Discipline: Mechanical Engineering

Stream: Industrial Automation and Robotics (IAR)

Semester I

CODE	COMPUTATIONAL METHODS FOR ENGINEERS	CATEGORY	L	T	P	CREDIT
J1PIAT101		Discipline Core	3	0	0	3

Preamble:

Numerical simulations are the most reliable tool of mechanical engineers to solve the problems in the domain and advanced computational methods are a critical component of that. This course targets to introduce the advanced numerical techniques required to solve the mechanical engineering problems.

Course Outcomes:

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

CO 1	Solve system of equations using numerical techniques
CO 2	Apply numerical schemes to integrate, differentiate and curve fit
CO 3	Determine solutions of ODE and PDE using computational methods
CO 4	Formulate a Mechanical Engineering problem and solve that using computer based numerical procedure and submit micro-project
CO 5	Apply two different numerical methods to solve (manual/computer) a problem and compare the merits and demerits of those schemes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3	2	3	2
CO 2			3	2	3	2
CO 3			3	2	3	2
CO 4	3	2		2	3	2
CO 5	2	2		2	3	2

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 40 Marks

Micro project/Course based project: 20 marks

(Formulate a mechanical engineering problem and solve that using computer based numerical procedure and submit as project. The project shall be done individually. Group projects not permitted.)
Course based task (programming)/Seminar/Quiz: 10 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.

Model Question paper

QP Code: **Total Pages:**

Reg No.:_____ **Name:**_____

JYOTHI ENGINEERING COLLEGE (AUTONOMUS)
FIRST SEMESTER M.TECH DEGREE EXAMINATION, Month & Year
Discipline: Mechanical Engineering
Course Code: J1PIAT101
Course Name: Computational Methods for Engineers

Max. Marks: 60 **Duration: 2.5 Hours**

PART A

Answer all questions, each carries 5 marks. **Marks**

1 Use Gauss elimination to solve $3x_1 - 0.1x_2 - 0.2x_3 = 7.85$
$0.1x_1 + 7x_2 - 0.3x_3 = -19.3$
$0.3x_1 - 0.2x_2 + 10x_3 = 71.4$ **(5)**

2 Explain the procedure of Newton-Raphson method and draw a flowchart. **(5)**

3 Explain the Trapezoidal rule and derive the equation for the same. **(5)**

4 Use the classical fourth-order RK method to integrate $f(x, y) = -2x^3 + 12x^2 - 20x + 8.5$ using a step size of h = 0.5 and an initial condition of y = 1 at x = 0. **(5)**

5 Write a short note on any simple implicit method. **(5)**

PART B
Answer any 5 full questions, each question carries 7 marks.

6 Use Newton- Raphson method to determine a root of the equation
$f(x) = x^3 - 13x - 12$ **(7)**

7 Given these data, **(7)**

x	1.6	2	2.5	3.2	4	4.5
f(x)	2	8	14	15	8	2

Calculate f(2.8) using Newton's interpolating polynomials of order 1 through 3. Choose the sequence of the points for your estimates to attain the best possible accuracy.

8 Evaluate the following integral:

$$\int_0^{\pi/2} (6 + 3\cos x)\, dx$$ **(7)**

(a) single application of Simpson's 1/3 rule
(b) multiple-application Simpson's 1/3 rule, with n = 4. **(7)**

9 Solve the following initial value problem over the interval from t = 0 to 2 where y(0) = 1. Display all your results on the same graph.

$\frac{dy}{dt} = yt^2 - 1.1y$ **(7)**

(a) Euler's method with h = 0.5 and 0.25.
(b) Fourth-order RK method with h = 0.5. **(7)**

10 Use the shooting method to solve $7\, d^2y/dx^2 - 2\, dy/dx - y + x = 0$ with the boundary conditions y(0) = 5 and y(20) = 8.

11

Use Liebmann's method (Gauss-Seidel) to solve for the temperature of the heated plate in figure. Employ overrelaxation with a value of 1.5 for the weighting factor and iterate to es
$\varepsilon_S = 1\%$.

2 Use the simple implicit method to solve for the temperature distribution of a long, thin rod **(7)**

with a length of 10 cm and the following values: $k' = 0.49$ cal/(s . cm . °C), $\Delta x = 2$ cm, and $\Delta t = 0.1$ s. At t =- 0, the temperature of the rod is zero and the boundary conditions are fixed for all times at T(0) = 100°C and T(10) = 50°C. Note that the rod is aluminium with C = 0.2174 cal/(g . °C) and $\rho = 2.7$ g/cm^3 . Therefore, k = 0.49/ (2.7 . 0.2174) 5 0.835 cm^2 /s and $\lambda = 0.835(0.1)/(2)^2 = 0.020875$.

Syllabus

Module 1

Introduction to Computational methods, system of equations-Revision – Formulation of engineering problems and solution using computational methods; significant figures, accuracy, precision, round off error, truncation error, Taylor series expansion of a polynomial. Roots of equation – Bisection, Newton-Raphson, and Bairstow methods. Linear algebraic equations – Gauss Elimination method, LU decomposition. Non- linear equation- Gauss-Jordan method, Newton- Raphson for simultaneous equations. Case studies with computer programs (Python/Scilab/ C++/Fortran/other).

Module 2

Curve fitting- Linear regression- linearization of non linear relation, linear least squares, multiple linear regression. Non linear regression- polynomial regression, Gauss- Newton method. Case studies with computer programs (Python/Scilab/ C++/Fortran/other).

Module 3

Numerical differentiation and integration- Derivatives- Newton's forward, backward, divided difference and Sterling formula. Integration -Trapezoidal rule, Simpsons one third, Simpsons three eighth, Gauss quadrature-two & three point. Case studies with computer programs (Python/Scilab/ C++/Fortran/other).

Module 4

Numerical solutions to ordinary differential equations- Taylors method, Eulers method, Runge-Kutta method fourth order, simultaneous first order, Milne's predictor corrector. Initial value problem – shooting method, Eigen values – polynomial method, power method. Case studies with computer programs (Python/Scilab/ C++/Fortran/other).

Module 5

Solution of partial differential equation & Interpolation-

Interpolation – Newtons forward and backward, divided difference linear & quadratic, Lagrange interpolation, cubic splines, Hermites interpolation. Solution of partial differential equation – Difference equations, Elliptic equation- Laplace equation, Poisson equation, Liebmann's iterative methods, Parabolic equation- Bender-Schmidt method, simple implicit, Crank- Nicolson scheme, Solution of hyperbolic equation. Case studies with computer programs (Python/Scilab/ C++/Fortran/other).

Course Plan

No	Topic	No. of Lectures – 40 Hrs
1	**Introduction to Computational methods, system of equations**	
1.1	Revision – Formulation of engineering problems and solution using computational methods; significant figures, accuracy, precision, round off error, truncation error, Taylor series expansion of a polynomial	2
1.2	Roots of equation - Bisection, Newton Raphson, and Bairstow methods	2
1.3	Linear algebraic equations – Gauss Elimination method, LU decomposition. Non- linear equation- Gauss-Jordan method, Newton- Raphson for simultaneous equations	3
1.4	Case studies with computer programs (Python/Scilab/ C++/Fortran/other) (Not for End Semester Examination)	2
2	**Curve fitting**	
2.1	Linear regression- linearization of non linear relation, linear least squares, multiple linear regression	2
2.2	Non linear regression- polynomial regression, Gauss- Newton method	3
2.3	Case studies with computer programs (Python/Scilab/C++/Fortran/other) (Not for End Semester Examination)	2

3	**Numerical differentiation and integration**	
3.1	Derivatives - Newton's forward, backward, divided difference and Sterling formula	3
3.2	Integration -Trapezoidal rule,Simpsons one third, Simpsons three eighth, Gauss quadrature-two & three point.	3
3.3	Case studies with computer programs (Python/Scilab/ C++/Fortran/other) (Not for End Semester Examination)	2
4	**Numerical solutions to ordinary differential equations**	
4.1	Taylors method, Eulers method, Runge-Kutta method fourth order, simultaneous first order, Milne's predictor corrector	3
4.2	Initial value problem – shooting method, Eigen values -polynomial method, power method	3
4.3	Case studies with computer programs (Python/Scilab/C++/Fortran/other)(Not for End Semester Examination)	2
5	**Solution of partial differential equation & Interpolation**	
5.1	Interpolation – Newtons forward and backward, divided difference linear & quadratic, Lagrange interpolation, cubic splines, Hermites interpolation	3
5.2	Solution of partial differential equation - Difference equations, Elliptic equation- Laplace equation, Poisson equation, Liebmann's iterative methods, Parabolic equation- Bender-Schmidt method, simple implicit, Crank-Nicolson scheme, Solution of hyperbolic equation	3

5.3	Case studies with computer programs (Python/Scilab/ C++/Fortran/other) (Notfor End Semester Examination)	2

Reference Books

1. Steven C. Chapra, Raymond P Canale, Numerical Methods for Engineering, 8e, Mc-Graw Hill Education (2020)
2. B.S. Grewal, numerical methods in engineering science with programs in C, C++ and MATLAB(10th edition) Khanna Publisher (2020)
3. E Balaguruswamy, Numerical Methods, McGraw Hill (2017)
4. P. Kandasamy , K. Thilagavathy and K. Gunavathy., Numerical Methods, S Chand & Co Ltd (2016)
5. S. P. Venkateshan, Prasanna Swaminathan, Computational Methods in Engineering, Ane Books (2014)
6. VN Vedamurthy & SN Iyengar, Numerical Methods, S Chand & Co Ltd (2014)
7. AK Jaiswal and Anju Khandelwal, Computer Based Numerical and Statistical Techniques, New Age International (2009)
8. Gilbert Strang, Computational Science and Engineering, Wellesley-Cambridge Press (2007)
9. Joe D Hoffman, Numerical Methods for Engineers and Scientists, Second Edition, Marcel Dekker (2001)

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
J1PIAT102	ROBOTICS AND AUTOMATION	PROGRAMME CORE	3	0	0	3

Preamble: Nil

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

CO 1	Understand the basics about an industrial robot and to perform basic transformations of robot frames
CO 2	Perform forward and inverse kinematics of industrial robots
CO 3	Perform velocity and force analysis of industrial robots
CO 4	Control the trajectory of industrial robots and to program the robot
CO 5	Understand the industrial applications of robots.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	✓	✓		
CO 2	✓	✓	✓			
CO 3	✓	✓	✓	✓		
CO 4	✓	✓	✓	✓		
CO 5	✓	✓	✓			

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Micro project/Course based project: 20 marks

Course based task/Seminar/Quiz: 10 marks

Test paper, 1 no.: 10 marks

End Semester Examination Pattern:

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.

MODEL QUESTION PAPER

ROBOTICS AND AUTOMATION

PART A

(Answer all the questions. Each question carries 5 Marks)

1. A frame {B} is rotated relative to a frame {A} about Z by 30^o and translated 10 units in X_A and 5 units in Y_A . Find ${}^AP$ where ${}^BP= [3,7,0]^T$.

2. Explain the joint parameters according to D-H convention.

3. Explain the concept of manipulator jacobians.

4. What is powered lead through programming?

5. Write any four applications of robots in industries

PART B

(Answer any 5 questions. Each carry 7 Marks)

6. Explain the working principle of laser range meter.

7. Assign frames and derive the forward kinematics for the following robot configuration

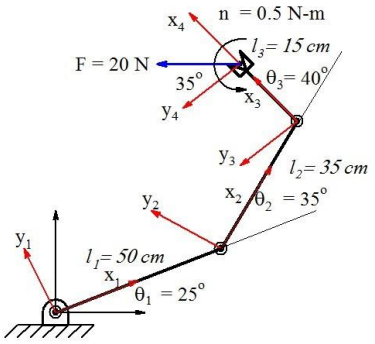
8. Calculate the inverse kinematics of a 3 link planar manipulator whose Forward kinematics and the desired position and orientation of the end effector are given by

$$B \begin{bmatrix} C_{123} & -S_{123} & 0 & C_1L_1 + L_2C_{12} + L_3C_{123} \\ S_{123} & C_{123} & 0 & L_1S_1 + L_2S_{12} + L_3S_{123} \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 0.951 & 0.309 & 0 & 0.2116 \\ -0.309 & 0.951 & 0 & 0.4799 \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

$$W^T = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$$

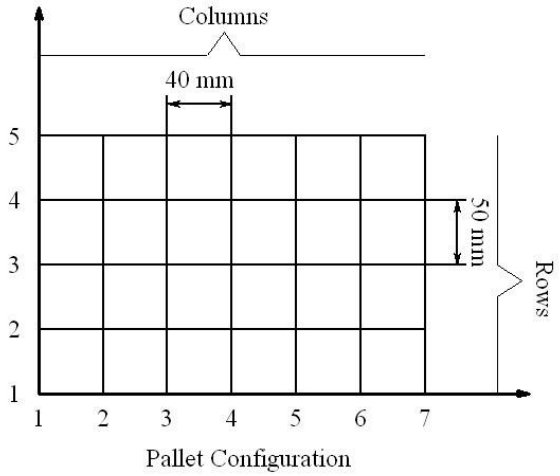
9. A 3 link planar robot is shown below. Calculate the forces and moments propagated from the tip to the base of the robot. Also determine the joint

torques.



10 A single-link robot with a rotary joint is motionless at θ = -5°. It is desired to move the joint in a smooth manner to θ = 80° in 4 seconds and stop smoothly. Compute the corresponding parameters of a linear trajectory with parabolic blends. Plot the position, velocity, and acceleration of the joint as a function of time

11 A robot is to be programmed to pick up parts from an input chute; and place them on a pallet with 35 positions. When a start signal is given, the robot begin picking up the parts and loading them into the pallet, continuing until all 35 positions on the pallet are filled. The robot then generate a signal to indicate that the pallet is full and wait for the start of the next cycle.



12 What are required features for an arc welding robot?

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Introduction to robotics-Classification and structure of robots, Drives systems: AC and DC servo motors, Stepper motors, Pneumatic and Hydraulic actuators, Sensors: Proximity sensors, range sensors, Encoders, Force and torque sensors, Vision sensors, basic control schemes, Spatial descriptions and transformations: Basic rotation matrices, general transformations, Workspace analysis, Euler angles	**8**	**20**
II	Forward Kinematics: DH Convention for affixing frames to links, Link parameters, Derivation of direct kinematic equations, Inverse manipulator kinematics, Solvability, algebraic and geometric solutions, Piper's solution when three axes intersect, Repeatability and accuracy	**8**	**20**
III	Velocities and static forces- Linear and rotational velocity of rigid bodies, Velocity propagation from link to link, Jacobians, Singularities, Static forces in manipulators, Jacobians in force domain, Cartesian transformation of velocities and static forces	**8**	**20**
IV	Trajectory generation: General considerations in path descriptions and generation, Joint space schemes, Cubic polynomials, Linear function with parabolic blends, Cartesian space schemes, Robot programming: Teach by showing, Textual Language Programming using AL, AML, VAL etc.,	**8**	**20**
V	Industrial applications: Spray painting, Spot welding, Arc welding, drilling, Assembly operations, loading unloading, Role of a robot in a manufacturing cell, Safety considerations.	**8**	**20**

Course Plan

No	Topic	No. of Lecture Hours
1	**Introduction to Robotics**	
1.1	Classification and structure of robots	1
1.2	Drives systems: AC and DC servo motors, Stepper motors, Pneumatic and Hydraulic actuators	1
1.3	Sensors: Proximity sensors, range sensors	1
1.4	Force and torque sensors, Vision sensors, encoders	1
1.5	Tactile sensors and basic control schemes	1
1.6	Basic rotation matrices, general transformations	2
1.7	Workspace analysis. Euler angles	1
2	**Forward and Inverse kinematics**	
2.1	DH Convention for affixing frames to links, Link parameters	2
2.2	Derivation of direct kinematic equations	2
2.3	Inverse manipulator kinematics, Solvability, algebraic and geometric solutions	2
2.4	Piper's solution when three axes intersect, Repeatability and accuracy	2
3	**Velocities and Static forces**	
3.1	Linear and rotational velocity of rigid bodies,	1
3.2	Velocity propagation from link to link	2
3.3	Jacobians, Singularities, Static forces in manipulators	2
3.4	Jacobians in force domain	1
3.5	Cartesian transformation of velocities and static forces	2
4	**Trajectory generation and Robot programming**	

4.1	General considerations in path descriptions and generation.	1
4.2	Joint space schemes, Cubic polynomials, Linear function with parabolic blends	2
4.3	Cartesian space schemes	2
4.4	Robot programming: Teach by showing,	1
4.5	Textual Language Programming using AL, AML, VAL etc.,(include sample programs)	2
5	**Industrial Applications of Robots**	
5.1	Spray-painting, Spot-welding robots	2
5.2	welding, drilling, Assembly operations using industrial robots	2
5.3	loading unloading, Role of a robot in a manufacturing cell	2
5.4	Safety considerations, precautions, and protective measures	2

Reference Books

1. John J Craig, Introduction to Robotics, Mechanics and Control, Third edition, Pearson Education International, 2005
2. Mark W. Spong & M. Vidyasagar, Robot Dynamics and Control, John Wiley & Sons, 2004
3. Mikell P. Groover et al, “Industrial Robots-Technology, Programming and Application”, McGraw Hill Publishing Company-2013.
4. Yoram Koran, “Robotics for Engineers”, McGraw-Hill International Student Edition, 2009

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
J1PIAT103	CAD/CAM	PROGRAME CORE	3	0	0	3

Preamble: Nil

Course Outcomes: The COs shown are only indicative. For each course, there can be 4 to 6 COs.

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

CO 1	Understand the basic concepts of CAD
CO 2	Impact general Awareness on components of geometric modelling.
CO 3	Identify the basic concepts of solid modelling and its applications
CO 4	Solve problems raised in engineering using CAD
CO 5	Apply knowledge in Assembling solid models in manufacturing process

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	✓		✓	
CO 2	✓	✓	✓		✓	
CO 3	✓	✓	✓			
CO 4	✓	✓	✓			
CO 5	✓	✓	✓			

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

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 Pattern:

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.

Model Question paper
CAD/CAM
PART A

(Answer all the questions. Each question carries 5 Marks)

1. Compare conventional and Computer Aided design process
2. Explain the basic transformations in CAD
3. Describe the functions of user interface for solid modelling
4. Explain the parametric modelling Process.
5. List out the various mating conditions in assembly modelling and explain with neat sketches.

PART B

(Answer any 5 questions. Each carry 7 Marks)

6 Draw layout representing hardware details in a CAD work station and elucidate.

7 Find the coordinates of a reflected triangle having vertices (2,4), (4,3) and (3,7) about an arbitrary line represented by y= 2x+2. Plot the transformed triangle.

8 A square having coordinates (2,2), (5,2), (5,4) and (2,4) is to be rotated about the point (2,2) in clockwise direction at an angle 60^{o} and after that it is scaled to 3 unit in X direction and 2 unit in Y direction. Find and plot the final coordinates of the geometry.

9 Describe Regularized Boolean set operations with examples.

10 Explicate any one hidden line removing algorithm with examples.

11 Define IGES? Describe its file structure.

12 Explain the top down assembly approach with an example.

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Overview of cad systems: Conventional and computer aided design process, subsystems of CAD hardware and software, Analytical and Graphics packages, CAD workstations. Networking of CAD systems, generative, cognitive and image processing graphics static and dynamic data graphics. Transport of graphic data.	8	20
II	Output primitives (points, lines, curves etc.,), 2-D & 3-D transformation (Translation, scaling, rotation) windowing - view ports - clipping transformation. Introduction to curves - Analytical curves: line, circle and conics – synthetic curves: Hermite cubic spline- Bezier curve and B-Spline curve. Introduction to surfaces - Analytical surfaces: Plane surface, ruled surface, surface of revolution and tabulated cylinder – synthetic surfaces: Hermite bicubic surface- Bezier surface and B- Spline surface	8	20
III	Solid modelling: Regularized Boolean set operations - primitive instancing - sweep representations - boundary representations – constructive solid Geometry - comparison of representations - user interface for solid modelling.	8	20
IV	Visual Realism: Hidden – Line – Surface – solid removal algorithms shading – colouring. Introduction to parametric and variational geometry-based software's and their principles, creation of prismatic and lofted parts using these packages.	7	20
V	Assembly modelling: interferences of positions and orientation - tolerances analysis – mass property calculations - mechanism simulation. Graphics and computing standards– Open GL Data Exchange standards – IGES, STEP etc– Communication standards.	8	20

Course Plan (For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30 hours).

No	Topic	No. of Lectures
1	**Overview of CAD systems**	
1.1	Overview of cad systems: Conventional and computer aided design process, subsystems of CAD hardware and software, Analytical and Graphics packages, CAD workstations.	3
1.2	Networking of CAD systems, generative, cognitive and image processing graphics static and dynamic data graphics	3
1.3	Transport of graphic data.	2
2	**Output primitives Curves and Surfaces**	
2.1	Output primitives (points, lines, curves etc.,), 2-D & 3-D transformation (Translation, scaling, rotation) windowing - view ports - clipping transformation.	3
2.2	Introduction to curves - Analytical curves: line, circle and conics – synthetic curves: Hermite cubic spline- Bezier curve and B-Spline curve	3
2.3	Introduction to surfaces - Analytical surfaces: Plane surface, ruled surface, surface of revolution and tabulated cylinder – synthetic surfaces: Hermite bicubic surface- Bezier surface and B-Spline surface.	2
3	**Solid modelling**	
3.1	Regularized Boolean set operations - primitive instancing.	2
3.2	Sweep representations - boundary representations.	2
3.3	Constructive solid Geometry - comparison of representations	2
3.4	User interface for solid modelling.	2
4	**Visual Realism**	
4.1	Hidden – Line – Surface – solid removal algorithms shading – colouring.	3
4.2	Introduction to parametric and variational geometry-based software's and their principles.	2
4.3	creation of prismatic and lofted parts using these packages.	2
5	**Assembly modelling**	

5.1	Assembly modelling: interferences of positions and orientation.	2
5.2	Tolerances analysis, mass property calculations, mechanism simulation.	2
5.3	Graphics and computing standards– Open GL Data Exchange standards – IGES, STEP etc– Communication standards.	4

Reference Books

1. David F. Rogers, James Alan Adams "Mathematical elements for computer graphics" second edition, Tata McGraw-Hill edition.2003
2. Donald Hearn and M. Pauline Baker "Computer Graphics", Prentice Hall, Inc., 1992.
3. Foley, Wan Dam, Feiner and Hughes – Computer graphics principles & practices, Pearson Education – 2003.
4. Ibrahim Zeid Mastering CAD/CAM – McGraw Hill, International Edition, 2007.
5. William M Neumann and Robert F.Sproull "Principles of Computer Graphics", McGraw Hill Book Co. Singapore, 1989.

PROGRAM ELECTIVE I

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
J1PIAT114	COMPOSITE MATERIALS	PROGRAMME ELECTIVE 1	3	0	0	3

Preamble: Nil

Course Outcomes: The COs shown are only indicative.

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

CO 1	Summarize the significance of advanced materials
CO 2	Compare the set of technological properties of the advanced materials with the conventional materials.
CO 3	Distinguish the construction, constituent's phases & characteristics of the composite materials.
CO 4	Extract the fabrication techniques of different types of composite materials
CO 5	Select and apply the appropriate polymer matrix composites material for recent industrial applications.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	✓		✓	
CO 2	✓	✓	✓		✓	
CO 3	✓	✓	✓			
CO 4	✓	✓	✓			
CO 5	✓	✓	✓			

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

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. (Test paper shall include minimum 80% of the syllabus): 10 marks

End Semester Examination Pattern:

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.

Model Question Paper

COMPOSITE MATERIALS

PART A

(Answer all the questions. Each question carries 5 Marks)

1. Classify composite materials based on reinforcement.
2. Differentiate short and continuous fibers.
3. What are the advantages of PMC'S over MMC's
4. Differentiate CVD & CVI
5. List down some of the applications of nano composites.

PART B

(Answer any 5 questions. Each carry 7 Marks)

6 Explain in details, the different types of reinforcements in Composite materials. List out the advantages and applications of each.

7 With the help of a neat sketch, explain the fabrication of Carbon – glass – carbon fiber reinforced epoxy hybrid composite.

8 Explain the process of rotational moulding with neat sketch.

9 With the help of neat sketch, explain hand layup and spray layup techniques of polymer matrix composites.

10 Explain the process of diffusion bonding in the manufacturing of MMC's.

11 Explain the environmental advantage of using natural fibers as the reinforcement.

12 Explain with neat sketch the manufacturing of a surface metal matrix composite.

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Introduction to Composites: Matrices, Reinforcements, Classifications, Applications, Comparison with Metals and Importance over other materials, design fabrication and economic consideration, General requirements. Classification of composites based on reinforcement and matrix, Classification of Reinforcement, Form and functions of reinforcement, Functions of matrices. Dispersion strengthened, particle strengthened and fiber-reinforced composites.	8	20
II	Strengthening mechanisms, Aspect Ratio, Rule of Mixture, discontinuous and continuous fiber composites and their comparison, Characteristics and materials of reinforcements and matrices. Critical Fiber Length, Short and Continuous Fibres, Fibre Orientation. Major composite classes: polymer matrix, metal matrix, ceramic matrix, carbon-carbon, and intermetallic composites. Hybrid composites, Laminated composites. Examples of each class of composites.	7	20
III	Manufacturing of Polymer matrix composites (PMC)Hand and spray lay - up, injection molding, resin injection, filament winding, pultrusion, centrifugal casting, Rotational	8	20

	moulding and prepregs. Fibre/Matrix Interface. Measurement of interface strength. Characterization of systems; carbon fibre/epoxy, glass fibre/polyester, etc.		
IV	Fabrication of CMC's: Hot-Pressing, Infiltration, In Situ Chemical Reaction Techniques. CVD & CVI, Sol-gel. Fabrication of MMC'S: Liquid Infiltration-Casting, Solid State Processes-Diffusion Bonding & In Situ Technique.	8	20
V	Applications of advanced composite materials. Environmental effects in Composites, Green composites, Synthesis and Properties of Nanocomposites. Surface Composites & Surface metal matrix composites: Need, Synthesis, Properties, and applications	8	20

Course Plan

No	Topic	No. of Lectures
1	**Introduction to Composites**	
1.1	Matrices, Reinforcements, Classifications, Applications, Comparison with Metals and Importance over other materials, design fabrication and economic consideration, General requirements	2
1.2	Classification of composites based on reinforcement and matrix	2
1.3	Classification of Reinforcement, Form and functions of reinforcement, Functions of matrices	2
1.4	Dispersion strengthened, particle strengthened and fiber-reinforced composites.	2
2	**Major composite classes**	
2.1	Strengthening mechanisms, Aspect Ratio, Rule of Mixture, discontinuous and continuous fiber composites and their comparison, Characteristics and materials of reinforcements and matrices. Critical Fiber Length, Short and Continuous Fibers, Fiber Orientation.	2
2.2	Polymer matrix, metal matrix, ceramic matrix, carbon-carbon, and intermetallic composites.	3
2.3	Hybrid composites, Laminated composites. Examples of each class of composites.	2
3	**Manufacturing of Polymer matrix composites**	
3.1	Hand and spray lay - up, injection molding.	1
3.2	Injection molding, resin injection.	1
3.3	Filament winding, pultrusion, centrifugal casting, Rotational moulding and prepregs.	2
3.4	Fibre/Matrix Interface. Measurement of interface strength.	2
3.5	Characterization of systems; carbon fibre/epoxy, glass fibre/polyester, etc	2
4	**Fabrication of CMC's**	
4.1	Hot-Pressing, Infilration, In Situ Chemical Reaction Techniques.	2
4.2	CVD & CVI, Sol-gel.	2
4.3	Liquid Infiltration- Casting	2
4.4	Solid State Processes-Diffusion Bonding & In Situ Technique.	2

5	**Applications of advanced composite materials**	
5.1	Environmental effects in Composites, Green composites.	2
5.2	Synthesis and Properties of Nanocomposites.	2
5.3	Surface Composites &amp.	2
5.4	Surface metal matrix composites Need, Synthesis, Properties, and applications.	2

Reference Books

1. Autar K. Kaw, Mechanics of Composite materials, CRC Taylor & Francis, 2nd Ed, 2005
2. Composite Material Science and Engineering, Krishan K. Chawla, Springer, 3e, 2012
3. Robert M. Jones, Mechanics of Composite Materials, Taylor & Francis, 1999.
4. Madhijit Mukhopadhay, Mechanics of Composite Materials & Structures, Universities Press,2004
5. Michael W, Hyer, Stress analysis of fiber Reinforced Composite Materials, Mc-Graw Hill International, 2009
6. Fibre Reinforced Composites, P.C. Mallik, Marcel Decker, 1993
7. Hand Book of Composites, P.C. Mallik, Marcel Decker, 1993

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
J1PIAT124	FINITE ELEMENT ANALYSIS	PROGRAMME ELECTIVE 1	3	0	0	3

Preamble: Nil

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

CO 1	To familiarize computational procedures in linear finite element analysis.
CO 2	To understand the basic mathematics of finite element analysis and equip the students to formulate finite element procedures for engineering problems in structural, thermal and fluid flow domain.
CO 3	To impart knowledge in co-ordinate transformation and error estimation.
CO 4	To make the students aware of computational methods applicable for finite element analysis.
CO 5	To apply FEA in advanced Engineering problems.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓				
CO 2	✓	✓				
CO 3	✓	✓				
CO 4	✓	✓			✓	
CO 5	✓	✓			✓	

Assessment Pattern

Bloom's Category	End Semester Examination (marks)
Apply	20
Analyse	40
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	3 hours

Continuous Internal Evaluation Pattern:

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

End Semester Examination Pattern:

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.

Model Question Paper

FINITE ELEMENT ANALYSIS

PART A

(Answer all the questions. Each question carries 5 Marks)

1. Compare with figure CST element and LST element

2. Explain how the rise of temperature causes stress in a body?

3. Formulate the finite element equation for truss element?

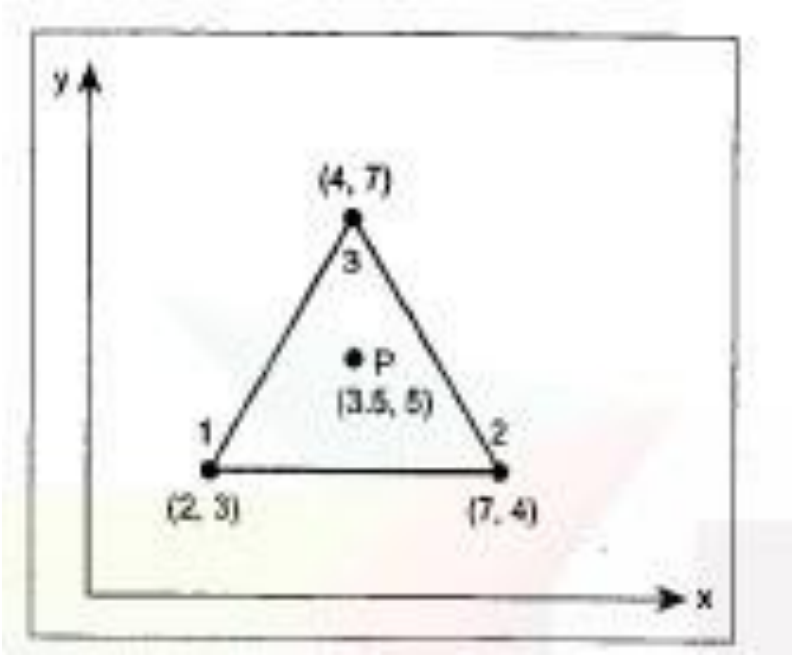
4. Write the steps for finding solution using Rayleigh-Ritz method?

5. Write the criteria of convergence of Newton-Raphson method?

PART B

(Answer any 5 questions. Each carry 7 Marks)

6. Determine the shape functions N1, N2 and N3 at the interior point P for the triangular element shown in Figure. $(x_1, y_1) = (2,3)$, $(x_2, y_2) = (7,4)$, $(x_3, y_3) = (4,7)$,



7. An axial load of 4 x10^5 N is applied at 30^0C to the rod as shown in Figure. The temperature is then raised to 60^0C. Calculate the following

   a. Assemble the K and F matrices

   b. Nodal displacements

   c. Stresses in each material

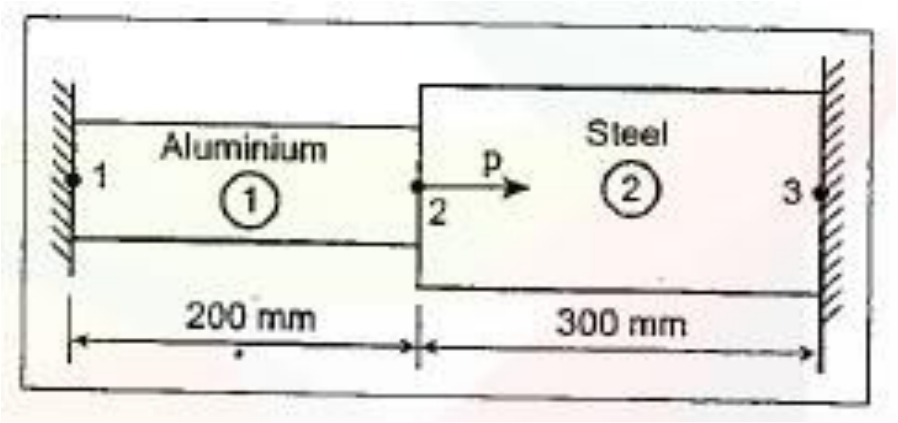
For Aluminum A_1= 1000 mm^2 For Steel A_2= 1500 mm^2

E_1= 0.7 × 10^5 N/mm^2

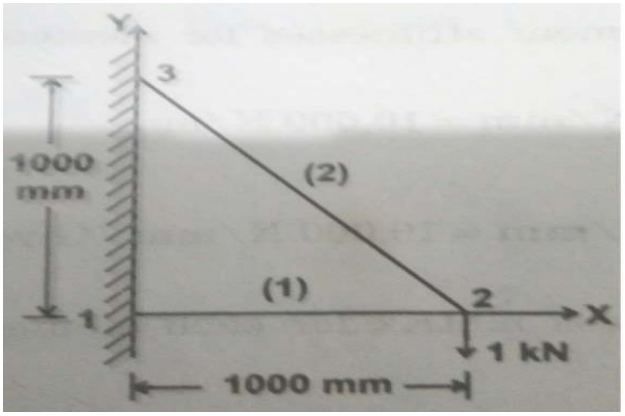
E_2= 2 × 10^5 N/mm^2

$\alpha_1 = 23 \times 10^{-6}$

$A_2 = 12 \times 10^{-6}$

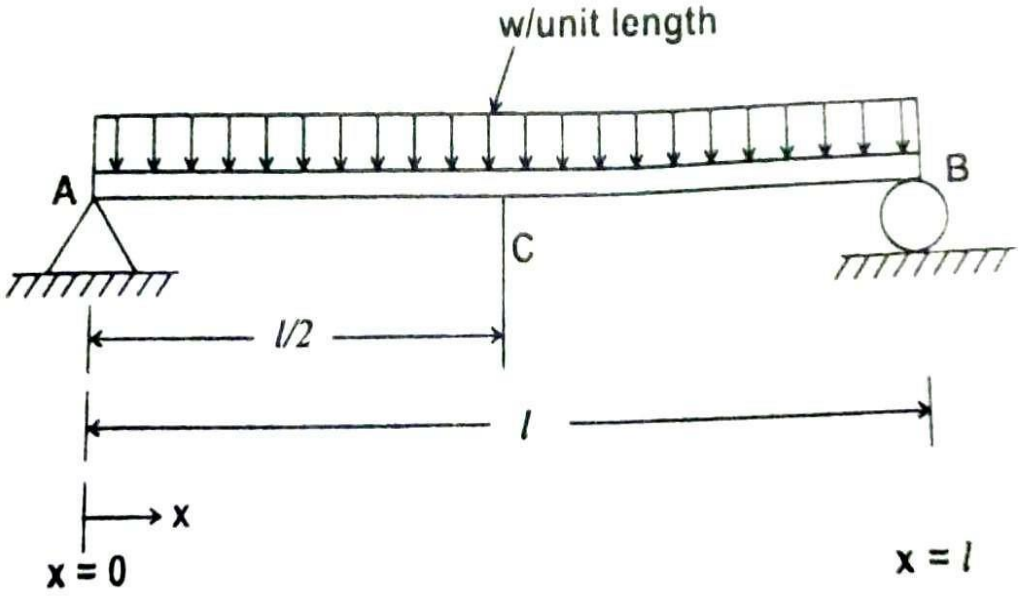


8. A truss structure is subjected to a load of 1 KN as shown in Figure. Calculate the nodal displacements and forces if the element stiffness of the truss is 10 kN/mm



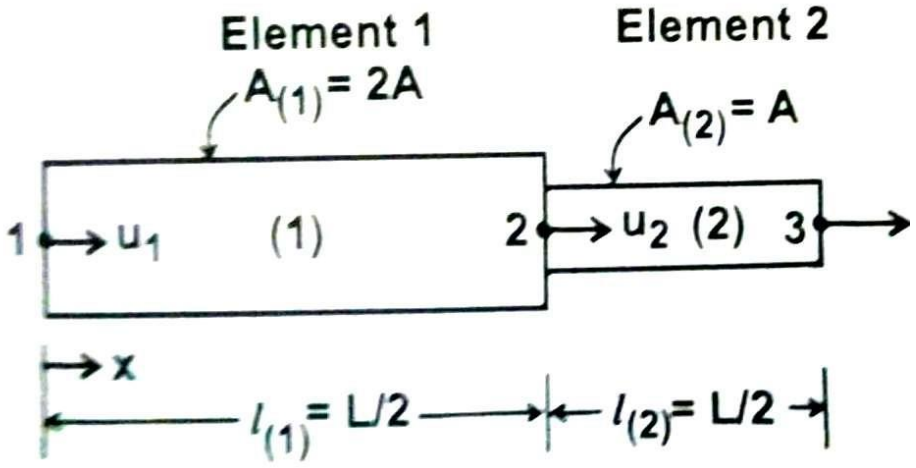
9. For a simply supported beam of span length *l* subjected to uniformly

distributed load throughout its length as shown in Figure, Find the deflection at the centre of the beam using one term trigonometric trial function in Rayleigh – Ritz method



10 Explain any four weighted residual methods

11 Find the natural frequencies of longitudinal vibration of the unconstrained stepped bar as shown in Figure?



12 Find the positive root of $x^4-x= 10$ correct to three places using Newton-Raphson method

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	FEA introduction: Discretization- Co- ordinates- Stiffness Matrix-Review of computational procedures with 1-D elements –Interpolation and shape functions – 2-D elements – Plane stress and plane strain analysis – CST and LST elements	**8**	**20**
II	Heat transfer and fluid flow problems – Choice of interpolation functions – Numerical integration. Axi–Symmetric problems, Modelling considerations – Symmetry – Applications – Iso-parametric formulation – 1-D and 2-D elements	**8**	**20**
III	Analysis of trusses- Coordinate transformation – Transformation of characteristic matrix–Lagrange multiplier and penalty function methods– Error – Sources of error –Convergence–Error estimates.	**8**	**20**
IV	Boundary value problems – Weak and strong forms – Functional –Euler-Lagrange equations – Rayleigh-Ritz method-Weighted- residual methods – Galerkin, Least-square and collocation methods – Galerkin finite element formulation – Applications to structural, Thermal and fluid flow problems.	**8**	**20**
V	Finite element formulation for non-linear problems – Solution methods– Method of false position- Newton-Raphson method – Modified Newton-Raphson method – Convergence criteria – Applications- FEA in vibration analysis–Fluid structure interaction–Thermo-mechanical problems and contact problems.	**8**	**20**

Course Plan

No	Topic	No. of Lecture Hours
1	**FEA Procedure**	
1.1	FEA introduction:	1
1.2	Discretization, Co-ordinates- (Local, Global, Natural)	1
1.3	Stiffness Matrix	1
1.4	Review of computational procedures with 1-D elements	1
1.5	Interpolation and shape functions	1
1.6	2-D elements	1
1.7	Plane stress and plane strain analysis	1
1.8	CST and LST elements	1
2	**Numerical integration and modelling consideration**	
2.1	Heat transfer and fluid flow problems	1
2.2	Choice of interpolation functions	1
2.3	Numerical integration	2
2.4	Axi–Symmetric problems	1
2.5	Modelling considerations	2
2.6	Iso-parametric formulation of 1-D and 2-D elements	1
3	**Coordinate transformation and error estimation**	
3.1	Analysis of trusses	1
3.2	Coordinate transformation	1
3.3	Transformation of characteristic matrix	1
3.4	Lagrange multiplier and penalty function methods	1
3.5	Error –Sources of error	1
3.6	Convergence	1
3.7	Error estimates.	2
4	**Finite element formulation**	
4.1	Boundary value problems	1
4.2	Weak and strong forms	1
4.3	Functional –Euler-Lagrange equations	1
4.4	Rayleigh-Ritz method	1
4.5	Weighted-residual methods	1
4.6	Galerkin, Least-square and collocation methods	1
4.7	Galerkin finite element formulation – Applications to structural, Thermal and fluid flow problems.	2

5	**Solution methods and advanced applications**	
5.1	Finite element formulation for non-linear problems, – Solution methods	1
5.2	Method of false position	1
5.3	Newton-Raphson method	1
5.4	Modified Newton-Raphson method	1
5.5	Convergence criteria	1
5.6	Applications of FEA in vibration analysis	1
5.7	Fluid structure interaction	1
5.8	Thermo-mechanical problems and contact problems.	1

Reference Books

1. R. D. Cook, D. S. Malkus, M. E. Plesha, R. J. Witt, Concepts & Applications of Finite Element Analysis, John Wiley & Sons, Fourth Edition, 2007
2. D. V. Hutton, Fundamentals of Finite Element Analysis, Tata McGraw Hill, 2005.
3. S. S. Rao, The Finite Element Method in Engineering, Butterworth Heinemann,5/E, 2010
4. J. N. Reddy, An Introduction to the Finite Element Method, McGraw Hill International, Third Edition, 2009
5. K. J. Bathe, Finite Element Procedures in Engineering Analysis, Prentice Hall of India, 2014.
6. O. C. Zienkiewicz, R. L. Taylor, The Finite Element Method, McGraw Hill, 7/E, 2013.
7. Dr. Sudhir K. Pundir, Numerical methods in science and Engineering, CBS publishers and distributers

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
J1PIAT134	DESIGN FOR MANUFACTURING	PROGRAMME ELECTIVE 1	3	0	0	3

Preamble: Nil

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

CO 1	Recognize the need to transform an industrial scenario from the traditional approach of no interaction between design and manufacturing engineers towards DFM.
CO 2	Design formed metal components with their manufacturing requirements in mind.
CO 3	Design machined components with their manufacturing requirements in mind.
CO 4	Design castings & non-metallic parts with their manufacturing requirements in mind.
CO 5	Design weldments with their assembly requirements in mind.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			✓	✓		✓
CO 2			✓	✓		✓
CO 3			✓	✓		✓
CO 4			✓	✓		✓
CO 5			✓	✓		✓

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

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

End Semester Examination Pattern:

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.

Model Question Paper

DESIGN FOR MANUFACTURING

PART A

(Answer all the questions. Each question carries 5 Marks)

1. Describe the important factors to be considered while analysing the alternative methods for production?
2. Illustrate the process of Extrusion and comment on the economic production quantities for Extrusion?
3. Explain the typical applications of Automatic - Screw – Machine parts?
4. Illustrate the typical characteristics of Sand-Cast parts?
5. Explain the common in-process industrial cleaning operations?

PART B

(Answer any 5 questions. Each carry 7 Marks)

6 Discuss the processes of training and indoctrination with respect to managing the DFM in an engineering industry?

7 Explain the significance of Concurrent Engineering approach in managing the DFM?

8 Illustrate the important design recommendations for Powder Metallurgy parts?

9 For a design engineer, identify the important points for consideration applicable to machined, moulded, cast, formed, or stamped gears? Explain in details the important design recommendations?

10 Explain the Thermoset-moulding processes and summarize the important design recommendations for Thermosetting-Plastic parts?

11 Describe the important design recommendations for industrial cleaning processes?

12 Summarize the various industrial cleaning processes and their

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Economics of process selection – General design principles for manufacturability – History of Design for Manufacturability (DFM) – Managing DFM – Evaluating design proposals – Economical use of raw materials: Design recommendations for utilizing ferrous metals, nonferrous metals and non-metallic materials.	**8**	**20**
II	**Formed Metal Components**: Process description and Design recommendations for Metal extrusions, Metal stampings, Fine- blanked parts, Four-slide parts, Springs and wire forms, Spun-metal parts, Cold-headed parts, Cod extruded parts, Rotary-swaged parts, Tube and section bends, Roll-formed sections, Powder metallurgy parts, Forging, Electroformed parts, Metal injection-moulded parts.	**8**	**20**
III	**Machined Components**: General guidelines for Designing for Machining – Process description and Design recommendations for parts cut to length, Screw machine products, Other turned parts, Machined round holes, Parts produced on Milling, Planning, Shaping and Slotting machines, Screw threads, Broached parts, Internally ground parts, Cylindrically ground parts, Flat-ground surfaces, Honed, Lapped and Superfinished parts, Parts by Electrical Discharge Machining, Electrochemically machined parts, Gears - Designing parts for economical Deburring.	**8**	**20**
IV	**Castings**: Process description and Design recommendations for castings made in sand moulds, Permanent-mould castings, Centrifugal castings, Plaster-mould castings, Ceramic-mould castings, Investment castings, Die castings. **Non-metallic Parts**: Process description and Design recommendations for Thermosetting-	**8**	**20**

	plastic parts, Injection-moulded thermoplastic parts, Structural-foam-moulded parts, Rotationally moulded plastic parts, Blow-moulded plastic parts, Reinforced-Plastic/Composite parts, Plastic profile extrusions, Thermoformed-plastic parts, Welded plastic assemblies, Rubber parts, Ceramic and glass parts.		
V	**Assemblies:** Design for Assembly (DFA) – Process description and Design recommendations for Arc weldments and other weldments, Resistance weldments, Soldered and brazed assemblies, adhesively bonded assemblies. **Finishes:** Designing for cleaning - Process description and Design recommendations for Polished and plated surfaces, Hot-dip metallic coatings, Thermal-sprayed coatings, Vacuum-metallized surfaces, Heat treatments, Organic finishes. DFM for low quantity production – Guidelines.	**8**	**20**

Course Plan

No	Topic	No. of Lectures
1	**Design For Manufacturability (DFM)**	
1.1	Economics of process selection	1
1.2	General design principles for manufacturability, History of Design for Manufacturability (DFM)	1
1.3	Managing DFM, Evaluating design proposals – Economical use of raw materials	1
1.4	Design recommendations for utilizing ferrous metals	2
1.5	Design recommendations for utilizing nonferrous metals	2
1.6	Design recommendations for utilizing non-metallic materials.	1
2	**Process description and Design recommendations for Formed Metal Components**	
2.1	Process description and Design recommendations for Metal extrusions	1
2.2	Process description and Design recommendations for Metal stampings, Fine-blanked parts,	1
2.3	Process description and Design recommendations for Four-slide parts, Springs and wire forms	1
2.4	Process description and Design recommendations for Spun-metal parts, Cold-headed parts	1
2.5	Process description and Design recommendations for Cold extruded parts, Rotary-swaged parts,	1
2.6	Process description and Design recommendations for Tube and section bends, Roll-formed sections	1
2.7	Process description and Design recommendations for Powder metallurgy parts, Forging, Electroformed parts,	1
2.8	Process description and Design recommendations for Metal injection-moulded parts.	1
3	**Process description and Design recommendations for Machined Components**	
3.1	General guidelines for Designing for Machining	1
3.2	Process description and Design recommendations for parts cut to length, Screw machine products,	1
3.3	Process description and Design recommendations for Other turned parts, Machined round holes,	1
3.4	Process description and Design recommendations for	1

	Parts produced on Milling, Planning, Shaping and Slotting machines	
3.5	Process description and Design recommendations for Screw threads, Broached parts, internally ground parts, cylindrically ground parts,	1
3.6	Process description and Design recommendations for Flat-ground surfaces, Honed, Lapped and Superfinished parts,	1
3.7	Process description and Design recommendations for Parts by Electrical Discharge Machining, electrochemically machined parts,	1
3.8	Process description and Design recommendations for Gears; Designing parts for economical Deburring.	1
4	**Process description and Design recommendations for Castings & Non-metallic Parts**	
4.1	Process description and Design recommendations for castings made in sand moulds, Permanent-mould castings	1
4.2	Process description and Design recommendations for Centrifugal castings, Plaster-mould castings	1
4.3	Process description and Design recommendations for Ceramic-mould castings, Investment castings, Die castings.	1
4.4	Process description and Design recommendations for Thermosetting-plastic parts, Injection-moulded thermoplastic parts,	1
4.5	Process description and Design recommendations for Structural-foam-moulded parts, rotationally moulded plastic parts,	1
4.6	Process description and Design recommendations for Blow-moulded plastic parts, Reinforced-Plastic/Composite parts,	1
4.7	Process description and Design recommendations for Plastic profile extrusions, Thermoformed-plastic parts,	1
4.8	Process description and Design recommendations for Welded plastic assemblies, Rubber parts, Ceramic and glass parts.	1
5	**Design For Assembly (DFA) & Finishes**	
5.1	Design For Assembly (DFA)	1
5.2	Process description and Design recommendations for Arc weldments and other weldments,	1

5.3	Process description and Design recommendations for Resistance weldments, Soldered and brazed assemblies	1
5.4	Process description and Design recommendations for Adhesively bonded assemblies.	1
5.5	Designing for cleaning - Process descriptionand Design recommendations for Polished and plated surfaces,	1
5.6	Process description and Design recommendations for Hot-dip metallic coatings, Thermal-sprayed coatings, Vacuum-metallized surfaces,	1
5.7	Process description and Design recommendations for Heat treatments, Organic finishes	1
5.8	DFM for low quantity production – Guidelines.	1

Reference Books

1. "Design for Manufacturability Handbook", JAMES G. BRALLA, 2nd Edition, McGraw Hill, 1998

2. "Product Design for Manufacture and Assembly", GEOFFREY BOOTHROYD, PETER DEWHURST, WINSTON A. KNIGHT, CRC Press; 3rd edition, 2010

3. "Design for Manufacturing and assembly", O. Molloy, S. Tilley and E.A. Warman, First Edition, Chapman &Hall, London, UK, 1998

4. "Engineering Design", G. E. Dieter and L. C. Schmidt, Fourth edition, McGraw-Hill companies, New York, USA, 2009

PROGRAM ELECTIVE II

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
J1PIAT115	PRODUCTION AND OPERATIONS MANAGEMENT	PROGRAMME ELECTIVE 2	3	0	0	3

Preamble: Nil

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

CO 1	Develop manufacturing planning and control system and an appropriate forecasting strategy for atypical manufacturing industry.
CO 2	Design an appropriate SOP and MPS for an organization
CO 3	Develop an appropriate MRP and ERP strategies for an organization
CO 4	Solve the company wide problems in plant layout, line balancing and quality.
CO 5	Design an ideal strategy to establish quality on a companywide basis.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	✓	✓		
CO 2	✓	✓	✓			
CO 3	✓	✓	✓	✓		
CO 4	✓	✓	✓	✓		
CO 5	✓	✓	✓			

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	20%
Analyse	60%
Evaluate	20%
Create	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

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

End Semester Examination Pattern:

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.

Model Question Paper

PRODUCTION AND OPERATIONS MANAGEMENT

PART A (Answer all the questions. Each question carries 5 Marks)

1. Explain the importance of forecasting in manufacturing industry?

2. Discuss the need of a balance between demand and supply?

3. Clarify the term Economic Order quantity?

4. Explain how the calculation of bill of materials helps in manufacturing a product?

5. Summarize the benefits of QFD?

PART B (Answer any 5 questions. Each carry 7 Marks)

6. Company ABC manufacturing safety shoe has a forecast of 165 units every month. The demand for each moth is given in the following table. Calculate (i)

   Mean Deviation (ii) Mean absolute deviation (iii) Mean square error and (iv) Mean absolute percentage error

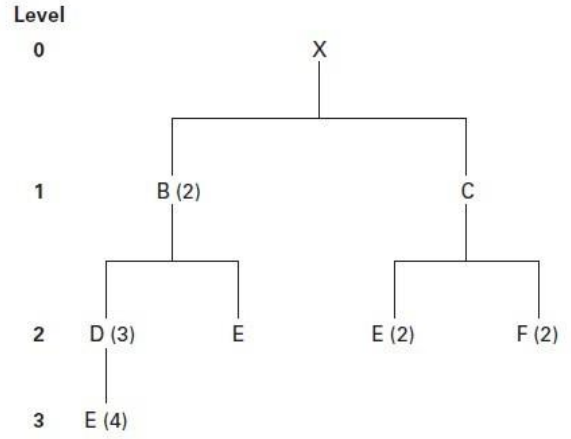
Month	1	2	3	4	5
Demand	150	160	165	175	180

7. Company EFG is manufacturing plastic chairs. Demand for each month is shown in the following table. A weight of 0.50 is assigned to the most recent demand value. A weight of 0.30 is assigned to the next most recent demand value and a weight of 0.20 is assigned to the oldest of the demand value included in the average. Calculate the weighted moving average

1	2	3	4	5	6
120	130	110	140	110	130

8. Differentiate between chase strategy, level strategy and mixed strategy

9. Utilize the information presented in Figure to compute the following:
   i. Compute the quantities of B, C, D, E, and F needed to assemble one X.
   ii. Compute the quantities of these components that will be required to assemble 10 Xs, taking into account the quantities on hand (i.e., in inventory) of various components:



Component	**On Hand**
B	4
C	10
D	8
E	60

10 Consider the following 2 machines and five jobs flow shop problem. Apply Johnson's algorithm to obtain optimal sequence which will minimize the makes span

Job(i)	Processing Time	
	Machine 1	Machine 2
A	6	8
B	11	6
C	7	3
D	9	7
E	5	10

11 Substantiate benchmarking as a potential manufacturing strategy

12 Demonstrate the concept of lean manufacturing.

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Manufacturing Planning and Control (MPC) system framework -Matching MPC system with the needs of the firm -Demand management in MPC System -Nature and Use of Forecast -Demand patterns -Forecasting Models -Measures of Forecast accuracy	**8**	**20**
II	Sales and operation planning (SOP) process- Managerial inputs to SOP -Planning strategies -Master Production Scheduling Process -MPS Techniques -Time fencing and MPS stability	**8**	**20**
III	Bill of materials (BOM)- MRP Concept -Lot sizing methods in MRP- Enterprise Resource Planning (ERP)and functional units- Performance measures	**8**	**20**
IV	Single machine scheduling - Flow Shop scheduling, Johnson's problem - Computerized layout planning, ALDEP, CRAFT -Line balancing - TQM -TPM - Quality audits	**8**	**20**
V	Quality costs – Direct and indirect costs – SERVQUAL- Quality function deployment – Kaizen – Benchmarking – 5 S Principle –Elements of JIT manufacturing – Introduction to lean and agile manufacturing	**8**	**20**

Course Plan

No	Topic	No. of Lecture Hours
1	Manufacturing Planning and Control and Forecasting	
1.1	Manufacturing Planning and Control (MPC) system framework	1
1.2	Matching MPC system with the needs of the firm	1
1.3	Demand management in MPC System	1
1.4	Nature and Use of Forecast	1
1.5	Demand patterns	1
1.6	Forecasting Models	2
1.7	Measures of Forecast accuracy	1
2	Sales and operation planning and Master Production Schedule (MPS)	
2.1	Sales and operation planning (SOP) process	1
2.2	Managerial inputs to SOP	1
2.3	Planning strategies	3
2.4	Master Production Scheduling Process	1
2.5	MPS Techniques	1
2.6	Time fencing and MPS stability	1
3	Material Requirement Planning (MRP) and Enterprise Resource Planning (ERP)	
3.1	Bill of materials (BOM)	2
3.2	MRP Concept	1
3.3	Lot sizing methods in MRP	3
3.4	Enterprise Resource Planning (ERP)and functional units	1
3.5	Performance measures	1
4	Production management and quality systems	
4.1	Single machine scheduling.	1
4.2	.Flow Shop scheduling, Johnson's problem	1
4.3	Computerized layout planning ALDEP, CRAFT	2
4.4	Line balancing	1
4.5	TQM	1
4.6	TPM	1

4.7	Quality audits	1
5	Quality performance measures	
5.1	Quality costs – Direct and indirect costs	1
5.2	SERVQUAL	1
5.3	Quality function deployment	1
5.4	Kaizen	1
5.5	Benchmarking	1
5.6	5 S Principle	1
5.7	Elements of JIT manufacturing	1
5.8	Introduction to lean and agile manufacturing	1

Reference Books

1. Thomas E. Vollmann, William L. Berry, D Clay Whybark, and F. Robert Jacobs, Manufacturing Planning and Control for Supply Chain Management, Mc Graw Hill Int. Ed., 2010.
2. Edward A. Silver, David F. Pyke and Rein Peterson, "Inventory Management and Production Planning and Scheduling", 3rd Ed., John Wiley & Sons, 1998.
3. S N Chary, Production and Operations Management, Tata McGraw-Hill, 2012
4. R Panneerselvam, Production and Operations Management, PHI Learning pvt Ltd., 2012
5. Francis, R.L. and White, J.A., Facility Layout and Location: An Analytical Approach Prentice-Hall Inc., New Jersey, 2010.
6. Apple, J.M., Plant Layout and Material Handling, Kreiger Publishing, 3rd Edition, 2005
7. Dale H Besterield, Total quality Management, Pearson Education, 3rd Edition, 2011
8. William J Stevenson, Operations management, Tata McGraw Hill, 2014.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
J1PIAT125	SOFT COMPUTING TECHNIQUES	PROGRAMME ELECTIVE 2	3	0	0	3

Preamble: Nil

Course Outcomes:

CO 1	Develop a Genetic Algorithm to optimize the given single objective optimization problem.
CO 2	Design a Genetic Algorithm to optimize the given multi-objective optimization problem.
CO 3	Solve a multi-variable single objective optimization problem using Simulated Annealing.
CO 4	Develop a Fuzzy Inference System (FIS) to model input-output relationship with respect to a given real life problem.
CO 5	Design an optimized Artificial Neural Network (ANN) model for establishing input-output relationship with respect to a given engineering problem.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓		✓	✓	✓	✓
CO 2	✓		✓	✓	✓	✓
CO 3	✓		✓	✓	✓	✓
CO 4	✓		✓	✓	✓	✓
CO 5	✓		✓	✓	✓	✓

Assessment Pattern

Bloom's Category	End Semester Examination (marks)
Apply	20
Analyse	40
Evaluate	-
Create	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

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

End Semester Examination Pattern:

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.

Model Question Paper SOFT COMPUTING TECHNIQUES

PART A

(Answer all the questions. Each question carries 5 Marks)

1. How do you select a suitable scheme of computing (either soft computing or hard computing or hybrid computing) to solve a particular problem?

2. Define Pareto-optimal front of solutions in connection with multi-objective optimization?

3. Discuss the principle of Particle Swarm Optimization (PSO) algorithm as an optimizer? How does it differ from the Genetic Algorithm?

4. Explain the principle of Takagi and Sugeno's approach of Fuzzy Logic Controller (FLC)?

5. State the differences between Incremental and Batch modes of training of a neural network?

PART B

(Answer any 5 questions. Each carries 7 Marks)

6. A binary-coded Genetic Algorithm (GA) is to be used to solve an optimization problem involving one real and another integer variable. The real and integer variables are allowed to vary in the ranges of (0.2, 10.44) and (0, 63), respectively. Design a suitable GA-string to ensure a precision level of 0.01 for the real variable?

7. Use a binary-coded GA to minimize the function

   , in the range of

   Use a random population of size N = 6, tournament selection, a single-point crossover with probability $p_c = 1.0$ and neglect mutation. Assume 3 bits for each variable and thus, the GA-string will be 6-bits long. Show

only one iteration.

8. Use Distance-based Pareto-GA (DPGA) to update non-dominated front of solutions for a few solution points: (2.0, 5.0), (6.5, 2.5), (8.0, 1.5), (3.2, 7.8) through hand-calculations in order to solve the two-objective optimization problem as given below.

Subject to

9. Use simulated annealing to solve the optimization problem given below.

Minimize

Subject to

Assume, the initial temperature of molten metal initial solution selected at random and termination criterion Let us assume the random numbers varying in the range of (0.0, 1.0) are as follows: and so on. Show three iterations only.

10 Let us consider a fuzzy set A(x) in a discrete universe of discourse as follows:

Calculate its entropy value?

11 What is Fuzzy C-Means Clustering? Explain the algorithm for Fuzzy C-Means Clustering?

12 A Radial Basis Function Network (RBFN) is to be used to model input-output relationships of a manufacturing process having three inputs and one output. Fig. 1 shows the RBFN with one hidden layer containing three

neurons. The hidden neurons are assume to have Gaussian Transfer Functions of the form: $y = f(x) = \exp\left[-\frac{(x-\mu)^2}{2\sigma^2}\right]$ with the values of mean μ and standard deviation σ as follows: $(\mu_1 = 4.0, \sigma_1 = 0.4)$; $(\mu_2 = 4.5, \sigma_2 = 0.6); (\mu_3 = 5.0, \sigma_3 = 0.8).$ Assume initial weights as Use $w_{11} = 0.2, w_{21} = 0.1, w_{31} = 0.3.$ incremental training scheme with the help of a scenario: $x_{11} = 0.8, x_{12} = 1.5, x_{13} = 2.5$ and output O=0.5. Use back-propagation algorithm with a learning ratio $\eta = 0.2.$ Calculate the updated values of $w_{11}, w_{21}, w_{31}, \mu s \; and \; \sigma s.$ Show only one iteration.

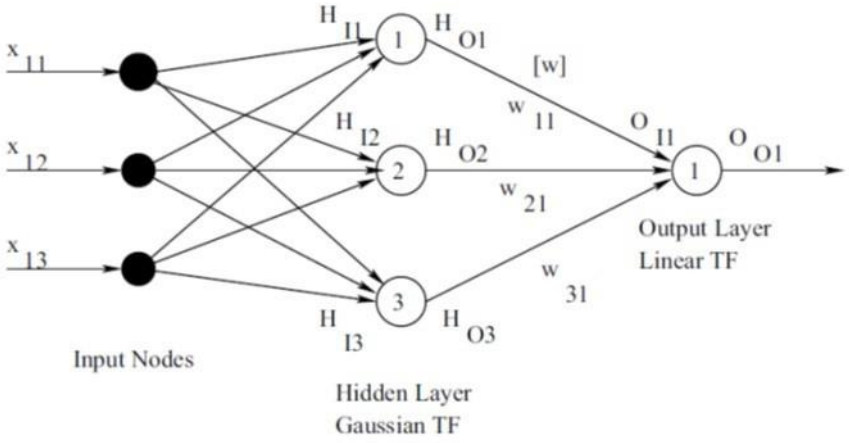


Fig. 1 A Radial Basis Function Neural network

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Hard computing, Soft computing, Hybrid computing; Principle of optimization, Traditional methods of optimization; Genetic Algorithm (GA): Binary-coded GA, Parameters setting, Constraints handling, Real-coded GA, Micro-GA, Visualized interactive GA, Scheduling GA.	**8**	**20**
II	Multi-objective optimization: Different approaches – Weighted sum approach, Goal/Target programming, Vector Evaluated GA, Distance-based Pareto-GA, Non-dominated sorting GA.	**8**	**20**
III	Simulated Annealing (SA): Introduction, Working principle, Examples, Applications; Particle Swarm Optimization (PSO): Introduction, Algorithm, Examples, Comparison between GA and PSO.	**8**	**20**
IV	Fuzzy Logic: Crisp sets - Operations, Properties; Fuzzy sets – Operations, Properties; Measures of fuzziness and inaccuracy of fuzzy sets; Fuzzy logic controller – Mamdani approach, Takagi and Sugeno's approach, Hierarchical fuzzy logic controller, Sensitivity analysis; Fuzzy clustering – Fuzzy C-Means clustering, Entropy-based Fuzzy clustering.	**8**	**20**
V	Artificial Neural Network (ANN): Biological neuron, Artificial neuron, Static and dynamic neural networks, Supervised learning, Un-supervised learning, Incremental training, Batch mode of training; Multi-Layer Feed- Forward Neural Network (MLFFNN); Radial Basis Function Neural Network (RBFNN); Self-Organizing Map (SOM); Counter- Propagation Neural Network (CPNN); Recurrent Neural Network (RNN) – Elman network, Jordan network, Combined Elman and Jordan network; Introduction to Neuro-fuzzy systems - ANFIS.	**8**	**20**

Course Plan

No	Topic	No. of Lecture Hours
1	**Introduction to Genetic Algorithm**	
1.1	Hard computing, Soft computing, Hybrid computing	1
1.2	Principle of optimization	1
1.3	Traditional methods of optimization; Genetic Algorithm (GA)	1
1.4	Binary-coded GA	1
1.5	Parameters setting, Constraints handling	1
1.6	Real-coded GA, Micro-GA	1
1.7	Visualized interactive GA	1
1.8	Scheduling GA	1
2	**Multi-objective Genetic Algorithm**	
2.1	Multi-objective optimization	2
2.2	Different approaches – Weighted sum approach	1
2.3	Goal/Target programming	1
2.4	Vector Evaluated GA	1
2.5	Distance-based Pareto-GA	2
2.6	Non-dominated sorting GA	1
3	**Simulated Annealing (SA) and Particle Swarm Optimization (PSO)**	
3.1	Simulated Annealing (SA)	1
3.2	Introduction, Working principle	1
3.3	Examples, Applications	1
3.4	Particle Swarm Optimization (PSO)	1
3.5	Introduction, Algorithm	1
3.6	Examples	2
3.7	Comparison between GA and PSO	1
4	**Fuzzy Logic**	
4.1	Fuzzy Logic: Crisp sets, Operations, Properties	1
4.2	Fuzzy sets – Operations, Properties	1
4.3	Measures of fuzziness and inaccuracy of fuzzy sets	1
4.4	Fuzzy logic controller – Mamdani approach	1
4.5	Takagi and Sugeno's approach	1
4.6	Hierarchical fuzzy logic controller; Sensitivity analysis	1
4.7	Fuzzy clustering – Fuzzy C-Means clustering	1

4.8	Entropy-based Fuzzy clustering	1
5	**Artificial Neural Network (ANN)**	
5.1	Artificial Neural Network (ANN): Biological neuron	1
5.2	Artificial neuron, Static and dynamic neural networks	1
5.3	Supervised learning, Un-supervised learning	1
5.4	Incremental training, Batch mode of training	1
5.5	Multi-Layer Feed-Forward Neural Network (MLFFNN)	1
5.6	Radial Basis Function Neural Network (RBFNN)	1
5.7	Self-Organizing Map (SOM); Counter-Propagation Neural Network (CPNN)	1
5.8	Recurrent Neural Network (RNN) – Elman network, Jordan network, Combined Elman and Jordan network, Introduction to Neuro-fuzzy systems - ANFIS.	1

Reference Books

1. Dilip K. Pratihar, *Soft Computing: Fundamentals and applications,* Alpha Science International Ltd., Oxford, UK, 2014

2. Deb, Kalyanmoy, *Optimization for engineering design: Algorithms and examples*. PHI Learning Pvt. Ltd., 2012.

3. Deb, Kalyanmoy, *Multi-objective optimization using evolutionary algorithms*. John Wiley& Sons, 2001

4. Schalkoff ,R.J., *Artificial Neural Networks,* McGraw-Hill Companies Inc., 1997.

5. Sundareswaran, K, *A Learner 's Guide to Fuzzy Logic Systems,* Jaico Publishing House, 2005.

6. Randy L. Haupt & Sue Ellen Haupt, *Practical Genetic Algorithms*, Wiley-Interscience, 2nd edition, 2004.

7. Yegnanarayanan, B., *Artificial Neural Networks,* Prentice Hall of lndia, 1999

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
J1PIAT135	MICRO AND NANO MANUFACTURING	PROGRAMME ELECTIVE 2	3	0	0	3

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

CO 1	Identify the need and requirements of micro and nano manufacturing systems to address evolving challenges in materials and designs
CO 2	Understand some of the conventional and non-conventional micro-nano manufacturing systems
CO 3	Understand the concept of nano level manufacturing-Nano structured materials-Size effects. Synthesis of nano particles
CO 4	Understand various characterisation, quantification and imaging techniques needed for micro and nano manufacturing
CO 5	Understand various advanced finishing techniques for micro nano level manufacturing

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓		✓	✓		✓
CO 2	✓		✓	✓		✓
CO 3	✓		✓	✓		✓
CO 4	✓		✓	✓		✓
CO 5	✓		✓	✓		✓

Assessment Pattern

Bloom's Category	End Semester Examination (marks)
Apply	20
Analyse	40
Evaluate	-
Create	-

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

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

End Semester Examination Pattern:

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.

Model Question Paper

MICRO AND NANO MANUFACTURING

PART A

(Answer all the questions. Each question carries 5 Marks)

1. What is the need for precision manufacturing? Explain in the contexts of dimensions and tolerances?
2. Explain the method of making tools for micro milling
3. Describe Ion beam machining system with sketches?
4. With the help of schematic sketch, explain how PVD coating is deposited?
5. Explain the mechanism of material removal in magneto rheological abrasive flow finishing process?

PART B

(Answer any 5 questions. Each carries 7 Marks)

6 Compare top-down and bottom-up techniques of nano manufacturing with ONE example each.

7 List special features of diamond turning in comparison with conventional turning? What is the tool used in diamond turning

8 Prepare a schematic layout of focussed ion beam (FIB) machining? How FIB system can be used for imaging

9 Explain the synthesis of single walled carbon nanotubes?

10 How thin coatings can be deposited by physical vapor deposition? Explain the process with ONE example

11 Explain with sketch, Magneto Rheological Abrasive Flow Finishing (MRAFF) process, List process parameters affecting the finish

12 Explain the working principle of atomic force microscope (AFM) with sketch, How the tip of AFM is made

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Introduction: Need for precision manufacturing. Classification of micro and nano manufacturing systems. Requirements of micro-machining systems – MEMS and NEMS devices, Top down and bottom-up approach for micro and nano manufacturing	8	20
II	Micro-machining methods: Micro turning, Diamond turning -drilling and milling -. Micro EDM and micro ECM, mechanism of material removal, difference between macro scale machining	8	20
III	Lithography, LIGA, Laser beam machining - Effect of process parameters, Heat affected zone, Electron beam machining - Ion beam machining, Principle of operation, Material removal mechanisms	8	20
IV	Nano structured material- thin wires-films-Quantum dots. plasma coating-CVD, PVD techniques and applications. Synthesis of carbon nanotubes	8	20
V	Advanced finishing techniques- Need for advanced finishing- Magneto Rheological finishing -Magneto Rheological Abrasive Flow Finishing Characterizations methods at micro and nano levels- Electron microscopy-SEM, STM-Atomic force microscopy-Confocal microscopy- Micro and nano hardness determination	8	20

Course Plan

No	Topic	No. of Lectures
1	**Introduction to precision engineering, MEMS, NEMS devices, Approaches to micro/nano manufacturing**	
1.1	Need for precision manufacturing, new materials, geometry, tolerances	1
1.2	Classifications of micro/nano manufacturing, Conventional, non conventional, thermal energy, electro chemical methods	2
1.3	Requirements of micro/nano manufacturing, characterization, metrology systems	2
1.4	Microelectromechanical systems and nanoelectromechanical devices	1
1.5	Top down and bottom-up approaches with case studies	2
2	**Mechanical and electric discharge type micro and nano manufacturing methods**	
2.1	Micro turning and diamond turning systems	2
2.2	Micro drilling and micro milling-tools and fabrication methods	2
2.3	Micro EDM, difference between EDM and micro EDM, Micro WEDM	2
2.4	Micro ECM, differences from ECM, features and tolerances, advantages	2
3	**Lithography and High energy beam micro/nano manufacturing methods**	
3.1	Lithography, LIGA	2
3.2	Laser beam machining, Types, Pulsed laser, Heat affected zone	2
3.3	Focused ion beam machining, principle, Uses and advantages	2
3.4	Micro Electron beam machining	2
4	**Nano structured materials and coatings, Methods of coating, Synthesis of CNT**	
4.1	Nano structured materials, Bulk and surface structures	2
4.2	Thin wires and films, quantum dots	2
4.3	Plasma coating methods CVD, PVD coatings	2
4.4	Synthesis of single and multi-walled carbon nano tubes	2

5	**Advanced finishing techniques and metrology**	
5.1	Introduction to Micro and Nano Finishing Processes	1
5.2	Abrasive flow machining, process, advantages	1
5.3	Magnetorheological Finishing (MRF) processes, Material removal mechanism	1
5.4	Magnetorheological Abrasive Flow Finishing (MRAFF) processes, Material removal mechanism	1
5.5	Micro and nano metrology, defining the scale, uncertainty	1
5.6	Scanning Electron Microscopy, Scanning tunnelling microscopy – description, principle of atomic force microscopy - description, different modes of operation application, confocal microscopy	2
5.7	Estimation of hardness at micro and nano level, depth sensing indentation methods and stiffness estimation	1

Reference Books

J. Mc Geough, Micromachining of engineering materials, CRC press, 1st Edition, 2002

2. N. Taniguchi, Nanotechnology: Integrated processing systems for ultra-precision and ultra-fine products, Oxford University Press Inc, 1996

3. V. K. Jain, Introduction to micro machining, Narosa publishing house, 2014

4. Mark J Jackson, Micro and Nano manufacturing, Springer, 2nd Edition, 2008

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
J1PIAL107	ADVANCED MANUFACTURING LAB 1	LABORATORY	0	0	2	1

Preamble: Nil

Course

Outcomes:

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

CO 1	To gather knowledge on 2D drawing using any software package
CO 2	To gather knowledge on 3D modelling using any software package
CO 3	To impart gather knowledge on static Finite Element analysis
CO 4	To impart gather knowledge on dynamic Finite Element analysis
CO 5	To gather knowledge on assembling of various parts, fits tolerance, surface quality and measurements
CO 6	To gather knowledge on synthesis of mechanism design for manufacturing systems and robotics:

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	✓	✓	✓	
CO 2	✓	✓	✓	✓	✓	
CO 3	✓	✓	✓	✓	✓	
CO 4	✓	✓	✓	✓	✓	
CO 5	✓	✓	✓	✓	✓	
CO 6	✓	✓	✓	✓	✓	

Continuous Internal Evaluation (CIE) Pattern: Total Marks: 100

Attendance	15 marks
Regular class work/Modelling and Simulation Lab Record and Class Performance	60 marks
Continuous Assessment Test (Minimum 1 Test)	25 marks

Syllabus

1. Exercises on solid modelling: Introduction to computer graphics - viewing transformations, curves and surfaces generation, curve fitting and curve fairing techniques - 2D, wire frame
2. 3D shading - familiarity with Boolean operations - sweep, revolve, loft, extrude, filleting, chamfer, splines etc. - windowing, view point, clipping, scaling and rotation transformations using commercial solid modelling packages
3. Exercises on finite element analysis: Introduction to FEM - 1D, 2D and 3D elements - shape functions – pre-processing - boundary conditions, structured and free mesh generation - analysis - linear and non-linear analysis - static analysis - post processing - display, animation, extraction of nodal data - exercises on heat conduction and elasticity may be given using commercial FEM packages
4. Dynamic analysis using FE package-Modal and harmonic analysis. Impact analysis.
5. Exercises on Assembly and mechanism design: Assembling of various parts and tolerance analysis - synthesis and design of mechanisms - animations - exercises on various mechanisms like four bar linkages and its variations - cam and follower – Limits fits and tolerances- Surface Measurements-Parameters
6. Synthesis of mechanisms-Programming techniques for analytical synthesis-Robotic arm motion synthesis

No	List of Exercise	Course Outcomes
1	Preparation of 2D drawing using basic operations	**CO 1**
2	Preparation of 2D drawing using basic operations	**CO 1**
3	Preparation of 2D drawing using basic operations	**CO 1**
4	Preparation of 3D drawing using Boolean operations	**CO 2**
5	Preparation of 3D drawing using Extrude operations	**CO 2**
6	Preparation of 3D drawing using Mirror/copy operations	**CO 2**
7	Preparation of 3D drawing using rotation operations	**CO 2**
8	FE analysis static problems	**CO 3**
9	FE analysis static problems	**CO 3**
10	FE analysis static and thermal problems	**CO 3**
11	FE analysis static and thermal problems	**CO 3**
12	FE analysis dynamic problems	**CO 4**
13	FE analysis dynamic problems	**CO 4**
14	Exercises on limits fits and tolerances	**CO 5**

15	Exercises on surface measurements	**CO 5**
16	Exercise on synthesis of mechanisms involving linkages	**CO 6**

References:

1. ANSYS Software manual-ANSYS Inc

2. P.Radhakrishnan, Computer Numerical Control and Computer Aided Manufacture, New Age International Publishers, 2012

3. K. J. Bathe, Finite Element Procedures in Engineering Analysis, Prentice Hall of India, 2014

Discipline: Mechanical Engineering

Stream: Industrial Automation and Robotics (IAR)

Semester II

CODE J1PIAT201	COURSE NAME DESIGN OF EXPERIMENTS	CATEGORY	L	T	P	CREDIT
		Discipline Core	3	0	0	3

Preamble:

Investigators perform experiments in virtually all fields of inquiry, usually to discover something about a particular process or system. In this course, you will learn the basic concepts of experimental design, and the statistical analysis of data. On completion of the course, you would be able to plan and conduct experiments, and analyse the resulting data so that valid conclusions can be drawn.

Course Outcomes:

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

CO 1	Perform statistical analysis of data.
CO 2	Conduct statistical hypothesis tests on mean and variance of populations.
CO 3	Design and analyse single factor experiments.
CO 4	Design and analyse full and fractional factorial experiments.
CO 5	Apply Response Surface Methodology to optimise the response in an experiment.
CO 6	Carry out an experimental project and analyse the results using a statistical software.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 40 Marks

Course based project/Mini project: 20 Marks.

(Identify a relevant problem and design experiments to be carried out. Analyse the results using a software package like R, Minitab, Design Expert, Python etc. and establish the results between the dependent and independent variables.)

Course based task/ Quiz: 10 Marks

Test paper: 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.

Model Question paper:

JYOTHI ENGINEERING COLLEGE (AUTONOMUS)

SECOND SEMESTER M.TECH DEGREE EXAMINATION

MECHANICAL ENGINEERING

J1PIAT201: DESIGN OF EXPERIMENTS

Max. Marks: 60 Duration: 2.5 Hours

PART A

Answer all the questions. Each question carries 5 *marks* Marks

1	Following data refer to 6 observations on natural frequency (in Hertz) of beams subjected to a load in an experiment: 230.66, 233.05, 232.58, 229.48, and 232.58. Construct a 90% confidence interval for the data.	(5)
2	A cement manufacturer claims that the mean settling time of his cement is not more than 45 minutes. A random sample of 20 bags of cement selected and tested showed an average settling time of 49.5 minutes with a standard deviation of 3 minutes. Test whether the company's claim is true. Use 5 % level of significance.	(5)

3 Describe the roles of randomization, replication and blocking in experimental design. (5)

4 What are the model adequacy checks generally carried out in a factorial experimental design? (5)

5 What are the advantages and limitations of fractional factorial designs? (5)

PART B

Answer any five full questions. Each question carries 7 marks.

6 (a) The following data refer to the weights of 10 students (kg) in a class: 63, 64, 59, 58, 65, 70, 56, 68, 60 and 62. Construct a normal probability plot of the data. Does it seem reasonable to assume that the students' weight is normally distributed? (4)

(b) The following data refer to the number of sales of cakes on different days in a season. Represent the data as a box plot. (3)

54, 60, 65, 66, 67, 69, 70, 72, 73, 75, 76

7 Fifteen adults between the ages of 35 and 50 participated in a study to evaluate the effect of diet and exercise on blood cholesterol levels. The total cholesterol was measured for each person initially, and then three months after participating in an aerobic exercise program and switching to a low-fat diet. The blood cholesterol level data are shown in the following table. (7)

Subject	1	2	3	4	5	6	7	8	9	10	11	12
Before	265	240	258	295	251	245	287	314	260	279	283	240
After	229	231	227	240	238	241	234	256	247	239	246	218

8 An agricultural officer wants to study the effect of four different fertilizers on the yield (in tons) of a specific crop. Since there might be variability from one plot to another plot, he decides to use the randomized complete block design. The data are presented in the table. Test whether the type of fertilizer used has significant effect on the yield of the crop. (7)

Plot	**Fertilizer**			
	A	B	C	D
1	100	150	120	70
2	80	70	110	100
3	68	90	85	78
4	125	138	60	124

9 An oil company wants to test the effect of four different blends of gasoline (A, B, C, D) on fuel efficiency. The company has used four cars for testing the four types of fuel. To control the variability due to cars and drivers, Latin square design has been used. The collected data from the experiment is shown in the table below. Analyse the data and test whether the four blends of gasoline, cars and the drivers significantly affect the fuel efficiency. (7)

Driver	Cars			
	I	II	III	IV
1	D = 15.5	B = 33.9	C = 13.2	A = 29.1
2	B = 16.3	C = 26.6	A=19.4	D = 22.8
3	C = 10.8	A = 31.1	D = 17.1	B = 30.3
4	A = 14.7	D = 34.0	B = 19.7	C = 21.6

10 The yield of a chemical process is being studied. The two most important variables are thought to be the pressure and temperature. Three levels of each factor are selected, and a factorial experiment with two replicates is performed. The yield data are given in the table below. Analyse the data and draw conclusions. Use $\alpha = 0.05$ (7)

Temperature (^oC)	Pressure (psi)		
	200	215	230
150	90.4	90.7	90.2
	90.2	90.6	90.4
160	90.1	90.5	89.9
	90.3	90.6	90.1
170	90.5	90.8	90.4
	90.7	90.9	90.1

11 A 2^3 factorial design was used to develop a nitride etch process on a plasma etching tool. The design factors are the gap between the electrodes (A), the gas flow (B), and the power applied to the cathode (C). Each factor is run at two levels, and the design is replicated twice. The response variable is the etch rate for silicon nitride. The data are given in the table below. Analyse the data to identify the significant factors and interactions. (7)

Coded factors			Etch rate	
A	**B**	**C**	**Replication 1**	**Replication 2**
-1	-1	-1	550	604
1	-1	-1	669	650
-1	1	-1	633	601
1	1	-1	642	635
-1	-1	1	1037	1052
1	-1	1	749	868
-1	1	1	1075	1063
1	1	1	729	860

12 The yield of a melting furnace in a foundry is suspected to be affected by the temperature 'T' and melting time 'M'. The data of this experiment with one replication in different treatment combinations are summarized in the table below. Further, five replications are taken at the centre point. Fit a first order response surface for this problem to determine the optimum settings for the temperature and melting time at a significance level of 0.05. (7)

		Melting time	
		60 min.	66 min.
Temperature	400°C	75	77
	410°C	80	84
Centre point replications Temperature (405°C) Melting time (63 min)	1	79	
	2	78	
	3	76	
	4	79	
	5	80	

Syllabus:

Module 1

Introduction to Design of Experiments: One factor at a time experiments and designed experiments; Role of DoE in experimentation. Application of software packages for designing experiments.

Basic statistical concepts: Probability distributions; pdf and cdf; mean and variance. Normal and Student's *t* distributions; Normal probability plot. Tables and charts to represent data; Stem and leaf; Box plot; Pareto chart.

Sampling distribution of the mean: Central Limit Theorem. Constructing Confidence Intervals for a single mean, variance, and difference of two means.

Module 2

Hypothesis Testing: Hypothesis testing of single means. Testing of two means - with known and unknown population variance. Paired t-test. Testing of variances. Analysis of Variance (ANOVA).

Module 3

Single Factor Experiments: Completely randomized design. Replication, Randomization, Blocking. Randomized complete block design. Latin square design.

Model adequacy checking: Residual plots.

Module 4

Factorial experiments: Two and three factors full factorial experiments. 2-level full factorial experiments. Effects and contrasts; Yate's algorithm. Single replicate case. Addition of central points to the 2^k design. Blocking and confounding in the 2^k factorial design.

Module 5

Fractional Factorial Experiments: 2-level fractional factorial design. One-half fraction of the 2^k design. Alias structures in fractional factorial designs; Confounding; Design resolutions.

Response Surface Methodology: Central Composite Design.

Course Plan

No.	Topic	No. of Lectures
1	**Introduction to Design of Experiments**	
1.1	One factor at a time experiments and designed experiments; Role of DoE in experimentation.	1
1.2	Application of software packages for designing experiments.	1
1.3	Basic statistical concepts; Probability distributions; pdf and cdf; mean and variance.	1
1.4	Normal and Student's *t* distributions; Normal probability plot.	1
1.5	Tables and charts to represent data; Stem and leaf; Box plot; Pareto chart.	1
1.6	Sampling distribution of the mean; Central Limit Theorem.	1
1.7	Constructing Confidence Intervals for a single mean, variance, and difference of two means.	2
2	**Hypothesis Testing**	
2.1	Hypothesis testing of single means.	2
	Testing of two means - with known and unknown population variance.	2
2.2	Paired t-test.	1
2.3	Testing of variances.	1
2.4	Analysis of Variance.	2
3	**Single Factor Experiments**	
3.1	Completely randomized design.	2
3.2	Replication, Randomization, Blocking.	1
3.3	Randomized complete block design.	2
3.4	Latin square design.	1
3.5	Model adequacy checking; residual plots.	2
4	**Factorial experiments**	
4.1	Two and three factors full factorial experiments.	2
4.2	2^k full factorial experiments.	2
4.3	Effects and contrasts; Yate's algorithm.	1
4.4	Single replicate case.	1
4.5	Addition of central points to the 2^k design.	1
4.6	Blocking and confounding in the 2^k factorial design.	1
5	**Fractional Factorial Experiments**	
5.1	2-level fractional factorial design.	2
5.2	Alias structures in fractional factorial designs; Confounding; Design resolutions.	2
5.3	Response Surface Methodology.	2
5.4	Central Composite Design.	2

Reference Books

1. Montgomery, D. C. (2001). Design and analysis of experiments, John Wiley, New York.
2. Montgomery, D. C. & Runger, G. C. (2007). Applied Statistics and Probability for Engineers, John Wiley, New York.
3. Krishnaiah, K. & Shahabudeen, P. (2012). Applied Design of Experiments and Taguchi Methods, PHI, New Delhi.
4. George, E. P., et al. (2005). Statistics for experimenters: design, innovation, and discovery, John Wiley, New York.
5. Panneerselvam, R. (2012), Design and Analysis of Experiments, PHI, New Delhi

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
J1PIAT202	Modern Manufacturing systems	PROGRAM CORE	3	0	0	3

Preamble: Nil

Course Outcomes:

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

CO 1	Analyse the fundamental machining principles
CO 2	Demonstrate the mechanisms in the non-traditional machining processes
CO 3	Understand various advanced metal cutting and forming operations
CO 4	Understand experimental methods using various computational methods
CO 5	Demonstrate the concept of Explosive forming Process.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6
CO 1	✓		✓	✓	✓	✓
CO 2	✓		✓	✓	✓	✓
CO 3	✓		✓	✓	✓	✓
CO 4	✓		✓	✓	✓	✓
CO 5	✓		✓	✓	✓	✓

Assessment Pattern

Bloom's Category	End Semester Examination (marks)
Apply	**20**
Analyse	**40**
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

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. The project shall be done individually. Group projects not permitted.

End Semester Examination Pattern:

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.

Model Question paper

J1PIAT202 MODERN MANUFACTURING SYSTEMS

PART A

(Answer all the questions. Each question carries 5 Marks)

1. Explain the need and characteristics of non-traditional machining?
2. Mention the advantages and disadvantages of ultrasonic machining?
3. What are the process variables that affect the performance of water jet machining process?
4. What are the functions of dielectric fluid?
5. Explain the types of explosive forming?

PART B

(Answer any 5 questions. Each carry 7 Marks)

6 What are the advantages of non-traditional machining process?

7 With a neat sketch explain the working principle of ultrasonic machining process?

8 Explain the following variables that influence the metal removal and accuracy of machining in abrasive jet machining, carrier gas, types of abrasives and standoff distance?

9 Explain with neat sketch Electron beam machining process?

10 Explain flushing and explain any two methods of flushing in EDM process?

11 Explain with sketch, the mechanism of metal removal in laser beam machining process?

12 Explain the principle of plasma generation and mechanism of metal removal in plasma arc machining?

Syllabus

MODULE	CONTENT
I	Mechanical Processes: Ultrasonic Machining- Elements of process, cutting tool system design, effect of parameters, economic considerations, applications, limitations of the process, advantages and disadvantages. Abrasive Jet Machining- Variables in AJM, metal removal rate in AJM. Water Jet Machining- Jet cutting equipment, process details, advantages and applications
II	Electrochemical and Chemical Metal Removal Processes: Electrochemical Machining- Elements of ECM process, tool work gap, chemistry of the process, metal removal rate, accuracy, surface finish and other work material characteristics, economics, advantages, applications, limitations. Electrochemical Grinding– Material removal, surface finish, accuracy, advantages, applications
III	Thermal Metal Removal Processes: Electric Discharge Machining (EDM) or spark erosion machining processes, mechanism of metal removal, spark erosion generators; electrode feed control, dielectric fluids, flushing, electrodes for spark erosion, selection of electrode material, tool electrode design, surface finish, machining accuracy, machine tool selection, applications, Wire cut EDM. Laser beam machining (LBM)- Apparatus, material removal, cutting speed and accuracy of cut, metallurgical effects, advantages and limitations
IV	Plasma Arc Machining (PAM): Plasma, non-thermal generation of plasma, mechanism of metal removal, PAM parameters, equipment for D.C. plasma torch unit, safety precautions, economics, other applications of plasma jets, Electron Beam Machining (EBM) – Generation and control of electron beam, theory of electron beam machining, process capabilities and limitations. High Velocity Forming Processes: - Conventional versus High velocity forming methods – Material behaviour – stress waves and deformation in solids – Stress wave

	induced fractures – Applications
V	Explosive Forming Processes: - Principles – Explosives – Length of reactions – Energy in plastic deformations – Expression for change in size required for deforming a flat disc into a bulged form – Effect of process in material properties – Types of Explosives forming – die construction. Magnetic Pulse Forming Processes: - General principles – Applications

Course Plan

No	**Topic**	**No. of Lectures**
1	**Introduction to mechanical processes**	
1.1	Mechanical Processes: Ultrasonic Machining- Elements of process	1
1.2	Cutting tool system design, effect of parameters, economic considerations	1
1.3	Applications, limitations of the process, advantages and disadvantages	1
1.4	Abrasive Jet Machining- Variables in AJM, metal removal rate in AJM	1
1.5	Water Jet Machining- Jet cutting equipment, process details, advantages and applications	2
2	**Electrochemical and Chemical Metal Removal Processes**	
2.1	Electrochemical and Chemical Metal Removal Processes: Electrochemical Machining	2
2.2	Elements of ECM process, tool work gap, chemistry of the process, metal removal rate	2
2.3	accuracy, surface finish and other work material characteristics, economics, advantages, applications, limitations	2
2.4	Electrochemical Grinding– Material removal, surface finish, accuracy, advantages, applications	2
3	**Thermal Metal Removal Processes**	
3.1	Thermal Metal Removal Processes: Electric Discharge Machining (EDM) or spark erosion machining processes	2
3.2	Mechanism of metal removal, spark erosion generators; electrode feed control, dielectric fluids	1
3.3	Flushing, electrodes for spark erosion, selection of electrode material, tool electrode design, surface finish	2
3.4	Machining accuracy, machine tool selection, applications, Wire cut EDM	1
3.5	Laser beam machining (LBM)- Apparatus, material removal, cutting speed and accuracy of cut, metallurgical effects, advantages and limitations	2
4	**Plasma Arc Machining (PAM), Electron Beam Machining (EBM) and High Velocity Forming Processes**	

4.1	Plasma Arc Machining (PAM): Plasma, non-thermal generation of plasma, mechanism of metal removal	2
4.2	PAM parameters, equipment for D.C. plasma torch unit, safety precautions, economics, other applications of plasma jets	2
4.3	Electron Beam Machining (EBM) – Generation and control of electron beam, theory of electron beam machining, process capabilities and limitations	2
4.4	High Velocity Forming Processes: - Conventional versus High velocity forming methods – Material behaviour – stress waves and deformation in solids	2
4.5	Stress wave induced fractures – Applications	1
5	**Explosive Forming Processes**	
5.1	Explosive Forming Processes: - Principles – Explosives – Length of reactions	1
5.2	Energy in plastic deformations – Expression for change in size required for deforming a flat disc into a bulged form	2
5.3	Effect of process in material properties, Types of Explosives forming – die construction	2
5.4	Magnetic Pulse Forming Processes: - General principles – Applications	2

Reference Books

1. J. Ghosh and Mallik, Manufacturing Science, East West Press, (2006)
2. HMT, Production Technology, Tata McGraw Hill, New Delhi. (2005)
3. C. Pandey, H.S. Shan, Modern Machining Processes, Tata McGraw Hill, (2008)
4. Mc Geongh J. A., Advanced Methods of Machining, Chapman and Hall, (2006)

Program Elective 3

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
J1PIAT213	CELLULAR MANUFACTURING AND GROUP TECHNOLOGY	PROGRAMME ELECTIVE - 3	3	0	0	3

Preamble: Nil

Course Outcomes:

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

CO 1	Develop an understanding about Group Technology and part classification and coding
CO 2	Understand the algorithms and methods for part grouping
CO 3	Understand the concepts of cellular manufacturing
CO 4	Understand about the design methods of Cellular manufacturing systems
CO 5	Understand about quantitative analysis of cellular manufacturing

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓		✓	✓	✓	✓
CO 2	✓		✓	✓	✓	✓
CO 3	✓		✓	✓	✓	✓
CO 4	✓		✓	✓	✓	✓
CO 5	✓		✓	✓	✓	✓

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

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. (Test paper shall include minimum 80% of the syllabus) : 10 marks

End Semester Examination Pattern:

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.

Model Question paper

J1PIAT213 CELLULAR MANUFACTURING AND GROUP TECHNOLOGY

PART A

(Answer all the questions. Each question carries 5 Marks)

1. Justify the need of Group Technology citing the limitations in traditional manufacturing systems.
2. Explain about methods for cell formation.
3. Describe key machine concept in cellular manufacturing
4. Explain about machine component group analysis.
5. Explain briefly about the parametric analysis of GT.

PART B

(Answer any 5 questions. Each carries 7 Marks)

6 Explain in detail about the OPITZ multiclass coding system citing an example.

7 Explain in detail about part classification based on design attributes and manufacturing attributes citing relevant examples.

8 Explain in detail about the different machine cell layouts in cellular manufacturing systems.

9 Explain how the concepts of genetic algorithms can be implemented for design and modelling of a cellular manufacturing system.

10 Explain the Application of Genetic algorithm in CMS

11 Explain various life cycle issues in GT/CMS.

12 Describe the following terms Inter and Intra cell layout, cost and non-cost-based models,

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Limitations of traditional manufacturing systems, Introduction to Group Technology, GT concepts, Advantages of GT, Part family formation –Part classification and coding systems. GT and Economics of GT. Features of part classification and coding-examples- OPITZ multiclass coding system, Benefits of GT and issues in GT.	8	20
II	Design attributes, manufacturing attributes, characteristics, and design of groups, PFA, FFA. Part machine group analysis, Methods for cell formation, Use of different algorithms, mathematical programming, and graph theoretic model approach for part grouping.	8	20

III	Cellular Manufacturing- composite part concept- examples machine cell design- types of machine cell and layout, Types of manufacturing cell, Design of cellular manufacturing systems, determination of best cell arrangement, key machine concept.	**8**	**20**
IV	Cell formation approach- Machine component group analysis, similarity coefficient-based approach, exceptional parts and bottleneck machines, Problems in GT/CMS - Design of CMS - Models, traditional approaches and non-traditional approaches - Genetic Algorithms, Simulated Annealing, Neural networks	**8**	**20**
V	Quantitative analysis in cellular manufacturing- arranging machines in GT cell- examples. Inter and Intra cell layout, cost and non-cost-based models, batch sequencing and sizing, life cycle issues in GT/CMS. Measuring CMS performance - Parametric analysis - PBC in GT/CMS, Human aspects of GT/CMS	**8**	**20**

Corse Plan

No	**Topic**	**No. of Lectures**
1	**Introduction to group technology and basics of part classification and coding**	
1.1	Limitations of traditional manufacturing systems, Introduction to Group Technology	1
1.2	GT concepts, Advantages of GT, Part classification and coding systems	2
1.3	GT and Economics of GT	1
1.4	OPITZ multiclass coding system	2
1.5	Benefits of GT and issues in GT.	2
2	**Part grouping analysis**	
2.1	Design attributes, manufacturing attributes	1
2.2	Characteristics, and design of groups	2
2.3	Production flow analysis and factory flow analysis	1
2.3	Methods for cell formation, Use of different algorithms	2
2.4	Mathematical programming, and graph theoretic model approach for part grouping.	2
3	**Concepts of cellular manufacturing**	
3.1	Composite part concept in cellular manufacturing and examples	2
3.2	Types of machine cell and layout	1
3.3	Types of manufacturing cell	1

3.4	Design of cellular manufacturing systems, determination of best cell arrangement,	2
3.5	Key machine concept	2
4	**Methods of cell formation, problems in GT/CMS, Design of CMS**	
4.1	Cell formation approach- Machine component group analysis	1
4.2	similarity coefficient-based approach, exceptional parts and bottleneck machines	2
4.3	Problems in GT/CMS	1
4.4	Design and Modelling of CMS-traditional approaches and non-traditional approaches	2
4.5	Use of Genetic Algorithms, Simulated Annealing, Neural networks in CMS design	2
5	**Quantitative analysis in cellular manufacturing**	
5.1	arranging machines in GT cell- examples	1
5.2	Inter and Intra cell layout, cost and non-cost based models	2
5.3	batch sequencing and sizing	1
5.4	life cycle issues in GT/CMS.	2
5.5	Parametric analysis - PBC in GT/CMS,	1
5.6	Human aspects of GT/CMS	1

Reference Books

1. Mikell P. Groover, “Automation, Production systems and Computer integrated manufacturing”, Prentice hall of India private limited.

2. Ali Kamrani, Hamid R Parsaei, Donald H Liles, “Planning, Design and Analysis of cellular manufacturing system”, Elsevier, 1995

3. Manua Singh, “Systems approach to Computer Integrated Design and Manufacturing”, John Wiley & Sons Inc, 1996

4. Irani.S.A, “Cellular Manufacturing Systems”, Hand Book 5. Kamrani, A.K, and Nasr, E.A. (Eds), "Collaborative Engineering: Theory and Practice Springer science, business media, 2008.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
J1PIAT223	ENTERPRISE RESOURCE PLANNING	PROGRAMME ELECTIVE - 3	3	0	0	3

Preamble: Nil

Course Outcomes:

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

CO 1	Understand the fundamental concepts of enterprise resource planning
CO 2	Apply the basic knowledge of the subject to design various modules as well as an integrated ERP system for an enterprise.
CO 3	Design and implement the various ERP modules as per the requirements of the clients
CO 4	Analyse the fitting requirements of ERP packages in different industrial domains.
CO 5	Understand how companies have implemented ERP successfully.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓		✓	✓		✓
CO 2	✓		✓	✓		✓
CO 3	✓		✓	✓		✓
CO 4	✓		✓	✓		✓
CO 5	✓		✓	✓		✓

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

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. (Test paper shall include minimum 80% of the syllabus) : 10 marks

End Semester Examination Pattern:

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.

Model Question paper

J1PIAT223 Enterprise Resource Planning

PART A

(Answer all the questions. Each question carries 5 Marks)

1. Explain the role of enterprise in business modelling.
2. Illustrate Business Process Reengineering.
3. Write shote notes on Basic modules of ERP Package.
4. Write shot note on ERP in manufacturing industry.
5. What are the implementation methodologies of ERP software?

PART B

(Answer any 5 questions. Each carry 7 Marks)

6. Explain the conceptual model of ERP.

7. Explain in detail about following terms in ERP environment i) Data Warehousing and Data mining ii) Data extraction and transformation

8. Explain the various performance measures of ERP

9. Describe about the ERP functional modules i) Human capital Management ii) Financial management iii) Supply chain planning iv) Sales and service.

10. Explain in detail about application of ERP in service industries

11. Explain the terms in ERP Related technology

(i)Data base Management System (ii) Decision Support Systems

12. Explain in detail about ERP implementation methodology.

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Introduction of ERP: Concept of Enterprise, ERP Overview, Integrated information system, The role of Enterprise, Business Modelling, Myths about ERP, Basic ERP Concepts. Enabling Technologies, Conceptual Model of ERP, Structure of ERP, Intangible benefits of ERP, Justifying ERP investment, Risks of ERP, Benefits of ERP.	8	20
II	ERP and related Technology: Business Process Reengineering (BPR), Management Information System (MIS), Data base Management System (DBMS), Decision Support Systems (DSS), Executive Support Systems (ESS), Data Warehousing and Data Mining, Online Analytical Processing (OLTP), Supply Chain Management (SCM), Customer Relationship	8	20

	Management (CRM).		
III	Modules of ERP: Basic modules of ERP Package- Human Resources Management, Financial Management, Inventory Management, Quality Management, Sales and Distribution.	**8**	**20**
IV	ERP packages and Cases: ERP for manufacturing Industries, ERP for Service Industries. Performance measures for ERP, Cloud ERP.	**8**	**20**
V	ERP Implementation: ERP Implementation Strategies, ERP Implementation Life Cycle, Implementation Methodologies, ERP package selection, ERP Projects Teams, Vendors and Consultants, Reasons for failure and reasons for success of ERP implementation, Dealing with employee resistance, Training and Education, data migration, Project Management and monitoring, Post Implementation activities.	**8**	**20**

Corse Plan

No	**Topic**	**No. of Lectures**
1	**Introduction of ERP**	
1.1	Concept of Enterprise, ERP Overview, Integrated information system	1
1.2	The role of Enterprise, Business Modelling	1
1.3	Myths about ERP	1
1.4	Basic ERP Concepts.	1
1.5	Enabling Technologies	1
1.6	Conceptual Model of ERP& Structure of ERP	1
1.7	Intangible benefits of ERP	1
1.8	Justifying ERP investment, Risks of ERP, Benefits of ERP	1
2	**ERP and related Technology**	
2.1	Business Process Reengineering (BPR), Management Information System (MIS).	2
2.2	Data base Management System (DBMS), Decision Support Systems (DSS).	2
2.3	Executive Support Systems (ESS), Data Warehousing and Data Mining, Online Analytical Processing (OLTP).	2
2.4	Supply Chain Management (SCM), Customer Relationship Management (CRM).	2
3	**Modules of ERP**	

3.1	Basic modules of ERP Package, Human Resources Management.	2
3.2	Financial Management, Inventory Management.	2
3.3	Quality Management.	2
3.4	Sales and Distribution.	2
4	**ERP packages and Cases**	
4.1	ERP for manufacturing Industries.	2
4.2	ERP for Service Industries.	2
4.3	Performance measures for ERP	2
4.4	Cloud ERP.	2
5	**ERP Implementation**	
5.1	ERP Implementation Strategies, ERP Implementation Life Cycle.	1
5.2	Implementation Methodologies, ERP package selection, ERP Projects Teams.	2
5.3	ERP Projects Teams, Vendors and Consultants, Reasons for failure and reasons for success of ERP implementation.	1
5.4	Dealing with employee resistance, Training and Education, data migration.	2
5.5	Project Management and monitoring, Post Implementation activities.	2

Reference Books

1. Rajesh Ray "Enterprise Resource Planning'', Tata McGraw Hill Education Private Limited, New Delhi.
2. Vinod Kumar Garg and Venkitakrishnan N K,"Enterprise Resource Planning- Concepts and Practice". PHI, 2006
3. David L. Olson, "Managerial issues of Enterprise Resource Planning systems" TMH Edition 2008.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
J1PIAT233	FLEXIBLE MANUFACTURING SYSTEMS	PROGRAMME ELECTIVE - 3	3	0	0	3

Course Outcomes:

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

CO 1	Demonstrate in detail about FMS, types and equipment
CO 2	Understand some of the flexibility achievements and economic justification and functional requirements for FMS
CO 3	Understand the concept of FMS processing and QA equipment
CO 4	Evaluate the types of storage systems and cutting tool management
CO 5	Analyse various work holding considerations in FMS environment

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓		✓	✓	✓	✓
CO 2	✓		✓	✓	✓	✓
CO 3	✓		✓	✓	✓	✓
CO 4	✓		✓	✓	✓	✓
CO 5	✓		✓	✓	✓	✓

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

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. (Test paper shall include minimum 80% of the syllabus) : 10 marks

End Semester Examination Pattern:

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.

Model Question paper

J1PIAT233 FLEXIBLE MANUFACTURING SYSTEMS

PART A

(Answer all the questions. Each question carries 5 Marks)

1. What is the need for FMS? Explain in the context of evolution of FMS?
2. Enumerate the economic justification for FMS and functional requirements for FMS equipment?
3. Describe material handling principles in FMS?
4. Differentiate Conventional and Automated storage systems
5. Describe the fixture considerations in FMS environment?

PART B

(Answer any 5 questions. Each carry 7 Marks)

6 What are the different types of flexibilities. Mention its measurement?

7 Define a flexible manufacturing system. Also, explain its evolution from mechanized machine to a contemporary flexible manufacturing system?

8 Enumerate components structure of FMS and their functions with neat sketch?

9 Explain AGV and its types in detail with a neat sketch?

10 Discuss the problems involved in implantation of FMS?

11 Describe the use of deterministic models for quantitative analysis of FMS?

12 List out the typical data handled by an FMS. Explain their role in detail

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Introduction: Introduction to FMS, FMS definition, evolution, equipment, and classification of FMS - configuration of FMS-application of FMS, Automated production cycle, Need of flexibility, Concept of flexibility, Types of flexibilities and its measurement. FMS Equipment: Why FMS, Factors responsible for the growth of FMS	**9**	**20**
II	FMS types and applications, user- host supplier flexibilities- flexibility achievement-how to develop FMS, Economic justification for FMS, Functional requirements for FMS equipments	**8**	**20**
III	FMS processing and QA equipment, e.g., turning and machining centers, Coordinate measuring machines, Cleaning and deburring machines, FMS system support equipment, Material handling principles- transport system-industrial truck, Automated material handling, AGV- monorail and other guided vehicle-conveyor-crane- hoist	**9**	**20**
IV	Storage system- performance- location strategies-conventional and automated storage systems-equipment	**7**	**20**

	used for storage, engineering analysis. Cutting tool and tool management		
V	Work holding considerations, Fixture considerations in FMS environment, FMS production, and its importance, Manufacturing support system- process planning for parts and assemblies- CAPP retrieval and generative	**7**	**20**

Corse Plan

No	**Topic**	**No. of Lectures**
1	**Introduction: Introduction to FMS, FMS definition, evolution, equipment and classification of FMS**	
1.1	Introduction: Introduction to FMS, FMS definition, evolution, equipment and classification of FMS	2
1.2	Configuration of FMS	1
1.3	Application of FMS Automated production cycle	2
1.4	Need of flexibility, Concept of flexibility, Types of flexibilities and its measurement	2
1.5	FMS Equipment: Why FMS, Factors responsible for the growth of FMS	2
2	**FMS types, applications and equipment**	
2.1	FMS types and applications	2
2.2	User- host supplier flexibilities	2
2.3	Flexibility achievement-how to develop FMS	2
2.4	Economic justification for FMS, Functional requirements for FMS equipment	2
3	**FMS processing and QA equipment and AGV**	
3.1	FMS processing and QA equipment, e.g., turning and machining centres	2
3.2	Coordinate measuring machines, Cleaning and deburring machines	2
3.3	FMS system support equipment	1
3.4	Material handling-principles- transport system-industrial truck Automated material handling	2
3.5	AGV- monorail and other guided vehicle-conveyor- crane- hoist	2
4	**Storage system and Cutting tool, equipment and management**	
4.1	Storage system- performance- location strategies	2
4.2	Conventional and automated storage systems	2
4.3	Equipments used for storage, engineering analysis	1
4.4	Cutting tool and tool management	2
5	Work holding considerations, Manufacturing support systems and CAPP retrieval	
5.1	Work holding considerations	1

5.2	Fixture considerations in FMS environment	1
5.3	FMS production and its importance	1
5.4	Manufacturing support system	1
5.5	process planning for parts and assemblies	1
5.6	CAPP retrieval and generative	2

Reference Books

1. D. J. Parrish. Butterworth Heinmann; Flexible manufacturing systems
2. Groover, M.P., "Automation, Production System and CIM", Prentice-Hall of India, 2006.3. V. K. Jain, Introduction to micro machining, Narosa publishing house, 2014
3. David Bedworth, "Computer Integrated Design and Manufacturing", TMH, New Delhi, III Edition 2005

Program Elective 4

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
J1PIAT214	COMPUTER AIDED MEASUREMENTS	PROGRAME ELECTIVE - 4	3	0	0	3

Preamble: Nil

Course Outcomes:

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

CO 1	Under stand the fundamentals of measurements and its dynamics
CO 2	Identify the use of sensors and transducers in measurement.
CO 3	Evaluate the basic concepts for measuring the displacement and pressure,
CO 4	Analyse the importance of temperature and flow measurement.
CO 5	Knowledge and skills in using sensors with conditioning circuits for automation systems which has applications in diverse areas of process and manufacturing automation

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	✓		✓	
CO 2	✓	✓	✓		✓	
CO 3	✓	✓	✓			
CO 4	✓	✓	✓			
CO 5	✓	✓	✓			

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

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. (Test paper shall include minimum 80% of the syllabus) : 10 marks

End Semester Examination Pattern:

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.

Model Question paper

J1PIAT214 COMPUTER AIDED MEASUREMENTS

PART A

(Answer all the questions. Each question carries 5 Marks)

1. What is measurement? State and explain the requirements to be satisfied in the act of measurement.
2. What is a passive transducer? Give examples. How does it differ from an active transducer.
3. Describe, in brief, a variable resistance transducer used for measurement of small displacements.
4. Suggest and explain about an instrumentation circuit which will produce a linear output with temperature.

5. Explain the basic working principle of any one magnetic sensor with a neat diagram.

PART B

(Answer any 5 questions. Each carry 7 Marks)

6 Define dynamic system response of a measuring system and explain. (i) Amplitude response (ii) phase response (iii) delay or rise time (iv) bandwidth of frequency response

7 With the aid of a block diagram explain the generalised measuring system.

8 Define what is meant by a transducer and state their desirable operational characteristics. Explain why all transducers are designed to give electrical output by linking primary mechanical detectors to electrical secondary sensors give reasons.

9 What are the three major classes of digital displacement transducers? Draw diagrams of each of them. Discuss their relative merits and demerits.

10 What is process loading? If a potentiometer is used as displacement sensor, then prove that the relation ship between load voltage and fractional displacement of wiper is nonlinear.

11 Describe the principle of operation of a head -type flowmeter based on differential pressure measurement. what is Reynolds number?

12 With the aid of neat sketches explain briefly any two radiation sensors used for measurement.

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Introduction to Measurement: Significance of measurement, Different methods of measurement, Classification of measuring instruments, Application of measurement systems, typical measurement schemes. Dynamic Characteristics: Dynamic response; Transient response; speed of response, fidelity, measuring lag etc, Linear approximation, Introduction to compensation techniques. Significance of testing and calibration, Calibration curve, Standards for calibration, Different calibration procedures-primary, secondary, direct, indirect, routine calibration, Calibration setup: pressure gauge, level etc.	8	20
II	Introduction to Sensors: Definition and differences of sensors and transducers, Classification, static and dynamic characteristics, electrical characterization, mechanical and thermal characterization including bathtub curve. Introduction to Transducers: Transducer classification, Active and Passive Transducers, Potentiometric Transducers, Linear and non-linear potentiometer, Feedback transducer system, Inverse transducer, Self-balancing transducer, Servo- operated manometer, Feedback pneumatic load cell, integrating servo.	8	20
III	Displacement Measurement: Linear /Angular displacement, Pneumatic/Electric/ Optical/ Ultrasonic/Electronic Displacement Transducers, Tactile and Proximity Sensors, Typical application schemes, Tacho-generators. Pressure Measurement: Pressure Units, Force Summing Devices, Secondary Transducers, Vacuum Measurement, Torque Measurement, Resistance/Bonded Type Strain Gauge.	8	20
IV	Temperature Measurement: Electric Method, Change in Electrical Properties, RTD, Thermocouples, Thermistors,	8	20

	Thermowells. Nuclear thermometers, resistance change type thermometric sensors. Flow Measurement: Reynold Number, Head type flowmeters, Velocity measurement type flowmeters, Mass flow measurement type flow meters.		
V	Magnetic sensors: Basic working principles, Magneto-strictive, Hall effect, Eddy current type. Radiation sensors: Photo-detectors, Photo-emissive, photomultiplier, scintillation detectors. Electroanalytical sensors: Electrochemical cell, SHE, Polarization, Reference electrode, Metal electrodes, Membrane electrodes.	**8**	**20**

Corse Plan

No	**Topic**	**No. of Lectures**
1	**Introduction to Measurement & Dynamic Characteristics**	
1.1	Significance of measurement, Different methods of measurement, Classification of measuring instruments, Application of measurement systems, typical measurement schemes.	2
1.2	Dynamic response; Transient response; speed of response, fidelity, measuring lag etc,	2
1.3	Linear approximation, Introduction to compensation techniques.	1
1.4	Significance of testing and calibration, Calibration curve, Standards for calibration, Different calibration procedures-primary, secondary, direct, indirect, routine calibration, Calibration setup: pressure gauge, level etc.	3
2	**Introduction to Sensors and Transducers**	
2.1	Definition and differences of sensors and transducers, Classification.	2
2.2	Static and dynamic characteristics, electrical characterization, mechanical and thermal characterization including bathtub curve.	2
2.3	Introduction to Transducers: Transducer classification, Active and Passive Transducers, Potentiometric Transducers, Linear and non- linear potentiometer, Feedback transducer system, Inverse transducer, Self-balancing transducer.	2
2.4	Servo- operated manometer, Feedback pneumatic load cell, integrating servo.	2

3	**Displacement and Pressure Measurements**	
3.1	Linear /Angular displacement, Pneumatic/Electric/ Optical/ Ultrasonic/Electronic Displacement Transducers.	2
3.2	Tactile and Proximity Sensors, Typical application schemes, Tacho-generators.	2
3.3	Pressure Units, Force Summing Devices, Secondary Transducers.	2
3.4	Vacuum Measurement, Torque Measurement, Resistance/Bonded Type Strain Gauge.	2
4	**Temperature and flow Measurements**	
4.1	Electric Method, Change in Electrical Properties, RTD, Thermocouples, Thermistors, Thermowells.	3
4.2	Nuclear thermometers, resistance change type thermometric sensors	2
4.3	Reynold Number, Head type flowmeters, Velocity measurement type flowmeters, Mass flow measurement type flow meters.	2
5	**Magnetic, Radiation and Electroanalytical sensors**	
5.1	Basic working principles, Magneto-strictive, Hall effect, Eddy current type.	2
5.2	Photo-detectors, Photo-emissive, photomultiplier, scintillation detectors	2
5.3	Electrochemical cell, SHE, Polarization, Reference electrode, Metal electrodes, Membrane electrodes.	4

Reference Books

1. K.L. Kishore, Electronic Measurement and Instrumentation, Pearson.
2. D. Patranabis, Sensors and Transducers, PHI Learning Pvt. Ltd., 2nd Edition
3. A. K. Ghosh, Introduction to Measurements and Instrumentation, 4th Edition, PHI.
4. D V S Murty, Transducers and Instrumentation, PHI Learning Pvt. Ltd.
5. B. C. Nakra, K. K. Chaudhry, Instrumentation, Measurement and Analysis, 4th Edition, Tata McGraw Hill.
6. W. D. Cooper, Modern Electronics Instrumentation & Measurement Techniques, PHI.
7. John. P. Bentley, Principles of Measurement Systems, Pearson
8. E. O. Doebelin, Dhanesh N Manik, Measurement Systems, 6th Edition, McGraw Hill.
9. Bolton W, Mechatronics- Electronic Control Systems in Mechanical & Electrical Engineering, 2nd Edition, Longman Publishers, 2002.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
J1PIAT224	MODELING AND SIMULATION OF ENGINEERING SYSTEMS	Program Elective 4	3	0	0	3

Preamble: Nil

Course Outcomes:

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

CO 1	Understand in detail about fundamental concepts in mathematical modeling
CO 2	Demonstrate some of the lumped element modeling
CO 3	Understand the modelling of first order and second order systems
CO 4	Analyse the frequency response of linear and time invariant systems
CO 5	Understand various feedback systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓		✓	✓		✓
CO 2	✓		✓	✓		✓
CO 3	✓		✓	✓		✓
CO 4	✓		✓	✓		✓
CO 5	✓		✓	✓		✓

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

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. (Test paper shall include minimum 80% of the syllabus) : 10 marks

End Semester Examination Pattern:

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.

Model Question paper

J1PIAT224 MODELING AND SIMULATION OF ENGINEERING SYSTEMS

PART A

(Answer all the questions. Each question carries 5 Marks)

1. Explain the fundamental concepts in Mathematical modeling?
2. Explain the thermal systems and hydraulic systems in lumped element modelling?
3. Describe time domain and frequency domain?
4. Explain Conventional and Automated storage systems in detail?
5. Explain the phase and gain margins?

PART B

(Answer any 5 questions. Each carries 7 Marks)

6 Explain balance and conservation laws and system boundary approach?

7 Explain various lumped element modelling techniques?

8 Derive the governing equation for first order free responses?

9 Derive the governing equations for forced responses?

10 Derive the equations for frequency response of the first order system?

11 Derive the equations for frequency response of the second order system?

12 Discuss feedback systems with block diagram?

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Fundamental Concepts in Mathematical Modelling: Abstraction – linearity and superposition – balance and conservation laws and the system – boundary approach.	8	20
II	Lumped – Element Modeling: Mechanical systems – Translational, rotational. Hydraulic systems. Thermal systems. RLC Electrical Systems.	7	20
III	Modeling of First–order and Second–order Systems: Governing equations for free and forced responses – transient response specifications – experimental determination – Laplace transform. Time Domain, Frequency Domain and State Space.	9	20
IV	Frequency response of Linear, Time invariant systems – frequency response of first–order and second–order systems – state space formulations of systems problems relating frequency response to pole location – transient	9	20

	response-poles and frequency response.		
V	Feedback systems: Systems with feedback – block diagrams – properties of feedback systems – relative stability – phase and gain margins.	7	20

Corse Plan

No	Topic	No. of Lectures
1	**Fundamental Concepts in Mathematical Modelling:**	
1.1	Fundamental Concepts in Mathematical Modelling	1
1.2	Fundamental Concepts in Mathematical Modelling: Abstraction	1
1.3	Linearity and superposition	2
1.4	Balance and conservation laws and the system	2
1.5	Boundary approach	2
2	**Mechanical, Hydraulic, Thermal & Electrical systems**	
2.1	Lumped – Element Modeling	2
2.2	Mechanical systems – Translational, rotational	2
2.3	Hydraulic systems	1
2.4	Thermal systems. RLC Electrical Systems	2
3	**Modeling of First–order and Second–order Systems**	
3.1	Modeling of First–order and Second–order Systems	2
3.2	Governing equations for free and forced responses	2
3.3	Transient response specifications – experimental determination	2
3.4	Laplace transform	1
3.5	Time Domain, Frequency Domain and State Space.	2
4	**Frequency response**	
4.1	Frequency response of Linear, Time invariant systems	2
4.2	Frequency response of first–order and second–order systems	2
4.3	State space formulations of systems	1
4.4	Problems relating frequency response to pole location	2
4.5	Transient response-poles and frequency response	2
5	**Feedback systems**	
5.1	Feedback systems	1
5.2	Systems with feedback – block diagrams	1
5.3	Systems with feedback – block diagrams	1
5.4	properties of feedback systems	1
5.5	relative stability	1
5.6	phase and gain margins	2

Reference Books

1. Cha P. D., Rosenberg J. J. and Dym C. L. – 'Fundamentals of Modeling and Analyzing Engineering Systems'- Cambridge University – 2000
2. Woods Robert L. and Kent L.- 'Modeling and Simulation of Dynamic Systems'- Prentice Hall – 1997
3. Mukherjee A. and Karmakar R. – 'Modeling and Simulation of Engineering Systems through Bondgraphs' – Narosa – 2000
4. Frederick C. – 'Modeling and Analysis of Dynamic Systems' – Wiley – 2001 – 3rd Edition

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
J1PIAT234	OPTIMIZATION TECHNIQUES	PROGRAMME ELECTIVE - 4	3	0	0	3

Preamble: Nil

Course Outcomes:

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

CO 1	Understand the theory of simplex method
CO 2	Understand the concepts of non-linear programming in manufacturing process
CO 3	Identify algorithms for unconstrained optimization.
CO 4	Understand the basic concepts of multi-objective decision making and sequential decision making.
CO 5	Solve a multi-variable single objective optimization problem using Metaheuristics.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓		✓	✓	✓	✓
CO 2	✓		✓	✓	✓	✓
CO 3	✓		✓	✓	✓	✓
CO 4	✓		✓	✓	✓	✓
CO 5	✓		✓	✓	✓	✓

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

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. (Test paper shall include minimum 80% of the syllabus) : 10 marks

End Semester Examination Pattern:

The end semester examination will be conducted by the respective College. 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.

Model Question paper

J1PIAT234 OPTIMIZATION TECHNIQUES

PART A

(Answer all the questions. Each question carries 5 Marks)

1. Explain various theorems of duality.
2. Explain the necessity conditions for constrained multivariable optimization with equality and inequality constraints.
3. Explain the various step by step procedure for Fibonacci search for find the maximum and minimum of a unimodal univariate objective function.
4. Explain the various steps involved in goal programming.

5. Explain the difference between heuristics and Metaheuristics

PART B

(Answer any 5 questions. Each carry 7 Marks)

6 Find the values of basic variables for the following LPP if the optimum solution is having Basic variable set $X_B = [X_1, X_2]$ using revised simplex method. Also find the range of b_1 (right hand side value of the first constant) so that the solution set will have same optimum basic variables.

$$Max\ Z = 4X_1 + 6X_2 + 2X_3$$

Sub to

$$X_1 + X_2 + X_3 \leq 3$$

$$X_1 + 4X_2 + 7X_3 \leq 9$$

$$X_1, X2, X_3 \geq 0$$

7 Solve the following LPP by Duel Simplex method.

$$Min\ Z = 2X_1 + 4X_2$$

Sub to

$$2X_1 + X_2 \geq 4$$

$$X_1 + 2X_2 \geq 3$$

$$2X_1 + 2X_2 \leq 12$$

$$X_1, \quad X_2 \geq 0$$

8 Determine the maximum or minimum point (if any) for the function

$f(X) = 2X_1^2 + X_2^2 + X_3^2 + 2X_1X_2 - 8X_1 - 4X_2 - 6X_3 + 37$

9 Market state of a product for the next month can be Strong Moderate or Weak (S, M, W) and depends only on the market condition of the current month. One step transient probabilities for the market states are given. The manufacturing company has to adopt one of the three marketing strategies namely Aggressive, Basic or Cautions (A , B, C).he returns per month for each of the strategies given a particular state of the market occurs in that month is also given , assuming the state f the
product follows a Markov chain, determine the ideal long term marketing strategy to

adopt in order to maximize the expected returns per month.

One step Transient Probabilities

		Next month S	M	W
Current Month	S	0.7	0.3	0.0
	M	0.0	0.6	0.4
	W	02	0.0	0.8

Returns per month in

Lakhs of Rs

		Market State S	M	W
Marketing Strategy	A	43	32	25
	B	35	40	30
	C	20	28	32

10 Minimize

$f(x) = x^4 + 15x^3 + 7x^2 - 1135x$

Terminate when ,

$|f(x_n) - f(x_{(n-1)})| \leq 0.5$

Using Golden search method

11 Explain the principles of Simulated Annealing Algorithm used in optimization.

12 Explain the principles of Genetic Algorithm used in optimization

Syllabus

MODULE	CONTENT	HOURS	SEMESTER EXAM MARKS (%)
I	Theory of simplex method, Duality Theory, Duality theorems, Dual simplex method, Revised simplex method – Bounded variables algorithm, Sensitivity analysis, Parametric programming. Integer programming: Cutting plane method, Branch and bound method. Network models and solutions: Shortest route problems, Minimal spanning tree problems, Maximal flow problems.	**8**	**20**
II	Non-linear programming problems: General non-linear programming problems; Convex, Quasi-convex, Concave and uni-modal functions, Theory of unconstrained optimization – Necessary and sufficient conditions for extrema, Theory of constrained optimization –Lagrange multipliers and Lagrangian optimization, Inequality constraints, Kuhn-Tucker conditions.	**8**	**20**
III	Algorithms for unconstrained optimization: Fibonacci search method, Golden section search method, Cauchy's (steepest descent) method. Algorithms for constrained optimization: Quadratic programming, Separable convex programming.	**8**	**20**
IV	Multi-objective decision models: Introduction to multi- objective decision making, Concept of pareto-optimality, Goal programming formulation, The weighting method	**8**	**20**

	of solution, Analytic hierarchy process. Sequential decision making (stochastic case): Stochastic processes, Markov processes, Markov chains, Markov decision problems, Algorithms for solving Markov decision problems.		
V	Metaheuristics: Nature of metaheuristics, Tabu search, Simulated annealing, Genetic algorithm. Complexity of algorithms: Complexity of algorithms for combinatorial optimization problems.	**8**	**20**

Corse Plan (For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30 hours).

No	Topic	No. of Lectures
1	**Parametric programming. Integer programming:**	
1.1	Theory of simplex method, Duality Theory, Duality theorems, Dual simplex method, Revised simplex method.	2
1.2	Bounded variables algorithm, Sensitivity analysis, Parametric programming.	2
1.3	Integer programming: Cutting plane method, Branch and bound method.	2
1.4	Network models and solutions: Shortest route problems, Minimal spanning tree problems, Maximal flow problems.	2
2	**Non-linear programming problems**	
2.1	General non-linear programming problems; Convex, Quasi-convex, Concave and uni-modal functions.	2
2.2	Theory of unconstrained optimization – Necessary and sufficient conditions for extrema.	2
2.3	Theory of constrained optimization –Lagrange multipliers and Lagrangian optimization, Inequality constraints, Kuhn-Tucker conditions.	4
3	**Algorithms for unconstrained optimization**	
3.1	Fibonacci search method.	2
3.2	Golden section search method.	2
3.3	Cauchy's (steepest descent) method.	2
3.4	Quadratic programming, Separable convex programming.	2
4	**Multi-objective decision models & Sequential decision making**	
4.1	Introduction to multi-objective decision making, Concept of pareto-optimality, Goal programming formulation, The weighting method of solution.	2

4.2	Analytic hierarchy process.	2
4.3	Stochastic processes, Markov processes, Markov chains, Markov decision problems.	2
4.4	Algorithms for solving Markov decision problems.	2
5	**Metaheuristics**	
5.1	Nature of metaheuristics.	1
5.2	Tabu search.	2
5.3	Simulated annealing.	1
5.4	Genetic algorithm.	2
5.5	Complexity of algorithms for combinatorial optimization problems	2

Reference Books

4. Rao S.S, Optimization: Theory and Applications, Wiley Eastern, Fourth edition, 2009.
5. Ravindran A., Philips D.T. and Solberg J.J., Operations Research: Principles and Practice, John Wiley & Sons, 4th Edition, 2009.
6. Taha H.A., Operations Research: An Introduction, Pearson Education, 9th Edition, 2013
7. Deb K., Optimization for Engineering Design: Algorithms and Examples, Prentice- Hall of India, 2nd 2012
8. Papadimitriou C.H. and Steghtz K., Combinatorial Optimization: Algorithms and Complexity, Dover Publications Inc, 2000 .
9. Hillier F.S. and Liberman G.J., Introduction to Operations Research, McGraw-Hill International, 10th edition, 2014
10. Reklatis G.V., Ravindran A. and Ragsdell K.M., Engineering Optimization: Methods and applications, John Wiley and Sons, 2nd Edition, 2006

INTERDISCIPLINARY ELECTIVE

CODE J1PIAO215	Internet of Things	CATEGORY	L	T	P	CREDIT
		INTERDISCIPLINARY ELECTIVE	3	0	0	3

Preamble: Nil

Course Outcomes:

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

CO 1	Evaluate IoT enabling technologies
CO 2	Analyse protocols implemented for IoT connected devices.
CO 3	Design and develop Smart Devices using IoT
CO 4	Analyse the vulnerabilities for IoT and security requirements of IoT
CO 5	Apply IoT for various domains

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2		2			
CO 2	2		2			
CO 3	2		2			
CO 4	2		2			
CO 5	3	3	3			

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	80%
Analyse	10%
Evaluate	10%
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 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 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.

Syllabus

Module1

Introduction to Internet of Things: An overview; Definition, scope and characteristics of IoT; IoT enabling technologies; Structure of IoT; Major components. Sensor technology: sensor types and applications, Actuators: principles and properties. Basics of IoT Networking, Communication Protocols: MQTT, CoAP, AMQP

Module 2

Connectivity Technologies: Zigbee, Bluetooth, RFID. Wireless Sensor Network (WSN) technology- concepts and applications. Machine-to-Machine Communications, IoT and M2M, Interoperability in IoT.

Module 3

IoT device- definition and building blocks; Embedded platforms for prototyping, features and IoT applications; Connecting things to embedded devices. Introduction to Arduino Programming using an IDE (basics only), Integration of Sensors and Actuators with Arduino.

Module 4

Introduction to Raspberry Pi; Python programming; Interfacing Raspberry Pi with basic peripherals; Implementation of IoT with Raspberry Pi (basics only). Cloud platforms for IoT; Cloud security requirements

Module 5

Sensor-cloud, Industrial IoT(IIoT): Requirements of IIoT, applications. Case studies:

Smart grid, Smart parking, Remote vehicle diagnostics, Smart Irrigation, Health and fitness monitoring.

Corse Plan

No	Topic	No. of Lectures
1	The Internet of Things: An overview	
1.1	Introduction to Internet of Things, Definition, scope and characteristics of IoT	1
1.2	IoT enabling technologies, Structure of IoT, Major components	2
1.3	Sensor technology, Actuators, principles and properties	2
1.4	Basics of IoT Networking, Communication Protocols	2
2	Architecture, design and connectivity principles	
2.1	Connectivity Technologies	2
2.2	Wireless Sensor Network (WSN) technology, concepts and applications	2
2.3	Machine-to-Machine Communications, IoT and M2M	2
2.4	Interoperability in IoT	1
3	Development of IoT platforms	
3.1	IoT device, definition and building blocks	1
3.2	Embedded platforms for prototyping, Connecting things to embedded devices	2
3.3	Introduction to Arduino Programming using an IDE	3
3.4	Integration of Sensors and Actuators with Arduino	3
4	IoT prototyping and security	
4.1	Introduction to Raspberry Pi, Python programming	2
4.2	Interfacing Raspberry Pi with basic peripherals	3
4.3	Implementation of IoT with Raspberry Pi	2
4.4	Cloud platforms for IoT, Cloud security requirements	2
5	Case studies	
5.1	Sensor-cloud	1
5.2	Industrial IoT(IIoT), Requirements of IIoT, applications	2
5.3	Case studies: Smart grid, Smart parking, Remote vehicle diagnostics	3
5.4	Case studies: Smart Irrigation, Health and fitness monitoring.	2

Reference Books

1. Internet of Things: A Hands-On Approach by Arshdeep Bahga, Vijay Madisetti. Universities press (India)
2. Internet of Things: Architecture and Design principles by Raj Kamal, Publisher: Mc Graw Hill Education
3. The Internet of Things: Enabling Technologies, Platforms, and Use Cases, by Pethuru Raj and Anupama C. Raman , CRC Press.
4. The Internet of Things by Samuel Greengard, The MIT Press Essential Knowledge series.

J1PIAO225	DIGITAL PRODUCT DESIGN AND MANUFACTURING	CATEGORY	L	T	P	CREDIT
		INTERDISCIPLINARY ELECTIVE	3	0	0	3

Preamble:

The focus of digital product design and manufacturing is the integration of digital technology in design and manufacturing functions in creating new products. It also envisages the use of digital tools such as virtual-augmented reality and additive manufacturing in product design and manufacturing.

Course Outcomes:

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

CO 1	Demonstrate the principles of product development process and the role of computers in it.
CO 2	Implement the principles of industrial design to develop new products
CO 3	Apply the innovative digital tools in product design and development
CO 4	Apply the innovative digital tools in simulation and analysis at the design stage
CO 5	Summarize the innovative prototyping techniques in design and understand the industrial practices.

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3			
CO 2			3	2		
CO 3			3			
CO 4			3	2		
CO 5			3		2	

Assessment Pattern

Bloom's Category	End Semester Examination
Apply	☒
Analyse	☒
Evaluate	
Create	

Mark distribution

Total Marks	CIE	ESE	ESE Duration

100	40	60	2.5 hours

Continuous Internal Evaluation

Pattern: ELECTIVE COURSES

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 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.

Model Question paper

QP Code: **Total Pages:**

Reg No.:_____ **Name:**_____

JYOTHI ENGINEERING COLLEGE (AUTONOMOUS) CHERUTHURUTHY

SECOND SEMESTER M. TECH DEGREE EXAMINATION, Month & Year

Stream: INDUSTRIAL AUTOMATION & ROBOTICS

Course Code: J1PIAO225

Course Name: DIGITAL PRODUCT DESIGN AND MANUFACTURING

Max. Marks: 60 **Duration: 2.5 Hours**

PART A

Answer all questions, each carries 5 marks. Marks

1	Elaborate different phases in design.	(5)
2	Explain the role of planning for product distribution.	(5)
3	Explain how VR can be utilised in product development.	(5)
4	Illustrate the role of virtual human in product development.	(5)
5	Differentiate between material extrusion and material jetting additive manufacturing techniques.	(5)

PART B

Answer any 5 full question, each question carries 7 marks.

6	Explain the concept of standardization in product design with the help of an example.	(7)
7	Explain the various aspects of human factors to be considered in product development.	(7)
8	Explain the importance of break-even analysis during design.	(7)
9	Illustrate with examples how VR and AR can be useful in product development.	(7)
10	Demonstrate the significance of product digitalisation in analysis and simulation.	(7)

11	Explain the role of aesthetics in product design.	(7)
12	With the help of neat sketch explain the direct energy deposition method.	(7)

Syllabus:

Module 1

Concept of Product Design: Definition of engineering design, design constraints, different phases in design- conceptual design, embodiment design, detail design, planning for manufacture, planning for distribution, planning for use, Human factors design- ergonomics, anthropometry, comfort criteria, concepts of size, texture and colour, Introduction to product design, product design practices in industry.

Module 2

Tools for product design- drafting-modelling software CAE/CAD, computer aided styling, production process- CAM interface, product development- time and costs. Description of planning for product distribution, Economic factors affecting design.

Module 3

Digital tool enabled design -I: Evolution of digital tools for product design and manufacturing, 2D/3D models to digital mock-up and virtual prototyping (VP). Virtual reality (VR), augmented reality (AR) and Mixed reality, Implementation in product design and manufacturing. Interaction technology, Visualisation technology, Visual display-types- head mounted, organic LEDs, large volume displays, wall type, equipments, characteristics.

Module 4

Digital tool enabled design-II: AR-, tangible, collaborative; examples; AR tracking technology and devices; interaction techniques, haptic technology, olfactory technology. Product digitalization, analysis and simulation. Virtual humans (VH)- for clothing, for ergonomics analysis, biomechanical models.

Module 5

Digital manufacturing: 3D printing- additive manufacturing technology- Classification of additive manufacturing technologies: vat- photo polymerisation, powder bed fusion, material jetting, sheet lamination, material extrusion and direct energy deposition, infill lattice structures.

Corse Plan

No	Topic	No. of lectures
1	**Product development process:**	
1.1	Concept of Product Design: Definition of engineering design, design constraints	2
1.2	Different phases in design- conceptual design, embodiment design, detail design, planning for manufacture, planning for distribution, planning for use	3
	Human factors design- ergonomics, anthropometry, comfort criteria, concepts of size, texture and colour	1
1.3	Introduction to product design, product design practices in industry.	2
2	**Embodiment design:**	
2.1	Tools for product design- drafting-modelling software CAE/CAD, computer aided styling, production process- CAM interface, product development- time and costs.	4
2.2	Description of planning for product distribution, economic factors affecting design.	4
3	**Digital tool enabled design-I**	
3.1	Evolution of digital tools for product design and manufacturing, 2D/3D models to digital mock-up, virtual prototyping (VP).	2
3.2	Virtual reality (VR), augmented reality (AR) and Mixed reality implementation in product design and manufacturing.	3
3.3	Interaction technology, VR- immersive, non-immersive, Visualisation technology, Visual display-types- head mounted, organic LEDs, large volume displays, wall type, equipments, characteristics.	3
4	**Digital tool enabled design-II**	
4.1	AR- tangible, collaborative; examples; AR tracking technology and devices; Interaction techniques, Haptic technology, Olfactory technology	3
4.2	Product digitalization, Analysis and simulation.	2
4.3	Virtual humans (VH)- for clothing, for ergonomics analysis, Biomechanical models.	2
5	**Digital manufacturing**	
5.1	3D printing- additive manufacturing technology- Classification of additive manufacturing technologies: Vat-photo polymerisation, powder bed fusion, material jetting, sheet lamination,	4

5.2	Material extrusion and direct energy deposition, Infill lattice structures	3

Reference Books

1. George Dieter and Linda C. Schmidt, Engineering Design, 4th Edition, Published by McGraw-Hill.
2. Monica Bordegoni and Caterina Rizzi, "Innovation In Product Design From CAD To Virtual Prototyping", Springer.
3. Karl T Ulrich and Steven D Eppinger, "Product Design & Development." Tata Mc- Graw Hill, 2003.
4. Ian Gibson, David Rosen and Brent Stucker, "Additive Manufacturing Technologies-3D Printing, Rapid Prototyping, and Direct Digital Manufacturing." Springer.
5. Fei Tao, Meng Zhang and A. Y. C. Nee, "Digital Twin Driven Smart Manufacturing", Academic Press, Elsevier.
6. D. T. Pham, S.S. Dimov, Rapid Manufacturing-The Technologies and Applications of Rapid Prototyping and Rapid Tooling, Springer – Verlag, London, 2001.
7. Kevin Otto & Kristin Wood Product Design: "Techniques in Reverse Engineering and New Product Development.", Pearson Education New Delhi, 2000.
8. N J M Roozenberg , J Ekels , N F M Roozenberg " Product Design Fundamentals and Methods''. John Wiley & Sons.
9. AK Chitale & RC Gupta, "Product Design and Manufacturing", PHI, 2000.

CODE	RELIABILITY ENGINEERING	CATEGORY	L	T	P	CREDIT
J1PIAO235		Inter Disciplinary Elective	3	0	0	3

Preamble:

Reliability engineering fundamentals and applications, Failure data analysis - Basics of Reliability Prediction Hazard models -System reliability models - Fault-tree analysis

Course Outcomes:

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

CO 1	Explain the tools of statistics and probability to determine the reliability of an item or a system.
CO 2	Discuss the methods of reliability prediction and maintenance strategies according to system characteristics and design transition programs to implement these strategies.
CO 3	Develop ability in formulating suitable strategies to enhance system reliability of a manufacturing system.
CO 4	Implement the concepts of RCM, FTA, FMEA and FMECA in managing the manufacturing organisation with highest possible levels of reliability/ availability.
CO 5	Differentiate various strategies adopted for life testing and maintenance.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1	2		2	2	
CO 2			3	2	
CO 3			2		2
CO 4			2	3	2
CO 5			2		2

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

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. (Test paper shall include minimum 80% of the syllabus) : 10 marks

End Semester Examination Pattern:

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.

Syllabus and Corse Plan

No	Topic	No. of Lectures
1	**Probability and reliability**	
1.1	Probability: Conditional probability, Bayes theorem	1
1.2	Probability distributions – Normal, Lognormal, Poisson, Exponential and Weibull distributions – relationship between them and their significance	2
1.3	Central tendency and dispersion of Normal, Lognormal, Poisson, Exponential and Weibull distributions	1
1.4	Reliability: Definitions, Importance, Quality and reliability,	1
1.5	Bath tub curve -Failure data analysis: Hazard rate, failure rate,	1
1.6	MTTF, MTBF, reliability functions, hazard functions,	1
1.7	Availability and Maintainability	1
2	**Hazard models and system reliability**	
2.1	Reliability hazard models: Parts stress model	1
2.2	Constant and linearly increasing models	1
2.3	Time dependent failure rates, Weibull model	1
2.4	Distribution functions and reliability analysis	1
2.5	System Reliability: Series system configuration	1
2.6	Parallel system configurations	1
2.7	Mixed configurations	1
2.8	k out of m system, standby systems	1
3	**Reliability evaluation and system analysis**	
3.1	Reliability evaluation using Markov model - Development of logic diagram	1
3.2	Set theory, optimal cut set and tie set methods, Markov analysis	2

3.3	Fault-tree analysis: Fault tree construction, calculation of reliability from fault tree	2
3.4	Event tree analysis	1
3.5	FMEA	1
3.6	FMECA	1
4	**Design for reliability**	
4.1	Load – strength interference - Distributed load and strength	1
4.2	Analysis of interference – Effect of safety margin	2
4.3	Software Reliability – software errors – fault tolerance – data reliability – hardware / software interfaces	2
4.4	Reliability prediction of equipments and systems using MIL-217 standards	1
4.5	Reliability prediction of equipments and systems using and NSWC standards	1
4.6	Human Reliability	1
5	**Life testing and maintenance**	
5.1	Maintenance and reliability – Preventive and predictive maintenance	1
5.2	Reliability cantered maintenance	1
5.3	Life Testing – Objectives, Types - Censoring, replacement,	2
5.4	Accelerated life testing – Temperature stress and failure rates – stress combinations, accelerated cycling	2
5.5	HALT	1
5.6	HASS	1

Reference Books

1. Patrick O'Connor, Andre Kleyner, Practical Reliability Engineering, 5th Edition, Wiley India, 2012
2. A Birolini, Reliability Engineering, 8th edition Springer, 2017
3. Naikan V. N. A., Reliability Engineering and Life Testing, PHI, New Delhi, 2009
4. Ebling C. E., "An introduction to Reliability and Maintainability Engineering" Waveland Press, 2019.
5. Balagurusamy E., Reliability Engineering, McGraw Hill Education India P Ltd, 2017
6. Kapoor K. C., Pecht M., Reliability Engineering, Wiley, 2014
7. LS Srinath , Reliability Engineering, East West Press,2017

CODE J1PIAO245	INDUSTRIAL SAFETY IN ENGINEERING	CATEGORY	L	T	P	CREDIT
		Inter disciplinary Elective	3	0	0	3

Preamble:

The course is intended to give knowledge of various safety management systems, accident prevention techniques, various machine guarding devices, different types of hazards and fire prevention methods. Students will be able to understand the impact of safe industrial operations and become aware of safety responsibilities.

Course Outcomes:

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

CO 1	Discuss the basic concepts of Safety Management.
CO 2	Explain the factors contributing to accidents and how that can be controlled.
CO 3	Summarize general safety precautions and safe practices to be followed in Engineering Industries.
CO 4	Explain the occupational health hazards and the methods of control.
CO 5	Implement the firefighting techniques and understand the methods of pollution control.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5
CO 1		2	3		
CO 2			3		
CO 3			3		
CO 4	2		3		
CO 5		2	3		

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Syllabus and Course Plan

No	Topic	No. of Lectures
1	**Module 1**	
1.1	Introduction to safety and safety management - Objectives and principles of safety management - Need for integration of safety, health and environment	2
1.2	Management's safety policy and Formulation – Safety auditing – Safety budget	2
1.3	Safety committees and its functions - Safety education and training - Motivation and communicating safety	2
1.4	Significance of health and safety culture - 4 E's in industrial safety - Role of management in Industrial Safety - Factors impeding safety.	2
2	**Module II**	
2.1	Accidents and Hazard control - Accident causation - Classification of accidents	2
2.2	Accident proneness - Cost of accidents - Accident investigation – Hazard control programme	2
2.3	Risk analysis - Quantitative risk assessment- Roles and functions of safety professional- Job safety analysis	3
3	**Module III**	
3.1	Machine Guarding - Types of guards	1
3.2	Housekeeping: Responsibility of management and employees. Advantages of good housekeeping. 5 s of housekeeping.	2
3.3	Personal protective equipments and personal safety	2
3.4	General safety considerations in material handling - Manual and mechanical - Safety in machine shop	2
3.5	Safety in sewage disposal and cleaning - Disaster management plan for industrial plant.	2
4	**Module IV**	
4.1	Occupational health and industrial hygiene - Functions of occupational health services	1
4.2	Occupational health risks - Functional units of OHS	1
4.3	Occupational diseases - Silicosis - Asbestosis - lead poisoning - Nickel toxicity - Chromium toxicity	2
4.4	Hearing conservation programme - First aid and CPR	1

4.5	Types of industrial hazards and their control - Physical, Mechanical, Electrical, Chemical and Ergonomic hazards	3
5	**Module V**	
5.1	Industrial fire prevention -Methods of extinguishing fire - Classification of fires	1
5.2	Factors contributing towards fire - Fire risk assessment - Fire load	1
5.3	Fire safety plan	1
5.4	Fire detection systems – Fire protection systems	1
5.5	Pollution control in engineering industry - Recent development of safety engineering approaches	2

Reference Books

1. R.K Jain (2000) Industrial Safety, Health and Environment management systems, Khanna Publications.
2. Ronald P. Blake. (1973). *Industrial safety*. Prentice Hall, New Delhi.
3. Krishnan, N.V. (1997). *Safety management in Industry*. Jaico Publishing House, New Delhi.
4. Frank P Lees, 'Loss prevention in process industries',Vol I, II, III, Butterworth, London 1980
5. Heinrich H.W, 'Industrial accident prevention', McGraw Hill Company, New York, 1980.

Model Question paper

JYOTHI ENGINEERING COLLEGE (AUTONOMOUS) CHERUTHURUTHY

SECOND SEMESTER M.TECH DEGREE EXAMINATION

J1PIAO245 – Industrial Safety in Engineering

Time: 2.5 hrs Max. Marks: 60

Part A

(Answer all questions. Each question carries five marks)

1. Discuss the significance of a safety committee in improving the safety performance of an industry
2. What are the functions of safety professional
3. Which are five 'S' used in housekeeping?
4. Discuss the functions of occupational health services
5. Describe the importance of fire detection systems

Part B

(Answer any five questions. Each question carries seven marks)

6. Discuss the significance of safety policy in reducing the accidents.
7. Differentiate Hazard and Risk with examples
8. Which are the various types of machine guarding devices used industries.
9. Classify the personal protective equipment. List the suitability of at least ten types of PPEs.
10. Discuss the important types of ergonomic hazards associated with industries
11. Describe the selection of different types of fire extinguishers accordance to type of fire
12. Discuss about different types of chemical hazards

COURSE CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
J1PIAP106	MINI PROJECT	PROJECT	0	0	4	2

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 progress of 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.

Evaluation Committee – Programme Coordinator, One Senior Professor and Guide.

Sl. No	Type of evaluations	Mark	Evaluation criteria
1	Interim evaluation 1	20	
2	Interim evaluation 2	20	
3	Final evaluation by a Committee	35	Will be evaluating the level of completion and demonstration of functionality/ specifications, clarity of presentation, oral examination, work knowledge and involvement
4	Report	15	the committee will be evaluating for the technical content, adequacy of references, templates followed and permitted plagiarism level(not more than 25%)
5	Supervisor/Guide	10	
	Total Marks	100	

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
J1PIAL107	ADVANCED MANUFACTURING LAB II	Laboratory	0	0	2	1

Preamble: Nil

Course Outcomes:

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

CO 1	To gather knowledge on CNC part programming
CO 2	To gather knowledge on CNC machine tool operations
CO 3	To impart knowledge on surface quality of machined parts
CO 4	To impart gather knowledge on measurement of tool wear and machine vision-based inspection
CO 5	To gather knowledge on software and hardware aspects of additive manufacturing
CO 6	To gather knowledge on programming of industrial robots

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	✓	✓	✓	✓	✓	✓
CO 2	✓	✓	✓	✓	✓	✓
CO 3	✓	✓	✓	✓	✓	✓
CO 4	✓	✓	✓	✓	✓	✓
CO 5	✓	✓	✓	✓	✓	✓
CO 6	✓	✓	✓	✓	✓	✓

Continuous Internal Evaluation (CIE)

Pattern: Total Marks: 100

Attendance	15 marks
Regular class work/Modelling and Simulation Lab Record and Class Performance	60 marks
Continuous Assessment Test (Minimum 1 Test)	25 marks

Continuous Assessment Test Pattern

Bloom's Taxonomy	Continuous Assessment Test (Marks)
Apply	15
Analyse	10

Syllabus

1. Exercises on Computer aided manufacturing: Part programming fundamentals – manual part programming and computer aided part programming - Simulations
2. Hands on training in computer controlled turning and milling operations - exercises on CNC lathe and machining centre /milling machines.
3. Practical study on surface quality of machined surfaces: Exercises on grinding /turning of components and measurement of surface finish and study of influence of cutting variables on surface quality
4. Study on thread angle measurements/Inspection of tool wear using tool makers microscope. Exercises on machine vision systems-– Machine vision – Computer imaging systems, Image Analysis, Preprocessing, Image model, Image enhancement, gray scale models, Image Transforms.
5. Additive manufacturing basics- Part Consolidation - Topology Optimization - CAD Modeling - Data Formats - Data Interfacing - Part Orientation - Support Structure Design and Support Structure Generation - Model Slicing - Tool Path Generation. Exercises on 3D printing
6. Exercises on Programming of industrial robots: Introduction to robotics - structure, workspace analysis and various components - hands on training on industrial robots - manual and programmed path planning

No	List of Exercise	Course Outcomes
1	Part programming to do basic turning operations	**CO 1**
2	Part programming to do basic milling operations	**CO 1**
3	Exercises on CNC Lathe/drilling machine operations	**CO 2**
4	Exercises on CNC milling operations	**CO 2**
5	Study on surface quality assessment using Talysurf/other surface metrology instruments	**CO 3**
6	Exercises on tool wear measurements and thread angle measurements	**CO 4**
7	Exercises on machine vision systems-part quality inspection	**CO 4**
8	Exercises on machine vision systems-image enhancement and analysis	**CO 4**
9	Exercises on additive manufacturing; CAD modelling and data formats	**CO 5**
10	Exercises on additive manufacturing; polymer/metal 3D printing	**CO 5**
11	Exercises on industrial robots- study of sensors and actuators	**CO 6**
12	Exercises on industrial robots- manual and programmed path planning	**CO 6**

(Minimum 8 experiments to be done)

References:

1. Chang T.C., Wysk, R.A. and Wang.H.P., “Computer Aided Manufacturing”, Pearson Prentice Hall, India ,2009, ISBN: 978-0131429192

2. Andreas Gebhardt and Jan-Steffen Hotter, “Additive Manufacturing:3D Printing for Prototyping and Manufacturing”, Hanser publications Munchen, Germany, 2016. ISBN:978-1-56990-582-1

3. P. Radhakrishnan, Computer Numerical Control and Computer Aided Manufacture, New Age International Publishers, 2012

4. Deb, S.R.” Robotics Technology and Flexible Automation”, Tata McGraw-Hill, 2009

Discipline: Mechanical Engineering

Stream: Industrial Automation and Robotics (IAR)

Semester III

J1PIAM301 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.

CODE J1PIAG312	ACADEMIC WRITING	CATEGORY	L	T	P	CREDIT
		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: The COs shown are only indicative. For each course, there can be 4 to 6 COs. After the completion of the course the student will be able to

CO 1	Understand the principles of scientific/ academic writing
CO 2	Analyse the technique of scientific writing from the reader's perspective
CO 3	Apply the concepts of setting expectations and laying the progression tracks
CO 4	Evaluate the merits of a title, abstract , introduction, conclusion and structuring of a research paper
CO 5	Justify the need using a project proposal or a technical report
CO 6	Prepare a review paper, an extended abstract and a project proposal

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 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: 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.

Model Question paper

		SET1	**Total Pages:**
Reg No.:_____		Name:_____	
JYOTHI ENGINEERING COLLEGE (AUTONOMOUS) CHERUTHURUTHY THIRD SEMESTER M. TECH DEGREE EXAMINATION, MONTH, YEAR			
Course Code: J1PIAG312			
Course Name: Academic Writing			
Max. Marks: 60			Duration: 2.5 Hours
Answer any five full questions, each carries 12 marks.			

1 a)		Make clear-cut distinctions between 6 factors that take their toll on readers' memory.	6
1	b)	How can you sustain the attention of the reader to ensure continuous reading?	6
2 a)		What are the different methods by which you can create expectations in the reader?	6
2 b)		Give an account of the topic and non-topic based progression schemes.	6
3 a)		Bring out the differences between an abstract and the introduction of a research paper.	8
3	b)	How are the title of the research paper and its structure related?	4

4	What are 7 principles for including visuals in your research paper. What are the recommended constituents of a conclusion segment of a research paper?	12
5	Give a detailed description of the process and contents of a project proposal for funding.	12
6 a)	What are the contexts recommended for choosing between active and passive voices in technical writing?	8
6 b)	What are the different visual forms that are relevant in a research paper and how do you choose them?	4
7	Give the design of a research paper with the purposes each part serves.	12
****		

Syllabus and Course Plan (For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30 hours).

Syllabus:

CODE J1PIAG312	**ACADEMIC WRITING**	**Audit**
Module No.	Topics in a module	Hours
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.	6
2	Fluid reading & reading energy consumption: setting expectations and laying Progression tracks; Reading energy consumption	6
3	How to write the Title, abstract, introduction ; Structure the writing with headings & subheadings	6
4	Visuals: Resources, Skills, and Methods; Conclusion; References; Bibliography; Grammar in technical writing	6
5	Techniques of writing: An extended abstract, a project proposal, a research paper, a technical report.	6

Course Plan:

No	Topic	No. of Lectures
1	Fundamentals of Academic writing from a reader's perspective: acronyms, synonyms, pronouns, disconnected phrases, background ghettos, abusive detailing, cryptic captions, long sentences all take their toll on readers' memory.	
1.1	The Reading tool-kit to reduce memory required; reduce reading time	1
1.2	Acronyms, Pronouns, Synonyms; Background, broken couple, words overflow	1
1.3	Sustain attention: Keep the story moving forward; Twists, shouts, Pause to clarify, recreate suspense	2
1.4	Keep the reader motivated: Fuel and meet Expectations; Bridge knowledge gap: ground level; Title words; Just In Time to local background	2
2	Fluid reading & reading energy consumption: setting expectations and laying Progression tracks; Reading energy consumption	
2.1	Setting expectations of the reader from Grammar, from theme	1
2.2	Progression tracks for fluid reading: Topic & stress; topic and non topic based progression tracks; pause in progression	2
2.3	Detection of sentence fluidity problems: No expectations/ Betrayed expectations	2

2.4	Controlling reading energy consumption: the energy bill; Energy fuelling stations: Pause	1
3	How to write the Title, abstract, introduction ; Structure the writing with headings & subheadings	
3.1	Title: Face of the paper: Techniques, Qualities & Purpose of title; Metrics	1
3.2	Abstract: Heart of the paper: 4 parts; coherence; tense of verbs, precision; purpose & qualities of the abstract; Metrics	2
3.3	Structure: Headings & sub-headings: Skeleton of the paper: principles for a good structure; Syntactic rules; Quality & Purpose of structures; Metrics	1
3.4	Introduction: Hands of the paper: Start, finish; scope, definitions; answers key reader questions; As a personal active story; Traps, qualities; Metrics	2
4	Visuals: Resources, Skills, and Methods; Conclusion; References; Bibliography; Grammar in technical writing	
4.1	Visuals as the voice of your paper: principles; purpose & qualities of visuals; metrics	2
4.2	Conclusion: contents; purpose, quality; metrics; Abstracts Vs. Conclusion; examples, counter-examples	1
4.3	References, Bibliography: Styles, punctuation marks, quotes, citations	1
4.4	Grammar in Technical writing: Articles, Syntax, Main and subordinate clauses; Active & passive voices; some commonly made mistakes in technical writing.	2
5	Techniques of writing: An extended abstract, a project proposal, a research paper, a technical report.	
5.1	Extended abstract: abstract and keywords, introduction and objective, method, findings and argument, conclusion and suggestions and references.	1
5.2	Project Proposal:Types, executive summary, background including status, objectives, solution, milestones, deliverables, timelines, resources, budgeting, conclusion	2
5.3	Research paper: writing an overview article: provide a comprehensive foundation on a topic; explain the current state of knowledge; identify gaps in existing studies for potential future research; highlight the main methodologies and research techniques	2
5.4	Writing Technical Reports: Title page; Summary; Table of contents; Introduction; Body; Figures, tables, equations and formulae; Conclusion; Recommendations.	1
	TOTAL	30

Reference Books

1. SCIENTIFIC WRITING 2.0 A Reader and Writer's Guide: Jean-Luc Lebrun, World ScientiVic Publishing Co. Pte. Ltd., 2011

2. How to Write and Publish a ScientiVic Paper: Barbara Gastel and Robert A. Day, Greenwood publishers, 2016

3. Grammar, Punctuation, and Capitalisation; a handbook for technical writers and editors. www.sti.nasa.gov/publish/sp7084.pdf www.sti.nasa.gov/sp7084/contents.html

4. Everything You Wanted to Know About Making Tables and Figures. http://abacus.bates.edu/%7Eganderso/biology/resources/writing/ HTWtableVigs.html

J1PIAG322	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: After the completion of the course the student will be able to

CO 1	Analyse the requirement and find appropriate solution for use of materials.
CO 2	Differentiate the properties of polymers, ceramics and composite materials.
CO 3	Recognize basic concepts and properties of functional materials.
CO 4	Comprehend smart and shape memory materials for various applications.
CO 5	Appraise materials used for high temperature, energy production and storage applications.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7
CO 1	□				□	□	
CO 2	□				□	□	
CO 3	□				□	□	
CO 4	□				□	□	
CO 5	□				□	□	

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 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: 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 Vive. Each question can carry 12 marks.

Model Question paper

AUDIT COURSE

J1PIAG322 - ADVANCED ENGINEERING MATERIALS

(Answer any five questions. Each question carries 12 Marks)

1.	a) State the relationship between material selection and processing.	**5**
	b) Write about the criteria for selection of materials with respect to the cost and service requirements for engineering applications.	**7**
2.	a) Differentiate thermosetting and thermoplastics with suitable examples.	**5**
	b) Briefly discuss about the properties and applications of polymer nano composite materials.	**7**
3.	a) Write about the potential application areas of functionally graded materials.	**5**
	b) With a neat sketch describe any one processing technique of functionally graded materials.	**7**
4.	a) "Smart materials are functional"? Justify the statement.	**5**
	b) Explain the terms electrostriction and magnetostriction with its application.	**7**

5.	a) What are the factors influencing functional life of components at elevated temperature?	**5**
	b) What are super alloys and what are their advantages?	**7**
6	a) What is a shape memory alloy? What metals exhibit shape memory characteristics?	**4**
	b) Explain about the detection capabilities and uses of pyroelectric sensors.	**8**
7	a) Differentiate between conventional batteries and fuel cells.	**4**
	b) Explain the construction and working of a Li-ion battery.	**8**

Syllabus

Module	Content	Hours	Semester Exam Marks (%)
I	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.	**5**	**20**
II	Classification of non-metallic materials. Polymer, Ceramics: Properties, processing and applications. Nano Composites - Polymer nanocomposites (PNCs), Processing and characterisation techniques – properties and potential applications.	**7**	**20**
III	Functionally graded materials (FGMs), Potential Applications of FGMs, classification of FGMs, processing techniques. limitations of FGMs.	**6**	**20**
IV	Smart Materials: Introduction, smart material types - pyroelectric sensors, piezoelectricmaterials, electrostrictors and magnetostrictors, shape memory alloys – associated energy stimulus and response forms, applications.	**5**	**20**
V	High Temperature Materials: super alloys – main classes, high temperature properties of superalloys, applications. Energy Materials: materials for batteries.	**7**	**20**

Course Plan

No	Topic	No. of Lectures
1	**Selection of materials for engineering applications**	
1.1	Benefits of advanced materials, classification of materials, importance of materials selection	2
1.2	Selection of materials for different properties, strength, toughness, fatigue and creep	1
1.3	Selection for surface durability, corrosion and wear resistance	1
1.4	Relationship between materials selection and processing	1
2	**Classification of non-metallic materials & nano composites**	
2.1	Rubber: properties, processing and applications.	1
2.2	Plastics: thermosetting and thermoplastics, applications and properties.	2
2.3	Ceramics: properties and applications.	1
2.4	Introduction to nano composites, classification	1
2.5	Processing and characterisation techniques applicable to polymer nanocomposites.	2
3	**Functionally graded materials**	
3.1	General concept, Potential Applications of FGMs	2
3.2	Classification of FGMs	1
3.3	FGMs processing techniques: powder metallurgy route, melt-processing route	2
3.4	Limitations of FGMs	1
4	**Smart materials**	
4.1	Introduction to smart materials, types	1
4.2	Pyroelectric sensors-material class, stimulus, detection capabilities and uses	1
4.3	Piezoelectric materials- material class, stimulus, sensing and actuating applications	1
4.4	Electrostrictors and magnetostrictors - material class, stimulus, micro positioning capabilities and applications	1
4.5	Shape memory alloys (SMAs) - material class, stimulus, temperature sensing and high strain responses, applications.	1
5	**High Temperature Materials and Energy Materials**	
5.1	Characteristics of high-temperature materials, superalloys as high-temperature materials	1
	superalloys - properties and applications	2
5.2	Introduction to lithium-ion battery (LIBs), operating mechanisms and applications	2
5.3	Introduction to Zn-based battery system, types and existing challenges	2

Reference Books

1. DeGarmo et al, “Materials and Processes in Manufacturing”, 10th Edition, Wiley, 2008.
2. R.E. Smallman and A.H.W. Ngan, Physical Metallurgy and Advanced Materials, Seventh Edition, Butterworth-Heinemann, 2007
3. Vijayamohanan K. Pillai and Meera Parthasarathy, “Functional Materials: A chemist’s perspective”, Universities Press Hyderabad (2012).
4. M.V. Gandhi, B.S. Thompson: Smart Materials and Structures, Chapman & Hall, 1992.
5. G. W. Meetham and M. H. Van de Voorde, Materials for High Temperature Engineering Applications (Engineering Materials) Springer; 1 edition (May 19, 2000)
6. Inderjit Chopra, Jayant Sirohi, “Smart Structures Theory”, Cambridge University Press, 2013

J1PIAG332	DATA SCIENCE FOR ENGINEERS	CATEGORY	L	T	P	CREDIT
		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: After the completion of the course the student will be able to

CO 1	Study Data Science Concepts and statistics
CO 2	Demonstrate Understanding of Mathematical Foundations needed for Data Science
CO 3	Understand Exploratory analysis and Data Visualization and Preprocessing on given dataset
CO 4	Implement Models such as Naive Bayes, K-Nearest Neighbors, Linear and Logistic Regression
CO 5	Build real time data science applications and test use cases

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO7
CO 1	2		2			2	
CO 2	2		2	1		2	
CO 3	2		2	2	2	2	
CO 4	2		2	2	3	2	
CO 5	2		2	3	3	3	2

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 40 marks

Course based task (Project/Assignments/Simulations/Case studies): 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:**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 mark.

Syllabus

Module	Content	Hours	Semester Exam Marks (%)
I	**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.	6	20
II	**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	6	20

III	**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	**6**	**20**
IV	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	**6**	**20**
V	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	**6**	**20**

Course Plan

No	Topic	No. of Lectures
1	**Statistics for Data science**	
1.1	Probability: Basic concepts of probability, conditional probability, total probability	1
1.2	independent events, Bayes' theorem, random variable, Population	1
1.3	Sample, Population Mean, Sample Mean, Population Distribution	1
1.4	Sample Distribution and sampling Distribution, Mean, Mode, Median, Range, Propositional logic and predicate logic	1
1.5	Measure of Dispersion, Variance, Standard Deviation	1
1.6	Gaussian/Normal Distribution, covariance, correlation.	1
2	**Linear Algebra**	
2.1	Vectors and their properties,	1
2.2	Sum and difference of Vectors, distance between Vectors	1
2.3	Matrices,Inverse of Matrix,	2
2.4	Determinant of Matrix, Trace of a Matrix, Dot Product, Eigen Values, Eigen Vectors, Single Value Decomposition	2
3	**Hypothesis Testing**	
3.1	Understanding Hypothesis Testing, Null and Alternate Hypothesis	1
3.2	Non-directional Hypothesis, Directional Hypothesis Critical Value Method, P-Value Method,	2
3.3	Types of Errors-Type1 Error,Type2 Error,	1
3.4	Types of Hypothesis Test Z Test, Chi-Square,	2
4	**Exploratory Data Analysis**	
4.1	Data Collection –Public and Private Data	1
4.2	Data Cleaning-Fixing Rows and Columns	1
4.3	Missing Values	1
4.4	Standardizing values	1
4.5	Invalid values, filtering data	1
4.6	Data Integration, Data Reduction, Data Transformation	1

5	**Machine Learning and Python for Data Science**	
5.1	Python Data structures-List, Tuple, Set,	1
5.2	Dictionary, Pandas, Numpy, Matplotlib	2
5.3	Machine Learning-Supervised Machine Learning, Unsupervised Machine Learning	1
5.4	Regression, Classification	1
5.5	Naïve-Bayes	1

Reference Books

1. Python Data Science Handbook. Essential Tools for Working with Data, Author(s): Jake VanderPlas, Publisher: O'Reilly Media, Year: 2016
2. Practical Statistics for Data Scientists: 50 Essential Concepts, Author(s): Peter Bruce, Andrew Bruce, Publisher: O'Reilly Media, Year: 2017
3. Practical Linear Algebra for Data Science, by Mike X Cohen, Released September 2022, Publisher(s): O'Reilly Media, Inc.
4. Data Science from Scratch 'by Joel Grus, Released, April 2015, Publisher(s): O'Reilly Media, Inc.
5. Hands-On Exploratory Data Analysis with Python, by Suresh Kumar Mukhiya, Usman Ahmed, Released March 2020,Publisher(s): Packt Publishing

SET1 **Total Pages:**

Reg No.:_ Name:_____

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MODEL QUESTION PAPER

THIRD SEMESTER M. TECH DEGREE EXAMINATION, MONTH, YEAR

Course Code: J1PIAG332

Course Name: DATA SCIENCE FOR ENGINEERS

Max. Marks: 60 Duration: 2.5 Hours

Answer any five full questions, each carries 12 marks.

1 a) It is observed that 50% of mails are spam. There is software that filters spam mail before reaching the inbox. It accuracy for detecting a spam mail is 99% and chances of tagging a non-spam mail as spam mail is 5%. If a certain mail is tagged as spam finds the probability that it is not a spam mail. 5

b) Depict the relevance of measures of central tendency in data wrangling with a suitable example 7

2. a) Calculate the inverse of the Matrix 4

$$\begin{matrix} 2 & 4 & -6 \\ 7 & 3 & 5 \\ 1 & -2 & 4 \end{matrix}$$

b)Find all Eigenvalues and Corresponding Eigenvectors for the matrix if 8

$$\begin{matrix} 2 & -3 & 0 \\ 2 & -5 & 0 \\ 0 & 0 & 3 \end{matrix}$$

3. a) A statistician wants to test the hypothesis H0: $\mu = 120$ using the alternative hypothesis $H\alpha: \mu > 120$ and assuming that $\alpha = 0.05$. For that, he took the sample values as $n = 40$, $\sigma = 32.17$ and $\bar{x} = 105.37$. Determine the conclusion for this hypothesis? 5

b) Hypothesis testing is an integral part of statistical inference, list out the various types of hypothesis testing and also mentions their significances in data science. 7

4. a) Brief in detail directional and non-directional hypothesis 6

b) Differentiate null and alternate hypothesis and also elaborate on type 1 6 and type 2 errors

5. a) Explain the concepts of Tuple, List and Directory in python with example 6

b) Elucidate reinforcement learning and application in real world. 6

6. a) What is Feature Engineering , demonstrate with an example 6

b) Describe in detail different steps involved in data preprocessing. 6

7. a) Illustrate supervised learning model with linear regression model 5

b) Predict the probability for the given feature vector if an accident will happen or not? 7

Weather condition: rain, Road condition: good, Traffic condition: normal, Engine problem: no, the task is to predict using Naïve Bayes classification.

SNo.	Weather condition	Road condition	Traffic condition	Engine problem	Accident
1	Rain	bad	high	no	yes
2	snow	average	normal	yes	yes
3	clear	bad	light	no	no
4	clear	good	light	yes	yes
5	snow	good	normal	no	no
6	rain	average	light	no	no
7	rain	good	normal	no	no
8	snow	bad	high	no	yes
9	clear	good	high	yes	no
10	clear	bad	high	yes	yes

J1PIAG342	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:

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

CO 1	Identify and frame design challenges effectively.
CO 2	Generate creative ideas through brainstorming and ideation
CO 3	Iterate on designs based on user insights
CO 4	Apply Design Thinking to real-world problems and projects.

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

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation

Pattern: AUDIT COURSES

Continuous Internal Evaluation Pattern: 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: 60 marks

The examination will be conducted by the respective College. The examination willbe 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.

Model Question paper

		SET1	**Total Pages:**
Reg No.:_____		Name:_____	
MODEL QUESTION PAPER THIRD SEMESTER M. TECH DEGREE EXAMINATION, MONTH, YEAR			
Course Code: J1PIAG342			
Course Name: DESIGN THINKING			
Max. Marks: 60		Duration: 2.5 Hours	
Answer any five full questions, each carries 12 marks.			
1 a)	How can a multidisciplinary team collaborate effectively to implement design principles?		7
1 b)	What are the key differences between human-centred design and other design methodologies?		5
2 a)	How do you measure the success of a design project in terms of user satisfaction and impact?		7
2 b)	How does the iterative nature of the design process contribute to better outcomes		5

3 a)	What are the fundamental principles of effective brainstorming, and how do they differ from traditional problem-solving approaches?	7
3 b)	What are some key principles of ergonomic design, and how do they contribute to the usability and comfort of products?	5
4 a)	Enumerate some examples of successful and unsuccessful market testing scenarios, and what lessons can be learned from these experiences to improve future product or service launches?	7
4b)	What is the primary purpose of creating prototypes in the design and development process?	5
5	What strategies and methodologies can designers use to embrace agility and respond quickly to changing user needs and market dynamics?	12
6	Illustrate any four examples of successful bio-mimicry applications in various industries.	12
7	What ethical considerations should designers keep in mind when designing for diverse user groups?	12
****		

Syllabus:

Module 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-centred design process. Design space, Design Thinking in a Team Environment, Team formation.

Module 2

Design Thinking Stages: Empathize, Define, Ideate, Prototype and Test. The importance of empathy, Building a user-centred mindset. Problem statement formulation, User needs and pain points, establishing target specifications, Setting the final specifications.

Module 3

Generating Ideas, Brainstorming techniques, Application of Aesthetics and Ergonomics in Design. Bio-mimicry, Conceptualization, Visual thinking, Drawing/Sketching, Presenting ideas.

Module 4

Use of prototyping, Types of prototypes, Rapid prototyping techniques, User testing and feedback collection, Iterative prototyping, testing to gauge risk and market interest

Module 5

Entrepreneurship/business ideas, Patents and Intellectual Property, Agility in design, Ethical considerations in design. Overcoming common implementation challenges

Corse Plan Syllabus and Course Plan (For 3credit courses, the content can be for 40 hrs and for 2credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30hours).

No	Topic	No. of lectures
1	**Design process:**	
1.1	Design process: Traditional design, Design Thinking Approach, Introduction to Design Thinking, History and evolution of Design Thinking.	3
1.2	Role of design thinking in the human-centered design process. Design space,	2
1.3	Design Thinking in a Team Environment, Team formation.	2

2	**Design Thinking Stages:**	
2.1	Design Thinking Stages: Empathize, Define, Ideate, Prototype and Test.	2
2.2	The importance of empathy, Building a user-centered mindset.	2
2.3	Problem statement formulation, User needs and pain points, establishing target specifications, Setting the final specifications.	3
3	**Ideation**	
3.1	Generating Ideas, Brainstorming techniques.	2
3.2	Application of Aesthetics and Ergonomics in Design. Bio-mimicry.	3
3.3	Conceptualization, Visual thinking, Drawing/Sketching, Presenting ideas.	2
4	**Prototyping and testing**	
4.1	Use of prototyping, Types of prototypes, Rapid prototyping techniques.	3
4.2	User testing and feedback collection, Iterative prototyping, testing to gauge risk and market interest	2
5	**IPR in design**	
5.1	Entrepreneurship/business ideas, Patents and Intellectual Property.	2
5.2	Agility in design, Ethical considerations in design. Overcoming common implementation challenges	2

Reference Books

1. Christoph Meinel, Larry Leifer and Hasso Plattner- "Design Thinking: Understand – Improve – Apply", Springer Berlin, Heidelberg, 2011.
2. Thomas Lockwood and Edgar Papke – "Design Thinking: Integrating Innovation, Customer Experience, and Brand Value", Allworth Press, 2009.
3. Pavan Soni – "Design Your Thinking", Penguin Random House India Private Limited, 2020.
4. Andrew Pressman- "Design Thinking : A Guide to Creative Problem Solving for Everyone", Taylor & Francis, 2018.
5. N Siva Prasad, "Design Thinking Techniques an Approaches" Ane Books Pvt. Ltd.,2023

SYLLABUS

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
J1PIAG352	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:

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

CO 1	Understand the functional programming paradigm which is based on the mathematics of lambda calculus.
CO 2	Develop Haskell programs using functions, guards and recursive functions
CO 3	Apply the concept of tuples, lists and strings in Haskell programming
CO 4	Apply the concept of algebraic data types, abstract data types, modules, recursive data types and user defined data types in Haskell programming
CO 5	Develop Haskell programs with files for reading input and storing output

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation: 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: 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.

Model Question paper

			Total Pages:
Reg No.:_____		Name:_____	
MODEL QUESTION PAPER THIRD SEMESTER M. TECH DEGREE EXAMINATION, MONTH, YEAR			
Course Code: J1PIAG352			
Course Name: Functional Programming in Haskell			
Max. Marks: 60		Duration: 2.5 Hours	
Answer any five full questions, each carries 12 marks.			
1 a.	Explain the basic differences between imperative style programming and functional style programming.		3
1 b.	Analyse each of the following lambda expressions to clarify its structure. If the expression is a function, identify the bound variable and the body expression, and then analyse the body expression. If the expression is an application, identify the function and argument expressions, and then analyse the function and argument expressions: i) λa.(a λb.(b a)) ii) λx.λy.λz.((z x) (z y)) iii) (λf.λg.(λh.(g h) f) λp.λq.p)		9
2 a.	Design a recursive function to find 2^n where n is a natural number.		4

2 b.	Explain various forms of function definitions in Haskell with the help of examples.	8
3 a.	Explain any three list operations along with function definitions and examples.	6
3 b.	Write a program to duplicate only even numbers among the elements of a list using a Haskell function by (i) Recursion (ii) List Comprehension and explain. Example : λ> dupli [1, 2, 3] ANS: [2,2]	6
4	Write Recursive definitions along with an explanation for the below arithmetic operations. Illustrate the recursive flow with the help of a diagram. i. add x y ii. mult x y iii. div x y	12
5	Write the Haskell code to split a list into two lists such that the elements with odd index are in one list while the elements with even index are in the other list.	12
6 a	Give the type definition of a binary tree along with explanation of two functions on binary trees.	6
6 b	Define a queue data type in Haskell along with any two operations on it with examples.	6
7 a.	Explain the basic steps of reading from files and writing to files in Haskell.	4
7 b.	Write a Haskell program to read from the file "input.txt", display the contents on the screen and write the contents to another file "output.txt".	8
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Syllabus and Corse Plan (For 3 credit courses, the content can be for 40 hrs and for 2 credit courses, the content can be for 26 hrs. The audit course in third semester can have content for 30 hours).

Module 1 (5 Hrs)

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.

Module 2 (6 Hrs)

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.

Module 3 (7 Hrs)

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

Module 4 (6 Hrs)

Type classes, Algebraic data types, Modules, Recursive data types.

User defined data types, Records, Stacks, Queues, Binary trees, Constructors, Destructors.

Module 5 (6 Hrs)

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.

No	Topic	No. of Lectures
1	**Introduction to Functional Programming**	
1.1	Programming language paradigms, imperative style programming, comparison of programming paradigms	1
1.2	Functional programming, Functions - Mathematical concepts and terminology	1
1.3	Lambda calculus	1
1.4	Function definitions, programs as functions, Functional programming Languages	1
1.5	Haskell basics, GHCi interpreter	1
2	**Haskell basics**	
2.1	Expressions and evaluation, Lazy evaluation	1
2.2	let expressions, scopes, Basic data types in Haskell	1
2.3	operators, infix operators, associativity and precedence, Arithmetic	1

	functions	
2.4	types, definitions, currying and uncurrying, type abstraction.	1
2.5	Function definitions, pattern matching, Guards	1
2.6	anonymous functions, higher order functions, Recursion	1
3	**Data types: tuples and lists**	
3.1	Tuples , Lists: building lists, decomposing lists	1
3.2	functions on lists, built-in functions on lists	1
3.3	primitive and general recursion over lists	1
3.4	infinite lists	1
3.5	Strings: functions on strings	1
3.6	Polymorphism and overloading	1
3.7	conditional polymorphism	1
4	**User defined data types**	
4.1	Type classes, Algebraic data types, Modules	1
4.2	Recursive data types	1
4.3	User defined data types, Records	1
4.4	Stacks, Queues	1
4.5	Binary trees	1
4.6	Constructors, Destructors	1
5	**Programming with actions**	
5.1	Functor, Applicative functor,	1
5.2	Monad	1
5.3	Programming with actions: Functions vs actions, Basics of input / output, the do notation	1
5.4	interacting with the command line and lazy I/O	1
5.5	File I/O	2

Reference Books

[1] Richard Bird, “Introduction to functional programming using Haskell', second edition, Prentice hall series in computer science

[2] Bryan O'Sullivan, Don Stewart, and John Goerzen, “Real World Haskell”

[3] Richard Bird, “Thinking Functionally with Haskell”, Cambridge University Press, 2014

[4] Simon Thompson, “Haskell: The Craft of Functional Programming”, Addison-Wesley, 3rd Edition, 2011

[5] H. Conrad Cunningham, “Notes on Functional Programming with Haskell”, 2014

[6] Graham Hutton, “Programming in Haskell”, Cambridge University Press, 2nd Edition, 2016

[7] Alejandro Serrano Mena, “Practical Haskell: A Real-World Guide to Functional Programming”, 3rd Edition, Apress, 2022

[8] Miran Lipovaca, “Learn You a Haskell for Great Good!: A Beginner's Guide”, No Starch Press, 2011

J1PIAG372	REUSE AND RECYCLE TECHNOLOGY	CATEGORY	L	T	P	CREDIT
		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: After the completion of the course the student will be able to

CO 1	Explain the principles and technologies behind waste reduction, resource conservation, and sustainable practices
CO 2	Describe and Analyze waste generation and management.
CO 3	Apply the knowledge of various reuse strategies and their application in different industries and Analyze various recycling technologies
CO 4	Appraise the methods of E-waste management and Eco friendly packaging
CO 5	Comprehend Environmental Regulations and Policies**,** Understand the importance of environmental regulations and policies in addressing environmental challenges

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1			3			
CO 2				3		
CO 3				3		
CO 4					3	
CO 5			3			

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 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: 60 marks

The examination willbe 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.

Model Question paper

AUDIT COURSE

J1PIAG372 - REUSE AND RECYCLE TECHNOLOGY

Answer any five full questions, each carries 12 marks.

1.	(a) What are the 3 pillars of sustainability? *(b)* What is sustainable waste management? What makes sustainable waste management so important?	5 7
2.	(a)How do the three categories of municipal solid waste differ? *(b)* Discuss the municipal waste collection and management?	5 7
3.	(a)Explain the major differences between Reuse and Recycle? *(b)* Give an overview of recycling technologies used for any two materials. Discuss the Process involved.	5 7
4.	(a)What are the common source of E-waste *(b)* What are the challenges and opportunities in E-waste management	5 7
5.	(a)What is the case law for waste recycling in India *(b)* Discuss sustainable packaging and its environmental impacts	5 7
6.	Explain the various environmental regulations in India for addressing Environmental challenges	12
7.	a) Give examples of water reuse technologies in circular economy b) How can we reduce e-waste with sustainable solutions	5 7

Syllabus

Module	Content	Hours	Semester Exam Marks (%)
I	**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.	**6**	**20**
II	**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.	**6**	**20**
III	**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.	**6**	**20**
IV	**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	**6**	**20**
V	**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	**6**	**20**

Course Plan

No	Topic	No. of Lectures
1	**Introduction to Sustainability (6)**	
1.1	Understanding sustainability and its importance	1
1.2	The three pillars of sustainability: Environmental, Social, and Economic.	3
1.3	Biodiversity conservation, Climate change and mitigation	1
1.4	Sustainable resource management	1
2	**Waste Management (6)**	
2.1	Definition and classification of waste	1
2.2	Waste Generation and Composition	1
2.3	Waste Collection and Transportation.	1
2.4	Waste Segregation and Sorting.	1
2.5	Waste Disposal Methods	1
2.6	Historical perspectives on waste management, The three Rs: Reduce, Reuse, and Recycle.	1
3	**Recycling and Reuse (6)**	
3.1	Importance of reuse, Examples of reuse in various industries.	1
3.2	Challenges and opportunities in reuse	1
3.3	Overview of recycling technologies, Sorting and processing of recyclable materials	2
3.4	Advanced recycling methods	1
3.5	Emerging technologies in recycling.	1
4	**E-waste Recycling (6)**	
4.1	Challenges and environmental impact of electronic waste	1
4.2	E-waste recycling methods and regulations	1
4.3	Sustainable electronics design	1
4.4	Packaging materials and their environmental impact	1
4.5	Eco-friendly packaging alternatives	1
4.6	Packaging design for sustainability	1
5	**Environmental Regulations and Policies (6)**	
5.1	Importance of environmental regulations and policies in addressing environmental challenges	2
5.2	National and international waste and recycling regulations	2
5.3	Industry standards and certifications, Compliance and enforcement	2

Reference Books

1. Sustainable Engineering: Concepts, Design and Case Studies, David T. Allen, Pearson Publication.
2. A Comprehensive Book on Solid Waste Management with Application, Dr. H.S. Bhatia , Misha Books, 2019
3. "Cradle to Cradle: Remaking the Way We Make Things" by William McDonough and Michael Braungart.
4. "Recycling of Plastic Materials" edited by Vijay Kumar Thakur
5. E-waste: Implications, Regulations and Management in India and Current Global Best Practices, Rakesh Johri, TERI
6. "Sustainable Packaging", Subramanian Senthilkannan Muthu , Springer Nature.
7. **I**ndian Environmental Law: Key Concepts and Principles " Orient Black swan Private Limited, New Delhi.

J1PIAG392	EXPERT SYSTEMS	CATEGORY	L	T	P	CREDIT
		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: After the completion of the course the student will be able to:

CO 1	Explain the concepts of Artificial Intelligence and different ways of knowledge representations.
CO 2	Explain the components of expert systems, development stages of expert systems and tools available for expert system design.
CO 3	Apply the concept of knowledge representation in expert systems
CO 4	Differentiate the classes of expert systems and examine properties of existing systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO7
CO 1	1		2	1	2	2	
CO 2	1		1	3	2	2	
CO 3	1		1	2	2	2	
CO 4	2		2	2	3	2	

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 40 marks

Course based task (Project/Assignments/Simulations/Case studies): 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:**60 marks**

The examination will be conducted by the respective College. 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 mark.

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY THIRD SEMESTER M.TECH DEGREE EXAMINATION, MARCH 2024		
Course Code: J1PIAG392		
Course Name: EXPERT SYSTEMS		
Max. Marks: 60		Duration: 2.5 Hours
Answer any five full questions, each carries 12 marks.		
1	a) What are the types of AI? Explain with examples .	6
	b) What do you mean by knowledge in AI and explain the different ways of knowledge representation used in AI?	6
2.	a) Write note on semantic network.	6
	b) What are Predicates? Explain its syntax and semantics.	6
3.	a) Write notes on different tools available for expert system design.	6
	b). What are the different stages in the development of an expert system?	6
4.	a) Illustrate Conceptual Dependencies with an example.	6
	b) Illustrate with an example the Structured Knowledge representation of an Expert System.	6
5.	a) What do you mean by Frame based Expert System? Explain	6
	b)Explain the architecture of MYCIN	6
6.	a)Explain Fuzzy based expert systems	6
	b) Explain the neural network based expert systems	6
7.	a) Explain any two applications of expert systems?	6
	b)What are the limitations of expert system ? Explain	6

Syllabus

Module	Content	Hours	Semester Exam Marks (%)
I	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.	**6**	**20**
II	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	**6**	**20**
III	Knowledge representation in expert systems: Structured Knowledge representation: Graphs, Frames and related structures, Associative networks, Conceptual dependencies, Examples of structured knowledge representation.	**6**	**20**
IV	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)	**7**	**20**
V	Currents trends in expert systems, Advantages and limitations of expert systems, Applications of expert systems.	**5**	**20**

Course Plan

No	Topics	No. of Lectures
1	**Overview of Artificial Intelligence& Knowledge general concepts**	
1.1	Definition & Importance of AI	1
1.2	Definition and Importance of Knowledge,	1
1.3	Knowledge-Based Systems, Knowledge Organization	1
1.4	Knowledge Manipulation and acquisition	1
1.5	Knowledge Representation: Introduction, Syntax and Semantics	1
1.6	Propositional logic and predicate logic	1
2	**Basic concepts of expert systems**	
2.1	Introduction to Expert System, Components of expert systems	2
2.2	Features of Expert System, Stages in the development of expert system	2
2.3	Types of tools available for expert system design	2
3	**Knowledge representation in expert systems**	
3.1	Structured Knowledge representation	1
3.2	Graphs, Frames and Related Structures	2
3.3	Associative Networks, Conceptual Dependencies	2
3.4	Examples of structured knowledge representation	1
4	**Classes of expert systems**	
4.1	A rule-based expert system -Introduction	1
4.2	MYCIN	1
4.3	IF-THEN structure	1
4.4	Frame-based expert system	2
4.5	Fuzzy based expert systems	1
4.6	Neural network based expert systems	1
5	**Currents trends and applications of expert systems**	
5.1	Currents trends of expert systems	2
5.2	Advantages and limitations of expert systems	1
5.3	Applications of expert systems	2

Reference Books

1. E. Rich & K. Knight - Artificial Intelligence, 2/e, TMH, New Delhi, 2005.
2. P.H. Winston - Artificial Intelligence, 3/e, Pearson Edition, New Delhi, 2006.
3. D.W. Rolston - Principles of AI & Expert System Development, TMH, New Delhi
4. Kevin Night and Elaine Rich, Nair B., "Artificial Intelligence (SIE) ", McGraw Hill – 2010
5. Dan W Patterson, 'Introduction to Artificial intelligence and Expert systems', Prentice Hall of India Pvt. Ltd,2007
6. Russel (Stuart), 'Artificial Intelligence- Modern approach, Pearson Education series in AI', 3rd Edition, 2009.
7. I. Gupta, G. Nagpal · Artificial Intelligence and Expert Systems, Mercury Learning and Information -2020

J1PIAG382	SYSTEM MODELLING	CATEGORY	L	T	P	CREDIT
		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: After the completion of the course the student will be able to

CO 1	Analyse the requirement and find appropriate tool for simulation.
CO 2	Differentiate the different statistical models.
CO 3	Discuss the different techniques for generating random numbers.
CO 4	Analyse the different methods for selecting the different input models..
CO 5	Discuss the different measures of performance and their estimation

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
CO 1	2		1	1	2	
CO 2	2		1	1	1	
CO 3	1					
CO 4	1		1	1		
CO 5	2		1	1	1	

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern:

Course based task (Project/Assignments/Simulations/Case studies): 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:

The examination will be conducted by the respective College. 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.

Model Question paper

AUDIT COURSE

J1PIAG382 – SYSTEM MODELLING

Answer any five questions Each carries 12 marks

PART A

1. a. Discuss the advantages and disadvantages of simulation. (5marks)

   b. What are the areas of applications of simulation (7 marks)

2. a.A bus arrives every 20 minutes at a specified stop beginning at 6:40 A.M. and continuing until 8:40 A.M. A certain passenger does not know the schedule, but arrives randomly (uniformly distributed) between 7:00A.M. and 7:30 A.M. every morning. What is the probability that the passenger waits more than 5 minutes for a bus? (5 marks)
   b. A production process manufactures computer chips on the average at 2% nonconforming. Every day, a random sample of size 50 is taken from the process.
   If the sample contains more than two nonconforming chips, the process will be stopped. Compute the probability that the process is stopped by the sampling scheme. (7 marks)

3. a.Discuss the different types of tests for random numbers. (5 marks)

   b. Generate random numbers using multiplicative congruential method with X0 = 5, a 11, and m = 64. (7 marks)

4. a. What are the different methods of data collection. (4marks)

   b. Records pertaining to the monthly number of job-related injuries at an underground coalrnine were
   being studied by a federal agency. The values for the past 100 months were as follows:

Injuries per Month	Frequency of Occurrence
0	35
1	40
2	13
3	6
4	4
5	1
6	1

(a) Apply the chi-square test to these data to test the hypothesis that the underlying distribution is Poisson. Use the level of significance α== 0.05.
(b) Apply the chi-square test to these data to test the hypothesis that the distribution is Poisson with mean 1.0. Again let α = 0.05. ·
c) What are the differences between parts (a) and (b), and when might each case arise? (8 marks)

5. a.What is the difference between validation and verification.(5 marks)
   b. Discuss the different measures of performance and their estimation(7 marks)
6. a. Discuss the different methods of parameter estimation(5 marks)
   b. With an example, describe the Poisson process.(7 marks)
7. a. Distinguish between discrete and continuous systems(5 marks)
   b.What are the different components of a simulation system(7 marks)

Syllabus

Module	Content	Hours	Semester Exam Marks (%)
I	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.	**6**	**20**
II	Review of terminology and concepts, Useful statistical models, Discrete distributions. Continuous distributions, Poisson process, Empirical distributions. (basic idea only)	**6**	**20**
III	Properties of random numbers; Generation of pseudo- random numbers, Techniques for generating random numbers, Tests for Random Numbers	**6**	**20**
IV	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.	**6**	**20**

V	Measures of performance and their estimation, Output analysis for terminating simulations, Output analysis for steady-state simulations, Verification, calibration and validation	**6**	**20**

Course Plan

No	Topic	No. of Lectures
1	**Introduction**	
1.1	When simulation is the appropriate tool	1
1.2	Advantages and disadvantages of Simulation;	1
1.3	Areas of application, Systems and system environment;	1
1.4	Components of a system; Discrete and continuous systems,	1
1.5	Model of a system; Types of Models,	1
1.6	Discrete-Event System Simulation ,Steps of a simulation study	1
2	**Statistical Models in Simulation**	
2.1	Review of terminology and concepts, Empirical distributions. (basic idea only)	1
2.2	Useful statistical models,	1
2.3	Discrete distributions.	1
2.4	Continuous distributions,.	1
2.5	Poisson process	1
2.6	Empirical distributions	1
3	**Random Number Generation**	
3.1	Properties of random numbers;	1
3.2	Generation of pseudo-random numbers,	
3.3	Techniques for generating random numbers	1
3.4	Techniques for generating random numbers(cont)	1
3.5	Tests for Random Numbers	1
3.6	Tests for Random Numbers(cont)	1
4	**Input Modelling**	
4.1	Data Collection;	1
4.2	Identifying the distribution with data.	1
4.3	Parameter estimation, Goodness of Fit Tests	1
4.4	Fitting a non-stationary Poisson process	1
4.5	Selecting input models without data,	1
4.6	Multivariate and Time-Series input models	1
5	**Measures of Performance and their Estimation**	
5.1	Measures of performance and their estimation	1
5.2	Measures of performance and their estimation(cont)	1
5.3	Output analysis for terminating simulations	1
5.4	Output analysis for steady-state simulations	1
5.5	Verification, calibration and validation	1
5.6	Verification, calibration and validation(cont)	1

Textbooks:

1. Jerry Banks, John S. Carson II, Barry L. Nelson, David M. Nicol: Discrete-Event System Simulation, 5th Edition, Pearson Education, 2010.

Reference Books:

1. Lawrence M. Leemis, Stephen K. Park: Discrete – Event Simulation: A First Course, Pearson Education, 2006.

2. Averill M. Law: Simulation Modeling and Analysis, 4 th Edition, Tata McGraw-Hill, 2007

3. System Modelling and Response by Ernest O. Doebelin

4. Averill M Law, “Simulation Modeling and Analysis”,McGraw-Hill Inc,2007
Geoffrey Gorden, “System Simulation”,Prentice Hall of India,1992.

J1PIAG362	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: After the completion of the course the student will be able to

CO 1	Explain the fundamentals of sensor systems and to choose a suitable sensor system for the given application based on the evaluation of the constraints.
CO 2	Explain the fundamentals of signal conditions and to design a suitable signal conditioning scheme for given application.
CO 3	Describe the characteristics of various actuator systems and to decide the right type of actuator for the given application.
CO 4	Describe the importance of an industrial robot and fundamentals of numerical control in automation.
CO 5	Explain the fundamentals of controllers used in industrial automation and to construct simple automation schemes by ladder logic programs.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
100	40	60	2.5 hours

Continuous Internal Evaluation Pattern: 40 marks

Course based task (Project/Assignments/Simulations/Case studies): 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: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.

Model Question Paper

J1PIAG362 Principles of Automation

Time 2.5 Hrs Marks 60

Answer any five questions Each carries 12 marks

1. (a) Differentiate the static and dynamic characteristics of a temperature sensor and explain how it affects the selection of a suitable temperature sensor. (6 marks)
   (b) Explain the working of a strain-gauge. (6marks)

2. (a) Explain why anti-aliasing filters are used in analog to digital converters. (3 marks)
   (b) Design a first order low pass filter with a cutoff frequency of 2 kHz. (9 marks)

3. (a) What are the factors to consider while deciding choosing between hydraulic, pneumatic or electrical actuation systems for an automation scheme? (4 marks)
   (b) Explain the working of a three-way pressure reducing valve. (4 marks)
   (c) Explain the working of solenoids. In what applications would you use a Solenoid valve. (4 marks)

4. (a) Explain the principle of the Touch sensor and also mention how they are used in robots. (5 marks)
   (b) Explain the basic terminologies in robotic system and also explain the components of robotic system. (7 marks)

5. (a)With neat schematic explain the architecture of the PLC. (6 marks)
   (b) Explain the use of an up-down counter in PLC with a suitable example. (6 marks)

6. (a) Write short note on SCADA. What is difference PLC and SCADA? (3 marks) (b)Construct a ladder logic for controlling a process tank as per the logic given below;

i. The tank should be filled by a valve V1 when low level float switch L1 is ON and an external input S1 is received.

ii. V1 should be closed when the liquid level reaches a high-level float switch L2.

iii. An agitator motor should be turned on after a delay of 5sec after L2 is triggered.

iv. After agitating for 30mins, contents of the tank should be emptied by opening another valve V2.

v. The temperature should be maintained at 70°C using a thermostat T1 and Heater H (9 marks)

7. (a) Explain the levels of Automation. (6 marks)
(b) Explain the working of Flow sensor (6 marks)

Syllabus and Course Plan

No	Topics	No. of Lectures
1	**Introduction to Industrial Automation**	
1.1	Basic Elements of an Automated System, Levels of Automation	2
1.2	Hardware components for Automation: Sensors, classification, Static and dynamic behaviour of sensors.	2
1.3	Basic working principle of different sensors: Proximity sensors, Temperature sensors, flow sensors, Pressure sensors, Force sensors. Position sensors	4
2	**Signal conditioning**	
2.1	Need for signal conditioning, Types of signal conditioning.	2
2.2	Signal conditioning using operational amplifier-Amplifier (Inverting and Non-inverting) and Filter circuits (Basic concepts). Design of first order low pass filter.	2
2.3	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	4
3	**Actuators**	
3.1	Types of actuators- mechanical, electrical, pneumatic and hydraulic actuators. (Basic working principle)	2
3.2	Mechanical systems for motion conversion, transmission systems	3
3.3	Solenoids, Electric and stepper motors control.	3

4	**Robotics and Automated Manufacturing Systems**	
4.1	Robot Anatomy and Related Attributes: Joints and Links, Common Robot Configurations, Joint Drive Systems, Sensors in Robotics (Basic concepts)	3
4.2	Robot Control Systems, Applications of Industrial Robots- Material handling	4
4.3	Fundamentals of Numerical control (NC) Technology	1
5	**Discrete Control and Programmable Logic Controllers**	
5.1	Discrete Process Control: Logic and Sequence control	2
5.2	Ladder Logic Diagrams, Programmable Logic Controllers: Components of the PLC, PLC Operating Cycle, Programming the PLC (Basic concepts only)	4
5.3	Introduction to Distributed control system (DCS) and Supervisory Control and Data Acquisition Systems (SCADA)	2

Reference Books

1. Mikell Groover, Automation, Production Systems, and Computer-Integrated Manufacturing, 5th Edition, Pearson, 2019.
2. Yoram Koren, "Computer Control of Manufacturing Systems",TataMcGraw Hill Edition2005.
3. S. R. Deb; Sankha Deb. Robotics Technology and Flexible Automation, Second Edition McGraw-Hill Education: New York, 2010.
4. W. Bolton, "Mechatronics: Electronic Control Systems in Mechanical and Electrical Engineering" - PrenticeHall- 2013 - 5th Edition.
5. Doebelin, E.O. and Manic, D.N., "Measurement Systems: Applications and Design", 7th Edition, McGraw Hill, 2019.
6. Krishna Kant, Computer Based Industrial Control-, EEE-PHI,2nd edition,2010.
7. Nathan Ida, Sensors, Actuators, and Their Interfaces- A multidisciplinary introduction, 2nd Edition, IET Digital Library, 2020.
8. Salivahanan, S., and VS Kanchana Bhaaskaran. Linear integrated circuits. McGraw- Hill Education, 2nd edition, 2014.
9. Petruzella, Frank D. Programmable logic controllers. Tata McGraw-Hill Education, 2005
10. Chapman and Hall, "Standard Handbook of Industrial Automation", Onsidine DM C & Onsidine GDC", NJ, 1986

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 cultivatethe 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 :_____

Internship 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

Discipline: Mechanical Engineering

Stream: Industrial Automation and Robotics (IAR)

Semester IV

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
J1PIAP401	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.