RAD416	PROJECT PHASE II	CATEGORY	L	T	P	CREDIT
		PWS	0	0	12	4

Preamble: The course 'Project Work' is mainly intended to evoke the innovation and invention skills in a student. The course will provide an opportunity to synthesize and apply the knowledge and analytical skills learned, to be developed as a prototype or simulation. The project extends to 2 semesters and will be evaluated in the 7th and 8th semester separately, based on the achieved objectives. One third of the project credits shall be completed in 7th semester and two third in 8th semester. It is recommended that the projects may be finalized in the thrust areas of the respective engineering stream or as interdisciplinary projects. Importance should be given to address societal problems and developing indigenous technologies.

Course Objectives

- To apply engineering knowledge in practical problem solving.
- To foster innovation in design of products, processes or systems.
- To develop creative thinking in finding viable solutions to engineering problems.

Course Outcomes [COs]: After successful completion of the course, the students will be able to:

CO1	Model and solve real world problems by applying knowledge across domains (Cognitive knowledge level: **Apply**).
CO2	Develop products, processes or technologies for sustainable and socially relevant applications (Cognitive knowledge level: **Apply**).
CO3	Function effectively as an individual and as a leader in diverse teams and to comprehend and execute designated tasks (Cognitive knowledge level: **Apply**).
CO4	Plan and execute tasks utilizing available resources within timelines, following ethical and professional norms (Cognitive knowledge level: **Apply**).
CO5	Identify technology/research gaps and propose innovative/creative solutions (Cognitive knowledge level: **Analyze**).
CO6	Organize and communicate technical and scientific findings effectively in written and oral forms (Cognitive knowledge level: **Apply**).

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	2	2	2	1	2	2	2	1	1	1	1	2
CO2	2	2	2		1	3	3	1	1		1	1
CO3									3	2	2	1
CO4					2			3	2	2	3	2
CO5	2	3	3	1	2							1
CO6					2			2	2	3	1	1

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	PO0	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Lifelong learning

PROJECT PHASE II

Phase 2 Targets

- In depth study of the topic assigned in the light of the report prepared under Phase - I;
- Review and finalization of the approach to the problem relating to the assigned topic.
- Preparing a detailed action plan for conducting the investigation, including teamwork.
- Detailed Analysis/ Modeling / Simulation/ Design/ Problem Solving/Experiment as needed.
- Final development of product/ process, testing, results, conclusions and future directions.
- Preparing a paper for Conference Presentation/ Publication in Journals, if possible.
- Presenting projects in Project Expos conducted by the University at the cluster level and/ or state level as well as others conducted in India and abroad.
- Filing Intellectual Property Rights (IPR) if applicable.
- Preparing a report in the standard format for being evaluated by the Department Assessment Board.
- Final project presentation and viva voce by the assessment board including the external expert.

Evaluation Guidelines & Rubrics

Total: 150 marks (Minimum required to pass: 75 marks).

- Project progress evaluation by guide: 30 Marks.
- Two interim evaluations by the Evaluation Committee: 50 Marks (25 marks for each evaluation).
- Final evaluation by the Final Evaluation committee: 40 Marks
- Quality of the report evaluated by the evaluation committee: 30 Marks

(The evaluation committee comprises HoD or a senior faculty member, Project coordinator and project supervisor. The final evaluation committee comprises of Project coordinator, expert from Industry/research/academic Institute and a senior faculty from a sister department).

Evaluation by the Guide

The guide/supervisor must monitor the progress being carried out by the project groups on regular basis. In case it is found that progress is unsatisfactory it should be reported to the Department Evaluation Committee for necessary action. The presence of each student in the group and their involvement in all stages of execution of the project shall be ensured by the guide. Project evaluation by the guide: 30 Marks. This mark shall be awarded to the students in his/her group by considering the following aspects:

Project Scheduling & Distribution of Work among Team members: Detailed and extensive Scheduling with timelines provided for each phase of project. Work breakdown structure well defined. (5)

Literature survey: Outstanding investigation in all aspects. (4)

Student's Diary/ Daily Log: The main purpose of writing daily diary is to cultivate the habit of documenting and to encourage the students to search for details. It develops the students' thought process and reasoning abilities. The students should record in the daily/weekly activity diary the day to day account of the observations, impressions, information gathered and suggestions given, if any. It should contain the sketches & drawings related to the observations made by the students. The daily/weekly activity diary shall be signed after every day/week by the guide. (7)

Individual Contribution: The contribution of each student at various stages. (9)

Completion of the project: The students should demonstrate the project to their respective guide. The guide shall verify the results and see that the objectives are met. (5)

EVALUATION RUBRICS for PROJECT Phase II: Interim Evaluation - 1

No.	Parameters	Marks	Poor	Fair	Very Good	Outstanding
2-a	Novelty of idea, and Implementation scope [CO5] [Group Evaluation]	5	The project is not addressing any useful requirement. The idea is evolved into a non-implementable one. The work presented so far is lacking any amount of original work by the team.	Some of the aspects of the proposed idea can be implemented. There is still lack of originality in the work done so far by the team. The project is a regularly done theme/topic without any freshness in terms of specifications, features, and/or improvements.	Good evidence of an implementable project. There is some evidence for the originality of the work done by the team . There is fresh specifications/ features/improvements suggested by the team. The team is doing a design from fundamental principles, and there is some independent learning and engineering ingenuity.	The project has evolved into incorporating an outstandingly novel idea. Original work which is not yet reported anywhere else. Evidence for ingenious way of innovation which is also Implementable. Could be a patentable / publishable work.
			(0 – 1 Marks)	(2 – 3 Marks)	(4 Marks)	(5 Marks)
2-b	Effectiveness of task distribution among team members. [CO3] [Group Evaluation]	5	No task distribution of any kind. Members are still having no clue on what to do.	Task allocation done, but not effectively, some members do not have any idea of the tasks assigned. Some of the tasks were identified but not followed individually well.	Good evidence of task allocation being done, supported by project journal entries, identification of tasks through discussion etc. However, the task distribution seems to be skewed, and depends a few members heavily than others. Mostly the tasks are being followed by the individual members.	Excellent display of task identification and distribution backed by documentary evidence of team brainstorming, and project journal entries. All members are allocated tasks according to their capabilities, and as much as possible in an equal manner. The individual members are following the tasks in an excellent manner.
			(0 – 1 Marks)	(2 – 3 Marks)	(4 Marks)	(5 Marks)
2-c	Adherence to project schedule. [CO4] [Group Evaluation]	5	Little or no evidence of continued planning or scheduling of the project. The students did not stick to the plan what they were going to build nor plan on what materials / resources to use in the project. The students do not have any idea on the budget required even after the end of phase - I. No project journal kept or the journal.	There is some improvement in the primary plan prepared during phase I. There were some ideas on the materials /resources required, but not really thought out. The students have some idea on the finances required, but they have not formalized a budget plan. Schedules were not prepared. The project journal has no useful details on the project.	Good evidence of planning done and being followed up to a good extent after phase I. Materials were listed and thought out, but the plan wasn't followed completely. Schedules were prepared, but not detailed, and needs improvement. Project journal is presented but it is neither complete nor updated regularly.	Excellent evidence of enterprising and extensive project planning and follow-up since phase I. Continued use of project management/version control tool to track the project. Material procurement if applicable is progressing well. Tasks are updated and incorporated in the schedule. A well-kept project journal showed evidence for all the above, in addition to the interaction with the project guide.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)

2-d	Interim Results. [CO6] [Group assessment]	**5**	There are no interim results to show.	The team showed some interim results, but they are not complete / consistent to the current stage, Some corrections are needed.	The interim results showed were good and mostly consistent/correct with respect to the current stage. There is room for improvement.	There were significant interim results presented which clearly shows the progress.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-e	Presentation [Individual assessment]	**5**	Very poor presentation and there is no interim results. The student has no idea about the project proposal.	Presentation is average, and the student has only a feeble idea about the team work.	Good presentation. Student has good idea about the team's project. The overall presentation quality is good.	Exceptionally good presentation. Student has excellent grasp of the project. The quality of presentation is outstanding.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
Phase-II Interim Evaluation - 1 Total Marks: 25						

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EVALUATION RUBRICS for PROJECT Phase II: Interim Evaluation – 2

No	Parameters	Marks	Poor	Fair	Very Good	Outstanding
2-f	Application of engineering knowledge [CO1] [Individual Assessment]	**10**	The student does not show any evidence of applying engineering knowledge on the design and the methodology adopted. The student's contribution in application of engineering knowledge in the project is poor.	The student appears to apply some basic knowledge, but not able to show the design procedure and the methodologies adopted in a comprehensive manner.	The student is able to show some evidence of application of engineering knowledge in the design and development of the project to good extent.	Excellent knowledge in design procedure and its adaptation. The student is able to apply knowledge from engineering domains to the problem and develop solutions.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)
2-g	Involvement of individual members [CO3] [Individual Assessment]	**5**	No evidence of any Individual participation in the project work.	There is evidence for some amount of individual contribution, but is limited to some of the superficial tasks.	The individual contribution is evident. The student has good amount of involvement in core activities of the project.	Evidence available for the student acting as the core technical lead and has excellent contribution to the project.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-h	Results and inferences upon execution [CO5] [Group Assessment]	**5**	None of the expected outcomes are achieved yet. The team is unable to derive any inferences on the failures/ issues observed. Any kind o f observations or studies are not made.	Only a few of the expected outcomes are achieved. A few inferences are made on the observed failures/issues. No further work suggested.	Many of the expected outcomes are achieved. Many observations and inferences are made, and attempts to identify the issues are done. Some suggestions are made for further work.	Most of the stated outcomes are met. Extensive studies are done and inferences drawn. Most of the failures are addressed and solutions suggested. Clear and valid suggestions made for further work.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-i	Documentation and presentation. ·[CO6] [Individual assessment]	**5**	The individual student has no idea on the presentation of his/her part. The presentation is of poor quality.	Presentation's overall quality needs to be improved.	The individual's presentation performance is satisfactory.	The individual's presentation is done professionally and with great clarity. The individual's performance is excellent.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
Phase-II Interim Evaluation - 2 Total Marks: 25						

EVALUATION RUBRICS for PROJECT Phase II: Final Evaluation						
No	**Parameters**	**Marks**	**Poor**	**Fair**	**Very Good**	**Outstanding**
2-j	Engineering knowledge. [CO1] [Group Assessment]	10	The team does not show any evidence of applying engineering knowledge on the design and the methodology adopted.	The team is able to show some of the design procedure and the methodologies adopted, but not in a comprehensive manner.	The team is able to show evidence of application of engineering knowledge in the design and development of the project to good extent. There is scope for improvement.	Excellent knowledge in design procedure and its adaptation. The team is able to apply knowledge from engineering domains to the problem and develop an excellent solution.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)
2-k	Relevance of the project with respect to societal and/or industrial needs. [Group Assessment] [CO2]	5	The project as a whole do not have any societal / industrial relevance at all.	The project has some relevance with respect to social and/or industrial application. The team has however made not much effort to explore further and make it better.	The project is relevant to the society and/or industry. The team is mostly successful in translating the problem into an engineering specification and managed to solve much of it.	The project is exceptionally relevant to society and/or industry. The team has made outstanding contribution while solving the problem in a professional and/ or ethical manner.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-i	Innovation / novelty / Creativity [CO5] [Group Assessment]	5	The project is not addressing any useful requirement. The idea is evolved into a non-implementable one. The work presented so far is lacking any amount of original work by the team.	Some of the aspects of the proposed idea appears to be practical. There is still lack of originality in the work done. The project is a regularly done theme/topic without any freshness in terms of specifications, features, and/ or improvements.	Good evidence of an implementable project. There is some evidence for the originality of the work done by the team. There is fresh specifications/ features/improvements suggested by the team. The team is doing a design from fundamental principles, and there is some independent learning and engineering ingenuity. Could be translated into a product / process if more work is done.	The project has evolved into incorporating an outstandingly novel idea. Original work which is not yet reported anywhere else. Evidence for ingenious way of innovation which is also Implementable. Could be a patentable publishable work.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
2-m	Quality of results / conclusions / solutions. [CO1] [Group Assessment]	10	None of the expected outcomes are achieved. The team is unable to derive any inferences on the failures/issues observed. Any kind of observations or studies is not made.	Only a few of the expected outcomes are achieved. A few inferences are made on the observed failures/issues. No further work suggested.	Many of the expected outcomes are achieved. Many observations and inferences are made, and attempts to identify the issues are done. Some suggestions are made for further work.	Most of the stated outcomes are met. Extensive studies are done and inferences drawn. Most of the failures are addressed and solutions suggested. Clear and valid suggestions made for further work.
			(0 – 3 Marks)	(4 – 6 Marks)	(7 - 9 Marks)	(10 Marks)

2-n	Presentation - Part I Preparation of slides. [CO6] [Group Assessment].	5	The presentation slides are shallow and in a clumsy format. It does not follow proper organization.	Presentation slides follow professional style formats to some extent. However, its organization is not very good. Language needs to be improved. All references are not cited properly, or acknowledged. Presentation slides needs to be more professional.	Presentation slides follow a good style format and there are only a few issues. Organization of the slides is good. Most of references are cited properly. The flow is good and team presentation is neatly organized. Some of the results are not clearly shown. There is room for improvement.	The presentation slides are exceptionally good. Neatly organized. All references cited properly. Diagrams/Figures, Tables and equations are properly numbered, and l i s ted. Results/ inferences clearly highlighted and readable.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
	Presentation - Part II: Individual Communication [CO6] [Individual Assessment].	5	The student is not communicating properly. Poor response to questions.	The student is able to explain some of the content. The student requires a lot of prompts to get to the idea. There are language issues.	Good presentation/ communication by the student. The student is able to explain most of the content very well. There are however, a few areas where the student shows lack of preparation. Language is better.	Clear and concise communication exhibited by the student. The presentation is outstanding. Very confident and tackles all the questions without hesitation. Exceptional traits of communicator.
			(0 - 1 Marks)	(2 - 3 Marks)	(4 Marks)	(5 Marks)
Phase-II Final Evaluation, Marks: 40						

EVALUATION RUBRICS for PROJECT Phase II: Report Evaluation						
Sl. No.	**Parameters**	**Marks**	**Poor**	**Fair**	**Very Good**	**Outstanding**
2-o	Report [CO6]	30	The prepared report is shallow and not as per standard format. It does not follow proper organization. Contains mostly unacknowledged content. Lack of effort in preparation is evident. References are not cited. Unprofessional and inconsistent formatting.	Project report follows the standard format to some extent. However, its organization is not very good. Language needs to be improved. All references are not cited properly in the report. There is lack of formatting consistency.	Project report shows evidence of systematic documentation. Report is mostly following the standard style format and there are only a few issues. Organization of the report is good. Mostly consistently formatted. Most of references/sources are cited/ acknowledged properly.	The report is exceptionally good. Neatly organized. All references cited properly. Diagrams/Figures, Tables and equations are properly numbered, and listed and clearly shown. Language is excellent and follows professional styles. Consistent formatting and exceptional readability.
			(0 - 11 Marks)	(12 - 18 Marks)	(19 - 28 Marks)	(29 - 30 Marks)
Phase - II Project Report Marks: 30						

RAT404	COMPREHENSIVE COURSE VIVA	CATEGORY	L	T	P	CREDIT
		PCC	1	0	0	1

Preamble: The objective of this Course viva is to ensure the basic knowledge of each student in the most fundamental core courses in the curriculum. The viva voce shall be conducted based on the core subjects studied from third to eighth semester. This course helps the learner to become competent in placement tests and other competitive examinations.

Guidelines

1. The course should be mapped with a faculty and classes shall be arranged for practicing questions based on the core courses listed in the curriculum.
2. The viva voce will be conducted by the same three member committee assigned for final project phase II evaluation. It comprises of Project coordinator, expert from Industry/research Institute and a senior faculty from a sister department.
3. The pass minimum for this course is 25.
4. The mark will be treated as internal and should be uploaded along with internal marks of other courses.
5. Comprehensive Viva should be conducted along with final project evaluation by the three member committee.

Mark Distribution

Total marks: 50, only CIE, minimum required to pass : 25 Marks

RAT478	AI FOR ROBOTICS	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: This course will introduce selected topics in Artificial Intelligence (AI) with a focus on Robotics. Develop a basic understanding of the building blocks of AI as presented in terms of intelligent agents: Search, Knowledge representation, inference, logic, and learning. Introduce concepts of expert systems and machine learning.

Prerequisite: Nil

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

CO 1	Identify and solve problems using appropriate AI methods.
CO 2	Formalize a given problem in the language/framework of different AI methods
CO 3	Describe the learning methods adopted in AI
CO 4	Perform an empirical evaluation of different algorithms on a problem formalization
CO 5	Interpret variousapplications of AI in Robotic 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	**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. Define the concept of Agent based Intelligence representation
2. Compare and contrast different types of search strategies

Course Outcome 2 (CO2):

1. What is planning and need of planning?
2. What is ontology in Al?

Course Outcome 3 (CO3):

1. What is Bayesian networks?
2. Explain different decision networks.

Course Outcome 4 (CO4):

1. Explain supervised, unsupervised and reinforcement learning with examples
2. Give a short note on Expert systems in AI.

Course Outcome 5 (CO5):

1. Ethical issues of AI in Robotics
2. Explain how robotics is a technology for future.

SYLLABUS

Module I (7 Hours)

Introduction and Problem solving

History, state of the art, Need for AI in Robotics. Thinking and acting humanly, intelligent agents, structure of agents.

Solving problems by searching –Informed search and exploration–Constraint satisfaction problems– Adversarial search,

Module II (7 Hours)

Knowledge representation and Planning

knowledge representation, first order logic.

Planning with forward and backward State space search – Partial order planning – Planning graphs– Planning with propositional logic – Planning and acting in real world.

Module III(8 Hours)

Reasoning and Decision making

Uncertainty – Probabilistic reasoning, Dynamic Bayesian Networks;
Basis of utility theory, decision theory, sequential decision problems;

Module IV(7 Hours)

Learning and Expert System

Forms of learning – Knowledge in learning – Statistical learning methods –reinforcement learning, communication, perceiving and acting, Probabilistic language processing, and perception.

Module V (6 Hours)

AI In Robotics and Applications

Robotic perception, localization, mapping- configuring space, planning uncertain movements, dynamics and control of movement, Ethics and risks of artificial intelligence in robotics

Text Books

1. Stuart Russel, Peter Norvig, “Artificial Intelligence: A modern approach” Pearson Education, India,2016
2. Kevin Murphy, Machine Learning; A Probabilistic Perspective (MLAPP), MIT Press,2012

3. Negnevitsky, M, "Artificial Intelligence: A guide to Intelligence Systems", Harlow:AddisonWesley,2002
4. Introduction to Robotics by S K Saha, McGraw Hill Education
5. Introduction to Autonomous Mobile Robots, Siegwart, Roland, Cambridge, Mass. : MIT Press, 2nd ed.

Reference Books

1. Robin Murphy, Robin R. Murphy, Ronald C. Arkin,"Introduction to AI Robotics"MIT Press,2000
2. David Jefferis, "Artificial Intelligence: Robotics and Machine Evolution", Crabtree Publishing Company, 1992
3. Fransis X. Govers, "Artificial Intelligence for Robotics", Packt Publishing, 2018
4. Sicilliano, Khatib , "Handbook of Robotics", Springer
5. John J. Craig, Introduction to Robotics – Mechanics and Control

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**MODULE 1: Introduction to AI and Problem Solving**	
1.1	Foundations of AI, need for AI in Robotics., Thinking and acting humanly;	2
1.2	Intelligent agents: reactive, deliberative, goal-driven, utility driven and learning agent;	2
1.3	Problem solving: Solving problems by searching: Forward and backward, Informed search and exploration, Constraint satisfaction problems, Adversarial search;	3
2	**MODULE 2: Knowledge representation and Planning**	
2.1	Knowledge representations and reasoning: Ontologies, Foundations of knowledge representation and reasoning, representing and reasoning about objects, relations, events, actions, time and space. First order logic;	4
2.2	Planning with forward and backward state space search, Partial order planning, Construction and use of planning graphs, planning with propositional logic, Planning and acting in real world;	3
3	**MODULE 3: Reasoningand Decision making**	
3.1	Reasoning with uncertain knowledge: Probabilistic reasoning- Filtering and prediction,	2
3.2	Hidden Markov Models, connection to logic, Baye's rule, Dynamic	3

	Bayesian Networks	
3.3	Decision making: Basis of utility theory, decision theory, sequential decision problems, elementary game theory, sample applications;	3
4	**MODULE 4: Learning and Expert System**	
4.1	Forms of learning – Knowledge in learning – Statistical learning methods –reinforcement learning, communication, perceiving and acting, Probabilistic language processing, and perception;	4
4.2	Expert System: Introduction to expert system, Phases of expert system, characteristics of expert system and a case study;	3
5	**MODULE 5: AI in Robotics and its Applications**	
5.1	AI In Robotics: Robotic perception, localization, mapping- configuring space, planning uncertain movements, dynamics and control of movement, Ethics and risks of artificial intelligence in robotics;	3
5.2	Robotics and Its applications, DDD concept, Intelligent robots, Accuracy and repeatability of Robotics-Simple problems;	3

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
EIGHTH -SEMESTER B.TECH. DEGREE EXAMINATION

Course Code: RAT478

Course Name: AI For Robotics

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1	Describe the PEAS description of a task environment.	(3)
2	Explain depth bounded DFS (Depth Limited DFS) algorithm with an example.	(3)
3	Explain the concept of ontological engineering.	(3)
4	How is description logic suitable to represent definitions and properties of categories of objects?	(3)
5	What are the problem areas of spatial reasoning?	(3)
6	State value of perfect information and its properties	(3)
7	Mention any five characteristics of expert system	(3)
8	What is a near miss situation in case of Concept learning?	(3)

9 Differentiate between various types of drives used for robot system. (3)

10 Which design approach is similar to object-oriented design in DDD? List the common terms under design tool? (3)

PART B

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

MODULE I

11 a) What is an agent? Explain how it can interact with the environment? "Surely computers cannot be intelligent—they can do only what their programmers tell them." Is the latter statement true, and does it imply the former? (9)

b) For the activity named 'Playing soccer' give a PEAS description of the task environment and its characteristics (5)

12 a) The initial state and final state of an 8-puzzle problem is given below. Compute the heuristic function and solve using an informed search algorithm. (8)

Initial state

1	2	3
4	6	
7	5	8

Final state

1	2	3
4	5	6
7	8	

b) What are the disadvantages of hill climbing approach? Is simulated annealing a better solution when compared to hill climbing? (6)

MODULE II

13 a) Using knowledge reasoning how can you reason the default information? (7)

b) Explain knowledge-based agent. Give an example for a knowledge-based agent. Describe the environment of a knowledge –based agent. (7)

14 a) How is planning graph used for heuristic estimation? Explain (7)

b) Represent the following sentences in first-order logic, using a consistent vocabulary (which you must define): (7)

a. Some students took French in spring 2001.

b. Every student who takes French passes it.

c. Only one student took Greek in spring 2001.

d. The best score in Greek is always higher than the best score in French.

e. Every person who buys a policy is smart.

f. No person buys an expensive policy.

g. There is an agent who sells policies only to people who are not insured.

MODULE III

15 a) How AI handles reasoning under uncertainty. Explain with example. (6)

b) Explain the following with examples: (8)

(i) Forward reasoning
(ii) Non-Monotonic Reasoning

16 a) For the 4 × 3 world shown in Figure, calculate which squares can be reached from (1,1) by the action sequence [Up, Up, Right, Right, Right] and with what probabilities. (7)
Explain how this computation is related to the prediction task for a hidden Markov model.

b) Illustrate decision networks with an example in detail. (7)

MODULE IV

17 a) Differentiate between the various learning methods: neural networks, reinforcement learning and genetic algorithms. (7)

b) What is an expert system? Draw the architecture and explain each block in detail. (7)

18 a) How forward chaining is different from backward chaining inference method? (5)

b) Consider the following case, (9)

"As per the law, it is a crime for an American to sell weapons to hostile nations. Country A, an enemy of America, has some missiles, and all the missiles were sold to it by Robert, who is an American citizen."

Prove that **"Robert is criminal."** using Forward chaining algorithm.

MODULE V

19	a)	What is mobile robot localization? Why it is important? How the landmark is measured in robot localization?	(8)
	b)	Explain ethics and risks of artificial intelligence in robotics	(6)
20	a)	Describe basic structure of a robotic system with neat sketch.	(7)
	b)	Robots find applications not only in industry. Explain three non-industrial applications of Robots.	(7)

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RAT468	ADAPTIVE CONTROL	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: This paper will make the learners to acquire knowledge about the controllers that could adapt to changes in process dynamics and disturbance characteristics.

Prerequisites: Nil

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

CO 1	Understand the adaptive control system with an introduction to adaptive schemes.
CO 2	Design self- tuning controllers.
CO3	Design stochastic self -tuning controllers.
CO4	Understand Model Reference Adaptive Control systems

Mapping of course outcomes with program outcomes

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12
CO 1	3	3	1									
CO 2	3	3	2									
CO 3	3	3	2									
CO 4	3	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 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 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 basics of adaptive control system.
2. Explain adaptive control schemes.

Course Outcome 2 (CO2):

1. Explain pole placement techniques.
2. Explain different self-tuning controllers.

Course Outcome 3 (CO3):

1. Explain the stochastic self-tuning regulators.
2. Discuss minimum phase and moving average controllers.

Course Outcome 4 (CO4):

1. Explain the Model reference adaptive controllers.
2. Discuss applications of adaptive control.
3. Explain properties of adaptive control systems.

SYLLABUS

Module I(8 Hours)

Introduction to adaptive control; linear feedback; Effects of process variations; Adaptive schemes. Applications of adaptive control systems, Direct and indirect adaptive control

Module II (7 Hours)

Introduction to self-tuning regulators- Pole placement design-pole placement design, Indirect self-tuning controllers, Continuous time self -tuner, Direct self -tuning regulators,

Module III (7 Hours)

Introduction to Stochastic self-tuning regulators- Design of minimum variance and moving average controllers.

Stochastic Self tuning regulators: stochastic Indirect self-tuning regulator-Unification of direct self- tuning regulators Adaptive Predictive Control.

Module IV (7 Hours)

Introduction to model-reference adaptive systems; MIT Rule, Lyapunov theory, design of MRAS using Lyapunov theory; Bounded-input bounded-output stability; applications to adaptive control.

Module V (7 Hours)

Properties of Adaptive Systems: Nonlinear dynamics, Analysis of Indirect discrete time self-tuners, Stability of direct discrete time algorithms, Averaging, Application of averaging techniques, Averaging in stochastic systems, Robust adaptive controllers.

Text Books:

1. Karl J Astrom and Bjorn Wittenmark, “Adaptive Control”, Pearson Education Inc., New Delhi, 2008

Reference Books

1. Ioannou P A and Sun J, “Robust Adaptive Control”, Prentice Hall, 1996.
2. Krstic M, Kanellakopoulos I and Kokotovic P, “Nonlinear and Adaptive Control Design”, Wiley -Interscience , 1995.
3. Chalam V V, “Adaptive Control Systems – Techniques and Applications”, Marcel Dekkar Inc., NewJersey, 1987.
4. Shankar Sastry and Marc Bodson, “Adaptive Control – Stability, Convergence and Robustness”, Prentice Hall Englewood Cliffs, New Jersey, 1989

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1		
1.1	Introduction to adaptive control; linear feedback	1
1.2	Effects of process variations	2
1.3	Adaptive schemes	2
1.4	Applications of adaptive control systems	1
1.5	Direct and indirect adaptive control	1
2		
2.1	Pole Placement design-pole placement design	2
2.2	Indirect self-tuning controllers	2
2.3	Continuous time self -tuner	2
2.4	Direct self -tuning regulators	1
3		
3.1	Design of minimum variance and moving average controllers	2
3.2	stochastic Indirect self tuning regulator	1
3.3	Unification of direct self tuning regulators	2
3.4	Unification of direct self tuning regulators Adaptive Predictive Control.	2
4		
4.1	Introduction to model-reference adaptive systems; MIT Rule	3
4.2	Lyapunov theory, design of MRAS using Lyapunov theory	2
4.3	Bounded-input bounded-output stability; applications to adaptive control.	2
5		
5.1	Properties of Adaptive Systems: Nonlinear dynamics, Analysis of Indirect discrete time self-tuners	2
5.2	Stability of direct discrete time algorithms	2
5.3	Averaging, Application of averaging techniques, Averaging in stochastic systems, Robust adaptive controllers.	3

Model Question Paper

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

Course Code: RAT468

Course Name: ADAPTIVE CONTROL

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1		Enumerate how the controller is becoming non linear in an adaptive control system.	(3)
2		Discuss the reason for ringing.	(3)
3		Express the Bezout identity.	(3)
4		Differentiate between minimum phase and non-minimum phase systems.	(3)
5		Summarize the properties of Minimum Variance controller	(3)
6		Discuss the properties of self-turning regulators	(3)
7		Define MIT Rule	(3)
8		State the Lyapunov's condition for stability of linear system.	(3)
9		What is meant by Robust adaptive controller.	(3)
10		Discuss the use of Gronwall-Bellman lemma.	(3)

PART B

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

MODULE 1

11	a)	Discuss the effect of changes in process variations in performance of a control system.	(8)
	b)	Discuss the direct and indirect adaptive control system. Discuss about moving average controller.	(6)
12	a)	Consider a process described by $G_0(s) = \frac{k_p}{s}$, The sign of the gain kp is unknown. Discuss the conditions for the system to be stable.	(6)
	b)	Summarize the different adaptive schemes.	(8)

MODULE II

13	a)	Consider a process $G(s) = \frac{1}{s(s+a)}$ where a is a unknown parameter. Assume that the desired closed loop system is $G_{m(s)=\frac{w^2}{s^2+2\zeta ws+w^2}}$. Construct continuous time indirect self-tunning algorithm for the system.	(8)

	b)	Develop an algorithm for indirect self-tuning controller without zero cancellation.	(6)
14	a)	Consider the process $G(S) = \frac{1}{S(S+5)}$. Desired closed loop system is $G_d(S) = \frac{4}{S^2+3S+4}$. Construct an indirect self-tuning algorithm for this system.	(8)
	b)	Discuss different pole placement designs	(6)

MODULE III

15	a)	Employ the design steps for a minimum variance controller	(7)
	b)	Discuss adaptive predictive control	(7)
16	a)	Articulate the design steps of a moving average controller.	(14)

MODULE IV

17	a)	Explain methods for constructing Lyapunov functions for linear systems with an example in each case	(14)
18	a)	Discuss about the design MRAS using Lyapunov theory.	(8)
	b)	Explain the passivity theorem	(6)

MODULE V

19	a)	Write short notes on the applications of averaging techniques	(7)
	b)	Explain Robust adaptive controllers	(7)
20	a)	Discuss the conditions for stability of non-linear systems	(8)
	b)	Highlight the algorithm for stability of direct discrete time systems	(6)

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RAT458	HUMAN-MACHINE INTERFACE	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: To get knowledge about the state-of-the-art human machine interactive systems.

Prerequisite: Nil

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

CO 1	Understand the basics of human and computational abilities and limitations.
CO 2	Design GUIs for human computer interactions.
CO3	Understand the fundamental aspects of designing mobile ecosystems.
CO4	Design the web based interaction systems
CO5	apply appropriate HMI modalities and sensors to design systems that are usable by people.

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What are the fundamental elements in human computer interaction systems.
2. Explain the role of human factors in design.

Course Outcome 2 (CO2):

1. Explain the models of interaction.
2. What are the features of ergonomics in interaction?

Course Outcome 3 (CO3):

1. Explain the mobile ecosystem for interaction.
2. Explain the widgets in mobiles.

Course Outcome 4 (CO4):

1. Explain the web interfaces and their design for interaction
2. Explain the case studies for web based interaction.

Course Outcome 5 (CO5):

1. Explain the role of haptics in interaction.
2. Explain the various displays and projections used for human-machine interaction.

SYLLABUS

Module I (6 Hours)

Introduction to HMI -Natural Communication, types of human-machine interfaces, Human perception and recognition, Psychology of users, attention, thinking, perception of visual, sound and haptic incitements. Multimodality, concept of combined reality, virtual reality, technologies, existing scientific and commercial projects.

Module II (7 Hours)

The interaction: Models of interaction, the terms of interaction, interaction framework, the ergonomics of interaction, interaction styles, WIMP interface, Experience, engagement and fun, paradigm of interaction

Module III(7 Hours)

Mobile Ecosystem: Platforms, Application frameworks- Types of Mobile Applications: Widgets, Applications, Games- Mobile Information Architecture, Mobile 2.0, Mobile Design: Elements of Mobile Design, Tools. - Case Studies

ModuleIV(7 Hours)

Designing Web Interfaces – Drag & Drop, Direct Selection, Contextual Tools, Overlays, Inlays and Virtual Pages, Process Flow - Case Studies

Module V(8 Hours)

Technologies and concepts. Haptic interfaces, Haptic perception and recognition,sensors for sensing of fingers, hands and touching, interactive digital surfaces, manipulation of digital objects, displays with rear projection.Sound interaction. Basics of acoustics.Psychoacoustics. Analysis and synthesis of sound.

Text Books:

1. Alan Dix, Janet Finlay, Gregory Abowd, Russell Beale Human Computer Interaction, 3rd Edition Prentice Hall, 2004.
2. Brian Fling, ―Mobile Design and Development‖, First Edition, O‘Reilly Media Inc., 2009
3. Bill Scott and Theresa Neil, ―Designing Web Interfaces‖, First Edition, O‘Reilly, 2009.
4. Subhas Chandra Mukhopadhyay and Tarikul Islam, Wearable Sensors Applications, design and implementation, IOP Science 2017
5. Haptics and Haptic Interfaces
6. Katherine Kuchenbecker, Haptics and Haptics interfaces, https://doi.org/10.1007/978-3-642-41610-1_19-1

7. https://www.researchgate.net/publication/3663200_Multimodal_interfaces_with_voice_and_gesture_input

Reference Books

1. Jonathan Lazar Jinjuan Heidi Feng, Harry Hochheiser, Research Methods in Human Computer Interaction, Wiley, 2010.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1		
1.1	Introduction to HMI -Natural Communication, types of human-machine interfaces, Human perception and recognition, Psychology of users, attention, thinking	2
1.2	perception of visual, sound and haptic incitements.	2
1.3	Multimodality, concept of combined reality, virtual reality, technologies, existing scientific and commercial projects	2
2		
2.1	The interaction: Models of interaction, the terms of interaction, interaction framework	2
2.2	the ergonomics of interaction	3
2.3	interaction styles, WIMP interface, Experience, engagement and fun, paradigm of interaction	2
3		
3.1	Mobile Ecosystem: Platforms, Application frameworks	2
3.2	Types of Mobile Applications: Widgets, Applications, Games- Mobile Information Architecture,	3
3.3	Mobile 2.0, Mobile Design: Elements of Mobile Design, Tools. - Case Studies	2
4		
4.1	Designing Web Interfaces – Drag & Drop, Direct Selection,	2
4.2	Contextual Tools, Overlays, Inlays and Virtual Pages	2
4.3	Process Flow - Case Studies	3
5		
5.1	Technologies and concepts. Haptic interfaces, Haptic perception and	2

	recognition,.	
5.2	sensors for sensing of fingers, hands and touching, interactive digital surfaces, manipulation of digital objects, displays with rear projection.	3
5.3	Sound interaction. Basics of acoustics.Psychoacoustics. Analysis and synthesis of sound	3

Model Question Paper

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

Course Code: RAT458
Course Name: HUMAN MACHINE INTERFACE

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1	Explain how the concept of virtual reality is integrated into human machine interaction systems.	(3)
2	Explain the concept of multimodality	(3)
3	What is meant by command line interaction.	(3)
4	Illustrate the designing experience.	(3)
5	List out the layers of the mobile ecosystem.	(3)
6	What is meant by application framework?	(3)
7	List any five events available for cueing the user during a drag and drop interaction?	(3)
8	What is a web widget?	(3)
9	Write a short note on psychoacoustics.	(3)
10	Explain the working principle of a touch sensor.	(3)

PART B

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

MODULE1

11	a)	Describe the different perceptions of visual system.	(7)
	b)	With an example illustrate optical illusion	(7)

12	a)	Illustrate the role of psychology of users in design.	(6)
	b)	Explain the concept of multimodality, combined modality and virtual reality in human machine interactive systems.	(8)

MODULE II

13	a)	Explain interaction framework in detail.	(8)
	b)	What are the elements of WIMP interface.	(6)
14		Discuss the features of ergonomics in physical interaction in detail	(14)

MODULE III

15	a)	Disuse about mobile design tools.	(8)
	b)	Discuss in detail about Mobile Web Widgets.	(6)
16	a)	Write detailed note on platforms in mobile ecosystem.	(8)
	b)	Discuss about different mobile elements like typography, palatte.	(6)

MODULE IV

17	a)	What is meant by virtual pages.	(6)
	b)	Draw the schematic of a drag and drop selection.	(8)
18	a)	Explain the steps for designing a web interface for an agriculture store with proper steps.	(14)

MODULE V

19	a)	Explain the different sensors for fingers, hands and touching in detail	(14)
20	a)	Explain the different types of displays and projections used for interaction..	(8)
	b)	Highlight the methods through which haptics interfaces are done	(6)

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RAT448	ROBOT NAVIGATION	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Robot navigation deals with the ability of the robot to determine its own position in its frame of reference and then to plan a path towards a goal location. Students will learn the various aspects and techniques associated with robot navigation.

Prerequisite: RAT301 Introduction to Robotics

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

CO 1	Describe sensors for perception in navigation
CO 2	Compare various methods for robot localization
CO 3	Explain the techniques of motion in Potential Field and Navigation Function
CO 4	Use information from satellites for navigation
CO 5	Apply SLAM and Occupancy Grid mapping to localization and mapping in robot navigation

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	20	10	20
Understand	30	20	40
Apply		20	40
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 terms perception and localization.
2. Describe odometry sensor with necessary diagrams.
3. Explain color tracking sensors.

Course Outcome 2 (CO2):

1. Describe Markov localization.
2. Compare Localization-Based Navigation versus Programmed Solutions.
3. Describe any two challenges of the localization problem.

Course Outcome 3 (CO3):

1. Define configuration space and free configuration space.
2. Describe the technique of Gradient Descent without constraints.
3. Derive the navigation function in static deterministic environments.

Course Outcome 4 (CO4):

1. Describe Trilateration with necessary diagrams.
2. Describe the issues associated with Urban Navigation using GNSS and the solutions.
3. Outline the threats to GNSS.

Course Outcome 5 (CO5):

1. Distinguish between the online SLAM and full SLAM problems.
2. Explain multi sensor data fusion for mapping.
3. Explain the SLAM algorithm for the case with known correspondence.

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SYLLABUS

Module I (6 Hours)

Building blocks of navigation: Definitions - perception, localization, cognition, motion control

Perception: Sensors for Perception - Schematic representation of the sensing unit, Obstacle Sensor (Bumper), the odometry sensor, Heading sensors - Gyroscopes, IMUs, Distance sensors - ToF, Phase shift, triangulation, ultrasonic rangefinders, Ground based beacons, GPS, Motion field and optical flow, Color tracking sensors, Feature Extraction - Feature Definition, Target Environment, Environment representation

Module II (8 Hours)

Localization: General schematic for mobile robot localization, Challenge of Localization - Sensor noise and Sensor aliasing, Effector noise, Error model for odometric position estimation

Localization-Based Navigation versus Programmed Solutions, Belief Representation, Map Representation - Continuous Representation, Decomposition Strategies, current challenges in map representation, Probabilistic Map-Based Localization - Markov localization, Kalman filter localization, Application to mobile robots: Kalman filter localization - schematic, Robot position prediction, Observation, Measurement prediction, Matching, Estimation, Landmark-based navigation, Globally unique localization, Positioning beacon systems, Route-based localization, Autonomous Map Building - stochastic map technique, Challenges - Cyclic environments, Dynamic environments

Module III (7 Hours)
Motion in Potential Field and Navigation Function

Problem Statement, configuration space, free configuration space, Gradient Descent Method of Optimization, Gradient Descent without and with Constraints, Minkowski Sum, Potential Field, Navigation Function - in Static Deterministic Environment, in Static Uncertain Environment, Navigation Function and Potential Fields in Dynamic Environment - Estimation, Prediction, Optimization

Module IV (7 Hours)
Satellite Navigation

Introduction to Satellite Navigation, Trilateration, Position Calculation - Multipath Signals, GNSS Accuracy Analysis, Dilution of Precision, Coordinate Systems, UTM Projection, Local Cartesian Coordinates, Velocity Calculation, Urban Navigation - Urban Canyon Navigation, Map Matching, Dead Reckoning – Inertial Sensors, Incorporating GNSS Data with INS - Modified Particle Filter, Estimating Velocity by Combining GNSS and INS, A-GPS, DGPS Systems,, RTK Navigation, GNSS Threats

Module V (7 Hours)

Simultaneous Localization and Mapping SLAM:

Introduction to SLAM, SLAM with Extended Kalman Filters - Setup and Assumptions, SLAM with known correspondence (mathematical derivation not required), SLAM with unknown correspondences, The General EKF SLAM Algorithm, Feature Selection and Map Management

SLAM implementation in ROS (Assignment only)

Occupancy Grid Mapping - the Occupancy Grid Mapping Algorithm, Multi sensor fusion, Learning Inverse Measurements Models - Inverting the measurement model, Sampling from the Forward Model, The Error Function

Text Books

1. Introduction to Autonomous Mobile Robots, Roland Siegwart and Illah R. Nourbakhsh, MIT Press
2. Autonomous Mobile Robots and Multi-Robot Systems - Motion-Planning, Communication, and Swarming, Kagan, Shvalb, Ben-Gal, Wiley
3. Probabilistic Robots, Thrun, Burgard, Fox, MIT Press

Reference Books

1. Planning Algorithms, Steven M. LaValle, Cambridge University Press
2. Robot Motion Planning, Jean- Claude Latombe, Springer Science+Business Media

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Building blocks of navigation**	
1.1	Definitions - perception, localization, cognition, motion control **Perception:** Sensors for Perception - Schematic representation of the sensing unit	1
1.2	Obstacle Sensor (Bumper), the odometrysensor,Heading sensors - Gyroscopes, IMUs	2
1.3	Distance sensors - ToF, Phase shift, triangulation, ultrasonic rangefinders, Ground based beacons, GPS, Motion field and optical flow	2
1.4	Color tracking sensors, Feature Extraction - Feature Definition, Target Environment, Environment representation	1
2	**Localization**	
2.1	General schematic for mobile robot localization, Challenge of Localization - Sensor noise and Sensor aliasing, Effector noise, Error	1

	model for odometric position estimation	
2.2	Localization-Based Navigation versus Programmed Solutions, Belief Representation, Map Representation - Continuous Representation, Decomposition Strategies, current challenges in map representation	2
2.3	Probabilistic Map-Based Localization - Markov localization, Kalman filter localization, Application to mobile robots: Kalman filter localization - schematic, Robot position prediction, Observation, Measurement prediction, Matching, Estimation	3
2.4	Landmark-based navigation, Globally unique localization, Positioning beacon systems, Route-based localization, Autonomous Map Building - stochastic map technique, Challenges - Cyclic environments, Dynamic environments	2
3	**Motion in Potential Field and Navigation Function**	
3.1	Problem Statement, configuration space, free configuration space, Gradient Descent Method of Optimization, Gradient Descent without and with Constraints, Minkowski Sum	4
3.2	Navigation Function - in Static Deterministic Environment, in Static Uncertain Environment, Potential Field, Navigation Function and Potential Fields in Dynamic Environment - Estimation, Prediction, Optimization	3
4	**Satellite Navigation**	
4.1	Introduction to Satellite Navigation, Trilateration, Position Calculation - Multipath Signals, GNSS Accuracy Analysis, Dilution of Precision, Coordinate Systems, UTM Projection, Local Cartesian Coordinates, Velocity Calculation	3
4.2	Urban Navigation - Urban Canyon Navigation, Map Matching, Dead Reckoning – Inertial Sensors, Incorporating GNSS Data with INS - Modified Particle Filter, Estimating Velocity by Combining GNSS and INS	3
4.3	A-GPS, DGPS Systems,, RTK Navigation, GNSS Threats	1
5	**Simultaneous Localization and Mapping SLAM**	
5.1	Introduction to SLAM, SLAM with Extended Kalman Filters - Setup and Assumptions, SLAM with known correspondence (mathematical derivation not required), SLAM with unknown correspondences, The General EKF SLAM Algorithm, Feature Selection and Map Management SLAM implementation in ROS (Assignment only)	4
5.2	Occupancy Grid Mapping - the Occupancy Grid Mapping Algorithm, Multi sensor fusion, Learning Inverse Measurements Models - Inverting	3

	the measurement model, Sampling from the Forward Model, The Error Function	

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
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Estd.
2014

Model Question Paper

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

Course Code: RAT 448

Course Name: Robot Navigation

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1		Describe the working of the bumper obstacle sensor.	(3)
2		Explain the terms perception and localization.	(3)
3		Describe any two challenges of the localization problem.	(3)
4		Distinguish between map building in cyclic and dynamic environments.	(3)
5		Define configuration space and free configuration space.	(3)
6		Summarize the Gradient Descent Method of Optimization.	(3)
7		Explain how the accuracy of GNSS is analysed and improved.	(3)
8		Outline the threats to GNSS.	(3)
9		Distinguish between the online SLAM and full SLAM problems.	(3)
10		Summarize the factors that affect the hardness of a mapping problem.	(3)

PART B

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

MODULE1

11	a)	Describe a sensing unit using a block schematic representation.	(7)
	b)	Explain Motion field and optical flow techniques.	(7)
12	a)	Describe odometry sensor with necessary diagrams.	(7)
	b)	Explain color tracking sensors.	(7)

MODULE II

13	a)	Compare Localization-Based Navigation versus Programmed Solutions.	(7)
	b)	Describe Markov localization.	(7)
14	a)	Explain in detail Kalman filter localization.	(14)

MODULE III

15	a)	Describe the technique of Gradient Descent without constraints.	(7)
	b)	Derive the navigation function in static deterministic environments.	(7)
16	a)	Explain how the Navigation Function and Potential Fields are considered in dynamic environments.	(14)

MODULE IV

17	a)	Summarize the various coordinate systems used in GNSS.	(7)
	b)	Describe Trilateration with necessary diagrams.	(7)
18	a)	Describe the issues associated with Urban Navigation using GNSS and the	(7)
	b)	solutions. Explain how modified particle filters can be used to solve the problem due to multipath signals in obtaining position.	(7)

MODULE V

19	a)	Explain multi sensor data fusion for mapping.	(7)
	b)	Derive the error function for the inverse measurement models.	(7)
20	a)	Explain the SLAM algorithm for the case with known correspondence.	(14)

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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
KTU
Estd.
2014

RAT438	COOPERATIVE ROBOTICS	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: This course helps the student to have a basic idea of Cooperative robotics. Students are introduced to the basic design consideration of algorithms. Discussion on various control problems, consensus algorithms and their applications are also included as part of the course to get an overall idea on this topic.

Prerequisite: Nil

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

CO 1	Familiarise with various robotic components and controllers
CO 2	Describe various design approaches
CO 3	Understand various consensus algorithms and their applicability
CO 4	Analyse the use of coupling in cooperative control problems
CO 5	Apply distributed cooperative control problems with and without an optimization objective
CO 6	Familiarise various applications to multivehicle cooperative control

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Differentiate between effector and actuator in robots.
2. What is meant by Degrees of Freedom?

Course Outcome 2 (CO2):

1. Differentiate between top-down and bottom-up approaches with the help of examples.

Course Outcome 3 (CO3):

1. Differentiate between Formation Manoeuvring and Flocking.
2. Explain Lyapunov Analysis of Consensus Algorithms.

Course Outcome 4 (CO4):

1. Differentiate between Objective Coupling and Local Coupling.
2. What is meant by Dynamic coupling?

Course Outcome 5 (CO5):

1. Differentiate between centralized and decentralized architecture.
2. How to find formation control strategies for each spacecraft

SYLLABUS

Module I (6 Hours)

Introduction to robotics: Components, Odometry, Kinematics, Control, Finite State Machines as Robot Controllers, State Transitions Based on Robot–Robot Interactions, Early Micro-Macro Problems, Macroscopic Perspective, Expected Macroscopic Dynamics and Feedbacks

Module II (7 Hours)

Discrete Consensus Achievement in Artificial Systems: Consensus Achievement, The Best-of-n Problem, Overview of Current Design Approaches, Bottom–Up Design Approaches, Top–Down Design Approaches

Module III (7 Hours)

Consensus Algorithms in Cooperative Control: Fundamental Consensus Algorithms, Convergence Analysis of Consensus Algorithms, Synthesis and Extensions of Consensus Algorithms, Design of Coordination Strategies via Consensus Algorithms.

Module IV (7 Hours)

Consensus-based Design Methodologies for Distributed Multivehicle Cooperative Control:

Coupling in Cooperative Control Problems: Objective Coupling, Local Coupling, Full Coupling, Dynamic Coupling

Approach to Distributed Cooperative Control Problems with an Optimization Objective: Cooperation Constraints and Objectives, Coordination Variables and Coordination Functions, Centralized Cooperation Scheme, Consensus Building

Approach to Distributed Cooperative Control Problems Without an Optimization Objective: Coordination Variable Constituted by a Group-level Reference State, Coordination Variable Constituted by Vehicle States

Module V (7 Hours)

Applications to Multivehicle Cooperative Control: Rendezvous and Axial Alignment with Multiple Wheeled Mobile Robots, Distributed Formation Control of Multiple Wheeled Mobile Robots with a Virtual Leader, Deep Space Spacecraft Formation Flying, Cooperative Fire Monitoring with Multiple UAVs, Cooperative Surveillance with Multiple UAVs

Text Books

1. Hamann, Heiko, Swarm robotics: A formal approach, Springer, 2018.
2. Ren, Wei, and Randal W. Beard, Distributed consensus in multi-vehicle cooperative control, Springer London, 2008.
3. Valentini, Gabriele. "Achieving consensus in robot swarms", Studies in computational intelligence, 2017.

Reference Books

1. Mahulea, Cristian, Marius Kloetzer, and Ramón González, Path planning of cooperative mobile robots using discrete event models, John Wiley & Sons, 2020.
2. Koubâa, Anis, and AbdelmajidKhelil, Cooperative Robots and Sensor Networks 2014, Springer, 2014.
3. Asama, Hajime, Toshio Fukuda, Tamio Arai, and Isao Endo, Distributed autonomous robotic systems 2, Springer Science & Business Media, 2013.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**MODULE 1**	
1.1	**Introduction to robotics:** Components, Odometry, Kinematics, Control, Finite State Machines as Robot Controllers, State Transitions Based on Robot–Robot Interactions, Early Micro-Macro Problems, Macroscopic Perspective, Expected Macroscopic Dynamics and Feedbacks	6
2	**MODULE 2**	
2.1	**Discrete Consensus Achievement in Artificial Systems:** Consensus Achievement, The Best-of-n Problem, Overview of Current Design Approaches, Bottom–Up Design Approaches, Top–Down Design Approaches	7
3	**MODULE 3**	
3.1	**Consensus Algorithms in Cooperative Control:** Fundamental Consensus Algorithms, Convergence Analysis of Consensus Algorithms, Synthesis and Extensions of Consensus Algorithms, Design of Coordination Strategies via Consensus Algorithms .	7
4	**MODULE 4**	
	Consensus-based Design Methodologies for Distributed Multivehicle Cooperative Control:	
4.1	Coupling in Cooperative Control Problems: Objective Coupling, Local Coupling, Full Coupling, Dynamic Coupling	2
4.2	Approach to Distributed Cooperative Control Problems with an	2.5

	Optimization Objective: Cooperation Constraints and Objectives, Coordination Variables and Coordination Functions, Centralized Cooperation Scheme, Consensus Building	
4.3	Approach to Distributed Cooperative Control Problems Without an Optimization Objective: Coordination Variable Constituted by a Group-level Reference State, Coordination Variable Constituted by Vehicle States	2.5
5	**MODULE 5**	
5.1	**Applications to Multivehicle Cooperative Control:** Rendezvous and Axial Alignment with Multiple Wheeled Mobile Robots, Distributed Formation Control of Multiple Wheeled Mobile Robots with a Virtual Leader, Deep Space Spacecraft Formation Flying, Cooperative Fire Monitoring with Multiple UAVs, Cooperative Surveillance with Multiple UAVs	7

Model Question Paper

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

Course Code: RAT438

Course Name: Cooperative Robotics

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1	Explain the problem of forward kinematics.	(3)
2	Explain the terms: Non-systematic Errors, Systematic Errors, and Calibration	(3)
3	Briefly explain navigation-based Approaches for consensus achievement	(3)
4	What is meant by Automatic Modular Design?	(3)
5	Explain lyapunov analysis of consensus algorithms	(3)
6	What is meant by the rendezvous problem?	(3)
7	Explain the terms: Local Coupling, Full Coupling and Dynamic Coupling	(3)
8	What is meant by cooperation constraints and objectives?	(3)

9		Briefly explain any three applications to Multivehicle Cooperative Control	(3)
10		Explain centralized coordination architecture via the virtual structure approach.	(3)

PART B

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

MODULE I

11	a)	Briefly explain various components of a robot.	(7)
	b)	What is meant by Kinematics? Discuss various kinematics problem	(7)
12	a)	Write a note on various robot controllers.	(6)
	b)	Explain odometry in robotics.	(8)

MODULE II

13	a)	Describe the current design approaches used for consensus achievement	(7)
	b)	Which are the top-down design approaches used for consensus achievement? Explain in detail.	(7)
14	a)	Explain the best-of-n problem in detail.	(6)
	b)	Explain various bottom–up design approaches used for consensus achievement.	(8)

MODULE III

15	a)	Briefly explain convergence analysis of consensus algorithms.	(7)
	b)	Explain the design of coordination strategies via consensus algorithms	(7)
16	a)	Describe the synthesis and extensions of consensus algorithms.	(7)
	b)	Explain the convergence analysis for dynamic communication topologies	(7)

MODULE IV

17	a)	Write a note on coupling in cooperative control problems.	(8)
	b)	Explain coordination variables and coordination functions	(6)
18	a)	Explain the term consensus building.	(7)
	b)	Explain the approach to distributed cooperative control problems without an optimization objective	(7)

MODULE V

19	a)	Explain the distributed formation control architecture that accommodates an arbitrary number of subgroup leaders and ensures accurate formation maintenance through information coupling between neighbors.	(7)
	b)	Explain the decentralized architecture via the virtual structure approach	(7)
20	a)	Explain the decentralized formation control strategies for each space craft.	(7)
	b)	Explain any one of the applications to multivehicle cooperative control	(7)

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KTU
Estd. 2014

RAT428	VIBRATION	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: The objective of this course is to present the fundamentals of various types of vibrations and develop mathematical models of vibratory system, analyze free and forced vibration of single and two-degree of freedom systems and free vibration of continuous systems

Prerequisite: Engineering Mechanics

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

CO 1	Classify different types of vibrations and develop mathematical models of vibratory systems.
CO 2	Analyse free and forced vibrations of single degree of freedom systems.
CO 3	Analyse the free and forced vibration of two degree of freedom systems.
CO 4	Analyse free vibration of continuous systems

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember			
Understand	15	15	30
Apply	21	21	42
Analyse	14	14	28
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 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 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. Discuss the SHM and natural undamped vibrations
2. Find the equivalent spring constant of a uniform rod of length *l*, cross-sectional area A, Area Moment of Inertia I and Young's modulus E

Course Outcome 2 (CO2):

1. Formulate equation of motion of a single-degree-of-freedom system using D'Alembert's principle
2. Explain free vibration of a simple pendulum using Newton's law

Course Outcome 3 (CO3):

1. Obtain the solution to undamped SDOF to harmonic excitation
2. Discuss Harmonic response of damped SDOF systems

Course Outcome 4 (CO4):

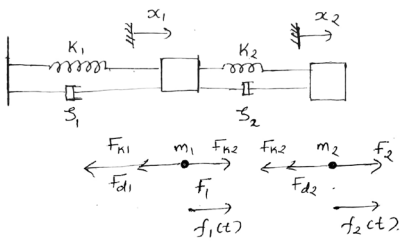

Fig. A

1. Derive the equations of motion for the system given in Fig. A and express them in second order form with mass matrix, stiffness matrix and damping matrix
2. Consider the two degree freedom system of Fig. B below with m1= 10 kg, m2= 1 kg, k1 = 30N/m, k2=5N/m, k3=0N/m. For c1=c2=c3=0,
   Find the normal modes (or eigenvectors) for free vibration response of the system

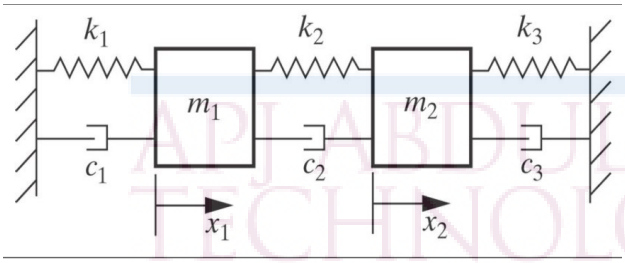

Fig. B

Course Outcome 5 (CO5):

1. Compare torsional vibrations and lateral vibrations
2. Find the natural frequencies of two inertias connected by a single spring

SYLLABUS

Module 1 (6 Hours)

Introduction to Vibrations

Mechanical vibrations - Vibrational elements – problem classification – steps in vibration analysis - elements of mechanical vibration systems – periodic and harmonic motion – equation of motion of various dynamic systems

Module 2 (7 Hours)

Free vibration of single-degree-of-freedom systems

Vibration of Single Degree Of Freedom (SDOF) systems- equation of motion of a single-degree-of-freedom system using Newton's second law - D'Alembert's principle - and the principle of conservation of energy - natural frequency and damped frequency for the single-degree-of freedom system - Free vibration of SDOF systems - undamped and viscously damped free vibration – underdamped - overdamped - critically damped systems.

Module 3 (7 Hours)

Harmonically Excited vibration

Response of the undamped single-degree-freedom system to harmonic excitations - resonance and beating phenomena - response of the damped single-degree-freedom system to harmonic excitations - response of the single-degree-of-freedom system to arbitrary forces using convolution integral - Forced vibration of SDOF systems - Harmonically excited SDOF systems - rotating unbalance - support harmonic excitation

Module 4 (9 Hours)

Vibration of two-degree-of-freedom Systems

Vibration of two degree of freedom systems - equations of motion of two-degree-of-freedom systems - mass, stiffness and damping matrices from the equations of motion - mode shapes and natural frequencies of the system - free vibration and forced vibration solution for two-degree-of freedom systems – co-ordinate decoupling – principal coordinates.

Module 5 (7 Hours)

Vibration of continuous systems

Vibration of continuous systems - Transverse vibration of a string - axial vibration of a rod - torsional vibration of a shaft - free vibration response of a rectangular membrane - formulation and solution of differential eigenvalue problem

Text Books

1. W T Thomson, M D Dahleh and C Padmanabhan, ”Theory of Vibrations”, Pearson Education International, 2018
2. S S Rao, “Mechanical Vibrations”, Pearson Education, 2018
3. Daniel J. Inman, “Engineering Vibrations”, Prentice Hall, 2007.

Reference Books

1. Leonard Meirovitch, “Fundamentals of Vibrations”, McGraw Hill International Edition, 2010
2. J. P. Den Hartog, “Mechanical Vibrations”, Crastre Press, 2008
3. Bruno, S. Tamadonni & Graham S. Kelly, ” Mechanical Vibrations ” Schaum’s Out line Series, Mc-Graw Hill Inc, 1998.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction to Vibrations (6 Hours)**	
1.1	Introduction to Vibrations – Vibrational elements	1 Hour
1.2	Problem classification and Study of mechanical vibrations	1 Hours
1.3	Steps in vibration analysis and important elements of every mechanical vibration systems	2 Hours
1.4	Periodic and harmonic motion and equation of motion of various dynamic systems	2 Hours

2	**Free vibration of single-degree-of-freedom systems (6 Hours)**	
2.1	Vibration of Single Degree Of Freedom (SDOF) systems and equation of motion of a single-degree-of-freedom system using Newton's second law, D'Alembert's principle and the principle of conservation of energy -	3 Hours
2.2	Natural frequency and damped frequency for the single-degree-of freedom system	1 Hours
2.3	Free vibration of SDOF systems - undamped and viscously damped free vibration. Underdamped, overdamped and critically damped systems.	2 Hours
3	**Harmonically Excited vibration (7 Hours)**	
3.1	Response of the undamped single-degree-freedom system to harmonic excitations. Resonance and beating phenomena. Response of the damped single-degree-freedom system to harmonic excitations	3 Hours
3.2	Response of the single-degree-of-freedom system to arbitrary forces using convolution integral	2 Hour
3.3	Quality factor of the vibrations.	1 Hour
3.4	Forced vibration of SDOF systems - Harmonically excited SDOF systems - rotating unbalance - support harmonic excitation	1 Hour
4	**Vibration of two-degree-of-freedom Systems (9 Hours)**	
4.1	Vibration of two degree of freedom systems and equations of motion of two-degree-of-freedom systems	2 Hour
4.2	Mass, stiffness and damping matrices from the equations of motion. Mode shapes and natural frequencies of the system Trajectory generation	2 Hour
4.3	Free vibration and forced vibration solution for two-degree-of freedom systems. Perform co-ordinate decoupling and obtain principal coordinates.	1 Hours
4.4	Cubic polynomial for a path, Joint space trajectory generation using single degree polynomial	2 Hour
4.5	Numerical examples on finding the coefficients of cubic that accomplishes the motion of a joint	2 Hour
5	**Vibration of continuous systems (7 Hours)**	
5.1	Vibration of continuous systems and Transverse vibration of a string	2 Hours

5.2	Axial vibration of a rod and torsional vibration of a shaft	2 Hours
5.3	Free vibration response of a rectangular membrane	2 Hours
5.4	Formulation and solution of differential eigen value problem	1 Hour

Model Question Paper

Course Code: RAT428

Course Name: VIBRATION

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

PART A

Answer all Questions. Each question carries 3 Marks

1. Discuss the elements of a vibratory system.
2. Illustrate different types of vibratory motion
3. Explain any two single degree of freedom system.
4. Present the equation of motion of single degree of freedom system using Newton's laws of motion.
5. Explain forced vibration due to rotating unbalance
6. Comment on harmonically excited vibration
7. Explain undamped 2- degree of freedom system model.
8. When will the differential equations of motion for two DOF free vibration system are said to be coupled?
9. Discuss the vibration of membranes
10. Compare vibration of continuous and discrete systems.

PART B

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

Module 1

11. a. A table has a vertical sinusoidal motion with constant frequency. What is the largest amplitude that the table can have if an object on the table is to remain in contact? (7)
b. A periodic motion is described by the equation $x = 5 \sin 2\pi t + 3 \sin 4\pi t$. In a plot of x versus t , sketch the motion for $0 \leq t \leq 1.5s$ (7)

12. a. The motion of a particle is described as $x = 4 \sin (\omega t + \pi/6)$. If the motion has two components, one of which is $x_1=2\sin(\omega t-\pi/3)$ determine the other harmonic component. (7)

b. An accelerometer indicates that the acceleration of a body is sinusoidal at a frequency of 40 Hz. If the maximum acceleration is 100 m/s^2 find the amplitudes of the displacement and the velocity. (7)

Module 2

13. Derive the equation of motion of a spring mass system using energy method. Also derive the natural frequency of the system. (14)

14. A component of a machine is represented schematically in Fig. 1.Derive its equation of motion (14)

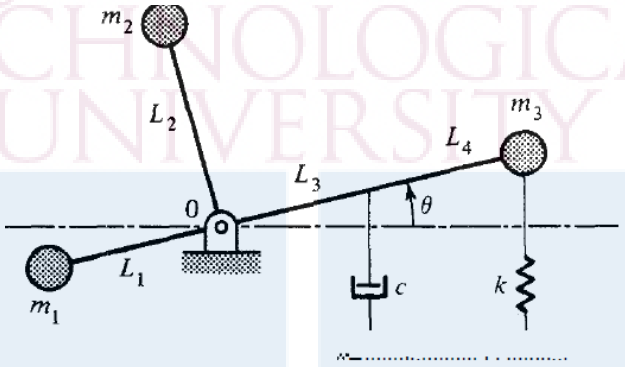

Fig 1: One degree of freedom system with damping

Module 3

15 Describe the two important phenomena, beats and resonance, that occurs when driving frequency comes close to the system's natural frequency. (14)

16 Develop the equation for the total response of a single degree of freedom system with damping to harmonic excitation using a spring – mass model (14)

Module 4

17 Obtain the equation of motion for a two degree of freedom system shown in Fig. 2 (14)

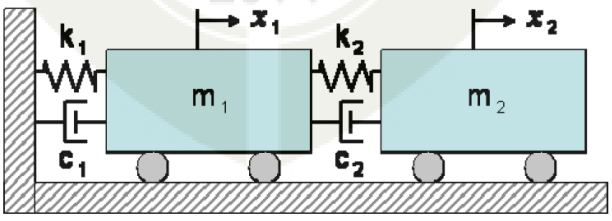

Fig. 2

18. Find the natural frequencies and mode shapes of a spring mass system shown in Fig. 3 , which is constrained to move in the vertical direction

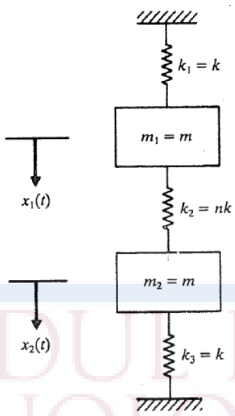

Fig. 3 (14)

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Module 5

19. Fig. 4 shows a tightly stretched elastic string or cable of length *l* subjected to a distributed transverse force f (x, t) per unit length. Obtain one dimensional wave equation

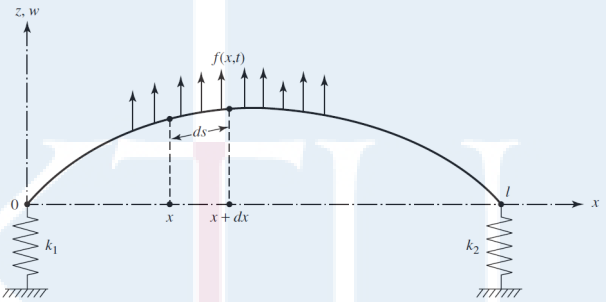

Fig.4 (14)

20. Find the free vibration response of a rectangular membrane when it is struck such that the middle point experiences a velocity V_0 at t = 0. (14)

RAT418	MECHATRONIC SYSTEM DESIGN	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: To expose students to the basics of Mechatronics which include principles and working of devices and elements for Mechatronics

Prerequisite: Basic knowledge in Sensors and Transducers, Control engineering

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

CO 1	Explain the basics of Mechatronics which include Integrated circuit and printed circuit board manufacturing processes.
CO 2	Examine various types of transducers used in industrial automation, machine control systems and instrumentation systems.
CO 3	Examine different types of actuators and its actuating mechanism.
CO 4	Perceive basic concepts of feedback and intelligent control, Components Based Modular Design.
CO 5	Explain basic concepts of design and integration of Mechatronic systems.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	50
Apply	20	20	40
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. Elucidate the design aspect of Mechatronics discipline.
2. Enlist the main technical areas under research domain Mechatronics.

Course Outcome 2 (CO2):

1. Determine the acceptance angle for a single fiber with a numerical aperture of 0.096.
2. A piezoelectric transducer has an output voltage of 3V at no load conditions. It has a capacitance 250 Pf. Find the voltage across the load at high frequencies.

Course Outcome 3 (CO3):

1. A 6 pole lap connected shunt generator has armature and field resistance of 0.05W and 125W respectively.If it drives a current of 200 A and 500 V, calculate shunt field current, armature current and generated emf..
2. Differentiate between shaft, spindle and axle. Give practical examples of each.

Course Outcome 4 (CO4):

1. Draw the block diagram of a process influenced by the fault..
2. Discuss the various stages of the design process in terms of validation implementation

Course Outcome 5 (CO5):

1. Why is the present trend towards flexible automation rather than fixed automation?.
2. Give an overview of AGV architecture.

SYLLABUS

Module 1 (9 Hours)

Introduction to Mechatronics: Introduction -multidisciplinary scenario – origins – evolution of Mechatronics – an overview of Mechatronics – brief introduction to manufacturing – design – Mechatronics in products Scope of Mechatronics-advantages and disadvantages - applications.

Transducers and Sensors Difference between transducer and sensor – transducer types – transduction principle – photoelectric transducers – thermistors – thermo devices – thermocouple – inductive transducers – capacitive transducers – pyro electric transducers – piezoelectric transducer – hall-effect transducer – light emitting diode – optical encoder – bimetallic strip – bourdon tube – strain gauge – load cell diaphragms – mechanical switches – flow transducers – fibre optic transducers.

Module 2 (7 Hours)

Actuators and Mechanisms Actuator types and application areas – electromechanical actuators – DC motor – AC motors – pneumatic actuators – Fluid power actuators – piezoelectric actuators – magneto strictive actuators – memory metal actuator – mechanisms – bearings – belt & chain – pulleys – gears – rack and pinion – ratchet, pawl & crank – slider and crank – cams and followers – Geneva wheel – four bar linkages.

Module 3 (6 Hours)

Feedback and Intelligent Control Defining automatic control methods – Artificial Neural Network-Fuzzy logic-Diagnostics: mathematical description of process and faults, FDI phases - FDI approaches- merits and demerits – analog versus digital control.

Module 4 (8 Hours)

Components Based Modular Design and System: Validation Introduction-Components based modular design view – system validation – validation methodology – more about validation scheme – fusion technique.

Integration Background – advanced actuators – consumer mechatronic products – hydraulic fingers – surgical equipment – industrial robot – drilling machine – conveyor based material handling systems

Module 5 (6 Hours)

Mechatronic Design Strategy spindle system review – dynamic modelling of HSSS – important design criteria – diagnostics and prognostics – sea scheme – approach to the design of a control systems – remote monitoring and control.

Text Books

1. Nitaigour Premchand Mahalik, "Mechatronics: Principles, Concepts and Applications", McGraw Hill Education.
2. A.K Sawhney, "A course in Electrical and Electronic Measurements and Instrumentation", Dhanpat Rai & Co. (P) Limited.
3. D. Patranabis, "Sensor & transducers", Prentice Hall India Learning Private Limited, 2/e.
4. 4. Godfrey Onwubolu "Mechatronics-Principles and Applications",ButterworthHeinemann.

Reference Books

1. M.D.Singh & J.G.Joshi, "Mechatronics", Prentice Hall India Learning Private Limited.
2. Yoram Koren, "Computer Control of Manufacturing Systems", McGraw Hill Education, 1/e.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**MODULE 1**	
1.1	Introduction -multidisciplinary scenario – origins – evolution of Mechatronics – an overview of Mechatronics – brief introduction to manufacturing – design – Mechatronics in products-Scope of Mechatronics-advantages and disadvantages - applications.	2
1.2	Difference between transducer and sensor, transducer types, transduction principle.	1
1.3	Photoelectric transducers, thermistors, thermo devices, thermocouple	1
1.4	Inductive transducers, capacitive transducers, pyro electric transducers, piezoelectric transducer, hall-effect transducer.	2
1.5	Light emitting diode, optical encoder, bimetallic strip, bourdon tube.	1
1.6	Strain gauge, load cell diaphragms, mechanical switches, flow transducers, fibre optic transducers.	2
2	**MODULE 2**	
2.1	Actuator types and application areas, electromechanical actuators, DC motor, AC motors- pneumatic actuators	2

2.2	Fluid power actuators, piezoelectric actuators, magneto strictive actuators, memory metal actuator	2
2.3	mechanisms, bearings, belt & chain, pulleys, gears, rack and pinion	1.5
2.4	Ratchet, pawl & crank, slider and crank, cams and followers, Geneva wheel, four bar linkages.	1.5
3	**MODULE 3**	
3.1	Defining automatic control methods – Artificial Neural Network-Fuzzy logic	2
3.2	Diagnostics: mathematical description of process and faults	2
3.3	FDI phases, FDI approaches, merits and demerits, analog versus digital control	2
4	**MODULE 4**	
4.1	Introduction, Components based modular design view, system validation.	2
4.2	Validation methodology, more about validation scheme, fusion technique.	1
4.3	Integration Background ,advanced actuators ,consumer mechatronic products , hydraulic fingers ,surgical equipment ,industrial robot	3
4.4	drilling machine , conveyor based material handling systems	2
5	**MODULE 5**	
5.1	Spindle system review ,dynamic modelling of HSSS , important design criteria , diagnostics and prognostics ,sea scheme	3
5.2	Approach to the design of a control systems – remote monitoring and control.	3

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Model Question Paper

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

Course Code: RAT418

Course Name: MECHATRONIC SYSTEM DESIGN

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1	Explain the purpose of standardization and importance of interchangeability.	(3)
2	A flat frequency response within10% is required from a piezoelectric crystal. Find the value of minimum frequency for which it can be used if the time constant is 2ms.Find also the phase shift.	(3)
3	A 220 V DC shunt motor takes 10 kW at a speed of 700 RPM. The armature resistance is 0.50 Ohm and the brush contact drop is 1.6 V mechanical and iron losses are 495 W. Calculate the efficiency and net torque	(3)
4	Which type of bearing in nanotechnology conformant machineries. Why?	(3)
5	Give an illustration how the neural network concept has been adopted in the engineering domain	(3)
6	Discuss the merits and demerits of FDI approaches	(3)
7	Explain any two validation methodologies used in component based modular design approach	(3)
8	Why diagnosis is essential in Mechatronic system? Explain.	(3)
9	What do you mean by flexible manufacturing? What are the components of flexible manufacturing? Explain.	(3)
10	Explain the role of electromagnetic balancer in HSSS.	(3)

PART B

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

MODULE I

11	a)	Mechatronics is the synergistic integration of mechanical engineering with electronics and intelligent control algorithms in the design and manufacture of products process. Justify the statement.	(7)
	b)	How has Mechatronics discipline been evolved? Briefly explain various evolution stages.	(7)

12	a)	A Bimetal cantilever with invar, and brass as two metal strips of equal thickness has a total thickness of 0.125 cm and length 5 cm. Its one end is fixed, estimate the end deflection for the change of temperature of 40°C.	(7)
	b)	A metallic diaphragm of thickness 3mm used for the measurement of a differential pressure 2kg/$cccc2$ is required to give a deflection of its centre by 1 mm. What should be its diameter if the Young's modulus and Poisson's ratio of the element are 1, 00,000 kg/$cccc2$ and 0.3 respectively	(7)

MODULE II

13	a)	Two spur gears of 30 teeth and 40 teeth of 8mm module and 20° pressure angle are in mesh .Addendum of each gear is 7.5mm .The teeth are of involute form. Determine i) The angle through which the pinion turns while any pair of teeth are in contact ii) The velocity of sliding between teeth when the contact on the pinion is at a radius of 101mm.The speed of the pinion is 445 rpm	(14)
14	a)	Define gear ratio. With a suitable example, illustrate how to calculate gear ratio.	(14)

MODULE III

15	a)	Draw the general architecture of a model based FDI scheme and explain	(14)
16	a)	Discuss in detail on artificial neural network.	(14)

MODULE IV

17	a)	Discuss in detail about the design considerations of a hydraulic finger and its applications	(14)
18	a)	What are the issues and challenges faced in the design of a conveyor based material handling systems. Propose a solution to address any one of the concern discussed	(14)

MODULE V

19	a)	Draw and explain a possible scheme for smart motorized actuator integration	(14)
20	a)	What is SEA scheme? Explain in detail.	(14)

****

RAT476	SUPERVISORY CONTROL	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: To get knowledge about different supervisory control systems in industrial automation.

Prerequisite: Nil

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

CO1	Understand basic process control loops
CO2	Design and develop ladder based PLC programs
CO3	Illustratesimple computerized process control systems such as DAQ and DDC
CO4	Illustrate SCADA systems and its building blocks for industrial automation
CO5	Understand Distributed Control System and its 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	3										
CO 2	3	2										
CO 3	3	2										
CO 4	3	3										
CO 5	3	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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Discuss the steps for compuetrized process control
2. Discuss different control algorithms such as feedforward and cascade control loops.

Course Outcome 2 (CO2):

1. Discuss the programming languages and simple programs with PLC.
2. Explain the protocols for PLC communication.

Course Outcome 3 (CO3):

1. Explain Direct Digital Control(DDC).
2. Explain Data Acquisition Systems.

Course Outcome 4 (CO4):

1. Discuss the architecture of SCADA systems.
2. Discuss the communication systems applicable to SCADA.

Course Outcome 5 (CO5):

1. Explain the basics of Distributed Control System(DCS).
2. Explain various interfaces in DCS.
3. Explain the protocols used in DCS.

SYLLABUS

Module I (6 Hours)

Process Control Loops: Feedback control, feed forward control, Cascade control, Ratio control, Split range control.

Computerized control: Basic building blocks of Computer controlled systems, advantages.

Programmable Logic Controller: Definition of PLC Architecture of PLC, Input and output modules, Types of inputs and outputs, analog and discrete I/O modules, power supply of PLCs

Module II (8 Hours)

PLC programming languages, Ladder programming, Relay logic, Timers and counters, simple programs in PLC, math operations, sequencers, program control instructions, analog instructions, case studies- bottle filling system, gate control system.

Interfacing PLC to SCADA/DCS using communication link (RS232, RS485) , Protocols (Modbus ASCII/RTU) and OPC.

Module III (7 Hours)

Direct digital control: block diagram, multiplexers, demultiplexers, ADC, Data Acquisitions systems.

SCADA: SCADA Fundamentals: Introduction, Open system: Need and advantages, Building blocks of SCADA systems, Remote terminal unit (RTU), Human-Machine Interface (HMI) subsystem.

Module IV (7 Hours)

SCADA communication systems, Master Station: Master station software components, Master station hardware components, Server systems in the master station, Small, medium, and large master stations, Global positioning systems (GPS), software architecture of SCADA

Distributed Control System : DCS - Architectures, Comparison, Local control unit, Process interfacing issues, Communication facilities. Various function Blocks.

Module V (7 Hours)

LCU communication Facilities - Communication system requirements – Architectural Issues Operator displays, Operator Interfaces – Engineering Interfaces. Development of Field Control Unit (FCU) diagram for simple control applications. Introduction to HART and Field

bus protocol. Interfacing Smart field devices (wired and wireless) with DCS controller. Introduction to Object Linking and Embedding (OLE) for Process Control, Automation in the cloud with case studies.

Text Books:

1. Programmable Logic Controllers Frank D Petruzella McGraw Hill 4th Edition, 2011
2. Power System SCADA and Smart Grids Mini S. Thomas CRC Press 3rd Edition,2015
3. Michael P. Lukas, Distributed Control Systems: Their Evaluation and Design, Van Nostrand Reinhold Co., 1986
4. D. Popovic and V.P.Bhatkar,' Distributed computer control for industrial Automation' Marcel Dekker, Inc., Newyork ,1990.

Reference Books

1. Deshpande P.B and Ash R.H, Elements of Process Control Applications, ISA Press, New
   York, 1995.
2. Curtis D. Johnson, Process Control Instrumentation Technology, Pearson New International, 8th Edition, 2013.
3. Krishna Kant, Computer-based Industrial Control, Prentice Hall, New Delhi, 2nd Edition, 2011.
4. D. Patranabis , P, Principles of Process Control, Tata McGraw Hill Education, 2012.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1		
1.1	Process Control Loops: Feedback control, feed forward control, Cascade control, Ratio control, Split range control	1
1.2	Computerized control: Basic building blocks of Computer controlled systems, advantages. .	1
1.3	Programmable Logic Controller: Definition of PLC Architecture of PLC, Input and output modules, Types of inputs and outputs, ,analog and discrete I/O modules, power supply of PLCs	4
2		

2.1	PLC programming languages, Ladder programming, Relay logic, Timers and counters, simple programs in PLC	2
2.2	math operations, sequencers, program control instructions, analog instructions, case studies-bottle filling system, gate control system .	3
2.3	Interfacing PLC to SCADA/DCS using communication link (RS232, RS485) , Protocols (Modbus ASCII/RTU) and OPC	3
3		
3.1	Direct digital control: block diagram, multiplexers, demultiplexers, ADC, Data Acquisitions systems	2
3.2	SCADA: SCADA Fundamentals: Introduction, Open system: Need and advantages, Building blocks of SCADA systems	3
3.3	Remote terminal unit (RTU), Human-Machine Interface (HMI) subsystem.	2
4		
4.1	SCADA communication systems, Master Station: Master station software components, Master station hardware components, Server systems in the master station	2
4.2	Small, medium, and large master stations, Global positioning systems (GPS), software architecture of SCADA	2
4.3	Distributed Control System : DCS - Architectures, Comparison, Local control unit, Process interfacing issues, Communication facilities. Various function Blocks.	3
5		
5.1	LCU communication Facilities - Communication system requirements – Architectural Issues Oprator displays, Operator Interfaces – Engineering Interfaces. Development of Field Control Unit (FCU) diagram for simple control applications	3
5.2	Introduction to HART and Field bus protocol. Interfacing Smart field devices (wired and wireless) with DCS controller	2
5.3	Introduction to Object Linking and Embedding (OLE) for Process Control, Automation in the cloud with case studies.	2

MODEL QUESTION PAPER

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

Course Code: RAT 476

Course Name: Supervisory Control

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

PART A

Answer all questions, each carries 3 marks. Marks

1		List out the power supplies commonly used for PLC.	(3)
2		How the set point is controlled in a cascade control loop.	(3)
3		Which all the registers are available in a counter of a PLC.	(3)
4		Differentiate between RS 232, RS422, and Rs 485.	(3)
5		Define the resolution of an ADC. Find out the resolution of a 10 bit ADC	(3)
6		What will be the main role of RTU in a local station in a SCADA system.	(3)
7		What is the role of GPU in a SCADA system.	(3)
8		Illustrate the role of DIO in local stations in a Distributed Control System.	(3)
9		Illustrate the communication facilities arranged in LCUs.	(3)
10		.Demonstrate the features of OLE for process control.	(3)

PART B

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

MODULE1

11	a)	Describe thecascade control with a suitable application.	(7)
	b)	Why the feed forward control is called an anticipatory control.	(7)
12	a)	Illustrate the different types of Input modules in PLC	(8)
	b)	With a neat diagram explain the architecture of PLC.	(6)

MODULE II

13	a)	Explain the different types of timers used in PLC ladder program.	(8)
14	b)	Design a PLC program and prepare a typical I/O connection diagram and ladder logic program for the following counter specifications. 1. Counts the number of times a push button is closed. 2. Decrements the accumulated value of the counter each time a second push button is closed.	(6)

3. Turns on a light any time the accumulated value of the counter is less than 20.

Describe MODBUS protocol. Differentiate between different modes of operations. (14)

MODULE III

15 a) Discuss the basic building blocks of a SCADA system. (8)

b) With a neat block diagram explain DAQ. (6)

16 a) Describe the process of developing the HMIs and its role in SCADA system. (8)

b) With a neat diagram explain the Direct Digital Control for an HVAC system. (6)

MODULE IV

17 a) Explain with a neat diagram the software architecture of a SCADA system (6)

b) Differentiate the role of LLHI and HLHI in DCS. (8)

18 a) Explain the architecture of DCS with appropriate diagrams. (7)

b) Discuss the master station software and hardware components in SCADA. (7)

Module V

19 a) Write short notes on the communication system requirements of DCS (14)

b) How the smart devices are interconnected to Distributed Control System both in wired and wireless manner.

20 a) Write shore notes on 1. HART protocol 2. Fieldbus.. (8)

b) Differentiate between operator level interface and engineering level interface in DCS (6)

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RAT456	IOT AND APPLICATIONS	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: To expose the students to the field of IoT and its applications.

Prerequisite: Nil

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

CO 1	Explain the basic concepts of IoT and IoT networking.
CO 2	Perceive ideas on the different connectivity technologies and Wireless Sensor Networks.
CO 3	Discuss on UAV Networks & M2M Communication, Software defined networking.
CO 4	Explain the basic concepts of cloud computing and fog computing.
CO 5	Apply the basics of IoT for different applications like Smart Homes and Industrial IoT.

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember			
Understand	50	50	100
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 : 15 marks
Course Project (Application of IoT) : 10 marks

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 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. Define IoT.
2. Enlist any three characteristics of IoT and explain.

Course Outcome 2 (CO2):

1. Discuss on Plasma HART and Wireless HART.
2. Explain the challenges in WSN.

Course Outcome 3 (CO3):

1. Discuss on different UAV components.
2. Define Software Defined WSN.

Course Outcome 4 (CO4):

1. Explain public cloud.
2. List out the advantages of Fog.

Course Outcome 5 (CO5):

1. Use course project to evaluate the CO.

SYLLABUS

Module 1 (7 Hours)

Introduction to Internet of Things

Introduction- Characteristics of IoT- Applications of IoT- IoT categories- IoT Enablers and Connectivity Layers - Baseline Technologies-Sensors-Characteristics of a Sensor-Classification of Sensors-Actuators-Types of Actuators-IoT components and implementation-Service Oriented Architecture-IoT Interdependencies-Challenges for IoT.

IoT Networking

Connectivity Terminologies, Gateway Prefix Allotment-Impact of Mobility on Addressing-Multihoming-Deviations from Regular Web-IoT Identifications and Data Protocols.

Module 2 (7 Hours)

Connectivity Technologies

Introduction-IEEE 802.15.4-ZigBee-6LoWPAN-RFID-HART and wireless HART-NFC-Bluetooth-Z-wave-ISA 100.11A.

Wireless Sensor Networks

Introduction-Components of a sensor Node-Modes of Detection-Challenges in WSN-Sensor Web-Cooperation-Behaviour of Nodes in WSN-Information Theoretic Self-Management of WSN-Social Sensing in WSN-Applications of WSN-Wireless Multimedia Sensor Networks-Wireless Nano sensor Networks-Under Water Acoustic Sensor Networks-WSN Coverage-Optimal Geographical Density Control (OGDC) Algorithm-Stationary WSN-Mobile WSN.

Module 3 (7 Hours)

UAV Networks & M2M Communication

Introduction-UAV Components-UAV Networks-Features-Challenges-Topology-FANET-Features-Difference between FANET and the Existing Ad hoc Networks, FANET Design Considerations-FANET communication-Gateway Selection in FANETS-M2M Communication-M2M Applications-Types of Node in M2M-M2M Ecosystem-M2M Service platform-Interoperability-Need for Interoperability-Types of Interoperability.

Software Defined Networking

Introduction, Limitations of Current Network-Origin of SDN-SDN Architecture-Rule Placement-OpenFlow Protocol-Controller Placement-Security in SDN-Integrating SDN in IoT-Software defined WSN-SDN for Mobile Networking-Rule Placement at Access Devices.

Module 4 (7 Hours)

Cloud Computing

Introduction-Architecture-Characteristics-Deployment Models-Public Cloud-Private Cloud-Hybrid Cloud-Community Cloud-Multi Cloud-Distributed Cloud-Inter Cloud-Big Data Cloud-HPC Cloud-Service Models-Service Management-Cloud Security.

Fog Computing

Introduction-Why Fog Computing-Requirements of IoT-Architecture of Fog-Working of Fog-Advantages of Fog-Applications of Fog-Challenges in Fog.

Module 5 (7 Hours)

IoT Applications-Smart Homes

Introduction-Origin of Smart Home-Examples of Smart Home Technologies-Smart Home Implementation-Home Area Networks-HAN Elements-HAN Standards-HAN Architectures-HAN Initiatives-Smart Home Benefits and Issues.

Industrial IoT

Introduction-IIoT Requirements-Design Considerations-Applications of IIoT-Manufacturing Industry-Health Care Service Industry-Transportation and Logistics-Mining-Firefighting-Smart Dust-Drones-Futuristic Farming-Aerospace-Energy Networks-Benefits of IIoT-Challenges of IIoT.

Text Books

1. Jeeva Jose, “Internet of Things”, Khanna Book Publishing Co.(P) Ltd, 1/e.
2. RMD Sundaram Shriram K Vasudevan, & Abhishek S Nagarajan, “Internet of Things”, Wiley.

Reference Books

1. Hanes David , Salgueiro Gonzalo , Grossetete Patrick , Barton Rob , Henry Jerome, “IoT Fundamentals: Networking Technologies, Protocols and Use Cases for the Internet of Things”, Pearson, 1/e.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Introduction to Internet of Things**	
1.1	Introduction- Characteristics of IoT- Applications of IoT- IoT categories- IoT Enablers and Connectivity Layers	2
1.2	Baseline technologies-Sensors-Characteristics of a Sensor-Classification of Sensors-Actuators-Types of Actuators-IoT components and implementation-Service Oriented Architecture-IoT Interdependencies-Challenges for IoT.	2
	IoT Networking	
1.3	Connectivity Terminologies, Gateway Prefix Allotment-Impact of Mobility on Addressing-Multihoming-Deviations from Regular Web-IoT Identifications and Data Protocols	3
2	**Connectivity Technologies**	
2.1	Introduction-IEEE 802.15.4-ZigBee-6LoWPAN-RFID-HART and wireless HART-NFC-Bluetooth-Z-wave-ISA 100.11A	2
	Wireless Sensor Networks	
2.2	Introduction-Components of a sensor Node-Modes of Detection-Challenges in WSN-Sensor Web-Cooperation-Behaviour of Nodes in WSN-Information Theoretic Self-Management of WSN-Social Sensing in WSN-Applications of WSN	2
2.3	Wireless Multimedia Sensor Networks-Wireless Nano sensor Networks-Under Water Acoustic Sensor Networks-WSN Coverage-Optimal Geographical Density Control (OGDC) Algorithm-Stationary WSN-Mobile WSN	3
3	**UAV Networks & M2M Communication**	
3.1	Introduction-UAV Components-UAV Networks-Features-Challenges-Topology-FANET-Features-Difference between FANET and the Existing Ad hoc Networks, FANET Design Considerations	2
3.2	FANET communication-Gateway Selection in FANETS-M2M Communication-M2M Applications-Types of Node in M2M-M2M Ecosystem-M2M Service platform-Interoperability-Need for Interoperability-Types of Interoperability	2
	Software Defined Networking	
3.3	Introduction, Limitations of Current Network-Origin of SDN-SDN Architecture-	1

3.4	Rule Placement-OpenFlow Protocol-Controller Placement-Security in SDN-Integrating SDN in IoT-Software defined WSN-SDN for Mobile Networking-Rule Placement at Access Devices	2
4	**Cloud Computing**	
4.1	Introduction-Arhitecture-Characteristics-Deployment Models-Public Cloud-Private Cloud-Hybrid Cloud-Community Cloud-	2
4.2	Multi Cloud-Distributed Cloud-Inter Cloud-Big Data Cloud-HPC Cloud-Service Models-Service Management-Cloud Security	2
	Fog Computing	
4.3	Introduction-Why Fog Computing-Requirements of IoT-	1
4.4	Architecture of Fog-Working of Fog-Advantages of Fog-Applications of Fog-Challenges in Fog	2
5	**IoT Applications-Smart Homes**	
5.1	Introduction-Origin of Smart Home-Examples of Smart Home Technologies	1
5.2	Smart Home Implementation-Home Area Networks-HAN Elements-HAN Standards-HAN Architectures-HAN Initiatives-Smart Home Benefits and Issues	2
	Industrial IoT-Introduction	
5.3	IIoT Requirements-Design Considerations-Applications of IIoT-Manufacturing Industry-Health Care Service Industry	2
5.4	Transportation and Logistics-Mining-Firefighting-Smart Dust-Drones-Futuristic Farming-Aerospace-Energy Networks-Benefits of IIoT-Challenges of IIoT	2

Model Question Paper

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

Course Code: RAT456
Course Name: IoT AND APPLICATIONS

Max. Marks: 100 Duration: 3 Hours

PART A
Answer all Questions. Each question carries 3 Marks

1. Discuss on the applications of IoT.
2. Define multihoming.
3. Explain the working of RFID.
4. Compare Stationary WSN and Mobile WSN.
5. Explain the difference between FANET and the existing Ad hoc Networks.
6. What is Open Flow protocol? Explain.
7. Discuss on Community cloud.
8. Explain the challenges in Fog.
9. Discuss on smart home implementation.
10. Explain the benefits of IIoT.

PART B
Answer any one full question from each module. Each question carries 14 Marks

Module 1

11. With neat sketch explain the Functional components of IoT and implementation of IoT.
12. Discuss on IoT identification and data protocols.

Module 2

13. Discuss on (a) ZigBee (b) NFC.
14. Explain the applications of WSN with suitable examples.

Module 3

15. Discuss M2M communication in detail.
16. Explain the architecture and controller Placement of SDN.

Module 4

17. With neat sketch discuss on the different Cloud computing service models.
18. Explain the architecture and working of Fog.

Module 5

19. Discuss in detail on Home Area Networks (HANs).
20. With suitable examples explain the applications of IIoT.

RAT446	PROBABILISTIC ROBOTICS	CATEGORY	L	T	P	CREDIT
		PCC	2	1	0	3

Preamble: This course helps the student to have a basic idea of Probabilistic robotics. Students are introduced to the basic design consideration of algorithms. Discussion on various localization techniques , mapping algorithms and their applications are also included as part of the course to get an overall idea on this topic.

Prerequisite: Nil

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

CO 1	Understand the basic concepts of probabilistic robotics
CO 2	Describe appropriate models to solve real world problems efficiently.
CO 3	Comprehend and implement various localization techniques
CO 4	Describe different types of mapping algorithms
CO 5	Apply various Markov processes and and their applicability
CO 6	Understand the applicability of probability in robotics

Mapping of course outcomes with program outcomes

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

Assessment Pattern

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

Mark distribution

Total Marks	CIE	ESE	ESE Duration
150	50	100	3 hours

Continuous Internal Evaluation Pattern:

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

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What are probabilistic generative laws?
2. What do you mean by state?

Course Outcome 2 (CO2):

1. Differentiate between velocity motion model and odometry motion model.
2. Explain different techniques to reduce the computational complexity of localization process

Course Outcome 3 (CO3):

1. Differentiate between grid localization and monte carlo localization.
2. What is occupancy grid mapping?

Course Outcome 4 (CO4):

1. What is layered EM mapping?
2. What are the fast incremental mapping algorithms

Course Outcome 5 (CO5):

1. Characteristics of finite environments.
2. What are augmented markov decision processes?
3.

SYLLABUS

Module I (9 Hours)

Introduction to Probabilistic Robotics: Uncertainty in Robotics, Probabilistic Robotics, Basic Concepts in Probability

Robot Environment Interaction: State, Environment Interaction, Probabilistic Generative Laws, Belief Distributions

Bayes Filters: The Bayes Filter Algorithm, Mathematical Derivation of the Bayes Filter, The Markov Assumption

Gaussian and Nonparametric Filters: Kalman Filter, Extended Kalman Filter, Information Filter, Histogram Filter, Particle Filter

Module II (7 Hours)

Robot motion: Introduction, Preliminaries, Velocity Motion Model, Odometry Motion Model, Motion and Maps

Measurements: Maps, Beam Models of Range Finders, Likelihood Fields for Range Finders, Correlation-Based Sensor Models, Feature-Based Sensor Models

Module III (8 Hours)

Mobile Robot Localization: Taxonomy of Localization Problems, Markov Localization, Illustration of Markov Localization, EKF Localization, Estimating Correspondences, Multi-Hypothesis Tracking

Grid and Monte Carlo Localization: Grid Localization, Monte Carlo Localization, Localization in Dynamic Environments,

Mapping: Occupancy Grid Mapping, Simultaneous Localization and Mapping

Module IV (7 Hours)

Mapping with Unknown Data Association: Mapping with the EM Algorithm, Grid-Based Implementation, Layered EM Mapping

Fast Incremental Mapping Algorithms: Incremental Likelihood Maximization, Maximum Likelihood as Gradient Descent, Incremental Mapping with Posterior Estimation, Multi-Robot Mapping, Mapping in 3D

Module V (6 Hours)

Markov Devision Processes: Uncertainty in Action Selection, Value Iteration

Partially Observable Markov Decision Processes: Finite Environments, General POMDPs, Monte Carlo Approximation, Augmented Markov Decision Processes

Text Books

1. Thrun, Sebastian, Wolfram Burgard, and Dieter Fox, "Probalistic robotics", Kybernetes 2006.

Reference Books

1. Bessière, Pierre, Christian Laugier, and Roland Siegwart, Probabilistic reasoning and decision making in sensory-motor systems, Springer, 2008.
2. AshitavaGhosal, "Robotics-Fundamental concepts and analysis", Oxford University press.
3. Sicilliano, Khatib , "Handbook of Robotics", Springer

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**MODULE 1**	
1.1	Introduction to Probabilistic Robotics: Uncertainty in Robotics, Probabilistic Robotics, Basic Concepts in Probability	1.5
1.2	Robot Environment Interaction: State, Environment Interaction, Probabilistic Generative Laws, Belief Distributions	1.5
1.3	Bayes Filters: The Bayes Filter Algorithm, Mathematical Derivation of the Bayes Filter, The Markov Assumption	2
1.4	Gaussian and Nonparametric Filters: Kalman Filter, Extended Kalman Filter, Information Filter, Histogram Filter, Particle Filter	2
2	**MODULE 2**	
2.1	Robot motion: Introduction, Preliminaries, Velocity Motion Model, Odometry Motion Model, Motion and Maps	3

2.2	Measurements: Maps, Beam Models of Range Finders, Likelihood Fields for Range Finders, Correlation-Based Sensor Models, Feature-Based Sensor Models	4
3	**MODULE 3**	
3.1	Mobile Robot Localization: Taxonomy of Localization Problems, Markov Localization, Illustration of Markov Localization, EKF Localization, Estimating Correspondences, Multi-Hypothesis Tracking	3
3.2	Grid and Monte Carlo Localization: Grid Localization, Monte Carlo Localization, Localization in Dynamic Environments	2
3.3	Mapping: Occupancy Grid Mapping, Simultaneous Localization and Mapping	3
4	**MODULE 4**	
4.1	Mapping with Unknown Data Association: Mapping with the EM Algorithm, Grid-Based Implementation, Layered EM Mapping	3.5
4.2	Fast Incremental Mapping Algorithms: Incremental Likelihood Maximization, Maximum Likelihood as Gradient Descent, Incremental Mapping with Posterior Estimation, Multi-Robot Mapping, Mapping in 3D	3.5
5	**MODULE 5**	
5.1	Markov Devision Processes: Uncertainty in Action Selection, Value Iteration	2
5.2	Partially Observable Markov Decision Processes: Finite Environments, General POMDPs, Monte Carlo Approximation, Augmented Markov Decision Processes	4

Model Question Paper

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

Course Code: RAT446

Course Name: Probabilistic Robotics

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1	Write any three complimentary sources of approximation error, each of which gives rise to improved versions of the particle filter.	(3)
2	In mobile robot localization, xt is the robot's pose, and Bayes filters are applied to estimate the pose relative to a fixed map. Find three factors that may have a systematic effect on sensor readings.	(3)
3	What is meant by a map of the environment?	(3)
4	Explain the drawbacks of beam-based sensor model, while closely linked to the geometry and physics of range finders.	(3)
5	Briefly explain any three techniques to reduce the computational complexity of grid localization.	(3)
6	Explain any three factors that results the hardness of the mapping problem.	(3)
7	Write the general EM mapping algorithm.	(3)
8	Explain the limitations of incremental maximum likelihood approach.	(3)
9	Distinguish two types of uncertainty in markov decision processes: uncertainty in action, and uncertainty in perception.	(3)
10	Briefly explain Augmented State Space	(3)

PART B

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

MODULE I

11	a)	Derive the mathematical representation of the Bayes Filter.	(6)
	b)	Explain the properties of particle filters.	(8)
12	a)	What are range finders? Explain beam models of range finders.	(6)
	b)	Explain the basic algorithm of particle filter.	(8)

MODULE II

13	a)	Write algorithms for the following:- (i) Algorithm for computing p(xt | ut, xt−1) based on velocity information (ii) Algorithms for computing densities of a zero-centered normal distribution and the triangular distribution with variance b.	(6)
	b)	Explain the velocity motion model in detail.	(8)
14	a)	What is odometry motion model? Write the algorithm for computing p(xt | ut, xt−1) based on odometry information.	(6)
	b)	Explain EKF algorithm and derive the mathematical representation of EKF.	(8)

MODULE III

15	a)	Distinguish the following with examples. (i)Local and Global Localization, (ii) Static and Dynamic Environments, (iii) Passive and Active Approaches, (iv) Single-Robot and Multi-Robot localization.	(8)
	b)	What is meant by markov localization and EKF localization?	(6)
16	a)	Briefly explain occupancy grid mapping algorithm.	(7)
	b)	Explain MCL algorithm.	(7)

MODULE IV

17	a)	Explain the basic idea of mapping with EM with necessary diagrams.	(6)
	b)	Explain the Perceptual model for Layered Maps	(8)
18	a)	Briefly explain various fast incremental mapping algorithms.	(7)
	b)	Explain the concept of multi-robot mapping.	(7)

MODULE V

19	a)	How to find Control Policies in fully observable domains	(7)
	b)	Write short note on general POMDPs	(7)
20	a)	What are augmented markov decision processes? Explain value Iteration in AMDPs.	(7)
	b)	Briefly explain Monte Carlo approximations.	(7)

****

RAT436	DIGITAL CONTROL SYSTEMS	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: This course is designed to equip the students to analyse and designing digital control system

Prerequisite: control system design

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

CO 1	Analyse discrete data control system
CO 2	Understand Z-transform, its properties and do steady state error analysis of digital control system
CO 3	Understand and gain knowledge in stability analysis of digital control systems
CO 4	Develop state space representation of discrete time systems and find solution of state equation.
CO 5	Test controllability and observability of linear systems also design discrete-date control systems.

Mapping of course outcomes with program outcomes

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	40
Apply	20	20	50
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 a maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. Explain how to model the sampling process mathematically. Also, with and without aliasing. plot the amplitude spectrum of the sampler output.
2. With suitable diagrams explain how data reconstruction is done in zero order hold and first order hold. Derive transfer functions for each

Course Outcome 2 (CO2):

1. Derive the expression for acceleration error constant and velocity error constant of a Type 1digital system
2. Describe the mapping of the following locus from s-plane to z-plane
    a. Constant damping loci
    b. Constant frequency loci
    c. Constant damping ratio loci

Course Outcome 3 (CO3):

1. Explain in detail about gain margin and phase margin
2. Test the stability of the polynomial using Jury's stability test
   F(z)=$z^5 + 2.6z^4 - .56z^3 - 2.05z^2 + 0.0775z + 0.35 = 0$

Course Outcome 4 (CO4):

1. Obtain the state transition Matrix of the given state space representation
   $x\ (k + 1) = (k)+ Bu(k)$
   $y(k)= Cx(k)+ Du(k)$
   where
   A=[0 1 $-$.21 1];B=[0 1]; C=[1 0]

2. Obtain the state space representation of the following transfer function in observable canonical form and controllable canonical form.

$$\frac{Y(z)}{U(z)} = \frac{0.368z^{-1}+0.264z^{-2}}{1-1.368z^{-1}+.368z^{-2}}$$

Course Outcome 5 (CO5):

1. Explain the concept of pole placement by state feedback.
2. Find out the state feedback gain matrix K for the following system by converting the system into controllable canonical form such that the closed loop poles are located at 0.5 and 0.6

$$x(k+1)=\begin{bmatrix}-1 & -1\\ 0 & -2\end{bmatrix}x(k)+\begin{bmatrix}0\\ 1\end{bmatrix}u(k)$$

SYLLABUS

Module 1

Introduction: Basic Elements of discrete data control systems, advantages of discrete data control systems, examples. Signal conversion & processing: Digital signals & coding, data conversion & quantization, sample and hold devices, Mathematical modelling of the sampling process; Data reconstruction and filtering of sampled signals: Zero order hold, first order Hold and polygonal hold.

Module 2

Digital control systems- Pulse transfer function. z transform analysis of closed loop open loop systems-Modified z- transfer function Difference equation. Solution by recursion and z transform. Steady state error analysis- Examples on static error coefficients. Bilinear transformation- mapping from s-plane to z-plane.

Module 3

Stability of linear digital control systems- Routh Hurwitz criteria, Jury's test. Root loci of digital control systems – rules for construction of root locus. Frequency domain analysis - Bode Plots-Gain margin and Phase margin

Module 4

Review of state space techniques to continuous data systems, state space representation of discrete time systems- Transfer function from state space model-various canonical forms- conversion of transfer function model to state space model-characteristics equation- solution to discrete state equations.

Module-5

Controllability and Observability - Response between sampling instants using state variable approach-Pole placement using state feedback. Dynamic output feedback- Effects of finite word length on controllability and closed loop pole placement

Text Books

1.B. C. Kuo , "*Digital control systems*" (Second Edition) , Oxford University Press,2007

2. K. Ogatta, "*Discrete Time control systems"*, 2nd ed. PHI),1995

3. M. Gopal, "*Digital Control systems and state variable methods*", Tata McGraw Hill

Reference

1. John Dorsey, "*Continuous & Discrete Control Systems* ", (MGH).

2. R John Dorsey, "*Continuous & Discrete Control Systems* ", (MGH).

3.R Nagrath & Gopal, "*Control System Engineering*" (Wiley Eastern).

4.R F. Franklin, J.D. Powell, and M.L. Workman, "*Digital control of Dynamic Systems"*, Addison - Wesley Longman, Inc., Menlo Park, CA , 1998

Course Contents and Lecture Plan

Topic	No. of Lectures
Module 1	
Introduction: Basic Elements of discrete data control systems, advantages of discrete data control systems, examples. Signal conversion & processing: Digital signals & coding, data conversion & quantization, sample and hold devices,	**4**
Mathematical modelling of the sampling process; Data reconstruction and filtering of sampled signals: Zero order hold, first order Hold and polygonal hold	**3**
Module 2	
Digital control systems- Pulse transfer function. z transform analysis of closed loop open loop Systems-Modified z- transfer function. Difference equation. Solution by recursion and z transform.	**5**
Steady state error analysis- Examples on static error coefficients. Bilinear transformation- mapping from s-plane to z-plane.	**2**
Module 3	
Stability of linear digital control systems- Routh Hurwitz criteria, Jury's test. Root loci of digital control systems – rules for construction of root locus.	**4**
Frequency domain analysis - Bode Plots-Gain margin and Phase margin	**3**
Module 4	
Review of state space techniques to continuous data systems, state space representation of discrete time systems- Transfer function from state space model-various canonical forms	**4**
conversion of transfer function model to state space model-characteristics equation- solution to discrete state equations.	**3**
Module 5	
Controllability and Observability - Response between sampling instants using state variable approach-Pole placement using state feedback.	**4**

Dynamic output feedback- Effects of finite word length on controllability and closed loop pole placement	**3**

Model Question Paper			
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY EIGHTH SEMESTER B.TECH. DEGREE EXAMINATION			
Course Code: RAT436			
Course Name: DIGITAL CONTROL SYSTEM			
Max. Marks: 100			Duration: 3 Hours
PART A			
	Answer all questions, each carries 3 marks.		Marks
1	Explain the advantages of Digital Data system		(3)
2	Why control systems are designed with high gain feedback		(3)
3	Obtain the transfer function of zero order hold circuit		(3)
4	Explain Liapunov stability analysis		(3)
5	Write the properties of the state transition matrix of discrete time system		(3)
6	Find the stability of the following system using Jurys test F(z)=$4z^2 + 2z + 1$		(3)
7	Discuss the principle of optimality		(3)
8	Draw the block diagram of the system described by the state model $[\dot{x}1\ \dot{x}2\ \dot{x}3\ ]$=[1 0 0 0 1 0 0 $a2$ $a3$][$x1$ $x2$ $x3$]+[0 0 1][u] ,y=x1		(3)
9	What do you mean by controllability and observability of discrete time control systems? Explain		(3)
10	How the s-plane is mapped to z plane		(3)
PART B			
Answer any one full question from each module, each carries14 marks.			
MODULE1			
11	a)	Explain the basic sampled data control system with a neat block diagram	(10)
	b)	Illustrate the digital control system with a stepper motor control	(4)
12	a)	For a sampled data system with $G(s) = \frac{1}{s+1}$, a zero order hold and unity feedback; find find the unit step response with Ts=1sec	(10)
	b)	Write short not on impulse sampling	(4)
MODULE II			
13	a)	Solve the difference equation c(k+2)+3c(k+1)+2c(k)=u(k) given c(0)=1;c(1)=-3;c(k)=0, for k<0.	(10)
	b)	What are the methods for methods for obtaining G(z) from G(s)	(4)
14	a)	Explain the general rules and procedures for constructing Root Loci in detail	(10)
	b)	Derive the expression for static error constants for a typical closed loop system	(4)
MODULE III			

15		Find the range of gain k to make the system stable. The open-loop transfer function is given by G(z)=$\frac{k(.3679z+.264z)}{(z-.3679)(z-1)}$ with T=1sec	(14)
16		The input output relation of a sampled data system is described by the equation y(k+2) +5y(k+1) +6y(k) = x(k+1)-x(k). Determine the pulse transfer function	(14)
		MODULE IV	
17	a)	Determine the state space representation of the following discrete time system $G(z)\frac{1}{(z+1)^2(z+0.1)}$	(10)
	b)	Briefly explain "Diophantine equation".	(4)
18	a)	A discrete time system is described by the difference equation equation Y(k+2) +5y(k+1) +6y(k)=u(k); y (0) =y (1) =0; T=1sec Determine: i)a state model in diagonal canonical form. ii) for input u(k)=1, k≥ 1 , find the o/p y(k).	
	b)	Explain the different types of canonical form representations	(4)
		MODULE V	
19	a)	For the system described by the transfer function G(s)= $\frac{10}{s(s+1)(s+2)}$. Design a feedback controller with state feedback so that the closed loop poles are at -2,-1±j1.	(10)
	b)	Explain pole placement design approach briefly	(4)
20	a)	Design a regulator system using polynomial equations approach with suitable diagrams	(10)
	b)	Explain full order observer with a state diagram	(12)
		****	

RAT426	NATURAL LANGUAGE PROCESSING	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: This course enables the learners to understand the concepts of Natural Language Processing. The course covers basic pre-processing steps, language models, text classification using machine learning algorithms, information and relation extraction methods, Information Retrieval, Question Answer Systems and Machine Translation models. This course enables the students to apply techniques and methods to solve challenging real-world problems in NLP.

Prerequisite: Nil.

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

CO1	Understand the fundamental concepts of NLP
CO2	Explain the different representation methods on text data
CO3	Make use of NLP techniques in Text Classification
CO4	Demonstrate the NLP techniques in Information Extraction and Information Retrieval
CO5	Explain QA Systems and Machine Translation

Mapping of course outcomes with program outcomes

	PO 1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO1 0	PO11	PO1 2
CO1	3	2										2
CO2	3	2	2									2
CO3	3	2		2								2
CO4	3	2	2	2								2
CO5	3	2										2

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	15	15	30
Understand	20	20	40
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 Outcome1 (CO1):

1. Explain the fundamental tasks that make up an NLP system.
2. Why is NLP considered a challenging problem domain?

Course Outcome 2(CO2):

1. Mention two issues associated with sentence segmentation.
2. Compare Bag-of-Words model and Bag-of-n-gram model.

3. Illustrate how TF-IDF model is used to represent text. Mention the advantage of TF-IDF over other models.

4. A corpus of data is given below :

D1	Dog bites man.
D2	Man bites dog.
D3	Dog eats meat.
D4	Man eats food.

Use one hot-encoding and Bag-of-words models to represent "dog bites man".

Course Outcome 3(CO3):

1. The following table shows data about the profile of customers and whether they purchase computers or not. Given this data, use Naïve Bayes Classifier to classify the customer ***X*** (*age = youth, income = medium, student = yes, credit rating = fair*)

RID	*age*	*income*	*student*	*credit_rating*	*Class: buys_computer*
1	youth	high	no	fair	no
2	youth	high	no	excellent	no
3	middle_aged	high	no	fair	yes
4	senior	medium	no	fair	yes
5	senior	low	yes	fair	yes
6	senior	low	yes	excellent	no
7	middle_aged	low	yes	excellent	yes
8	youth	medium	no	fair	no
9	youth	low	yes	fair	yes
10	senior	medium	yes	fair	yes
11	youth	medium	yes	excellent	yes
12	middle_aged	medium	no	excellent	yes
13	middle_aged	high	yes	fair	yes
14	senior	medium	no	excellent	no

2. Illustrate how linearly inseparable data can be made linearly separable by suitable mapping using kernel functions.

Course Outcome 4(CO4): .

1. Given the following data about documents and contents, use tf-idf document scoring method to retrieve the document for the query "best game"

Doc 1	The game was so exciting. The players excelled in every department of the game.
Doc 2	It was an excellent game.
Doc 3	The game was not good. The moves were boring

2. Explain Name Entity Recognition using Sequence Labeling.

Course Outcome 5(CO5):

1. Explain the phases of a factoid question-answering system.
2. Explain a statistical algorithm for word alignment in Machine Translation.

SYLLABUS

Module – 1 (Introduction to NLP)

NLP Tasks and Applications, Language-Building Blocks, Challenges of NLP, Regular Expressions, Text Normalization, Edit Distance, N-gram Language Models, Approaches to NLP-- Heuristics-Based NLP, Machine Learning-based NLP.

Module - 2(Representation Models)

Text Representation—Preprocessing, Sentence segmentation, Word tokenization, Stemming and lemmatization, Vector Space Models--Basic Vectorization Approaches--One-Hot Encoding, Bag of Words, Bag of N-Grams TF-IDF; Distributed Representations-- Word Embeddings, Doc2Vec.

Module - 3 (Classification)

Text Classification--Text classification applications – Pipeline for building text classification systems, Naïve Bayes for Sentiment Classification – Naïve Bayes Classifier Training – Optimizing for Sentiment Analysis, Logistic Regression, Support Vector Machine for Text Classification

Module - 4 (Information Extraction and Retrieval)

Information Extraction(IE)—IE Applications – The General Pipeline for IE - Named Entity Recognition(NER), Ambiguity in Named Entity Recognition – NER as Sequence Labeling – Evaluation of NER.

Information Retrieval – Term weighting and document scoring – Inverted Index – Evaluation of Information Retrieval Systems.

Module - 5 (QA Systems and Machine Translation)

Question-Answering Systems – Factoid Question Answering – Question Processing – Passage Retrieval – Answer Processing – Evaluation of Factoid Answers

Machine Translation – Why Machine Translation is Hard – Classical Machine Translation – Direct Translation – Transfer – Statistical Machine Translation- The Phrase based Translation model – Alignment in MT – Training Alignment Models – Symmetrizing Alignments for Phrase-based MT – Decoding for Phrase-based Statistical MT

Text Books

1. Daniel Jurafsky, James H. Martin , "Speech and Language Processing"(2nd and 3rd editions), Pearson Prentice Hall
2. Sowmya Vajjala, Bodhisattwa Majumder, Anuj Gupta, Harshit Surana," Practical Natural Language Processing: A Comprehensive Guide to Building Real-World NLP Systems " June 2020 Publisher(s): O'Reilly Media, Inc. ISBN: 9781492054054.

Reference Books

1. James Allen, "Natural Language Understanding", Second Edn , Pearson.
2. Christopher Manning and Hinrich Schutze, Statistical Natural Language Processing, MIT Press.

Course Contents and Lecture Schedule

No	Topic	No of Lecture Hrs
Module 1 : Introduction to NLP (7 hours)		
1.1	Introduction to NLP – Tasks and Applications	1
1.2	Language – Building Blocks, Challenges of NLP	1
1.3	Regular Expressions	1
1.4	Text Normalization	1
1.5	Edit Distance	1
1.6	N-gram Language Models	1
1.7	Approaches to NLP-- Heuristics-Based NLP, Machine Learning-based NLP.	1

Module 2 : Representation Models (8 hours)		
2.1	Text Representation--Preprocessing , Sentence segmentation, Word tokenization, Stemming and lemmatization	2
2.2	Vector Space Model	1
2.3	Vectorization Approaches – One hot encoding, Bag of words	1
2.4	Bag of n-grams, TF-IDF	1
2.5	Word Embeddings – Word2Vec	1
2.6	CBOW, SkipGram models	1
Module 3 : Classification (7 hours)		
3.1	Text Classification--Text classification applications – Pipeline for building text classification systems	1
3.2	Naïve Bayes for Sentiment Classification	1
3.3	Naïve Bayes Classifier Training-Optimizing for Sentiment Analysis	2
3.4	Logistic Regression	1
3.5	Support Vector Machine for Text Classification	1
Module 4 : Information Extraction and Retrieval (7 hours)		
4.1	Information Extraction (IE) and Applications, IE Tasks and the IE Pipeline	1
4.2	Named Entity Recognition (NER) – Ambiguity in NER	1
4.3	NER as Sequence Labeling	1
4.4	Evaluation of NER, Practical NER Systems	1
4.5	Information Retrieval – Term weighting and document scoring	1

4.6	Inverted Index, Evaluation of Information-Retrieval Systems	1
Module 5 : QA Systems and Machine Translation (9 hours)		
5.1	Question-Answering Systems – Factoid Question Answering, Question Processing	1
5.2	Passage Retrieval	1
5.3	Answer Processing, Evaluation of Factoid Answers	1
5.4	Machine Translation – Why Machine Translation is Hard	1
5.5	Classical Machine Translation	1
5.6	Statistical Machine Translation	1
5.7	The Phrase based Translation model	1
5.8	Alignment in Machine Translation	1
5.9	Decoding for Phrase-based Statistical MT	1

Model Question Paper
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
EIGHTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR
Course Code: RAT 426
Course Name: Natural Language Processing
Max. Marks : 100 **Duration: 3 Hours**
PART A
Answer All Questions. Each Question Carries 3 Marks

1.		What is text normalization.	(3)
2.		State Bayes' Theorem.	(3)
3.		List three preprocessing steps that are necessary for an HTML file.	(3)
4.		Differentiate CBOW and Skipgram models	(3)
5.		Explain the role of support vectors in SVM Classification.	(3)
6.		Explain challenges in Name Entity Recognition.	(3)
7.		Differentiate information extraction and information retrieval.	(3)
8.		Explain the need for an inverted index in an information retrieval system. Are there any more efficient data structures that serve the same purpose.	(3)
9.		How do you extract answers to DEFINITION questions?	(3)
10.		What are the components that make up a noisy channel model of statistical Machine Translation?	(3)
		Part B **(Answer any one question from each module. Each question carries 14 Marks)**	
11.	(a)	Explain the language models of NLP	**(8)**
	(b)	Explain the different approaches of NLP	**(6)**
		OR	
12.	(a)	Why is NLP considered a challenging problem domain?	**(6)**
	(b)	Explain the fundamental tasks that make up an NLP system.	**(8)**
13.	(a)	Explain sentence segmentation. Mention the issues associated with sentence segmentation.	**(7)**

<table>
<tr><td></td><td>(b)</td><td>Illustrate Bag-of-ngrams model with an example.</td><td>(7)</td></tr>
<tr><td colspan="4">OR</td></tr>
<tr><td>14.</td><td>(a)</td><td>Explain the concept of word embeddings as a model for text representation.</td><td>(8)</td></tr>
<tr><td></td><td>(b)</td><td>Compare word embeddings model with vectorization approaches.</td><td>(6)</td></tr>
<tr><td>15.</td><td>(a)</td><td>Given the following data about movie review and its classification, classify “predictable with no fun” to one of the classes using Naïve Bayes Classifier.
<table>
<tr><td>Document</td><td>Category</td></tr>
<tr><td>just plain boring</td><td>Negative</td></tr>
<tr><td>entirely predictable and lacks energy</td><td>Negative</td></tr>
<tr><td>no surprises and very few laughs</td><td>Negative</td></tr>
<tr><td>very powerful</td><td>Positive</td></tr>
<tr><td>the most fun film of the summer</td><td>Positive</td></tr>
</table></td><td>(14)</td></tr>
<tr><td colspan="4">OR</td></tr>
<tr><td>16.</td><td>(a)</td><td>Explain Logistic Regression for Text Classification.</td><td>(8)</td></tr>
<tr><td></td><td>(b)</td><td>Illustrate the steps involved in classification in Naïve Bayes Classifier.</td><td>(6)</td></tr>
<tr><td>17.</td><td>(a)</td><td>Explain Name Entity Recognition using Sequence Labeling.</td><td>(10)</td></tr>
<tr><td></td><td>(b)</td><td>How is term selection done for indexing?</td><td>(4)</td></tr>
<tr><td colspan="4">OR</td></tr>
<tr><td>18.</td><td>(a)</td><td>Given the following data about documents and contents, use tf-idf document scoring method to retrieve the document for the query “sweet love”.
<table>
<tr><td>Doc 1</td><td>Sweet sweet nurse! Love</td></tr>
<tr><td>Doc 2</td><td>Sweet sorrow</td></tr>
<tr><td>Doc 3</td><td>How sweet is love?</td></tr>
<tr><td>Doc 4</td><td>Nurse!</td></tr>
</table></td><td>(10)</td></tr>
<tr><td></td><td>(b)</td><td>Explain challenges in Name Entity Recognition.</td><td>(4)</td></tr>
</table>

19.	(a)	Explain the phases of a factoid question-answering system.	**(8)**
	(b)	Give an algorithm for word alignment in Machine Translation.	**(6)**
		OR	
20.	(a)	How is decoding done in a Phrase-based Statistical Machine Translation System?	**(10)**
	(b)	Explain the concept of Mean Reciprocal Rank.	**(4)**

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
KTU
Estd.
2014

RAT416	DESIGN FOR MANUFACTURING AND ASSEMBLY	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: The main objective of this course is to understand the basic design rules for manufacturing and material selection and applying the production process for ease of manufacturing. Apply the concepts of design for manufacturing and assembly for product manufacturing.

Prerequisite: Basic knowledge in Metallurgy and material Science, Production technology

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

CO 1	Remember the basic principles of designing for economical production and understand the principles of selection of materials for product development.
CO 2	Understand the general design recommendations for machined parts.
CO 3	Enumerate the general design considerations for casting, casting tolerances and Remember the factors in design of weldments.
CO 4	Analyze the effects of thermal stresses in welded joints and Understand the various advantages and limitations of joining techniques.
CO5	Remember the design factors for forging and Understand the design guidelines for extruded sections.
CO6	Remember Keeler-Goodman formability diagram and its concept and Apply design guidelines to assembly

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	3	1	1	1						1	1
CO 2	3	2	1	1	1						1	1
CO 3	3	3	1	2	1						1	1
CO 4	3	2	1	1	1						1	1
CO 5	3	2	1	2	2						1	1
CO6	3	2		2	1						1	1

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember			
Understand	15	15	30
Apply	21	21	42
Analyse	14	14	28
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 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 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 Ashby charts for material selection.
2. Explain 7 phases of design manufacturing

Course Outcome 2 (CO2):

1. Describe steps in selecting manufacturing process
2. Decision on manufacturing process and steps in selecting a manufacturing process-case study

Course Outcome 3 (CO3):

1. Describe Selection and evaluation of casting processes
2. List examples of poor and good design for machining

Course Outcome 4 (CO4):

1. Metal joining processes and classification
2. Designing forgings for horizontal machines

Course Outcome 5 (CO5):

1. Explain manual assembly methods
2. Explain Robot assembly

Course Outcome 6 (CO6):

1. What do you mean by formability?
2. Explain the use of Forming Limit Diagram in manufacturing.

SYLLABUS

RAT416 DESIGN FOR MANUFACTURING AND ASSEMBLY

Module 1 (6 Hours)

INTRODUCTION TO DFM

Introduction: Design philosophy, steps in design process, general design rules for manufacture ability, basic principles of designing for economical production, creativity in design; materials: Selection of materials for design, developments in material technology, criteria for material selection, and material selection interrelationship with process selection.

Module 2 (6 Hours)

DESIGN FOR MACHINING

Machining Process: Overview of various machining processes, general design rules for machining, dimensional tolerance and surface roughness, design for machining ease, redesigning of components for machining ease with suitable examples, general design recommendations for machined parts.

Module 3 (8 Hours)

DESIGN FOR METAL CASTING & JOINING

Metal Casting: Appraisal of various casting processes, selection of casting process, - general design considerations for casting - casting tolerances - use of solidification simulation in casting design - product design rules for sand casting.

Metal Joining: Appraisal of various welding processes, Factors in design of weldments - general design guidelines - pre and post treatment of welds - effects of thermal stresses in weld joints - design of brazed joints.

Module 4 (7 Hours)

Forging: Design factors for forging, closed die forging, design parting lines of dies, drop forging die design, General design recommendations.

EXTRUSION: Sheet metal work and plastics, Design guide lines for extruded sections, Design principles for punching, blanking, bending, deep drawing, Keeler -Goodman formability diagram,(forming limit diagram) Component design for blanking

Module 5 (8 Hours)

DESIGN OF MANUAL ASSEMBLY

Design for assembly fits in the design process, general design guidelines for manual assembly, development of the systematic DFA methodology, assembly efficiency, classification system for manual handling, classification system for manual insertion and fastening, effect of part symmetry on handling time, effect of part thickness and size on handling time, effect of weight on handling time, parts requiring two hands for manipulation, effects of combinations of factors, effect of symmetry effect of chamfer design on insertion operations, estimation of insertion time

Text Books

1. Geoffrey Boothroyd, “Assembly Automation and Product Design”, Marcel and Dekken, Inc., NY, 2002.
2. George E. Deiter, “Engineering Design - Material & Processing Approach”, McGraw Hill Intl. 2nd Edition, 2010

3. Geoffrey Boothroyd," Hand Book of Product Design", Marcel and Dekken,, N.Y. 2008

Reference Books

1. Geoffrey Boothroyd, "Hand Book of Product Design", Marcel and Dekken, 1st Edition, 2013

2. Geoffrey Boothroyd, Peter Dewhurst, Winston, "Product Design for Manufacturing and Assembly", CRC Press, 1st Edition, 2010

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**INTRODUCTION TO DFM (6 Hours)**	
1.1	Introduction: Design philosophy, steps in design process.	1 Hour
1.2	General design rules for manufacture ability.	1 Hours
1.3	Basic principles of designing for economical production, creativity in design Materials: Selection of materials for design, developments in material technology.	2 Hours
1.4	Criteria for material selection, and material selection interrelationship with process selection, process selection charts.	2 Hours
2	**DESIGN FOR MACHINING (6 Hours)**	
2.1	Machining Process: Overview of various machining processes, general design rules for machining.	2 Hours
2.2	Dimensional tolerance and surface roughness.. Design for machining ease.	2 Hours
2.3	Redesigning of components for machining ease with suitable examples, general design recommendations for machined parts.	2 Hours
3	**DESIGN FOR METAL CASTING & METAL JOINING (8 Hours)**	

3.1	Metal Casting: Appraisal of various casting processes, selection of casting process, - general design considerations for casting.	2 Hours
3.2	Casting tolerances - use of solidification simulation in casting design - product design rules for sand casting.	2 Hours
3.3	Metal Joining: Appraisal of various welding processes, Factors in the design of weldments.	2 Hours
3.4	General design guidelines - pre and post treatment of welds - effects of thermal stresses in weld joints - design of brazed joints.	2 Hours
4	**FORGING AND EXTRUSION (6 Hours)**	
4.1	Design factors for forging, closed die forging, design parting lines of dies, drop forging die design, General design recommendations.	2 Hours
4.2	Sheet metal work and plastics, Design guide lines for extruded sections, Design principles for punching.	2 Hour
4.3	Blanking, Bending, Deep Drawing - Keeler Goodman Forming Line Diagram - Component Design for Blanking.	3 Hours
5	**DESIGN OF MANUAL ASSEMBLY (8 Hours)**	
5.1	Design for assembly fits in the design process, general design guidelines for manual assembly, development of the systematic DFA methodology.	2 Hours
5.2	Assembly efficiency, classification system for manual handling, classification system for manual insertion and fastening	2 Hours
5.3	Effect of part symmetry on handling time, effect of part thickness and size on handling time, effect of weight on handling time, parts requiring two hands for manipulation,	2 Hours
5.4	Effects of combinations of factors, effect of symmetry effect of chamfer design on insertion operations, estimation of insertion time	2 Hours

Model Question Paper

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

Course Code: RAT 416
Course Name: Design for Manufacturing and Assembly

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

PART A

Answer all Questions. Each question carries 3 Marks

1. Explain the Definition of Design for Manufacture & Assembly (DFMA)
2. Explain the relation of Materials Selection to Design
3. Compare Planing, Shaping and Broaching.
4. Distinguish between traditional and Non Traditional Machining Processes
5. List the benefits and bottlenecks of casting simulation
6. Compare fusion welding and pressure welding
7. List the design guidelines for sheet metal bending
8. Explain the design factors for closed die-forging
9. Discuss the types of manual assembly methods
10. Explain the manual handling insertion of parts.

PART B

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

Module 1

11. a. Explain the flow diagram of various steps undertaken for applying DFMA during product design (8)

    b. List the advantages of applying DFMA during product Design (6)

12. a. Discuss the general Criteria for Selection of materials (6)
    b. Explain process selection charts and process shape matrix (8)

Module 2

13. a. With a Schematic depiction, explain Abrasive Jet Machining (7)

b. Discuss the machinability of materials (7)

14. a. Describe the classification of machining processes (7)
b. With a schematic depiction, describe turning operation (7)

Module 3

15 a. Describe the important pre- heating and post heating guidelines for a good welding design (7)
b. List the design considerations for casting (7)
16 a. Explain Brazing, Soldering and Adhesive bonding in Metal joining process (7)
b. List the benefits and bottlenecks of casting simulation (7)

Module 4

17 a. Differentiate between forward and backward extrusion process. (4)
b. What are the advantages of cold extrusion over hot extrusion? Discuss cold extrusion processes. (5)
c. Distinguish between direct and indirect extrusion. (5)

18. a. What is upset forging ? Show the different parts of the forging die punch set up (7)
b. What is the purpose of heat treatment of forging ? (3)
c. Explain sequentially the various passes used in drop forging with a suitable diagram. (4)

Module 5

19. a. Explain the effect of chamfer design on manual insertion (6)
b. Discuss the effect of the following part features:
i) Effect of part symmetry on handling Time
ii) Effect of weight on handling time
iii) Effect of product thickness and size on handling time (8)

20. a. Explain the design guidelines for component insertion and mechanical fastening (7)

b. List the assembly rules and criteria. Discuss the major benefits of design of assembly (7)

CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
RAT474	DATA ANALYTICS FOR ENGINEERS	PEC	2	1	0	3

Preamble: The student will understand the techniques to analyse different types of data, characterize it and can apply them to make decision modelling process more intelligent.

Prerequisite: Nil

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

CO 1	Explain different data analysis techniques
CO 2	Discuss the concepts behind the descriptive analytics and predictive analytics of data
CO 3	Familiarize with Big Data and its sources
CO 4	Illustrate different visualization techniques in data analysis

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	30
Understand	30	30	40
Apply	10	10	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. Explain the different types of prediction errors.

2. What is the need for sampling? Explain about different sampling methods.

3. Compare and contrast analysis and reporting in data analytics with suitable example

Course Outcome 2 (CO2)

1. Differentiate descriptive and predictive analysis technique.

2. Explain how attribute selection is carried out in decision tree induction.

3. Write different steps in Apriori algorithm used for finding frequent item sets.

Course Outcome 3(CO3):

1. Explain 3V's in big data analytics
2. List the different sources of bigdata.
3. With suitable example, give the difference between Business intelligence and data analytics.

Course Outcome 4 (CO4):

1. Discuss file system used for big data analysis.

2. Explain how recommender systems help in big data analysis.

3. Explain different techniques used for data visualization,

Model Question Paper

APJ Abdul kalam Technological University

VIII Semester B.Tech Degree Examination

RAT 474 Data Analytics for Engineers

PART A

Answer all questions, each carries 3 marks

1. Explain how significance level affects inferences drawn from data.

2. Define the term correlation between data points.

3. Differentiate classification and prediction.

4. State the different activation functions used in neural networks.

5. Give a brief description about how to perform descriptive analysis in a dataset.

6. Explain frequent item sets in association rule mining with example ?

7. Define bigdata.

8. List the challenges in big data acquisition

9. Explain the term social media analytics.

10. What is the significance of scatter plot matrix?

PART B

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

Module I

11.Give the significance of resampling technique. Explain the different types of resampling techniques.

12. Describe the process of hypothesis technique with the help of a suitable example.

Module II

13. Illustrate regression analysis in predictive modelling.

14. Explain how principal components are extracted using PCA.

Module III

15. Differentiate K-means and hierarchical clustering techniques with suitable example.

16. Describe market-based model used in descriptive analysis.

Module IV

17. With the help of a neat diagram, describe data analytics lifecycle.

18. a. Describe the characteristics of Big data?

    b. Summarize the challenges and applications of big data analytics

Module V

19. What is HDFS? How does it handle Big Data?

20. Illustrate and explain the concept of Map Reduce framework

SYLLABUS

Module 1 (7 hours)

Introduction to Data Analysis - Evolution of Analytic scalability, analytic processes and tools, Analysis vs reporting - Modern data analytic tools. Statistical concepts: Sampling distributions, re-sampling, statistical inference, prediction error.

Module 2 (7 hours)

Predictive Analytics – Regression, Decision Tree, Neural Networks. Dimensionality Reduction - Principal component analysis

Module 3 (7 hours)

Descriptive Analytics - Mining Frequent item sets - Market based model – Association and Sequential Rule Mining - Clustering Techniques – Hierarchical – K- Means

Module 4 (6 hours)

Introduction to Big data framework - Fundamental concepts of Big Data management and analytics - Current challenges and trends in Big Data Acquisition

Module 5 (8 hours)

Popular Big Data Techniques and tools- Map Reduce paradigm and the Hadoop system- Applications Social Media Analytics, Recommender Systems- Fraud Detection

Text Books

1. EMC Education Services, Data Science and Big Data Analytics: Discovering, Analyzing, Visualizing and Presenting Data. John Wiley & Sons, 2015.

2. Jaiwei Han, Micheline Kamber, “Data Mining Concepts and Techniques”, Elsevier, 2006.

3. Michael Berthold, David J. Hand, Intelligent Data Analysis, Springer, 2007.2.

Reference Books

1. Bart Baesens," Analytics in a Big Data World: The Essential Guide to Data Science and its Business Intelligence and Analytic Trends", John Wiley & Sons, 2013 Challenges and Future Prospects, Springer, 2014.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
	Module 1	
1.1	Introduction to Data Analysis - Evolution of Analytic scalability	1
1.2	Analytic processes and tools	2
1.3	Analysis vs reporting - Modern data analytic tools	2
1.4	Statistical concepts: Sampling distributions, re-sampling, statistical inference, prediction error.	2
	Module 2	
2.1	Predictive Analytics – Regression	2
2.2	Decision Tree	2
2.3	Neural Networks	1
2.4	Dimensionality Reduction - Principal component analysis	2
	Module 3	
3.1	Descriptive Analytics - Mining Frequent item sets	2
3.2	Market based model	2
3.3	Association and Sequential Rule Mining	1
3.4	Clustering Techniques – Hierarchical	1
3.5	K- Means	1
	Module 4	
4.1	Introduction: Fundamental concepts of Big Data management and analytics	2
4.2	Data Analytics Lifecycle Overview	2
4.3	Current challenges and trends in Big Data Acquisition	2
	Module 5	
5	Popular Big Data Techniques and tools	1
5.1	Map Reduce paradigm	2
5.2	Hadoop system	2
5.3	Applications Social Media Analytics, Recommender Systems- Fraud Detection	2
5.4	Data Visualization techniques-overview	1

RAT464	NONLINEAR CONTROL	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: This course is designed to equip the students to analyse and designing nonlinear control system

Prerequisite: Control System Theory

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

CO 1	Understand nonlinear system behaviour
CO 2	Analyse nonlinear system using phase plane method
CO 3	Understand describing function method for analysing nonlinear system
CO 4	Analyse the stability of nonlinear system using Lyapunov method
CO 5	Describe various Adaptive Control Schemes and analyze its stability.

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	20	20	40
Apply	20	20	50
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 a maximum 2 subdivisions and carry 14 marks.

Course Level Assessment Questions

Course Outcome 1 (CO1): Understand nonlinear system behaviour

1. Differentiate between autonomous and non-autonomous systems.
2. Distinguish linear system from nonlinear system
3. Explain the modelling of nonlinear mass damper system

Course Outcome 2 (CO2): Analyse nonlinear system using phase plane method

1. Explain how the properties of a system can be best explained by analyzing the nature of singular points.
2. Generate the phase portrait of system by employing the method of isoclines.
3. Explain the concept of limit cycles in the stability analysis of non-linear systems.

Course Outcome 3 (CO3): Understand describing function method for analysing nonlinear system

1. Define Describing function. Explain how describing functions can be used to discover theexistence of limit cycles and their stability.
2. Compute the describing function for saturation non-linearity.
3. Explain the Limit cycle detection for frequency dependent describing functions.

Course Outcome 4 (CO4): Analyse the stability of nonlinear system using Lyapunov method

1. State and explain the Lyapunov's linearization method.
2. Explain Lyapunov's direct method and apply it to a non-linear mass damper spring system.
3. Explain Lyapunov's theorem for local stability.

Course Outcome 5 (CO4): Describe various Adaptive Control Schemesand analse its stability.

1. Obtain the controller and identifier structure in the input error direct adaptive control scheme.
2. Explain the implementation of output error direct adaptive control algorithm.
3. Differentiate between input error and output error direct adaptive control schemes

SYLLABUS

Module 1

Introduction: Linear vs non-linear system- non-linear systems and equilibrium points- non–linear system behaviour-examples-Common Nonlinearities in control systems-Autonomous and non-autonomous systems modelling of simple pendulum- mass spring system

Module 2

Phase Plane Analysis: Singular points-construction of phase portraits- method of isoclines- phase plane analysis of linear systems- phase plane analysis of nonlinear systems- local behaviour of non-linear systems-limit cycles- Stability- poincare- bendixon theorems.

Module 3

Describing Function: Describing Function Fundamentals Describing functions of common nonlinearities-hysteresis, backlash, relay, dead zone, saturation and combined effects stability analysis and limit cycles

Module 4

Stability of nonlinear systems-Lyapunov theory (review)-autonomous and non-autonomous systems equilibrium points, Stability in the sense of Lyapunov, asymptotic stability and exponential stability, Linearization and local stability, Lyapunov's direct method, positive definite functions and Lyapunov functions, Lyapunov theorem for local stability and global stability

Module-5

Parametric models of dynamical systems-SISO LTI Identification- Linear ErrorEquation- Gradient Algorithm-Least Squares Algorithm-Model Reference Identifier.Model Reference Adaptive Control-Input Error Direct Adaptive Control- Output Error Direct Adaptive Control- Indirect Adaptive Control

Text Books

1. Jean Jacques Slotine and Weiping Li , "Applied Nonlinear Control", Prentice Hall Inc., 1991
2. Shankar Sastry and Marc Bodson, Adaptive Control- Stability, Convergence and Robustness, Springer,2011
3. Shankar Sastry, Nonlinear Systems; Analysis, Stability and Control, Springer. 1999
4. K.J. Astrom and B. Wittenmark, Adaptive Control, 2nd ed., Pearson Education, 1995

References

1. H. K. Khalil., "Nonlinear Systems", Pearson Education, 3rdEd.
2. M Gopal "Digital Control and State Variable Methods", Tata McGraw-Hill Ltd, New Delhi, 2003.
3. NagoorKani, "Advanced Control System", Rba Publications

Course Contents and Lecture Plan

Topic	No. of Lectures
Module 1	
Introduction: Linear vs non-linear system- non-linear systems and equilibrium points- non–linear system behaviour-examples-Common Nonlinearities in control systems	4
Autonomous and non-autonomous systems, modelling of simple pendulum-mass spring system analysis and design of nonlinear system.	3
Module 2	
Phase Plane Analysis: Singular points-construction of phase portraits- method of isoclines- phase plane analysis of linear systems- phase plane analysis of nonlinear systems	3
local behaviour of non-linear systems-limit cycles- Stability- Poincare-bendixon theorems	4
Module 3	
Describing Function: Describing Function Fundamentals Describing functions of common nonlinearities-hysteresis, backlash, relay, dead zone, saturation and combined effects stability analysis and limit cycles	7
Module 4	
Stability of nonlinear systems-Lyapunov theory (review)-autonomous and non-autonomous systems equilibrium points, Stability in the sense of Lyapunov, asymptotic stability and exponential stability	3
Linearization and local stability , Lyapunov's direct method, positive definite functions and Lyapunov functions, Lyapunov theorem for local stability and global stability	4
Module 5	
Parametric models of dynamical systems-SISO LTI Identification- Linear Error Equation- Gradient Algorithm-Least Squares Algorithm-Model Reference Identifier. Model Reference Adaptive Control-Input Error Direct Adaptive Control- Output Error Direct Adaptive Control	4
Indirect Adaptive Control. Stability- Input Error Direct Adaptive Control-Output Error Direct Adaptive Control- Indirect Adaptive Control.	3

Model Question Paper

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

Course Code: RAT 464

Course Name: NON LINEAR CONTROL

Max. Marks: 100 | Duration: 3 Hours

PART A

		Answer all questions, each carries 3 marks.	Marks
1		Compare the features of linear and non-linear system	(3)
2		Explain the term Jump resonance in a nonlinear system	(3)
3		Define singular points. How are they classified?	(3)
4		Explain basic concept of phase plane analysis	(3)
5		Explain the features of describing function method	(3)
6		Determine the definiteness for the following quadratic form V(x)=$10x_1{}^2 + 4x_2{}^2 + x_3{}^2 + 2x_1x_2 - 2x_2x_3 - 4x_1x_3$	(3)
7		Explain limit cycle phenomenon with a suitable example	(3)
8		Deduce the phase variable representation of the following transfer function $G(s)\frac{2s+3}{s^3+0.1)}$	(3)
9		Explain the bounded input bounded state stability concept for adaptive systems.	(3)
10		Explain the major differences between input error and output error adaptive control schemes.	(3)
		PART B	
		Answer any one full question from each module, each carries14 marks.	
		MODULE1	
11	a)	Explain different types of a non-linearties in a control system	(10)
	b)	Differentiate between autonomous and non-autonomous control system.	(4)
12	a)	Explain the mathematical modelling of mass damper system taking into account the associated nonlinearities	(10)
	b)	The response of a system is given as y=a+b(dx/dt) .Test whether the system is linear or non-linear.	(4)
		MODULE II	
13	a)	A second order system is represented by the differential equation ë + 2$\zeta$$\omega$ė +$\omega^2$e = 0 where ζ= 0.25, ω= 1 rad/sec, e(0) = 2.5 and ė(0) = 0. Determine the singular point. Construct the phase trajectory using isocline method.	(10)
	b)	Explain any one method for the construction of a phase portrait.	(4)
14	a)	Determine the type of singularity for the following system	(10)

		$\dot{x}_1$=-$x_1 + {x_1}^2 x_2$ and$\dot{x}_2$=-$x_1 + x_2$	
	b)	Determine the sign definiteness of scalar function $F(x) = -5{x_1}^2 - 4{x_2}^2 - 2{x_3}^2 - 2x_1x_2 + 2x_2x_3 + 4x_1x_3$	(4)
		MODULE III	
15	a	Derive the describing function of Dead-zone Non-Linearity	(7)
	b	Derive the describing function of Backlash Non-Linearity?	(7)
16	a	Derive the describing function of Relay with Dead-zone and Hysteresis non-linearity?	(10)
	b	What is the significance of describing function analysis?	(4)
		MODULE IV	
17	a)	Test the stability of non-linear system $\dot{X} = \begin{bmatrix} 0 & 1 \\ -1 & -{x_1}^2 \end{bmatrix}$	(10)
	b)	Distinguish between local stability and global stability.	(4)
18	a)	Determine the value of K such that system is stable in the sense of Lyapunov $\dot{X} = \begin{bmatrix} 0 & K \\ -1 & -1 \end{bmatrix} X$	(10)
	b)	Describe asymptotic stabilization problem in nonlinear control systems.	(4)
		MODULE V	
19	a)	Define the update law for standard gradient algorithm. Explain the implementation of identifier with normalized gradient algorithm.	(7)
	b)	Define covariance propagation equation for least squares algorithm. Explain the implementation of identifier with normalized least squares algorithm and covariance resetting.	(7)
20	a)	Obtain the input error identifier structure and explain the implementation of input error direct adaptive control algorithm.	(14)
		****	

RAT454	CNC MACHINES	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: To make students familiar with basis of CNC machines and CNC machine tools

To provide knowledge on write manual part program and program using APT

To provide knowledge about computer numerical control system.

Prerequisite: Advanced automation system

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

CO 1	Understand about basics of CNC system and CNC machine tools
CO 2	Understand about constructional features of CNC machine tools
CO 3	Write manual part program and program using APT
CO 4	Understand about computer numerical control system
CO 5	Understand about manufacturing automation

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	25	25	25
Understand	15	15	45
Apply	10	10	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. List the operations that could be performed on a machining center
2. What are the different types machining centers?
3. Describe the classification of CNC turning machines.
4. List the operations that could be performed an a machining center.

Course Outcome 2 (CO2):

1. What are the special constructional features of CNC machine tools?
2. What are the requirements of the slideway system of CNC machine tools?

Course Outcome 3 (CO3):

1. What is the purpose of a feedback device in a CNC machine tool?
2. Describe the broad classification of feed- back transducers.
3. What are the various word address codes used in a CNC program
4. What is contouring?

Course Outcome 4 (CO4):

1. Describe programming procedure for CNC turning.
2. Describe with the aid of a block diagram the various steps involved in computer aided part programming

3. Describe with the aid of a block diagram the principal components of a typical CNC system
4. Explain the G-Functions and M-Functions used in part programming

Course Outcome 5 (CO5):

1. What are the different types of interpolation systems? Explain each one of them
2. Explain the functions of CNC systems.

SYLLABUS

Module 1 (7 Hours)

INTRODUCTION TO COMPUTOR NUMERICAL CONTROL: Introduction, CNC system-an overview, fundamental aspects of machine control, types of interpolation, CNC machine components.

CNC MACHINE TOOLS: machining centers, turning centers/CNC lathes, CNC drilling and milling machines, CNC grinding machines

Module 2 (6 Hours)

CONSTRUCTIONAL FEATURES OF CNC MACHINE TOOL: Introduction, spindle drives of CNC machine tools, transmission belting, axes feed drives, slide ways for machines, ball screws, accessories of machining centers, accessories and constructional features of CNC lathes.

Module 3 (8 Hours)

FEEDBACK DEVICES IN CNC MACHINE TOOLS: Introduction, digital incremental displacement measuring systems, the digital absolute measuring system, electro-magnetic analogue position transducers

MANUAL PART PROGRAMMING: Introduction, manual part programming, nomenclature of the CNC machines, preparatory functions (G-functions), miscellaneous functions (M-functions), further part programming examples, hints for programming, program examples of machining centers.

Module 4 (7 Hours)

COMPUTER AIDED PART PROGRAMMING: Introduction, languages for computer programming, geometric system in APT, point-to-point programming, programming in tool path, motion commands, post processor statements, part programming examples in APT

Module 5 (8 Hours)

COMPUTER NUMERICAL CONTROL SYSTEMS: Introduction, description of a simple CNC control system, interpolation systems, interpolator, types of interpolators, contour programming, hardware of interpolation systems, functions of a CNC system, advantages microprocessor based numerical control systems, programmable machine interface(PMI), features available in typical CNC system, new developments in CNC systems

Text Books

1. P RADHAKRISHNAN, computer numerical control machines, New central book agency(p) ltd.
2. MIKELL P. GROOVER,Automation production systems, computer – integrated manufacturing

Reference Books

1. P M AGRAWAL , CNC fundamentals and programming
2. ASHOK KUMAR SINGH, CNC programming, vayu education of India.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**MODULE 1**	
1.1	Introduction, CNC system-an overview, fundamental aspects of machine control, types of interpolation, CNC machine components.	3
1.2	machining centers, turning centers/CNC lathes, CNC drilling and milling machines, CNC grinding machines	4
2	**MODULE 2**	
2.1	Introduction, spindle drives of CNC machine tools, transmission belting, axes feed drives, slide ways for machines	3
2.2	ball screws, accessories of machining centers, accessories and constructional features of CNC lathes.	3
3	**MODULE 3**	
3.1	Introduction, digital incremental displacement measuring systems, the digital absolute measuring system, electro-magnetic analogue position transducers	3
3.2	Introduction, manual part programming, nomenclature of the CNC machines, preparatory functions (G-functions), miscellaneous functions (M-functions), further part programming examples, hints for programming, program examples of machining centers.	5
4	**MODULE 4**	
4.1	Introduction, languages for computer programming, geometric system in APT, point-to-point programming, programming in tool path,	4
4.2	motion commands, post processor statements, part programming examples in APT	3
5	**MODULE 5**	
5.1	Introduction, description of a simple CNC control system, interpolation systems, interpolator, types of interpolators	2

5.2	contour programming, hardware of interpolation systems, functions of a CNC system, advantages microprocessor based numerical control systems,	3
5.3	programmable machine interface(PMI), features available in typical CNC system, new developments in CNC systems	2

Model Question Paper

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
EIGHTH SEMESTER B.TECH. DEGREE EXAMINATION
Course Code: RAT 454
Course Name: CNC MACHINES

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1	Define CNC systems.	(3)
2	Write a short note on machine centers .	(3)
3	What are the major types of spindle drives.	(3)
4	Discuss any two common transmission belting mechanism	(3)
5	Write a short note on electro-magnetic analog position transducers.	(3)
6	List out the common G-codes used for manual part programming.	(3)
7	write a short note on geometric statements APT	(3)
8	What are M-Functions? List out any 3 M-Functions and their usage	(3)
9	List out the types of interpolators.	(3)
10	Shortly explain the functions of CNC systems.	(3)

PART B

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

MODULE I

11	a)	Explain the working of CNC system with the help of a block diagram.	(14)
12	a)	Discuss in detail about CNC grinding machines. What are the types of CNC grinding machines	(14)

MODULE II

13	a)	Discuss in detail about accessories and constructional features of CNC lathes	(14)
14	a)	List out the different accessories of machining centers and their purposes	(14)

MODULE III

15	a)	Compare digital incremental displacement measuring systems and digital absolute measuring systems	(14)
16	a)	Write an example of a manual part program for turning operations	(14)

MODULE IV

17	a)	Write a part program example in APT.(14 Marks)	(14)
18	a)	Explain the different Post processor statements used in part programming	(14)

MODULE V

19	a)	What are the major features available in a typical CNC system. (14 Marks)	(14)
20	a)	Compare the advantages and disadvantages of hardware and software interpolations	(14)

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RAT444	ROBOT MOTION PLANNING	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Motion planning for robots deals with the planning and computation of the movement of one or more physical or virtual robots or agents. These algorithms can be used to generate motions in a workspace in order to achieve a goal-specified task.

Prerequisite: RAT301 Introduction to Robotics

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

CO 1	Explain the concepts of topology and configuration space in motion planning
CO 2	Describe the classical motion planning techniques
CO 3	Describe the working of sampling-based motion planners
CO 4	Apply sensor information to motion planning and obstacle avoidance
CO 5	Explain dynamic motion planning techniques

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	20	10	20
Understand	30	20	40
Apply		20	40
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. Distinguish between connected and path connected topological spaces.
2. Describe how obstacles are dealt with in the configuration space of a circular mobile robot.
3. Explain Homeomorphism and Diffeomorphism in the topology of a configuration space.

Course Outcome 2 (CO2):

1. Describe the terms Accessibility, Departability, Connectivity with reference to Roadmaps
2. Describe Silhouette Methods in motion planning.
3. Explain deformation retracts in roadmap motion planning.

Course Outcome 3 (CO3):

1. Describe the characteristics of Sampling-Based Planners.
2. Describe the basic Probabilistic Roadmap PRM construction.
3. Explain Rapidly-Exploring Random Trees RRTs.

Course Outcome 4 (CO4):

1. Apply motion planning concepts to the motion of flexible objects.
2. Describe the A* algorithm with a suitable example.
3. Explain the Bug1 algorithm.

Course Outcome 5 (CO5):

1. Explain Configuration-Time space.
2. Describe the configuration space of a planar two revolute joint manipulator.
3. Explain Centralized Planning and Decoupled planning

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SYLLABUS

Module I (7 Hours)

Overview of robot motion planning: Application areas of robot motion planning - Personal Transport Vehicles, Planetary Exploration, Demining, Fixed-base Robot Arms in Industry, Search and Rescue Robots, Surgical Robots; Concepts in Motion Planning – Task, Properties of the Robot, Properties of the Algorithm

Basic Topological Concepts: Basic definitions of Topological Spaces, Homeomorphism, Diffeomorphism, Differentiable Manifolds, Paths and Connectivity – Paths, connected vs. path connected

Configuration space: Specifying a Robot's Configuration, Obstacles and the Configuration Space - Circular Mobile Robot, Two-Joint Planar Arm, C obstacles, Topology of the Configuration Space

Module II (7 Hours)

Classical motion planning paradigms:

Roadmaps: Definition, Accessibility, Departability, Connectivity, Types of roadmaps: visibility maps – visibility graphs, deformation retracts – Generalized Voronoi Diagram GVD, Sensor-Based Construction of the GVD, Polygonal Spaces, Grid Configuration Spaces - The Brushfire Method, Silhouette Methods - Canny's Roadmap Algorithm

Cell decomposition: Exact cell decomposition, Approximate cell decomposition, Trapezoidal Decomposition, Morse Cell Decomposition, Boustrophedon Decomposition

Potential Field Planning: Potential Field Method, Attractive, Repulsive potential

Module III (7 Hours)

Sampling-Based Algorithms: Characteristics of Sampling-Based Planners, Probabilistic Roadmaps: Basic PRM – Roadmap Construction, Query Phase, PRM Sampling Strategies - Sampling near the obstacles, Sampling inside narrow passages, Visibility-Based Sampling, Manipulability-Based Sampling, Single-Query Sampling-Based Planners - Expansive-Spaces Trees EST, Rapidly-Exploring Random Trees RRTs

Module IV (7 Hours)

Sensor-Based Motion Planning Algorithms: Bug1, Bug2, Tangent Bug algorithms, Vector field histogram, the bubble band technique, curvature velocity techniques, Dynamic window approaches

A*, D* Algorithms

Manipulation Planning, Assembly planning, Motion planning for flexible objects

Case studies: Going to location A in a given environment (differential drive robot); Finding an object B in a given environment

Module V (7 Hours)

Multiple Moving Objects Motion Planning:

Multiple Robot Motion Planning: Problem Formulation, Composite Configuration Space, Centralized Planning, Decoupled planning - Prioritized planning - Fixed-path coordination, Fixed-roadmap coordination

Dynamic Motion Planning: Moving Obstacles, Configuration Time space, Planning without velocity bound - Exact Cell Decomposition, Approximate Cell Decomposition, Planning with velocity bound - Asteroid Avoidance Problem, Approximate Cell Decomposition, Velocity Tuning

Motion Planning for Articulated Robots: Configuration space – planar two revolute joint manipulator, articulated three joint manipulator, Path planning methods

Text Books

1. Principles of Robot Motion - Theory, Algorithms, and Implementation, Choset, Lynch, Hutchinson, Kantor, Burgard, Kavraki, Thrun, MIT Press
2. Planning Algorithms, Steven M. LaValle, Cambridge University Press
3. Introduction to Autonomous Mobile Robots, Roland Siegwart and Illah R. Nourbakhsh, MIT Press

Reference Books

1. Autonomous Mobile Robots and Multi-Robot Systems - Motion-Planning, Communication, and Swarming, Kagan, Shvalb, Ben-Gal, Wiley
2. Robot Motion Planning, Jean- Claude Latombe, Springer Science+Business Media

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1	**Overview of robot motion planning**	
1.1	Application areas of robot motion planning - Personal Transport Vehicles, Planetary Exploration, Demining, Fixed-base Robot Arms in Industry, Search and Rescue Robots, Surgical Robots; Concepts in Motion Planning – Task, Properties of the Robot, Properties of the Algorithm	1
1.2	Basic Topological Concepts: Basic definitions of Topological Spaces, Homeomorphism, Diffeomorphism, Differentiable Manifolds, Paths and Connectivity – Paths, connected vs. path connected	3
1.3	Configuration space: Specifying a Robot's Configuration, Obstacles and the Configuration Space - Circular Mobile Robot, Two-Joint Planar Arm, C obstacles, Topology of the Configuration Space	3
2	**Classical motion planning paradigms**	

2.1	Roadmaps: Definition, Accessibility, Departability, Connectivity, Types of roadmaps: visibility maps – visibility graphs, deformation retracts – Generalized Voronoi Diagram GVD, Sensor-Based Construction of the GVD, Polygonal Spaces, Grid Configuration Spaces - The Brushfire Method, Silhouette Methods - Canny's Roadmap Algorithm	4
2.2	Cell decomposition: Exact cell decomposition, Approximate cell decomposition, Trapezoidal Decomposition, Morse Cell Decomposition, Boustrophedon Decomposition	2
2.3	Potential Field Planning: Potential Field Method, Attractive, Repulsive potential	1
3	**Sampling-Based Algorithms**	
3.1	Characteristics of Sampling-Based Planners, Probabilistic Roadmaps: Basic PRM – Roadmap Construction, Query Phase	3
3.2	PRM Sampling Strategies - Sampling near the obstacles, Sampling inside narrow passages, Visibility-Based Sampling, Manipulability-Based Sampling	2
3.3	Single-Query Sampling-Based Planners - Expansive-Spaces Trees EST, Rapidly-Exploring Random Trees RRTs	2
4	**Sensor-Based Motion Planning Algorithms**	
4.1	Bug1, Bug2, Tangent Bug algorithms	2
4.2	Vector field histogram, the bubble band technique, curvature velocity techniques, Dynamic window approaches	1
4.3	A*, D* Algorithms	2
4.4	Manipulation Planning, Assembly planning, Motion planning for flexible objects	1
4.5	Case studies: Going to location A in a given environment (differential drive robot); Finding an object B in a given environment	1
5	**Multiple Moving Objects Motion Planning**	
5.1	Multiple Robot Motion Planning: Problem Formulation, Composite Configuration Space, Centralized Planning, Decoupled planning - Prioritized planning - Fixed-path coordination, Fixed-roadmap coordination	3
5.2	Dynamic Motion Planning: Moving Obstacles, Configuration Time space, Planning without velocity bound - Exact Cell Decomposition, Approximate Cell Decomposition, Planning with velocity bound - Asteroid Avoidance Problem, Approximate Cell Decomposition, Velocity Tuning	2
5.3	Motion Planning for Articulated Robots: Configuration space – planar two revolute joint manipulator, articulated three joint manipulator, Path planning methods	2

Model Question Paper

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

Course Code: RAT444
Course Name: Robot Motion Planning

Max. Marks: 100 Duration: 3 Hours

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

1		Explain the application of robot motion planning in any three areas.	(3)
2		Distinguish between connected and path connected topological spaces.	(3)
3		Describe the terms Accessibility, Departability, Connectivity with reference to Roadmaps	(3)
4		Distinguish between Exact cell decomposition and Approximate cell decomposition	(3)
5		Describe the characteristics of Sampling-Based Planners.	(3)
6		Define Expansive-Spaces Trees EST.	(3)
7		Is the Bug2 algorithm better than the Bug1 algorithm? Justify your answer.	(3)
8		Apply motion planning concepts to the motion of flexible objects.	(3)
9		Explain Centralized Planning, Decoupled planning with reference to multi robot motion planning.	(3)
10		Explain the terms direct motion, contact motion and fundamental motion of a moving object.	(3)

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

MODULE1

11	a)	Describe how obstacles are described in C space.	(7)
	b)	Explain Homeomorphism and Diffeomorphism in the topology of a configuration space.	(7)
12	a)	Describe how obstacles are dealt with in the configuration space of a circular mobile robot.	(7)
	b)	Explain manifold and chart in topology.	(7)

MODULE II

13	a)	Explain deformation retracts in roadmap motion planning.	(7)
	b)	Describe Silhouette Methods in motion planning.	(7)
14	a)	Explain Trapezoidal Decomposition, Morse Cell Decomposition and	(6)

Boustrophedon Decomposition.

b) Describe motion planning using the Potential field method. (8)

MODULE III

15 a) Describe basic Probabilistic Roadmap PRM construction. (7)

b) Explain Rapidly-Exploring Random Trees RRTs. (7)

16 Explain the various sampling strategies used in Probabilistic Roadmaps. (14)

MODULE IV

17 a) Describe the A* algorithm with a suitable example. (7)

b) Apply suitable motion planning techniques for moving a differential drive robot to a specified point on a plane. (7)

18 a) Explain the Bug1, Bug2, Tangent Bug algorithms with advantages and disadvantages of each. (14)

MODULE V

19 a) Describe the configuration space of a planar two revolute joint manipulator. (7)

b) Explain Configuration-Time space. (7)

20 a) Describe dynamic motion planning with velocity bound. (14)

****

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY KTU Estd. 2014

RAT434	INDUSTRIAL MANIPULATORS	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: This course will enable the students to learn the fundamentals of industrial manipulators. It will enable the learner to have an idea about kinematics and mechanics of industrial manipulators. The learners are also expected to understand the manipulator dynamics.

Prerequisites: control systems,

Course Outcomes: After the completion of the course the student will

CO 1	Understand the basics of industrial manipulator
CO 2	Understand manipulator kinematics and mechanics of robot motion, forward and inverse kinematic transformation of position
CO3	Understand forward and inverse kinematic transformation of velocity, end effectors force transformations
CO4	Understand about manipulator dynamics
CO5	Understand robot control schemes

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

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 are the different types of end effectors
2. Discuss the sensors and actuators used in robotic systems.

Course Outcome 2 (CO2):

1. Explain rotation matrices and Euler angles.
2. Explain direct kinematics of manipulators.
3. Explain the inverse kinematics

Course Outcome 3 (CO3):

1. Explain differential kinematics and statics.
2. Explain kinematic transformation of velocity

Course Outcome 4 (CO4):

1. Illustrate the dynamic model of simple manipulator structures
2. Compare different inverse kinematic algorithms.

Course Outcome 5 (CO5):

1. Explain the trajectory planning in manipulators
2. Explain the feedback control in a joint control scheme for manipulator motion.

Model Question Paper

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

Course Code: RAT434

Course Name: INDUSTRIAL MANIPULATORS

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1	Write short note on industrial applications of manipulators	(3)
2	Compare different types of grippers	(3)
3	Express the rotation matrices in 3-Dimensions.	(3)
4	Choose the link parameters for a three-link cylindrical manipulator.	(3)
5	Infer the need for kinematic decoupling.	(3)
6	Explain the features of a workspace.	(3)
7	Classify different types of Jacobians.	(3)
8	Establish the relationship between closed chain and joint variables.	(3)
9	List out the inputs and outputs for a trajectory planning algorithm.	(3)
10	What are the different control schemes available for the manipulators?	(3)

PART B

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

MODULE1

11	a)	Write short notes on 1. Position sensors 2. Vision sensors	(7)
	b)	Illustrate the power transmission systems in the robot manipulator.	(7)
12	a)	Explain different types of grippers.	(7)
	b)	Discuss the power transmission in robotic manipulators	(7)

MODULE II

13	a)	.A vector v= 3i + 2j + 7k is rotated by 30^0 about the z axes of the reference frame. It is then rotated by 45^0 about the x-axes of the reference frame. Find the rotation transformation.	(9)
	b)	Discuss the concepts of Euler angles and rotation matrix.	(6)
14	a)	Explain the steps for increasing the degree of freedom from 2 to 3..	(7)

b) Explain the Denavit-Hartenberg convention for deriving the forward kinematics for any manipulator. (7)

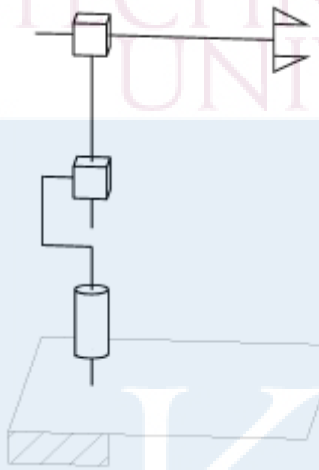
MODULE III

15 a) Differentiate between joint space and operational space. (8)

b) Discuss the inverse solution for the Euler angles ZYZ in the case $s_\Theta = 0$. (6)

16 a) Explain the procedure to compute the direct kinematics function for a closed-chain manipulator using the convention. (5)

b) Solve the inverse kinematics for the cylindrical arm in Figure (9)



MODULE IV

17 a) Discuss inverse kinetic algorithm with Jacobian inverse and Inverse Jacobian transpose. (14)

18 a) Articulate how the kineto-statics duality can be used to characterize the transformation of velocities and forces between two coordinate frames. (6)

b) Compute the dynamic model of a two-link cartesian arm (8)

Module V

19 a) Discuss the position feedback control scheme for the manipulator. (14)

20 a) Detail with a block diagram the general independent joint control scheme. (9)

b) Discuss the decentralized control scheme to reduce the tracking error.. (5)

****

SYLLABUS

Module I

Robot Subsystems -Classification of Robots -Industrial Applications

Robotic configurations- robot motion- joint notation schemes-End effectors- types-mechanical, vacuum, magnetic grippers- Actuators: mechanical, hydraulic, electrical-sensors: proximity sensors position sensors, velocity sensors, force sensors and vision sensors- power transmission systems- modelling and control of single joint robot.

Industrial robot- manipulator structures

Module II

Kinematics-: Position definitions- Coordinate frames - Different orientation descriptions - Free vectors- Translations, rotations and relative motion - Position and Orientation of a Rigid Body- Rotation Matrix- Elementary Rotations- Representation and rotation of a Vector - Composition of Rotation Matrices-Euler Angles- YZY angles- Roll-Pitch-Yaw Angles-Angle and axis

Introduction to manipulator kinematics- position representation -forward and reverse transformations of the 2-DOF arm—adding dimensions – Homogeneous transformation and robot kinematics.

Direct Kinematics: Kinematic Chains - Denavit Hartenberg Representation- Kinematics of manipulator structures- Three link planar arm- parallelogram arm- spherical arm - anthropomorphic arm- spherical arm – Stanford manipulator.

Module III

Manipulator Kinematics-2

Inverse Kinematics- The General Inverse Kinematics Problem- kinematic decoupling - inverse position – inverse orientation- joint space and operational space -workspace.

Differential Kinematics and Statics:- Geometric Jacobian- Derivative of a Rotation Matrix - Link Velocity -Jacobian Computation.-Jacobian of Typical Manipulator Structures- Three-link Planar Arm - Anthropomorphic Arm- Stanford Manipulator - Kinematic Singularities- Singularity Decoupling - Wrist Singularities- Arm Singularities -Analysis of Redundancy - Differential Kinematics Inversion -Redundant Manipulators - Kinematic Singularities - Analytical Jacobian. -

Module IV

Inverse Kinematics Algorithms -Jacobian (Pseudo-)Inverse -Jacobian Transpose - Orientation Error- A Comparison Between Inverse Kinematics Algorithms -Statics - Kineto-statics-Duality - Velocity and Force Transformation - Closed Chain.

Manipulator Dynamics-1

Lagrange Formulation -Properties of Dynamic Model -Dynamic Model of Simple Manipulator Structures - Two-link Cartesian Arm- Two-link Planar Arm.- Parallelogram Arm - Dynamic Parameter Identification-Newton-Euler Formulation- Link Acceleration

Module V

Manipulator Dynamics-2

Trajectory Planning - Path and Trajectory -Joint Space Trajectories-Point-to-point Motion

Path Motion- Operational Space Trajectories-Path Primitives -position -Orientation -

Dynamic Scaling of Trajectories -

Motion Control : Joint Space Control- Independent Joint Control - Feedback Control- Decentralized Feedforward Compensation .

Text Books:

1. S K Saha Introduction to Robotics – MC GRAW HILL INDIA
2. Groover Mikell P., M. Weiss, R.N. Nagel, N.G. Odrey, Industrial Robotics, McGrawHill, 1986, ISBN-13: 978-0070249899 ISBN-10: 007024989X
3. Sciavicco, L., B. Siciliano, Modelling & Control of Robot Manipulators, 2nd Edition, Springer Verlag, 2000, ISBN 978-1-84628-641-4 e-ISBN 978-1-84628-642-1
4. Mark W. Spong & M. Vidyasagar Robot Dynamics and Control John Wiley & Sons, 1989, ISBN: 978-0-471-61243-8

Reference Books:

1. Patrick Maurine, Calibration of Industrial Robot Manipulators, Wiley ISTE, 2015, ISBN-10: 1848212542 ISBN-13: 978-1848212541
2. Gray J.O., D.G. Caldwell(Ed), Advanced Robotics & Intelligent machines, The Institution of Electrical Engineers, UK, 1996, ISBN-13: 978-0852968536 ISBN-10: 0852968531
3. Craig, John J., Introduction to Robotics: Mechanics & Control, 2nd Edition, Pearson Education, 1989, ISBN 0131236296
4. Frank L.Lewis, Darren M.Dawson, Chaouki T.Abdallah Robot Manipulator Control Theory and Practice, Marcel Dekker Inc, 2006, ISBN: 0-8247-4072-6

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1		
1.1	Robot Subsystems -Classification of Robots -Industrial Applications	1
1.2	Robotic configurations- robot motion- joint notation schemes-End effectors- types- mechanical, vaccum, magnetic grippers-	2

1.3	Actuators: mechanical, hydraulic, electrical- sensors: proximity senssors position sensors, velocity sensors, force sensors and vision sensors-	2
1.4	power transmission systems- modelling and control of single joint robot, Industrial robot- manipulator structures	2
2		
2.1	Position definitions- Coordinate frames - Different orientation descriptions -Free vectors- Translations, rotations and relative motion Introduction to manipulator kinematics- position representation -forward and reverse transformations of the 2-DOF arm—adding dimensions	2
2.2	Homogeneous transformation and robot kinematics.	1
2.3	Kinematics-: Position and Orientation of a Rigid Body- Rotation Matrix- Elementary R otations- Representation and rotation of a Vector - Composition of Rotation Matrices-Euler Angles- YZY angles- Roll-Pitch-Yaw Angles-Angle and axis	2
2.4	Direct Kinematics: Kinematic Chains - Denavit Hartenberg Representation- Kinematics of manipulator structures- Three link planar arm- parallelogram arm- spherical arm -anthrepomorphic arm- spherical arm – Standford manipulator	2
3		
3.1	Inverse Kinematics- The General Inverse Kinematics Problem- kinematic decoupling -inverse position – inverse orientation- joint space and operational space -workspace	3
3.2	Differential Kinematics and Statics:- Geometric Jacobian- Derivative of a Rotation Matrix - Link Velocity -Jacobian Computation.-Jacobian of Typical Manipulator Structures- Three-link Planar Arm - Anthropomorphic Arm- Stanford Manipulator	2
3.3	Kinematic Singularities-Singularity Decoupling - Wrist Singularities- Arm Singularities -Analysis of Redundancy - Differential Kinematics Inversion -RedundantManipulators - Kinematic Singularities - Analytical Jacobian.	2
4		
4.1	Inverse Kinematics Algorithms -Jacobian (Pseudo-)Inverse -Jacobian Transpose - Orientation Error- A Comparison Between Inverse Kinematics Algorithms	2
4.2	Statics - Kineto-statics -Duality - Velocity and Force Transformation - Closed Chain	2

4.3	Lagrange Formulation -Properties of Dynamic Model -Dynamic Model of Simple Manipulator Structures - Two-link Cartesian Arm- Two-link Planar Arm.- Parallelogram Arm - Dynamic Parameter Identification- Newton-Euler Formulation- Link Acceleration.	3
5		
5.1	Trajectory Planning - Path and Trajectory -Joint Space Trajectories- Point-to-point Motion-	2
5.2	Path Motion- Operational Space Trajectories-Path Primitives -position - Orientation	2
5.3	Dynamic Scaling of Trajectories	1
5.4	Motion Control : Joint Space Control- IndependentJoint Control - Feedback Control- Decentralized Feedforward Compensation	2

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
KTU
Estd.
2014

RAT424	BEHAVIORAL ROBOTICS	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: Behavioural robotics is an approach in robotics that focuses on robots that are able to exhibit complex-appearing behaviours despite little internal variable state to model its immediate environment, mostly gradually correcting its actions via sensory-motor links. This course introduces the student to the concepts and challenges involved in the development of such a robot

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

CO 1	Apply behaviour-based techniques on robots
CO 2	Understand methods and models in embodied cognitive science and artificial intelligence
CO 3	Analyse models and architectures with respect to their conceptual clarity, supported by empirical data, robotic programming
CO 4	Apply embodied cognitive science and robot work cell design
CO 5	Develop dynamic model and design the controller for robotic manipulators, Robot Languages

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	30	30	40
Apply	10	10	50
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 behavioural architectures of a robot
2. What is variable speed transmission on robots ?

Course Outcome 2 (CO2):

1. Why is the concept of embodied cognition important?
2. What is sub-sumption architecture of robot

Course Outcome 3 (CO3):

1. What is - Lead through programming of robot
2. Explain motion commands of robot

Course Outcome 4 (CO4):

1. What are the considerations for robot work cell design?
2. Explain Safety monitoring devices in Robot

Course Outcome 5 (CO5):

1. Explain robot language structure
2. What is RAPID language in robotics

SYLLABUS

Module I:

Behaviour-based techniques on robots, Features of behaviour-based robots, Behavioural architectures, robot design Linkages, Types, Transmission elements , Flexible connectors, pulley-and- Belt drives, variable speed transmission, Comparison with classical AI.

Module II

Introduction to embodied cognitive science and behaviour-based robotics, reactive behaviour-based architectures, perception, deliberative systems, hybrid systems, sub-sumption architecture. representational issues for behavioral systems, adaptive behavior, social behavior, fringe robotics

Module III

Basics of robot programming ,Introduction-Types- Flex Pendant- Lead through programming, , Robot controller- major components, functions-Wrist Mechanism-Interpolation-Interlock commands- Jogging-Types, Robot specifications- Motion commands, end effectors and sensors commands**.**

Module IV

Robot work cell design and control-Sequence control, Operator interface, Safety monitoring devices in Robot-Mobile robot working principle, Robot applications- Material handling, Machine loading and unloading, assembly, Inspection, Welding, Spray painting and undersea robot. Fabrication of micro/ Nano grippers .

Module V

Robot Languages-Classifications, Structures- VAL- language commands, motion control, hand control, program control, , Robot welding application using VAL program- RAPID-language basic commands- Motion Instructions-. VAL-II programming-basic commands, applications-Simple pick and place applications-. AML Language-General description, elements and functions,mProgram control statements.

Text Books

1. Arkin, C. Ronald, “Behaviour-Based Robotics”, MIT Press, Cambridge: MA, 1998.
2. Murphy, R., "Introduction to AI Robotics." Second Edition, MIT Press, Cambridge: MA,
   2002.
3. S. R.Deb, “Robotics technology and flexible automation”, Tata McGraw Hill publishing company limited, 1994
4. Mikell. P. Groover, “Industrial Robotics Technology”, Programming and Applications, McGraw Hill Co, 1995..

References:

1. Craig. J. J. "Introduction to Robotics mechanics and control", Addison- Wesley,1999.
2. S.R. Deb, Robotics Technology and flexible automation, Tata McGraw-Hill Education., 2009

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1		
1.1	Behaviour-based techniques on robots,	1
1.2	Features of behaviour-based robots,	1
1.3	Behavioural architectures,	2
1.4	robot design Linkages, Types	1
1.5	Transmission elements Flexible connectors, pulley-and- Belt drives, variable speed transmission, Comparison with classical AI,	2
2		
2.1	introduction to embodied cognitive science and behaviour-based robotics,	1
2.2	reactive behaviour-based architectures, perception	2
2.3	deliberative systems, hybrid systems, sub-umption architecture.	2
2.4	representational issues for behavioral systems,	1
2.5	adaptive behavior, social behavior, fringe robotics	1
3		
3.1	Basics of robot programming , Robot programming-Introduction-Types- Flex Pendant- Lead through programming,	3
3.2	Robot controller- major components,	2
3.3	functions-Wrist Mechanism-Interpolation-Interlock commands-, Jogging-Types, Robot specifications- Motion commands, end effectors and sensors commands	2
4		
4.1	Robot work cell design and control-Sequence control, Operator interface	2
4.2	Safety monitoring devices in Robot-Mobile robot working principle, Robot applications- Material handling, Machine loading and unloading, assembly, Inspection, Welding, Spray painting and undersea robot.	3
4.3	Fabrication of micro/ Nano grippers	2
5		
5.1	Robot Languages-Classifications, Structures- VAL- language commands, motion control, hand control, program control	2
5.2	Robot welding application using VAL program- RAPID- language basic commands- Motion Instructions-.	2
5.3	VAL-II programming-basic commands, applications-Simple pick and place applications-. AML Language-General description, elements and functions, Program control statements..	3

Model Question Paper

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

Course Code: RAT 424
Course Name: BEHAVIORAL ROBOTICS

Max. Marks: 100 Duration: 3 Hours

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

1		What are the three basic robot behaviours?	(3)
2		What is Behaviour based control?	(3)
3		Briefly explain main objectives of cognitive robotics?	(3)
4		What is meant by embodied cognition?.	(3)
5		Explain the basic elements of robotic programming?	(3)
6		What is end effectors and sensors commands of robotic programming	(3)
7		Explain the various functions performed by robot work cell controller?	(3)
8		What are the types of robot cell design?	(3)
9		What are the different types of robot languages?	(3)
10		Briefly explain robot language structure?	(3)

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

MODULE1

11	a)	Explain in detail the behavioural architectures of a robot .	(10)
	b)	What is robot design Linkages?	(4)
12	a)	Explain in detail features of behaviour-based robots.	(10)
	b)	Write short notes on Flexible connectors	(4)

MODULE II

13	a)	Explain Sub-sumption architecture of robots	(10)
	b)	What is fringe robotics	(4)
14	a)	Explain in detail representational issues for behavioural systems.	(8)
	b)	Briefly explain social behaviour of robot .	(6)

MODULE III

15	a)	Explain robot controller in detail	(14)
16	a)	Briefly explain Robot specifications	(14)

MODULE IV

17	a)	Explain in detail all robot applications.	(14)

18 a) Describe the fabrication of micro/ Nano grippers (14)

ROBOTICS AND AUTOMATION

MODULE V

19 a) Briefly explain VAL,VAL-II, RAPID AND AML robot languages (14)

20 b) Describe program control statements of AML language ? (8)

a) Briefly explain Robot welding application using VAL program (6)

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APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
KTU
Estd.
2014

RAT414	MACHINE VISION	CATEGORY	L	T	P	CREDIT
		PEC	2	1	0	3

Preamble: This course will enable the students to learn fundamental digital image processing and machine vision concepts and their application to the fields of robotics and automation.

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

CO 1	Understand the vision capturing systems and its industry standards.
CO 2	Acquire images and standardize the images by applying standard techniques like smoothing and filtering.
CO3	Apply various transform tools like frequency domain and affine transform.
CO4	Apply various segmentation algorithms.
CO5	Apply state-of-the-art pattern analysis techniques like clustering, classifying and dimensionality reduction.

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

Course Level Assessment Questions

Course Outcome 1 (CO1):

1. What are the different types of cameras and their classification
2. Discuss the performance analysis of cameras.

Course Outcome 2 (CO2):

1. Explain image enhancement techniques.
2. Explain different image smoothing algorithms used in computer vision

Course Outcome 3 (CO3):

1. Explain the different image transformation techniques
2. Explain the different thresholding algorithms used in image processing.

Course Outcome 4 (CO4):

1. Discuss edge based approaches to segmentation.
2. Explain the technique for texture image segmenting.

Course Outcome 5 (CO5):

1. Explain different clustering and classification algorithms.
2. Discuss various techniques for dimensionality reduction.

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

Course Code: RAT 414

Course Name: MACHINE VISION

Max. Marks: 100 Duration : 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1		Illustrate the purpose of the lens in a camera.	(3)
2		Differentiate between USB2.0 and USB3.0	(3)
3		List the properties of affine transforms.	(3)
4		What is meant by contrast stretching.	(3)
5		List out the applications of morphological operations.	(3)
6		Discuss the limitation of variation model of thresholding.	(3)
7		In which context we use bicubic interpolation over bilinear one.	(3)
8		How overfitting affects the watershed model.	(3)
9		What is a discriminant function.	(3)
10		differentiate clustering and classification	(3)

PART B

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

MODULE1

11	a)	Write short on different type of lenses.	(8)
	b)	Illustrate the types of lens aberrations	(6)
12	a)	Explain the standards to interface between camera and computer.	(7)
	b)	Discuss any two types of cameras.	(7)

MODULE II

13	a)	.Apply a)mean Filter and b) median filter and compare the effects on the given matrix [10 0 10 0 10 0 10 0 10 0 10 0 10 0 10 0 10 0 10 0 10 0 10 0 10]	(8)
	b)	Differentiate between affine transform and projective transformations	(6)
14	a)	Explain how noise is getting supressed by smoothing.	(7)
b)		Define 2-D DFT. Explain any 4 properties of Fourier Transform	(7)

MODULE III

15	a)	Write short notes on 1. Nearest neighbour 2. Bicubic and 3.Bilinear interpolation techniques.	(8)

	b)	With an example explain morphological gradient operations.	(6)
16	a)	Compare and contrast different types of thresholding techniques.	(8)
	b)	Discuss the operations pf canny edge detector.	(6)

MODULE IV

17	a)	With an example illustrate region split and merge algorithm.	(8)
	b)	Discuss the methods for texture segmentation.	(6)
18	a)	Discuss any object detection algorithm.	(6)
	b)	Differentiate between density based hierarchy based clustering method and illustrate the role of mean shift method in segmentation.	(8)

Module V

19	a)	Explain the steps for LDA, PCA algorithms and compare.	(14)
20	a)	State the K-Means algorithm for clustering. Apply K-Means algorithm on the following data set to obtain three clusters: (1, 1) (1.5, 2), (3, 4), (5, 7), (3.5, 5), (4.5, 5) and (3.5, 4.5).	(9)
	b)	Discuss the Gaussian mixture models.	(5)

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SYLLABUS

Module I

Image Acquisition, Lenses and Cameras:
Pinhole camera, Gaussian Optics, Depth Field, Telemetric lenses, Lens aberrations Cameras: CCD cameras, CMOS Camera, Colour cameras: Single chip cameras, Three chip cameras, Camera performance parameters: noises, dynamic range, Camera-Computer interfaces, Digital video signals: camera link, IEEE1394, USB2.0, USB 3 vision

Module II

Image Fundamentals

Images, regions, piecewise contours, Image Enhancement: contrast enhancement, contrast normalization, Image Smoothing: Temporal Averaging, Mean Filter, Noise Suppression by Linear Filters, Median and Rank Filters, 2-D Fourier Transform: Continuous Fourier Transform, Discrete Fourier Transform.

Geometric Transformations: Affine Transformations, Projective Transformations.

Module III

Image Transformations: Nearest-Neighbour Interpolation, Bilinear Interpolation, Bicubic Interpolation, Smoothing to Avoid Aliasing, Projective Image Transformations, Transformations, Image Segmentation Thresholding: Global Thresholding, Automatic Threshold Selection, Dynamic Thresholding, Variation Model, morphological operations.

Module IV

Image Segmentation: Region Growing, Edge Based approaches to segmentation, Graph-Cut, Mean-Shift, MRFs, Texture Segmentation; Object detection.

Module V

Pattern Analysis

Clustering: K-Means, Mixture of Gaussians, Classification: Discriminant Function, Supervised, Un-supervised, Semi-supervised; Classifiers: Bayes, KNN, ANN models; Dimensionality Reduction: PCA, LDA, ICA

Text Books:

1. Carsten Steger, Markus Ulrich, Christian Wiedemann, Machine Vision Algorithms and Applications, WILEY-VCH, Weinheim,2008.
2. Richard Szeliski, Computer Vision: Algorithms and Applications, Springer-Verlag London Limited 2011.
3. Computer Vision: A Modern Approach, D. A. Forsyth, J. Ponce, Pearson Education, 2003.

Reference Books

1. Rafael C. Gonzalez and Richard E.woods, Digital Image Processing, Addition – Wesley Publishing Company, New Delhi, 2007.
2. Shimon Ullman, High-Level Vision: Object recognition and Visual Cognition, A Bradford Book, USA, 2000.
3. R.Patrick Goebel, ROS by Example: A Do-It-Yourself Guide to Robot Operating System -Volume I, A Pi Robot Production, 2012.

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1		
1.1	Image Acquisition, Lenses and Cameras: Pinhole camera, Gaussian Optics, Depth Field, Telemetric lenses, Lens aberrations	2
1.2	Cameras: CCD cameras, CMOS Camera, Colour cameras: Single chip cameras, Three chip cameras,	2
1.3	, Camera performance parameters: noises, dynamic range, Camera-Computer interfaces,	1
1.4	Digital video signals: camera link, IEEE1394, USB2.0, USB 3 vision	2
2		
2.1	Images, regions, piecewise contours	1
2.2	Image Enhancement: contrast enhancement, contrast normalization,	1

ROBOTICS AND AUTOMATION

2.3	Image Smoothing: Temporal Averaging, Mean Filter, Noise Suppression by Linear Filters, Median and Rank Filters, Fourier Transform: Continuous Fourier Transform, Discrete Fourier Transform.	3
2.4	Geometric Transformations: Affine Transformations, Projective Transformations	2
3		
3.1	Image Transformations: Nearest-Neighbour Interpolation, Bilinear Interpolation, Bicubic Interpolation, Smoothing to Avoid Aliasing,	3
3.2	Projective Image Transformations, Transformations, Image Segmentation	2
3.3	Thresholding: Global Thresholding, Automatic Threshold Selection, Dynamic Thresholding, Variation Model, morphological operations edge detector- canny edge detector.	2
4		
4.1	Image Segmentation: Region Growing,	2
4.2	Edge Based approaches to segmentation, Graph-Cut, Mean-Shift, MRFs,.	3
4.3	Texture Segmentation; Object detection	2
5		
5.1	Clustering: K-Means, Mixture of Gaussians,	2
5.2	Classification: Discriminant Function, Supervised, Un-supervised, Semi-supervised;	1
5.3	Classifiers: Bayes, KNN, ANN models;	2
5.4	Dimensionality Reduction: PCA, LDA, ICA	2

RAT402	AI AND MACHINE LEARNING	CATEGORY	L	T	P	CREDIT
		PCC	2	1	0	3

Preamble: Artificial Intelligence can be applied to a wide range of engineering application and is a topic of study by itself. This course provides an introduction to the areas of AI that can be used for robotic application which include computer vision, path planning, object recognition etc.

Prerequisite: Nil

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

CO 1	Appreciate the role of AI in solving problems in different domains and their evolution of AI
CO 2	Explain the different learning techniques used in Machine learning
CO3	Recognize the need for multilayer neural network for solving complex tasks
CO4	Understand the fundamental concepts of Image processing and its application in computer vision
CO5	Explain the different ways of perception of the environment by a robot and its use in path planning

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	10	10	10
Understand	30	30	50
Apply	10	10	40
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. Discuss the use of Machine learning technique for classifying objects
2. Elaborate on the various AI techniques that can be used in robotics applications

Course Outcome 2 (CO2):

3. Compare and contrast Supervised and Unsupervised Learning techniques
4. How is Stochastic Gradient Descent algorithm better compared to other traditional learning techniques

Course Outcome 3 (CO3):

5. Explain how Back propagation algorithm can be used for character recognition application
6. Explain the basic Recurrent Neural Network architecture and its applications

Course Outcome 4 (CO4):

7. Discuss the any two techniques used for Edge detection in image processing
8. What is segmentation and how is it used in Image processing applications

Course Outcome 5 (CO5):

9. Explain Robotic Perception and the challenges faced in robotic perception
10. How can AI be used in path planning for robotic applications

SYLLABUS

Module 1

Artificial intelligence - Introduction, its importance, The Turing test, Foundations of artificial intelligence, A brief historical overview

Application areas of AI - vision and speech processing, robotics, expert systems -basic overview

Module 2

Learning - Forms of learning, Supervised Learning Algorithms, Unsupervised Learning Algorithms, Reinforcement based learning - overview with basic elements agent, environment, action, state, reward only; Stochastic Gradient Descent, Challenges Motivating Deep Learning

Module 3

Deep Feedforward Networks- Example: Learning XOR, Gradient-Based Learning, Hidden Units. Architecture Design, Back-Propagation and Other Differentiation Algorithms, Convolutional Networks -basic outline and functions of each layers only, Sequence Modeling: Recurrent and Recursive Nets -Need for sequence models, basic RNN architecture and types

Module 4

Machine vision - Introduction, Computer vision - Introduction, Image formation, Basic image processing operations - edge detection, texture, optical flow, segmentation. challenges in image detection, Image features optimization.

Case study- crop monitoring using drones, traffic sign detection

Module 5

Robotics - Robotic perception, Localization and mapping, Machine learning in robot perception, Application domains

Textbooks:

1. Ian Goodfellow, Yoshua Bengio, Aaron Courville, Deep Learning, MIT Press, 2016
2. Stuart J. Russell and Peter Norvig, Artificial Intelligence - A Modern Approach Third Edition, 2016
3. Bishop, C. ,M., Pattern Recognition and Machine Learning, Springer, 2006.
4. Berthold Klaus, Paul Horn “Robot vision” The MIT Press, 1987.
5. Richard Szeliski, “Computer Vision: Algorithms and Applications”, 2010.
6. Grigorescu, Sorin, et al. "A survey of deep learning techniques for autonomous driving." *Journal of Field Robotics* 37.3 (2020): 362-386.

Reference Books:

1. Robin R. Murphy – Introduction to AI Robotics, The MIT Press
2. Chandra S.S.V, Anand Hareendran S. - Artificial Intelligence and Machine Learning, PHI
3. *Simon J. D. Prince* - Computer Vision – Models, Learning and Inference Cambridge University Press

Course Contents and Lecture Schedule

No	Topic	No. of Lectures
1		
1.1	Artificial intelligence - Introduction, its importance, The Turing test, Foundations of artificial intelligence, A brief historical overview (Ref 2, chapter 1 section 1.3).	3
1.2	Application area of AI: vision and speech processing, robotics, expert systems--basic overview only	3
2		
2.1	Learning - Forms of learning, (Ref 2 Chapter 18 section 18.1.1), Supervised Learning Algorithms, Unsupervised Learning Algorithms, Reinforcement based learning-- overview with basic elements agent, environment, action, state, reward only; (Ref 2, Chapter 20, section 20.1)	5
2.2	Stochastic Gradient Descent, Challenges Motivating Deep Learning (Ref 1, chapter 5 sections 5.7 – 9 and 5.11, Ref 2 Chapter 18 section 18.2),).	3
3		
3.1	Deep Feedforward Networks - Example: Learning XOR, Gradient-Based Learning, Hidden Units. Architecture Design, Back-Propagation and Other Differentiation Algorithms	3
3.2	Convolutional Networks-basic outline and functions of each layers only, Sequence Modeling: Recurrent and Recursive Nets - Need for sequence models, basic RNN architecture and types (Ref 1 chapter 6, 9, 10, Ref 3 - chapter 5).	4
4		
4.1	Machine vision - Introduction (Ref **4**, chapter 1), Computer vision - Introduction (Ref **5** chapter 1, section 1.2),	2

4.2	Image formation, Basic image processing operations - edge detection, texture, optical flow, segmentation. (Ref 4, 5) challenges in image detection, Image features optimization.	4
4.3	Case study-crop monitoring using drones, traffic sign detection	1
5		
5.1	Robotics - Robotic perception, Localization and mapping, Machine learning in robot perception,	5
5.2	Application domains (Ref 2, chapter 25 sections 25.1, 25.3.1, 25.3.3, 25.8)	2

Model Question Paper

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

Course Code: RAT 402

Course Name: AI AND MACHINE LEARNING

Max. Marks: 100 Duration: 3 Hours

PART A

Answer all questions, each carries 3 marks. Marks

1	Explain the Turing Test approach for the definition of AI. What are the additional capabilities required by an AI system to completely satisfy the total Turing Test	(3)
2	How can AI be used in Speech Processing?	(3)
3	"A machine learning algorithm is an algorithm that is able to learn from data" – What do we mean by the term 'learn' in the above statement	(3)
4	Explain the term 'Feature' under machine learning context	(3)
5	What is a multilayer feed forward Network?	(3)
6	What is the role of activation function in a neural network?	(3)
7	Define Sampling pitch for a digital camera. Explain its effect on the quality of the image	(3)
8	What is aliasing in a digital image? What is the use of PSF in aliasing?	(3)
9	Explain Robotic perception and discuss the challenges faced in robotic perception	(3)
10	Discuss the motion model for localization in robotics	(3)

PART B

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

MODULE1

11	a)	Explain the contribution of Mathematics in the development of AI	(8)

	b)	What are the different applications of AI in Visual Processing	(6)
12	a)	What are Expert Systems? What is the role of knowledge base and Inference Engine in a knowledge based System	(7)
	b)	What are the application areas of AI in a Robotics	(7)

MODULE II

13	a)	Explain the kind of problems that can be solved using Machine Learning techniques	(6)
	b)	Explain the gradient descent Algorithm used in Machine Learning	
14	a)	Explain Supervised and Unsupervised Learning techniques in machine learning. Discuss the advantages and disadvantages of each.	(14)

MODULE III

15	a)	With an example, explain the working of Back Propagation algorithm	(14)
16	a)	What is a Convolutional Neural Network? Explain the functionality of each layer	(14)

MODULE IV

17	a)	Explain the method of image segmentation using multilevel threshold	(7)
	b)	Explain the 'Snakes' method of detecting active contours	(7)
18	a)	Explain region splitting and merging algorithm for segmentation	(7)
	b)	What is the use of Edge Linking and how it is carried out?	(7)

Module V

19	a)	Explain the Monte-Carlo localization algorithm using a range scan sensor model	(14)
20	a)	Discuss in detail the role of Machine learning in Robotic perception	(14)

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