

APJ ABDUL KALAM
TECHNOLOGICAL
UNIVERSITY

SEMESTER -4

KTU



CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT
MAT 206	GRAPH THEORY	BSC	3	1	0	4

Preamble: This course introduces fundamental concepts in Graph Theory, including properties and characterisation of graph/trees and graph theoretic algorithms, which are widely used in Mathematical modelling and has got applications across Computer Science and other branches in Engineering.

Prerequisite: The topics covered under the course Discrete Mathematical Structures (MAT 203)

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

CO 1	Explain vertices and their properties, types of paths, classification of graphs and trees & their properties. (Cognitive Knowledge Level: Understand)
CO 2	Demonstrate the fundamental theorems on Eulerian and Hamiltonian graphs. (Cognitive Knowledge Level: Understand)
CO 3	Illustrate the working of Prim's and Kruskal's algorithms for finding minimum cost spanning tree and Dijkstra's and Floyd-Warshall algorithms for finding shortest paths. (Cognitive Knowledge Level: Apply)
CO 4	Explain planar graphs, their properties and an application for planar graphs. (Cognitive Knowledge Level: Apply)
CO 5	Illustrate how one can represent a graph in a computer. (Cognitive Knowledge Level: Apply)
CO 6	Explain the Vertex Color problem in graphs and illustrate an example application for vertex coloring. (Cognitive Knowledge Level: Apply)

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	√	√	√							√		√
CO 2	√	√	√	√						√		√
CO 3	√	√	√	√						√		√
CO 4	√	√	√	√						√		√
CO 5	√	√	√							√		√
CO 6	√	√	√			√				√		√

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests (%)		End Semester Examination (%)
	1	2	
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40
Analyse			
Evaluate			
Create			

Mark Distribution

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

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks

First Internal Examination shall be preferably conducted after completing the first half of the syllabus and the Second Internal Examination shall be preferably conducted after completing remaining part of the syllabus.

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

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 anyone. Each question can have maximum 2 sub-divisions and carries 14 marks.

Syllabus

Module 1

Introduction to Graphs : Introduction- Basic definition – Application of graphs – finite, infinite and bipartite graphs – Incidence and Degree – Isolated vertex, pendant vertex and Null graph. Paths and circuits – Isomorphism, sub graphs, walks, paths and circuits, connected graphs, disconnected graphs and components.

Module 2

Eulerian and Hamiltonian graphs : Euler graphs, Operations on graphs, Hamiltonian paths and circuits, Travelling salesman problem. Directed graphs – types of digraphs, Digraphs and binary relation, Directed paths, Fleury's algorithm.

Module 3

Trees and Graph Algorithms : Trees – properties, pendant vertex, Distance and centres in a tree - Rooted and binary trees, counting trees, spanning trees, Prim's algorithm and Kruskal's algorithm, Dijkstra's shortest path algorithm, Floyd-Warshall shortest path algorithm.

Module 4

Connectivity and Planar Graphs : Vertex Connectivity, Edge Connectivity, Cut set and Cut Vertices, Fundamental circuits, Planar graphs, Kuratowski's theorem (proof not required), Different representations of planar graphs, Euler's theorem, Geometric dual.

Module 5

Graph Representations and Vertex Colouring : Matrix representation of graphs- Adjacency matrix, Incidence Matrix, Circuit Matrix, Path Matrix. Coloring- Chromatic number, Chromatic polynomial, Matchings, Coverings, Four color problem and Five color problem. Greedy colouring algorithm.

Text book:

1. Narsingh Deo, Graph theory, PHI, 1979

Reference Books:

1. R. Diestel, *Graph Theory*, free online edition, 2016: diestel-graph-theory.com/basic.html.
2. Douglas B. West, *Introduction to Graph Theory*, Prentice Hall India Ltd., 2001
3. Robin J. Wilson, *Introduction to Graph Theory*, Longman Group Ltd., 2010
4. J.A. Bondy and U.S.R. Murty. *Graph theory with Applications*

Sample Course Level Assessment Questions.**Course Outcome 1 (CO1):**

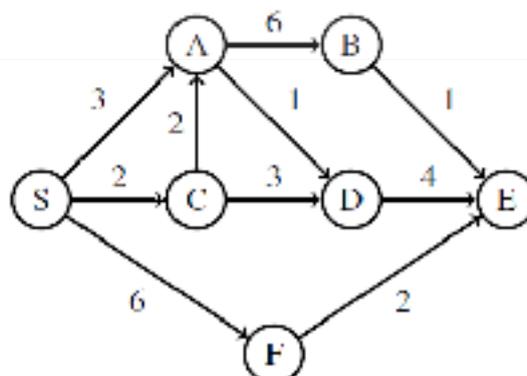
1. Differentiate a walk, path and circuit in a graph.
2. Is it possible to construct a graph with 12 vertices such that two of the vertices have degree 3 and the remaining vertices have degree 4? Justify
3. Prove that a simple graph with n vertices must be connected, if it has more than $\frac{(n-1)(n-2)}{2}$ edges.
4. Prove the statement: If a graph (connected or disconnected) has exactly two odd degree, then there must be a path joining these two vertices.

Course Outcome 2 (CO2):

1. Define Hamiltonian circuit and Euler graph. Give one example for each.
2. Define directed graphs. Differentiate between symmetric digraphs and asymmetric digraphs.
3. Prove that a connected graph G is an Euler graph if all vertices of G are of even degree.
4. Prove that a graph G of n vertices always has a Hamiltonian path if the sum of the degrees of every pair of vertices V_i, V_j in G satisfies the condition $d(V_i) + d(V_j) = n - 1$

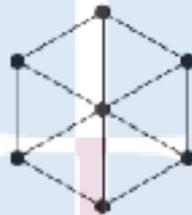
Course Outcome 3 (CO3):

1. Discuss the centre of a tree with suitable example.
2. Define binary tree. Then prove that number of pendant vertices in a binary tree is $\frac{(n+1)}{2}$
3. Prove that a tree with n vertices has $n - 1$ edges.
4. Explain Floyd Warshall algorithm.
5. Run Dijkstra's algorithm on the following directed graph, starting at vertex S .



Course Outcome 4 (CO4):

1. Define edge connectivity, vertex connectivity and separable graphs. Give an example for each.
2. Prove that a connected graph with n vertices and e edges has $e - n + 2$ faces.
3. Prove the statement: Every cut set in a connected graph G must also contain at least one branch of every spanning tree of G .
4. Draw the geometrical dual (G^*) of the graph given below, also check whether G and G^* are self-duals or not, substantiate your answer clearly.

**Course Outcome 5 (CO5):**

1. Show that if $A(G)$ is an incidence matrix of a connected graph G with n vertices, then rank of $A(G)$ is $n-1$.
2. Show that if B is a cycle matrix of a connected graph G with n vertices and m edges, then rank $B = m-n+1$.
3. Derive the relations between the reduced incidence matrix, the fundamental cycle matrix, and the fundamental cut-set matrix of a graph G .
4. Characterize simple, self-dual graphs in terms of their cycle and cut-set matrices.

Course Outcome 6 (CO6):

1. Show that an n vertex graph is a tree iff its chromatic polynomial is $P_n(\lambda) = \lambda(\lambda - 1)^{n-1}$
2. Prove the statement: "A covering g of a graph is minimal if g contains no path of length three or more."
3. Find the chromatic polynomial of the graph



Model Question paperQP
Code :**Total Pages: 4**

Reg No.: _____

Name: _____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
 IV SEMESTER B.TECH DEGREE EXAMINATION, MONTH and YEAR

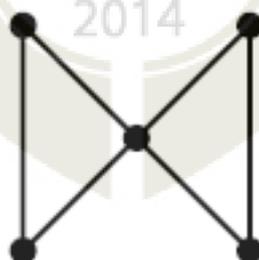
Course Code: MAT 206**Course Name: GRAPH THEORY**

Max. Marks: 100

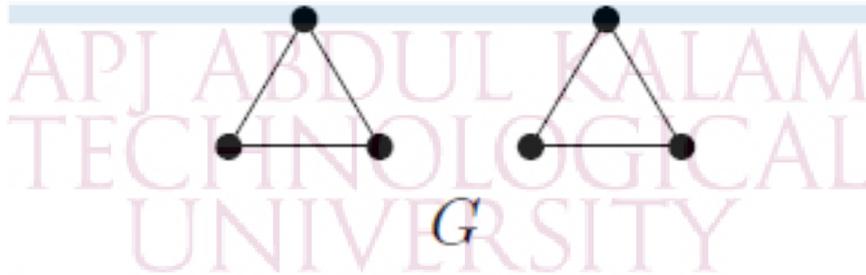
Duration: 3 Hours

PART A*Answer all questions, each carries 3 marks.*Mark
s

- 1 Construct a simple graph of 12 vertices with two of them having degree 1, three having degree 3 and the remaining seven having degree 10. (3)
- 2 What is the largest number of vertices in a graph with 35 edges, if all vertices are of degree at least 3 ? (3)
- 3 Define a Euler graph. Give an example of Eulerian graph which is not Hamiltonian (3)
- 4 Give an example of a strongly connected simple digraph without a directed Hamiltonian path. (3)
- 5 What is the sum of the degrees of any tree of n vertices? (3)
- 6 How many spanning trees are there for the following graph (3)



- 7 Show that in a simple connected planar graph G having V -vertices, E -edges, (3)
and no triangles $E \leq 3V - 6$.
- 8 Let G be the following disconnected planar graph. Draw its dual G^* , and the (3)
dual of the dual $(G^*)^*$.



- 9 Consider the circuit matrix B and incidence matrix A of a simple connected (3)
graph whose columns are arranged using the same order of edges. Prove that
every row of B is orthogonal to every row of A ?
- 10 A graph is *critical* if the removal of any one of its vertices (and the edges (3)
adjacent to that vertex) results in a graph with a lower chromatic number.
Show that K_n is critical for all $n > 1$.

PART B

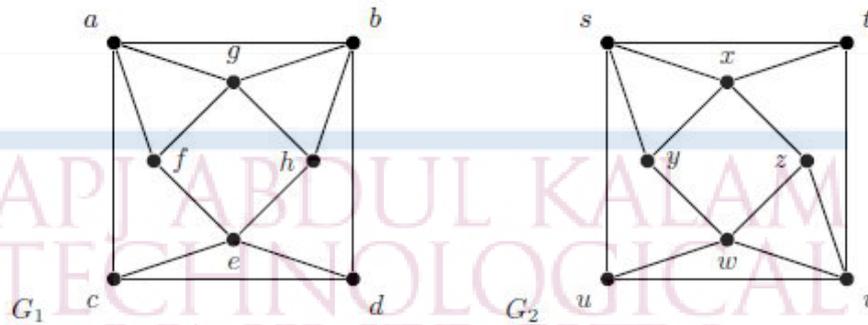
Answer any one Question from each module. Each question carries 14 Marks

- 11 a) Prove that for any simple graph with at least two vertices has two vertices of (6)
the same degree.
- b) Prove that in a complete graph with n vertices there are $(n-1)/2$ edge disjoint (8)
Hamiltonian circuits and $n \geq 3$

OR

2014

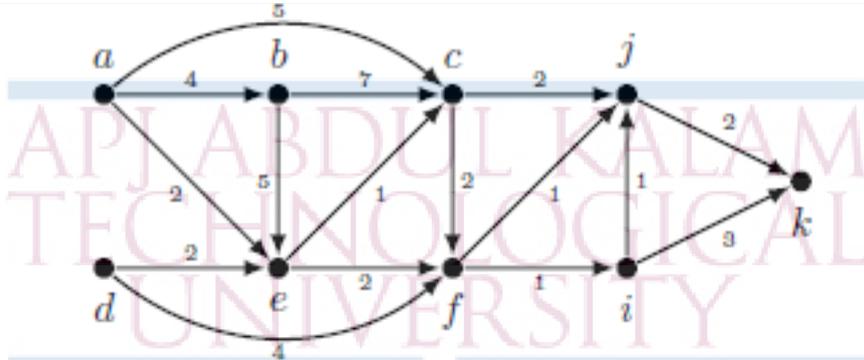
- 12 a) Determine whether the following graphs $G_1 = (V_1, E_1)$ and $G_2 = (V_2, E_2)$ are (6)
isomorphic or not. Give justification.



- b) Prove that a simple graph with n vertices and k components can have at (8)
most $(n-k)(n-k+1)/2$ edges
- 13 a) Let S be a set of 5 elements. Construct a graph G whose vertices are subsets (8)
of S of size 2 and two such subsets are adjacent in G if they are disjoint.
- Draw the graph G .
 - How many edges must be added to G in order for G to have a Hamiltonian cycle?
- b) Let G be a graph with exactly two connected components, both being (6)
Eulerian. What is the minimum number of edges that need to be added to G to obtain an Eulerian graph?
- OR
- 14 a) Show that a k -connected graph with no hamiltonian cycle has an (8)
independent set of size $k + 1$.
- b) i. Let G be a graph that has exactly two connected components, both (6)
being Hamiltonian graphs. Find the minimum number of edges that one needs to add to G to obtain a Hamiltonian graph.
- ii. For which values of n the graph Q_n (hyper-cube on n vertices) is Eulerian.
- 15 a) A tree T has at least one vertex v of degree 4, and at least one vertex w of (5)
degree 3. Prove that T has at least 5 leaves.

- b) Write Dijkstra's shortest path algorithm. (9)

Consider the following weighted directed graph G .



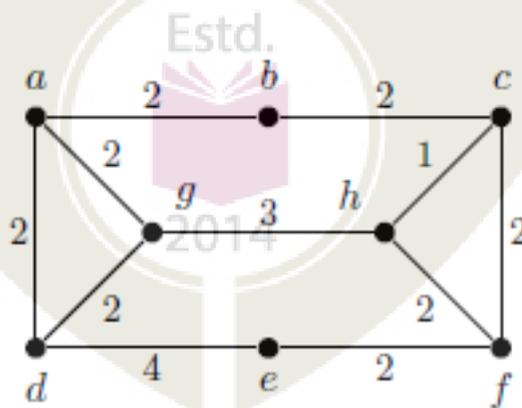
Find the shortest path between a and every other vertices in G using Dijkstra's shortest path algorithm.

OR

- 16 a) Define pendent vertices in a binary tree? Prove that the number of pendent vertices in a binary tree with n vertices is $(n+1)/2$. (5)

- b) Write Prim's algorithm for finding minimum spanning tree. (9)

Find a minimum spanning tree in the following weighted graph, using Prim's algorithm.



Determine the number of minimum spanning trees for the given graph.

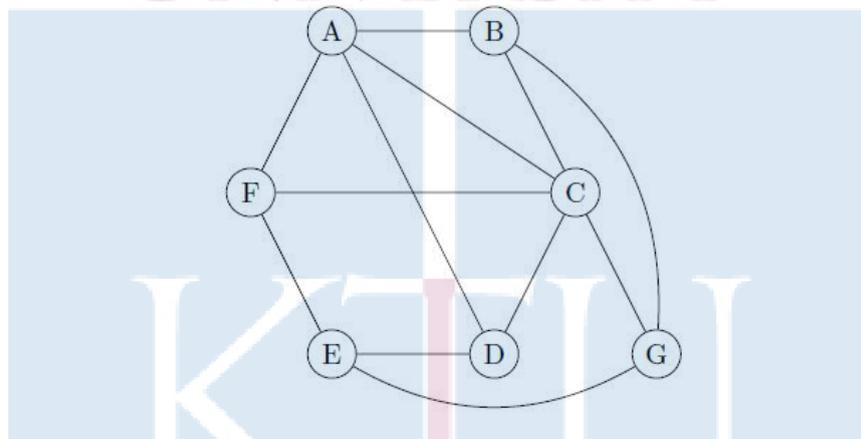
17 a) i. State and prove Euler's Theorem relating the number of faces, edges and vertices for a planar graph. (9)

ii. If G is a 5-regular simple graph and $|V| = 10$, prove that G is non-planar.

b) Let G be a connected graph and e an edge of G . Show that e is a cut-edge if and only if e belongs to every spanning tree. (5)

OR

18 a) State Kuratowski's theorem, and use it to show that the graph G below is not planar. Draw G on the plane without edges crossing. Your drawing should use the labelling of the vertices given. (9)



b) Let G be a connected graph and e an edge of G . Show that e belongs to a loop if and only if e belongs to no spanning tree. (5)

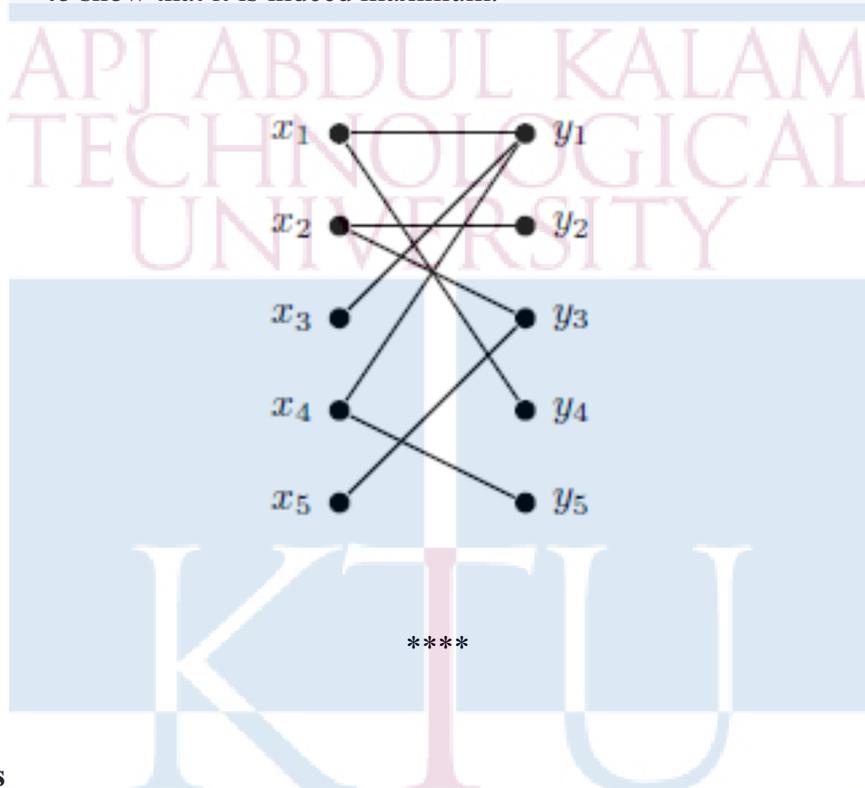
19 a) Define the circuit matrix $B(G)$ of a connected graph G with n vertices and e edges with an example. Prove that the rank of $B(G)$ is $e-n+1$ (7)

b) Give the definition of the chromatic polynomial $P_G(k)$. Directly from the definition, prove that the chromatic polynomials of W_n and C_n satisfy the identity $P_{W_n}(k) = k P_{C_{n-1}}(k-1)$. (7)

OR

20 a) Define the incidence matrix of a graph G with an example. Prove that the rank of an incidence matrix of a connected graph with n vertices is $n-1$. (4)

- b) i. A graph G has chromatic polynomial $P_G(k) = k^4 - 4k^3 + 5k^2 - 2k$. How many vertices and edges does G have? Is G bipartite? Justify your answers.
- ii. Find a maximum matching in the graph below and use Hall's theorem to show that it is indeed maximum.



(10)

Assignments

Assignment must include applications of the above theory in Computer Science.

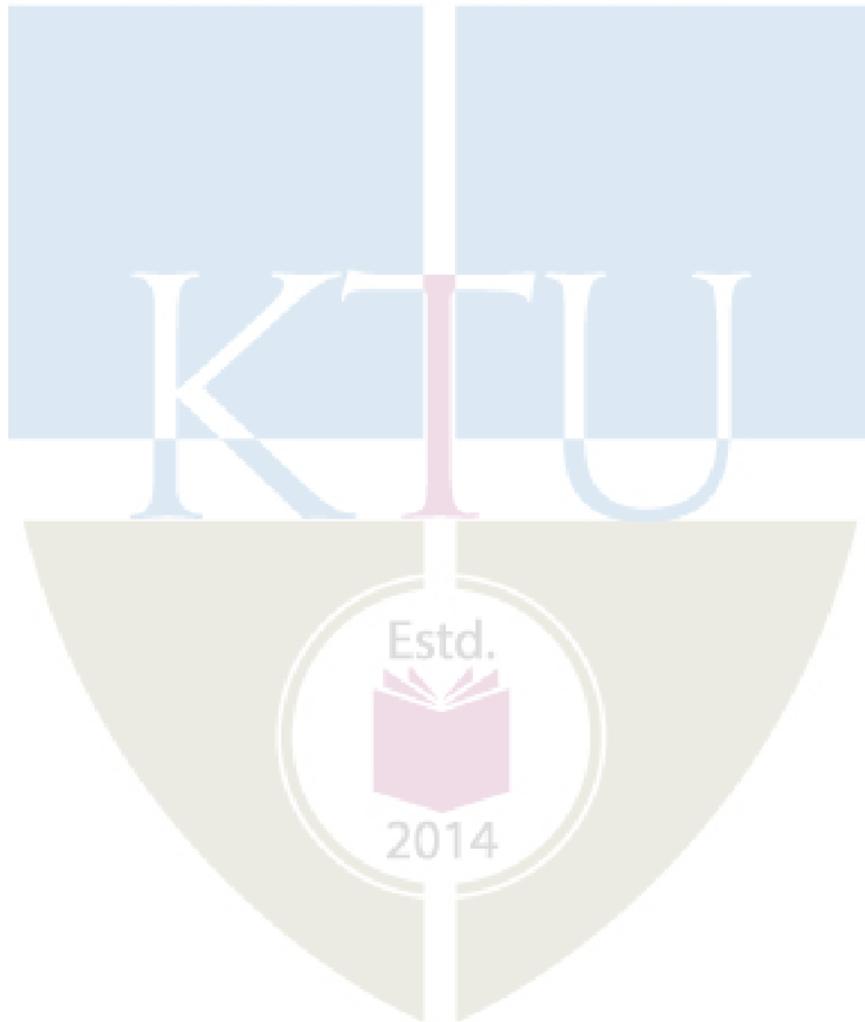


Teaching Plan		
No	Topic	No. of Lectures
1	Module-I (Introduction to Graphs)	(8)
1.	Introduction- Basic definition – Application of graphs – finite and infinite graphs, bipartite graphs,	1
2.	Incidence and Degree – Isolated vertex, pendent vertex and Null graph	1
3.	Paths and circuits	1
4.	Isomorphism	1
5.	Sub graphs, walks	1
6.	Paths and circuits	1
7.	Connected graphs.	1
8.	Disconnected graphs and components	1
2	Module-II (Eulerian and Hamiltonian graphs)	(8)
1.	Euler graphs	1
2.	Operations on graphs	1
3.	Hamiltonian paths and circuits	1
4.	Hamiltonian paths circuits	1
5.	Travelling salesman problem	1
6.	Directed graphs – types of digraphs,	1
7.	Digraphs and binary relation, Directed paths	1
8.	Fleury's algorithm	1
3	Module-III (Trees and Graph Algorithms)	(11)
1.	Trees – properties	1
2.	Trees – properties	1
3.	Trees – properties, pendent vertex	1
4.	Distance and centres in a tree	1

5.	Rooted and binary tree	1
6.	Counting trees	1
7.	Spanning trees, Fundamental circuits	1
8.	Prim's algorithm	1
9.	Kruskal's algorithm	1
10.	Dijkstra's shortest path algorithm	1
11.	Floyd-Warshall shortest path algorithm	1
4	Module-IV (Connectivity and Planar Graphs)	(9)
1.	Vertex Connectivity, Edge Connectivity	1
2.	Cut set and Cut Vertices	1
3.	Fundamental circuits	1
4.	Fundamental circuits	1
5.	Planar graphs	1
6.	Kuratowski's theorem	1
7.	Different representations of planar graphs	1
8.	Euler's theorem	1
9.	Geometric dual	1
5	Module-V (Graph Representations and Vertex Colouring)	(9)
1.	Matrix representation of graphs- Adjacency matrix, Incidence Matrix	1
2.	Circuit Matrix, Path Matrix	1
3.	Colouring- chromatic number,	1
4.	Chromatic polynomial	1
5.	Matching	1
6.	Covering	1
7.	Four colour problem and five colour problem	1

8.	Four colour problem and five colour problem	1
9.	Greedy colouring algorithm.	1

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CST202	COMPUTER ORGANISATION AND ARCHITECTURE	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		PCC	3	1	0	4	2019

Preamble:

The course is prepared with the view of enabling the learners capable of understanding the fundamental architecture of a digital computer. Study of Computer Organization and Architecture is essential to understand the hardware behind the code and its execution at physical level by interacting with existing memory and I/O structure. It helps the learners to understand the fundamentals about computer system design so that they can extend the features of computer organization to detect and solve problems occurring in computer architecture.

Prerequisite : Topics covered under the course Logic System Design (CST 203)

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

CO#	CO
CO1	Recognize and express the relevance of basic components, I/O organization and pipelining schemes in a digital computer (Cognitive knowledge: Understand)
CO2	Explain the types of memory systems and mapping functions used in memory systems (Cognitive Knowledge Level: Understand)
CO3	Demonstrate the control signals required for the execution of a given instruction (Cognitive Knowledge Level: Apply)
CO4	Illustrate the design of Arithmetic Logic Unit and explain the usage of registers in it (Cognitive Knowledge Level: Apply)
CO5	Explain the implementation aspects of arithmetic algorithms in a digital computer (Cognitive Knowledge Level:Apply)
CO6	Develop the control logic for a given arithmetic problem (Cognitive Knowledge Level: Apply)

Mapping of course outcomes with program outcomes

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

Abstract POs defined by National Board of Accreditation			
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PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Life long learning

Assessment Pattern

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	Test1 (%)	Test2 (%)	
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End Semester Examination Pattern:

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

Syllabus

Module 1

Basic Structure of computers – functional units - basic operational concepts - bus structures. Memory locations and addresses - memory operations, Instructions and instruction sequencing , addressing modes.

Basic processing unit – fundamental concepts – instruction cycle – execution of a complete instruction - single bus and multiple bus organization

Module 2

Register transfer logic: inter register transfer – arithmetic, logic and shift micro operations.

Processor logic design: - processor organization – Arithmetic logic unit - design of arithmetic circuit - design of logic circuit - Design of arithmetic logic unit - status register – design of shifter - processor unit – design of accumulator.

Module 3

Arithmetic algorithms: Algorithms for multiplication and division (restoring method) of binary numbers. Array multiplier , Booth's multiplication algorithm.

Pipelining: Basic principles, classification of pipeline processors, instruction and arithmetic pipelines (Design examples not required), hazard detection and resolution.

Module 4

Control Logic Design: Control organization – Hard_wired control-microprogram control – control of processor unit - Microprogram sequencer,micro programmed CPU organization - horizontal and vertical micro instructions.

Module 5

I/O organization: accessing of I/O devices – interrupts, interrupt hardware -Direct memory access.

Memory system: basic concepts – semiconductor RAMs. memory system considerations – ROMs, Content addressable memory, cache memories - mapping functions.

Text Books

1. Hamacher C., Z. Vranesic and S. Zaky, Computer Organization ,5/e, McGraw Hill, 2011
2. Mano M. M., Digital Logic & Computer Design, PHI, 2004
3. KaiHwang, Faye Alye Briggs, Computer architecture and parallel processing McGraw-Hill, 1984

Reference Books

1. Mano M. M., Digital Logic & Computer Design, 3/e, Pearson Education, 2013.
2. Patterson D.A. and J. L. Hennessy, Computer Organization and Design, 5/e, Morgan Kaufmann Publishers, 2013.
3. William Stallings, Computer Organization and Architecture: Designing for Performance, Pearson, 9/e, 2013.
4. Chaudhuri P., Computer Organization and Design, 2/e, Prentice Hall, 2008.
5. Rajaraman V. and T. Radhakrishnan, Computer Organization and Architecture, Prentice Hall, 2011

Sample Course Level Assessment Questions

Course Outcome1(CO1): Which are the registers involved in a memory access operation and how are they involved in it?

Course Outcome 2(CO2): Explain the steps taken by the system to handle a write miss condition inside the cache memory.

Course Outcome 3(CO3): Generate the sequence of control signals required for the execution of the instruction MOV [R1],R2 in a threebus organization.

Course Outcome 4(CO4): Design a 4-bit combinational logic shifter with 2 control signals H0 and H1 that perform the following operations :

H1	H0	Operation
0	0	Transfer 1's to all output line
0	1	No shift operation
1	0	Shift left
1	1	Shift right

Course Outcome 5(CO5): Explain the restoring algorithm for binary division. Also trace the algorithm to divide $(1001)_2$ by $(11)_2$

Course Outcome 6(CO6): Design a software control logic based on microprogrammed control to perform the addition of 2 signed numbers represented in sign magnitude form.



Model Question Paper

QP CODE:

PAGES:2

Reg No: _____

Name: _____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
THIRD SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CST 202

Course Name: Computer organization and architecture

Max.Marks:100

Duration: 3 Hours

PART A

Answer all Questions. Each question carries 3 Marks

1. Give the significance of instruction cycle.
2. Distinguish between big endian and little endian notations. Also give the significance of these notations.
3. Compare I/O mapped I/O and memory mapped I/O.
4. Give the importance of interrupts in I/O interconnection.
5. Justify the significance of status register.
6. How does the arithmetic circuitry perform logical operations in an ALU.
7. Illustrate divide overflow with an example.
8. Write notes on arithmetic pipeline.
9. Briefly explain the role of micro program sequence.
10. Differentiate between horizontal and vertical micro instructions.

Part B

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

11.

11.(a) What is the significance of addressing modes in computer architecture.

(4)

11.(b) Write the control sequence for the instruction $DIV R1,[R2]$ in a three bus structure. (10)

OR

12. Explain the concept of a single bus organization with help of a diagram. Write the control sequence for the instruction $ADD [R1],[R2]$.

(14)

13. Explain various register transfer logics.

(14)

OR

14.

14.(a) Design a 4 bit combinational logic shifter with 2 control signals H1 and H2 that perform the following operations (bit values given in parenthesis are the values of control variable H1 and H2 respectively.) : Transfer of 0's to S (00), shift right (01), shift left (10), no shift (11).

(5)

14.(b) Design an ALU unit which will perform arithmetic and logic operation with a given binary adder.

(9)

15.

15.(a) Give the logic used behind Booth's multiplication algorithm.

(4)

15.(b) Identify the appropriate algorithm available inside the system to perform the multiplication between -14 and -9. Also trace the algorithm for the above input.

(10)

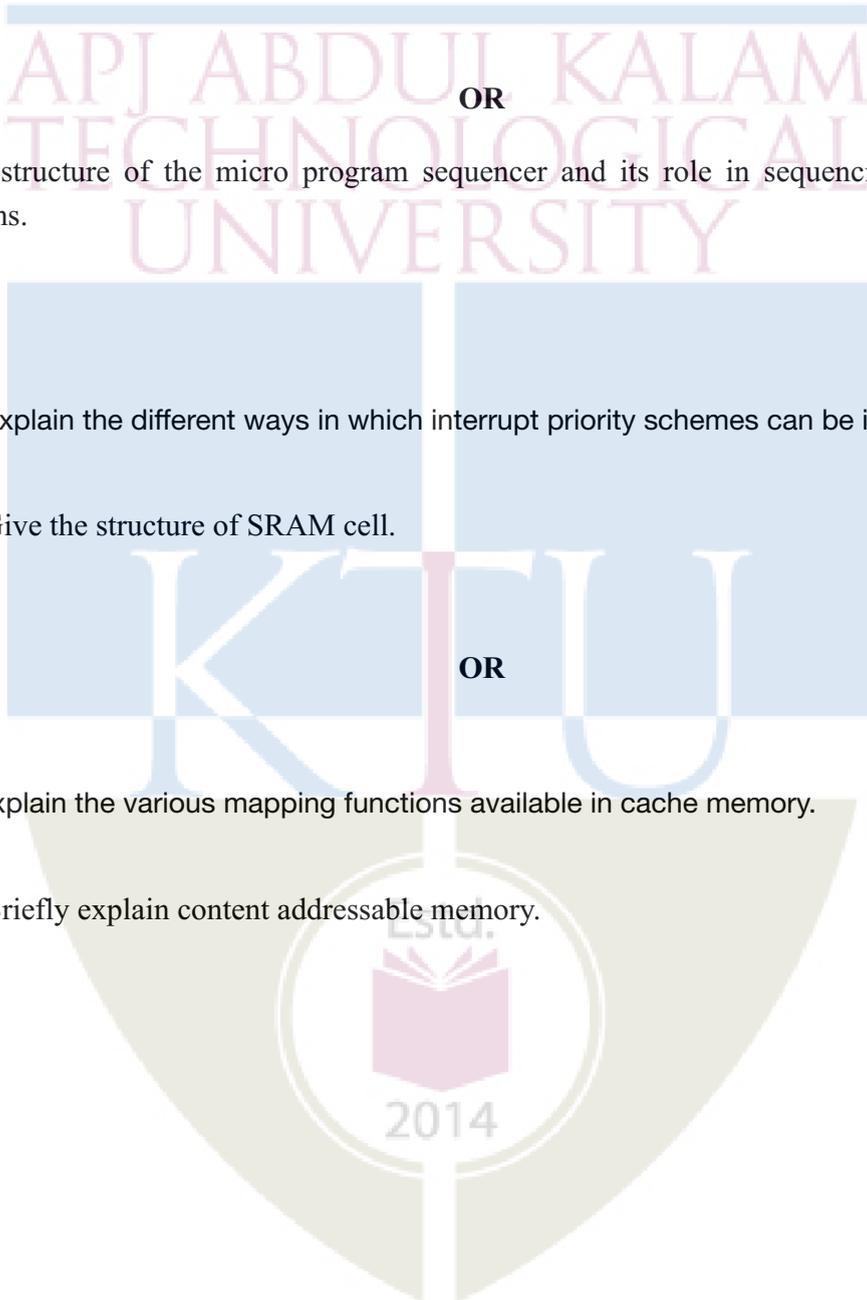
OR

16.

16.(a) List and explain the different pipeline hazards and their possible solutions

(10)

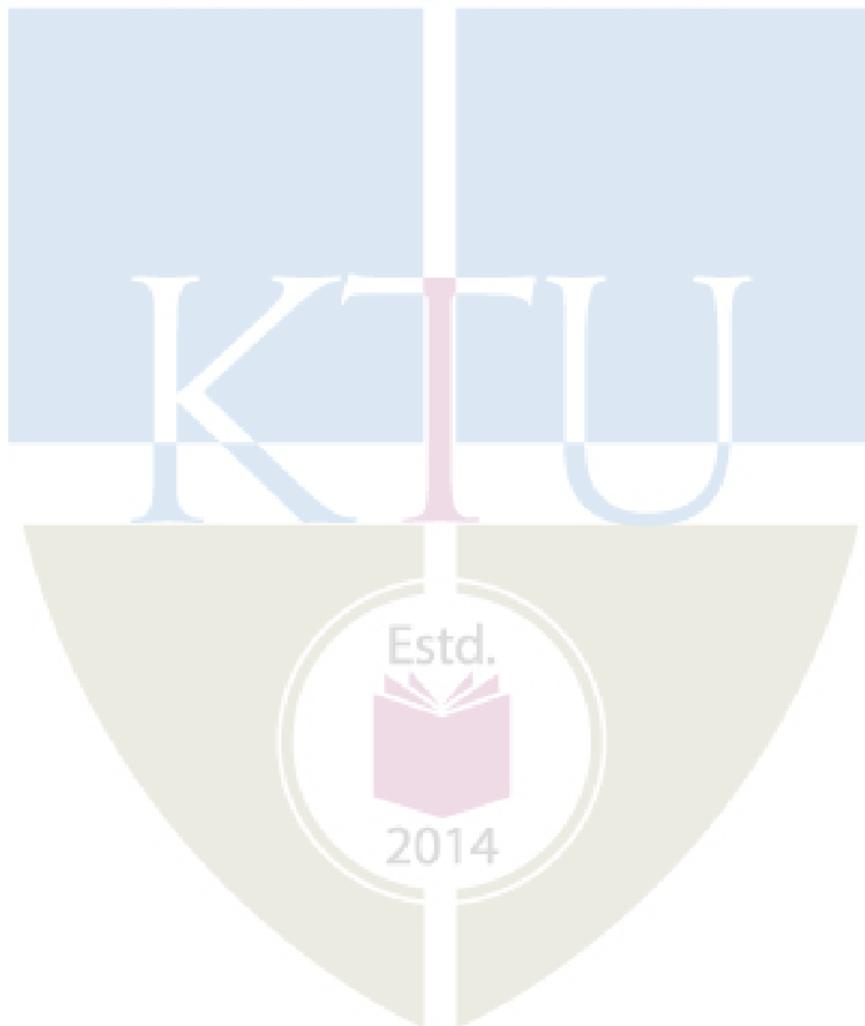
- 16.(b) Design a combinational circuit for 3×2 multiplication. (4)
17. Design a hardware control unit used to perform addition/subtraction of 2 numbers represented in sign magnitude form. (14)
- OR
18. Give the structure of the micro program sequencer and its role in sequencing the micro instructions. (14)
- 19.
- 19.(a) Explain the different ways in which interrupt priority schemes can be implemented (10)
- 19.(b) Give the structure of SRAM cell. (4)
- OR
- 20.
- 20.(a) Explain the various mapping functions available in cache memory. (9)
- 20.(b) Briefly explain content addressable memory. (5)



TEACHING PLAN		
No	Contents	No of Lecture Hrs
Module 1 : (Basic Structure of computers) (9 hours)		
1.1	Functional units,basic operational concepts,bus structures (introduction)	1
1.2	Memory locations and addresses , memory operations	1
1.3	Instructions and instruction sequencing	1
1.4	Addressing modes	1
1.5	Fundamental concepts of instruction execution, instruction cycle	1
1.6	Execution of a complete instruction - single bus organization (Lecture 1)	1
1.7	Execution of a complete instruction - single bus organization (Lecture 2)	1
1.8	Execution of a complete instruction - multiple bus organization (Lecture 1)	1
1.9	Execution of a complete instruction - multiple bus organization (Lecture 2)	1
Module 2 :(Register transfer logic and Processor logic design) (10 hours)		
2.1	Inter register transfer – arithmetic micro operations	1
2.2	Inter register transfer – logic and shift micro operations	1
2.3	Processor organization	1
2.4	Design of arithmetic circuit	1
2.5	Design of logic circuit	1
2.6	Design of arithmetic logic unit	1
2.7	Design of status register	1
2.8	Design of shifter - processor unit	1

2.9	Design of accumulator (Lecture 1)	1
2.10	Design of accumulator (Lecture 2)	1
Module 3 : (Arithmetic algorithms and Pipelining) (9 hours)		
3.1	Algorithm for multiplication of binary numbers	1
3.2	Algorithm for division (restoring method) of binary numbers	1
3.3	Array multiplier	1
3.4	Booth's multiplication algorithm	1
3.5	Pipelining: Basic principles	1
3.6	Classification of pipeline processors (Lecture 1)	1
3.7	Classification of pipeline processors (Lecture 2)	1
3.8	Instruction and arithmetic pipelines (Design examples not required)	1
3.9	Hazard detection and resolution	1
Module 4 :(Control Logic Design) (9 hours)		
4.1	Control organization –design of hardwired control logic (Lecture 1)	1
4.2	Control organization –design of hardwired control logic (Lecture 2)	1
4.3	Control organization –design of hardwired control logic (Lecture 3)	1
4.4	Design of microprogram control logic–control of processor unit (Lecture1)	1
4.5	Design of microprogram control logic–control of processor unit (Lecture2)	1
4.6	Design of microprogram control logic–control of processor unit (Lecture3)	1
4.7	Microprogram sequencer	1
4.8	Micro programmed CPU organization	1
4.9	Microinstructions –horizontal and vertical micro instructions	1
Module 5 : (Basic processing units, I/O and memory) (8 hours)		
5.1	Accessing of I/O devices –interrupts	1
5.2	Interrupt hardware	1

5.3	Direct memory access	1
5.4	Memory system: basic concepts –semiconductor RAMs	1
5.5	Memory system considerations – ROMs	1
5.6	Content addressable memory	1
5.7	Cache memories -mapping functions (Lecture 1)	1
5.8	Cache memories -mapping functions (Lecture 2)	1



CST 204	DATABASE MANAGEMENT SYSTEMS	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
			3	1	0		

Preamble: This course provides a clear understanding of fundamental principles of Database Management Systems (DBMS) with special focus on relational databases to the learners. The topics covered in this course are basic concepts of DBMS, Entity Relationship (ER) model, Relational Database principles, Relational Algebra, Structured Query Language (SQL), Physical Data Organization, Normalization and Transaction Processing Concepts. The course also gives a glimpse of the alternative data management model, NoSQL. This course helps the learners to manage data efficiently by identifying suitable structures to maintain data assets of organizations and to develop applications that utilize database technologies.

Prerequisite: Topics covered under the course Data Structures (CST 201), Exposure to a High Level Language like C/python.

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

CO1	Summarize and exemplify fundamental nature and characteristics of database systems (Cognitive Knowledge Level: Understand)
CO2	Model real word scenarios given as informal descriptions, using Entity Relationship diagrams. (Cognitive Knowledge Level: Apply)
CO3	Model and design solutions for efficiently representing and querying data using relational model (Cognitive Knowledge Level: Analyze)
CO4	Demonstrate the features of indexing and hashing in database applications (Cognitive Knowledge Level: Apply)
CO5	Discuss and compare the aspects of Concurrency Control and Recovery in Database systems (Cognitive Knowledge Level: Apply)
CO6	Explain various types of NoSQL databases (Cognitive Knowledge Level: Understand)

Mapping of course outcomes with program outcomes

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

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks (%)
	Test1 (%)	Test2 (%)	
Remember	30	30	30
Understand	40	40	40
Apply	30	30	30

Analyze			
Evaluate			
Create			

Mark Distribution

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

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks

First Internal Examination shall be preferably conducted after completing the first half of the syllabus and the Second Internal Examination shall be preferably conducted after completing remaining part of the syllabus.

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

End Semester Examination Pattern:

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

Syllabus

Module 1: Introduction & Entity Relationship (ER) Model

Concept & Overview of Database Management Systems (DBMS) - Characteristics of Database system, Database Users, structured, semi-structured and unstructured data. Data Models and Schema - Three Schema architecture. Database Languages, Database architectures and classification.

ER model - Basic concepts, entity set & attributes, notations, Relationships and constraints, cardinality, participation, notations, weak entities, relationships of degree 3.

Module 2: Relational Model

Structure of Relational Databases - Integrity Constraints, Synthesizing ER diagram to relational schema

Introduction to Relational Algebra - select, project, cartesian product operations, join - Equi-join, natural join. query examples, introduction to Structured Query Language (SQL), Data Definition Language (DDL), Table definitions and operations – CREATE, DROP, ALTER, INSERT, DELETE, UPDATE.

Module 3: SQL DML (Data Manipulation Language), Physical Data Organization

SQL DML (Data Manipulation Language) - SQL queries on single and multiple tables, Nested queries (correlated and non-correlated), Aggregation and grouping, Views, assertions, Triggers, SQL data types.

Physical Data Organization - Review of terms: physical and logical records, blocking factor, pinned and unpinned organization. Heap files, Indexing, Single level indices, numerical examples, Multi-level-indices, numerical examples, B-Trees & B+-Trees (structure only, algorithms not required), Extendible Hashing, Indexing on multiple keys – grid files.

Module 4: Normalization

Different anomalies in designing a database, The idea of normalization, Functional dependency, Armstrong's Axioms (proofs not required), Closures and their computation, Equivalence of Functional Dependencies (FD), Minimal Cover (proofs not required). First Normal Form (1NF), Second Normal Form (2NF), Third Normal Form (3NF), Boyce Codd Normal Form (BCNF), Lossless join and dependency preserving decomposition, Algorithms for checking Lossless Join (LJ) and Dependency Preserving (DP) properties.

Module 5: Transactions, Concurrency and Recovery, Recent Topics

Transaction Processing Concepts - overview of concurrency control, Transaction Model, Significance of concurrency Control & Recovery, Transaction States, System Log, Desirable Properties of transactions.

Serial schedules, Concurrent and Serializable Schedules, Conflict equivalence and conflict serializability, Recoverable and cascade-less schedules, Locking, Two-phase locking and its variations. Log-based recovery, Deferred database modification, check-pointing.

Introduction to NoSQL Databases, Main characteristics of Key-value DB (examples from: Redis), Document DB (examples from: MongoDB)

Main characteristics of Column - Family DB (examples from: Cassandra) and Graph DB (examples from : ArangoDB)

Text Books

1. Elmasri R. and S. Navathe, Database Systems: Models, Languages, Design and Application Programming, Pearson Education, 2013.
2. Sliberschatz A., H. F. Korth and S. Sudarshan, Database System Concepts, 6/e, McGraw Hill, 2011.

Reference Books:

1. Adam Fowler, NoSQL for Dummies, John Wiley & Sons, 2015
2. NoSQL Data Models: Trends and Challenges (Computer Engineering: Databases and Big Data), Wiley, 2018
3. Web Resource: <https://www.w3resource.com/redis/>
4. web Resource: <https://www.w3schools.in/category/mongodb/>
5. Web Resource: https://www.tutorialspoint.com/cassandra/cassandra_introduction.htm
6. Web Resource : <https://www.tutorialspoint.com/arangodb/index.htm>

Sample Course Level Assessment Questions

Course Outcome1 (CO1):

1. List out any three salient features of database systems, which distinguish it from a file system.
2. Give one example each for logical and physical data independence.

Course Outcome 2(CO2):

1. What facts about the relationships between entities EMPLOYEE and PROJECT are conveyed by the following ER diagram?



1. Design an ER diagram for the following scenario:
There is a set of teams, each team has an ID (unique identifier), name, main stadium, and to which city this team belongs. Each team has many players, and each player belongs to one team. Each player has a number (unique identifier), name, DoB, start year, and shirt number that he uses. Teams play matches, in each match there is a host team and a guest team.

Course Outcome 3(CO3):

1. For the SQL query, `SELECT A, B FROM R WHERE B='apple' AND C = 'orange'` on the table `R(A, B, C, D)`, where `A` is a key, write any three equivalent relational algebra expressions.
2. Given the FDs `P→Q`, `P→R`, `QR→S`, `Q→T`, `QR→U`, `PR→U`, write the sequence of *Armstrong's Axioms* needed to arrive at the following FDs: (a) `P → T` (b) `PR → S` (c) `QR → SU`
3. Consider a relation `PLAYER (PLAYER-NO, PLAYER-NAME, PLAYER-POSN, TEAM, TEAM-COLOR, COACH-NO, COACH-NAME, TEAM-CAPTAIN)`. Assume that `PLAYER-NO` is the *only* key of the relation and that the following dependencies hold:
 - `TEAM→{TEAM-COLOR, COACH-NO, TEAM-CAPTAIN}`
 - `COACH-NO→COACH-NAME`.
 - i. Is the relation in 2NF? If not, decompose to 2NF.
 - ii. Is the relation in 3NF? If not, decompose to 3NF.

4. In the following tables foreign keys have the same name as primary keys except DIRECTED-BY, which refers to the primary key ARTIST-ID. Consider only *single-director* movies.

MOVIES(MOVIE-ID, MNAME, GENRE, LENGTH, DIRECTED-BY)

ARTIST(ARTIST-ID, ANAME)

ACTING(ARTIST-ID, MOVIE-ID)

Write SQL expressions for the following queries:

- Name(s) and director name(s) of movie(s) acted by 'Jenny'.
- Names of actors who have never acted with 'Rony'
- Count of movies genre-wise.
- Name(s) of movies with maximum length.

Course Outcome 4(CO4):

- Consider an EMPLOYEE file with 10000 records where each record is of size 80 bytes. The file is sorted on employee number (15 bytes long), which is the primary key. Assuming un-spanned organization, block size of 512 bytes and block pointer size of 5 bytes. Compute the number of block accesses needed for retrieving an employee record based on employee number if (i) No index is used (ii) Multi-level primary index is used.

Course Outcome 5(CO5):

- Determine if the following schedule is *recoverable*. Is the schedule *cascade-less*? Justify your answer. $r1(X), r2(Z), r1(Z), r3(X), r3(Y), w1(X), c1, w3(Y), c3, r2(Y), w2(Z), w2(Y), c2$. (Note: $ri(X)/wi(X)$ means transaction T_i issues read/write on item X; ci means transaction T_i commits.)
- Two-phase locking protocol ensures serializability. Justify.

Course Outcome 6(CO6):

- List out any three salient features of NoSQL databases. Give example of a document in MongoDB.

Model Question Paper

QPCODE

Reg No: _____

Name: _____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR

Course Code: CST 204

Course Name: Database Management Systems

Max.Marks:100

Duration: 3 Hours

PART A

Answer all Questions. Each question carries 3 Marks

- 1 List out any three salient features of a database systems.
- 2 When is multi-valued composite attribute used in ER modelling?
- 3 For the SQL query, `SELECT A, B FROM R WHERE B='apple' AND C = 'orange'` on the table R(A, B, C, D), where A is a key, write any two equivalent relational algebra expressions.
- 4 Outline the concept of *theta*-join.
- 5 How is the purpose of *where* clause is different from that of having clause?
- 6 What is the use of a trigger?
- 7 When do you say that a relation is not in 1NF?
- 8 Given the FDs $P \rightarrow Q$, $P \rightarrow R$, $QR \rightarrow S$, $Q \rightarrow T$, $QR \rightarrow U$, $PR \rightarrow U$, write the sequence of Armstrong's Axioms needed to arrive at a. $P \rightarrow T$ b. $PR \rightarrow S$
- 9 What is meant by the lost update problem?
- 10 What is meant by check pointing?

2014

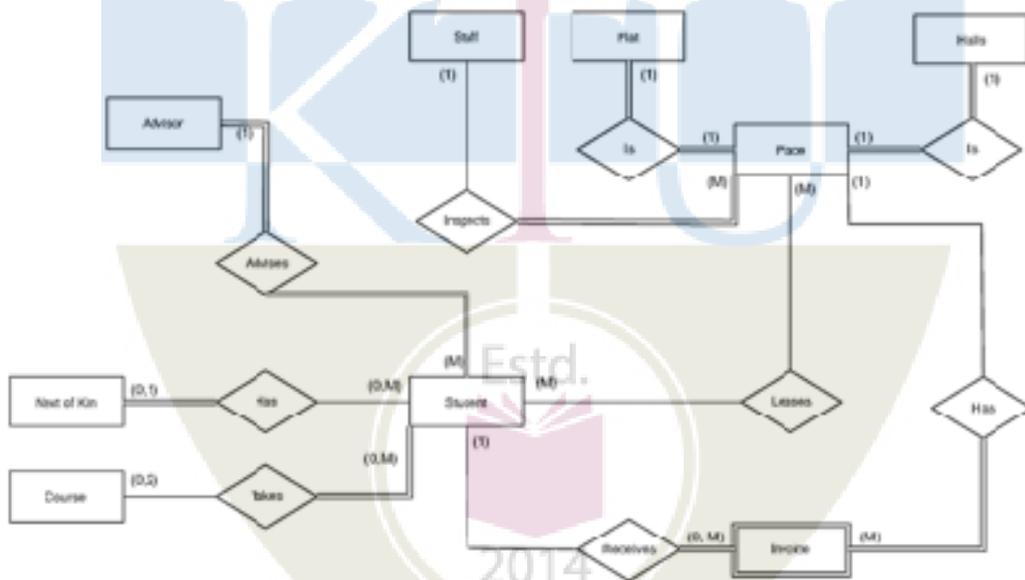
PART B

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

- 11 a. Design an ER diagram for the following scenario: There is a set of teams, each team has an ID (unique identifier), name, main stadium, and to which city this team belongs. Each team has many players, and each player belongs to one team. Each player has a number (unique identifier), name, DoB, start year, and shirt number that he uses. Teams play matches, in each match there is a host team and a guest team. The match takes place in the stadium of the host team. For each match we need to keep track of the following: The date on which the game is played The final result of the match. The players participated in the match. For each player, how many goals he scored, whether or not he took yellow card, and whether or not he took red card. During the match, one player may substitute another player. We want to capture this substitution and the time at which it took place. Each match has exactly three referees. For each referee we have an ID (unique identifier), name, DoB, years of experience. One referee is the main referee and the other two are assistant referee. (14)

OR

- 12 a. Interpret the the following ER diagram. (8)



- b. Distinguish between physical data independence and logical data independence with suitable examples. (6)

- 13 **EMPLOYEE(ENO, NAME, ADDRESS, DOB, AGE, GENDER, SALARY, DNUM, SUPERENO)** (14)
DEPARTMENT(DNO, DNAME, DLOCATION, DPHONE, MGRENO)
PROJECT(PNO, PNAME, PLOCATION, PCOST, CDNO)

DNUM is a foreign key that identifies the department to which an employee belongs. MGRENO is a foreign key identifying the employee who manages the department. CDNO is a foreign key identifying the department that controls the project. SUPERENO is a foreign key identifying the supervisor of each employee.

Write relational algebra expressions for the following queries:-

- Names of female employees whose salary is more than 20000.
- Salaries of employee from 'Accounts' department
- Names of employees along with his/her supervisor's name
- For each employee return name of the employee along with his department name and the names of projects in which he/she works
- Names of employees working in all the departments

OR

- 14 a. Write SQL DDL statements for the the following (Assume suitable domain types): (10)
- Create the tables STUDENT(ROLLNO, NAME, CLASS, SEM, ADVISER), FACULTY(FID, NAME, SALARY, DEPT). Assume that ADVISER is a foreign key referring FACUTY table.
 - Delete department with name 'CS' and all employees of the department.
 - Increment salary of every faculty by 10%.
- b. Illustrate foreign key constraint with a typical example. (4)

- 15 For the relation schema below, give an expression in SQL for each of the queries (14) that follows:

employee(employee-name, street, city)
works(employee-name, company-name, salary)
company(company-name, city)
manages(employee-name, manager-name)

- Find the names, street address, and cities of residence for all employees who work for the Company 'RIL Inc.' and earn more than \$10,000.
- Find the names of all employees who live in the same cities as the companies for which they work.
- Find the names of all employees who do not work for 'KYS Inc.'. Assume that all people work for exactly one company.
- Find the names of all employees who earn more than every employee of 'SB Corporation'. Assume that all people work for at most one company.
- List out number of employees company-wise in the decreasing order of number of employees.

OR

- 16 a. Consider an EMPLOYEE file with 10000 records where each record is of size 80 bytes. The file is sorted on employee number (15 bytes long), which is the primary key. Assuming un-spanned organization and block size of 512 bytes compute the number of block accesses needed for selecting records based on employee number if, (9)
- No index is used
 - Single level primary index is used
 - Multi-level primary index is used
- Assume a block pointer size of 6 bytes.
- b. Illustrate correlated and non-correlated nested queries with real examples. (5)
- 17 a. Illustrate 3NF and BCNF with suitable real examples. (6)
- b. Given a relation $R(A_1, A_2, A_3, A_4, A_5)$ with functional dependencies $A_1 \rightarrow A_2, A_4$ and $A_4 \rightarrow A_5$, check if the decomposition $R_1(A_1, A_2, A_3), R_2(A_1, A_4), R_3(A_2, A_4, A_5)$ is lossless. (8)

OR

- 18 a. Consider the un-normalized relation $R(A, B, C, D, E, F, G)$ with the FDs $A \rightarrow B, AC \rightarrow G, AD \rightarrow EF, EF \rightarrow G, CDE \rightarrow AB$. Trace the normalization process to reach 3NF relations. (7)

b. Illustrate Lossless Join Decomposition and Dependency Preserving Decomposition with typical examples. (7)

19 a. Discuss the four ACID properties and their importance. (7)

b. Determine if the following schedule is conflict serializable. Is the schedule recoverable? Is the schedule cascade-less? Justify your answers. (7)

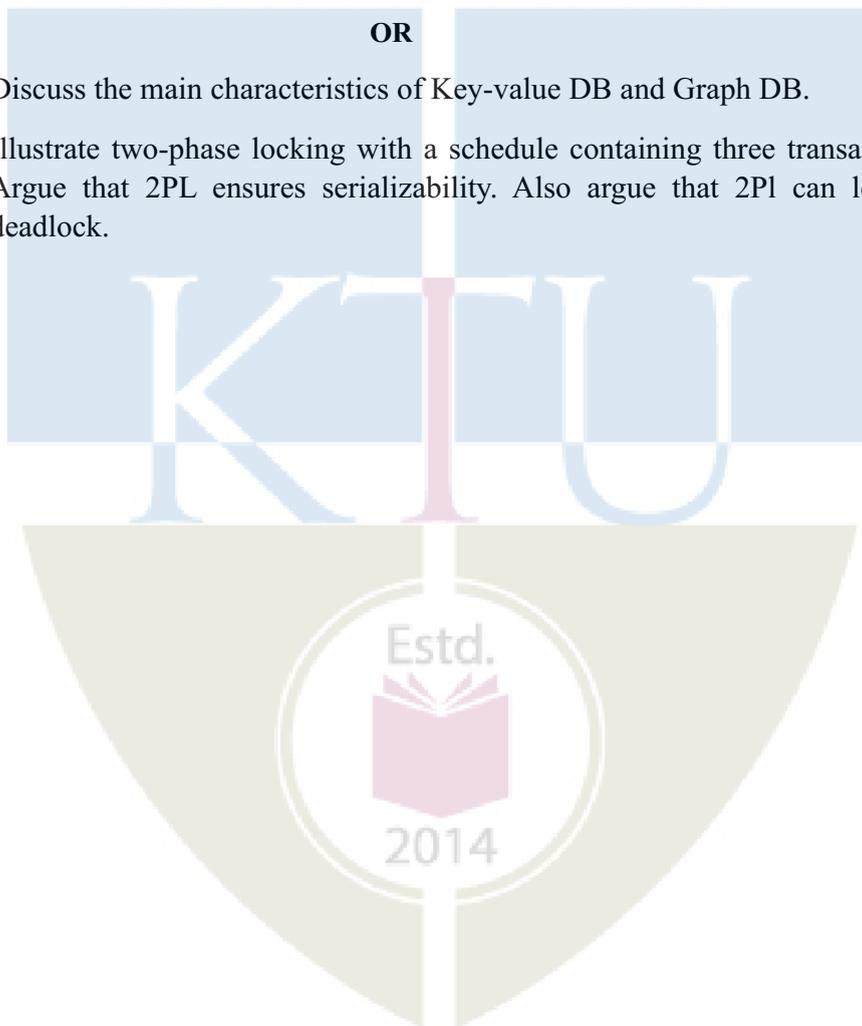
$r_1(X), r_2(Z), r_1(Z), r_3(X), r_3(Y), w_1(X), c_1, w_3(Y), c_3, r_2(Y), w_2(Z), w_2(Y), c_2$

(Note: $ri(X)/wi(X)$ means transaction T_i issues read/write on item X ; ci means transaction T_i commits.)

OR

20 a. Discuss the main characteristics of Key-value DB and Graph DB. (7)

b. Illustrate two-phase locking with a schedule containing three transactions. Argue that 2PL ensures serializability. Also argue that 2PL can lead to deadlock. (7)



Teaching Plan

	Course Name	Hours (48)
	Module 1: Introduction & ER Model	8
1.1	Concept & Overview of DBMS, Characteristics of DB system, Database Users.	1
1.2	Structured, semi-structured and unstructured data. Data Models and Schema	1
1.3	Three-Schema-architecture. Database Languages	1
1.4	Database architectures and classification	1
1.5	ER model: basic concepts, entity set & attributes, notations	1
1.6	Relationships and constraints – cardinality, participation, notations	1
1.7	Weak entities, relationships of degree 3	1
1.8	ER diagram – exercises	1
	Module 2: Relational Model	7
2.1	Structure of relational Databases, Integrity Constraints	1
2.2	Synthesizing ER diagram to relational schema, Introduction to relational algebra.	1
2.3	Relational algebra: select, project, Cartesian product operations	1
2.4	Relational Algebra: join - Equi-join, Natural join	1
2.5	Query examples	1
2.6	Introduction to SQL, important data types	1
2.7	DDL, Table definitions and operations – CREATE, DROP, ALTER, INSERT, DELETE, UPDATE	1
	Module 3: SQL DML, Physical Data Organization	11
3.1	SQL DML, SQL queries on single and multiple tables	1
3.2	Nested queries (correlated and non-correlated)	1
3.3	Aggregation and grouping	1

	Course Name	Hours (48)
3.4	Views, assertions (with examples)	1
3.5	Triggers (with examples), SQL data types	1
3.6	Review of terms: physical and logical records, blocking factor, pinned and unpinned organization. Heap files, Indexing	1
3.7	Singe level indices, numerical examples	1
3.8	Multi-level-indices, numerical examples	1
3.9	B-Trees and B+Trees (structure only, algorithms not required)	1
3.10	Extendible Hashing	1
3.11	Indexing on multiple keys – grid files	1
	Module 4: Normalization	8
4.1	Different anomalies in designing a database, The idea of normalization	1
4.2	Functional dependency, Armstrong's Axioms (proofs not required)	1
4.3	Closures and their computation, Equivalence of FDs, minimal Cover (proofs not required).	1
4.4	1NF, 2NF	1
4.5	3NF, BCNF	1
4.6	Lossless join and dependency preserving decomposition	1
4.7	Algorithms for checking Lossless Join and Dependency preserving properties (Lecture 1)	1
4.8	Algorithms for checking Lossless Join and Dependency preserving properties (Lecture 2)	1
	Module 5: Transactions, Concurrency and Recovery, Recent Topics	14
5.1	Transaction Processing Concepts: Transaction Model	1
5.2	Overview of concurrency control, Significance of concurrency Control & Recovery	1
5.3	Transaction States, System Log	1

	Course Name	Hours (48)
5.4	Desirable Properties of transactions, Serial schedules	1
5.5	Concurrent and Serializable Schedules	1
5.6	Conflict equivalence and conflict serializability	1
5.7	Recoverable and cascade-less schedules	1
5.8	Locking, Two-phase locking, strict 2PL.	1
5.9	Log-based recovery	1
5.10	Deferred database modification (serial schedule), example	1
5.11	Deferred database modification (concurrent schedule) example, check-pointing	1
5.12	Introduction to NoSQL Databases	1
5.13	Main characteristics of Key-value DB (examples from: Redis), Document DB (examples from: MongoDB) [detailed study not expected]	1
5.14	Main characteristics of Column-Family DB (examples from: Cassandra) and Graph DB (examples from : ArangoDB) [detailed study not expected]	1



CST 206	OPERATING SYSTEMS	Category	L	T	P	Credit	Year of Introduction
		PCC	3	1	0		

Preamble: Study of operating system is an essential to understand the overall working of computer system, tradeoffs between performance and functionality and the division of jobs between hardware and software. This course introduces the concepts of memory management, device management, process management, file management and security & protection mechanisms available in an operating system. The course helps the learner to understand the fundamentals about any operating system design so that they can extend the features of operating system to detect and solve many problems occurring in operating system and to manage the computer resources appropriately.

Prerequisite: Topics covered in the courses are **Data Structures (CST 201)** and **Programming in C (EST 102)**

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

CO1	Explain the relevance, structure and functions of Operating Systems in computing devices. (Cognitive knowledge: Understand)
CO2	Illustrate the concepts of process management and process scheduling mechanisms employed in Operating Systems. (Cognitive knowledge: Understand)
CO3	Explain process synchronization in Operating Systems and illustrate process synchronization mechanisms using Mutex Locks, Semaphores and Monitors (Cognitive knowledge: Understand)
CO4	Explain any one method for detection, prevention, avoidance and recovery for managing deadlocks in Operating Systems. (Cognitive knowledge: Understand)
CO5	Explain the memory management algorithms in Operating Systems. (Cognitive knowledge: Understand)
CO6	Explain the security aspects and algorithms for file and storage management in Operating Systems. (Cognitive knowledge: Understand)

Mapping of course outcomes with program outcomes

B.TECH COMPUTER SCIENCE AND DESIGN

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

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

Assessment Pattern

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

Mark Distribution

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

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test : 25 marks

Continuous Assessment Assignment : 15 marks

Internal Examination Pattern:

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

End Semester Examination Pattern:

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

Syllabus**Module I**

Introduction: Operating system overview – Operations, Functions, Service – System calls, Types – Operating System structure - Simple structure, Layered approach, Microkernel, Modules – System boot process.

Module II

Processes - Process states, Process control block, threads, scheduling, Operations on processes - process creation and termination – Inter-process communication - shared memory systems, Message passing systems.

Process Scheduling – Basic concepts- Scheduling criteria -scheduling algorithms- First come First Served, Shortest Job First, Priority scheduling, Round robin scheduling

Module III

Process synchronization- Race conditions – Critical section problem – Peterson’s solution, Synchronization hardware, Mutex Locks, Semaphores, Monitors – Synchronization problems - Producer Consumer, Dining Philosophers and Readers-Writers.

Deadlocks: Necessary conditions, Resource allocation graphs, Deadlock prevention, Deadlock avoidance – Banker’s algorithms, Deadlock detection, Recovery from deadlock.

Module IV

Memory Management: Concept of address spaces, Swapping, Contiguous memory allocation, fixed and variable partitions, Segmentation, Paging. Virtual memory, Demand paging, Page replacement algorithms.

Module V

File System: File concept - Attributes, Operations, types, structure – Access methods, Protection. File-system implementation, Directory implementation. Allocation methods.

Storage Management: Magnetic disks, Solid-state disks, Disk Structure, Disk scheduling, Disk formatting.

Text Book

Abraham Silberschatz, Peter Baer Galvin, Greg Gagne, ' Operating System Concepts' 9th Edition, Wiley India 2015.

Reference Books:

1. Andrew S Tanenbaum, “Modern Operating Systems” , 4th Edition, Prentice Hall, 2015.
2. William Stallings, “Operating systems”, 6th Edition, Pearson, Global Edition, 2015.
3. Garry Nutt, Nabendu Chaki, Sarmistha Neogy, “Operating Systems”, 3rd Edition, Pearson Education.
4. D.M.Dhamdhare, “Operating Systems”, 2nd Edition, Tata McGraw Hill, 2011.
5. Sibsankar Halder, Alex A Aravind, “Operating Systems”, Pearson Education.

Sample Course Level Assessment Questions

B.TECH COMPUTER SCIENCE AND DESIGN

Course Outcome 1 (CO1): What is the main advantage of the micro kernel approach to system design? How do user program and system program interact in a microkernel architecture?

Course Outcome 2 (CO2): Define process. With the help of a neat diagram explain different states of process.

Course Outcome 3 (CO3): What do you mean by binary semaphore and counting semaphore? With C, explain implementation of wait () and signal().

Course Outcome 4 (CO4): Describe resource allocation graph for the following. a) with a deadlock b) with a cycle but no deadlock.

Course Outcome 5 (CO5): Consider the following page reference string 1, 2, 3, 4, 2, 1, 5, 6, 2, 1, 2, 3, 7, 6, 3, 2, 1, 2, 3, 6. Find out the number of page faults if there are 4 page frames, using the following page replacement algorithms. i) LRU ii) FIFO iii) Optimal

Course Outcome 6 (CO6): Explain the different file allocation methods with advantages and disadvantages.

Model Question Paper

QP CODE: _____

PAGES: ____

Reg No: _____

Name: _____

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FOURTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

Course Code: CST 206

Course name : OPERATING SYSTEMS

Max Marks: 100

Duration: 3 Hours

PART-A

(Answer All Questions. Each question carries 3 marks)

1. How does hardware find the Operating System kernel after system switch-on?
2. What is the purpose of system call in operating system?
3. Why is context switching considered as an overhead to the system?

4. How is inter process communication implement using shared memory?
5. Describe resource allocation graph for the following.
- a) with a deadlock b)with a cycle but no deadlock.
6. What is critical section? What requirement should be satisfied by a solution to the critical section problem?
7. Consider the reference string 1, 2, 3, 4, 2, 1, 5, 6, 2, 1, 2, 3, 7, 6, 3, 2, 1, 2, 3, 6. How many page faults occur while using FCFS for the following cases.
- a) frame=2 b)frame=3
8. Differentiate between internal and external fragmentations.
9. Compare sequential access and direct access methods of storage devices.
10. Define the terms (i) Disk bandwidth (ii) Seek time.

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

11. a) Explain the following structures of operating system (i) Monolithic systems (ii) Layered Systems (iii) Micro Kernel (iv) Modular approach. (12)
- b) Under what circumstances would a user be better of using a time sharing system than a PC or a single user workstation? (2)
- OR**
12. a) What is the main advantage of the micro kernel approach to system design? How do user program and system program interact in a microkernel architecture? (8)
- b) Describe the differences between symmetric and asymmetric multiprocessing? What are the advantages and disadvantages of multiprocessor systems? (6)
13. a) Define process. With the help of a neat diagram explain different states of process. (8)
- b) Explain how a new process can be created in Unix using fork system call. (6)
- OR**
- 14 a) Find the average waiting time and average turnaround time for the processes given in the table below using:- i) SRT scheduling algorithm ii) Priority scheduling algorithm (9)

Process	Arrival Time (ms)	CPU Burst Time (ms)	Priority
P1	0	5	3
P2	2	4	1
P3	3	1	2
P4	5	2	4

b) What is a Process Control Block? Explain the fields used in a Process Control Block. (5)

15. Consider a system with five processes P₀ through P₄ and three resources of type A, B, C. Resource type A has 10 instances, B has 5 instances and C has 7 instances. Suppose at time t₀ following snapshot of the system has been taken:

Process	Allocation			Max			Available		
	A	B	C	A	B	C	A	B	C
P ₀	0	1	0	7	5	3	3	3	2
P ₁	2	0	0	3	2	2			
P ₂	3	0	2	9	0	2			
P ₃	2	1	1	2	2	2			
P ₄	0	0	2	4	3	3			

i) What will be the content of the Need matrix? Is the system in a safe state? If Yes, then what is the safe sequence? (8)

iii) What will happen if process P₁ requests one additional instance of resource type A and two instances of resource type C? (6)

OR

16. a) State dining philosopher's problem and give a solution using semaphores. (7)

b) What do you mean by binary semaphore and counting semaphore? With C struct, explain implementation of wait () and signal() (7)

17. a) Consider the following page reference string 1, 2, 3, 4, 2, 1, 5, 6, 2, 1, 2, 3, 7, 6, 3, 2, 1, 2, 3, 6. Find out the number of page faults if there are 4 page frames, using the following page replacement algorithms i) LRU ii) FIFO iii) Optimal (9)
- b) Explain the steps involved in handling a page fault. (5)

OR

18. a) With a diagram, explain how paging is done with TLB. (5)
- b) Memory partitions of sizes 100 kb, 500 kb, 200 kb, 300 kb, 600 kb are available, how would best, worst and first fit algorithms place processes of size 212 kb, 417 kb, 112 kb, 426 kb in order. Rank the algorithms in terms of how efficiently they use memory. (9)

19. a) Suppose that a disk drive has 5000 cylinders, numbered 0 to 4999. The drive currently services a request at cylinder 143, and the previous request was at cylinder 125. The queue of pending requests in FIFO order is 86, 1470, 913, 1774, 948, 1509, 1022, 1750, 130. Starting from the current position, what is the total distance (in cylinders) that the disk arm moves to satisfy all pending requests for each of the following algorithms
- i) FCFS ii) SSTF iii) SCAN iv) LOOK v) C-SCAN (10)
- b) What is the use of access matrix in protection mechanism? (4)

OR

20. a) Explain the different file allocation operations with advantages and disadvantages. (8)
- b) Explain the following i) file types ii) file operation iii) file attributes (6)

Teaching Plan

Module 1 - Introduction		5 Hours
1.1	Introduction to Operating System	1
1.2	Operating System operations, functions, service	1
1.3	System calls, Types	1
1.4	Operating System Structure: Simple, Layered, Microkernel, Modules	1
1.5	System Boot Process	1
Module 2 – Processes and Process Scheduling		9 Hours
2.1	Processes, Process states	1
2.2	Process Control Block, Threads	1

2.3	Scheduling	1
2.4	Operations on processes: process creation and termination	1
2.5	Inter-process communication: Shared memory systems, Message Passing	1
2.6	Process Scheduling – Basic concepts, Scheduling Criteria	1
2.7	Scheduling algorithms - Basics	1
2.8	First come First Served, Shortest Job First	1
2.9	Priority scheduling, Round Robin Scheduling	1
	Module 3 - Process synchronization and Dead locks	13 Hours
3.1	Process synchronization, Race conditions	1
3.2	Critical Section problem, Peterson's solution	1
3.3	Synchronization hardware, Mutex Locks	1
3.4	Semaphores	1
3.5	Monitors	1
3.6	Synchronization problem examples (Lecture 1)	1
3.7	Synchronization problem examples (Lecture 2)	1
3.8	Deadlocks: Necessary conditions, Resource Allocation Graphs	1
3.9	Deadlock prevention	1
3.10	Deadlock avoidance	1
3.11	Banker's algorithm	1
3.12	Deadlock detection	1
3.13	Deadlock recovery	1
	Module 4 - Memory Management	9 Hours
4.1	Memory Management: Concept of Address spaces	1
4.2	Swapping	1
4.3	Contiguous memory allocation, fixed and variable partitions	1
4.4	Segmentation.	1
4.5	Paging (Lecture 1)	1
4.6	Paging (Lecture 2)	1
4.7	Virtual memory, Demand Paging	1

4.8	Page replacement algorithms (Lecture 1)	1
4.9	Page replacement algorithms (Lecture 2)	1
	Module 5 - File and Disk management	9 Hours
5.1	File concept, Attributes, Operations, types, structure	1
5.2	Access methods	1
5.3	Protection	1
5.4	File-System implementation	1
5.5	Directory implementation	1
5.6	Allocation methods	1
5.7	Magnetic disks, Solid-state disks, Disk structure	1
5.8	Disk scheduling	1
5.9	Disk formatting	1



CSL202	DIGITAL LAB	CATEGORY	L	T	P	CREDIT
		PCC	0	0	3	2

Preamble: This course helps the learners to get familiarized with (i) Digital Logic Design through the implementation of Logic Circuits using ICs of basic logic gates & flip-flops and (ii) Hardware Description Language based Digital Design. This course helps the learners to design and implement hardware systems in areas such as games, music, digital filters, wireless communications and graphical displays.

Prerequisite: Topics covered under the course Logic System Design (CST 203)

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

CO 1	Design and implement combinational logic circuits using Logic Gates (Cognitive Knowledge Level: Apply)
CO 2	Design and implement sequential logic circuits using Integrated Circuits (Cognitive Knowledge Level: Apply)
CO 3	Simulate functioning of digital circuits using programs written in a Hardware Description Language (Cognitive Knowledge Level: Apply)
CO 4	Function effectively as an individual and in a team to accomplish a given task of designing and implementing digital circuits (Cognitive Knowledge Level: Apply)

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	PO10	PO11	PO12
CO 1	✓	✓	✓	✓				✓				✓
CO 2	✓	✓	✓	✓				✓				✓
CO 3	✓	✓	✓	✓	✓			✓				✓
CO 4	✓	✓	✓	✓				✓	✓			✓

Assessment Pattern

Bloom's Category	Continuous Assessment Test (Internal Exam) (Percentage)	End Semester Examination (Percentage)
Remember	20	20
Understand	20	20
Apply	60	60
Analyse		
Evaluate		
Create		

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	75	75	3 hours

Continuous Internal Evaluation Pattern:

Attendance : 15 marks

Continuous Evaluation in Lab : 30 marks

Continuous Assessment Test : 15 marks

Viva-voce : 15 marks

Internal Examination Pattern: The marks will be distributed as Design/Algorithm 30 marks, Implementation/Program 20 marks, Output 20 marks and Viva 30 marks. Total 100 marks which will be converted out of 15 while calculating Internal Evaluation marks.

End Semester Examination Pattern: The marks will be distributed as Design/Algorithm 30 marks, Implementation/Program 20 marks, Output 20 marks and Viva 30 marks. Total 100 marks will be converted out of 75 for End Semester Examination.

Fair Lab Record:

All Students attending the Digital Lab should have a Fair Record. The fair record should be produced in the University Lab Examination. Every experiment conducted in the lab should be noted in the fair record. For every experiment in the fair record, the right hand page should contain Experiment Heading, Experiment Number, Date of Experiment, and Aim of Experiment. The left hand page should contain components used, circuit design or a print out of the code used for the experiment and sample output obtained.

SYLLABUS

Conduct a minimum of **8** experiments from **Part A** and a minimum of **4** experiments from **Part B**. The starred experiments in Part A are mandatory. The lab work should be conducted in groups (maximum group size being 4). The performance of a student in the group should be assessed based on teamwork, integrity and cooperation.

Part A (Any 8 Experiments)

- A 2 hour session should be spent to make the students comfortable with the use of trainer kit/breadboard and ICs.
 - The following experiments can be conducted on breadboard or trainer kits.
 - Out of the 15 experiments listed below, a minimum of 8 experiments should be completed by a student, including the mandatory experiments (5).
1. Realization of functions using basic and universal gates (SOP and POS forms).
 2. Design and realization of half adder, full adder, half subtractor and full subtractor using: a) basic gates (b) universal gates. *
 3. Code converters: Design and implement BCD to Excess 3 and Binary to Gray code converters.
 4. Design and implement 4 bit adder/subtractor circuit and BCD adder using IC7483.
 5. Implementation of Flip Flops: SR, D, T, JK and Master Slave JK Flip Flops using basic gates.*
 6. Asynchronous Counter: Design and implement 3 bit up/down counter.
 7. Asynchronous Counter: Realization of Mod N counters (At least one up counter and one down counter to be implemented). *
 8. Synchronous Counter: Realization of 4-bit up/down counter.
 9. Synchronous Counter: Realization of Mod-N counters and sequence generators. (At least one mod N counter and one sequence generator to be implemented) *
 10. Realization of Shift Register (Serial input left/right shift register), Ring counter and Johnson Counter using flipflops. *
 11. Realization of counters using IC's (7490, 7492, 7493).
 12. Design and implement BCD to Seven Segment Decoder.
 13. Realization of Multiplexers and De-multiplexers using gates.
 14. Realization of combinational circuits using MUX & DEMUX ICs (74150, 74154).
 15. To design and set up a 2-bit magnitude comparator using basic gates.

PART B (Any 4 Experiments)

- The following experiments aim at training the students in digital circuit design with *Verilog*. The experiments will lay a foundation for digital design with Hardware Description Languages.
- A 3 hour introductory session shall be spent to make the students aware of the fundamentals of development using Verilog
- Out of the 8 experiments listed below, a minimum of 4 experiments should be completed by a student

Experiment 1. Realization of Logic Gates and Familiarization of Verilog

- (a) Familiarization of the basic syntax of Verilog
- (b) Development of Verilog modules for basic gates and to verify truth tables.
- (c) Design and simulate the HDL code to realize three and four variable Boolean functions

Experiment 2: Half adder and full adder

- (a) Development of Verilog modules for half adder in 3 modeling styles (dataflow/structural/behavioural).
- (b) Development of Verilog modules for full adder in structural modeling using half adder.

Experiment 3: Design of code converters

Design and simulate the HDL code for

- (a) 4- bit binary to gray code converter
- (b) 4- bit gray to binary code converter

Experiment 4: Mux and Demux in Verilog

- (a) Development of Verilog modules for a 4x1 MUX.
- (b) Development of Verilog modules for a 1x4 DEMUX.

Experiment 5: Adder/Subtractor

- (a) Write the Verilog modules for a 4-bit adder/subtractor
- (b) Development of Verilog modules for a BCD adder

Experiment 6: Magnitude Comparator

Development of Verilog modules for a 4 bit magnitude comparator

Experiment 7: Flipflops and shiftregisters

- (a) Development of Verilog modules for SR, JK, T and D flip flops.
- (b) Development of Verilog modules for a Johnson/Ring counter

Experiment 8: Counters

- (a) Development of Verilog modules for an asynchronous decade counter.
- (b) Development of Verilog modules for a 3 bit synchronous up-down counter.

Practice Questions**PART A**

1. Design a two bit parallel adder using gates and implement it using ICs of basic gates
2. A combinatorial circuit has 4 inputs and one output. The output is equal to 1 when (a) all inputs are 1, (b) none of the inputs are 1, (c) an odd number of inputs are equal to 1. Obtain the truth table and output function for this circuit and implement the same.
3. Design and implement a parallel subtractor.
4. Design and implement a digital circuit that converts Gray code to Binary.
5. Design a combinational logic circuit that will output the 1's compliment of a 4-bit input number.
6. Implement and test the logic function $f(A, B, C) = \sum m(0,1,3,6)$ using an 8:1 MUX IC
7. Design a circuit that will work as a ring counter or a Johnson counter based on a mode bit, M.
8. Design a 4-bit synchronous down counter.
9. Design a Counter to generate the binary sequence 0,1,3,7,6,4
10. Design an asynchronous mod 10 down counter
11. Design and implement a synchronous counter using JK flip flop ICs to generate the sequence: 0 - 1 - 3 - 5 - 7 - 0.

PART B

1. Develop Verilog modules for a full subtractor in structural modeling using half subtractors.
2. Design a 4 bit parallel adder using Verilog.
3. Develop Verilog modules for a 4 bit synchronous down counter.
4. Write Verilog code for implementing a 8:1 multiplexer.
5. Develop Verilog modules for a circuit that converts Excess 3 code to binary.
6. Write the Verilog code for a JK Flip flop, and its test-bench. Use all possible combinations of inputs to test its working
7. Write the hardware description in Verilog of a 8-bit register with shift left and shift right modes of operations and test its functioning.
8. Write the hardware description in Verilog of a mod-N ($N > 9$) counter and test it.

CSL204	OPERATING SYSTEMS LAB	CATEGORY	L	T	P	CREDIT	YEAR OF
							INTRODUCTION
		PCC	0	0	3	2	2019

Preamble: The course aims to offer students a hands-on experience on Operating System concepts using a constructivist approach and problem-oriented learning. Operating systems are the fundamental part of every computing device to run any type of software.

Prerequisite: Topics covered in the courses are **Data Structures (CST 201)** and **Programming in C (EST 102)**

Course Outcomes:

At the end of the course, the student should be able to

CO1	Illustrate the use of systems calls in Operating Systems. (Cognitive knowledge: Understand)
CO2	Implement Process Creation and Inter Process Communication in Operating Systems. (Cognitive knowledge: Apply)
CO3	Implement First Come First Served, Shortest Job First, Round Robin and Priority-based CPU Scheduling Algorithms. (Cognitive knowledge: Apply)
CO4	Illustrate the performance of First In First Out, Least Recently Used and Least Frequently Used Page Replacement Algorithms. (Cognitive knowledge: Apply)
CO5	Implement modules for Deadlock Detection and Deadlock Avoidance in Operating Systems. (Cognitive knowledge: Apply)
CO6	Implement modules for Storage Management and Disk Scheduling in Operating Systems. (Cognitive knowledge: Apply)

Mapping of course outcomes with program outcomes

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

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

Assessment Pattern:

Bloom's Category	Continuous Assessment Test (Internal Exam) Marks in percentage	End Semester Examination Marks in percentage
Remember	20	20
Understand	20	20
Apply	60	60
Analyse		
Evaluate		
Create		

Mark Distribution

Total Marks	CIE Marks	ESE Marks	ESE Duration
150	75	75	3 hours

Continuous Internal Evaluation Pattern:

Attendance	:	15 marks
Continuous Evaluation in Lab	:	30 marks
Continuous Assessment Test	:	15 marks
Viva Voce	:	15 marks

Internal Examination Pattern: The marks will be distributed as Algorithm 30 marks, Program 20 marks, Output 20 marks and Viva 30 marks. Total 100 marks which will be converted out of 15 while calculating Internal Evaluation marks.

End Semester Examination Pattern: The percentage of marks will be distributed as Algorithm 30 marks, Program 20 marks, Output 20 marks and Viva 30 marks. Total 75 marks.

Operating System to Use in Lab : Linux

Compiler/Software to Use in Lab : gcc.

Programming Language to Use in Lab : Ansi C

Fair Lab Record:

All Students attending the Operating System Lab should have a Fair Record. The fair record should be produced in the University Lab Examination. Every experiment conducted in the lab should be noted in the fair record. For every experiment in the fair record, the right hand page should contain Experiment Heading, Experiment Number, Date of experiment, Aim of the Experiment and the operations performed on them, Details of experiment including algorithm and result of Experiment. The left hand page should contain a print out of the code used for experiment and sample output obtained for a set of input.

SYLLABUS
OPERATING SYSTEMS LAB

* mandatory

1. Basic Linux commands
2. Shell programming
 - Command syntax
 - Write simple functions with basic tests, loops, patterns
3. System calls of Linux operating system: *
 - fork, exec, getpid, exit, wait, close, stat, opendir, readdir
4. Write programs using the I/O system calls of Linux operating system (open, read, write)
5. Implement programs for Inter Process Communication using Shared Memory *
6. Implement Semaphores*
7. Implementation of CPU scheduling algorithms. a) Round Robin b) SJF c) FCFS d) Priority *
8. Implementation of the Memory Allocation Methods for fixed partition*
 - a) First Fit b) Worst Fit c) Best Fit
9. Implement 1 page replacement algorithms a) FIFO b) LRU c) LFU*
10. Implement the banker's algorithm for deadlock avoidance. *
11. Implementation of Deadlock detection algorithm
12. Simulate file allocation strategies.
 - b) Sequential b) Indexed c) Linked
13. Simulate disk scheduling algorithms. *
 - c) FCFS b)SCAN c) C-SCAN

OPERATING SYSTEMS LAB - PRACTICE QUESTIONS

1. Write a program to create a process in linux.
2. Write programs using the following system calls of Linux operating system:
 - fork, exec, getpid, exit, wait, close, stat, opendir, readdir
3. Write programs using the I/O system calls of Linux operating system (open, read, write)

4. Given the list of processes, their CPU burst times and arrival times, display/print the Gantt chart for FCFS and SJF. For each of the scheduling policies, compute and print the average waiting time and average turnaround time
5. Write a C program to simulate following non-preemptive CPU scheduling algorithms to find turnaround time and waiting time.
a)FCFS b) SJF c) Round Robin (pre-emptive) d) Priority
6. Write a C program to simulate following contiguous memory allocation techniques
a) Worst-fit b) Best-fit c) First-fit
7. Write a C program to simulate paging technique of memory management.
8. Write a C program to simulate Bankers algorithm for the purpose of deadlock avoidance.
9. Write a C program to simulate disk scheduling algorithms a) FCFS b) SCAN c) C-SCAN
10. Write a C program to simulate page replacement algorithms a) FIFO b) LRU c) LFU
11. Write a C program to simulate producer-consumer problem using semaphores.
12. Write a program for file manipulation for display a file and directory in memory.
13. Write a program to simulate algorithm for deadlock prevention.
14. Write a C program to simulate following file allocation strategies.
a)Sequential b) Indexed c) Linked



APJ ABDUL KALAM
TECHNOLOGICAL
UNIVERSITY

SEMESTER -4
MINOR



CST 282	PROGRAMMING METHODOLOGIES	CATEGORY	L	T	P	CREDIT	YEAR OF INTRODUCTION
		VAC	3	1	0		

Preamble: This is the second course for awarding B.Tech Minor in Computer Science and Engineering with specialization in *Software Engineering*. The course provides the learners a clear understanding of the main constructs of contemporary programming languages and the various systems of ideas that have been used to guide the design of programming languages. This course covers the concepts of Names, Bindings & Scope, Statement-Level Control Structures, Sub Programs, support for Object Oriented Programming, Exception Handling, Event Handling, Concurrency Control, Functional Programming and Logic Programming. This course helps the learners to equip with the knowledge necessary for the critical evaluation of existing and upcoming programming languages. It also enables the learner to choose the most appropriate language for a given programming task, apply that language's approach to structure or organize the code and classify programming languages based on their features.

Prerequisite:

1. Topics covered under the course Programming in C (EST 102)
2. Object Oriented Programming (CST 251)

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

CO1	Explain the criteria for evaluating programming languages and compare Imperative, Functional and Logic programming languages (Cognitive Knowledge Level: Understand)
CO2	Explain the characteristics of data types and variables (Cognitive Knowledge Level: Understand)
CO3	Illustrate how control flow structures and subprograms help in developing the structure of a program to solve a computational problem (Cognitive Knowledge Level: Apply)
CO4	Explain the characteristics of Object Oriented Programming Languages (Cognitive Knowledge Level: Understand)
CO5	Compare concurrency constructs in different programming languages (Cognitive Knowledge Level: Understand)

Mapping of course outcomes with program outcomes

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

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

Assessment Pattern

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

Mark Distribution

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

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Test : 25 marks

Continuous Assessment Assignment : 15 marks

Internal Examination Pattern:

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

End Semester Examination Pattern:

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

SYLLABUS

Module 1

Introduction – Role of Programming Languages, Programming Domains, Language Evaluation Criteria, Influence on Language Design, Language Design Trade-offs, Implementation Methods. **Names, Bindings & Scope** – Names, Variables, Concept of Binding, Scope and Lifetime, Referencing Environments.

Module 2

Data Types – Primitive Data Types, Character String Types, User-Defined Ordinal Types, Array Types, Record Types, List Types, Pointer & Reference Types, Type Checking, Strong Typing, Type Equivalence. **Expressions** – Arithmetic Expressions, Overloaded Operators, Type Conversions, Relational and Boolean Expressions, Short-Circuit Evaluation. **Assignment - Assignment Statements, Mixed-mode Assignment.**

Module 3

Statement-Level Control Structures – Selection Statements, Iterative Statements, Unconditional Branching, Guarded Commands. **Subprograms** – Design Issues of Subprograms, Local Referencing Environments, Parameter Passing Methods, Subprograms as Parameters, Overloaded Subprograms, Closures, Co-routines.

Module 4

Support for Object Oriented Programming – Inheritance, Dynamic Binding, Design Issues for Object Oriented Languages, Support for Object Oriented Programming in C++, Implementation of Object-Oriented Constructs. **Exception Handling** – Basic Concepts, Design Issues. **Event Handling** - Introduction to Event Handling.

Module 5

Concurrency – Subprogram Level Concurrency, Semaphores, Monitors, Message Passing. **Functional Programming Languages** – Introduction to LISP and Scheme, Comparison of Functional and Imperative Languages. **Logic Programming Languages** – Basic Elements of Prolog, Applications of Logic Programming.

Text Books

1. Robert W. Sebesta, Concepts of Programming Languages, 10th Edition, Pearson.
2. Scott M. L., Programming Language Pragmatics, 3rd Edn., Morgan Kaufmann Publishers.

Reference Books:

1. Kenneth C. Loudon, Programming Languages: Principles and Practice, 2nd Edn., Cengage Learning.
2. Tucker A. B. and R. E. Noonan, Programming Languages: Principles and Paradigms, 2nd Edn. –TMH.
3. Ravi Sethi, Programming Languages: Concepts & Constructs, 2nd Edn., Pearson Education.
4. David A. Watt, Programming Language Design Concepts, Wiley Dreamtech

Sample Course Level Assessment Questions

Course Outcome 1 (CO1): Compare any three programming languages based on the language evaluation criteria. Prepare a list of characteristics that affect the language evaluation criteria. Identify the advantages and disadvantages of imperative, functional and logic programming languages.

Course Outcome 2 (CO2): Two most important design issues that are specific to character string types are (1) whether a string is simply a special kind of character array or a primitive type (2) whether strings have static or dynamic length. Justify your answer.

Course Outcome 3 (CO3):

1. Describe three situations where a combined counting and logical looping statement is needed.
2. Describe the ways that aliases can occur with pass-by-reference parameters.
3. Identify the two fundamental design considerations for parameter-passing methods.

Course Outcome 4 (CO4):

1. Describe the role of a virtual method table in implementing dynamic method binding.
2. Identify one disadvantage of inheritance.

Course Outcome 5 (CO5): Evaluate the use of semaphores and monitors for providing competition synchronization and cooperation synchronization.

Model Question paper

QP CODE:

PAGES:3

Reg No: _____

Name : _____

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

FOURTH SEMESTER B.TECH (MINOR) DEGREE EXAMINATION, MONTH &

YEAR Course Code: CST 282

Course Name: Programming Methodologies

Max.Marks:100

Duration: 3 Hours

PART A

Answer all Questions. Each question carries 3 Marks

1. Differentiate between readability and writability.
2. Define binding and binding time
3. What are the advantages of user-defined enumeration types?
4. Define narrowing and widening conversions.
5. Why **for** statement in C language is more flexible than that of older languages?
6. What are the advantages and disadvantages of dynamic local variables in subprograms?
7. Explain the concept of dynamic method binding with an example.
8. Is it mandatory to use constructors in object oriented languages? Justify your answer.
9. What are the applications of logical programming languages?
10. Explain the working of *let* and *let-rec* constructs in Scheme.

Part B

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

11.
 - (a) Explain different criteria used for evaluating languages. (7 marks)
 - (b) Explain the major methods of implementing programming languages. (7 marks)

OR

12.
 - (a) Explain the meanings, purposes, advantages and disadvantages of four categories of scalar variables according to their storage bindings. (7 marks)

- (b) What is referencing environment of a statement? Show the referencing environment at the indicated program points (1), (2), (3) & (4) for the following program segment. Assume that the programming language used is statically scoped.

program example;

```

var a, b : integer;
procedure sub1;
  var x, y: integer;
  begin { sub1 }
  ..... (1)
  end { sub1 }
procedure sub2;
  var x : integer;
  .....
  procedure sub3;
    var x: integer;
    begin { sub3 }
    ..... (2)
    end { sub3 }
  begin { sub2 }
  ..... (3)
  end { sub2 }
begin {example}
  ..... (4)
end {example}

```

(7 Marks)

13.

- (a) Explain any two problems associated with the pointer data types and also indicate how dangling pointer problem can be solved. (7 marks)
- (b) Describe the lazy and eager approaches for reclaiming garbage. (7 marks)

2018 OR

14.

- (a) What is meant by *side effect* and illustrate the advantages of referential transparency? (8 marks)
- (b) Explain the terms: compound assignment operator, coercion and short circuit evaluation. (6 marks)

15.

- (a) Explain different categories of iteration control statements. (8 marks)
- (b) Explain techniques used for identifying correct referencing environment for a subprogram that was sent as a parameter. (6 marks)

OR

16.

- (a) Describe the implementation models of Parameter passing. (10 Marks)
- (b) Differentiate coroutines from conventional subprograms. (4 marks)

17.

- (a) What is an exception handler? Explain how exceptions are handled in object oriented language? (7 Marks)
- (b) What are the design issues in object oriented languages? (7 Marks)

OR

18. Explain the following object oriented features:

- (i) Encapsulation
- (ii) Inheritance
- (iii) Constructors and Destructors
- (iv) Operator Overloading
- (v) Polymorphism

(14 Marks)

19.

- (a) Compare functional and imperative programming languages. (7 Marks)
- (b) Explain the role of monitors in concurrency. (7 Marks)

OR

20.

- (a) Explain the searching strategies used in Prolog. Why backward chaining is preferred over forward chaining in Prolog? (10 Marks)
- (b) How does a binary semaphore differ from an ordinary semaphore? (4 Marks)

Teaching Plan

Module 1 (Introduction)		9 Hours
1.1	Introduction : Reasons for studying Concepts of programming languages, Programming Domains	1 Hour
1.2	Language Evaluation Criteria (Lecture 1)	1 Hour
1.3	Language Evaluation Criteria (Lecture 2)	1 Hour
1.4	Influence on Language Design, Language Design Trade-offs	1 Hour
1.5	Implementation Methods	1 Hour
1.6	Names, Variables	1 Hour
1.7	Concept of Binding	1 Hour
1.8	Scope and Lifetime	1 Hour
1.9	Referencing Environments	1 Hour
Module 2 (Data Types, Expressions and Assignment Statements)		8 Hours
2.1	Primitive Data Types, Character String Types	1 Hour
2.2	User-Defined Ordinal Types, Array Types	1 Hour
2.3	Record Types, List Types, Pointer and Reference Types	1 Hour
2.4	Implementation of pointer and reference types, Type Checking, Strong Typing, Type Equivalence	1 Hour
2.5	Expressions and Assignment Statements, Arithmetic Expressions	1 Hour
2.6	Overloaded Operators, Type Conversions	1 Hour
2.7	Relational and Boolean Expressions, Short-Circuit Evaluation	1 Hour
2.8	Assignment Statements, Mixed-mode Assignment	1 Hour
Module 3 (Statement Level Control Structures, Subprograms)		8 Hours
3.1	Selection Statements, Iterative Statements	1 Hour
3.2	Unconditional Branching	1 Hour

3.3	Guarded Commands	1 Hour
3.4	Subprograms: Design Issues of Subprograms	1 Hour
3.5	Local Referencing Environments	1 Hour
3.6	Parameter Passing Methods	1 Hour
3.7	Subprograms as Parameters, Overloaded Subprograms	1 Hour
3.8	Closures, Co-routines	1 Hour
Module 4 (Support for Object Oriented Programming, Exception Handling, Event handling)		10 Hours
4.1	Inheritance	1 Hour
4.2	Dynamic Binding	1 Hour
4.3	Design Issues for Object Oriented Languages	1 Hour
4.4	Support for Object Oriented Programming in C++	1 Hour
4.5	Implementation of Object-Oriented Constructs (Lecture 1)	1 Hour
4.6	Implementation of Object-Oriented Constructs (Lecture 2)	1 Hour
4.7	Implementation of Object-Oriented Constructs (Lecture 3)	1 Hour
4.8	Basic Concepts	1 Hour
4.9	Exception Handling - Design Issues	1 Hour
4.10	Introduction to Event Handling	1 Hour
Module 5 (Concurrency, Functional Programming Languages, Logic Programming languages)		10 Hours
5.1	Subprogram Level Concurrency	1 Hour
5.2	Semaphores	1 Hour
5.3	Monitors	1 Hour
5.4	Message Passing	1 Hour
5.5	Introduction to LISP and Scheme (Lecture 1)	1 Hour
5.6	Introduction to LISP and Scheme (Lecture 2)	1 Hour
5.7	Comparison of Functional and Imperative Languages	1 Hour
5.8	Basic Elements of Prolog (Lecture 1)	1 Hour

5.9	Basic Elements of Prolog (Lecture 2)	1 Hour
5.10	Applications of Logic Programming	1 Hour

APJ ABDUL KALAM
TECHNOLOGICAL
UNIVERSITY



CODE	MATHEMATICS FOR MACHINE LEARNING	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	

Preamble: This is the foundational course for awarding B. Tech. Honours in Computer Science and Engineering with specialization in *Machine Learning*. The purpose of this course is to introduce mathematical foundations of basic Machine Learning concepts among learners, on which Machine Learning systems are built. This course covers Linear Algebra, Vector Calculus, Probability and Distributions, Optimization and Machine Learning problems. Concepts in this course help the learners to understand the mathematical principles in Machine Learning and aid in the creation of new Machine Learning solutions, understand & debug existing ones, and learn about the inherent assumptions & limitations of the current methodologies.

Prerequisite: A sound background in higher secondary school Mathematics.

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

CO 1	Make use of the concepts, rules and results about linear equations, matrix algebra, vector spaces, eigenvalues & eigenvectors and orthogonality & diagonalization to solve computational problems (Cognitive Knowledge Level: Apply)
CO 2	Perform calculus operations on functions of several variables and matrices, including partial derivatives and gradients (Cognitive Knowledge Level: Apply)
CO 3	Utilize the concepts, rules and results about probability, random variables, additive & multiplicative rules, conditional probability, probability distributions and Bayes' theorem to find solutions of computational problems (Cognitive Knowledge Level: Apply)
CO 4	Train Machine Learning Models using unconstrained and constrained optimization methods (Cognitive Knowledge Level: Apply)

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	√	√	√	√								√
CO 2	√	√	√									√
CO 3	√	√	√	√								√
CO 4	√	√	√	√		√						√

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	20%	20%	20%
Understand	40%	40%	40%
Apply	40%	40%	40%
Analyse			
Evaluate			
Create			

Mark Distribution

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

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
 Continuous Assessment Tests : 25 marks
 Continuous Assessment Assignment : 15 marks

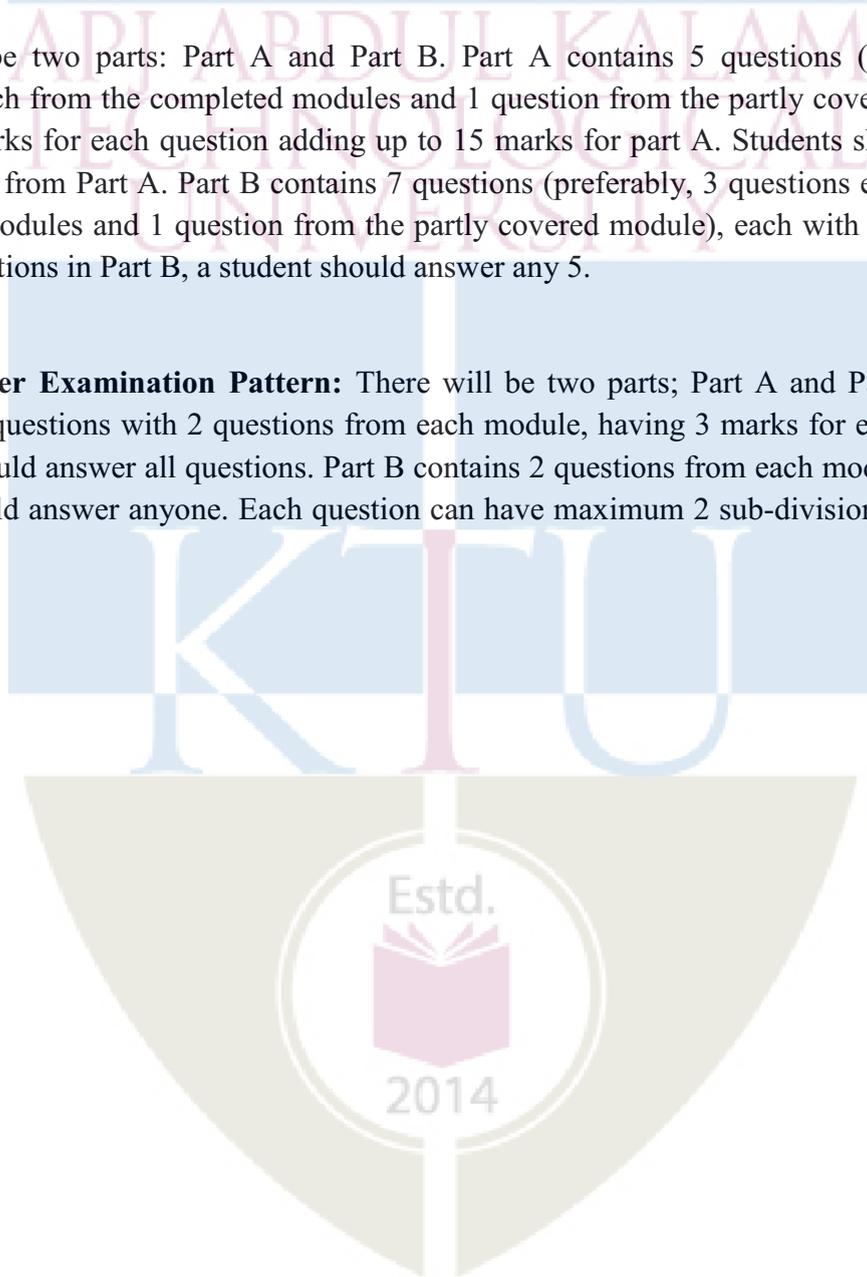
Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks

First Internal Examination shall be preferably conducted after completing the first half of the syllabus and the Second Internal Examination shall be preferably conducted after completing remaining part of the syllabus.

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

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



Syllabus**Module 1**

LINEAR ALGEBRA: Systems of Linear Equations – Matrices, Solving Systems of Linear Equations. Vector Spaces – Vector Spaces, Linear Independence, Basis and Rank. Linear Mappings – Matrix Representation of Linear Mappings, Basis Change, Image and Kernel.

Module 2

ANALYTIC GEOMETRY, MATRIX DECOMPOSITIONS: Norms, Inner Products, Lengths and Distances, Angles and Orthogonality, Orthonormal Basis, Orthogonal Complement, Orthogonal Projections – Projection into One Dimensional Subspaces, Projection onto General Subspaces, Gram-Schmidt Orthogonalization.

Determinant and Trace, Eigenvalues and Eigenvectors, Cholesky Decomposition, Eigen decomposition and Diagonalization, Singular Value Decomposition, Matrix Approximation.

Module 3

VECTOR CALCULUS : Differentiation of Univariate Functions - Partial Differentiation and Gradients, Gradients of Vector Valued Functions, Gradients of Matrices, Useful Identities for Computing Gradients. Back propagation and Automatic Differentiation – Gradients in Deep Network, Automatic Differentiation. Higher Order Derivatives- Linearization and Multivariate Taylor Series.

Module 4

PROBABILITY AND DISTRIBUTIONS : Construction of a Probability Space - Discrete and Continuous Probabilities, Sum Rule, Product Rule, and Bayes' Theorem. Summary Statistics and Independence – Gaussian Distribution - Conjugacy and the Exponential Family - Change of Variables/Inverse Transform.

Module 5

OPTIMIZATION : Optimization Using Gradient Descent - Gradient Descent With Momentum, Stochastic Gradient Descent. Constrained Optimization and Lagrange Multipliers - Convex Optimization - Linear Programming - Quadratic Programming.

Text book:

1. Mathematics for Machine Learning by Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong published by Cambridge University Press (freely available at <https://mml-book.github.io>)

Reference books:

1. Linear Algebra and Its Applications, 4th Edition by Gilbert Strang
2. Linear Algebra Done Right by Axler, Sheldon, 2015 published by Springer
3. Introduction to Applied Linear Algebra by Stephen Boyd and Lieven Vandenberghe, 2018 published by Cambridge University Press
4. Convex Optimization by Stephen Boyd and Lieven Vandenberghe, 2004 published by Cambridge University Press
5. Pattern Recognition and Machine Learning by Christopher M Bishop, 2006, published by Springer
6. Learning with Kernels – Support Vector Machines, Regularization, Optimization, and Beyond by Bernhard Scholkopf and Smola, Alexander J Smola, 2002, published by MIT Press
7. Information Theory, Inference, and Learning Algorithms by David J. C MacKay, 2003 published by Cambridge University Press
8. Machine Learning: A Probabilistic Perspective by Kevin P Murphy, 2012 published by MIT Press.
9. The Nature of Statistical Learning Theory by Vladimir N Vapnik, 2000, published by Springer



Sample Course Level Assessment Questions. APJ ABDUL KALAM TECHNICAL UNIVERSITY

Course Outcome 1 (CO1):

1. Find the set S of all solution $\sin x$ of the following in homogeneous linear systems $Ax = b$, where A and b are defined as follows:

$$A = \begin{bmatrix} 1 & -1 & 0 & 0 & 1 \\ 1 & 1 & 0 & -3 & 0 \\ 2 & -1 & 0 & 1 & -1 \\ -1 & 2 & 0 & -2 & -1 \end{bmatrix}, \quad b = \begin{bmatrix} 3 \\ 6 \\ 5 \\ -1 \end{bmatrix}$$

2. Determine the inverses of the following matrix if possible

$$A = \begin{bmatrix} 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 \\ 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 \end{bmatrix}$$

3. Find the characteristic equation, eigenvalues, and eigenspaces corresponding to each eigenvalue of the following matrix

$$\begin{bmatrix} 2 & 0 & 4 \\ 0 & 3 & 0 \\ 0 & 1 & 2 \end{bmatrix}$$

4. Diagonalize the following matrix, if possible

$$\begin{bmatrix} 3 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 1 & 0 & 0 & 3 \end{bmatrix}$$

5. Find the singular value decomposition (SVD) of the following matrix

$$\begin{bmatrix} 0 & 1 & 1 \\ \sqrt{2} & 2 & 0 \\ 0 & 1 & 1 \end{bmatrix}$$

Course Outcome 2 (CO2):

1. For a scalar function $f(x, y, z) = x^2 + 3y^2 + 2z^2$, find the gradient and its magnitude at the point $(1, 2, -1)$.
2. Find the maximum and minimum values of the function $f(x,y)=4x+4y-x^2-y^2$ subject to the condition $x^2 + y^2 \leq 2$.
3. Suppose you were trying to minimize $f(x, y) = x^2 + 2y + 2y^2$. Along what vector should you travel from $(5, 12)$?
4. Find the second order Taylor series expansion for $f(x, y) = (x + y)^2$ about $(0, 0)$.
5. Find the critical points of $f(x, y) = x^2 - 3xy + 5x - 2y + 6y^2 + 8$.
6. Compute the gradient of the Rectified Linear Unit (ReLU) function $ReLU(z) = \max(0, z)$.
7. Let $L = \|Ax - b\|^2$, where A is a matrix and x and b are vectors. Derive dL in terms of dx .

Course Outcome 3 (CO3):

1. Let J and T be independent events, where $P(J)=0.4$ and $P(T)=0.7$.
 - i. Find $P(J \cap T)$
 - ii. Find $P(J \cap T')$
 - iii. Find $P(J \cap T')$
2. Let A and B be events such that $P(A)=0.45$, $P(B)=0.35$ and $P(A \cup B)=0.5$. Find $P(A|B)$.
3. A random variable R has the probability distribution as shown in the following table:

r	1	2	3	4	5
$P(R=r)$	0.2	a	b	0.25	0.15

- i. Given that $E(R)=2.85$, find a and b .
 - ii. Find $P(R > 2)$.
4. A biased coin (with probability of obtaining a head equal to $p > 0$) is tossed repeatedly and independently until the first head is observed. Compute the probability that the first head appears at an even numbered toss.
 5. Two players A and B are competing at a trivia quiz game involving a series of questions. On any individual question, the probabilities that A and B give the correct answer are p and q respectively, for all questions, with outcomes for different

questions being independent. The game finishes when a player wins by answering a question correctly. Compute the probability that A wins if

- i. A answers the first question,
 - ii. B answers the first question.
6. A coin for which $P(\text{heads}) = p$ is tossed until two successive tails are obtained. Find the probability that the experiment is completed on the n^{th} toss.

Course Outcome 4(CO4):

1. Find the extrema of $f(x, y) = x$ subject to $g(x, y) = x^2 + 2y^2 = 3$.
2. Maximize the function $f(x, y, z) = xy + yz + xz$ on the unit sphere $g(x, y, z) = x^2 + y^2 + z^2 = 1$.
3. Provide necessary and sufficient conditions under which a quadratic optimization problem be written as a linear least squares problem.
4. Consider the univariate function $f(x) = x^3 + 6x^2 - 3x - 5$. Find its stationary points and indicate whether they are maximum, minimum, or saddle points.
5. Consider the update equation for stochastic gradient descent. Write down the update when we use a mini-batch size of one.
6. Consider the function

$$f(x) = (x_1 - x_2)^2 + \frac{1}{1 + x_1^2 + x_2^2}.$$

- i. Is $f(x)$ a convex function? Justify your answer.
 - ii. Is $(1, -1)$ a local/global minimum? Justify your answer.
7. Is the function $f(x, y) = 2x^2 + y^2 + 6xy - x + 3y - 7$ convex, concave, or neither? Justify your answer.
 8. Consider the following convex optimization problem

$$\text{minimize } \frac{x^2}{2} + x + 4y^2 - 2y$$

Subject to the constraint $x + y \geq 4, x, y \geq 1$.

Derive an explicit form of the Lagrangian dual problem.

9. Solve the following LP problem with the simplex method.

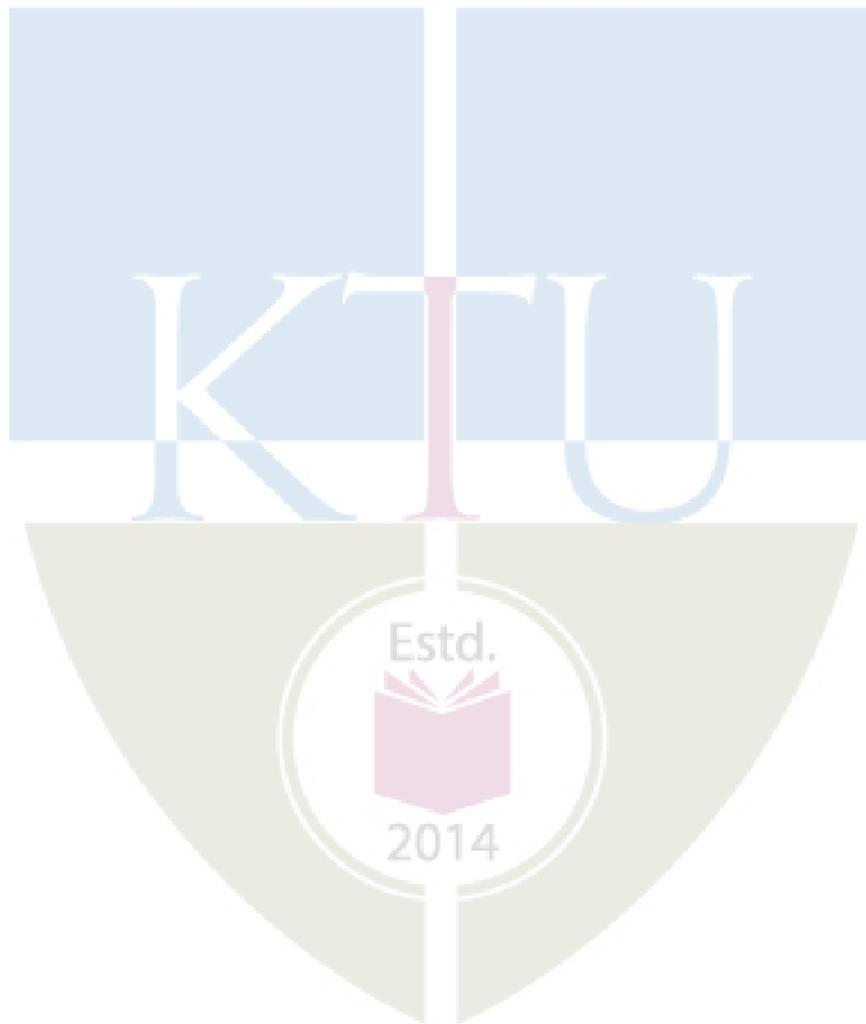
$$\max 5x_1 + 6x_2 + 9x_3 + 8x_4$$

subject to the constraints

$$x_1 + 2x_2 + 3x_3 + x_4 \leq 5$$

$$x_1 + x_2 + 2x_3 + 3x_4 \leq 3$$

$$x_1, x_2, x_3, x_4 \geq 0$$



QP Code :		Total Pages : 5	
Reg No.:		Name:	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY IV SEMESTER B.TECH (HONOURS) DEGREE EXAMINATION, MONTH and YEAR			
Course Code: CST 284			
Course Name: MATHEMATICS FOR FOR MACHINE LEARNING			
Max. Marks: 100		Duration: 3 Hours	
PART A			
<i>Answer all questions, each carries 3 marks.</i>			Marks
1		Show that with the usual operation of scalar multiplication but with addition on reals given by $x \# y = 2(x + y)$ is not a vector space.	
2		Are the following sets of vectors linearly independent? Explain your answer. $x_1 = \begin{bmatrix} 2 \\ -1 \\ 3 \end{bmatrix}, \quad x_2 = \begin{bmatrix} 1 \\ 1 \\ -2 \end{bmatrix}, \quad x_3 = \begin{bmatrix} 3 \\ -3 \\ 8 \end{bmatrix}$	
3		Find the angle between the vectors $x = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ and $y = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$.	
4		Find the eigen values of the following matrix in terms of k. Can you find an eigen vector corresponding to each of the eigen values? $\begin{bmatrix} 1 & k \\ 2 & 1 \end{bmatrix}$	
5		Let $f(x, y, z) = xye^r$, where $r = x^2 + z^2 - 5$. Calculate the gradient of f at the point $(1, 3, -2)$.	
6		Compute the Taylor polynomials $T_n, n = 0, \dots, 5$ of $f(x) = \sin(x) + \cos(x)$ at $x_0 = 0$.	
7		Let X be a continuous random variable with probability density function on $0 \leq x \leq 1$ defined by $f(x) = 3x^2$. Find the pdf of $Y = X^2$.	
8		Show that if two events A and B are independent, then A and B' are independent.	
9		Explain the principle of the gradient descent algorithm.	
10		Briefly explain the difference between (batch) gradient descent and stochastic gradient descent. Give an example of when you might prefer one over the other.	
PART B			
<i>Answer any one Question from each module. Each question carries 14 Marks</i>			
11	a)	i. Find all solutions to the system of linear equations $-4x + 5z = -2$ $-3x - 3y + 5z = 3$ $-x + 2y + 2z = -1$	(4)

		ii. Prove that all vectors orthogonal to $[2, -3, 1]^T$ forms a subspace W of R^3 . What is $\dim(W)$ and why?	(4)
	b)	A set of n linearly independent vectors in R^n forms a basis. Does the set of vectors $(2, 4, -3), (0, 1, 1), (0, 1, -1)$ form a basis for R^3 ? Explain your reasons.	(6)
		OR	
12	a)	Find all solutions in $x = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} \in R^3$ of the equation system $Ax = 12x$, where $A = \begin{bmatrix} 6 & 4 & 3 \\ 6 & 0 & 9 \\ 0 & 8 & 0 \end{bmatrix}$ and $\sum_{i=1}^3 x_i = 1$.	(7)
	b)	Consider the transformation $T(x, y) = (x + y, x + 2y, 2x + 3y)$. Obtain $\ker T$ and use this to calculate the nullity. Also find the transformation matrix for T .	(7)
13	a)	Use the Gram-Schmidt process to find an orthogonal basis for the column space of the following matrix. $\begin{bmatrix} 2 & 1 & 0 \\ 1 & -1 & 1 \\ 0 & 3 & 1 \\ 1 & 1 & 1 \end{bmatrix}$	(7)
	b)	Find the SVD of the matrix. $\begin{bmatrix} 2 & 2 \\ -1 & -1 \end{bmatrix}$	(7)
		OR	
14	a)	i. Let L be the line through the origin in R^2 that is parallel to the vector $[3, 4]^T$. Find the standard matrix of the orthogonal projection onto L . Also find the point on L which is closest to the point $(7, 1)$ and find the point on L which is closest to the point $(-3, 5)$.	(6)
		ii. Find the rank-1 approximation of $\begin{bmatrix} 3 & 2 & 2 \\ 2 & 3 & -2 \end{bmatrix}$	
	b)	i. Find an orthonormal basis of R^3 consisting of eigenvectors for the following matrix. $\begin{bmatrix} 1 & 0 & -2 \\ 0 & 5 & 0 \\ -2 & 0 & 4 \end{bmatrix}$	(8)
		ii. Find a 3×3 orthogonal matrix S and a 3×3 diagonal matrix D such that $A = SDS^T$	

15	a)	<p>Askierisonamountainwithequation$z=100-0.4x^2-0.3y^2$,wherez denotes height.</p> <p>i. The skier is located at the point with xy-coordinates $(1, 1)$, and wants to ski downhill along the steepest possible path. In which direction (indicated by a vector (\mathbf{a}, \mathbf{b}) in the xy-plane) should the skier beginskiing.</p> <p>ii. The skier begins skiing in the direction given by the xy-vector (\mathbf{a}, \mathbf{b}) you found in part (i), so the skier heads in a direction in space given by the vector $(\mathbf{a}, \mathbf{b}, \mathbf{c})$. Find the value of \mathbf{c}.</p>	(8)
	b)	Find the linear approximation to the function $f(x,y) = 2 - \sin(-x - 3y)$ at the point $(0, \pi)$, and then use your answer to estimate $f(0.001, \pi)$.	(6)
		OR	
16	a)	<p>Let g be the function given by</p> $g(x, y) = \begin{cases} \frac{x^2 y}{x^2 + y^2} & \text{if } (x, y) \neq (0, 0); \\ 0 & \text{if } (x, y) = (0, 0). \end{cases}$ <p>i. Calculate the partial derivatives of g at $(0,0)$.</p> <p>ii. Show that g is not differentiable at $(0,0)$.</p>	(8)
	b)	Find the second order Taylor series expansion for $f(x,y) = e^{-(x^2+y^2)} \cos(xy)$ about $(0, 0)$.	(6)
17	a)	<p>There are two bags. The first bag contains four mangos and two apples; the second bag contains four mangos and four apples. We also have a biased coin, which shows “heads” with probability 0.6 and “tails” with probability 0.4. If the coin shows “heads”. we pick a fruit at random from bag 1; otherwise we pick a fruit at random from bag 2. Your friend flips the coin (you cannot see the result), picks a fruit at random from the corresponding bag, and presents you a mango.</p> <p>What is the probability that the mango was picked from bag 2?</p>	(6)
	b)	<p>Suppose that one has written a computer program that sometimes compiles and sometimes not (code does not change). You decide to model the apparent stochasticity (success vs. no success) x of the compiler using a Bernoulli distribution with parameter μ:</p> $p(x \mu) = \mu^x (1 - \mu)^{1-x}, \quad x \in \{0, 1\}$ <p>Choose a conjugate prior for the Bernoulli likelihood and compute the posterior distribution $p(\mu x_1, \dots, x_N)$.</p>	(8)
		OR	
18	a)	<p>Two dice are rolled.</p> <p>A = ‘sum of two dice equals 3’</p> <p>B = ‘sum of two dice equals 7’</p> <p>C = ‘at least one of the dice shows a 1’</p>	(6)

		<p>i. What is P(A C)?</p> <p>ii. What is P(B C)?</p> <p>iii. Are A and C independent? What about B and C?</p>																									
	b)	<p>Consider the following bivariate distribution p(x,y) of two discrete random variables X and Y .</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td style="padding: 5px;">y_1</td> <td style="padding: 5px;">0.01</td> <td style="padding: 5px;">0.02</td> <td style="padding: 5px;">0.03</td> <td style="padding: 5px;">0.1</td> <td style="padding: 5px;">0.1</td> </tr> <tr> <td style="padding: 5px;">y_2</td> <td style="padding: 5px;">0.05</td> <td style="padding: 5px;">0.1</td> <td style="padding: 5px;">0.05</td> <td style="padding: 5px;">0.07</td> <td style="padding: 5px;">0.2</td> </tr> <tr> <td style="padding: 5px;">y_3</td> <td style="padding: 5px;">0.1</td> <td style="padding: 5px;">0.05</td> <td style="padding: 5px;">0.03</td> <td style="padding: 5px;">0.05</td> <td style="padding: 5px;">0.04</td> </tr> <tr> <td style="padding: 5px;"></td> <td style="padding: 5px;">x_1</td> <td style="padding: 5px;">x_2</td> <td style="padding: 5px;">x_3</td> <td style="padding: 5px;">x_4</td> <td style="padding: 5px;">x_5</td> </tr> </table> <p style="text-align: center;">X</p> <p>Compute:</p> <p>i. The marginal distributions p(x) and p(y).</p> <p>ii. The conditional distributions p(x Y = y₁) and p(y X = x₃).</p>	y_1	0.01	0.02	0.03	0.1	0.1	y_2	0.05	0.1	0.05	0.07	0.2	y_3	0.1	0.05	0.03	0.05	0.04		x_1	x_2	x_3	x_4	x_5	(8)
y_1	0.01	0.02	0.03	0.1	0.1																						
y_2	0.05	0.1	0.05	0.07	0.2																						
y_3	0.1	0.05	0.03	0.05	0.04																						
	x_1	x_2	x_3	x_4	x_5																						
19	a)	<p>Find the extrema of $f(x,y,z) = x - y + z$ subject to $g(x,y,z) = x^2 + y^2 + z^2 = 2$.</p>	(8)																								
	b)	<p>Let</p> $P = \begin{bmatrix} 13 & 12 & -2 \\ 12 & 17 & 6 \\ -2 & 6 & 12 \end{bmatrix}, q = \begin{bmatrix} -22.0 \\ -14.5 \\ 13.0 \end{bmatrix}, \text{ and } r = 1.$ <p>Show that $x^* = (1, 1/2, -1)$ is optimal for the optimization problem</p> $\begin{aligned} \min & \quad \frac{1}{2}x^T P x + q^T x + r \\ \text{s.t.} & \quad -1 \leq x_i \leq 1, i = 1, 2, 3. \end{aligned}$	(6)																								
		OR																									
20	a)	<p>Derive the gradient descent training rule assuming that the target function is represented as $o_d = w_0 + w_1 x_1 + \dots + w_n x_n$. Define explicitly the cost/ error function E, assuming that a set of training examples D is provided, where each training example $d \in D$ is associated with the target output t_d.</p>	(8)																								
	b)	<p>Find the maximum value of $f(x,y,z) = xyz$ given that $g(x,y,z) = x + y + z = 3$ and $x,y,z \geq 0$.</p>	(6)																								

Teaching Plan COMPUTER SCIENCE AND DESIGN		
No	Topic	No. of Lectures (49)
Module-I (LINEAR ALGEBRA)		8
1.1	Matrices, Solving Systems of Linear Equations	1
1.2	Vector Spaces	1
1.3	Linear Independence	1
1.4	Basis and Rank (Lecture – 1)	1
1.5	Basis and Rank (Lecture – 2)	1
1.6	Linear Mappings	1
1.7	Matrix Representation of Linear Mappings	1
1.8	Images and Kernel	1
Module-II (ANALYTIC GEOMETRY, MATRIX DECOMPOSITIONS)		11
2.1	Norms, Inner Products	1
2.2	Lengths and Distances, Angles and Orthogonality	1
2.3	Orthonormal Basis, Orthogonal Complement	1
2.4	Orthogonal Projections – Projection into One Dimensional Subspaces	1
2.5	Projection onto General Subspaces.	1
2.6	Gram-Schmidt Orthogonalization	1
2.7	Determinant and Trace, Eigen values and Eigenvectors.	1
2.8	Cholesky Decomposition	1
2.9	Eigen decomposition and Diagonalization	1
2.10	Singular Value Decomposition	1
2.11	Matrix Approximation	1
Module-III (VECTOR CALCULUS)		9
3.1	Differentiation of Univariate Functions, Partial Differentiation and Gradients	1
3.2	Gradients of Vector Valued Functions (Lecture 1)	1
3.3	Gradients of Vector Valued Functions (Lecture 2)	1

3.4	Gradients of Matrices	B.TECH COMPUTER SCIENCE AND DESIGN	1
3.5	Useful Identities for Computing Gradients		1
3.6	Backpropagation and Automatic Differentiation – Gradients in deep Network		1
3.7	Automatic Differentiation		1
3.8	Higher Order Derivatives		1
3.9	Linearization and Multivariate Taylor Series		1
	Module-IV (PROBABILITY AND DISTRIBUTIONS)		10
4.1	Construction of a Probability Space		1
4.2	Discrete and Continuous Probabilities (Probability Density Function, Cumulative Distribution Function)		1
4.3	Sum Rule, Product Rule		1
4.4	Bayes' Theorem		1
4.5	Summary Statistics and Independence (Lecture 1)		1
4.6	Summary Statistics and Independence (Lecture 2)		1
4.7	Bernoulli, Binomial, Uniform (Discrete) Distributions		1
4.8	Uniform (Continuous), Poisson Distributions		1
4.9	Gaussian Distribution		1
4.10	Conjugacy and the Exponential Family (Beta – Bernoulli, Beta – Binomial Conjugacies)		1
	Module-V (OPTIMIZATION)		7
5.1	Optimization Using Gradient Descent.		1
5.2	Gradient Descent With Momentum, Stochastic Gradient Descent		1
5.3	Constrained Optimization and Lagrange Multipliers (Lecture 1)		1
5.4	Constrained Optimization and Lagrange Multipliers (Lecture 2)		1
5.5	Convex Optimization		1
5.6	Linear Programming		1
5.7	Quadratic Programming		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	PO10	Communication
PO5	Modern tool usage	PO11	Project Management and Finance
PO6	The Engineer and Society	PO12	Life long learning

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks (%)
	Test 1 (%)	Test 2 (%)	
Remember	30	30	30
Understand	30	30	30

Apply	40	40	40
Analyze			
Evaluate			
Create			

Mark Distribution

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

Continuous Internal Evaluation Pattern:

Attendance **10marks**

Continuous Assessment Tests (Average of Series Tests 1&2) **25marks**

Internal Examination Pattern:

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

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

Syllabus**Module 1(3D Display Methods, Visible Surface Detection Algorithms)**

3D Display Methods. Visible Surface Detection Algorithms - Classification of Visible Surface Detection Algorithms – Back Face Detection, Back Face Removal, Z-Buffer Algorithm, A-Buffer Algorithm, Depth-Sorting Method, ScanLine Algorithm, Area Sub Division Method.

Module 2(Illumination models, Surface rendering methods)

Basic illumination models-Ambient Light, Diffuse reflection, Specular reflection, Polygon rendering methods-Constant intensity shading, Gouraud shading, Phong shading, Fast Phong Shading.

Module 3(Color models, Fractals and Animation)

Properties of light, RGB color model, YIQ color model, CMY color model, HSV color model, HLS color model. Computer animation- Design of animation sequences, General computer animation functions, Raster animations, Key frame systems, morphing. Fractal Geometry Methods – Classification of Fractals – Self-Squaring Fractals, Ray Tracing and Ray Casting

Module 4(Introduction to Image processing)

Image as 2D data. Fundamental steps in digital image processing. Components of image processing system. Basic concepts in Sampling and quantization. Spatial and Gray Level Resolution. Basic relationship between pixels– neighborhood, adjacency, connectivity, Distance measures. Spatial correlation and convolution

Module–5(Image Enhancement)

Basic intensity transformation functions - Log transformations, Power-Law transformations, Contrast stretching. Histogram equalization. Basics of spatial filtering - Smoothing spatial filter- Linear and nonlinear filters, and Sharpening spatial filters-Gradient and Laplacian. Edge Detection - Edge Operators- Sobel and Prewitt

Text Book

1. Donald Hearn and M. Pauline Baker, Computer Graphics, PHI, 2e,1996
2. Rafael C. Gonzalez and Richard E. Woods, Digital Image Processing. Pearson, 4e,2017

References

- 1) William M. Newman and Robert F. Sproull, Principles of Interactive Computer Graphics. McGraw Hill,2001
- 2) David F. Rogers , Procedural Elements for Computer Graphics, Tata McGrawHill,2001.
- 3) M. Sonka, V. Hlavac, and R. Boyle, Image Processing, Analysis, and Machine Vision, Thomson India Edition, 4e, 2017.

Course-Level Assessment Questions**Course Outcome 1(CO1):**

1. Explain scan line algorithm with suitable example.
- 2 Explain z-buffer method and A-buffer method for determining the visible surfaces.

Course Outcome 2 (CO2):

1. Explain basic illumination models.
2. Describe the constant intensity shading method.

Course Outcome 3 (CO3):

1. Explain the various classifications of fractals
2. Explain the animation sequences.

Course Outcome 4 (CO4):

1. Consider the image segment and compute the length of the shortest 4- , 8- and m-path between p and q by considering two set of values for V: (i) $V=\{0,1,2\}$ (ii) $V=\{1,2\}$. If a particular path does not exist explain the reason for the above two cases of V .

4 11 20

11 0 32(q)

2 2 3 1 3

2. Give an image representation model and describe how the representation changes in grayscale, binary and colour images.

3. The spatial resolution of an image is given by 128 X 128. What are its storage requirements if it is represented by 64 gray levels?

Course Outcome 5 (CO5):

1. A 4x4, 4 bits/pixel original image is given by

10	12	8	9
10	12	12	14
12	13	10	9
14	12	10	12

- (a) Apply histogram equalization to the image by rounding the resulting image pixels to integers
- (b) Sketch the histogram of the original image and the histogram-equalized image.

2. A skilled medical technician is charged with the job of inspecting a certain class of monochrome images generated by electronic microscope. To facilitate the inspection, the technician uses image processing aids. However when he examines the images he finds the following problems.

- (a) Presence of bright isolated dots that are not of interest.
- (b) Lack of sharpness
- (c) Poor contrast

Identify the sequence of preprocessing steps that the technician may use to overcome the above mentioned problems and explain it.

3. You have Sobel operator and Laplacian operator for edge detection. Which operator will you select for edge detection in the case of noisy image? Explain. (Assignment

Model Question Paper

QP CODE:

RegNo: _____

Name: _____

PAGES :4

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FOURTH SEMESTER B.TECH DEGREE (MINOR) EXAMINATION, MONTH &
YEAR**

Course Code: CXT 286

Course Name: COMPUTER GRAPHICS AND IMAGE PROCESSING

Max. Marks:100

Duration: 3Hours

PART A

Answer All Questions. Each Question Carries 3 Marks

1. Differentiate between the object space and image space method for the hidden surface removal of an image.
2. Explain various 3D display methods.
3. Describe the constant intensity shading method
4. List and briefly explain the basic illumination models.
5. Give any three applications of digital imageprocessing
6. Explain the basic principle of animation.
7. Define Sampling and Quantization of animage.
8. Explain the terms adjacency and connectivity in the context of digital images .
9. A captured image appears very dark because of wrong lens aperture setting. Describe an enhancement technique which is appropriate to enhance such an image.

10. Define the following terms related to pixel of an image:

i) pixel neighborhood ii) Digital path

(10x3=30)

Part B

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

11 (a) Describe about the depth-sorting method to display the visible surfaces of any given object with plane faces. Also explain the tests to identify overlapping surfaces. (8)

(b) List out the differences between z-buffer method and A-buffer method for determining the visible surfaces. (6)

OR (8)

12 (a).Describe in detail the depth buffer visible surface detection technique. Derive the equation to find the depth values for a surface position (x, y).

(b).Explain scan line algorithm with suitable example . (6)

13. (a)Explain the interpolative shading methods. (14)

OR

14. (a) Describe in detail about basic illumination models. (14)

15. (a) What is morphing? (3)

(b)Write in detail about i)raster animation ii)Self squaring fractals (11)

OR

16. (a) Describe in detail about the classification of fractals. (5)
(b)Explain the color models in details. (9)

17 . (a) Explain the components of an image processing system with suitable diagram . (9)

- (b) Define Resolution of an image. Explain the spatial and -gray level resolution of an image with an example. (5)

OR

18. (a) Explain the fundamental steps in Digital Image Processing with a neat diagram? (7)

(b) Define 4-adjacency, 8 adjacency and m-adjacency. Consider the image segments shown.

3 24 2 (q)
 0 3 13
 2 4 22
 (p) 2 1 24

Let $V=\{1,2\}$ and compute the length of the shortest 4-, 8- and m-path between p and q. If a particular path does not exist between these two points explain the reason. (7)

19. (a) Explain the Robert's, Prewitt's and Sobel's edge detectors (6)

(b) A 4x4, 4 bits/pixel original image is given by

$$\begin{pmatrix} 12 & 14 & 9 & 8 \\ 10 & 12 & 14 & 12 \\ 12 & 13 & 10 & 9 \\ 14 & 12 & 10 & 12 \end{pmatrix}$$

- (a) Apply histogram equalization to the image by rounding the resulting image pixels to integers
 (b) Sketch the histogram of the original image and the

OR

20. Explain the basic intensity transformation functions in images with examples (14)

Teaching Plan

No	Contents	No of Lecture Hrs (43 hrs)
Module – 1 (3D Display Methods, Visible Surface Detection Algorithms) (9hrs)		
1.1	3D Display Methods. Visible Surface Detection Algorithms	1
1.2	Classification of Visible Surface Detection Algorithms	1
1.3	Back Face Detection	1
1.4	Back Face Removal, Z-Buffer Algorithm	1
1.5	A-Buffer Algorithm, Depth-Sorting Method	1
1.6	Scan Line Algorithm,	1
1.7	Scan Line Algorithm,	1
1.8	Area Sub Division Method	1
1.9	Area Sub Division Method	1
Module - 2 (Illumination models, Surface rendering methods) (7hrs)		
2.1	Basic illumination models	1
2.2	Diffuse reflection	1
2.3	Specular reflection	1
2.4	Polygon rendering methods-Constant intensity shading	1
2.5	Gouraud shading	1
2.6	Phong shading	1
2.7	Fast Phong shading	1
Module - 3 (Color models, Fractals and Animation) (10hrs)		

3.1	Color models: Properties of light	1
3.2	RGB color model, YIQ color model	1
3.3	CMY color model, HSV color model	1
3.4	HLS color model	1
3.5	Computer animation- Design of animation sequences	1
3.6	General computer animation functions	1
3.7	Raster animations, Keyframe systems, morphing	1
3.8	Fractal Geometry Methods – Classification of Fractals	1
3.9	Self-Squaring Fractals	1
3.10	Ray Tracing and Ray Casting	1
Module - 4 (Introduction to Image processing) (8 hrs)		
4.1	Introduction to Image processing. Image as 2D data.	1
4.2	Fundamental steps in image processing	1
4.3	Components of image processing system	1
4.4	Basic concepts in Sampling and quantization. Spatial and Gray Level Resolution	1
4.5	Basic relationship between pixels – neighborhood, adjacency, connectivity	1
4.6	Illustration of basic relationship between pixels– neighborhood, adjacency, connectivity	1
4.7	Distance measures	1
4.8	Spatial correlation and convolution	1
Module - 5 (Image Enhancement) (9 hrs)		
5.1	Basic intensity transformation functions- Log transformations.	1
5.2	Power-Law transformations, Contrast stretching	1

5.3	Histogram equalization	1
5.4	Illustration of Histogram equalization	1
5.5	Basics of spatial filtering, Smoothing spatial filter- Linear and nonlinear filters	1
5.6	Sharpening spatial filtering-Gradient filter mask	1
5.7	Sharpening spatial filtering-Laplacian filter mask	1
5.8	Basics of Edge Detection	1
5.9	Sobel and Prewitt edge detection masks	1



APJ ABDUL KALAM
TECHNOLOGICAL
UNIVERSITY

SEMESTER -4
HONOURS



CODE	COURSE NAME	CATEGORY	L	T	P	CREDIT	Year of Introduction
CST292	NUMBER THEORY	VAC	4	0	0	4	2019

Preamble: This is the foundational course for awarding B. Tech. Honours in Computer Science and Engineering with specialization in *Security in Computing*. The purpose of this course is to create awareness among learners about the important areas of number theory used in computer science. This course covers Divisibility & Modular Arithmetic, Primes & Congruences, Euler's Function, Quadratic Residues and Arithmetic Functions, Sum of Squares and Continued fractions. Concepts in Number Theory help the learner to apply them eventually in practical applications in Computer organization & Security, Coding & Cryptography, Random number generation, Hash functions and Graphics.

Prerequisite: A sound background in Higher Secondary School Mathematics

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

CO1	Illustrate modular arithmetic operations, methods and techniques (Cognitive Knowledge Level: Understand)
CO2	Use the methods - Induction, Contraposition or Contradiction to verify the correctness of mathematical assertions (Cognitive Knowledge Level: Apply)
CO3	Utilize theorems and results about prime numbers, congruences, quadratic residues and integer factorization for ensuring security in computing systems (Cognitive Knowledge Level: Analyse)
CO4	Illustrate uses of Chinese Remainder Theorem & Euclidean algorithm in Cryptography and Security (Cognitive Knowledge Level: Apply)
CO5	Explain applications of arithmetic functions in Computer Science (Cognitive Knowledge Level: Understand)
CO6	Implement Number Theoretic Algorithms using a programming language (Cognitive Knowledge Level: Apply)

Mapping of course outcomes with program outcomes

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

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks (Percentage)
	Test1 (Percentage)	Test2 (Percentage)	
Remember	30	30	30
Understand	30	30	30
Apply	40	40	40
Analyse			
Evaluate			
Create			

Mark Distribution

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

Continuous Internal Evaluation Pattern:

Attendance : 10 marks

Continuous Assessment Tests : 25 marks

Continuous Assessment Assignment : 15 marks

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks

First Internal Examination shall be preferably conducted after completing the first half of the syllabus and the Second Internal Examination shall be preferably conducted after completing remaining part of the syllabus.

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

End Semester Examination Pattern:

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

SYLLABUS

Module 1

Divisibility and Modular Arithmetic:

Finite Fields – Groups, Rings and Fields.

Divisibility - Divisibility and Division Algorithms, Well ordering Principle, Bezout's Identity.

Modular Arithmetic- Properties, Euclid's algorithm for the greatest common divisor, Extended Euclid's Algorithm, Least Common multiple, Solving Linear Diophantine Equations, Modular Division.

Module 2

Primes and Congruences:

Prime Numbers-Prime Numbers and prime-power factorization, Fermat and Mersenne primes., Primality testing and factorization.

Congruences-Linear congruences, Simultaneous linear congruences, Chinese Remainder Theorem, Fermat's little theorem, Wilson's theorem.

Module 3

Congruences with a Prime-Power Modulus&Euler's Function:

Congruences with a Prime-Power Modulus-Arithmetic modulo p , Pseudoprimes and Carmichael numbers, Solving congruences modulo prime powers.

Euler's Function-Euler's Totient function, Applications of Euler's Totient function, Traditional Cryptosystem, Limitations.

The Group of units- The group U_n , Primitive roots, Existence of primitive roots, Applications of primitive roots.

Module 4

Quadratic Residues & Arithmetic Functions :

Quadratic Residues- Quadratic Congruences, The group of Quadratic residues, Legendre symbol, Jacobi Symbol, Quadratic reciprocity.

Arithmetic Functions- Definition and examples, Perfect numbers, Mobius function and its properties, Mobius inversion formula, The Dirichlet Products.

Module 5

Sum of Squares and Continued Fractions:

Sum of Squares- Sum of two squares, The Gaussian Integers, Sum of three squares, Sum of four squares.

Continued Fractions -Finite continued fractions, Infinite continued fractions, Pell's Equation, Solution of Pell's equation by continued fractions.

Text Books

1. G.A. Jones & J.M. Jones, Elementary Number Theory, Springer UTM, 2007.
2. Joseph Silverman, A Friendly introduction to Number Theory, Pearson Ed. 2009.

Reference Books

1. William Stallings, Cryptography and Network Security Principles and Practice, Pearson Ed.
2. Tom M.Apostol, 'Introduction to Analytic Number Theory', Narosa Publishing House Pvt. Ltd, New Delhi, (1996).
3. Neal Koblitz, A course in Number Theory and Cryptography, 2nd Edition, Springer ,2004.

Sample Course Level Assessment Questions

Course Outcome 1 (CO1): Describe the properties of modular arithmetic and modulo operator.

Course Outcome 2 (CO2): Prove that the equation $y^2 = x^3 - 2$ has only the integer solution $(3, \pm 5)$.

Course Outcome 3 (CO3): State the law of reciprocity for Jacobi symbols and use it to determine whether 888 is a quadratic residue or non residue of the prime 1999.

Course Outcome 4 (CO4): Using Chinese remainder theorem, solve the system of congruence $x \equiv 2 \pmod{3}$, $x \equiv 3 \pmod{5}$, $x \equiv 2 \pmod{7}$

Course Outcome 5(CO5): State and prove Dirichlet product.

Course Outcome 6 (CO6): Use extended Euclid's algorithm to solve Diophantine equations efficiently. Given three numbers $a > 0$, $b > 0$, and c , the algorithm should return some x and y such that $ax + by = c$.



Model Question Paper

QP CODE:

PAGES: 03

RegNo :

Name :

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
FOURTH SEMESTER BTECH (HONOURS) DEGREE EXAMINATION, MONTH & YEAR**

Course Code:CST 292 Course

Name: Number Theory

Max.Marks:100

Duration: 3 Hours

PART A

Answer all Questions. Each question carries 3 Marks (10x3=30)

1. State and prove well ordering principle.
2. Find gcd d of $x=525$ and $y=231$ and express d as $ax + by$ where a and b are integers.
3. Solve the congruence equation $103x \equiv 57 \pmod{211}$.
4. Use Fermat's Little theorem to show that 91 is not a prime.
5. If m is relatively prime to n, show that $\Phi(mn) = \Phi(m) \Phi(n)$.
6. Explain how public key cryptography can be used for digital signatures.
7. Define Mobius function and prove Mobius function is a multiplicative.
8. State and prove Dirichlet product.
9. Show that every prime of the form $4k+1$ can be represented uniquely as the sum of two squares.
10. Find the continued fraction representation of the rational number $55/89$.

Part B

Answer any one Question from each module.

Each question carries 14 Marks

11. (a) State the Euclidean algorithm and its extension with an example. (7)
(b) Find all the solutions of $24x + 34y = 6$. (7)

OR

12. (a) Describe the properties of modular arithmetic and modulo operator. (7)
(b) Explain Extended Euclidean algorithm. Using the algorithm find the

multiplicative inverse of $135 \pmod{61}$ (7)

13. (a) State and prove Wilson's theorem (7)
 (b) Explain Fermat's factorization method and use it to factor 809009 (7)

OR

14. (a) Using Chinese remainder theorem, solve the system of congruences,
 $x \equiv 2 \pmod{3}$, $x \equiv 3 \pmod{5}$, $x \equiv 2 \pmod{7}$ (7)
 (b) Define Fermat primes. Show that any two distinct Fermat numbers are Relatively prime. (7)

15. (a) Distinguish between public key and private key encryption techniques. Also point out the merits and demerits of both. (7)
 (b) Define Carmichael number and show that a Carmichael number must be the product of at least three distinct primes. (7)

OR

16. (a) Define a pseudo prime to a base and find all non trivial bases for which 15 is a pseudo prime. (6)
 (b) Find an element of
 i) order 5 modulo 11 ii) order 4 modulo 13
 iii) order 8 modulo 17 iv) order 6 modulo 19 (8)

17. (a) Determine the quadratic residues and non residues modulo 17. Also determine whether 219 is a quadratic residue or non residue of the prime 383. (8)
 (b) State the law of quadratic reciprocity. Determine those odd primes p for which 3 is a quadratic residue and those for which it is a non residue. (6)

OR

18. (a) State and prove properties of Legendre's symbol. (7)
 (b) State the law of reciprocity for Jacobi symbols and using it determine whether 888 is a quadratic residue or non residue of the prime 1999. (7)

19. (a) Prove that the equation $y^2 = x^3 - 2$ has only the integer solution $(3, \pm 5)$. (7)

(b) Define a Gaussian integer. Factorize the Gaussian integer $440 - 55i$. (7)

OR

20. (a) If m , and n can be expressed as sum of four squares, then show that mn can also be expressed the sum of four squares. (7)

(b) Find all the solutions of the Diophantine equation $x^2 - 6y^2 = 1$. (7)

Teaching Plan

Module 1: Divisibility and Euclidean Algorithm		9 hours
1.1	Finite Fields – Groups and Rings.	1 hour
1.2	Finite Fields – Fields.	1 hour
1.3	Divisibility and Division Algorithms, Well ordering Principle.	1 hour
1.4	Decimal Expansion of a positive Integer, Greatest Common Divisor, Bezout’s Theorem.	1 hour
1.5	Modular Arithmetic- Properties of congruences, Modular Arithmetic Operations, Properties of Modular Arithmetic.	1 hour
1.6	Euclid's algorithm for the greatest common divisor, Extended Euclid’s Algorithm.	1 hour
1.7	Solving Linear Diophantine Equations.	1 hour
1.8	Least Common multiple and Modular Division.	1 hour
1.9	Implementation of Euclid’s algorithm, Extended Euclid’s Algorithm and solution of Linear Diophantine Equations.	1 hour
Module 2: Primes and Congruences		9 hours
2.1	Prime Numbers and prime-power Factorization.	1 hour
2.2	Fermat and Mersenne primes.	1 hour
2.3	Primality testing and factorization, Miller -Rabin Test for Primality.	1 hour
2.4	Pollard's Rho Method for Factorization, Fermat’s Factorization.	1 hour

2.5	Linear congruences, Simultaneous linear congruences.	1 hour
2.6	Chinese Remainder Theorem.	1 hour
2.7	Implementation of Chinese Remainder Theorem.	1 hour
2.8	Fermat's little theorem.	1 hour
2.9	Wilson's theorem.	1 hour
Module 3: Congruences with a Prime-Power Modulus & Euler's Function		9 hours
3.1	Congruences with a Prime-Power Modulus, Arithmetic modulo p .	1 hour
3.2	Pseudo-primes and Carmichael numbers.	1 hour
3.3	Solving congruences modulo prime powers.	1 hour
3.4	Definition of Euler Totient function, Examples and properties.	1 hour
3.5	Multiplicativity of Euler's Totient function.	1 hour
3.6	Applications of Euler's function, Euler's Theorem.	1 hour
3.7	Traditional Cryptosystem, Limitations, Public Key Cryptography.	1 hour
3.8	The Group of Units, Primitive Roots.	1 hour
3.9	Existence of primitive roots for Primes, Applications of primitive roots.	1 hour
Module 4: Quadratic Residues and Arithmetic Functions		9 hours
4.1	Quadratic congruences, The group of Quadratic Residues.	1 hour
4.2	Legendre symbol, Jacobi Symbol.	1 hour
4.3	Quadratic reciprocity.	1 hour
4.4	Quadratic residues for prime-power moduli.	1 hour
4.5	Arithmetic Functions: Definition and examples.	1 hour

4.6	Perfect numbers, Definition and proposition.	1 hour
4.7	Mobius inversion formula., application of the Mobius inversion formula.	1 hour
4.8	Mobius function and its properties.	1 hour
4.9	The Dirichlet Product, Definition and proof.	1 hour
Module 5: Sum of Squares and Continued Fractions		9 hours
5.1	Sum of Squares, Sum of two squares.	1 hour
5.2	The Gaussian Integers.	1 hour
5.3	Sum of three squares.	1 hour
5.4	Sum of four squares.	1 hour
5.5	Continued Fractions, Finite continued fractions.	1 hour
5.6	Continued Fractions, Finite continued fractions.	1 hour
5.7	Infinite continued fractions.	1 hour
5.8	Pell's Equation, Definition.	1 hour
5.9	Solution of Pell's equation by continued fractions.	1 hour

CODE CST294	COMPUTATIONAL FUNDAMENTALS FOR MACHINE LEARNING	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This is the foundational course for awarding B. Tech. Honours in Computer Science and Engineering with specialization in *Machine Learning*. The purpose of this course is to introduce mathematical foundations of basic Machine Learning concepts among learners, on which Machine Learning systems are built. This course covers Linear Algebra, Vector Calculus, Probability and Distributions, Optimization and Machine Learning problems. Concepts in this course help the learners to understand the mathematical principles in Machine Learning and aid in the creation of new Machine Learning solutions, understand & debug existing ones, and learn about the inherent assumptions & limitations of the current methodologies.

Prerequisite: A sound background in higher secondary school Mathematics.

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

CO 1	Make use of the concepts, rules and results about linear equations, matrix algebra, vector spaces, eigenvalues & eigenvectors and orthogonality & diagonalization to solve computational problems (Cognitive Knowledge Level: Apply)
CO 2	Perform calculus operations on functions of several variables and matrices, including partial derivatives and gradients (Cognitive Knowledge Level: Apply)
CO 3	Utilize the concepts, rules and results about probability, random variables, additive & multiplicative rules, conditional probability, probability distributions and Bayes' theorem to find solutions of computational problems (Cognitive Knowledge Level: Apply)
CO 4	Train Machine Learning Models using unconstrained and constrained optimization methods (Cognitive Knowledge Level: Apply)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	√	√	√	√								√
CO 2	√	√	√									√
CO 3	√	√	√	√								√
CO 4	√	√	√	√		√						√

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination
	1	2	
Remember	20%	20%	20%
Understand	40%	40%	40%
Apply	40%	40%	40%
Analyse			
Evaluate			
Create			

Mark Distribution

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

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
 Continuous Assessment Tests : 25 marks
 Continuous Assessment Assignment : 15 marks

Internal Examination Pattern:

Each of the two internal examinations has to be conducted out of 50 marks

First Internal Examination shall be preferably conducted after completing the first half of the syllabus and the Second Internal Examination shall be preferably conducted after completing remaining part of the syllabus.

There will be two parts: Part A and Part B. Part A contains 5 questions (preferably, 2 questions each from the completed modules and 1 question from the partly covered module), having 3 marks for each question adding up to 15 marks for part A. Students should answer all questions from Part A. Part B contains 7 questions (preferably, 3 questions each from the completed modules and 1 question from the partly covered module), each with 7 marks. Out of the 7 questions in Part B, a student should answer any 5.

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



Syllabus**Module 1**

LINEAR ALGEBRA: Systems of Linear Equations – Matrices, Solving Systems of Linear Equations. Vector Spaces – Vector Spaces, Linear Independence, Basis and Rank. Linear Mappings – Matrix Representation of Linear Mappings, Basis Change, Image and Kernel.

Module 2

ANALYTIC GEOMETRY, MATRIX DECOMPOSITIONS: Norms, Inner Products, Lengths and Distances, Angles and Orthogonality, Orthonormal Basis, Orthogonal Complement, Orthogonal Projections – Projection into One Dimensional Subspaces, Projection onto General Subspaces, Gram-Schmidt Orthogonalization.

Determinant and Trace, Eigenvalues and Eigenvectors, Cholesky Decomposition, Eigen decomposition and Diagonalization, Singular Value Decomposition, Matrix Approximation.

Module 3

VECTOR CALCULUS : Differentiation of Univariate Functions - Partial Differentiation and Gradients, Gradients of Vector Valued Functions, Gradients of Matrices, Useful Identities for Computing Gradients. Back propagation and Automatic Differentiation – Gradients in Deep Network, Automatic Differentiation. Higher Order Derivatives- Linearization and Multivariate Taylor Series.

Module 4

Probability and Distributions : Construction of a Probability Space - Discrete and Continuous Probabilities, Sum Rule, Product Rule, and Bayes' Theorem. Summary Statistics and Independence – Gaussian Distribution - Conjugacy and the Exponential Family - Change of Variables/Inverse Transform.

Module 5

Optimization : Optimization Using Gradient Descent - Gradient Descent With Momentum, Stochastic Gradient Descent. Constrained Optimization and Lagrange Multipliers - Convex Optimization - Linear Programming - Quadratic Programming.

Text book:

1. Mathematics for Machine Learning by Marc Peter Deisenroth, A. Aldo Faisal, and Cheng Soon Ong published by Cambridge University Press (freely available at <https://mml-book.github.io>)

Reference books:

1. Linear Algebra and Its Applications, 4th Edition by Gilbert Strang
2. Linear Algebra Done Right by Axler, Sheldon, 2015 published by Springer
3. Introduction to Applied Linear Algebra by Stephen Boyd and Lieven Vandenberghe, 2018 published by Cambridge University Press
4. Convex Optimization by Stephen Boyd and Lieven Vandenberghe, 2004 published by Cambridge University Press
5. Pattern Recognition and Machine Learning by Christopher M Bishop, 2006, published by Springer
6. Learning with Kernels – Support Vector Machines, Regularization, Optimization, and Beyond by Bernhard Scholkopf and Smola, Alexander J Smola, 2002, published by MIT Press
7. Information Theory, Inference, and Learning Algorithms by David J. C MacKay, 2003 published by Cambridge University Press
8. Machine Learning: A Probabilistic Perspective by Kevin P Murphy, 2012 published by MIT Press.
9. The Nature of Statistical Learning Theory by Vladimir N Vapnik, 2000, published by Springer



Sample Course Level Assessment Questions.**Course Outcome 1 (CO1):**

1. Find the set S of all solutions in x of the following inhomogeneous linear systems $Ax = b$, where A and b are defined as follows:

$$A = \begin{bmatrix} 1 & -1 & 0 & 0 & 1 \\ 1 & 1 & 0 & -3 & 0 \\ 2 & -1 & 0 & 1 & -1 \\ -1 & 2 & 0 & -2 & -1 \end{bmatrix}, \quad b = \begin{bmatrix} 3 \\ 6 \\ 5 \\ -1 \end{bmatrix}$$

2. Determine the inverses of the following matrix if possible

$$A = \begin{bmatrix} 1 & 0 & 1 & 0 \\ 0 & 1 & 1 & 0 \\ 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 0 \end{bmatrix}$$

3. Find the characteristic equation, eigenvalues, and eigenspaces corresponding to each eigenvalue of the following matrix

$$\begin{bmatrix} 2 & 0 & 4 \\ 0 & 3 & 0 \\ 0 & 1 & 2 \end{bmatrix}$$

4. Diagonalize the following matrix, if possible

$$\begin{bmatrix} 3 & 0 & 0 & 0 \\ 0 & 2 & 0 & 0 \\ 0 & 0 & 2 & 0 \\ 1 & 0 & 0 & 3 \end{bmatrix}$$

5. Find the singular value decomposition (SVD) of the following matrix

$$\begin{bmatrix} 0 & 1 & 1 \\ \sqrt{2} & 2 & 0 \\ 0 & 1 & 1 \end{bmatrix}$$

Course Outcome 2 (CO2):

1. For a scalar function $f(x, y, z) = x^2 + 3y^2 + 2z^2$, find the gradient and its magnitude at the point $(1, 2, -1)$.
2. Find the maximum and minimum values of the function $f(x,y)=4x+4y-x^2-y^2$ subject to the condition $x^2 + y^2 \leq 2$.
3. Suppose you were trying to minimize $f(x, y) = x^2 + 2y + 2y^2$. Along what vector should you travel from $(5,12)$?
4. Find the second order Taylor series expansion for $f(x, y) = (x + y)^2$ about $(0, 0)$.
5. Find the critical points of $f(x, y) = x^2 - 3xy + 5x - 2y + 6y^2 + 8$.
6. Compute the gradient of the Rectified Linear Unit (ReLU) function $ReLU(z) = \max(0, z)$.
7. Let $L = \|Ax - b\|^2$, where A is a matrix and x and b are vectors. Derive dL in terms of dx .

Course Outcome 3 (CO3):

1. Let J and T be independent events, where $P(J)=0.4$ and $P(T)=0.7$.
 - i. Find $P(J \cap T)$
 - ii. Find $P(J \cap T')$
 - iii. Find $P(J \cap T')$
2. Let A and B be events such that $P(A)=0.45$, $P(B)=0.35$ and $P(A \cup B)=0.5$. Find $P(A|B)$.
3. A random variable R has the probability distribution as shown in the following table:

r	1	2	3	4	5
$P(R=r)$	0.2	a	b	0.25	0.15

- i. Given that $E(R)=2.85$, find a and b .

- ii. Find $P(R>2)$.
4. A biased coin (with probability of obtaining a head equal to $p > 0$) is tossed repeatedly and independently until the first head is observed. Compute the probability that the first head appears at an even numbered toss.
5. Two players A and B are competing at a trivia quiz game involving a series of questions. On any individual question, the probabilities that A and B give the correct answer are p and q respectively, for all questions, with outcomes for different questions being independent. The game finishes when a player wins by answering a question correctly. Compute the probability that A wins if
- A answers the first question,
 - B answers the first question.
6. A coin for which $P(\text{heads}) = p$ is tossed until two successive tails are obtained. Find the probability that the experiment is completed on the n^{th} toss.

Course Outcome 4(CO4):

- Find the extrema of $f(x, y) = x$ subject to $g(x, y) = x^2 + 2y^2 = 3$.
- Maximize the function $f(x, y, z) = xy + yz + xz$ on the unit sphere $g(x, y, z) = x^2 + y^2 + z^2 = 1$.
- Provide necessary and sufficient conditions under which a quadratic optimization problem be written as a linear least squares problem.
- Consider the univariate function $f(x) = x^3 + 6x^2 - 3x - 5$. Find its stationary points and indicate whether they are maximum, minimum, or saddle points.
- Consider the update equation for stochastic gradient descent. Write down the update when we use a mini-batch size of one.
- Consider the function

$$f(x) = (x_1 - x_2)^2 + \frac{1}{1 + x_1^2 + x_2^2}$$

- Is $f(x)$ a convex function? Justify your answer.
 - Is $(1, -1)$ a local/global minimum? Justify your answer.
- Is the function $f(x, y) = 2x^2 + y^2 + 6xy - x + 3y - 7$ convex, concave, or neither? Justify your answer.
 - Consider the following convex optimization problem

$$\text{minimize } \frac{x^2}{2} + x + 4y^2 - 2y$$

Subject to the constraint $x + y \geq 4, x, y \geq 1$.

Derive an explicit form of the Lagrangian dual problem.

9. Solve the following LP problem with the simplex method.

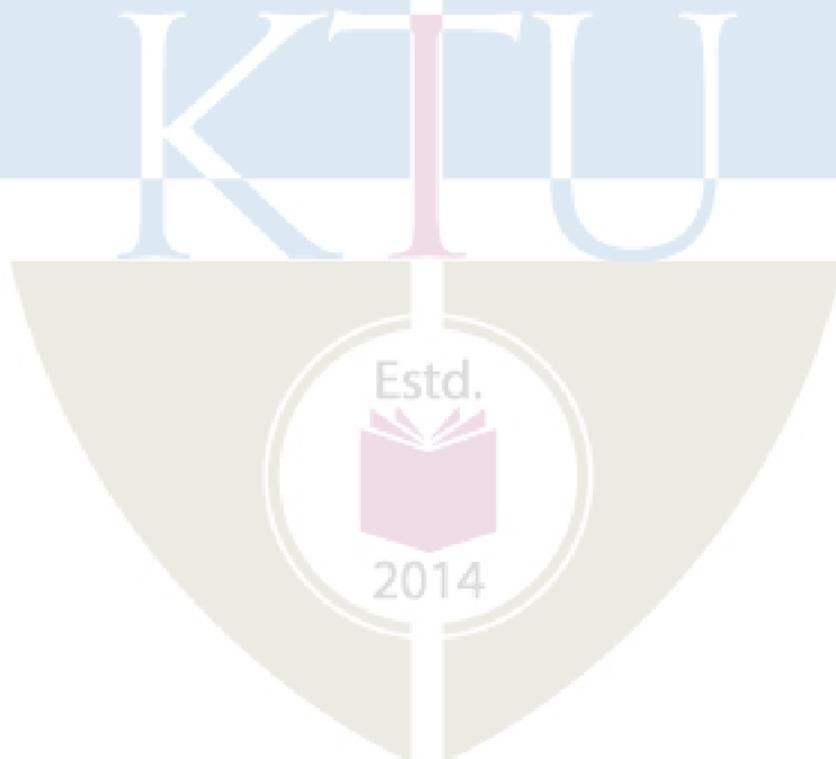
$$\text{max } 5x_1 + 6x_2 + 9x_3 + 8x_4$$

subject to the constraints

$$x_1 + 2x_2 + 3x_3 + x_4 \leq 5$$

$$x_1 + x_2 + 2x_3 + 3x_4 \leq 3$$

$$x_1, x_2, x_3, x_4 \geq 0$$



Model Question paper

QP Code :		Total Pages : 5	
Reg No.: _____		Name: _____	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY IV SEMESTER B.TECH (HONOURS) DEGREE EXAMINATION, MONTH and YEAR			
Course Code: CST 294			
Course Name: COMPUTATIONAL FUNDAMENTALS FOR MACHINE LEARNING			
Max. Marks: 100		Duration: 3 Hours	
PART A			
<i>Answer all questions, each carries 3 marks.</i>			Marks
1	Show that with the usual operation of scalar multiplication but with addition on reals given by $x \# y = 2(x + y)$ is not a vector space.		
2	Are the following sets of vectors linearly independent? Explain your answer. $x_1 = \begin{bmatrix} 2 \\ -1 \\ 3 \end{bmatrix}, x_2 = \begin{bmatrix} 1 \\ 1 \\ -2 \end{bmatrix}, x_3 = \begin{bmatrix} 3 \\ -3 \\ 8 \end{bmatrix}$		
3	Find the angle between the vectors $x = \begin{bmatrix} 1 \\ 1 \end{bmatrix}$ and $y = \begin{bmatrix} 1 \\ 2 \end{bmatrix}$.		
4	Find the eigen values of the following matrix in terms of k. Can you find an eigen vector corresponding to each of the eigen values? $\begin{bmatrix} 1 & k \\ 2 & 1 \end{bmatrix}$		
5	Let $f(x, y, z) = xye^r$, where $r = x^2 + z^2 - 5$. Calculate the gradient of f at the point $(1, 3, -2)$.		
6	Compute the Taylor polynomials $T_n, n = 0, \dots, 5$ of $f(x) = \sin(x) + \cos(x)$ at $x_0 = 0$.		
7	Let X be a continuous random variable with probability density function on $0 \leq x \leq 1$ defined by $f(x) = 3x^2$. Find the pdf of $Y = X^2$.		
8	Show that if two events A and B are independent, then A and B' are independent.		
9	Explain the principle of the gradient descent algorithm.		
10	Briefly explain the difference between (batch) gradient descent and stochastic gradient descent. Give an example of when you might prefer one		

		over the other.	
PART B			
<i>Answer any one Question from each module. Each question carries 14 Marks</i>			
11	a)	i. Find all solutions to the system of linear equations $\begin{aligned} -4x + 5z &= -2 \\ -3x - 3y + 5z &= 3 \\ -x + 2y + 2z &= -1 \end{aligned}$	(4)
		ii. Prove that all vectors orthogonal to $[2, -3, 1]^T$ forms a subspace W of R^3 . What is $\dim(W)$ and why?	(4)
	b)	A set of n linearly independent vectors in R^n forms a basis. Does the set of vectors $(2, 4, -3), (0, 1, 1), (0, 1, -1)$ form a basis for R^3 ? Explain your reasons.	(6)
OR			
12	a)	Find all solutions in $x = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} \in R^3$ of the equation system $Ax = 12x$, where $A = \begin{bmatrix} 6 & 4 & 3 \\ 6 & 0 & 9 \\ 0 & 8 & 0 \end{bmatrix}$ and $\sum_{i=1}^3 x_i = 1$.	(7)
	b)	Consider the transformation $T(x, y) = (x + y, x + 2y, 2x + 3y)$. Obtain $\ker T$ and use this to calculate the nullity. Also find the transformation matrix for T .	(7)
13	a)	Use the Gram-Schmidt process to find an orthogonal basis for the column space of the following matrix. $\begin{bmatrix} 2 & 1 & 0 \\ 1 & -1 & 1 \\ 0 & 3 & 1 \\ 1 & 1 & 1 \end{bmatrix}$	(7)
	b)	Find the SVD of the matrix. $\begin{bmatrix} 2 & 2 \\ -1 & -1 \end{bmatrix}$	(7)

		OR	
14	a)	<p>i. Let L be the line through the origin in R^2 that is parallel to the vector $[3, 4]^T$. Find the standard matrix of the orthogonal projection onto L. Also find the point on L which is closest to the point $(7, 1)$ and find the point on L which is closest to the point $(-3, 5)$.</p> <p>ii. Find the rank-1 approximation of</p> $\begin{bmatrix} 3 & 2 & 2 \\ 2 & 3 & -2 \end{bmatrix}$	(6)
	b)	<p>i. Find an orthonormal basis of R^3 consisting of eigenvectors for the following matrix.</p> $\begin{bmatrix} 1 & 0 & -2 \\ 0 & 5 & 0 \\ -2 & 0 & 4 \end{bmatrix}$ <p>ii. Find a 3×3 orthogonal matrix S and a 3×3 diagonal matrix D such that $A = SDS^T$</p>	(8)
15	a)	<p>Askier is on a mountain with the equation $z = 100 - 0.4x^2 - 0.3y^2$, where z denotes height.</p> <p>i. The skier is located at the point with xy-coordinates $(1, 1)$, and wants to ski downhill along the steepest possible path. In which direction (indicated by a vector (a, b) in the xy-plane) should the skier begin skiing.</p> <p>ii. The skier begins skiing in the direction given by the xy-vector (a, b) you found in part (i), so the skier heads in a direction in space given by the vector (a, b, c). Find the value of c.</p>	(8)
	b)	Find the linear approximation to the function $f(x, y) = 2 - \sin(-x - 3y)$ at the point $(0, \pi)$, and then use your answer to estimate $f(0.001, \pi)$.	(6)
		OR	
16	a)	<p>Let g be the function given by</p> $g(x, y) = \begin{cases} \frac{x^2 y}{x^2 + y^2} & \text{if } (x, y) \neq (0, 0); \\ 0 & \text{if } (x, y) = (0, 0). \end{cases}$	(8)

		<p>i. Calculate the partial derivatives of g at $(0,0)$.</p> <p>ii. Show that g is not differentiable at $(0,0)$.</p>	
	b)	Find the second order Taylor series expansion for $f(x,y) = e^{-(x^2+y^2)} \cos(xy)$ about $(0, 0)$.	(6)
17	a)	<p>There are two bags. The first bag contains four mangos and two apples; the second bag contains four mangos and four apples. We also have a biased coin, which shows “heads” with probability 0.6 and “tails” with probability 0.4. If the coin shows “heads”, we pick a fruit at random from bag 1; otherwise we pick a fruit at random from bag 2. Your friend flips the coin (you cannot see the result), picks a fruit at random from the corresponding bag, and presents you a mango.</p> <p>What is the probability that the mango was picked from bag 2?</p>	(6)
	b)	<p>Suppose that one has written a computer program that sometimes compiles and sometimes not (code does not change). You decide to model the apparent stochasticity (success vs. no success) x of the compiler using a Bernoulli distribution with parameter μ:</p> $p(x \mu) = \mu^x (1 - \mu)^{1-x}, \quad x \in \{0, 1\}$ <p>Choose a conjugate prior for the Bernoulli likelihood and compute the posterior distribution $p(\mu x_1, \dots, x_N)$.</p>	(8)
		<p>OR</p>	
18	a)	<p>Two dice are rolled.</p> <p>A = ‘sum of two dice equals 3’</p> <p>B = ‘sum of two dice equals 7’</p> <p>C = ‘at least one of the dice shows a 1’</p> <p>i. What is $P(A C)$?</p> <p>ii. What is $P(B C)$?</p> <p>iii. Are A and C independent? What about B and C?</p>	(6)
	b)	Consider the following bivariate distribution $p(x,y)$ of two discrete random	(8)

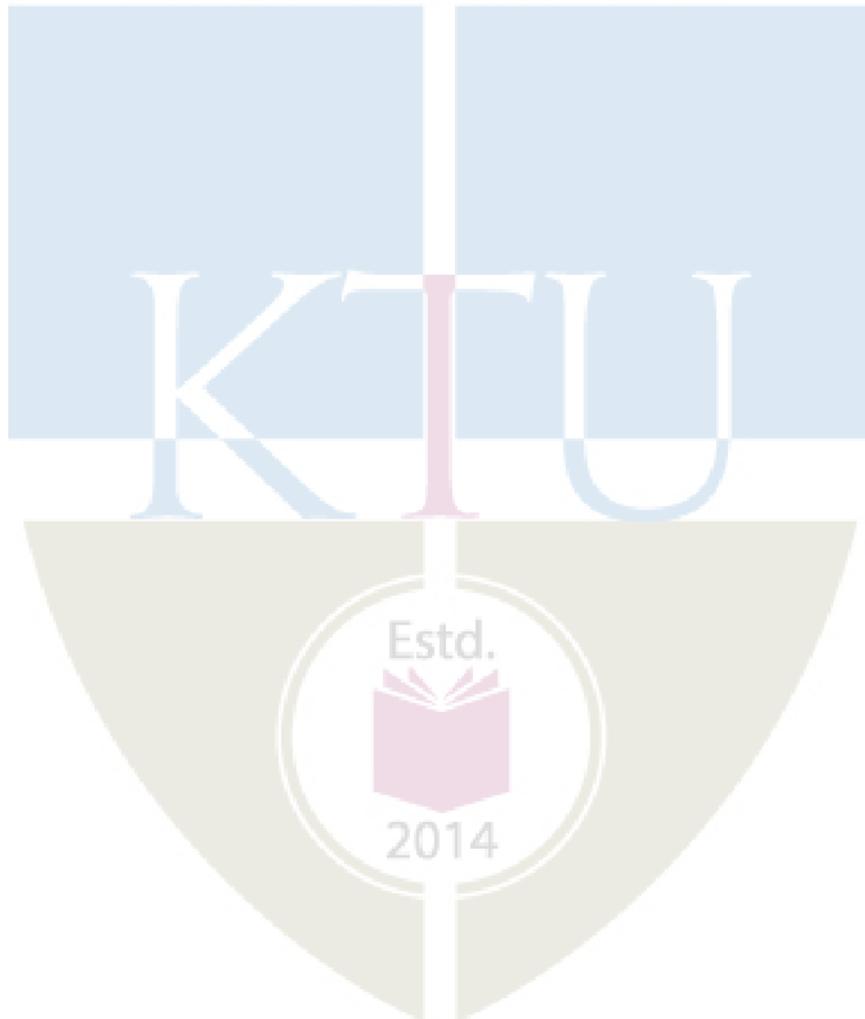
		<p>variables X and Y .</p> <table border="1" style="margin-left: auto; margin-right: auto;"> <tr> <td>y_1</td> <td>0.01</td> <td>0.02</td> <td>0.03</td> <td>0.1</td> <td>0.1</td> </tr> <tr> <td>y_2</td> <td>0.05</td> <td>0.1</td> <td>0.05</td> <td>0.07</td> <td>0.2</td> </tr> <tr> <td>y_3</td> <td>0.1</td> <td>0.05</td> <td>0.03</td> <td>0.05</td> <td>0.04</td> </tr> <tr> <td></td> <td>x_1</td> <td>x_2</td> <td>x_3</td> <td>x_4</td> <td>x_5</td> </tr> </table> <p style="text-align: center;">X</p> <p>Compute:</p> <ol style="list-style-type: none"> i. The marginal distributions $p(x)$ and $p(y)$. ii. The conditional distributions $p(x Y = y_1)$ and $p(y X = x_3)$. 	y_1	0.01	0.02	0.03	0.1	0.1	y_2	0.05	0.1	0.05	0.07	0.2	y_3	0.1	0.05	0.03	0.05	0.04		x_1	x_2	x_3	x_4	x_5	
y_1	0.01	0.02	0.03	0.1	0.1																						
y_2	0.05	0.1	0.05	0.07	0.2																						
y_3	0.1	0.05	0.03	0.05	0.04																						
	x_1	x_2	x_3	x_4	x_5																						
19	a)	Find the extrema of $f(x,y,z) = x - y + z$ subject to $g(x,y,z) = x^2 + y^2 + z^2 = 2$.	(8)																								
	b)	<p>Let</p> $P = \begin{bmatrix} 13 & 12 & -2 \\ 12 & 17 & 6 \\ -2 & 6 & 12 \end{bmatrix}, q = \begin{bmatrix} -22.0 \\ -14.5 \\ 13.0 \end{bmatrix}, \text{ and } r = 1.$ <p>Show that $x^* = (1, 1/2, -1)$ is optimal for the optimization problem</p> $\min \frac{1}{2}x^T Px + q^T x + r$ <p>s.t. $-1 \leq x_i \leq 1, i = 1, 2, 3.$</p>	(6)																								
		OR																									
20	a)	Derive the gradient descent training rule assuming that the target function is represented as $o_d = w_0 + w_1x_1 + \dots + w_nx_n$. Define explicitly the cost/ error function E , assuming that a set of training examples D is provided, where each training example $d \in D$ is associated with the target output t_d .	(8)																								
	b)	Find the maximum value of $f(x,y,z) = xyz$ given that $g(x,y,z) = x + y + z = 3$ and $x,y,z \geq 0$.	(6)																								

Teaching Plan		
No	Topic	No. of Lectures
	Module-I (LINEAR ALGEBRA)	8
1.1	Matrices, Solving Systems of Linear Equations	1
1.2	Vector Spaces	1
1.3	Linear Independence	1
1.4	Basis and Rank (Lecture – 1)	1
1.5	Basis and Rank (Lecture – 2)	1
1.6	Linear Mappings	1
1.7	Matrix Representation of Linear Mappings	1
1.8	Images and Kernel	1
	Module-II (ANALYTIC GEOMETRY, MATRIX DECOMPOSITIONS)	11
2.1	Norms, Inner Products	1
2.2	Lengths and Distances, Angles and Orthogonality	1
2.3	Orthonormal Basis, Orthogonal Complement	1
2.4	Orthogonal Projections – Projection into One Dimensional Subspaces	1
2.5	Projection onto General Subspaces.	1
2.6	Gram-Schmidt Orthogonalization	1
2.7	Determinant and Trace, Eigen values and Eigenvectors.	1
2.8	Cholesky Decomposition	1
2.9	Eigen decomposition and Diagonalization	1
2.10	Singular Value Decomposition	1
2.11	Matrix Approximation	1

	Module-III (VECTOR CALCULUS)	9
3.1	Differentiation of Univariate Functions, Partial Differentiation and Gradients	1
3.2	Gradients of Vector Valued Functions (Lecture 1)	1
3.3	Gradients of Vector Valued Functions (Lecture 2)	1
3.4	Gradients of Matrices	1
3.5	Useful Identities for Computing Gradients	1
3.6	Backpropagation and Automatic Differentiation – Gradients in deep Netwok	1
3.7	Automatic Differentiation	1
3.8	Higher Order Derivatives	1
3.9	Linearization and Multivariate Taylor Series	1
	Module-IV (PROBABILITY AND DISTRIBUTIONS)	10
4.1	Construction of a Probability Space	1
4.2	Discrete and Continuous Probabilities (Probability Density Function, Cumulative Distribution Function)	1
4.3	Sum Rule, Product Rule	1
4.4	Bayes' Theorem	1
4.5	Summary Statistics and Independence (Lecture 1)	1
4.6	Summary Statistics and Independence (Lecture 2)	1
4.7	Bernoulli, Binomial, Uniform (Discrete) Distributions	1
4.8	Uniform (Continuous), Poisson Distributions	1
4.9	Gaussian Distribution	1
4.10	Conjugacy and the Exponential Family (Beta – Bernoulli, Beta – Binomial Conjugacies)	1
	Module-V (OPTIMIZATION)	7
5.1	Optimization Using Gradient Descent.	1
5.2	Gradient Descent With Momentum, Stochastic Gradient Descent	1
5.3	Constrained Optimization and Lagrange Multipliers (Lecture 1)	1

5.4	Constrained Optimization and Lagrange Multipliers (Lecture 2)	1
5.5	Convex Optimization	1
5.6	Linear Programming	1
5.7	Quadratic Programming	1

APJ ABDUL KALAM
TECHNOLOGICAL
UNIVERSITY



CODE CXT296	IOT ARCHITECTURE AND ITS PROTOCOLS	CATEGORY	L	T	P	CREDIT
		VAC	3	1	0	4

Preamble: This is the foundational course for awarding B. Tech. Honours in Computer Science and Design with specialization in *Internet of Things*. The purpose of this course is to introduce architectural and protocol foundations of basic Internet of Things among learners, on which IoT systems are built. Concepts in this course help the learners to understand the concepts, impact, issues application level protocols and challenges of IoT.

Prerequisite: NIL.

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

CO 1	Summarizethe concepts, impact, issues,IoT Access Technologies and challenges of IoT (Knowledge Level: Understand)
CO 2	Understand IoT network architecture and design (Knowledge Level: Understand)
CO 3	Explain the network/application protocol in IoT (Knowledge Level: Understand)
CO 4	Use the sensors , architectures, protocols in various scenarios (Knowledge Level: Apply)

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO 1	√	√	√	√								√
CO 2	√	√	√									√
CO 3	√	√	√	√								√
CO 4	√	√	√	√	√	√						√

Abstract POs defined by National Board of Accreditation

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

Assessment Pattern

Bloom's Category	Continuous Assessment Tests		End Semester Examination Marks
	Test 1	Test 2	
Remember	20%	20%	20%
Understand	40%	40%	40%
Apply	40%	40%	40%
Analyse			
Evaluate			
Create			

Mark Distribution

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

Continuous Internal Evaluation Pattern:

Attendance : 10 marks
 Continuous Assessment Tests : 25 marks
 Continuous Assessment Assignment : 15 marks

Internal Examination Pattern:

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

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 anyone. Each question can have a maximum of 2 subdivisions and carries 14 marks.

Syllabus

Module-1(INTRODUCTION TO IOT)

Genesis of IoT, IoT and Digitization, IoT Impact- Connected Roadways, Connected Factory, Smart Connected Buildings, Smart Creatures. Convergence of IT and OT, IoT Challenges.

Smart Objects: The “Things” in IoT- Sensors, Actuators, and Smart Objects. Sensor Networks - Wireless Sensor Networks (WSNs). Communication Protocols for Wireless Sensor Networks

Module-2 (IOT NETWORK ARCHITECTURE AND DESIGN)

Drivers Behind New Network Architectures – Scale, Security, Constrained Devices and Networks , Data, Legacy Device Support. Comparing IoT Architectures- The oneM2M IoT Standardized Architecture, The IoT World Forum (IoTWF) Standardized Architecture. Additional IoT Reference Models, A Simplified IoT Architecture, The Core IoT Functional Stack, IoT Data Management and Compute Stack.

Module-3 (Connecting Smart Objects)

Communications Criteria, Range-Frequency Bands, Power Consumption. Topology, Constrained Devices, Constrained Node Networks, Data Rate and Throughput, Latency and Determinism, Overhead and Payload. IoT Access Technologies - IEEE 802.15.4 , IEEE 802.15.4g and 802.15.4e, IEEE 1901.2a, IEEE 802.11ah, LoRaWAN, NB-IoT and Other LTE Variations.

Module-4 (IP as the IoT Network Layer)

The Business Case for IP- The Key Advantages of Internet Protocol, Adoption or Adaptation of the Internet Protocol. The Need for Optimization - Constrained Nodes, Constrained Networks, IP Versions, Optimizing IP for IoT. From 6LoWPAN to 6Lo, Header Compression , Fragmentation , Mesh Addressing , Mesh Under Versus Mesh Over Routing, 6Lo Working Group, 6TiSCH, RPL, Objective Function (OF) – Rank, RPL Headers, Metrics, Authentication and Encryption on Constrained Nodes, ACE , DICE. Profiles and Compliances - Internet Protocol for Smart Objects (IPSO) Alliance, Wi-SUN Alliance, Thread

Module- 5(Application Protocols for IoT)

The Transport Layer, IoT Application Transport Methods- Application Layer Protocol Not Present, SCADA, A Little Background on SCADA, Adapting SCADA for IP, Tunneling Legacy SCADA over IP Networks , SCADA Protocol Translation , SCADA Transport over LLNs with MAP-T. Generic Web-Based Protocols, IoT Application Layer Protocols, CoAP, Message Queuing Telemetry Transport (MQTT), Simple use case.

Text book:

1. IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Robert Barton, Jerome Henry, published by CISCO Press, 2017

Reference books:

1. Enabling things to talk, Bassi, Alessandro, et al published by Springer-Verlag Berlin An, 2016.
2. The internet of things: Key applications and protocols, Hersent, Olivier, David Boswarthick, and Omar Elloumi, published by John Wiley & Sons, 2011.
3. Internet of Things: Principles and paradigms, Buyya, Rajkumar, and Amir Vahid Dastjerdi, published by Elsevier, 2016.
4. From Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence, 1st Edition, Jan Holler, VlasiosTsiatsis, Catherine Mulligan, Stefan Avesand, StamatisKarnouskos, David Boyle, published by Academic Press,2014.
5. Learning Internet of Things, Peter Waher, published by PACKT publishing, BIRMINGHAM –MUMBAI
6. Architecting the Internet of Things, ISBN 978-3-642-19156-5 e-ISBN 978-3-642-19157-2, Bernd Scholz-Reiter, Florian Michahelles, published by Springer.
7. Building the Internet of Things with Ipv6 and MIPv6: The Evolving World of M2M Communications, ISBN: 978-1-118-47347-4, Daniel Minoli published by Wiley Publications
8. Internet of Things (A Hands-onApproach), 1st Edition, Vijay Madiseti and Arshdeep Bahga published by VPT, 2014.

Sample Course Level Assessment Questions.**Course Outcome 1 (CO1):**

1. Briefly describe the impact of IoT.
2. What are the main challenges facing in the manufacturing- factory environment?
3. Briefly explain wireless sensor network.
4. Summarize briefly about sensors, actuators and smart objects

Course Outcome 2 (CO2):

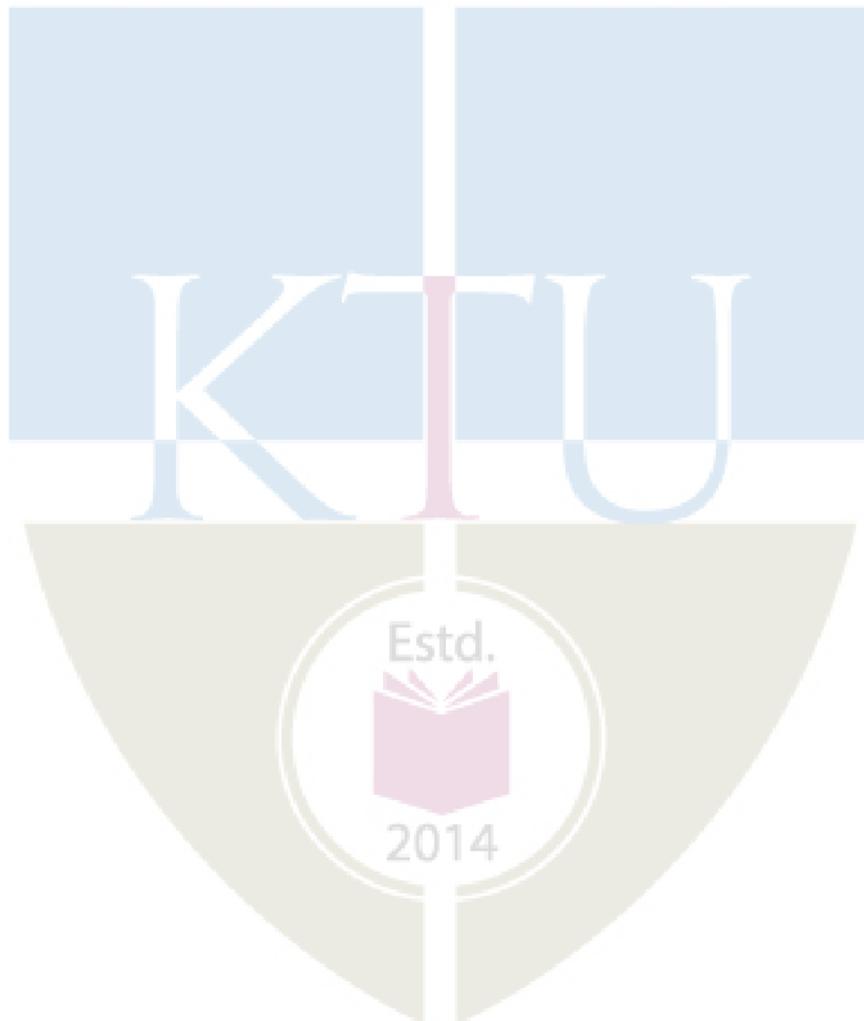
1. Compare the The oneM2M IoT Standardized Architecture and The IoT World Forum (IoTWF) Standardized Architecture
2. Explain the simplified IoT architecture.
3. What are the layers in the core IoT functional stack?
4. Briefly discuss the IoT data management and compute stack.

Course Outcome 3 (CO3):

1. What are the key advantages of internet protocol?
2. List out the need for optimizing internet protocol for IoT?
3. Explain the IPV6 header compression. Why is it done?
4. What are the different compliances and policies associated with IoT.

Course Outcome 4(CO4):

1. Design a simple IOT based health monitoring system
2. With a neat design describe how IOT can be used in house monitoring.
3. Design an IOT architecture for car parking in shopping mall.



Model Question paper

QP Code :		Total Pages :	
Reg No.: _____		Name: _	
APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY IV SEMESTER B.TECH (HONOURS) DEGREE EXAMINATION, MONTH and YEAR			
Course Code: CXT 296			
Course Name: IOT ARCHITECTURE AND ITS PROTOCOLS			
Max. Marks: 100		Duration: 3 Hours	
PART A			
<i>Answer all questions, each carries 3 marks.</i>			Marks
1		How the evolution of the Internet is categorized?	
2		What are the main challenges facing in the manufacturing- factory environment?	
3		Explain the sensors and actuators.	
4		Describe the Traditional IT Cloud Computing Model	
5		What is Micro-Electro-Mechanical Systems (MEMS)?	
6		What are the advantages and disadvantages a wireless-based solution offers?	
7		Explain the key advantages of the IP suite for the Internet of Things	
8		Why optimization is necessary for IP?	
9		Explain the CoAP Message Fields.	
10		Describe about the MQTT Message Types	
PART B			
<i>Answer any one Question from each module. Each question carries 14 Marks</i>			
11	a)	List out in details the issues in IoT	(4)
		Compare Operational Technology (OT) and Information Technology (IT)	(4)
	b)	Explain the smart connected building.	(6)
OR			
12	a)	Explain the Connected Roadways. Explain the current challenges being addressed by Connected Roadways	(7)
	b)	Write a note on smart creatures.	(7)
13	a)	What are the unique challenges posed by IoT networks and explain how these challenges have driven new architectural models	(7)
	b)	Discuss the IoT Architectural Drivers in detail.	(7)

		OR	
14	a)	With a neat diagram explain in detail the simplified IOT architecture	(6)
	b)	List out architectural considerations for WiMAX and cellular technologies. Describe the communications Network layer.	(8)
15	a)	Describes the characteristics and attributes you should consider when selecting and dealing with connecting smart objects	(8)
	b)	Explain IoT access Technologies	(6)
		OR	
16	a)	Explain the design constraints for wireless smart objects. Also explain data aggregation in Wireless Sensor Networks	(8)
	b)	Write a note on LoRaWAN.	(6)
17	a)	Describe about fragmentation and Mesh addressing.	(6)
	b)	Explain the RPL routing metrics and constraints defined in RFC 6551	(8)
		OR	
18	a)	Explain the authentication and encryption on constrained nodes.	(6)
	b)	What are three 6TiSCH forwarding models? Explain	(8)
19	a)	Design an IOT architecture for car parking in shopping mall	(8)
	b)	Explain with a diagram the Protocol Stack for Transporting Serial DNP3 SCADA over IP.	(6)
		OR	
20	a)	Discuss the DNP3 Protocol Translation.	(8)
	b)	Design a simple IOT based health monitoring system	(6)

Teaching Plan		
No	Topic	No. of Lectures(46)
	Module-1(INTRODUCTION TO IOT)	8
1.1	Genesis of IoT –IoT and Digitization -	1
1.2	IoT Impact, Connected Roadways –Connected Factory	1
1.3	Smart Connected Buildings, Smart Creatures	1
1.4	Convergence of IT and OT, IoT Challenges	1
1.5	Smart Objects: The “Things” in IoT : Sensors, Actuators, and Smart Objects	1
1.6	Sensor Networks – Wireless Sensor Networks (WSNs)	1
1.7	Sensor Networks – Wireless Sensor Networks (WSNs)	
1.8	Communication Protocols for Wireless Sensor Networks	1
	Module-2(Iot Network Architecture And Design)	11
2.1	Drivers Behind New Network Architectures – Scale – Security	1
2.2	Constrained Devices and Networks	1
2.3	Data –Legacy Device Support	1
2.4	Comparing IoT Architectures	1
2.5	The oneM2M IoT Standardized Architecture	1
2.6	The IoT World Forum (IoTWF) Standardized Architecture	1
2.7	Additional IoT Reference Models	1
2.8	A Simplified IoT Architecture	1
2.9	The Core IoT Functional Stack	1
2.10	IoT Data Management and Compute Stack	1
2.11	IoT Data Management and Compute Stack	1

	Module-3(Connecting Smart Objects)	9
3.1	Communications Criteria- Range-Frequency Bands	1
3.2	Power Consumption-Topology-Constrained Devices	1
3.3	Constrained-Node Networks- Data Rate and Throughput	1
3.4	Latency and Determinism - Overhead and Payload	1
3.5	IoT Access Technologies - IEEE 802.15.4	1
3.6	IEEE 802.15.4g and 802.15.4e- IEEE 1901.2a- IEEE 802.11ah	1
3.7	IEEE 802.15.4g and 802.15.4e- IEEE 1901.2a- IEEE 802.11ah	1
3.8	LoRaWAN- NB-IoT and Other LTE Variations	1
3.9	LoRaWAN- NB-IoT and Other LTE Variations	1
	Module-4 (IP as the IoT Network Layer)	10
4.1	The Business Case for IP- The Key Advantages of Internet	1
4.2	Adoption or Adaptation of the Internet Protocol	1
4.3	The Need for Optimization – Constrained Nodes – Constrained Networks	1
4.4	Optimizing IP for IoT	1
4.5	From 6LoWPAN to 6Lo – Header Compression – Fragmentation – Mesh Addressing	1
4.6	From 6LoWPAN to 6Lo – Header Compression – Fragmentation – Mesh Addressing	1
4.7	Mesh-Under Versus Mesh-Over Routing – 6Lo Working Group – 6TiSCH – RPL – Objective Function (OF)	1
4.8	Protocol - Rank – RPL Headers – Metrics – Authentication and Encryption on Constrained – Nodes – ACE – DICE – Profiles and Compliances	1
4.9	Protocol - Rank – RPL Headers – Metrics – Authentication and Encryption on Constrained – Nodes – ACE – DICE – Profiles and Compliances	1
4.10	Internet Protocol for Smart Objects (IPSO) Alliance – Wi-SUN Alliance – Thread	1
	Module-5 (Application Protocols for IoT)	8
5.1	The Transport Layer - IoT Application Transport Methods	1

5.2	Application Layer Protocol Not Present – SCADA – A Little Background on SCADA	1
5.3	Adapting SCADA for IP – Tunneling Legacy SCADA over IP Networks	1
5.4	SCADA Protocol Translation – SCADA Transport over LLNs with MAP-T	1
5.5	Generic Web-Based Protocols – IoT Application Layer Protocols	1
5.6	CoAP – Message Queuing Telemetry Transport (MQTT)	1
5.7	Simple use case	1
5.8	Simple use case	1

