRPE29	Precision Engineering	PRPC14	3
21.	PRPE30	Manufacturing of Composite Materials	---	3
22.	PRPE31	Machine Tool Technology	PRPC14	3
23.	PRPE32	Non Destructive Testing	---	3
24.	PRPE33	Surface Engineering	---	3
25.	PRPE34	Processing of Polymeric Composites	---	3
26.	PRPE35	Introduction to Friction Composites	---	3
27.	PRPE36	Work Design and Facilities Planning	---	3
28.	PRPE37	Reliability and Maintenance Engineering	---	3
29.	PRPE38	Noise and Vibration Analysis	---	3
30.	PRPE39	Data Analytics for Production Engineering	---	3
31.	PRPE40	Numerical Methods for Engineers	---	3
32.	PRPE41	Product and Service Life Cycle Management	---	3
33.	PRPE42	Laser Micromachining	---	3
34.	PRPE43	Strategic Design for Additive Manufacturing	---	3
35.	PRPE44	Control Systems	---	3

b. OPEN ELECTIVE (OE)

The courses listed below are offered by the Department of Production Engineering for students of all Departments.

Sl.No.	Course Code	Course Title	Pre requisites	Credits
1.	PROE10	Operations Management	---	3
2.	PROE11	Project Management	---	3
3.	PROE12	Value Engineering	---	3
4.	PROE13	Artificial Intelligence and Expert systems	---	3
5.	PROE14	Processing and Manufacturing of	---	3
6.	PROE15	Finite Element Methods for Engineers	---	3
7.	PROE16	Laser Materials processing	---	3
8.	PROE17	Digital Manufacturing for Industry 4.0	---	3
9.	PROE18	Micro and Nano Manufacturing Processes	---	3
10.	PROE19	Sustainability in Manufacturing Processes	---	3
11.	PROE20	Green Material Joining and Forming	---	3
12.	PROE21	Automobile component manufacturing	---	3

c. MINOR (MI) (offered for the students of other departments)

Students of other departments who desire B.Tech. Minor in Production Engineering can opt to study any 5 of the courses listed below.

Sl. No.	Course Code	Course Title	Pre requisites	Credits
1.	PRMI10	Product Design and Development	---	3
2.	PRMI11	Manufacturing Processes	---	3
3.	PRMI12	CAD, CAM and CAE	---	3
4.	PRMI13	Quality Engineering	---	3
5.	PRMI14	Industrial Engineering and Management	---	3

(III) ESSENTIAL PROGRAMME LABORATORY REQUIREMENT (ELR)

Sl. No.	Course Code	Course Title	Pre requisites	Credits
1.	PRLR10	Manufacturing Processes Laboratory	PRPC11, PRPC14	2
2.	PRLR11	Weldability, Foundry and Formability Laboratory	PRPC11, PRPC14	2
3.	PRLR12	Metrology and Computer Numerical Control (CNC) Laboratory	PRPC16, PRPC17	2
4.	PRLR13	Machine Drawing (CAD) and Cost Estimation Laboratory	MEIR12	2
5.	PRLR14	Manufacturing System Simulation Laboratory	PRPC20	2
6.	PRLR15	Industrial Automation and Mechatronics Laboratory	PRPC18	2
7.	PRLR16	Advanced Manufacturing Laboratory	PRPC24	2
8.	PRLR17	Industrial Engineering Laboratory	PRPC22, PRPC23	2

IV. ONLINE COURSES (OC)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.				
2.				
3.				
4.				
5.				
6.				

V. ADVANCED LEVEL COURSES FOR B.Tech. (HONOURS)

Sl. No.	Course Code	Course Title	Pre requisites	Credits
1.	PRHO10	Tolerance Technology	---	4
2.	PRHO11	Robotics	---	4
3.	PRHO12	Intelligent Manufacturing Systems	---	4
4.	PRHO13	Total Quality Engineering	---	4
5.	PRHO14	Product Analysis and Cost Optimization	---	4
6.	PRHO15	Decision Support Systems	---	4
7.	PRHO16	Knowledge Management	---	3
8.	PRHO17	Product Life Cycle Management	---	3
9.	PRHO18	Technology Management	---	3
10.	PRHO19	Multi-Criteria Decision Making Techniques	---	3
11.	PRHO20	Advanced Optimization techniques	---	4
12.	PRHO21	Modeling of Manufacturing Processes	---	3
13.	PRHO22	Control of Manufacturing Processes	---	4
14.	PRHO23	Flexible Manufacturing Systems	---	3
15.	PRHO24	Lasers in Manufacturing	---	3

VI. MICROCREDITS (MC) (Students can opt 3 courses of 1 credit (4 weeks) each as microcredits instead of 1 OE/OC)

Sl. No.	Course Code	Course Title	Credit
1.			
2.			

PROGRAMME CORE (PC)

Course Code	:	Applied Mechanics
Course Title	:	**PRPC10**
Type of Course	:	PC
Prerequisites	:	Nil
Contact Hours	:	3-1-0-4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the concept forces and moments and draw shear force and bending moment diagrams for beams.
CLO2	To understand the fundamental concepts of stress and strain and the relationship between both through the strain-stress equations.
CLO3	To solve problems relating to pure and non-uniform bending, torsional deformation of bars.
CLO4	To understand the concept of buckling and be able to solve the problems related to isolated bars.

Course Content

Review of Forces and Moments, Introduction to Equilibrium, Application of the Equations of Equilibrium, Forces and Moments Transmitted by Slender Members.

Shear Force and Bending Moment Diagrams – Mechanics of Deformable Bodies.

Force-Stress-Equilibrium, Multiaxial Stress and Strain, Multiaxial Strain and Multiaxial Stress-strain Relationships, Linear Elasticity - Material Behaviour, Stress Transformations and Principal Stress, Stress and Strain Transformations, Failure of Materials.

Pure Bending, Moment-curvature Relationship, Beam Deflection, Symmetry, Superposition.

Statically Indeterminate Beams, Buckling, Torsion and Twisting, Energy Methods.

References

1.	R. C.Hibbeler, Mechanics of Materials (SI Edition), Pearson Prentice Hall, 9th Ed, 2014.
2.	Crandall, S. H., N. C. Dahl, and T. J. Lardner, An Introduction to the Mechanics of Solids. 3rd ed. Tata McGraw Hill, 2017.
3.	Egor P Popov, "Engineering Mechanics of Solids", 2nd Edition, Prentice Hall of India., 2008.
4.	S.P. Timoshenko & D.H. Young, J.V.Rao, Sukumar Pati, “Engineering Mechanics” McGraw Hill Education, 5th Edition, 2017.
5.	L.S. Srinath, “Advanced Mechanics of Solids”, McGraw Hill Education, 3rd Edition, 2017.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Analyze forces and moments and develop and interpret shear force and bending moment diagrams for beams.
CO2	Understand the mechanics of deformable bodies, stress transformation, stress-strain relationships, and analyze material behaviour and failure.
CO3	Analyze material behaviour and predict the failure of materials.
CO4	Evaluate structural elements under pure bending, torsion, and apply energy methods.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPC11
Course Title	:	**Casting and Welding Technology**
Type of Course	:	PC
Prerequisites	:	Nil
Contact Hours	:	4-0-0-4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To spotlight the fundamental concepts of manufacturing process.
CLO2	To make the student understand clearly how the different components are manufactured in the present scenario with the help of casting and welding processes.
CLO3	To aid the student in governing the input parameters in casting and welding processes for controlling the product quality.

Course Content

Sand casting, Core making processes - Different Moulding and Casting Processes-Die Casting-Centrifugal Casting-Investment Casting-Continuous Casting-Squeeze Casting-. Gating System and its Design, Riser Design and its Placement, Pouring and Fluidity, Solidification of Pure Metals and Alloys,

Casting defects - inspection and testing of castings – Different types of furnaces – Casting of complicated shapes: automotive components, casting of light alloys – Aluminum, Magnesium and Titanium alloys.

Arc welding power sources- Basic physics of arc - Different arc welding processes (SMAW, GTAW, GMAM, SAW, ESW and EGW) - Soldering, Brazing and its types – Types of joint Configuration-Types of welding position- Gas welding and Gas cutting.

Design of welded joints – Resistance welding – Heat flow characteristics and metallurgical changes in resistance welding - Solid state welding processes – laser and EBW welding processes - hybrid (laser +GMAW/GTAW) welding process.

Inspection and testing of welded joints– welding Defects, Causes and Remedies-Destructive tests – Non-destructive testing techniques – surface treatments-safety aspects in welding - Introduction about CMT, A-TIG and Hot wire TIG welding processes.

References

1.	P.L.Jain " Principles of foundry Technology" Tata Mc Graw Hill Publishers, 2003.
2.	Peter Beelay, "Foundry Technology" Butterworth-Heinemann Publishers, Oxford. 2001
3.	H.S.Bawa "Manufacturing Technology-I" Tata Mc Graw Hill Publishers New Delhi, 2007.
4.	Dr. R.S.Parmer "Welding processes and Technology" Khanna Publishers, 3rd Edition, 1996.
5.	V.Nadkarni, Modern Arc Welding Technology, Oxford & IBH Publishing Co.Pvt. Ltd., 2008.
6.	D.L. Olson, T.A. Siewert, S. Liu, G.R. Edwards, ASM Handbook Volume 6: Welding, Brazing, and Soldering, ASM International, 1993, ISBN: 978-0-87170-382-8.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Describe fundamental concepts of manufacturing process
CO2	Understand the components manufactured using casting and welding processes.
CO3	Identify the input parameters in casting and welding processes for controlling the product quality.

Mapping of Programme Outcomes with Course Outcomes:

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

Course Code	:	PRPC12
Course Title	:	**Metallurgy and Materials Engineering**
Type of Course	:	PC
Prerequisites	:	CHIR11
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the structure of metals and alloys.
CLO2	To understand the various heat treatment processes for steel and other alloys.
CLO3	To impart knowledge on different types of materials.
CLO4	To develop knowledge on different destructive and non-destructive testing methods for materials.

Course Content

Art and science of metallurgy-structure of metals and alloys-phase and structural constitutions, Equilibrium diagrams.

Ferrous metals and alloys-Fe-Fe3C diagram-Effect of alloying elements in steel, Classification of ferrous alloys and their applications.

Heat treatment of steel: TTT diagram, CCT diagram, Different heat treatment processes, Surface hardening processes.

Non-Ferrous Metals Alloys: composition, properties and applications of copper, nickel, lead, tin, zinc, aluminium, Mg and Ti alloys. Heat treatment of Non-Ferrous alloys. Non-Metallic materials: ceramic material, polymers, composite material, Nano-structured materials.

Testing of Materials: Non-Destructive Testing, Tensile testing, compression testing - Hardness Testing, Impact testing, Fatigue testing, Creep, other related testing methods. Characterization of TEM, XRD, SEM.

References

1.	Raghavan V, Physical Metallurgy - Principles and Practice, Prentice - Hall of India, 2nd Edition, 2007.
2.	Avner S.H., Introduction to Physical Metallurgy, Tata McGraw Hill, 2nd Edition, 2008.
3.	Callister W. D., Rethwisch D. G., Material Science and Engineering, Willey & Sons, 8th edition, 2010.
4.	Dieter G. E., Mechanical Metallurgy, McGraw Hill Co- Koga, 1st Edition, 2002.
5.	Suryanarayana AVK, Testing of Metallic Materials, BS Publications, 2nd Edition, 2007.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Interpret microstructure of engineering materials and explain equilibriumdiagrams.
CO2	Demonstrate understanding of various materials available and their applications.
CO3	Understand heat treatment processes for alloys, & summarize different testing methods and characterization methods like TEM, XRD, SEM.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPC13
Course Title	:	**Fluid Mechanics and Thermal Engineering**
Type of Course	:	PC
Prerequisites	:	Nil
Contact Hours	:	4-0-0-4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand fluid flows and thermodynamic principles.
CLO2	To analyse I.C. Engines, Compressors and Turbines.
CLO3	To understand refrigeration and air conditioning systems.
CLO4	To understand the working principal of pump.

Course Content

Vapour Pressure - Pressure at a point its variation - Measurement with Piezo meter, manometers and gauges.

Continuity equation in one dimension - Bernoulli's equation - Venturi meters and Orificie meters - Flow through pipes - Laminar Turbulent flow Major losses
Pumps - General principles of displacement and Centrifugal pumps - Efficiency and Performance Curves of Pumps - Cavitation in Pumps - Turbines - Efficiency - Governing of turbines

Laws of Thermodynamics - concept of reversible process – Fundamentals of Heat transfer.

Air standard cycles - Otto, diesel and dual cycles - I.C. engines, S.I. engines and CI engines.

Reciprocating compressor - effect of clearance volume, single and multistage compressor - Volumetric efficiency - calculation of power requirement - gas turbines - open and closed cycle - intercooling, reheating and regenerative cycles Wankel engine.

References

1.	Kothandaraman, C.P. and Rudramoorthy, R., Basic Fluid Mechanics, New Age International, 1st Edition, 1999.
2.	Nag,P.K. “Engineering Thermodynamics”, 3rd Edition, Tata McGraw Hill, 2005.
3.	Kothandaraman, C.P. and Domkundwar, S. "A Course in Thermodynamics and Heat Engines", Part- I, SI units, 3rd Edition, DhanpatRai and Sons, 1993.
4.	Nagarathnam, S. 'Fluid Mechanics', Khanna Publishers,New Delhi, 1995.
5.	Bansal, R.K., Textbook of Fluid Mechanics and Hydraulic Machines,Lakshmi Publications, 9th Edition 2008.
6.	Ganesan, V., "Internal Combustion Engine", Tata McGraw Hill, New Delhi, 2004.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand properties of fluids.
CO2	Determine flow through hydraulics machines and pipes.
CO3	Apply thermodynamic laws in engineering applications and solve heat transfer problems.
CO4	Calculate power requirements of gas turbines and flow rates through nozzles.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPC14
Course Title	:	**Forming and Machining Technology**
Type of Course	:	PC
Prerequisites	:	Nil
Contact Hours	:	3-1-0-4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To study metal forming techniques with design aspects and acquire knowledge about process behaviour.
CLO2	To impart the knowledge on metal cutting mechanics, cutting force, stress, strain etc., effect of process parameters
CLO3	To demonstrate the fundamentals of machining processes and machine tools.
CLO4	To develop knowledge and importance of metal cutting parameters, tool materials, cutting fluids and tool wear mechanisms

Course Content

Elastic and plastic deformation of metals and alloys – material properties –fundamentals of plasticity – yield criteria.

Fundamentals of metal working – temperature, strain rate in metal forming – cold working – theory and analysis of bulk forming processes – theory and analysis of sheet metal forming processes – tools and dies – unconventional forming processes.

Introduction to machining and machine tools – tool geometry – mechanics of machining – chip formation – heat transfer mechanism and cutting and cutting temperature generation – tool materials – tool wear mechanism – tool life and control of tool wear – cutting fluids.

Working principle – operations - process parameters - drilling - milling - grinding machines.

Control of machining processes for machinability and surface characteristics – economics of machining – Environmental conscious machining processes.

References

1.	Dieter G.E., “Mechanical Metallurgy”, McGraw Hill, Co., S.I. Edition, 2001
2.	Metal Forming: Mechanics and Metallurgy, Wiliam F. Hosford, Robert M, Cambridge University Press, 2007
3.	Manufacturing Science, Amitabha Ghosh and Ashok Kumar Mallik, East-West Press, 2010
4.	Nagendra Parashar, and Mittal, R.K, Elements of manufacturing processes, Prentice Hall of India Private Limited,1st Edition, 2003.
5.	HajraChoudhury SK, Bose HK and HajraChoudhury AK, Elements of Workshop Technology, Vol. II, Media promoters and Publishers Pvt. Ltd. 12thEdition, 2007.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the effects of temperature, speed on metal forming process
CO2	Understand the principle, procedure and applications of Bulk Metal Forming and Sheet Metal Forming
CO3	Demonstrate understanding of metal cutting principles and mechanism
CO4	Identify cutting tool geometry of single point and multipoint cutting tool

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPC15
Course Title	:	**Kinematics and Dynamics of Machines**
Type of Course	:	PC
Prerequisites	:	PRPC10
Contact Hours	:	3-1-0-4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the basic concepts of machines and machinery.
CLO2	To understand working principle and application of different machine elements like cam, gear, flywheel and governor.
CLO3	To understand balancing, lubrication and vibration of machine elements.
CLO4	To evaluate various mechanisms of machines.

Course Content

Kinematic links, pairs, chain and inversion - Displacement, velocity and acceleration analysis of planar linkages – static and dynamic analysis of simple mechanisms.

Cams - Terminology, Types of Cam, Follower motion, Cam profile synthesis based on follower motions. Gear - Terminology, Type of gear and gear trains, law of gearing, gears dynamic force analysis.

Flywheel - Working principle, Turning-moment diagram, fluctuation of energy and speed. Governors - Working principle, governor terminology, analysis of different types of governors.

Inertia forces and their balancing for rotating and reciprocating machines. Hydrodynamic and boundary lubrication in journal and thrust bearings.

Vibration - Types - one degree – Two degrees of freedom systems – modal analysis.

References

1.	Shigley, J.E. and Uicker, J.J.,Theory of Machines and Mechanisms, Oxford University Press, 3rd Edition, 2008.
2.	Thomas Bevan, Theory of Machines, CBS Publishers. 3rd Edition, 2008.
3.	Rattan S.S., Theory of Machines, Tata McGraw Hill Pub Co, 2nd Edition, 2008.
4.	Rao, J.S., and Dukkipati, R.V.,Mechanism and Machine Theory, Wiley Eastern Ltd., 2nd Edition, 1992.
5.	Ghosh A and Mallik A.K., Theory of Mechanisms and Machines, Affiliated EWP Pvt. Ltd, 3rd Edition, 2003.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the basic concepts of machines, mechanisms, and machine elements like cams, gears, flywheels, and governors.
CO2	Construct cam profiles and turning moment diagrams for specified motions.
CO3	Estimate and balance unbalanced rotating and reciprocating parts in machines.
CO4	Design and evaluate various mechanisms used in machines.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	**:**	PRPC16
Course Title	**:**	**Metrology, Quality and Safety**
Type of Course	**:**	PC
Prerequisites	**:**	Nil
Contact Hours	**:**	3-0-0-3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To study the fundamentals of measurements and its application.
CLO2	To apply various measurement techniques to inspect and test products.
CLO3	To learn statistical tools for quality analysis.
CLO4	To study the various industrial safety measures.

Course Content

Introduction to Measurement – objectives – classification of methods of measurements - Precision and Accuracy - Standards and their evolution -Types of errors in measurements – Limit gauging

Comparators – types – applications – Linear, angular and form measurements – Surface roughness methods of surface finish – Direct instrument measurements. Limits, fits and tolerances.

Screw Thread Measurement- Standard thread profiles, Effective diameter, Terminology of gear tooth – Gear measurement – Parkinson gear tester- Alignment testing of machine tools – Coordinate measuring machines – Machine vision – Nano measurements.

Introduction to quality assurance and quality control – statistical process control – control charts for variable and attributes - process capability studies - acceptance sampling - Quality System standard –TQM.

Safety - Importance of safety - Fundamental Concepts and Terms- Workers' Compensation - Product Liability - Hazards and their Control – safety regulations.

References

1.	Jain R. K., "Engineering Metrology", Khanna Publications, 34th Edition, 2024.
2.	Douglas C. Montgomery, "Introduction to Statistical Quality Control", Wiley Publications, 6th Edition, 2004.
3.	Roger L. Brauer, "Safety and Health for Engineers", John Wiley Sons, 2nd Edition, 2006
4.	Gupta. I.C., "Engineering Metrology", DhanpatRai and Sons, 7th Edition, 1997.
5.	Beckwith G. Thomas, Roy D. Marangoni, John H. Lienhard V, "Mechanical Measurements 6th Edition" Pearson publications, 3th Edition, 2006.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the fundamentals of measurements.
CO2	Practice the usage of measurement techniques.
CO3	Use quality control tools.
CO4	Ascertain industrial safety measures.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPC17
Course Title	:	**Computer Numerical Control (CNC) Systems**
Type of Course	:	PC
Prerequisites	:	PRPC14
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the fundamentals and classifications of NC and CNC systems.
CLO2	To analyze the role and applications of NC/CNC in computer-aided manufacturing.
CLO3	To develop skills in CNC programming and interpolation techniques.

Course Content

Fundamentals of numerical control – NC and CNC - classification of NC/CNC systems– introduction to multi-axes machines, configurations, control strategies - role of NC /CNC in CAM – applications, benefits and limitations of NC/CNC – DNC – Adaptive Control: ACO and ACC systems.

Machine tool - components of CNC machine tool, drives and controls - automatic tool changers, automatic pallet changers, tool offsets and work offsets, high speed and precision machining concepts

Machine control unit – elements, functions - interpolators - types and stages of interpolation-principles of interpolation - interpolation schemes - stairs approximation, digital differential analyser, direct function calculation; DDA-hardware and software; software interpolators-feedback devices.

Part program and its elements- methods of programming – manual part programming, formats. codes and cycles-computer assisted part programming - custom macro – APT and its variations – FMS.

References

1.	Yorem Koren, Computer Control of Manufacturing systems, McGraw Hill, 1986.
2.	Mikell P Groover, “Automation, Production Systems and Computer Integrated Manufacturing”, Prentice Hall Publications, 2007.
3.	P. Radhakrishnan, “Computer Numerical Control Machines”, New Central Book Agency(P) Ltd., India, 1998.
4.	Paul Ranky, “Fundamentals of Computer Integrated Manufacturing”, Prentice Hall Publications, 1991.
5.	Reinbold U, Blume C and Dilmann R, Computer Integrated Manufacturing Technology & Systems, Marcel Dekker, 1985.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand and classify NC/CNC systems
CO2	Develop CNC programming skills
CO3	Explore and analyze machine tool components and control strategies.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	**:**	PRPC18
Course Title	**:**	**Industrial Automation and Mechatronics**
Type of Course	**:**	PC
Prerequisites	**:**	EEIR11
Contact Hours	**:**	3-0-0-3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand hydraulic devices and their applications.
CLO2	To analyze the integrated product design.
CLO3	To generate electro-hydraulic, electro-pneumatic solutions.

Course Content

Introduction to automation - need – hard and soft automation production system facilities-automation in production systems-automation principles and strategies-elements of automation-advanced automation functions-levels of automation.

Introduction – principles and application of hydraulic, pneumatic, electric controls system – control theory.

Hydraulic system, hydraulic components - pressure-flow-direction controls valves – proportional, servo, cartridge (logic) valves- accumulator, accessories. Hydraulic components symbols - Design and application of hydraulic circuits of machine tool, press, Mobile hydraulic.

Pneumatic system, pneumatic components - pressure-flow-direction controls valves - pneumatic components symbols- Design and application of pneumatic circuits of machine tool.

Semi automats-automats-transfer lines - automatic assembly - transfer devices and feeders-classifications and applications-job orienting and picking devices- setting of automats and transfer lines.

Introduction to mechatronics, mechatronics system, Microprocessors and their applications in automation, Sensors and actuators, PLC system, examples of mechatronics systems.

References

1.	Michael J. Pinches and John G. Ashby, Power Hydraulics, Prentice Hall, 1989.
2.	DudleytA.Pease and John, J. Pippenger, Basic Fluid Power, Prentice Hall, 1983.
3.	Doeblin, E.O. Measurement Systems, McGraw Hill, 1995.
4.	Mechatronics 3/e,W, Bolton (Addison Wesley, ISBN 981-235-874-9.
5.	Geoffrey Boothroyd, Assembly Automation and Product Design,Hardcover , 1992.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand hydraulic devices and their applications.
CO2	Analyze the integrated product design.
CO3	Generate electro-hydraulic, electro-pneumatic solutions.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPC19
Course Title	:	**Design of Machine Elements**
Type of Course	:	PC
Prerequisites	:	PRPC10
Contact Hours	:	3-1-0-4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand material properties, design process and various theories of failures.
CLO2	To design various basic machine components.
CLO3	To design new components based on design principles.

Course Content

Introduction to the design process, factor influencing machine design, mechanical properties of materials, direct stress, bending stress, torsional stress and variable stress in machine parts, theories of failure, stress concentration factor, factor of safety.

Design of shafts based on bending moment, twisting moment, combined of bending and twisting moments, axial loads in addition to combined torsional and bending loads, rigidity and stiffness. Design of springs.

Belt and chain drives: selection of flat belt, V belt and chain drives. Design of couplings, keys and bearings.

Welded joints: types of joints, welding symbol and weld symbol and their representation, strength of welded joints subjected to various types of load. Riveted joints: types of joints, design of riveted joints for structure.

Design of spur and helical gears. Design of gear box: layout diagram, speed diagram, fixing number of teeth and module of gears.

References

1.	Bhandari, V.B., “Design of Machine Elements”,Tata McGraw-Hill, 2007.
2.	Prabhu, T.J. "Design of Transmission Elements", Mani Offset, Chennai, 2005.
3.	Shigley, J.E. and Mischke, C.R. "Mechanical Engineering Design" Tata McGraw Hill, 2006.
4.	Sharma, C.S. and Purohit, K. “Design of Machine Elements”, Eurasia Publishing House (P) Ltd, New Delhi, 2005.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the various theories of failures.
CO2	Design various machine components.
CO3	Design new components based on the design principles.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPC20
Course Title	:	**Manufacturing System Simulation**
Type of Course	:	PC
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the role of simulation modeling in manufacturing decision making.
CLO2	To understand the applications of probability in modeling uncertainty in manufacturing applications.
CLO3	To analyze the design of simulation experiments, statistical verification of input data and results.
CLO4	To understand the simulation languages, packages and advanced simulation applications.

Course Content

Introduction to Simulation - Components of a system, Types of models, Monte Carlo Simulation, System Dynamics-Steps in simulation, applications -Discrete Event Simulation – components of DES -Time advance mechanism.

Probability functions in simulation modeling- Discrete distributions – Continuous distributions –Empirical Distributions. Properties of random numbers- Random number generation techniques –, linear, additive congruential. Test on random numbers- uniformity, independence.

Input Analysis Methods-fitting distribution to data- Expert Fit-Verification of simulation models-Validation of simulation models-Measure of performance and their estimation- Output Analysis Methods-Transient and steady state behavior – Evaluation of alternate system design –

Simulation Based Optimization (SBO) - Software packages, and languages for simulation-Manufacturing applications

Introduction to Agent based simulation, role of simulation in Industry 4.0, data analytics and AI in simulation, Emulation, Virtual reality and Augmented reality applications in manufacturing.

References

1.	Jerry Banks and John S.Carson, Barry L Nelson, David M.Nicol, P.Shahabudeen, Discrete event system simulation, Pearson Education, 2013.
2.	Law A.M, Simulation Modelling and Analysis, Tata Mc Graw Hill,2008
3.	Virtual reality technology (2nd edn). Grigore C. Burdea and Philippe Coiffet, Wiley, New York, 2003. No. of pages: xvi+444. ISBN 0-471-36089-9
4.	System simulation and modeling, Sankar Sengupta, 2014 Pearson
5.	Kelton, W. David, Randall P. Sadowski Simulation with Arena ,McGraw-Hill,2014
6.	https://archive.nptel.ac.in/courses/112/107/112107220/

Course Outcomes (CO)

At the end of the course student will be able

CO1	Learn the role of simulation in manufacturing decision making.
CO2	Learn the applications of probability functions in manufacturing system simulation.
CO3	Learn the methods for random number and variate generation.
CO4	Learn the methods used for input modeling, design of simulation experiments, statistical verification and output modelling of results.

MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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

Course Code	:	PRPC21
Course Title	:	**Manufacturing Tooling and Automated Inspection**
Type of Course	:	PC
Prerequisites	:	PRPC14
Contact Hours	:	3-1-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To identify the elements and its potential of Tooling in manufacturing.
CLO2	To design and Develop Tooling for Casting Welding Forming and Machining.
CLO3	To design and development of Automation systems for Inspection.

Course Content

Introduction - Manufacturing Processes-objectives of manufacturing processes-classification of manufacturing process-Objectives of Tool design-Tool design process- Tool engineering principles Tooling economics-Tool planning – tool materials and its selection.

Tooling for Metal Casting and Metal Joining Processes: Tools and Equipment for molding-patterns – pattern allowances – pattern construction-die casting tools-mechanization of foundries. Tooling for Physical joining processes Design of welding fixtures – Arc welding, Gas welding, Resistance welding, laser welding fixtures-Tooling for Soldering and Brazing Tooling for Mechanical Joining processes – assembly fixtures.

Tooling for Metal Forming Processes: Classification of Forming processes-Types of presses-design of -blanking and piercing dies-simple, compound, combination and progressive dies-Drawing dies-Bending dies-Forging dies-plastic Moulding dies.

Tooling for Metal Removal Processes: - Traditional machining processes -work and tool holding devices-tool nomenclatures- Mechanism of machining- force temperature and tool life of single point tool-multipoint tools -tool design- tool wear- special processes-capstan and turret lathe- tooling layout of automats-tooling in NC and CNC machines-tooling for Machining centres-Jigs and fixtures-design – modular fixtures.

Tooling for Inspection and Gauging: Survey of linear and angular measurements-Comparators-Types of Limit Gauges-Design and Manufacturing of Limit gauges-Measurement of Form-Inspection bench center-Co-ordinate measuring machine- Tooling in CMM. Flexible and Automated inspection systems - introduction to tooling for robotics.

References

1.	Kalpakjian S., Manufacturing Engineering and Technology Addison Wesley, 8th Edition, 1995.
2.	Hoffman E.G Fundamentals of tool design SME, 6th Edition, 1984.
3.	Venkataraman K. Design of jigs, fixtures and press tools, Wiley Publications, 2015.
4.	Sharma,P C "A Text Book of Production Engineering", S.Chand & Company Ltd., 2010.
5.	McDonaldson, C., "Tool Design", Tata McGraw Hill Pub.Co., 3rd Edition, 1997.

Course Outcomes (CO)

At the end of the course student will be able

CO1	State of Art in Tooling in Manufacturing and Inspection
CO2	Design and Develop tooling for Manufacturing
CO3	Design and Develop Automated Inspection Systems

MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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

Course Code	:	PRPC22
Course Title	:	**Operations Research**
Type of Course	:	PC
Prerequisites	:	Nil
Contact Hours	:	3-1-0-4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand Linear programming, assignment and queuing problems.
CLO2	To make decisions under uncertainty.
CLO3	To prepare project network and perform project scheduling.

Course Content

Concept of linear programming model-Development of LP models - Graphical method. Simplex method - Big M method - Two-phase method - Special cases in Linear Programming. Introduction to duality theory.

Introduction-Mathematical model for Transportation problem –balanced and unbalanced transportation problem. Methods to solve transportation problem-finding basic feasible solution- testing solution for optimality - Assignment problem-unbalanced assignment problem- maximization problem-problem with assignment restrictions. Travelling sales man problem.

Introduction-characteristics of queuing problem-terminologies of queuing problem-applications of queuing model -single server model. Simulation-need for simulation- Random number generation-methods. Applications of simulation-maintenance, queuing and inventory. Line balancing.

Decision under Uncertainty-Laplace criterion, Maximin criterion, minimax criterion, Savage minimax regret criterion, Hurwicz criterion. Decision making under risk- expected value criterion- decision tree, Investment decisions –present worth method, annual equivalent method, rate of return method, Replacement Analysis-types of replacement problem. Replacement of item that fail with respect to time. Replacement of item that fail suddenly-individual replacement and group replacement.

Project network construction – Critical Path Method (CPM) - determination of critical path - Project Evaluation and Review Technique (PERT)-probability of completing a project in a scheduled date - Crashing of project network-cost considerations in project scheduling.

References

1.	Gupta, P.K. and Hira, D.S, Operations Research, 3rd Edition, S.Chand and Company Ltd., New Delhi, 2008.
2.	Taha H.A, Operations research,Prentice – Hall of India, New Delhi, 8th Edition, 2006.
3.	Panneerselvam, R, Operations Research,Prentice – Hall of India, 2nd Edition, New Delhi, 2006.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Summarize different techniques for production planning like queuing uncertainty and mathematical modeling are involved.
CO2	Apply optimization in utilization of resources.
CO3	Apply resource management techniques to industrial operations.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPC23
Course Title	:	**Analysis of Production Systems**
Type of Course	:	PC
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand production function, and design of product.
CLO2	To gain knowledge of forecasting for production systems.
CLO3	To understand planning functions, material planning and layout and scheduling.

Course Content

Engineering Economy and Costing: Elementary cost accounting and methods of depreciation; break-even analysis, techniques for evaluation of capital investments.

Basics of product management – Forecast models, errors, tracking signals. Inventory costs – types of systems – policies – analysis & static models.

Concept of capacity and aggregate production planning – strategies – charting techniques – master production scheduling.

MRP concepts – problems – lot sizing – techniques - Push and pull production systems – concept of JIT manufacturing systems.

Scheduling concepts – various types of scheduling – methods and tools to solve scheduling problems.

References

1.	Buffa, E.S., "Modern Production/Operations Management", 8th edition, John Wiley sons, 2003.
2.	Elsayed A Elsayed, Thomas O. Boucher, “Analysis and control of Production System”, Prentice Hall, 2002.
3.	Ehud Menipaz, “Essentials of Production and Operations Management”, Prentice-Hall, 1984.
4.	Panneerselvam, R. “Production and Operations Management”, PHI Learning Private Limited, 2012.
5.	Chary, S.N., “Production and Operations Management”, McGraw Hill Education (India) Private Limited, 2012.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Forecast Production functions.
CO2	Enhance Planning of Product Design and Service Operations.
CO3	Facilitate Planning and Project Management.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPC24
Course Title	:	**Computer Aided Design and Rapid Prototyping**
Type of Course	:	PC
Prerequisites	:	CSIR11
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To realize basics of geometric modelling and transformation techniques.
CLO2	To understand exchange standards and rapid prototyping processes.
CLO3	To explore applications of CAD and rapid prototyping.

Course Content

Fundamentals of CAD Interactive graphics - point plotting techniques. Transformations techniques, viewing operations - window, viewport and clipping.

Visual realism - Hidden line/surface removal, shading and colour models. Geometric modeling: Wireframe modeling, Surface modeling: Representation of curves and surfaces, Design of curves - cubic splines, Bezier curves and B-spline, design of surfaces.

Solid modeling - Constructive solid geometry (C-rep) and Boundary representation (B-rep). Graphics standards: GKS, and IGES standards, STEP - Parametric design programmes. Applications of CAD.

Overview on Rapid Prototyping, Classification of Rapid Prototyping processes, STL file format.

Principle, process details and applications of Stereo lithography systems, Selective Laser Sintering, Solid Ground Curing, Laser Engineered Net Shaping.

Process details and applications of Fused Deposition Modeling, Binder Jetting, Laminated Object Manufacturing, 3D Printing.

References

1.	Anand, V.B., Computer Graphics and Geometric Modeling for Engineers, John Wiley and Sons, Inc., 2000.
2.	Zeid,I and Sivasubramanian, R., CAD/CAM- Theory and Practice, Tata McGraw-Hill, 2018 (23rd Reprint).
3.	Pham D T and Dimov S S, "Rapid Manufacturing", Verlag, 2001.
4.	Paul F Jacobs, "Stereo lithography and other RP&M Technologies", SME, 1996.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Recognize the fundamentals and concepts of CAD.
CO2	Competence on surface and solid modelling.
CO3	Understand on principles and applications of Rapid Prototyping processes.

Mapping of Programme Outcomes with Course Outcomes

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

PROGRAMME ELECTIVE (PE)

Course Code	:	PRPE10
Course Title	:	**Rapid Product Development**
Type of Course	:	PE
Prerequisites	:	PRPC11, PRPC14
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand advancements in rapid manufacturing.
CLO2	To gain competence on rapid product development.
CLO3	To recognize industrial applications of rapid product development.

Course Content

Overview of Rapid Product Development: Product Development Cycle, Definition of Rapid Product Development, Overview on Solid, Liquid and Power based processes, Virtual prototypical and rapid manufacturing technologies.

Rapid Tooling: Introduction to Rapid Tooling, Indirect Rapid Tooling Processes, Direct Rapid Tooling Processes, Emerging Trends in Rapid Tooling, Design for Additive Manufacturing.

Advances and Trends in Rapid Manufacturing – Light weighting - 4D Printing, Metal based Printing, Friction based process, Hybrid Layered Manufacturing, Segmented Object Manufacturing, Rapid Casting

Selection of a suitable Rapid Manufacturing process for a given application, Criteria for Technology selection – Problem formulation – Sustainable Rapid Manufacturing – Life Cycle Assessment

Applications and Case Studies: Engineering Applications, Medical Applications, Industrial applications, Modelling aspects and STL files, Modelling and Optimization for Rapid Manufacturing, Scope of Rapid Manufacturing research centers.

References

1.	Pham D T and Dimov S S, "Rapid Manufacturing: The Technologies and Applications of Rapid Prototyping and Rapid Tooling", Springer, 2011.
2.	Paul F Jacobs, "Stereo lithography and other RP&M Technologies", SME, 1996.
3.	C.K. Chua K.F. Leong, and C.S. Lim, “Rapid Prototyping: Principles And Applications”, World Scientific Publishing, 2008
4.	M. Adithan, “Rapid Product Development”, New Age International Private Limited (1 January 2015
5.	Terry Wohlers, "Wohlers Report 2001", Wohlers Associates, 2008.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand advancements in rapid manufacturing.
CO2	Competence on rapid product development.
CO3	Recognize industrial applications of rapid manufacturing.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE11
Course Title	:	**Product Development Strategies**
Type of Course	:	PE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the complexities in product development.
CLO2	To gain knowledge on tools/techniques of product development.
CLO3	To recognize the need for design to suit environment.

Course Content

Product development versus design, types of design and redesign, modern product development process, reverse engineering and redesigning product development process, examples of product development process, scoping product development – S-curve, new product development.

Gathering customer needs, organizing and prioritizing customer needs, establishing product function, FAST method, establishing system functionality.

Tear Down and Experimentation- Tear down method, post teardown report, benchmarking and establishing engineering specifications, product portfolios.

Generating Concepts- Information gathering, brain ball, C-sketch/6-3-5 method, morphological analysis, concept selection, technical feasibility, ranking, measurement theory, DFMA, design for robustness.

Design for the Environment: DFE methods, life cycle assessment, weighted sum assessment method, techniques to reduce environmental impact – disassembly, recyclability, remanufacturing regulations and standards, analytical and numerical model solutions.

References

1.	Kevin Otto and Kristin Wood, “Product Design – Techniques in Reverse Engineering and New Product Development”, Pearson Education, 2004.
2.	Karl T Ulrich and Stephen D Eppinger, “Product Design and Development”, McGraw Hill, 1994.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Explain modern product development process.
CO2	Design for the Environment through DFE method life cycle assessment.
CO3	Gather customer needs.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE12
Course Title	:	**Design for Manufacture and Assembly**
Type of Course	:	PE
Prerequisites	:	PRPC19,
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To identify opportunities for design.
CLO2	To address technical considerations of design and manufacturing.
CLO3	To utilize DFM and Concurrent Engineering Principles on a "real life" project.

Course Content

Engineering design – Kinds of design – Design process steps – Factors influencing design – Concurrent Engineering – Material selection process – Evaluation methods for material selection

Process capability analysis – Cumulative effect of tolerances – Centrality analysis – Compound assembly – Selective and Interchangeable assembly – Grouped Datum systems

Design for castings – Design for weldments – Design for forgings – Design for sheet metal formed parts – Design for powder metallurgy parts – Design for plastic parts

Design for machining – Design for economy – Design for clampability – Design for ease of assembly – Design for disassembly

Advances in DFMA- Design for robustness – Axiomatic design – Design for environment – DFA index – Poka Yoke – Lean principles – Six sigma concepts – Computer aided DFA using software.

References

1.	Dieter, G.E., Engineering Design: A Materials and processing Approach, McGraw Hill Co. Ltd, 2000.
2.	Boothroyd, G., Assembly, Automation and product design, CRC press, 2005.
3.	Eggert, R.J., Engineering Design, Pearson Education, Inc. New Jersey, 2005.
4.	KalandarSaheb, S.D and Prabhakar, O., Engineering Design for Manufacture, ISPE 1999. 3Boothroyd, DFMA.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Identify opportunities for design.
CO2	Address technical considerations of design and manufacturing.
CO3	Utilize DFM and Concurrent Engineering Principles on a "real life" project.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	**:**	PRPE13
Course Title	**:**	**Finite Element Methods for Engineers**
Type of Course	**:**	PE
Prerequisites	**:**	PRPC10,
Contact Hours	**:**	3-0-0-3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the need in Design for the Finite Element Method
CLO2	To tie his/her understanding of mechanical engineering design concepts to use the Finite Element Method software correctly and efficiently
CLO3	To analyze a physical problem, develop finite element procedures for accurately investigating the problem, and effectively perform and document findings

Course Content

Introduction, Calculus of Variations, Approximate methods for solving differential equations, Ritz and Galernkin FEM formulations.

One dimensional FEM formulations, bending of beams, trusses and Frames.

Two dimensional problems, Heat transfer, fluid flow and torsional problems.

Numerical integration, Plane stress and plane strain problems. Free vibration problems, Time history problems.

Introduction to non-linear FE Methods. Error analysis in FEM, Developing FEM code.

References

1.	US Dixit, Finite Element Methods for Engineers, Cengage Learning Asia; 1st edition, 2009.
2.	M.Asghar Bhatti, “Fundamental Finite Element Analysis and Applications: with Mathematica and Matlab Computations”, Wiley; 1 edition, 2003.
3.	Bathe KJ, “Finite Element Procedures”, Prentice Hall, 1994.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the numerical methods involved in Finite Element Theory and its direct/indirect methods.
CO2	Understand the formulation of one dimensional and two dimensional elements for structural, heat transfer and flow problems.
CO3	Perform and verify FEA using commercial FEA software.

MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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

Course Code	:	PRPE14
Course Title	:	**Concepts of Engineering Design**
Type of Course	:	PE
Prerequisites	:	PRPC19
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To study about fundamental design standards and needs.
CLO2	To learn about human and product factors involved in design concepts and rapid prototyping methods.
CLO3	To learn about material selection processing and design concepts.

Course Content

Importance of design- The design process-Considerations of Good Design –Morphology of Design – Organization for design– Computer Aided Engineering – Designing to codes and standards – Concurrent Engineering – Product and process cycles – Technological Forecasting – Market Identification – Competition Bench marking.

Identification of customer needs- customer requirements- Quality Function Deployment-Product Design Specifications- Human Factors in Design – Ergonomics and Aesthetics. Societal consideration - Contracts – Product liability – Protecting intellectual property – Legal and ethical domains – Codes of ethics – Ethical conflicts – Environment responsible design-future trends in interaction of engineering with society.

Creativity and Problem Solving –Creativity methods-Theory of Inventive Problem Solving(TRIZ)– Conceptual decomposition-Generating design concepts-Axiomatic Design – Evaluation methods-Embodiment Design-Product Architecture Configuration Design-Parametric Design. Role of models in design-Mathematical Modeling – Simulation – Geometric Modeling –Rapid prototyping- Finite Element Analysis– Optimization – Search Methods.

Material Selection Process – Economics – Cost Vs Performance – Weighted property Index – Value Analysis – Role of Processing in Design – Classification of Manufacturing Process – Design for Manufacture – Design for Assembly –Designing for castings, Forging, Metal Forming, Machining and Welding Residual Stresses – Fatigue, Fracture and Failure.

Probability – Distributions - Test of Hypothesis – Design of Experiments – Reliability Theory – Design for Reliability – Reliability centered Maintenance-Robust design – FMEA.

References

1.	Dieter, George E., “Engineering Design - A Materials and Processing Approach”, McGraw Hill, International Editions, Singapore, 2000.
2.	Suh, N.P., “The principles of Design”, Oxford University Press, NY.1990.
3.	Karl T. Ulrich and Steven D. Eppinger “Product Design and Development” McGraw Hill Edition 2000.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Demonstrate fundamental design standards and customer needs.
CO2	Understand human and product factors involved in design concepts.
CO3	Apply engineering design concepts.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE15
Course Title	:	**Engineering Optimization**
Type of Course	:	PE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand and apply the various constrained optimization techniques to solve engineering problems.
CLO2	To understand and apply the various unconstrained optimization techniques to solve engineering problems.
CLO3	To explore modern optimization methods.

Course Content

Introduction to engineering optimization - General principles –Classification - Problem formulation & their classifications

Single variable and multivariable optimization-Single and Multi objectives-Pareto Optimal solutions.

Techniques of unconstrained optimization – Golden section, Random, Pattern and Gradient search methods – Interpolation methods.

Optimization with equality and inequality constraints - Direct methods – Indirect methods using penalty functions.

Genetic Algorithms, Particle Swarm Optimization, Simulated Annealing and Ant Colony algorithm.

References

1.	S.S. Rao, “Engineering Optimization – Theory & Practice”, New Age International (P) Limited, New Delhi, 2009.
2.	Kalyanamoy Deb, “Optimization for Engineering Design Algorithms and Examples”, Prentice Hall of India Pvt. Ltd., 2006.
3.	C. Johnson Ray, “Optimum Design of Mechanical Elements”, Wiley, John & Sons,Digitized 2007.
4.	D.E.Goldberg, “Genetic Algorithms in Search, Optimization and Machine”, Barnen, AddisonWesley, New York, 1989.
5.	C.S.Rao, “Optimization Techniques”, DhanpatRai& Sons, New Delhi

Course Outcomes (CO)

At the end of the course student will be able

CO1	Solve engineering problems using constrained optimization techniques.
CO2	Solve engineering problems using unconstrained optimization techniques.
CO3	Apply modern optimization methods for production engineering problems.

Mapping of Programme Outcomes with Course Outcomes:

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

Course Code	**:**	PRPE16
Course Title	**:**	**Computational Fluid Dynamics**
Type of Course	**:**	PE
Prerequisites	**:**	PRPC13
Contact Hours	**:**	3-0-0-3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To perform numerical modelling and its role in the field of fluid flow and heat transfer.
CLO2	To use various discretization methods, solution procedures and turbulence modelling to solve flow and heat transfer problems.
CLO3	To study flow field analysis.

Course Content

Basics of computational fluid dynamics – Governing equations of fluid dynamics – Continuity, Momentum and Energy equations – Chemical species transport – Physical boundary conditions Time-averaged equations for Turbulent Flow – Turbulent–Kinetic Energy Equations – Mathematical behaviour of PDEs on CFD – Elliptic, Parabolic and Hyperbolic equations.

Finite difference and finite volume methods for diffusion- Derivation of finite difference equations – Simple Methods – General Methods for first and second order accuracy – Finite volume formulation for steady state One, Two and Three – dimensional diffusion problems – Parabolic equations – Explicit and Implicit schemes – Example problems on elliptic and parabolic equations – Use of Finite Difference and Finite Volume methods.

Finite volume method for convection diffusion – Steady one-dimensional convection and diffusion – Central, upwind differencing schemes properties of discretization schemes – Conservativeness, Boundedness, Transportiveness, Hybrid, Power-law, QUICK Schemes.

Flow field analysis **–** Finite volume methods –Representation of the pressure gradient term and continuity equation –Staggered grid – Momentum equations – Pressure and Velocity corrections – Pressure Correction equation, SIMPLE algorithm and its variants – PISO Algorithms.

Turbulence models and mesh generation **–** Turbulence models, mixing length model, Two equation (k-Є) models – High and low Reynolds number models – Structured Grid generation – Unstructured Grid generation – Mesh refinement – Adaptive mesh – Software tools.

References

1.	Versteeg, H.K., and Malalasekera, W., “An Introduction to Computational Fluid Dynamics: The finite volume Method”, Pearson Education Ltd.Second Edition, 2007.
2.	Ghoshdastidar, P.S., “Computer Simulation of flow and heat transfer”, Tata McGraw Hill Publishing Company Ltd., 1998.
3.	Patankar, S.V. “Numerical Heat Transfer and Fluid Flow”, Hemisphere Publishing Corporation,2004.

4.	Chung, T.J. “Computational Fluid Dynamics”, Cambridge University, Press, 2002.
5.	Ghoshdastidar P.S., “Heat Transfer”, Oxford University Press, 2005

Course Outcomes (CO)

At the end of the course student will be able

CO1	Perform numerical modelling and its role in the field of fluid flow and heat transfer.
CO2	Use various discretization methods, solution procedures and turbulence modelling to solve flow and heat transfer problems.
CO3	Analyze flow field by finite volume method and different algorithms.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE17
Course Title	:	**Experimental Stress Analysis**
Type of Course	:	PE
Prerequisites	:	PRPC10
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the experimental stress analysis techniques.
CLO2	To explore the principles of photoelasticity and advanced methods for analyzing stress fields.
CLO3	To learn calibration, application, and analysis of photoelastic materials.

Course Content

Overview of Experimental Stress Analysis- Optical Methods Work as Optical Computers- Stress, Strain and Displacement Fields- Physical Principle of Strain Gauges, Photo elasticity and Moiré- Introduction to Moiré, Brittle Coatings and Holography- Hologram Interferometry, Speckle Methods- Introduction to Shearography, TSA, DIC and Caustics- Fringe Patterns – Richness of Qualitative Information.

Multi-Scale Analysis in Experimental Mechanics- Selection of an Experimental Technique- Introduction to Transmission Photo elasticity- Ordinary and Extraordinary Rays- Light Ellipse, Passage of Light Through a Crystal Plate- Retardation Plates, Stress-optic Law- Plane Polariscope- Jones Calculus.

Circular Polariscope-Determination of Photoelastic Parameters at an Arbitrary Point- Tardy's Method of Compensation-Calibration of Photo elastic Materials-Fringe Thinning Methodologies Photo elasticity Ordering Fringe in Miscellaneous-Topics in Transmission Photoelasticity -Three Dimensional Photoelasticity.

Overview of Digital Photo elasticity-Introduction to Photoelastic Coatings-Correction Factors for Photoelastic Coatings-Coating Materials, Selection of Coating Thickness, Industrial Application of Photoelastic Coatings-Calibration of Photoelastic Coatings, Introduction to Brittle Coatings-Analysis of Brittle Coatings -Introduction to Strain Gauges-Strain Sensitivity of a Strain Gauge, Bridge Sensitivity, Rosettes.

Strain Gauge Alloys, Carriers and Adhesives-Performance of Strain Gauge System-Strain Gauge Selection-Bonding of a Strain Gauge-Soldering, Accounting for Transverse Sensitivity Effects-Correction Factors for Special Applications-Special Gauges.

References

1.	K. Ramesh, e-Book on Experimental Stress Analysis, IIT Madras, 2009. URL: http://apm.iitm.ac.in/smlab/kramesh/book_5.htm
2.	K. Ramesh, Digital Photoelasticity â€“ Advanced Techniques and Applications, Springer, 2000.
3.	W.N. Sharpe (Ed.), Springer Handbook of Experimental Solid Mechanics, Springer, 2008.
4.	J.W. Dally and W.F. Riley, Experimental Stress Analysis, McGraw-Hill, 1991.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Select appropriate experimental techniques for stress analysis.
CO2	Interpret fringe patterns to analyze stress and strain fields.
CO3	Learn calibration of stress-strain measurement systems.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	**:**	PRPE18
Course Title	**:**	**Supply Chain Management**
Type of Course	**:**	PE
Prerequisites	**:**	PRPC22
Contact Hours	**:**	3-0-0-3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To provide an insight on the fundamentals of supply chain strategy, logistics, sourcing and outsourcing supply chain networks, tools and techniques.
CLO2	To study the supply chain configuration design.
CLO3	To understand the role of Transportation in SCM.

Course Content

Evolution of supply chain-essentials of SCM-structure of supply chain, examples process views-decision phases, issues - aligning supply chain with business strategy–supply chain decision variables, performance measures-new challenges – reverse logistics.

Supply chain configuration design - factors involved - sourcing, models for strategic alliances – supplier selection, outsourcing and procurement process – facility location and capacity allocation - modeling approaches LP, MILP - network design in uncertain environment – evaluation using simulation models.

Demand forecasting-collaborative forecasting models-bullwhip effect-information sharing - aggregate planning in supply chain- strategies-multi echelon inventory planning-models-discounting- risk pooling- centralized versus decentralized systems.

Roles of transportation- tradeoffs in transportation design-modes of transportation and their design - vehicle routing and scheduling - models - packaging-pricing and revenue management.

Role of IT in supply chain - IT infrastructure-CRM-SRM-e-business-RFID-supply chain collaboration-Decision Support System (DSS) for supply chain- selection of DSS for supply chain.

References

1.	Supply Chain Management: Strategy, Planning and Operations-Sunil Chopra, Peter Meindl, Prentice Hall India , 3rd ed., 2007.
2.	Designing and Managing the Supply Chain: Concepts, Strategies, and Cases- David Simchi-Levi, Philip Kaminsky, Edith Simchi-Levi, Tata McGraw Hill, 3rd ed, 2007.
3.	Modeling the supply chain, J. Shapiro, Thomson, 2nd ed., 2002

Course Outcomes (CO)

At the end of the course student will be able

CO1	Define structure of supply chain.
CO2	Design supply chain configuration.
CO3	Analyze the role of Transportation in SCM.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE19
Course Title	:	**Plant Engineering**
Type of Course	:	PE
Prerequisites	:	NIL
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To exemplify different types of plants and its functions.
CLO2	To analyse the principles used in plants maintenance.
CLO3	To understand the safety methods in plants.

Course Content

Organization of the plant engineering function-Classification of maintenance work- Electric power supply system's-Electric generators and turbines-compressors,

Ventilation and air-conditioning Producer Gas Plants-operation and safety aspects in P.G. Compressor and Oxygen plants Material handling system-AS and RS (Automatic Storage and Retrieval System).

AGV and robotics- piping system design and components-Pollution control and plant safety.

Noise and vibration control - safety in plant operations, fire and electrical protection and prevention security equipment.

Lubrication and corrosion**-** Synthetic and solid lubricants -lubrication systems - causes and control deterioration - paints and protective coatings.

References

1.	Rosaler, R.C. "Standard HandBook of Plant Engineering", 3rd Edition, McGraw Hill, 2002.
2.	Lindley and Higgins, "Maintenance Engineers Hand Book", 7th Edition, McGraw HillProfessional, 2008.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the different type of plant and material handling system AS and RS (Automatic Storage and Retrieval System)-AGV and robotics.
CO2	Define the principles, functions and practices adapted in industry for the successful management of maintenance activities.
CO3	Know about safety in plant operation, fire and electrical protection and prevention security equipment.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE20
Course Title	:	**Design and Analysis of Experiments**
Type of Course	:	PE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To provide an introduction to fundamental concepts of statistical Process control.
CLO2	To enhance student understanding of the complexities of Statistical Analysis and control chart interpretation.
CLO3	To learn Taguchi Techniques.

Course Content

Introduction- Planning of experiments – Steps – Need - Terminology: Factors, levels, variables, experimental error, replication, Randomization, Blocking, Confounding.

Single Factor Experiments- ANOVA rationale - Sum of squares – Completely randomized design, Randomized block design, effect of coding, Comparison of treatment means – Newman Kuel's test, Duncan's Multiple Range test, Latin Square Design, Graeco-Latin Square Design, Balanced incomplete design.

Factorial Experiments-Main and interaction effects –Two and three Factor full factorial Designs, 2k deigns with Two and Three factors-Unreplicated design- Yate's Algorithm

Special Experimental Designs: Blocking in factorial design, Confounding of 2k design, nested design-Response Surface Methods.

Taguchi Techniques- Fundamentals of Taguchi methods, Quality Loss function, orthogonal designs, application to Process and Parameter design.

References

1.	Montgomery, D.C. "Design and Analysis of Experiments", John Wiley and Sons, 5th Edition,2002.
2.	Hicks,C.R. "Fundamental concepts in the Design of Experiments", Holt, Rinehort and Winston, 2000.
3.	Bagchi, T.P. "Taguchi Methods explained", PHI, 2002.
4.	Ross, P.J. "Taguchi Techniques for quality Engineering", Prentice Hall, 2000.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Create steps, need and terminology for experiments.
CO2	Know about factorial experiments and special experimental techniques.
CO3	Apply Taguchi techniques for various design problems.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE21
Course Title	:	**Lean Manufacturing**
Type of Course	:	PE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the principles and concepts of lean manufacturing.
CLO2	To gain hands on experience on lean tools and techniques.
CLO3	To realize the industrial applications of lean manufacturing.

Course Content

Lean Manufacturing – Scope – Waste and Activity analysis – Examples – Elements of Lean Manufacturing, Mass vs Lean Manufacturing

Primary tools of Lean manufacturing – 5S, Total Productive Maintenance, OEE Calculation, Process mapping and Value Stream Mapping – Development and analysis of Current and Future state maps, Workcell, Application cases on lean tools

Secondary tools – Poka-Yoke, Spider Chart, DFMA, Kanban, Autonomation, JIT, Pull system

Lean Manufacturing rules – Training & Implementation for lean manufacturing, Lean measurement, Project selection for lean systems.

Lean integration with other strategies: Lean Six Sigma, Lean and ERP, ISO 9001 with Lean, Optimized Production Technology, Lean in service domain.

References

1.	Askin R G and Goldberg J B, “Design and Analysis of Lean Production Systems”, John Wiley and Sons Inc., 2003.
2.	Hobbs, D.P. “Lean Manufacturing implementation”, Narosa Publisher, 2004.
3.	Devadasan S.R, “Lean and Agile Manufacturing: Theoretical, Practical and Research Futurities”, Prentice Hall India Learning, 2012.
4.	Pascal Dennis, “ Lean Production Simplified: A Plain-Language Guide to the World's Most Powerful Production System”, Productivity Press, 2015
5.	William M Feld, “Lean Manufacturing: Tools, Techniques, and How to Use Them (Resource Management)”, CRC Press, 2000.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Competence to recognize and eliminate waste.
CO2	Understand and apply appropriate lean tools/techniques.
CO3	Explore applications of lean concepts in various domains.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE22
Course Title	:	**Material Handling and Storage**
Type of Course	:	PE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand about material handling systems.
CLO2	To understand material storage methods.
CLO3	To understand automation in material transfer.

Course Content

Introduction to material handling- Principle of material handling equipment-layout and aerial handling systems- Types of material handling systems.

Fixed Path Equipment- flexible-path equipment - Conveyers-automated guided vehicles (AGV) - Applications of AGV Production line equipment.

Pick and place robots-transfer devices-feeder lines, robotic devices.

Conveyors-storage equipments-Automated ware houses- types of storage systems- small containers - unit load containers - rack and shelving.

Automated storage and retrieval systems-methods of protecting materials for packages - auxiliary equipments -automated identifications systems.

References

1.	Groover, M.P. "Automation ,Production systems and computer integrated manufacturing" Part V , P HAllInc.New Delhi, 2007.
2.	Apple, J.M. "Materials handling systems design", The Ronald Press Co.N.Y. 2001.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Classify various material handling and storage systems.
CO2	Identify various fixed path equipment.
CO3	Summarize various packaging techniques.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE23
Course Title	:	**Sustainable Manufacturing**
Type of Course	:	PE
Prerequisites	:	NIL
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To study various tools/techniques of sustainable manufacturing.
CLO2	To perform Life Cycle Assessment and assess environmental impacts of manufacturing processes.
CLO3	To develop eco-friendly products/processes.

Course Content

Sustainable Manufacturing - Concept of Triple bottom line, Environmental, Economic and Social Dimensions of Sustainability, Relation between lean and sustainable manufacturing.

Tools and Techniques – Environmental Conscious Quality Function Deployment, Life cycle assessment, Design for Environment, R3 and R6 cycles, Design for Disassembly, Design for recycling, Eco friendly product design methods.

Environmental Impact Assessment Methods –CML, EI 95 and 99, ISO 14001 EMS and PAS 2050 standards, Environmental Impact parameters.

Sustainability Assessment – Concept Models and Various Approaches, Product Sustainability and Risk/Benefit assessment– Corporate Social Responsibility.

Sustainable characteristics of manufacturing processes - Energy efficiency analysis of manufacturing processes - Software packages for sustainability analysis and LCA - Scope of sustainable manufacturing research centres.

References

1.	G. Atkinson, S. Dietz, E. Neumayer, “Handbook of Sustainable Manufacturing”. Edward Elgar Publishing Limited, 2007.
2.	D. Rodick, Industrial Development for the 21st Century: Sustainable Development Perspectives, UN New York, 2007.
3.	Rainer Stark and Günther Seliger, “Sustainable Manufacturing: Challenges, Solutions and Implementation Perspectives (Sustainable Production, Life Cycle Engineering and Management)”, Springer, 2017
4.	J. Paulo Davim, “Sustainable Manufacturing”, Wiley-ISTE, 2013
5.	P. Lawn, Sustainable Development Indicators in Ecological Economics, Edward Elgar Publishing Limited.
6.	S. Asefa, The Economics of Sustainable Development, W.E. Upjohn Institute for Employment Research, 2005.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Recognize the need for sustainable manufacturing.
CO2	Competence on State-of-art tools and techniques of sustainable manufacturing.
CO3	Design Eco friendly processes/products.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE24
Course Title	:	**Industry 4.0**
Type of Course	:	PE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To recognize need and trends of Industry 4.0.
CLO2	To understand concepts and technologies supporting Industry 4.0.
CLO3	To explore challenges and industrial applications of Industry 4.0.

Course Content

Various Industrial Revolutions, Digitalization and the Networked Economy, Drivers, Enablers, Compelling Forces and Challenges for Industry 4.0, Digital twin - Trends of Industrial Big Data and Predictive Analytics for Smart Business Transformation, Lean Production Systems.

Sensing and actuation, Internet of Things (IoT) & Industrial Internet of Things (IIoT) & Internet of Services, Smart Manufacturing, Smart Devices and Products, Smart Logistics, Predictive Analytics

Cyberphysical Systems, Robotic Automation and Collaborative Robots, Support System for Industry 4.0, Cyber Security, Collaborative Platform and Product Lifecycle Management, Augmented Reality and Virtual Reality, Artificial Intelligence, Big Data and Advanced Analysis

Resource-based view of a firm, Data as a new resource for organizations, Harnessing and sharing knowledge in organizations, Cloud Computing Basics, Cloud Computing and Industry 4.0

Industry 4.0 laboratories, IIoT case studies, Application Domains, Business Issues, Opportunities and Challenges, Strategies for competing in an Industry 4.0 world

References

1.	Gilchrist, A. (2016). Industry 4.0: the industrial internet of things. (1st ed.), New York, NY: Apress.
2.	Schwab, K. (2017). The fourth industrial revolution. (1st ed.), UK: Portfolio Penguin.
3.	Garbie, I. (2016). Sustainability in manufacturing enterprises: Concepts, analyses and assessments for industry 4.0. (1st ed.), Switzerland: Springer International Publishing.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand trends of Industry 4.0.
CO2	Competence on systems and technologies of Industry 4.0.
CO3	Recognize industrial applications of Industry 4.0.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE25
Course Title	:	**Integrated Materials Management**
Type of Course	:	PE
Prerequisites	:	NIL
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand various concepts and functions of material management.
CLO2	To classify inventory management.
CLO3	To summarize Material handling and Logistic.

Course Content

Importance of materials management – Scope – Functions of Materials Management – Need for Integrated Materials Management – Benefits.

Corporate Policy – Organization and control – Materials planning and budgeting – Codification and standardization.

Forecasting – Purchasing Management – Objectives – Types of purchasing – Legal aspects.

Value Engineering – Buyer-Seller relationship – Ethics.

Warehousing and Stores Management – Introduction – Store accounting and stock verification – ABC analysis – stores location and layout – Material handling – Inventory management.

References

1.	Gopalakrisnan, P. “Purchasing and Materials Management”, McMillan Company, 2006
2.	Gopalakrishnan, P. and Sundaresan, M. “Materials Management and Integrated Approach”, PHI Private Limited, 2014.
3.	Datta, A.K. “Materials Management Procedures, Text and Cases”, PHI Private Limited, Second Edition, 2008.
4.	Telsang, M.“Industrial Engineering and Production Management”, S.Chand and Company, 2006.
5.	Prem Vrat, “Materials Management An Integrated Systems Approach”, Springer, 2014.
6.	Chary, S.N.“Production and Operations Management”, Tata McGraw Hill, 2006.
7.	Panneerselvam, R. “Production and Operations Management”, PHI Learning Private Limited, 2012.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand various concepts and functions of material management.
CO2	Classify inventory management.
CO3	Summarize Material handling and Logistic.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE26
Course Title	:	**Agile Manufacturing**
Type of Course	:	PE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the significance and scope of Agile Manufacturing.
CLO2	To recognize technologies and managerial enablers of Agile Manufacturing.
CLO3	To realize industrial applications of Agile Manufacturing.

Course Content

Types of Production- Agile Production Paradigm- History of Agile Manufacturing- Agile Manufacturing Vs Mass Manufacturing, Agile Manufacturing Vs Mass Customization

Agile Practices- Agile practice for product development - Manufacturing agile practices - Concept models of Agile Manufacturing- Infusing managerial principles for enabling agility.

Implementing technology to enhance agility- Information Technology applications for Agile Manufacturing, Strategic approach to agility – Agile Wheel.

Performance Measurement and Costing: Measurement of agility – methods – Scoring and Fuzzy approaches – Costing for Agile Manufacturing practices – Activity Based Costing.

Applications of Agile Manufacturing – Scope of Agile Manufacturing Research Centers.

References

1.	Gunasekaran A, “Agile Manufacturing, 21st Strategy Competitiveness Strategy”, Elsevier Publications, 2001.
2.	Montgomery J C and Levine L O, “The Transition to Agile Manufacturing – Staying Flexible for Competitive Advantage”, ASQC Quality Press, Wisconsin, 1995.
3.	Carter Mathews, “Agile Manufacturing: Lean Processes that Improve Business Tranctions”, Brithe Publishing, 2017
4.	M P Chowdiah, “Agile Manufacturing: Globalised Customerized”, I K International Publishing, 2011
5.	Goldman S L, Nagal R N and Preiss K, “Agile Competitors and Virtual Organizations”, Van Nostrand Reinhold, 1995.
6.	Brian H Maskell, “Software and the Agile Manufacturer, Computer Systems and World Class Manufacturing, Productivity Press, 1993

Course Outcomes (CO)

At the end of the course student will be able

CO1	Recognize the principles and concepts of agile manufacturing.
CO2	Competence on applying models enabling agility.
CO3	Explore industrial applications of agile manufacturing.

MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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

Course Code	:	PRPE27
Course Title	:	**Industrial Robotics**
Type of Course	:	PE
Prerequisites	:	NIL
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the components of robot.
CLO2	To understand the drives and programs used to actuate the robot.
CLO3	To utilize robot technology in various applications.

Course Content

Fundamentals of Robotics - Definition - robot classification - robot arm geometry - power sources, application areas - control techniques - path control - robot controller operation - open loop and closed loop systems.

End of arm tooling and sensors - characteristics - classification - special purpose tools - Typical designs, compliance in Wrists. End Effectors: types, mechanical and other types of griper - types of sensors and applications.

Robot Programming And Languages - Language classification - program commands, arm motion, task point diagram - on line/off line programming, sample programs, program analysis - AI and experts systems.

Robot Applications - Robot applications in manufacturing - material transfer and machine loading / unloading - Processing operations like welding and painting - Assembly operations - Inspection Automation. Robot cell layouts - multiple robots and machine interference.

Recent developments in advanced Robotics – Modular concept - Special applications of robotics - micro robotics, Bio robotics - technologies and applications.

References

1.	Keramas,J.G. " Robot Technology Fundamentals", Delmer Publisher, 2002
2.	Jain, K.C, and Aggarwal, L.N., "Robotics Principles and Practice", Khanna Publishers, 2001
3.	Groover, M.P., "Industrial Robotics", McGraw Hill International Editions, 2008.
4.	Deb, S.R., "Robotics Technology and Flexible automation", Tata McGraw Hill Pub., New Delhi, 1994.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Explain the basic concepts, parts of robots and types of robots.
CO2	Identify the various drive systems for robot, sensors and their applications in robots, programming of robots.
CO3	Discuss about the various applications of robots, justification, implementation and safety of robot.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE28
Course Title	:	**Unconventional Machining Processes**
Type of Course	:	PE
Prerequisites	:	PRPC14
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand several non-traditional machining process in micro and precision manufacturing field.
CLO2	To select suitable machining process for materials considering their merits and demerits.
CLO3	To understand several non-traditional machining process in micro and precision manufacturing field.

Course Content

Introduction - Classification - process economy - Mechanical machining – Types - Ultrasonic machining (USM) - Abrasive Jet Machining (AJM) - Abrasive Flow Machining (AFM) - Water Jet Machining (WJM) - Operating principle – Process parameters - Applications - Limitations.

Electro chemical machining - Chemical material removal - Types – Electro chemical machining (ECM) - Electro chemical drilling (ECD) - Electro chemical grinding (ECG) - Electro chemical honing (ECH) - Shaped tube electrolytic machining - Operating principle - Process parameters - Applications - Limitations.

Thermo electrical machining - Types – Electrical discharge machining (EDM) - Electrical discharge wire cutting (EDWC).

Electron beam machining (EBM) – Ion Beam Machining (IBM)-Plasma Arc Machining (PAM) - Operating principle - Process parameters - Applications – Limitations.

Laser materials processing - Laser types - Processes - Laser beam machining (LBM) – Laser cutting (LC) – Laser drilling (LD) - Laser marking and engraving (LM) - Laser micromachining (LMM) - Laser engineered net shaping (LENS) - Applications - Limitations.

References

1.	Abdel, H. and El-Hofy, G. “Advanced Machining Processes”, McGraw-Hill, USA, 2005.
2.	Wellar, E.J. "Non-Traditional Machining Processes", Society of ManufacturingEngineers Publications, 2nd Edition, Michigan, 1984.
3.	Steen, W.M. and Watkins, K. “Laser Materials Processing”, Springer London Ltd, 2003.
4.	Groover, M.P. “Fundamentals of modern manufacturing processes - Materials, Processes and Systems”, 3rd Edition, John Wiley and Sons Inc., 2007.
5.	

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the contribution of non-traditional machining process in micro and precision manufacturing field.
CO2	Select suitable machining process for suitable materials
CO3	Summarize the merits and demerits of the non-traditional manufacturing process.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE29
Course Title	:	**Precision Engineering**
Type of Course	:	PE
Prerequisites	:	PRPC14
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To provide and enhance technical knowledge in precision engineering, its components and applications.
CLO2	To Introduce latest topics in manufacturing like micro machining, Lithography and nano finishing.
CLO3	To learn application of Precision Metrology in practical cases.

Course Content

Precision machining – Concepts and significance – Classification - Top down – Bottom up approaches– Precision and micromachining - Machining of micro-sized components - Ultra precision machining grinding

Lithography – Photolithography - Electron beam lithography – Ion Beam lithography - Deep UV lithography–MEMS – Principle – Elements – Characteristics – Applications- Design and fabrication approaches.

Micro-manufacturing- Limits of capability of conventional mechanical manufacturing-Micro-machining-concepts-Types–Tools–Electrical Discharge Micro-Machining–Wire cut EDMM–Electro Chemical Micro-Machining-Abrasive Jet Micromachining - Laser based micromachining

Nano surface generation-Concepts and applications-Types- Ductile mode of machining-Diamond turning of parts to nanometer accuracy – ELID grinding – Chemo Mechanical Polishing- Magnetorhelogical finishing.

Precision metrology –In-process measurement of position of processing point - Post process and online measurement of dimensional features -Mechanical measuring systems - Optical measuring systems - Electron beam measuring systems – Scanning Tunneling – Atomic Force Microscope.

LAB EXERCISES

1. Exercise on Micro-turning operation on DT-110 Multi-process micro-machining center.
2. Exercise on Micro-milling operation on DT-110 Multi-process micro-machining center.
3. Exercise on Micro-drilling operation on DT-110 Multi-process micro-machining center.

References

1.	Serope Kalpakjain, “Manufacturing Engg. and Technology”, Pearson Education, 2005.
2.	V.K.Jain, “Introduction to Micromachining”, Narosa Publishing House, 2010.
3.	M.J. Madou, “Fundamentals of Micro Fabrication”, CRC Press, 2002.
4.	Mark J. Jackson, “Micro Fabrication and Nano machining”, Taylor and Francis, 2006.
5.	Yi Qin, “Micro-Manufacturing Engineering and Technology”, Elsevier Publication, 2010.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the concept of precision engineering, its principles and importance as applicable to instruments and machines.
CO2	Explore Micro and nano manufacturing process
CO3	Apply Precision Metrology in Practical cases

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE30
Course Title	:	**Manufacturing of Composite Materials**
Type of Course	:	PE
Prerequisites	:	NIL
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand and classify the properties of composite materials.
CLO2	To understand and study the Polymer matrix composite processing methods.
CLO3	To design and study the metal matrix composite and Ceramic matrix composites processing methods.

Course Content

FRP composites – Fiber types, fiber forms and properties, matrices type and properties, lamina, laminate, orthotrophy, anisotrophy, composites.

Macro and micro-mechanical analysis and properties, Failure theories – Tsai – Hill, Tsai-Wu.

Primary and secondary manufacturing of composites – Lay-up, Autoclave Molding filament Winding, Pultrusion, Compression Molding, RTM, RIM, SRIM, machining, drilling and routing.

Metal matrix composites – Manufacturing route Design, Structural and testing, application.

Ceramic matrix composites – Manufacturing routes and application.

References

1.	Mein Schwartz., “Composite Materials Handbook”, McGraw Hill, 1992
2.	AutarK.Kaw, “Mechanics of Composite Materials”, CRC Press, 2005.
3.	“ASM Hand book on Composites”, Volume 21, 2001

Course Outcomes (CO)

At the end of the course student will be able

CO1	Define and classify the fundamentals of composite material.
CO2	Identify processing methods of the polymer matrix composite material.
CO3	Select and identify processing methods for metal matrix composite and ceramic matrix composites.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE31
Course Title	:	**Machine Tool Technology**
Type of Course	:	PE
Prerequisites	:	PRPC14
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand different types of machine tools.
CLO2	To analyse the source of vibration in machine structure.
CLO3	To apply automation in machine control.

Course Content

Classification of machine tools - features construction and operation of basic machine tools - different types and mechanics of transmission of machine tool motion - kinematic structure of machine tools

Mechanical drives for rotational movement - stepped and step less O/P -mechanical drives for reciprocation

Strength and rigidity of machine tool structures - design of lathe beds - design of drill columns - analysis of spindle bearings hydrodynamic bearings - stack slip motion - hydrostatic bearings

Vibration of machine - sources of vibration.

Semi automation - automatic machines with mechanic controls.

References

1.	Sen, G.C. and Bhattacharya, A., "Principles of machine tools", New Central Book Agency, Calcutta, 2006.
2.	Mehta, N.K., "Machine tool design", Tata McGraw Hill Co., N.Delhi , 2008.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Classify different types of machine tools.
CO2	Analyse vibration of machine structures.
CO3	Design lathe beds, drill columns.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE32
Course Title	:	**Non Destructive Testing**
Type of Course	:	PE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To study various Non-Destructive Testing methods and evaluation and their industrial applications.
CLO2	To describe appropriate techniques to detect the defects in components
CLO3	To impart knowledge on quantification and calibration of equipment

Course Content

NDT Versus Mechanical testing, Overview of the Non Destructive Testing Methods for the detection of manufacturing defects as well as material characterization. Relative merits and limitations, Various physical characteristics of materials and their applications in NDT., Visual inspection – Unaided and aided.

Surface NDE methods - Liquid Penetrant Testing - Principles, types and properties of liquid penetrants, developers, advantages and limitations of various methods, Testing Procedure, Interpretation of results. Magnetic Particle Testing- Theory of magnetism, inspection materials Magnetization methods, Interpretation and evaluation of test indications, Principles and methods of demagnetization, Residual magnetism.

Thermography and eddy current testing - Thermography- Principles, Contact and non-contact inspection methods, Techniques for applying liquid crystals, Advantages and limitation - infrared radiation and infrared detectors, Instrumentations and methods, applications. Eddy Current Testing-Generation of eddy currents, Properties of eddy currents, Eddy current sensing elements, Probes, Instrumentation, Types of arrangement, Applications, advantages, Limitations, Interpretation/Evaluation.

Ultrasonic testing and acoustic emission - Ultrasonic Testing-Principle, Transducers, transmission and pulse-echo method, straight beam and angle beam, instrumentation, data representation, A/Scan, B-scan, C-scan. Phased Array Ultrasound, Time of Flight Diffraction. Acoustic Emission Technique –Principle, AE parameters, Applications

Radiography - Principle, interaction of X-Ray with matter, imaging, film and film less techniques, types and use of filters and screens, geometric factors, Inverse square, law, characteristics of films - graininess, density, speed, contrast, characteristic curves, Penetrameters, Exposure charts, Radiographic equivalence. Fluoroscopy- Xero-Radiography, Computed Radiography, Computed Tomography.

References

1.	Baldev Raj, T.Jayakumar, M.Thavasimuthu "Practical Non-Destructive Testing", Narosa Publishing House, 2009.
2.	Ravi Prakash, "Non-Destructive Testing Techniques", 1st revised edition, New Age International Publishers, 2010
3.	ASM Metals Handbook,"Non-Destructive Evaluation and Quality Control", American Society of Metals, Metals Park, Ohio, USA, 200, Volume-17.
4.	Paul E Mix, "Introduction to Non-destructive testing: a training guide", Wiley, 2nd Edition New Jersey, 2005
5.	Charles, J. Hellier," Handbook of Nondestructive evaluation", McGraw Hill, New York 2001.
6.	ASNT, American Society for Non Destructive Testing, Columbus, Ohio, NDT Handbook,Vol. 1, Leak Testing, Vol. 2, Liquid Penetrant Testing, Vol. 3, Infrared and Thermal Testing Vol. 4, Radiographic Testing,

Course Outcomes (CO)

At the end of the course student will be able

CO1	Apply the various Non Destructive Testing methods to identify the defects in components
CO2	Identifying the nature and quantifying the defects
CO3	Select the suitable NDT techniques for various defects

Mapping of Programme Outcomes with Course Outcomes

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	-	-	-	-	2	-	-	-	-	-	-
CO2	2	-	-	-	-	2	-	-	-	-	-	-
CO3	2	-	-	-	-	2	-	-	-	-	-	-

Course Code	:	PRPE33
Course Title	:	**Surface Engineering**
Type of Course	:	PE
Prerequisites	:	NIL
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To study the fundamental concepts and significance of surface engineering.
CLO2	To explore various surface coating techniques.
CLO3	To study the methods of characterizing surface properties.

Course Content

Introduction- Significance of surface engineering- Solid surface- Surface energy-Superficial layer- Physico-chemical parameters- Properties of the superficial layer-Surface coating-Classification. Physical vapor deposition (PVD): Ion plating- Sputter deposition- Reactive deposition- Magnetron sputtering- Chemical vapor deposition (CVD)- Ion implantation-Electron beam technology- Applications.

Thermal Spraying Techniques- Flame Spraying, Atmospheric Plasma Spraying (APS), Vacuum Plasma Spraying (VPS), Detonation-Gun Spraying (D-GUN), High-Velocity Oxy-Fuel (HVOF) Spraying-Applications.

Laser surface engineering- Laser transformation hardening - Laser remelting- Laser alloying-Laser cladding- Laser ablation- Pulsed laser deposition- Laser doping - Laser crystallization-Laser surface texturing- Laser shock peening.

Methods of characterization-Microstructure- Mechanical: Adhesion-Hardness-Residual stress- Friction-Wear- Physical: Porosity-Density- Electrical: Conductivity- Magnetic-Chemical.

References

1.	Tadeusz Burakowski, TadeuszWierzchon, “Surface Engineering of Metals-Principles, equipment and technologies”, CRC Press, 1999.
2.	Lech Pawlowski, "The Science and Engineering of Thermal Spray Coatings", 2nd Edition, John Wiley & Sons, 2008.
3.	William M. Steen, JyotirmoyMazumder, “Laser Material Processing”, 4th Edition, Springer Verlag, 2010.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the importance of surface engineering.
CO2	Explore various surface coating techniques.
CO3	Analyze surface properties using various methods.

Mapping of Programme Outcomes with Course Outcomes

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	-	3	2	-	-	2	2	2	-	-
CO2	1	3	2	-	-	2	2	-	1	-	2	1
CO2	1	-	2	-	2	-	-	-	-	-	-	-

Course Code	:	PRPE34
Course Title	:	**Processing of Polymeric Composites**
Type of Course	:	PE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the methods of preparation, properties and applications of thermoplastic materials.
CLO2	To identify engineering and high performance plastics for specific application.
CLO3	To study the methods of manufacturing of various polymer composites.

Course Content

Methods of manufacturing - Properties and applications of polyethylene - LDPE -LLDPE- HDPE, HMWHDPE- UHMWHDPE - Cross linked polyethylene- Chlorinated polyethylene - Polypropylene - Homopolymers - Copolymers.

Methods of manufacturing - Properties and applications of poly(vinyl chloride)- Poly (vinylidene chloride)- Poly(vinyl alcohol) - Poly(vinyl acetate)- Chlorinated poly(vinyl chloride)- Plastisols, Poly vinylpyrrolidiene, Polystyrene, HIPS, EPS, SAN, EVA, EPDM, ABS.

Methods of manufacturing - properties and applications of Acrylates - Poly (methyl methacrylate) - Polyacrylonitrile. Aliphatic polyamides –Aromatic polyamides- Polyethylene terephthalate - Polybutylene terephthalate - Polyacetals and copolymers -Polycarbonates- Thermoplastic polyurethane (TPU)

Methods of manufacturing- Properties and applications of Fluoro polymers - Polytetrafluoroethylene, Polychlorofluoroethylene, Thermoplastic polyurethanes, Biodegradable polymers - poly ξ–caprolactone and copolymers - polylactic acid-Bacterial polyhydroxy alkonates.

Preparation, properties and applications of High performance Thermoplastic materials PPS, PO, Polysulphone, Polyether Sulphone, PEEK, Polyimide. Biopolymer-cotton wool, collagen, hyaluroran.

References

1.	J.A.Brydson, “Plastics Materials”, Butterworth- Heinemann - Oxford, 6th Ed., 1995.
2.	Feldman.D and Barbalata.A, “Synthetic Polymers”, Chapman Hall, 1996.
3.	OlagokeOlabisi, “Hand Book of Thermoplastics”, Marcel Decker, inc., 1997
4.	K.J. Saunders, “Organic Polymer chemistry”, Chapman & Hall, NY, 1988.
5.	Irvin.I. Rubin, “Hand Book of Plastic Materials and Technology”, Wiley Interscience, NY, 1990.
6.	Charles Gebelein, Biotechnological Polymers: Medical, pharmaceutical and industrial applications, CRC press,1993

Course Outcomes (CO)

At the end of the course student will be able

CO1	Familiarize in manufacturing process of polymer.
CO2	Acquire skills in selecting polymeric materials for specific applications.
CO3	Explore various methods of manufacturing of various polymer composites.

MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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

Course Code	:	PRPE35
Course Title	:	**Introduction to Friction Composites**
Type of Course	:	PE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To demonstrate knowledge of brake systems principles and operations.
CLO2	To identify various raw materials and different types of friction composites.
CLO3	To study industrial standard practices in testing the friction composites and brake systems.

Course Content

Laws of friction- types of friction- wear- types of wear- mechanism involved in wear.

Brake system and Assembly - Basic requirements and functions of braking system, Types of brakes, hydraulic brake system, compressed air brake system, parking brakes, dual power brake system, regenerative brake system, fail-safe brake, ABS, EBSD, anti-skid braking system, brake efficiency and testing, weight transfer, braking ratio.

Types of Friction Materials and Applications - Friction Materials -Definition and Nature Overview of types- Organic Friction Materials- Ceramic Friction Materials- Sintered Friction Materials- Applications of friction materials with industrial case studies.

Ingredients and Manufacturing - Raw Materials- Classification of raw materials: Fillers, Binders, Friction Modifiers, Structural Reinforcement- Properties of raw materials - Manufacturing Process– Industrial case studies.

Characterizations - Physical, Chemical, Mechanical, Thermal, Tribological and Microstructural characterization as per industrial standards– case studies.

References

1.	Automotive Brake Systems, Robert Bosh GmbH, 1995, First edition, USA.
2.	ASM Handbook, Friction, Lubrication, and Wear Technology, Volume18, 1992, USA.
3.	Peter J.Blau, Friction Science and Technology- From Concepts to Applications, Second Edition, 2009, CRC Press, USA.
4.	Rudolf Limpert, Brake design and safety, II edition, SAE International, Warrendale,1999.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Demonstrate knowledge of brake systems principles and operations.
CO2	Identify various raw materials and different types of friction composites.
CO3	Study industrial standard practices in testing the friction composites and brake systems.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE36
Course Title	:	**Work Design and Facilities Planning**
Type of Course	:	PE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand method study and work management techniques
CLO2	To learn ergonomic analysis.
CLO3	To understand computerized layout planning.

Course Content

Methods study - motion and time study, and productivity - micromotion and macromotion study - Ergonomics.

Work measurement - techniques of work measurement - time study - production study. Facility layout - steps in facility location study - layout types and analysis.

Layout design process - systematic layout planning - analysis - designing the layout - Assignment model.

Computerized layout planning - CRAFT, ALDEP and CORELAP

References

1.	Barnes, Motion and time study, John Wiley, New York, 1990.
2.	ILO, Introduction to work study, ILO,Geneva,1974.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Perform ergonomic analysis.
CO2	Perform computerized layout planning.
CO3	Perform work measurements.

MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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

Course Code	:	PRPE37
Course Title	:	**Reliability and Maintenance Engineering**
Type of Course	:	PE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To identify and analyze failures of components and subcomponents of mechanical and electronic items.
CLO2	To distinguish different concepts in maintenance and explore in order to increase service life of the products/machines
CLO3	To learn about preventive maintenance and condition monitoring of machines.

Course Content

Definition of reliability – reliability Vs quality-reliability function-MTTF – hazard rate function-bathtub curve – derivation of the reliability function-constant failure rate model – time dependent failure models.

Weibull distribution – normal distribution – the lognormal distribution. Serial configuration – parallel configuration – combined series parallel systems – system structure function, minimal cuts and minimal paths.

Markov analysis – load sharing systems, standby system, degraded systems, three state devices – covariate models, static models, dynamic models, physics of failure models.

Basic Principles of maintenance planning – Objectives and principles of planned maintenance activity – Importance and benefits of sound Maintenance systems – Reliability and machine availability – MTBF, MTTR and MWT – Factors of availability – Maintenance organization – Maintenance economics.

Maintenance categories – Comparative merits of each category – Preventive maintenance, maintenance schedules, repair cycle – Principles and methods of lubrication – TPM – Condition monitoring.

References

1.	David J Smith, Butterworth-Heinemann,Reliability Maintainability and Risk; Practical methods for engineers, New Delhi, 2001
2.	B.S. Dhillon, Maintainability, Maintenance and Reliability for Engineers,CRC Press, 2006
3.	Roger L. Brauer, Safety and Health for Engineers, John Wiley Sons, 2006
4.	Hoang Pha, Handbook of Reliability engineering, Springer Publication, 2003.
5.	B.S. Dhillon, Engineering maintenance; a modern approach,CRCPress, 2002
6.	Butterworth-Heinemann,R. Keith Mobley, Maintenance Fundamentals, II edition, 2004

Course Outcomes (CO)

At the end of the course student will be able

CO1	Identify and analyze the failures of the components and subcomponents of mechanical and electronic items.
CO2	Distinguish different concepts in maintenance and explore in order to increase the service life of the products/machines.
CO3	Apply preventive maintenance techniques for machines.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE38
Course Title	:	**Noise and Vibration Analysis**
Type of Course	:	PE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To appreciate the basic concepts of vibration in damped and undamped systems.
CLO2	To determine the natural frequencies and mode shapes of the multi degree freedom and continuous systems.
CLO3	To learn the fundamentals of control techniques of vibration and noise levels.
CLO4	To use the instruments for the measuring and analyzing the vibration.

Course Content

Simple Harmonic motion, Fourier analysis, Conservative systems. classification of vibration: free and forced vibration, undamped and damped vibration, determination of natural frequencies.

Systems with two and multi Degrees of Freedom: static and dynamic coupling, principal modes of vibration, undamped dynamic vibration absorber, centrifugal pendulum absorber, Influence coefficients, eigen values and eigen vectors, matrix iteration; Dunkerley and Rayleigh's method.

Noise - Introduction, amplitude, frequency, wavelength and sound pressure level, addition, subtraction and averaging decibel levels, noise dose level, legislation, measurement and analysis of noise, measurement environment, equipment, frequency analysis, tracking analysis, sound quality analysis.

Transducers and vibration pickup, Vibrometer, Accelerometer, Velocity pickup or Velometer, Phase distortion and frequency measurement, Undamped dynamic vibration absorber, Tuned absorber, Damped dynamic vibration absorber, Optimally tuned vibration absorber.

Control strategies and limitations, integrated approach to low noise design, typical mechanical noise sources, mechanism of noise generation– vibration, impact, flow excitation, filters, silencers, damping, enclosure, absorbers, active noise control principle.

Signal Analysis and Measurements Techniques - Fourier methods in sound and vibration, Vibration exciters Measuring Devices, Analysers, signal processing; vibration trouble-shooting and diagnosis; time-domain and frequency-domain vibration analysis. FFT analyzer, vibration exciters, signal analysis, experimental modal analysis, machine conditioning and monitoring, fault diagnosis, Vibration Analysis by FEM.

References

1.	SingiresuS.Rao, "Mechanical Vibrations", 5th Edition, Pearson Education, 2010.
2.	Abom, M., "Sound and Vibration", KTH, Stockholm
3.	Rao, J.S., and Gupta, K., "Theory and Practice of Mechanical Vibrations", New Age International (Pvt) Ltd
4.	Fahy, F.J,. and Walker, J.G., "Fundamentals of Noise and Vibration", E and FN, Spon
5.	Kinsler, L.E., Frey, A.R., Coppens, A.B., and Sanders, J.V., "Fundamentals of Acoustics", John Wiley
6.	Norton, M.P., and Karcazub, D.G., "Fundamentals of Noise and Vibration Analysis for Engineers", 2nd 2003 Ed., Cambridge University Press

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand causes, source and types of vibrations in machineries.
CO2	Gain knowledge in sources and measurement standard of noise.
CO3	Design and develop vibrations and noise control systems.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE39
Course Title	:	**Data Analytics for Production Engineering**
Type of Course	:	PE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To realize the importance of data analytics.
CLO2	To gain competence on data analytics approaches
CLO3	To explore real life applications of data analysis and handling big data.

Course Content

Introduction to Multivariate Statistics-Degree of Relationship among Variables-Review of Univariate and Bivariate Statistics-Screening Data Prior to Analysis-Missing Data, Outliers, Normality, Linearity, and Homoscedasticity.

Regression Modelling - Multiple Regression- Linear and Nonlinear techniques- Hierarchical regression-Testing interactions (2way interaction) - Analysis of Variance and Covariance - Multivariate Analysis of Variance and Covariance. Logistic regression: Regression with binary dependent variable -Simple Discriminant Analysis- Multiple Discriminant analysis-Assessing classification accuracy- Conjoint analysis.

Principal Component Analysis -Factor Analysis- Orthogonal and Oblique Rotation-Factor Score Estimation-Multidimensional Scaling-Perceptual Map-Cluster Analysis.

Bayesian Modelling, Inference and Bayesian Networks, Support Vector and Kernel methods, Neural networks -Supervised and Unsupervised learning and Fuzzy logic approaches.

Latent Variable Models an Introduction to Factor, Path, and Structural Equation Modelling-Time series data analysis (ARIMA model) – Decision tree analysis- Introduction to Big Data Management, Approaches for handling big data- Overview on Machine Learning- Brief review of R and Python for data analysis.

References

1.	Hair, J. F., Black, W. C., Babin, B. J., Anderson, R. E., & Tatham, R. L. “Multivariate data analysis”, (7^{th}edition). Pearson India.2015
2.	Tabachnick, B. G., &Fidell, L. S., “Using multivariate statistics”, (5^{th}edition). Pearson Prentice Hall,2001
3.	Gujarati, D. N. , “Basic econometrics”, Tata McGraw-Hill Education,2012
4.	Malhotra, N. K., “ Marketing research: An applied orientation”, 5/e. Pearson EducationIndia, 2008
5.	Cohen, J., Cohen, P., West, S. G., & Aiken, L. S. “ Applied multiple regression/correlation analysis for the behavioral sciences”, Routledge.,2013
6.	Han, J., Kamber, M., & Pei, J. “Data mining: concepts and techniques: concepts and techniques”, Elsevier,2011
7.	Anil Mahershwari , Data Analytics, McGraw Hill Education; First edition (1 July 2017)

Course Outcomes (CO)

At the end of the course student will be able

CO1	Recognize the concepts of data analytics
CO2	Understand various approaches of data analytics
CO3	Explore the scope of data analytics in industrial applications

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE40
Course Title	:	**Numerical Methods for Engineers**
Type of Course	:	PE
Prerequisites	:	NIL
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To apply various numerical computational techniques to solve various engineering problems.
CLO2	Develop and implement numerically stable and accurate procedure for all the basic tasks of engineering.
CLO3	To understand the use of interpolation for numerical differentiation and integration
CLO4	To develop stable solution algorithms for ordinary differential equations

Course Content

Introduction - computer architecture - number representations – recursion, error propagation - error estimation - condition numbers.

Linear Systems - Gaussian elimination – pivoting - LU factorization - tri-diagonal systems special matrices - iterative methods - convergence of iterative schemes.

Roots of non-linear equations – bisection – Newton-Raphson iteration - interpolation of functions by polynomials -Lagrange Interpolation - triangular family -numerical differentiation and integration.

Ordinary differential equations -initial value problems - Euler and Runge-Kutta Methods - boundary Value problems,

Finite difference methods - minimization Problems - least square approximation – optimization.

References

1.	Numerical Methods Using MATLAB, John H. Mathews, Kurtis K. Fink, Pearson Publishers, 2004.
2.	Numerical methods for engineers by Steven C. Chapra and Raymond P. Canale. McGraw-Hill. 2015.
3.	Numerical methods for engineers and scientists by Joe D. Hoffman. Marcel Dekker, Inc. 2001.
4.	Numerical methods with programs in C by T. Veerarajan and T. Ramachandran. Tata McGraw-Hill. 2006.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Develop stable algorithms for solving linear systems of equations.
CO2	Develop efficient and stable algorithms for solving non-linear equations.
CO3	Implement numerically stable recursion algorithms for evaluating mathematical functions.
CO4	Develop stable solution algorithms for ordinary differential equations.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE41
Course Title	:	**Product and Service Life Cycle Management**
Type of Course	:	PE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	Define the fundamentals of PLCM system.
CLO2	Choose a suitable strategy for the requirement.
CLO3	Understand the importance of concurrent engineering.
CLO4	Discuss the various components of PDM with related concepts, projects and roles.

Course Content

Product life cycle management – Need for PLM, Components of PLM, Product Data and Product workflow, Drivers for Change, The PLM Strategy, Developing a PLM Strategy, A Five-step Process.

Cost of design changes, Concurrent Engineering, schemes for concurrent engineering like Design for manufacturing and assembly, robust design, failure mode and effect-analysis, Computer aided DFM, Design rules.

Basic functionality of PDM: Information architecture, PDM System architecture, Applications used in PDM systems. Trends in PDM. Document Management Systems- Document management and PDM, Document life cycle, Content Management - Workflow Management in PDM: Structure Management, Engineering Change Management, Release Management, Version Management, Configuration Management.

Creating Product Structures: Part centric approach, CAD centric approach, Product Structure configuration, Managing Product Structures.

Service life cycle management: Workforce administration, Components planning and forecasting, Enterprise asset management, Reverse logistics, knowledge administration, Contract management, Returns and repair management.

References

1.	Product Lifecycle Management Paradigm for century Product Realization **-** John Stark, Springer- Verlag, 21st, London, 3rd printing -2006, ISBN: 1-85233-810-5.
2.	Crnkovic, Ivica; Asklund, Ulf; & Dahlqvist, Annita Persson. Implementing and Integrating Product Data Management and Software Configuration Management, Artech House Publishers, 2003. ISBN 1580534988
3.	Burden, Rodger PDM: Product Data Management, Resource Pub, 2003. ISBN 0970035225
4.	Grieves, Michael. Product Lifecycle Management, McGraw-Hill, 2006. ISBN 0071452303

Course Outcomes (CO)

At the end of the course student will be able

CO1	Explain product life cycle management concepts.
CO2	Analyse schemes of concurrent engineering.
CO3	Appraise product data management concepts and adapt PDM system architecture for a case study.
CO4	Applications of service life cycle management.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE42
Course Title	:	**Laser Micromachining**
Type of Course	:	PE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the mechanism of material removal during laser micromachining process.
CLO2	To emphasize the importance of short and ultra-short pulse laser and their applications.
CLO3	To explore the sensor integration for process monitoring of laser micromachining process.

Course Content

Laser fundamentals- properties and types- theory and modes of operation- short pulse- Ultrashort pulse laser ablation- Ablation threshold theory- Laser micro machining methods- Laser scanning techniques- Laser texturing- Laser polishing and cleaning- Laser safety.

Surface and hole morphology defects- Barreling and hole taper- Hole roundness- Spatter and recast layer- Microcracks- Heat affected zone- Microstructure.

Laser micromachining of non-ferrous, ferrous, ceramics, composite and difficult-to-cut materials - Under water laser ablation - Laser assisted mechanical micromachining- process modelling and optimization.

Miniaturised laser machine tools - Fabrication of micro cutting tools- Sensor integration for process monitoring - Dimensional, form, and surface integrity measurement of laser micro machined surface.

Role of Artificial intelligence in laser micromachining process.

References

1.	Joseph Mc Geough, Micromachining of Engineering Materials, Marcel Dekker Inc, New York, 2002.
2.	Ronald Schaeffer , Fundamentals of Laser Micromachining, Taylor & Francis, 2012
3.	V. K. Jain, Introduction to Micromachining, Narosa Publishing House Pvt Ltd, New Delhi, 2010.
4.	J. Paulo Davim and Mark J. Jackson, Nano and Micromachining, John Wiley & Sons, London, UK.,2013.
5.	Svelto, O. and D. C. Hanna. Principles of Lasers, Springer US, 2013.
6.	S. S. Charschan, “Lasers in Industry”, Wiley & Sons Inc., 1974.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Demonstrate the basic concepts of laser micro-machining process.
CO2	Select suitable laser micromachining technique for a given application.
CO3	Understand the dimensional, form and surface integrity measurement of laser micro machined component.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE43
Course Title	:	**Strategic Design for Additive Manufacturing**
Type of Course	:	PE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To inculcate fundamentals of additive manufacturing technologies and their importance in industry 4.0.
CLO2	To understand, evaluate, analyze strategic design considerations for additive manufacturing, part consolidation and software tools.
CLO3	To familiarize on design and guidelines for polymer, metal additive manufacturing techniques and post-processing considerations.

Course Content

Overview to Additive Manufacturing (AM), Recent AM growth trends and developments around the world. Benefits of AM and their importance in Industry 4.0. In the context of DfAM, how AM is being applied, and how certain parts can be designed for AM. AM Data Formats, economics of AM.

Introduction to Design for Additive Manufacturing DfAM, General Guidelines for Designing AM Parts, Design to Avoid Anisotropy, The Economics of Additive Manufacturing, Design to Minimize Print Time, Design to Minimize Post-processing, Take Advantage of Design Complexity.

Various Software Tools- Solid modeling, Topology Optimization, Finite Element Analysis-Autodesk Inventor, nTopology, Magic's, ANSYS additive. Aims of Using Design Analysis for AM, Special Considerations for Analysis of AM parts, Mesh, Boundary Conditions, Topology Optimization-Objective and Constraints, Common Setting, Post-Processing and Interpreting Results, Parametric or Size Optimization, Build Process Simulation-Layer by Layer Simulation, Scan Pattern Simulation, Limitations.

Design for Polymer AM- Anisotropy, Wall thickness, Overhangs, and Support Material, Polymer Design Guidelines.

Design for Metal AM- Designing for Metal Powder Bed Fusion, Metal Powder Production, Powder Morphology, Potential Defects in AM Materials, Metal AM Guidelines, The Reality of Metal AM, Lattice Structures, Overhangs and Support Material, Residual Stress, Stress Concentrations, Post- processing.

References

1.	Martin L. (2019) "Design for Additive Manufacturing." Elsevier Science ISBN:9780128168875, 0128168870
2.	Olaf Diegel, Axel Nordin, Damien Motte – 'A Practical Guide to Design for Additive Manufacturing' Springer-ISBN 978-981-13-8280-2 ISBN 978-981-13-8281-9
3.	Gibson I, Rosen D, Stucker B (2015) "Additive manufacturing technologies: 3D printing, rapid prototyping, and direct digital manufacturing." 2nd edition. Springer, Berlin.
4.	T.S. Srivatsan, T.S. (2016) "Additive Manufacturing Innovations, Advances, and Applications." CRC Press-ISBN-13: 978-1-4987-1478-5

Course Outcomes (CO)

At the end of the course student will be able

CO1	Impart a basic understanding of the Additive manufacturing and DfAM strategic design and part consolidation.
CO2	Understand the computational tools for design, analysis and optimization of AM parts.
CO3	Enable the design and use guidelines for polymer and metal AM techniques.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRPE44
Course Title	:	**Control Systems**
Type of Course	:	PE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To provide knowledge of any industrial operations involving control of position, velocity, temperature, pressure etc.
CLO2	To make familiar with theory and practice of automatic control.
CLO3	To study PID controllers.

Course Content

Introduction - Review of Laplace Transform, Close-loop control versus open-loop control, Linear Time Invariant (LTI) systems.

Representation of physical system - Transfer function and impulse response function, modelling in state space, transformation of mathematical models with MATLAB, signal flow graphs, linearization of nonlinear mathematical models - Mathematical modeling of control systems - Mechanical, Electrical and Electronic systems, liquid-level systems, pneumatic and hydraulic systems.

Time response analysis - Transient and Steady-State Response Analyses, 1st order, 2nd order and higher-order systems, Routh's Stability Criterion, Effects of Integral and Derivative Control Actions on System Performance, SteadyState Errors in Unity-Feedback Control Systems.

Control Systems Analysis and Design by the Root-Locus Method - Plotting Root Loci with MATLAB, Root-Locus Plots of Positive Feedback Systems, Lag, Lead and Lag–Lead Compensation – Frequency-Response Method – Bode Diagrams, Polar Plots, Log-Magnitude-versus-Phase Plots, Nyquist Stability Criterion.

PID Controllers – Ziegler–Nichols Rules for Tuning PID Controllers, Design of PID Controllers with Frequency-Response Approach.

References

1.	Modern Control Engineering by K.Ogata, 5th edition, Prentice Hall, 2010.
2.	Automatic Control Engineering by F.H.Raven, 5th ed., McGraw Hill International, 1994.
3.	Digital Control Systems by B.C.Kuo, Prentice Hall.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Describe the open-loop and closed-loop control system used in practice.
CO2	Compare the performance of different control systems by using both the time response and the frequency response method.
CO3	Design PID Controllers.

Mapping of Programme Outcomes with Course Outcomes

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

OPEN ELECTIVE (OE)

Course Code	:	PROE10
Course Title	:	**Operations Management**
Type of Course	:	OE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand core concepts, decision-making, and the differences between manufacturing and service sectors.
CLO2	To apply capacity and aggregate planning methods to optimize operations.
CLO3	To develop expertise in production scheduling, MRP, and Just-In-Time strategies.

Course Content

Overview of Production System, Objectives of Operation Management, Scope of Operations Management, Operations Management Frame work, Relationship of operations with other Functional areas, Manufacturing Vs Service sector, Operations Decision making, Production Design Process and Process choices.

Measures of capacity, Factors affecting capacity, Capacity planning, Systematic approach to capacity planning, Long-term and short-term capacity decisions, Tools for capacity planning, Capacity Requirement planning- Business process outsourcing.

Aggregate Planning strategies and methods-Pure and mixed strategies-Transportation method- LPP method.

Master Production Schedule, MRP-Lot sizing methods - Wagner and whitens algorithm,

MRP II, CRP.

Assembly Line Balancing – algorithms, Group technology – Production Flow analysis – Rank order clustering, Business Process Reengineering-JIT.

References

1.	Analysis and control of Production System by Elsayed A Elsayed, Thomas O. Boucher, Prentice Hall publications, 1993
2.	Buffa, E.S., "Modern Production/Operations Management", 7th edition, John Wiley sons,2007.
3.	Krajewski and Ritzman, "Operations management", Addison Wesley Pub. Co, 2007
4.	Norman Gaither, Greg Frazier, Operations Management, Thomson Learning, 9thEdition,2002.
5.	Monks J.G. Operations Management, McGraw Hill, 2004

Course Outcomes (CO)

At the end of the course student will be able

CO1	Perform production management tasks.
CO2	Describe the various components and functions of production planning and control.
CO3	Know the recent trends like manufacturing requirement Planning (MRP II) and Master production schedule (MPS).

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PROE11
Course Title	:	**Project Management**
Type of Course	:	OE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To enable the students to understand the methods for project identification and appraisal.
CLO2	To plan and schedule a project with resource and environmental constraints.
CLO3	To develop quantitative methods for project selection, risk assessment, monitoring and control.

Course Content

Introduction - Project Management: An Overview – Types, Characteristics of Projects – Project life cycle. Identification of investment opportunities - Screening and Selection.

Project Appraisal, Market and demand analysis- market survey-demand forecasting methods-Technical analysis – manufacturing process, materials-product mix, plant location-project charts and layouts.

Financial analysis – cash flows for project appraisal- Investment evaluation using capital budgeting techniques - net present value, profitability index internal rate of return, payback period, accounting rate of return.

Mathematical Techniques for project evaluation – Linear programming, goal programming, Network technique for Project Management – CPM, PERT, Multiple projects and constraints, scheduling. Performance metrics for project evaluation.

Organization systems for project implementation- Work Breakdown-coordination and control-Project Management Soft wares, Role of AI in project management.

References

1.	Prasanna Chandra, “Projects – Planning, Analysis, Financing, Implementation and Review”, Tata McGraw Hill,8th Ed, 2017
2.	S.Choudry “Project Management”, ”, Tata McGraw Hill,5th Ed, 1995
3.	Mike Field and Laurie Keller, “Project Management”, Thompson Business press, 2002
4.	http://nptel.ac.in/courses/110104073/

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the process and approaches for executing projects.
CO2	Develop and analyze quantitative models for project selection and scheduling.
CO3	Apply engineering and management principles to manage real time projects considering constraints.
CO4	Apply tools for managing complex projects.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	**:**	PROE12
Course Title	**:**	**Value Engineering**
Type of Course	**:**	OE
Prerequisites	**:**	NIL
Contact Hours	**:**	3-0-0-3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the concept and approaches of value analysis and engineering.
CLO2	To justify the value of money and value of product.
CLO3	To Implement Value Engineering in any type of organization.

Course Content

An Overview of Value Engineering**-**Concepts and approaches of value analysis and engineering -importance of value, Function - identity, clarify – analysis.

Evaluation of VE-Evaluation of function, Problem setting system, problem solving system, setting and solving management - decision - type and services problem, evaluation of value.

Results accelerators, Basic steps in using the systems.

Understanding the decision environment, Effect of value analysis on other work in the business- Life Cycle Cost (LCC), Case studies.

VE Level Of Effort-VE Team, coordinator, designer, different services, definitions, construction management contracts, value engineering case studies, Effective organization for value work, function analysis system techniques- FAST diagram, Case studies.

References

1.	Parker, D.E., “Value Engineering Theory”, Sundaram publishers, 1990.
2.	Khanna, O.P., “Industrial Engineering and Management”, DhanpatRai and Sons, 1999.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the concept and approaches of value analysis and engineering.
CO2	Justify the value of money and value of product.
CO3	Implement of Value Engineering in any type of organization.

MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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

Course Code	:	PROE13
Course Title	:	**Artificial Intelligence and Expert systems**
Type of Course	:	OE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To study the concepts of Artificial Intelligence.
CLO2	To understand the methods of solving problems using Artificial Intelligence.
CLO3	To learn about the components of decision support system and expert systems.

Course Content

Aspects of intelligence and AI - heuristic search - logic programming and reasoning - automatic programming-scope of AI-in manufacturing - components of intelligent manufacturing.

Requirements of AI languages - Languages Lisp and Prolog - simple programs.

Knowledge engineering- protocol analysis - fuzzy logic - Semantic networks, learning systems - inference engine.

Vision programs - factory vision systems - machine learning.

Features of Experts systems - applications in manufacturing planning and control.

References

1.	Simons, G.L., "Introducing Artificial Intelligence", NCC Publications, 1984
2.	Maus, R and Keyes J Handbook of Expert Systems in manufacturing McGraw Hill, 1991
3.	Ernest R Tello, "Mastering AI tools and techniques"

Course Outcomes (CO)

At the end of the course student will be able

CO1	Describe the basic concepts, Operations and Principles of Artificial Intelligence.
CO2	Recognize the basic concepts, Operations and Principles of Fuzzy Logic.
CO3	Employ the concept of AI & fuzzy logic in Manufacturing Environments.

MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES

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

Course Code	:	PROE14
Course Title	:	**Processing and Manufacturing of Semiconductors**
Type of Course	:	OE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand semiconductor and its types.
CLO2	To understand and apply various processing techniques to fabricate semiconductors.
CLO3	To learn modern semiconductor manufacturing.

Course Content

Introduction to semiconductors – Energy band theory – Classification – Intrinsic and extrinsic – P-type and N-type – P-N junction diode – semiconductor device design – photo-voltaic cells, bipolar and MOSFET transistor – applications

Basic requirements for semiconductor manufacturing - clean room – yield model – Wafer IC manufacturing – feature micro fabrication technologies – PSM – IC industry – New Materials – Bonding and layer transfer – devices – micro fabrication industries

Processing sequence – Oxidation – Growth kinetics, thin oxide growth, oxide quality – photolithography – Exposure tools, pattern transfer, deep UV sub-micron, E-beam lithography, X-Ray lithography – Etching – Wet chemical and dry etching

Doping – diffusion, Ion implantation – Physical and chemical vapour deposition – Planarization – chemical mechanical planarization – chemical-mechanical polish (CMP) – maintenance and troubleshooting

Modern semiconductor manufacturing – Process integration – Bipolar technology, CMOS technology – CMOS fabrication sequence – BiCMOS technology – Packaging – Die separation, Package types, attachment methods.

References

1.	Yoshio Nishi, Robert Doering, “Handbook of Semiconductor Manufacturing Technology”, Second Edition, CPC press, 2008
2.	Gary S. May, Costas J. Spanos, “Fundamentals of Semiconductor Manufacturing and Process Control”, Wiley- interscience, 2006
3.	Hwaiyu Geng, “Semiconductor Manufacturing Handbook”, McGraw Hill Professional, 2005.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand semiconductor and its types.
CO2	Understand and apply various processing techniques to fabricate semiconductors.
CO3	Explore modern semiconductor manufacturing.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PROE15
Course Title	:	**Finite Element Analysis for Solids and Structures**
Type of Course	:	OE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand FEM and Differential Equations
CLO2	To analyze elastic solids and multifield formulations.
CLO3	To explore plates, shells, and non-linear problems.

Course Content

Introduction, Calculus of Variations, methods for solving differential equations, Ritz and Galernkin FEM formulations

Analysis of elastic solids –Mapped solid elements – stress calculation –– static condensation -Patch test – computer implementation - Solids of revolution – axisymmetric analysis - unsymmetrical loading

Multifield formulations - beam elements – Euler-Bernouli and Timoshenko theories – displacement based team elements – mixed beam element methods

Multifield formulations - Elastic solids – assumed stress filed for mixed formulations – analysis for nearly imcompressible solids

Plates and shells – Kirchoff's plate theory for rectangular and triangular plate elements – Mindlind plate theory – analysis of shell structure- introduction to non-linear problems.

References

1.	M.Asghar Bhatti, "Fundamental Finite Element Analysis and Applications: with Mathematica and Matlab Computations", Wiley; 1 edition, 2003
2.	Advanced Topics in Finite Element analysis of structures with Mathematica and Matlab computations, M.Asghar Bhatti, Wiley; 2006
3.	Bathe KJ, "Finite Element Procedures", Prentice Hall, 1994

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the numerical methods involved in Finite Element Theory and its direct/indirect methods.
CO2	Understand the FE procedure for solving solids and structures using mulitfiled formulations
CO3	Perform and verify FEA using commercial FEA software.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PROE16
Course Title	:	**Laser Materials processing**
Type of Course	:	OE
Prerequisites	:	NIL
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand laser properties, types, and how laser radiation interacts with materials.
CLO2	To study laser based manufacturing and material processes.
CLO3	To study post processes by using laser.

Course Content

Fundamentals of laser - properties - spectrum and wavelength - types of laser - laser components - interaction of laser radiation with materials.

Laser surface treatment - laser transformation hardening - advantages over conventional processes - laser surface melting - laser alloying - laser cladding.

Introduction to laser welding - process arrangement - process mechanisms - operating characteristics - process variations - applications.

Introduction - methods of cutting - theoretical models of cutting - practical performance - applications - process variations - drilling - applications.

Laser marking-engraving-methods and processing-applications-laser cleaning-laser shock processing-laser peening-laser engineered net shaping.

References

1.	William M. Steen, “Laser Material Processing”, Springer Verlag, 2003.
2.	K.Thyagarajan, Ajoy K.Ghatak, “Lasers, Theory and Applications”, Plenum Press, 1981.
3.	J.F. Reddy, “Industrial Applications of Lasers”, Academic Press, New York, 1978.
4.	Michael Bass, “Laser Materials Processing”, Elsevier Science, 1983.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand of Laser Principles.
CO2	Explore laser surface treatments, welding, cutting, and marking processes in various applications.
CO3	Explore post processing of materials by laser.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PROE17
Course Title	:	**Digital Manufacturing for Industry 4.0**
Type of Course	:	OE
Prerequisites	:	NIL
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To use engineering application software CAD/CAM/CAE skillfully to accomplish a digital manufacturing/validation of mechanical parts.
CLO2	To understand the components that constitute Industry 4.0.
CLO3	To establish a comprehensive understanding on modern manufacturing systems.

Course Content

Basics of Design and Manufacturing- Digital Technologies in manufacturing - Basic terminologies: CAD, CAE, CAPP, CAM - Digital twin - Digital thread - NX for Design - NX CAM: NC programming - post processing - machine simulation - NX CAE: Nastran - Basics - Finite element analysis - meshing - solving - integration - case examples.

Process Simulation and Plant Design- Digital twins of production facilities - virtual commissioning of automation systems - human centered design and planning - assembly simulation for virtual process verification - robotics programming - optimization of production logistics and material flow - configuration of digital factory layout - case studies involving Tecnomatix.

Virtual testing and optimization-Innovation through design exploration - Simulation of actuators and controls - Acoustics - Durability - Model based system - Rotating machinery - Structural dynamics - Transfer path analysis - SCADAS - Sound and vibration analysis - case studies involving simcenter.

Basics of Internet of Things - outline of IoT architecture - networking and communication - technology roadmap - challenges - future and potential of IoT - application in manufacturing industry - case studies.

Industry 4.0 - Introduction to Industrial revolution - Components of Industry 4.0: Digital manufacturing, augmented reality, Industrial Internet of Things, Big data analytics, cyber physical systems, cloud computing, artificial intelligence, cognitive computing, machine learning, cyber security.

References

1.	Zhou, Zude, Xie, Sheng, Chen, Dejun, Fundamentals of Digital Manufacturing Science. Springer Series in Advanced Manufacturing, 1st Edition, 2012.
2.	S. Jeschke, C. Brecher, H. Song, and D. B. Rawat, Industrial Internet of Things: Cybermanufacturing Systems, Springer, 1st edition, 2017.
3.	Web Reference: https://www.plm.automation.siemens.com/global/en/

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand CAD/CAM/CAE working process and technology development trend and digital manufacturing.
CO2	Apply IoT for manufacturing solutions.
CO3	Apply Industry 4.0 concepts on any existing systems.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PROE18
Course Title	:	**Micro and Nano Manufacturing Processes**
Type of Course	:	OE
Prerequisites	:	NIL
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand micro and nano manufacturing
CLO2	To explore advanced machining and finishing techniques
CLO3	To study Additive Manufacturing and Surface Modification

Course Content

Introduction to meso, micro and nano manufacturing- miniaturization and applications – micro-manufacturing – classification – micro-machining: concepts and significance- theory of micro-machining – chip formation -size effect in micro-machining.

LIGA, micro-stereolithography – micro-turning, micro-drilling, micro-milling, diamond turn machining - electric discharge micro-machining-ultrasonic micro-machining- laser beam micro-machining - elastic emission micro machining – focused ion beam micro-machining.

Abrasive flow finishing, magnetic abrasive finishing, magnetorheological finishing, magnetorheological abrasive flow finishing, magnetic float polishing – Hybrid finishing processes-chemo mechanical polishing, electro discharge grinding, electrolytic in process dressing grinding.

Introduction – classification – principles, advantages limitations and applications-stereolithography – selective laser sintering – FDM, SGC, LOM, 3D printing - Surface modification techniques: sputtering-CVD-PVD-plasma spraying technique - diffusion coatings - pulsed layer deposition.

Metrology for micro machined components - optical microscopy, white light interferrometry, micro CMM, scanning probe microscopy – scanning electron microscope, transmission electron microscope, atomic force microscope-Tribological characteristics -micro abrasion wear-nano indentation- ellipsometric analysis.

LAB EXERCISES

1) Micro-turning 2) Micro-drilling 3) Electrical discharge micro-machining.

References

1.	Jain, V.K “Introduction to Micro-machining”, Narosa publishing house, ISBN: 978-81-7319-915-8, 2010.
2.	Jain, V.K, “Micro-manufacturing Processes”, by CRC Press, ISBN: 9781439852903, 2012.
3.	Madou, M.J., “Fundamentals of Micro-fabrication: The science of miniaturization”, CRC Press, 2006.
4.	Mcgeoug.J.A., “Micromachining of Engineering Materials”, CRC Press, 2001.
5.	Kalpakjian.S, “Manufacturing Engineering and Technology”, Pearson Education, 2001.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the principles of various micro and nano manufacturing processes.
CO2	Execute micro-machining and hybrid finishing processes with precision and accuracy
CO3	Apply additive manufacturing methods and metrology tools to enhance the quality and performance of micro-manufactured components.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PROE19
Course Title	:	Sustainability in Manufacturing Processes
Type of Course	:	OE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To emphasize the importance of sustainability in basic and advanced manufacturing processes.
CLO2	To emphasize hybrid joining processes in sustainable manufacturing.
CLO3	To improve the joining and forming quality.

Course Content

Introduction to Sustainable manufacturing processes - Importance – Manufacturing processes and sustainability implementation, Fundamentals of mechanical behaviour of materials, Sustainability assessment, Computer-aided analyses and sustainable Manufacturing, Industry 4.0 and sustainable manufacturing.

Sustainability in foundry and metal casting industry – Green joining – Green Forming – Strategies to improve the forming quality of sheet – Sustainable machining techniques – Machining with surface textured tools – Sustainable nonconventional machining processes.

Sustainability in additive manufacturing processes – Sustainability issues in additive manufacturing – hybrid manufacturing – Role of post-treatment processes in sustainable manufacturing processes.

Sustainable product development process – Innovation and product development – Sustainability in remanufacturing.

Sustainability performance evaluation in manufacturing – Inclusive manufacturing.

References

1.	R. Ganesh Narayanan, Jay S. Gunasekara, Sustainable Manufacturing Processes, CRC Press, Taylor & Francis Group, ISBN 13: 978-1-138-06020-3, 2019, New York.
2.	Davim J, Paulo, Green Manufacturing Processes and Systems (Materials Forming, Machining and Tribology), Springer, ISBN-13: 978-3642431951, 2014.
3.	David A. Dornfeld, Green Manufacturing: Fundamentals and Applications (Green Energy and Technology), Springer, ISBN-13: 978-1441960153, 2012.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Identify sustainable candidates in manufacturing processes and evaluate sustainability.
CO2	Explore casting and machining for sustainable manufacturing.
CO3	Explore the strategies to improve the joining and forming quality.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PROE20
Course Title	:	**Green Material Joining and Forming**
Type of Course	:	OE
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To emphasize the importance of green joining and forming methods.
CLO2	To improve sustainability in friction and lubrication in metal forming practice.
CLO3	To emphasize hybrid joining process in sustainable manufacturing.

Course Content

Introduction to Sustainable manufacturing processes - Metal Forming Processes, Joining Processes, Sustainable Manufacturing, Sustainable Material Forming and Joining, Computer-Aided Engineering Analyses – Life cycle assessment.

Green Joining - Traditional Joining Methods and Sustainability, Sustainable and Green Joining Methods - Hybrid Joining Processes.

Green Forming - Metal-Forming Process Design, Aspects of Green Forming, Green Rolling, Some Recent Developments in Microforming, Tubular Hydroforming and Hydropiercing, Hot Stamping of Ultra-High-Strength Steel Parts and Smart Hot Stamping, Laser Metal Forming.

Strategies to Improve the Forming Quality of Sheets - Rolling Method and Conditions, Forming at Elevated Temperature, Incremental Sheet Forming, Hydroforming, Sandwich Sheet Formability, Tooling: Flexible Forming and Blank Holding.

Development in Materials for Sustainable Manufacturing - Environmental Impact Assessment, Material Selection, High-Performance Steels, Aluminum Alloys, Magnesium Alloys, Biocomposites, Eco-Materials, Waste Utilization from Paper and Pulp Industry, Green Lubricants and Lubrication.

Sustainability, Health, and Environment – A Case Study of Waste Management Sector.

References

1.	R.Ganesh Narayanan, Jay S. Gunasekara, Sustainable material forming and joining, CRC Press, Taylor & Francis Group, ISBN 13: 978-1-138-06020-3, 2019, New York.
2.	Davim J, Paulo, Green Manufacturing Processes and Systems (Materials Forming, Machining and Tribology), Springer, ISBN-13: 978-3642431951, 2014.
3.	David A. Dornfeld , Green Manufacturing: Fundamentals and Applications (Green Energy and Technology), Springer, ISBN-13: 978-1441960153, 2012.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Identify green joining and forming methods.
CO2	Improve sustainability in friction and lubrication in metal forming practice.
CO3	Explore hybrid joining process for sustainable manufacturing.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	**:**	PROE21
Course Title	**:**	**Automobile component manufacturing processes**
Type of Course	**:**	OE
Prerequisites	**:**	NIL
Contact Hours	**:**	3-0-0-3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To learn the basic processes available to make an automobile part/product.
CLO2	To select the best manufacturing process based on quality/time/cost/ mechanical properties.
CLO3	To learn finishing processes of automobile components.

Course Content

Introduction - Classification and comparison of manufacturing processes. Criteria for selection of a process.

Casting of engine block - conventional and expendable pattern, Casting for cylinder heads, connecting rod and gudgeon pins, Casting of piston, upset forging of valves, piston ring and engine bearing manufacturing, Manufacturing of friction plates, Manufacture of composite friction lining, Casting of gear box casing, precision forging of gears, Continuous casting of propeller shaft, Forging of rear axles, casting of rear axle casing, wheels, brake drum.

Basic concepts and classification of forming processes. Thermoforming, hydro forming and press forming, welding of body panels, Rolling, Extrusion, Wire drawing, Spinning. Powder metallurgy, steps involved, applications.

Use of EDM, ECM, ECG, USM, PAM, LBM for manufacturing of automobile components. Super Finishing Processes: Introduction to Grinding, Lapping, Honing, Buffing, Barrel Tumbling, Burnishing, Powder coating, Polishing.

Application of sensors and actuators – Emission control system – catalytic converter – Hydro forming of exhaust manifold and lamp housing – stretch forming of Auto body panels – MMC liners – thermal barrier coating of Engine head and valves – Selection of materials for Auto components.

References

1.	Hajra Choudhury, Elements of Workshop Technology, Vol-I and Vol-II Asia Publishing House, 1996.
2.	R.K.Jain and S.C.Gupta, Production Technology, Hanna Publishers, 1997.
3.	H.M.T. Production Technology-Hand Book, Tata McGraw Hill, 1990
4.	Philip F Ostwald and Jairo Munuz, "Manufacturing Processes and Systems", John Wiley & Sons, New York, 1998.
5.	Kalpakjian, "Manufacturing Engineering and Technology", Pearson Education, 2005.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Identify and select the methods of forging of various automobile components.
CO2	Select the non-conventional machining like EDM, ECM, ECG, USM, PAM, LBM for manufacturing automobile components.
CO3	Select finishing processes for automobile components.

Mapping of Programme Outcomes with Course Outcomes

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

MINOR (MI)

Course Code	:	PRMI10
Course Title	:	**Product Design and Development**
Type of Course	:	MI
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To develop skills in product design and development, from concept to prototype.
CLO2	To enable integration of customer needs into the design process.
CLO3	To apply tools for concept selection, product architecture, and industrial design.

Course Content

Characteristics of successful product development - Overview of product design and development processes - Challenges in product development (time, cost, and complexity) – Product development processes and organizations.

Product planning process: identifying opportunities and prioritizing projects – Resource allocation and timing in product planning – Gathering and interpreting customer needs – Organizing and prioritizing customer requirements.

Concept generation techniques: brainstorming, TRIZ, and systems-level thinking – Tools for solving contradictions and analysing functional requirements – Concept selection methods: concept screening, scoring, and using the Pugh matrix – Concept testing and Failure Mode Effect Analysis (DFMEA and PFMEA)

Understanding product architecture and its implications – Platform planning and supply chain considerations – Introduction to industrial design: process, impact, and quality assessment – Design for X (DFX): manufacturing, assembly, service, and quality.

Basics and principles of prototyping – Prototyping technologies and planning – Economic analysis of product development: financial models – Sensitivity analysis, and project trade-offs – Influence of qualitative factors on product success.

References

1.	Karl.T.Ulrich and Steven D Eppinger Irwin, Product Design and Development, 5th Edition, McGraw-Hill, 2011.
2.	George E Deiter, Engineering Design, 5th Edition, McGraw-Hill , 2012.
3.	Boothroyd G, Dewhurst P and Knight W, Product Design for Manufacture and Assembly, 2nd Edition, Marcel Dekker, New York, 2002.
4.	A K Chitale and R C Gupta, Product Design and Manufacturing, 6th Edition, PHI, New Delhi, 2003.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Describe key principles of product design and development.
CO2	Integrate customer requirements into the product design process.
CO3	Apply structured methods for concept generation, testing, and design evaluation.

MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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

Course Code	:	PRMI11
Course Title	:	**Manufacturing Processes**
Type of Course	:	MI
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the core principles and techniques of casting, welding, and metal forming processes.
CLO2	To acquire knowledge of traditional and advanced machining methods, emphasizing precision and efficiency.
CLO3	To develop practical skills in applying a wide range of manufacturing processes, from moulding to modern machining technologies.

Course Content

Types of pattern - Types of cores - Green Sand Moulding - Tools and equipment - Cupola and Blast Furnaces.

Welding Principle and Types - Gas Welding – GMAW – TIG – Plasma Welding – Resistance Welding - Friction welding

Classification of Forming – Forging and its Types – Upsetting –Extrusion of Solid Rod – Rolling of Plate – Drawing of wire – Sheet metal operations

Studies on Centre Lathe – Drilling – Milling– Shaper – Grinding-SPCT geometry – Orthogonal Cutting – Machining cylindrical Job –Gear Cutting –Taper turning and Thread Cutting Methods

Non-traditional mechanical machining - Electro chemical machining - Thermo electrical machining - Laser materials processing.

References

1.	Paul De Garmo, J.T.Black, and Ronald.A.Kohser, “Material and Processes in Manufacturing” 8thEdition, Prentice Hall of India Pvt. Ltd., New Delhi , 2001.
2.	Groover, M.P. “Fundamentals of modern manufacturing processes - Materials, Processes and Systems”, 3rd Edition, John Wiley and Sons Inc., 2007.
3.	Nagendra Parashar, and Mittal, R.K, Elements of manufacturing processes, Prentice Hall of India PrivateLimited,1st Edition,2003.
4.	Khanna,O.P and Lal, M,A Text book of Production Technology, Vol.II, Dhanpat Rai Publications (P)ltd.,1stEdition, 2009.
5.	H.M.T, Production Technology, Tata McGrawHill Publishing Co.Ltd, 1stEdition, 2008.
6.	Abdel, H. and El-Hofy, G. “Advanced Machining Processes”, McGraw-Hill, USA, 2005.
7.	Pandey P.C. and Shan H.S. “Modern Machining Processes” Tata McGraw-Hill, New Delhi, 2007.
8.	Benedict. G.F. “Nontraditional Manufacturing Processes” Marcel Dekker Inc., New York, 1987.
9.	McGeough, “Advanced Methods of Machining” Chapman and Hall, London (1998).

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand casting processes, including patterns, cores, and furnace operations.
CO2	Apply welding techniques and metal forming processes in manufacturing.
CO3	Demonstrate skills in traditional and non-traditional machining methods.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRMI12
Course Title	:	**CAD, CAM and CAE**
Type of Course	:	M
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand geometric modeling and graphic standards of CAD systems
CLO2	To understand basics of CAM
CLO3	To understand finite element modeling and DBMS

Course Content

Basic concepts of CAD, CAD workstation, CAD software, application of CAD, Interactive graphics: point plotting techniques, Transformations techniques, viewing operations.

Geometric modeling: Wireframe modeling, Surface modeling, Solid modeling. Graphics standards, Parametric design, Visual realism.

Computer aided manufacturing: NC/CNC, computer aided process monitoring - adaptive control, computer-aided process planning.

Production planning - capacity planning - shop floor control - computer integrated manufacturing systems, application.

Finite element modeling and analysis: types of analysis, degrees of freedom, element and structure-stiffness equation, assembly procedure. Database concepts and data base management systems - SQL.

LAB EXERCISES: Part modelling using CAD, Turning operation using CNC, Engineering analysis using CAE

References

1.	Anand, V.B., Computer Graphics and Geometric Modeling for Engineers, John Wiley and Sons, Inc., 2000.
2.	Zeid,I and Sivasubramanian, R., CAD/CAM, Tata McGraw-Hill, 2007.
3.	Mikell P. Groover and Emory W. Zimmers, Jr., CAD/CAM Computer Aided and Manufacturing Eastern Economy Edition,PHI
4.	Larry J Segerlind ,“ Applied Finite Element Analysis”, John Wiley, 1984
5.	YoramKoren, "Computer Control of Manufacturing Systems", McGraw Hill Book co. New Delhi, 1986.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Summarize the concepts and applications of CAD and modelling.
CO2	Generate CNC code for CNC Turning.
CO3	Analyze engineering components using finite element analysis software.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRMI13
Course Title	:	**Quality Engineering**
Type of Course	:	M
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To impart knowledge to enable the students to design and implement Statistical Process Control in any industry.
CLO2	To design and implement acceptance sampling inspection methods in industry.
CLO3	To achieve savings in rupees to the companies through quality control and improvement programmes.

Course Content

Importance of quality- evolution of quality- definitions of quality- dimensions of quality- quality control- quality assurance- areas of quality- quality planning- quality objectives and policies quality costs- economics of quality- quality loss function- Quality Gurus and their contributions.

Process variation- preliminary decisions- control limits and their computation- construction and application of X bar, R and S charts- warning and modified control limits- process adjustment for trend,- Comparison of process variation with specification limits

Process stability- process capability study using control charts- capability evaluation- Cp, Cpk and Cpm – machine capability study- gauge capability study- setting statistical tolerances for components and assemblies - individual measurement charts- X-chart, moving average and moving range chart.

Limitations of variable control charts- Control charts for fraction non-conforming- p and np charts, variable sample size, - Control chart for nonconformities (defects)- c, u, demerits control chart- applications.

Need- economics of sampling- sampling procedure- single and double sampling- O.C. curves- Average outgoing quality- Average sample number- Average total inspection- Multiple and sequential sampling- Design of sampling plans.

REFERENCES

1.	Douglus C. Montgomery, “Introduction to Statistical Quality Control”, John Wiley & Sons, 2004.
2.	Krishnaiah K.,” Applied Statistical Quality Control and Improvement”, PHI, 2014.
3.	Eugene L. Grant and Richard S. Leaven Worth, “Statistical Quality Control”, TMH, Seventh Edition, 2000.
4.	Dale H. Besterfield, Quality Control, Pearson Education Asia, Seventh Edition, 2004.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Control the quality of processes using control charts for variables in manufacturing industries.
CO2	Control the occurrence of defects in services.
CO3	Achieve savings in rupees to the companies through quality control and improvement programmes.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRMI14
Course Title	:	**Industrial Engineering and Management**
Type of Course	:	M
Prerequisites	:	NIL
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To learn the concepts of Industrial Engineering, Operational Research Techniques, and Quality Engineering.
CLO2	To learn supply chain management.
CLO3	To study production planning and control.

Course Content

Introduction to Industrial Engineering – Method study, Time study, Motion Economy, Value Analysis, Demand Forecasting, Scheduling

Production Planning and Control - Inventory Control, Material Requirement Planning, Aggregate Planning, Material Handing.

Group technology, Facility planning, Design of Product and Process Layouts.

Supply Chain Management - Understanding the Supply Chain, Achieving Strategic Fit, Drivers and Metrics, Designing the Supply Chain Network - Managing Cross Functional Drivers in a Supply Chain.

Operational Research Techniques – Linear Programming, Transportation, Assignment models, Queuing Theory, Simulation.

References

1.	Sunil Chopra and Peter Meindel , Supply Chain Management: Strategy, Planning, and Operation, Prentice Hall of India, 2002.
2.	R.Paneerselvam, Production and Operations Management, (3rd edition) PHI Learning Pvt Ltd,2012.
3.	Jerry Banks, Discrete Event System Simulation, Prentice Hall ,2010.
4.	Hamdy A. Taha, Operations Research an Introduction, Prentice Hall ,1997.
5.	O.P.Khanna, Industrial Engineering and Management, Dhanpat Rai, 1980.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Summarize different techniques for production planning and control like inventory control and Material requirement.
CO2	Apply optimization in utilization of resources like queuing uncertainty and mathematical modeling are involved
CO3	Perform work measurements and computerized layout planning

Mapping of Programme Outcomes with Course Outcomes

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

Essential programme laboratory Requirement (ELR)

Course Code	:	PRLR10
Course Title	:	**Manufacturing Processes Lab**
Type of Course	:	ELR
Prerequisites	:	PRPC11, PRPC14
Contact Hours	:	0-0-3-2
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To impart practical knowledge on various operation on Lathe.
CLO2	To Perform tasks on milling and grinding machine.
CLO3	To deliver hands-on expertise in EDM machines

Course Content

EXERCISE-1: Step turning
EXERCISE-2: Taper turning and parting off
EXERCISE-3: Knurling
EXERCISE-4: Thread cutting
EXERCISE-5: Boring
EXERCISE-6: Eccentric turning
EXERCISE-7: Copy turning
EXERCISE-8: Shaping rectangular block or cube
EXERCISE-9: Slot cutting/ Step-cutting/ V-lock
EXERCISE-10: Milling rectangular block or cube
EXERCISE-11: T -Slot milling
EXERCISE-12: Spur gear cutting
EXERCISE-13: Surface grinding
EXERCISE-14: Single point tool grinding
EXERCISE-15: Spur and Helical gear generation on hobbing machine
EXERCISE-16: Complex shaped component production using EDM.
EXERCISE-17: Drilling
EXERCISE-18: Fabrication of Polymeric based Product and Near net shape product manufacturing.

References

1.	Hajra Choudhury SK, Bose HK and Hajra Choudhury AK, Elements of Workshop Technology, Vol. II, Media promoters and Publishers Pvt. Ltd. 12thEdition, 2007.
2.	ASM Handbook Volume 16: Machining
3.	Manufacturing Science, Amitabha Ghosh and Ashok Kumar Mallik, East-West Press, 2010
4.	Nagendra Parashar, and Mittal, R.K, Elements of manufacturing processes, Prentice Hall of India Private Limited,1st Edition, 2003.
5.	H.M.T, Production Technology, Tata McGrawHill Publishing Co.Ltd, 1st Edition, 2008.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Perform precise turning operations, including step turning, taper turning, and thread cutting.
CO2	Execute milling and grinding tasks to create components such as T-slots, spur gears, and complex shapes.
CO3	Demonstrate proficiency in advanced machining techniques, including EDM, gear generation, and polymeric product fabrication.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	**:**	PRLR11
Course Title	**:**	**Weldability, Foundry and Formability Laboratory**
Type of Course	**:**	ELR
Prerequisites	**:**	PRPC11, PRPC14
Contact Hours	**:**	0-0-3-2
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To Weld materials effectively and evaluate the performance of the weldment.
CLO2	To test and prepare sand and quality mould.
CLO3	To test the formability of sheet metals

Course Content

WELDING LAB EXERCISES:

1. Arc butt welding of mild steel.
2. Macrostructure and microstructure of weld.
3. Microhardness test on weldments.

FOUNDRY EXERCISES:

1. Sand testing – Shape and size of sand, AFS Sieve analysis of sand, percentage of clay content.
2. Permeability test and Mould hardness test.
3. Preparation of a green sand mould with a pattern.

FORMING LAB EXERCISES:

1. Tensile test.
2. Three-point bend test.
3. Deep drawing test.

References

1.	P.L.Jain " Principles of foundry Technology" Tata Mc Graw Hill Publishers
2.	Dr.R.S.Parmer "Welding processes and Technology" Khanna Publishers.
3.	H.S.Bawa "Manufacturing Technology-I" Tata Mc Graw Hill Publishers New Delhi, 2007.
4.	Wiliam F. Hosford, Robert M., "Metal Forming: Mechanics and Metallurgy", , Cambridge University Press, 2007
5.	Dieter G.E., "Mechanical Metallurgy", McGraw Hill, Co., S.I. Edition, 2001

Course Outcomes (CO)

At the end of the course student will be able

CO1	Apply welding skills to evaluate the quality of weldment and fabricate sound parts.
CO2	Test sand and mould quality and prepare quality mould.
CO3	Evaluate formability of sheet metals.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	**:**	PRLR12
Course Title	**:**	**Metrology and Computer Numerical Control (CNC) Laboratory**
Type of Course	**:**	ELR
Prerequisites	**:**	PRPC16, PRPC17
Contact Hours	**:**	0-0-4-2
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To impart practical knowledge on various measuring instruments.
CLO2	To deliver hands-on expertise in Calibration of instruments and machines.
CLO3	To offer practical insights into CNC programming.
CLO4	To deliver hands-on expertise in CNC machines.

Course Content

Metrology Lab

1. Experiments using Comparators / Mechanical / Electrical / Electronic / Pneumatic / Optical / Hybrid, etc.
2. Contact measurements of 2D/3D geometric features using a Coordinate Measuring Machine.
3. Non-contact measurements of 2D/3D geometric features using Profile Gauge/ VMC/ WLI/ BLI/LI/Machine Vision System, etc.
4. Experiments on linear measurements using Scaled/ Vernier/ Micrometer Instruments and Slip Gauges.
5. Experiments on angular measurements using Protractor / Sine Bar / Angle Gauges / Spirit level / Optical Instruments.
6. Experiment on the measurement of Gear / Screw threads parameters.
7. Analysis of Surface Finish using Contact measuring instruments.
8. Analysis of Surface Finish using Non-Contact measuring instruments.
9. Force / Thermal / Vibration measurements during manufacturing processes.
10. Exercise on Statistical Process Control.

Computer Numerical Control Machines Lab

1. To understand the machine tool structure, spindle drive system and control system of CNC machine tool.
2. Plain turning, facing and chamfering operations on CNC turning machine
3. Step turning operation on CNC turning machine.
4. External threading operation on CNC turning machine.
5. Taper turning operation on CNC turning machine.
6. Parting operation on CNC turning machine.
7. Boring operation on CNC machine tool.
8. Profile milling operation on vertical machining center.
9. Circular and rectangular pocketing operations on vertical machining center.
10. Drilling operation on vertical machining center.

References

1.	Jain R. K., “Engineering Metrology”, Khanna Publications, 2010
2.	Gupta. I.C., “Engineering Metrology”, DhanpatRai and Sons, 1997.
3.	Beckwith G. Thomas, Roy D. Marangoni, John H. Lienhard V, “Mechanical Measurements 6th Edition” Pearson publications, 2006.
4.	Yorem Koren, Computer Control of Manufacturing systems, McGraw Hill, 1986.
5.	Mikell P Groover, “Automation, Production Systems and Computer Integrated Manufacturing”, Prentice Hall Publications, 2007
6.	P. Radhakrishnan, “Computer Numerical Control Machines”, New Central Book Agency(P) Ltd., India, 1998

Course Outcomes (CO)

At the end of the course student will be able

CO1	Use precision measurement tools for accurate assessments of gear tooth thickness, surface roughness, and other metrics.
CO2	Perform CNC turning, milling, and drilling operations on various machines and conduct inspections using CMM.
CO3	Apply statistical process control methods to ensure quality and precision in manufacturing processes.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRLR13
Course Title	:	**Machine Drawing (CAD) and Cost Estimation Lab**
Type of Course	:	ELR
Prerequisites	:	MEIR12
Contact Hours	:	1-0-2-2
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To prepare the precise machine drawings for manufacture of components.
CLO2	To facilitate better product design and interpret and generate suggestions about drawings.
CLO3	To estimate cost for production.

Course Content

Conventions, Abbreviations and symbols: Conventional representations of interrupted views, symmetrical objects, intersection curves, square ends and openings, adjacent parts, common machine elements, springs, gear drives–Abbreviations, designation and composition of ferrous materials, nonferrous materials and engineering drawing.

Limits, Fits and Tolerances, tolerance grades, fundamental deviation, indication of tolerances-classification, system, selection and indication of fits, geometrical tolerances, surface texture.

Screw threads and threaded fasteners, types of bolts and nuts, locking pins, screws. Rivet joints, Keys and welded joints.

Assembly Drawing: Cotter and pin joints, couplings, clutches, pulleys and pipe joints.

Assembly Drawing: Bearings, heat engine parts, valves, pumps and machine parts.

Cost Estimation: Preparation of Process chart for a given component-estimation of setting time and machining time-estimation of material cost, labour cost and overhead cost based on supplied data-Kaizen Costing-Activity Based costing-Lifecycle costing.

References

1.	David Allan Low, An Introduction to Machine Drawing and Design, Andesite Press, ISBN-13: 978-1375955713.
2.	Gregory K. Mislick, Daniel A. Nussbaum, Cost Estimation: Methods and Tools (Wiley Series in Operations Research and Management Science), ISBN-13: 978-1118536131 Wiley-Blackwell; 1 Edition, 2015.
3.	Gopalakrishna, K. R., Machine Drawing, Subhas stores, Bangalore, 16th Edition, 2002.
4.	Varghese, P. L. and John, K.C., Machine Drawing, Jovast Publishers, 1993.
5.	BIS, SP:46 -1988 - Engineering Drawing Practice for Schools and Colleges, 1992.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Prepare the precise machine drawings for manufacture of components.
CO2	Facilitate better product design.
CO3	Estimate cost for production.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	**:**	PRLR14
Course Title	**:**	**Manufacturing System Simulation Lab.**
Type of Course	**:**	ELR
Prerequisites	**:**	PRPC20,
Contact Hours	**:**	0-0-3-2
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the role of simulation in decision making.
CLO2	To develop and analyze simulation models for manufacturing and service system.
CLO3	To analyse the outcome and offer suggestions for improvement.

Course Content

LIST OF EXERCISES:

1. Simulation of Manufacturing Shop.
2. Simulation of Multiple Servers Queuing System.
3. Simulation of Supply Chain Inventory System.
4. Simulation of Batch Production System.
5. Simulation of Multi Machine Assignment System.
6. Simulation of Manufacturing and Material Handling Systems.
7. Simulation of a Shop Floor.
8. Simulation of Material Handling Systems.
9. Simulation of healthcare system.

References

1.	Jerry Banks and John S.Carson, Barry L Nelson, David M.Nicol, P.Shahabudeen, Discrete event system simulation, Pearson Education, 2007.
2.	Law A.M, Simulation Modelling and Analysis, Tata Mc Graw Hill,2008
3.	Virtual reality technology (2nd edn). Grigore C. Burdea and Philippe Coiffet, Wiley, New York, 2003. No. of pages: xvi+444. ISBN 0-471-36089-9
4.	Thomas J.Schriber, Simulation using GPSS, John Wiley, 1991.
5.	Kelton, W. David, Simulation with Arena ,McGraw-Hill,2006

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the role of simulation in decision making.
CO2	Develop and analyze simulation models for manufacturing and service system.
CO3	Analyse the outcome and offer suggestions for improvement.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRLR15
Course Title	:	**Industrial Automation and Mechatronics Laboratory**
Type of Course	:	ELR
Prerequisites	:	PRPC18
Contact Hours	:	0-0-3-2
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To Learn and simulate Hydraulic, Pneumatic, Electro Hydraulic and Electro Pneumatic circuits.
CLO2	To Understand and simulate PLC circuits for fluid power control system.
CLO3	To Learn, generate and understand Robot programming.

Course Content

1. Design, simulate and testing of Pneumatic and Electro Pneumatic circuits for engineering applications using actuators and control valves (pressure, flow and direction).
2. Design, simulate and testing of Hydraulic and Electro Hydraulic circuits for engineering applications using actuators and control valves (pressure, flow and direction).
3. Design, simulate and testing of PLC circuits for engineering applications using sensors.
4. Using MAT Lab/ SCI lab -Study on Robot programming and operation with vision systems

References

1.	Michael J. Pinches and John G. Ashby, Power Hydraulics, Prentice Hall, 1989.
2.	DudleytA.Pease and John, J. Pippenger, Basic Fluid Power, Prentice Hall, 1983.
3.	Doeblin, E.O. Measurement Systems, McGraw Hill, 1995.
4.	Mechatronics 3/e,W, Bolton (Addison Wesley, ISBN 981-235-874-9.
5.	Geoffrey Boothroyd, Assembly Automation and Product Design,Hardcover , 1992.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Design Hydraulic, Pneumatic, Electro Hydraulic and Electro Pneumatic circuits for industrial automation.
CO2	Design and simulate PLC circuits for industrial automation.
CO3	Generate robot programming for industrial automation.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	**:**	PRLR16
Course Title	**:**	**Advanced Manufacturing Laboratory**
Type of Course	**:**	ELR
Prerequisites	**:**	PRPC24,
Contact Hours	**:**	0-0-3-2
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To have real time experience on rapid prototyping processes.
CLO2	To have real time experience on tribological and advanced fabrication tests.
CLO3	To study the advanced fabrication process- Ultrasonic Welding, Microwave welding and Fusion bonding process to manufacture product.

Course Content

RAPID PROTOTYPING

1. Generation and Analysis of Stl files / Development of CAD model from scan data (using 3D Scanner).
2. Study of 3D Printer architecture, Demonstration on software for 3D Printer and analysis of process parameters.
3. Development of Prototypes using 3D Printer.
4. Life Cycle Assessment of 3D Printed parts.

SURFACE ENGINEERING

1. Pin-on-disc based tribological characterization of materials at different load conditions with constant sliding speed.
2. Pin-on-disc based tribological characterization of materials at different sliding speeds with constant load.
3. Measurement of bonding strength of coating using Scratch Tester.
4. Measurement of surface roughness using 3D Non-Contact Profilometer.
5. Exercise on tribo-corrosion using corrosive wear monitor.

ADVANCED FABRICATION TECHNIQUES

1. Experimental investigation on Application of Ultrasonic Processing method on Advanced materials and investigate it process parameters.
2. Study on Application of Microwave Processing method on advanced materials and investigate it process parameters.
3. Study on Fusion Bonding Process on Advanced materials and investigate it process parameters.
4. Study on Frictional Vibration Joining on Advanced materials and investigate it process parameters.

References

1.	Anand, V.B., Computer Graphics and Geometric Modeling for Engineers, John Wiley and Sons, Inc., 2000.
2.	Zeid,I and Sivasubramanian, R., CAD/CAM- Theory and Practice, Tata McGraw-Hill, 2018 (23rd Reprint).
3.	Pham D T and Dimov S S, "Rapid Manufacturing", Verlag, 2001.
4.	Paul F Jacobs, "Stereo lithography and other RP&M Technologies", SME, 1996.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Apply rapid prototyping processes for fabricating standard products.
CO2	Characterize samples through tribological and advanced fabrication tests.
CO3	Apply Advance Fabrication Process to develop Product.

MAPPING OF PROGRAMME OUTCOMES WITH COURSE OUTCOMES:

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

Course Code	**:**	PRLR17
Course Title	**:**	**Industrial Engineering Lab.**
Type of Course	**:**	ELR
Prerequisites	**:**	PRPC22, PRPC23
Contact Hours	**:**	0-0-3-2
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To apply forecasting methods for industrial engineering problems.
CLO2	To apply different methods for scheduling problems.
CLO3	To apply inventory model – case studies.

Course Content

1. Forecasting Method – Simple Moving Average
   – Weighted Moving Average
   – Exponential Smoothing
2. Scheduling Problem - Shortest Processing Time
   - Earliest Due Date
   - Johnson's Method
3. Inventory Model - EOQ with Service Level
   – EOQ
   – Fixed Time Period
4. Material Requirement Planning
5. Barnes Peg Board Experiment
6. Time Study Trainer
7. Performance Rating (Walking)

References

1.	Gupta, P.K. and Hira, D.S, Operations Research, 3rd Edition, S.Chand and Company Ltd., New Delhi, 2008.
2.	Taha H.A, Operations research,Prentice – Hall of India, New Delhi, 8th Edition, 2006.
3.	Buffa, E.S., "Modern Production/Operations Management", 8th edition, John Wiley sons, 2003.
4.	Elsayed A Elsayed, Thomas O. Boucher, "Analysis and control of Production System", Prentice Hall, 2002.
5.	Ehud Menipaz, "Essentials of Production and Operations Management", Prentice-Hall, 1984

Course Outcomes (CO)

At the end of the course student will be able

CO1	Apply forecasting methods and inventory models for industrial engineering case studies.
CO2	Apply different methods for scheduling problems.
CO3	Use Barnes Peg Board in an experiment and learn time study.

Mapping of Programme Outcomes with Course Outcomes

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

ADVANCED LEVEL COURSES FOR B.Tech. (HONOURS)

Course Code	:	PRHO10
Course Title	:	**Tolerance Technology**
Type of Course	:	HO
Prerequisites	:	Nil
Contact Hours	:	4-0-0-4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To learn the importance of tolerances.
CLO2	To perform tolerance analysis.
CLO3	To practice using tolerance charts.

Course Content

Introduction to Geometric Dimensioning and Tolerancing, Scope, Definitions, and General Dimensioning, General Tolerancing and Related Principles, Symbology, Datum Referencing, Tolerances of Location, Tolerances of Form, Profile, Orientation, and Runout

Properties of the surface, Principles for tolerancing, Principles for geometrical tolerancing. Profile tolerancing, Tolerancing of cones, Positional tolerancing, Projected tolerance zone, Substitute elements, Maximum material requirement, Envelope requirement, Least material requirement.

Tolerancing of flexible parts, Tolerance chains (accumulation of tolerances), Statistical tolerancing.

General geometrical tolerances, Tolerancing principles, Tolerancing of edges, ISO Geometrical Product Specifications (GPS).

(Use of approved design data book is permitted in the examination)

References

1.	Gene R. Cogorno “Geometric Dimensioning and Tolerancing for Mechanical Design”, McGraw-Hill,2006
2.	Georg Henzold “Geometrical Dimensioning and Tolerancing for Design, Manufacturing and Inspection-A Handbookfor Geometrical Product Specification using ISOand ASME Standards”, Elsevier, Second edition
3.	Bryan R. Fischer “Mechanical Tolerance Stack up and Analysis” Advanced Dimensional Management, Sherwood, Oregon, U.S.A., Marcel Dekker,Inc.
4.	ASME “Dimensioning and Tolerancing”,Y14.5M-1994 [REVISION OF ANSI Y14.5M-1982 (RI98811)]

Course Outcomes (CO)

At the end of the course student will be able

CO1	Interpret tolerances.
CO2	Perform tolerance analysis.
CO3	Apply tolerance in product design and manufacturing.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRHO11
Course Title	:	**Robotics**
Type of Course	:	HO
Prerequisites	:	Nil
Contact Hours	:	4-0-0-4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the fundamentals of robotics.
CLO2	To perform robot programming.
CLO3	To explore recent developments in robotics.

Course Content

Fundamentals of robotics– wrists design -end effectors – actuators -modular robots.

Robot and its peripherals-sensors, machine vision-image processing &analysis-application of artificial intelligence, voice communication-robot control units-motion controls.

Robot kinematics-homogeneous transformations-forward & inverse kinematics-problems of dynamics-differential relationships-motion trajectories-dynamics of a robot control of single multiple link robot-static force analysis.

Robot Programming -different languages-expert systems.

Robot applications in manufacturing-material transfer& machine loading/unloading-processing operations–inspection-automation-robot cell design–control–recent developments and special applications-Micro &Bio robotics.

References

1.	Richard D Klafter, Thomas A Chmielewski&Michael Negin,“RoboticEngineering– An Integrated Approach”, PrenticeHall, 1994.
2.	Deb, S.R., “RoboticTechnology and FlexibleAutomation”, Tata McGrawHill, 1994.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Apply robotic engineering.
CO2	Develop programming for robot applications.
CO3	Analyze the dynamics of robots.

Mapping of Programme Outcomes with Course Outcomes

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	2	3	2	2	-	-	-	-	2	1
CO2	1	-	2	2	2	2	-	-	-	-	2	1
CO2	1	-	3	3	3	2	-	-	-	-	2	1

Course Code	:	PRHO12
Course Title	:	**Intelligent Manufacturing Systems**
Type of Course	:	HO
Prerequisites	:	Nil
Contact Hours	:	4-0-0-4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the basic concepts of intelligent manufacturing.
CLO2	To develop knowledge base systems for various applications.
CLO3	To explore artificial intelligence in the factory.

Course Content

Basic concepts of Artificial intelligence and expert systems-System Components-System architecture and Data flow– System Operations

Knowledge based systems-knowledge representation– knowledge acquisition and optimization-Knowledge based approaches to design mechanical parts and mechanisms and design for automated assembly

Knowledge based system for material selection–Intelligent process planning system.
Intelligent system for equipment selection-Intelligent system for project management& factory monitoring. Scheduling in manufacturing–scheduling the shop floor–Diagnosis & trouble shooting
The role of Artificial Intelligence in the factory of the future–Intelligent systems.

References

1.	Andrew Kussiak,, “Intelligent Manufacturing Systems”, PrenticeHall , 1990.
2.	Simons, G.L,“Introducing Artificial Intelligence”, NCC Pub, 1990.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Develop knowledge based systems
CO2	Apply Artificial Intelligence for automated factories.
CO3	Explore the status of artificial Intelligence in the factory.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRHO13
Course Title	:	**Total Quality Engineering**
Type of Course	:	HO
Prerequisites	:	Nil
Contact Hours	:	4-0-0-4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To apply TQM principle for continuous process improvement.
CLO2	To evaluate quality production.
CLO3	To utilize modern tool like QFD, FMECA to design and manage the business.

Course Content

Principles of TQM–Quality Gurus and their contributions–Old and New Quality Control tools-Quality Function Deployment–Failure Modes and Effect Analysis–

Vendor relations–vendor qualification process–vendor quality surveys–Vendor quality improvement–vendor quality rating and evaluation-ISO9000 standards–ISO14000 standards–Quality Costing–Quality Audit–Product and Process audit–Six Sigma–Benchmarking-TQM in Service Sector–Application case studies on TQM.

References

1.	Dale H.Besterfield, “Total Quality Management”, Pearson Education Asia, (Indian reprint 2002)
2.	Rose, J.E. Total Quality Management, Kogan Page Ltd. 1993.
3.	John Bank, The essence of total quality management, PHI1993.
4.	Greg Bounds, Lyle Yorks et al., Beyond Total Quality Management, McGraw Hill, 1994.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Apply TQM principle for continuous process improvement
CO2	Evaluate quality production
CO3	Utilize modern tool like QFD, FMECA to design and manage the business

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	**:**	PRHO14
Course Title	**:**	**Product Analysis and Cost Optimization**
Type of Course	**:**	HO
Prerequisites	**:**	Nil
Contact Hours	**:**	4-0-0-4
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand product development and planning.
CLO2	To apply value engineering techniques.
CLO3	To learn job planning and cost analysis.

Course Content

New product strategy, market definition-idea generation-design process-forecasting sales potential-product engineering, manufacturing planning-selection of economical process-standardization -simplification– specialization -break even analysis.

Value engineering – evaluation of function determining function-classifying function-evaluation of costs-evaluation of worth-determining worth-evaluation of value-value engineering.

Job plan information phase-speculation phase-analysis phase-development phase-presentation phase-implementation phase-follow up phase- fast diagramming-cost models-lifecycle costs.

Cost calculations for machined components, welding, casting and forging components-calculation of selling price – activity based cost analysis.

References

1.	Samual Eilon, “Elements of Production Planning and Control”, Universal Book Co, 1984
2.	Narang, C.B.S and Kumar V, “Production and Costing”, Khanna Publishers, 1983.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Develop Effective Product Strategies
CO2	Apply value engineering to enhance products.
CO3	Apply job planning and cost analysis.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRHO15
Course Title	:	**Decision Support Systems**
Type of Course	:	HO
Prerequisites	:	Nil
Contact Hours	:	4-0-0-4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To recognize the importance of decisions in the work and use DSS Software Tools.
CLO2	To evaluate of the success/failure of decision support systems
CLO3	To discuss the advantages/disadvantages of decision support systems and analyze practical cases.

Course Content

DSS components- Data warehousing, access, analysis, mining and visualization-modeling and analysis-DSS development -Group support systems- enterprise DSS- supply chain and DSS-knowledge management methods, technologies and tools-
Artificial intelligence and expert systems- Representation in logic and schemas, semantic networks, production rules and frames, inference techniques – DSS applications.

References

1.	Efraim Turban and Jay E Aronson, Decision Support and Intelligent Systems, Pearson education Asia, Seventh edition, 2005.
2.	Elain Rich and Kevin Knight, Artificial intelligence, TMH, 2006.
3.	VickiL. Sauter, Decision Support Systems for Business Intelligence John Wiley &Sons.
4.	Turban, Decision Support And Business Intelligence Systems,8/E, Pearson Education India, 2011.
5.	Frada Burnstein, Clyde W.Holsapple.,Handbook on Decision Support Systems Springer, 2008.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Recognize the importance of decisions in the work and use DSS Software Tools.
CO2	Evaluate of the Success/Failure of Decision Support Systems.
CO3	Analyze practical cases using decision support systems

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRHO16
Course Title	:	**Knowledge Management**
Type of Course	:	HO
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To learn the role and use of knowledge in organizations and institutions, and the typical obstacles that Knowledge Management aims to overcome.
CLO2	To understand the core concepts, methods, techniques, and tools for computer support of knowledge management.
CLO3	To understand how to apply and integrate appropriate components and functions of various knowledge management systems.

Course Content

Knowledge society- Drivers of knowledge management-Intellectual capital- KM and learning organizations.

Strategic alignment- Evaluation and strategic alignment-Infrastructural development and deployment.

Role of CKO-Analyzing business environment-knowledge audit and analysis – designing KM team, system–Technology components.

Intranet and Groupware solutions- tools for collaborative intelligence.

Social networking-package choices- knowledge security-Integrating with web -based and internal operational and support systems- change management- reward systems- continuous improvement – Intellectual Property Rights.

References

1.	Guus Schreiber, Hans Akkermans, Anjo Anjewierden, Robert de Hoog, Nigel Shadbolt, Walter Vande Velde and Bob Wielinga, “Knowledge Engineering and Management”, Universities Press, 2004.
2.	Elias M. Awad & Hassan M.Ghaziri,“Knowledge Management”, Pearson Education, 2004.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand the role and use of knowledge in organizations and institutions, and the typical obstacles that Knowledge Management aims to overcome.
CO2	Understand the core concepts, methods, techniques, and tools for computer support of knowledge management.
CO3	Apply and integrate appropriate components and functions of various knowledge management systems.

Mapping of Programme Outcomes with Course Outcomes

CO / PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	-	-	-	-	1	1	-	-	-	-	-
CO2	1	-	-	-	1	1	1	-	-	-	-	-
CO3	1	-	-	-	-	1	1	-	-	-	-	-

Course Code	:	PRHO17
Course Title	:	**Project Life Cycle Management**
Type of Course	:	HO
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand product life cycle management strategies
CLO2	To recognize PLM integration with other functions
CLO3	To Expertise on application of PLM software

Course Content

Product life cycle – Introduction, growth, maturity & decline, Product Lifecycle Management- Definition & Overview, Background for PLM-corporate challenges, Need of PLM, Components/Elements of PLM, Emergence of PLM, Significance of PLM - life cycle problems to be resolved, product development problems to be resolved, Customer Involvement. Principles for PLM strategy, preparing for the PLM strategy, developing a PLM strategy, Strategy identification and selection, Change Management for PLM.

PLM Life cycle model- plan, design, build, support & dispose. Threads of PLM Computer aided design (CAD), Engineering data management (EDM), Product data management (PDM), Computer integrated manufacturing (CIM). Comparison of PLM to Engineering resource planning (ERP). PLM characteristics - singularity, cohesion, traceability, reflectiveness, Information Mirroring Model. External drivers- scale, complexity, cycle times, globalization & regulation. Internal drivers - productivity, innovation, collaboration & quality. Board room drivers – income, revenues & costs.

Product life cycle management system- system architecture, Information models and product structure, Information model, the product information data model, the product model, functioning of the system. Reasons for the deployment of PLM systems

Product Data issues – Access, applications, Archiving, Availability, Change, Confidentiality. Product Workflow, The Link between Product Data and Product Workflow, Key Management Issues around Product Data and Product Workflow, Company's PLM vision, The PLM Strategy,

Different phases of product lifecycle and corresponding technologies, Foundation technologies and standards e.g. visualization, collaboration and enterprise application integration, Core functions e.g., data vaults, document and content management, workflow and program management, Functional applications e.g., configuration management. Human resources in product lifecycle. Application of PLM Software.

References

1.	Grieves Michael, Product Lifecycle Management- Driving the Next Generation of Lean Thinking, McGraw-Hill, 2006. ISBN 0071452303
2.	Antti Saaksvuori, Anselmi Immonen, Product Life Cycle Management - Springer, 1st Edition (Nov.5, 2003)
3.	Stark, John. Product Lifecycle Management: 21st Century Paradigm for Product Realization, Springer-Verlag, 2004. ISBN 1852338105

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand PLM and its applications.
CO2	Develop product data management tools.
CO3	Experience of State of Art PLM Software.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	**:**	PRHO18
Course Title	**:**	**Technology Management**
Type of Course	**:**	HO
Prerequisites	**:**	Nil
Contact Hours	**:**	3-0-0-3
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To develop an awareness of the range, scope, and complexity of technological innovation, and the issues related to managing technological change.
CLO2	To understand different approaches to manage innovation, with multi-criteria decision making techniques.
CLO3	To identify drivers and barriers to technological innovation within an organization.

Course Content

Definition-scope-components -Issues in managing new technology, Life cycle approach to technology Management-Approaches to forecasting, Technology performance parameters.

Use of Experts in technology forecasting, planning technological process, Morphological analysis of a Technology system-Techno-Economic feasibility study.

Application of multi-criteria decision making techniques in technologies evaluation and selection-AHP, fuzzy AHP-Modes of global technology transfer-Technology–Human Interface.

Organization structures and Technology Implementation issues in new technology.

Technology Management issues in the context of lean, agile and sustainable systems – Intellectual Property Rights.

References

1.	Joseph M. Putti, Management– A Functional Approach, McGraw Hill, 1997
2.	Kenneth C. Lauden , MIS: Organisation and Technology, Prentice Hall, 1995
3.	James A.Senn, Information technology in Business, Prentice Hall, 1995
4.	Ronald J. Jordan, Security analysis and Portfolio Management, Prentice Hall, 1995.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Develop an awareness of the range, scope, and complexity of technological innovation, and the issues related to managing technological change.
CO2	Understand different approaches to manage innovation, with multi-criteria decision making techniques.
CO3	Identify drivers and barriers to technological innovation within an organization.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRHO19
Course Title	:	**Multi-Criteria Decision Making Techniques**
Type of Course	:	HO
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To recognize the need for Multi-criteria decision making
CLO2	To understand various MCDM methods
CLO3	To develop appropriate model and decision.

Course Content

Multi-Criteria Decision Making – An Overview – Classification of MCDM methods – Simple Additive Weighting method – Weighted Product method.

Network based MCDM methods – Analytic Hierarchy Process – Revised Analytic Hierarchy Process – Analytic Network Process.

Outranking MCDM methods – PROMETHEE , ELECTRE , TOPSIS - Compromise Ranking method - VIKOR, ORESTE – DEMATEL.

Fuzzy based MCDM methods – Hybrid MCDM methods – Group Decision Making- Graph Theory and Matrix approach – Goal Programming.

Balanced Scorecard Approach - MCDM application areas – Case studies on application of MCDM techniques.

References

1.	Belton, V., Stewart,T.J.Multiple Criteria Decision Analysis: An Integrated Approach, Kluwer Academic Publishers, Dordrecht, 2003.
2.	Triantaphyllou, E., Multi-Criteria Decision Making Methods: A Comparative Study, Springer, 2010.
3.	Pedrycz, W., Ekel, P., Parreiras, R., 2011.Fuzzy Multi Criteria Decision-Making: Models, Methods and Applications, John Wiley & Sons, 2011.
4.	Kahraman,C.,Fuzzy Multi-criteria Decision Making: Theory and Applications with Recent Developments, Springer, 2008.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Understand various MCDM methods.
CO2	Apply MCDM methods for real time applications.
CO3	Develop appropriate model and decision for industrial management.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	**:**	PRHO20
Course Title	**:**	**Advanced Optimization Techniques**
Type of Course	**:**	HO
Prerequisites	**:**	Nil
Contact Hours	**:**	3-1-0
Course Assessment Methods	**:**	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To learn traditional optimization techniques.
CLO2	To learn Nonlinear Programming.
CLO3	To explore modern methods of optimization

Course Content

Classification of Optimization Problems - Optimization Techniques.

Classical Optimization Techniques- Single-Variable Optimization - Multivariable Optimization with No Constraints - Multivariable Optimization with Equality Constraints- Multivariable Optimization with Inequality Constraints- Transportation

Nonlinear Programming I: One-Dimensional Minimization Methods - Unimodal Function, elimination methods-Unrestricted Search -Exhaustive Search - Dichotomous Search- Interval Halving Method-Fibonacci Method- Golden Section Method, interpolation methods -Quadratic Interpolation Method - Cubic Interpolation Method -Direct Root Methods -Newton Method-Quasi-Newton Method -Secant Method

Nonlinear Programming II: Unconstrained Optimization Techniques -direct search methods - indirect search (descent) methods, Nonlinear Programming III: Constrained Optimization Techniques- direct methods-indirect methods , Geometric Programming , Dynamic Programming , Integer Programming -integer linear programming - Stochastic Programming.

Modern Methods of Optimization - Genetic Algorithms -Simulated Annealing -Particle Swarm Optimization -Ant Colony Optimization -Optimization of Fuzzy Systems - Neural-Network-Based Optimization, Practical Aspects of Optimization.

References

1.	Kalyanmoy Deb, Optimization for Engineering design – algorithms and examples. PHI, New Delhi, 1995.
2.	Singiresu S.Rao, “Engineering optimization – Theory and practices”, John Wiley and Sons, 1998.
3.	Garfinkel, R.S. and Nemhauser, G.L., Integer programming, John Wiley & Sons, 1972.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Apply traditional optimization techniques in engineering field.
CO2	Develop Nonlinear Programming for optimization of production engineering problems.
CO3	Apply modern optimization methods for production engineering problems.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRHO21
Course Title	:	**Modelling of Manufacturing Processes**
Type of Course	:	HO
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To arrange the application of numerical method for non-linear problems.
CLO2	To apply numerical methods for manufacturing processes.
CLO3	To evaluate the numerical results of manufacturing processes.

Course Content

Review of manufacturing processes, need for numerical solution – Review of basic concepts of numerical methods.

FE concepts – variational and weighted residual approaches – Element types – 2D elements – plane triangular, quadrilateral, 3 dimensional axi-symmetric, plate and shell elements – mapping of elements.

FE solution for Steady state and transient problems. FE procedure for non-linear problems - Material and geometric non-linearities – solution using implicit and explicit methods.

Lagrangean and Eulerian formulations for modelling of machining, rolling, forging, drawing. ALE elements.

Thermal modelling for induction hardening, arc welding, cooling of castings – deduction of cooling rate and metallurgical transformations.

References

1.	M.Asghar Bhatti “Advanced Topics in Finite Element Analysis of Structures” John Wiley & sons, Inc,2006.
2.	Lewis R.W.Morgan, K, Thomas, H.R. and Seetharaman, K.N. The Finite Element Method in Heat Transfer Analysis, John Wiley, 1994.
3.	Edward R Champion Jr, “Finite Element Analysis in Manufacturing Engineering”, McGraw Hill, 1992.
4.	Prakash M. Dixit, Uday S. Dixit”Modeling of Metal Forming and Machining Processes”, 1st Edition, 2008, Springer Verlog.
5.	Lars-Erik Lindgren, “Computational welding mechanics” , 1st Edition, 2007, CRC Press.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Arrange the application of numerical method for non-linear problems.
CO2	Apply numerical methods for manufacturing processes.
CO3	Evaluate the numerical results of manufacturing processes.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRHO22
Course Title	:	**Control of Manufacturing Processes**
Type of Course	:	HO
Prerequisites	:	Nil
Contact Hours	:	4-0-0-4
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To apply and interfere the application of statistical methods in manufacturing processes.
CLO2	To identify the causes of process variation through statistical process control.
CLO3	To apply the experimental design concepts in manufacturing process for problem solving.

Course Content

Review of probability and statistic distributions used in manufacturing processes. Statistical process control and process capability analysis.

Mechanical process variation – analyzing the causes and interpreting data.

Alternate SPC methods for manufacturing process control.

Application of experimental design in manufacturing.

Full factorial models, Response surface modeling and process optimization, Analysis of Process robustness, Case studies.

References

1.	Montgomery, Douglas C. Introduction to Statistical Quality Control. 5th Ed. New York, NY: Wiley, 2004.
2.	Montgomery, Douglas C. Design and Analysis of Experiments. 5th Ed. New York, NY: Wiley, 2004.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Apply and interfere the application of statistical methods in manufacturing processes.
CO2	Identify the causes of process variation through statistical process control.
CO3	Apply the experimental design concepts in manufacturing process for problem solving.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRHO23
Course Title	:	**Flexible Manufacturing Systems**
Type of Course	:	HO
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the concepts of PPC and GT to the development of FMS.
CLO2	To identify hardware and software components of FMS.
CLO3	To understand the concepts of modern manufacturing such as JIT, supply chain management and lean manufacturing etc.

Course Content

Introduction to flexible manufacturing systems. Planning and scheduling and control of FMS. Knowledge based scheduling. manufacturing in a competitive environment, concept, automation of manufacturing process, numerical control, adaptive control, material handling and movement, industrial robots, flexible fixturing, design for assembly, disassembly and service - Group technology, classification and coding, production flow analysis.

Planning issues - components of FMS, types of flexibility, tradeoffs, computer control and functions, planning, scheduling and control of FMS, scheduling and knowledge-based scheduling.

Hierarchy of computer control, supervisory computer, introduction to turning center, machining center, cleaning and deburring equipment, coordinate measuring machines: types, working and capabilities. FMS computer hardware and software, general structure and requirements, PLCs, FMS installation and implementation, acceptance testing.

System support equipment, types, working capability, automated material movement and automated storage and retrieval systems, scheduling of AGVs, cutting tools and tool management, work holding considerations.

Characteristics of JIT pull method, small lot sizes, work station loads, flexible work force, line flow strategy - supply chain management Preventive maintenance - Kanban system, value engineering, MRD JIT, lean manufacture, quality concepts and management. Economic justification of FMS; Artificial Intelligence in the Design of FMS

References

1.	Jha, N.K. “Handbook of flexible manufacturing systems”, Academic Press Inc., 1991
2.	Groover M.P., “Automation, Production Systems and Computer Integrated Manufacturing”, Prentice Hall of India Pvt., New Delhi, 1996.
3.	Kalpakjin, “Manufacturing Engineering and Technology ", AddisonWesley Publishing Co., 1995.
4.	Shivanand H.K., Benal MM, Koti V, “Flexible Manufacturing System”, New age international (P) Limited, New Delhi, 2006
5.	William W Luggen, “Flexible Manufacturing Cells and System” Prentice Hall of Inc New Jersey, 1991

Course Outcomes (CO)

At the end of the course student will be able

CO1	Apply the concepts of PPC and GT to the development of FMS.
CO2	Perform Planning, Scheduling and control of Flexible Manufacturing systems
CO3	Identify hardware and software components of FMS.

Mapping of Programme Outcomes with Course Outcomes

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

Course Code	:	PRHO24
Course Title	:	**Lasers in Manufacturing**
Type of Course	:	HO
Prerequisites	:	Nil
Contact Hours	:	3-0-0-3
Course Assessment Methods	:	Continuous Assessment, End Assessment

Course Learning Objectives (CLO)

CLO1	To understand the fundamental properties of laser beams as advanced materials processing and manufacturing tool.
CLO2	To describe the various types of operation in laser surface treatment, welding, cutting and drilling of different materials.
CLO3	To develop skills necessary to effectively analyse laser based physical processes and their implications in material processing and manufacturing processes.

Course Content

Fundamentals of laser –lasing action- properties - spectrum and wavelength –wave length chart-types of laser- modes of operation-continuous mode-pulsed mode-laser components - interaction of laser radiation with materials-long pulse and short pulse interaction.

Laser surface treatment –forms of laser surface treatment-laser transformation hardening - advantages - laser surface melting - laser alloying - laser cladding-co-axial powder feeding-lateral powder feeding-laser texturing-case examples-.

Laser welding-process arrangement - mechanisms - applications –modes of welding conduction limited welding-key hole welding-heat flow theory - one dimensional heat flow - model for stationary and moving point source - simulation of laser welding.

Laser cutting –process characteristics-theoretical models of cutting – practical performance-applications - process variations - drilling –single pulse drilling-percussion drilling- trepanning-applications.

Fiber Laser and UV Laser based marking - micromachining solutions - laser shock loading - basics - applications - laser safety - danger - safety limits - eye and skin - class four safety arrangements - electric hazards - fume hazards.

References

1.	William M. Steen, “Laser Material Processing”, Springer Verlag, 2003.
2.	M.Young, “Optics and Lasers”, Springer, 1993.
3.	K.Thyagarajan, Ajoy K.Ghatak, “Lasers, Theory and Applications”, Plenum Press, 1981.
4.	J.F. Reddy, “Industrial Applications of Lasers”, Academic Press, New York, 1978.
5.	S. S. Charschan, “Lasers in Industry”, Wiley & Sons Inc., 1974.
6.	Michael Bass, “Laser Materials Processing”, Elsevier Science, 1983.

Course Outcomes (CO)

At the end of the course student will be able

CO1	Compare the types of lasers and its applications.
CO2	Employ laser for surface engineering, welding, cutting and drilling.
CO3	Analyse the micro machining processes by Laser

Mapping of Programme Outcomes with Course Outcomes

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