ST. JOSEPH'S
COLLEGE OF ENGINEERING
AND TECHNOLOGY,
- PALAI -
AUTONOMOUS

Master of Technology (M. Tech.) in

ADVANCED MANUFACTURING AND PRODUCTION MANAGEMENT

MECHANICAL ENGINEERING

CURRICULUM

2024

SEMESTER I

SLOT	COURSE CODE	COURSE NAME	MARKS		L-T-P	HOURS	CREDIT
			CIA	ESE			
A	24SJ1TPE003	APPLIED STATISTICS	40	60	3-0-0	3	3
B	24SJ1TPE00	ADVANCED MANUFACTURING SYSTEMS	40	60	3-0-0	3	3
C	24SJ1TPE007	ADVANCED OPERATION MANAGEMENT	40	60	3-0-0	3	3
D	24SJ1EPEXXX	PROGRAM ELECTIVE 1	40	60	3-0-0	3	3
E	24SJ1EPEXXX	PROGRAM ELECTIVE 2	40	60	3-0-0	3	3
S	24SJ1RGE100	RESEARCH METHODOLOGY AND IPR	40	60	2-0-0	2	2
T	24SJ1LPE002	ADVANCED MANUFACTURING LAB	100	--	0-0-2	2	1
Total			**340**	**360**		**19**	**18**

Teaching Assistance: 6 hours

PROGRAM ELECTIVE 1

SLOT	SL NO	COURSE CODE	COURSE NAME	L-T-P	HOURS	CREDIT
D	1	24SJ1EPE024	ADVANCED MATERIALS FOR MANUFACTURING AND PROCESS	3-0-0	3	3
	2	24SJ1EPE025	SAFETY ENGINEERING AND INDUSTRIAL HYGIENE	3-0-0	3	3
	3	24SJ1EPE100	ADDITIVE MANUFACTURING	3-0-0	3	3
	4	24SJ1EPE026	ADVANCED MATERIAL JOINING AND TESTING	3-0-0	3	3
	5	24SJ1EPE027	METROLOGY AND COMPUTER AIDED INSPECTION	3-0-0	3	3
	6	24SJ1EPE028	INDUSTRIAL ROBOTICS AND EXPERT SYSTEMS	3-0-0	3	3

PROGRAM ELECTIVE 2

SLOT	SL NO	COURSE CODE	COURSE NAME	L-T-P	HOURS	CREDIT
E	1	24SJ1EPE029	INDUSTRIAL ENERGY MANAGEMENT	3-0-0	3	3
	2	24SJ1EPE030	ADVANCED OPERATIONS RESEARCH	3-0-0	3	3
	3	24SJ1EPE031	PROCESS PLANNING AND COST ESTIMATION	3-0-0	3	3
	4	24SJ1EPE032	ENTERPRISE RESOURCE PLANNING	3-0-0	3	3
	5	24SJ1EPE033	PRODUCTION PLANNING AND CONTROL	3-0-0	3	3
	6	24SJ1EPE034	SUPPLY CHAIN MANAGEMENT	3-0-0	3	3

SEMESTER II

SLOT	COURSE CODE	COURSE NAME	MARKS		L-T-P	HOURS	CREDIT
			CIA	ESE			
A	24SJ2TPE002	ADVANCED OPTIMIZATION TECHNIQUES	40	60	3-0-0	3	3
B	24SJ2TPE004	MODELING AND ANALYSIS OF MANUFACTURING SYSTEMS	40	60	3-0-0	3	3
C	24SJ2EPEXXX	PROGRAM ELECTIVE 3	40	60	3-0-0	3	3
D	24SJ2EPEXXX	PROGRAM ELECTIVE 4	40	60	3-0-0	3	3
E	24SJ2EPEXXX	INTERDISCIPLINARY ELECTIVE	40	60	3-0-0	3	3
S	24SJ2PPE100	MINI PROJECT	100	--	0-0-4	4	2
T	24SJ2LPE002	COMPUTATIONAL LAB	100	--	0-0-2	2	1
Total			**400**	**300**		**21**	**18**

Teaching Assistance: 6 hours

PROGRAM ELECTIVE 3

SLOT	SL NO	COURSE CODE	COURSE NAME	L-T-P	HOURS	CREDIT
C	1	24SJ2EPE024	MODERN MACHINING PROCESS	3-0-0	3	3
	2	24SJ2EPE025	COMPOSITE MATERIALS AND MANUFACTURING	3-0-0	3	3
	3	24SJ2EPE026	MICRO AND NANO MACHINING	3-0-0	3	3
	4	24SJ2EPE027	CLOUD MANUFACTURING	3-0-0	3	3
	5	24SJ2EPE028	INTEGRATED PRODUCT DEVELOPMENT	3-0-0	3	3
	6	24SJ2EPE029	REVERSE ENGINEERING	3-0-0	3	3

PROGRAM ELECTIVE 4

SLOT	SL NO	COURSE CODE	COURSE NAME	L-T-P	HOURS	CREDIT
D	1	24SJ2EPE030	TOTAL QUALITY MANAGEMENT	3-0-0	3	3
	2	24SJ2EPE031	PRODUCT DESIGN AND DEVELOPMENT	3-0-0	3	3
	3	24SJ2EPE032	SIMULATION OF MANUFACTURING SYSTEMS	3-0-0	3	3
	4	24SJ2EPE033	RELIABILITY ENGINEERING	3-0-0	3	3
	5	24SJ2EPE034	DESIGN OF EXPERIMENTS	3-0-0	3	3
	6	24SJ2EPE035	ADVANCED MAINTENANCE MANAGEMENT	3-0-0	3	3

INTERDISCIPLINARY ELECTIVE

SLOT	SL NO	COURSE CODE	COURSE NAME	L-T-P	HOURS	CREDIT
E	1	24SJ2EPE048	ENTREPRENEURSHIP DEVELOPMENT	3-0-0	3	3
	2	24SJ2EPE049	INDUSTRIAL SAFETY	3-0-0	3	3
	3	24SJ2EPE050	INDUSTRY 4.0	3-0-0	3	3

SEMESTER III

SLOT	COURSE CODE	COURSE NAME	MARKS		L-T-P	HOURS	CREDIT
			CIA	ESE			
TRACK 1							
A*	223MPEXXX	MOOC	To be completed successfully		--	--	2
B	24SJ3AGEXXX	AUDIT COURSE	40	60	3-0-0	3	-
C	24SJ3IPE100	INTERNSHIP	50	50	--	--	3
D	24SJ3PPE100	DISSERTATION PHASE 1	100	--	0-0-17	17	11
TRACK 2							
A*	24SJ3MPEXXX	MOOC	To be completed successfully		--	--	2
B	24SJ3AGEXXX	AUDIT COURSE	40	60	3-0-0	3	-
C	24SJ3IPE100	INTERNSHIP	50	50	---	--	3
D	24SJ3PPE001	RESEARCH PROJECT PHASE 1	100	--	0-0-17	17	11
Total			190	110		20	16

Teaching Assistance: 6 hours

*MOOC Course to be successfully completed before the commencement of fourth semester (starting from semester 1)

AUDIT COURSE

SLOT	SL NO	COURSE CODE	COURSE NAME	L-T-P	HOURS	CREDIT
B	1	24SJ3AGE100	ACADEMIC WRITING	3-0-0	3	-
	2	24SJ3AGE001	ADVANCED ENGINEERING MATERIALS	3-0-0	3	-
	3	24SJ3AGE002	FORENSIC ENGINEERING	3-0-0	3	-
	4	24SJ3AGE003	DATA SCIENCE FOR ENGINEERS	3-0-0	3	-
	5	24SJ3AGE004	DESIGN THINKING	3-0-0	3	-
	6	24SJ3AGE005	FUNCTIONAL PROGRAMMING IN HASKELL	3-0-0	3	-
	7	24SJ3AGE006	FRENCH LANGUAGE (A1 LEVEL)	3-0-0	3	-
	8	24SJ3AGE007	GERMAN LANGUAGE (A1 LEVEL)	3-0-0	3	-
	9	24SJ3AGE008	JAPANESE LANGUAGE (N5 LEVEL)	3-0-0	3	-
	10	24SJ3AGE009	PRINCIPLES OF AUTOMATION	3-0-0	3	-
	11	24SJ3AGE010	REUSE AND RECYCLE TECHNOLOGY	3-0-0	3	-
	12	24SJ3AGE011	SYSTEM MODELING	3-0-0	3	-
	13	24SJ3AGE012	EXPERT SYSTEMS	3-0-0	3	-

SEMESTER IV

SLOT	COURSE CODE	COURSE NAME	MARKS		L-T-P	HOURS	CREDIT
			CIA	ESE			
TRACK 1							
A	24SJ4PPE100	DISSERTATION PHASE II	100	100	0-0-24	24	16
TRACK 2							
A	24SJ4PPE001	RESEARCH PROJECT PHASE II	100	100	0-0-24	24	16
Total			100	100		24	16

Teaching Assistance: 5 hours

ASSESSMENT PATTERN

[1]. CORE COURSES

Evaluation shall only be based on application, analysis or design-based questions (for both internal and end semester examinations).

Continuous Internal Evaluation: 40 marks

Micro project/Course based project:	20 marks
Course based task/Seminar/Quiz:	10 marks
Test paper, 1 no:	10 marks

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

(ii) ELECTIVE COURSES

Evaluation shall only be based on application, analysis or design-based questions (for both internal and end semester examinations)

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed original publications (minimum 10 Publications shall be referred):	15 marks
Course based task/Seminar/Data Collection and interpretation:	15 marks
Test paper, 1 no:	10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall

achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Note: The marks obtained for the ESE for an elective course shall not exceed 20% over the average ESE mark % for the core courses. ESE marks awarded to a student for each elective course shall be normalized accordingly. For example, if the average end semester mark % for a core course is 40, then the maximum eligible mark % for an elective course is 40+20 = 60 %.

(iii) RESEARCH METHODOLOGY & IPR/AUDIT COURSE

Continuous Internal Evaluation:	40 marks
Course based task:	15 marks
Seminar/Quiz:	15 marks
Test paper, 1 no.:	10 marks

(iv) LABORATORY COURSES

The laboratory courses will be having only Continuous Internal Evaluation and carries 100 marks. Final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

(v) INTERDISCIPLINARY ELECTIVE

Engineering students frequently aspire to work in areas and domains that are key topics in the industry. There are concerns by recruiters that skill sets of engineering students did not match with the Industry requirements, especially in the field of latest topics. In response to their desires, the Academic Council has incorporated Industry/Interdisciplinary electives in the curriculum. Interdisciplinary knowledge is critical for connecting students with current industry trends, where multitasking is the norm. Interdisciplinary knowledge aids in the bridge-building process between academic institutions and industry. It aids pupils in expanding their knowledge and innovating by allowing them to create something new. While core engineering courses provide students with a strong foundation, evolving technology necessitates new methods and approaches to progress, prosperity, and the inculcation of problem- solving techniques. Other courses' knowledge, on the other hand, can assist them to deal with any scenario more effectively. Interdisciplinary courses may be one approach to address such needs, as they can aid in the enhancement of engineering education and the integration of desirable specialized subjects into the current engineering education system. This will enable students to fulfil the current industry demands. Students with multidisciplinary knowledge and projects are more likely to be placed in top industries, according to the placement trend. The future of developing engineers will be influenced by their understanding of emerging

technology and interdisciplinary approaches such as big data, machine learning, and 3-D printing.

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred):	15 marks
Course based task/Seminar/Data collection and interpretation:	15 marks
Test paper, 1 no:	10 marks

Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

(vi) MOOC COURSES

The MOOC course shall be considered only if it is conducted by the agencies namely AICTE/NPTEL/SWAYAM or NITTTR. The MOOC course should have a minimum duration of 8 weeks and the content of the syllabus shall be enough for at least 40 hours of teaching. The course should have a proctored/offline end semester examination. The students can do the MOOC according to their convenience, but shall complete it by third semester. The list of MOOC courses will be provided by the concerned BoS if at least 70% of the course content match with the area/stream of study. The course shall not be considered if its content has more than 50% of overlap with a core/elective course in the concerned discipline or with an open elective.

MOOC Course to be successfully completed before the commencement of fourth semester (starting from semester 1). A credit of 2 will be awarded to all students whoever successfully completes the MOOC course as per the evaluation pattern of the respective agency conducting the MOOC.

(vii) MINIPROJECT

Total marks: 100 (only CIA)

Mini project can help to strengthen the understanding of student's fundamentals through application of theoretical concepts and to boost their skills and widen the horizon of their thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects increases problem- solving skills. The introduction of mini projects ensures preparedness of students to undertake dissertation. Students should identify a topic of interest in consultation with PG Programme Coordinator that should lead to their dissertation/research project. Demonstrate the novelty of the project through the results and outputs. The progressof the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required at the end of the semester.

Interim evaluation: 40 (20 marks for each review), final evaluation by a Committee (will be evaluating the level of completion and demonstration of functionality/specifications, clarity of presentation, oral examination, work knowledge and involvement): 35, Report (the committee will be evaluating for the technical content, adequacy of references, templates followed and permitted plagiarism level is not more than 25%): 15, Supervisor/Guide: 10

TEACHING ASSISTANCESHIP (TA)

All M Tech students irrespective of their category of admission shall undertake TA duties for a minimum duration as per the curriculum. Being a TA, the student will get an excellent opportunity to improve their expertise in the technical content of the course, enhance communication skills, obtain a hands-on experience in handling the experiments in the laboratory and improve peer interactions.

The possible TA responsibilities include the following: facilitate a discussion section or tutorial for a theory/ course, facilitate to assist the students for a laboratory course, serve as a mentor for students, and act as the course web-master. TAs may be required to attend the instructor's lecture regularly. A TA shall not be employed as a substitute instructor, where the effect is to relieve the instructor of his or her teaching responsibilities (specifically prohibited by Institution Policy).

For the tutorial session:

(i) Meet the teacher and understand your responsibilities well in advance, attend the lectures of the course for which you are a tutor, work out the solutions for all the tutorial problems yourself, approach the teacher if you find any discrepancy or if you need help in solving the tutorial problems, use reference text books, be innovative and express everything in English only.

(ii) Try to lead the students to the correct solutions by providing appropriate hints rather than solving the entire problem yourself, encourage questions from the students, lead the group to a discussion based on their questions, plan to ask them some questions be friendly and open with the students, simultaneously being firm with them.

(iii) Keep track of the progress of each student in your group, give a periodic feedback to the student about his/her progress, issue warnings if the student is consistently under-performing, report to the faculty if you find that a particular student is consistently underperforming, pay special attention to slow-learners and be open to the feedback and comments from the students and faculty.

(iv) After the tutorial session you may be required to grade the tutorials/assignments/tests. Make sure that you work out the solutions to the questions yourself, and compare it with the answer key, think and work out possible alternate solutions to the same question, understand the marking scheme from the teacher. Consult the teacher if are and make sure that you are not partial to some student/students while grading. Follow basic ethics.

Handling a laboratory Session:

(i) Meet the faculty-in-charge a few days in advance of the actual lab class and get the details of the experiment, get clarifications from him/her regarding all aspects of the experiment and the expectations, prepare by reading about the theoretical background of the experiment, know the physical concepts involved in the experiment, go to the laboratory and check out the condition of the equipment/instrumentation, perform the laboratory experiment at least once one or two days before the actual laboratory class, familiarize with safety/ security aspects of the experiment / equipment/laboratory, prepare an instruction sheet for the experiment in consultation with the faculty, and keep sufficient copies ready for distribution to students for their reference.

(ii) Verify condition of the equipment/set up about 30 minutes before the students arrive in the class and be ready with the hand outs, make brief introductory remarks about the experiment, its importance, its relevance to the theory they have studied in the class, ask the students suitable questions to know their level of preparation for the experiment, discuss how to interpret results, ask them comment on the results.

(iii) Correct/evaluate/grade the submitted reports after receiving suitable instructions from the faculty in charge, continue to interact with students if they have any clarifications regarding any aspect of the laboratory session, including of course grading, Carefully observe instrument and human safety in laboratory class, Preparing simple questions for short oral quizzing during explanation of experiments enables active participation of students, facilitate attention, provides feedback and formative assessment.

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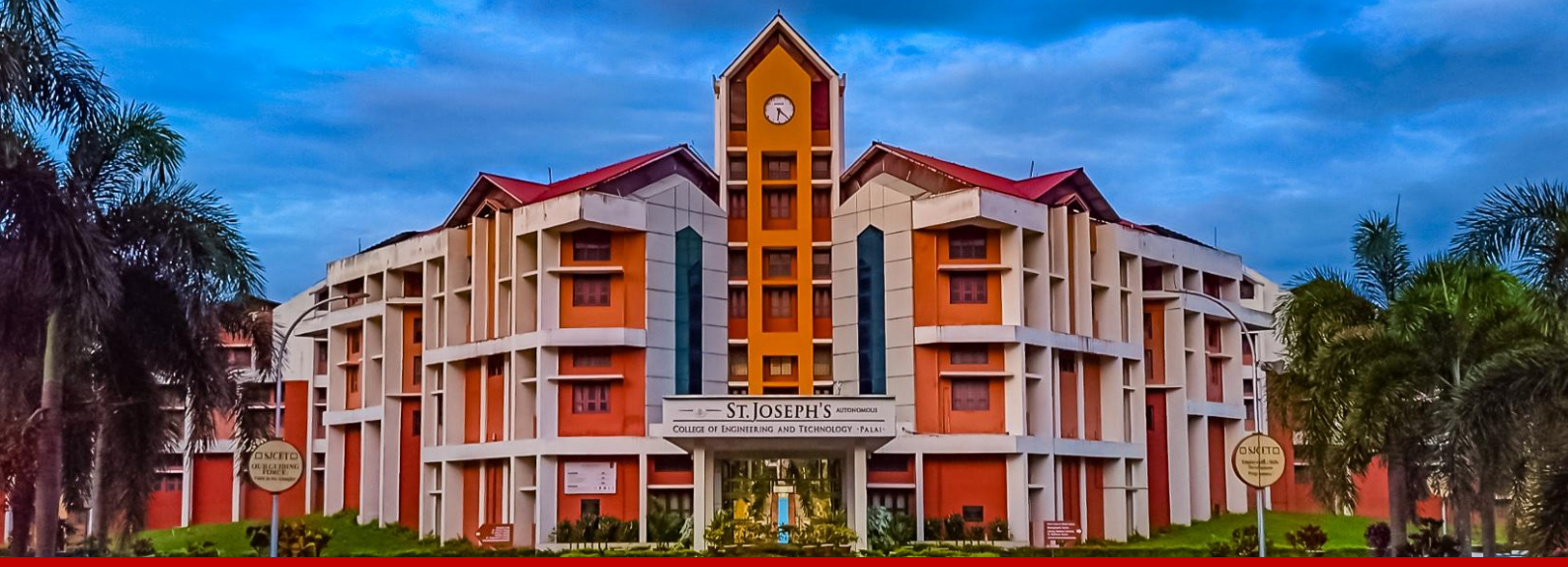

SYLLABUS

M. Tech.

ADVANCED MANUFACTURING AND PRODUCTION MANAGEMENT

(Mechanical Engineering)

2024 SCHEME

ST. JOSEPH'S
COLLEGE OF ENGINEERING AND TECHNOLOGY, - PALAI -
AUTONOMOUS

Vision

Developing into a world class, pace setting institute of Engineering and Technology with distinct identity and character, meeting the goals and aspirations of the society.

Mission

- To maintain a conducive infrastructure and learning environment for world class education.
- To nurture a team of dedicated, competent and research-oriented faculty.
- To develop students with moral and ethical values, for their successful careers, by offering variety of programs and services.

Department of

Mechanical Engineering

Vision

To develop into a center for imparting knowledge and technical skills of international standards, in Mechanical Engineering.

Mission

- To follow a teaching-learning process, with the support of qualified and committed faculty, in undergraduate and post graduate Mechanical Engineering programs.
- To establish an infrastructure and academic ambience for collaborating with Industry, Academia and Community to serve local and national enterprises.
- To make the students self-learners and socially committed engineers, for individual and collective accomplishments.

Programme Outcomes (POs)

PO1: An ability to independently carry out research/investigation and development work in engineering and allied streams.

PO2: An ability to communicate effectively, write and present technical reports on complex engineering activities by interacting with the engineering fraternity and with society at large.

PO3: An ability to demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program

PO4: An ability to apply stream knowledge to design or develop solutions for real world problems by following the standards.

PO5: An ability to identify, select and apply appropriate techniques, resources and state-of-the-art tool to model, analyse and solve practical engineering problems.

PO6: An ability to engage in life-long learning for the design and development related to the stream related problems taking into consideration sustainability, societal, ethical and environmental aspects.

PO7: An ability to develop cognitive load management skills related to project management and finance which focus on Entrepreneurship and Industry relevance.

Program Specific Outcomes (PSOs)

The post graduates of the program will be able to:

- Apply knowledge & research skill to develop optimum solution to problems in areas of manufacturing & management.
- Identify and adopt advancement in Advanced Manufacturing and Production Management for academic, industrial and social application.

COURSES

SEMESTER – I

SEMESTER I							
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Teaching Assistance: 6 hours

PROGRAM ELECTIVE 1

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	5	24SJ1EPE027	METROLOGY AND COMPUTER AIDED INSPECTION	3-0-0	3	3
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PROGRAM ELECTIVE 2

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	4	24SJ1EPE032	ENTERPRISE RESOURCE PLANNING	3-0-0	3	3
	5	24SJ1EPE033	PRODUCTION PLANNING AND CONTROL	3-0-0	3	3
	6	24SJ1EPE034	SUPPLY CHAIN MANAGEMENT	3-0-0	3	3

APPLIED STATISTICS

24SJ1TPE003	APPLIED STATISTICS	CATEGORY	L	T	P	CREDIT
		DISCIPLINE CORE	3	0	0	3

Preamble:

This course introduces some statistical methods for modelling and analyzing data. The course includes problem solving using probability distributions, estimation of population parameters, testing of hypotheses about population, analyzing variability among samples from populations using ANOVA models and multivariate linear regression analysis. This course gives some basic statistical tools for analyzing problems in the engineering field.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Apply Probability Distributions for the analysis of practical problems	**K3**
CO2	Evaluate the confidence interval for the estimation of population parameters of a distribution	**K3**
CO3	Apply the methods of statistical hypothesis testing for testing population parameters	**K3**
CO4	Analyze given data using ANOVA models	**K3**
CO5	Analyze a multivariate data set using multivariate statistical data analysis methods	**K3**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	2	-	-	1	2	-	-	2	-
CO2	2	-	-	1	2	-	-	1	-
CO3	2	-	-	1	2	-	-	-	2
CO4	2	-	-	1	2	-	-	-	2
CO5	2	-	-	1	2	-	-	1	-

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Probability Distributions** Discrete and Continuous Probability distribution, mean, variance and higher moments of the distribution. Normal Distribution and Problems using Z tablet, Chi Square and F distributions and problems using the tables of the distribution	9	1
2	**Sampling Distribution and Estimation** Introduction to Sampling distribution, Central Limit Theorem-Distribution of sample mean and sample proportion (large and small samples). Introduction to Confidence interval and estimation of confidence of population mean. Estimation of confidence interval of population proportion.	7	2
3	**Testing of Hypothesis** Introduction to Hypothesis testing- Testing of hypothesis about population mean using random sample (large and small). Testing of hypothesis about equality of two population means using random samples (large and small). Testing of hypothesis about population proportion and equality of two population proportions.	8	3
4	**Analysis of Variance** Introduction ANOVA. One-way classification (completely randomized design)- model equation- testing means of multiple population using one-way ANOVA. Two-way classification (randomized block design)- model equation- testing the variability between rows and between columns. Model equation for latin square design- and testing the variability	9	4
5	**Multiple Regression and correlation** Introduction to different regression models for data analysis. Multiple linear regression analysis of data. Introduction to Multiple correlation and evaluation. Introduction to Partial correlation and evaluation of partial correlation	7	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	Continuous Internal Evaluation	End Semester Examination
Apply	20	30
Analyse	10	15
Evaluate	10	15
Create	-	0

Continuous Internal Evaluation Marks (CIE):

Micro Project/Course based project : 20 marks
Course based task/Seminar/Quiz : 10 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern: 60 Marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Text Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Probability and statistics for engineers,	Johnson, R. A., Miller, I., & Freund, J. E.	, 8th Edition, Pearson India	2015
2	Fundamentals of mathematical statistics.	Gupta, S. C., & Kapoor, V. K	3rd Edition, Tata McGraw Hill.	2008
3	Probability statistics and random processes	Sultan Chand & Sons. Veerarajan, T	, 8th Edition, Cengage learning	2009
4	Probability and statistics for engineering and the sciences,	Devore, J. L.	. Pearson Education.	2011

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	An introduction to statistical methods and data analysis	Ott, R. L., & Longnecker, M. T.	7th Edition, Cengage Learning.	2016
2	Linear regression analysis: theory and computing	Yan, X., & Su, X	World Scientific	2009
3	Regression analysis and linear models: Concepts, applications, and implementation	Darlington, R. B., & Hayes, A. F	Guilford Publications	2016
4	Regression Modelling Strategies	Harrell, F. E.	2nd Edition, Springer Publishers	2015
5	Regression: Models, Methods and Applications	Fahrmeir, L., Kneib, T., Lang, S., & Marx	Springer, New York.	2013

ADVANCED MANUFACTURING SYSTEMS

		CATEGORY	L	T	P	CREDIT
24SJ1TPE006	ADVANCED MANUFACTURING SYSTEMS	Discipline Core	3	0	0	3

Preamble:

Basics of manufacturing engineering.

Course Outcomes (COs)

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

	Course Outcome	Bloom's KnowledgeLevel (KL)
CO1	Understand Manufacturing and Management systems	K2
CO2	Apply CAD/CAM and CIM in Manufacturing.	K3
CO3	Prepare Process planning and the Application of AI in manufacturing.	K3
CO4	Apply the Technology management and system analysis in manufacturing.	K3
CO5	Apply Innovations in Manufacturing and Management.	K3

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

CO-PO Mapping

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PSO1	PSO2
CO 1	2	-	-	-	-	-	-	2	-
CO 2	3	-	-	-	-	-	-	-	2
CO 3	3	-	-	-	-	-	-	2	-
CO 4	-	3	-	-	-	-	-	2	-
CO 5	-	-	3	-	-	-	-	-	2

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	Manufacturing systems – production and manufacturing – principles of manufacturing – flows in manufacturing – system concept - attributes characterizing systems – structural aspect, procedural aspect, transformational aspect - integrated manufacturing system - manufacturing management system – functions and structures – Hierarchical and Functional Structure systems - frame work of integrated manufacturing system –functions and activities	8	1
2	CAD/CAM and CIM - scope of CIM – segments of generic CIM - computers and workstations - an overview of CIM software - product development through CAD and CAE – geometric modelling techniques - automated drafting - graphic standards – engineering analysis - optimization - principles of concurrent engineering - Comparison of concurrent engineering and sequential engineering - implementation of concurrent engineering	8	2
3	Automated process planning - general methodology of group technology- part families - parts classification and coding system - code structures - OPTIZ classification system - MICLASS system - variant and generative process planning methods - AI in process planning - process planning software.	8	3
4	Manufacturing management - Responsive manufacturing - Introduction to STEP NC- product data management - database systems - management of technology - Simulation of manufacturing systems – Types of simulation - techniques of simulation – simulation software packages – application of simulation.	8	4
5	Social manufacturing system - Manufacturing excellence for future production – Green manufacturing – Robotics in manufacturing – Smart manufacturing – Digital Twin, IOT and Mind Sphere in manufacturing - AI in manufacturing - Industry 4.o, Industry 5.o, Industry 6.o in manufacturing.	8	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	30
Evaluate	20
Create	20

Continuous Internal Evaluation Marks (CIE):

Continuous Internal Evaluation : 40 marks
Micro project/Course based project : 20 marks
Course based task/Seminar/Quiz : 10 marks
Test paper, 1 no. : 10 marks

The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Text Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Manufacturing Systems Engineering - A unified approach to manufacturing technology, production management, and industrial economics	Katsundo Hitom	Taylor & Francis Ltd, London	1996
2	CAD/CAM/CIM	P Radhakrishnan, S Subramanyan, V Raju	New Age International Publishers	2008
3	Automation, Production Systems and Computer Integrated Manufacturing	Michael P Groover	Prentice-Hall of India Pvt. Ltd., New Delhi	1996
4	Computer Integrated Manufacturing Handbook	Eric Teicholz & Joel Orr	McGraw Hill Book Co.	1987

Reference Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Computer Integrated Manufacturing	Ranky P.G	Prentice Hall of India	1985
2	Manufacturing Engineering and Technology	Kalpakjian	Addison-Wesley Publishing Co.,	1995
3	The Internet of Things: Industry 4.0	Ulrich Sendler	Springer	2018
4	Society 5.0 : industry of the future, technologies, methods and tools	Salgues , Bruno	Wiley Eastern	2018

ADVANCED OPERATIONS MANAGEMENT

24SJ1TPE007	ADVANCED OPERATIONS MANAGEMENT	CATEGORY	L	T	P	CREDIT
		Programme Core 2	3	0	0	3

Preamble:

The course is intended to introduce students to basic operations and supply chain concepts so that they appreciate its functions to the success of the firm. Success involves the clever integration of a great operations-related strategy, processes that can deliver the products and services, and analytics that support the ongoing decisions needed to manage the firm.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Explain the basic concepts in operations management.	**K2**
CO2	Explain the design of operations and supply chain.	**K2**
CO3	Illustrate the management of demand and capacity.	**K3**
CO4	Apply resource and supply chain management techniques.	**K3**
CO5	Illustrate scheduling, sequencing and lean operating systems.	**K3**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	3	-	3	-	3	-	2	2	-
CO2	3	-	3	-	3	-	2	2	-
CO3	3	-	3	-	3	-	2	-	1
CO4	3	-	3	-	3	-	2	-	-
CO5	3	-	3	-	3	-	2	-	-

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	Concepts in Operations management and value chains: Operations management and value chains:-Operations management, Goods and services, value, value chains, value chain frameworks, history of operations management Measuring performance in operations and value chains:- Types of performance measures, Analytics in operations management, designing measurement systems in operations, models of organisational performance Operations strategy:- Customer wants and needs, Evaluating goods and services, Competitive priorities, Operations management and strategic planning, Framework for operations strategy.	8	1
2	Designing operations and supply chain: Goods and service design:-phases, customer focussed design and quality function deployment, designing manufactured goods, service delivery system design, service encounter design Supply chain design: Global supply chains, supply chain design trade-offs, Global supply chain example, location decisions Process selection design and improvement: process choice decisions, product process matrix, service positioning matrix, process design, mistake-proofing processes, process improvement Facility and work design: facility layout, designing product layout, designing process layouts, work measurement, workplace and job design	8	2
3	Demand and capacity management: Forecasting and demand planning: Basic concepts in forecasting, statistical forecasting models, regression as a forecasting approach, Forecasting in practice. Capacity management: understanding capacity, capacity measurement, long-term capacity strategies, short-term capacity management. Process analysis and resource utilization: Resource utilization, process throughput and bottlenecks, little's law, managing waiting lines, theory of constraints Managing inventories in supply chains: understanding inventory, inventory characteristics, ABC inventory analysis, Managing fixed- quantity inventory systems, Managing fixed-period inventory systems, single period inventory model.	8	3
4	Supply chain management and Resource management Supply chain management and logistics: Managing supply chains, Logistics, Risk management in supply chain, supply chains in E-Commerce, Measuring supply chain performance, sustainability in supply chains. Resource management: Resources planning framework for goods and services, Aggregate planning options, strategies for aggregate production planning, Disaggregation in Manufacturing, Material requirement planning, Capacity requirement planning.	8	4

5	Operations scheduling and sequencing, Lean operating systems Operations scheduling and sequencing: understanding Scheduling and sequencing, Scheduling applications and approaches, sequencing, dispatching rules for scheduling, vehicle routing and scheduling Lean operating systems: Principles of lean operating systems, Lean tools and approaches, Lean six sigma, Just in time systems	**8**	**5**

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	15
Evaluate	15

Continuous Internal Evaluation Marks (CIE):

Continuous Internal Evaluation: 40 marks

Micro project/Course based project : 20 marks
Course based task/Seminar/Quiz : 10 marks
Test paper, 1 no. : 10 marks
The project shall be done individually. Group projects not permitted. Test paper shall include minimum 80% of the syllabus

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Text Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Operations and supply chain management	Collier, D.A., and Evans, J. R.,	Cengage	2nd Edition 2020

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Operations and Supply Chain Management	Jacobs, F.R. and Chase R. B.	McGraw-Hill Education	5th Edition 2020
2	Operations Management	Heizer, J., Render, B., Munson, C.	Pearson Education	12th edition 2017
3	Manufacturing Planning and control for supply chain management	Jacobs,F R, Berry,W L, Whybark, D C, Vollmann, T E	McGraw-Hill	6th Edition 2012
4	Operations management	William J Stevenson	Tata McGraw Hill	13th Edition, 2018
5	Competitive Manufacturing Management	Nicholas J.M	McGraw Hill Education Private Limited, New Delhi	2007

SEMESTER 1 – PROGRAMME ELECTIVE 1

ADVANCED MATERIALS FOR MANUFACTURING AND PROCESS

24SJ1EPE024	**ADVANCED MATERIALS FOR MANUFACTURING AND PROCESS**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**
		Programme Elective 1	3	0	0	3

Preamble:

This course imparts the information on the structure; properties and classifications of new generation materials called advanced materials and also meant to convey information on the processing techniques so as to get an awareness of these materials on their properties and possible industrial applications.

Course Outcomes (COs)

At the end of the course students should be able to

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Explain the various types of composites	**K2**
CO2	Explain the various techniques used for processing composites	**K2**
CO3	Explain the various types of advanced materials	**K2**
CO4	Explain the various non-conventional machining processes	**K2**
CO5	Explain the various techniques used for surface coating	**K2**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	3	3	-	-	-	3	-	-	1
CO2	3	3	2	2	-	3	-	2	-
CO3	3	3	2	2	-	3	-	-	1
CO4	3	3	2	2	-	3	-	-	1
CO5	3	3	2	2	-	3	-	-	-

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Composites** Conventional materials, Limitations of conventional materials, Need for composites, Constituents of composites, Classification of composites, Matrix materials: Metal matrix, Ceramic matrix, Polymer matrix, Reinforcement materials: Particulate reinforcement, Fiber reinforcement, Properties of composites, Advantages and disadvantages of composites, Applications of composites	8	1
2	**Processing of Composites** Processing of metal matrix composites: Stir casting method, Duralcan process, Gas pressure infiltration, Squeeze casting infiltration, Pressure die infiltration, Diffusion bonding, Powder metallurgy route. Processing of ceramic matrix composites: Slurry infiltration technique, Melt infiltarion technique, Direct oxidation process, Processing of polymer matrix composites: Hand lay- up, Spray lay-up, Filament winding, Pultrusion process, Resin transfer moulding.	8	2
3	**Advanced Materials** Relevance and classification of smart materials, Shape memory alloys: Martensitic transformations, Austenitic transformations, One way and two-way shape memory effect, Electro-rheological fluids, Magneto rheological Fluids, Chromogenic materials, Halochromic materials, Nano materials: Synthesis of nano materials, Characteristics and significance of nano materials, Effect of size reduction on properties, Carbon nano structures	8	3
4	**Non-conventional Machining** Electro-chemical machining, Electrical discharge machining, Wire EDM, Water jet machining, Abrasive water jet machining, Laser beam machining, Electron beam machining, Ultrasonic machining, Advantages and disadvantages of non-conventional machining	8	4
5	**Surface Coating Processes** Surface structure and properties, Need for surface modifications, Types of coating processes: Hard facing, Plasma spraying, Detonation spraying, High velocity oxy-fuel coating, Physical vapour deposition, Chemical vapour deposition	8	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	15
Evaluate	15

Continuous Internal Evaluation:40 marks

Preparing a review article based on peer reviewed Original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation :15marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Text Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Composite Materials – Science & Engg	K.K. Chawla	Springer- Verlag, New York	1988
2	Materials and Processing in Manufacturing	E. Paul Degarmo, J.T. Black, and Ronald A Kohser,	John Wiley and Sons Inc.,	12th Edition, 5th July 2017
3	Smart Structures and Materials	Brian Culshaw	Artech House	2000

Reference Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Nanomaterials: An Introduction to Synthesis, Properties and Applications	Dieter Vollath	Wiley-VCH Verlag Gmbh	2008
2	Advanced Surface Coatings: A Hand book of Surface Engineering	Mathews, A	Spinger	1991
3	Surface Engineering	D Srinivasa Rao and Srikant V Joshi	Daya Publishing House	2010

SAFETY ENGINEERING AND INDUSTRIAL HYGIENE

		CATEGORY	L	T	P	CREDIT
24SJIEPE025	SAFETY ENGINEERING AND INDUSTRIAL HYGIENE	Programme Elective 1	3	0	0	3

Preamble:

This course is to impart awareness about the importance of safety in industrial operations and to understand various techniques available for ensuring safety in industries.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Explain the basic aspects of Industrial Safety	**K2**
CO2	Describe different aspects of Industrial Hygiene	**K2**
CO3	Compare different hazard identification tools and choose most appropriate based on the nature and type of the industry	**K3**
CO4	Describe various fire prevention methods in industries	**K3**
CO5	Describe various hazards associated with different machines, processes and mechanical material handling.	**K3**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	1	2	2	1	2	2	1	-	2
CO2	1	2	2	1	2	2	1	-	2
CO3	2	2	2	2	2	2	1	2	-
CO4	2	2	2	2	2	2	1	-	1
CO5	2	2	2	2	2	2	1	1	-

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	Introduction to Industrial Safety and Management- History and development of Industrial safety- Safety, quality and productivity- Safety organizations- Safety committees and structure- Role of management in industrial safety- The Occupational Safety and Health Act (OSHA) - Environmental management systems and ISO 14001.	8	1
2	Introduction to Industrial hygiene- History of Industrial hygiene- Housekeeping- OSHA and industrial hygiene - Safety and health program management- Work place stressors- Chemical stressor- Physical stressor- Biological Stressor- Ergonomic stressor- Industrial toxicology- Material safety data sheet- Hazard communication standard- Airborne contaminants- Air monitoring and sampling- Noise and vibration and their control- Radiation safety program- Thermal stressors and their control- Ventilation investigation and analysis- Engineering control- Work practice control- Administrative control- Use of Personal Protection Equipment (PPE)- Training, maintenance and storage of PPE- Accident precautions- Education and training for industrial safety and hygiene	8	2
3	Hazard identification and risk control- Industrial safety and hygiene terminologies- Physical and chemical hazards- Electrical and biological hazards- Ergonomic and psychological hazards- Hazard identification methods-Safety inspection-Job safety analysis- Risk analysis methods- Map method- Tabular method- fault tree analysis- HAZOP analysis- Elimination of Hazards- Isolation of Hazards – Control of hazards- Economic aspects of accidents- Accident reporting.	8	3
4	Fire protection systems- Fire chemistry- Causes of fire- principles of fire extinction- Water sprinkler and fire hydrant- Explosion protection system- Alarm and detection system- Suppression system- Carbon dioxide system- Foam system and halon system- Portable extinguisher.	8	4
5	Toxicology and risk - Chemical and Biological hazards- -Systems and organs commonly affected by toxins - Exposure sensitive Occupations- Abrasive Blast Cleaning- Welding, Burning, and Torch Cutting- Spray Painting with Lead-Based Paint- Soldering and Brazing- Hazardous Waste Safety Program- Effective Ergonomics Program.	8	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	15
Evaluate	15

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed Original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation : 15 marks
Test paper, 1 no. : 10marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Text Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Industrial Safety	Blake R.P	Prentice Hall Inc., New Jersey	3rd Edition 2006
2	Industrial Safety Management	Deshmukh. L.M	Tata McGraw Hill, New Delhi	3rd Edition 2008
3	Industrial Safety, Health and Environmental Management Systems	Jain.R.K and Sunil Rao	Khanna Delhi	1st Edition 2006
4	Chemical Hazards and Safety	Shrikant Dawande	Khanna Publishers	2nd Edition 2012

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Chemical Process Safety: Fundamentals with applications,	Daniel A.Crowl, Joseph F. Louvar	Prentice Hall Inc., New Jersey	3rd Edition 2011
2	Safety management	John V.Grimaldi and Rollin H. Simonds	All India Travellers Book, Seller,New Delhi	1989

ADDITIVE MANUFACTURING

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
24SJ1EPE100	ADDITIVE MANUFACTURING	Programme Elective 1	3	0	0	3

Preamble:

This is an elective course in Manufacturing and Production. It covers the different aspects of Additive Manufacturing – from basics to advanced. The topics covered in this course have wide applications in Industry 4.0 and including Rapid Prototyping, Manufacturing and Tooling. The course also covers basics of software side involved with AM.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the fundamentals, various process, merits and demerits of Additive Manufacturing.	K2
CO2	Analyse and select suitable process, materials and energy sources used in Additive Manufacturing.	K3
CO3	Identify and analyse different processes and techniques of Additive Manufacturing.	K3
CO4	Understand and Apply knowledge of FDM, Designing for AM, Rapid Tooling in additive manufacturing for various applications.	K2
CO5	Understand the concepts of reverse engineering for geometry transformations, software including CAD software, Data formats and Scanning Technologies used in additive manufacturing to identify and analyse different real-life Applications of AM.	K2

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	1	-	2	1	1	-	-	2	-
CO2	1	-	2	1	2	1	-	2	-
CO3	1	-	2	2	2	-	1	-	2
CO4	1	1	2	2	3	2	1	-	2
CO5	1	1	3	2	3	3	2	-	2

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Introduction, Fundamentals, Merits and Demerits of Additive Manufacturing (AM).** History of AM – Start of 3D Printing, Moving from Rapid Prototyping to AM. Current manufacturing challenges – Part vs System level manufacturing, Centralised and projection-based manufacturing, Generalised design. Prototyping, Tooling and Manufacturing, Direct and Indirect AM Processes. Advantages of AM and AM Processes, Comparison of AM with CNC machining, deformation processes and shaping processes. Merits and demerits of AM with respect to conventional manufacturing – Part flexibility, Waste prevention, Production flexibility, Process running cost, Start-up investment, Mass production and Raw material. CAM to AM, Influence of AM, Future trends and On- Demand manufacturing, Challenges of AM	8	1
2	**Understanding Metal for AM and sources of energy**. Structure, Physical and thermal properties, Mechanical, Electrical, Magnetic and Optical properties, Chemistry, Physical and Process metallurgy, Sintered and Solidification microstructures and Bulk properties. Forms of metal for AM – Powder, wire and electrodes, Composites and metallic glass, Recycled metals. Material Characterisation for AM of liquid-based, Solid- based and Powder based additive manufacturing. High energy density sources for AM – Lasers, Electron beam and Plasma arc	8	2
3	**AM Processes and Techniques** General Classification of AM Processes. AM using Vat Polymerisation Techniques – Materials, Resins, Post-processing Stereolithography, TPP, DLP-SLA. Advantages and Limitations. AM using Powder bed fusion technique – SLM and EBM – strengths and weakness. Powder characteristics. AM processes using Material jetting and binder jetting Directed Energy deposition processes – Laser based and Electron beam based – Advantage and Drawbacks advantages and drawbacks. Sheet lamination techniques – LOM, UAM – Materials, Advantages and Drawbacks. Directed Energy deposition processes – Laser based and Electron beam based – Advantage and Drawbacks	8	3
4	**FDM, Designing for AM, Rapid Tooling** FDM – History, Working and Materials, Rapid tooling with FDM, Surface finish, Pre-processing techniques and post-processing techniques in FDM Designing for AM – AM workflow - Modelling to AM, Rapid Tooling – Properties, Indirect and Direct methods of direct tooling processes for metals and plastic.	8	4
5	**Software, Data formats, Scanning Technologies and Applications of AM** Software and Data format in AM – STL, IGES, STEP, OBJ, VRML, NURBS Scanning Technologies for AM – Contact and Non- contact scanners, Time-of-flight, Triangulation, Volumetric method etc. Typical Applications of AM – Automobile, Aerospace and Education. Medical applications of AM – Implants, Hearing aids, craniofacial, Cardiology, Orthopaedic, Dental applications and Tissue engineering	8	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	40
Analyse	10
Evaluate	10

Continuous Internal Evaluation Marks (CIE):40 Marks

Preparing a review article based on peer reviewed Original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Text Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Additive Manufacturing	Amit Bandyopadhyay, Susmita Bose	CRC Press, Taylor & Francis Group	Second Edition 2020
2	Additive Manufacturing: Fundamentals and Advancements	Manu Srivastava, Sandeep Rathee, Sachin Maheshwari and T. K. Kundra	CRC Press Taylor & Francis Group	2020
3	Additive Manufacturing of Metals: From Fundamental Technology to Rocket Nozzles, Medical Implants, and Custom Jewelry	John O. Milewski	Springer Series in Materials Science,	Volume 258 2017
4	Additive Manufacturing of Metals: The Technology, Materials, Design and Production	Li Yang, Keng Hsu, Brian Baughman, Donald Godfrey, Francisco Medina Mamballykalathil Menon, Soeren Wiener	- Springer Series in Advanced Manufacturing	2017

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Additive Manufacturing: Applications And Innovations	Rupinder Singh, J. Paulo Davim	Crc Press, Taylor & Francis Group	2019
2	Additive Manufacturing: Innovations, Advances, And Applications	T.S. Srivatsan, T.S. Sudarshan	Crc Press, Taylor & Francis Group	2016
3	Additive Manufacturing: 3d Printing For Prototyping And Manufacturing	Andreas Gebhardt, Jan-Steffen Hötter	Hanser Publishers, Munich	2016
4	Standards, Quality Control, And Measurement Sciences In 3d Printing And Additive Manufacturing	Chee Kai Chua, Chee How Wong, Wai Yee Yeong	Academic Press (Imprint Of Elsevier)	2017

ADVANCED MATERIAL JOINING AND TESTING

		CATEGORY	L	T	P	CREDIT
24SJ1EPE026	ADVANCED MATERIAL JOINING AND TESTING	Programme Elective 1	3	0	0	3

Preamble:

Students will be able to understand the basics of materials joining. They get an idea about different joining techniques and response of materials on joining. Also, students understands the need for destructive and non-destructive testing methods.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the fundamental advanced materials joining and testing	K2
CO2	Develop the working models of various fabrication systems.	K3
CO3	Understand the application and concepts of fusion welding and high energy welding.	K2
CO4	Impart the knowledge of advanced metallurgy in welding	K3
CO5	Understand the concepts of destructive and non-destructive welding.	K2

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	2	1	1	-	-	-	-	-	2
CO2	2	1	1	-	-	-	-	2	-
CO3	2	-	1	-	-	-	-	-	2
CO4	2	-	1	1	-	-	-	2	-
CO5	2	1	1	1	1	-	-	-	2

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Welding Introduction** Introduction: Classification – heat sources , applications Residual stresses: formation and relieving Capillary and welding action temperature range – filler material and fluxes – types of joints and welding positions	8	1
2	**Weldability** Design, process and metallurgical consideration – testing and improvement. Conventional joining techniques: Bolting – riveting – soldering – blazing. Adhesive bonding – diffusion bonding – mechanical joining	8	2
3	**Types of welding:** Fusion welding: Oxyacetylene welding – Analysis, process parameters SMAW – GTAW – GMAW – Analysis, process parameters FCAW – SAW – ESW. Analysis, process parameters. High energy beam welding: EBW, LBW, PAW – friction stir welding. Output parameter variation – advantages and disadvantages – applications.	8	3
4	**Responses of materials to welding** Microstructural changes, metallurgical effect of weld. – Distortion Defects: undercuts – overlaps – grain growth – blowholes – inclusions – segregation – lamellar tearing – porosity.	8	4
5	**Welding Test** Destructive tests for welds: Introduction – need – principles – Applications. Destructive tests: tensile, bend, impact, hardness, fatigue, cracking, etching. Non-destructive tests: Visual, dye penetrants, magnetic particle, acoustics, pressure, radiographic, ultrasonic, eddy current testing.	8	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	10
Evaluate	10
Create	10

Continuous Internal Evaluation Marks (CIE):40 Marks

Preparing a review article based on peer reviewed Original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation : 15 marks
Test paper, 1 no. : 10 marks

Test paper shall include minimum 80% of the syllabus

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Text Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Welding and welding technology	Richard L. Little	McGraw Hill Education	2000
2	Modern Arc Welding technology	S. W. Nadkarni	Ador Welding Ltd	2008

Reference Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Metallurgy of welding, soldering and brazing	J. F. Lacaster	Pergamon Press	2012
2	Welding handbooks	--	American Welding Society	1991
3	Metal handbooks	--	American Society of Metals	1982
4	Text book of welding technology	O. P. Khanna	Dhanpat Rai & Sons	2015
5	Modern welding technology	Carry	Pearson	1997

METROLOGY AND COMPUTER AIDED INSPECTION

24SJ1EPE027	**METROLOGY AND COMPUTER AIDED INSPECTION**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**
		Programme Elective 1	3	0	0	3

Preamble:

Students will be able to understand the importance of precision engineering and computer aided inspection. They will be able to learn the latest advancements in high precision measurements.

Course Outcomes (COs)

At the end of the course students should be able to

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the fundamental of precision measurements	**K2**
CO2	Impart the need of tolerance in measurement	**K3**
CO3	Understand the application and concepts of laser metrology	**K2**
CO4	Impart the knowledge of advanced measurements with CMM	**K3**
CO5	Understand the concepts of machine vision system	**K2**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	2	1	1	-	-	-	-	2	-
CO2	2	1	1	-	-	-	-	2	-
CO3	2	-	1	-	-	-	-	-	2
CO4	2	-	1	1	-	-	-	-	2
CO5	2	1	1	1	1	-	-	1	-

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Welding Introduction** Abbe's principle, Need for high precision measurements Problems associated with high precision measurements Standards for length measurement; Shop floor standards and their calibration. Light interference; Slip gauge calibration	8	1
2	**Tolerances and specifications** Gauging principles; Selective assembly Comparators. Angular measurements, Thread measurements Surface and form metrology; Flatness, roughness, waviness, roundness etc. Computer aided metrology.	8	2
3	**Laser metrology** Applications of lasers in precision measurements, Laser telemetric system, Laser interferometer, Speckle measurements, Laser inspection, Dimensional measurement techniques	8	3
4	**Co-ordinate measuring machine** Contact and non-contact CMM. Causes of errors, Accuracy specifications, Contact and non-contact probes. Calibration of CMM; Measuring scales, Moiré fringes in linear grating, Advantages and applications of CMM.	8	4
5	**Machine vision system** Image formation, Binary and grayscale image, Image histogram, Histogram operations. Binary and grayscale image, Image histogram, Histogram operations, Pixel point processing and pixel group processing, Image sharpening and smoothing, Edge detection and enhancement.	8	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	10
Evaluate	10
Create	10

Continuous Internal Evaluation Marks (CIE): 40 marks

Preparing a review article based on peer reviewed Original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Reference Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Hand book of industrial metrology	--	ASME	1967
2	Metrology	Hume	McDonald	1970

INDUSTRIAL ROBOTICS AND EXPERT SYSTEMS

24SJ1EPE028	**INDUSTRIAL ROBOTICS AND EXPERT SYSTEMS**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**
		Programme Elective 1	3	0	0	3

Preamble:

Basics of robotics and expert systems.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Recall fundamental concepts of robots and robot kinematics and dynamics.	**K3**
CO2	Analyze and design path planning and image processing.	**K3**
CO3	Implement drives concepts in end effectors.	**K3**
CO4	Design robot work cell and robot program for automation industries.	**K3**
CO5	Apply the concepts of AI and expert systems.	**K3**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	2	3	3	2	3	2	1	2	-
CO2	3	3	3	2	2	3	1	2	-
CO3	2	3	3	2	2	3	1	-	2
CO4	2	3	3	3	3	3	1	2	-
CO5	2	3	3	3	3	3	1	2	1

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	Introduction and Robot Kinematics: Definition need and scope of Industrial robots – Robot anatomy – Work volume – Precision movement – End effectors – Sensors. Robot Kinematics – Direct and inverse kinematics – Robot trajectories – Control of robot manipulators – Robot dynamics – Methods for orientation and location of objects	8	1
2	Robot sensors: Transducers and Sensors – Tactile sensor – Proximity and range sensors – Sensing joint forces – Robotic vision system – Image Representation - Image Grabbing –Image processing and analysis – Edge Enhancement – Contrast Stretching – Band Rationing - Image segmentation – Pattern recognition – Training of vision system	8	2
3	Robot drives and control: Controlling the Robot motion – Position and velocity sensing devices – Design of drive systems – Hydraulic and Pneumatic drives – Linear and rotary actuators and control valves – Electro hydraulic servo valves, electric drives – Motors – Designing of end effectors – Vacuum, magnetic and air operated grippers	8	3
4	Robot Cell Design and Application: Robot work cell design and control – Safety in Robotics – Robot cell layouts – Multiple Robots and machine interference – Robot cycle time analysis. Industrial application of robots- Robot programming- task level and lead through programming - Motion interpolation.	8	4
5	Artificial intelligence: Artificial intelligence – Basics – Goals of artificial intelligence – AI techniques– problem representation in AI – Problem reduction and solution techniques - Application of AI and KBES in Robots	8	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	28
Analyse	17
Evaluate	7
Create	0

Continuous Internal Evaluation Marks (CIE):40 marks

Preparing a review article based on peer reviewed Original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Text Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Robotics Control, Sensing, Vision and Intelligence	K. S. Fu, R.C. Gonzalez, C.S.G. Lee	Mc Graw Hill	1987
2	Robotics for Engineers	Yoram Koren	Mc Graw Hill	1987
3	Robotic Engineering – An Integrate Approach	Richard D. Klafter, Thomas A Chmielewski, Michael Negin	Prentice Hall	1994
4	Robotic Technology and Flexible Automation	Deb, S.R	Tata McGraw Hill	1994
5	Industrial Robotics	Fu & Gonzales	Tata Mc Graw Hill	1988
6	Industrial Robotics	Kozyrey, Yu	MIR Publishers Moscow	1998.
7	Industrial Robotics Technology, Programming and Applications	Mikell,P. Groover, Mitchell Weis, Roger N. Nagel, Nicholas Odrey	McGraw Hill, Int	1987

Reference Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Expert Systems and Robotics	Timothy Jordonides et. al	Springer-Verlag, New York	May 1991.
2	Introduction to Artificial Intelligence and Expert Systems	Dan. W. Patterson	PHI	2nd Ed., 2009
3	Artificial Intelligence	George. F. Luger	Pearson Education,	3rd Edition,

			Asia	2009
4	Artificial Intelligence An Engineering Approach	. Robert J. Schalkeff,	PHI	2nd Ed., 1990.
5	Artificial Intelligence: A Modern Approach	Stuart Russell, Peter Nowig	Pearson	3rd Ed
6	A Guide to Expert Systems	Donald A. Waterman	Addison Wesley	2nd Edition, 1986

SEMESTER 1 – PROGRAMME ELECTIVE 2

INDUSTRIAL ENERGY MANAGEMENT

24SJ1EPE029	**INDUSTRIAL ENERGY MANAGEMENT**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**
		Programme Elective 2	3	0	0	3

Preamble:

This course is designed to provide a comprehensive understanding of modern industrial energy management and is expected to lead the engineer to the National Certification Examination for Energy Managers and Auditors (BEE, GoI).

Course Prerequisites

Knowledge in Basic Mechanical and Basic Electrical Engineering at UG level

Course Outcomes (COs)

At the end of the course students should be able to

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Develop a thorough knowledge on current energy scenario	**K3**
CO2	Develop a thorough knowledge on energy, energy management and energy audit	**K3**
CO3	Develop a thorough knowledge on material and energy balance and energy action planning	**K3**
CO4	Apply project management and financial management principle in energy management	**K3**
CO5	Apply energy monitoring and targeting techniques, develop comprehensive awareness on energy and nature and NRES	**K3**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	-	-	-	-	-	-	1	-	2
CO2	-	-	-	-	1	-	-	-	2
CO3	-	-	2	-	-	-	-	-	2
CO4	2	-	-	1	-	1	-	2	-
CO5	-	2	-	-	-	-	-	2	-

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	Energy scenario: Commercial and non-commercial energy, Primary energy resources, Commercial energy production, Final energy consumption, Indian energy scenario, Sectoral energy consumption, Energy needs of growing economy, Energy intensity on purchasing power parity (PPP) basis, Long term energy scenario, Energy pricing, Energy security, Energy strategy for the future, Energy conservation and its importance Energy conservation act 2001 and related policies: Energy conservation act -2001 and its features, Notification under the act schemes of Bureau of Energy Efficiency (BEE) – ECBC, S&L, DSM, BLY, SME's, Designated agencies, Electricity act 2003, Integrated energy policy, National action plan on climate change	8	1
2	Basics of energy and its various forms: Electricity basics – DC & AC currents, Electricity tariff, Thermal basic – Fuels, Thermal energy, Contents of fuel, Temperature & pressure, Heat capacity, Sensible and latent heat, Evaporation, Condensation, Steam, Moist air and humidity, Heat transfer, Units and conversion, MTOE conversions **Energy Management and Audit**: Definition, Energy audit, Need, Types of energy audit, Energy management (audit approach), Understanding energy costs, Benchmarking energy performance, matching energy use to requirement, Maximizing system efficiencies, Optimizing the input energy requirements, Fuel and energy substitution, Energy audit instruments and metering, Manner and intervals of EA regulation	8	2
3	Material and energy balance: Introduction, Components of material and energy balance, Basic principles of material and energy balance, Classification of processes, Material balance, Energy balance, Facility as an energy system, Energy analysis and Sankey diagram **Energy action planning:** Energy policy – Key elements – Formulation – Ratification Organizing – Location of energy management – Top management support – Managerial function – Roles and responsibilities of energy manager – Accountability-Force field analysis – Marketing and communication – training and planning – Motivation – Information system: designing, Barriers, Strategies, Management tools (5S, TPM, TQM, Kaizen, small group activities, ISO 50001)	8	3
4	Financial Management: Investment – Need, Appraisal and Criteria, Financial analysis techniques – Simple payback period, Return on investment, Net present value, Internal rate of return, Cash flows, Risk and sensitivity analysis, Financing options, Energy performance contracts and role of ESCOs **Project Management:** Definition and scope of project, Technical design, Financing, Contracting, Implementation and performance monitoring, Implementation plan for top management, Planning budget, Procurement procedures, Construction, Measurement and verification	8	4

5	**Energy Monitoring and Targeting**: Defining monitoring and targeting, Elements of monitoring and targeting, Data and information analysis, Techniques – energy consumption and production, Cumulative sum of differences (CUSUM), EMIS **Energy efficiency and climate change:** Energy and environment: Energy and environment – Air pollution, Climate change, United Nations Framework Convention on climate change (UNFCCCC), Kyoto protocol, Conference of parties (COP), Clean development Mechanism (CDM), CDM methodology and procedure, Sustainable development New and renewable energy sources (NRES): Concept of renewable energy, Biomass energy (biomass combustion, biogasification, biomethanation and biofuels), Hydro energy, Fuel cells, Energy from wastes, Wave, Tidal and Geothermal energy.	**8**	**5**

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	20
Evaluate	20

Continuous Internal Evaluation Marks (CIE): 40 Marks

Preparing a review article based on peer reviewed Original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Text Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Applied industrial energy and environmental management	Zoran K Morvay	Wiley	2008
2	National Action Plan on Climate Change prepared by Prime minister's Council on Climate Change.	--	NAPCC	2008
3	General aspects of energy management and audit, Guidebook for national certification exam for energy managers and energy auditors.	--	Vol.1, Bureau of energy efficiency, New Delhi	2016
4	NPC Energy Audit Manual and Reports	--	--	2021
Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Energy Management Handbook	John Wiley and Sons – Wayne C Turner	River Publishers; 9th edition	2018
2	Guide to Energy Management	Cape Hart, Turner and Kennedy	River Publishers; 8th edition	2016
3	Energy Conservation in Industries	Center of Plant Engineering Services, Hyderabad	NAPCC	2001
4	Financial Management	Prasanna Chandra	Tata Mc-Graw Hill	2011

ADVANCED OPERATIONS RESEARCH

		CATEGORY	L	T	P	CREDIT
24SJ1EPE030	ADVANCED OPERATIONS RESEARCH	Programme Elective 2	3	0	0	3

Preamble:

This course provides a detailed understanding of various mathematical techniques for the effective solution of real world problems. The objective of this course is to impart the ability to formulate problems and find its optimal solution.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Apply Linear Programming methods for the formulation and solution of real-world problems.	**K3**
CO2	Solve Transportation and Assignment problems, Integer Programming problems and Goal Programming problems.	**K3**
CO3	Apply Dynamic Programming approach for optimization and solve non- linear programming problems.	**K3**
CO4	Analyse decision problems under different environments.	**K3**
CO5	Analyse network problems.	**K3**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	2	-	1	3	3	2	-	1	-
CO2	2	-	1	3	3	2	-	1	-
CO3	3	-	2	3	3	2	-	-	1
CO4	2	-	1	2	3	1	2	2	-
CO5	2	-	2	2	3	2	3	2	1

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Linear Programming:** LPP formulation and Graphical solution, Simplex method, Artificial starting solution methods, Dual simplex method, Duality theory and applications, Sensitivity Analysis.	7	1
2	**Extensions of Linear Programming:** Transportation problem, Assignment problem, Integer Programming: Branch and Bound method, Gomory's cutting plane method, Goal Programming: GP formulation, Simplex method for solving Goal Programming.	7	2
3	**Dynamic Programming and Non-Linear Programming:** Bellman's Principle of optimality, Deterministic Dynamic, Programming models: Reliability improvement model, Capital budgeting model Non-Linear Programming methods: Lagrangean method, Kuhn-Tucker conditions	7	3
4	**Decision Analysis** Decision making environments, Decisions under Certainty, Decisions under Risk, Decisions under uncertainty, Decision trees, Multi criteria decision making, Pareto optimality	7	4
5	**Network Models** Shortest Route Problem: Systematic method, Dijkstra's algorithm, Floyd's algorithm, Minimal Spanning Tree Problem: PRIM algorithm, Kruskal's algorithm, Maximum Flow Problem: Maximal flow algorithm	7	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	20
Evaluate	10

Continuous Internal Evaluation Marks (CIE): 40 Marks

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such

questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Text Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Operations research principles and practice	Ravindran, Phillips, Solberg	Willey & Sons	1987
2	Operations research	Hamdy A. Taha	Pearson	2004

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Operations research	R. Paneerselvam	PHI, New Delhi	2008
2	Operations Research-Principles and Applications	G. Srinivasan	PHI Pvt. Ltd	2010.

PROCESS PLANNING AND COST ESTIMATION

24SJ1EPE031	PROCESS PLANNING AND COST ESTIMATION	CATEGORY	L	T	P	CREDIT
		Programme Elective 2	3	0	0	3

Preamble:

Process planning is a knowledge intensive domain in CAD CAM integrated environment. In-depth and correlative knowledge on engineering representations of products, material properties, manufacturing processes and constraints are to be applied in creation of process plans and cost estimation. This course provides a clear insight on process planning and its activities. It introduces the procedure of cost estimation of products manufactured in different processes.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Interpret drawings for Geometric analysis, manufacturing considerations and material evaluation	**K3**
CO2	Select materials and processes for manufacture with an integrated approach for product and process	**K2**
CO3	Select appropriate production equipment and tooling for a given problem	**K2**
CO4	Identify the various elements which constitute the ultimate cost of products	**K3**
CO5	Prepare production cost estimation for common manufacturing processes.	**K3**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	1	3	3	2	2	-	-	2	-
CO2	1	2	2	2	2	-	-	-	2
CO3	-	2	-	-	-	-	-	-	2
CO4	1	1	-	-	-	-	-	1	-
CO5	1	2	-	-	-	-	-	1	-

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Process planning** Definition – Process planning terminologies and methods, process planning activities, Types of Process plan, Process planning documents Information flow in design, Interpretation of engineering drawing and other standard representations for material selection and process selection from product representation, Analysis and interpretation of engineering drawings of components	8	1
2	**Material and Process selection** Review of material properties and manufacturing processes, limits fits tolerance, standard components. Process selection metal cutting, casting, metal joining, forming processes, plastic and composite processes-application of heat treatments. Prepare an outline process plan for a given component or assembly.	8	2
3	**Selection of Machine, tooling and process parameters.** Selection of process for specific manufacturing process - welding, casting, machining, forming, processes for plastic and composites, Factors affecting tooling performance, tooling selection method, Factors of selection of machines, tooling and accessories with reference to manufacturing processes, selection of process parameters, Selection of machines for specific process – welding, casting, machining, forming, processes for plastic and composites , Tooling for NC machines Selection of process parameters for specific processes - welding, casting, machining, forming, plastic and composites, Selection of tooling for managing given process or product, Examples	8	3
4	**Product cost estimation** Product cost estimation, components of costing, cost estimation procedure, ladder of costs, Types of cost estimation, Methods of cost estimation	8	4
5	**Production Cost estimation** Production cost estimation – foundry shop, casting, Production cost estimation - welding shop, Production cost estimation – forging shop	8	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	15
Evaluate	15

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Reference Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Process Planning: The design/manufacture interface	Peter Scallan	Elsevier Science & Technology Books	2002
2	Process planning and cost estimation	M. Adithan	New age international publishers, New Delhi	2009
3	Manufacturing systems engineering	Katsundo Hitomi	Taylor and Francis	1996
4	Process planning and cost estimation	R Kesavan, et al	New age international publishers.	2004

ENTERPRISE RESOURCE PLANNING

		CATEGORY	L	T	P	CREDIT
24SJ1EPE032	ENTERPRISE RESOURCE PLANNING	Programme Elective 2	3	0	0	3

Preamble:

Students will be able to understand the importance of Enterprise planning. They will be able to learn the latest advancements resource planning.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Develop a thorough knowledge on ERP and MRP I	K3
CO2	Develop a thorough knowledge on MRP II, JIT, SCM etc	K3
CO3	Develop a thorough knowledge on ERP systems and technology background	K3
CO4	Conceive, design and implement an ERP system for a given manufacturing system	K3
CO5	Project and educate on relative benefits of ERP system implementation.	K3

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	-	-	-	-	-	-	2	1	-
CO2	-	-	-	-	2	-	-	1	-
CO3	-	-	2	-	-	-	-	-	2
CO4	2	-	-	2	-	2	-	1	-
CO5	-	2	-	-	-	-	-	-	1

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Introduction to ERP and MRP I** Introduction, history and requirements of ERP and MRP I, Generation of material requirement planning (MRP I), Closing the MRP I loop	8	1
2	**MRP II, JIT, SCM and related topics** Manufacturing resources planning (MRP II) Just–in–time (JIT) to lean manufacturing, Kanban, Kaizen, 5S Supply chain management (SCM), internet's impact on ERP	8	2
3	**Systems and technology background** ERP systems background, ERP data input and output capabilities, Business Process Re-engineering (BPR), Value creation using ERP systems, need to investigate ERP systems.	8	3
4	**Design of ERP systems** ERP system implementation life cycle, deciding to go for ERP and choosing an ERP system, ERP system design, gap analysis, process re-engineering and ERP software customization, Choosing standard models, artifacts and processes (MAPs)	8	4
5	**ERP Implementation** ERP Implementation, big bang, phased and parallel, merits and demerits Pre and post live-go ERP training, ERP and electronic commerce, ERP risks, successes and failures, Introduction to Key ERP software packages like SAP, Oracle, Microsoft Dynamics etc.	8	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	20
Evaluate	10

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed original publications (minimum 10)publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students).

Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Text Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Enterprise Resource Planning: Concepts and Practice	Garg V. K. and Venkitakrishnan N.K	Prentice – Hall of India Private Limited	2004
2	Enterprise Resources Planning Systems: System Life cycle Electronic Commerce and Risk	O'Leary D.E	John Wiley & Sons	2000

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	ERP Tools Techniques and Applications for Integrating the Supply Chain	Ptak C.A. and Eli S	St. Lucie Press/ APICS Series on Resource Management	1999
2	Making it Happen: The Implementer's Guide to Success with Enterprise Resource Planning	Wallace T.F. and Kremzar M.H	John Wiley & Sons	2001

PRODUCTION PLANNING AND CONTROL

24SJ1EPE033	PRODUCTION PLANNING AND CONTROL	CATEGORY	L	T	P	CREDIT
		Programme Elective 2	3	0	0	3

Preamble:

This course is designed to provide a comprehensive understanding of Production Planning and Control and its application in industry.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Develop an introductory knowledge on PPC	**K3**
CO2	Develop a comprehensive knowledge o n aggregate planning	**K3**
CO3	Develop a thorough knowledge on lot sizing and scheduling	**K3**
CO4	Develop a thorough knowledge on flow shop sequencing	**K3**
CO5	Design and Implementation of a PPC system	**K3**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	-	-	-	-	-	-	2	-	1
CO2	-	-	-	-	2	-	-	-	1
CO3	-	-	3	-	-	-	-	1	-
CO4	3	-	-	2	-	2	-	-	1
CO5	-	3	-	-	-	-	-	2	-

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**General introduction to Production Planning and Control** General introduction to Production Planning and Control: Introduction to facilities location and layout, Plant location, facility location, facilities layout, CRAFT, ALDEP, CORELAP, Simple averaging, moving averages, methods Exponential smoothing, method Holt's linear method Holt-winter's method.	8	1
2	**Aggregate Planning, Capacity Management** Aggregate Planning, Capacity Management: Introduction to aggregate planning, linear decision rules, graphical approach mathematical programming model, introduction to disaggregation, MPS BOM MRP introduction to capacity management RRP RCCP CRP, scheduling strategies infinite versus finite loading comparison of the strategies	8	2
3	**Lot sizing rules** Lot sizing rules, Scheduling: FOQ EOQ LFL, FPR POQ LUC, LTC PPB W-W algorithm, Analysis of lot sizing heuristics such as EOQ W-W GR SM and Freeland Colley analysis of the entire data set, Introduction to scheduling decision rules, scheduling approaches types of decisions single machine sequencing, shop floor control, input-output control infinite and finite loading forward and backward scheduling	8	3
4	**Flow shop sequencing and job shop scheduling** Flow shop sequencing and job shop scheduling: flow shop sequencing techniques, Critical ratio, least changeover cost, non-quantifiable sequencing rules, two and three machine scheduling problem, job shop scheduling, common rule for job shop scheduling problem, minimizing make span in job shop, line of balance technique, run out technique, optimize production technology.	8	4
5	**Design and implementation of Integrated PPC Systems** Design and implementation of Integrated PPC Systems: Design of PPC systems, basic concepts MRP II -JIT –Kanban design of continuous flow manufacturing system multi-agent manufacturing planning and control system implementation of Kanban. Design and implementation of an integrated production planning System, design of forecasting models using SAP APO multiproduct	8	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	10
Analyse	20
Evaluate	30

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed Original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Text Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Production Planning and Control: Text and Cases	Mukhopadhyay S.K	Prentice Hall of India	2007
2	Eilon Elements of Production Planning and Control	Samuel Eilon	Universal Publishing Corporation	2015
3	Topology and Modern Analysis	G.F.Simmons	McGraw Hill	1963

Reference Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	An Introduction to Wavelets through Linear Algebra	Frazier Michael W	Springer Publications.	1999
2	Linear Algebra and its Applications	Strang G	Saunders	1988

SUPPLY CHAIN MANAGEMENT

		CATEGORY	L	T	P	CREDIT
24SJ1EP034	SUPPLY CHAIN MANAGEMENT	Programme Elective 2	3	0	0	3

Preamble:

In today's business scenario, fulfilment of customers' requirements is possible only through the coordination and involvement of the suppliers of the organisation. Proper design of the supply chain is of paramount importance in order to achieve this. This course provides the basic knowledge of the key issues of the supply chains, its design and operation

Prerequisite: Operations management

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand basic concept of supply chain.	**K2**
CO2	Interpret the role of Sourcing & procurement in supply chain.	**K3**
CO3	Understand how supply chain plays an important role in Inventory control.	**K2**
CO4	Develop the concepts and role of Logistics in supply chain management.	**K3**
CO5	Understand how logistics and supply chain strategies can create value generation and utilise IT applications.	**K2**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	1	-	-	-	-	1	-	-	1
CO2	1	-	2	-	2	2	-	-	1
CO3	-	3	-	-	-	3	-	1	-
CO4	1	-	-	3	-	3	-	1	-
CO5	-	-	-	-	-	3	3	-	1

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	Supply chains-objectives of Supply chain, Decision phases in supply chain-Design, Planning& Operation-decision areas Types of supply chain views-flows in supply chain-supply chain & competitive performance-Performance measures for Supply Chain Management- Drivers of supply chain performance-strategic fit & its obstacles	8	1
2	Sourcing & procurement-Sourcing-Factors in source selection-vendor rating-qualitative& quantitative methods-Purchasing-objective and procedure-purchasing systems-tender method- computer based systems/EDI Network Design-Role of Network design in supply chain-Factors influencing Network design decisions, network design in uncertain environment	8	2
3	Multi-Echelon Inventory systems-Inventory Planning Decision, Estimate of cycle Inventory (EOQ)-Inventory Models-Q model& P model –Selective control of inventory-classification for selective control of inventory(ABC,VED,SDE,HML,FSN,SOS,XYZ Analysis)- Discounting Models-Multiple item inventory Models-Safety Inventory-Impact of supply uncertainty on safety inventory-Multi Echelon Distribution supply chain-Bull whip effect	8	3
4	Logistic Management-3PL & 4PL-Benefits,Types. Role of transportation in supply chain – factors affecting transportations decision – Design option for transportation network – Tailored transportation – Routing , scheduling & Sequencing in transportation-Vehicle routing problems.	8	4
5	Role of IT in supply chain- The supply chain IT frame work- Customer Relationship Management – Challenges in implementing supply chain Information systems- Internal supply chain management-ERP – supplier relationship management – future of IT in supply chain – E-Business in supply chain, Security issues in IT	8	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	15
Evaluate	15

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed Original publications (minimum 10 publications shall be referred) : 15 marks

Course based task/Seminar/Data collection and interpretation : 15 marks

Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Text Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Design & Managing the Supply chain Concepts, Strategies & cases	David simichi-levi, Philip kaminsky,	Mc Grawhill companies inc	2000
2	Operations, Logistics& supply chain management	Henk zijm .Matthies Klumpp& Alberto Regattieri. sunderesh	Springer International publisher	2019
3	Strategy, Planning & Operation	Chopra S & Meindl P	Pearson Education	2000

Reference Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Supply chain management process, system & Practice	. N chandresekaran	Oxford University press	2010
2	Supply chain models: Forward. Reverse, uncertain Intelligent	Hamed Fazlollahtabar	CRC press Taylor& Francis group	2017

RESEARCH METHODOLOGY AND IPR

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
24SJ1RGE100	RESEARCH METHODOLOGY AND IPR		2	0	0	2

Preamble:

This course introduces the strategies and methods related to scientific research. The students are also trained in the oral presentation with visual aids and writing technical thesis/reports/research papers. The salient aspects of publication and patenting along with the crucial role of ethics in research is discussed.

Course Outcomes: After the completion of the course the student will be able to

	Course Outcome	Bloom's Knowledge Level (KL)
CO 1	Approach research projects with enthusiasm and creativity.	**K2**
CO 2	Conduct literature survey and define research problem	**K2**
CO 3	Adopt suitable methodologies for solution of the problem	**K2**
CO 4	Deliver well-structured technical presentations and write technical reports.	**K2**
CO 5	Publish/Patent research outcome.	**K2**

CO-PO Mapping:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PSO 1	PSO 2
CO 1	3	2	-	-	-	-	-	2	-
CO 2	3	2	-	-	-	-	-	2	-
CO 3	3	2	-	-	2	-	-	2	-
CO 4	3	3	2	-	-	-	-	2	-
CO 5	3	3	-	-	-	-	3	2	-

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	70 %
Analyse	30 %
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Course based task: 15 marks

Some sample course-based tasks that can be performed by the student given below.

- *Conduct a group discussion based on the good practices in research.*
- *Conduct literature survey on a suitable research topic and prepare a report based on this.*

Seminar: 15 marks Test paper: 10 marks

End Semester Examination Pattern:

Total Marks: 60

The examination will be for 150 minutes and contain two parts; Part A and Part B. Part A will contain 6 short answer questions with 1 question each from modules 1 to 4, and 2 questions from module 5. Each question carries 5 marks. Part B will contain only 1 question based on a research article from the respective discipline and carries 30 marks. The students are to answer the questions based on that research article.

SYLLABUS

No	Topic	No. of Lectures
1	**Introduction**	
1.1	Meaning and significance of research, Skills, habits and attitudes for research, Types of research,	1
1.2	Characteristics of good research, Research process	1
1.3	Motivation for research: Motivational talks on research: "You and Your Research"- Richard Hamming	1
1.4	Thinking skills: Levels and styles of thinking, common-sense and scientific thinking, examples, logical thinking, division into sub-problems, verbalization, awareness of scale.	1
1.5	Creativity: Some definitions, illustrations from day to day life, intelligence versus creativity, creative process, requirements for creativity	1
2	**Literature survey Problem definition**	
2.1	Information gathering – reading, searching and documentation; types of literature. Journal index and impact factor.	1
2.2	Integration of research literature and identification of research gaps	1
2.3	Attributes and sources of research problems; problem formulation, Research question, multiple approaches to a problem	1
2.4	Problem solving strategies – techniques of representation, representation; examples. reformulation Importance or of rephrasing, graphical	1
2.5	Analytical and analogical reasoning, examples; Creative problem solving using Triz, Prescriptions for developing creativity and problem solving.	1
3	**Experimental and modelling skills**	
3.1	Scientific method; role of hypothesis in experiment; units and dimensions; dependent and independent variables; control in experiment	1
3.2	precision and accuracy; need for precision; definition, detection, estimation and reduction of random errors; statistical treatment of data; definition, detection and elimination of systematic errors;	1
3.3	Design of experiments; experimental logic; documentation	1
3.4	Types of models; stages in modelling; curve fitting; the role of approximations; problem representation; logical reasoning; mathematical skills;	1
3.5	Continuum/meso/micro scale simulation; approaches for numerical Two case studies illustrating experimental and modelling skills.	1
4	**Effective communication - oral and written**	

4.1	Examples illustrating the importance of effective communication; stages and dimensions of a communication process.	1
4.2	Oral communication –verbal and non-verbal, casual, formal and informal communication; interactive communication; listening; form, content and delivery; various contexts for speaking-conference, seminar etc.	1
4.3	Guidelines for preparation of good presentation slides.	1
4.4	Written communication - form, content and language; layout, typography and illustrations; nomenclature, reference and citation styles, contexts for writing – paper, thesis, reports etc. Tools for document preparation-LaTeX.	1
4.5	Common errors in typing and documentation	1
5	**Publication and Patents**	
5.1	Relative importance of various forms of publication; Choice of journal and reviewing process, Stages in the realization of a paper.	1
5.2	Research metrics-Journal level, Article level and Author level, Plagiarism and research ethics	1
5.3	Introduction to IPR, Concepts of IPR, Types of IPR	1
5.4	Common rules of IPR practices, Types and Features of IPR Agreement, Trademark	1
5.5	Patents- Concept, Objectives and benefits, features, Patent process – steps and procedures	2

Text Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	How to get a PhD - a handbook for PhD students and their supervisors	E. M. Phillips and D. S. Pugh	Viva books Pvt. Ltd.	2010
2	Practical physics	G. L. Squires	Cambridge University Press	2001
3	Handbook of Science Communication	Antony Wilson, Jane Gregory, Steve Miller	Overseas Press India Pvt Ltd	2005
4	Research Methodology	C. R. Kothari	New Age International	2004
5	Research Methodology	Panneerselvam	Prentice Hall of India	2004

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Practical Research: Planning and Design	Leedy P. D.	McMillan Publishing Co.	1980
2	How to Write and Publish a Scientific Paper	Day R. A.	Cambridge University Press	1989
3	Elements of Style	William Strunk Jr.	Fingerprint Publishing	2020
4	Advice to Young Scientist	Peter Medawar	Alfred P. Sloan Foundation Series	1979
5	Letters to a Young Scientist	E. O. Wilson	Liveright	2014

SEMESTER 1 – LABORATORY

ADVANCED MANUFACTURING LAB

24SJ1LPE002	ADVANCED MANUFACTURING LAB	CATEGORY	L	T	P	CREDIT
		Laboratory Course	0	0	2	1

Preamble:

The objective of this course is to familiarise the students to different design and analysis softwares, and to enable them to write part programmes for CNC machines. They also get hands-on experience with the automation systems using pneumatic controls, part inspection using CMM etc. Thus, the students are familiarised with the modern tools for design, analysis, manufacture and quality control in a production industry.

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Develop 3D models of parts and assemblies using software.	**K3**
CO2	Develop and execute part programs on CNC machines.	**K3**
CO3	Design automation systems using pneumatic controls and equipment.	**K3**
CO4	Perform statistical quality inspection of components using software.	**K3**
CO5	Analyse engineering components for strength and stiffness	**K3**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	2	2	1	2	3	2	1	2	-
CO2	2	2	1	2	3	2	1	2	-
CO3	2	2	2	3	3	1	1	-	2
CO4	3	2	2	2	3	1	1	1	
CO5	2	2	1	2	3	2	1	-	2

SYLLABUS

List of Experiments

1. 3D modelling using CAD software
2. Assembly modelling using CAD software.
3. Study and programming of CNC production machines.
4. Study of fluid control valves and actuators.
5. Design of pneumatic circuits for automation.
6. Study and measurements of components using CMM.
7. Surface roughness measurements using light, stylus, interference methods.
8. Process control using control charts through spread sheet/statistical software.
9. Acceptance sampling decisions using OCC and AOQL generated using statistical software.
10. Determination of process capability indices and sigma level of process
11. Computer aided drafting: 2D
12. Solid modelling: part creation, surface generation and assemblies of parts.
13. Surface modelling.
14. Study of slip gauges, surface plates, straight edges, angle plate, V-block etc.
15. Measurement of out of roundness using roundness-measuring instrument - V block and dial indicator etc.
16. Measurements of straightness using sprit level, auto collimator etc.
17. Measurement of thread parameters using three wire method etc.
18. Measurement of tool angles of single point tool using toolmaker's microscope.
19. Measurement of gear parameters using profile projector.
20. Study and use of ultrasonic flaw detector

Assessment Pattern

- The laboratory courses will be having only Continuous Internal Evaluation and carries 100 marks.
- Final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

Mark distribution

Total Marks	CIE
100	100

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Manual of CNC, CMM, Design and Analysis software	--	--	--
2	CAD CAM principles, practice and manufacturing management	Chris McMahon & Jimmie Browne	Pearson Education	2000

SEMESTER II

SEMESTER II							
SLOT	**COURSE CODE**	**COURSE NAME**	**MARKS**		**L-T-P**	**HOURS**	**CREDIT**
			CIA	**ESE**			
A	24SJ2TPE002	ADVANCED OPTIMIZATION TECHNIQUES	40	60	3-0-0	3	3
B	24SJ2TPE004	MODELING AND ANALYSIS OF MANUFACTURING SYSTEMS	40	60	3-0-0	3	3
C	24SJ2EPEXXX	PROGRAM ELECTIVE 3	40	60	3-0-0	3	3
D	24SJ2EPEXXX	PROGRAM ELECTIVE 4	40	60	3-0-0	3	3
E	24SJ2EPEXXX	INTERDISCIPLINARY ELECTIVE	40	60	3-0-0	3	3
S	24SJ2PPE100	MINI PROJECT	100	--	0-0-4	4	2
T	24SJ2LPE002	COMPUTATIONAL LAB	100	--	0-0-2	2	1
Total			**400**	**300**		**21**	**18**

Teaching Assistance: 6 hours

PROGRAM ELECTIVE 3

SLOT	SL NO	COURSE CODE	COURSE NAME	L-T-P	HOURS	CREDIT
C	1	24SJ2EPE024	MODERN MACHINING PROCESS	3-0-0	3	3
	2	24SJ2EPE025	COMPOSITE MATERIALS AND MANUFACTURING	3-0-0	3	3
	3	24SJ2EPE026	MICRO AND NANO MACHINING	3-0-0	3	3
	4	24SJ2EPE027	CLOUD MANUFACTURING	3-0-0	3	3
	5	24SJ2EPE028	INTEGRATED PRODUCT DEVELOPMENT	3-0-0	3	3
	6	24SJ2EPE029	REVERSE ENGINEERING	3-0-0	3	3

PROGRAM ELECTIVE 4

SLOT	SL NO	COURSE CODE	COURSE NAME	L-T-P	HOURS	CREDIT
D	1	24SJ2EPE030	TOTAL QUALITY MANAGEMENT	3-0-0	3	3
	2	24SJ2EPE031	PRODUCT DESIGN AND DEVELOPMENT	3-0-0	3	3
	3	24SJ2EPE032	SIMULATION OF MANUFACTURING SYSTEMS	3-0-0	3	3
	4	24SJ2EPE033	RELIABILITY ENGINEERING	3-0-0	3	3
	5	24SJ2EPE034	DESIGN OF EXPERIMENTS	3-0-0	3	3
	6	24SJ2EPE035	ADVANCED MAINTENANCE MANAGEMENT	3-0-0	3	3

INTERDISCIPLINARY ELECTIVE

SLOT	SL NO	COURSE CODE	COURSE NAME	L-T-P	HOURS	CREDIT
E	1	24SJ2EPE048	ENTREPRENEURSHIP DEVELOPMENT	3-0-0	3	3
	2	24SJ2EPE049	INDUSTRIAL SAFETY	3-0-0	3	3
	3	24SJ2EPE050	INDUSTRY 4.0	3-0-0	3	3

SEMESTER 2 – DISCIPLINE CORE

ADVANCED OPTIMIZATION TECHNIQUES

24SJ2TPE002	ADVANCED OPTIMIZATION TECHNIQUES	CATEGORY	L	T	P	CREDIT
		DISCIPLINE CORE	3	0	0	3

Preamble:

This course is designed to facilitate the students to acquire knowledge about the fundamental concepts, theories and methods in optimization. Also, to understand how to take optimal decisions using appropriate optimization techniques

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Formulate real world problems into mathematical models and to understand one dimensional search methods	**K3**
CO2	Apply the theory of linear programming and integer programming	**K3**
CO3	Understand the constrained optimization using various techniques	**K2**
CO4	Apply multi-objective methodologies in optimization of real-life problems	**K3**
CO5	Develop algorithms for problem using unconventional optimization methods	**K3**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	1	-	3	3	2	1	-	2	-
CO2	1	-	1	3	2	1	-	-	1
CO3	1	-	1	3	2	1	-	2	-
CO4	1	-	3	3	2	1	-	2	-
CO5	1	-	3	3	2	1	-	-	1

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Introduction to Optimization & Classical Optimization Techniques**. Introduction – Optimization, classification of optimization problems, engineering applications of optimization, concepts of local and global maxima and minima, monotonic and unimodal functions. Non-linear programming – single variable unconstraint optimization: search and elimination methods - exhaustive search method, Fibonacci method and golden section search. Gradient methods – Newton-Raphson method, steepest descent method and bisection method.	6	1
2	**Linear Programming & Integer Programming.** Linear programming – problem formulation, simplex method, concept of duality, dual simplex method. Sensitivity analysis profit coefficients, capacity of resources, shadow price.Integer Programming – formulation of pure, binary and mixed integer programming problems	8	2
3	**Single/Multi variable constraint Optimization** Mathematical statement, equality and inequality constraints, direct substitution (calculus) method. Lagrange multipliers method – Lagrange algorithm, necessary and sufficient conditions for optimality. Problems with equality constraints, handling inequality constraints, Kuhn-Tucker conditions.	8	3
4	**Multi-objective Optimization** Multi-objective optimization - generalized mathematical statement, concept of pareto improvement and pareto optimality. Goal programming – problem formulation, the weighted method. Analytic hierarchy process.	8	4
5	**Non-traditional Optimization Techniques** Introduction to evolutionary and swam intelligence algorithms, Genetic Algorithm - working principles, basic GA logic, GA for constrained optimization, other GA operators, Random mixing – mutation, Elitist strategy. Particle swarm optimization – PSO algorithm, implementation of PSO algorithm - psychosocial compromise, inertial weights and acceleration coefficients. Simulated annealing – basic principle, SA analogy, SA algorithm, metropolis criterion.	10	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	20
Evaluate	10
Create	10

Continuous Internal Evaluation Marks (CIE):

Continuous Internal Evaluation Pattern: 40 Marks

Micro project/Course based project : 20 marks
Course based task/Seminar/Quiz : 10 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern: 60 Marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Text Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Optimization: Theory and Applications	Rao, S.S	Second edition, Wiley eastern.	2nd edition 1994
2	Operation Research	Gupta, P. K., and Hira, D.S	S Chand	6th edition 2007

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Non-linear Programming for Operations Research	Simmons, D.M., Ravindran, A	Prentice-Hall, New Jersey	1975
2	Operations Research: Principles and Practice	Ravindran, A., Philips, D.T., and Solberg, J. J	John Wiley & Sons	2nd edition 1987
3	Engineering Optimization: Methods and applications	Reklatis, G.V., Ravindran, A., and Ragsdell, K.M.	Wiley Interscience, New York	1987

SEMESTER 2 – PROGRAMME CORE

MODELLING AND ANALYSIS OF MANUFACTURING SYSTEMS

24SJ2TPE004	MODELLING AND ANALYSIS OF MANUFACTURING SYSTEMS	CATEGORY	L	T	P	CREDIT
		Programme Core	3	0	0	3

Preamble:

Basics of manufacturing engineering.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand Manufacturing Systems and Models.	**K2**
CO2	Build models in Processes Planning and operations.	**K3**
CO3	Design Factory layout.	**K3**
CO4	Model Ware Housing including Storage and Retrieval Systems.	**K3**
CO5	Model the Material Handling devices and its operations in manufacturing.	**K3**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	2	-	-	-	-	-	-	-	2
CO2	2	-	-	-	-	-	-	2	-
CO3	2	-	-	-	-	-	-	2	-
CO4	-	2	-	-	-	-	-	-	2
CO5	-	-	2	-	-	-	-	-	2

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Manufacturing Systems and Models** Introduction to manufacturing models – manufacturing activities and information flow- types of manufacturing system - principles of manufacturing system - nine laws for manufacturing model building - types and uses of manufacturing models – physical models, mathematical models - model uses - model building sequence – examples.	8	1
2	**Processes Planning and system design.** Process planning - Process Design – key problems – work flow – selection of work stations - Operation Design – problems – tools for human factor analysis - productive operations - Operation Sheets - Standard Time - Division of Labour and Job Design - Learning Effect – Learning Curves - Production progress Function**.**	8	2
3	**Factory layout planning and design.** Factory Layout planning – scopes and problems - Principles & Objectives of good Layout - Types of Layout - Pattern of plant layout – plant layout design- Major considerations - Layout Procedure – systematic layout planning – procedures and steps– activity relationship diagram. Case studies - design of layout of factories –machinery operation area – factory office - storage area - equipment for amenities of working people – layout design with software	8	3
4	**Logistic Planning and Warehouse Design.** Storage and Retrieval Systems – building shell – storage medium – storage and retrieval transport system - warehouse design, stacking pattern, location in ware houses– dedicated storage, open storage, class base storage, storing complementary items-Order picking – forming pick list, pick sequencing	8	4
5	**Material Handling and AGV Systems** Introduction- material flow in layout - basic equipment types - principles of material handling – Equipment selection - conveyor analysis - closed loop conveyor- AGVsystems – Design and operation of AGV, vehicle requirements analysis- pallet sizing and loading – Softwares for material handling system.	8	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	10
Evaluate	10
Create	20

Continuous Internal Evaluation: 40 marks

Micro project/Course based project : 20 marks
Course based task/Seminar/Quiz : 10 marks
Test paper, 1 no. : 10 marks
The project shall be done individually. Group projects not permitted.
Test paper shall include minimum 80% of the syllabus**.**

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A contain 5 numerical questions (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students), with 1 question from each module, having 5 marks for each question. Students shall answer all questions. Part B contains 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student shall answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Text Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Modeling and analysis of manufacturing systems	Ronald G. Askin and Charles R. Standridge	John Wiley & Sons, Inc	2000
2	Manufacturing Systems Engineering - A unified approach to manufacturing technology, production management, and industrial economics	Katsundo Hitomi	Taylor & Francis Ltd, London	1996

Reference Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Automation, Production Systems and Computer Integrated Manufacturing	Groover M.P	Prentice-Hall of India Pvt. Ltd., New Delhi	1996
2	Handbook of Flexible Manufacturing Systems	Jha, N.K	Academic Press Inc	1991
3	Manufacturing Engineering and Technology	Kalpakjian	Addison-Wesley Publishing Co.,	1995

SEMESTER 2 – PROGRAMME ELECTIVE 3

MODERN MACHINING PROCESSES

24SJ2EPE024	MODERN MACHINING PROCESSES	CATEGORY	L	T	P	CREDIT
		Programme Elective 3	3	0	0	3

Preamble:

The student will understand the advanced machining operations and its applications. Students will be introduced to the importance of precision engineering and its applications.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the fundamental concepts of micromachining and laser machining	K2
CO2	Develop the working models of mechanical micro machining process.	K3
CO3	Understand the application and concepts of nano machining.	K2
CO4	Impart the knowledge of advanced finishing processes	K3
CO5	Understand the concepts of modern machining processes with its applications.	K2

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	2	1	1	-	-	-	2	-	2
CO2	2	1	1	-	-	-	2	2	-
CO3	2	-	1	-	-	-	2	-	2
CO4	2	-	1	1	-	1	2	-	2
CO5	2	1	1	1	1	1	2	1	2

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Laser beam machining** Introduction to advanced machining processes, classification ofnon-conventional machining process, physical parameters of the processes and work materials. Laser beam machining: Integration of laser system for cutting operation - principles of laser material removal – detailed discussion on process analysis, Thermal dynamic instability, hydrodynamic instability -characteristics of cut front, temperature at cut front, heat-affected zone - characteristics of cut surface, striation**.**	**8**	**1**
2	**Mechanical micromachining** Mechanical micromachining: theory of micromachining; micromilling force analysis Initial chip curl modeling, burr formation in micromachining. Micromachining tool design - high speed air turbine spindles-Mechanical design of high-speed rotors, basic geometry of the rotor, rotor with fillet surfaces**.**	**8**	**2**
3	**Nano machining** Nano machining: Introduction, nanometric machining, Theoretical basis of nanomachining, Comparison of nanometric, machining and conventional machining- implementation, Single point diamond turning	**8**	**3**
4	**Advanced finishing processes** Advanced finishing processes (AFPs), abrasive flow machining, (AFM),Magnetic abrasive finishing (MAF), Magnetorheological finishing (MRF), Magnetorheological abrasive flow finishing(MRAFF), magnetic float polishing (MFP),Elastic emission machining (EEM), ion beam machining (IBM),and chemical mechanical polishing (CMP).	**8**	**4**
5	**Modified conventional machining** Modified conventional machining, hot machining, Principle of restricted contact cutting, high production cutting tools for turning and drilling deep hole drilling SPDT, Micro-manufacturing for document security: Optically variable device - OVD foil microstructures- generic OVD Microstructures Nano codes, applications	**8**	**5**

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	10
Evaluate	10
Create	10

Continuous Internal Evaluation Marks (CIE):

ELECTIVE COURSES

Evaluation shall only be based on application, analysis or design-based questions (for both internal and end semester examinations).

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed Original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation: 15marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Text Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Advanced analysis of non-traditional machining	Hong Hocheng and Hung-Yin Tsai	Springer	2012
2	Micromanufacturing and nanotechnology	Nitaigour Premchand Mahalik	Springer	2006

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Nontraditional machining processes	Paulo Davim J	Springer-Verlag	London, 2013
2	Micromachining of engineering materials mechanical engineering	Joseph McGeough	CRC Press	2001
3	Micromachining techniques for fabrication of micro, nano structures	M. Kahrizi	In Tech	2012
4	Micro and nanomanufacturing	Mark J. Jackson	Springer	2007

COMPOSITE MATERIALS AND MANUFACTURING

24SJ2EPE025	**COMPOSITE MATERIALS AND MANUFACTURING**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**
		Programme Elective 3	3	0	0	3

Preamble:

This course provides a detailed understanding of various composite materials and their manufacturing methods. The objective of this course is to making the learner capable of selecting suitable composite material and its fabrication method based on application and to understand the failure criterion.

Course Outcomes (COs)

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

	Course Outcomes	Bloom's Knowledge Level (KL)
CO1	Identify different fiber materials their fabrication and applications	**K2**
CO2	Understand different matrix materials their structure and bonding	**K2**
CO3	Choose suitable fabrication methods of composite based on application	**K2**
CO4	Choose different fabrication methods of PMC based on application	**K2**
CO5	Determine the effect of stress strain on failure of composite materials.	**K3**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	1	-	3	3	3	1	-	-	2
CO2	1	-	3	2	1	-	-	-	2
CO3	2	-	3	3	3	1	-	2	-
CO4	2	-	3	3	1	1	-	2	-
CO5	2	-	3	2	2	-	-	-	1

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Introduction: composite materials** Fibers: Introduction – glass fibers: fabrication, structure, properties and applications. Boron fibers: fabrication, structure, morphology, properties and application. Carbon fibers: different preparation methods, structural change during preparation, properties and application Aramid fibers: fabrication, structure, properties and applications. Ceramic fibers: alumina and silicon carbide fibers. Metallic fibers.	6	1
2	**Matrix materials** Polymers and its characteristics – metals: fiber reinforcement of metals. Ceramic matrix materials: bonding and structure, effect of flaws on strength and common ceramic matrix materials.Interfaces: Wettability and bonding interface in composites – Types of bonding at interface –Tests for interfacial strength.	5	2
3	**Metal matrix composites (MMC) and Ceramic matrix composites (CMC)** Different fabrication methods of CMC, interface in CMC – detailed discussion on properties toughness of CMC – applications, Different fabrication methods of MMC.interface in MMC– discontinues reinforcement of MMC. Detailed discussion on mechanical properties – Applications.	11	3
4	**Polymer matrix composites (PMC)** Different fabrication methods of PMC, interface in PMC – detailed discussion on properties –of PMC - applications. Carbon fiber composites: Fabrication – properties– interface.	9	4
5	**Micromechanics of composites** Maximum stress and strain criterion, Tsai-Hill and Tsai-Wu failure criterion (derivations),Mechanics of load transfer from matrix to fiber (description only).	9	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	35
Analyse	15
Evaluate	10

Continuous Internal Evaluation Marks (CIE):

ELECTIVE COURSES

Evaluation shall only be based on application, analysis or design-based questions (for both internal and end semester examinations).

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed Original publications (minimum 10publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Text Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Composite materials	Chawla Krishana K	Springer Verlag	1987

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Mechanics of composite materials	Autar K. Kaw	CRC Press	1999

MICRO AND NANO MACHINING

24SJ2EPE026	**MICRO AND NANO MACHINING**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**
		Programme Elective 3	3	0	0	3

Preamble:

With the advancement of technology, miniaturization of equipment is increasing. Material and hence equipment behaviour at such a small scale is different. New technologies are required to manufacture at such a small scale. The course intends to introduce technologies used for manufacturing of products at micro and Nano scale.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Develop a thorough knowledge on various microfabrication techniques and apply the same on industrial problems	**K3**
CO2	Select suitable manufacturing process suited to specific applications	**K2**
CO3	Impart knowledge on nano fabrication processes	**K3**
CO4	Impart knowledge to nano materials and get awareness of different applications of micro and nano technology	**K3**
CO5	Provide knowledge on metrological aspects of micro and nano manufacturing.	**K3**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	2	1	1	1	-	1	-	-	2
CO2	2	1	1	1	-	1	-	2	-
CO3	2	1	-	-	-	1	-	-	2
CO4	2	1	-	-	-	1	-	-	2
CO5	2	1	-	-	-	1	-	1	-

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Introduction to Micro fabrication Techniques**. **Introduction**: Meso, micro and nano machining-Definition of micro-machining and nano-machining -Nanotechnology –Requirements of micro-machining systems – Scale down approach and bottom-up approach for micro machining. **Micro fabrication Techniques:** Micro-fabrication of MEMS and semiconductor devices; basics of micro-fabrication, integrated circuit fabrication- Crystallography and its effects, silicon as substrate and structural material, stress and strain, - crystal plane effects on etching, micro-fabrication of MEMS and semiconductor devices; basics of micro-fabrication **Etching:** Characterizing etching processes in bulk micromachining. wet etching process, reaction phenomena, anisotropic etching, isotropic etch curves, masking for anisotropic etchants, etching control, fusion bonding of silicon on an insulator, deep reactive ion etching, fabrication of a cantilever probe, manufacture, microprocessors and applications, problems with etching in bulk micromachining.	5	1
2	**MEMS Fabrication** Processing of MEMS/NEMS and Microsystems Silicon processing, Structure & properties – Single crystal growth - Overview of Lithographic process – Additive processes for Semiconductors, Ceramics, Metals, and polymers MEMS Fabrication – Doping process - Bulk micromachining - Wet & Dry Etching- Isotropic and anisotropic etching and mechanism - Etch stop techniques – DRIE and other processes Mechanics and Materials. Overview of MEMS and Microsystems – Thin film growth and models –Mechanical, Electrical, Thermal properties for Thin Films/MEMS – Measurement techniques – Materials for MEMS- Semiconductors, Metals and Metal alloys, Ceramics, Polymers – Silicon and other substrate materials. Surface Micromachining – LIGA and laser assisted processing – Classification – Optical principles, Fresnel and Fraunhofer diffraction – Exposure methods –contact, proximity, and projection printing – Mask Fabrication– Photoresist – positive and negative – properties of photoresist. Characterizing the surface micromachining process, isolation layer, sacrificial layer, structural material, selective etching – properties, stress, stress measurement, friction; wafer bonding: anodic and fusion, bonding.	8	2

3	**Overview of Lithographic process** Lithography – Near field optical microscopy – Interference optical lithography – Maskless optical lithography– Resolution Enhancement Techniques– Vacuum techniques – Oxidation – Diffusion- Metallization - Doping techniques – ion implantation Limitations of Optical Lithography – Lasers for Lithography Electron (E) - Beam Lithography: Electron Optics – Process, E beam sources, Raster and Vector scan – Proximity/Projection printing - SCALPEL – Direct writing – Interaction of electron with substrate – Electron Beam resist – E beam applications. X-ray Lithography: Principle, X-ray sources, system, and components – resists, mask preparation, resolution enhancement. Ion Beam Lithography: Focused Ion Beam – Process, Ion Source, Ion Column – Masked Ion Beam Lithography and Ion Projection Lithography Lithography: Principle of the soft lithography and applications; principle of micro contact printing and applications. Non lithographic patterning Template based fabrication –Nano stencil, Nanoimprint and Nanosphere Lithography in device fabrication– Soft Lithography, Microcontact Printing – Inkjet and Screen Printing – 3D printing Stereolithography - Principle and methods of Nanowire Formation - Assembly, Integration - Additive and subtractive techniques of nano fabrication – Anodic Oxidation, Dip Pen Lithography	**9**	**3**
4	**Mechanics and Materials** Micro and nanotechnology: Applications for space micro propulsion - subsystems and devices for miniaturised spacecrafts-micro propulsion: microbolometer, micro FEEP, integrated cold gas Micro thruster, microturbogas, pyrotechnic actuator and microvalve etc - propulsion systems: solid propellant, ADCS etc. Nano mechanic actuator and artificial muscles, fuel cells, membrane electrode assembly, mechanical and electrical reinforcement of bipolar plates, hydrogen storage etc. Carbon nanotube production and applications: Basis of nanotechnology - structure and properties of carbon nanotubes- production of carbon nanotube: chemical vapour deposition, arc discharge, laser ablation, mechanisms of growth, purification of carbon nanotube – applications: electrical transport of carbon nanotubes for FET, Computers, nanodevices for biomedical, X- ray equipment Carbon based nanostructures: - Structure of carbon nanotubes, Y-shaped, double helical, bamboo, hierarchical morphology - structure of fullerenes - structure of carbon nano balls- structure of carbon nano fibres - porous carbon - properties of carbon nanostructures – synthesis – potential applications of nanostructures - composite materials - nanotechnology for fuel. cell applications: nanoparticles in heterogeneous catalysis, O2 electro reduction reaction on carbon- supported Pt catalysts, carbon nanotubes as catalyst supports.	**7**	**4**

5	**Micro and Nano Measurement** Metrology Critical dimension (CD) – optical line width, defects, thickness, and reflectance tools – ellipsometry – reflectometry –scatterometry – photoacoustic metrology –ElectricaL Measurement Nanostructured materials Characterization Techniques X-ray diffraction (XRD), SEM, EDAX, TEM, Elemental mapping, FTIR, UV-Visible spectrophotometer Nanomechanical Characterization using Nanoindentation, Differential Scanning Calorimeter (DSC), Differential Thermal Analyzer (DTA), Thermogravimetric Analysis (TGA), TEM, AFM X-ray Photoelectron Spectroscopy (XPS), Electrochemical Characterization measurements.	**8**	**5**

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	10
Evaluate	10
Create	10

Continuous Internal Evaluation Pattern:

ELECTIVE COURSES

Evaluation shall only be based on application, analysis or design-based questions (For both internal and end semester examinations).

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Text Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Jackson Nano and Micromachining	J. Paulo Davim, Mark J. Jackson	John Wiley & Sons	2013
2	Micro and Nano-manufacturing	Mark. J. Jackson	Springer	2006
3	Micro-fabrication, and Nano-manufacturing - Pulsed water drop micromachining	Mark. J. Jackson	CRC Press	2006

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Micro-manufacturing, and Nanotechnology	Nitaigour Premchand Mahalik	Springer	2006
2	Micro-manufacturing Processes	V.K. Jain	CRC Press	2012
3	Micro-manufacturing Engineering and Technology	Yi Qin	Elsevier	2015
4	Micro and Precision Manufacturing	Kapil Gupta	Springer	2017
5	Introduction to Nano science and Nanotechnology	Gabor L H, Tibbals H F, Dutta J and Moore J	CRC Press	2008
6	Micro & nano technologies	Ramsden J	Elsevier	2011
7	Micromachining techniques for fabrication of micro, nano structures	Kahrizi M	In Tech	2012

CLOUD MANUFACTURING

		CATEGORY	L	T	P	CREDIT
24SJ2EPE027	CLOUD MANUFACTURING	Programme Elective 3	3	0	0	3

Preamble:

Basic concepts of product design and integrated product development

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the concept of cloud based distributed environment for collaborative manufacturing.	K2
CO2	Develop cloud community for small and medium industries	
CO3	Carry out vendor selection and supply chain management in cloud environment	K3
CO4	To apply the cloud concepts in a sustainable and global product development	K2
CO5	To understand the concept of visualization and information sharing in collaborative cloud-based systems	K3

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	3	2	3	3	2	2	1	2	-
CO2	3	3	3	3	3	3	2	-	-
CO3	2	3	2	2	2	3	2	2	-
CO4	3	3	3	3	3	2	2	-	2
CO5	2	3	2	3	2	2	1	2	-

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	Cloud based manufacturing systems- Introduction to cloud computing – definition. Architecture of cloud manufacturing- resouce requirements – service-oriented manufacturing environment – IaaS, SaaS, PaaS. Interoperability of systems, cloud-based systems and inter-operability – virtual service layer.	8	1
2	Distributed service – definition – application of manufacturing, assembly processes and management of products for recycling of e-waste. Customizable decision-making model. Development of cloud community for small and medium industries - Integrating OEMs and suppliers, out sourcing machining process.	8	2
3	Cloud based manufacturing of parts, Vendor selection and supply chain management in cloud environment. Factors affecting cloud technology adoption and implementation – Benefits of cloud. Barriers and approaches of cloud adoption, various perspectives of users, developers and market teams. Data as a service, Business process as a service.	8	3
4	Sustainable manufacturing system, product design, manufacturing. Needs of sustainability - adaptation of sustainability factors in product development- manufacturing requirement, strategy, domain for production paradigm. Re-use, Recycle, Re-manufacture for sustainability- Lifecycle sustainable information management.	8	4
5	Cloud based integrated systems for design and manufacturing – collaborative cloud based systems Visualization information sharing – Designing by service for collaborative product development.Real time work in progress management- modeling for operational information exchange network.	8	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	10
Evaluate	10
Create	10

Continuous Internal Evaluation Pattern:

ELECTIVE COURSES

Evaluation shall only be based on application, analysis or design-based questions (for both internal and end semester examinations).

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed Original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts;Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Text Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Cloud Manufacturing: Distributed computing technologies for global and sustainable manufacturing	Weidong Li, Jorn Mehnen, Eds	Springer, New York	2013
2	Product Lifecycle Management - 21st Century Paradigm for Product Realization	Stark J.	Springer-	2005

Reference Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Cloud-Based Design and Manufacturing (CBDM) A Service-Oriented Product Development Paradigm for the 21st Century	Dirk Schaefer, Eds	Springer	2014
2	Frontiers of Manufacturing Science and Measuring Technology II, Part 1	W. Sung, J.C. Kao, R. Chen	Trans Tech. Kreuzstrasse	2012

INTEGRATED PRODUCT DEVELOPMENT

24SJ2EPE028	**INTEGRATED PRODUCT DEVELOPMENT**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**
		Program Elective 3	3	0	0	3

Preamble:

Integrated product development is the prevailing product innovation approach for the concurrent development of new products and processes using a cross functional teams that enables collaboration and coordination between all the participants and is strategically aligned to the needs of customers and stakeholders. Manufacturers are increasing shifting from the product sellers' role to service providers' role leading to design of product service system. This subject deals with the fundamental aspects of developing integrated systems for managing the lifecycle of products

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the needs of product innovation and new product development	**K2**
CO2	Develop Product data framework for simple product cases.	**K3**
CO3	Suggest integration framework for products in lifecycle perspectives	**K2**
CO4	Design Product service system for products	**K3**
CO5	Understand cyber physical systems for manufacturing and process planning	**K2**

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

CO-PO Mapping:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PSO 1**	**PSO 2**
CO1	1	2	2	2	3	-	-	-	2
CO2	1	2	2	3	2	-	-	2	-
CO3	-	2	-	3	-	-	-	-	2
CO4	1	1	-	2	-	-	-	2	-
CO5	1	2	-	-	3	-	-	-	2

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Product Innovation and New Product Development** Introduction to Product innovation and New product development ,Integrated Product development-Definition, framework, New product strategy formulation, Value proposition, Team development for NPD	8	1
2	**Product data Management** Product data management – Definition, function, benefits, architecture of PDM, Design data, manufacturing data, operational data, Product structure, UML notations, Engineering change management, Product configuration management, Document management, workflow, Development of product data integration framework for products	9	2
3	**Product lifecycle management** Definition of Product lifecycle management, benefits, internet standards – xml, STEP,ISO 10303, Integration with ERP, CRM, Product information management, systems integration, Interoperability of systems , PLM grid, Key performance indicators in PLM environment Develop a framework for lifecycle management of Products	9	3
4	**Product Service integration** Introduction to Product service systems, Layer method- Industrial application. Product service systems – characteristics, benefits, steps towards integrated product service, lifecycle perspectives Manufacturing, Delivery, Usage, Maintenance, Recycling and re-manufacturing Service delivery, Managing service delivery Industrial case studies	8	4
5	**Cloud based Integration** Introduction to cloud computing, Definition, infrastructure of the cloud manufacturing, Relationship between cloud computing and cloud manufacturing, Characteristics of cloud manufacturing, Advantages of cloud manufacturing- Advancements in IOT application, Cloud based cyber physical systems in manufacturing, IoT enabled manufacturing systems, cloud-based monitoring, planning and control Cloud based distributed process planning	8	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	15
Evaluate	15

Continuous Internal Evaluation Pattern:

(ii) ELECTIVE COURSES

Evaluation shall only be based on application, analysis or design-based questions (for both internal and end semester examinations).

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed Original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Text Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Product Innovation : Leading change through Integrated product development'	David Rainey	Cambridge University PRess	2005
2	Implementing and Integrating Product Data Management and Software	Ivica crnKovic, etal	Artech house London	2003

Reference Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Product Lifecycle management (Volume 3), The executive summary	John Stark	Springer	2017
2	Introduction to product service system design	Tomohiko sakavo etal	springer	2014
3	Designing and managing Industrial Product service systems	Petri halo	Springer	2016
4	Cloud based cyber physical systems in manufacturing	Li hui wang, et al	Springer	2017

REVERSE ENGINEERING

24SJ2EPE029	**REVERSE ENGINEERING**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**
		Programme Elective 3	3	0	0	3

Preamble:

This course introduces the student to the Fundamentals of Reverse Engineering, techniques of scanning physical parts using digital imaging and computer vision, strategy for converting scanned data into 3-D surface or solid model, selection of Reverse Engineering System, Rapid Prototyping and application of Reverse Engineering in industry.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the terminologies and different phases of Reverse Engineering.	**K2**
CO2	Understand Reverse Engineering methodologies and techniques.	**K2**
CO3	Understand the hardware and software in Reverse Engineering.	**K2**
CO4	Apply the techniques of rapid prototyping and rapid tooling	**K3**
CO5	Apply the techniques of Reverse Engineering to Industrial Problems	**K3**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	1	1	1	-	-	1	-	-	2
CO2	1	1	1	-	-	1	-	-	2
CO3	1	1	1	-	-	-	-	1	-
CO4	-	-	-	1	1	1	-	1	-
CO5	-	-	-	1	1	1	1	-	1

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Introduction to Reverse Engineering.** Definition and use, The generic process of Reverse Engineering. Different Phases of RE: Scanning – Contact and Non- Contact, Point Processing, Application Geometric Model Development	6	1
2	**Methodologies and Techniques for Reverse Engineering** Computer Aided Reverse Engineering, Computer Vision: Coordinate Measuring Machine, Active Illumination 3D Stereo. Benefits and Drawbacks. Structured Light Range Imaging: Source Illumination Categories, Sheet-of-light Range Imaging, Scanner Pipeline: Data Collection, Mesh Reconstruction, Surface Fitting.	9	2
3	**Hardwares and Softwares in Reverse Engineering.** Introduction, RE hardware: Contact, Noncontact and Destructive methods, RE software: Software classification, RE phases, Fundamental RE operations. Selection of RE System: The selection process, team formation, vendor and system information gathering, short listing and assessment, bench marking, commercial evaluation. Point capture devices, triangulation approaches, ranging systems, Structured light and stereoscopic imaging system Tracking and internal measurement systems	8	3
4	**Rapid Prototyping:** The basic process, techniques such as stereolithography, selective laser sintering, Fused deposition modelling, 3D. printing, Applications: Rapid tooling and Rapid manufacturing. Relation between rapid prototyping and reverse engineering, Modelling cloud data, layer-based model generation. Adaptive slicing approach, planar polygon curve construction, determination of adaptive layer thickness, examples	8	4
5	**Reverse Engineering in Industry:** Automotive industry: application of RE in Workflow for automotive body design, advantages, examples from automotive industry. Aerospace industry: introduction, reduction in hard tooling cost and inspection times, examples from aerospace industry. Medical device industry: application in orthodontics- digital dentistry, hearing instruments, knee replacement and artificial hearts	9	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	15
Evaluate	15

Continuous Internal Evaluation Marks (CIE):

Continuous Internal Evaluation Pattern:

(ii) ELECTIVE COURSES

Evaluation shall only be based on application, analysis or design-based questions (for both internal and end semester examinations).

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed Original publications (minimum10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Text Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	. Reverse Engineering	Wills, Linda M., Newcomb, Philip (Eds.),	Springer	1996
2	Reversing: Secret of Reverse Engineering	Eldad Eilam,Wiley	Publishing, Inc.	2005

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Reverse Engineering: An Industrial Perspective	Raja and Fernandes	Springer-Verlag	2008
2	Reverse Engineering	Katheryn, A. Ingle	McGraw-Hill	1994

SEMESTER 2 – PROGRAMME ELECTIVE 4

TOTAL QUALITY MANAGEMENT

24SJ2EPE030	**TOTAL QUALITY MANAGEMENT**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**
		Program Elective 4	3	0	0	3

Preamble:

Managing quality within organisations has evolved from a state of meagre inspection, to a philosophy of managing the whole by the contemporary TQM approaches to achieve excellence. TQM is both a philosophy and a set of guiding principles that represent the foundation of a continuously improving organization. In this way, TQM has become an integral component of manufacturing systems management. This course aims to provide the essential knowledge in the area of TQM.

Prerequisites

Courses in UG/PG level related to Manufacturing Systems, Operations Management, Statistics, Design Engineering & Quality Control.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the role of TQM leaders and the significance of continuous improvement in organisations	**K2**
CO2	Apply customer satisfaction monitoring approaches, involving employees and partnering suppliers in TQM	**K3**
CO3	Apply statistical process control, analyse process capability and the six-sigma approach of continuous improvement.	**K3**
CO4	Apply the approaches of quality function deployment, quality by design and FMEA in TQM	**K3**
CO5	Apply Quality Management Systems, Environment Management Systems and performance measures through excellence models	**K3**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	1	-	3	-	-	2	-	2	-
CO2	2	-	3	-	-	2	-	-	1
CO3	3	1	3	3	2	2	-	1	-
CO4	3	1	3	3	2	2	-	1	-
CO5	2	1	3	3	2	2	2	-	1

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Introduction, TQM Leadership and Continuous Improvement** Basic approach, TQM framework, basic approach, obstacles and benefits Leadership concepts, Deming philosophy, Role of TQM leaders, quality statements, strategic planning Juran Trilogy, Plan Do Study Act Cycle, Kaizen, Reengineering	8	1
2	**Customer satisfaction monitoring, involving employees and partnering with suppliers** Customer perception of quality, feedback, mass customisation, customer complaints, customer retention, Motivation theories, empowerment, teams, recognition and reward, performance appraisal Principles of supplier relations, supplier selection and certification, relationship development.	8	2
3	**Statistical Process Control, Process capability and Six Sigma Approach.** Variation, Probability distribution, Process capability and indices, Measurement system analysis, Key six sigma concepts, six sigma quality level and shifts, DPMO, Six sigma strategy, lean six sigma Implementing Six sigma, DMAIC approach, Cost of quality and six sigma.	8	3
4	**Quality function deployment, Quality by design and FMEA** Benefit and need of QFD, Voice of customer, House of quality, Building the house of quality, Design for Six Sigma, Communication models, implementation, QFD Tools, Reliability and intent of FMEA, FMEA Team, FMEA Documentation, Design and process FMEA	8	4
5	**Quality Management Systems, Environment Management Systems and TQM Excellence Models** ISO 9001 QMS Standards, Principles, Requirements, Implementation, Documentation, Audits, Environmental and occupational health and safety management system, ISO 14001 and OHSAS 18001,TQM Excellence models - Criteria and evaluation, MBNQA, Deming Prize, CII-EXIM, RGNQA, RBNQA, CMMI	8	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	15
Evaluate	15

Continuous Internal Evaluation Pattern:

(ii) ELECTIVE COURSES

Evaluation shall only be based on application, analysis or design-based questions (for both internal and end semester examinations).

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed Original publications (minimum 10publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks

Text Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Total Quality Management (TQM) Principles, Methods, and Applications	Sunil Luthra, Dixit Garg, Ashish Agarwal, and Sachin K. Mangla	CRC Press , Taylor & Francis Group, LLC	1st edition 2021
2	Total Quality Management and Operational Excellence Text with cases	John S. Oakland	Routledge, Taylor & Francis Group	4th edition 2014

Reference Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Total Quality Management	Dale H. Besterfield, Carol Besterfield-Michna, Glen H. Besterfield, Mary Besterfield-Sacre, Hemant Urdhwareshe, Rashmi Urdhwareshe	Pearson India Education Services Pvt. Ltd	5th edition 2019
2	Total Quality Management	Poornima M. Charantimath	, Pearson India Education Services Pvt. Ltd	3rd edition 2017

PRODUCT DESIGN AND DEVELOPMENT

		CATEGORY	L	T	P	CREDIT
24SJ2EPE031	PRODUCT DESIGN AND DEVELOPMENT	Programme Elective 4	3	0	0	3

Preamble:

This course enables the students to conceive, develop and demonstrate concepts and ideas into marketable physical products, blending the perspectives of Marketing, Design and Manufacturing into a single approach to product development.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Assimilate and prioritise the needs of customers, for a new engineering product.	K2
CO2	Optimize the concept and architecture of a new product, for maximum economic advantage.	K3
CO3	Apply DFM and DFA considerations for new products.	K3
CO4	Enhance the ergonomic and aesthetic values of new product designs.	K3
CO5	Estimate and reduce the environmental impact of manufactured products.	K3

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	3	2	3	2	3	1	1	1	-
CO2	2	2	2	1	2	2	1	2	-
CO3	2	2	1	1	2	3	1	-	2
CO4	2	2	1	1	2	3	1	-	2
CO5	2	3	1	1	2	3	1	-	1

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Introduction to Products and Product Development** Types of products, Structured methods to product development, Design morphology, Development teams Product Planning; Customer need identification, Product specifications, Design attributes, Need-Metric matrices, House of Quality, Successful product development, 'S' curve, Customer satisfaction, KANO diagram	8	1
2	**Concept Generation and Product Architecture** Product concept – stages in concept development process, Concept screening and Selection, Value engineering, Introduction to Robust design	9	2
3	**Design for 'X'** DFM, DFA and DFMA, Primary and secondary manufacturing processes, Process constraints. Design for Quality, Reliability, Strength, Maintainability, Recyclability, Robust design	9	3
4	**Industrial Engineering and Ergonomics** Human & Machine system – Manual, Mechanical, Automated systems, Input/ Output systems, Anthropometric data and applications Ergonomics-Psychological and Physiological considerations. Aesthetics in product design, Concepts of size, texture and colour. Prototyping: Principles of prototyping, Rapid prototyping, Development of RP systems. Three Dimensional Printing- Selective Laser Sintering, Direct Metal Laser Sintering, Selective Laser Melting, Electron Beam Melting, Virtual prototyping.	11	4
5	**Design for Environment** Design guidelines, Life-cycle assessment, Global initiatives-Kyoto protocol, Paris convention, IPR and Patent Disclosure	9	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	40
Analyse	10
Evaluate	10

Continuous Internal Evaluation Pattern:

(ii) ELECTIVE COURSES

Evaluation shall only be based on application, analysis or design-based questions (for both internal and end semester examinations).

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed Original publications (minimum 10publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks

Text Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Designing for manufacture	Harry Peck	Pitman Publications	1983
2	Product design and manufacturing	C. Chitale and R. C. Gupta	PHI	2004
3	Product design for manufacture and assembly	Geoffery Boothroyd, Peter Dewhurst and Winston Knight	CRC Press Inc	2010

Reference Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Product design and development	Karl. T. Ulrich, Steven D. Eppinger	McGraw Hill	2000
2	Product design	. Kevien Otto and Kristin Wood	Pearson Publication	2004
3	Engineering design - a materials and processing approach	Dieter, George E	McGraw Hill, Singapore,	2000

SIMULATION OF MANUFACTURING SYSTEMS

24SJ2EPE032	**SIMULATION OF MANUFACTURING SYSTEMS**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**
		Programme Elective 4	3	0	0	3

Preamble:

The course gives an introduction to different aspects of simulation modelling and subsequent analysis of manufacturing systems and supply chains

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the basic concepts in system modelling and simulation.	**K2**
CO2	Perform the generation of random numbers and random variate.	**K3**
CO3	Perform analysis of simulation data.	**K3**
CO4	Conduct simulation modelling and analysis of manufacturing systems	**K3**
CO5	Conduct the simulation of supply chains through system dynamics approach.	**K3**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	3	-	3	-	3	3	-	-	2
CO2	3	-	3	-	3	3	-	-	1
CO3	3	-	3	-	3	3	-	1	-
CO4	3	-	3	-	3	3	-	1	-
CO5	3	-	3	-	3	3	-	1	-

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Basic Concepts in System Modelling and Simulation System Concept**: Systems and system environment, Components of a system, Discrete and continuous systems, Systems approach to problem solving, Types of system study, System analysis, system design and system postulation, System modelling, Types of models. System Simulation: Technique of simulation, Comparison of simulation and analytical methods, Types of system simulation, Steps in simulation study, Monte Carlo simulation. Concepts in Discrete Event Simulation: Event scheduling/ Time advance algorithm, Modelling world views, Simulation programming tasks, Comparison and selection of simulation languages	8	1
2	**Generation of Random numbers and random variates Random Number Generation:** Techniques for generating random numbers, Linear congruential method, Test for random numbers, Frequency tests, run tests, tests for autocorrelation, gap test, and Poker test. Random Variate Generation: Inverse transformation technique, Exponential, Uniform, Weibull, Triangular, Empirical-Discrete and continuous distributions. Convolution method, Acceptance- Rejection technique	6	2
3	**Analysis of simulation data** Input Modelling for Simulation: Data collection, Identifying the distribution with data, Parameter estimation, Goodness of fit test, Chi square, Kolmogrov and Smirnov tests, Selecting input model when data are not available. Verification and Validation of Simulation Models: Verification of simulation models, Calibration and validation of models, Face validity, Validation of model assumption, validating input-output transformation, Input-output validation using historical input data. Output Analysis for a Single Model: Measures of performance and their estimation, Point estimation, Interval estimation, Output analysis for terminating simulations and Steady state simulations.Meta-modelling: Simple linear regression, Testing for significance of regression, Multiple linear regression	10	3
4	**Simulation Modelling and Analysis of Manufacturing Systems:** Objectives, Performance measures, Issues in simulation of manufacturing systems, Simulation software for manufacturing applications, Simulation of job shop manufacturing systems, Simulation Modelling and Analysis of Single Server and Single Queue Systems, Inventory systems and PERT networks.	8	4
5	**Simulation of supply chains through system dynamics approach:** Basic concepts of system dynamics, Causal-loop diagram, Stock and Flow diagram, parameter estimation and sensitivity analysis Dynamic analysis of supply chains: Conceptual framework for supply chain simulation, constructing a model, supply chain simulation variables, starting to model the supply chain: warehouse management, Modelling a traditional supply chain using causal loop diagrams, modelling an entire traditional supply chain	8	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	15
Evaluate	15

Continuous Internal Evaluation Pattern:

ELECTIVE COURSES

Evaluation shall only be based on application, analysis or design-based questions (for both internal and end semester examinations).

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed Original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Text Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Modelling and Analysis of Manufacturing Systems	Askin R.G. and Standridge, C.R	John Wiley Sons	1993
2	Simulation of Manufacturing Systems	Carrie, A.S	John Wiley & Sons Ltd	1988
3	Business Modelling and Simulation	Les Oakshott	Pitman Publishing, London	1997

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Discrete-Event System Simulation	Banks, J., Carson, J.S., Nelson, B.L., and Nicol, D.M	Pearson Education, Inc	5th edition 2014
2	System Dynamics: Modelling and Simulation	Bala, B K, Arshad ,F M, Noh, K M,	Springer	2017
3	Supply Chain Simulation: A System Dynamics Approach for Improving Performance	Campuzano, F, Mula, J	Springer	2011
4	Simulation Modelling and Analysis	Law, A.M	Tata McGraw-Hill Publishing Company Limited, New Delhi.	5th edition 2013

RELIABILITY ENGINEERING

		CATEGORY	L	T	P	CREDIT
24SJ2EPE033	RELIABILITY ENGINEERING	Programme Elective 4	3	0	0	3

Preamble: Managerial statistics

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Develop a basic knowledge in the concept of reliability & failure.	**K3**
CO2	Analyze failure data, hazard models, system reliability and solve related numerical problems.	**K3**
CO3	Illustrate technique of reliability prediction.	**K3**
CO4	Derive expressions for time dependent and limiting state probabilities using Markov model	**K3**
CO5	Apply reliability improvement and allocation methods to engineering systems and perform reliability design & testing	**K3**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	1	1	1	1	1	1	1	-	1
CO2	3	1	1	1	3	1	1	-	1
CO3	3	1	2	3	3	1	1	2	-
CO4	2	1	2	1	3	1	1	-	1
CO5	3	2	2	1	3	1	1	1	-

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Reliability and its management:** Definition of reliability- definition of failure, Reliability concepts and patterns of failure, Reliability management – reliability for system effectiveness.	8	1
2	**Failure Statistics, reliability and hazard rates:** Failure data- derivation of reliability function- the expected life- failure rate and hazard function-Reliability and hazard function for distribution functions, Product life and hazard models- Hazard, failure and reliability functions from empirical data, Model selection for component failures-methods of generic failure rate determination- failure analysis.	9	2
3	**Reliability prediction:** Reliability prediction based on exponential distribution, Reliability prediction during design based on Weibull distribution, Method of reliability prediction-system reliability models.	8	3
4	**Fault analysis:** FMECA analysis, Tribological analysis- ferrographs- failure mechanisms, Markov decision process- master logic diagrams.	8	4
5	**Reliability design and testing:** Design for reliability- design process- assessment methodology ,Stress strength time models- reliability of the system- reliability based design-reliability allocation, Reliability effort function- reliability growth-selection of components to improve system reliability, Reliability life testing- burn-in test- acceptance test.	8	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	15
Evaluate	15

Continuous Internal Evaluation Pattern:

(ii) ELECTIVE COURSES

Evaluation shall only be based on application, analysis or design-based questions (for both internal and end semester examinations).

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed original publications (minimum 10

publications shall be referred): 15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no: 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Text Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Reliability Engineering Handbook	Dimitri Kececioglu	Prentice-Hall	1991
2	Practical Reliability Engineering,	O'Connor Patrick, Andre Kleyner	Wiley–Blackwell	5th Edition, 2012.
3	A Practical Approach to Reliability	Rowland H. Caplan	Century,	1972
4	Reliability Engineering	E.A. Elsayed	Wiley	2nd edition 2012

Reference Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Reliability, Maintenance and Safety Engineering, Laxmi Publications	A. K. Gupta	Laxmi Publications	2015
2	Reliability Engineering	L. S. Srinath	East West Publications	2005
3	Reliability Engineering	E. Balagurusamy	Tata McGraw Hill	2017
4	Reliability Engineering	A. K. Govil	McGraw-Hill Education	1989
5	Mechanical Reliability	Carter A.D.S	Palgrave Macmillan	1989
6	Introduction to Reliability Engineering	E. E., Lewis	Wiley	2nd Edition 1989
7	Reliability Engineering Handbook	Dimitri Kececioglu	Prentice-Hall	1991

DESIGN OF EXPERIMENTS

		CATEGORY	L	T	P	CREDIT
24SJ2EPE034	DESIGN OF EXPERIMENTS	Programme Elective 4	3	0	0	3

Preamble:

This course is about planning and conducting experiments and about analysing the resulting data so that valid and objective conclusions are obtained. The focus is on experiments in engineering and science. Experimentation plays an important role in technology commercialization and product realization activities, which consist of new product design and formulation, manufacturing process development, and process improvement

Prerequisite: Applied Statistics Course

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Apply statistical methods in designing and analysing experiments and familiarising with sampling distributions	K3
CO2	Setting up a completely randomised experiment and perform a single factor analysis of variance	K2
CO3	Understand randomised block designs , Latin square and related designs	K2
CO4	Understand how analysis of variance can be extended to factorial experiments and sample size decisions can be evaluated	K2
CO5	Understand regression model inference, testing of significance and hypothesis testing	K2

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	2	-	2	1	2	-	-	1	-
CO2	2	-	2	1	2	-	-	-	1
CO3	2	-	2	1	2	-	-	-	1
CO4	2	-	2	1	2	-	-	-	1
CO5	2	-	2	1	2	-	-	1	-

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Introduction and simple comparative experiments** Strategy of experimentation – applications – principles – guidelines for designing experiments – Sampling and sampling distributions - Inferences About the Differences in Means, Randomized Designs, Paired Comparison Designs and Variances of Normal Distributions.	8	1
2	**Experiments with a Single Factor: The Analysis of Variance** The analysis of variance – Analysis of the fixed effects model – Model adequacy checking – practical interpretation of results – determining sample size – random effects model – regression approach – non parametric methods.	8	2
3	**Randomized Blocks, Latin Squares, and Related Designs** The randomised complete block design – statistical analysis – model adequacy – The Latin square design - The Graeco-Latin Square Design – balanced incomplete block designs – statistical analysis – least squares estimation.	8	3
4	**Factorial Designs** Definitions – two factor factorial design – general factorial design – fitting response curves and surfaces – blocking in a factorial design – 2k factorial design -22, 23 and replicates of 2k – optimal designs – centre points – coded design variables.	8	4
5	**Fitting Regression Models** Linear regression models – estimation of parameters – hypothesis testing in multiple regression – confidence intervals – prediction of new response observations– regression model diagnostics – testing for lack of fit.	8	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	15
Analyse	30
Evaluate	15

Continuous Internal Evaluation Pattern:

ELECTIVE COURSES

Evaluation shall only be based on application, analysis or design-based questions (for both internal and end semester examinations).

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed Original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Text Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Design and Analysis of Experiments	Douglas C. Montgomery	John Wiley & Sons, Inc	9th edition, 2017

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Design of Experiments - A Modern Approach	Bradley Jones, Douglas C. Montgomery	Wiley	2020

ADVANCED MAINTENANCE MANAGEMENT

24SJ2EPE035	**ADVANCED MAINTENANCE MANAGEMENT**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**
		Programme Elective 4	3	0	0	3

Preamble:

This course is designed to provide a comprehensive understanding of Advanced Maintenance Management and Engineering and its application in industry.

Course Prerequisites

Knowledge in Manufacturing and Industrial Engineering at UG level.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Develop an introductory knowledge on Maintenance Organization	**K3**
CO2	Develop a comprehensive knowledge on FMEA, Maintenance Control	**K3**
CO3	System, and Budgeting and Costing for Planned Maintenance	**K3**
CO4	Develop a thorough knowledge on Simulation based approaches, Forecasting and Capacity planning, Spare parts management and TAM	**K3**
CO5	Develop a thorough knowledge on Planning and scheduling, Inspection models and Applied maintenance module	**K3**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	-	-	-	-	-	-	2	-	1
CO2	-	-	-	-	2	-	-	1	-
CO3	-	-	2	-	-	-	-	-	1
CO4	2	-	-	2	-	2	-	-	1
CO5	-	2	-	-	-	-	-	1	-

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	Maintenance Organization: Introduction, Objectives and Responsibility, Maintenance Capacity Planning , Centralization vs Decentralization, Material and Spare Parts Management, Establishment of Authority and Reporting, Quality of Leadership and Supervision, Incentives, Training, Labour Relations, Performance Measurement and Maintenance Productivity, Maintenance Performance, Measurement (MPM) of Maintenance Productivity, Maintenance Performance Indicator (MPI),MPM System, MPI Standards for industries, Maintenance Indicators by EFNMS, SMRP Metrics, Maintenance indicators in Nuclear, Oil and Gas, Railways, Process, Utility, Auto industries etc., MPIs for the CEO	8	1
2	Methods and Tools in Maintenance: Failure Statistics, Failure Mode and Effect Analysis (FMEA): Introduction to Probability, Probability Distributions, Reliability and Failure Rate Functions, Mean Time Between Failure (MTBF), Distributions, Falure statstics, FMEA Process and Applications. Root Cause Analysis, Root Cause Analysis, Cause and Effect Diagram, Maintenance Control Systems: Structure, Function and Process. Work order system, Work Control, Cost Control, Quality Control, Plant Condition Control, Emergency Maintenance, Reliability Improvement, Total Productive Maintenance, Computerized Maintenance Management and Information Technology, Budgeting and Costing Planned Maintenance Services: Overview of budgeting and costing systems, The Budget Cycle, Planned Maintenance Job Costing	8	2
3	Maintenance Control Systems: Simulation Based Approaches for Maintenance Strategies Optimization: Reliability Models Estimation, Regression and ML Methods, Maintenance Performance, Availability Model, Costs Model, Simulation Based Maintenance Framework, Maintenance Forecasting and Capacity Planning: Forecasting techniques, Delphi method, Moving averages, Regression, Exponential smoothing, Seasonal forecasting, Box-Jenkins model, Error analysis, Maintenance Capacity Planning, Modified Transportation Tableau Method, Mathematical Programming Methods, Stochastic Techniques for Capacity Planning, Queuing Models, Stochastic Simulation, Integrated Spare Parts Management: Spare Parts Identification and Classification, Determination of the Required Quantity of Spare Parts, Inventory Control Policies, Joint Maintenance and Provisioning Strategies, Inventory and Maintenance Policies for Reconditioned Spare Parts, Collaborative Management of Spare Parts, Turnaround Maintenance: TAM initiation, work scope, Contractors, Planning, Organizing, Quality and safety plans, Execution and closing	8	3

4	Maintenance Planning and Scheduling: Strategic Planning in Maintenance, Medium/short Range Planning, Scheduling Techniques, Gantt Charts and Scheduling Theory, Project Scheduling, Critical Path Method, Program Evaluation Review Techniques (PERT), Scheduling Using Computers, Maintenance Planning in Stochastic Manufacturing Systems: Problem Statement and Preliminary Results, Linier/Dynamic Programming Approach, Inspection Strategies for Randomly Failing Systems: Basic Inspection Model, Extensions of the Basic Model, Inspection Models for Multi-component Systems, Conditional Maintenance Models, System Health Monitoring and Prognostics, Maintenance Strategies: Motivations for Health Monitoring, Health Monitoring Tools and Techniques, Applied Maintenance Models: Missile Maintenance, Phased Array Radar Maintenance, Self-diagnosis for FADEC, Co-generation System Maintenance	**8**	**4**
5	Maintenance Strategies: Reliability Centered Maintenance: RCM Philosophy, Failure and its Nature, RCM Methodology, Total Productive Maintenance: Need of TPM, TPM Methodology, Barriers in TPM Implementation, Warranty and Maintenance: Maintenance Modelling, Warranties, Link Between Warranty and Maintenance, Maintenance Logistics for Warranty Servicing, Outsourcing of Maintenance for Warranty Servicing,Delay Time Modelling for Optimized Inspection Intervals of Production Plant: DT Concept and Modelling Characteristics, the DT Models for Complex Plant, Delay Time Model Parameters Estimation, Integrated E-maintenance and Intelligent Maintenance Systems: Condition-based Maintenance Technology and the State of the art development, Integrated E-maintenance Solutions and Current Status, Watchdog Agent-based Intelligent Maintenance Systems	**8**	**5**

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	15
Evaluate	15

Continuous Internal Evaluation Pattern:

ELECTIVE COURSES

Evaluation shall only be based on application, analysis or design-based questions (for both internal and end semester examinations).

Continuous Internal Evaluation: 40 marks

Preparing a review article based on peer reviewed original publications (minimum10 publications shall be referred): 15 marks
Course based task/Seminar/Data collection and interpretation: 15 marks
Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination: 60 marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks.

Text Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Management for Engineers Scientists and Technologists,	Chelson VJ, Payne CA, Reavill RP	Wiley, Chichester England	2nd Edition 2005
2	Performance Measurement Explained	Andersen B and Fagerhaug T.	ASQ Quality Press, Milwaukee, Wisconsin.	2002
3	Maintenance Organization and System	Kelly A	Butterworth Heinemann, UK.	1997

Reference Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Handbook of Maintenance Management and Engineering	Mohamed Ben-Daya, Salih O. Duffuaa, Abdul Raouf, Jezdimir Knezevic, Daoud Ait-Kadi	Springer Nature	2009
2	Maintenance Theory of Reliability	Toshio Nakagawa	Springer Series in reliability Engineering	2005

INTERDISCIPLINARY ELECTIVE

ENTREPRENEURSHIP DEVELOPMENT

		CATEGORY	L	T	P	CREDIT
24SJ2EPE048	ENTREPRENEURSHIP DEVELOPMENT	Interdisciplinary elective	3	0	0	3

Preamble:

The course enables the student to have a thorough understanding on entrepreneurship. The course brings forth the different opportunities and resources which are available in the domain of entrepreneurship within the country

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Identify the opportunities of entrepreneurship	K2
CO2	Develop Proficiency in business plan preparation	K3
CO3	Make use of Entrepreneurial finance concepts in real time scenario	K3
CO4	Make use of entrepreneur concepts for the well-being of society	K3
CO5	Evaluate the scope of e-commerce, MSME and the challenges in entrepreneurship	K3

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	1	-	3	1	1	-	2	-	1
CO2	1	-	3	2	2	-	2	-	1
CO3	1	-	3	2	1	-	2	1	-
CO4	1	-	3	2	2	-	2	-	-
CO5	1	-	3	1	1	-	2	-	-

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Introduction To Entrepreneurship:** Types of entrepreneurs, entrepreneurial Traits and competencies. Ethics and Social responsibility of Entrepreneurs, opportunities for Entrepreneurs in India and abroad. Start-up India, Stand up India, National Skill Development Program, PMEGP, Mudra Yojana, and KVIC schemes.	8	1
2	**Entrepreneurship Ideation and Decision Process.** Incubation procedures and processes, Business plan preparation, DPR preparation. Managing Finance and Growth, Role of Financial Institutions and Commercial Banks for loans and financial controls. Features and evaluation of joint ventures, acquisitions, mergers, franchising, public issues, rights issues, bonus issues and stock splits.	8	2
3	**Entrepreneurial Finance** Managing cash flow, types and costs of financial capital, valuing early-stage ventures, real estate investment ventures, differences between new venture finance and corporate finance. Finance of large public corporations- means of testing assumptions, validating, learning, measuring, signalling. Recognize the importance of financial modelling and strategic planning - venture capital industry - contracts that are used in the industry-potential challenges faced by entrepreneurial initiatives	8	3
4	**Social Entrepreneurship** Social entrepreneurship business models, for-profit, not for profit, hybrid, community-based, difference between social and commercial entrepreneurship. Double bottom line, social and institutional environmental factors, opportunity identification, discovery and recognition. Social value creation and social inclusion, social change and role of social entrepreneur.	8	4
5	**E-commerce and Entrepreneurship** Starting an MSME unit, phases, training requirements, legal frameworks, registration procedures, concessions and reliefs by Government Rural entrepreneurship, Challenges in entrepreneurship. Successful Entrepreneurs from the contemporary Indian business world.	8	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	25
Analyse	35

Continuous Internal Evaluation Pattern:

Continuous Internal Evaluation Pattern: 40 Marks
Preparing a review article based on peer reviewed original publications (Minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern: 60 Marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Text Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Entrepreneurial Development	Khanka, S. S	S. Chand & Company Pvt. Ltd	2012
2	Entrepreneurship	Hisrich, R. D., Manimala, M. J., Peters M. P. and Shephered D. A.	McGraw Hill Education India	9th edition 2014
3	Business Legends	Piramal, G	Penguin Books	2003

Reference Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Entrepreneurial Finance	Adelman, P. J. and Marks, A. M	Pearson Education	6th Edition 2013
2	Entrepreneurial Finance: Finance and Business Strategies for the Serious Entrepreneur	Rogers, S. and Makonnen, R	McGraw-Hill Education.	3rd Edition 2014
3	Management for social enterprise	Doherty, B., Foster, G., Meehan, J., & Mason, C	Sage Publications	2009
4	Social entrepreneurship for the 21st century: Innovation across the nonprofit, private, and public sectors	Keohane, G. L	McGraw Hill Professional	2013

INDUSTRIAL SAFETY

24SJ2EPE049	INDUSTRIAL SAFETY	CATEGORY	L	T	P	CREDIT
		Interdisciplinary elective	3	0	0	3

Preamble:

The course is intended to give knowledge of various safety management principles, safety systems, safety performance monitoring methods, hazard identification techniques and controlling methods, consequence analysis, risk assessment, legal provisions in safety and its need in the present industrial scenarios. context. Learners will be able to compare different hazard identification tools and choose the most appropriate based on the nature of industry. The development and implementation of SMS in process industries and procedure for emergency planning are also included in the syllabus. It aims to equip students in working with projects related to safety and to take up research work in connected areas

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Describe the concept of safety and measurement of different safety performance level in industry.	**K2**
CO2	Design and develop various safety training programs and measures the human factors contributing to accidents.	**K3**
CO3	Illustrate various hazard identification, assessment and control techniques and describe the concepts of risk assessment.	**K3**
CO4	Describe the safety management systems for safe operations in process industries and develop appropriate emergency response planning.	**K2**
CO5	Describe the features of the regulations in Factories Act, Workmen act, Compensation act, OSHAS 18000 and ISO 14000	**K2**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	1	1	1	1	2	-	1	-	2
CO2	3	3	2	1	2	-	1	2	-
CO3	3	1	3	1	2	-	1	-	1
CO4	3	2	3	1	2	-	1	-	-
CO5	1	3	2	1	2	-	1	-	1

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Introduction to industrial safety – Concepts:** Concept of safety - Need for safety - Accident, Injury, Unsafe act and Unsafe Conditions, Reportable and Non reportable accidents. Accident Investigation and analysis -Safety committee-need, types, advantages. Duties of safety officer, Laws related to the Industrial Safety Measurement of Safety Performance -Calculation of accident indices-frequency rate- severity rate-frequency severity incidence, incident rate- accident rate, Work permit system.	7	1
2	**Occupational safety and safety training:** Health Hazards, Promoting Safety, Safety and Health training, Stress and Safety. Ergonomics - Introduction, Definition, Objectives, Advantages. Ergonomics Hazards - Musculoskeletal Disorders and Cumulative. Trauma Disorders. Design & development of training programme. Training methods and strategies. Training of managers, supervisors & workers. Evaluation of training programmes. Human behaviour and safety: Human factors contributing to accidents- Control measures against human errors-Personal Protective Equipment.	8	2
3	**Hazard Identification and consequence/risk analysis – Concepts** Introduction, hazard, hazard monitoring and control -concept of risk assessment - Hazard assessment, procedure, methodology, safety audit, checklist analysis, what-if analysis. Examples safety review, preliminary hazard analysis (PHA), HAZOP, Fault Tree Analysis & Event Tree Analysis, FMEA and FMECA. Examples Logics of consequence analysis of major hazards Fire, Explosion and Toxic gas release– Concept of Software on Risk analysis- ALOHA. Plotting the damage distances on plot plant/layout-Examples	9	3
4	**Process safety management systems.** Planning for safe operations, Safety management systems - structures and components, Development and implementation of SMS.Emergency planning and Response-Process system life cycle components – Risk management steps in the life cycle. Inherently Safer Design (ISD) – Components- Process safety implementation at design stage – Explanation with examples Emergency planning procedures. Case studies	10	4
5	**Regulations for health, safety and environment** Factories act and rules; Workmen compensation act-1923. Indian explosive act - Gas cylinder rules - SMPV Act Indian petroleum act and rules. Environmental pollution act Manufacture, Storage and Import of Hazardous Chemical rules 1989	7	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	20
Evaluate	10

Continuous Internal Evaluation Pattern: 40 Marks

Preparing a review article based on peer reviewed original publications (Minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern: 60 Marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks**.** Total duration of the examination will be 150 minutes.

Text Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Accident Prevention Manual for Industrial Operations	Wm. H. Pool Company	NSC Chicago	1982
2	Handbook of Occupational Health and Safety	--	NSC Chicago	1982
3	Industrial Accident Prevention	Heinrich, H.W	McGraw-Hill Company, New York	1980

Reference Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Loss Prevention in Process Industries	Lees, F. P	Butterworth-Heinemann	1986
2	The Factories Act 1948	--	Madras Book Agency, Chennai	2000
3	Process Systems Risk Management	Cameron, I. and Raman, R	Elsevier Academic Press.	2005
4	Loss Prevention in Process Industries, Butterworth-Heinemann UK (Vol. I, II & III).	Lees, F. P	Knovel	1990
5	Methodologies for Risk and Safety Assessment in Chemical Process Industries	K. V. Raghavan, A. A. Khan	Commonwealth Science Council, UK.	1990

INDUSTRY 4.0

24SJ2EPE050	**INDUSTRY 4.0**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**
		Interdisciplinary elective	3	0	0	3

Preamble:

This course provides an introduction to the concepts in of Industry 4.0 and provide students with in-depth knowledge of designing Industrial 4.0 Systems for different applications. Industry 4.0 is considered a new industrial stage in which vertical and horizontal manufacturing processes integration and product connectivity can help companies to achieve higher industrial performance. After completion of the course the student is expected to be in a position to formulate a framework for Industry 4.0 implementation in a new age organization

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Describe the core idea of Industry 4.0 and related fields	**K2**
CO2	Formulate Industry 4.0 framework for a manufacturing organization	**K3**
CO3	Frame Cognitive Architecture for Cyber-Physical Robotics	**K3**
CO4	Describe the advances in Robotics in industry 4	**K2**
CO5	Identify obstacles in Industry 4.0 implementation and find solutions	**K2**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	1	-	1	1	2	-	1	-	2
CO2	1	-	1	1	2	-	1	1	-
CO3	1	-	1	1	2	-	2	1	-
CO4	1	-	1	1	2	-	2	-	1
CO5	1	-	1	1	2	-	2	-	1

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Introduction to Industry 4.0** Introduction, core idea of Industry 4.0, origin concept of industry 4.0, Supportive Technologies Additive manufacturing, Robotization and automation, Industry 4.0 production system Current state of industry 4.0, How is India preparing for Industry 4.0	8	1
2	**A Conceptual Framework for Industry 4.0** Main Concepts and Components of Industry 4.0, Pillars of Industry 4.0 State of Art, Digitally enabled factory, Digital transformation Proposed Framework for Industry 4.0.	7	2
3	**Technology Roadmap for Industry 4.0** Framework for Technology Roadmap, Strategy Phase, New Product and Process Development Phase Implementation for Small and Medium-Sized Enterprises, Industry 4.0 implementation case studies	6	3
4	**Advances in Robotics in the Era of Industry 4.0** Recent Technological Components of Robots- Advanced Sensor Technologies, Internet of Robotic Things, Cloud Robotics Cognitive Architecture for Cyber-Physical Robotics, Architecture of Cyber Physical Systems, Industrial Robotic Applications- Manufacturing, Maintenance and Assembly. The Role of Augmented Reality, AR Hardware and Software Technology, Industrial Applications of AR.	10	4
5	**Obstacles in Industry 4.0 implementation** Lack of A digital Strategy alongside resource Scarcity, Lack of standards and poor data security, Financing conditions, availability of skilled workers Comprehensive broadband infrastructure, state support, legal framework, Protection of corporate data, liability, handling personal data. Evaluating Industry 4.0 readiness for organizations, Sustainability perspective	9	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	30
Analyse	20
Evaluate	10

Continuous Internal Evaluation Pattern: 40 Marks

Preparing a review article based on peer reviewed Original publications (minimum 10 publications shall be referred) : 15 marks
Course based task/Seminar/Data collection and interpretation : 15 marks
Test paper, 1 no. : 10 marks
Test paper shall include minimum 80% of the syllabus

End Semester Examination Pattern: 60 Marks

There will be two parts; Part A and Part B. Part A will contain 5 numerical/short answer questions with 1 question from each module, having 5 marks for each question (such questions shall be useful in the testing of knowledge, skills, comprehension, application, analysis, synthesis, evaluation and understanding of the students). Students should answer all questions. Part B will contain 7 questions (such questions shall be useful in the testing of overall achievement and maturity of the students in a course, through long answer questions relating to theoretical/practical knowledge, derivations, problem solving and quantitative evaluation), with minimum one question from each module of which student should answer any five. Each question can carry 7 marks. Total duration of the examination will be 150 minutes.

Text Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Industry 4.0	Jean-Claude André	Wiley - ISTE	2019
2	Handbook of Industry 4.0 and SMART Systems	Pascual, D. G., Daponte, P. and Uday Kumar	Taylor and Francis	2020
3	The internet of things: How smart TVs, smart cars, smart homes, and smart cities are changing the world	Miller, M.	Pearson Education	2015

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Implementing Industry 4.0 in SMEs: Concepts, Examples and Applications.	Dominik T. Matt, Modrák, V	Palgrave Macmillan	2021
2	Industry 4.0: Technologies and Management in the Digital Transformation of the Industry	Fernandez, M	Independently Published	2020

MINIPROJECT

		CATEGORY	L	T	P	CREDIT
24SJ2PPE100	MINIPROJECT	Project	0	0	4	2

Total marks: 100 (only CIA)

Mini project can help to strengthen the understanding of student's fundamentals through application of theoretical concepts and to boost their skills and widen the horizon of their thinking. The ultimate aim of an engineering student is to resolve a problem by applying theoretical knowledge. Doing more projects increases problem-solving skills. The introduction of mini projects ensures preparedness of students to undertake dissertation. Students should identify a topic of interest in consultation with PG Programme Coordinator that should lead to their dissertation/research project. Demonstrate the novelty of the project through the results and outputs. The progressof the mini project is evaluated based on three reviews, two interim reviews and a final review. A report is required at the end of the semester.

Interim evaluation: 40 (20 marks for each review), final evaluation by a committee(will be evaluating the level of completion and demonstration of functionality/specifications, clarity of presentation, oral examination, work knowledge and involvement): 35, Report (the committee will be evaluating for the technical content, adequacy of references, templates followed and permitted plagiarism level is not more than 25%): 15, Supervisor/Guide: 10 marks

SEMESTER 2 – LABORATORY

COMPUTATIONAL LAB

24SJ2LPE002	COMPUTATIONAL LAB	CATEGORY	L	T	P	CREDIT
		LABORATORY	0	0	2	1

Preamble:

The laboratory is introduced to provide an exposure to model and analyse real-world decision-making problems relevant to a manufacturing system

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Develop and analyse simulation models of manufacturing systems /supply chains	**K3**
CO2	Develop and analyse optimization models of manufacturing systems/supply chains.	**K3**
CO3	Model and analyse business or manufacturing scenarios using multivariate models (like	**K3**
CO4	Regression and factor analysis).	**K3**
CO5	Model and analyse business or manufacturing scenarios using neural network/fuzzy logic techniques.	**K3**
CO6	Perform modelling and analysis using software like Excel, ARENA, SPSS, Vensim, Anylogic, CPLEX/LINGO, R/Python and MATLAB	**K3**
CO7	Perform work system design through industrial engineering principles	**K2**
CO8	Analyse quality using statistical quality control	**K3**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	3	3	3	-	3	-	3	-	1
CO2	3	3	3	-	3	-	3	2	-
CO3	3	3	3	-	3	-	3	2	-
CO4	3	3	3	-	3	-	3	2	-
CO5	3	3	3	-	3	-	3	-	1

CO6	2	-	2	2	2	2	2	-	1
CO7	1	-	1	2	2	2	1	2	-
CO8	3	-	2	2	2	1	2	1	-

LIST of Experiments

Experiments

(Minimum of 8 experiments can be chosen from the list given below)

1. Manual simulation of a manufacturing system
2. Performance analysis of production system using simulation software ARENA/WITNESS and theoretical model.
3. Performance analysis of a 4 stage serial supply chain under P-system of inventory control at all stages of the supply chain using excel spread sheet.
4. Supply chain role play game
5. Exercise on MATLAB programming to determine the inventory policy for the given problem using simulation
6. Model and optimise the given production planning problem using the optimisation software CPLEX/Excel/LINGO
7. Model, analyse and infer the given management problem through regression analysis using SPSS
8. An exercise on confirmatory factor analysis using SPSS.
9. Experiment illustrating the application of soft-computing techniques like neural network/fuzzy logic techniques.
10. Experiment illustrating dynamic simulation with the aid of software like Vensim, Anylogic etc.
11. Experiment to illustrate demand forecasting using primary/secondary data.
12. Experiments on work system design.
13. Method analysis
14. Micro motion study
15. Work measurement
16. Construction of variable control charts (X-bar and R charts)
17. Construction of attribute control charts (np chart and p chart)
18. Study and construction of OC curve of a sampling plan
19. Data Analysis using SPSS/Excel/R/Python.

Course Assessment

Assessment Pattern

The laboratory courses will be having only Continuous Internal Evaluation and carries 100 marks. Final assessment shall be done by two examiners; one examiner will be a senior faculty from the same department.

Mark distribution

Total Marks	CIE
100	100

Text Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Simulation Modelling and Analysis with ARENA	Altiok, T., and Benjamin, M	Academic Press, Elsevier	2011
2	Applied Simulation Modelling	Seila, A.F., Ceric, V., and Tadikamalla, P	Cengage Learning	2000
3	System Dynamics: Modelling and Simulation	. Bala, B K, Arshad ,F M, Noh, K M	Springe	2007

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Simulation Modelling and Analysis with ARENA	Tayfur Altiok and Benjamin Melamed	Academic Press	2007
2	Discrete-Event System Simulation	Banks, J., Carson, J.S., Nelson, B.L., and Nicol, D.M.,	Pearson Education, Inc	5th edition 2007
3	Simulation Modelling and Analysis,	Law, A.M	Tata McGraw-Hill Publishing Company Limited, New Delhi.,	3rd edition 2007
4	Automation, Production Systems, and Computer-Integrated Manufacturing	Mikell P. Groover	Prentice Hall of India Private Limited	2nd edition 2001
5	Simulation with Arena	Kelton, W.D., Sadowski, R.P., and Sturrock, D.T:	McGraw Hill.	4th edition 2007
6	Inventory Management and Production Planning and Scheduling	Edward A. Silver, David F. Pyke and Rein Peterson	John Wiley & Sons	3rd edition 1998

SEMESTER III

SEMESTER III							
SLOT	**COURSE CODE**	**COURSE NAME**	**MARKS**		**L-T-P**	**HOURS**	**CREDIT**
			CIA	**ESE**			
TRACK 1							
A*	223MPEXXX	MOOC	To be completed successfully		--	--	2
B	24SJ3AGEXXX	AUDIT COURSE	40	60	3-0-0	3	-
C	24SJ3IPE100	INTERNSHIP	50	50	--	--	3
D	24SJ3PPE100	DISSERTATION PHASE 1	100	--	0-0-17	17	11
TRACK 2							
A*	24SJ3MPEXXX	MOOC	To be completed successfully		--	--	2
B	24SJ3AGEXXX	AUDIT COURSE	40	60	3-0-0	3	-
C	24SJ3IPE100	INTERNSHIP	50	50	---	--	3
D	24SJ3PPE001	RESEARCH PROJECT PHASE 1	100	--	0-0-17	17	11
Total			190	110		20	16

Teaching Assistance: 6 hours

*MOOC Course to be successfully completed before the commencement of fourthsemester (starting from semester 1)

AUDIT COURSE

SLOT	SL NO	COURSE CODE	COURSE NAME	L-T-P	HOURS	CREDIT
B	1	24SJ3AGE100	ACADEMIC WRITING	3-0-0	3	-
	2	24SJ3AGE001	ADVANCED ENGINEERING MATERIALS	3-0-0	3	-
	3	24SJ3AGE002	FORENSIC ENGINEERING	3-0-0	3	-
	4	24SJ3AGE003	DATA SCIENCE FOR ENGINEERS	3-0-0	3	-
	5	24SJ3AGE004	DESIGN THINKING	3-0-0	3	-
	6	24SJ3AGE005	FUNCTIONAL PROGRAMMING IN HASKELL	3-0-0	3	-
	7	24SJ3AGE006	FRENCH LANGUAGE (A1 LEVEL)	3-0-0	3	-
	8	24SJ3AGE007	GERMAN LANGUAGE (A1 LEVEL)	3-0-0	3	-
	9	24SJ3AGE008	JAPANESE LANGUAGE (N5 LEVEL)	3-0-0	3	-
	10	24SJ3AGE009	PRINCIPLES OF AUTOMATION	3-0-0	3	-
	11	24SJ3AGE010	REUSE AND RECYCLE TECHNOLOGY	3-0-0	3	-
	12	24SJ3AGE011	SYSTEM MODELING	3-0-0	3	-
	13	24SJ3AGE012	EXPERT SYSTEMS	3-0-0	3	-

ACADEMIC WRITING

		CATEGORY	L	T	P	CREDIT
24SJ3AGE100	ACADEMIC WRITING	AUDIT COURSE	3	0	0	NIL

Preamble:

Learning academic writing sharpens minds, teaches students how to communicate, and develops their thinking capacities and ability to understand others. Writing is thinking, and every student deserves to be a strong thinker. It can also make them think more carefully about what they write. Showing work to others can help to foster a better culture of learning and sharing among students. It also gives students a sense of how they are contributing to the body of work that makes up an academic subject.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the principles of scientific/ academic writing	**K2**
CO2	Analyse the technique of scientific writing from the reader's perspective	**K4**
CO3	Apply the concepts of setting expectations and laying the progression tracks	**K3**
CO4	Evaluate the merits of a title, abstract , introduction, conclusion and structuring of a research paper	**K5**
CO5	Justify the need using a project proposal or a technical report	**K5**
CO6	Prepare a review paper, an extended abstract and a project proposal	**K6**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	-	3	1	-	-	-	-	-	2
CO2	-	3	1	-	-	-	-	1	-
CO3	-	3	1	-	-	2	-	1	-
CO4	-	3	1	-	-	-	-	1	-
CO5	-	3	2	2	-	2	-	-	1
CO6	1	3	3	2	-	2	-	-	1

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	Fundamentals of Academic writing from a reader's perspective: acronyms, synonyms, pronouns, disconnected phrases, background ghettos, abusive detailing, cryptic captions, long sentences: all that take their toll on readers' memory.	9	1
2	Fluid reading & reading energy consumption: setting expectations and laying Progression tracks; Reading energy consumption	9	2
3	How to write the Title, abstract, introduction; Structure the writing with headings & subheadings	9	3
4	Visuals: Resources, Skills, and Methods; Conclusion; References; Bibliography; Grammar in technical writing	9	4
5	Techniques of writing: An extended abstract, a project proposal, a research paper, a technical report.	9	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	40%
Analyse	30%
Evaluate	30%
Create	20

Continuous Internal Evaluation Pattern (CIE): 40 Marks

Course based task: 15 marks Seminar/Quiz: 15 marks Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern (ESE): 60 marks

The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Five. Each question can carry 12 marks.

Text Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	SCIENTIFIC WRITING 2.0 A Reader and Writer's Guide	Jean-Luc Lebrun	World Scientific Publishing Co. Pvt. Ltd.,	2011

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	How to Write and Publish a Scientific Paper	Barbara Gastel and Robert A. Day	Greenwood publishers	2016

ADVANCED ENGINEERING MATERIALS

24SJ3AGE001	**ADVANCED ENGINEERING MATERIALS**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**
		AUDIT COURSE	3	0	0	-

Preamble:

This course is designed in a way to provide a general view on typically used advanced classes of engineering materials including metals, polymers, ceramics, and composites.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Analyse the requirement and find appropriate solution for use of materials.	**K4**
CO2	Differentiate the properties of polymers, ceramics and composite materials.	**K2**
CO3	Recognize basic concepts and properties of functional materials.	**K2**
CO4	Comprehend smart and shape memory materials for various applications.	**K2**
CO5	Appraise materials used for high temperature, energy production and storage applications.	**K2**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	1	1	1	1	1	-	-	1	-
CO2	-	-	1	1	1	-	-	-	1
CO3	2	-	1	1	1	-	-	-	1
CO4	2	-	1	1	1	-	-	1	-
CO5	1	1	1	1	1	1	-	1	-

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	Requirements / needs of advanced materials. Classification of materials, Importance of materials selection, Criteria for selection of materials; motivation for selection, cost basis and service requirements. Relationship between materials selection and processing.	9	1
2	Classification of non-metallic materials. Polymer, Ceramics: Properties, processing and applications. Nano Composites - Polymer nanocomposites (PNCs), Processing and characterisation techniques – properties and potential applications.	9	2
3	Functionally graded materials (FGMs), Potential Applications of FGMs, classification of FGMs, processing techniques. limitations of FGMs.	9	3
4	Smart Materials: Introduction, smart material types – pyroelectric sensors, piezoelectric materials, electrostrictions and magnetostrictions, shape memory alloys – associated energy stimulus and response forms, applications.	9	4
5	High Temperature Materials: super alloys – main classes, high temperature properties of superalloys, applications. Energy Materials: materials for batteries.	9	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Understand	60%
Apply	20%
Analyse	20%

Continuous Internal Evaluation Pattern (CIE): 40 Marks

Course based task: 15 marks Seminar/Quiz: 15 marks Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern (ESE): 60 marks

The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Five. Each question can carry 12 marks.

Text Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Materials and Processes in Manufacturing	DeGarmo et al.	Wiley	10th Edition, 2008
2	Physical Metallurgy and Advanced Materials	R.E. Smallman and A.H.W. Ngan	Butterworth-Heinemann	7th Edition, 2007
3	Functional Materials: A Chemist's Perspective	Vijayamohanan K. Pillai and Meera Parthasarathy	Universities Press, Hyderabad	2012

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Smart Materials and Structures	M.V. Gandhi, B.S. Thompson	Chapman & Hall	1992
2	Materials for High Temperature Engineering Applications	G. W. Meetham and M. H. Van de Voorde	Springer	1st Edition, 2000
3	Smart Structures Theory	Inderjit Chopra, Jayant Sirohi	Cambridge University Press	2013

DATA SCIENCE FOR ENGINEERS

		CATEGORY	L	T	P	CREDIT
24SJ3AGE003	DATA SCIENCE FOR ENGINEERS	AUDIT COURSE	3	0	0	0

Preamble:

This course covers essentials of statistics and Linear Algebra and how to prepare the data before processing in real time applications. The students will be able to handle missing data and detection of any outliers available in the dataset. This course explores data science, Python libraries and it also covers the introduction to machine learning for engineers.

Course Outcomes (COs)

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

Course Outcome		Bloom's Knowledge Level (KL)
CO1	Study Data Science Concepts and statistics	K2
CO2	Demonstrate and Understanding of Mathematical Foundations needed for Data Science	K2
CO3	Understand Exploratory analysis and Data Visualization and Pre-processing on given dataset	K2
CO4	Implement Models such as Naive Bayes, K-Nearest Neighbours, Linear and Logistic Regression	K3
CO5	Build real time data science applications and test use cases	K6

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	2	-	2	-	-	2	-	-	1
CO2	2	-	2	1	-	2	-	-	1
CO3	2	-	2	2	2	2	-	1	-
CO4	2	-	2	2	3	2	-	-	1
CO5	2	-	2	3	3	3	2	1	-

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Statistics for Data science:** Probability: Basic concepts of probability, conditional probability, total probability, independent events, Bayes' theorem, random variable, Population, Sample, Population Mean, Sample Mean, Population Distribution, Sample Distribution and sampling Distribution, Mean, Mode, Median, Range, Measure of Dispersion, Variance, Standard Deviation, Gaussian/Normal Distribution, covariance, correlation.	9	1
2	**Linear Algebra:** Vectors and their properties, Sum and difference of Vectors, distance between Vectors, Matrices, Inverse of Matrix, Determinant of Matrix, Trace of a Matrix, Dot Product, Eigen Values, Eigen Vectors, Single Value Decomposition	9	2
3	**Hypothesis Testing:** Understanding Hypothesis Testing, Null and Alternate Hypothesis, Non-directional Hypothesis, Directional Hypothesis Critical Value Method, P-Value Method, Types of Errors-Type1 Error, Type2 Error, Types of Hypothesis Test Z Test, Chi-Square	9	3
4	**Exploratory Data Analysis:** Data Collection –Public and Private Data, Data Cleaning-Fixing Rows and Columns, Missing Values, Standardizing values, invalid values, filtering data, Data-Integration, Data-Reduction, Data Transformation	9	4
5	**Machine Learning and Python for Data Science:** Python Data Structures-List, Tuple, Set, Dictionary, Pandas, NumPy, SciPy, Matplotlib, Machine Learning- Supervised Machine Learning, Unsupervised Machine Learning, Regression, Classification, Naïve-Bayes	9	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Understand	50%
Apply	30%
Analyse	20%

Continuous Internal Evaluation Pattern (CIE): 40 Marks

Course based task: 15 marks Seminar/Quiz: 15 marks Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern (ESE): 60 marks

The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Five. Each question can carry 12 marks.

Text Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Python Data Science Handbook: Essential Tools for Working with Data	Jake VanderPlas	O'Reilly Media	2016
2	Practical Statistics for Data Scientists: 50 Essential Concepts	Peter Bruce, Andrew Bruce	O'Reilly Media	2017

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Practical Linear Algebra for Data Science	Mike X Cohen	O'Reilly Media, Inc.	September 2022
2	Data Science from Scratch	Joel Grus	O'Reilly Media, Inc.	April 2015
3	Hands-On Exploratory Data Analysis with Python	Suresh Kumar Mukhiya, Usman Ahmed	Packt Publishing	March 2020

DESIGN THINKING

24SJ3AGE004	DESIGN THINKING	CATEGORY	L	T	P	CREDIT
		AUDIT COURSE	3	0	0	-

Preamble:

This course offers an introductory exploration of fundamental engineering concepts and techniques, the design process, analytical thinking and creativity, as well as the fundamentals and development of engineering drawings, along with their application in engineering problems.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Identify and frame design challenges effectively.	K2
CO2	Generate creative ideas through brainstorming and ideation	K2
CO3	Iterate on designs based on user insights	K2
CO4	Apply Design Thinking to real-world problems and projects.	K3
CO5	Develop Entrepreneurship/business ideas, Patents and Intellectual Property	K3

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	-	-	-	2	-	2	2	1	-
CO2	2	-	2	2	-	-	2	-	1
CO3	-	2	-	2	-	2	2	-	1
CO4	2	-	2	3	2	-	2	-	-
CO5	1	-	1	-	-	-	-	-	1

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	Design process: Traditional design, Design Thinking Approach, Introduction to Design Thinking, History and evolution of Design Thinking, Role of design thinking in the human-centered design process. Design space, Design Thinking in a Team Environment, Team formation.	9	1
2	Design Thinking Stages: Empathize, Define, Ideate, Prototype and Test. The importance of empathy, Building a user-centered mindset. Problem statement formulation, User needs and pain points, establishing target specifications, Setting the final specifications.	9	2
3	Generating Ideas, Brainstorming techniques, Application of Aesthetics and Ergonomics in Design. Bio-mimicry, Conceptualization, Visual thinking, Drawing/Sketching, Presenting ideas.	9	3
4	Use of prototyping, Types of prototypes, Rapid prototyping techniques, User testing and feedback collection, Iterative prototyping, testing to gauge risk and market interest	9	4
5	Entrepreneurship/business ideas, Patents and Intellectual Property, Agility in design, Ethical considerations in design. Overcoming common implementation challenges	9	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	40%
Analyse	30%
Evaluate	30%
Create	

Continuous Internal Evaluation Pattern (CIE): 40 Marks

Course based task: 15 marks Seminar/Quiz: 15 marks Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern (ESE): 60 marks

The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Five. Each question can carry 12 marks.

Text Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Design Thinking: Understand – Improve – Apply	Christoph Meinel, Larry Leifer and Hasso Plattner	Springer Berlin, Heidelberg	2011
2	Design Thinking: Integrating Innovation, Customer Experience, and Brand Value	Thomas Lockwood and Edgar Papke	Allworth Press	2009

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Design Your Thinking	Pavan Soni	Penguin Random House India Private Limited	2020
2	Design Thinking: A Guide to Creative Problem Solving for Everyone	Andrew Pressman	Taylor & Francis	2018
3	Design Thinking Techniques and Approaches	N Siva Prasad	Ane Books Pvt. Ltd.	2023

FUNCTIONAL PROGRAMMING IN HASKELL

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
24SJ3AGE005	FUNCTIONAL PROGRAMMING IN HASKELL	AUDIT COURSE	3	0	0	-

Preamble:

This course introduces a functional programming approach in problem solving. Salient features of functional programming like recursion, pattern matching, higher order functions etc. and the implementation in Haskell are discussed.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Understand the functional programming paradigm which is based on the mathematics of lambda calculus.	K2
CO2	Develop Haskell programs using functions, guards and recursive functions	K6
CO3	Apply the concept of tuples, lists and strings in Haskell programming	K3
CO4	Apply the concept of algebraic data types, abstract data types, modules, recursive data types and user defined data types in Haskell programming	K3
CO5	Develop Haskell programs with files for reading input and storing output	K6

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	-	-	-	-	3	-	-	-	1
CO2	2	-	-	2	3	-	-	-	1
CO3	2	-	-	2	3	-	-	1	-
CO4	2	-	-	2	3	-	-	1	-
CO5	2	-	-	2	3	-	-	-	1

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Introduction to Functional Programming:** Programming language paradigms, imperative style programming, comparison of programming paradigms. Functional programming, Functions - Mathematical concepts and terminology, Lambda calculus, Function definitions, programs as functions, Functional programming Languages. Haskell basics, GHCi interpreter.	9	1
2	**Programming in Haskell:** Expressions and evaluation, Lazy evaluation, let expressions, scopes. Basic data types in Haskell, operators, infix operators, associativity and precedence, Arithmetic functions. types, definitions, currying and uncurrying, type abstraction. Function definitions, pattern matching, guards, anonymous functions, higher order functions. Recursion, Programming exercises.	9	2
3	**Data types: tuples and lists**: Tuples, Lists: building lists, decomposing lists, functions on lists, built- in functions on lists, primitive and general recursion over lists, infinite lists. Strings: functions on strings. Polymorphism and overloading, conditional polymorphism	9	3
4	Type classes, Algebraic data types, Modules, Recursive data types. User defined data types, Records, Stacks, Queues, Binary trees, Constructors, Destructors.	9	4
5	Functor, Applicative functor, Monad. Programming with actions: Functions vs actions, Basics of input / output, the do notation, interacting with the command line and lazy I/O, File I/O.	9	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	40%
Analyse	40%
Evaluate	20%
Create	

Continuous Internal Evaluation Pattern (CIE): 40 Marks

Course based task: 15 marks Seminar/Quiz: 15 marks Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern (ESE): 60 marks

The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Five. Each question can carry 12 marks.

Text Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Introduction to Functional Programming using Haskell	Richard Bird	Prentice Hall Series in Computer Science	2nd Edition
2	Real World Haskell	Bryan O'Sullivan, Don Stewart, and John Goerzen	O'Reilly Media	2008

Reference Books

Sl. No	Title of the Book	Name of Author(s)	Name of Publisher	Edition and Year
1	Thinking Functionally with Haskell	Richard Bird	Cambridge University Press	2014
2	Haskell: The Craft of Functional Programming	Simon Thompson	Addison-Wesley	3rd Edition, 2011
3	Notes on Functional Programming with Haskell	H. Conrad Cunningham	—	2014
4	Programming in Haskell	Graham Hutton	Cambridge University Press	2nd Edition, 2016
5	Practical Haskell: A Real-World Guide to Functional Programming	Alejandro Serrano Mena	Apress	3rd Edition, 2022
6	Learn You a Haskell for Great Good! A Beginner's Guide	Miran Lipovaca	No Starch Press	2011

REUSE AND RECYCLE TECHNOLOGY

		CATEGORY	L	T	P	CREDIT
24SJ3AGE010	REUSE AND RECYCLE TECHNOLOGY	AUDIT COURSE	3	0	0	-

Preamble:

"Reuse and Recycle Technology" typically focuses on sustainable practices and technologies aimed at reducing waste, conserving resources, and promoting environmental responsibility.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Explain the principles and technologies behind waste reduction, resource conservation, and sustainable practices	K2
CO2	Describe and Analyse waste generation and management.	K4
CO3	Apply the knowledge of various reuse strategies and their application in different industries and analyse various recycling technologies	K3
CO4	Appraise the methods of E-waste management and Eco-friendly packaging	K3
CO5	Comprehend Environmental Regulations and Policies, Understand the importance of environmental regulations and policies in addressing environmental challenges	K2

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	-	-	3	-	-	-	-	-	1
CO2	-	-	-	3	-	-	-	1	-
CO3	-	-	-	3	-	-	-	1	-
CO4	-	-	-	-	3	-	-	-	1
CO5	-	-	3	-	-	-	-	-	1

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Introduction to Sustainability:** Understanding sustainability and its importance, The three pillars of sustainability: Environmental, Social, and Economic. Biodiversity conservation, Climate change and mitigation Sustainable resource management.	9	1
2	**Waste Management:** Definition and classification of waste, Waste Generation and Composition**,** Waste Collection and Transportation, Waste Segregation and Sorting. Waste Disposal Methods Historical perspectives on waste management, the three Rs: Reduce, Reuse, and Recycle.	9	2
3	**Recycling and Reuse**: Importance of reuse, Application of reuse in various industries, Challenges and opportunities in reuse, Overview of recycling technologies, Circular economy, Sorting and processing of recyclable materials, Advanced recycling methods. Emerging technologies in recycling.	9	3
4	**E-waste Recycling**: Challenges and environmental impact of electronic waste, E-waste recycling methods and regulations, Sustainable electronics design. **Sustainable Packaging:** Packaging materials and their environmental impact, Eco-friendly packaging alternatives, Packaging design for sustainability	9	4
5	**Environmental Regulations and Policies**: Understand the importance of environmental regulations and policies in addressing environmental challenges, National and international waste and recycling regulations, Compliance and enforcement, Industry standards and certifications	9	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Understand	60%
Apply	20%
Analyse	20%

Continuous Internal Evaluation Pattern (CIE): 40 Marks

Course based task: 15 marks Seminar/Quiz: 15 marks Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern (ESE): 60 marks

The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Five. Each question can carry 12 marks.

Text Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Sustainable Engineering: Concepts, Design and Case Studies	David T. Allen	Pearson Publication	2012
2	A Comprehensive Book on Solid Waste Management with Application	Dr. H.S. Bhatia	Misha Books	2019

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Cradle to Cradle: Remaking the Way We Make Things	William McDonough and Michael Braungart	Farrar, Straus and Giroux	2010
2	Recycling of Plastic Materials	Vijay Kumar Thakur (Ed.)	Smithers Information Limited	2015
3	E-waste: Implications, Regulations and Management in India and Current Global Best Practices	Rakesh Johri	TERI	2008
4	Sustainable Packaging	Subramanian Senthilkannan Muthu	Springer Nature	2021
5	Indian Environmental Law: Key Concepts and Principles	-	Orient BlackSwan Private Limited, New Delhi	-

EXPERT SYSTEMS

		CATEGORY	L	T	P	CREDIT
24SJ3AGE012	EXPERT SYSTEMS	AUDIT COURSE	3	0	0	-

Preamble:

The course aims to provide an understanding of the basic concepts of Artificial Intelligence (AI) and Expert Systems. The course also covers the knowledge representation in expert systems, classes of expert systems, applications of expert systems.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Explain the concepts of Artificial Intelligence and different ways of knowledge representations.	K2
CO2	Explain the components of expert systems, development stages of expert systems and tools available for expert system design.	K2
CO3	Apply the concept of knowledge representation in expert systems	K3
CO4	Differentiate the classes of expert systems and examine properties of existing systems	K3
CO5	Explain the application and limitations of expert system	K2

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	1	-	2	1	2	2	-	-	1
CO2	1	-	1	3	2	2	-	-	1
CO3	1	-	1	2	2	2	-	1	-
CO4	2	-	2	2	3	2	-	1	-
CO5	2	-	1	1	-	-	-	-	1

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Overview of Artificial Intelligence (AI):** Definition & Importance of AI. **Knowledge general concepts:** Definition and Importance of knowledge, Knowledge-Based Systems, Knowledge organization, Knowledge Manipulation and acquisition. **Knowledge Representation:** Introduction, Syntax and Semantics-Propositional logic and predicate logic.	9	1
2	Basic concepts of expert systems-Introduction to expert systems, Components of expert systems. Features of Expert System, Stages in the development of expert system, Types of tools available for expert system design.	9	2
3	**Knowledge representation in expert systems:** Structured Knowledge representation - Graphs, Frames and related structures, Associative networks, Conceptual dependencies, Examples of structured knowledge representation.	9	3
4	**Classes of expert systems:** Rule-based expert systems, Example- MYCIN, Frame-based expert system, terminologies, IF-THEN structure. Fuzzy and Neural network based expert systems (basic concepts)	9	4
5	Currents trends in expert systems, Advantages and limitations of expert systems, Applications of expert systems.	9	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Understand	60%
Apply	20%
Analyse	20%

Continuous Internal Evaluation Pattern (CIE): 40 Marks

Course based task: 15 marks Seminar/Quiz: 15 marks Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern (ESE): 60 marks

The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Five. Each question can carry 12 marks.

Text Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Artificial Intelligence	E. Rich & K. Knight	TMH, New Delhi	2/e, 2005
2	Artificial Intelligence	P.H. Winston	Pearson Edition, New Delhi	3/e, 2006

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Principles of AI & Expert System Development	D.W. Rolston	TMH, New Delhi	-
2	Artificial Intelligence (SIE)	Kevin Night, Elaine Rich, Nair B.	McGraw Hill	2010
3	Introduction to Artificial Intelligence and Expert Systems	Dan W Patterson	Prentice Hall of India Pvt. Ltd	2007
4	Artificial Intelligence - Modern Approach	Stuart Russel	Pearson Education series in AI	3rd Edition, 2009
5	Artificial Intelligence and Expert Systems	I. Gupta, G. Nagpal	Mercury Learning and Information	2020

SYSTEM MODELLING

		CATEGORY	L	T	P	CREDIT
223AGE011	SYSTEM MODELLING	AUDIT COURSE	3	0	0	-

Preamble:

Study of this course provides the learners a clear understanding of fundamental concepts in simulation and modelling. This course covers the different statistical models, importance of data collection and various types of simulations. The course helps the learners to find varied applications in engineering, medicine and bio-technology.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Analyse the requirement and find appropriate tool for simulation.	K3
CO2	Differentiate the different statistical models.	K2
CO3	Discuss the different techniques for generating random numbers.	K2
CO4	Analyse the different methods for selecting the different input models.	K3
CO5	Discuss the different measures of performance and their estimation	K2

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	2	-	1	1	2	-	-	1	-
CO2	2	-	1	1	1	-	-	-	1
CO3	1	-	-	-	-	-	-	-	1
CO4	1	-	1	1	-	-	-	1	-
CO5	2	-	1	1	1	-	-	1	-

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	When simulation is the appropriate tool. Advantages and disadvantages of Simulation; Areas of application, Systems and system environment; Components of a system; Discrete and continuous systems, Model of a system; Types of Models, Discrete-Event System Simulation, Steps of a simulation study.	9	1
2	Review of terminology and concepts, Useful statistical models, Discrete distributions. Continuous distributions, Poisson process, Empirical distributions. (basic idea only)	9	2
3	Properties of random numbers; Generation of pseudo- random numbers, Techniques for generating random numbers, Tests for Random Numbers	9	3
4	Data Collection; Identifying the distribution with data, Parameter estimation, Goodness of Fit Tests, fitting a non-stationary Poisson process, Selecting input models without data, Multivariate and Time-Series input models.	9	4
5	Measures of performance and their estimation, Output analysis for terminating simulations, Output analysis for steady-state simulations, Verification, calibration and validation	9	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Understand	60%
Apply	20%
Analyse	20%

Continuous Internal Evaluation Pattern (CIE): 40 Marks

Course based task: 15 marks Seminar/Quiz: 15 marks Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern (ESE): 60 marks

The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Five. Each question can carry 12 marks.

Text Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Discrete-Event System Simulation	Jerry Banks, John S. Carson II, Barry L. Nelson, David M. Nicol	Pearson Education	5th Edition, 2010

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Discrete – Event Simulation: A First Course	Lawrence M. Leemis, Stephen K. Park	Pearson Education	2006
2	Simulation Modeling and Analysis	Averill M. Law	Tata McGraw-Hill	4th Edition, 2007
3	System Modelling and Response	Ernest O. Doebelin	Not Specified	Not Specified
4	Simulation Modeling and Analysis	Averill M Law	McGraw-Hill Inc	2007
5	System Simulation	Geoffrey Gordon	Prentice Hall of India	1992

PRINCIPLES OF AUTOMATION

24SJ3AGE009	**PRINCIPLES OF AUTOMATION**	**CATEGORY**	**L**	**T**	**P**	**CREDIT**
		CREDIT COURSE	3	0	0	0

Preamble:

This course deals in detail with the various aspects of automation such as sensors, actuators, controllers, mechanical and electrical elements and their integration for automating new and existing manufacturing and process industries and applications. This course will be beneficial to students in designing automation schemes for industries and to design automated systems

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Explain the fundamentals of sensor systems and to choose a suitable sensor system for the given application based on the evaluation of the constraints.	**K2**
CO2	Explain the fundamentals of signal conditions and to design a suitable signal conditioning scheme for given application.	**K2**
CO3	Describe the characteristics of various actuator systems and to decide the right type of actuator for the given application.	**K2**
CO4	Describe the importance of an industrial robot and fundamentals of numerical control in automation.	**K2**
CO5	Explain the fundamentals of controllers used in industrial automation and to construct simple automation schemes by ladder logic programs.	**K3**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	2	-	2	2	2	-	-	-	1
CO2	2	-	2	2	2	-	-	-	1
CO3	2	-	2	2	2	-	-	-	1
CO4	2	-	2	2	2	-	-	1	-
CO5	2	-	2	-	-	-	-	1	-

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Introduction to Industrial Automation**: Basic Elements of an Automated System, Levels of Automation. Hardware components for Automation: Sensors, classification, Static and dynamic Behaviour of sensors. Basic working principle of different sensors: Proximity sensors, Temperature sensors, flow sensors, Pressure sensors, Force sensors. Position sensors	9	1
2	**Signal conditioning:** Need for signal conditioning, Types of signal conditioning.Signal conditioning using operational amplifier-Amplifier (Inverting and Non-inverting) and Filter circuits (Basic concepts). Design of first order low pass filter. Signal conditioning for data acquisition systems, anti-aliasing filters, Analog–Digital Conversions, Analog-to-Digital Converters (ADC)- Steps in analog-to-digital conversion, Successive Approximation Method, Digital-to-Analog Converters (DAC)- Steps in digital to analog conversion, Zero-order and first order data hold circuits	9	2
3	**Actuators:** Types of actuators- mechanical, electrical, pneumatic and hydraulic actuators (Basic working principle). Mechanical systems for motion conversion, transmission systems Solenoids, Electric and stepper motors control.	9	3
4	**Robotics and Automated Manufacturing Systems:** Robot Anatomy and Related Attributes: Joints and Links, Common Robot Configurations, Joint Drive Systems, Sensors in Robotics (Basic concepts). Robot Control Systems, Applications of Industrial Robots- Material handling Fundamentals of Numerical control (NC) Technology	9	4
5	**Discrete Control and Programmable Logic Controllers:** Discrete Process Control: Logic and Sequence control Ladder Logic Diagrams, Programmable Logic Controllers: Components of the PLC, PLC Operating Cycle, Programming the PLC (Basic concepts only) Introduction to Distributed control system (DCS) and Supervisory Control and Data Acquisition Systems (SCADA)	9	5

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	End Semester Examination
Understand	70%
Apply	30%

Continuous Internal Evaluation Pattern (CIE): 40 Marks

Course based task: 15 marks Seminar/Quiz: 15 marks Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern (ESE): 60 marks

The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Five. Each question can carry 12 marks.

Text Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Automation, Production Systems, and Computer-Integrated Manufacturing	Mikell Groover	Pearson	5th Edition, 2019

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Computer Control of Manufacturing Systems	Yoram Koren	Tata McGraw Hill	2005
2	Robotics Technology and Flexible Automation	S. R. Deb; Sankha Deb	McGraw-Hill Education: New York	Second Edition, 2010
3	Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering	W. Bolton	Prentice Hall	5th Edition, 2013
4	Measurement Systems: Applications and Design	Doebelin, E.O. and Manic, D.N.	McGraw Hill	7th Edition, 2019
5	Computer Based Industrial Control	Krishna Kant	EEE-PHI	2nd Edition, 2010
6	Sensors, Actuators, and Their Interfaces	Nathan Ida	IET Digital Library	2nd Edition,2020
7	Linear Integrated Circuits	Salivahanan, S., and VS Kanchana Bhaaskaran	McGraw-Hill Education	2nd Edition, 2014
8	Programmable Logic Controllers	Petruzella, Frank D.	Tata McGraw-Hill Education	2005
9	Standard Handbook of Industrial Automation	Chapman and Hall (Onsidine DM C & Onsidine GDC)	NJ	1986

FORENSIC ENGINEERING

24SJ3AGE002	FORENSIC ENGINEERING	CATEGORY	L	T	P	CREDIT
		Audit Course	3	0	0	-

Preamble:

This course explores various aspects of Forensic Engineering and different methods, tools and procedures used by Engineers to investigate and analyse. The students will learn to develop their awareness in Forensic Engineering.

Course Outcomes (COs)

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

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Identify the fundamental aspects of forensic Engineering	**K2**
CO2	Apply forensic Engineering in Practical work flow and Investigation	**K3**
CO3	Apply methods and analysis in Forensic Investigation	**K3**
CO4	Develop practical strategies and standards of Investigation	**K6**
CO5	Create an awareness in criminal cases and create Engineering expertise in court room on forensic Engineering	**K6**

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

CO-PO Mapping:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PSO 1	PSO 2
CO1	2	2	3	3	3	3	-	-	1
CO2	2	2	3	3	3	3	1	1	-
CO3	3	3	3	3	3	3	1	1	-
CO4	3	3	3	3	3	3	1	1	-
CO5	3	3	3	3	3	3	-	-	1

SYLLABUS

Module	Syllabus Description / Topic	Hours	CO
1	**Introduction to Forensic Engineering**: Forensic Engineering-Definition, Investigation Pyramid, Eyewitness Information, Role in Legal System; Scientific Method-Applying scientific methods in Forensic Engineering- Engineer as expert Witness-Scientific methods and legal system; Qualification of Forensic Engineer-Technical-Knowledge- Oral-written- Communication- other skills-Personality Characteristics; Ethics and professional responsibilities.	9	1
2	**Forensic Engineering Workflow and Investigation Methods:** Forensic Engineering Workflow-Team &planning-preliminary onsite investigation. Sampling-selection of sample-collection- packing-sealing of samples. Source and type of evidence - Paper documentation- digital documentation-electronic data. Physical Evidence-Collection of photograph-cataloguing -Recognizing the Evidence-organizing-Evidence Analysis -Reporting Investigation Methods- Cause and Causal mechanism analysis-Time and event sequence-STEP method. Human Factors, Human errors - Analysis of Operative Instruction and working Procedures	9	2
3	**Physical Product Failure & Analytical Methods:** Introduction to typical Forensic Engineering Tool box-NDT, Crack detection and human eye -Hardness testing- and Destructive testing Methods with case studies. Indirect stress strain Analysis-Brittle lacquer technique, Contact Radiography-Metallography-EDAX method. Forensic Optical Microscopy-Examination- Magnification-USB Microscopy -Wifi Enabled microscopy -Reflected microscopy. Novel Tools and System -Contour Method-Flash Thermography-Thermographic signal reconstruction (TSR)-Electromagnetically induced acoustic Emission (EMAE)-Pulsed Eddy Current (PEA)-Theory only	9	3
4	**Cyber Forensic, Civil ,Electrical Accidents & Standards:** Basics of Digital & Cyber forensics: Technical concepts; labs and tools; collecting evidence Operating System Forensic basics with - Windows, Linux -Mobile Forensic-Anti forensics-Malware- Web attack forensics with Email Crimes-Cyber Laws Different types of Forensic accident investigations- Civil Engineering-Structural- Road accidents -Fire accidents - Water related accidents-Electrical accidents and Investigation methods Protocol for forensic Investigations-Standard guides-scope significance -use -procedures- reports. Standards – ASTM standards -FMV Standards -SAE Standards -Relevant Standards -NFPA Standards -International Standards	9	4

5	**Engineer in the Court room& Criminal Cases:** Role of an Engineering Expert-Report-pre trial meetings-Alternative dispute resolution-Single joint expert. Engineer in the court room. Criminal Cases-Introduction-Counterfeit coins-fraudulent road accidents-Fraudulent Insurance claims. Cyber Crimes and Cases- SIM Swapping -ATM Cloning-Microsoft Internal Spam- Intellectual property cases.	**9**	**5**

Course Assessment

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Assessment Pattern

Bloom's Category	Continuous Internal Evaluation	End Semester Examination
Understand	40%	60%
Apply	40%	40%
Evaluate	20%	-

Continuous Internal Evaluation Pattern (CIE): 40 Marks

Course based task: 15 marks Seminar/Quiz: 15 marks Test paper, 1 no.: 10 marks
Test paper shall include minimum 80% of the syllabus.

End Semester Examination Pattern (ESE): 60 marks

The examination will be for 150 minutes and will contain 7 questions, with minimum one question from each module of which student should answer any Five. Each question can carry 12 marks.

Text Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Forensic Engineering: The Art & Craft of a Failure Detective	Colin R Gagg	Taylor & Francis Publishing	2020

Reference Books				
Sl. No	**Title of the Book**	**Name of Author(s)**	**Name of Publisher**	**Edition and Year**
1	Principles of Forensic Engineering Applied to Industrial Accidents	Luca Fiorentini, Luca Marmo	Wiley	2019
2	Forensic Engineering Fundamentals	Harold Franck, Darren Franck	Taylor & Francis Publishing	2013
3	Forensic Engineering Investigation	Randall K Noon	CRC Press Limited	2001
4	Forensic Engineering: Damage Assessment for Residential and Commercial Structures	Stephen E Petty	CRC Press	2nd Edition, 2017
5	Guidelines for Forensic Engineering Practice	Joshua B Kardon	ASCE	2012
6	Engineering Standards for Forensic Applications	Richard W. Mclay and Robert N. Anderson	Academic Press	1st Edition, 2018
7	Forensic Engineering (Advanced Forensic Science)	Max M Houck	Academic Press	1st Edition, 2017
8	Practical Cyber Forensics: An Incident-based Approach to Forensic Investigations	Niranjan Reddy	Apress	2019
9	Forensic Materials Engineering Case Studies	Peter Rhys Lewis, Ken Reynolds, Colin Gagg	CRC Press	2003

INTERNSHIP

A student shall opt for carrying out the Internship at an Industry/Research Organization or at another institute of higher learning and repute (Academia). The organization for Internship shall be selected/decided by the students on their own with prior approval from the faculty advisor/respective PG Programme Coordinator/Guide/Supervisor. Every student shall be assigned an internship Supervisor/Guide at the beginning of the Internship. The training shall be related to their specialisation after the second semester for a minimum duration of six to eight weeks. On completion of the course, the student is expected to be able to develop skills in facing and solving the problems experiencing in the related field.

Objectives

- Exposure to the industrial environment, which cannot be simulated in the classroom and hence creating competent professionals for the industry.
- Provide possible opportunities to learn understand and sharpen the real time technical / managerial skills required at the job.
- Exposure to the current technological developments relevant to the subject area of training.
- Create conducive conditions with quest for knowledge and its applicability on the job.
- Understand the social, environmental, economic and administrative considerations that influence the working environment.
- Expose students to the engineer's responsibilities and ethics.

Benefits of Internship Benefits to Students

- An opportunity to get hired by the Industry/ organization.
- Practical experience in an organizational setting & Industry environment.
- Excellent opportunity to see how the theoretical aspects learned in classes are integrated into the practical world. On-floor experience provides much more professional experience which is often worth more than classroom teaching.
- Helps them decide if the industry and the profession is the best career option to pursue.
- Opportunity to learn new skills and supplement knowledge.
- Opportunity to practice communication and teamwork skills.
- Opportunity to learn strategies like time management, multi-tasking etc in an

industrial setup.

- Makes a valuable addition to their resume.
- Enhances their candidacy for higher education/placement.
- Creating network and social circle and developing relationships with industry people.
- Provides opportunity to evaluate the organization before committing to a full time position.

Benefits to the Institute

- Build industry academia relations.
- Makes the placement process easier.
- Improve institutional credibility & branding.
- Helps in retention of the students.
- Curriculum revision can be made based on feedback from Industry/ students.
- Improvement in teaching learning process.

Benefits to the Industry

- Availability of ready to contribute candidates for employment.
- Year round source of highly motivated pre-professionals.
- Students bring new perspectives to problem solving.
- Visibility of the organization is increased on campus
- Quality candidate's availability for temporary or seasonal positions and projects.
- Freedom for industrial staff to pursue more creative projects.
- Availability of flexible, cost-effective workforce not requiring a long-term employer commitment.
- Proven, cost-effective way to recruit and evaluate potential employees.
- Enhancement of employer's image in the community by contributing to the educational enterprise.

Types of Internships

- Industry Internship with/without Stipend
- Govt / PSU Internship (BARC/Railway/ISRO etc)
- Internship with prominent education/research Institutes

- Internship with Incubation centres /Start-ups

Guidelines

- All the students need to go for internship for minimum duration of 6 to 8 weeks.
- Students can take mini projects, assignments, case studies by discussing it with concerned authority from industry and can work on it during internship.
- All students should compulsorily follow the rules and regulations as laid by industry.
- Every student should take prior permissions from concerned industrial authority if they want to use any drawings, photographs or any other document from industry.
- Student should follow all ethical practices and SOP of industry.
- Students have to take necessary health and safety precautions as laid by the industry.
- Student should contact his /her Guide/Supervisor from college on weekly basis to communicate the progress.
- Each student has to maintain a diary/log book
- After completion of internship, students are required to submit
    - Report of work done
    - Internship certificate copy
    - Feedback from employer / internship mentor
    - Stipend proof (in case of paid internship).

Total Marks 100: The marks awarded for the Internship will be on the basis of (i) Evaluation done by the Industry (ii) Students diary (iii) Internship Report and (iv) Comprehensive Viva Voce.

Continuous Internal Evaluation: 50 marks

Student's diary	- 25 Marks Evaluation done by
the industry	- 25 Marks

Student's Diary/ Daily Log: The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily training diary the day-to-day account of the observations,

impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily training diary should be signed after every day by the supervisor/ in charge of the section where the student has been working. The diary should also be shown to the Faculty Mentor visiting the industry from time to time and got ratified on the day of his visit. Student's

diary will be evaluated on the basis of the following criteria:

- Regularity in maintenance of the diary
- Adequacy & quality of information recorded
- Drawings, design, sketches and data recorded
- Thought process and recording techniques used
- Organization of the information.

The format of student's diary

Name of the Organization/Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From ..... To .....

Brief description about the nature of internship:

Day	Brief write up about the Activities carried out: Such as design, sketches, result observed, issues identified, data recorded, etc.
1	
2	
3	

Signature of Industry Supervisor *Signature of Section Head/HR Manager*

Office Seal

Attendance Sheet

Name of the Organization/Section:

Name and Address of the Section Head:

Name and Address of the Supervisor:

Name and address of the student:

Internship Duration: From ..... To .....

Month & Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	...
Month & Year																					
Month & Year																					

Signature of Industry Supervisor *Signature of Section Head/HR Manager*

Office Seal

Note:

- Student's Diary shall be submitted by the students along with attendance record and an evaluation sheet duly signed and stamped by the industry to the Institute immediately after the completion of the training.
- Attendance Sheet should remain affixed in daily training diary. Do not remove or tear it off.
- Student shall sign in the attendance column. Do not mark 'P'.
- Holidays should be marked in red ink in the attendance column. Absent should be marked as 'A' in red ink.

Evaluation done by the Industry (Marks 25)

Format for Supervisor Evaluation of Intern

Student Name :_____Date:_____

Supervisor Name :_____Designation:_____

Company/Organization :_____

nternship Address: _____

Dates of Internship: From_____To _____

Please evaluate intern by indicating the frequency with which you observed the following parameters:

Parameters	**Marks**			
	Needs improvement (0 – 0.25 mark)	Satisfactory (0.25 – 0.50 mark)	Good (0.75 mark)	Excellent (1 mark)
Behavior				
Performs in a dependable Manner				
Cooperates with coworkers and supervisor				
Shows interest in work				
Learns quickly				
Shows initiative				
Produces high quality work				
Accepts responsibility				
Accepts criticism				
Demonstrates organizational skills				
Uses technical knowledge and expertise				
Shows good judgment				
Demonstrates creativity/originality				
Analyzes problems effectively				
Is self-reliant				
Communicates well				
Writes effectively				
Has a professional attitude				
Gives a professional appearance				
Is punctual				
Uses time effectively				

Overall performance of student

Intern (Tick one) : Needs improvement (0 - 0.50 mark) / Satisfactory (0.50 – 1.0 mark) / Good (1.5 mark) / Excellent (2.0 mark)

Additional comments, if any (2 marks) :

Signature of Industry Supervisor *Signature of Section Head/HR Manager*

Office Seal

End Semester Evaluation (External Evaluation): 50 Marks

Internship Report	-	25 Marks
Viva Voce	-	25 Marks

Internship Report: After completion of the internship, the student should prepare a comprehensive report to indicate what he has observed and learnt in the training period and should be submitted to the faculty Supervisor. The student may contact Industrial Supervisor/ Faculty Mentor for assigning special topics and problems and should prepare the final report on the assigned topics. Daily diary will also help to a great extent in writing the industrial report since much of the information has already been incorporated by the student into the daily diary. The training report should be signed by the Internship Supervisor, Programme Coordinator and Faculty Mentor.

The Internship report (25 Marks) will be evaluated on the basis of following criteria:

- Originality
- Adequacy and purposeful write-up
- Organization, format, drawings, sketches, style, language etc.
- Variety and relevance of learning experience
- Practical applications, relationships with basic theory and concepts taught in the course

Viva Voce (25 Marks) will be done by a committee comprising Faculty Supervisor, PG Programme Coordinator and an external expert (from Industry or research/academic Institute). This committee will be evaluating the internship report also.

RESEARCH PROJECT/DISSERTATION

Research Project: Students choosing track 2 shall carry out the research project in their parent Institution only under the guidance of a supervisor assigned by the DLAC.

Dissertation: All categories of students in track 1 are to carry out the dissertation in the Institute they are studying or can work either in any CSIR/Industrial R&D organization/any other reputed Institute which have facilities for dissertation work in the area proposed.

Mark Distribution:

Phase 1: Total marks: 100, only CIA

SEMESTER IV

SEMESTER – IV							
SLOT	**COURSE CODE**	**COURSE NAME**	**MARKS**		**L-T-P**	**HOURS**	**CREDIT**
			CIA	**ESE**			
TRACK 1							
A	24SJ4PPE100	DISSERTATION PHASE II	100	100	0-0-24	24	16
TRACK 2							
A	24SJ4PPE001	RESEARCH PROJECT PHASE II	100	100	0-0-24	24	16
Total			100	100		24	16

Teaching Assistance: 5 hours

DISSERTATION PHASE II

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
24SJ4PBT100	DISSERTATION PHASE II	Project Work	0	0	24	16

All categories of students in track 1 are to carry out the DISSERTATION PHASE II in the institute they are studying or in any Industrial/ R&D organization/any other reputed institute which have facilities for dissertation work in the area proposed. DISSERTATION PHASE II shall not compulsorily continuation of DISSERTATION PHASE I. The student has to publish a research article in a conference or a reputed journal before appearing for the end-semester examination. The eligibility criteria for registering to the end semester examination are attendance in the course and no pending disciplinary action. The minimum attendance for appearing for the end semester examination is 75%. Students who do not meet these eligibility criteria are ineligible (identified by FE grade) to appear for the ESE. Students, who have completed a course but could not appear for the end semester examination, shall be awarded 'AB' Grade, provided they meet other eligibility criteria The pass minimum for the course is 45% for ESE and 50% for (CIA and ESE) put together.

Continuous Internal Assessment (CIA) Total Marks: 100

The evaluation committee comprises

1- Project Coordinator(s)
2- A Senior faculty member
3- Supervisor of the student

Pattern (CIA)

Zeroth evaluation by the Evaluation Committee	-
Interim evaluation by the Evaluation Committee	30 marks
Final evaluation by the Evaluation Committee	50 marks
Project progress evaluation by supervisor	20 marks

Evaluation by the supervisor

The guide/supervisor shall monitor the progress being carried out by the student on a regular basis. In case it is found that progress is unsatisfactory it shall be reported to the Department Evaluation Committee for necessary action.

Student's Diary/ Log book: The main purpose of writing diary/log book is to cultivate the habit of documenting and to encourage the students to search for details. The activity diary shall be signed after every week by the supervisor.

End Semester Evaluation (ESE) Total Marks: 100

The evaluation committee comprises

1- Project Coordinator(s)

2- An external expert (from Industry or research/academic institute)

3- Supervisor of the student

Pattern (ESE)

1. **Innovation and Originality (10 marks):**

   Assessment of the uniqueness and innovation demonstrated in the project work. Original contributions, if any, to the field or problem area.

2. **Implementation and Execution (20 marks):**

   Evaluation of the actual implementation or execution of the project, including: Quality of work done

   Demonstrated skills and techniques applied Adherence to project timelines and milestones

3. **Project Documentation (25 marks):**

   Comprehensive project report evaluation including: Introduction and problem statement

   Literature review Methodology and approach Results and analysis

   Conclusion and recommendations References and citations

   Details of the publications Plagiarism certificate

   The Plagiarism level in the project report shall be less than 25%.

4. **Presentation and Defence (40 marks):**

   Oral presentation of the project to a panel of examiners, including: Clarity and effectiveness of the presentation

   Ability to explain the project objectives, methodologies, and findings Handling questions and providing satisfactory answers during the defence

5. **Publication of the work either in a conference or in a journal (5 marks)**

SYLLABUS:

DETAILS	HOURS
1. `Literature study/survey of published literature on the assigned topic 2. Topic Selection and Proposal 3. Formulation of objectives 4. Research and Planning 5. Formulation of work plan and task allocation. 6. Execution 7. Documentation and Reporting 8. Project Showcase reflecting on the project experience and lessons learned	200

Dissertation outside the Institute: For doing dissertation outside the Institution, the following conditions are to be met:

i. They have completed successfully the course work prescribed in the approved curriculum up to the second semester.
ii. The student has to get prior approval from the DLAC and CLAC.
iii. Facilities required for doing the dissertation shall be available in the Organization/Industry (A certificate stating the facilities available in the proposed organization and the time period for which the facilities shall be made available to the student, issued by a competent authority from the Organization/Industry shall be submitted by the student along with the application).
iv. They should have an external as well as an internal supervisor. The internal supervisor should belong to the parent institution and the external supervisor should be Scientists or Engineers from the Institution/Industry/ R&D organization with which the student is associated for doing the dissertation work. The external supervisor shall be with a minimum post graduate degree in the related area.
v. The student has to furnish his /her monthly progress as well as attendance report signed by the external supervisor and submit the same to the concerned internal supervisor.
vi. The external supervisor is to be preferably present during all the stages of evaluation of the dissertation.