APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

# SEMESTER V

KTU
Estd.
2014

| CST 301 | FORMAL LANGUAGES AND AUTOMATA THEORY | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| | | PCC | 3 | 1 | 0 | 4 | 2019 |

**Preamble**: This is a core course in theoretical computer science. It covers automata and grammar representations for languages in Chomsky Hierarchy. For regular languages, it also covers representations using regular expression and Myhill-Nerode Relation. The topics covered in this course have applications in various domains including compiler design, decidability and complexity theory, software testing, formal modelling and verification of hardware and software.

**Prerequisite: Basic knowledge about the following topic is assumed: sets, relations - equivalence relations, functions, proof by Principle of Mathematical Induction.**

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

| | |
|---|---|
| **CO1** | Classify a given formal language into Regular, Context-Free, Context Sensitive, Recursive or Recursively Enumerable. **[Cognitive knowledge level: Understand]** |
| **CO2** | Explain a formal representation of a given regular language as a finite state automaton, regular grammar, regular expression and Myhill-Nerode relation. [**Cognitive knowledge level: Understand**] |
| **CO3** | Design a Pushdown Automaton and a Context-Free Grammar for a given context-free language. [**Cognitive knowledge level** : **Apply**] |
| **CO4** | Design Turing machines as language acceptors or transducers. [**Cognitive knowledge level: Apply]** |
| **CO5** | Explain the notion of decidability. [**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 | **30** | **30** | **30** |
| Apply | **40** | **40** | **40** |
| 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. 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 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

## CST 301 Formal Languages and Automata Theory

**Module - 1 (Introduction to Formal Language Theory and Regular Languages)**

Introduction to formal language theory– Alphabets, Strings, Concatenation of strings, Languages.

Regular Languages - Deterministic Finite State Automata (DFA) (Proof of correctness of construction not required), Nondeterministic Finite State Automata (NFA), Equivalence of DFA and NFA**,** Regular Grammar (RG), Equivalence of RGs and DFA.

**Module - 2 (More on Regular Languages)**

Regular Expression (RE), Equivalence of REs and DFA, Homomorphisms, Necessary conditions for regular languages, Closure Properties of Regular Languages, DFA state minimization (No proof required).

**Module - 3 (Myhill-Nerode Relations and Context Free Grammars)**

Myhill-Nerode Relations (MNR)- MNR for regular languages, Myhill-Nerode Theorem (MNT) (No proof required), Applications of MNT.

Context Free Grammar (CFG)- CFG representation of Context Free Languages (proof of correctness is required), derivation trees and ambiguity, Normal forms for CFGs.

**Module - 4 (More on Context-Free Languages)**

Nondeterministic Pushdown Automata (PDA), Deterministic Pushdown Automata (DPDA), Equivalence of PDAs and CFGs (Proof not required), Pumping Lemma for Context-Free Languages (Proof not required), Closure Properties of Context Free Languages.

**Module - 5 (Context Sensitive Languages, Turing Machines)**

Context Sensitive Languages **-** Context Sensitive Grammar (CSG), Linear Bounded Automata.

Turing Machines - Standard Turing Machine, Robustness of Turing Machine, Universal Turing Machine, Halting Problem, Recursive and Recursively Enumerable Languages.

Chomsky classification of formal languages.

**Text Book**

1. Dexter C. Kozen, Automata and Computability, Springer (1999)

**Reference Materials**

1. John E Hopcroft, Rajeev Motwani and Jeffrey D Ullman, Introduction to Automata Theory, Languages, and Computation, 3/e, Pearson Education, 2007
2. Michael Sipser, Introduction To Theory of Computation, Cengage Publishers, 2013.

**Sample Course Level Assessment Questions**

**Course Outcome 1 (CO1):** Identify the class of the following languages in Chomsky Hierarchy:

- $L_1 = \{a^p | p is\ a\ prime\ number\}$
- $L_2 = \{x\{0,1\}^* | x is\ the\ binary\ representation\ of\ a\ decimal\ number\ which\ is\ a\ multiple\ of 5\}$
- $L_3 = \{a^n b^n c^n | n \geq 0\}$
- $L_4 = \{a^m b^n c^{m+n} | m > 0, n \geq 0\}$
- $L_5 = \{M\#x | M halts\ on x\}$. Here, $M$ is a binary encoding of a Turing Machine and $x$ is a binary input to the Turing Machine.

**Course Outcome 2 (CO2):**

(i) Design a DFA for the language $L = \{axb | x \in \{a, b\}^*\}$

(ii) Write a Regular Expression for the language: $L = \{x \in \{a, b\}^* | third\ last\ symbol\ in\ x\ is\ b\}$

(iii) Write a Regular Grammar for the language: $L = \{x \in \{0,1\}^* | there\ are\ no\ consecutive\ zeros\ in x\}$

(iv) Show the equivalence classes of the canonical Myhill-Nerode relation induced by the language: $L = \{x \in \{a, b\}^* | x contains\ even\ number\ of a's\ and\ odd\ number\ of b's\}$.

**Course Outcome 3 (CO3):**

(i) Design a PDA for the language $L = \{ww^R | w \in \{a, b\}^*\}$. Here, the notation $w^R$ represents the reverse of the string $w$.

(ii) Write a Context-Free Grammar for the language $L = \{a^n b^{2n} | n \geq 0\}$.

**Course Outcome 4 (CO4):**

(i) Design a Turing Machine for the language $L = \{a^n b^n c^n | n \geq 0\}$

(ii) Design a Turing Machine to compute the square of a natural number. Assume that the input is provided in unary representation.

**Course Outcome 5 (CO5):** Argue that it is undecidable to check whether a Turing Machine $M$ enters a given state during the computation of a given input $x$.

**Model Question paper**

**QP CODE:** **PAGES:3**

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

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: CST301**

**Course Name: Formal Languages and Automata Theory**

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

**PART A**

**Answer all Questions. Each question carries 3 Marks**

1. Design a DFA for the language $L = \{x \in \{a,b\}^* | aba \text{ is not a substring in } x\}$.

2. Write a Regular Grammar for the language: $L = \{axb | x \in \{a,b\}^*\}$

3. Write a Regular Expression for the language:
   $L = \{x \in \{0,1\}^* | \text{there are no consecutive } 1\text{'s in } x\}$

4. Prove that the language $L_1 = \{a^{n!} | n \in N\}$ is not regular.

5. List out the applications of Myhill-Nerode Theorem.

6. Write a Context-Free Grammar for the language: $L = \{x \in \{a,b\}^* | \#_a(x) = \#_b(x)\}$. Here, the notation $\#_1(w)$ represents the number of occurrences of the symbol 1 in the string $w$.

7. Design a PDA for the language of odd length binary palindromes (no explanation is required, just list the transitions in the PDA).

8. Prove that Context Free Languages are closed under set union.

9. Write a Context Sensitive Grammar for the language $L = \{a^n b^n c^n | n \geq 0\}$ (no explanation is required, just write the set of productions in the grammar).

10. Differentiate between Recursive and Recursively Enumerable Languages.

**(10x3=30)**

**Part B**

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

11. (a) Draw the state-transition diagram showing an NFA $N$ for the following language $L$. Obtain the DFA$D$ equivalent to $N$ by applying the subset construction algorithm. **(7)**

$$L = \{x \in \{a,b\}^* | the\ second\ last\ symbol\ in\ x\ is\ b\}$$

(b) Draw the state-transition diagram showing a DFA for recognizing the following language: **(7)**

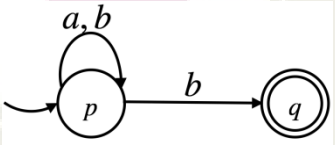
$$L = \{x \in \{0,1\}^* | x\ is\ a\ binary\ representation\ of\ a\ natural\ number\ which\ is\ a \text{multiple of } 5\}$$

**OR**

12. (a) Write a Regular grammar $G$ for the following language $L$defined as: $L = \{x \in \{a,b\}^* | xdoes\ not\ conatin\ consecutiveb's\}$. **(7)**

(b) Obtain the DFA $A_G$ over the alphabet set $\Sigma = \{a,b\}$, equivalent to the regular grammar $G$ with start symbol $S$ and productions: $S \rightarrow aA$ and $A \rightarrow aA|bA|b$. **(7)**

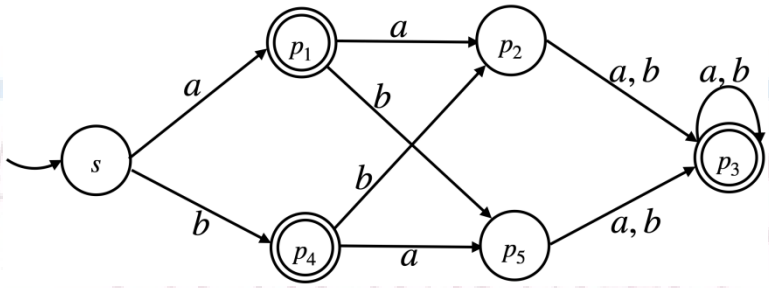
13. (a) Using Kleen's construction, obtain the regular expression for the language represented by the following NFA **(8)**




(b) Using pumping lemma for regular languages, prove that the language $L = \{a^n b^n | n \geq 0\}$ is not regular. **(7)**

**OR**

14. (a) Obtain the minimum -state DFA from the following DFA. **(8)**




(b) Using ultimate periodicity for regular languages, prove that the language $L = \{a^{n^2} | n \geq 0\}$ is not regular. **(6)**

15. (a) Show the equivalence classes of the canonical Myhill-Nerode relation for the language of binary strings with odd number of 1′s and even number of 0s. **(7)**

(b) With an example, explain ambiguity in Context Free Grammar **(7)**

**OR**

16. (a) Convert the Context-Free Grammar with productions: $\{S \rightarrow aSb|\epsilon\}$ into Greibach Normal form. **(8)**

(b) Convert the Context-Free Grammar with productions: $\{S \rightarrow aSa|bSb|SS|\epsilon\}$ into Chomsky Normal form. **(6)**

17. (a) Design a PDA for the language $L = \{a^m b^n c^{m+n} | n \geq 0, m \geq 0\}$. Also illustrate the computation of the PDA on a string in the language **(7)**

(b) With an example illustrate how a multi-state PDA can be transformed into an equivalent single-state PDA. **(7)**

**OR**

18. (a) Using pumping lemma for context-free languages, prove that the language: $L = \{ww | w \in \{a, b\}^*\}$ is not a context-free language. **(6)**

(b) With an example illustrate how a CFG can be converted to a single-state PDA **(8)**

19. (a) Design a Turing machine to obtain the sum of two natural numbers $a$ and $b$, both represented in unary on the alphabet set {1}. Assume that initially the tape contains $\vdash 1^a 0 1^b \not{b}^\omega$. The Turing Machine should halt with $\vdash 1^{a+b} \not{b}^\omega$ as the tape content. Also, illustrate the computation of your Turing Machine on the input $a = 3$and $b = 2$. **(7)**

(b) With an example illustrate how a CFG can be converted to a single-state PDA. **(7)**

**OR**

20. (a) Design a Turing machine to obtain the sum of two natural numbers $a$and $b$, both represented in unary on the alphabet set {1}. Assume that initially the tape contains $\vdash 1^a 0 1^b \not{b}^\omega$. The Turing Machine should halt with $\vdash 1^{a+b} \not{b}^\omega$ as the tape content. Also, illustrate the computation of your Turing Machine on the input $a = 3$and $b = 2$. **(7)**

(b) Write a context sensitive grammar for the language $L = \{a^n b^n c^n | n \geq 0\}$. Also illustrate how the the string $a^2 b^2 c^2$ can be derived from the start symbol of the proposed grammar. **(7 )**

## Teaching Plan

| Sl. No | Topic | No. of Hours (45 hrs) |
|---|---|---|
| **Module - 1 (Introduction to Formal Language Theory and Regular Languages)** | | **9 Hours** |
| 1.1 | Introduction to formal language theory – Alphabets, strings, concatenation of strings, Languages | 1 Hour |
| 1.2 | Deterministic Finite State Automata (DFA) – Example DFA (Proof of correctness of construction not required) | 1 Hour |
| 1.3 | Formal definition of DFA, Language accepted by the class of DFA | 1 Hour |
| 1.4 | Nondeterministic Finite State Automata (NFA) – Example NFA | 1 Hour |
| 1.5 | Formal definition of NFA, NFA with □ transitions - examples, formal definition | 1 Hour |
| 1.6 | Equivalence of DFA and NFA with and without □ transitions - Subset construction | 1 Hour |
| 1.7 | Regular Grammar (RG) – Example RGs, derivation of sentences | 1 Hour |
| 1.8 | Formal definition of RG, Language represented by a RG | 1 Hour |
| 1.9 | Equivalence of RG and DFA | 1 Hour |
| **Module - 2 (More on Regular Languages)** | | **9 Hours** |
| 2.1 | Regular Expression (RE) - Example REs and formal definition | 1 Hour |
| 2.2 | Conversion of RE to NFA with □ transition | 1 Hour |
| 2.3 | Conversion of NFA with □ transition to RE (Kleen's construction) | 1 Hour |
| 2.4 | Homomorphisms | 1 Hour |
| 2.5 | Pumping Lemma for regular languages | 1 Hour |
| 2.6 | Ultimate periodicity | 1 Hour |
| 2.7 | Closure Properties of Regular Languages (proof not required) | 1 Hour |

| | | |
|---|---|---|
| 2.8 | DFA state minimization - Quotient construction | 1 Hour |
| 2.9 | State Minimization Algorithm - Example | 1 Hour |
| **Module - 3 (Myhill-Nerode Relations and Context Free Grammars)** | | **10 Hours** |
| 3.1 | Myhill-Nerode Relations (MNR) - Example, Properties of MyhillNerode Relation | 1 Hour |
| 3.2 | Conversion of DFA to MNR (Proof of correctness not required) | 1 Hour |
| 3.3 | Conversion of MNR to DFA(Proof of correctness not required) | 1 Hour |
| 3.4 | Myhill-Nerode Theorem (MNT) | 1 Hour |
| 3.5 | Applications of MNT | 1 Hour |
| 3.6 | Context Free Grammar (CFG) - Example CFGs and formal definition | 1 Hour |
| 3.7 | Proving correctness of CFGs | 1 Hour |
| 3.8 | Derivation Trees and ambiguity | 1 Hour |
| 3.9 | Chomsky Normal Form | 1 Hour |
| 3.10 | Greibach Normal Form | 1 Hour |
| **Module - 4 (More on Context-Free Languages)** | | **8 Hours** |
| 4.1 | Nondeterministic Pushdown Automata (PDA) – Example PDAs, formal definition | 1 Hour |
| 4.2 | Acceptance criteria - equivalence | 1 Hour |
| 4.3 | Deterministic PDA | 1 Hour |
| 4.4 | Conversion of CFG to PDA (No proof required) | 1 Hour |
| 4.5 | Conversion of PDA to CGF - Part I (No proof required) | 1 Hour |
| 4.6 | Conversion of PDA to CGF - Part II (No proof required) | 1 Hour |
| 4.7 | Pumping Lemma for context-free languages (No proof required) | 1 Hour |
| 4.8 | Closure Properties of Context Free Languages | 1 Hour |

| Module - 5 (Context Sensitive Languages, Turing Machines ) | | 9 Hours |
|---|---|---|
| 5.1 | Context Sensitive Grammar (CSG) - Examples, formal definition | 1 Hour |
| 5.2 | Linear Bounded Automata (LBA) - Example LBA, formal definition | 1 Hour |
| 5.3 | Turing Machine (TM) - TM as language acceptors - examples, formal definition | 1 Hour |
| 5.4 | TM as transducers - examples | 1 Hour |
| 5.5 | Robustness of the standard TM model - Multi-tape TMs, Nondeterministic TM | 1 Hour |
| 5.6 | Universal Turing Machine | 1 Hour |
| 5.7 | Halting Problem of TM - proof of its undecidability | 1 Hour |
| 5.8 | Recursive and Recursively Enumerable Languages | 1 Hour |
| 5.9 | Chomsky classification of formal languages | 1 Hour |

| CST 303 | COMPUTER NETWORKS | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| | | PCC | 3 | 1 | 0 | 4 | 2019 |

**Preamble:** Study of this course provides the learners a clear understanding of how computer networks from local area networks to the massive and global Internet are built, how they allow computers to share information and communicate with one another. This course covers the physical aspects of computer networks, layers of OSI Reference model, and inter-networking. The course helps the learners to compare and analyze the existing network technologies and choose a suitable network design for a given system.

**Prerequisite:** Nil

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

| CO# | Course Outcomes |
|---|---|
| CO1 | Explain the features of computer networks, protocols, and network design models **(Cognitive Knowledge: Understand)** |
| CO2 | Describe the fundamental characteristics of the physical layer and identify the usage in network communication **(Cognitive Knowledge: Apply)** |
| CO3 | Explain the design issues of data link layer, link layer protocols, bridges and switches **(Cognitive Knowledge: Understand)** |
| CO4 | Illustrate wired LAN protocols (IEEE 802.3) and wireless LAN protocols (IEEE 802.11) **(Cognitive Knowledge: Understand)** |
| CO5 | Select appropriate routing algorithms, congestion control techniques, and Quality of Service requirements for a network **(Cognitive Knowledge: Apply)** |
| CO6 | Illustrate the functions and protocols of the network layer, transport layer, and application layer in inter-networking **(Cognitive Knowledge: 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 teamwork |
| PO4 | Conduct investigations of complex problems | PO10 | Communication |
| PO5 | Modern tool usage | PO11 | Project Management and Finance |
| PO6 | The Engineer and Society | PO12 | Lifelong learning |

**Assessment Pattern**

| Bloom's Category | Test 1 (Marks in percentage) | Test 2 (Marks in percentage) | End Semester Examination (Marks in percentage) |
|---|---|---|---|
| Remember | 40 | 30 | 30 |

| | | | |
|---|---|---|---|
| Understand | **50** | **50** | **50** |
| Apply | **10** | **20** | **20** |
| Analyze | | | |
| 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. The first series test shall be preferably conducted after completing the first half of the syllabus. 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 questions from each module of which a student should answer anyone. Each question can have maximum 2 sub-divisions and carries 14 marks.

## Syllabus

**Module - 1 (Introduction and Physical Layer)**

Introduction – Uses of computer networks, Network hardware, Network software. Reference models – The OSI reference model, The TCP/IP reference model, Comparison of OSI and TCP/IP reference models.

Physical Layer – Modes of communication, Physical topologies, Signal encoding, Repeaters and hub, Transmission media overview. Performance indicators – Bandwidth, Throughput, Latency, Queuing time, Bandwidth–Delay product.

**Module - 2 (Data Link Layer)**

Data link layer - Data link layer design issues, Error detection and correction, Sliding window protocols, High-Level Data Link Control(HDLC)protocol. Medium Access Control (MAC) sublayer –Channel allocation problem, Multiple access protocols, Ethernet, Wireless LANs - 802.11, Bridges & switches - Bridges from 802.x to 802.y, Repeaters, Hubs, Bridges, Switches, Routers and Gateways.

**Module - 3 (Network Layer)**

Network layer design issues. Routing algorithms - The Optimality Principle, Shortest path routing, Flooding, Distance Vector Routing, Link State Routing, Multicast routing, Routing for mobile hosts. Congestion control algorithms. Quality of Service (QoS) - requirements, Techniques for achieving good QoS.

**Module - 4 (Network Layer in the Internet)**

IP protocol, IP addresses, Internet Control Message Protocol (ICMP), Address Resolution Protocol (ARP), Reverse Address Resolution Protocol (RARP), Bootstrap Protocol (BOOTP), Dynamic Host Configuration Protocol (DHCP). Open Shortest Path First(OSPF) Protocol, Border Gateway Protocol (BGP), Internet multicasting, IPv6, ICMPv6.

**Module – 5 (Transport Layer and Application Layer)**

Transport service – Services provided to the upper layers, Transport service primitives. User Datagram Protocol (UDP). Transmission Control Protocol (TCP) – Overview of TCP, TCP segment header, Connection establishment &release, Connection management modeling, TCP retransmission policy, TCP congestion control.

Application Layer –File Transfer Protocol (FTP), Domain Name System (DNS), Electronic mail, Multipurpose Internet Mail Extension (MIME), Simple Network Management Protocol

(SNMP), World Wide Web(WWW) – Architectural overview.

**Text Books**

1. Andrew S. Tanenbaum, Computer Networks, 4/e, PHI (Prentice Hall India).
2. Behrouz A Forouzan, Data Communication and Networking, 4/e, Tata McGraw Hill

**Reference Books**

1. Larry L Peterson and Bruce S Dave, Computer Networks – A Systems Approach, 5/e, Morgan Kaufmann.
2. Fred Halsall, Computer Networking and the Internet, 5/e.
3. James F. Kurose, Keith W. Ross, Computer Networking: A Top-Down Approach, 6/e.
4. Keshav, An Engineering Approach to Computer Networks, Addison Wesley, 1998.
5. W. Richard Stevens. TCP/IP Illustrated Volume 1, Addison-Wesley, 2005.
6. William Stallings, Computer Networking with Internet Protocols, Prentice-Hall, 2004.
7. Request for Comments (RFC) Pages - IETF -https://www.ietf.org/rfc.html

**Course Level Assessment Questions**

**Course Outcome1 (CO1)**

1. Compare TCP/IP and OSI reference model.
2. The purpose of physical layer is to transport a raw bit stream from one machine to another. Justify.

**Course Outcome2 (CO2)**

1. Write the physical and transmission characteristics of Optical Fibre Cable guided transmission media.
2. The distance between the sender and receiver systems is about 200 KM. The speed of transmission is 2GB/s. Find out the propagation time?

**Course Outcome3 (CO3)**

1. Ethernet frames must be at least 64 bytes long to ensure that the transmitter is still going in the event of a collision at the far end of the cable. Fast Ethernet has the same 64-byte minimum frame size but can get the bits out ten times faster. How is it possible to maintain the same minimum frame size?
2. What do you mean by bit stuffing?

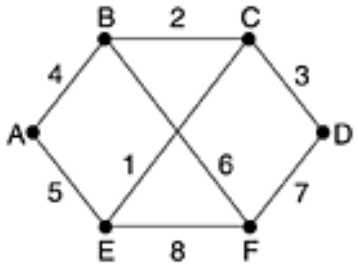
**Course Outcome4 (CO4)**

1. Draw and explain the frame format for Ethernet.
2. Give the differences between CSMA/CD and CSMA/CA protocol.

**Course Outcome5 (CO5)**

1. Consider the given subnet in which distance vector routing is used, and the vectors just come in to router C as follows: from B: (5, 0, 8, 12, 6, 2); from D: (16, 12, 6, 0, 9, 10);

and from E: (7, 6, 3, 9, 0, 4). The measured delays from C to B, D, and E, are 6, 3, and 5, respectively. What is C's new routing table? Give both the outgoing line to use and the expected delay.




2. Illustrate the leaky bucket congestion control technique.

**Course Outcome 6 (CO6)**

1. How do you subnet the Class C IP Address 206.16.2.0 so as to have 30 subnets. What is the subnet mask for the maximum number of hosts? How many hosts can each subnet have?
2. Give the architecture of World Wide Web.

**Model Question Paper**

**QP CODE:** **PAGES:**

**Reg No:_____**

**Name:_____**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: CST 303**

**Course Name : Computer Networks**

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

**PART-A**

**(Answer All Questions. Each question carries 3 marks)**

1. What does "negotiation" mean when discussing network protocols in a layered architecture? Give an example.

2. Define simplex, half-duplex, and full-duplex transmission modes. Give one example for each.

3. Data link protocols almost always put the CRC in a trailer rather than in a header. Why?

4. An 8-bit byte with binary value 10101111 is to be encoded using an even-parity Hamming code. What is the binary value after encoding?

5. Illustrate the Count to Infinity problem in routing.

6. Describe two major differences between the warning bit method and the Random Early Detection (RED) method.

7. The Protocol field used in the IPv4 header is not present in the fixed IPv6 header. Why?

8. How many octets does the smallest possible IPv6 (IP version 6) datagram contain?

9. Can Transmission Control Protocol(TCP) be used directly over a network (e. g. an Ethernet) without using IP? Justify your answer.

10. When Web pages are sent out, they are prefixed by MIME headers. Why?

**(10x3=30)**

## Part B

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

11. (a) With a neat diagram, explain Open Systems Interconnection (OSI) Reference Model. **(8)**

    (b) Compare Twisted Pair, Coaxial Cable and Optical Fibre guided transmission media. **(6)**

**OR**

12. (a) Consider two networks providing reliable connection-oriented service. One of them offers a reliable byte stream and the other offers a reliable message stream. Are they identical? Justify your answer. **(8)**

    (b) Sketch the waveform in Manchester and Differential Manchester Encoding for the bitstream 11000110010. **(6)**

13. (a) A bit stream 10011101 is transmitted using the standard CRC method. The generator polynomial is $□^3 + 1$. Show the actual bit string transmitted. Suppose the third bit from the left is inverted during transmission. Show that this error is detected at the receiver's end. **(8)**

(b) Explain the working of High-Level Data Link Control (HDLC) protocol. **(6)**

**OR**

14. (a) Explain the working of IEEE 802.11 MAC sublayer. **(10)**

(b) Distinguish between Bridges and Switches. **(4)**

15. (a) Illustrate Distance Vector Routing algorithm with an example. **(8)**

(b) Explain the characteristics of Routing Information Protocol (RIP). **(6)**

**OR**

16. (a) A computer on a 6-Mbps network is regulated by a token bucket. The token bucket is filled at a rate of 1 Mbps. It is initially filled to capacity with 8 megabits. How long can the computer transmit at the full 6 Mbps? **(8)**

(b) Explain how routing is performed for mobile hosts. **(6)**

17. (a) Explain the address resolution problem using Address Resolution Protocol (ARP) and Reverse Address Resolution Protocol (RARP)with an example network. **(10)**

(b) A network on the Internet has a subnet mask of 255.255.240.0. What is the maximum number of hosts it can handle? **(4)**

**OR**

18. (a) How do you subnet the Class C IP address 195.1.1.0 so as to have 10 subnets with a maximum of 12 hosts in each subnet. **(6)**

(b) Draw IPv6 Datagram format and explain its features. **(8)**

19. (a) Distinguish the header formats of Transmission Control protocol (TCP) and User Datagram Protocol (UDP). **(8)**

(b) Explain the principal Domain Name System (DNS) resource record types for **(6)**

IPv4.

**OR**

20. (a) What is the role of Simple Mail Transfer Protocol (SMTP) in E- mail? **(6)**

(b) With the help of a basic model, explain the working of World Wide Web (WWW). **(8 )**

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## Teaching Plan

| No | Contents | No of Lecture Hrs |
|---|---|---|
| | **Module – 1 (Introduction and Physical Layer) (10 hrs)** | |
| 1.1 | Introduction, Uses of computer networks. | 1 hour |
| 1.2 | Network Hardware, Local Area Networks (LAN), Metropolitan Area Networks (MAN), Wide Area Networks (WAN), Wireless networks, Home networks, Internetworks. | 1 hour |
| 1.3 | Network Software, Protocol hierarchies, Design issues for the layers. | 1 hour |
| 1.4 | Connection-oriented and Connectionless services, Service primitives, Relationship of services to protocols. | 1 hour |
| 1.5 | Reference models, The OSI reference model. | 1 hour |
| 1.6 | The TCP/IP reference model, Comparisonof OSI and TCP/IP reference models. | 1 hour |
| 1.7 | Physical layer, Modes of communication, Simplex, Half-duplex, and Full-duplex, Physical topologies, Mesh, Star, Bus, Ring, Hybrid. | 1 hour |
| 1.8 | Signal encoding, Manchester, Differential Manchester. | 1 hour |
| 1.9 | Transmission media overview, Guided media (twisted pair, coaxial and fiber optic media), Unguided/wireless media (radio, microwave, and infrared). | 1 hour |
| 1.10 | Performance indicators, Bandwidth (in Hertz and in Bits per Seconds), | 1 hour |

| | | |
|---|---|---|
| | Throughput, Latency (Delay), Queuing time, Bandwidth-Delay product. | |
| **Module 2 – (Data Link Layer) (10 hrs)** | | |
| 2.1 | Data link layer design issues. | 1 hour |
| 2.2 | Error detection and correction, Error correcting codes | 1 hour |
| 2.3 | Error detecting codes. | 1 hour |
| 2.4 | Sliding window protocols. | 1 hour |
| 2.5 | High-Level Data Link Control(HDLC) protocol. | 1 hour |
| 2.6 | Medium Access Control (MAC) sublayer, Channel allocation problem, Multiple access protocols. | 1 hour |
| 2.7 | Ethernet, Ethernet cabling, Manchester encoding, Ethernet MAC sublayer protocol, Binary Exponential Backoff algorithm. | 1 hour |
| 2.8 | Ethernet performance, Switched Ethernet, Fast Ethernet, Gigabit Ethernet, IEEE 802.2: Logical Link Control. | 1 hour |
| 2.9 | Wireless LANs, 802.11 protocol stack, Physical layer, MAC Sublayer protocol, Frame structure. | 1 hour |
| 2.10 | Bridges &switches, Bridges from 802.x to 802.y, Repeaters, Hubs, Bridges, Switches, Routers, and Gateways. | 1 hour |
| **Module 3 - (Network Layer) (8 hrs)** | | |
| 3.1 | Network layer design issues. | 1 hour |
| 3.2 | Routing algorithms, The Optimality Principle, Shortest path routing, Flooding. | 1 hour |
| 3.3 | Distance Vector Routing. | 1 hour |
| 3.4 | Link State Routing. | 1 hour |
| 3.5 | Multicast routing, Routing for mobile hosts. | 1 hour |

| | | |
|---|---|---|
| 3.6 | General principles of congestion control, Congestion prevention policies, Congestion control in virtual circuit subnets. | 1 hour |
| 3.7 | Congestion control algorithms, Congestion control in Datagram subnets, Load shedding, Jitter control. | 1 hour |
| 3.8 | Quality of Service, Requirements, Techniques for achieving good Quality of Service. | 1 hour |
| **Module 4 – (Network Layer in the Internet) (9 hrs)** | | |
| 4.1 | Network layer in the Internet, Internet Protocol (IP). | 1 hour |
| 4.2 | IP Addresses, Subnets, Classless Inter-Domain Routing (CIDR). | 1 hour |
| 4.3 | IP Addresses, Network Address Translation (NAT). | 1 hour |
| 4.4 | Internet Control Message Protocol (ICMP), Address Resolution Protocol (ARP), Reverse Address Resolution Protocol (RARP). | 1 hour |
| 4.5 | Bootstrap Protocol (BOOTP), Dynamic Host Configuration Protocol (DHCP). | 1 hour |
| 4.6 | Open Shortest Path First (OSPF) protocol. | 1 hour |
| 4.7 | Border Gateway Protocol (BGP). | 1 hour |
| 4.8 | Internet multicasting. | 1 hour |
| 4.9 | IPv6, Header format, Extension headers, Internet Control Message Protocol version 6 (ICMPv6). | 1 hour |
| **Module 5 - ( Transport Layer and Application Layer) (8 hrs)** | | |
| 5.1 | Transport Service, Services provided to the upper layers, Transport service primitives. User Datagram Protocol (UDP). | 1 hour |
| 5.2 | Transmission Control Protocol (TCP), TCP segment header, Connection establishment &release, Connection management modeling. | 1 hour |
| 5.3 | TCP retransmission policy, TCP congestion control. | 1 hour |
| 5.4 | Application layer, File Transfer Protocol (FTP). | 1 hour |

| | | |
|---|---|---|
| 5.5 | Domain Name System (DNS). | 1 hour |
| 5.6 | Electronic Mail, Multipurpose Internet Mail Extension (MIME). | 1 hour |
| 5.7 | Simple Network Management Protocol (SNMP). | 1 hour |
| 5.8 | World Wide Web, Architectural overview. | 1 hour |

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| CCT305 | SYSTEMS & NETWORK SECURITY | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| | | PCC | 3 | 1 | 0 | 4 |

**Preamble:** Study of this course provides the learners a clear understanding of the fundamental concepts of network and wireless security and the processes and means required to implement a secure network. It covers the techniques to transfer a message securely over insecure channel.This course covers the security measures in Windows and Linux operating systems. The course helps the learners to understand the various threats faced in the Internet and web services.

**Prerequisite:** Sound knowledge in Computer Networks.

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

| CO# | Course Outcomes |
|---|---|
| CO1 | Explainthe techniques for network protection and explore new tools and attacks in network security domain**(Cognitive Knowledge Level: Understand)** |
| CO2 | Identify the challenges, attacks and defences in Operating Systems.**(Cognitive Knowledge Level: Understand)** |
| CO3 | Summarize the basic functionalities of Windows and Linux Hardening**(Cognitive Knowledge Level: Understand)** |
| CO4 | Illustrate the characteristics and applications of cryptography and steganography principles.**(Cognitive Knowledge Level: Apply)** |
| CO5 | Explain the various attacks as well as security in Internet and Web services. **(Cognitive Knowledge Level: Understand)** |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | P10 | P11 | P12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 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** | Lifelong learning |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination Marks(%)** |
|---|---|---|---|
| | **Test1(%)** | **Test2(%)** | |
| 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. The first series test shall be preferably conducted after completing the first half of the syllabus. 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 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 a student should answer anyone. Each question can have maximum 2 sub-divisions and carries 14 marks.

## Syllabus

**Module-1 (Principles of Network Security)**
Network Security Terminologies, Network Security and Data Availability, Components of Network Security, Network Security Policies.
Network segments-Perimeter Defense, NAT, Basic architecture issues, Subnetting, Switching and VLANs, Address Resolution protocol and media access control, Dynamic Host Configuration Protocol and Addressing Control.

**Module-2(Windows Security)**
Windows Security at the heart of the defense, Out-ofthe-box Operating system hardening, Installing applications, Putting the workstation on the network, Operating Windows safely, Upgrades and Patches, Maintain and test the security, Attacks against the Windows workstation.
Linux Security- Physical security, Controlling the configuration, Operating Linux safely, Hardening Linux.

**Module-3 (Web Browser Security)**

Web Browser and Client risk- How a web browser works, Web browser attacks, Operating safely, Web security- How HTTP works, Server and Client contents, State, Attacking Web servers, Web Services. E-mail security- The e-mail risk, Protocols, Authentication, Operating safely when using email, Domain Name System – DNS basics, Purpose of DNS, Security Issues with DNS, DNS attacks.

**Module-4 (Cryptography and Steganography)**

Cryptography- Principles, four cryptographic primitives, Proprietary versus open source algorithms. Steganography - overview, Core areas of network security and their relation to steganography, Principles of Steganography, Types of Steganography, Steganography Versus Digital Watermarking, Types of Digital Watermarking, Goals of Digital Watermarking.

**Module-5 (Network Security)**

Security In Data Networks: Wireless Device security issues-GPRS security, GSM security, IP security. Wireless Transport Layer Security: Secure Socket Layer - Wireless Transport Layer Security - WAP Security Architecture - WAP Gateway.

Firewalls-types, rules, personal firewalls, Intrusion detection systems, responses to intrusion detection, Penetration testing, Auditing and Monitoring.

**Text Books**

1. Eric Cole, Ronald Krutz, James W. Conley, “Network Security Bible”, First Edition Wiley India Pvt Ltd, 2010
2. Michael A Whitman, Herbert J.Mattord, “Principles of Information Security”,Cengage Learning, Fourth Edition, 2016.

**References**

1. William Stallings, “Network Security Essentials”,Pearson Education, 4th Edition, 2011
2. Eric Maiwald, ”Fundamentals of Network Security”, Tata McGraw-Hill, 2011

**Sample Course Level Assessment Questions**

**CourseOutcome1(CO1):**A class B network on the internet has a subnet mask of 255.255.240.0. What is the maximum number of hosts per subnet?

**CourseOutcome2(CO2):** What are the different steps involved while hardening Windows and Linux OS?

**CourseOutcome3 (CO3):** Describe the basic request and response model in an HTTP session.

**CourseOutcome4 (CO4):**Explain the Insertion-based steganography, Algorithmic-based steganography and Grammar-based steganography.

**Course Outcome 5 (CO5):** What is tiered architecture in the perspective of firewalls?

**Model Question Paper**

**QP CODE:**
**Reg No:**_____
**Name :**_____ **PAGES : 3**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**
**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**
**Course Code: CCT 305**
**Course Name: Systems & Network Security**

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

**PART A**
**Answer all Questions. Each question carries 3 Marks**

1. What is Network Address Translation?
2. How can you create a VLAN environment?
3. Describe the steps to be followed before putting a workstation on any network?
4. What is Defense-in-depth methodology?
5. Explain the role of Web servers.
6. What is reverse lookup of DNS?
7. What are keyed hash functions?
8. Briefly explain the principles of steganography.
9. What are the disadvantages of firewalls?
10. Differentiate white-box, grey-box and black-box testing. **(10 x 3 = 30 Marks)**

**PART B**

**Answer any one Question from each module.**

**Each question carries 14 Marks**

11. a) Explain the principles of network security and network security policies. **(8 Marks)**
    b) Explain the different types of ARP. **(6 Marks)**

**OR**

12. a) What is DHCP and why it is used? **(8 Marks)**
    b) What are the different ways to protect a computer network? **(6 Marks)**

13. a) What are the steps to befollowed while putting a windows workstation on the network? **(8 Marks)**
    b) Why Linux is considered less attractive target for security attacks? **(6 Marks)**

**OR**

14. a) How can you prepare a UNIX workstation for the inevitable attack? **(8 Marks)**
    b) Briefly describe the general process of windows system hardening. **(6 Marks)**

15. a) Explain the working of HTTP with neat diagram? **(8 Marks)**
    b) What are the problems that are caused due to DNS misconfiguration? **(6 Marks)**

**OR**

16. a) Explain in detail account harvesting and SQL injection. **(6 Marks)**
    b) What do you mean by
    (i)Hijacking attack (ii) Replay attack (iii) Browser Parasites **(8 Marks)**

17. a) Explain the four cryptographic primitives. **(8 Marks)**
    b) Discuss the difference between proprietary and Open Source Algorithms. **(6 Marks)**

**OR**

18. a) What is Steganography, how does it differ from Digital Watermarking? **(8 Marks)**
    b) What are the different types of steganography? **(6 Marks)**

19. a) Describe the WAP architecture. **(8 Marks)**
    b) Explain the different types of firewall . **(6 Marks)**

**OR**

20. a) With a neat diagram explain the SSL handshaking protocol. **(8 Marks)**
    b) Draw the packet format of ESP and AH protocol. **(6 Marks)**

# TEACHING PLAN

| Sl.No. | Contents | No. of Lecture Hours |
|---|---|---|
| **Module-1(Principles of Network Security)( 7 hrs)** | | |
| 1.1 | Principles of Network Security, Network Security Terminologies | 1 hour |
| 1.2 | Network Security and Data Availability, | 1 hour |
| 1.3 | Components of Network Security, Network Security Policies | 1 hour |
| 1.4 | Network segments-Perimeter Defense, NAT | 1 hour |
| 1.5 | Basic architecture issues, Subnetting , switching and VLANs, | 1 hour |
| 1.6 | Address Resolution protocol and media access control, | 1 hour |
| 1.7 | Dynamic Host Configuration Protocol | 1 hour |
| **Module-2 (Windows Security)(10 hrs)** | | |
| 2.1 | Windows Security- Windows Security at the heart of the defense | 1 hour |
| 2.2 | Out-of the-box Operating system hardening | 1 hour |
| 2.3 | Installing applications | 1 hour |
| 2.4 | Putting the workstation on the network, Operating Windows safely | 1 hour |
| 2.5 | Upgrades and Patches | 1 hour |
| 2.6 | Maintain and test the security | 1 hour |
| 2.7 | Attacks against the Windows workstation | 1 hour |
| 2.8 | Linux Security- Physical security | 1 hour |

| | | |
|---|---|---|
| 2.9 | Controlling the configuration, Operating Linux safely | 1 hour |
| 2.10 | Hardening Linux | 1 hour |
| **Module-3 (Web Browser Security)(11 hrs)** | | |
| 3.1 | Components of Internet, Weak points of Internet, Techniques of Web Hacking | 1 hour |
| 3.2 | Methods of Attacking users. Web Browser and Client risk- | 1 hour |
| 3.3 | How a web browser works | 1 hour |
| 3.4 | Web browser attacks | 1 hour |
| 3.5 | Operating safely, Web security- How HTTP works | 1 hour |
| 3.6 | Server and Client contents | 1 hour |
| 3.7 | State, Attacking Web servers, Web Services | 1 hour |
| 3.8 | E-mail security- The e-mail risk | 1 hour |
| 3.9 | Protocols, Authentication | 1 hour |
| 3.10 | Operating safely when using email, Domain Name System – DNS basics | 1 hour |
| 3.11 | Purpose of DNS, Security Issues with DNS, DNS attacks. | 1 hour |
| **Module-4 (Cryptography and Steganography)( 8 hrs)** | | |
| 4.1 | Cryptography- Principles | 1 hour |
| 4.2 | four cryptographic primitives | 1 hour |
| 4.3 | Proprietary versus open source algorithms. Steganography - overview | 1 hour |
| 4.4 | Core areas of network security and their relation to steganography | 1 hour |

| | | |
|---|---|---|
| 4.5 | Principles of Steganography, Types of Steganography | 1 hour |
| 4.6 | Steganography Versus Digital Watermarking, | 1 hour |
| 4.7 | Types of Digital Watermarking | 1 hour |
| 4.8 | Goals of Digital Watermarking | 1 hour |
| **Module-5 (Network Security)( 9 hrs)** | | |
| 5.1 | Security In Data Networks: Wireless Device security issues | 1 hour |
| 5.2 | GPRS security | 1 hour |
| 5.3 | GSM security | 1 hour |
| 5.4 | Wireless Transport Layer Security: Secure Socket Layer | 1 hour |
| 5.5 | Wireless Transport Layer Security - WAP Security | 1 hour |
| 5.6 | WAP Security Architecture - WAP Gateway | 1 hour |
| 5.7 | Firewalls-types, rules, personal firewalls, | 1 hour |
| 5.8 | Intrusion detection systems, responses to intrusion detection | 1 hour |
| 5.9 | Penetration testing, Auditing and Monitoring | 1 hour |

| CCT307 | APPLIED CRYPTOGRAPHY | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| | | PCC | 3 | 1 | 0 | 4 |

**Preamble:** The course on Applied Cryptography aims at exploring various algorithms deployed in offering confidentiality, integrity and authentication and non-repudiation services. This course covers classical encryption techniques, symmetric and public key crypto-system, key exchange and management, and authentication functions. The concepts covered in this course enable the learners in effective use of cryptographic algorithms for real life applications.

**Prerequisite:** A sound background in foundations of security.

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

| | |
|---|---|
| **CO1** | Explain the concepts of security and different types of attacks. (**Cognitive Knowledge Level: Understand**) |
| **CO2** | Discussthe key management techniques and message authentication functions for a secure communication.(**Cognitive Knowledge Level: Understand)** |
| **CO3** | Summarize the classical encryption techniques for information hiding.(**Cognitive Knowledge Level: Understand**) |
| **CO4** | Illustrate symmetric/asymmetric key cryptographic algorithms for secure communication. (**Cognitive Knowledge Level: Apply)** |
| **CO5** | Illustrate authentication algorithms for secure communication.(**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 teamwork |
| **PO4** | Conduct investigations of complex problems | **PO10** | Communication |
| **PO5** | Modern tool usage | **PO11** | Project Management and Finance |
| **PO6** | The Engineer and Society | **PO12** | Lifelong learning |

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination Marks(%)** |
|---|---|---|---|
| | **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 | 3hours |

**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 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 anyone. Each question can have a maximumof 2 subdivisions and carries14 marks.

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

**Syllabus**

**Module -1(Basic Concepts of Cryptography)**

Attacks on Computers and Computer Security-Introduction, The need for security, Security approaches, Principles of security, Types of Security attacks, Security services, Security Mechanisms.

Cryptography: Concepts and Techniques-Introduction, plaintext and cipher text, substitution techniques, transposition techniques, encryption and decryption, symmetric and asymmetric key cryptography, stenography, key range and key size, possible types of attacks.

**Module-2 (Symmetric and Asymmetric Cryptography)**

Symmetric key Ciphers-Block Cipher principles & Algorithms (DES, AES, Blowfish),Differential and Linear Cryptanalysis, Block cipher modes of operation, Stream ciphers,RC4,Location and placement of encryption function, Key distribution.

Asymmetric key Ciphers- Principles of public key cryptosystems, Public key Infrastructure, Algorithms (RSA, Diffie-Hellman, ECC), Key Distribution.

**Module-3 (Message Authentication Algorithms)**

Message Authentication Algorithms and Hash Functions- Authentication requirements, Authentication functions, Message authentication codes (MAC), Hash functions, Security of Hash functions and MAC, Message Digest 5 (MD5), Secure Hash Algorithm (SHA)-512, Hash-based Message Authentication Code (HMAC), Cipher-based Message Authentication Code (CMAC), X.509 Authentication services.

**Module-4(Cryptographic Applications)**

Authentication Applications- Kerberos, X.509 Authentication Service, Public – Key Infrastructure, Biometric Authentication, Multi factor Authentication.
Cryptographic Protocols-Types of protocols, Trust and computation, Validating Cryptographic protocols and attacks.Digital Signatures and Certificates-Digital Signatures, Digital Certificates,PKI and Certificate Authorities.

**Module -5(Applications of Cryptography)**

User authentication- password, challenge-response and zero-knowledge protocols, server authentication; application secure online banking; digital cash, application keeping/storing secrets, block chain, application crypto currencies, implementation aspects: weakest key, key modularity, key management in cryptography, clear text cryptography.

Quantum computing, quantum-resistant cryptography, implementation aspects: creating correct and secure programs, quality of code, side-channel attacks, implementation flaws, Quantum safe cryptography, Cloud security.

**Text Books**

1. William Stallings, “Cryptography and Network Security Principles and Practice”, Pearson Education, 6th Edition, 2013.
2. BruiceSchneier, “Applied Cryptography Protocols, Algorithms and source code in C”, JohnWiley,2nd Edition,1995.

**References**

1. Behrouz A. Forouzan,“Cryptography and Network Security”, McGraw Hill, 2nd Edition, 2010.
2. Hans Delfs and HelmutKnebl, “Introduction to Cryptography: Principles and Applications”, 2nd Edition, 2007.
3. Douglas R and Stinson, “Cryptography Theory and Practice”, Chapman & Hall/CRC, 3rd Edition, 2006.
4. Bernard Menezes, “Network Security and Cryptography”, Cengage Learning, First Edition, 2010
5. Jonathan Katz, Yehuda Lindell, “Introduction to Modern Cryptography”, Chapman and Hall/CRC, First Edition,2007.

**Sample Course Level Assessment Questions**

**Course Outcome1 (CO1):**

1. Consider an automated teller machine (ATM) in which users provide a personal identification number (PIN) and a card for account access. Give examples of confidentiality, integrity, and availability requirements associated with the system and, in each case, indicate the degree of importance of the requirement.

**Course Outcome2 (CO2):**

1. The encryption key in a transposition cipher is (3,2,6,1,5,4). Find the decryption key.

**Course Outcome3 (CO3):**

1. Consider the following elliptic curve signature scheme. We have a global elliptic curve, prime *p*, and "generator" G. Alice picks a private signing key $X_A$ and forms the public verifying $Y_A = X_AG$. To sign a message *M*:
    - Alice picks a value k
    - Alice sends Bob *M*, k and the signature $S = M - kX_AG$.
    - Bob verifies that $M=S+kY_A$.

   Show that the verification process produces equality if the signature is valid.

**Course Outcome4 (CO4):**

1. How can a message encrypted with the Public Key be decrypted with the receiver's appropriate Private Key?

**Course Outcome 5 (CO5):**

1. State the value of the length field in SHA-512 if the length of the message is 1919 bits and 1920 bits.

**Model Question Paper**

CSE(CYBER SECURITY)

**QP CODE:**

**Reg No:_____**

**Name :_____** **PAGES : 2**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**

**Course Code: CCT 307**

**Course Name: APPLIED CRYPTOGRAPHY**

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

**PART A**

**Answer all Questions. Each question carries 3 marks.**

1. State the two approaches in attacking a cipher.
2. Compare Substitution and Transposition techniques.
3. Write down the purpose of S-Boxes in Data Encryption Standard (DES).
4. What is diffusion and confusion?
5. Perform encryption and decryption using RSA Algorithm for the following $p$=7; $q$=11; $e$=17; $M$=8.
6. Is Diffie-Hellman key exchange protocol vulnerable? Justify.
7. What is symmetric key distribution?
8. List the components of Public Key Infrastructure.
9. Define the classes of Message Authentication Function.
10. When a combination of symmetric encryption and an error control code is used for message authentication, in what order must the two functions be performed?

**(10 x 3 = 30 Marks)**

**PART B**

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

11. a) With a neat sketch, Explain OSI Security architecture model. **(8 Marks)**
    b) How does link encryption differ from end-to-end encryption? Explain. **(6 Marks)**

**OR**

12. a) Encrypt the message “meet me at the usual place at ten rather than eight o’clock” using the Hill Cipher with the key $\begin{pmatrix} 9 & 4 \\ 5 & 7 \end{pmatrix}$.Show the calculations. **(8 Marks)**
    b) State the steps involved in encrypting a plain text using playfair cipher. **(6 Marks)**

13. a) Explain in detail the block cipher modes of operation. **(8 Marks)**
    b) Explain Stream ciphers. **(6 Marks)**

**OR**

14. a) Compare the substitution method in DES and AES. **(7 Marks)**
    b) Why do we need only one substitution table in AES, but several in DES? **(7 Marks)**

15. a) Explain about Hash based Message Authentication Code. **(7 Marks)**
    b) Explain about Cipher based Message Authentication Code . **(7 Marks)**

**OR**

16. a) User A and B use the Diffie Hellman key exchange technique with a common prime q=71 and primitive root alpha=7,
    i. If user A has private key $X_A$ =3, What is A's public key $Y_A$
    ii. If user B has private key $X_B$ =6, What is A's public key $Y_B$ **(10 Marks)**
    b) Explain about various Authentication requirements and functions **(4 Marks)**

17. a) Explain the problems with key management and how it affects symmetric cryptography. **(7 Marks)**
    b) How the process of Cryptographic Protocols and attacks can be validated? **(7 Marks)**

**OR**

18. a) Describe the following
    (i) Updating keys **(3 Marks)**
    (ii) Compromised Keys **(3 Marks)**
    b) What are the core components of a PKI? Describe each component. **(8Marks)**

19. a) Describe how Quantum Computing can be applied in Cloud Security. **(7 Marks)**
    b) Explain about Block chain and Crypto currencies. **(7 Marks)**

**OR**

20. a) Write the format for X.509 certificate. How are user's certificates obtained? **(6 Marks)**
    b) With Suitable diagram, explain the types of functions that may be used to produce an authenticator. **(8 Marks)**

**TEACHING PLAN**

| No. | Contents | No. of Lecture Hrs |
|---|---|---|
| **Module-1 (Basic Concepts of Cryptography) (9hrs)** | | |
| 1.1 | Introduction, Need for Security, Security Approaches, Principles of Security. | 1 |
| 1.2 | Types of Security Attacks, Security Services, Security Mechanisms | 1 |
| 1.3 | OSI Security Architecture | 1 |
| 1.4 | Introduction, plain text and cipher text, Encryption and Decryption. | 1 |
| 1.5 | Classical Encryption Techniques: Substitution Techniques | 1 |
| 1.6 | Classical Encryption Techniques: Transposition Techniques | 1 |
| 1.7 | Stream Cipher, Block Cipher, Public- key cryptosystems vs. Symmetric key cryptosystems | 1 |
| 1.8 | Encrypting Communication channels | 1 |
| 1.9 | Stenography, Key range and Key size, Possible types of Attacks. | 1 |
| **Module-2(Symmetric and Asymmetric Cryptography)(12hrs)** | | |
| 2.1 | Overview of symmetric key cryptography | 1 |
| 2.2 | Block Cipher Principles | 1 |
| 2.3 | Data Encryption Standard (DES) | 1 |
| 2.4 | Differential and Linear Cryptanalysis | 1 |
| 2.5 | Double DES, Triple DES | 1 |
| 2.6 | Advanced Encryption Algorithm (AES) | 1 |
| 2.7 | Block Cipher modes of Operation | 1 |
| 2.8 | Stream Cipher, RC4 | 1 |

| | | |
|---|---|---|
| 2.9 | Location and placement of encryption function, Key distribution | 1 |
| 2.10 | RSA Algorithm | 1 |
| 2.11 | Diffie-Hellman Key Exchange Algorithm | 1 |
| 2.12 | Elliptical Curve Cryptosystems | 1 |
| **Module-3 (Message Authentication Algorithms)(8 hrs)** | | |
| 3.1 | Authentication requirements, Authentication functions | 1 |
| 3.2 | Message authentication codes (MAC), Hash functions | 1 |
| 3.3 | Security of Hash functions and MAC | 1 |
| 3.4 | Message Digest 5 (MD5) | 1 |
| 3.5 | Hash-based Message Authentication Code (HMAC) | 1 |
| 3.6 | Secure Hash Algorithm (SHA)-512 | 1 |
| 3.7 | Cipher-based Message Authentication Code (CMAC) | 1 |
| 3.8 | X.509 Authentication services | 1 |
| **Module-4(Cryptographic Applications)(8 hrs)** | | |
| 4.1 | Authentication Applications: Kerberos, X.509 Authentication Service. | 1 |
| 4.2 | Public – Key Infrastructure, | 1 |
| 4.3 | Biometric Authentication, Multi factor Authentication. | 1 |
| 4.4 | Validating Cryptographic protocols and attacks. | 1 |
| 4.5 | Types of protocols, Trust and computation | 1 |
| 4.6 | Digital Signatures, Digital Certificates, | 1 |
| 4.7 | PKI and Certificate Authorities | 1 |
| 4.8 | Public Key Infrastructure | 1 |
| **Module-5(Applications of Cryptography)(8hrs)** | | |

| | | |
|---|---|---|
| 5.1 | User authentication : password, challenge-response and zero-authentication | 1 |
| 5.2 | Application secure online banking; digital cash | 1 |
| 5.3 | Application keeping/storing secrets, block chain, | 1 |
| 5.4 | Application crypto currencies; implementation aspects: weakest key, | 1 |
| 5.5 | key modularity, key management in cryptography, clear text cryptography | 1 |
| 5.6 | Quantum computing, quantum-resistant cryptography; | 1 |
| 5.7 | Implementation aspects,creating correct and secure programs, quality of code | 1 |
| 5.8 | Quantum safe cryptography. Cloud security. | 1 |

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY
KTU
Estd.
2014

| CST 309 | MANAGEMENT OF SOFTWARE SYSTEMS | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| | | PCC | 3 | 0 | 0 | 3 | 2019 |

**Preamble**: This course provides fundamental knowledge in the Software Development Process. It covers Software Development, Quality Assurance, Project Management concepts and technology trends. This course enables the learners to apply state of the art industry practices in Software development.

**Prerequisite**: Basic understanding of Object Oriented Design and Development.

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

| | |
|---|---|
| CO1 | Demonstrate Traditional and Agile Software Development approaches **(Cognitive Knowledge Level: Apply)** |
| CO2 | Prepare Software Requirement Specification and Software Design for a given problem. **(Cognitive Knowledge Level**: **Apply**) |
| CO3 | Justify the significance of design patterns and licensing terms in software development, prepare testing, maintenance and DevOps strategies for a project. **(Cognitive Knowledge Level: Apply**) |
| CO4 | Make use of software project management concepts while planning, estimation, scheduling, tracking and change management of a project, with a traditional/agile framework**. (Cognitive Knowledge Level: Apply**) |
| CO5 | Utilize SQA practices, Process Improvement techniques and Technology advancements in cloud based software models and containers & microservices. **(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 | ✓ | ✓ | ✓ | ✓ | | ✓ | | | | | | ✓ |

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

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination Marks |
|---|---|---|---|
| | Test1 (Percentage) | Test2 (Percentage) | |
| Remember | **30** | **30** | **30** |
| Understand | **40** | **40** | **50** |
| Apply | **30** | **30** | **20** |
| 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** ( Each student shall identify a software development problem and prepare Requirements Specification, Design Document, Project Plan and Test case documents for the identified problem as the assignment. )

**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 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 a maximum of 2 subdivisions and carries 14 marks.

**Syllabus**

**Module 1 : Introduction to Software Engineering (7 hours)**

Introduction to Software Engineering - Professional software development, Software engineering ethics. Software process models - The waterfall model, Incremental development. Process activities - Software specification, Software design and implementation, Software validation, Software evolution. Coping with change - Prototyping, Incremental delivery, Boehm's Spiral Model. Agile software development - Agile methods, agile manifesto - values and principles. Agile development techniques, Agile Project Management. Case studies : An insulin pump control system. Mentcare - a patient information system for mental health care.

**Module 2 : Requirement Analysis and Design (8 hours)**

Functional and non-functional requirements, Requirements engineering processes. Requirements elicitation, Requirements validation, Requirements change, Traceability Matrix. Developing use cases, Software Requirements Specification Template, Personas, Scenarios, User stories, Feature identification. Design concepts - Design within the context of software engineering, Design Process, Design concepts, Design Model. Architectural Design - Software Architecture, Architectural Styles, Architectural considerations, Architectural Design Component level design - What is a component?, Designing Class-Based Components, Conducting Component level design, Component level design for web-apps. Template of a Design Document as per “IEEE Std 1016-2009 IEEE Standard for Information Technology Systems Design Software Design Descriptions”. Case study: The Ariane 5 launcher failure.

**Module 3 : Implementation and Testing (9 hours)**

Object-oriented design using the UML, Design patterns, Implementation issues, Open-source development - Open-source licensing - GPL, LGPL, BSD. Review Techniques - Cost impact of Software Defects, Code review and statistical analysis. Informal Review, Formal Technical Reviews, Post-mortem evaluations. Software testing strategies - Unit Testing, Integration Testing, Validation testing, System testing, Debugging, White box testing, Path testing, Control Structure testing, Black box testing, Testing Documentation and Help facilities. Test automation, Test-driven development, Security testing. Overview of DevOps and Code Management - Code management, DevOps automation, Continuous Integration, Delivery, and Deployment (CI/CD/CD). Software Evolution - Evolution processes, Software maintenance.

**Module 4 : Software Project Management (6 hours)**

Software Project Management - Risk management, Managing people, Teamwork. Project Planning, Software pricing, Plan-driven development, Project scheduling, Agile planning. Estimation techniques, COCOMO cost modeling. Configuration management, Version management, System building, Change management, Release management, Agile software management - SCRUM framework. Kanban methodology and lean approaches.

**Module 5 : Software Quality, Process Improvement and Technology trends (6 hours)**

Software Quality, Software Quality Dilemma, Achieving Software Quality Elements of Software Quality Assurance, SQA Tasks , Software measurement and metrics. Software Process Improvement(SPI), SPI Process CMMI process improvement framework, ISO 9001:2000 for Software. Cloud-based Software - Virtualisation and containers, Everything as a service(IaaS, PaaS), Software as a service. Microservices Architecture - Microservices, Microservices architecture, Microservice deployment.

**Text Books**

1. Book 1 - Ian Sommerville, Software Engineering, Pearson Education, Tenth edition, 2015.
2. Book 2 - Roger S. Pressman, Software Engineering : A practitioner’s approach, McGraw Hill publication, Eighth edition, 2014
3. Book 3 - Ian Sommerville, Engineering Software Products: An Introduction to Modern Software Engineering, Pearson Education, First Edition, 2020.

**References**

1. IEEE Std 830-1998 - IEEE Recommended Practice for Software Requirements SpeciÞcations
2. IEEE Std 1016-2009 IEEE Standard for Information Technology—Systems Design—Software Design Descriptions

3. David J. Anderson, Kanban, Blue Hole Press 2010
4. David J. Anderson, Agile Management for Software Engineering, Pearson, 2003
5. Walker Royce, Software Project Management : A unified framework, Pearson Education, 1998
6. Steve. Denning, The age of agile, how smart companies are transforming the way work gets done. New York, Amacom, 2018.
7. Satya Nadella, Hit Refresh: The Quest to Rediscover Microsoft's Soul and Imagine a Better Future for Everyone, Harper Business, 2017
8. Henrico Dolfing, Project Failure Case Studies: Lessons learned from other people's mistakes, Kindle edition
9. Mary Poppendieck, Implementing Lean Software Development: From Concept to Cash, Addison-Wesley Signature Series, 2006
10. StarUML documentation - https://docs.staruml.io/
11. OpenProject documentation - https://docs.openproject.org/
12. BugZilla documentation - https://www.bugzilla.org/docs/
13. GitHub documentation - https://guides.github.com/
14. Jira documentation - https://www.atlassian.com/software/jira

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. What are the advantages of an incremental development model over a waterfall model?
2. Illustrate how the process differs in agile software development and traditional software development with a socially relevant case study. (Assignment question)

**Course Outcome 2 (CO2):**

1. How to prepare a software requirement specification?
2. Differentiate between Architectural design and Component level design.
3. How does agile approaches help software developers to capture and define the user requirements effectively?
4. What is the relevance of the SRS specification in software development?
5. Prepare a use case diagram for a library management system.

**Course Outcome 3 (CO3):**

1. Differentiate between the different types of software testing strategies.
2. Justify the need for DevOps practices?
3. How do design patterns help software architects communicate the design of a complex system effectively?

4. What are the proactive approaches one can take to optimise efforts in the testing phase?

**Course Outcome 4 (CO4):**

1. Illustrate the activities involved in software project management for a socially relevant problem?
2. How do SCRUM, Kanban and Lean methodologies help software project management?
3. Is rolling level planning in software project management beneficial? Justify your answer.
4. How would you assess the risks in your software development project? Explain how you can manage identified risks?

**Course Outcome 5 (CO5):**

1. Justify the importance of Software Process improvement?
2. Explain the benefits of cloud based software development, containers and microservices.
3. Give the role of retrospectives in improving the software development process.
4. Illustrate the use of project history data as a prediction tool to plan future socially relevant projects.

**Model Question Paper**

**QP CODE:**
**Reg No:_____**
**Name :_____** **PAGES : 3**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**
**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**
**Course Code: CST 309**
**Course Name: Management of Software Systems**

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

**PART A**
**Answer all Questions. Each question carries 3 marks**

1. Why professional software that is developed for a customer is not simply the programs that have been developed and delivered.
2. Incremental software development could be very effectively used for customers who do not have a clear idea about the systems needed for their operations. Justify.
3. Identify any four types of requirements that may be defined for a software system
4. Describe software architecture
5. Differentiate between GPL and LGPL?
6. Compare white box testing and black box testing.
7. Specify the importance of risk management in software project management?
8. Describe COCOMO cost estimation model.
9. Discuss the software quality dilemma
10. List the levels of the CMMI model? **(10x3=30)**

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

11. (a) Compare waterfall model and spiral model **(8)**

(b) Explain Agile ceremonies and Agile manifesto **(6)**

12. (a) Illustrate software process activities with an example. **(8)**

(b) Explain Agile Development techniques and Agile Project Management **(6)**

13. (a) What are functional and nonfunctional requirements? Imagine that you are developing a library management software for your college, list eight functional requirements and four nonfunctional requirements. **(10)**

(b) List the components of a software requirement specification? **(4)**

**OR**

14. (a) Explain Personas, Scenarios, User stories and Feature identification? **(8)**

(b) Compare Software Architecture design and Component level design **(6)**

15. (a) Explain software testing strategies. **(8)**

(b) Describe the formal and informal review techniques. **(6)**

**OR**

16. (a) Explain Continuous Integration, Delivery, and Deployment CI/CD/CD) **(8)**

(b) Explain test driven development **(6)**

17. (a) What is a critical path and demonstrate its significance in a project schedule with the help of a sample project schedule. **(8)**

(b) Explain plan driven development and project scheduling. **(6)**

**OR**

18. (a) Explain elements of Software Quality Assurance and SQA Tasks. **(6)**

(b) What is algorithmic cost modeling? What problems does it suffer from when **(8)**

compared with other approaches to cost estimation?

19. (a) Explain elements of Software Quality Assurance and SQA Tasks. **(8)**

(b) Illustrate SPI process with an example. **(6)**

**OR**

20. (a) Compare CMMI and ISO 9001:2000. **(8)**

(b) How can Software projects benefit from Container deployment and Micro service deployment? **(6 )**

**Teaching Plan**

| No | Contents | No of Lecture Hrs |
|---|---|---|
| **Module 1 : Introduction to Software Engineering (7 hours)** | | |
| 1.1 | Introduction to Software Engineering.[ Book 1, Chapter 1] | 1 hour |
| 1.2 | Software process models [Book 1 - Chapter 2] | 1 hour |
| 1.3 | Process activities [Book 1 - Chapter 2] | 1 hour |
| 1.4 | Coping with change [Book 1 - Chapter 2, Book 2 - Chapter 4] | 1 hour |
| 1.5 | Case studies : An insulin pump control system. Mentcare - a patient information system for mental health care. [Book 1 - Chapter 1] | 1 hour |
| 1.6 | Agile software development [Book 1 - Chapter 3] | 1 hour |
| 1.7 | Agile development techniques, Agile Project Management.[Book 1 - Chapter 3] | 1 hour |
| **Module 2 : Requirement Analysis and Design (8 hours)** | | |
| 2.1 | Functional and non-functional requirements, Requirements engineering processes [Book 1 - Chapter 4] | 1 hour |
| 2.2 | Requirements elicitation, Requirements validation, Requirements change, Traceability Matrix [Book 1 - Chapter 4] | 1 hour |
| 2.3 | Developing use cases, Software Requirements Specification Template [Book 2 - Chapter 8] | 1 hour |

| | | |
|---|---|---|
| 2.4 | Personas, Scenarios, User stories, Feature identification [Book 3 - Chapter 3] | 1 hour |
| 2.5 | Design concepts [Book 2 - Chapter 12] | 1 hour |
| 2.6 | Architectural Design [Book 2 - Chapter 13] | 1 hour |
| 2.7 | Component level design [Book 2 - Chapter 14] | 1 hour |
| 2.8 | Design Document Template. Case study: The Ariane 5 launcher failure. [Ref - 2, Book 2 - Chapter 16] | 1 hour |
| **Module 3 : Implementation and Testing (9 hours)** | | |
| 3.1 | Object-oriented design using the UML, Design patterns [Book 1 - Chapter 7] | 1 hour |
| 3.2 | Implementation issues, Open-source development - Open-source licensing - GPL, LGPL, BSD [Book 1 - Chapter 7] | 1 hour |
| 3.3 | Review Techniques - Cost impact of Software Defects, Code review and statistical analysis. [Book 2 - Chapter 20] | 1 hour |
| 34 | Informal Review, Formal Technical Reviews, Post-mortem evaluations. [Book 2 - Chapter 20] | 1 hour |
| 3.5 | Software testing strategies - Unit Testing, Integration Testing, Validation testing, System testing and Debugging (basic concepts only). [Book 2 - Chapter 22] | 1 hour |
| 3.6 | White box testing, Path testing, Control Structure testing, Black box testing. Test documentation [Book 2 - Chapter 23] | 1 hour |
| 3.7 | Test automation, Test-driven development, Security testing. [Book 3 - Chapter 9] | 1 hour |
| 3.8 | DevOps and Code Management - Code management, DevOps automation, CI/CD/CD. [Book 3 - Chapter 10] | 1 hour |
| 3.9 | Software Evolution - Evolution processes, Software maintenance. [Book 1 - Chapter 9] | 1 hour |
| **Module 4 : Software Project Management (6 hours)** | | |
| 4.1 | Software Project Management - Risk management, Managing people, Teamwork [Book 1 - Chapter 22] | 1 hour |
| 4.2 | Project Planning - Software pricing, Plan-driven development, Project scheduling, Agile planning [Book 1 - Chapter 23] | 1 hour |
| 4.3 | Estimation techniques [Book 1 - Chapter 23] | 1 hour |
| 4.4 | Configuration management [Book 1 - Chapter 25] | 1 hour |

| | | |
|---|---|---|
| 4.5 | Agile software management - SCRUM framework [Book 2 - Chapter 5] | 1 hour |
| 4.6 | Kanban methodology and lean approaches.[Ref 9 - Chapter 2] | 1 hour |
| **Module 5 : Software Quality, Process Improvement and Technology trends (6 hours)** | | |
| 5.1 | Software Quality, Software Quality Dilemma, Achieving Software Quality. [Book 2 - Chapter 19] | 1 hour |
| 5.2 | Elements of Software Quality Assurance, SQA Tasks , Software measurement and metrics. [Book 3 - Chapter 21] | 1 hour |
| 5.3 | Software Process Improvement (SPI), SPI Process [Book 2 - Chapter 37] | 1 hour |
| 5.4 | CMMI process improvement framework, ISO 9001:2000 for Software. [Book 2 - Chapter 37] | 1 hour |
| 5.5 | Cloud-based Software - Virtualisation and containers, IaaS, PaaS, SaaS.[Book 3 - Chapter 5] | 1 hour |
| 5.6 | Microservices Architecture - Microservices, Microservices architecture, Microservice deployment [Book 3 - Chapter 6] | 1 hour |

| CCL331 | CRYPTOGRAPHY LAB | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| | | PCC | 0 | 0 | 4 | 2 |

**Preamble**: The aim of the Course is to give practical exposure on basic security attacks, encryption algorithms, and authentication techniques.

**Prerequisite:** Sound knowledge inApplied Cryptography and programming in C/ Java.

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

| | |
|---|---|
| **CO1** | Use the different cipher techniques for securing information(**Cognitive Knowledge Level: Apply**) |
| **CO2** | Familiarize symmetric and asymmetric cryptography. (**Cognitive Knowledge Level: Apply**) |
| **CO3** | Demonstrate cryptographic principles and its applications. **(Cognitive Knowledge Level: Apply)** |
| **CO4** | Explain various approaches to Encryption techniques and message Authentication Codes. (**Cognitive Knowledge Level: Apply**) |
| **CO5** | Implement the algorithms DES,RSA(**Cognitive Knowledge Level: Apply**) |
| **CO6** | Write a program using linked lists to simulate Memory Allocation and Garbage Collection(**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 teamwork |
| **PO4** | Conduct investigations of complex problems | **PO10** | Communication |
| **PO5** | Modern tool usage | **PO11** | Project Management and Finance |
| **PO6** | The Engineer and Society | **PO12** | Lifelong learning |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Test(Internal Exam) (%) | End Semester Examination (%) |
|---|---|---|
| Remember | 20 | 20 |
| Understand | 20 | 20 |
| Apply | 60 | 60 |
| Analyze | | |
| Evaluate | | |
| Create | | |

**Mark Distribution**

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

**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, Program20 marks, Output 20 marks and Viva 30 marks. Total 100 marks which will be converted out of 75 while calculating Internal Evaluation marks.

**End Semester Examination Pattern:**

The marks will be distributed as Algorithm 30 marks, Program 20 marks, Output 20 marks and Viva 30 marks. Total 100 marks will be converted out of 75 for End Semester Examination.
Operating System to Use in Lab :Linux

**Compiler/Software to Use in Lab:**gcc
**Programming Language to Use in Lab :**Ansi C and Java

**Fair Lab Record**:

All Students attending the 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 Experiment, Data Structure used 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 the experiment and sample output obtained for a set of input.

**Syllabus**

*mandatory

1. Represent a string (char pointer) with a value “Hello world”. The program should XOR each character in this string with 0 and displays the result.*
2. Represent string (char pointer) with a value “Hello world” The program should AND or and XOR each character in this string with 127and display the result.
3. Perform encryption and decryption using the following algorithms*
    a. Ceaser cipher b. Substitution cipher c. Hill Cipher
4. Implementation of Encryption and Decryption using DES*
5. Implementation of RSA Encryption Algorithm
6. Implementation of Hash Functions*
7. Implementation of Blowfish algorithm logic*
8. Implement the Diffie-Hellman Key Exchange mechanism

9. Implement RC4 logic using Java*
10. Encrypt the text “Hello world” using Blowfish.
11. Implement the SIGNATURE SCHEME –Digital Signature Standard*

**PRACTICE QUESTIONS**

1. Write a C program that contains a string (char pointer) with a value”Helloworld”. The program should XOR each character in this string with 0 and displays the result.
2. Write a C program that contains a string (char pointer) with a value „Hello world“. The program should AND or and XOR each character in this string with 127 and display the result.
3. Write a Java program to perform encryption and decryption using the following algorithms
   a.Caeser cipher b. Substitution cipher c.Hill Cipher
4. Write a C/JAVA program to implement DES Encryption and Decryption
5. Write a C/JAVA program to implement RSA Encryption Algorithm
6. Write a C/JAVA program to implementation of Hash Functions.
7. Write a C/JAVA program to implement the Blowfish algorithm logic.
8. Write the RC4 logic in Java Using Java cryptography; encrypt the text Hello world using Blowfish. Create your own key using Java key tool.
9. Write a C/JAVA program to implement the Diffie-Hellman Key Exchange mechanism
10. Implement the SIGNATURE SCHEME –Digital Signature Standard

| CCL333 | SYSTEM AND NETWORK SECURITY LAB | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| | | PCC | 0 | 0 | 4 | 2 |

**Preamble**: The course aims to offerstudents a hands-on experience on network related commands and configuration files in Linux operating system. This course also introduces tools for network traffic analysis and network monitoring and also provides hands-on experience in tools used in security.

**Prerequisite**: C programming, Operating Systems and Computer Networks.

**Course Outcomes**: Attheendofthe course thestudent will beableto

| | |
|---|---|
| **CO1** | Familiarize tools to prevent latest threats**(CognitiveKnowledge Level :Understand)** |
| **CO2** | Analyze the network traffic using sniffing tools.**(Cognitive Knowledge Level :Apply)** |
| **CO3** | Use network scanning tools**(Cognitive Knowledge Level :Apply)** |
| **CO4** | Familiarize various Steganography tools**(Cognitive Knowledge Level :Understand)** |
| **CO5** | Usetools for Penetration testing**(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 | EngineeringKnowledge | PO7 | EnvironmentandSustainability |
| PO2 | ProblemAnalysis | PO8 | Ethics |
| PO3 | Design/Developmentofsolutions | PO9 | Individualandteamwork |
| PO4 | Conduct investigations of complexproblems | PO10 | Communication |
| PO5 | Moderntoolusage | PO11 | ProjectManagementandFinance |
| PO6 | TheEngineerandSociety | PO12 | Lifelong learning |

**Assessment Pattern:**

| Bloom's Category | Continuous Assessment Test(Internal Exam) Marks inpercentage | EndSemesterExamination Marksinpercentage |
|---|---|---|
| Remember | 20 | 20 |
| Understand | 20 | 20 |
| Apply | 60 | 60 |
| Analyze | | |
| Evaluate | | |
| Create | | |

**Mark Distribution:**

| TotalMarks | CIE Marks | ESE Marks | ESE Duration |
|---|---|---|---|
| 150 | 75 | 75 | 3hours |

**Continuous Internal Evaluation Pattern**:

Attendance : 15
Continuous Evaluation in Lab : 30
ContinuousAssessmentTest : 15
VivaVoce : 15

**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 beconvertedout of 15 whilecalculating 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 :AnsiC

**Fair Lab Record:**

All Students attending the System and Network Security 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 codeusedfor experiment and sampleoutput obtained for a set of input.

**Syllabus**

**SYSTEM & NETWORK SECURITYLAB**

* mandatory

1. Preventing PC against latest threats using Windows Defender*.
2. Protecting PC using Microsoft Security Essentials*.
3. Steganographic Tools*
4. Website mirroring using HTTrack*
5. Monitoring Live Network capturing packets and analyzing over the live network using Wireshark*
6. Network discovery and security auditing with nmap.*
7. Password Guessing and Password cracking*
8. Port Scanning using Superscan
9. Monitoring Network Communication: Working with Trojans, Backdoors and

sniffer*

10. Penetration testing and justification of penetration testing through risk analysis
11. Vulnerability Scanning*
12. Monitoring Network Communication: Working with Trojans, Backdoors and sniffer*

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**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 turn around time.
5. Write a C program to simulate following non-preemptive CPU scheduling algorithms to find turn a round time and waiting time.

   a) FCFS b)SJF c)Round Robin(pre-emptive) d)Priority
6. Write a program to prevent PC against latest threats using Windows Defender.
7. Write a program to Protect PC using Microsoft Security Essentials.
8. a) View the configuration, including addresses of your computers network interfaces.
   b) Test the network connectivity between your computer and several other computers.
   c) View the active TCP connections in the computer after visiting a website.
   d) Find the hardware/MAC address of another computer in the network using ARP.
9. Write a program to implement Client-Server communication using Socket Programming and TCP as transport layerprotocol.
10. Write a program to implement Client-Server communication using Socket Programming and UDP as transport layerprotocol.
11. Write a program to implement a multi user chat server using TCP as transport layer protocol.
12. Write a program to implement a simple web proxy server that accepts HTTP requests and forwardingto remote servers and returning data to the client using TCP.
13. Write a program to implement Concurrent Time Server application using UDP to execute the program at remote server. Client sends a time request to the server; server

sends its system time back to the client. Client displays the result.

14. Write a program to implement Simple Mail Transfer Protocol.
15. Develop concurrent file server which will provide the file requested by client if it exists. If not server sends appropriate message to the client. Server should also send its process ID (PID) to clients for display along with file or the message.
16. Develop a packet capturing and filtering application using raw sockets.
17. Design and configure a network with multiple subnets with wired and wireless LANs using required network devices. Configure the following services in the network- TELNET, SSH, FTP server, Web server, File server, DHCP server and DNS server.

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KTU
Estd.
2014

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# SEMESTER V

## MINOR

KTU
Estd.
2014

| CST 381 | CONCEPTS IN SOFTWARE ENGINEERING | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| | | VAC | 3 | 1 | 0 | 4 | 2019 |

**Preamble**: This course provides fundamental knowledge in the Software Development Process. It covers Software Development, Quality Assurance and Project Management concepts. This course enables the learners to apply state of the art industry practices in Software development.
**Prerequisite**: Basic understanding of Object Oriented Design and Development.

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

| | |
|---|---|
| **CO1** | Differentiate Traditional and Agile Software Development approaches **(Cognitive Knowledge Level: Understand)** |
| **CO2** | Prepare Software Requirement **Specification** and Software Design for a given problem. **(Cognitive Knowledge Level: Apply)** |
| **CO3** | Justify the significance of design patterns and licensing terms in software development, prepare testing, maintenance and DevOps strategies for a project. **(Cognitive Knowledge Level: Apply)** |
| **CO4** | Make use of software project management concepts while planning, estimation, scheduling, tracking and change management of a project, with proper application of SCRUM, Kanban and Lean frameworks. (**Cognitive Knowledge Level: Apply**) |
| **CO5** | Utilize SQA practices, Process Improvement techniques and Technology improvements **namely** cloud based software model and containers & microservices in a Software Development Process. (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** | ✓ | ✓ | ✓ | ✓ | | ✓ | | | | | | ✓ |

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

**Assessment Pattern**

| **Bloom's Category** | **Continuous Assessment Tests** | | **End Semester Examination Marks** |
|---|---|---|---|
| | **Test1 (Percentage)** | **Test2 (Percentage)** | |
| **Remember** | **30** | **30** | **30** |
| **Understand** | **30** | **30** | **30** |

| | | | |
|---|---|---|---|
| **Apply** | **40** | **40** | **40** |
| **Analyse** | | | |
| **Evaluate** | | | |
| **Create** | | | |

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**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** ( Each student shall identify a software development problem and prepare Requirements Specification, Design Document, Project Plan and Test case documents for the identified problem as the assignment. )

**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 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 a maximum of 2 subdivisions and carries 14 marks.

**Syllabus**

**Module 1 : Introduction to Software Engineering (8 hours)**

Introduction to Software Engineering - Professional software development, Software engineering ethics. Software process models - The waterfall model, Incremental development. Process activities - Software specification, Software design and implementation, Software validation, Software evolution. Coping with change - Prototyping, Incremental delivery, Boehm's Spiral Model. Agile software development - Agile methods, agile manifesto - values and principles. Agile development techniques, Agile Project Management. Case studies : An insulin pump control system. Mentcare - a patient information system for mental health care.

**Module 2 : Requirement Analysis and Design (10 hours)**

Functional and non-functional requirements, Requirements engineering processes. Requirements elicitation, Requirements validation, Requirements change, Traceability Matrix. Developing use cases, Software Requirements Specification Template, Personas, Scenarios, User stories, Feature identification. Design concepts - Design within the context of software engineering, Design Process, Design concepts, Design Model. Architectural Design - Software Architecture, Architectural Styles, Architectural considerations, Architectural Design Component level design - What is a component?, Designing Class-Based Components, Conducting Component level design, Component level design for web-apps. Template of a Design Document as per "IEEE Std 1016-2009 IEEE Standard for Information Technology Systems Design Software Design Descriptions". Case study: The Ariane 5 launcher failure.

**Module 3 : Implementation and Testing (12 hours)**

Object-oriented design using the UML, Design patterns, Implementation issues, Open-source development - Open-source licensing - GPL, LGPL, BSD. Review Techniques - Cost impact of Software Defects, Code review and statistical analysis. Informal Review, Formal Technical Reviews, Post-mortem evaluations. Software testing strategies - Unit Testing, Integration Testing, Validation testing, System testing, Debugging, White box testing, Path testing, Control Structure testing, Black box testing, Testing Documentation and Help facilities. Test automation, Test-driven development, Security testing. Overview of DevOps and Code Management - Code management, DevOps automation, CI/CD/CD. Software Evolution - Evolution processes, Software maintenance.

**Module 4 : Software Project Management (8 hours)**

Software Project Management - Risk management, Managing people, Teamwork. Project Planning, Software pricing, Plan-driven development, Project scheduling, Agile planning. Estimation techniques, COCOMO cost modeling. Configuration management, Version management, System building, Change management, Release management, Agile software management - SCRUM framework. Kanban methodology and lean approaches.

**Module 5 : Software Quality and Process Improvement (6 hours)**

Software Quality, Software Quality Dilemma, Achieving Software Quality Elements of Software Quality Assurance, SQA Tasks , Software measurement and metrics. Software Process Improvement(SPI), SPI Process CMMI process improvement framework, ISO 9001:2000 for Software.

**Text Books**


1. Book 1 - Ian Sommerville, Software Engineering, Pearson Education, Tenth edition, 2015.
2. Book 2 - Roger S. Pressman, Software Engineering : A practitioner's approach, McGraw Hill publication, Eighth edition, 2014
3. Book 3 - Ian Sommerville, Engineering Software Products: An Introduction to Modern Software Engineering, Pearson Education, First Edition, 2020.


**References**


1. IEEE Std 830-1998 - IEEE Recommended Practice for Software Requirements Specifications
2. IEEE Std 1016-2009 IEEE Standard for Information Technology—Systems Design—Software Design Descriptions
3. David J. Anderson, Kanban, Blue Hole Press 2010
4. David J. Anderson, Agile Management for Software Engineering, Pearson, 2003
5. Walker Royce, Software Project Management : A unified framework, Pearson Education, 1998
6. Steve. Denning, The age of agile, how smart companies are transforming the way work gets done. New York, Amacom, 2018.
7. Satya Nadella, Hit Refresh: The Quest to Rediscover Microsoft's Soul and Imagine a Better Future for Everyone, Harper Business, 2017
8. Henrico Dolfing, Project Failure Case Studies: Lessons learned from other people's mistakes, Kindle edition
9. Mary Poppendieck, Implementing Lean Software Development: From Concept to Cash, Addison-Wesley Signature Series, 2006
10. StarUML documentation - https://docs.staruml.io/
11. OpenProject documentation - https://docs.openproject.org/

12. BugZilla documentation - https://www.bugzilla.org/docs/
13. GitHub documentation - https://guides.github.com/
14. Jira documentation - https://www.atlassian.com/software/jira

## Course Level Assessment Questions

**Course Outcome 1 (CO1):**

1. What are the advantages of an incremental development model over a waterfall model?
2. Compare agile software development with traditional software development?

**Course Outcome 2 (CO2):**

1. How to prepare a software requirement specification?
2. Differentiate between Architectural design and Component level design.
3. How do agile approaches help software developers to capture and define the user requirements effectively?
4. What is the relevance of the SRS specification in software development?
5. Prepare a use case diagram for a library management system.

**Course Outcome 3 (CO3):**

1. Differentiate between the different types of software testing strategies.
2. What are the benefits of DevOps?
3. How do design patterns help software architects communicate the design of a complex system effectively?
4. What are the proactive approaches one can take to optimise efforts in the testing phase?

**Course Outcome 4 (CO4):**

1. What are the activities involved in software project management?
2. What is the need for SCRUM, Kanban and Lean methodologies?
3. What are the benefits of rolling level planning in software project management and how would you implement it?
4. How would you assess the risks in your software development project? How would you plan for risk mitigation and contingency?

**Course Outcome 5 (CO5):**

1. What is the importance of Software Process improvement?
2. How will retrospectives help in improving the software development process?
3. What are the important skills required for the SQA role?
4. How would you use project history data as a prediction tool to plan future projects?

**Model Question Paper**

**QP CODE:**
**Reg No:_____**
**Name :_____**

**PAGES : 3**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**
**FIFTH SEMESTER B.TECH DEGREE EXAMINATION(MINOR), MONTH & YEAR**
**Course Code: CST 381**
**Course Name: Concepts in Software Engineering**

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

**PART A**
**Answer all Questions. Each question carries 3 Marks**

1. Explain why professional software that is developed for a customer is not simply the programs that have been developed and delivered
2. Incremental software development could be very effectively used for customers who do not have a clear idea about the systems needed for their operations. Discuss.
3. Identify and briefly describe four types of requirements that may be defined for a computer based system.
4. Describe software architecture in your own words.
5. What are the major differences between GPL and LGPL?
6. Compare between white box testing and black box testing.
7. What is the importance of risk management in software project management?
8. Explain COCOMO cost estimation model
9. Describe the software quality dilemma in your own words
10. Which are the levels of the CMMI model?

**(10x3=30)**

## Part B

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

11. (a) Compare between waterfall model and spiral model **(8)**

    (b) Explain Agile methods and Agile manifesto **(6)**

**OR**

12. (a) Explain software process activities **(7)**

    (b) Explain Agile Development techniques and Agile Project Management. **(7)**

13. (a) What are functional and nonfunctional requirements? Imagine that you are developing a library management software for your college, identify at least 8 functional requirements and 4 nonfunctional requirements. **(10)**

    (b) What are the contents of a software requirement specification? **(4)**

**OR**

14. (a) Explain Personas, Scenarios, User stories and Feature identification? **(8)**

    (b) Compare between Software Architecture design and Component level design **(6)**

15. (a) Describe the formal and informal review techniques in detail. **(6)**

    (b) Explain various software testing strategies. **(8)**

**OR**

16. (a) Explain DevOps CI/CD/CD in detail. **(8)**

    (b) Explain test driven development. **(6)**

17. (a) What is a critical path and demonstrate its significance in a project schedule with the help of a sample project schedule. **(6)**

    (b) Explain plan driven development and project scheduling **(6)**

**OR**

18. (a) Explain the SCRUM framework. **(8)**

    (b) What is algorithmic cost modeling? What problems does it suffer from when compared with other approaches to cost estimation? **(6)**

19. (a) Explain elements of Software Quality Assurance and SQA Tasks. **(8)**

    (b) Explain the SPI process. **(6)**

**OR**

20. (a) Compare between CMMI and ISO 9001:2000 **(8)**

    (b) Compare Quality Control and Quality Assurance. **(6)**

| **Teaching Plan [44 hours]** | | |
|---|---|---|
| **Module 1 : Introduction to Software Engineering (8 hours)** | | **Hours** |
| 1.1 | Introduction to Software Engineering. [ Book 1, Chapter 1] | 1 hour |
| 1.2 | Software process models [Book 1 - Chapter 2] | 1 hour |
| 1.3 | Process activities [Book 1 - Chapter 2] | 1 hour |
| 1.4 | Coping with change [Book 1 - Chapter 2, Book 2 - Chapter 4] | 1 hour |
| 1.5 | Agile software development [Book 1 - Chapter 3] | 1 hour |
| 1.6 | Agile development techniques [Book 1 - Chapter 3] | 1 hour |
| 1.7 | Agile Project Management.[Book 1 - Chapter 3] | 1 hour |
| 1.8 | Case studies : An insulin pump control system. Mentcare - a patient information system for mental health care. [Book 1 - Chapter 1] | 1 hour |
| **Module 2 : Requirement Analysis and Design (10 hours)** | | |
| 2.1 | Functional and non-functional requirements, Requirements engineering processes [Book 1 - Chapter 4] | 1 hour |

| | | |
|---|---|---|
| 2.2 | Requirements elicitation, Requirements validation, Requirements change, Traceability Matrix [Book 1 - Chapter 4] | 1 hour |
| 2.3 | Developing use cases, Software Requirements Specification Template [Book 2 - Chapter 8] | 1 hour |
| 2.4 | Personas, Scenarios [Book 3 - Chapter 3] | 1 hour |
| 2.5 | User stories, Feature identification [Book 3 - Chapter 3] | 1 hour |
| 2.6 | Design concepts [Book 2 - Chapter 12] | 1 hour |
| 2.7 | Architectural Design [Book 2 - Chapter 13] | 1 hour |
| 2.8 | Component level design [Book 2 - Chapter 14] | 1 hour |
| 2.9 | Component level design, Design Document Template. [Book 2 - Chapter 14, Ref - 2] | 1 hour |
| 2.10 | Case study: The Ariane 5 launcher failure. [ Book 2 - Chapter 16] | 1 hour |
| **Module 3 : Implementation and Testing (12 hours)** | | |
| 3.1 | Object-oriented design using the UML, Design patterns [Book 1 - Chapter 7] | 1 hour |
| 3.2 | Implementation issues, Open-source development - Open-source licensing - GPL, LGPL, BSD [Book 1 - Chapter 7] | 1 hour |
| 3.3 | Review Techniques - Cost impact of Software Defects, Code review. [Book 2 - Chapter 20] | 1 hour |
| 34 | Informal Review, Formal Technical Reviews, Post-mortem evaluations. [Book 2 - Chapter 20] | 1 hour |
| 3.5 | Software testing strategies [Book 2 - Chapter 22] | 1 hour |
| 3.6 | Software testing strategies [Book 2 - Chapter 22] | 1 hour |
| 3.7 | White box testing, Path testing, Control Structure testing [Book 2 - Chapter 23] | 1 hour |
| 3.8 | Black box testing. Test documentation [Book 2 - Chapter 23] | 1 hour |
| 3.9 | Test automation, Test-driven development [Book 3 - Chapter 9] | 1 hour |
| 3.10 | Security testing. DevOps and Code Management [Book 3 - Chapter 9, Chapter 10] | 1 hour |
| 3.11 | DevOps and Code Management - Code management, DevOps automation, CI/CD/CD. [Book 3 - Chapter 10] | 1 hour |

| | | |
|---|---|---|
| 3.12 | Software Evolution - Evolution processes, Software maintenance. [Book 1 - Chapter 9] | 1 hour |
| **Module 4 : Software Project Management (8 hours)** | | |
| 4.1 | Software Project Management - Risk management, Managing people, Teamwork [Book 1 - Chapter 22] | 1 hour |
| 4.2 | Project Planning - Software pricing, Plan-driven development, Project scheduling, Agile planning [Book 1 - Chapter 23] | 1 hour |
| 4.3 | Estimation techniques [Book 1 - Chapter 23] | 1 hour |
| 4.4 | Configuration management [Book 1 - Chapter 25] | 1 hour |
| 4.5 | Agile software management - SCRUM framework [Book 2 - Chapter 5] | 1 hour |
| 4.6 | Agile software management - SCRUM framework [Book 2 - Chapter 5] | 1 hour |
| 4.7 | Kanban methodology and lean approaches. [Ref 9 - Chapter 2] | 1 hour |
| 4.8 | Kanban methodology and lean approaches.[Ref 9 - Chapter 2] | 1 hour |
| **Module 5 : Software Quality, Process Improvement and Technology trends (6 hours)** | | |
| 5.1 | Software Quality, Software Quality Dilemma, Achieving Software Quality. [Book 2 - Chapter 19] | 1 hour |
| 5.2 | Elements of Software Quality Assurance, SQA Tasks [Book 3 - Chapter 21] | 1 hour |
| 5.3 | Software measurement and metrics. [Book 3 - Chapter 21] | 1 hour |
| 5.4 | Software Process Improvement(SPI), SPI Process[Book 2 - Chapter 37] | 1 hour |
| 5.5 | Software Process Improvement(SPI), SPI Process[Book 2 - Chapter 37] | 1 hour |
| 5.6 | CMMI process improvement framework, ISO 9001:2000 for Software. [Book 2 - Chapter 37] | 1 hour |

| CST 383 | CONCEPTS IN MACHINE LEARNING | Category | L | T | P | Credit | Year of introduction |
|---|---|---|---|---|---|---|---|
| | | VAC | 3 | 1 | 0 | 4 | 2019 |

**Preamble**: This course enables the learners to understand the fundamental concepts and algorithms in machine learning. The course covers the standard and most popular supervised learning algorithms such as linear regression, logistic regression, decision trees, Bayesian learning & the naive Bayes algorithm, support vector machines& kernels, basic clustering algorithms and dimensionality reduction methods. This course helps the students to provide machine learning based solutions to real world problems.

**Prerequisite:** Familiarity with basics in linear algebra, probability and Python programming.

| | Course Outcomes |
|---|---|
| **CO1** | Illustrate Machine Learning concepts and basic parameter estimation methods.**(Cognitive Knowledge Level: Apply)** |
| **CO2** | Demonstrate supervised learning concepts (regression, linear classification). **(Cognitive Knowledge Level**: **Apply)** |
| **CO3** | Illustrate the concepts of Multilayer neural network and Support Vector Machine **(Cognitive Knowledge Level: Apply)** |
| **CO4** | Describe unsupervised learning concepts and dimensionality reduction techniques. (**Cognitive Knowledge Level**: **Apply**) |
| **CO5** | Solve real life problems using appropriate machine learning models and evaluate the performance measures (**Cognitive Knowledge Level: Apply**) |

**Mapping of course outcomes with program outcomes**

| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO 7 | PO8 | PO9 | PO10 | PO11 | PO1 2 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **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** |
|---|---|---|---|
| | **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 carry 14 marks.

**Syllabus**

**Module-1 (Overview of machine learning)**

Machine learning paradigms-supervised, semi-supervised, unsupervised, reinforcement learning. Basics of parameter estimation - maximum likelihood estimation(MLE) and maximum a posteriori estimation(MAP). Introduction to Bayesian formulation.

**Module-2 (Supervised Learning)**

Regression - Linear regression with one variable, Linear regression with multiple variables, solution using gradient descent algorithm and matrix method, basic idea of overfitting in regression. Linear Methods for Classification- Logistic regression, Perceptron, Naive Bayes, Decision tree algorithm ID3.

**Module-3 (Neural Networks (NN) and Support Vector Machines (SVM))**

NN - Multilayer feed forward network, Activation functions (Sigmoid, ReLU, Tanh), Backpropagation algorithm.

SVM - Introduction, Maximum Margin Classification, Mathematics behind Maximum Margin Classification, Maximum Margin linear separators, soft margin SVM classifier, non-linear SVM, Kernels for learning non-linear functions, polynomial kernel, Radial Basis Function(RBF).

**Module-4 (Unsupervised Learning)**

Clustering - Similarity measures, Hierarchical Agglomerative Clustering, K-means partitional clustering, Expectation maximization (EM) for soft clustering. Dimensionality reduction – Principal Component Analysis, factor Analysis, Multidimensional scaling, Linear Discriminant Analysis.

**Module-5 (Classification Assessment)**

Classification Performance measures - Precision, Recall, Accuracy, F-Measure, Receiver Operating Characteristic Curve(ROC), Area Under Curve(AUC. Bootstrapping, Cross Validation, Ensemble methods, Bias-Variance decomposition. Case Study: Develop a classifier for face detection.

**Text Book**

1. Ethem Alpaydin, Introduction to Machine Learning, 2nd edition, MIT Press 2010.
2. Mohammed J. Zaki and Wagner Meira, Data Mining and Analysis: Fundamental Concepts and Algorithms, Cambridge University Press, First South Asia edition, 2016.
3. Jake VanderPlas, Python Data Science Handbook, O'Reilly Media, 2016
4. Tom Mitchell, Machine Learning, McGraw-Hill, 1997.

**Reference Books**

1. Christopher Bishop. Neural Networks for Pattern Recognition, Oxford University Press, 1995.
2. Kevin P. Murphy. Machine Learning: A Probabilistic Perspective, MIT Press 2012.
3. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements Of Statistical Learning, Second edition Springer 2007.
4. P. Langley, Elements of Machine Learning, Morgan Kaufmann, 1995.
5. Richert and Coelho, Building Machine Learning Systems with Python.
6. Davy Cielen, Arno DB Meysman and Mohamed Ali. Introducing Data Science: Big Data, Machine Learning, and More, Using Python Tools, Dreamtech Press 2016.

**Sample Course Level Assessment Questions**

**Course Outcome1(CO1):**

1. A coin is tossed 100 times and lands heads 62 times. What is the maximum likelihood estimate for $\theta$, the probability of heads.
2. Suppose data $x_1, \ldots, x_n$ are independent and identically distributed drawn from an exponential distribution $exp(\lambda)$. Find the maximum likelihood for $\lambda$.
3. Suppose $x_1, \ldots, x_n$ are independent and identically distributed(iid) samples from a distribution with density

$$f_X(x \mid \theta) = \begin{cases} \frac{\theta x^{\theta-1}}{3^\theta}, & 0 \le x \le 3 \\ 0, & \text{otherwise} \end{cases}$$

   Find the maximum likelihood estimate(MLE) for $\theta$.
4. Find the maximum likelihood estimator (MLE) and maximum a posteriori (MAP) estimator for the mean of a univariate normal distribution. Assume that we have $N$ samples, $x_1, \ldots, x_N$ independently drawn from a normal distribution with known variance $\sigma^2$ and unknown mean $\mu$ and the prior distribution for the mean is itself a normal distribution with mean $v$ and variance $\beta^2$. What happens to the MLE and MAP estimators as the number of samples goes to infinity.

**Course Outcome 2 (CO2):**

1. Explain the difference between (batch) gradient descent and stochastic gradient descent. Give an example of when you might prefer one over the other.
2. Suppose that you are asked to perform linear regression to learn the function that outputs $y$, given the $D$-dimensional input $x$. You are given $N$ independent data points, and that all the $D$ attributes are linearly independent. Assuming that $D$ is around 100, would you prefer the closed form solution or gradient descent to estimate the regressor?
3. Suppose you have a three class problem where class label $y \in 0, 1, 2$ and each training example $X$ has 3 binary attributes $X_1, X_2, X_3 \in 0, 1$. How many parameters (probability distribution) do you need to know to classify an example using the Naive Bayes classifier?

**Course Outcome 3 (CO3):**

1. What are support vectors and list any three properties of the support vector classifier solution?
2. Why do you use kernels to model a projection from attributes into a feature space, instead of simply projecting the dataset directly?
3. Describe how Support Vector Machines can be extended to make use of kernels. Illustrate with reference to the Gaussian kernel $K(x, y) = e^{-z}$, where $z = (x-y)^2$ .

4. Briefly explain one way in which using tanh instead of logistic activations makes optimization easier.
5. ReLU activation functions are most used in neural networks instead of the tanh activation function. Draw both activation functions and give a) an advantage of the ReLU function compared to the tanh function. b) a disadvantage of the ReLU function compared to the tanh function.

**Course Outcome 4(CO4):**

1. Describe cluster analysis? Identify two applications where cluster analysis can be applied to multimedia data?
2. Given two objects represented by the tuples (22, 1, 42, 10) and (20, 0, 36, 8):

   (i) Compute the Euclidean distance between the two objects.

   (ii) Compute the Manhattan distance between the two objects.
3. Use PCA to reduce the dimension from 2 to 1 for the design matrix ***X***.

$$X = \begin{bmatrix} 6 & -4 \\ -3 & 5 \\ -2 & 6 \\ 7 & -3 \end{bmatrix}$$

4. What is Principal Component Analysis (PCA)? Which eigen value indicates the direction of largest variance?
5. Suppose that one runs a principal component analysis on a data set and tells that the percentage of variance explained by the first 3 components is 80%. How is this percentage of variance explained?

**Course Outcome 5 (CO5):**

1. Suppose that you are contacted by a food processing company that wants you to develop a classifier that detects whether a rat is present in an image. You collect a large dataset of images by crawling the web, and have annotators determine which images contain rats. This set of images can then be used as the training set for your classifier.
   a. Suggest a machine learning method to use for this classification task and evaluate its performance.
   b. After you have delivered your solution to the company, they get back to you and complain that when they evaluate on a new test set, they get precision and recall values that are much lower than what you reported to them. Explain what might have gone wrong and propose remedial measures .
2. A real estate firm would like to build a system that predicts the sale prices of a house. They create a spreadsheet containing information about 1,500 house sales in the Kochi

area. In addition to the price, there are 10 features describing the house, such as number of bedrooms, total indoor area, lot area, a swimming pool, location, etc. Explain how you would implement a machine learning model that would solve this prediction task. Give all steps you would carry out when developing it. Explain why the model you built is probably useless in the long run.

3. For a classifier, the confusion matrix is given by:

| | + | - |
|---|---|---|
| + | 9 | 9 |
| - | 1 | 5 |

What is the precision, recall and accuracy of that classifier?

**Model Question Paper**

QP CODE: PAGES:3

Reg No:_____

Name:_____

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION(MINOR), MONTH & YEAR**

**Course Code: CST 383**

**Course Name: CONCEPTS IN MACHINE LEARNING**

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

**PART A**

**Answer all Questions. Each question carries 3 Marks**

1. Define supervised learning? Name special cases of supervised learning depending on whether the inputs/outputs are categorical, or continuous.
2. Differentiate between Maximum Likelihood estimation (MLE) and Maximum a Posteriori (MAP) estimation?
3. What is overfitting and why is it a problem? Give an example of a method to reduce the risk of overfitting.
4. Specify the basic principle of gradient descent algorithm.
5. Suppose that you have a linear support vector machine(SVM) binary classifier. Consider a point that is currently classified correctly, and is far away from the decision boundary. If you

remove the point from the training set, and re-train the classifier, will the decision boundary change or stay the same? Justify your answer.

6. Mention the primary motivation for using the kernel trick in machine learning algorithms?
7. Expectation maximization (EM) is designed to find a maximum likelihood setting of the parameters of a model when some of the data is missing. Does the algorithm converge? If so, do you obtain a locally or globally optimal set of parameters?
8. Illustrate the strength and weakness of k-means algorithm.
9. Classifier A attains 100% accuracy on the training set and 70% accuracy on the test set. Classifier B attains 70% accuracy on the training set and 75% accuracy on the test set. Which one is a better classifier. Justify your answer.
10. How does bias and variance trade-off affect machine learning algorithms?

**(10x3=30)**

## Part B

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

11. a) Suppose that ***X*** is a discrete random variable with the following probability mass function: where ***0 ≤ θ ≤ 1*** is a parameter. The following 10 independent observations

| $X$ | 0 | 1 | 2 | 3 |
|---|---|---|---|---|
| $P(X)$ | $2\theta/3$ | $\theta/3$ | $2(1-\theta)/3$ | $(1-\theta)/3$ |

were taken from such a distribution: ***(3, 0, 2, 1, 3, 2, 1, 0, 2, 1)***. What is the maximum likelihood estimate of ***θ***. **(6)**

b) A gamma distribution with parameters ***α, β*** has the following density function, where ***Γ(t)*** is the gamma function.

$$p(x) = \frac{\beta^{\alpha}}{\Gamma(\alpha)} x^{\alpha-1} e^{-\beta x}$$

If the posterior distribution is in the same family as the prior distribution, then we say that the prior distribution is the conjugate prior for the likelihood function. Using the Gamma distribution as a prior, show that the Exponential distribution is a conjugate prior of the Gamma distribution. Also, find the maximum a posteriori estimator for the parameter of the Exponential distribution as a function of ***α*** and ***β***. **(8)**

OR

12. a) Traffic between 8AM and 9AM at a certain place was measured by counting the number of vehicles that passed at that time. Suppose the counts follow a Poisson process. A random sample of 9 observations was collected, having observed the following number of vehicles: (95, 100, 80, 70, 110, 98, 97, 90, 70). Derive the maximum likelihood estimator for the

average number of vehicles that pass by that place between 8 AM and 9 AM, and compute the corresponding estimate using the given sample. **(7)**

b) Find the maximum a posteriori (MAP) estimator for the mean of a univariate normal distribution. Assume that we have $N$ samples, $x_1,..., x_N$ independently drawn from a normal distribution with known variance $\sigma^2$ and unknown mean $\mu$ and the prior distribution for the mean is itself a normal distribution with mean $\nu$ and variance $\beta^2$. **(7)**

13.a) Derive the gradient descent training rule assuming for the target function $o_d = w_0 + w_1x_1 + ... + w_nx_n$. Define explicitly the squared 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 $t_d$. **(10)**

b) How can we interpret the output of a two-class logistic regression classifier as a probability? **(4)**

OR

14. a) In a two-class logistic regression model, the weight vector $w = [4, 3, 2, 1, 0]$. We apply it to some object that we would like to classify; the vectorized feature representation of this object is $x = [-2, 0, -3, 0.5, 3]$. What is the probability, according to the model, that this instance belongs to the positive class? **(6)**

b) The following dataset can be used to train a classifier that determines whether a given person is likely to own a car or not. There are three features: education level (primary, secondary, or university); residence (city or country); gender (female, male).

| education | residence | gender | has car? |
|---|---|---|---|
| sec | country | female | yes |
| univ | country | female | yes |
| prim | city | male | no |
| univ | city | male | no |
| sec | city | female | no |
| sec | country | male | yes |
| prim | country | female | yes |
| univ | country | male | yes |
| sec | city | male | yes |
| prim | city | female | no |
| univ | city | female | no |
| prim | country | male | yes |

Find the root attribute and justify your answer **(8)**

15. a) Consider a support vector machine whose input space is 2-D, and the inner products are computed by means of the kernel $K(x, y) = (x.y + 1)^2 - 1$, where $x.y$ denotes the ordinary inner product. Show that the mapping to feature space that is implicitly defined by this kernel is the mapping to 5-D given by **(10)**

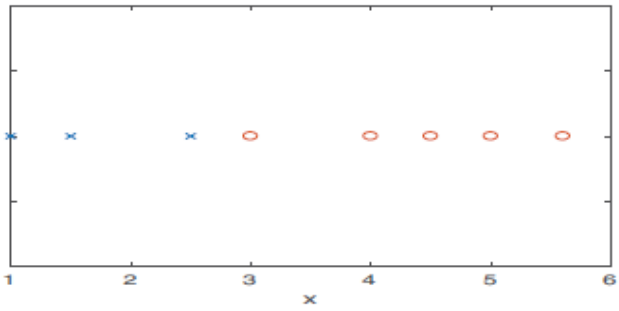
$$\mathbf{x} = \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} \rightarrow \phi(\mathbf{x}) = \begin{bmatrix} x_1^2 \\ x_2^2 \\ \sqrt{2}\, x_1 x_2 \\ \sqrt{2}\, x_1 \\ \sqrt{2}\, x_2 \end{bmatrix}.$$

b) What is the basic idea of a Support Vector Machine? **(4)**

OR

16. a) Explain how back propagation can be used to solve XOR problem which is not linearly separable. **(8)**

b) Consider the following one dimensional training data set, 'x' denotes negative examples and 'o' positive examples. The exact data points and their labels are given in the table. Suppose a SVM is used to classify this data. Indicate which are the support vectors and mark the decision boundary. Find the equation of the hyperplane. (6)




| x | 1 | 1.5 | 2.5 | 3 | 4 | 4.5 | 5 | 5.6 |
|---|---|---|---|---|---|---|---|---|
| y | -1 | -1 | -1 | 1 | 1 | 1 | 1 | 1 |

17. a)Suppose that we have the following data (one variable). Use single linkage Agglomerative clustering to identify the clusters.
Daa: (2, 5, 9, 15, 16, 18, 25, 33, 33, 45). **(8)**

b) Given two objects represented by the tuples (22, 1, 42, 10) and (20, 0, 36, 8):

(i) Compute the Euclidean distance between the two objects.

(ii) Compute the Manhattan distance between the two objects.

(iii) Compute the Minkowski distance between the two objects, using p = 3 **(6)**

OR

18. a) Suppose that we have the following data:

| *a* | *b* | *c* | *d* | *e* | *f* | *g* | *h* | *i* | *j* |
|---|---|---|---|---|---|---|---|---|---|
| (2,0) | (1,2) | (2,2) | (3,2) | (2,3) | (3,3) | (2,4) | (3,4) | (4,4) | (3,5) |

Identify the cluster by applying the k-means algorithm, with k = 2. Try using initial cluster centers as far apart as possible. **(10)**

b) List the steps involved in Principal Component Analysis. **(4)**

19. a) Suppose the dataset had 9700 cancer-free images from 10000 images from cancer patients. Find precision, recall and accuracy ? Is it a good classifier? Justify. **(8)**

| **Actual Class\ Predicted class** | **cancer = yes** | **cancer = no** | **Total** |
|---|---|---|---|
| **cancer = yes** | 90 | 210 | 300 |
| **cancer = no** | 140 | 9560 | 9700 |
| **Total** | 230 | 9770 | 10000 |

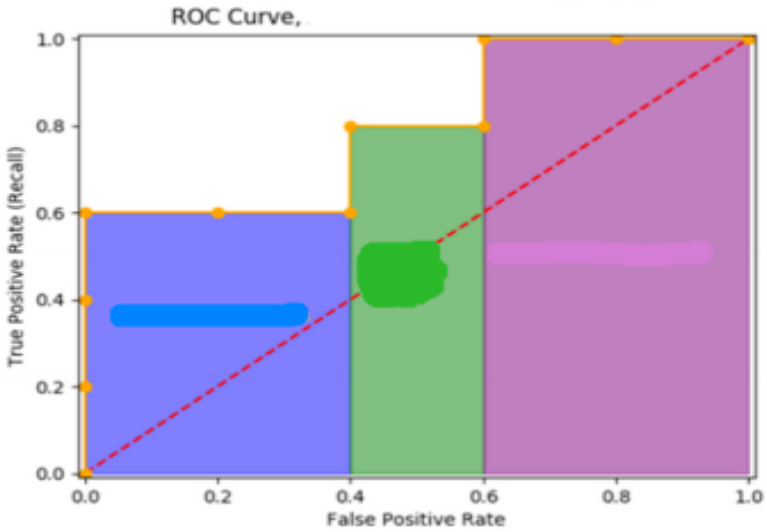
b) Suppose that you have a classification problem where our feature representation contains about 10,000,000 features. We would like to develop a classifier that can be deployed in a mobile phone, so preferably it should have a small memory footprint. Discuss one solution for how this can be done. **(6)**

OR

20. a) What are ROC space and ROC curve in machine learning? In ROC space, which points correspond to perfect prediction, always positive prediction and always negative prediction? Why? **(6)**

b)Suppose there are three classifiers A,B and C. The (FPR, TPR) measures of the three classifiers are as follows – A (0, 1), B (1, 1) , C (1,0.5). Which can be considered as a perfect classifier? Justify your answer. **(4)**

c) Given the following ROC Curve? Find the AUC? **(4)**




**Teaching Plan**

| No | Contents | No of Lecture Hrs |
|---|---|---|
| **Module 1 :Overview of machine learning (7 hours)** | | |
| 1.1 | Supervised, semi-supervised, unsupervised learning, reinforcement learning (Text Book (TB) 1: Chapter 1) | 1hour |
| 1.2 | Maximum likelihood estimation(MLE) (TB 1: Section 4.2) | 1hour |
| 1.3 | Maximum likelihood estimation (MLE)- example (TB 1: Section 4.2) | 1hour |
| 1.4 | Maximum a posteriori estimation(MAP) (TB 4: Section 6.2) | 1hour |
| 1.5 | Maximum a posteriori estimation(MAP)-example (TB 4: Section 6.2) | 1hour |
| 1.6 | Bayesian formulation (TB 1: Section 14.1, 14.2) | 1hour |
| 1.7 | Bayesian formulation -example (TB 1: Section 14.1, 14.2) | 1hour |
| **Module 2 : Supervised Learning (8 hours)** | | |

| | | |
|---|---|---|
| 2.1 | Linear regression with one variable (TB 1: Section 2.6) | 1hour |
| 2.2 | Multiple variables, Solution using gradient descent algorithm and matrix method (No derivation required) (TB 1: Section 5.8) | 1hour |
| 2.3 | Overfitting in regression, Lasso and Ridge regularization | 1hour |
| 2.4 | Logistic regression | 1hour |
| 2.5 | Perceptron | 1hour |
| 2.6 | Naive Bayes (TB 2: Section 18.2) | 1hour |
| 2.7 | Decision trees (TB 2: Chapter 19) | 1hour |
| 2.8 | Decision trees- ID3 algorithm (TB 2: Chapter 19) | 1hour |
| **Module 3 : Neural Networks and Support Vector Machines (TB 2: Chapter 21) (11 hours)** | | |
| 3.1 | Multilayer Feed forward Network, Activation Functions (Sigmoid, ReLU, Tanh) | 1hour |
| 3.2 | Back Propagation Algorithm | 1hour |
| 3.3 | Illustrative Example for Back Propagation | 1hour |
| 3.4 | Introduction, Maximum Margin Hyperplane, | 1hour |
| 3.5 | Mathematics behind Maximum Margin Classification | 1hour |
| 3.6 | Formulation of maximum margin hyperplane and solution | 1hour |
| 3.7 | Soft margin SVM | 1hour |
| 3.8 | Solution of Soft margin SVM | 1hour |
| 3.9 | Non-linear SVM | 1hour |
| 3.10 | Kernels for learning non-linear functions and properties of kernel functions. | 1hour |
| 3.11 | Example Kernels functions- Linear, RBF, Polynomial. | 1hour |
| **Module 4 : Unsupervised Learning (10 hours)** | | |
| 4.1 | Similarity measures- Minkowski distance measures( Manhattan, Euclidean), Cosine Similarity | 1hour |
| 4.2 | Clustering - Hierarchical Clustering (TB 2: Chapter 14) | 1hour |
| 4.3 | K-means partitional clustering (TB 2: Chapter 13) | 1hour |
| 4.4 | Expectation maximization (EM) for soft clustering (TB 2: Chapter 13) | 1hour |
| 4.5 | Expectation maximization (EM) for soft clustering (TB 2: Chapter 13) | 1hour |

| | | |
|---|---|---|
| 4.6 | Dimensionality reduction – Principal Component Analysis (TB 1: Section 6.3) | 1hour |
| 4.7 | Dimensionality reduction – Principal Component Analysis (TB 1: Section 6.3) | 1hour |
| 4.8 | Factor Analysis (TB 1: Section 6.4) | 1hour |
| 4.9 | Multidimensional scaling (TB 1: Section 6.5) | 1hour |
| 4.10 | Linear Discriminant Analysis (TB 1: Section 6.6) | 1hour |
| **Module 5 : Classification Assessment (8 hours)** | | |
| 5.1 | Performance measures - Precision, Recall, Accuracy, F-Measure, ROC, AUC. (TB 2: Chapter 22.1) | 1hour |
| 5.2 | Boot strapping, Cross validation | 1hour |
| 5.3 | Ensemble methods- bagging | 1hour |
| 5.4 | Ensemble methods- boosting | 1hour |
| 5.5 | Bias-Variance decomposition (TB 2: Chapter 22.3) | 1hour |
| 5.6 | Bias-Variance decomposition (TB 2: Chapter 22.3) | 1hour |
| 5.7 | Face detection (TB 3: Chapter 5 Section Application: A Face Detection Pipeline) | 1hour |
| 5.8 | Face detection (TB 3: Chapter 5 Section Application: A Face Detection Pipeline) | 1hour |

| CST 385 | CLIENT SERVER SYSTEMS | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| | | VAC | 3 | 1 | 0 | 4 | 2019 |

**Preamble:**

The syllabus is prepared with the view of preparing the Engineering Graduates to build effective Client/Server applications. This course aims at providing a foundation in decentralized computer systems, using the client/server model. The course content is decided to cover the essential fundamentals which can be taught within the given slots in the curriculum.

Prerequisite: **Basic knowledge in Computer**

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

| | Course Outcomes |
|---|---|
| **CO 1** | Identify the basics of client/server systems and the driving force behind the development of client/server systems**(Cognitive Knowledge Level: Understand)** |
| **CO 2** | Outline the architecture and classifications of client/server systems**(Cognitive Knowledge Level: Understand)** |
| **CO 3** | Summarize the client/server network services for an application**(Cognitive Knowledge Level: Understand)** |
| **CO 4** | Identify management services and issues in network **(Cognitive Knowledge Level: Understand)** |
| **CO 5** | Outline the Client/Server technology in respect of databases and Client/Server database architecture **(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 (Percentage) | Test 2 (Percentage) | |
| Remember | 40 | 40 | 40 |
| Understand | 40 | 40 | 40 |
| Apply | 20 | 20 | 20 |
| Analyse | | | |
| Evaluate | | | |
| Create | | | |

**Mark distribution**

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

**Continuous Internal Evaluation Pattern:**

Attendance : **10 marks**

Continuous Assessment Test 1 (for theory, for 2 hrs) : **20 marks**

Continuous Assessment Test 2 (for lab, internal examination, for 2hrs) : **20 marks**

**Internal Examination Pattern:**

There will be two parts; Part A and Part B. Part A contains 5 questions with 2 questions from each module (2.5 modules x 2 = 5), having 3 marks for each question. Students should answer all questions. Part B also contains 5 questions with 2 questions from each module (2.5 modules

x 2 = 5), of which a student should answer any one. The questions should not have sub-divisions and each one carries 7 marks.

**End Semester Examination Pattern:**

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

**Sample Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

**1.** Computing in client server architecture over Mainframe architecture has certain advantages and disadvantages. Describe at least three advantages and disadvantages for each architecture.

**Course Outcome 2 (CO2):**

**1.** Explain the role of mainframe-centric model in Client/Server computing?

**Course Outcome 3(CO3):**

1. Describe the client server system development methodology? Explain different phases of System Integration Life-Cycle.

**Course Outcome 4 (CO4):**

**1.** Explain about network management and remote system management. How can security be provided to the network?

**Course Outcome 5 (CO5):**

**1.** Explain various types of Client/Server Database Architecture

**Syllabus**

**Module – 1 (Introduction)**

Introduction to Client/Server computing - Basic Client/Server Computing Model, Server for Every Client- File Server, Print Server, Application Server, Mail Server, Directory Services Server, Web Server, Database Server, Transaction Servers. Client/Server-Fat or Thin, Stateless

or Stateful, Servers and Mainframes, Client/Server Functions. Driving Forces behind Client/Server Computing- Business Perspective, Technology Perspective.

**Module -2 (Client/Server Classification)**

Client/Server Types-Single Client/Single Server, Multiple Clients/Single Server, Multiple Clients/Multiple Servers, Integration With Distributed Computing, Alternatives To Client/Server Systems. Classification of Client/Server Systems- Two-Tier Computing, Middleware, Three-Tier Computing- Model View Controller (MVC), Principles behind Client/Server Systems.Client/Server Topologies. Existing Client/Server Architecture. Architecture for Business Information System.

**Module -3 (Client/Server Application Components)**

Client- Services, Request for services, RPC, Windows services, Print services, Remote boot services, other remote services, Utility Services. Server- Detailed server functionality, Network operating system, Available platforms, Server operating system. Organizational Expectations, Improving performance of client/server applications, Single system image, Downsizing and Rightsizing, Advantages and disadvantages of Client/Server computing, Applications of Client/Server.

**Module -4 (Client/ Server Systems Services and Support)**

Services and Support- System administration, Availability, Reliability, Scalability, Observability, Agility, Serviceability. Software Distribution, Performance, Network management. Remote Systems Management- RDP, Telnet, SSH, Security. LAN and Network Management issues.

**Module -5(Client/Server Technology and Databases)**

Client/Server Technology and Databases - Storing Data, Database System Architectures. Client/Server In Respect Of Databases- Client/Server Databases, Client/Server Database Computing, Database Computing Vs. Mainframe, PC/File Server Computing. Client/Server Database Architecture - Process-Per-Client Architecture, Multi-Threaded Architecture, Hybrid Architecture. Database Middleware Component - Application Programming Interface, Database Translator, Network Translator.

**Text Book**

1. Patrick Smith &Steve Guengerich, Client / Server Computing, PHI

2. Subhash Chandra Yadav, Sanjay Kumar Singh, An Introduction to Client/Server Computing, New Age International Publishers

**Reference Books**

1. Jeffrey D.Schank, "Novell's Guide to Client-Server Application & Architecture" Novell Press

2. Robert Orfali, Dan Harkey, Jeri Edwards, Client/Server Survival Guide, Wiley-India Edition, Third Edition

3. Dawna Travis Dewire, Client Server Computing — McGraw Hill

4. W.H.Inman, Developing Client Server Applications, BPB

**Model Question Paper**

**QP CODE:** **PAGES: ___**

**Reg No:_____**

**Name:_____**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION(MINOR), MONTH & YEAR**

**Course Code: CST 385**

**Course Name : Client Server Systems**

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

**PART-A**

**(Answer All Questions. Each question carries 3 marks)**

1. Differentiate between Stateful and Stateless servers
2. List the different phases and activities of client/server system development methodology.
3. How does transmission protocol work in client/server applications?
4. List any six services in single system image environment.
5. Specify the role of the client in Client/Server computing and also list any six services provided by the client.
6. Why do most RPC system support call by value semantics for parameter passing?
7. What do you mean by a thin client network? List three advantages of the Thin

Client Network system.

8. How are connectivity and interoperability between .client/server achieved?

9. One disadvantage of the Client/Server system is lack of control in a Database Management environment. Justify.

10. Explain the DBMS concept in client/server architecture.

**(10x3=30)**

**Part B**

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

11. (a) Differentiate between Transaction server and Data server system with examples. **(7)**

(b) Computing in client server architecture over Mainframe architecture has certain advantages and disadvantages. Describe at least three advantages and disadvantages for each architecture. **(7)**

**OR**

12. (a) Explain various Clients/Server system development tools. **(6)**

(b) Classify and describe the driving forces that drive the move to Client/Server computing. **(8)**

13. (a) Explain the role of mainframe-centric model in Client/Server computing? **(5)**

(b) Describe the three types of Client/Server systems in existence **(9)**

**OR**

14. (a) List and explain the general forces behind the architecture for business information systems **(7)**

(b) Explain the different distribution styles. **(7)**

15. (a) Illustrate the concept of rightsizing and downsizing in Client/Server Computing **(7)**

(b) What is client server system development methodology? Explain the **(7)**

different phases of System Integration Life-Cycle.

**OR**

16. (a) In Client/Server computing, explain the following with examples **(10)**
    i. Dynamic Data Exchange
    ii. RPC, Remote Procedure Call
    iii. Remote Boot Service
    iv. Diskless Computer
    v. Object-linking and embedding

    (b) Explain the functions and features of Network Operating System **(4)**

17. (a) Explain about network management and remote system management. How can security be provided to the network ? **(10)**

    (b) In client server architecture, what do you mean by Availability, Reliability, Serviceability and Security? Explain with examples. **(4)**

**OR**

18. (a) Client server is modular infrastructure, this is intended to improve Usability, Flexibility, Interoperability and Scalability. Explain each term with an example, in each case how it helps to improve the functionality of client server architecture. **(7)**

    (b) Explain about network management and remote system management. How can security be provided to network? **(7)**

19. (a) Explain the different types of Client/Server Database Architecture **(9)**

    (b) List and explain the main components of Database middleware **(5)**

**OR**

20. (a) Discuss types of database utilities, tools and their functions **(7)**

    (b) Discuss about the role of traditional and web databases in handling client/server based applications. **(7 )**

## Teaching Plan

| Module- 1( Introduction) | | (10 hours) |
|---|---|---|
| 1.1 | Basic Client/Server Computing Model | 1 hour |
| 1.2 | Server for Every Client- File Server, Print Server | 1 hour |
| 1.3 | Application Server, Mail Server, Directory Services Server | 1 hour |
| 1.4 | Web Server, Database Server | 1 hour |
| 1.5 | Transaction Servers | 1 hour |
| 1.6 | Client/Server-Fat or Thin | 1 hour |
| 1.7 | Stateless or Stateful | 1 hour |
| 1.8 | Servers and Mainframes | 1 hour |
| 1.9 | Client/Server Functions | 1 hour |
| 1.10 | Driving Forces behind Client/Server Computing- Business Perspective, Technology Perspective | 1 hour |
| **Module- 2 (Client/Server Classification)** | | **(10 hours)** |
| 2.1 | Client/Server Types-Single Client/Single Server | 1 hour |
| 2.2 | Multiple Clients/Single Server, Multiple Clients/Multiple Servers | 1 hour |
| 2.3 | Integration With Distributed Computing | 1 hour |
| 2.4 | Alternatives To Client/Server Systems | 1 hour |
| 2.5 | Classification of Client/Server Systems- Two-Tier Computing, Middleware | 1 hour |
| 2.6 | Three-Tier Computing- Model View Controller (MVC) | 1 hour |
| 2.7 | Principles behind Client/Server Systems. | 1 hour |
| 2.8 | Client/Server Topologies | 1 hour |
| 2.9 | Existing Client/Server Architecture | 1 hour |
| 2.10 | Architecture for Business Information System | 1 hour |
| **Module -3 (Client/Server Application Components)** | | **(9 hours)** |
| 3.1 | The client: Services, Request for services, RPC | 1 hour |
| 3.2 | Windows services, Print services, Remote boot services | 1 hour |

| | | |
|---|---|---|
| 3.3 | Utility Services & Other Services | 1 hour |
| 3.4 | Server- Detailed server functionality, Network operating system | 1 hour |
| 3.5 | Available platforms, Server operating system | 1 hour |
| 3.6 | Organizational Expectations, Improving performance of client/server applications | 1 hour |
| 3.7 | Single system image, Downsizing and Rightsizing | 1 hour |
| 3.8 | Advantages and disadvantages of Client/Server computing | 1 hour |
| 3.9 | Applications of Client/Server | 1 hour |
| **Module -4 (Client/ Server Systems Services and Support)** | | **(8 hours)** |
| 4.1 | Services and Support, System administration | 1 hour |
| 4.2 | Availability, Reliability | 1 hour |
| 4.3 | Scalability, Observability, Agility | 1 hour |
| 4.4 | Serviceability, Software Distribution | 1 hour |
| 4.5 | Performance | 1 hour |
| 4.6 | Network management | 1 hour |
| 4.7 | Remote Systems Management- RDP, Telnet, SSH | 1 hour |
| 4.8 | Security, LAN and Network Management issues | 1 hour |
| **Module -5(Client/Server Technology and Databases)** | | **(8 hours)** |
| 5.1 | Client/Server Technology and Databases - Storing Data | 1 hour |
| 5.2 | Database System Architectures | 1 hour |
| 5.3 | Client/Server In Respect Of Databases- Client/Server Databases | 1 hour |
| 5.4 | Client/Server Database Computing | 1 hour |
| 5.5 | Database Computing Vs. Mainframe, PC/File Server Computing | 1 hour |
| 5. | Client/Server Database Architecture - Process-Per-Client Architecture | 1 hour |
| 5.7 | Multi-Threaded Architecture, Hybrid Architecture | 1 hour |
| 5.8 | Database Middleware Component - Application Programming Interface, Database Translator, Network Translator | 1 hour |

APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY

# SEMESTER V

## HONOURS

KTU
Estd.
2014

| CCT393 | WEB APPLICATION SECURITY | CATEGORY | L | T | P | CREDITS |
|---|---|---|---|---|---|---|
| | | VAC | 4 | 0 | 0 | 4 |

**Preamble:** This course basically aims at exploring the fundamentals of Web applications & Common Vulnerabilities and exploits. This course also covers the different information Gathering methodologies and the different mitigation and management strategies. The concepts covered in this course also enable the learners in effective use of web application development Technologies and to identify the security threats in computing.

**Prerequisite:** Knowledge in fundamental concepts of security.

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

| CO# | Course Outcomes |
|---|---|
| CO1 | Identify the basic type of web application security testing, vulnerabilities and countermeasures. (**Cognitive Knowledge Level: Understand**) |
| CO2 | Trace out the different Information Gathering methodologies.(**Cognitive Knowledge Level: Apply)** |
| CO3 | Interpret and detect the different vulnerabilities and exploits prone to systems. **(Cognitive Knowledge Level: Apply)** |
| CO4 | Discover Web Application Vulnerabilities & threats and adopt mitigation and management Strategies. **(Cognitive Knowledge Level: Understand)** |
| CO5 | Summarize the different web application development Technologies. **(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** | Lifelong learning |

**Assessment Pattern**

| Bloom's Category | Continuous Assessment Tests | | End Semester Examination Marks (%) |
|---|---|---|---|
| | Test 1 (%) | Test 2 (%) | |
| Remember | 20 | 20 | 20 |
| Understand | 50 | 50 | 50 |
| Apply | 30 | 30 | 30 |
| 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 (Average of SeriesTests1& 2) **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 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 a student should answer any one. Each question can have maximum 2 sub-divisions and carries 14 marks.

## Syllabus

**Module -1 (Introduction to Web Application)**
Web Application, Web Client, History of Web Application, Web Application Security Terminology, Types of Web Application Security Testing, Web Application Vulnerabilities and Counter measures.

**Module -2 (Reconnaissance)**
Web Application Reconnaissance: Information Gathering, Web Application Mapping. Finding Subdomains- Multiple Applications per Domain, Browser's Built-in Network Analysis Tools, Public Records, Brute Forcing Subdomain, Dictionary Attacks.

**Module -3 (Web Application Offense)**
Cross-Site Scripting (XSS)- XSS Discovery & Exploitation, Stored XSS, Reflected XSS. Cross-Site Request Forgery- Query Parameter Tampering. XML External Entity(XXE)- Direct XXE, Indirect XXE. Injection- SQL Injection, Code Injection. Denial of Service- Logical DoS Vulnerabilities, Distributed DoS.

**Module –4 (Securing and Hardening Web Applications)**
Securing Modern Web Applications- Defensive Software Architecture, Vulnerability Discovery, Vulnerability Analysis, Vulnerability Management, Mitigation Strategies. Secure Application Architecture: Authentication and Authorization. Vulnerability Discovery: Security Automation. Vulnerability Management: Common Vulnerability Scoring System. Securing Sessions: Different types of Sessions, Data Transmission Security: SSL/TLS: Certificate Validation Types and Authorities, Creating Self-Signed Certificate for Testing, OWASP Top 10 Vulnerabilities.

**Module –5 (Web Application Development Technologies)**
Basic workflow with a text editor, version control system, and web browser, user interface with HTML, styles with CSS, JQuery and JavaScript, AJAX, JavaScript objects, and JSON, Server-side programming with Node.js, Storage with Redis and MongoDB, Cloud uploading Cloud Foundry.

**Text Books**

1. Ron Lepofsky, “The Manager’s Guide to Web Application Security: A Concise Guide to the weaker side of the web”, First Edition, Apress, 2015.
2. Andrew Hoffman “Web Application Security: Exploitation and Countermeasures for Modern Web Applications”, O’Reilly, First Edition, 2020.
3. Semmy Purewal “Learning Web App Development”, O'Reilly Media, Inc., First Edition, 2014

**References**

1. Jonathan LeBlanc & Tim Messerschmidt ,”Identity and Data Security for Web Development”, O’Reilly, First Edition, 2016
2. Bryan Sullivan, Vincent Liu “Web Application Security, A Beginners Guide”, McGraw-Hill First Edition, 2011

**Course Level Assessment Questions**

**Course Outcome 1 (CO1):**

1. Consider an automated teller machine (ATM) in which users provide a personal identification number (PIN) and a card for account access. Give examples of confidentiality, integrity, and availability requirements associated with the system and, in each case, indicate the degree of importance of the requirement.

**Course Outcome 2 (CO2):**

1. Information about a particular website is crucial for the hackers and intruders to pierce into the system. Explain how the information be gathered and give what all information are crucial for the users to safeguard their systems from intruder attacks. Use any appropriate tool.

**Course Outcome 3 (CO3):**

1. What is Cross site Scripting? How is it identified on a website?
2. What is SQL injection? How can you find whether the website is affected by SQL injection?

**Course Outcome 4 (CO4):**

1. What is vulnerability? How is it identified?
2. How Vulnerability management is done?

**Course Outcome 5 (CO5):**

1. Discuss the different web development technologies used for Creating Styles.
2. Explain how data is shared to cloud using Cloud Front.

**Model Question Paper**

**QP CODE:** **PAGES: ___**

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

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**
**FIFTH SEMESTER B.TECH DEGREE EXAMINATION, MONTH & YEAR**
**Course Code: CST 393**
**Course Name : WEB APPLICATION SECURITY**

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

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

1. Explain the history of Web Application.
2. Compare Penetration Testing and manual testing techniques.
3. What is Reconnaissance?
4. How can you analyze the Network Traffic going through your browser?
5. What is Cross site Request Forgery?
6. What is Denial of Service attack?
7. Differentiate between authentication and Authorization.
8. List the latest OWASP Top Ten Vulnerabilities.
9. Enumerate how to Structure a user interface with HTML, and include styles with CSS.
10. Explain how to Store data outside your application with Redis and MongoDB

**(10x3=30 Marks)**

## Part B

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

| | | | |
|---|---|---|---|
| 11. | (a) | Define the following web application security terminologies<br>(i) Temporal Risk (ii) Breach<br>(iii) Mitigation (iv) Vulnerability | **(8 Marks)** |
| | (b) | Explain any three web application vulnerabilities and the damages they cause | **(6 Marks)** |
| | | **OR** | |
| 12. | (a) | Explain Weak Access Control Vulnerability and how to mitigate the vulnerability. | **(6 Marks)** |
| | (b) | Write down the components of a Web Application | **(8 Marks)** |
| 13. | (a) | Define Brute Force Attack. Explain how to brute forcing the subdomain. | **(6 Marks)** |
| | (b) | Explain how subdomain information about a website is found. | **(8 Marks)** |
| | | **OR** | |
| 14. | (a) | List out the different Built-in Network Analysis Tools found in a browser. | **(7 Marks)** |
| | (b) | How a network analysis is done using the Built-in Network Analysis Tools found in a browser? | **(7 Marks)** |
| 15. | (a) | What is Query Parameter Tampering? How is it identified? | **(7 Marks)** |
| | (b) | What is Direct XXE? How is it identified? | **(7 Marks)** |
| | | **OR** | |
| 16. | (a) | Give the different Logical DoS Vulnerabilities with suitable examples | **(6 Marks)** |
| | (b) | What is XML External Entity(XEE)? How is affects a website? | **(8 Marks)** |
| 17. | (a) | Explain how vulnerability can be discovered. | **(4 Marks)** |
| | (b) | How Vulnerability Management is done using Common Vulnerability Scoring System. | **(10 Marks)** |
| | | **OR** | |

18. (a) Write down the methods used for securing sessions. **(7 Marks)**

(b) Explain how SSL/TLS validation can be done. **(7 Marks)**

19. (a) What is JSON? Explain its relevance in Website development. **(6 Marks)**

(b) Give the role of HTML5 in Web development. **(8 Marks)**

**OR**

20. (a) Decsribe how server side programming be done with Node.js. **(8 Marks)**

(b) Explain the difference in usage of JQuery and JavaScript. **(6 Marks)**

**Teaching Plan**

| No | Contents | No.of Lecture Hrs |
|---|---|---|
| **Module -1 (Introduction to Web Application) (6 hrs)** | | |
| 1.1 | Web Application and Web Client | 1 |
| 1.2 | History of Web Application | 1 |
| 1.3 | Web Application Security Terminology | 1 |
| 1.4 | Types of Web Application Security Testing- Lecture 1 | 1 |
| 1.5 | Types of Web Application Security Testing- Lecture 2 | 1 |
| 1.6 | Web Application Vulnerabilities and Counter measures | 1 |
| **Module -2 (Reconnaissance) (9 hrs)** | | |
| 2.1 | Web Application Reconnaissance: Information Gathering | 1 |
| 2.2 | Web Application Mapping | 1 |
| 2.3 | Finding Subdomains | 1 |
| 2.4 | Multiple Applications per Domain | 1 |
| 2.5 | Browser's Built-in Network Analysis Tools- Lecture 1 | 1 |

| | | |
|---|---|---|
| 2.6 | Browser's Built-in Network Analysis Tools- Lecture 2 | 1 |
| 2.7 | Public Records | 1 |
| 2.8 | Brute Forcing Subdomain | 1 |
| 2.9 | Dictionary Attacks | 1 |
| **Module -3 (Web Application Offense) (11 hrs)** | | |
| 3.1 | Cross-Site Scripting(XSS) | 1 |
| 3.2 | XSS Discovery & Exploitation | 1 |
| 3.3 | Stored XSS | 1 |
| 3.4 | Reflected XSS | 1 |
| 3.5 | Cross- Site Request Forgery- Query Parameter Tampering | 1 |
| 3.6 | XML External Entity(XXE) | 1 |
| 3.7 | Direct XXE | 1 |
| 3.8 | Indirect XXE | 1 |
| 3.9 | Injection- SQL Injection, Code Injection | 1 |
| 3.10 | Denial of Service- Logical DoS Vulnerabilities | 1 |
| 3.11 | Distributed DoS | 1 |
| **Module –4 (Securing and Hardening Web Applications) (11 hrs)** | | |
| 4.1 | Securing Modern Web Applications | 1 |
| 4.2 | Defensive Software Architecture, Vulnerability Discovery | 1 |
| 4.3 | Vulnerability Analysis, Vulnerability Management | 1 |
| 4.4 | Mitigation Strategies | 1 |
| 4.5 | Secure Application Architecture: Authentication and Authorization. | 1 |
| 4.6 | Vulnerability Discovery: Security Automation. | 1 |
| 4.7 | Vulnerability Management: Common Vulnerability Scoring System. | 1 |

| | | |
|---|---|---|
| 4.8 | Securing Sessions: Different types of Sessions, | 1 |
| 4.9 | Data Transmission Security: SSL/TLS: Certificate Validation Types and Authorities, Creating Self-Signed Certificate for Testing, | 1 |
| 4.10 | OWASP Top 10 Vulnerabilities-Lecture 1 | 1 |
| 4.11 | OWASP Top 10 Vulnerabilities-Lecture 2 | 1 |
| **Module –5 (Web Application Development Technologies) (8 hrs)** | | |
| 5.1 | Basic workflow with a text editor, version control system, and web browser | 1 |
| 5.2 | User interface with HTML | 1 |
| 5.3 | Styles with CSS | 1 |
| 5.4 | JQuery and JavaScript | 1 |
| 5.5 | AJAX, JavaScript objects, and JSON | 1 |
| 5.6 | Server-side programming with Node.js | 1 |
| 5.7 | Storage with Redis and MongoDB | 1 |
| 5.8 | Cloud uploading CloudFoundry | 1 |

| CST 395 | NEURAL NETWORKS AND DEEP LEARNING | Category | L | T | P | Credit | Year of Introduction |
|---|---|---|---|---|---|---|---|
| | | VAC | 3 | 1 | 0 | 4 | 2019 |

**Preamble:**

Neural networks is a biologically inspired programming paradigm which enables a computer to learn from observational data and deep learning is a powerful set of techniques for training neural networks. This course introduces the key concepts in neural networks, its architecture and learning paradigms, optimization techniques, basic concepts in deep learning, Convolutional Neural Networks and Recurrent Neural Networks. The students will be able to provide best solutions to real world problems in domains such as computer vision and natural language processing.

**Prerequisite:** A Sound knowledge in Computational fundamentals of machine learning

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

| | |
|---|---|
| **CO1** | Demonstrate the basic concepts of machine learning models and performance measures. **(Cognitive Knowledge Level : Understand)** |
| **CO2** | Illustrate the basic concepts of neural networks and its practical issues**(Cognitive Knowledge Level : Apply)** |
| **CO3** | Outline the standard regularization and optimization techniques for deep neural networks (**Cognitive Knowledge Level : Understand)** |
| **CO4** | Build CNN and RNN models for different use cases. **(Cognitive Knowledge Level : Apply)** |
| **CO5** | Explain the concepts of modern RNNs like LSTM, GRU **(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 |
| **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 |
| 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 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 a maximum 2 subdivisions and carry 14 marks.

## Syllabus

**Module - 1 (Basics of Machine Learning )**

Machine Learning basics - Learning algorithms - Supervised, Unsupervised, Reinforcement, Overfitting, Underfitting, Hyper parameters and Validation sets, Estimators -Bias and Variance. Challenges in machine learning. Simple Linear Regression, Logistic Regression, Performance measures - Confusion matrix, Accuracy, Precision, Recall, Sensitivity, Specificity, Receiver Operating Characteristic curve( ROC), Area Under Curve(AUC).

**Module -2 (Neural Networks )**

Introduction to neural networks -Single layer perceptrons, Multi Layer Perceptrons (MLPs), Representation Power of MLPs, Activation functions - Sigmoid, Tanh, ReLU, Softmax. Risk minimization, Loss function, Training MLPs with backpropagation, Practical issues in neural network training - The Problem of Overfitting, Vanishing and exploding gradient problems, Difficulties in convergence, Local and spurious Optima, Computational Challenges. Applications of neural networks.

**Module 3 (Deep learning)**

Introduction to deep learning, Deep feed forward network, Training deep models, Optimization techniques - Gradient Descent (GD), GD with momentum, Nesterov accelerated GD, Stochastic GD, AdaGrad, RMSProp, Adam. Regularization Techniques - L1 and L2 regularization, Early stopping, Dataset augmentation, Parameter sharing and tying, Injecting noise at input, Ensemble methods, Dropout, Parameter initialization.

**Module -4 (Convolutional Neural Network)**

Convolutional Neural Networks – Convolution operation, Motivation, Pooling, Convolution and Pooling as an infinitely strong prior, Variants of convolution functions, Structured outputs, Data types, Efficient convolution algorithms. Practical use cases for CNNs, Case study - Building CNN model AlexNet with handwritten digit dataset MNIST.

**Module- 5 (Recurrent Neural Network)**

Recurrent neural networks – Computational graphs, RNN design, encoder – decoder sequence to sequence architectures, deep recurrent networks, recursive neural networks, modern RNNs LSTM and GRU, Practical use cases for RNNs. Case study - Natural Language Processing.

**Text Book**

1. Goodfellow, I., Bengio,Y., and Courville, A., Deep Learning, MIT Press, 2016.
2. Neural Networks and Deep Learning, Aggarwal, Charu C., c Springer International Publishing AG, part of Springer Nature 2018
3. Fundamentals of Deep Learning: Designing Next-Generation Machine Intelligence Algorithms (1st. ed.). Nikhil Buduma and Nicholas Locascio. 2017. O'Reilly Media, Inc.

**Reference Books**

1. Satish Kumar, Neural Networks: A Classroom Approach, Tata McGraw-Hill Education, 2004.
2. Yegnanarayana, B., Artificial Neural Networks PHI Learning Pvt. Ltd, 2009.
3. Michael Nielsen, Neural Networks and Deep Learning, 2018

## Course Level Assessment Questions

**Course Outcome 1 (CO1):**

1. Predict the price of a 1000 square feet house using the regression model generated from the following data.

| No. | Square feet | Price(Lakhs) |
|---|---|---|
| 1 | 500 | 5 |
| 2 | 900 | 10 |
| 3 | 1200 | 13 |
| 4 | 1500 | 18 |
| 5 | 2000 | 25 |
| 6 | 2500 | 32 |
| 7 | 2700 | 35 |

2. Consider a two-class classification problem of predicting whether a photograph contains a man or a woman. Suppose we have a test dataset of 10 records with expected outcomes and a set of predictions from our classification algorithm. Compute the confusion matrix, accuracy, precision, recall, sensitivity and specificity on the following data.

| Sl.**No.** | Actual | Predicted |
|---|---|---|
| 1 | man | woman |
| 2 | man | man |
| 3 | woman | woman |
| 4 | man | man |

| | | |
|---|---|---|
| 5 | man | woman |
| 6 | woman | woman |
| 7 | woman | man |
| 8 | man | man |
| 9 | man | woman |
| 10 | woman | woman |

**Course Outcome 2 (CO2):**

1. Suppose you have a 3-dimensional input x = (x1, x2, x3) = (2, 2, 1) fully connected with weights (0.5, 0.3, 0.2) to one neuron which is in the hidden layer with sigmoid activation function. Calculate the output of the hidden layer neuron.
2. Consider the case of the XOR function in which the two points {(0, 0),(1, 1)} belong to one class, and the other two points {(1, 0),(0, 1)} belong to the other class. Design a multilayer perceptron for this binary classification problem.

**Course Outcome 3 (CO3):**

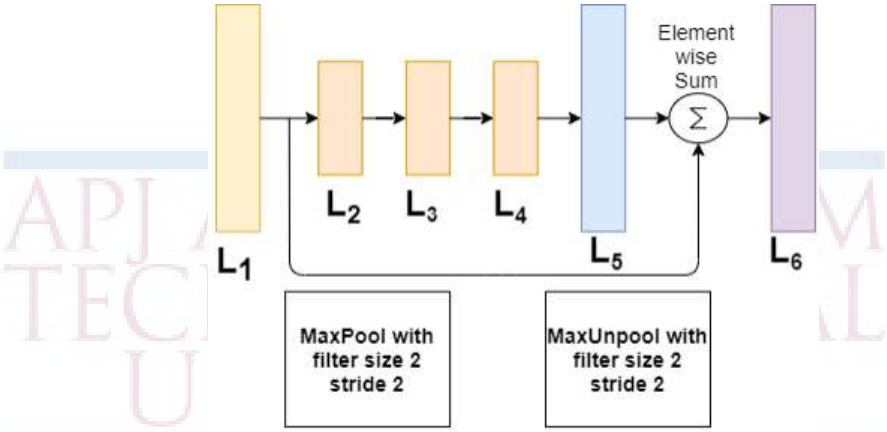
1. Derive a mathematical expression to show L2 regularization as weight decay.
2. Explain how L2 regularization improves the performance of deep feed forward neural networks.
3. Explain how L1 regularization method leads to weight sparsity.

**Course Outcome 4 (CO4):**

1. Draw and explain the architecture of convolutional neural networks.
2. You are given a classification problem to classify the handwritten digits. Suggest a learning and/or inference machine with its architecture, an objective function, and an optimization routine, along with how input and output will be prepared for the classifier.

3. In a Deep CNN architecture the feature map $L_1$ was processed by the following operations as shown in the figure. First down sampled using max pool operation of size 2 and stride 2, and three convolution operations and finally max unpool operation and followed by an element wise sum. The feature map $L_1$ and $L_4$ are given below. Compute the matrix L6.

$$L_1 = \begin{matrix} 10 & 20 & 15 & 22 \\ 20 & 16 & 28 & 30 \\ 30 & 12 & 20 & 16 \\ 20 & 20 & 40 & 12 \end{matrix} \qquad L_4 = \begin{matrix} 10 & 20 \\ 20 & 30 \end{matrix}$$




4. Illustrate the workings of the RNN with an example of a single sequence defined on a vocabulary of four words.

**Course Outcome 5 (CO5):**

1. Draw and explain the architecture of LSTM.
2. List the differences between LSTM and GRU

**Model Question Paper**

**QP CODE:** **PAGES:4**

**Reg No:_____**

**Name:_____**

**APJ ABDUL KALAM TECHNOLOGICAL UNIVERSITY**

**FIFTH SEMESTER B.TECH DEGREE EXAMINATION(HONORS), MONTH & YEAR**

**Course Code: CST 395**

**Course Name: Neural Networks and Deep Learning**

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

**PART A**

**Answer all Questions. Each question carries 3 Marks**

1. List and compare the types of machine learning algorithms
2. Suppose 10000 patients get tested for flu; out of them, 9000 are actually healthy and 1000 are actually sick. For the sick people, a test was positive for 620 and negative for 380. For healthy people, the same test was positive for 180 and negative for 8820. Construct a confusion matrix for the data and compute the

accuracy, precision and recall for the data

3. Illustrate the limitation of a single layer perceptron with an example
4. Specify the advantages of ReLU over sigmoid activation function.
5. Derive weight updating rule in gradient descent when the error function is a) mean squared error b) cross entropy
6. List any three methods to prevent overfitting in neural networks
7. What happens if the stride of the convolutional layer increases? What can be the maximum stride? Justify your answer.
8. Consider an activation volume of size 13×13×64 and a filter of size 3×3×64. Discuss whether it is possible to perform convolutions with strides 2, 3 and 5. Justify your answer in each case.
9. How does a recursive neural network work?
10. List down three differences between LSTM and RNN

**(10x3=30)**

**Part B**

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

11. (a) Prove that the decision boundary of binary logistic regression is linear **(9)**

(b) Given the following data, construct the ROC curve of the data. Compute the AUC. **(5)**

| Threshold | **TP** | TN | FP | FN |
|---|---|---|---|---|
| 1 | 0 | 25 | 0 | 29 |
| 2 | 7 | 25 | 0 | 22 |
| 3 | 18 | 24 | 1 | 11 |
| 4 | 26 | 20 | 5 | 3 |
| 5 | 29 | 11 | 14 | 0 |

| | | | | |
|---|---|---|---|---|
| 6 | 29 | 0 | 25 | 0 |
| 7 | 29 | 0 | 25 | 0 |

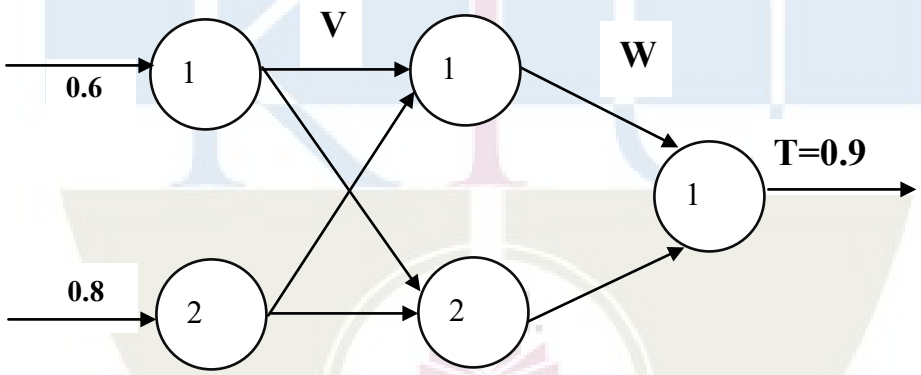
**OR**

12. (a) With an example classification problem, explain the following terms:
a) Hyper parameters b) Training set c) Validation sets d) Bias e) Variance **(8)**

(b) Determine the regression equation by finding the regression slope coefficient and the intercept value using the following data. **(6)**

| | | | | | |
|---|---|---|---|---|---|
| x | 55 | 60 | 65 | 70 | 80 |
| y | 52 | 54 | 56 | 58 | 62 |

13. (a) Update the parameters $V_{11}$ in the given MLP using back propagation with learning rate as 0.5 and activation function as sigmoid. Initial weights are given as $V_{11}$= 0.2, $V_{12}$=0.1, $V_{21}$=0.1, $V_{22}$=0.3, $V_{11}$=0.2, $W_{11}$=0.5, $W_{21}$=0.2



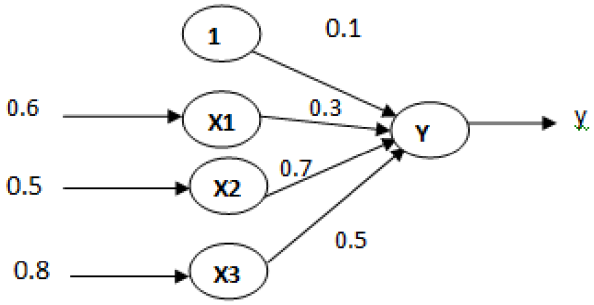

**(10)**

(b) Explain the importance of choosing the right step size in neural networks **(4)**

**OR**

14. (a) Explain in detail any four practical issues in neural network training **(8)**

(b) Calculate the output of the following neuron Y with the activation function as a) binary sigmoid b) tanh c)ReLU **(6)**




15. (a) Explain, what might happen in ADAGRAD, where momentum is expressed as $\Delta w_i = -\eta g_i / \sqrt{(\sum_{\tau=1}^{t} g_\tau^2)}$ where the denominator computes the L2 norm of all previous gradients on a per-dimension basis and $\eta$ is a global learning rate shared by all dimensions. **(6)**

(b) Differentiate gradient descent with and without momentum. Give equations for weight updation in GD with and without momentum. Illustrate plateaus, saddle points and slowly varying gradients. **(8)**

**OR**

16. (a) Suppose a supervised learning problem is given to model a deep feed forward neural network. Suggest solutions for the following a) small sized dataset for training b) dataset with both labelled and unlabeled data c) large data set but data from different distribution **(9)**

(b) Describe the effect in bias and variance when a neural network is modified with more number of hidden units followed with dropout regularization. **(5)**

17. (a) Draw and explain the architecture of Convolutional Neural Networks **(8)**

(b) Suppose that a CNN was trained to classify images into different categories. It performed well on a validation set that was taken from the same source as the training set but not on a testing set. What could be the problem with the training of such a CNN? How will you ascertain the problem? How can those problems be solved? **(6)**

**OR**

18. (a) Explain the following convolution functions a)tensors b) kernel flipping c) down sampling d) strides e) zero padding. **(10)**

(b) What is the motivation behind convolution neural networks? **(4)**

19. (a) Describe how an LSTM takes care of the vanishing gradient problem. Use some hypothetical numbers for input and output signals to explain the concept **(8)**

(b) Explain the architecture of Recurrent Neural Networks **(6)**

**OR**

20. (a) Explain LSTM based solution for anyone of the problems in the Natural Language Processing domain. **(8)**

(b) Discuss the architecture of GRU **(6 )**

**Teaching Plan**

| | | |
|---|---|---|
| **Module 1 : [Text book 1: Chapter 5, Textbook 2: Chapter 2](9 hours)** | | |
| 1.1 | Introduction, Learning algorithms - Supervised, Unsupervised, Reinforcement | 1 hour |
| 1.2 | Overfitting, Underfitting, Hyperparameters | 1 hour |
| 1.3 | Validation sets, Estimators -Bias and Variance. Challenges in machine learning. | 1 hour |
| 1.4 | Simple Linear Regression | 1 hour |
| 1.5 | Illustration of Linear Regression | 1 hour |
| 1.6 | Logistic Regression | 1 hour |
| 1.7 | Illustration of Logistic Regression | 1 hour |
| 1.8 | Performance measures - Confusion matrix, Accuracy, Precision, Recall, Sensitivity, Specificity, ROC, AUC. | 1 hour |
| 1.9 | Illustrative Examples for performance measures | 1 hour |
| **Module 2 : Text book 2, Chapter 1 (8 hours)** | | |
| 2.1 | Introduction to neural networks -Single layer perceptrons | 1 hour |
| 2.2 | Multi Layer Perceptrons (MLPs), Representation Power of MLPs | 1 hour |
| 2.3 | Activation functions - Sigmoid, Tanh, ReLU, Softmax. Risk minimization, Loss function | 1 hour |

| | | |
|---|---|---|
| 2.4 | Training MLPs with backpropagation | 1 hour |
| 2.5 | Illustration of back propagation algorithm | 1 hour |
| 2.6 | Practical issues in neural network training - The Problem of Overfitting, Vanishing and exploding gradient problems | 1 hour |
| 2.7 | Difficulties in convergence, Local and spurious Optima, Computational Challenges. | 1 hour |
| 2.8 | Applications of neural networks | 1 hour |
| **Module 3 : Text book 1: Chapter 7, 8, Text book 2, Chapter 3, 4 (10 hours)** | | |
| 3.1 | Introduction to deep learning, Deep feed forward network | 1 hour |
| 3.2 | Training deep models - Introduction, setup and initialization issues | 1 hour |
| 3.3 | Solving vanishing and exploding gradient problems | 1 hour |
| 3.4 | Concepts of optimization, Gradient Descent (GD), GD with momentum. | 1 hour |
| 3.5 | Nesterov accelerated GD, Stochastic GD. | 1 hour |
| 3.6 | AdaGrad, RMSProp, Adam. | 1 hour |
| 3.7 | Concepts of Regularization, L1 and L2 regularization. | 1 hour |
| 3.8 | Early stopping, Dataset augmentation | 1 hour |
| 3.9 | Parameter sharing and tying, Injecting noise at input, Ensemble methods | 1 hour |
| 3.10 | Dropout, Parameter initialization. | 1 hour |
| **Module 4 : Text book 1, Chapter 9, Text book 2: Chapter 8 (8 hours)** | | |
| 4.1 | Convolutional Neural Networks, architecture | 1 hour |
| 4.2 | Convolution and Pooling operation with example | 1 hour |
| 4.3 | Convolution and Pooling as an infinitely strong prior | 1 hour |
| 4.4 | Variants of convolution functions, structured outputs, data types | 1 hour |
| 4.5 | Efficient convolution algorithms. | 1 hour |
| 4.6 | Practical use cases for CNNs | 1 hour |
| 4.7 | Case study - Building CNN with MNIST and AlexNet. | 1 hour |
| 4.8 | Case study - Building CNN with MNIST and AlexNet | 1 hour |
| **Module 5 : Text book 1 :Chapter 10, 11, Text book 2:Chapter 7 (10 hours)** | | |

| | | |
|---|---|---|
| 5.1 | Recurrent neural networks – Computational graphs, RNN design | 1 hour |
| 5.2 | Encoder – decoder sequence to sequence architectures | 1 hour |
| 5.3 | Deep recurrent networks- Architecture | 1 hour |
| 5.4 | Recursive neural networks | 1 hour |
| 5.5 | Modern RNNs - LSTM | 1 hour |
| 5.6 | Modern RNNs - LSTM | 1 hour |
| 5.7 | GRU | 1 hour |
| 5.8 | Practical use cases for RNNs. | 1 hour |
| 5.9 | Case study - Natural Language Processing. | 1 hour |
| 5.10 | Case study - Natural Language Processing. | 1 hour |

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