CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
RAD334	MINIPROJECT/ CORE LAB	PWS	0	0	3	2

Preamble: This course is designed for enabling the students to apply the knowledge to address the real-world situations/problems and find solutions. The course is also intended to estimate the ability of the students in transforming theoretical knowledge studied as part of the curriculum so far in to a working model. The students are expected to design and develop a software/hardware project to innovatively solve a real-world problem.

Prerequisites: Subjects studied up to sixth semester.

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

CO No.	Course Outcome (CO)	Bloom's Category Level
CO 1	Make use of acquired knowledge within the selected area of technology for project development.	Level 3: Apply
CO 2	Identify, discuss and justify the technical aspects and design aspects of the project with a systematic approach.	Level 3: Apply
CO 3	Interpret, improve and refine technical aspects for engineering projects.	Level 3: Apply
CO 4	To exercise their creative and innovative qualities in a group project environment	Level 3: Apply
CO 5	Report effectively the project related activities and findings.	Level 2: Understand

Mapping of course outcomes with program outcomes

POs / COs	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	3	3	3	3	3	3	3	-	-	-	3
CO 2	3	3	3	3	3	-	2	3	-	3	2	3
CO 3	3	3	3	3	3	2	3	3	-	2	3	3
CO 4	3	3	2	2	-	-	-	3	3	3	3	3
CO 5	3	-	-	-	2	-	-	3	2	3	2	3

Assessment Pattern

The End Semester Evaluation (ESE) will be conducted as an internal evaluation based on the product/project, the report and a viva- voce examination, conducted by a 3-member committee appointed by Head of the Department comprising HoD or a senior faculty member, academic coordinator for that program and project guide/coordinator. The

Committee will be evaluating the level of completion and demonstration of functionality/specifications, presentation, oral examination, working knowledge and involvement.

The Continuous Internal Evaluation (CIE) is conducted by evaluating the progress of the miniproject through minimum of TWO reviews. At the time of the 1st review, students are supposed to propose a new system/design/idea, after a thorough literature study of the existing systems under the chosen area. In the 2nd review students are expected to highlight the implementation details of the proposed solution. The review committee should assess the extent to which the implementation reflects the proposed design. The final CIE mark is the average of 1st and 2nd review marks.

A zeroth review may be conducted before the beginning of the project to give a chance for the students to present their area of interest or problem domain or conduct open brain storming sessions for innovative ideas. Zeroth review will not be apart of the CIE evaluation process.

In the final review students are expected to demonstrate the product with its full specification along with a final report. A well coded, assembled and completely functional product is the expected output during the end of the semester.

Marks Distribution

Total Marks	CIE	ESE
150	75	75

Continuous Internal Evaluation Pattern:
Attendance : 10 marks
Marks awarded by Guide : 15 marks
Project Report: 10 marks
Evaluation by the Committee : 40 Marks

End Semester Examination Pattern: The following guidelines should be followed regarding award of marks.
(a) Demonstration : 50 Marks
(b) Project report: 10 Marks
(d) Viva voce : 15marks

Course Plan

In this course, each group consisting of three/four members is expected to design and develop a moderately complex software/hardware system with practical applications. This should be a working model. The basic concept of product design may be taken into consideration.

Students should identify a topic of interest in consultation with Faculty-in-charge of miniproject/Advisor. Review the literature and gather information pertaining to the chosen topic. State the objectives and develop a methodology to achieve the objectives. Carryout the design/fabrication or develop codes/programs to achieve the objectives. Demonstrate the novelty of the project through the results and outputs. The progress of the mini project is evaluated based on a minimum of two reviews**.**

The review committee may be constituted by the Head of the Department. A project report is required at the end of the semester. The product has to be demonstrated for its full design specifications. Innovative design concepts, reliability considerations, aesthetics/ergonomic aspects taken care of in the project shall be given due weight.

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
RAL332	ROBOTICS LAB	PCC	0	0	3	2

Preamble: Robotics lab provides students with exposure to the common Robotic manipulators with atleast 3DOF and mobile robots. Students are also made to do experiments with sensors and feedback controls as well as object detection and tracking.

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

CO 1	Test forward, inverse kinematic modelling and path planning of robotic manipulators
CO 2	Test basic control algorithms in mobile robots to move to a point, to follow a line, to follow a path and for obstacle avoidance.
CO 3	Familiarise about localisation of mobile robots
CO 4	Calibrate sensors used in robots
CO 5	Design and develop sensor-based systems in 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	3	2	2	2		2			2	2		3
CO 2	3	2	2	2		2			2	2		3
CO 3	3	2	2	2		2			2	2		3
CO 4	3	2	2	2		2			2	2		3
CO 5	3	2	2	2		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: Practical examination to be conducted immediately after the second series test covering entire syllabus given below. Evaluation is a serious process that 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 University examination only on submitting the duly certified record. The external examiner shall endorse the record.

LIST OF EXPERIMENTS

All experiments from Part A, Part B and Part C are mandatory

Part A: Robotic Manipulators (3 DOF or greater) (All experiments mandatory)

1. Joint space and Cartesian space trajectory planning for a pick and place task
2. Obtain forward and inverse kinematic models (check end effector and joint positions with theoretical and actual values)
3. Point to point control and continuous path control

Part B: Mobile Robots

1. Control of mobile robot for moving to a point(xg, yg) , following a line (ax+by+c=0), moving to a specific target orientation (θ_g) (Closed loop control considering kinematic models)
2. Obstacle avoidance of a mobile robot while moving to a point.
3. Localization of a mobile robot using LIDAR

PART C: Sensor based experiments

1. Calibration of sensors-sonar, IR sensors and obtain the calibration curve
2. Object detection using any one standard algorithm
3. Object tracking and visual servoing
4. Following a moving target/ Object tracking from a moving vehicle

PART D: Mini Project (any one –compulsory)

1. Design and develop a servo controlled robotic manipulator (1 DOF) with visual feedback for pick and place task
2. Design and develop a mobile robot capable of obstacle avoidance and localisation
3. Assemble a quadcopter drone kit and make it hover.

Reference Books

1. Introduction to Robotics (Mechanics and control), John. J. Craig, Pearson Education Asia 2002.
2. Introduction to Robotics by S K Saha, Mc Graw Hill Education
3. R K Mittal and I J Nagrath, "Robotics and Control", Tata McGraw Hill, New Delhi,2003.
4. Ashitava Ghosal, "Robotics-Fundamental concepts and analysis", Oxford University press.
5. Robotics Technology and Flexible Automation, Second Edition, S. R. Deb
6. Introduction to Autonomous Mobile Robots, Siegwart, Roland, Cambridge, Mass. : MIT Press, 2nd ed.
7. Robotics, Vision and Control: Fundamental Algorithms in MATLAB, Peter Corke, Springer

RAT308	COMPREHENSIVE COURSE WORK	Category	L	T	P	Credit	Year of Introduction
		PCC	1	0	0	1	2019

Preamble: The course is designed to ensure that the students have firmly grasped the fundamental knowledge in Robotics & Automation Engineering familiar enough with the technological concepts. It provides an opportunity for the students to demonstrate their knowledge in various Robotics & Automation subjects.

Pre-requisite: Nil

Course outcomes: After the course, the student will able to:

CO1	Learn to prepare for a competitive examination
CO2	Comprehend the questions in Robotics & AutomationEngineering field and answer them with confidence
CO3	Communicate effectively with faculty in scholarly environments
CO4	Analyze the comprehensive knowledge gained in basic courses in the field of Robotics & AutomationEngineering

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2	PSO3	PSO 4
CO1	3	1	1			2										
CO2	3	1				2				3			1	1	1	1
CO3	3	1			1	2				3						
CO4	3	3			1	2							1	1	1	1

Assessment pattern

Bloom's Category	End Semester Examination (Marks)
Remember	25
Understand	15
Apply	5
Analyze	5
Evaluate	
Create	

End Semester Examination Pattern:

A written examination will be conducted by the University at the end of the sixth semester.The written examination will be of objective type similar to the GATE examination.Syllabus for the comprehensive examination is based on the following five Robotics & Automation Engineering core courses.

RAT 202- Kinematics And Dynamics Of Mechanisms

RAT206- Microcontrollers and Embedded Systems

RAT307- Control Systems

RAT 301- Introduction to Robotics

RAT 305–Industrial Automation

The written test will be of 50 marks with 50 multiple choice questions (10 questions from each module) with 4 choices of 1 mark each covering all the five core courses. There will be no negative marking. The pass minimum for this course is 25. The course should be mapped with a faculty and classes shall be arranged for practicing questions based on the core courses listed above.

Written examination	:	50marks
Total	**:**	**50 marks**

Course Level Assessment and Sample Questions:

1) Which of the following conditions can be used to minimize undercutting in cam and follower mechanism?
   a. By using larger roller diameter
   b. By using internal cams
   c. By decreasing the size of the cam
   d. All of the above

2) A point is moving at the end of the link rotating with constant angular velocity ω, what will be the value of radial component of acceleration?

a) 0
b) $\omega^2 R$
c) Infinite
d) $\omega^2 R/2$

3) D' Alembert's principle is used for_____?
   a) reducing the problem of kinetics to equivalent statics problem

b) determining stresses in the truss
c) stability of floating bodies
d) designing safe structures
e) solving kinematic problems

4) When the microcontroller executes some arithmetic operations, then the flag bits of which register are affected?.

a) PSW
b) SP
c) DPTR
d) PC

5) What is the width of the 8051 address bus?

a. 16-bit address bus
b. 8-bit address bus
c. 32-bit address bus
d. None of the above

6) Single-bit indicators that may be set or cleared to show the results of logical or arithmetic operations are the

a. Flags
b. Monitors
c. Registers
d. Decisions

7) What will be the nature of time response if the roots of the characteristic equation are located on the s-plane imaginary axis?

a) Oscillations
b) Damped oscillations
c) No oscillations
d) Under damped oscilaations

8) Consider a system with transfer function $G(s) = s+6/Ks^2+s+6$. Its damping ratio will be 0.5 when the values of k is:

a) 2/6
b) 3
c) 1/6
d) 6

9) The unit step response of a second order system is = $1-e^{-5t}-5te^{-5t}$. Consider the following statements:
1. The under damped natural frequency is 5 rad/s.
2. The damping ratio is 1.
3. The impulse response is $25te^{-5t}$.
Which of the statements given above are correct?
a) Only 1 and 2
b) Only 2 and 3

c) Only 1 and 3
d) 1,2 and 3

10) 9-Industrial Robots are generally designed to carry which of the following coordinate system(s).
(A) Cartesian coordinate systems
(B) Polar coordinate systems
(C) Cylindrical coordinate system
(D) All of the above

11) Which of the following work is done by General purpose robot?
(A) Part picking
(B) Welding
(C) Spray painting
(D) All of the above

12) Inverse kinematics problem of series manipulator with 6 DOF has
(a) a unique solution
(b) 2 solutions only
(c) 3 solutions only
(4) More than 6 solutions

13) In a PLC, the scan time refers to the amount of time in which
(A) the technician enters the program
(B) timers and counters are indexed by
(C) one “rung” of ladder logic takes to complete
(D) the entire program takes to execute
(E) transmitted data communications must finish

14) An OR function implemented in ladder logic uses
(A) Normally-closed contacts in series
(B) Normally-open contacts in series
(C) A single normally-closed contact
(D) Normally-open contacts in parallel
(E) Normally-closed contacts in parallel

15) LVDT windings are wound on
a) Steel sheets
b) Aluminium
c) Ferrite
d) Copper

Course Code: ICT 308

Comprehensive Course Work

MODULE I: Kinematics And Dynamics Of Mechanisms

Basics of mechanisms: Links, kinematic pairs, kinematic chain, mechanism and machine, common mechanisms like linkages, camsfollowermechanisms, gear trains, belt and chain, and multi-degrees of planar mechanisms in machines like earth moving machinery and planar versions of manipulators, mobility /degrees of freedom (DoF), Kutzbach's formula, determination of DoF of planar linkages and mechanisms with cam-follower pairs.position analysis, loop closure equations, fourbar, slider-crank,and multi DoF closed and open loop mechanisms, , exposure to graphical approach, inverse pose problem of an open loop 3R planar manipulator, and derivation of solution.Velocity analysis: forward and inverse velocity analysis of open loop 3R mechanism.Acceleration analysis: angular acceleration of a rigid link and relative acceleration of points,Corioli's acceleration.Static force analysis:nature of joint reaction forces, static force analysis,Euler's equation for rigid body rotation: moments of inertia, principal moments and principal axes, representation of relative orientation of reference frames using rotation matrices,properties of rotation matrices, transformation of moments of inertia matrices from one reference frame to another,

MODULE II: Microcontrollers & Embedded Systems

8051 microcontrollers-pin diagram; Architecture, I/O Port structure, Register organization - special function registers,-Memory organization- 8051 microcontrollers: Instruction set, Addressing modes - Simple Assembly language programs: Arithmetic (Addition, Subtraction, Multiplication & Division), -. Timers/Counters- Serial Communication, Interrupt structure-programming - Interfacing of peripherals – LED (ALP and embedded C programming). LCD, ADC, DAC, sensors, simple Switch and key board interfacing, 7 segment LED. Embedded System Architecture: HW - Processor, Controller, SoC, Memory, Peripherals; SW - Application, Middleware, OS, Device Drivers, Tool chain- Assembler, Interpreter, Compiler, Linker, Loader, Debugger Introduction to RTOS: Real time tasks and Systems, RTOS basics, Comparison of General Purpose OS and Real Time OS. Communication Protocols: RS232, I2C, SPI and USB

MODULE III: Control Systems

Feedback principles, signal flow graphs, transient response, time domain analysis of first and second order systems,step response of first and second order systems - steady-state-errors, static and dynamic error coefficients – Concept of stability – stability of feedback systems -, Routhstability criterion , root loci stability from root loci - ,effect of additional poles and zeros - Bode plot, log magnitude vs.phase plot phase and gain margins - Need of lead, lag and lead-lag compensators, state-space representation of systems; relationship between state equations and transfer functions - time-delay systems

MODULE IV: Introduction to 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.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.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.

MODULE V:Industrial 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. Elements of CNC systems-Material Handling and Identification Technologies.

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/electro hydraulic automation- Sequence control and programmable controllers – logic control and sequencing elements, ladder diagram, PLC, programming of PLC- analog and digital I/Os, timers, counters, function blocksMotion controllers-VFD, MLD, external relays and contactors

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

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

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
RAT 372	SOFT COMPUTING TECHNIQUES	PEC	2	1	0	3

Preamble: Soft computing techniques are gaining popularity in all domains of engineering application. This paper introduces the student to the basic mechanisms of finding solution to problems through the different soft computing techniques. This course explain in detail the 3 basic soft computing techniques namely - Neural networks, Fuzzy systems and Genetic Algorithms and how they can be applied to mimic the human mind

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

CO 1	Understand and design basic neural networks
CO 2	Develop the concepts of supervised/unsupervised learning
CO 3	Understand fuzzy based systems
CO 4	Apply Fuzzy logic for developing systems
CO 5	Understand the optimization techniques using Genetic Algorithm

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

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 soft computing and Hard computing techniques
2. Explain the different types of learning techniques used in Neural networks
3. Describe the architecture of Back propagation networks

Course Outcome 2 (CO2):
1. What is an activation function in a neural network? What is its significance?
2. Explain the generalized Hebbian learning algorithm
3. Discuss on Self-organizing computation maps and its uses

Course Outcome 3 (CO3):
1. Differentiate between Crisp set and fuzzy set
2. Explain what is a Tolerance relation and Equivalence relation.
3. Explain the steps involved in developing a fuzzy rule based systems

Course Outcome 4 (CO4):
1. Explain the working of a fuzzy inference system using Mamdani approach
2. Explain the different defuzzification methods
3. Explain what is a Neuro-fuzzy systems

Course Outcome 5 (CO5):
1. What is the significance of Genetic algorithms in artificial intelligence
2. Explain the different stages of a GA implementation
3. What do you mean by convergence of a GA.

MODEL QUESTION PAPER

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

Course Code: RAT 372

Course Name: SOFT COMPUTING TECHNIQUES

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1 Enumerate the difference between soft computing and hard computing. (3)

2 Explain hypermeter tuning (3)

3 What is Self Organizing maps (3)

4 Write short notes on supervised and unsupervised learning methods. (3)

5 Consider two fuzzy sets (3)

$$A = \left\{ \frac{0.2}{0}, \frac{0.2}{1}, \frac{1}{2}, \frac{0.1}{3}, \frac{0.5}{4} \right\}$$

$$B = \left\{ \frac{0.1}{0}, \frac{0.25}{1}, \frac{0.9}{2}, \frac{0.7}{3}, \frac{0.3}{4} \right\}$$

Find a. Algebraic Sum b. Bounded sum c. Bounded difference

6 What is tolerance and equivalence relations (3)

7 Enlist the characteristics of Fuzzy Control Systems (3)

8 Give the life cycle of a Genetic Algorithm (3)

9 Compare Mamdani and Sugeno approaches (3)

10 Explain fitness function in GA (3)

PART B

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

MODULE1

11 a) Explain the architecture and training algorithm of back propagation network. (8)

b) compare different activation functions (6)

12 a) With suitable examples explain supervised, unsupervised and reinforcement learning. (8)

b) What is meant by local minima problem? How it can be avoided (6)

MODULE II

13 a) Design a hebb network to realize AND gate (8)

b) Explain a neural network as associative memory (6)

14 a) Give the architecture of Boltzmann Machines (8)

b) With a neat functional diagram explain the Kohonen Self Organizing Maps. (6)

MODULE III

15 a) Compare and contrast between different Fuzzy decision making functions. (8)

b) Explain Fuzzy rule based systems (6)

16 a) Three elements of a medicinal search are given by (8)

$$A = \left\{ \frac{0.1}{2} + \frac{0.3}{4} + \frac{0.7}{6} + \frac{0.4}{8} + \frac{0.2}{10} \right\}$$

$$B = \left\{ \frac{0.1}{0.1} + \frac{0.3}{0.2} + \frac{0.3}{0.3} + \frac{0.4}{0.4} + \frac{0.5}{0.5} + \frac{0.2}{0.6} \right\}$$

$$C = \left\{ \frac{0.1}{0} + \frac{0.7}{0.5} + \frac{0.3}{1} \right\}$$

Find R= A X B, S = B x C,

$M = R \circ S(\max - \min composition)$

$N = R \circ S(\max - productcomposition)$

b) (6)

MODULE IV

17 a) Develop a Fuzzy inference System for controlling the temperature using air conditioner. (8)

b) Develop an ANFIS model with suitable example. (6)

18 a) Explain Mamdani and Sugeno approach with suitable examples (10)

b) Discuss the architecture and Operation of a Fuzzy logic Control system (4)

MODULE V

19 a) Illustrate the general architecture of Genetic Algorithm approach. (8)

b) State and explain theRoulette Wheel selection method (6)

20 a) How the cross over operation takes place for creating the operating. Explain the types of cross over in GA (8)

b) Write short notes on evolutionary algorithm (6)

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Syllabus

Module I (7 Hours)

Introduction to soft computing- soft computing Vs hard computing – applications of soft computing.

Neural Networks: Evolution- definition of neuron- artificial and biological neurons-supervised, unsupervised, reinforcement learning- examples- activation functions- McCulloch-Pits model-Single layer Perceptron-Multilayer Perceptron-Back Propagation networks-Architecture of Backpropagation(BP) Networks- Backpropagation Learning -variational back propagation– hyper parameters – learning rate – momentum factor- Radial basis function.

Module II (8 Hours)

Neural Networks as Associative Memories – architecture- Hopfield Networks, Bidirectional Associative Memory -activation functions. Unsupervised Learning: Hebbian Learning, Generalized Hebbian learning algorithm, Competitive learning, Self- Organizing Computational Maps: Kohonen Network. Introduction to Boltzmann Machines

Module III (7 Hours)

Fuzzy Systems: Fuzzy Set theory, Fuzzy versus Crisp set, operations on fuzzy sets-Fuzzy Relation- Min-Max Composition,- features of membership functions-Tolerance and equivalence function-Fuzzification, Fuzzy Logic, Fuzzy Rule based systems, Fuzzy Decision Making- types

Module IV (7 Hours)

Fuzzy Inference systems – Mamdani approach and Sugeno approach- Defuzzification Methods - Fuzzy Control Systems – characteristics- Fuzzy Classification.

Hybrid systems- Neuro-fuzzy systems- case studies- ANFIS model- case studies
Applications of Neural Networks and Fuzzy Systems.

Module V (6 Hours)

Evolutionary algorithms -Genetic algorithms: basic concepts, encoding, reproduction-Roulette wheel, tournament, rank, and steady state selections, cross over, mutation, fitness function, Convergence of GA, Applications of GA case studies. Introduction to genetic programming-basic concepts.

Text Books

1. R. Rajasekaran and G. A and Vijayalakshmi Pai, "*Neural Networks, Fuzzy Logic, and Genetic Algorithms: Synthesis and Applications*," Prentice Hall of India
2. S.N Sivandam and S.N Deepa, " Principles of Soft Computing," Wiley Publications.

3. D. E. Goldberg, *Genetic Algorithms in Search, Optimisation, and Machine Learning*, Addison-Wesley
4. Timothy J Ross, "Fuzzy Logic with Engineering Applications", McGraw Hill, 1997.
5. Eiben A. E. and Smith J. E., "Introduction to Evolutionary Computing", Second Edition, Springer, Natural Computing Series, 2007.
6.

References

1. N. K. Sinha and M. M. Gupta, Soft Computing & Intelligent Systems: Theory & Applications-Academic Press /Elsevier. 2009.
2. Simon Haykin, Neural Network- A Comprehensive Foundation- Prentice Hall International, Inc.
3. R. Eberhart and Y. Shi, Computational Intelligence: Concepts to Implementation, Morgan Kaufman/Elsevier, 2007.
4. Ross T.J. , Fuzzy Logic with Engineering Applications- McGraw Hill.
5. Driankov D., Hellendoorn H. and Reinfrank M., An Introduction to Fuzzy Control-Narosa Pub.
6. Bart Kosko, Neural Network and Fuzzy Systems- Prentice Hall, Inc., Englewood Cliffs

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction**	
1.1	Introduction to soft computing- soft computing Vs hard computing- applications of soft computing.	1
1.2	Neural Networks: Evolution- artificial and biological neurons- supervised, unsupervised, reinforcement learning- examples	1
1.3	McCulloch-Pits model-Single layer Perceptron- Multilayer Perceptron	1
1.4	Back Propagation networks-Architecture of Backpropagation(BP) Networks	2
1.5	variational back propagation– hyper parameters – learning rate	2
1.6	Momentum factor- radial basis function	1
2	**Neural Networks**	
2.1	Neural Networks as Associative Memories – architecture- Hopfield Networks	1
2.2	Bidirectional Associative Memory -activation functions	1
2.3	Unsupervised Learning: Hebbian Learning, Generalized Hebbian learning algorithm	1
2.4	Competitive learning, Self- Organizing Computational Maps	2
2.5	Kohonen Network.	1
2.6	Introduction to Boltzmann Machines	1

3	**Fuzzy Systems:**	
3.1	Fuzzy Set theory, Fuzzy versus Crisp set theory, operations on Fuzzy sets, Fuzzy Relation, Min-Max Composition -	3
3.2	Tolerance and equivalence , Fuzzification,	2
3.3	Fuzzy Logic, Fuzzy Rule based systems	1
3.4	Fuzzy Decision Making- types	1
4		
4.1	Fuzzy Inference systems – Mamdani approach and Sugeno approach- Defuzzification Methods	2
4.2	Fuzzy Control Systems - Fuzzy Classification	1
4.3	Hybrid systems- Neuro-fuzzy systems- case studies- ANFIS model- case studies	2
4.4	Applications of Neural networks and Fuzzy systems	2
5	**Genetic Algorithms**	
5.1	Evolutionary algorithms.	1
5.2	Genetic algorithms: basic concepts, encoding, fitness function, reproduction-Roulette wheel, Boltzmann, tournament, rank, and steady state selections	2
5.3	Convergence of GA	1
5.4	Applications of GA case studies. Introduction to genetic programming- basic concepts.-	2

RAT362	COMMUNICATIONS NETWORKS	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Communication plays an important role in remote data acquisition as well as mobile robotics. This course gives the student a basic knowledge of communication elements and the processes involved between a sender and a receiver. Few common industry specific protocols popular among mobile robotics and remote data capture are discussed as part of the course

Prerequisite: NIL

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

CO 1	Understand the basic concepts of wireless communication and techniques used for enhancing bandwidth
CO 2	Understand the process involved in the data transfer across a computer network and the different standards applicable
CO 3	Understand the various mechanisms used to address the different challenges in wireless networks
CO 4	Understand the working of two popular PAN protocols
CO 5	Understand the working of two popular low power PAN protocols

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**	**1**									2
CO 2	**3**	**2**	**1**									2
CO 3	**3**	**2**	**2**									2
CO 4	**3**	**2**	**2**									2
CO 5	**3**	**2**	**1**									2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	20	20	30
Understand	30	30	70
Apply			
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. State the advantages and disadvantages of wireless communication compared to wired communication.
2. Discuss the different Multiple Access Schemes used in communication
3. Explain the process involved in converting an analog signal to a digital signal

Course Outcome 2 (CO2):

1. What is the need of a protocol in data exchange between 2 devices
2. Explain the role of the lower 3 layers of ISO/OSI reference model
3. Explain the following media access protocols used in IEEE802 standards
    a. ALOHA b.) CSMA/CD

Course Outcome 3 (CO3):

1. What is CSMA/CA and how is it useful in wireless communication compared to CSMA/CD
2. What is an Adhoc wireless network? Explain the advantages and disadvantages of such a scheme
3. Discuss the issues involved in the design of a routing protocol for a Adhoc Wireless network

Course Outcome 4 (CO4):

1. Discuss the architecture of Bluetooth protocol
2. Using the state diagram, explain the working of Bluetooth protocol as the device goes through various stages
3. Discuss the architecture of Zigbee protocol stack in detail

Course Outcome 5 (CO5):

1. Discuss the features of 6LoWPAN and how it is useful for remote data collection
2. Explain the architecture of CoAP with diagram
3. How is GPS free positioning achieved in LoRaWAN.

MODEL QUESTION PAPER

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

Course Code: RAT 362
Course Name: Communications Networks

Max. Marks: 100 Duration: 3 Hours

PART A
Answer all questions, each carries 3 marks. Marks

1		Why do we need modulation in a communication system? Is modulation of any use in wired communication? Justify your answer.	(3)
2		What are the characteristics of a wireless channel?	(3)
3		Why do we need layering in network protocols?	(3)
4		How is CSMA/CD better compared to CSMA?	(3)
5		What are the issues faced in an IEEE802.11 network compared to IEEE802.3 w.r.to media access?	(3)
6		How is an ad-hoc network different from a convention wireless lan?	(3)
7		What are the different states that a node can be in a Bluetooth network and explain the need for each state.	(3)
8		Compared to Bluetooth, How is zigbee useful in Robotics applications?	(3)
9		What is a LoPAN ? Why do we need LoPANS?	(3)
10		Explain the basic architecture of a LoRaWaN network?	(3)

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

MODULE1

11	a)	Explain in detail the different digital modulation techniques used in communication networks	(7)
	b)	What are the different Multiple access techniques used in communication systems?	(7)
12	a)	What is the need of sampling and encoding in digital communication system? Explain with an example	(8)
	b)	Is digital communication better than analog communication? Justify your answer with appropriate reasons	(6)

ROBOTICS & AUTOMATION

MODULE II

13	a)	Discuss in detail the roles of different layers of OSI architecture.	(8)
	b)	Mention a scheme to solve the hidden terminal and exposed terminal problems in wireless networks.	(6)
14	a)	Explain in detail on the physical and data link layer of IEEE802.3 standard.	(8)
	b)	Discuss any two media access mechanisms that can be used in a wired network	(6)

MODULE III

15	a)	Discuss in detail the different design challenges of MAC layer in an Ad-hoc wireless network. Explain any one technique that can address these challenges	(9)
	b)	How is CSMA/CA different from CSMA/CD	(5)
16		Explain the challenges and design goals that need to be addressed while designing a routing protocol for an ad-hoc wireless network.	(14)

MODULE IV

17	a)	With appropriate diagram, Explain the different layers of Bluetooth protocol stack	(14)
18	a)	With appropriate diagram, Explain the different layers and functions of zigbee protocol stack	(14)

MODULE V

19	a)	Explain the architecture of CoAP with appropriate diagram	(8)
	b)	What is compression and Fragmentation in 6LowPAN	(6)
20	a)	Explain how adaptive Data rate and GPS free positioning implemented in LoRaWAN	(14)

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Syllabus

Module I (7 Hours)

Communication Systems: Components of a communication system(Block diagram level) – Introduction to wireless communication - Radio propagation – Characteristics of the wireless channel – Analog Modulation – Digital Modulation – Multiple Access Techniques – FDMA, TDMA, CDMA, SDMA – Sampling - Encoding – Error Control

Module II (7 Hours)

Computer Network Architecture: The OSI Reference model The TCP/IP reference Model – The ATM reference Model – comparison

IEEE 802 Networking Standards – Physical layer – Data link Layer – LLC – MAC – ALOHA – CSMA – CSMA/CD – IEEE802.3 Standard – Physical Layer – Data Link Layer

Module III (7 Hours)

Wireless LAN: Design Considerations – Network Architecture - IEEE 802.11 Standard – Physical Layer – MAC layer mechanisms – CSMA/CA – Additional MAC layer Functions

Ad-hoc wireless networks – Applications and issues of ad-hoc wireless networks – MAC protocols for AD-HOC wireless networks – Design issues of MAC – Design Goals - Routing protocols for Ad-HOC Wireless Networks – issues in designing routing protocols – classification

Module IV (7 Hours)

WPAN: IEEE802.15 - Bluetooth – User scenarios – Architecture – Networking - Protocol Stack – Radio Layer – Baseband Layer – Link Manager protocol – L2CAP – Security – Service Discovery Protocol – Bluetooth Profiles - Transport Protocol Group – Middleware protocol Group

Zigbee – Protocol Stack – Network layer – Application layer – Reduced Function Device- Full Function Device – Network Coordinator – Frame Formats – Channel Access Mechanism – Types of Data transfer- Network formation roles of Network Coordinator – Parent device – Child device

Module V (7 Hours)

Low Power Communication Protocols: 6LoWPAN – IPV6 – IP over IEEE 802.15.4 – Compression – Fragmentation – Reassembly – Routing – Constrained Application Protocol(CoAP) (Architecture only) – RPL Routing Protocol

LoRaWAN – Architecture – MAC Layer – LoRaWAN Classes – Physical Message Format – MAC message format – Channel Access – Adaptive Data Rate – GPS free positioning

Text Books

1. Ad-Hoc Wireless Networks Architectures and Protocols, C Siva Ram Murthy, B.S.Manoj, Prentice Hall
2. Wireless Networking and Mobile Data Management, R.K.Gosh, Springer

3. Mobile Communications Jochen Schiller, Pearson Education
4. Data Communication and Networking, Behrouz.A.Forouzan, Sophia Chung Fegan,McGraw Hill

Reference Books

1. Wireless Communication Networks and Systems, Cory Beard & William Stallings, Pearson
2. Beginning LoRa Radio Networks with Arduino: Build Long Range, Low Power Wireless IoT Networks, Pradeeka Seneviratne, Apress
3. Future Internet – open access journal published by mdpi - https://www.mdpi.com/1999-5903/11/10/216/htm

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Communication Systems**	
1.1	Components of a communication system, Introduction to wireless communication	1
1.2	Radio propagation, Characteristics of the wireless channel, Analog & Digital Modulation	2
1.3	Multiple Access Techniques – FDMA, TDMA, CDMA, SDMA	2
1.4	Sampling - Encoding – Error Control	2
2	**Computer Network Architecture**	
2.1	The OSI Reference model	1
2.2	The TCP/IP reference Model – IP Addressing, IP4	2
2.3	The ATM reference Model – Comparison,	1
2.4	IEEE 802 Networking Standards – Physical layer – Data link Layer - LLC – MAC – ALOHA	1
2.5	CSMA – CSMA/CD - IEEE802.3 Standard – Physical Layer – Data Link Layer	2
3	**Wireless LAN**	
3.1	Design Considerations – Network Architecture - IEEE 802.11 Standard	1
3.2	Physical Layer – MAC layer mechanisms – CSMA/CA	1
3.3	Additional MAC layer Functions	1
3.4	Ad-hoc wireless networks – Applications and issues of ad-hoc wireless networks	1
3.5	MAC protocols for AD-HOC wireless networks – Design issues of MAC – Design Goals	2
3.6	Routing protocols for Ad-HOC Wireless Networks – issues in designing routing protocols – classification	1
4	**WPAN**	
4.1	IEEE802.15 - Bluetooth – User scenarios – Architecture	1
4.2	Networking - Protocol Stack – Radio Layer – Baseband Layer – Link	1

	Manager protocol	
4.3	Security – Service Discovery Protocol – Bluetooth Profiles	2
4.4	Zigbee – Protocol Stack – Network layer – Application layer – Reduced Function Device-Full Function Device – Network Coordinator	1
4.5	Frame Formats – Channel Access Mechanism – Types of Data transfer-Network formation roles of Network Coordinator – Parent device – Child device	2
5	**Low Power Communication Protocols**	
5.1	6LoWPAN – IPV6 – IP over IEEE 802.15.4 – Compression – Fragmentation – Reassembly – Routing	2
5.2	Constrained Application Protocol(CoAP) (Architecture only) – RPL Routing Protocol	2
5.3	LoRaWAN – Architecture – MAC Layer – LoRaWAN Classes – Physical Message Format – MAC message format	2
5.4	Channel Access – Adaptive Data Rate – GPS free positioning	1

RAT352	ENGINEERING OPTIMIZATION	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Finding optimum solution for a given problem has a huge impact in any field of engineering. This paper introduces the student to the classical optimization techniques and various numerical methods of optimization. The course also provide the student with a basic knowledge in different evolutionary algorithms

Prerequisite: Nil

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

CO 1	Formulate constrained and unconstrained optimisation problems
CO 2	Solve different Linear programming problems
CO 3	Solve nonlinear optimisation problems
CO 4	Choose the suitable method for the solution of the typical constrained or unconstrained optimisation problem

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

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. A farmer has a choice of planting barley, oats, rice, or wheat on his 200-acre farm. The labor, water, and fertilizer requirements, yields per acre, and selling prices are given in the following table:

Type of crop	Labor cost ($)	Water required (m^3)	Fertilizer required (lb)	Yield (lb)	Selling price ($/lb)
Barley	300	10 000	100	1 500	0.5
Oats	200	7 000	120	3 000	0.2
Rice	250	6 000	160	2 500	0.3
Wheat	360	8 000	200	2 000	0.4

The farmer can also give part or all of the land for lease, in which case he gets $200 per acre. The cost of water is $0.02/m3 and the cost of the fertilizer is $2/lb. Assume that the farmer has no money to start with and can get a maximum loan of $50 000 from the land mortgage bank at an interest of 8%. He can repay the loan after six months. The irrigation canal cannot supply more than 4 × 105 m3 of water. Formulate the problem of finding the planting schedule for maximizing the expected returns of the farmer.

Two copper-based alloys (brasses), A and B, are mixed to produce a new alloy, C. The composition of alloys A and B and the requirements of alloy C are given in the following table:

Alloy	Composition by weight			
	Copper	Zinc	Lead	Tin
A	80	10	6	4
B	60	20	18	2
C	≥ 75	≥ 15	≥ 16	≥ 3

If alloy B costs twice as much as alloy A, formulate the problem of determining the amounts of A and B to be mixed to produce alloy C at a minimum cost.

Course Outcome 2 (CO2):

1. A real estate company wants to construct a multistory apartment building on a 500 × 500-ft lot. It has been decided to have a total floor space of 8 × 105 ft2. The height of each story is required to be 12 ft, the maximum height of the building is to be restricted to 75 ft, and the parking area is required to be at least 10% of the total floor area according to the city zoning rules. If the cost of the building is estimated at $(500,000h+2000F+500P), where h is the height in feet, F is the floor area in square feet, and P is the parking area in square feet. Find the minimum cost design of the building.

2. A manufacturer produces small refrigerators at a cost of $60 per unit and sells them to a retailer in a lot consisting of a minimum of 100 units. The selling price is set at $80 per unit if the retailer buys 100 units at a time. If the retailer buys more than 100 units at a time, the manufacturer agrees to reduce the price of all refrigerators by 10 cents for each unit bought over 100 units. Determine the number of units to be sold to the retailer to maximize the profit of the manufacturer.

Course Outcome 3 (CO3):

1. Solve the following nonlinear programming problem using Kuhn-Tucker conditions:

   Maximize $Z = -x_1^2 - x_2^2 - x_3^2 + 4x_1 + 6x_2$

   subject to the constraints

   $x_1 + x_2 \le 4$

   $2x_1 + 3x_2 \le 12$

   $x_1, x_2 \ge 0$

2. Using Quadratic Programming, Minimize $f = -4X_1 + X_1^2 - 2X_1X_2 + 2X_2^2$

   subject to :

   $$2x_1 + x_2 \le 6$$
   $$x_1 - 4x_2 \le 0$$
   $$x_1 \ge 0, \quad x_2 \ge 0$$

Course Outcome 4 (CO4):

1. Explain how Genetic algorithm can be used to optimize trajectories of robot
2. How can Particle Swarm Optimization be used for robotic path planning
3. Discuss the different optimization algorithms that can be used for robotic trajectory optimization..

MODEL QUESTION PAPER

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

Course Code: RAT 352

Course Name: Engineering Optimization

Max. Marks: 100 | Duration: 3 Hours

PART A

		Answer all questions, each carries 3 marks.	Marks
1		What is Degenerate solution in LPP?	(3)
2		Write the standard form of LPP maximize $Z = 2x_1 + 10x_2 + x_3$ subject to $5x_1 + 2x_2 + x_3 \geq -15$ $2x_1 + x_2 + 7x_3 \leq 20$ $x_1 + 3x_2 + 2x_3 \leq 25$ $x_1 \geq 0, x_2 \geq 0, x_3 \geq 0$	(3)
3		Find the dual of following LPP maximize $Z = 6x_1 + 14x_2 + 13x_3$ subject to $x_1 + 4x_2 + 2x_3 \leq 48$ $x_1 + 2x_2 + 4x_3 \leq 60$ $x_1 \geq 0, x_2 \geq 0, x_3 \geq 0$	(3)
4		Give an example for $0 - 1$ programming problem	(3)
5		Write the Lagrangian function for maximize $Z = f(x_1, x_2)$ subject to $g(x_1, x_2) = c$ $x_1 \geq 0, x_2 \geq 0$	(3)
6		What is integer linear programming problem	(3)
7		Explain the basic steps involved in solving a constrained optimization problem using Random Search Method?	(3)
8		Differentiate between local minima and global minima in search optimization problems. How are these related in the case of a convex programming problem	(3)

ROBOTICS & AUTOMATION

9		Consider the following two strings denoting the vectors $\mathbf{X}_1$ and $\mathbf{X}_2$ $\mathbf{X}_1$: {1000101101} $\mathbf{X}_2$: {0111110110} Find the result of crossover at location 2. Also, determine the decimal values of the variables before and after crossover if each string denotes a vector of two variables.	(3)
10		Explain the Roulette Wheel Selection Process	(3)
		PART B	
		Answer any one full question from each module, each carries 14 marks.	
		MODULE1	
11	a)	Solve graphically, Minimize Z = 2x + 4y Subject to $x + 3y \geq 8$ $x + y \geq 4$ and $x \geq 0, y \geq 0$.	(5)
	b)	Suppose Z = cx + 4y. Find all values of c, such that the optimal solution of LPP remains same.	(9)
12	a)	Solve the following LPP by Big-M method: Minimize $Z = -3x_1 - 3x_2 + x_3$ subject to the constraints $x_1 + 3x_2 - 2x_3 \geq 5$ $-3x_1 - 2x_2 + x_3 \leq 4$ where $x_1, x=, x_3 \geq 0$	(14)
		MODULE II	
13	a)	Solve the LPP by dual simplex method: Minimize $Z = 5x_1 + 3x_2 + x_3$ subject to the constraints $-x_1 + x_2 + x_3 \geq 1$ $3x_1 + x_2 - x_3 \geq 2$ where $x_1, x_2, x_3 \geq 0$	(14)
14	a)	Solve by branch and bound method: Maximize $Z = 500x_1 + 400x_2$ subject to constraints $8x_1 + 5x_2 \leq 42$ $3x_1 + 16x_2 \leq 60$ $x_1, x_2 \geq 0$, x_1, x_2 are integers	(14)
		MODULE III	
15	a)	Solve the following nonlinear programming problem using Kuhn-Tucker conditions: Maximize $Z = -x_1^2 - x_2^2 - x_3^2 + 4x_1 + 6x_2$ subject to the constraints	(14)

ROBOTICS & AUTOMATION

		$x_1 + x_2 \leq 4$ $2x_1 + 3x_2 \leq 12$ $x_1, x_2 \geq 0$	
16		Solve the following quadratic programming problem: Minimize $Z = x_1^2 - 2x_1x_2 + 2x_2^2 - 4x_1$ subject to the constraints $2x_1 + x_2 \leq 6$ $x_1 - 4x_2 \leq 0$ $x_1, x_2 \geq 0$	(14)
17	a)	Explain the algorithm of Sequential Linear Programming method for solving a non-linear programming problem. Discuss its advantages	(14)
18	a)	Explain the algorithm of gradient projection method for solving non-linear programming problems.	(9)
	b)	Minimize $f(x_1, x_2) = x_1^2 + x_2^2 - 2x_1 - 4x_2$ subject to $g_1(x_1, x_2) = x_1 + 4x_2 - 5 \leq 0$ $g_2(x_1, x_2) = 2x_1 + 3x_2 - 6 \leq 0$ $g_3(x_1, x_2) = -x_1 \leq 0$ $g_4(x_1, x_2) = -x_2 \leq 0$ starting from the point $\mathbf{X}_1 = \begin{Bmatrix} 1.0 \\ 1.0 \end{Bmatrix}$.	(5)
		MODULE V	
19	a)	Explain the steps involved in finding the optimum solution using Genetic Algorithm . Describe in detail the role of Genetic operators involved in the process	(14)
20	a)	Find the minimum of the function $f(x) = x^2 - 2x - 11$ in the range (0, 3) using the ACO method. Assume the number of ants is $N = 4$. Note that there is only one design variable in this example ($n = 1$). The permissible discrete values of $x = x_1$ are assumed, within the range of x_1, as ($p = 7$): $x_{11} = 0.0, x_{12} = 0.5, x_{13} = 1.0, x_{14} = 1.5, x_{15} = 2.0, x_{16} = 2.5, x_{17} = 3.0$ **Note:** A maximum of 3 iterations is sufficient, if the solution doesn't converge	(14)
		****	

Syllabus

Module I (8 Hours)

Definition- Optimisation problem, Formulation of optimisation problems- examples

Linear programming: Statement and classification of optimization problems, standard form of linear programming problems- Convex set and Linear Programming Problem – Mathematical Formulation of LPP, Graphical solution of LPP, Basic feasible solutions, Degenerate solution, Slack variables and Surplus variables, Standard form of LPP, Simplex Method, Artificial variables in LPP, Big-M method

Module II (8 Hours)

Unbounded solutions of LPP, Two-phase method, Revised simplex method, Dual Simplex Method.
Integer linear programming- Gomory‘s Cutting plane method, Branch and Bound method , zero-one programming

Module III (6 Hours)
Constrained non-linear Optimization- examples-method of Lagrange multiplier, Necessary and sufficient conditions-Equality and inequality constraints, Kuhn Tucker conditions, Quadratic programming.

Module IV (7 Hours)
Direct search methods-Random search-pattern search -Descent Methods-Steepest descent, conjugate gradient.
Case studies- Finding the connected components of collision-free paths for a robot using random search, motion planning problems- optimising path length, execution time etc

Module V (6 Hours)
Recent developments in optimization techniques: Genetic Algorithm, Particle Swarm Optimization, Ant colony Optimization, Bees Algorithm, Tabu search and Simulated Annealing

Case studies- Genetic algorithm for optimizing robot trajectories, PSO based path planning of robots.

Text Books

1. Frederick S Hillier, Gerald J. Lieberman, Introduction to Operations Research, Seventh Edition, Tata McGraw-Hill, 2001
2. Singiresu S Rao, *Engineering Optimization Theory and Practice*,5/e, John Wiley&Sons 2020.

Reference Books

1. Ravindran, Philips, Solberg, *Operations Research: Principles and Practice,* Wiley student Edition,2/e, 2007
2. Kanti Swarup, P. K. Gupta, Man Mohan , Operations Research, Sultan chand & Sons
3. Pierre, D.A. ‘Optimisation Theory with Applications’ John Wiley & Sons, 1969

4. Fox, R.L., 'Optimisation method for Engineering Design', Addition Welsey,1971.
5. Hadely,G., 'Linear Programming', Addition Wesley, 1962.
6. D.E. Goldberg, Genetic Algorithm in Search, Optimization, and Machine Learning. Reading, MA: Addison-Wesly, 1989.
7. Marco Dorigo, Vittorio Miniezza and Alberto Colorni "Ant System: Optimization by a colony of Cooperation Agents" IEEE transaction on system man and Cybernetics-Part B: cybernetics, Volume 26, No 1, pp. 29-41,1996.
8. Shi, Y. Eberhart, R.C., "A Modified Particle Swarm Optimizer", Proceedings of the IEEE International conference on Evolutionary Computation, Anchorage, AK, pp. 69-73, May 1998

Course Contents and Lecture Schedule

Total 35 Hours

No	Topic	No. of Lectures
1		
1.1	Definition- Optimisation problem, Formulation of optimisation problems- examples	2
1.2	Linear programming: Statement and classification of optimization problems, standard form of linear programming problems- Convex set and Linear Programming Problem – Mathematical Formulation of LPP	3
1.3	Graphical solution of LPP, Basic feasible solutions, Degenerate solution, Slack variables and Surplus variables, Standard form of LPP, Simplex Method, Artificial variables in LPP	3
2		
2.1	Unbounded solutions of LPP, Two-phase method	2
2.2	Revised simplex method, Dual Simplex Method.	3
2.3	Integer linear programming- Gomory's Cutting plane method, Branch and Bound method , zero-one programming	3
3		
3.1	Constrained non-linear Optimization- examples-method of Lagrange multiplier, Necessary and sufficient conditions-Equality and inequality constraints, Kuhn Tucker conditions	4
3.2	Quadratic programming	2
4		
4.1	Direct search methods-Random search-pattern search -Descent Methods-Steepest descent, conjugate gradient.	4
4.2	Case studies- Finding the connected components of collision-free paths for a robot using random search, motion planning problems- optimising path length, execution time etc	3
5		
5.1	Recent developments in optimization techniques: Genetic Algorithm, Particle Swarm Optimization, Ant colony Optimization, Bees Algorithm, Tabu search and Simulated Annealing	4
5.2	Case studies- Genetic algorithm for optimizing robot trajectories, PSO based path planning of robots	2

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
RAT 342	MECHANICAL MEASUREMENTS AND METROLOGY	PEC	2	1	0	3

Preamble: Measurements and Measuring devices are key to any engineering design. This course introduces to the student on the various tools and methods for measuring different physical parameters. The course also given the basic concepts of metrology and use of standards for measurements

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

CO 1	Describe basic concepts of mechanical measurement and errors in measurements.
CO 2	Select linear, angular and taper measurement devices for measurement of various components
CO 3	Describe methods of measurement for various quantities like force, torque, power, displacement, velocity and acceleration
CO 4	Select appropriate temperature measuring device for various applications
CO 5	Describe basic concepts of Metrology. Discriminate between various screws by measuring their dimensions.
CO 6	Select suitable comparators and choose the method of surface roughness measurement.

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.

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Course Level Assessment Questions
Course Outcome 1 (CO1):

1. What are slip gauges? Explain their usage
2. What are the types of errors that can occur in measurements?
3. Explain any three angular measurement techniques

Course Outcome 2 (CO2):

1. What advantages does a Vernier calliper provide while taking linear measurements
2. Explain the working of clinometers
3. Discuss on the various static performance characteristics in measurement systems

Course Outcome 3 (CO3):

1. Explain the working of differential transformers to measure force
2. Explain the different techniques available to measure torque
3. Explain the bridge arrangement for strain measurement using strain gauges

Course Outcome 4 (CO4):

1. Explain the working of thermocouples to measure temperature
2. Explain the advantages and disadvantages of Electrical and Photoelectric Tachometers
3. What is a Seismic Accelerometer? Explain its working

Course Outcome 5 (CO5):

1. Explain the need of Inspection, Accuracy and Precision in modern day engineering
2. List out the various gear tooth terminologies used in industry
3. Explain the sources of Errors in the manufacturing of gears
4. What is the working principle of AutoCollimators and how are they useful in interferometry

Course Outcome 6 (CO6):

1. Explain the stylus system of measurement for surface roughness
2. Explain the working of Optical Comparator
3. Using pneumatic method, explain how surface roughness can be measured.

MODEL QUESTION PAPER

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

Course Code: RAT 342

Course Name: MECHANICAL MEASUREMENTS AND METROLOGY

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1		Give the need of Mechanical measurement.	(3)
2		What are the characteristics of slip gauges?	(3)
3		Explain the working of load cells.	(3)
4		Explain the features of absorption dynamometer.	(3)
5		Explain the working of accelerometer.	(3)
6		Compare RTD and thermocouple.	(3)
7		Differentiate between accuracy and precision	(3)
8		Explain the principle of interferometry.	(3)
9		Define the terms surface texture, waviness and RMS value.	(3)
10		Give the functional requirements of comparators..	(3)

PART B

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

MODULE1

11	a)	Explain the static performance characteristics of measuring instruments .	(8)
	b)	Illustrate the use of slip gauges.	(6)
12	a)	Explain in detail the errors and types of errors in measurement	(10)
	b)	Give the significance of sine bar in angle measurement.	(4)

MODULE II

13	a)	Describe any one method for torque measurement.	(8)
	b)	Using electrical strain gauges how do we measure strain? explain	(6)
14	a)	Discuss the strain gauge materials.	(10)
	b)	What is temperature compensation?.	(4)

MODULE III

15		Explain the working of photoelectric tachometer. Also give the field of application.	(14)
16		List the type of thermocouples. Also explain the principle and working of any one type of thermocouple.	(14)

MODULE IV

17		Illustrate the use of gear tooth vernier to measure tooth thickness.	(14)

18	a)	Explain the three wire method of measuring effective diameter of screw thread.	(11)
	b)	Give the principle of working of optical flat.	(3)

MODULE V

19	a)	Describe the stylus system of measurement for surface roughness.	(8)
	b)	Explain the working of an electronic comparator.	(6)
20	a)	Explain the characteristics of CMM. Also list the types	(8)
	b)	Illustrate the working of Optical comparator	(6)

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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

Syllabus

Module I (7 Hours)

Mechanical Measurement: Need of mechanical measurement, Basic definitions: Hysteresis, Linearity, Resolution of measuring instruments, Threshold, Drift, Zero stability, loading effect and system response. Measurement methods, Generalized Measurement system, Static performance characteristics, Errors and their classification. Linear Measurement Instruments, Vernier calliper, Micrometer, Interval measurements: Slip gauges, Checking of slip gauges for surface quality .Angular measurements using bevel protractors, spirit levels, clinometers, sine bar, angle gauges and optical dividing head.

Module II (7 Hours)

Measurement of Force, Torque and Strain: Force measurement: load cells, cantilever beams, differential transformers. Measurement of torque: Torsion bar dynamometer, servo controlled dynamometer, absorption dynamometers. Power Measurements. Measurement of strain: Mechanical strain gauges, electrical strain gauges, strain gauge: materials, gauge factors, theory of strain gauges and method of measurement, bridge arrangement, temperature compensation.

Module III (7 Hours)

Displacement, Velocity/Speed, and Acceleration, Measurement: Working principal of Resistive Potentiometer, Linear variable differential transducers, Mechanical, Electrical and Photoelectric Tachometers, Piezoelectric Accelerometer, Seismic Accelerometer. Temperature measurement: Temperature Measuring Devices: Thermocouples, Resistance Temperature Detectors(RTD), Thermistor, Pyrometer, Bimetallic strip.

Module IV (7 Hours)

Metrology: Basics of Metrology, Need for Inspection, Accuracy and Precision, Objectives, Standards of measurements. Metrology of Gears and screw threads: Gear tooth terminology, Sources of errors in manufacturing of gears, Measurement of major elements of screw threads and gears, gear tooth vernier caliper. Optical measuring instruments: Tool maker's microscope, Principle of interferometry-optical flat-Interferometers-Autocollimators.

Module V (7 Hours)

Metrology of Surface finish: Surface Metrology Concepts and terminology, Specification of surface Texture characteristics, and Method of measuring surface finish: Stylus system of measurement, other methods for measuring surface roughness: Pneumatic method, Light Interference microscopes. Comparators: Functional Requirements, Classification, Mechanical, optical, Pneumatic, Electrical and Electronic Comparators, Introduction to Coordinate measuring machine (CMM).

Text Book

1. Engineering Metrology and Measurement, N V Raghavendra and Krishnamurthy, Oxford University Press,
2. Engineering Metrology and Measurements, Bentley,

Reference Books:

3. A Text book of Engineering Metrology, I C Gupta, Dhanpat Rai Publications
4. A course in Mechanical Measurements and Instrumentation, A K Sawhney, Dhanpat Rai Publications
5. Mechanical Measurements and Instrumentations, Er. R K Rajput, Kataria Publication(KATSON)
6. Mechanical Measurement and Metrology by R K Jain, Khanna publishers.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	Mechanical Measurement	
1.1	Need of mechanical measurement, Basic definitions: Hysteresis, Linearity, Resolution of measuring instruments, Threshold, Drift, Zero stability, loading effect and system response	2
1.2	Measurement methods, Generalized Measurement system, Static performance characteristics, Errors and their classification.	1

1.3	Linear Measurement Instruments, Vernier calliper, Micrometer, Interval measurements: Slip gauges, Checking of slip gauges for surface quality .Angular measurements using bevel protractors, spirit levels, clinometers, sine bar, angle gauges and optical dividing head.	4
2	Measurement of Force, Torque and Strain	
2.1	Force measurement: load cells, cantilever beams, differential transformers	1
2.2	Measurement of torque: Torsion bar dynamometer, servo controlled dynamometer, absorption dynamometers. Power Measurements	2
2.3	Measurement of strain: Mechanical strain gauges, electrical strain gauges, strain gauge: materials, gauge factors, theory of strain gauges and method of measurement, bridge arrangement, temperature compensation.	4
3		
3.1	Displacement, Velocity/Speed, and Acceleration, Measurement: Working principal of Resistive Potentiometer, Linear variable differential transducers, Mechanical, Electrical and Photoelectric Tachometers, Piezoelectric Accelerometer, Seismic Accelerometer.	4
3.2	Temperature measurement: Temperature Measuring Devices: Thermocouples, Resistance Temperature Detectors(RTD), Thermistor, Pyrometer, Bimetallic strip.	3
4		
4.1	Metrology: Basics of Metrology, Need for Inspection, Accuracy and Precision, Objectives, Standards of measurements	2
4.2	Metrology of Gears and screw threads: Gear tooth terminology, Sources of errors in manufacturing of gears, Measurement of major elements of screw threads and gears, gear tooth vernier caliper	3
4.3	Optical measuring instruments: Tool maker's microscope, Principle of interferometry-optical flat-Interferometers-Autocollimators.	2
5		
5.1	Metrology of Surface finish: Surface Metrology Concepts and terminology, Specification of surface Texture characteristics, and Method of measuring surface finish: Stylus system of measurement	2
5.2	other methods for measuring surface roughness: Pneumatic method, Light Interference microscopes	1
5.3	Comparators: Functional Requirements, Classification, Mechanical, optical, Pneumatic, Electrical and Electronic Comparators, Introduction to Coordinate measuring machine (CMM).	4

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
RAT332	FLUID POWER AUTOMATION	PEC	2	1	0	3

Preamble: Fluid power systems can transmit equivalent power within a much smaller space than mechanical or electrical drives can, especially when extremely high force or torque is required and hence plays an important role in automation applications in large industries. This course provides an understanding of the different pneumatic and hydraulic systems for various applications in automation.

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

CO 1	Understand the basic concepts of different types of drives and their comparison.
CO 2	Understand the working principle and applications of different types of pumps and motors
CO 3	Study proportional and servo valves.
CO 4	Develop different pneumatic and hydraulic circuits based on their applications.
CO 5	Develop multi actuator circuits using different methods.
CO 6	Develop different electro pneumatic and electro hydraulic circuits based on their applications.
CO 7	Familiarize the basic concepts of interfacing hydraulic and pneumatic circuits with PLC.

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 between pneumatic and electric drives
2. Discuss in detail the different components of a hydraulic system
3. Discuss the important criteria to be looked in to while choosing hydraulic drive for a automation system

Course Outcome 2 (CO2):

1. Explain in detail the working of a Vane motor
2. Explain the working of different types of piston pumps

3. What are the advantages of a pneumatic automation over hydraulic automation?

Course Outcome 3 (CO3):

1. Explain the working of a 4/3 tandem centre valve
2. What is the role of pressure relief valve in a hydraulic circuit
3. Explain the different types of direction control valves used in automation

Course Outcome 4 (CO4), Course Outcome 5 (CO5), Course Outcome 6 (CO6):

1. What is a regenerative type hydraulic circuit? Explain with an example
2. Design and draw hydraulic circuit for $A_1B_1B_0A_0$ sequencing operation using cascade method
3. Discuss the design steps involved in arriving at a hydraulic circuit for sequencing operation using Karnaugh-Veith method
4. Draw the displacement time diagram for the sequence $A_1B_1B_0A_0$
5. Explain the use of cylinder cushion
6. Explain the working of proportional solenoid operated flow control valve

Course Outcome 7 (CO7):

1. Differentiate between on timer delay and off timer delay with the help of a timing diagram
2. State the advantages of PLC systems over other conventional systems
3. State any one mechanism of interfacing a hydraulic circuit with PLC

MODEL QUESTION PAPER

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

Course Code: RAT 332

Course Name: FLUID POWER AUTOMATION

Max. Marks: 100 Duration: 3 Hours

PART A

	Answer all questions, each carries 3 marks.	Marks
1	Draw the ISO symbol for pilot controlled 5/2 direction control valve.	(3)
2	What are the advantages and disadvantages of pneumatic automation over hydraulic automation?	(3)
3	Distinguish between 4/3 tandem centre valve and closed centre valve.	(3)

4		Name four different types of hydraulic cylinder mountings.	(3)
5		What is the purpose of a cylinder cushion?	(3)
6		Describe proportional solenoid operated flow control valve.	(3)
7		Draw the displacement time diagram for the sequence $A_1B_1A_0B_0$.	(3)
8		With suitable diagram explain meter in type speed control in a hydraulic circuit.	(3)
9		What are the basic electrical devices used in electro hydraulics.	(3)
10		With a neat sketch explain the use of a pressure switch in an electro pneumatic circuit.	(3)

PART B

Answer any one full question, each carries14 marks.

MODULE I

11	a)	Explain in detail the basic components of a hydraulic system.	(7)
	b)	With neat sketch explain the working of i) Swash plate axial piston pump ii) Vane Motor	(7)
12	a)	Briefly explain different types of piston pump.	(6)
	b)	Find the offset angle for an axial piston pump that delivers $0.0019m^3/s$ at 3000rpm. The pump has nine 16mm diameter pistons arranged on a 127mm piston circle diameter. The volumetric efficiency is 95%.	(8)

MODULE II

13	a)	Describe the working of three basic types of hydraulic accumulators.	(6)
	b)	With a neat sketch explain the use of pressure relief valve in a hydraulic circuit.	(4)
	c)	Explain in detail different types of flow control valves.	(4)
14	a)	Explain in detail different types of direction control valves.	(8)
	b)	Briefly explain different types of pressure control valves.	(6)

MODULE III

15	a)	Explain the differences between an ordinary DCV solenoid and a proportional	(6)

valve solenoid.

b) With a neat sketch explain the working of single stage (Flapper nozzle type) servo valve. (8)

16 a) Write short note on electro hydraulic servo valve and explain the components of closed loop electro hydraulic servo system. (8)

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

MODULE IV

17 a) Explain in detail a regenerative type hydraulic circuit with a practical application. (8)

b) With suitable diagram explain different types of speed control in a hydraulic circuit. (6)

18 a) Design and draw hydraulic circuit for $A_1B_1B_0A_0$ sequencing operation using cascade method. (8)

b) Design and draw hydraulic circuit for $A_1A_0B_1B_0$ sequencing operation using Karnaugh-Veitch method. (6)

MODULE V

19 a) Components are to be stamped using stamping machine. A double acting cylinder is used to push the die attached down to a fixture when a push button is pressed. The die is to return to the initial position upon reaching sufficient stamping pressure as sensed by a pressure switch and one second delay. Develop an electro pneumatic control circuit to implement the control task for the stamping operation (8)

b) Differentiate between on timer delay and off timer delay with the help of a timing diagram. (6)

20 a) What are the advantages of PLC over electromechanical relay control? (6)

b) Double acting cylinder is used to perform to and fro operation. Cylinder has to move forward when PB1 button is pressed and continue to and fro motion till 10 cycles of operations is performed. Draw the pneumatic circuit, PLC wiring diagram and ladder diagram to implement this task. (8)

SYLLABUS

Module I (7Hours)

Classification of drives-hydraulic, pneumatic and electric –comparison ISO symbols for their elements, Selection Criteria

Generating Elements- Hydraulic pumps and motor gears, vane, piston pumps, motors-selection and specification

Module II (7Hours)

Drive characteristics – Utilizing Elements-- Linear actuator – Types, mounting details, cushioning, power packs, accumulators

Control and regulation Elements—Direction, flow and pressure control Valves, Methods of actuation, types, sizing of ports. spool valves-operating characteristics

Module III (7Hours)

Proportional control of hydraulic systems, Electro hydraulic servo valves-Different types-characteristics and performance

Module IV (7Hours)

Typical Design methods of hydraulic and pneumatic circuits– sequencing circuits design combinational logic circuit design- cascade method-Karnaugh Veitch map method.

Module V (7Hours)

Electrical control of pneumatic and hydraulic circuits- use of relays, timers and counters.

Interfacing hydraulic and pneumatic circuits with PLCs .

Text Books:

1. Antony Esposito, Fluid Power Systems and control Prentice-Hall, 1988
2. Peter Rohner, Fluid Power logic circuit design. The Macmillan Press Ltd.,London, 1979

References:

1. E.C.Fitch and J.B.Suryaatmadyn. Introduction to fluid logic, McGraw Hill, 1978
2. Herbert R. Merritt, Hydraulic control systems, John Wiley & Sons, Newyork, 1967
3. Dudbey. A. Peace, Basic Fluid Power, Prentice Hall Inc, 1967.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**MODULE 1**	
1.1	Classification of drives-hydraulic, pneumatic and electric – comparison ISO symbols for their elements, Selection Criteria	3
1.2	Generating Elements- Hydraulic pumps and motor, gear, vane, piston pumps, motors- selection and specification.	4
2	**MODULE 2**	
2.1	Drive characteristics – Utilizing elements-- Linear actuator – Types, mounting details, cushioning – power packs –accumulators	3
2.2	Control and regulation Elements— Direction, flow and pressure controlvalves-Methods of actuation, types, sizing of ports. spool valves-operating characteristics	4
3	**MODULE 3**	
3.1	Proportional control of hydraulic systems	3
3.2	Electro hydraulic servo valves-Different types-characteristics and performance.	4
4	**MODULE 4**	
4.1	Typical Design methods of hydraulic and pneumatic circuits-sequencing circuits design.	3
4.2	combinational logic circuit design, cascade method, Karnaugh veitch map method	4
5	**MODULE 5**	
5.1	Electrical control of pneumatic and hydraulic circuits- use of relays, timers and counters	4
5.2	Interfacing hydraulic and pneumatic circuits with PLCs	3

RAT322	ROBOTIC CONTROL SYSTEMS	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Control mechanisms are a crucial elements of any autonomous systems. This course provides the students an introduction to the various control mechanisms that can be used in the development of a robot.

Prerequisite: Basic course in Control Systems

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

CO 1	Design linear controllers for robotic manipulators
CO 2	Familiarise about various nonlinear control schemes for robotic manipulators
CO 3	Acquaint with force control schemes of manipulators
CO 4	Familiarise about controllers for mobile robots
CO 5	Familiarise about vision-based control schemes for 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	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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	20
Understand	25	25	50
Apply	15	15	30
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. With block diagrams, explain the closed loop and feed forward Robotic Control Systems
2. With an example, explain a trajectory following control used for robots.
3. Explain PID control of a single link manipulator

Course Outcome 2 (CO2):

1. What is an adaptive Control mechanism? How can it be used in robotic controls?
2. Explain one non-linear control scheme of robotic manipulator

Course Outcome 3 (CO3):

1. Discuss the response of a mass-Spring system with a driving force
2. Elaborate on the hybrid position –force problem and its control scheme

Course Outcome 4 (CO4):

1. Differentiate between a steered robot and a differentially driven mobile robot. Explain the kinematic model of any one of them
2. How is a line follower different from a mechanism designed to follow a path

Course Outcome 5 (CO5):

1. What is stereo vision and how is it useful?
2. Explain the working of an image based visual servo mechanism
3. Explain the import factors to be considered for camera calibration in a visual based control scheme?

MODEL QUESTION PAPER

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
SIXTH SEMESTER B.TECH. DEGREE EXAMINATION
Course Code: RAT 322
Course Name: ROBOTIC CONTROL SYSTEMS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1	Typically robotic systems are linear or non-linear? Can we implement linear controllers for robots? Justify your answer.	(3)
2	Draw the block schematic for feedback control of robotic manipulator. Which is the commonly used sensor in the feedback loop for the position control of a manipulator?	(3)
3	Explain PD gravity control of a robotic manipulator.	(3)
4	Explain resolved motion rate control of robots.	(3)
5	What are the applications of industrial robots where force control may be needed?	(3)
6	What do you mean by natural and artificial constraints for tasks in partially constrained environments?	(3)
7	What is a differentially driven mobile robot? How it is different from steered robot?	(3)
8	If a controller is to be designed to move a differentially driven mobile robot to point, which all sensors may be needed? Explain with the help of block schematic.	(3)
9	What is visual servoing?	(3)
10	What is the necessity of camera calibration for visual servoing applications?	(3)

PART B

Answer any one full question, each carries14 marks.

MODULE I

11 a) Differentiate between closed loop and feed forward control, with the help of block diagrams (7)

b) Explain PID control of a single link manipulator (7)

12 a) What do you mean by control law partitioning? (6)

b) A researcher has proposed the following control scheme for a serial manipulator, where [kp] and [Kv] are positive definite gain matrices (8)

$$\tau = [\mathbf{M}(\mathbf{q})]\ddot{\mathbf{q}}_d + \mathbf{C}(\mathbf{q}, \dot{\mathbf{q}}) + \mathbf{G}(\mathbf{q}) + [K_p](\mathbf{q}_d - \mathbf{q}) + [K_v](\dot{\mathbf{q}}_d - \dot{\mathbf{q}})$$

Draw the block schematic of the proposed controller and explain. What are the possible advantages of the scheme?

MODULE II

13 a) Explain any one non-linear control scheme of robotic manipulator. (7)

b) What the advantages and disadvantages of computed torque control? (7)

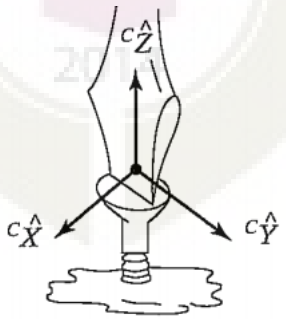
14 a) Explain about task space control schematic of robots (8)

b) Explain adaptive control of robotic manipulators (6)

MODULE III

15 a) Explain the assembly sequences used to put a round peg into a round hole (7)

b) Figure shows a manipulator tightening a screw. What are the natural and artificial constraints for this task? (7)



16 a) Explain the force control of a typical mass spring dashpot system (8)

b) Explain typical hybrid position/force control scheme with the help of block diagram (6)

MODULE IV

17	a)	Obtain the kinematic model of a differentially driven mobile robot.	(7)
	b)	With the help of block schematic explain how a differentially driven mobile robot is controlled to follow a line.	(7)
18		With the help of block schematic explain how a quadcopter can be controlled to track a trajectory?	(14)

MODULE V

19	a)	Explain the configuration of a vision system in a visual servoing scenario	(7)
	b)	How pose is estimated in a typical vision based control system?	(7)
20		Explain in detail position based visual servoing and Image based visual servoing	(14)

****

Syllabus

Module I (8 Hours)

Review of dynamic modelling of robots: Introduction to robot control- Necessity of Controllers for Robots, typical block schematic closed loop and feed forward control.
Linear control of manipulators - closed-loop control, second-order linear systems, control of second-order systems, control-law partitioning, trajectory-following control, Feedback control of single link manipulator
Case study- Matlab simulation-PID Control of single link manipulator and planar 2R manipulator , closed loop control of wall following robot- block schematic- sensor selection etc

Module II (7 Hours)

Nonlinear Control of manipulators- PD Gravity Control, Computed Torque Control, adaptive control
Task Space Control Schemes – resolved motion rate control and resolved motion acceleration control
Case study- resolved motion rate control of 2R manipulator

Module III (6 Hours)

Force control of manipulators- introduction, application of industrial robots to assembly tasks, force control of a mass—spring system, the hybrid position/force control problem, the hybrid position/force control scheme
Case study- force control of peg in hole assembly task, natural and artificial constraints

Module IV (7 Hours)

Kinematic model of steered robot and differentially driven mobile robot , Control of a mobile robot to move to a point, to follow a line, following a path, moving to a pose, Dynamic model of quadcopter, Controller design to track any desired trajectory.

Module V (8 Hours)

Vision based Control- configuration of a vision system, image segmentation, image interpretation, Pose estimation, Stereo vision, Camera Calibration, Position based visual servoing, Image based visual servoing, Hybrid visual servoing.

Text Books:

1. Introduction to Robotics Mechanics and Control, John J. Craig, 3e, Pearson
2. Robotics: Fundamental Concepts and Analysis, Ashitava Ghosal, Oxford
3. Robotics- Modelling planning and control- Bruno Siciliano , Lorenzo Sciavicco Luigi Villani, Giuseppe Oriolo, Springer-Verlag London
4. Peter Corke, "Robotics, Vision and Control-Fundamental Algorithms in MATLAB", Springer Tracts in Advanced Robotics, volume 73.
5. The Robotics Primer-Maja J Matari´c, The MIT Press

References:

1. Probabilistic Robotics: Sebastian Thrun, Wolfram Burgard, Dieter Fox, MIT Press
2. Modern Robotics Mechanics, Planning and Control, Kevin M.Lynch, Frank C. Park, Cambridge University Press, 2017

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**MODULE I**	
1.1	Review of dynamic modelling of robots. Introduction to robot control- Necessity of Controllers for Robots, typical block schematic closed loop and feed forward control. Linear control of manipulators- closed-loop control, second-order linear systems, control of second-order systems, control-law partitioning, trajectory-following control, Feedback control of single link manipulator (Ref 1 and 2)	7
1.2	Case study- Matlab simulation-PID Control of single link manipulator and planar 2R manipulator (Ref2)	0.5

	closed loop control of wall following robot- block schematic- sensor selection etc (Ref 5)	0.5
2	**MODULE II**	
2.1	**Nonlinear Control of manipulators-** PD Gravity Control, Computed Torque Control, adaptive control (Ref1)	3
2.2	**Task Space Control Schemes** – resolved motion rate control and resolved motion acceleration control (Ref1)	3
2.3	Case study- resolved motion rate control of 2R manipulator (Ref 1)	1
3	**MODULE III**	
3.1	Force control of manipulators- introduction, application of industrial robots to assembly tasks, force control of a mass—spring system, the hybrid position/force control problem, the hybrid position/force control scheme (Ref 1 and 2)	5
3.2	Case study- force control of peg in hole assembly task, natural and artificial constraints (Ref 2)	1
4	**MODULE IV**	
4.1	Kinematic model of steered robot and differentially driven mobile robot (Ref 4)	2
4.2	Control of a mobile robot to move to a point, to follow a line, following a path, moving to a pose (Ref 4)	3
4.3	Dynamic model of quadcopter, Controller design to track any desired trajectory(Ref 4)	2
5	**MODULE V**	
5.1	Vision based Control- configuration of a vision system, image segmentation, image interpretation, Pose estimation, Stereo vision, Camera Calibration (Ref 4)	3.5
5.2	Position based visual servoing, Image based visual servoing, Hybrid visual servoing (Ref 4)	3.5

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
RAT312	SENSORS AND TRANDUCERS	PEC	2	1	0	3

Preamble: It is through the various sensors and transducers that a robot interacts with the physical world. A thorough understanding of the working principle of these sensors and transducer are therefore necessary for a budding engineer to select appropriate components for the application. This course provide an exposure for the student to learn about various sensors, transducers and how they are selected by explaining the underlying theory followed by appropriate case studies.

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

CO 1	Analyze and select the most appropriate sensors and transducers for a robotic application
CO 2	Explain fundamental principle of working of sensors and transducers for robots
CO 3	Interpret typical manufacturer's data sheet of sensors and transducers and use them for selection in typical applications

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

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:

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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. List out the different sensor characteristics and their defintions
2. What is a LVDT? What is it used for?
3. What are the different types of Force sensors available? Under what condition will you chose a piezo electric based sensor over a strain gauge.
4. With example, explain the use of one Proprioceptive and exteroceptive sensor in a robotic application.

Course Outcome 2 (CO2):

1. Explain the working principle of real time differential GPS
2. Explain the working principle of Doppler based motion sensors. Discuss on the possible application of such sensors
3. Explain the various steps involved in an visual object detection process

Course Outcome 3 (CO3):

1. Discuss the important characteristics that need to be looked into while selecting a proximity sensor for obstacle avoidance application
2. List out the important properties to be looked into while selecting a CCD camera for object identifcation systems
3. Discuss the transducer performance characteristics based on the static and dynamic properties

MODEL QUESTION PAPER

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

Course Code: RAT 312

Course Name: SENSORS AND TRANSDUCERS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1		How proprioceptive sensors differ from exteroceptive sensors?	(3)
2		Mention the applications of force sensors.	(3)
3		A robot is moving in an environment amidst obstacles which are black in colour. Which sensor is preferred in this scenario for range measurement and obstacle avoidance? Justify your answer.	(3)
4		Explain the uses of tactile sensors.	(3)
5		Can we compute depth of an object using camera? Justify your answer.	(3)
6		What is visual servoing?	(3)
7		What's a force transducer?	(3)
8		Explain the performance characteristics of transducers.	(3)
9		Explain any two types of temperature transducer	(3)
10		How will you choose transducer for different robotic applications;	(3)

PART B

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

MODULE1

11	a)	What is LVDT? What are the parameters that can be measured by this? Describe with a neat diagram the principle of operation and output characteristics of the same.	(10)
	b)	A robot'scontrol memory has 8 bit storage capacity; it has two rotational joints and one linear joint. The linear link can varyits length from as short as 0.2 meters to as long as 1.2 meters. Compute the control resolution for encoder of each joint.	(4)
12	a)	What is Gyroscope? Enumerate various sources of errors in Gyroscopes? How will you rectify them while gyroscopes are used in robotic applications?	(10)
	b)	Can we use GPS sensors in indoor environments? Justify your answer.	(4)

MODULE II

13	a)	Which are the sensors used to detect closeness of objects? And how will you compute the same?	(10)
	b)	How range is measured using optical triangulation method?	(4)
14		Consider a scenario where a surveillance vehicle chases a car which violated traffic rules. Which all sensors are to be used in the surveillance vehicle to compute the position and relative velocity of the target vehicle (car)? Explain the working of the sensors being used.	(14)

MODULE III

15	a)	Which are the elements of a vision sensor? How will you extract features using vision sensor?	(6)
	b)	What are the advantages of CMOS cameras?	(8)
16		Explain the criteria for selection of sensors for different applications	(14)

MODULE IV

17	a)	1. What are transducers ? What are it's classifications?	(6)
	b)	Linear Resistance potentiometer is 50mm long & is uniformly wound with a wire having a resistance of 10,000Ω. Under normal conditions, the slider is at the center of the potentiometer. Find the linear displacement when the resistancesof the potentiometer as measured by Wheatstone bridge for two cases are (1)3850Ω (2)7560Ω. Are the two displacements in same direction. If it is possible to measure a minimum value of 10Ω resistancewith the bovearrangement, find the resolution	(8)
18	a)	With neat diagrams explain the following transducers (i) Position transducer (ii) Velocity transducer (iii)Force Transducer	(6)
	b)	What are the two basic materials used for resistive strain gages? Which of these is most sensitive? Describe in your words what "sensitive" means. What is a disadvantage of the more sensitive strain gage material?	(8)

MODULE V

19	a)	With neat diagrams explain the following transducers (i) Temperature transducer (ii) Pressure transducer (iii)Flow Transducer	(8)
	b)	What is the difference between a sensor and transducer ? Give some industrial applications of transducer.	(6)
20	a)	A pressure transducer uses a diaphragm as a pressure summing device. In application the diaphragm and fluid behave as a second-order, single-degree system. The static displacement is proportional to the applied force (pressure). If the natural undamped frequency of the system is 3600 Hz and the total viscous damping is 75% of critical, determine the frequency range(s) over which the ratio of dynamic amplitude to static amplitude (inherent error) deviates from unity by an amount no greater than 6%...	(7)
	b)	Consider the pressure transducer from the previous problem to be damaged such that its viscous damping ratio becomes changed to some unknown value. If the transducer is subjected to a harmonic input of 2400 Hz, the phase angle between output and input is measured as 45 degrees. With this in mind, determine the inherent error (attenuation) of the transducer when used to measure a harmonic pressure signal of 1800 Hz. What will be the phase angle between the output and input at this frequency?	(7)

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Syllabus

Module I (8 Hours)

Requirement of sensors in robots used in industry, agriculture, medical field, transportation, military, space and undersea exploration, human-robot interactions, robot control, robot navigation, tele-operational robot etc. **Sensor Characteristics**: Sensitivity, Linearity, Measurement/Dynamic range, Response Time, Accuracy, Repeatability & Precision, Resolution & Threshold, Bandwidth.

Proprioceptive or Internal sensors Position sensors- encoders- linear, rotary, incremental linear encoder, absolute linear encoder, Incremental rotary encoder, absolute rotary encoder; potentiometers; LVDTs; velocity sensors-optical encoders, tacho generator, Hall effect sensor, , acceleration sensors, Heading sensors- Compass, Gyroscope sensor, IMU, GPS, real time differential GPS; Force sensors-strain gauge based and Piezo electric based, Torque sensors; Block schematic representations; Interpreting typical manufacturer's data sheet of internal sensors;

CaseStudy: Choosing the best internal sensors for autonomous navigation of a mobile robot

Module II (7 Hours)

Exteroceptive or External sensors-contact type, noncontact type;Tactile, proximity-detection of physical contact or closeness, contact switches, bumpers , inductive proximity, capacitive proximity; semiconductor displacement sensor; Range sensors- IR, sonar, laser range finder, optical triangulation (1D), structured light(2D), performance comparison range sensors; motion/ speed sensors-speed relative to fixed or moving objects, Doppler radar, Doppler sound; Block schematic representations; Numerical problems ;Block schematic representations; Interpreting typical manufacturer's data sheet of external sensors;Examples - use of Exteroceptive sensors in robots.

Case Study : Obstacle avoidance robot using IR sensor;

Module III (7 Hours)

Vision based sensors- Elements of vision sensor, image acquisition, image processing, edge detection, feature extraction, object recognition, pose estimation and visual servoing, hierarchy of a vision system, CCD and CMOS Cameras, Monochrome, stereovision, night vision cameras, still vs video cameras, kinect sensor; Block schematic representations.

Choosing sensor for different robotic applications and application of sensors in flexible manufacturing

Case Study : Object Tracking robot using vision sensor

Module IV (7 Hours)

Introduction to transducers; Requirement of transducers in robots, medicine etc; Differences between Sensors and transducers; Transducer performance characteristics based on static and dynamic properties; Classification of transducers based on physical effect,

physical quantity and source of energy- Active vs Passive, Principle of transduction, Analog and Digital transducer, Primary and Secondary transducer;Transducer and Inverse Transducer.

Position transducers, Displacement transducer – LVDT's,Captive Armatures, Unguided Armatures, Force-Extended Armatures; Velocity Transducers - LVT; Accelerometer- using potentiometer, Strain gage, Piezoelectric;Light transducers;, Force transducers; Piezoelectric transducer;

Block schematic representations; Advantages and Disadvantages; choosing transducer for different robotic applications; Numeric problems; Interpreting typical manufacturer's data sheet;

Case Study : Learn to calculate end effectors position of a robot using position transducer

Module V (6 Hours)

Temperature transducer – thermocouple, RTD- common errors, Thermistor, Integrated circuit; Pressure transducer - Bourdon tube, diaphragm, Capacitive Pressure transducer; Oscillator transducer; Flow transducer – Orifice Plate, venture, Defective type flow sensor, spin type flow sensor, Electromagnetic flow sensor; Level Transducer- Discrete Level, Level measurement by pressure sensor, differential pressure sensor, force sensor, capacitive level sensor; Inductive transducer; Ultrasonic transducer; LIDAR

Block schematic representations; Advantages and Disadvantages; choosing transducer for different robotic applications; Numeric problems; Interpreting typical manufacturer's data sheet.

Text Book

1. Robotics Engineering: An Integrated Approach, by Richard D. Klafter, Prentice Hall Inc.
2. D. Patranabis, "Sensors and Transducers", PHI Learning Private Limited.

References

3. Clarence W. de Silva, Sensors and Actuators: Control System Instrumentation, CRC Press 2007, ISBN-13: 978-1420044836
4. Introduction to Robotics, S K Saha, Mc Graw Hill Eduaction
5. W. Bolton, "Mechatronics", Pearson Education Limited.
6. Automation, Production Systems and Computer Integrated Manufacturing, Groover M.P, Prentice – Hall Ltd., 1997.
7. Pillai S. K. "A first course on electric drives", Wieley Eastern Ltd, New Delhi
8. Journal of sensors, Special issue- Sensors for Robotics, Aiguo Song , Guangming Song, Daniela Constantinescu, Lei Wang, and Quanjun Song, Volume 2013
9. Mechatronics: Integrated mechanical electronic systems By K.P. Ramachandran, G.K. Vijayaraghavan, Wiley India
10. Linear Electric Actuators by I. Boldea
11. Piezoelectric Actuators (Electrical Engineering Developments), 2012, by Joshua E. Segel

12. Morecki, Adam and Knapczyk, "Sensors and Transducers Used in Robots", Basics of Robotics, Springer 1999, pp 275—304
13. Ruocco, S, "Robot sensors and transducers", Springer Science \& Business Media, 2013.
14. Instrumentation, Measurement and Analysis, 2016, By Nakra & Chaudhary.
15. "HANDBOOK OF FORCE TRANSDUCERS" by Hardcover and Stefanescu
16. "Transducers and Instrumentation" by D V S Murthy

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Proprioceptive or Internal sensors**	
	Requirement of sensors in robots used in industry, agriculture, medical field, transportation, military, space and undersea exploration, human-robot interactions, robot control, robot navigation, tele-operational robot etc.**Sensor Characteristics**: Sensitivity, Linearity, Measurement/Dynamic range, Response Time, Accuracy, Repeatability & Precision, Resolution & Threshold, Bandwidth.	2.5
1.2	Position sensors- encoders- linear, rotary, incremental linear encoder, absolute linear encoder, Incremental rotary encoder, absolute rotary encoder; potentiometers; LVDTs.	2
1.3	velocity sensors-optical encoders, tacho generator, Hall effect sensor, acceleration, Heading sensors- Compass, Gyroscope sensor, IMU, GPS, real time differential GPS	2
1.4	Force sensors-strain gauge based and Piezo electric based, Torque sensors	1.5
	Note- Block schematic representations, Interpretation of typical manufacturer's data sheet and Numerical problems of the main sensors are to be covered.	
2	**Exteroceptive or External sensors**	
2.1	contact type, noncontact type; Tactile, proximity- detection of physical contact or closeness, contact switches, bumpers , inductive proximity, capacitive proximity; semiconductor displacement sensor;	3
2.2	Range sensors- IR, sonar, laser range finder, optical triangulation (1D), structured light(2D), performance comparison range sensors;	2
2.3	Motion/ speed sensors-speed relative to fixed or moving objects, Doppler radar, Doppler sound; Numerical problems	2
	Note- Block schematic representations, Interpretation of typical manufacturer's data sheet and Numerical problems of the main sensors are to be covered.	
3	**Vision based sensors-**	
3.1	Vision based sensors - Elements of vision sensor, image acquisition, image processing, edge detection, feature extraction, object recognition, pose estimation and visual servoing, hierarchy of a vision system	3

3.2	CCD and CMOS Cameras, Monochrome, stereovision, night vision cameras, still vs video cameras, kinect sensor.	3
3.3	Choosing sensor for different robotic applications and application of sensors in flexible manufacturing	1
4	**Introduction to transducers**;	
4.1	**Introduction to transducers**; Requirement of transducers in robots, medicine etc; Differences between Sensors and transducers; Transducer performance characteristics based on static and dynamic properties; Classification of transducers based on physical effect, physical quantity and source of energy- Active vs Passive, Principle of transduction, Analog and Digital transducer, Primary and Secondary transducer;Transducer and Inverse Transducer.	4
4.2	Position transducers, Displacement transducer – LVDT's,Captive Armatures, Unguided Armatures, Force-Extended Armatures; Velocity Transducers - LVT; Accelerometer- using potentiometer, Strain gage, Piezoelectric;Light transducers;, Force transducers;Piezoelectric transducer;	3
5		
5.1	Temperature transducer – thermocouple, RTD- common errors, Thermistor, Integrated circuit; Pressure transducer - Bourdon tube, diaphragm, Capacitive Pressure transducer; Oscillator transducer; Flow transducer – Orifice Plate, venture, Defective type flow sensor, spin type flow sensor,	3
5.2	Electromagnetic flow sensor; Level Transducer- Discrete Level, Level measurement by pressure sensor, differential pressure sensor, force sensor, capacitive level sensor; Inductive transducer; Ultrasonic transducer; LIDAR	3

RAT306	SIGNALS AND SYSTEMS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: Starting with the understanding of what a signal is and the different types of signals available in the real world, this course provides the student with deep insights into the representation of signals in various domains and the need for such representations. The course also helps students to gain knowledge on transforming a signal from one domain to another domain. The course also discusses about the use of filters in signal processing and use of DFT for the same.

Prerequisite: Nil

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

CO 1	Familiarise with types of signals and systems
CO 2	Obtain the frequency domain representation of continuous signals
CO 3	Obtain frequency domain representation of discrete time signals
CO 4	Develop filtering methods based on DFT
CO 5	Computation of DFT

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	2									3
CO 4	3	2	2									3
CO 5	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):

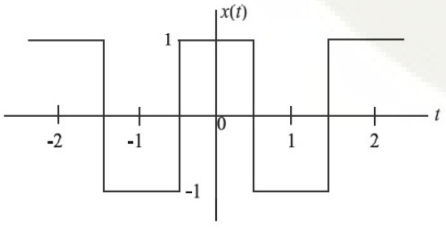
1. Compare and Contrast between a Continuous Time domain Signal and Discrete Time Domain Signal
2. How do you classify different systems in to CT and DT systems
3. Explain with an Example, how you will represent a discrete time system using difference equations

Course Outcome 2 (CO2):

1. With suitable examples, explain the properties of Continuous Fourier Series
2. State Sampling theorem and explain a mechanism to avoid aliasing
3. What do you mean by a response of a system? Explain the different types used in system design

Course Outcome 3 (CO3):

1. Find CTFS of the given signal x(t)



2. Derive the relationship between Fourier and Laplace transform
3. Determine the z-transform of $x(n)=(0.5)^n u(n)$

Course Outcome 4 (CO4):

1. Use linear convolution and find y(n)=x(n)*h(n),

2. where x(n)={0.5,2,-1.5,-,0,0.75,3,2,1.5,1,-.75,2} h(n)={1,2,-1}.
3. Solve it using the following two procedures a) Overlap-save method, (b) Overlap-add
4. How can we obtain Linear convolution using circular convolution
5. Explain Linear Filtering methods based on the DFT

Course Outcome 5 (CO5):

6. Find the 4-point DFT of x(n)={1,2,1,2}
7. Draw the basic butterfly diagram for DIT algorithm
8. Find the 8-point DFT of the sequence x(n)= {1,2,2,1,1,2,2,1} using DIF-FFT algorithm.

MODEL QUESTION PAPER

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

Course Code: RAT306

Course Name: Signals and Systems

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1	Find the period of signal $x(n)=e^{j6\pi n}$.	(3)
2	Check the system is static or dynamic y(n)=x(2n)	(3)
3	What is Nyquist rate in sampling?	(3)
4	What is differentiation in Fourier Domain?	(3)
5	State the initial value theorem in z-transform	(3)
6	Determine the z-transform of $x(n)=(0.5)^n u(n)$	(3)
7	Find the 4-point DFT of x(n)={1,2,1,2}	(3)
8	What is time reversal property of DFT?	(3)
9	What is the basic operation in DIF algorithm?	(3)
10	What is signal flow diagram?	(3)

PART B

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

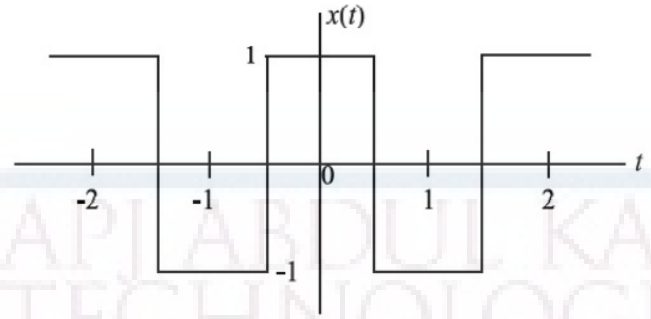
MODULE1

11	a)	Test if the following systems are causal or not (i)$y(n)=x(n)+x^2(n-1)$ (ii)y(n)=x(2n)	(5)
	b)	Determine power and energy of the following signals. Find whether the signals are power, energy or neither energy nor power signals (i) $x(n)=e^{2n}u(n)$ (ii) $x(n)=\sin(\pi/4.n)$ (iii)$x(n)=(1/3)^n u(n)$	(9)
12	a)	Determine the impulse response h(n) for the system described by difference equation y(n)+y(n-1)-2y(n-2)=x(n-1)+2x(n-2).	(8)
	b)	Compute convolution of the signals x(n)={3,2,1,2} and h(n)={1,2,1,2}.	(6)

MODULE II

13 a) State and Prove Parseval's theorem (4)

b) Find CTFS of the given signal x(t) (10)



14 a) What is sampling theorem? How can we avoid aliasing? (8)

b) Derive the relationship between Fourier and Laplace transform (6)

MODULE III

15 a) Determine the z-transform of the following (10)

(i) $x(n)= n^2u(n)$

(ii) $x(n)=(-1)^n\cos(\pi/3 \cdot n)\, u(n)$

b) List out four properties of z-transform (4)

16 a) Consider an LTI-system critically at rest described by the difference equation (10)
$y(n)=0.25\, y(n-2)+x(n)$. Determine the impulse response of the system

b) List out four properties of DTFS (4)

17 a) Use linear convolution find $y(n)=x(n)*h(n)$, where (14)
$x(n)=\{0.5,2,-1.5,-,0,0.75,3,2,1.5,1,-0.75,2\}$
$h(n)=\{1,2,-1\}$.
Solve it using the following two procedures
(a) Overlap-save method, (b) Overlap-add method

18 a) Find the circular convolution (6)

$x(n)=\{1,0,-1,0\}$ $h(n)=\{1,1,1\}$

b) Use the overlap-add method to find the step response of a filter with $h(n)=2^{-n}[u(n)-u(n-3)]$ and L=3. (8)

MODULE V

19 a) Find the 8-point DFT of the sequence $x(n)= \{1,2,2,1,1,2,2,1\}$ using DIF-FFT algorithm. (10)

b) What is the speed improvement factor in calculating 64-point DFT of a sequence using direct computation and FFT computation (4)

20 a) Draw the basic butterfly diagram for DIT algorithm (4)

b) Consider a causal linear time-invariant system whose system function is (10)
$H(z) = (1-0.5z^{-1})/(1-0.5z^{-1}+0.33z^{-2})(1+0.25z^{-1})$

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Syllabus

Module I (7 Hours)

Elementary Signals, Classification and representation of continuous time and discrete time signals, Signal operations. Continuous time and discrete time systems – Classification. Representation of systems: Differential equation representation of continuous time systems. Difference equation representation of discrete systems.

Module II (11 Hours)

Frequency domain representation of continuous time signals- continuous time Fourier series and its properties. Continuous time Fourier transform and its properties. Relation between Fourier and Laplace transforms. Analysis of LTI systems using Laplace and Fourier transforms. Concept of transfer function, Frequency response, Magnitude and phase response Sampling of continuous time signals, Sampling theorem for low pass signals, aliasing

Module III (8 Hours)

Z transform, ROC, Inverse transform, properties, Unilateral transform. Frequency domain representation of discrete time signals, Discrete time Fourier series and its properties. Discrete time Fourier transform (DTFT) and its properties

Module IV (9 Hours)

The Discrete Fourier Transform-IDFT-Properties of DFT-Circular convolution - Linear Filtering methods based on the DFT- linear convolution using circular convolution, overlap save and overlap add methods

Module V (10 Hours)

Computation of DFT: Radix-2 Decimation in Time and Decimation in Frequency FFT - Algorithms - IDFT computation using Radix-2 FFT Algorithms.
FIR and IIR Filters.- FIR Filter Structures: Direct Form, Cascade Form
IIR Filter Structures: Direct Form, Transposed Form, Cascade Form and Parallel Form (Design is not required)

Text Books

1. Alan V. Oppenheim and Alan Willsky, Signals and Systems, PHI, 2/e, 2009
2. Simon Haykin, Signals & Systems, John Wiley, 2/e, 2003R K Mittal and I J Nagrath, “Robotics and Control”, Tata McGraw Hill, New Delhi,2003.
3. B P. Lathi, Priciples of Signal Processing & Linear systems, Oxford University PressAshitava Ghosal, “Robotics-Fundamental concepts and analysis”, Oxford University press.
4. Oppenheim A. V., Schafer R. W. and Buck J. R., Discrete Time Signal Processing, 3/e, Prentice Hall, 2007.
5. Proakis J. G. and Manolakis D. G., Digital Signal Processing, 4/e, Pearson Education, 2007.

Reference Books

1. A.Papoulis, "Circuits and Systems: A Modern Approach", HW series in Electrical and Computer Engineering
2. Mahmood Nahvi, Signals and System, Mc Graw Hill (India),2015
3. H P Hsu, Signals And Systems, Schaum's Series – 3rd Edition
4. A Nagoor Kani, Signals and Systems, McGraw Hill Education.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1		
1.1	Classification and representation of continuous time signals	1
1.2	Classification and representation of discrete time signals;	1
1.3	Signal operations	2
1.4	Continuous time and discrete time systems – Classification.	1
1.5	Differential equation representation of continuous time systems.	1
1.6	Difference equation representation of discrete systems.	1
2		
2.1	Frequency domain representation of continuous time signals-	1
2.2	Continuous time Fourier series and its properties	2
2.3	Continuous time Fourier transform and its properties	2
2.4	Relation between Fourier and Laplace transforms	2
2.5	Analysis of LTI systems using Laplace and Fourier transforms. Concept of transfer function, Frequency response, Magnitude and phase response	2
2.6	Sampling of continuous time signals, Sampling theorem for lowpass signals, aliasing	2
3		
3.1	Z transform, ROC, Inverse transform,	2
3.2	Properties, Unilateral transform.	2
3.3	Frequency domain representation of discrete time signals,	1
3.4	Discrete time Fourier series and its properties.	1.5
3.5	Discrete time Fourier transform (DTFT) and its properties	1.5
4		
4.1	The Discrete Fourier Transform-IDFT	1
4.2	Properties of DFT	2
4.3	Circular convolution -Linear Filtering methods based on the DFT	2
4.4	linear convolution using circular convolution,	2
4.5	Overlap save and overlap add methods	2

ROBOTICS & AUTOMATION

5		
5.1	Computation of DFT: Radix-2 Decimation in Time FFT Algorithm IDFT computation using Radix-2 FFT Algorithms.	3
5.2	FIR and IIR Filters.	1
5.3	FIR Filter Structures: Direct Form, Cascade Form	3
5.4	IIR Filter Structures: Direct Form, Transposed Form, Cascade Form and Parallel Form (Design is not required)	3

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
KTU
Estd.
2014

RAT304	ELECTRIC DRIVES AND CONTROL	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: Robotics application span from very small mobile remote data collection equipment to large powerful robotic arms that can be used in production lines of huge manufacturing plants. Hence the design of motors and their associated drive mechanism used for the development of such robotsare quite challenging. This course provides sufficient exposure to students on the different types of robots and various drives that are used for the development of a robot.

Prerequisite: Nil

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

CO 1	Explain the working of different types of motors commonly used in robotics and the need for Electric drives
CO 2	Recognize the different power semiconductor device and their working principles
CO3	Describe the working of SCR and the various techniques used for triggering SCR
CO4	Demonstrate design of various speed control techniques of DC motors
CO5	Explain the working of single phase and Three phase inverters
CO6	Explain the working of Position control and speed control of different types of motors

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**	**1**									2
CO 2	**3**	**2**										2
CO 3	**3**	**3**	**2**									2
CO4	**3**	**3**	**3**									2
CO5	**3**	**2**	**1**									2
CO6	**3**	**2**	**1**									2

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 the principle and working of a Stepper Motor
2. Explain the working of a BLDC motor. How is it different from a normal DC motor and what are its advantages.
3. What are the different starting methods of DC motors
4. What are the factors that need to be considered in identifying a motor that meets the requirements of the load?
5. Why do we need Electric drives? With a block diagram, explain the important components and their roles of an electric drive

Course Outcome 2 (CO2):

1. Explain the working principle of IGBT. Discuss about an application where IGBT is used and state why IGBT is preferred over other power devices for that application
2. What is the need of isolation in electronic systems? Explain two commonly used isolation mechanisms used in electronic system design

Course Outcome 3 (CO3):

1. Draw the structure of an SCR and explain its working. Also discuss about the switching characteristics of an ACR.
2. Explain the different types of triggering circuits that can be used to trigger an SCR

Course Outcome 4 (CO4):

1. Explain the operation of a single phase fully controlled bridge rectifier in conduction modes

2. Explain how speed control of a DC motor can be achieved with the help of a chopper controlled DC drive
3. Explain the operation of a two quadrant speed control mechanism
4. What is a closed loop torque control? How do you choose between speed control and torque control during a system design

Course Outcome 5 (CO5):

1. Explain the operation of a 3-phase bridge inverter with a resistive load
2. Explain the different voltage control techniques used in single phase inverters
3. What is the impact of harmonics in an inverter? What are the ways in which harmonics can be removed from an inverter

Course Outcome 6 (CO6):

1. Differentiate between open loop and closed loop position control techniques of stepper motor
2. How is converter circuits used in speed control achieved in a BLDC motor. List out the different modes of operation of the same.
3. What is the principle behind sensorless control of motor speed ?
4. What is a self-controlled motor? How is self-control achieved in synchronous motors?

MODEL QUESTION PAPER			
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY SIXTH SEMESTER B.TECH. DEGREE EXAMINATION			
Course Code: RAT 304			
Course Name: ELECTRIC DRIVES AND CONTROL			
Max. Marks: 100			Duration: 3 Hours
PART A			
		Answer all questions, each carries 3 marks.	Marks
1		Compare and contrast the starting methods of DC motors.	(3)
2		Discuss the advantages of BLDC motors over conventional DC motors	(3)
3		Differentiate between latching current and holding current	(3)
4		Explain the role of opto-couplers in power drives with an example	(3)
5		Explain the condition where power may flow from load to source in chopper circuits.	(3)
6		Design a dc-dc converter with 15 V input and 200 V output at up to 50W. The ripple in the output voltage and input current should not exceed ±5% and ±20% respectively. Choose an appropriate switching device and frequency.	(3)
7		Compare methods to control output voltage of inverter.	(3)
8		What is the advantage of using DC Motor speed control using VFDs.	(3)
9		Sensorless control in BLDC used for high speed applications. Substantiate the	(3)

		statement.	
10		Write down the components of a servo system	(3)
PART B			
Answer any one full question from each module, each carries14 marks.			
MODULE1			
11	a)	Investigate the torque-speed of the drive system during dynamic conditions	(6)
	b)	Explain about the speed-torque characteristics of a DC Shunt Motor with suitable graph and equations	(8)
12	a)	Explain the selection of different power rating for different loading conditions	(7)
	b)	Suitably compare conventional motors and stepper motors. Calculate the stepping angle of a three phase, 32 teeth,variable reluctance stepper motor.	(7)
MODULE II			
13	a)	With schematics explain switching characteristics of power BJT and Explain any one drive circuit for power BJT	(10)
	b)	Describe the V-I characteristics of IGBT	(4)
14	a)	Compare Thyristor, Power MOSFET and IGBT on the basis of following parameters: i) Switching frequency ii) Voltage and current ratings iii) Applications (at least two)	(5)
	b)	Explain two quadrant and four quadrant choppers with its applications.	(9)
MODULE III			
15	a)	Design an R-triggering circuit for a half wave controlled rectifier circuit for 24 V ac supply. The SCR to be used has the following data. Igmin = 0.1 mA, Igmax = 12 mA, Vgmin = 0.6V, Vgmax = 1.5 V	(10)
	b)	Discuss regenerative breaking and its advantages	(4)
16		Graphically explain the three phase fully controlled bridge converter circuit with R Load and firing angle$\alpha = 60^{0.}$ For what firing angle,α, the current through the load becomes discontinuous.	(14)
		MODULE IV	
17	a)	With necessary diagrams and equations explain 3-phase bridge inverter with R load and 120^0 conduction mode.	(12)
	b)	Note down the advantages of single phase voltage source inverter.	(2)
18	a)	Briefly explain sinusoidal PWM.	(4)
	b)	What is the effect of blanking time in invert output? Suggest suitable methods to eliminate the effects of harmonics.	(10)
		MODULE V	
19	a)	Compare the full step and half step motor drive with applications. Also compare open loop and closed loop configurations	(14)
	b		
20	a)	Explain how position control is achieved in servo control system.	(4)
	b)	Explain how Hall sensors are used to achieve speed control in BLDC motors	(10)
****			

SYLLABUS

Module I (9 Hrs)

Introduction to electric motors used for robotic applications.

DC Motor -Construction– principle of operation –Back emf–Torque - characteristics of shunt, series and compound motors - necessity of starters- starting methods of dc motors

Introduction to Special Electrical Machines- DC servo motor,AC servo motors, stepper motor- variable reluctance - permanent magnet- hybrid , BLDC, PMSM- Construction , working and principle of operation

Electric drives- Introduction – Block diagram – advantages of electric drives -Dynamics of motor load system, fundamental equations, and types of load – classification of load torque-matching motor and load- Selection of motors for typical applications based on speed torque characteristics.

Module II (8Hrs)

Introduction to Power semiconductor devices-Power diode, BJT, MOSFET, IGBT -static and dynamic characteristics

SCR – structure- working- V-I and switching characteristics- Turn on methods of SCR- Gate triggering circuits – R and RC triggering circuits, line synchronised triggering – natural and forced commutation (concept only). Protection of SCR. Requirements of isolation and synchronisation in gate drive circuits- Opto and pulse transformer based isolation.

Module III (10Hrs)

Controlled Rectifiers –single phase fully controlled bridge rectifier with R, RL and RLE loads (continuous & discontinuous conduction) – output voltage equation. Three phase fully controlled converter with RLE load

DC-DC converters – step down and step up choppers – control methods- two-quadrant & four quadrant chopper.

DC Motor drives- Solid state speed control of DC motors-Armature control and field control, Single phase fully controlled converter drives (Rectifier and inverter mode). Chopper controlled DC drives-Regenerative braking control- Four quadrant chopper drives. Closed loop speed and torque control.

Module IV (9 Hrs)

Inverters — 1-phase full bridge voltage source inverters inverter with R & RL loads- 3-phase bridge inverter with R load – 120° & 180° conduction mode. Voltage control in inverters– Pulse Width Modulation – single pulse width, multiple pulse width & sine PWM-elimination of harmonics- Variable Voltage Variable Frequency Drive (Block diagram only).

Module V (9 Hrs)

Control of servomotors-Components of typical servo system-with DC and brushless DC servo motor**,** Feedback system -Sizing of servomotors

Position control of Stepper motor- Drive circuit – modes of excitation- open loop and closed loop control of Stepper Motor- applications

Permanent Magnet Motor drives- Speed control of BLDC motor- converter circuits, modes of operation - applications. Speed control of PMSM-Self control- Sensorless Control – Microcontroller based permanent magnet synchronous motor drives (schematic only)- applications

Text Books:

1. Ned Mohan, Tore m Undeland, William P Robbins, "Power electronics converters applications and design", John Wiley and Sons.

2.Dubey G. K. "Power semiconductor control drives" Prentice Hall, Englewood Cliffs, New Jersey, 1989

3. E. G. Janardhanan, '*Special Electrical Machines*' PHI Learning Private Limited.

4. NAGARATH.I.J& KOTHARI .D.P,"Electrical machines", Tata McGraw-Hill.1998

References:

1. VEDAM SUBRAMANIAM "Electric drives (concepts and applications)", Tata McGraw-Hill.2001
2. R. Krishnan, '*Permanent magnet synchronous and Brushless DC motor Drives*', CRC Press.
3. Bimal K. Bose "Modern power electronics and AC drives" Pearson Education, Asia 2003
4. Irvin L. Kosow.'*Electrical Machinery and Transformers*', Oxford Science Publications.
5. T. J. E. Miller, '*Brushless PM and Reluctance Motor Drives*'.C.Larendon Press, Oxford.
6. Dr. P. S. Bimbra "Power electronics", Khanna publishers
7. VedamSubrahmanyam, "Electric Drives", MC Graw Hill Education, New Delhi
8. Pillai S. K. "A first course on electric drives", Wieley Eastern Ltd, New Delhi
9. Theodore Wildi, '*Electric Machines, Drives and Power Systems*', Prentice Hall India Ltd.
10. M.D. SINGH, K.B.KHANCHANDANI,"Power electronics," Tata McGraw-Hill.1998
11. N. K. De, P. K. Sen "Electric drives" Prentice Hall of India 2002

Course Contents and Lecture Schedule

No.	Topic	No. of Lectures
1	**Electric Drives (9 hours)**	
1.1	Introduction to electric motors used for robotic applications. DC Motor -Construction– principle of operation –Back emf	1
1.2	Torque – electrical and mechanical characteristics of shunt, series and compound motors	1
1.3	necessity of starters- starting methods of dc motors- three point starter	1
1.4	Introduction to Special Electrical Machine - DC servo motor,AC servo motors- Construction , working and principle of operation	1
1.5	stepper motor- different types -variable reluctance - permanent magnet- hybrid- Construction , working and principle of operation	2
1.6	BLDC, PMSM- Construction , working and principle of operation	1
1.7	Electric drives- Introduction – Block diagram – advantages of electric drives -Dynamics of motor load system, fundamental equations,	1
1.8	types of load – classification of load torque-matching motor and load- Selection of motors for typical applications based on speed torque characteristics.	1
2	**Introduction to Power semiconductor devices- (8 hours)**	
2.1	Power diode, BJT, MOSFET, IGBT -static and dynamic characteristics	2
2.2	**SCR** – structure- working- V-I and switching characteristics- Turn on methods of SCR	2
2.3	Gate triggering circuits – R and RC triggering circuits, line synchronised triggering –	2
2.4	natural and forced commutation (concept only), Protection of SCR.	1
2.5	Requirements of isolation and synchronisation in gate drive circuits- Opto and pulse transformer based isolation.	1
3	**DC Motor Drives(11 Hours)**	
3.1	**Controlled Rectifiers** –single phase fully controlled bridge rectifier with R, RL and RLE loads (continuous & discontinuous conduction) – output voltage equation.	2
3.2	Three phase fully controlled converter with RLE load	1
3.3	DC-DC converters – step down and step up choppers – control methods-	1
3.4	two-quadrant & four quadrant chopper- output voltage waveforms	2
3.5	DC Motor drives- Solid state speed control of DC motors-Armature	1

	control and field control	
3.6	Single phase fully controlled converter drives (Rectifier and inverter mode)	1
3.7	Chopper controlled DC drives-Regenerative braking control- Four quadrant chopper drives.	2
3.8	Closed loop speed and torque control.	1
4	**Inverters (8 Hours)**	
4.1	1-phase full bridge voltage source inverters inverter with R & RL loads	1
4.2	3-phase bridge inverter with R load – 120° & 180° conduction mode – output line voltage and phase voltage waveforms	3
4.3	Voltage control in inverters– Pulse Width Modulation – single pulse width, multiple pulse width & sine PWM	2
4.4	Elimination of harmonics using PWM	1
4.5	Variable Voltage Variable Frequency Drive (Block diagram only).	1
5	**Control of servomotors - (9 Hours)**	
5.1	Control of servomotors- Components of typical servo system-with DC and brushless DC servo motor, Feedback system -Sizing of servomotors	2
5.2	Position control of Stepper motor- Drive circuit – modes of excitation- full step mode and half step mode-	2
5.3	open loop and closed loop control of Stepper Motor- applications	1
5.4	Permanent Magnet Motor drives- Speed control of BLDC motor- converter circuits, modes of operation - applications.	2
5.5	Speed control of PMSM-Self control- Sensorless Control – Microcontroller based permanent magnet synchronous motor drives (schematic only)- applications	2

RAT302	DESIGN OF MACHINE ELEMENTS	CATEGORY	L	T	P	CREDIT
		PCC	3	1	0	4

Preamble: This course helps students to apply the concepts of stress analysis, theories of failure and material science to analyse and design commonly used machine components. The course also provides an in-depth understanding on the design of different types of joints, gear drives, belt drives and bearings which are critical components of automation.

Prerequisite: NIL

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

CO 1	To review concepts of statics and strength of materials.
CO 2	To introduce fundamental approaches to failure prevention of components.
CO 3	To provide knowledge in the design of common machine elements such as fasteners, shafts, springs and couplings.
CO 4	To provide knowledge in the design of welded joints and fillet joints in tension, torsion and bending.
CO 5	To provide basic design methods for gear drives, belt drives and bearings

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

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:

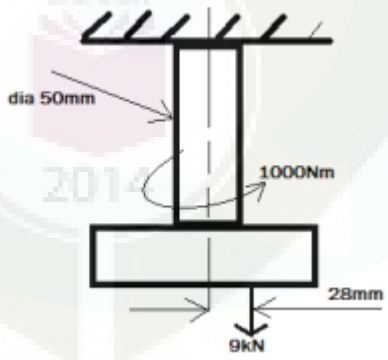
Attendance : 10 marks
Continuous Assessment Test (2 numbers) : 25 marks
Assignment/Quiz/Course project : 15 marks

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. What is factor of safety? What are the factors to be considered in selection of factor of safety(FoS)?
2. What are the factors affecting the endurance strength
3. A load of 9kN is applied to the steel rod of 50mm diameter as shown in figure. If a torsional moment of 100 N-m is applied on it, Determine the maximum tensile stress and maximum shear stress.



Course Outcome 2 (CO2):

1. Explain the stresses acting on a screw fastener.
2. A cylinder head is fastened to the cylinder of a compressor using 6 bolts of M20 size. Bolt material is C20 steel. The Maximum fluid pressure is 3.5MPa, and the cylinder

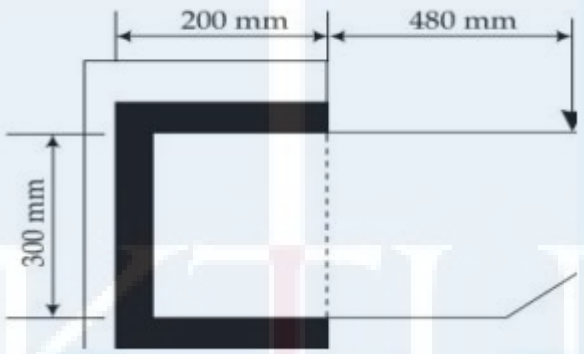
diameter is 75mm. A soft gasket is used. Assume the initial tension required in each bolt as 40kN.Determine the factor of safety.

Course Outcome 3 (CO3):

1. What is surging in springs?
2. Differentiate between torsional rigidity and lateral rigidity of shaft
3. Compare and Contrast rigid and flexible couplings List out any two application areas of rigid and flexible couplings

Course Outcome 4 (CO4):

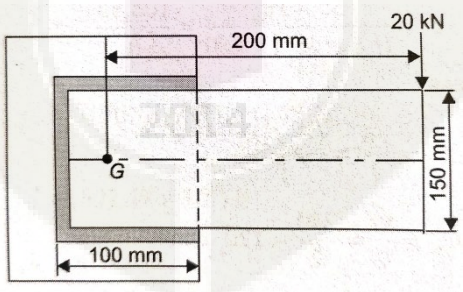
1. Explain the stresses acting in Fillet and Butt Welds
2. Why do we design the weld joints based on throat area?
3. Determine the size of the weld for a bracket loaded as shown in the figure. The allowable stress in the weld is 60MPa.



Course Outcome 5 (CO5):

1. State and explain law of gearing with a neat sketch
2. Elaborate on the different modes of failure of gear tooth
3. Explain the advantages and limitations of V-Belt drive

MODEL QUESTION PAPER			
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY SIXTH SEMESTER B.TECH. DEGREE EXAMINATION			
Course Code: RAT 302			
Course Name: DESIGN OF MACHINE ELEMENTS			
Max. Marks: 100			Duration: 3 Hours
PART A			
		Answer all questions, each carries 3 marks.	Marks
1		Distinguish between standards and codes	(3)
2		Explain the procedure to determine the endurance limit of a material	(3)
3		What is the role of washer in a bolted joint	(3)
4		What are the demerits of welded joints	(3)

5		Distinguish between rigid and flexible couplings	(3)
6		Explain shock and fatigue factor	(3)
7		Explain why dynamic factors need to be considered in the design of gears.	(3)
8		Enumerate the various types of flat belt drives.	(3)
9		Explain the mechanism of fluid film lubrication	(3)
10		Define equivalent bearing load	(3)
PART B			
Answer any one full question from each module, each carries14 marks.			
MODULE1			
11	a)	Explain the steps involved in the design process.	(4)
	b)	A carbon steel rod of circular cross section is subjected to a bending moment which varies from 300 Nm to 500 Nm and an axial load which varies from 6 kN to 9 kN.Determine the diameter of the rod for a factor of safety of 3.Take σ_u= 600 MPa, σ_y=400 MPa	(10)
12	a)	Explain impact factor.	(2)
	b)	A 50 mm diameter steel shaft with a 20 mm transverse hole is simultaneously subjected to a bending stress which varies from + 100 MPa to – 70 MPa and a torsional stress which varies from + 80 MPa to -50 MPa. Find the factor of safety for infinite life assuming the following properties. Ultimate strength in tension 800MPa, Yield strength 550MPa. Surface correction factor = 0.85, size factor =0.85 and Notch sensitivity factor = 0.9. Use maximum distortion energytheory.	(12)
MODULE II			
13	a)	What is meant by pre-tension in bolts? What is its significance?	(4)
	b)	The cylinder head is fastened to the cylinder of a compressor using 6 bolts (steel C 20) of M20 size. The maximum fluid pressure is 3.2 MPa, cylinder diameter is 70 mm. A soft copper gasket is used. Assume the initial tension required in each bolt as 40kN, Determine the factor of safety?	(10)
14	a)	What is weld reinforcement? Why is it done?	(2)
	b)	An eccentrically loaded bracket is welded to a support as shown in figure. The permissible shear stress for the weld material is 80 MPa. Determine the size of the weld. 	(12)
MODULE III			
15		A railway wagon weighing 3 tons is moving with a velocity of 3 m/s. It is brought to rest by two buffer springs of diameter 200 mm. The maximum deflection allowed is 160 mm. The allowable shear stress in spring material is600 MPa. Take G=84 GPa. Design the spring.	(14)
16		Design a shaft to transmit power from an electric motor to a lathe head stock through a pulley by means of a belt drive. The pulley weighs 200 N and is located at 300 mm from the centre of the bearing. The diameter of the pulley is	(14)

		200 mm and the maximum power transmitted is 1 kW at 120 rpm. The angle of lap of the belt is 180^0 and the coefficient of friction between the belt and pulley is 0.3. The shock and fatigue factors for bending and twisting are 1.5 and 2.0.The allowable shear stress in the shaft may be taken as 35 MPa.	
		MODULE IV	
17		A motor shaft rotating at 1440 rpm has to transmit 15 kW power to a low speed shaft running at 500 {pm. A 200 pressure angle full depth involute system of geartooth is used. The pinion has 25 teeth. Both gear and pinion are made of cast ironhaving allowable static strength of 55 MPa. Design a suitable spur gear drive andcheck the design for dynamic load and wear.	(14)
18		It is required to select a V-belt drive to connect a 15 kW, 2880 rpm normaltorque A.C. motor to a centrifugal pump, runningat approximately 2400 rpm, for a service of 18hours per day. The centre distance should beapproximately 400 mm. Assume that the pitchdiameter of the driving pulley is 125 mm.	(14)
		MODULE V	
19	a)	What is Sommerfeld number?	(2)
	b)	Design a journal bearing to support a load of 6 kN at 750 rpm, using hardened steel journal and bronze backed babbit bearing. The oil has a specific gravity of 0.9 at 15.5°C and a viscosity of 9 centistokes at 82°C which may be taken as limiting temperature for oil. Assume clearance of 0.003mm/mm diameter.	(12)
20	a)	Define static and dynamic load carrying capacity of ball bearing.	(2)
	b)	A single row deep groove ball bearing has a dynamic load capacity of 40210 N and operates on the work cycle consists of radial load of 2000 N at 1000 rpm for 25 % of the time, radial load of 5000 N at 1500 rpm for 50 % of time, and radial load of 3000 N at 700 rpm for the remaining 25 % of time. Calculate theexpected life of the bearing in hours.	(12)
		****	

Syllabus

Module I (10 Hours)

Introduction to Design- Definition, steps in design process, preferred numbers, standards and codes in design.

Shock and impact loads, fatigue loading, endurance limit stress, factors affecting endurance limit, factor of safety

Module II (8 Hours)

Threaded Joints- Terminology, thread standards, Selection of threaded joints. Bolted joints- effect of initial tension, eccentric loading, design of bolts for static and fatigue loading, gasketed joints, power screws.

Design of welded joints- welding symbols, stresses in fillet and butt welds, Butt joint in tension, fillet weld in tension, fillet joint under torsion, fillet weld under bending, eccentrically loaded welds.

Module III (8 Hours)

Springs- classification, spring materials, stresses and deflection of helical springs, Selection of springs, concentric springs, end constructions

Design of shafts and couplings-Shafting- material, design considerations, causes of failure in shafts, design based on strength, rigidity and critical speed, design for static and fatigue loads, repeated loading, reversed bending; Design of Coupling- selection, classification, rigid and flexible coupling, design of keys and pins

Module IV (10 Hours)

Gears- classification, Gear nomenclature, Tooth profiles, Materials of gears, virtual or formative number of teeth, gear tooth failures, Lewis equation, Buckingham's equation for dynamic load, wear load, endurance strength of tooth, surface durability, heat dissipation – lubrication of gears, Merits and demerits of each type of gears. Design of spur gear.
Basic idea of flat belt- materials for belts
Selection of V-belt drives, Advantages and limitations of V-belt drive

Module V (9 Hours)

Rolling contact bearing- Types, Selection of a bearing type, bearing life, static and dynamic load capacity, axial and radial loads, equivalent bearing load, selection of bearing life
Sliding contact bearing- modes of lubrication, lubricants, viscosity, Petroff's equation, Journal bearings, hydrodynamic theory, Sommerfeld number, friction guideways and LM guideways selection

Text Books

1. J. E. Shigley, Mechanical Engineering Design, McGraw Hill,2003

2.Jalaludeen , Machine Dsign, Anuradha Publications, 2016

3.V.B.Bhandari, Design of Machine elements, McGraw Hill, 2016

4. R. L. Norton, Machine Design – An Integrated Approach, Pearson Education, 2001

Data books permitted for reference in the final examination

1. K. Mahadevan, K.Balaveera Reddy, Design Data Hand Book, CBS Publishers & Distributors, 2013

2. NarayanaIyengar B.R &Lingaiah K, Machine Design Data Handbook, Tata McGraw Hill/Suma Publications, 1984

3. PSG Design Data, DPV Printers, Coimbatore, 2012

References Books

1. Juvinall R.C &Marshek K.M., Fundamentals of Machine Component Design, John Wiley, 2011

2. M. F. Spotts, T. E. Shoup, Design of Machine Elements, Pearson Education, 2006

3. RajendraKarwa, Machine Design , Laxmi Publications (P) LTD, New Delhi, 2006

4. Siegel, Maleev& Hartman, Mechanical Design of Machines, International Book Company, 1983

Course Contents and Lecture Schedule

Module	Contents	Hrs
1	Introduction to Design- Definition, steps in design process, preferred numbers, standards and codes in design.	4
	Shock and impact loads, fatigue loading, endurance limit stress, factors affecting endurance limit, factor of safety	6
2	Threaded Joints- Terminology, thread standards, Selection of threaded joints. Bolted joints- effect of initial tension, eccentric loading, design of bolts for static and fatigue loading, gasketed joints, power screws.	4
	Design of welded joints- welding symbols, stresses in fillet and butt welds, Butt joint in tension, fillet weld in tension, fillet joint under torsion, fillet wed under bending, eccentrically loaded welds.	4
3	Springs- classification, spring materials, stresses and deflection of helical springs, Selection of springs, concentric springs, end constructions	4
	Design of shafts and couplings-Shafting- material, design considerations, causes of failure in shafts, design based on strength, rigidity and critical speed, design for static and fatigue loads, repeated loading, reversed bending; Design of Coupling- selection, classification, rigid and flexible coupling, design of keys andpins	4
4	Gears- classification, Gear nomenclature, Tooth profiles, Materials of gears, virtual or formative number of teeth, gear tooth failures, Lewis equation, Buckingham's equation for dynamic load, wear load, endurance strength of tooth, surface durability, heat dissipation – lubrication of gears – Merits and demerits of each type of gears.	3
	Design of spur gear	3
	Basic idea of flat belt- materials for belts	1
	Selection of V-belt drives, Advantages and limitations of V-belt drive	3
5	Rolling contact bearing- Types, Selection of a bearing type, bearing life, static and dynamic load capacity, axial and radial loads, equivalent bearing load, selection of bearing life	2
	Design of Ball Bearings	2
	Sliding contact bearing- modes of lubrication, lubricants, viscosity, hydrodynamic theory, Petroff's equation, Journal bearings, Sommerfeld number	2
	Design of Journal bearings, Friction guideways and LM guideways selection	3