RAT301	INTRODUCTION TO ROBOTICS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: This course helps the student to basic idea of Robots. Students are introduced to the basic design consideration of robots. Concepts like trajectory planning and obstacle avoidance and kinematics of robots are introduced. Discussion on various mobile robots and robotic manipulators are also included as part of the course to get an overall idea on robotics

Prerequisite: Nil

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

CO 1	Familiarise with anatomy, specificationsand types of Robots
CO 2	Obtain forward and inverse kinematic models of robotic manipulators
CO 3	Plan trajectories in joint space & Cartesian space and avoid obstacles while robots are in motion
CO 4	Develop dynamic model and design the controller for robotic manipulators
CO 5	Choose appropriate Robotic configuration and list the technical specifications forrobots used in different applications
CO 6	Familiarise with different types of mobile robots, kinematic models, motion control and sensors for mobile robots

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	**2**	**1**										3
CO 2	**2**	**1**										3
CO 3	**2**	**1**										3
CO 4	**3**	**2**	**2**									3
CO 5	**3**	**2**	**2**									3
CO 6	**3**	**2**	**2**									3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Differentiate between open and closed kinematic chain with the help of examples.
2. What do you mean by degrees of freedom

Course Outcome 2 (CO2):

1. Differentiate between reachable and dexterous workspace.

Course Outcome 3 (CO3):

1. Differentiate between path and trajectory of a robotic manipulator.
2. What is cartesian space trajectory planning

Course Outcome 4 (CO4):

1. What is dynamic model of robotic manipulators.
2. What is robotic manipulators

Course Outcome 5 (CO5):

1. Characteristics of a spray painting robot.
2. Compare holonomic and non-holonomic robots.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIFTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 301

Course Name:Introduction to Robotics

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1	What do you mean by degrees of freedom? How many degrees of freedom required for a robotic manipulator to achieve any position (for the end effector) in 3D space? And how many more DOF required for achieving any orientation as well.	(3)
2	Differentiate between open and closed kinematic chain with the help of examples	(3)
3	If a point$P = [3 \quad 0 \quad -1 \quad 1]^T$, find the new location of the point P, if it is rotated by π about z-axis of fixed frame and then translated by 3 units along y axis	(3)
4	Differentiate between reachable and dexterous workspace. For a 2 link planar manipulator, the first link length is equal to 2nd link length, i.e. L_1=L_2. Sketch the reachable and dexterous workspace	(3)
5	Differentiate between path and trajectory of a robotic manipulator. Which are the inputs fed to the typical trajectory planner of a robotic manipulator?	(3)
6	Compare Joint space and cartesian space trajectory planning.	(3)
7	How will you obtain dynamic model of robotic manipulators?	(3)
8	Are robotic manipulators nonlinear systems? Can we use linear control schemes for the control of robotic manipulators?	(3)
9	What the technical specifications / characteristics of a spray painting robot?	(3)
10	Compare holonomic and non-holonomic robots.	(3)

PART B

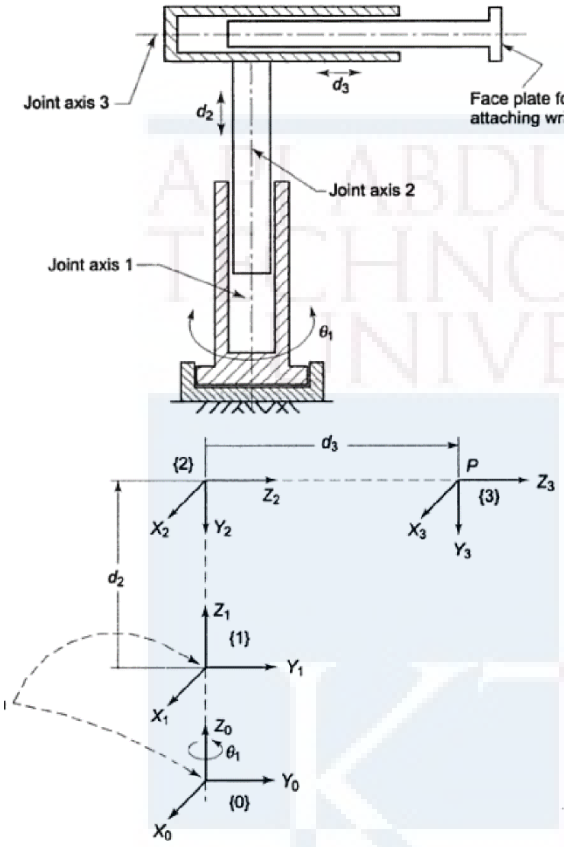
Answer any one full question from each module, each carries14 marks.

MODULE I

11	a)	How robotic manipulators are classified based on configurations? Explain with the help of diagrams.	(7)
	b)	How robots are classified based on motion control methods and drive technologies?	(7)
12	a)	Explain in detail the classification of end effectors.	(6)
	b)	Explain the general features of wheeled, legged and aerial robots.	(8)

MODULE II

13 a) For the following cylindrical robot arm, compute the position and orientation of the tool tip. (7)



b) Determine the joint angles θ_1, θ_2, θ_3 of a 3 axis robot if the origin of {3} is located at $[0.707, 1.707, 0.000]^T$ and the orientation of {3} with respect to {0} is given by the rotation matrix $R = \begin{bmatrix} 0.5 & -0.866 & 0 \\ 0.866 & 0.5 & 0 \\ 0 & 0 & 1 \end{bmatrix}$. (7)

Given $T_0^3 = \begin{bmatrix} C_{123} & -S_{123} & 0 & L_1C_1 + L_2C_{12} \\ S_{123} & C_{123} & 0 & L_1S_1 + L_2S_{12} \\ 0 & 0 & 1 & 0 \\ 0 & 0 & 0 & 1 \end{bmatrix}$

14 a) Let $F = \{f^1, f^2, f^3\}$ and $M = \{m^1, m^2, m^3\}$ be the fixed and mobile co-ordinate frames. Given $[P]^F = A = [1 \quad 2 \quad 0 \quad 1]^T$. If the homogeneous transformation matrix which maps mobile co-ordinates to fixed co-ordinates is given by (7)

$T = \begin{bmatrix} 0 & -1 & 0 & 0 \\ 1 & 0 & 0 & 2 \\ 0 & 0 & 1 & 2 \\ 0 & 0 & 0 & 1 \end{bmatrix}$. Find the homogeneous transformation which maps fixed frame to mobile frame. Also compute the co-ordinates of the point P with respect to mobile frame, $[P]^M$.

b) Explain how DH algorithm is used to obtain the forward kinematic model of a robotic manipulator. (7)

MODULE III

15 a) Which are the joint space trajectory planning methods? Explain in detail. (7)

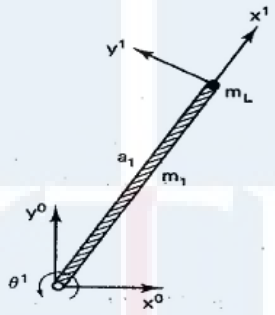
b) The second joint of a SCARA robot has to move from 15^0 to 45^0 in 3 sec. Find the coefficients of the cubic polynomial to interpolate a smooth trajectory.Also obtain the position, velocity and acceleration profiles (7)

16 a) How a circular trajectory is planned in cartesian space? (7)

b) Explain how artificial potential filed method is used for obstacle avoidance of robotic manipulators (7)

MODULE IV

17 a) Obtain the dynamic model of the following manipulator (6)



b) What is the need of a torque regulator in a typical robotic control system? Explain the working of the same with the help of block schematic. How will you choose Kp, KI and Kd values for single axis PID control of robotic manipulator? (8)

18 a) How will you compute the dynamic model of a 2 DOF planar manipulator? (7)

b) Explain in detail how computed torque control is implemented in robotic manipulators. (7)

MODULE V

19 a) Explain in detail how robotic manipulators are used for Material handling, welding and machining applications (8)

b) Obtain the kinematic model of a differential driven mobile robot. (6)

20 a) How will you choose robotic configuration for a pick and place task? (7)

b) Explain in detail different sensors used in mobile robots. (7)

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Syllabus

Module I (9 Hours)

Definitions- Robots, Robotics; Types of Robots- Manipulators, Mobile Robots-wheeled & Legged Robots, Aerial Robots; Anatomy of a robotic manipulator-links, joints, actuators, sensors, controller; open kinematic vs closed kinematic chain; degrees of freedom; Robot configurations-PPP, RPP, RRP, RRR; features of SCARA, PUMA Robots; Classification of robots based on motion control methods and drive technologies; 3R concurrent wrist;

Classification of End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and passive grippers, selection and design considerations of grippers in robot.

Module II (10 Hours)

Robot Kinematics

Direct Kinematics- Rotations-Fundamental and composite Rotations, Homogeneous co-ordinates, Translations and rotations, Composite homogeneous transformations, Screw transformations, Kinematic parameters, The Denavit-Hartenberg (D-H) representation, The arm equation, direct kinematics problems (upto 3DOF)
Inverse kinematics- general properties of solutions, Problems (upto 3DOF)
Inverse kinematics of 3DOF manipulator with concurrent wrist (demo/assignment only)
Tool configuration Jacobian, relation between joint and end effector velocities.

Module III(8 Hours)

Trajectory planning

Tasks□Path planning□ Trajectory Planning. Joint space trajectory planning- cubic polynomial, linear trajectory with parabolic blends, trajectory planning with via points; Cartesian space planning, Point to point vs continuous path planning. Obstacle avoidance methods- Artificial Potential field, A* algorithms.

Module IV(9 Hours)

Manipulator Dynamics

Lagrange'sformulation – Kinetic Energy expression, velocity Jacobian and Potential Energy expression, Generalised force, Euler-Lagrange equation, Dynamic model of planar and spatial serial robots upto 2 DOF, modelling including motor and gearbox.

Robot Control

The control problem, Single axis PID control-its disadvantages, PD gravity control, computed torque control.

Simulation of simple robot-control system-Matlab programming for control of robots(demonstration/assignment only)

Module V(9 Hours)

Industrial Applications-Material handling, welding, Spray painting, Machining. Case study-for robotic applications including robot selection considerations for a typical industrial

application- number of axes, work volume, capacity & speed, stroke &reach, Repeatability, Precision and Accuracy, Operating environment. foreg – the robotic configuration for pick and place robot, spot welding robot in a car manufacturing industry, peg in hole assembly. Applications in the medical, mining, space, defence, security, domestic, entertainment.

Field robotics

Locomotion, Key issues for locomotion, Legged Mobile Robots, Wheeled Mobile Robots. Aerial Mobile Robots.

Mobile Robot Kinematics (Differential Drive robot), simple Examples: Robot kinematic models and constraints, Mobile Robot Workspace- Degrees of freedom, Holonomic and nonholonomic robots.

Motion Control (Kinematic Control), Open loop control (trajectory-following), Feedback control.

Sensors for Mobile Robots, Sensor classification, Characterizing sensor performance, Representing uncertainty, Wheel/motor sensors, Heading sensors, Accelerometers, Inertial measurement unit (IMU), Ground beacons, Active ranging, Motion/speed sensors, Vision sensors.

Text Books

1. Robert. J. Schilling , “Fundamentals of robotics – Analysis and control”, Prentice Hall of India 1996.
2. Introduction to Robotics (Mechanics and control), John. J. Craig, Pearson Education Asia 2002.
3. Introduction to Robotics by S K Saha, Mc Graw Hill Education
4. R K Mittal and I J Nagrath, “Robotics and Control”, Tata McGraw Hill, New Delhi,2003.
5. AshitavaGhosal, “Robotics-Fundamental concepts and analysis”, Oxford University press.
6. Robotics Technology and Flexible Automation, Second Edition, S. R. Deb
7. Introduction to Autonomous Mobile Robots, Siegwart, Roland, Cambridge, Mass. : MIT Press, 2nd ed.

Reference Books

1. Sicilliano, Khatib , “Handbook of Robotics”, Springer
2. John J. Craig, Introduction to Robotics – Mechanics and Control
3. Kevin M. Lynch, Frank C. Park, Modern Robotics Mechanics, Planning and Control
4. Bruno Siciliano, Lorenzo Sciavicco, Luigi Villani, Giuseppe OrioloRobotics Modelling, Planning and Control, Springer

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**MODULE 1**	
1.1	Definitions- Robots, Robotics; Types of Robots- Manipulators, Mobile Robots-wheeled & Legged Robots, Aerial Robots;	2
1.2	Anatomy of a robotic manipulator-links, joints, actuators, sensors, controller; open kinematic vs closed kinematic chain; degrees of freedom;	1.5
1.3	Robot configurations-PPP, RPP, RRP, RRR; features of SCARA, PUMA Robots; Classification of robots based on motion control methods and drive technologies; 3R concurrent wrist	3
1.4	Classification of End effectors - mechanical grippers, special tools, Magnetic grippers, Vacuum grippers, adhesive grippers, Active and passive grippers, selection and design considerations of grippers in robot.	2.5
2	**MODULE 2**	
	Robot Kinematics	
2.1	Direct Kinematics- Rotations-Fundamental and composite Rotations, Homogeneous co-ordinates, Translations and rotations, Composite homogeneous transformations, Screw transformations	3
2.2	Kinematic parameters, The Denavit-Hartenberg (D-H) representation, The arm equation, direct kinematics problems (upto 3DOF)	3
2.3	Inverse kinematics- general properties of solutions, Problems (upto 3DOF)	2
2.4	Tool configuration Jacobian, relation between joint and end effector velocities.	2
3	**MODULE 3**	
	Trajectory planning	
3.1	How to arrive at trajectory planning from task descriptions? Joint space vs cartesian space trajectory planning	0.5
3.2	Trajectory planning cubic polynomial, linear trajectory with parabolic blends, trajectory planning with via points;	2.5
3.3	Cartesian space planning-straight line and circular trajectories, Point to point vs continuous path planning	3
3.2	Obstacle avoidance methods- Artificial Potential field, A* algorithms.	2
4	MODULE 4	
	Manipulator Dynamics and Robot Control	

4.1	Lagrange's formulation – Kinetic Energy expression, velocity Jacobian and Potential Energy expression, Generalised force, Euler-Lagrange equation, Dynamic model of planar and spatial serial robots upto 2 DOF, modelling including motor and gearbox.	4.5
4.2	The control problem, Single axis PID control-its disadvantages, PD gravity control, computed torque control. Simulation of simple robot-control system-Matlab programming for control of robots(demonstration/assignment only)	4.5
5	MODULE 5	
	Robot applications and Field Robotics	
5.1	Industrial Applications-Material handling, welding, Spray painting, Machining. Case study- for robotic applications including robot selection considerations for a typical industrial application- number of axes, work volume, capacity & speed, stroke &reach, Repeatability, Precision and Accuracy, Operating environment. foreg – the robotic configuration for pick and place robot, spot welding robot in a car manufacturing industry, peg in hole assembly. Applications in the medical, mining, space, defence, security, domestic, entertainment.	5
5.2	**Basic concepts of Field Robotics** Locomotion, Key issues for locomotion, Legged Mobile Robots, Wheeled Mobile Robots. Aerial Mobile Robots. Mobile Robot Kinematics (Differential Drive robot), simple Examples: Robot kinematic models and constraints, Mobile Robot Workspace- Degrees of freedom, Holonomic and nonholonomic robots. Motion Control (Kinematic Control), Open loop control and Feedback control. Sensors for Mobile Robots, Sensor classification, Characterizing sensor performance, Representing uncertainty, Wheel/motor sensors, Heading sensors, Accelerometers, Inertial measurement unit (IMU), Ground beacons, Active ranging, Motion/speed sensors, Vision sensors.	4

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
RAT303	SOLID MECHANICS	PCC	3	1	0	4

Preamble: This course helps the students to understand the concept of stress and strain in different types of structure/machine under various loading conditions. The course also covers simple and compound stresses due to forces, stresses and deflection in beams due to bending, torsion in circular, and non circular section, strain energy, different theories of failure, stress in thin cylinder thick cylinder and spheres due to external and internal pressure.

Prerequisite: ENGINEERING MECHANICS

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

CO 1	Determine the stresses, strains and displacements of structures by tensorial and graphical (Mohr's circle) approaches
CO 2	Analyse the strength of materials using stress-strain relationships for structural and thermal loading
CO 3	Perform basic design of circular shafts and thin walled structures subjected to torsional loading and analyse beams subjected to bending moments under different idealised loading conditions
CO 4	Determine the deformation of structures subjected to various loading conditions using strain energy methods
CO 5	Analyse column buckling and appreciate the theories of failures and its relevance in engineering design

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	**2**	**1**										3
CO 2	**2**	**1**										3
CO 3	**2**	**1**										3
CO 4	**3**	**2**	**2**									3
CO 5	**3**	**2**	**2**									3
CO 6	**3**	**2**	**2**									3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Write down the Cauchy's strain displacement relationships.

Course Outcome 2 (CO2):

1. Explain the generalized Hooke's law for a Linear elastic isotropic material.

Course Outcome 3 (CO3):

1. What is the significance of flexural rigidity and section modulus in the analysis of beams.

Course Outcome 4 (CO4):

1. Discuss reciprocal relation for multiple loads on a structure.

Course Outcome 5 (CO5):

1. Discuss Saint-Venant's theory of failure.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code : RAT 303

Course Name : Solid Mechanics

Max. Marks : 100 Duration : 3 Hours

PART – A

(*ANSWER ALL QUESTIONS, EACH QUESTION CARRIES 3 MARKS*)

1. Express the stress invariants in terms of Cartesian components of stress and principal stress.
2. Write down the Cauchy's strain displacement relationships.
3. Distinguish between the states of plane stress and plane strain.
4. Explain the generalized Hooke's law for a Linear elastic isotropic material.
5. List any three important assumptions in the theory of torsion.
6. Write the significance of flexural rigidity and section modulus in the analysis of beams.
7. Discuss reciprocal relation for multiple loads on a structure.
8. Express the strain energy for a cantilever beam subjected to a transverse point load at free end.
9. Discuss Saint-Venant's theory of failure.
10. Explain the term 'critical load' with reference to the buckling of slender columns.

PART – B

(*ANSWER ONE FULL QUESTION FROM EACH MODULE*)

MODULE – I

11 a) The state of stress at a point is given by σ_{xx} = 12.31 MPa, σ_{yy} = 8.96 MPa, σ_{zz} = 4.34 MPa, τ_{xy} =4.2 MPa, τ_{yz} = 5.27 MPa, τ_{xz} = 0.84 MPa. Determine the principal stresses. (7 marks)

b) The displacement field for a body is given by u= $(x^2 + y)i + (3 + z)\,j + (x^2 + 2y)k$. What is the deformed position of a point originally at (3,1,–2)? Write the strain tensor at the point (−3,−1,2) .(7 marks)

OR

12. a) The state of plane stress at a point is given by σ_{xx} = 40 MPa, σ_{yy} = 20 MPa and τ_{xy} = 16 MPa. Using Mohr's circle determine the i) principal stresses and principal planes and ii) maximum shear stress. (7 marks)

b) The state of stress at a point is given below. Find the resultant stress vector acting on a plane with direction cosines n_x=0.47, n_y=0.82 and n_z=0.33. Find the normal and tangential stresses acting on this plane. (7 marks)

$$\sigma_{ij} = \begin{bmatrix} 10 & 5 & -10 \\ 5 & 20 & -15 \\ -10 & -15 & -10 \end{bmatrix} MPa$$

MODULE – II

13. a) Calculate Modulus of Rigidity and Young's Modulus of a cylindrical bar of diameter 30 mm and of 1.5 m length if the longitudinal strain in a bar during a tensile stress is four times the lateral strain. Find the change in volume when the bar is subjected to a hydrostatic pressure of 100 N/mm2. Take E = 105 N/mm (9 marks)

b) A straight bar 450 mm long is 40 mm in diameter for the first 250 mm length and 20 mmdiameter for the remaining length. If the bar is subjected to an axial pull of 15 kN. Find themaximum axial stress produced and the total extension of the bar. Take E = 2x105 N/mm2 (5 marks)

OR

14. a) A brass bar 20mm diameter is enclosed in a steel tube of 25mm internal diameter and 50mm external diameter. Both bar and tube are of same length and fastened rigidly at their ends. The composite bar is free of stress at 20°C. To what temperature the assembly must be heated to generate a compressive stress of 48MPa in the brass bar? Also determine the stress in the steel tube. E_{steel} = 200GPa and E_{brass} = 84GPa, αsteel = 12 × 10−6 / °C and αbrass= 18 × 10−6 / °C. (9 marks)

b) Draw the stress-strain diagram for a ductile material and explain the salient points. (5 marks)

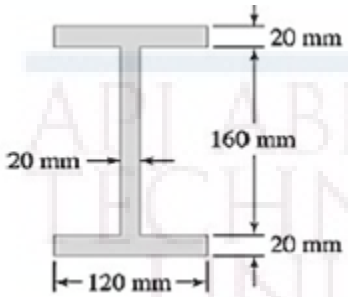
MODULE – III

15.a) Draw shear force and bending moment diagram for a simply supported beam of length 10 m carries a point load of 10N at a distance of 2 m from left support and a udl of 5N/m for the entire length. (9 marks)

b) Compare the strength of a hollow shaft of diameter ratio 0.75 to that of a solid shaft by considering the permissible shear stress. Both the shafts are of same material, of same length and weight. (5 marks)

OR

16. a) A simply supported beam of span of 10 m carries a UDL of 40 kN/m. The cross section is of **I** shape as given below. Calculate the maximum stress produced due to bending and plot the bending stress distribution. (9 marks)



b) The shear stress of a solid shaft is not to exceed 40 N/mm2 when the power transmitted is 20kW at 200 rpm. Determine the minimum diameter of the shaft. (5 marks)

MODULE – IV

17. a) A horizontal girder of steel having uniform section is 14 m long and is simply supported at itsends. It carries concentrated loads of 120 kN and 80 kN at two points 3 m and 4.5 m from thetwo ends respectively. Moment of inertia for the section of the girder is 16 × 108 mm4 and Es =210 kN/mm2. Calculate the deflection of the girder at points under the two loads and maximumdeflection using Macaulay's method. (8 marks)
b) Derive the expressions for elastic strain energy in terms of applied load/moment and materialproperty for the cases of a) Axial force b) Bending moment. (6 marks)

OR

18. a) Calculate the displacement at the load point due to the downward load P applied at a distance of L/3 from the left end for a simply supported beam of span L. (10 marks)
b) State Castigliano's second theorem and explain its significance. (4 marks)

MODULE – V

19. a) Find the crippling load for a hollow steel column 50mm internal diameter and 5mm thick. The column is 5m long with one end fixed and other end hinged. Use Rankine's formula andRankine's constant as 1/7500 and σc = 335 N/mm2. Compare this load by crippling load given byEuler's formula. Take E = 110 GPa. (8 marks)

b) Explain the maximum normal stress theory, maximum strain energy theory and maximumshear stress theory of failure. (6 marks)

OR

20. a) The principal stresses at a point in an elastic material are 22 N/mm2(tensile), 110 N/mm^2(tensile) and 55 N/mm2 (compressive). If the elastic limit in simple tension is 210 N/mm^2, thendetermine whether the failure of material will occur or not according to Maximum principalstress theory, Maximum shear stress theory and maximum distortion energy theory . (9 marks)

b) Derive Euler's formula for a column with both ends hinged. (5 marks)

SYLLABUS

Module I (10 Hours)

Deformation behavior of elastic solids in equilibrium under the action of a system of forces, method of sections. Stress vectors on Cartesian coordinate planes passing through a point, stress at a point in the form of a matrix. Equality of cross shear, Cauchy's equation. Displacement, gradient of displacement, Cartesian strain matrix, strain- displacement relations (small-strain only), Simple problems to find strain matrix.Stress tensor and strain tensor for plane stress and plane strain conditions. Principal planes and principal stress,meaning of stress invariants, maximum shear stress. Mohr's circle for 2D 3D case.

Module II (9 Hours)

Stress-strain diagram, Stress–Strain curves of Ductile and Brittle Materials, Poisson's ratio. Constitutive equations-generalized Hooke's law, equations for linear elastic isotropic solids in terms of Young's Modulus and Poisson's ratio, Hooke's law for Plane stress and plane strain conditions Relations between elastic constants E, G, ν and K(derivation not required). Calculation of stress, strain and change in length in axially loaded members with single and composite materials, Effects of thermal loading – thermal stress and thermal strain. Thermal stress on a prismatic bar with different end conditions

Module III (9 Hours)

Torsional deformation of circular shafts, assumptions for shafts subjected to torsion within elastic deformation range, torsion formula -no derivation .Torsional rigidity, Polar moment of inertia, basic design of transmission shafts. Simple problems to estimate the stress in solid and hollow shafts.Analysis of thin walled structures under torsional loading. Simple problems

Shear force and bending moment diagrams for cantilever,hinged and simply supported beams. Differential equations between load, shear force and bending moment-no derivation. Normal and shear stress in beams: Flexural formula-no derivation , section modulus, flexural rigidity, numerical problems to evaluate bending stress. Shear stress formula for beams-no derivation , shear stress distribution in rectangular,circular section.

Module IV (8 Hours)

Deflection of beams using Macauley's method Elastic strain energy and Complementary strain energy. Elastic strain energy for axial loading, transverse shear, bending and torsional loads.

Expressions for strain energy in terms of load, geometry and material properties of the body for axial, shearing, bending and torsional loads. Castigliano's second theorem, reciprocal relation-no proof required, reciprocal relation. Simple problems to find the deflections using Castigliano's theorem.

Module V (7 Hours)

Fundamentals of bucking and stability, critical load, equilibrium diagram for buckling of an idealized structure. Buckling of columns with pinned ends, Euler's buckling theory for long columns. Critical stress, slenderness ratio, Rankine's formula for short columns. Introduction to Theories of Failure, Rankine's theory for maximum normal stress, Guest's theory for maximum shear stress, Saint-Venant's theory for maximum normal strain, Hencky-von Mises theory for maximum distortion energy, Haigh's theory for maximum strain energy

Text Books

1. Mechanics of materials in S.I. Units, R .C. Hibbeler, Pearson Higher Education 2018
2. Mechanics Of Materials (In Si Units) , Ferdinand Beer, E. Russell Johnston, Jr, McGraw-Hill 2017.
3. Advanced Mechanics of Solids, L. S. Srinath, McGraw Hill Education 4
4. Design of Machine Elements, V. B Bhandari, McGraw Hill Education

Reference Books

1. Engineering Mechanics of Solids, Popov E., PHI 2002
2. Mechanics of Materials, Pytel A. and Kiusalaas J. Cengage Learning India Private Limited, 2ndEdition, 2015
3. Strength of Materials, Rattan, McGraw Hills 2011
4. Strength of Materials, Surendra Singh, S. K. Kataria& Sons

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Module 1: Stress and Strain Analysis**	
1.1	Describe the deformation behaviour of elastic solids in equilibrium under the action of a system of forces. Describe methods of sections to illustrate stress as resisting force per unit area. Stress vectors on Cartesian coordinate planes passing through a point and writing stress at a point in the form of a matrix.	2
1.2	Equality of cross shear (Derivation not required). Write Cauchy's equation	2

	(Derivation not required),Find resultant stress, Normal and shear stress on a plane given stress tensor and direction cosines (no questions for finding direction cosines).	
1.3	Displacement, gradient of displacement, Cartesian strain matrix, Write strain displacement relations (small-strain only), Simple problems to find strain matrix given displacement field (2D and 3D), write stress tensor and strain tensor for Plane stress and plane strain conditions.	2
1.4	Concepts of principal planes and principal stress, characteristic equation of stress matrix and evaluation of principal stresses and principal planes as an eigenvalue problem, meaning of stress invariants, maximum shear stress	2
1.5	Mohr's circle for 2D and 3D case: find principal stress, planes, stress on an arbitrary plane, maximum shear stress graphically using Mohr's circle	2
2	**Module 2: Stress - Strain Relationships**	
2.1	Stress-strain diagram, Stress–Strain curves of Ductile and Brittle Materials, Poisson's ratio	2
2.2	Constitutive equations-generalized Hooke's law, equations for linear elastic isotropic solids in terms of Young's Modulus and Poisson's ratio . Hooke's law for Plane stress and plane strain conditions Relations between elastic constants E, G, ν and K(derivation not required), Numerical problems. Calculation of stress, strain and change in length in axially loaded members with single and composite materials,	3
2.3	Hooke's law for Plane stress and plane strain conditions Relations between elastic constants E, G, ν and K(derivation not required), Numerical problems. Calculation of stress, strain and change in length in axially loaded members with single and composite materials,	2
2.4	Effects of thermal loading – thermal stress and thermal strain. Thermal stress on a prismatic bar held between fixed,pin joint and yielding supports. Numerical problems for axially loaded members.	2
3	**Module 3: Torsion , Shear Force-Bending Moment Diagrams and Pure bending**	
3.1	Torsional deformation of circular shafts, assumptions for shafts subjected to torsion within elastic deformation range, Torsional rigidity, Polar moment of inertia, comparison of solid and hollow shaft. Simple problems to estimate the stress in solid and hollow shafts .	2

3.2	Thin walled structures open and closed-calculating the shear stress distribution and overall angle of twist due to applied torque,simpleproblems,no derivation.	3
3.3	Shear force and bending moment diagrams for cantilever and simply supported beams subjected to point load, moment, UDL and linearly varying load ,Differential equations between load, shear force and bending moment.	2
3.4	Normal and shear stress in beams: section modulus, flexural rigidity, numerical problems to evaluate bending stress, Shear stress formula for beams: ,numerical problem to find shear stress distribution for rectangular,circular section	2
4	**Module 4: Deflection of beams, Strain energy**	
4.1	Deflection of cantilever and simply supported beams subjected to point load, moment and UDL using Macauley's method (procedure and problems with multiple loads)	3
4.2	Linear elastic loading, elastic strain energy and Complementary strain energy. Elastic strain energy for axial loading, transverse shear, bending and torsional loads (short derivations in terms of loads and deflections).	2
4.3	Castigliano's second theorem, reciprocal relation-proof. Simple problems to find the deflections subjected to point load,udl and moment using Castigliano's theorem.	3
5	**Module 5: Buckling and theories of failure**	
5.1	Fundamentals of bucking and stability, critical load, equilibrium diagram for buckling of an idealized structure. Buckling of columns with pinned ends, Euler's buckling theory for long columns. Critical stress, slenderness ratio, Rankine's formula for short columns	4
5.2	Introduction to Theories of Failure, Rankine's theory for maximum normal stress, Guest's theory for maximum shear stress, Saint-Venant's theory for maximum normal strain, Hencky-von Mises theory for maximum distortion energy, Haigh's theory for maximum strain energy.Simple problems under 2D stress conditions.	4

RAT305	INDUSTRIAL AUTOMATION	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: The objective of this course is to provide the student with a general idea of the different automation technologies used in manufacturing environments. Course discusses on the various types of sensors and actuators that acts as the backbone of any automation systems. Study of material handling devices, pneumatic and hydraulic circuits are part of the course. It also provides insights on computerised control and PLC programming.

Prerequisite: Nil

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

CO 1	Explain the basic concepts of automation methodologies and trends in manufacturing automation.
CO 2	Explain the working principle and applications of different types of sensors and actuators
CO 3	Discuss different automated inspection methods.
CO 4	Explain the design aspects of modern CNC machines.
CO 5	Explain the basic principles and operation of different types of material handling devices.
CO 6	Develop different pneumatic and hydraulic circuits based on their applications.
CO 7	Familiarize the basic concepts of PLC programming.

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	2	1	2							3
CO 2	3	2	2	1	2	1						2
CO 3	3	2	2	2	2	1						3
CO 4	3	2	2	2	1	1						2
CO 5	3	3	2	2	2	1						2
CO 6	3	3	2	2	2							2
CO 7	3	3	2	2	2	2						2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	25	25	30
Apply	15	15	60
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Compare and contrast the Detroit type automation and Automated Flow line
2. Explain the advantages of Mechanization and Automation in manufacturing industry

Course Outcome 2 (CO2):

3. Explain the working principle of LVDT and RVDT
4. Discuss the need for calibration and explain any one method

Course Outcome 3 (CO3):

5. Explain the principle and working behind the use of laser interferometer for automatic inspection
6. What are the different automated thickness measurement systems? Explain.

Course Outcome 4 (CO4):

7. Discuss in detail about the different types of automated tool changers available in CNC machines
8. What is adaptive control? How is it used in the design of CNC machines? Explain.

Course Outcome 5 (CO5):

9. Discuss the major design consideration of Material handling systems.
10. Discuss any two automated storage and retrieval systems (ASRS)

Course Outcome 6 (CO6):

11. Design a pneumatic circuit for A+B+ B-A-. sequencing operation using Karnaugh-Veitch method.
12. Explain the functions of the following
    a. Solenoid
    b. Pneumatic-electrical converters

Course Outcome 7 (CO1):

13. Develop a PLC ladder program for the following sequence: Start a motor with push switch, and then after a delay of 90s, start a pump. When the motor is switched off, the pump will get switched off after a delay of 5s. Mention the logic used for each rung in the program to substantiate your answer.

14. Design PLC ladder logic for operating two cylinders in the sequence A+B+A-B-.

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIFTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 305

Course Name: INDUSTRIAL AUTOMATION

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1	What are the methods adopted to group parts in to part families?	(3)
2	Explain programmable Automation.	(3)
3	Explain the working of any one non-contact temperature measurement system.	(3)
4	Explain any two situations when pneumatic actuators are preferred over hydraulic ones.	(3)
5	Explain linear motion guideways. Explain any one application for the use of LM guideways.	(3)
6	Briefly explain carousal type automated storage system.	(3)
7	Explain the different actuation mechanisms in DCVs.	(3)
8	Draw the ISO symbol for the following i) Double pilot operated 5/2 direction control valve. ii) Shuttle valve.	(3)
9	Draw the ladder diagram for the following logic functions. (i) XOR (ii) NAND (iii) NOR	(3)
10	Illustrate the significance of Internal Relays in PLC program.	(3)

PART B

Answer any one full question from each module, each carries14 marks.

MODULE1

11	a)	With neat sketch explain different types of automated transfer lines used in an industry.	(7)

b) Explain how group technology is used in designing manufacturing cells. (7)

12 a) An automated transfer line has 30 stations and an ideal cycle time of 2.0 min. Probability of a station failure is p=0.02, and the average downtime when a breakdown occurs is 15 min. Determine (a) average production rate Rp and (b) line efficiency E. (6)

b) Explain different types of FMS layout. (8)

MODULE II

13 a) Explain the working of an optical absolute encoder. How the number of tracks and sectors of absolute encoder is related to the resolution of the encoder? (6)

b) Explain the scanning laser optical measurement system with a neat sketch. (8)

14 a) With neat sketches explain the working of (8)

i) resolver ii) Synchros.

b) Design a hydraulic circuit to operate a winch fitted with a hydraulic motor. The motor should be run clockwise, counter clockwise and stopped. Use a manually operated valve. (6)

MODULE III

15 a) Sketch and explain working of an AC servomotor. (6)

b) With neat sketches explain adaptive control of machine tools. (8)

16 a) Explain the different types of AGVs used for automated material handling. (8)

b) Explain the different types of conveyors used for automated material handling. (6)

MODULE IV

17 a) Design a pneumatic circuit for A+B+ B-A-.sequencing operation using Karnaugh-Veitch method. (8)

b) Components are to be stamped using stamping machine. A double acting cylinder is used to push the die attached down to a fixture one second after push button is pressed. The die is to return to the initial position upon reaching sufficient stamping pressure as sensed by a pressure switch. Develop an electro pneumatic control circuit to implement the control task for the stamping operation. (6)

18 a) With neat sketches explain the basic electrical devices used in electro pneumatic control. (8)

b) Explain the design considerations of proportional control valve. (6)

MODULE V

19 a) Design PLC ladder logic for operating two cylinders in the sequence A+B+A-B-. (8)

b) Two motors are to be controlled in a sequence. The second motor starts 30 seconds after the starting of first motor by a push switch. Develop a PLC ladder diagram for the following cases and describe the circuit. (6)
Case (A): Only one motor operates at a time.
Case (B): Both the motor gets off together after 50 seconds

20 a) Design PLC based automated car parking barrier system with suitable sensors and actuators. Design the ladder logic for the PLC so that the system collects coins for parking cars and the barrier prevents the entry of one vehicle for a single coin collection. (7)

b) Develop a PLC ladder program for the following sequence: Start a motor with push switch, and then after a delay of 90s, start a pump. When the motor is switched off, the pump will get switched off after a delay of 5s. Mention the logic used for each rung in the program to substantiate your answer. (7)

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SYLLABUS

Module I

Automation methodologies: Concept of Mechanization and Automation – Types of Automation Detroit type Automation, Automated flow lines, Fundamentals of Transfer Lines. Trends in manufacturing – GT and Cellular Manufacturing, Flexible manufacturing systems – features of FMS, computer integrated manufacturing – need for AI and expert systems in CIM, Automated assembly system – flexible assembly automation.

Module II

Sensors and actuators for automation: Classification of position, proximity and motion sensors, inductive type, electromechanical switches, rotary position sensors – resolver, encoders, integrated motion systems, fundamental sensor methodologies, LVDT, RVDT, photo electric, thermo electric, capacitive, magnetic detectors, impedance type gauging transducers, linear potentiometer, strain gauges. Practical examples on design, selection and implementation of sensor systems, calibration of sensors.

Electrical, Hydraulic, and pneumatic actuators and their comparison, Examples - use of Electrical, Hydraulic and pneumatic actuators in industrial automation.

Sensor systems for automated inspection- online inspection systems, laser interferometer, non-contact inspection methods. Automatic gauging and size control systems, thickness measurement, machine vision systems.

Module III

Elements of CNC systems: servomotor and servo system design trends, stepper motors and controls, adaptive control, Drive systems. Automated tool changers and pallet changers- different types. Accessories, and selection of drives for CNC machines.

Material Handling and Identification Technologies: Overview of Material Handling Systems, Principles and Design Consideration, Material Transport Systems, Storage Systems, ASRS different types Overview of Automatic part Identification Methods, Automatic Guided Vehicles.

Module IV

Pneumatic/Hydraulic Automation: control valves – direction, pressure and flow, sequential control of single /multiple actuator systems, cascade and Karnaugh Veitch map methods, step-counter systems.

Electro pneumatic/electrohydraulic automation: Symbols: Basic electrical elements – relay, solenoid, timers, pneumatic – electrical converters, design of circuits and hands on models on material handling systems. Proportional valves and their control.

Module V

Automation Control: Sequence control and programmable controllers – logic control and sequencing elements, ladder diagram, PLC, programming of PLC- analog and digital I/Os, timers, counters, function blocks. Case studies on PLC ladder programming. Motion controllers-VFD, MLD, external relays and contactors.

Text Books:

1. Automation, Production Systems and Computer Integrated Manufacturing, Groover M.P, Prentice – Hall Ltd., 1997.

References:

1. Computer Control of Manufacturing Systems YoramKoren, Tata McGraw-Hill Edition 2005.
2. CNC Machines, Radhakrishnan P., New Central Book Agency, 1992.
3. Mechatronics: A Multidisciplinary Approach, 4/E, W. Bolton. Pearson Education India.
4. Mechatronics, HMT, Tata McGraw-Hill, 1998.
5. Standard Handbook of Industrial Automation, Considine D M C & Considine G D C, Chapman and Hall, NJ, 1986.
6. Pneumatic Control for Industrial Automation‖, Peter Rohner& Gordon Smith, John Wiley and Sons, 1987.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**MODULE 1**	
1.1	**Automation methodologies**: Concept of Mechanization and Automation – Types of Automation Detroit type Automation, Automated flow lines, Fundamentals of Transfer Lines.	4
1.2	**Trends in manufacturing** – GT and Cellular Manufacturing, Flexible manufacturing systems – features of FMS, computer integrated manufacturing – need for AI and expert systems in CIM, Automated assembly system – flexible assembly automation.	4
2	**MODULE 2**	
2.1	**Sensors and actuators for automation:** Classification of position and motion sensors, inductive type, electromechanical switches, rotary position sensors – resolver, encoders, integrated motion systems, fundamental sensor methodologies, LVDT, RVDT, photo electric, thermo electric, capacitive, magnetic detectors, impedance type gauging transducers, linear potentiometer, strain gauges. Practical examples on design, selection and implementation of sensor systems, calibration of sensors.	4
2.2	Electrical, Hydraulic and pneumatic actuators and their comparison, examples - use of Electrical, Hydraulic and pneumatic actuators in industrial automation.	2
2.3	Sensor systems for automated inspection- online inspection systems, laser interferometer, non-contact inspection methods. Automatic gauging and size control systems, thickness measurement, machine vision systems.	3
3	**MODULE 3**	
3.1	**Elements of CNC systems:** servomotor and servo system design trends, stepper motors and controls, adaptive control, ball screws and guideways, spindle, bearings and mountings. Drive systems. Automated tool changers and pallet changers. Accessories and selection of drives for CNC machines.	5
3.2	**Material Handling and Identification Technologies:** Overview of Material Handling Systems, Principles and Design Consideration, Material Transport Systems, Storage Systems, Overview of Automatic Identification Methods.	4
4	**MODULE 4**	

4.1	**Pneumatic/Hydraulic Automation:** control valves – direction, pressure and flow, sequential control of single /multiple actuator systems, cascade and Karnaugh Veitch map methods, step-counter systems.	5
4.2	**Electro pneumatic/electrohydraulic automation**: Symbols: Basic electrical elements – relay, solenoid, timers, pneumatic – electrical converters, design of circuits and hands on models on material handling systems.	5
5	**MODULE 5**	
5.1	**Automation Control:** Sequence control and programmable controllers – logic control and sequencing elements, ladder diagram, PLC, programming the PLC. Practical Examples on PLC ladder programming.	6
5.2	Motion controllers-VFD, MLD, external relays and contactors.	3

RAT307	CONTROL SYSTEMS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble : This course provides the basic idea of modelling a complex physical system into a simple model for different kinds of analysis. The course provides the student with in-depth knowledge on time domain and frequency analysis of systems, determine the stability of a dynamic system, functions of controllers and compensators in a system. It also discussed on various methods used for the analysis of non-linear systems

Prerequisite: Mathematics course in differential equations and Laplace transform, and basic electrical network analysis.

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

CO 1	Model the systems using transfer function approach as well as state space approach
CO 2	Employ time domain analysis to predict and diagnose transient performance parameters of the system for standard input functions.
CO3	Compute the time domain and frequency domain specifications of a system
CO4	Analyse dynamic systems for their stability and performance using root locus and Bode plot
CO5	Identify the needs of different types of controllers and compensator to ascertain the required dynamic response from the system.
CO6	Analyse systems using state space approach
CO7	Explain a variety of methods for analysing nonlinear systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	**3**	**2**	**2**									3
CO 2	**3**	**2**	**2**									3
CO 3	**3**	**2**	**2**									3
CO4	**3**	**2**	**2**									3
CO5	**3**	**2**	**2**									3
CO6	**3**	**2**	**2**									3
CO7	**3**	**2**	**2**									3

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	20
Apply	20	20	70
Analyse			
Evaluate			
Create			

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

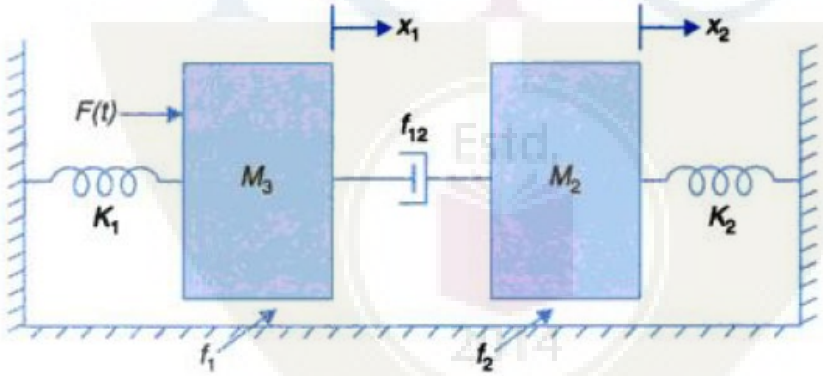
Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

End Semester Examination Pattern: There will be two parts; Part A and Part B. Part A contain 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which student should answer any one. Each question can have maximum 2 sub-divisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain Open Loop and Closed Loop Control Systems. Discuss the functionality of critical components of a control system
2. Determine the transfer function representation of the translational mechanical system shown in following figure. Take displacement x_2 as output and force F(t) as input.

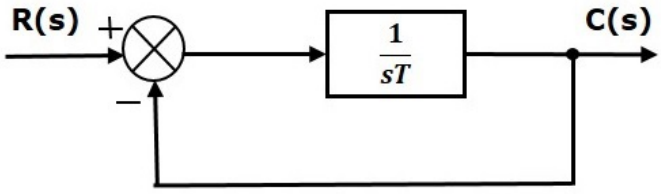


Course Outcome 2 (CO2):

3. Explain Static and Transient response of a system. List out the standard test signals and their characteristics
4. A unity feedback system has an open loop transfer function $\frac{20(s+3)}{(s+0.1)(s+5)}$. Determine steady state error for unit parabolic input?

Course Outcome 3 (CO3):

5. Determine the order of the system given below. Also find out the impulse response of the same.



6. Calculate the resonant peak, resonant frequency and bandwidth for a second order closed loop system given below.

$$T(s) = \frac{C(s)}{R(s)} = \frac{\omega_n^2}{s^2 + 2\delta\omega_n s + \omega_n^2}$$

Course Outcome 4 (CO4):

7. Sketch the root locus for the unity feedback system whose open loop transfer function is given below

$$G(s)H(S) = \frac{K}{s(s+4)(s^2+4s+20)}.$$

8. Sketch the Bode diagram for the following transfer function and hence compute the gain margin and phase margin.

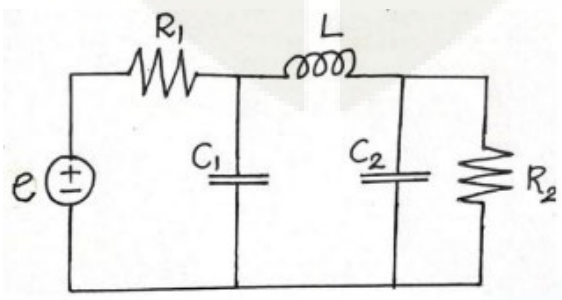
$$G(s) = \frac{75(1+0.2s)}{s(s^2+16s+100)}$$

Course Outcome 5 (CO5):

9. Describe the design procedure for a lag compensator
10. Explain in detail about the three different types of controllers.

Course Outcome 6 (CO6):

11. A system is defined by the transfer function $\frac{Y(s)}{U(s)} = \frac{10(s+4)}{s(S+2)(s+3)}$. Find the state and output equations of the system
12. Obtain the state space representation of the electrical system given below.



Course Outcome 7 (CO7):

13. Derive the Describing function of a Dead-zone nonlinearity.

14. Investigate the stability of the following non-linear system using Lyapunov direct method $\dot{x_1} = x_2 \dot{x_2} = -x_1 - x_1^2 x_2$

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FIFTH SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT 307

Course Name: Control Systems

Max. Marks: 100		Duration: 3 Hours

PART A

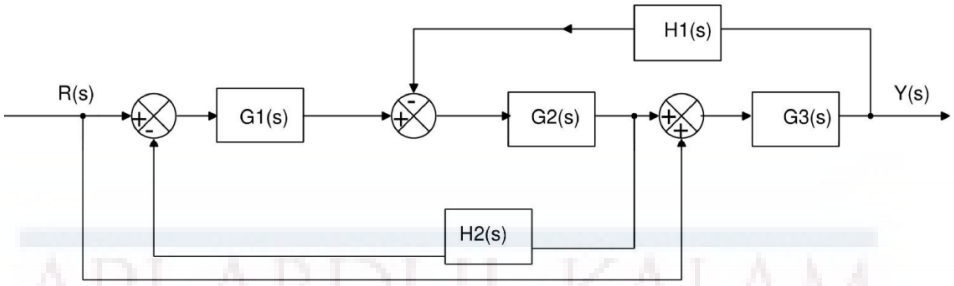
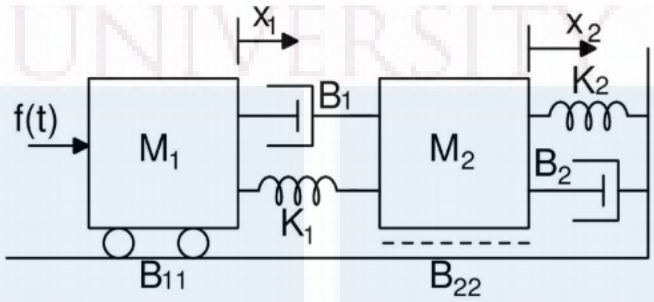
		Answer all questions, each carries 3 marks.	Marks
1		Derive the closed loop transfer function for a non-unity feedback system.	(3)
2		Draw the block schematic of a typical closed loop control system. Explain the components with respect to a robotic system.	(3)
3		Obtain the unit step response of $\frac{5}{s+3}$	(3)
4		A unity feedback system has an open loop transfer function $\frac{20(s+3)}{(s+0.1)(s+5)}$. Determine steady state error for unit parabolic input?	(3)
5		How do you determine the angle of departure of root locus branch from an open loop pole, using angle criterion?	(3)
6		What are frequency domain specifications?	(3)
7		Derive the transfer function of a PID Controller	(3)
8		Explain the terms (i) state (ii) state variables (iii) state vector	(3)
9		A robot is a linear or nonlinear system? Justify your answer. Can we use linear controllers in robots? If so how?	(3)
10		Define Describing function. What is the difference between stability analysis of linear and nonlinear systems?	(3)

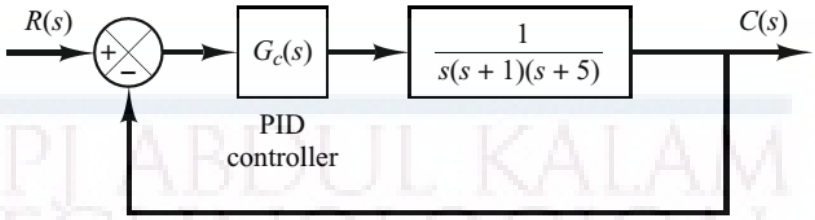
PART B

Answer any one full question from each module, each carries 14 marks.

MODULEI

11	a)	Explain in detail about different actuators and sensors used in a typical robotic control system	(5)
	b)	Analyse the effect of feedback block H(s) on the characteristic equation and pole-zero locations of the closed loop system having $G(s) = \frac{2}{s^2+4s+4}$ with (i) H(s)= $\frac{1}{s}$ and (ii) $H(s) = s$	(5)

		Derive the transfer function of an armature-controlled dc motor?	4
12	a)	Obtain the transfer function using block diagram reduction techniques 	(7)
	b)	Obtain the transfer function of 	(7)
		MODULE II	
13	a)	Determine the unit step response for the system with transfer function $G(s) = \frac{2}{s^2+4s+5}$ Also determine peak overshoot (Mp) and peak time (tp).	(8)
	b)	Check the stability of the system given by the characteristic equation $Q(s)=S^5+3s^4+4s^3+8s^2+16s+36$	(6)
14	a)	Test the stability of the unity negative feedback system with $G(s) = \frac{16}{s(s^5+s^4+8s^3+6s^2+20s+8}$ using Routh's stability criterion. Hence identify the location of roots of the system	(8)
	b)	Explain how does the type of the system control the steady state error for a ramp and parabolic inputs?	(6)
		MODULE III	
15	a)	Determine the stability of the closed loop system $G(s) = \frac{K(s+1)}{(s^2+4s+8}$ using Root locus plot. Hence, determine the value of K such that the damping factor is 0.866	(10)
	b)	Explain gain margin and phase margin of the system	(4)
16	a)	The open-loop transfer function of a unity feedback system is $\frac{K}{s(0.5s+!)(0.04s+1)}$. Use asymptotic approach to plot the bode diagram and determine the value of K for a gain margin of 10.5 dB	(10)
	b)	Discuss about the effect of addition of poles and zeros to the open-loop transfer	(4)

		function G(s) H(s) on the root locus.	
		MODULE IV	
17	a)	Design a PID controller for this system 	(8)
	b)	Obtain the state model of the system whose transfer function is given by $\frac{Y(s)}{U(s)} = \frac{10}{s^3+4s^{2+2s+1}}$	(6)
18	a)	Consider a linear system described by the transfer function $\frac{Y(s)}{U(s)} = \frac{10}{s(s+1)(s+2)}$. Design a feedback controller with a state feedback so that the closed loop poles are placed at -2, -1±j1.	(8)
	b)	A system is described by $\dot{X(t)} = \begin{bmatrix} 0 & 1 \\ -4 & -4 \end{bmatrix} X(t)$. Determine state transition matrix for the system Type equation here.	(6)
		MODULE V	
19	a)	Derive the Describing function of a Dead-zone nonlinearity.	(8)
	b)	Define Singular point. Explain the nature of Eigen values of system matrix for any five types of singular points.	(6)
20	a)	Discuss any three non linearities present in nature	(6)
	b)	Investigate the stability of the following non-linear system using Lyapunov direct method $\dot{x_1} = x_2 \dot{x_2} = -x_1 - x_1^2 x_2$	(8)
		****	

SYLLABUS

Module I (9 Hours)

Control System- Definition, Open loop vs closed loop control systems- components of a typical control system- Necessity of a control system in a Robot, bird's eye view of typical actuators in robot control systems-hydraulic, pneumatic and electric actuators- over view of basic types-DC motors for speed control, DC and AC servo motors for position control, Brushless DC motors for speed control of quadcoptersand linear actuation mechanisms. Basic idea of feedbacks in robotic systems-sensors-eg. Linear and rotary encoders.

Linear time invariant Systems- Transfer function, Necessity of knowing the transfer function, Modelling -Mechanical and Electromechanical systems –block diagram representation - block diagram reduction, characteristic equation, signal flow graph, overview Mason's gain formula -

Module II (9 Hours)

Time domain analysis of control systems: Transient and steady state responses - time domain specifications - first and second order systems - step responses of first and second order systems.steady state error analysis - static error coefficient of type 0,1, 2 systems - Dynamic error coefficients.

Concept of stability: Time response for various pole locations - stability of feedback system - Routh's stability criterion.

Module III (10 Hours)

Root locus - General rules for constructing Root loci – stability from root loci - effect of addition of poles and zeros.

Frequency domain analysis: Frequency domain specifications- Analysis based on Bode plot - Log magnitude vs. phase plot.

Design of P, PI and PID controller using Ziegler-Nichols tuning method, Overview-Necessity of using Lag,lead and lag-lead compensators in Control Systems.

Module IV (9 Hours)

State space analysis of systems: Introduction to state concept - state equation of linear continuous time systems, matrix representation of state equations. Phase variable and canonical forms of state representation-controllable, observable, diagonal and Jordan canonical forms- solution of time invariant autonomous systems, forced system-state transition matrix, relationship between state equations and transfer function.State feedback controller design: Controllability &observability-Kalman's method. State feed-back design via pole placement technique.

Case study- Feedback control of a single link manipulator. (Assignment/demo only)

Module V (8 Hours)

Nonlinear systems: Introduction - characteristics of nonlinear systems. Types of nonlinearities. Determination of describing function of nonlinearities (relay, dead zone and saturation only) - application of describing function for stability analysis of autonomous

system with single nonlinearity. Singular points – Classification of singular points. Definition of stability- asymptotic stability and instability, overview of Lyapunov methods to stability of linear and nonlinear, continuous time systems.

Case study-kinematic modelling of a differential drive robotand controlling the same to move to a point (Assignment/demo only)

TextBooks

1. I. J. Nagrath and M. Gopal, "Control Systems Engineering", New Age International Pvt Ltd, 6/e.
2. Katsuhiko Ogata, "Modern Control Engineering", Pearson Education India, 5/e.
4. M. Gopal, "Control Systems Principles and Design", McGraw Hill Education (India) Pvt. Ltd., 4/e.
5. A. Anand Kumar, "Control Systems", PHI, 2/e.
6. D. Roy Choudhury, "Modern Control Engineering", PHI.
7. K. Alice Mary and P. Ramana, "Control Systems", Orient Black Swan
8. Peter Corke, Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Springer

References

1. Nise N. S., Control Systems Engineering, 6/e, Wiley Eastern, 2010.
2. Dorf R. C. and R. H. Bishop, Modern Control Systems, Pearson Education, 2011.
3. Hassan K Khalil, Nonlinear Systems, Prentice - Hall International (UK), 2002
4. Ashitava Ghosal, Robotics- Fundamental Concepts and Analysis, , Oxford University press

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1		
1.1	Control System- Definition, Open loop vs closed loop control systems-components of a typical control system- Necessity of a control system in a Robot	1
1.2	bird's eye view of typical actuators in robot control systems-hydraulic, pneumatic and electric actuators	1
1.3	Overview of use of Electric actuators like DC motors for speed control, DC and AC servo motors for position control, Brushless DC motors for speed control of quadcopters and linear actuation mechanisms	1
1.4	Basic idea of feedbacks in robotic systems-sensors-eg. Linear and rotary encoders.	1
1.5	Linear time invariant Systems- Transfer function, Necessity of knowing the transfer function of a system	1
1.6	Modelling -Mechanical and Electromechanical systems	2
1.7	Block diagram representation - block diagram reduction, characteristic	2

	equation, signal flow graph - overview of Mason's gain formula -	
2		
2.1	Time domain analysis of control systems: Transient and steady state responses	2
2.2	time domain specifications - first and second order systems - step responses of first and second order systems.steady state error analysis - static error coefficient of type 0,1, 2 systems - Dynamic error coefficients.	4
2.3	Concept of stability: Time response for various pole locations - stability of feedback system - Routh's stability criterion	3
3		
3.1	Root locus - General rules for constructing Root loci – stability from root loci - effect of addition of poles and zeros	4
3.2	Frequency domain analysis: Frequency domain specifications- Analysis based on Bode plot - Log magnitude vs. phase plot.	4
3.3	Design of P, PI and PID controller using Ziegler-Nichols tuning method, Overview-Necessity of using Lag,lead and lag-lead compensators in Control Systems.	2
4		
4.1	State space analysis of systems: Introduction to state concept - state equation of linear continuous time systems, matrix representation of state equations	2
4.2	Phase variable and canonical forms of state representation-controllable, observable, diagonal and Jordan canonical forms	2.5
4.3	solution of time invariant autonomous systems, forced system-state transition matrix, relationship between state equations and transfer function.	2.5
4.4	State feedback controller design: Controllability & observability-Kalman's method- State feed-back design via pole placement technique	1
4.5	Case study- Feedback control of a single link manipulator – refer Robotics- Fundamental Concepts and Analysis, Ashitava Ghosal, Oxford University press	1
5		
5.1	Nonlinear systems: Introduction - characteristics of nonlinear systems. Types of nonlinearities.	2
5.2	Determination of describing function of nonlinearities (relay, dead zone and saturation only) -	2
5.3	application of describing function for stability analysis of autonomous system with single nonlinearity.	1
5.4	Singular points – Classification of singular points. Definition of stability- asymptotic stability and instability; overview of Lyapunov	2

	methods to stability of linear and nonlinear, continuous time systems.	
5.5	Case study-kinematic modelling of a differential drive robot and controlling the same to move to a point- refer Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Peter Corke, Springer.	1

HUT 300	Industrial Economics & Foreign Trade	Category	L	T	P	CREDIT
		HSMC	3	0	0	3

Preamble: To equip the students to take industrial decisions and to create awareness of economic environment.

Prerequisite: Nil

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

CO1	Explain the problem of scarcity of resources and consumer behaviour, and to evaluate the impact of government policies on the general economic welfare. (Cognitive knowledge level: **Understand**)
CO2	Take appropriate decisions regarding volume of output and to evaluate the social cost of production. (Cognitive knowledge level: **Apply**)
CO3	Determine the functional requirement of a firm under various competitive conditions. (Cognitive knowledge level: **Analyse**)
CO4	Examine the overall performance of the economy, and the regulation of economic fluctuations and its impact on various sections in the society. (Cognitive knowledge level: **Analyse**)
CO5	Determine the impact of changes in global economic policies on the business opportunities of a firm. (Cognitive knowledge level: **Analyse**)

Mapping of course outcomes with program outcomes

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

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	PO7	Environment and Sustainability
PO2	Problem Analysis	PO8	Ethics
PO3	Design/Development of solutions	PO9	Individual and team work
PO4	Conduct investigations of complex problems	PO10	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Lifelong learning

Assessment Pattern

Bloom's Category	**Continuous Assessment Tests**		**End Semester Examination Marks**
	Test 1 (Marks)	**Test 2 (Marks)**	
Remember	**15**	**15**	**30**
Understand	**20**	**20**	**40**
Apply	**15**	**15**	**30**

Mark Distribution

Total Marks	**CIE Marks**	**ESE Marks**	**ESE Duration**
150	**50**	**100**	**3 hours**

Continuous Internal Evaluation Pattern:

Attendance	: 10 marks
Continuous Assessment - Test (2 numbers)	: 25 marks
Continuous Assessment - Assignment	: 15 marks

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B.

Part A	: 30 marks
Part B	: 70 marks

Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have maximum 3 sub-divisions and carries 14 marks.

SYLLABUS

HUT 300 Industrial Economics & Foreign Trade

Module 1 (Basic Concepts and Demand and Supply Analysis)

Scarcity and choice - Basic economic problems- PPC – Firms and its objectives – types of firms – Utility – Law of diminishing marginal utility – Demand and its determinants – law of demand – elasticity of demand – measurement of elasticity and its applications – Supply, law of supply and determinants of supply – Equilibrium – Changes in demand and supply and its effects – Consumer surplus and producer surplus (Concepts) – Taxation and deadweight loss.

Module 2 (Production and cost)

Production function – law of variable proportion – economies of scale – internal and external economies – Isoquants, isocost line and producer's equilibrium – Expansion path – Technical progress and its implications – Cobb-Douglas production function - Cost concepts – Social cost: private cost and external cost – Explicit and implicit cost – sunk cost - Short run cost curves - long run cost curves – Revenue (concepts) – Shutdown point – Break-even point.

Module 3 (Market Structure)

Perfect and imperfect competition – monopoly, regulation of monopoly, monopolistic completion (features and equilibrium of a firm) – oligopoly – Kinked demand curve – Collusive oligopoly (meaning) – Non-price competition – Product pricing – Cost plus pricing – Target return pricing – Penetration pricing – Predatory pricing – Going rate pricing – Price skimming.

Module 4 (Macroeconomic concepts)

Circular flow of economic activities – Stock and flow – Final goods and intermediate goods - Gross Domestic Product - National Income – Three sectors of an economy- Methods of measuring national income – Inflation- causes and effects – Measures to control inflation- Monetary and fiscal policies – Business financing- Bonds and shares -Money market and Capital market – Stock market – Demat account and Trading account - SENSEX and NIFTY.

Module 5 (International Trade)

Advantages and disadvantages of international trade - Absolute and Comparative advantage theory - Heckscher - Ohlin theory - Balance of payments – Components – Balance of Payments

deficit and devaluation – Trade policy – Free trade versus protection – Tariff and non-tariff barriers.

Reference Materials

1. Gregory N Mankiw, 'Principles of Micro Economics', Cengage Publications
2. Gregory N Mankiw, 'Principles of Macro Economics', Cengage Publications
3. Dwivedi D N, 'Macro Economics', Tata McGraw Hill, New Delhi.
4. Mithani D M, 'Managerial Economics', Himalaya Publishing House, Mumbai.
5. Francis Cherunilam, 'International Economics', McGraw Hill, New Delhi.

Sample Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Why does the problem of choice arise?
2. What are the central problems?
3. How do we solve the basic economic problems?
4. What is the relation between price and demand?
5. Explain deadweight loss due to the imposition of a tax.

Course Outcome 2 (CO2):

1. What is shutdown point?
2. What do you mean by producer equilibrium?
3. Explain break-even point;
4. Suppose a chemical factory is functioning in a residential area. What are the external costs?

Course Outcome 3 (CO3):

1. Explain the equilibrium of a firm under monopolistic competition.
2. Why is a monopolist called price maker?
3. What are the methods of non-price competition under oligopoly?

4. What is collusive oligopoly?

Course Outcome 4 (CO4):

1. What is the significance of national income estimation?
2. How is GDP estimated?
3. What are the measures to control inflation?
4. How does inflation affect fixed income group and wage earners?

Course Outcome 5 (CO5):

1. What is devaluation?
2. Suppose a foreign country imposes a tariff on Indian goods. How does it affect India's exports?
3. What is free trade?
4. What are the arguments in favour of protection?

Model Question paper

QP CODE: **PAGES:3**

Reg No:_____ **Name :_____**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY FIFTH /SIXTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: HUT 300

Course Name: Industrial Economics & Foreign Trade

Max.Marks:100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1. Why does an economic problem arise?

2. What should be the percentage change in price of a product if the sale is to be increased by 50 percent and its price elasticity of demand is 2?

3. In the production function Q= $2L^{1/2}K^{1/2}$ if L=36 how many units of capital are needed to produce 60 units of output?

4. Suppose in the short run AVC 4. Suppose in the short run AVC<P<AC. Will this firm produce or shut down? Give reason.

5. What is predatory pricing?

6. What do you mean by non- price competition under oligopoly?

7. What are the important economic activities under primary sector?

8. Distinguish between a bond and share?

9. What are the major components of balance of payments?

10. What is devaluation? **(10 x 3 = 30 marks)**

PART B

(Answer one full question from each module, each question carries 14 marks)

MODULE I

11. a) Prepare a utility schedule showing units of consumption, total utility and marginal utility, and explain the law of diminishing marginal utility. Point out any three limitations of the law.

    b) How is elasticity of demand measured according to the percentage method? How is the measurement of elasticity of demand useful for the government?

Or

12. a) Explain the concepts consumer surplus and producer surplus.

    b) Suppose the government imposes a tax on a commodity where the tax burden met by the consumers. Draw a diagram and explain dead weight loss. Mark consumer surplus, producer surplus, tax revenue and dead weight loss in the diagram.

MODULE II

13. a) What are the advantages of large-scale production?

    b) Explain Producer equilibrium with the help of isoquants and isocost line. What is expansion path?

Or

14. a) Explain break-even analysis with the help of a diagram.

    b) Suppose the monthly fixed cost of a firm is Rs. 40000 and its monthly total variable cost is Rs. 60000.

    i. If the monthly sales is Rs. 120000 estimate contribution and break-even sales.
    ii. If the firm wants to get a monthly profit of Rs.40000, what should be the sales?

    c) The total cost function of a firm is given as $TC=100+50Q - 11Q^2+Q^3$. Find marginal cost when output equals 5 units.

MODULE III

15. a) What are the features of monopolistic competition?

b) Explain the equilibrium of a firm earning supernormal profit under monopolistic competition.

Or

16. a) Make comparison between perfect competition and monopoly.

b) Explain price rigidity under oligopoly with the help of a kinked demand curve.

MODULE IV

17. a) How is national income estimated under product method and expenditure method?

b) Estimate GDPmp, GNPmp and National income

Private consumption expenditure	= 2000 (in 000 cores)
Government Consumption	= 500
NFIA	= -(300)
Investment	= 800
Net=exports	=700
Depreciation	= 400
Net-indirect tax	= 300

Or

18. a) What are the monetary and fiscal policy measures to control inflation?

b) What is SENSEX?

MODULE V

19. a) What are the advantages of disadvantages of foreign trade?

b) Explain the comparative cost advantage.

Or

20. a) What are the arguments in favour protection?

b) Examine the tariff and non-tariff barriers to international trade.

(5 × 14 = 70 marks)

Teaching Plan

Module 1 (Basic concepts and Demand and Supply Analysis)		**7 Hours**
1.1	Scarcity and choice – Basic economic problems - PPC	1 Hour
1.2	Firms and its objectives – types of firms	1 Hour
1.3	Utility – Law of diminishing marginal utility – Demand – law of demand	1 Hour
1.4	Measurement of elasticity and its applications	1 Hour
1.5	Supply, law of supply and determinants of supply	1 Hour
1.6	Equilibrium – changes in demand and supply and its effects	1 Hour
1.7	Consumer surplus and producer surplus (Concepts) – Taxation and deadweight loss.	1 Hour
Module 2 (Production and cost)		**7 Hours**
2.1	Productions function – law of variable proportion	1 Hour
2.2	Economies of scale – internal and external economies	1 Hour
2.3	producers equilibrium – Expansion path	1 Hour
2.4	Technical progress and its implications – cob Douglas Production function	1 Hour
2.5	Cost concepts – social cost: private cost and external cost – Explicit and implicit cost – sunk cost	1 Hour
2.6	Short run cost curves & Long run cost curves	1 Hour
2.7	Revenue (concepts) – shutdown point – Break-even point.	1 Hour
Module 3 (Market Structure)		**6 hours**
3.1	Equilibrium of a firm, MC – MR approach and TC – TR approach	1 Hour
3.2	Perfect competition & Imperfect competition	1 Hour
3.3	Monopoly – Regulation of monopoly – Monopolistic competition	1 Hour
3.4	Oligopoly – kinked demand curve	1 Hour
3.5	Collusive oligopoly (meaning) – Non price competition	1 Hour
3.6	Cost plus pricing – Target return pricing – Penetration, Predatory pricing – Going rate pricing – price skimming	1 Hour

Module 4 (Macroeconomic concepts)		7 Hours
4.1	Circular flow of economic activities	1 Hour
4.2	Stock and flow – Final goods and intermediate goods – Gross Domestic Product - National income – Three sectors of an economy	1 Hour
4.3	Methods of measuring national income	1 Hour
4.4	Inflation – Demand pull and cost push – Causes and effects	1 Hour
4.5	Measures to control inflation – Monetary and fiscal policies	1 Hour
4.6	Business financing – Bonds and shares – Money market and capital market	1 Hour
4.7	Stock market – Demat account and Trading account – SENSEX and NIFTY	1 Hour
Module 5 (International Trade)		**8 Hours**
5.1	Advantages and disadvantages of international trade	1 Hour
5.2	Absolute and comparative advantage theory	2 Hour
5.3	Heckscher – Ohlin theory	1 Hour
5.4	Balance of payments - components	1 Hour
5.5	Balance of payments deficit and devaluation	1 Hour
5.6	Trade policy – Free trade versus protection	1 Hour
5.7	Tariff and non tariff barriers.	1 Hour

HUT 310	Management for Engineers	Category	L	T	P	Credit
		HMC	3	0	0	3

Preamble: This course is intended to help the students to learn the basic concepts and functions of management and its role in the performance of an organization and to understand various decision-making approaches available for managers to achieve excellence. Learners shall have a broad view of different functional areas of management like operations, human resource, finance and marketing.

Prerequisite: Nil

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

CO1	Explain the characteristics of management in the contemporary context (Cognitive Knowledge level: **Understand**).
CO2	Describe the functions of management (Cognitive Knowledge level: **Understand**).
CO3	Demonstrate ability in decision making process and productivity analysis (Cognitive Knowledge level: **Understand**).
CO4	Illustrate project management technique and develop a project schedule (Cognitive Knowledge level: **Apply**).
CO5	Summarize the functional areas of management (Cognitive Knowledge level: **Understand**).
CO6	Comprehend the concept of entrepreneurship and create business plans (Cognitive Knowledge level: **Understand**).

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	**2**				**1**	**2**	**2**	**2**		**2**	**1**	**1**
CO2	**2**				**1**	**1**		**2**	**1**	**2**	**1**	**1**
CO3	**2**	**2**	**2**	**2**	**1**							
CO4	**2**	**2**	**2**	**2**	**1**						**2**	**1**
CO5	**2**					**1**	**1**		**1**	**2**	**1**	
CO6		**2**	**2**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**

Abstract POs defined by National Board of Accreditation			
PO1	Engineering Knowledge	PO7	Environment and Sustainability
PO2	Problem Analysis	PO8	Ethics
PO3	Design/Development of solutions	PO9	Individual and team work
PO4	Conduct investigations of complex problems	PO10	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Life long learning

Assessment Pattern

Bloom's Category	**Test 1 (Marks in percentage)**	**Test 2 (Marks in percentage)**	**End Semester Examination (Marks in percentage)**
Remember	15	15	30
Understand	15	15	30
Apply	20	20	40
Analyse			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	50	100	3 Hours

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment - Test : 25 marks

Continuous Assessment - Assignment : 15 marks

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

SYLLABUS

HUT 310 Management for Engineers (35 hrs)

Module 1 (Introduction to management Theory- 7 Hours)

Introduction to management theory, Management Defined, Characteristic of Management, Management as an art-profession, System approaches to Management, Task and Responsibilities of a professional Manager, Levels of Manager and Skill required.

Module 2 (management and organization- 5 hours)

Management Process, Planning types , Mission, Goals, Strategy, Programmes, Procedures, Organising, Principles of Organisation, Delegation, Span of Control, Organisation Structures, Directing, Leadership, Motivation, Controlling..

Module 3 (productivity and decision making- 7 hours)

Concept of productivity and its measurement; Competitiveness; Decision making process; decision making under certainty, risk and uncertainty; Decision trees; Models of decision making.

. Module 4 (project management- 8 hours)

Project Management, Network construction, Arrow diagram, Redundancy. CPM and PERT Networks, Scheduling computations, PERT time estimates, Probability of completion of project, Introduction to crashing.

Module 5 (functional areas of management- 8 hours)

Introduction to functional areas of management, Operations management, Human resources management, Marketing management, Financial management, Entrepreneurship, Business plans, Corporate social responsibility, Patents and Intellectual property rights.

References:

1. H. Koontz, and H. Weihrich, Essentials of Management: An International Perspective. 8th ed., McGraw-Hill, 2009.
2. P C Tripathi and P N Reddy, Principles of management, TMH, 4th edition, 2008.
3. P. Kotler, K. L. Keller, A. Koshy, and M. Jha, Marketing Management: A South Asian Perspective. 14th ed., Pearson, 2012.
4. M. Y. Khan, and P. K. Jain, Financial Management, Tata-McGraw Hill, 2008.
5. R. D. Hisrich, and M. P. Peters, Entrepreneurship: Strategy, Developing, and Managing a New Enterprise, 4th ed., McGraw-Hill Education, 1997.
6. D. J. Sumanth, Productivity Engineering and Management, McGraw-Hill Education, 1985.
7. K.Ashwathappa, 'Human Resources and Personnel Management', TMH, 3 rd edition, 2005.
8. R. B. Chase, Ravi Shankar and F. R. Jacobs, Operations and Supply Chain Management, 14th ed. McGraw Hill Education (India), 2015.

Sample Course Level Assessment Questions

Course Outcome1 (CO1): Explain the systems approach to management?

Course Outcome 2 (CO2): Explain the following terms with a suitable example Goal, Objective, and Strategy.

Course Outcome 3 (CO3): Mr. Shyam is the author of what promises to be a successful novel. He has the option to either publish the novel himself or through a publisher. The publisher is offering Mr. Shyam Rs. 20,000 for signing the contract. If the novel is successful, it will sell 200,000 copies. Else, it will sell 10,000 copies only. The publisher pays a Re. 1 royalty per copy. A market survey indicates that there is a 70% chance that the novel will be successful. If Mr. Shyam undertakes publishing, he will incur an initial cost of Rs. 90,000 for printing and marketing., but each copy sold will net him Rs. 2. Based on the given information and the

decision analysis method, determine whether Mr. Shyam should accept the publisher's offer or publish the novel himself.

Course Outcome 4 (CO4): Explain the concepts of crashing and dummy activity in project management.

Course Outcome 5 (CO5): Derive the expression for the Economic order quantity (EOQ)?

Course Outcome 6 (CO6): Briefly explain the theories of Entrepreneurial motivation.?

Model Question Paper

QP CODE: PAGES: 4

Reg No:_____ Name:_____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: HUT 310

Course name: Management for Engineers

Max Marks: 100 **Duration: 3 Hours**

PART-A (Answer All Questions. Each question carries 3 marks)

1. "Management is getting things done through other." Elaborate.

2. Comment on the true nature of management. Is it a science or an art?

3. Planning is looking ahead and controlling is looking back. Comment with suitable examples

4. Explain the process of communication?

5. Explain the hierarchy of objectives?

6. Explain the types of decisions?

7. Describe the Economic man model?

8. Explain the concepts of crashing and dummy activity in project management.

9. Differentiate the quantitative and qualitative methods in forecasting.

10. What are the key metrics for sustainability measurement? What makes the measurement and reporting of sustainability challenging?

PART-B (Answer any one question from each module)

11. a) Explain the systems approach to management. **(10)**

b) Describe the roles of a manager **(4)**

OR

12. a) Explain the 14 principles of administrative management? **(10)**

b) Explain the different managerial skills (**4)**

13. a) What are planning premises, explain the classification of planning premises. **(10)**

b) Distinguish between strategy and policy. How can policies be made effective. **(4)**

OR

14 a) Explain three motivational theories. **(9)**

b) Describe the managerial grid. **(5)**

15. a) Modern forest management uses controlled fires to reduce fire hazards and to stimulate new forest growth. Management has the option to postpone or plan a burning. In a specific forest tract, if burning is postponed, a general administrative cost of Rs. 300 is incurred. If a controlled burning is planned, there is a 50% chance that good weather will prevail and burning will cost Rs. 3200. The results of the burning may be either successful with probability 0.6 or marginal with probability 0.4. Successful execution will result in an estimated benefit of Rs. 6000, and marginal execution will provide only Rs. 3000 in benefits. If the weather is poor, burning will be cancelled incurring a cost of Rs. 1200 and no benefit. i) Develop a decision tree for the problem. (ii) Analyse the decision tree and determine the optimal course of action. **(8)**

b) Student tuition at ABC University is $100 per semester credit hour. The Education department supplements the university revenue by matching student tuition, dollars per dollars. Average class size for typical three credit course is 50 students. Labour costs are $4000 per class, material costs are $20 per student, and overhead cost are $25,000 per class. (a) Determine the total factor productivity. (b) If instructors deliver lecture 14 hours per week and the semester lasts for 16 weeks, what is the labour productivity? **(6)**

OR

16. a) An ice-cream retailer buys ice cream at a cost of Rs. 13 per cup and sells it for Rs. 20 per cup; any remaining unsold at the end of the day, can be disposed at a salvage price of Rs. 2.5 per cup. Past sales have ranged between 13 and 17 cups per day; there is no reason to believe that

sales volume will take on any other magnitude in future. Find the expected monetary value and EOL, if the sales history has the following probabilities: **(9)**

Market Size	13	14	15	16	17
Probability	0.10	0.15	0.15	0.25	0.35

b) At Modem Lumber Company, Kishore the president and a producer of an apple crates sold to growers, has been able, with his current equipment, to produce 240 crates per 100 logs. He currently purchases 100 logs per day, and each log required 3 labour hours to process. He believes that he can hire a professional buyer who can buy a better quality log at the same cost. If this is the case, he increases his production to 260 crates per 100 logs. His labour hours will increase by 8 hours per day. What will be the impact on productivity (measured in crates per labour-hour) if the buyer is hired? What is the growth in productivity in this case? **(5)**

17. a) A project has the following list of activities and time estimates:

Activity	**Time (Days)**	**Immediate Predecessors**
A	1	-
B	4	A
C	3	A
D	7	A
E	6	B
F	2	C, D
G	7	E, F
H	9	D
I	4	G, H

(a) Draw the network. (b) Show the early start and early finish times. (c) Show the critical path. **(10)**

b) An opinion survey involves designing and printing questionnaires, hiring and training personnel, selecting participants, mailing questionnaires and analysing data. Develop the precedence relationships and construct the project network. **(4)**

OR

18. a) The following table shows the precedence requirements, normal and crash times, and normal and crash costs for a construction project:

Activity	Immediate Predecessors	Required Time (Weeks)		Cost (Rs.)	
		Normal	Crash	Normal	Crash
A	-	4	2	10,000	11,000
B	A	3	2	6,000	9,000
C	A	2	1	4,000	6,000
D	B	5	3	14,000	18,000
E	B, C	1	1	9,000	9,000
F	C	3	2	7,000	8,000
G	E, F	4	2	13,000	25,000
H	D, E	4	1	11,000	18,000
I	H, G	6	5	20,000	29,000

Draw the network. (b) Determine the critical path. (c) Determine the optimal duration and the associated cost. **(10)**

b) Differentiate between CPM and PERT. **(4)**

19. a) What is meant by market segmentation and explain the process of market segmentation **(8)**

b) The Honda Co. in India has a division that manufactures two-wheel motorcycles. Its budgeted sales for Model G in 2019 are 80,00,000 units. Honda's target ending inventory is 10,00, 000 units and its beginning inventory is 12, 00, 000 units. The company's budgeted selling price to its distributors and dealers is Rs. 40, 000 per motorcycle. Honda procures all its wheels from an

outside supplier. No defective wheels are accepted. Honda's needs for extra wheels for replacement parts are ordered by a separate division of the company. The company's target ending inventory is 3,00,000 wheels and its beginning inventory is 2,00,000 wheels. The budgeted purchase price is Rs. 1,600 per wheel.

(a) Compute the budgeted revenue in rupees.

(b) Compute the number of motorcycles to be produced.

Compute the budgeted purchases of wheels in units and in rupees.? **(6)**

OR

20. a) a) "Human Resource Management policies and principles contribute to effectiveness, continuity and stability of the organization". Discuss. (b) What is a budget? Explain how sales budget and production budgets are prepared? **(10)**

b) Distinguish between the following: (a) Assets and Liabilities (b) Production concept and Marketing concept (c) Needs and Wants (d) Design functions and Operational control functions in operations **(4)**

Teaching Plan

Sl.No	TOPIC	SESSION
	Module I	
1.1	Introduction to management	1
1.2	Levels of managers and skill required	2
1.3	Classical management theories	3
1.4	neo-classical management theories	4
1.5	modern management theories	5
1.6	System approaches to Management,	6
1.7	Task and Responsibilities of a professional Manager	7
	Module 2	
2.1	Management process – planning	8
2.2	Mission – objectives – goals – strategy – policies – programmes – procedures	9
2.3	Organizing, principles of organizing, organization structures	10
2.4	Directing, Leadership	11
2.5	Motivation, Controlling	12
	Module III	
3.1	Concept of productivity and its measurement Competitiveness	13
3.2	Decision making process;	14
3.3	Models in decision making	15
3.4	Decision making under certainty and risk	16
3.5	Decision making under uncertainty	17
3.6	Decision trees	18
3.7	Models of decision making.	19
	Module IV	
4.1	Project Management	20

Sl.No	TOPIC	SESSION
	Module I	
4.2	Network construction	21
4.3	Arrow diagram, Redundancy	22
4.4	CPM and PERT Networks	23
4.5	Scheduling computations	24
4.6	PERT time estimates	25
4.7	Probability of completion of project	26
4.8	Introduction to crashing	
	Module V	
5.1	Introduction to functional areas of management,	28
5.2	Operations management	29
5.3	Human resources management ,	30
5.4	Marketing management	31
5.5	Financial management	32
5.6	Entrepreneurship,	33
5.7	Business plans	34
5.8	Corporate social responsibility, Patents and Intellectual property rights	35

MCN 301	DISASTER MANAGEMENT	Category	L	T	P	CREDIT	YEAR OF INTRODUCTION
		Non - Credit	2	0	0	Nil	2019

Preamble: The objective of this course is to introduce the fundamental concepts of hazards and disaster management.

Prerequisite: Nil

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

CO1	Define and use various terminologies in use in disaster management parlance and organise each of these terms in relation to the disaster management cycle (Cognitive knowledge level: **Understand**).
CO2	Distinguish between different hazard types and vulnerability types and do vulnerability assessment (Cognitive knowledge level: **Understand**).
CO3	Identify the components and describe the process of risk assessment, and apply appropriate methodologies to assess risk (Cognitive knowledge level: **Understand**).
CO4	Explain the core elements and phases of Disaster Risk Management and develop possible measures to reduce disaster risks across sector and community (Cognitive knowledge level: **Apply**)
CO5	Identify factors that determine the nature of disaster response and discuss the various disaster response actions (Cognitive knowledge level: **Understand**).
CO6	Explain the various legislations and best practices for disaster management and risk reduction at national and international level (Cognitive knowledge level: **Understand**).

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO 9	PO1 0	PO1 1	PO1 2
CO1		2				2				2		2
CO2	2	3	2		2	2	3			3		2
CO3	2	3	2	2	2	2	3			3		2
CO4	3	3	3		2	2	3					2
CO5	3	3			2	2	3					2
CO6	3					2	3	3				2

Abstract POs defined by National Board of Accreditation			
PO#	**Broad PO**	**PO#**	**Broad PO**
PO1	Engineering Knowledge	PO7	Environment and Sustainability
PO2	Problem Analysis	PO8	Ethics
PO3	Design/Development of solutions	PO9	Individual and team work
PO4	Conduct investigations of complex problems	PO10	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks
	Test 1 (Marks)	Test 2 (Marks)	
Remember	**10**	**10**	**20**
Understand	**25**	**25**	**50**
Apply	**15**	**15**	**30**
Analyze			
Evaluate			
Create			

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	**50**	**100**	**3 hours**

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment - Test : 25 marks

Continuous Assessment - Assignment : 15 marks

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks. First series test shall be preferably conducted after completing the first half of the syllabus and the second series test shall be preferably conducted after completing remaining part of the syllabus. There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly completed module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A.

Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly completed module), each with 7 marks. Out of the 7 questions, a student should answer any 5.

End Semester Examination Pattern:

There will be two parts; Part A and Part B. Part A contains 10 questions with 2 questions from each module, having 3 marks for each question. Students should answer all questions. Part B contains 2 questions from each module of which a student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

SYLLABUS

MCN 301 Disaster Management

Module 1

Systems of earth

Lithosphere- composition, rocks, soils; Atmosphere-layers, ozone layer, greenhouse effect, weather, cyclones, atmospheric circulations, Indian Monsoon; hydrosphere- Oceans, inland water bodies; biosphere

Definition and meaning of key terms in Disaster Risk Reduction and Management- disaster, hazard, exposure, vulnerability, risk, risk assessment, risk mapping, capacity, resilience, disaster risk reduction, disaster risk management, early warning systems, disaster preparedness, disaster prevention, disaster mitigation, disaster response, damage assessment, crisis counselling, needs assessment.

Module 2

Hazard types and hazard mapping; Vulnerability types and their assessment- physical, social, economic and environmental vulnerability.

Disaster risk assessment –approaches, procedures

Module 3

Disaster risk management -Core elements and phases of Disaster Risk Management

Measures for Disaster Risk Reduction – prevention, mitigation, and preparedness.

Disaster response- objectives, requirements; response planning; types of responses.

Relief; international relief organizations.

Module 4

Participatory stakeholder engagement; Disaster communication- importance, methods, barriers; Crisis counselling

Capacity Building: Concept – Structural and Non-structural Measures, Capacity Assessment; Strengthening Capacity for Reducing Risk

Module 5

Common disaster types in India; Legislations in India on disaster management; National disaster management policy; Institutional arrangements for disaster management in India.

The Sendai Framework for Disaster Risk Reduction- targets, priorities for action, guiding principles

Reference Text Book

1. R. Subramanian, Disaster Management, Vikas Publishing House, 2018
2. M. M. Sulphey, Disaster Management, PHI Learning, 2016
3. UNDP, Disaster Risk Management Training Manual, 2016
4. United Nations Office for Disaster Risk Reduction, Sendai Framework for Disaster Risk Reduction 2015-2030, 2015

Sample Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What is the mechanism by which stratospheric ozone protects earth from harmful UV rays?
2. What are disasters? What are their causes?
3. Explain the different types of cyclones and the mechanism of their formation
4. Explain with examples, the difference between hazard and risk in the context of disaster management
5. Explain the following terms in the context of disaster management (a) exposure (b) resilience (c) disaster risk management (d) early warning systems, (e) damage assessment (f) crisis counselling (g) needs assessment

Course Outcome 2 (CO2):

1. What is hazard mapping? What are its objectives?
2. What is participatory hazard mapping? How is it conducted? What are its advantages?
3. Explain the applications of hazard maps
4. Explain the types of vulnerabilities and the approaches to assess them

Course Outcome 3 (CO3):

1. Explain briefly the concept of ‘disaster risk’

2. List the strategies for disaster risk management ‘before’, ‘during’ and ‘after’ a disaster
3. What is disaster preparedness? Explain the components of a comprehensive disaster preparedness strategy

Course Outcome 4 (CO4):

1. What is disaster prevention? Distinguish it from disaster mitigation giving examples
2. What are the steps to effective disaster communication? What are the barriers to communication?
3. Explain capacity building in the context of disaster management

Course Outcome 5 (CO5):

1. Briefly explain the levels of stakeholder participation in the context of disaster risk reduction
2. Explain the importance of communication in disaster management
3. Explain the benefits and costs of stakeholder participation in disaster management
4. How are stakeholders in disaster management identified?

Course Outcome 6 (CO6):

1. Explain the salient features of the National Policy on Disaster Management in India
2. Explain the guiding principles and priorities of action according to the Sendai Framework for Disaster Risk Reduction
3. What are Tsunamis? How are they caused?
4. Explain the earthquake zonation of India

Model Question paper

QP CODE: **PAGES:3**

Reg No:_____ **Name :_____**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: MCN 301

Course Name: Disaster Management

Max.Marks:100 **Duration: 3 Hours**

PART A

Answer all Questions. Each question carries 3 Marks

1. What is the mechanism by which stratospheric ozone protects earth from harmful UV rays?
2. What are disasters? What are their causes?
3. What is hazard mapping? What are its objectives?
4. Explain briefly the concept of 'disaster risk'
5. List the strategies for disaster risk management 'before', 'during' and 'after' a disaster
6. What is disaster prevention? Distinguish it from disaster mitigation giving examples
7. Briefly explain the levels of stakeholder participation in the context of disaster risk reduction
8. Explain the importance of communication in disaster management
9. What are Tsunamis? How are they caused?
10. Explain the earthquake zonation of India

Part B

Answer any one Question from each module. Each question carries 14 Marks

11. a. Explain the different types of cyclones and the mechanism of their formation [10]

b. Explain with examples, the difference between hazard and risk in the context of disaster management
[4]

OR

12. Explain the following terms in the context of disaster management [14]

(a) exposure (b) resilience (c) disaster risk management (d) early warning systems, (e) damage assessment (f) crisis counselling (g) needs assessment

13. a. What is participatory hazard mapping? How is it conducted? What are its advantages?

[8]

b. Explain the applications of hazard maps [6]

OR

14. Explain the types of vulnerabilities and the approaches to assess them [14]

15. a. Explain the core elements of disaster risk management [8]

b. Explain the factors that decide the nature of disaster response [6]

OR

16. a. What is disaster preparedness? Explain the components of a comprehensive disaster preparedness strategy [6]

b. Explain the different disaster response actions [8]

17. a. Explain the benefits and costs of stakeholder participation in disaster management [10]

b. How are stakeholders in disaster management identified? [4]

OR

18. a. What are the steps to effective disaster communication? What are the barriers to communication? [7]

b. Explain capacity building in the context of disaster management [7]

19. Explain the salient features of the National Policy on Disaster Management in India

[14]

OR

20. Explain the guiding principles and priorities of action according to the Sendai Framework for Disaster Risk Reduction [14]

Teaching Plan

	Module 1	**5 Hours**
1.1	Introduction about various Systems of earth, Lithosphere-composition, rocks, Soils; Atmosphere-layers, ozone layer, greenhouse effect, weather	1 Hour
1.2	Cyclones, atmospheric circulations, Indian Monsoon; hydrosphere-Oceans, inland water bodies; biosphere	1 Hour
1.3	Definition and meaning of key terms in Disaster Risk Reduction and Management- disaster, hazard,	1 Hour
1.4	Exposure, vulnerability, risk, risk assessment, risk mapping, capacity, resilience, disaster risk reduction, Disaster risk management, early warning systems	1 Hour
1.5	Disaster preparedness, disaster prevention, disaster, Mitigation, disaster response, damage assessment, crisis counselling, needs assessment.	1 Hour
	Module 2	**5 Hours**
2.1	Various Hazard types, Hazard mapping; Different types of Vulnerability types and their assessment	1 Hour
2.2	Vulnerability assessment and types, Physical and social vulnerability	1 Hour
2.3	Economic and environmental vulnerability, Core elements of disaster risk assessment	1 Hour
2.4	Components of a comprehensive disaster preparedness strategy approaches, procedures	1 Hour
2.5	Different disaster response actions	1 Hour
	Module 3	**5 Hours**
3.1	Introduction to Disaster risk management, Core elements of Disaster Risk Management	1 Hour
3.2	Phases of Disaster Risk Management, Measures for Disaster Risk Reduction	1 Hour
3.3	Measures for Disaster prevention, mitigation, and preparedness.	1 Hour

3.4	Disaster response- objectives, requirements. Disaster response planning; types of responses.	1 Hour
3.5	Introduction- Disaster Relief, Relief; international relief organizations.	1 Hour
	Module 4	**5 Hours**
4.1	Participatory stakeholder engagement	1 Hour
4.2	Importance of disaster communication.	1 Hour
4.3	Disaster communication- methods, barriers. Crisis counselling	1 Hour
4.4	Introduction to Capacity Building. Concept – Structural Measures, Non-structural Measures.	1 Hour
4.5	Introduction to Capacity Assessment, Capacity Assessment; Strengthening, Capacity for Reducing Risk	1 Hour
	Module 5	**5 Hours**
5.1	Introduction-Common disaster types in India.	1 Hour
5.2	Common disaster legislations in India on disaster management	1 Hour
5.3	National disaster management policy, Institutional arrangements for disaster management in India.	1 Hour
5.4	The Sendai Framework for Disaster Risk Reduction and targets	1 Hour
5.5	The Sendai Framework for Disaster Risk Reduction-priorities for action, guiding principles	1 Hour

RAL331	AUTOMATION LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: The lab familiarize the student with the various tools that uses hydraulic, and pneumatic controls that can be used for automation. Exposure to simulation packages for automation is also part of the course.

Prerequisite: NIL

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

CO 1	Design and develop various hydraulic and electro-hydraulic systems
CO 2	Design and develop various pneumatic and electro-pneumatic systems
CO 3	Familiarisation of ladder programming and testing of PLC circuits
CO 4	Familiarization of hydraulic, pneumatic, electrohydraulic, electropneumatic circuits in simulation package

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	2	2		2			2	2		3
CO 2	3	2	2	2		2			2	2		3
CO 3	3	2	2	2	3	2			2	2		3
CO 4	3	2	2	2	3	2			2	2		3

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance : 15 marks
Continuous Assessment : 30 marks
Internal Test (Immediately before the second series test) : 30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work : 15 Marks
(b) Implementing the work/Conducting the experiment : 10 Marks
(c) Performance, result and inference (usage of equipment and trouble shooting) : 25 Marks
(d) Viva voce : 20 Marks
(e) Record : 5 Marks

General instructions: End-semester practical examination is to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the examination only on submitting the duly certified record. The external examiner shall endorse the record.

List of Experiments(12 Experiments Mandatory)

1. Experiments using hydraulic actuators and study of their performance under various operating conditions.
2. Experiments using electro-hydraulic systems and study of their characteristics
3. Experiments to implement logic using electro-hydraulics.
4. Experiments using pneumatic actuators and study of their performance under various operating conditions.
5. Experiments in pneumatics logic
6. Experiments in electro-pneumatics
7. Experiments using proportional and servo hydraulic valves.
8. Experiments on PLC
9. Interfacing PLC with electro-hydraulics
10. Interfacing PLC with electro-pneumatics
11. Experiments on Motion Logic Drive
12. Experiments on Variable Frequency drive
13. Experiments on SCADA
14. Simulation of hydraulic, pneumatic circuits in simulation package (eg: Automation Studio)
15. Simulation of electrohydraulic, electro-pneumatic circuits in simulation package (eg: Automation Studio)

Text Books

1. Automation, Production Systems and Computer Integrated Manufacturing, Groover M.P, Prentice – Hall Ltd., 1997.
2. Computer Control of Manufacturing Systems YoramKoren, Tata McGraw-Hill Edition 2005.
3. CNC Machines, Radhakrishnan P., New Central Book Agency, 1992.
4. Mechatronics: A Multidisciplinary Approach, 4/E, W. Bolton. Pearson Education India.

5. Mechatronics, HMT, Tata McGraw-Hill, 1998.
6. Standard Handbook of Industrial Automation, Considine D M C &Considine G D C, Chapman and Hall, NJ, 1986.
7. Pneumatic Control for Industrial Automation‖, Peter Rohner& Gordon Smith, John Wiley and Sons, 1987.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
RAL 333	ROBOT OPERATING SYSTEM LAB	PCC	0	0	3	2

Preamble: The lab introduces the student to a Robot Operating System and familiarisation of few ROS tools

Pre-requisites

- ROS Installed Ubuntu System—UBUNTU 16.04LTS/18.04LTS
- Basic knowledge of Linux command line tools
- Basic programming in Python—2.7/3.5/3.6
- Robotics Basics
-

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

CO 1	Understand the applications of ROS in real world complex scenarios
CO 2	Work with turtlesim, Gazebo, MoveIt and Rviz
CO 3	Familiarise about the concepts behind navigation
CO 4	Interface with hardware and analyse the issues in hardware interfacing

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	2	2	2	3	2			2	2		3
CO 2	3	2	2	2	3	2			2	2		3
CO 3	3	2	2	2	3	2			2	2		3
CO 4	3	2	2	2	3	2			2	2		3

Assessment Pattern

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	75	75	2.5 hours

Continuous Internal Evaluation Pattern:

Attendance : 15 marks

Continuous Assessment : 30 marks

Internal Test (Immediately before the second series test) : 30 marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks

(a) Preliminary work : 15 Marks

(b) Implementing the work/Conducting the experiment : 10 Marks

(c) Performance, result and inference (usage of equipments and trouble shooting) : 25 Marks

(d) Viva voce : 20 Marks

(e) Record : 5 Marks

General instructions: End-semester practical examination is to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is to be conducted under the equal responsibility of both the internal and external examiners. The number of candidates evaluated per day should not exceed 20. Students shall be allowed for the examination only on submitting the duly certified record. The external examiner shall endorse the record.

ROS Essentials

- Installing and Configuring Your ROS Environment—ROS Kinetic/Melodic/Compatible versions
- Familiarisation with ROS (Master, nodes, topics, messages, services, parameters and actions)
- Familiarisation with ROS Tools – Gazebo , Moveit , Rviz
- Creating Workspace and Package in ROS

List of Experiments

PART A

10 Experiments mandatory

1. Writing a Simple Publisher and Subscriber, Simple Service and Client,Recording and playing back data, Reading messages from a bag file(Python/C++)
2. Getting Started with Turtlesim
3. Familiarisation with Rviz -- Markers: Sending Basic Shapes -- use visualization_msgs/Marker messages to send basic shapes, to send points and lines (C++), Interactive Markers: Writing a Simple Interactive Marker Server, Basic Controls
4. Introduction to tf -- broadcast the state of a robot to tf, get access to frame transformations, Adding a frame, waitForTransform function, Setting up your robot using tf, publish the state of your robot to tf, using the robot state publisher.
5. Building a Visual Robot Model with URDF from Scratch, Building a Movable Robot Model with URDF, Adding Physical and Collision Properties to a URDF Model.
6. Familiarisation with Gazebo--How to get Gazebo up and running,Creating and Spawning Custom URDF Objects in Simulation, Gazebo ROS API for C-Turtle, Simulate a Spinning Top, Gazebo Plugin - how to create a gazebo plugin, Create a Gazebo Plugin that Talks to ROS
7. Create a Gazebo Custom World (Building Editor, Gazebo 3D Models), Add Sensor plugins like Laser, Kinect, etc. to URDF of mobile robot
8. Create a 3DOF robotic arm from scratch
9. Familiarisation with MoveIt through its RViz plugin, Motion Planning with the Panda or other robot models.
10. Create Moveit package for robotic arm simulation and add controllers,Plan a path for a 3DOF Robotic Arm and execute the same, Move the 3DOF arm to a desired goal point
11. Attach 2DOF gripper as the end effector of 3DOF arm and execute gripping operations, Execute Pick and Place Operation
12. Familiarisation with 2D navigation stack, Basic ROS Navigation, Start robots in simulation.
13. Execute SLAM Mapping (Lidar based) using a differentially driven mobile robot
14. Execute AMCL Navigation in a known environment using a differentially driven mobile robot.

PART B (Hardware experiments)
(2 experiments mandatory)

15. Familiarise ROS Serial Arduino for hardware interface.
16. Obstacle avoidance using a differentially driven mobile robot

Text Books:

1. Lentin Joseph, “Robot Operating Systems (ROS) for Absolute Beginners, Apress, 2018

2. Aaron Martinez, Enrique Fernández, “Learning ROS for Robotics Programming”, Packt Publishing

Ltd, 2013.

Reference Books:

1. Jason M O'Kane, “A Gentle Introduction to ROS”, CreateSpace, 2013.

2. AnisKoubaa, “Robot Operating System (ROS) – The Complete Reference (Vol.3), Springer, 2018.

3. Kumar Bipin, “Robot Operating System Cookbook”, Packt Publishing, 2018.

4. Wyatt Newman, “A Systematic Approach to learning Robot Programming with ROS”, CRC Press,

2017.

5. Patrick Gabriel, “ROS by Example: A do it yourself guide to Robot Operating System”, Lulu, 2012.