JEPPIAAR INSTITUTE OF TECHNOLOGY
“Self-Belief | Self Discipline | Self Respect”

QUESTION BANK

Regulation : 2017

Year/Semester : II

Semester : 04

Batch : 2018-2022

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

Vision of the Institution

Jeppiaar Institute of Technology aspires to provide technical education in futuristic technologies with the perspective of innovative, industrial and social application for the betterment of humanity

Mission of the Institution

M1: To produce competent and disciplined high-quality professionals with the practical skills necessary to excel as innovative professionals and entrepreneurs for the benefit of the society.

M2: To improve the quality of education through excellence in teaching and learning, research, leadership and by promoting the principles of scientific analysis, and creative thinking.

M3: To provide excellent infrastructure, serene and stimulating environment that is most conducive to learning.

M4: To strive for productive partnership between the Industry and the Institute for research and development in the emerging fields and creating opportunities for employability.

M5: To serve the global community by instilling ethics, values and life skills among the students needed to enrich their lives.

DEPARTMENT VISION

To produce Engineers with visionary knowledge in the field of Computer Science and Engineering through scientific and practical education in stance of inventive, modern and communal purpose for the improvement of society.

DEPARTMENT MISSION

M1: Devise students for technical and operational excellence, upgrade them as competent engineers and entrepreneurs for country's development.

M2: Develop the standard for higher studies and perpetual learning through creative and critical thinking for the effective use of emerging technologies with a supportive infrastructure.

M3: Involve in a constructive, team-oriented environment and transfer knowledge to balance the industry-institute interaction.

M4: Enrich students with professional integrity and ethical standards that will make them deal social challenges successfully in their life.

PROGRAM EDUCATIONAL OBJECTIVES (PEOS)

PEO 1: To support students with substantial knowledge for developing and resolving mathematical, scientific and engineering problems.

PEO 2: To provide students with adequate training and opportunities to work as a collaborator with informative and administrative qualities.

PEO 3: To motivate students for extensive learning to prepare them for graduate studies, R&D and competitive exams.

PEO 4: To cater students with industrial exposure in an endeavour to succeed in the emerging cutting edge technologies.

PEO 5: To shape students with principled values and to follow the code of ethics in social and professional life.

PROGRAM SPECIFIC OUTCOMES (PSOS)

PSO 1 : Students are able to analyse, design, implement and test any software with the programming and testing skills they have acquired.

PSO 2: Students are able to design and develop algorithms for real time problems, scientific and business applications through analytical, logical and problems solving skills.

PSO 3: Students are able to provide security solution for network components and data storage and management which will enable them to work efficiently in the industry.

BLOOM’S TAXONOMY

Definition:

- A theory to identify cognitive levels (Levels of thinking)
- Represents the full range of cognitive functions.

Objectives:

- To classify educational learning objectives into levels of complexity and specificity. The classification covers the learning objectives in cognitive, affective and sensory domains.
- To structure curriculum learning objectives, assessments and activities.

Levels in Bloom’s Taxonomy:

- **BTL 1** – **Remember -** The learner is able to recall, restate and remember learned information.

- **BTL 2** – **Understand -** The learner grasps the meaning of information by interpreting and translating what has been learned.

- **BTL 3** – **Apply -** The learner makes use of information in a context similar to the one in which it was learned.

- **BTL 4** – **Analyze -** The learner breaks learned information into its parts to best understand that information.

- **BTL 5** – **Evaluate -** The learner makes decisions based on in-depth reflection, criticism and assessment.

- **BTL 6** – **Create -** The learner creates new ideas and information using what has been previously learned.

TABLE OF CONTENT

CS8493-OPERATING SYSTEMS

CS8494-SOFTWARE ENGINEERING

MA8402 PROBABILITY AND QUEUING THEORY L T P C

4 0 0 4

OBJECTIVES:

- To provide necessary basic concepts in probability and random processes for applications

such as random signals, linear systems in communication engineering.

- To understand the basic concepts of probability, one and two dimensional random variables and to introduce some standard distributions applicable to engineering which can describe real life phenomenon.
- To understand the basic concepts of random processes which are widely used in IT fields.
- To understand the concept of correlation and spectral densities.
- To understand the significance of linear systems with random inputs.

UNIT I PROBABILITY AND RANDOM VARIABLES 12

Probability – Axioms of probability – Conditional probability – Baye‘s theorem - Discrete and continuous random variables – Moments – Moment generating functions – Binomial, Poisson, Geometric, Uniform, Exponential and Normal distributions.

UNIT II TWO - DIMENSIONAL RANDOM VARIABLES 12

Joint distributions – Marginal and conditional distributions – Covariance – Correlation and linear regression – Transformation of random variables – Central limit theorem (for independent and identically distributed random variables).

UNIT III RANDOM PROCESSES12

Classification – Stationary process – Markov process - Markov chain - Poisson process – Random telegraph process.

UNIT IV QUEUEINGMODELS 12

Markovian queues – Birth and Death processes – Single and multiple server queueing models – Little‟s formula – Queues with finite waiting rooms – Queues with impatient customers: Balking and reneging.

UNIT V ADVANCED QUEUEING MODELS 12

Finite source models – M/G/1 queue – PollaczekKhinchin formula – M/D/1 and M/EK/1 as special cases – Series queues – Open Jackson networks.

TOTAL :60 PERIODS

OUTCOMES:

Upon successful completion of the course, students should be able to:

- Understand the fundamental knowledge of the concepts of probability and have knowledge of standard distributions which can describe real life phenomenon.
- Understand the basic concepts of one and two dimensional random variables and apply in engineering applications.
- Apply the concept random processes in engineering disciplines.
- Understand and apply the concept of correlation and spectral densities.
- The students will have an exposure of various distribution functions and help in acquiring skills in handling situations involving more than one variable. Able to analyze the response of random inputs to linear time invariant systems.

TEXT BOOKS:

1. Ibe, O.C.," Fundamentals of Applied Probability and Random Processes ", 1st Indian Reprint, Elsevier, 2007.

2. Peebles, P.Z., "Probability, Random Variables and Random Signal Principles ", Tata McGraw Hill, 4th Edition, New Delhi, 2002.

REFERENCES:

1. Cooper. G.R., McGillem. C.D., "Probabilistic Methods of Signal and System Analysis", Oxford University Press, New Delhi, 3rd Indian Edition, 2012.

2. Hwei Hsu, "Schaum‘s Outline of Theory and Problems of Probability, Random Variables and Random Processes ", Tata McGraw Hill Edition, New Delhi, 2004.

3. Miller. S.L. and Childers. D.G., ―Probability and Random Processes with Applications to Signal Processing and Communications ", Academic Press, 2004.

4. Stark. H. and Woods. J.W., ―Probability and Random Processes with Applications to Signal Processing ", Pearson Education, Asia, 3rd Edition, 2002.

5. Yates. R.D. and Goodman. D.J., ―Probability and Stochastic Processes", Wiley India Pvt. Ltd., Bangalore, 2nd Edition, 2012.

Subject Code:MA8402
Year/Semester: II /03
Subject Name: Probability &Queuing Theory

UNIT I –PROBABILITY & RANDOM VARIABLES

Probability – Axioms of probability – Conditional probability – Baye‘s theorem - Discrete and continuous random variables – Moments – Moment generating functions – Binomial, Poisson, Geometric, Uniform, Exponential and Normal distributions.

PART *A

Q.No.	Questions
1.	**Find the probability of a card drawn at random form an ordinary pack, is a diamond.** BTL2 Total number of ways of getting 1 card = 52 Number of ways of getting 1 diamond card is 13 $\Pr obability = \frac{Number\ of\ \ favourable\ events}{Number\ of\ exhaustive\ events}$ $=\frac{13}{52}=\frac{1}{4}$
2	**A bag contains 7 white, 6 red and 5 black balls. Two balls are drawn at random. Find the probability that they both will be white.**BTL2 Total balls = 18 From these 18 balls 2 balls can be drawn in 18C$_2$ ways Total number of ways of drawing 2 balls = 153 ---------------(1) 2 White balls can be drawn from 7 white balls in 7C$_2$ ways. Therefore number of favourable cases = 21 Probability of drawing white balls $=\frac{No.,of\ \ favourable\ events}{Total\ no.,\ of\ cases}$ $=\frac{21}{153}=\frac{7}{51}$
3	**Write the axioms of probability**.BTL1 Let S be a sample space. To each event A, there is a real number P(A) satisfying the following axioms.

	(i) For any event A, $P(A)\geq 0$ (ii) P(S) = 1 (iii) If $A_1, A_2, ..., A_n$ are finite number of disjoint events of S then $P(A_1\cup A_2\cup A_3\cup ...)=P(A_1)+P(A_2)+P(A_3)+...$
4	**A and B are events such that** $P(A\cup B)=\frac{3}{4}$; $P(A\cap B)=\frac{1}{4}, P(\overline{A})=\frac{2}{3}$, *Find* $P(\overline{A}/B)$**.** BTL2 $P(A\cup B)=P(A)+P(B)-P(A\cap B)$ $\frac{3}{4} \quad =\frac{1}{3}+P(B)-\frac{1}{4}$ $P(B) \ =\frac{2}{3}$ $P(\overline{A}/B)=\frac{P(\overline{A}\cap B)}{P(B)}=\frac{P(B)-P(A\cap B)}{P(B)}=\frac{\frac{2}{3}-\frac{1}{4}}{\frac{2}{3}}=\frac{5}{8}$
5	**Define Baye's theorem.**BTL1 Let $A_1, A_2, ..., A_n$ be 'n' mutually exclusive and exhaustive events with $P(A_i)\neq 0$ for I = 1,2,…n. Let 'B' be an event such that $B\subset\bigcup_{I=1}^{N}A_i$, $P(B)\neq 0$ then $P(A_i/B)=\frac{P(A_i).P(B/A_i)}{\sum_{i=1}^{n}P(A_i).P(B/A_i)}$
6	**Define Random variable. (Nov/Dec2013, Apr/May 2017)** BTL1 A random variable is a function that assigns a real number X(S) to every element $s\in S$ where 'S' is the sample space corresponding to a random experiment E.
7	**Prove that the function P(x) is a legitimate probability mass function of a discrete random variable X, where** $p(x)=\begin{cases}\frac{2}{3}\left(\frac{1}{3}\right)^x, & x=0,1,2...\\ 0 & , \ otherwise\end{cases}$ **(Apr/May 2017)** BTL5

$$\sum p(x)=\sum_{x=0}^{\infty}\frac{2}{3}\left(\frac{1}{3}\right)^{x}=\frac{2}{3}\left(\frac{1}{3}\right)^{0}+\frac{2}{3}\left(\frac{1}{3}\right)^{1}+\frac{2}{3}\left(\frac{1}{3}\right)^{2}+\ldots$$

$$=\frac{2}{3}\left[1+\frac{1}{3}+\left(\frac{1}{3}\right)^{2}+\ldots.\right]$$

$$=\frac{2}{3}\left[1-\frac{1}{3}\right]^{-1}=\frac{2}{3}\left[\frac{2}{3}\right]^{-1}$$

$$=\frac{2}{3}\left[\frac{3}{2}\right]\quad=1$$

Since $\sum p(x)=1$, the given function P(x) is a legitimate probability mass function of a discrete random variable ‘X’.

8

A random variable X has the following probability function.

X=x	0	1	2	3	4	5	6	7	8
P(x)	a	3a	5a	7a	9a	11a	13a	15a	17a

Find the value of ‘a’. BTL5

$$\sum P(x)=1$$

$$a+3a+5a+7a+9a+11a+13a+15a+17a=1$$

$$81a=1$$

$$a=\frac{1}{81}$$

9

If the random variable X takes the values 1,2,3 and 4nsuch that 2P[X=1] = 3P[X=2] = P[X=3] = 5P[X=4]. Find the probability distribution (Nov/Dec 2018)BTL3

Let P[X=3] = k

2P[X=1] = k $\Rightarrow\ p[X=1]=\frac{k}{2}$

3P[X=2] = k $\Rightarrow\ p[X=2]=\frac{k}{3}$

5P[X=4] = k $\Rightarrow\ p[X=4]=\frac{k}{5}$

We know that $\sum P(x)=1$

$$\frac{k}{2}+\frac{k}{3}+k+\frac{k}{5}=1\Rightarrow\frac{61}{30}k=1\Rightarrow k=\frac{30}{61}$$

The probability distribution of X is given by

X	1	2	3	4
P(x)	$\frac{15}{61}$	$\frac{10}{61}$	$\frac{30}{61}$	$\frac{6}{61}$

10 **Find the variance of the discrete random variable X with the probability mass function** $P_x(X)=\begin{cases}\frac{1}{3};x=0\\ \frac{2}{3};x=2\end{cases}$

(Nov/Dec2015 , Nov/Dec 2017)BTL3

The probability distribution of X given by

X	0	2
P(x)	$\frac{1}{3}$	$\frac{2}{3}$

$$E[X]=\sum x\,P(x)=(0)\left(\frac{1}{3}\right)+(2)\left(\frac{2}{3}\right)=0+\frac{4}{3}=\frac{4}{3}$$

$$E[X^2]=\sum x^2P(x)=(0)^2\left(\frac{1}{3}\right)+(2)^2\left(\frac{2}{3}\right)=\frac{8}{3}$$

$$VarX=E[X^2]-\left(E\left[X\right]\right)^2=\frac{8}{3}-\left(\frac{4}{3}\right)^2=\frac{8}{3}-\frac{16}{9}$$

11 **Test whether the function defined as follows a density function ?** $f(x)=\begin{cases}0 & x<2\\ \frac{1}{18}(3+2x) & 2\le x\le 4\\ 0 & x>4\end{cases}$ BTL4

$$\int_2^4 f(x)\,dx=\int_2^4\frac{1}{18}(3+2x)dx=\frac{1}{18}\left[3(x)_2^4+2\left(\frac{x^2}{2}\right)_2^4\right]$$

$$=\frac{1}{18}\left[3(4-2)+(16-4)\right]=\frac{1}{18}(18)=1$$

Hence the given function is a density function.

12	**Show that the function** $f(x)=\begin{cases} e^{-x} & x\ge 0\\ 0 & x<0\end{cases}$ **is a probability density function of a random variable X.**BTL5 $\int f(x)\,dx=\int_0^\infty e^{-x}\,dx=\left[-e^{-x}\right]_0^\infty=-\left[0-1\right]=1$ Hence the given function is a density function.
13	**Assume that X is a continuous random variable with the probability density function** $f(x)=\begin{cases}\frac{3}{4}\left(2x-x^2\right) & 0<x<2\\ 0 & otherwise\end{cases}$ **. Find P(X>1).** BTL3 $P[X>1]=\int_1^2 \frac{3}{4}\left(2x-x^2\right)dx=\frac{3}{4}\left[2\left(\frac{x^2}{2}\right)_1^2-\left(\frac{x^3}{3}\right)_1^2\right]$ $=\frac{3}{4}\left[(4-1)-\left(\frac{8}{3}-\frac{1}{3}\right)\right]=\frac{1}{2}$
14	**A random variable X is known to have a distributive function** $F(x)=u(x)\left[1-e^{-x^2/b}\right], b>0$ **is a constant. Determine density function.** BTL 3 $f(x)=F_x(x)=\frac{d}{dx}\left[u(x)\left(1-e^{-x^2/b}\right)\right]$ $=u(x)\left(e^{-x^2/b}\left(-\frac{2x}{b}\right)\right)+u'(x)\left(1-e^{-x^2/b}\right)$ $=\frac{2}{b}xu(x)e^{-x^2/b}+u'(x)\left(1-e^{-x^2/b}\right)$
15	**If** $f(x)=\frac{x^2}{3},-1<x<2$ **is the PDF of the random variable X then find P[0<X<1]. (Apr/May 2018)** BTL3 $\int f(x)\,dx=\int_0^1\frac{x^2}{3}dx=\frac{1}{3}\left[\frac{x^3}{3}\right]_0^1=\frac{1}{9}\left[1-0\right]=\frac{1}{9}$
16	**A continuous random variable X has probability density function** $f(x)=\begin{cases}3x^2 & 0\le x\le 1\\ 0 & otherwise\end{cases}$ **Find 'k' such that P[X>k]=0.5** . BTL4

	P[X>k] = 0.5 $\Rightarrow\int_k^1 f(x)\,dx=0.5$ $\Rightarrow\int_k^1 3x^2dx=0.5$ $\Rightarrow 3\left[\frac{x^3}{3}\right]_k^1=0.5 \Rightarrow 1-k^3=0.5$ $\Rightarrow k^3=1-0.5=0.5\Rightarrow k=(0.5)^{\frac{1}{3}}=0.7937$
17	**The cumulative distribution function of the random variable X is given by** $F_x(X)=\begin{cases}0 & ;x<0\\ x+\frac{1}{2} & ;0\le x\le\frac{1}{2}\\ 1 & ;\ x>\frac{1}{2}\end{cases}$**. Find** $P[X>\frac{1}{4}]$. BTL3 $P\left[X>\frac{1}{4}\right]=1-P\left[X\le\frac{1}{4}\right]=1-F\left[\frac{1}{4}\right]=1-\left[\frac{1}{4}+\frac{1}{2}\right]=\frac{1}{4}$
18	**Find the moment generating function of Binomial distribution. (May/June 2013)**BTL3 The P.M.F of Binomial distribution is $P[X=x]=nC_x p^x q^{n-x}$, $x=0,1,2,\ldots,n$ $M_x(t)=\sum_{x=0}^{n} e^{tx}p(x)=\sum_{x=0}^{n} e^{tx}nC_x p^x q^{n-x}$ $=\sum_{x=0}^{n} nC_x q^{n-x}\left(pe^t\right)^x$ $=nC_0q^{n-0}\left(pe^t\right)^0+nC_1q^{n-1}\left(pe^t\right)^1+nC_2\,nC_0q^{n-0}\left(pe^t\right)^0q^{n-2}\left(pe^t\right)^2+\ldots+nC_nq^{n-n}\left(pe^t\right)^n$ $=q^n+nC_1q^{n-1}\left(pe^t\right)+nC_2q^{n-2}\left(pe^t\right)^2+\ldots+\left(pe^t\right)^n=\left(q+pe^t\right)^n$
19	**The mean & variance of Binomial distribution are 5 and 4. Determine the distribution.(Apr/May 2015)**BTL4 Given: Mean = np = 5, variance = npq =4

	$= 5q = 4 \Rightarrow q = \frac{4}{5}$ $p = 1 - q = 1 - \frac{4}{5} = \frac{1}{5}$ $np = n\left(\frac{1}{5}\right) = 5 \Rightarrow n = 25$ The P.M.F of the binomial distribution is $P[X = x] = nC_x p^x q^{n-x} \quad x = 0,1,2, \ldots n$ $P[X = x] = 25C_x \left(\frac{1}{5}\right)^x \left(\frac{4}{5}\right)^{n-x} \;, \; x = 0,1,2,\ldots,25$
20	**Balls are tossed at random into 50 boxes. Find the expected number of tosses required to get the first ball in the fourth box. (Apr/May 2017)**BTL3 Let probability of success be $p = \frac{1}{50}$ According to Geometric distribution, Expected number of tosses to get the first ball in the fourth box = $E[x] = \frac{1}{p} = 50$
21.	**A random variable is uniformly distributed between 3 and 15. Find the variance of X. (Nov/Dec 2015)**BTL3 $Var\ X = \frac{(b-a)^2}{12}$ $= \frac{(15-3)^2}{12} = \frac{144}{12} = 12$
22.	**Messages arrive at a switchboard in a poisson manner at an average rate of six per hour. Find the probability for exactly 2 messages arrive within one hour. (Apr/May 2018)**BTL3 $Mean = \lambda = 6\ per\ hour$ $P[X = x] = \frac{e^{-\lambda}\lambda^x}{x!} = \frac{e^{-6}6^x}{x!}$ $P[X = 2] = \frac{e^{-6}6^2}{2!} = 0.0446$
23.	**Find the moment generating function of Poisson distribution. (Nov/Dec 2014, Apr/May 2015)**BTL2

	$P[X=x]=\frac{e^{-\lambda}\lambda^{x}}{x!}, x=0,1,2,... \qquad \lambda>0$ $M_x(t)=E[e^{tx}]=\sum e^{tx}p(x)$ The P.M.F of Poisson distribution is $=\sum_{x=0}^{\infty}e^{tx}\frac{e^{-\lambda}\lambda^{x}}{x!} \quad =e^{-\lambda}\sum_{x=0}^{\infty}\frac{(\lambda e^{t})^{x}}{x!}$ $= e^{-\lambda}\left[1+\frac{(\lambda e^{t})^{1}}{1!}+\frac{(\lambda e^{t})^{2}}{2!}+...\right]$ $=e^{-\lambda}e^{\lambda e^{t}}$
24.	**Let X be a random variable with M.G.F $M_x(t)=\frac{(2e^{t}+1)^{4}}{81}$. Find its mean and variance. (May/June 2016)**BTL3 $M_x(t)=\frac{\left(1+2e^{t}\right)^{4}}{81}=\left(\frac{1+2e^{t}}{3}\right)^{4}=\left(\frac{1}{3}+\frac{2e^{t}}{3}\right)^{4}$ Comparing the M.G.F of Binomial distribution , $M_x(t)=\left(q+pe^{t}\right)^{n}$, we have $p=\frac{2}{3},q=\frac{1}{3},n=4$ Hence $Mean=np=4\left(\frac{2}{3}\right)=\frac{8}{3}$ $Variance=npq=4\left(\frac{2}{3}\right)\left(\frac{1}{3}\right)=\frac{8}{9}$
25.	If **X and Y are independent random variables with variance 2 and 3. Find the variance of 3X+4Y. (May/June 2014)** BTL3 Given : Var(x)= 2 and Var(y) = 3 Var(aX+bY)= a^{2}Var(X) + b^{2}Var(Y) Var(3X+4Y) = 9(2)+16(3)=66
26.	**If $f(x)=\begin{cases} cxe^{-x} & x>0 \\ 0 & elsewhere \end{cases}$ is the p.d.f of a random variable X. Find ‘c’.**BTL5 $\int_{0}^{\infty}cxe^{-x}\,dx=1$ W.K.T $c\left[x\left(\frac{e^{-x}}{-1}\right)-(1)\left(e^{-x}\right)\right]_{0}^{\infty}=1$ $c[(0)-(0-1)]=1$ $c=1$

PART * B

1

A random variable X has the following probability distribution

X=x	-2	-1	0	1	2	3
P(X=x)	0.1	K	0.2	2k	0.3	3k

Find (i)The value of ‘k’

(ii) Evaluate P(X>2) and P(-2<X<2)

(iii)Find the cumulative distributation of X

(**iv) Evaluate the mean of X(8M)(May/June 2010, Nov/Dec 2011, Nov/Dec 2017)**BTL5**.**

Answer:Page: 1.80-Dr.A. Singaravelu

- Total Probability $\sum P(x)=1$
- C.D. F $F(x)=P(X\le x)=\sum_{t\le x} p(t)$
- Mean $E(x)=\sum xP(x)$
- $E(x^2)=\sum x^2P(x)$
- $VarX = E(X^2)-[E(x)]^2$

- Using $\sum P(x)=1$, we have $k=\frac{1}{15}$. (1M)
- P(X<2)=0.5, $P(-2<X<2)=\frac{2}{5}$. (2M)
- C.D. F , F(-2)=0.1, F(-1)= 0.17, F(0)= 0.37, F(1)=0.5, F(2)= 0.8, F(3)=1. (3M)
- Mean E(x) = $\frac{16}{15}$. (2M)

2

A random variable X has the following probability function

X	0	1	2	3	4	5	6	7
P(x)	0	K	2k	2k	3k	K^2	2k^2	7k^2+k

Find (i) the value of ‘k’

(ii) Evaluate $P[1.5<X<4.5/X>2]$

(iii) **The smallest value of** λ **for which** $P[X\le\lambda]>\frac{1}{2}$ **(8M)(Nov/Dec2012,May/June 2012,**

	May/June 2014, A/M 2015) BTL5 **Answer:Page: 1.74-Dr.A.Singaravelu** • Total Probability $\sum P(x)=1$ • C.D. F $F(x)=P(X \le x)=\sum_{t\le x} p(t)$ • Mean $E(x)=\sum xP(x)$ • $E(x^2)=\sum x^2P(x)$ • $VarX = E(X^2)-\left[E(x)\right]^2$ • Value of $k=\frac{1}{10}$. (2M) • $P[1.5<X<4.5/X>2]=\frac{P[1.5<X<4.5\cap X>2]}{P(X>2)}=\frac{5}{7}$ **.** (3M) • The minimum value of $\lambda=4$. (3M)
3	**If the probability mass function of a random variable X is given by** $P(X=r)=kr^3$ ***r=1,2,3,4*** **Find the value of 'k',** $P\left(\frac{1}{2}<X<\frac{5}{2}/X>1\right)$**, mean and variance of X. (8M)(Apr/May 2015)** BTL5 **Answer:Page: 1.24- Dr.G. Balaji** • Total Probability $\sum P(x)=1$ • C.D. F $F(x)=P(X \le x)=\sum_{t\le x} p(t)$ • Mean $E(x)=\sum xP(x)$ • $E(x^2)=\sum x^2P(x)$ • $VarX = E(X^2)-\left[E(x)\right]^2$ • Value of $k=\frac{1}{100}$. (2M) • $P\left(\frac{1}{2}<X<\frac{5}{2}/X>1\right)=\frac{P\left(\frac{1}{2}<X<\frac{5}{2}\cap X>1\right)}{P(X>1)}=\frac{8}{99}$ **.** (3M) • Mean $E(X)=3.54$, Var(X)= 0.4684. (3M)
4	**If the moments of a random variable 'X' are defined by E(X^r) =0.6; r=1,2,3,… Show that P(X=0)=0.4, P(X=1)=0.6,** $P(X \ge 2)=0$ BTL5

	Answer: Page: 1.70-Dr.G. Balaji • $M_x(t)=E\left(e^{tx}\right)=\sum_{x=0}^{\infty} e^{tx}p(x)$ • $M_x(t)=\sum_{x=0}^{\infty}\frac{t^r}{r!}\mu_r{}'$ • $M_x(t)=\sum_{x=0}^{\infty}\frac{t^r}{r!}\mu_r{}' = 0.4+(0.6)e^t$ • But $M_x(t)=E\left(e^{tx}\right)=\sum_{x=0}^{\infty}e^{tx}p(x)=p(0)+e^t p(1)+e^{2t}p(2)$. (3M) • Comparing P(X=0) = 0.4, P(X=1)=0.6. (3M) • $P(X\ge 2)=0$. (2M)
5	**A continuous random variable X that can assume any value between x=2 and x=5 has a density function f(x) = k(1+x). Find P[X<4]. (8M) (Nov/Dec 2012, Apr/May 2015)** BTL5 **Answer: Page: 1.88- Dr.A.Singaravelu** • Total probabability $\int_{-\infty}^{\infty} f(x)dx=1 \Rightarrow \int_{2}^{5} k(1+x)dx=1$. (2M) • The value of $k=\frac{2}{27}$. (3M) • $P[X<4]=\int_{2}^{4} f(x)dx=\frac{16}{27}$. (3M)
6	**If the density function of a continuous random variable X is given by** $f(x)=\begin{cases} ax & ,0\le x\le 1 \\ a & ,1\le x\le 2 \\ 3a-ax & ,2\le x\le 3 \\ 0 & ,otherwise \end{cases}$ **.Find the value of 'a, and find the c.d.f of X. (8M) (Apr/May 2015)**BTL5 **Answer :Page: 1.118- Dr. A. Singaravelu** • $\int_{-\infty}^{\infty} f(x)dx=1 \Rightarrow \int_{0}^{1} ax\,dx+\int_{1}^{2} a\,dx+\int_{2}^{3}(3a-ax)\,dx=1$ (1M) • Value of a=0.5. (1M) • For c.d.f , If x<0, F(x)=0. (1M)

	• If $0 \le x \le 1, F(x) = \frac{x^2}{4}$. (1M) • $1 \le x \le 2, F(x) = \frac{x}{2} - \frac{1}{4}$. (2M) • $2 \le x \le 3, F(x) = -\frac{x^2}{4} + \frac{3}{2}x - \frac{5}{4}$, For x>3, F(x)=1. (2M)
7	**A continuous random variable 'X' has the density function f(x) given by .** $f(x)=\frac{k}{1+x^2}, -\infty < x < \infty$ **Find the value of 'k' and the cumulative distribution of 'X'.(8M) (Nov/Dec 2014, Apr/May 2018)** BTL5 **Answer: Page: 1.123- Dr. A. Singaravelu** • $\int_{-\infty}^{\infty} f(x)dx=1 \Rightarrow \int_{0}^{1} \frac{k}{1+x^2}dx = 1$. (2M) • The value of $k = \frac{1}{\pi}$. (2M) • The c.d.f is $F(x)=\int_{-\infty}^{x} f(x)dx=\int_{-\infty}^{x} \frac{1}{\pi}\left(\frac{1}{1+x^2}\right)dx=\frac{1}{\pi}\left[\tan^{-1}x+\frac{\pi}{2}\right]$. (4M)
8	**Let 'X' be the random variable that denotes the outcome of the roll of a fair die. Compute the mean and variance of 'X'.(8M)(Apr/May 2018)** BTL4 **Answer : Page: 1.177- Dr. A. Singaravelu** • $P(X=i)=\frac{1}{6}, i=1,2,...,6$. (1M) • $M_x(t)=\sum_{i=1}^{6} e^{it}P(X=i)=\frac{1}{6}\left[e^t+e^{2t}+...+e^{6t}\right]$. (2M) • $E(x)=\left[M_x{}'(t)\right]_{t=0}=\frac{7}{2}$. (2M) • $.E(x^2)=\left[M_x{}''(t)\right]_{t=0}=\frac{91}{6}$. (2M) • $Var(X)=E(X^2)-\left[E(X)\right]^2=\frac{35}{12}$. (1M)
9	**For the triangular distribution** $f(x)=\begin{cases} x & ,0 < x \le 1 \\ 2-x, & 1 \le x \le 2 \\ 0 & ,otherwise \end{cases}$ **.Find the mean , variance, moment generating function. (8M) (Nov/Dec 2013)** BTL5 **Answer : Page: 1.180- Dr. A. Singaravelu** • $M_x(t)=E[e^{tx}]=\frac{\left[e^t-1\right]^2}{t^2}$. (3M)

	• Mean $E(X)=\int_{-\infty}^{\infty} x\, f(x)\, dx = 1$. (2M) • $E(X^2)=\int_{-\infty}^{\infty} x^2\ f(x)\, dx = \frac{7}{6}$. (2M) • $Var(X)=E(X^2)-[E(X)]^2=\frac{1}{6}$ (1M)
10	**Find the M.G.F of the random variable X having the probability density function** $f(x)=\begin{cases}\frac{x}{4}e^{-x/2} & ,x>0\\ 0 & ,elsewhere\end{cases}$ **(8M) (May/June2012, May/June 2014)** BTL5 **Answer: Page:1.74-Dr. G. Balaji** • $M_x(t)=E[e^{tx}]=\int_0^{\infty} e^{tx}\frac{x}{4}e^{-x/2}\, dx=\frac{1}{(1-2t)^2}$. (1M) • $M_x(t)=1+\frac{t}{1!}\mu_1{}'+\frac{t^2}{2!}\mu_2{}'+\frac{t^3}{3!}\mu_3{}'+...$ (1M) • $M_x(t)=1+\frac{t}{1!}(4)+\frac{t^2}{2!}(24)+\frac{t^3}{3!}(192)+...$ (2M) • $\mu_1{}' = coefficient\ of\ \frac{t}{1!}=4$. (1M) • $\mu_2{}' = coefficient\ of\ \frac{t^2}{2!}=24$. (1M) • $\mu_3{}' = coefficient\ of\ \frac{t^3}{3!}=192$. (1M) • $\mu_4{}' = coefficient\ of\ \frac{t^4}{4!}=1920$. (1M)
11	**Find the MGF of the Binomial distribution and hence find the mean and variance. (8M)(Apr/May 2011, May/June2014)**BTL2 **Answer : Page: 1.190- Dr. A. Singaravelu** • $P(x)=nC_x p^x q^{n-x}$, $x=0,1,2,...,n$. (1M) • $M_x(t)=E[e^{tx}]=(q+pe^t)^n$. (2M) • Mean $E(X)=\left[M_x{}'(t)\right]_{t=0}=np$. (2M) • $E(X^2)=\left[M_x{}''(t)\right]_{t=0}=n^2p^2+npq$. (2M) • Var(X)= npq. (1M)

12

Derive Poisson distribution form Binomial distribution. (8M)(Nov/Dec 2014, Nov/Dec 2017)BTL2

Answer : Page: 1.219 – Dr. A. Singaravelu

The Binomial distribution becomes Poisson distribution under the following conditions (2M)

- The number of trials is very large
- The probability of success is very small
- $np = \lambda$
- $P(X = x) = \lim\limits_{n\to\infty} nC_x p^x q^{n-x} = \lim\limits_{n\to\infty} \frac{(1-1/n)(1-2/n)\ldots(1-(x-1)/n)}{x!}\lambda^x \frac{(1-\lambda/n)^n}{(1-\lambda/n)^x}$. (4M)
- $P(X = x) = \frac{e^{-\lambda}\lambda^x}{x!}$. (2M)

13

It is known that the probability of an item produced by a certain machine will be defective is 0.05. If the produced items are sent to the market in packets of 20, find the number of packets containing atleast, exactly and atmost 2 defective items in a consignment of 1000packets using binomial and Poisson distribution.(8M) (Nov/Dec 2017) BTL5

Answer : Page: 1.116 – Dr. GBalaji

Probability of Binomial Distribution $P(X = x) = nC_x p^x q^{n-x}$

Probability of Poisson Distribution $P(X = x) = \frac{e^{-\lambda}\lambda^x}{x!}$

Binomial Distribution

- Number of packets containing atleast 2 defective items $= NP(X \ge 2) = 264$. (2M)
- Number of packets containing exactly 2 defective items $= NP(X = 2) = 189$. (1M)
- Number of packets containing atmost 2 defective items $= NP(X \le 2) = 925$. (1M)

Poisson Distribution

- Number of packets containing atleast 2 defective items $= NP(X \ge 2) = 264$. (2M)
- Number of packets containing exactly 2 defective items $= NP(X = 2) = 184$. (1M)
- Number of packets containing atmost 2 defective items $= NP(X \le 2) = 920$. (1M)

14

The number of monthly breakdown of a computer is a random variable having a Poisson distribution with mean equal to 1.8. Find the probability that this computer will function for a month (1)without a breakdown, (2)with only one breakdown and (3)with atleast one breakdown(8M) (Nov/Dec 2017) BTL5

Answer : Page: 1.227- Dr. A. Singaravelu

Probability of Poisson Distribution $P(X = x) = \frac{e^{-\lambda}\lambda^x}{x!}$

	• P(without a breakdown) = P(X=0) = 0.1653. (2M) • P(with only one breakdown) = P(X=1)=0.2975. (2M) • P(with atleast 1 breakdown)= $P(X\geq 1)=1-P(X<1)=0.8347$. (4M)
15	**State and prove the Memoryless property of Geometric distribution.(8M)(Nov/Dec2015, May/June 2016)** BTL1 **Answer : Page: 1.254- Dr. A. Singaravelu** Probability of Geometric distribution P(X=x) = $q^{x-1}p$, x=1,2,… • $P[X>m+n/X>m]=\frac{P[X>m+n\cap X>m]}{P[X>m]}$. (2M) • P[X>k] = q^k (4M) • $P[X>m+n/X>m]=\frac{P[X>m+n]}{P[X>m]}=q^n$. (2M)
16	**If the probability that an applicant for a driver's license will pass the road test on any given trial is 0.8, what is the probability that he will finally pass the test (a) on the fourth trial , (b) in fewer than 4 trials. (8M) (May/June2015)** BTL5 **Answer : Page: 1.137- Dr. G. Balaji** Probability of Geometric distribution P(X=x) = $q^{x-1}p$, x=1,2,… • P(on the fourth trial) = P(X=4) = 0.0064. (4M) • P(fewer than 4 trials) = P(X<4) = 0.992. (4M)
17	**A coin is tossed until the first head occurs. Assuming that the tosses are independent and the probability of a head occurring is 'p', find the value of 'p' so that the probability that an odd number of tosses is required, is equal to 0.6. Can you find a value of 'p' so that the probability is 0.5 that an odd number of tosses is required? (8M)(Nov/Dec 2016, Nov/Dec 2018)** BTL4 **Answer : Page: 1.135- Dr. G. Balaji** Probability of Geometric distribution P(X=x) = $q^{x-1}p$, x=1,2,… • P[X= odd number of tosses] $=\frac{1}{1+q}=0.6$ (3M) • $q=\frac{2}{3}, p=1-q=\frac{1}{3}$. (1M) • P[X= odd number of tosses] $=\frac{1}{1+q}=0.5$ (3M) • q=1, p=0 . (1M)

18	**Determine the moment generating function of Uniform distribution in (a,b) and hence find the mean and variance. (8M) (Nov/Dec 2017, Apr/May 2018)**BTL2 **Answer : Page: 1.256-Dr. A. Singaravelu** The probability function of Uniform distribution is $f(x)=\begin{cases}\frac{1}{b-a}, a<x<b\\ 0 \quad ,otherwise\end{cases}$ • $M_x(t)=E[e^{tx}]=\int_a^b e^{tx} f(x)dx=\frac{\left(e^{bt}-e^{at}\right)}{t(b-a)}$. (3M) • Mean $E(X)=\int_a^b x\, f(x)\, dx=\frac{b+a}{2}$. (2M) • $E(X^2)=\int_a^b x^2\ f(x)\, dx=\frac{b^2+ab+a^2}{3}$. (2M) • $Var(X)=\frac{(b-a)^2}{12}$. (1M)
19	**Suppose 'X' has an exponential distribution with mean=10, Determine the value of 'x' such that P(X<x)=0.95. (8M) (Nov/Dec 2015, Apr/May 2017)**BTL5 **Answer : Page: 1.143- P. SivaramakrishnaDass** The probability function of exponential distribution is $f(x)=\begin{cases}\lambda e^{-\lambda x}, x\geq 0\\ 0 \quad ,otherwise\end{cases}$ • $Mean=\frac{1}{\lambda}=10 \Rightarrow \lambda=\frac{1}{10}$. (2M) • P(X<x)= 1-P(X>x) =0.95. (2M) • $1-e^{-\frac{x}{10}}=0.95 \Rightarrow x=29.96$. (4M)
20	**The time in hours required to repair a machine is exponentially distributed with perimeter** $\lambda=\frac{1}{2}$. (i) **What is the probability that the repair time exceeds 2h** (ii) **What is the conditional probability that a repair takes atleast 10h given that its duration exceeds 9h? (8M) (May/June 2012, Nov/Dec 2016, Nov/Dec 2017)**BTL3 **Answer : Page: 1.274- Dr. A. Singaravelu** The probability function of exponential distribution is $f(x)=\begin{cases}\lambda e^{-\lambda x}, x\geq 0\\ 0 \quad ,otherwise\end{cases}$

	• P(the repair time exceeds 2h) $P(X>2)=\int_{2}^{\infty}\frac{1}{2}e^{-x/2}dx$ (2M) • $P(X>2)=0.3679$. (2M) • $P(X\ge 10/X>9)=P(X>1)=\int_{1}^{\infty}\frac{1}{2}e^{-x/2}dx$. (2M) • $P(X\ge 10/X>9)=0.6065$. (2M)
21	**In a test 2000 electric bulbs, it was found that the life of a particular make, was normally distributed with an average life of 2040 hours and S.D. of 60 hours. Estimate the number of bulbs likely to burn for (i)more than 2150 hours, (ii)less than 1950 hours and (iii) more than 1920 hours but less than 2160 hours. (8M) (Nov/Dec 2017)**BTL5 **Answer: Page:1.293 -A. Singaravelu** • $z=\frac{X-\mu}{\sigma}$ • P(more than 2150 hrs) = P(X>2150) =P(z > 1.833) = 0.5-P(0 < z < 1.833) = 0.0336. (2M) • The number of bulbs expected to burn for more than 2150hrs = 2000 x 0.0336 = 67. (1M) • P(Less than 1950 hrs) = P(X< 1950) = P(z< -1.5) = 0.5 – P(0< z< 1.5) = 0.0668. (2M) • The number of bulbs expected to burn for less than 1950hrs = 2000 x 0.0668 = 134. (1M) • P(more than 1920 hrs but less than 2160 hrs) = P(1920 <X < 2160) = P(-2 < z < 2) = 0.9546.(1M) • The number of bulbs = 2000 x 0.9546 = 1909. (1M)
22	**In a normal distribution 31% of the items are under 45 and 8% are over 64. Find the mean and variance of the distribution. (8M) (Nov/Dec 2012, Nov/Dec 2015)**BTL5 **Answer:Page: 1.295- A. Singaravelu** • $z=\frac{X-\mu}{\sigma}$ • $45-\mu=-0.49\sigma$. (2M) • P(Z > Z_1) = 0.8 or P(0 < Z < Z_2)= 0.42. (1M) • From tables , Z_2 = 1.40. (1M) • $64-\mu=1.40\sigma$. (2M) • Solving, $\sigma=10,\mu=50$. (2M)
23	**The contents of urns I, II, III are as follows:** **1 white, 2 red and 3 black balls** **2 white, 3 red and 1 black balls and** **3 white, 1 red and 2 black balls.** **One urn is chosen at random and 2 balls are drawn. They happen to be white and red. What is the probability that they came from urns I, II, III.**BTL5

Answer: Page: 1.60-Dr. A. Singaravelu

Let $A_1, A_2, ..., A_n$ be 'n' mutually exclusive and exhaustive events with $P(A_i) \neq 0$ for I = 1,2,…n. Let 'B' be an event such that $B \subset \bigcup_{I=1}^{N} A_i$, $P(B) \neq 0$ then $P(A_i / B) = \dfrac{P(A_i).P(B/A_i)}{\sum_{i=1}^{n} P(A_i).P(B/A_i)}$

- P(E$_1$)=P(E$_2$)= P(E$_3$) = $\frac{1}{3}$ (1M)
- $P(A/E_1) = \frac{1C_1 \times 2C_1}{6C_2} = \frac{2}{15}$, $P(A/E_2) = \frac{2C_1 \times 3C_1}{6C_2} = \frac{6}{15}$, $P(A/E_3) = \frac{3C_1 \times 1C_1}{6C_2} = \frac{3}{15}$ (2M)
- $P(E_2/A) = \dfrac{P(E_2).P(A/E_2)}{\sum_{i=1}^{3} P(E_i).P(A/E_i)} = \dfrac{6}{11}$ (2M)
- $P(E_3/A) = \dfrac{P(E_3).P(A/E_3)}{\sum_{i=1}^{3} P(E_i).P(A/E_i)} = \dfrac{3}{11}$ (2M)
- P(E$_1$/A) = 1- P(E$_2$/A) - P(E$_3$/A) = $\frac{2}{11}$ (1M)

UNIT II – TWO - DIMENSIONAL RANDOM VARIABLES

Joint distributions – Marginal and conditional distributions – Covariance – Correlation and linear regression – Transformation of random variables – Central limit theorem (for independent and identically distributed random variables).

PART *A

Q.No.	Questions
1.	**State the basic properties of joint distribution of (X,Y) where X and Y are random variables. (May/June 2014)**BTL1 Properties of joint distribution of (X,Y) are (i) $F[-\infty, y] = 0 = F[x, -\infty]$ *and* $F[-\infty, -\infty] = 0, F[\infty, \infty] = 0$ (ii) $P[a < X < b, Y \leq y] = F(b, y) - F(a, y)$ (iii) $P[X \leq x, c < Y < d] = F(x, d) - F(x, c)$ (iv) $P[a < X < b, c < Y < d] = F(b, d) - F(a, d) - F(b, c) + F(a, c)$ (v) At points of continuity of f(x,y), $\frac{\partial^2 F}{\partial x \partial y} = f(x, y)$

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The joint probability mass function of a two dimensional random variable (X,Y) is given by p(x,y) = f(2x + y); x = 1,2 and y = 1,2 where 'k' is a constant. Find the value of 'k'.(Nov/Dec 2015)BTL5

The joint pmf of (X,Y) is

<table>
<tr><th>x \ y</th><th>1</th><th>2</th></tr>
<tr><td>1</td><td>3k</td><td>4k</td></tr>
<tr><td>2</td><td>5k</td><td>6k</td></tr>
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We have $\sum\sum p(x,y)=1$

Therefore, 3k + 4k + 5k + 6k = 1

18 k=1 $k=\frac{1}{18}$.

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The joint probability density function of the random variables (X,Y) is given by $f(x,y)=kxye^{-(x^2+y^2)},\ x>0,y>0$**. Find the value of 'k'. (Apr/May 2015)**BTL5

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	$\iint f(x,y)\,dkxdy=1$ $\int_0^\infty\int_0^\infty kxye^{-\left(x^2+y^2\right)}\,dx\,dy=1$ $k\int_0^\infty ye^{-y^2}dy\int_0^\infty xe^{-x^2}dx=1$ Put $x^2=t$ $2xdx=dt$ $k\int_0^\infty ye^{-y^2}dy\int_0^\infty e^{-t}\frac{dt}{2}=1$ $xdx=\frac{dt}{2}$ $\frac{k}{2}\int_0^\infty ye^{-y^2}\left[-e^{-t}\right]_0^\infty dy=1$ $\frac{k}{2}\int_0^\infty ye^{-y^2}\left[0+1\right]dy=1$ $\frac{k}{2}\int_0^\infty e^{-t}\frac{dt}{2}=1$ We have $\frac{k}{4}\left[-e^{-t}\right]_0^\infty=1$ $\frac{k}{4}[0+1]=1\Rightarrow k=4$
4	**If the function f(x,y) = c(1-x)(1-y) , 0 < x < 1 , 0 < y < 1 is to be a density function, find the value of 'c'.(8M) (Nov/Dec 2017)**BTL5 $\iint f(x,y)\,dx\,dy=1$ $\int_0^1\int_0^1 c(1-x)(1-y)dx\,dy=1$ $c\int_0^1(1-y)dy\int_0^1(1-x)dx=1$ $c\left[y-\frac{y^2}{2}\right]_0^1\left[x-\frac{x^2}{2}\right]_0^1=1$ $c\left[1-\frac{1}{2}\right]\left[1-\frac{1}{2}\right]=1$ $c\left[\frac{1}{2}\right]\left[\frac{1}{2}\right]=1$ $c\left[\frac{1}{4}\right]=1\Rightarrow c=4$

5	**The joint pdf of (X,Y) is** $f_{xy}(x,y)=xy^2+\frac{x^2}{8}, 0\le x\le 2, 0\le y\le 1$**. Find P(X<Y). (May/June 2013, Apr/May 2017)**BTL5 $P(X<Y)=\int_0^1\int_0^y\left(xy^2+\frac{x^2}{8}\right)dx\,dy$ $=\int_0^1\left[y^2\left(\frac{x^2}{2}\right)_0^y+\frac{1}{8}\left(\frac{x^3}{3}\right)_0^y\right]dy$ $=\int_0^1\left[\frac{y^2}{2}\left(y^2\right)+\frac{1}{24}\left(y^3\right)\right]dy=\int_0^1\left[\frac{y^4}{2}+\frac{y^3}{24}\right]dy$ $=\frac{1}{2}\left(\frac{y^5}{5}\right)_0^1+\frac{1}{24}\left(\frac{y^4}{4}\right)_0^1=\frac{1}{10}(1-0)+\frac{1}{96}(1-0)=\frac{53}{480}$
6	**If the joint pdf of (X,Y) is** $f(x,y)=\begin{cases}\frac{1}{4} & ,0<x,y<2\\ 0 & ,otherwise\end{cases}$ **. Find** $P[X+Y\le 1]$BTL5 $P[X+Y\le 1]=\int_0^1\int_0^{1-y}\left(\frac{1}{4}\right)dx\,dy=\frac{1}{4}\int_0^1(x)_0^{1-y}\,dy$ $=\frac{1}{4}\int_0^1(1-y)dy \quad =\frac{1}{4}\left[y-\frac{y^2}{2}\right]_0^1$ $=\frac{1}{4}\left[1-\frac{1}{2}\right]=\frac{1}{8}$
7	**Find the marginal density function of X and Y if** $f(x,y)=\begin{cases}\frac{6}{5}\left(x+y^2\right) & ,0\le x,y\le 1\\ 0 & ,otherwise\end{cases}$**(Nov/Dec 2012)**BTL5 Marginal density function of X is $f_x(x)=\int f(x,y)\,dy=\int_0^1\frac{6}{5}\left(x+y^2\right)dy=\frac{6}{5}\left[xy+\frac{y^3}{3}\right]_0^1=\frac{6}{5}\left[x+\frac{1}{3}\right]\ 0\le x\le 1$ Marginal density function of Y is

	$f_y(y)=\int f(x,y)\,dx=\int_0^1 \frac{6}{5}\left(x+y^2\right)dy=\frac{6}{5}\left[\frac{x^2}{2}+y^2x\right]_0^1=\frac{6}{5}\left[\frac{1}{2}+y^2\right]\ \ 0\le y\le 1$
8	**The joint probability density function of the random variable X and Y is** $f(x,y)=\begin{cases}25e^{-5y} & ,0<x<0.2, y>0\\ 0 & ,otherwise\end{cases}$**.Find the marginal PDF of X and Y. (Nov/Dec 2016)**BTL5 Marginal density function of X is $f_x(x)=\int f(x,y)\,dy=\int_0^\infty 25e^{-5y}dy=25\left[\frac{e^{-5y}}{-5}\right]_0^\infty=-5\left[0-1\right]=5\ \ 0\le x\le 0.2$ Marginal density function of Y is $f_y(y)=\int f(x,y)\,dx=\int_0^{0.2}25e^{-5y}dx=25e^{-5y}\left[x\right]_0^{0.2}=2e^{-5y}\left[0.2-0\right]=5e^{-5y}\ \ \ y>0$
9	**If X and Y are independent random variables having the joint density function** $f(x,y)=\frac{1}{8}(6-x-y),0<x<2,\ 2<y<4$**. Find P[X+Y<3]**. BTL5 $P\left[X+Y<3\right]=\frac{1}{8}\int_2^3\int_0^{3-y}\left(6-x-y\right)dx\,dy$ $=\frac{1}{8}\int_2^3\left[\left(6-y\right)\left(x\right)-\frac{x^2}{2}\right]_0^{3-y}dy=\frac{1}{8}\int_2^3\left[\left(6-y\right)\left(3-y\right)-\frac{\left(3-y\right)^2}{2}\right]dy$ $=\frac{1}{8}\int_2^3\left[18-9y+y^2-\frac{1}{2}\left(3-y\right)^2\right]dy$ $=\left[18y-9\frac{y^2}{2}+\frac{y^3}{3}-\frac{1}{2}\frac{\left(3-y\right)^3}{-3}\right]_2^3$ $=\left[18(3)-\frac{9}{2}(9)+\frac{27}{3}+\frac{1}{6}(0)\right]-\left[18(2)-\frac{9}{2}(4)+\frac{8}{3}+\frac{1}{6}(1)\right]$ $=\left[18-\frac{45}{2}+\frac{19}{3}-\frac{1}{6}\right]=\frac{5}{24}$
10	**Let X and Y be random variables with joint density function** $f(x,y)=\begin{cases}4xy & ,0\le x\le 1,\ 0\le y\le 1\\ 0 & ,otherwise\end{cases}$ **Find E[XY].**BTL5

	$E[XY]=\int\int xy\,f(x,y)\,dx\,dy=\int_0^1\int_0^1 xy(4xy)dx\,dy$ $=4\int_0^1 x^2dx\int_0^1 y^2dy$ $=4\left[\frac{x^3}{3}\right]_0^1\left[\frac{y^3}{3}\right]_0^1=\frac{4}{9}(1)(1)=\frac{4}{9}$
11	**Let X and Y be a two-dimensional random variable. Define covariance of (X,Y). If X and Y are independent, what will be the covariance of (X,Y)? (May/June 2016)**BTL2 Covariance of (X,Y) is defined as *Cov(X,Y) = E[XY] – E[x]E[Y]* If X and Y are independent, then *Cov(X,Y) =0.*
12	**Two random variables X and Y have the joint pdf** $f(x,y)=\begin{cases}\frac{xy}{96} & ;0<x<4,1<y<5\\ 0 & ;otherwise\end{cases}$**. Find *Cov(X,Y)*. (May/June 2016)**BTL5 *Cov(X,Y) = E[XY] – E[x]E[Y]* $E[X]=\int\int x\,f(x,y)\,dx\,dy=\int_1^5\int_0^4 x\left(\frac{xy}{96}\right)dx\,dy=\frac{1}{96}\int_1^5 ydy\int_0^4 x^2\,dx$ $=\frac{1}{96}\left[\frac{y^2}{2}\right]_1^5\left[\frac{x^3}{3}\right]_0^4=\frac{1}{576}[25-1][64]=\frac{8}{3}$ $E[Y]=\int\int y\,f(x,y)\,dx\,dy=\int_1^5\int_0^4 y\left(\frac{xy}{96}\right)dx\,dy=\frac{1}{96}\int_1^5 y^2dy\int_0^4 x\,dx$ $=\frac{1}{96}\left[\frac{y^3}{3}\right]_1^5\left[\frac{x^2}{2}\right]_0^4=\frac{1}{576}[125-1][16]=\frac{31}{9}$ $E[XY]=\int\int xy\,f(x,y)\,dx\,dy=\int_1^5\int_0^4 xy\left(\frac{xy}{96}\right)dx\,dy=\frac{1}{96}\int_1^5 y^2dy\int_0^4 x^2\,dx$ $=\frac{1}{96}\left[\frac{y^3}{3}\right]_1^5\left[\frac{x^3}{3}\right]_0^4=\frac{1}{864}[125-1][64]=\frac{248}{27}$ $\therefore\ Cov(X,Y)=\left[\frac{248}{27}\right]-\left[\frac{8}{3}\right]\left[\frac{31}{9}\right]=0$
13	**Let X and Y be any two random variables a,b be constants. Prove that**

	Cov(aX,bY)=abCov(X,Y).BTL5 $Cov(X,Y) = E[XY] - E[X]E[Y]$ $Cov(aX,bY)= E[aXbY] - E[aX]\ E[bY]$ $=ab\ E[XY] - ab\ E[X]E[Y]$ $=ab[E[XY] - E[X]E[Y]]$ $= ab\,Cov(X,Y)$
14	**If Y = - 2X + 3, Find Cov(X,Y).**BTL3 $Cov(X,Y) = E[XY] - E[X]E[Y]$ $=E[X(-2X+3)]-E[X]E[-2X+3]$ $= E[-2X^2+3X] - E[X][-2E[X]+3]$ $= -2E[X^2]+3E[X]+2(E[X])^2-3E[x]$ $= -2(E[X^2]-(E[X])^2) = -2Var\ X$
15	**If X_1 has mean 4 and variance 9 while X_2 has mean -2 and variance 5 and the two are independent , find $Var(2X_1+X_2-5)$.**BTL3 $E[X_1]=4$, $E[X_2] = -2$ $Var[X_1] = 9$, $Var[X_2] = 5$ $Var(2X_1+X_2-5) = 4\ VarX_1 + VarX_2$ $= 4(9) + 5 = 41.$
16	**If X and Y are independent random variables then show that E[Y/X] = E[Y] ,E[X/Y] = E[X]. (Nov/Dec 2016)**BTL5 $E[Y/X]=\int y.\frac{f(x,y)}{f(x)}dy$ Since X and Y are independent, $E[Y/X]=\int y.\frac{f(x).f(y)}{f(x)}dy=\int y.f(y)\,dy = E[Y]$ $E[X/Y]=\int x.\frac{f(x,y)}{f(y)}dx$ Since X and Y are independent, $E[X/Y]=\int x.\frac{f(x).f(y)}{f(y)}dx=\int x.f(x)\,dx = E[X]$
17	**Find the acute angle between the two lines of regression. (Apr/May 2015, Apr/May 2018)**BTL3 The equations of the regression are

	$y-\bar{y}=r\frac{\sigma_y}{\sigma_x}\left(x-\bar{x}\right) \qquad ----------(1)$ $x-\bar{x}=r\frac{\sigma_x}{\sigma_y}\left(y-\bar{y}\right) \qquad ----------(2)$ Slope of line (1) is $m_1=r\frac{\sigma_y}{\sigma_x}$ Slope of line (2) is $m_2=\frac{1}{r}\frac{\sigma_y}{\sigma_x}$ If θ is the acute angle between the two lines, then $\tan\theta=\frac{\lvert m_1-m_2\rvert}{1+m_1m_2}$ $=\frac{\left\lvert r\frac{\sigma_y}{\sigma_x}-\frac{\sigma_y}{r\sigma_x}\right\rvert}{1+r\frac{\sigma_y}{\sigma_x}.\frac{\sigma_y}{r\sigma_x}}=\frac{\left\lvert\frac{\left(r^2-1\right)}{r}\frac{\sigma_y}{\sigma_x}\right\rvert}{1+\frac{\sigma_y^2}{\sigma_x^2}}$ $=\frac{\left\lvert\frac{-\left(1-r^2\right)}{r}\frac{\sigma_y}{\sigma_x}\right\rvert}{\frac{\sigma_x^2+\sigma_y^2}{\sigma_x^2}}=\frac{\left(1-r^2\right)\sigma_x\sigma_y}{\lvert r\rvert\left(\sigma_x^2+\sigma_y^2\right)}$
18	**The regression equations are 3x + 2y = 26 and 6x + y = 31. Find the correlation coefficient between X and Y.** BTL5 Let 3x + 2y = 26 be the regression equation of Y on X. Therefore, $2y=-3x+26 \Rightarrow y=-\frac{3}{2}x+\frac{26}{2}$. The regression coefficient $b_{yx}=-\frac{3}{2}$ Let 6x+ y = 31 be the regression equation of X on Y. Therefore, $6x=-y+31 \Rightarrow x=-\frac{1}{6}y+\frac{31}{6}$ The regression coefficient $b_{xy}=-\frac{1}{6}$ Hence, correlation coefficient r_{xy} is given by $r_{xy}=\pm\sqrt{b_{yx}\times b_{xy}}=\pm\sqrt{\left(\frac{-3}{2}\right)\left(\frac{-1}{6}\right)}=\pm\sqrt{\frac{1}{4}}=\pm 0.5$ =-0.5, since both the regression coefficients are negative.
19	**The two regression equations of two random variables X and Y are 4x – 5y +33 = 0 and 20x – 9y =107. Find the mean values of X and Y. (Nov/Dec 2018)** BTL5 Replace x and y as $\bar{x}$ and $\bar{y}$, we have

	$4\bar{x}-5\bar{y}=-33\quad ------(1)$ $20\bar{x}-9\bar{y}=107\quad ------(2)$ Solving the equations (1) and (2), we have $\bar{x}=13$ and $\bar{y}=17$.
20	**Can y=5+2.8x and x=3-0.5y be the estimated regression equations of y on x and x on y respectively, explain your answer. (Nov/Dec 2016)**BTL4 Since the signs of regression co-effieients are not the same, the given equation is not estimated regression equation of y on x and x on y.
21	**If X has an exponential distribution with parameter 1. Find the pdf of $y=\sqrt{x}$.**BTL3 $y=\sqrt{x}\Rightarrow x=y^2$ Since $dx=2y\,dy\ \Rightarrow\frac{dx}{dy}=2y$ Since X has an exponential distribution with parameter 1, the pdf of X is given by, $f_x(x)=e^{-x}, x>0\qquad [f(x)=\lambda e^{-\lambda x}, \lambda=1]$ $\therefore f_y(y)=f_x(x)\left\lvert\frac{dx}{dy}\right\rvert$ $=e^{-x}2y=2ye^{-y^2}\ \ y>0$
22	**State Central limit theorem.**BTL1 If X$_1$, X$_2$, …,X$_n$,… be a sequence of independent identically distributed random variables with $E(X_i)=\mu$ and $Var(X_i)=\sigma^2$, i=1,2,… and if S$_n$ = X$_1$ + X$_2$ + … + X$_n$, then under certain general conditions, S$_n$ follows a normal distribution with mean $n\mu$ and variance $n\sigma^2$ as $n\to\infty$
23	**If X and Y have joint pdf of $f(x,y)=\begin{cases}x+y, 0<x,y<1\\0\quad ,elsewhere\end{cases}$. Check whether X and Y are independent.**BTL4 The marginal function of X is $f(x)=\int_0^1(x+y)dy=\left[xy+\frac{y^2}{2}\right]_0^1=x+\frac{1}{2}$, 0<x<1 The marginal function of Y is $f(y)=\int_0^1(x+y)dx=\left[\frac{x^2}{2}+y\right]_0^1=y+\frac{1}{2}$, 0<y<1 Now, $f(x).f(y)=\left(x+\frac{1}{2}\right)\left(y+\frac{1}{2}\right)=xy+\frac{1}{2}(x+y)+\frac{1}{4}\neq x+y\neq f(x,y)$ Hence X and Y are not independent.
24	**Assume that the random variables X and Y have the probability density function f(x,y). What is E[E[X/Y]]? (Apr/May 2017)**BTL5

	$E\left[\left[X/Y\right]\right] = \int_{-\infty}^{\infty} E\left[X/Y\right] f(y)\,dy$ $= \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} x\, f(x/y)\,dx\, f(y)\,dy$ $= \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} x\, f(x/y)\; f(y)\,dx\,dy$ $= \int_{-\infty}^{\infty} x \int_{-\infty}^{\infty} f(x,y)\,dy\,dy\,dx$ $= \int_{-\infty}^{\infty} x\, f(x)\,dx = E(X)$
25	**Define the joint density function of two random variables X and Y.** BTL1 If (X,Y) is a two dimensional continuous random variables such that $P\left[x-\frac{dx}{2} \le X \le x+\frac{dx}{2}, y-\frac{dy}{2} \le Y \le y+\frac{dy}{2}\right] = f(x,y)\,dx\,dy$, then f(x,y) is called the joint pdf of (X,Y), provided f(x,y) satisfies the following conditions (i) $f(x,y) \ge 0,\ for\ all\ (x,y) \in R$ (ii) $\iint_R f(x,y)\,dx\,dy = 1$
	Part*B
1	**The joint pmf of (X,Y) is given by P(x,y) = k(2x + 3y), x = 0,1,2 ; y = 1,2,3. Find all the marginal and conditional probability distributions. Also, find the probability distribution of (X+Y). (10M) (Nov/Dec 2014, Nov/Dec 2015)** BTL5 **Answer: Pg. 2.8 – Dr. A. Singaravelu** • $k = \frac{1}{72}$. (1M) • Marginal distribution of X: $P(X=0) = \frac{18}{72}, P(X=1) = \frac{24}{72}, P(X=2) = \frac{30}{72}$ (1M) • Marginal distribution of Y: $P(Y=1) = \frac{15}{72}, P(Y=2) = \frac{24}{72}, P(Y=3) = \frac{33}{72}$ (1M) • Conditional distribution of X given Y: $P\left[X = x_i / Y = y_1\right] = \frac{1}{5}, \frac{1}{3}, \frac{7}{15}$ (1M) • $P\left[X = x_i / Y = y_2\right] = \frac{1}{4}, \frac{1}{3}, \frac{5}{12}$. (1M) • $P\left[X = x_i / Y = y_3\right] = \frac{9}{33}, \frac{1}{3}, \frac{13}{33}$. (1M) • Conditional distribution of Y given X: $P\left[Y = y_i / X = x_0\right] = \frac{1}{6}, \frac{1}{3}, \frac{1}{2}$. (1M) • $P\left[Y = y_i / X = x_1\right] = \frac{5}{24}, \frac{1}{3}, \frac{11}{24}$. (1M)

	• $P[Y=y_i/X=x_2]=\frac{7}{30},\frac{1}{3},\frac{13}{30}$. (1M) • Total probability distribution of X+Y is 1. (1M)
2	**The two dimensional random variable (X,Y) has the joint pmf** $f(x,y)=\frac{x+2y}{27}, x=0,1,2; y=0,1,2$ **Find the conditional distribution of Y for X=x. (8M) (Nov/Dec 2017)** BTL5 **Answer : Pg. 2.13 – Dr. A. Singaravelu** • Marginal distribution of X: $P(X=0)=\frac{6}{27}, P(X=1)=\frac{9}{27}, P(X=2)=\frac{12}{27}$ (1M) • Marginal distribution of Y: $P(Y=0)=\frac{3}{27}, P(Y=1)=\frac{9}{27}, P(Y=2)=\frac{15}{27}$ (1M) • Conditional distribution of Y given X: $P[Y=y_i/X=x_0]=0,\frac{1}{3},\frac{2}{3}$. (2M) • $P[Y=y_i/X=x_1]=\frac{1}{9},\frac{1}{3},\frac{5}{9}$. (2M) • $P[Y=y_i/X=x_2]=\frac{1}{6},\frac{1}{3},\frac{1}{2}$. (2M)
3	**Three balls are drawn at random without replacement from a box containing 2 white, 3 red and 4 black balls. If X denotes the number of white balls drawn and Y denote the number of red balls drawn, find the joint probability distribution of (X,Y).(8M)(Apr/May 2015, May/June 2016)** BTL5 **Answer: Page: 2.20- Dr. G. Balaji** • Let X denote number of white balls drawn and Y denote the number of red balls drawn. • $P(X=0,Y=0)=\frac{1}{21}, P(X=0,Y=1)=\frac{3}{14}, P(X=0,Y=2)=\frac{1}{7}, P(X=0,Y=3)=\frac{1}{84}$ (3M) • $P(X=1,Y=0)=\frac{1}{7}, P(X=1,Y=1)=\frac{2}{7}, P(X=1,Y=2)=\frac{1}{14}$ (3M) • $P(X=2,Y=0)=\frac{1}{21}, P(X=2,Y=1)=\frac{1}{28}$ (2M)
4	**The joint pdf of the random variable (X,Y) is given by** $f(x,y)=Kxye^{=(x^2+y^2)}, x>0, y>0$ **. Find the value of 'K' and also prove that X and Y are independent. (8M) (Apr/May 2015)**BTL5 **Answer : Pg. 2.25 – Dr.A. Singaravelu** • Marginal density function of X : $f(x)=\int_{-\infty}^{\infty} f(x,y)dy$ • Marginal density function ofY: $f(y)=\int_{-\infty}^{\infty} f(x,y)dx$ • X and Y are independent if f(x,y) = f(x). f(y) • $\int_0^{\infty}\int_0^{\infty} Kxye^{=(x^2+y^2)}dx\,dy=1 \Rightarrow K=4$. (2M)

	- Marginal density function of X : $f(x)=\int_{0}^{\infty}Kxye^{=(x^2+y^2)}dy=2xe^{-x^2}$. (2M) - Marginal density function of Y : $f(y)=\int_{0}^{\infty}Kxye^{=(x^2+y^2)}dx=2ye^{-y^2}$. (2M) - f(x). f(y) = $2xe^{-x^2}.2ye^{-y^2}=4xye^{=(x^2+y^2)}=f(x,y)$. (2M)
5	**Given $f_{XY}(x,y)=Cx(x-y),0<x<2,-x<y<x$ and 0 elsewhere. (a)Evaluate C; (b)Find f$_x$(x) ; (c) $f_{y/x}\left(\frac{y}{x}\right)$** **(d)**Find f$_y$(y).**(8M) (May, June 2013May/June2016)**BTL5 **Answer : Pg. 2.40 – Dr. A. Singaravelu** - $\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}f(x,y)dx\,dy=1$ - Marginal density function of X : $f(x)=\int_{-\infty}^{\infty}f(x,y)dy$ - Marginal density function ofY: $f(y)=\int_{-\infty}^{\infty}f(x,y)dx$ - $\int_{0}^{2}\int_{-x}^{x}Cx(x-y)dy\,dx=1\Rightarrow C=\frac{1}{8}$. (1M) - $f_x(x)=\int_{-x}^{x}Cx(x-y)dy=\frac{x^3}{4},0<x<2.$ (2M) - $f\left(\frac{y}{x}\right)=\frac{f(x,y)}{f(x)}=\frac{x-y}{2x^2},-x<y<x$. (2M) - $f_y(y)=\begin{cases}\int_{-y}^{2}\frac{1}{8}x(x-y)dx, if\ -2\le y\le 0\ =\frac{1}{3}-\frac{y}{4}+\frac{5}{28}y^3\\ \int_{y}^{2}\frac{1}{8}x(x-y)dx, if\ 0\le y\le 2\ =\frac{1}{3}-\frac{y}{4}+\frac{1}{28}y^3\end{cases}$ (3M)
6	**The joint pdf of (X,Y) is given by $f(x,y)=e^{-(x+y)},0\le x,y\le\infty$. Are X and Y independent.(8M)(Nov/Dec 2015, Apr/May 2018)** BTL4 **Answer :Page:2.28 – Dr. A. Singaravelu** - Marginal density function of X : $f(x)=\int_{-\infty}^{\infty}f(x,y)dy$ - Marginal density function ofY: $f(y)=\int_{-\infty}^{\infty}f(x,y)dx$ - X and Y are independent if f(x,y) = f(x). f(y)

	• $f(x)=\int_0^\infty e^{-(x+y)}dy=e^{-x}$. (3M) • $f(y)=\int_0^\infty e^{-(x+y)}dx=e^{-y}$. (3M) • $f(x).f(y)=e^{-x}\,e^{-y}=e^{-(x+y)}=f(x,y)$. (2M)
7	**The joint p.d.f of a two dimensional random variable (X,Y) is given by** $f(x,y)=xy^2+\frac{x^2}{8}, 0\le x\le 2, 0\le y\le 1$ **. Compute (i)** $P\left(X>1/Y<\frac{1}{2}\right)$**, (ii)** $P\left(Y<\frac{1}{2}/X>1\right)$**, (iii) P(X<Y), (iv)** $P(X+Y\le 1)$ **(8M) (Apr/May 2017)** BTL5 **Answer : Pg. 2.43 – Dr.A. Singaravelu** • $P\left(X>1/Y<\frac{1}{2}\right)=\frac{P\left(X>1,Y<\frac{1}{2}\right)}{P\left(Y<\frac{1}{2}\right)}=\frac{\frac{5}{24}}{\frac{1}{4}}=\frac{5}{6}$ (2M) • $P\left(Y<\frac{1}{2}/X>1\right)=\frac{P\left(X>1,Y<\frac{1}{2}\right)}{P(X>1)}=\frac{\frac{5}{24}}{\frac{19}{24}}=\frac{5}{19}$ (2M) • $P(X<Y)=\int_0^1\int_0^y\left(xy^2+\frac{x^2}{8}\right)dx\,dy=\frac{53}{480}$ (2M) • $P(X+Y\le 1)=\int_0^1\int_0^{1-y}\left(xy^2+\frac{x^2}{8}\right)dx\,dy=\frac{13}{480}$ (2M)
8	**Let X and Y have j.d.f f(x,y) = k , 0<x<y<2, Find the marginal pdf. Find the conditional density functions.(8M) (Nov/Dec 2016, Nov/Dec 2017)** BTL5 **Answer : Pg. 2.33 – Dr. A. Singaravelu** • $\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}f(x,y)dx\,dy=1$ • Marginal density function of X : $f(x)=\int_{-\infty}^{\infty}f(x,y)dy$ • Marginal density function ofY: $f(y)=\int_{-\infty}^{\infty}f(x,y)dx$ • The conditional density function of X given Y: $f(X/Y)=\frac{f(x,y)}{f(y)}$ • The conditional density function of Y given X: $f(Y/X)=\frac{f(x,y)}{f(x)}$

- $\int_0^2\int_0^y k\,dx\,dy = 1 \Rightarrow k = \frac{1}{2}$. (2M)
- $f(x)=\int_x^2 \frac{1}{2}dy=\frac{1}{2}(2-x), 0<x<1$ (2M)
- $f(y)=\int_0^y \frac{1}{2}dx=\frac{y}{2}, 0<y<2$ (2M)
- $f(X/Y)=\frac{1}{y}, 0<x<y$ (1M)
- $f(Y/X)=\frac{1}{2-x}, x<y<2$ (1M)

9

If the joint distribution function of X and Y is given by $F(x,y)=\left(1-e^{-x}\right)\left(1-e^{-y}\right), x>0, y>0$. Find the marginal density function of X and Y. Check if X and Y are independent. Also find P(1<X<3 / 1<Y<2). (8M) (Apr/May 2015, May/June 2016) BTL5

Answer :Pg. 2.50 – Dr. A. Singaravelu

- $f(x,y)=\frac{\partial^2 F(x,y)}{\partial x \partial y}=e^{-(x+y)}$
- $f(x)=\int_0^\infty e^{-(x+y)}dy=e^{-x}$. (2M)
- $f(y)=\int_0^\infty e^{-(x+y)}dx=e^{-y}$. (2M)
- $f(x).f(y)=e^{-x}\,e^{-y}=e^{-(x+y)}=f(x,y)$. (2M)
- $P(1<X<3,1<Y<2)=\left(\frac{1-e^2}{e^3}\right)\left(\frac{1-e}{e^2}\right)$. (2M)

10

Find the co-efficient of correlation between X and Y from the data given below.(8M) (May 2016) BTL5

X	65	66	67	67	68	69	70	72
Y	67	68	65	68	72	72	69	71

Answer : Page: 2.71- Dr. A. Singaravelu

- $\bar{X}=\frac{\sum X}{n}=\frac{544}{8}=68$ (1M)
- $\bar{Y}=\frac{\sum Y}{n}=\frac{552}{8}=69$ (1M)
- $\sigma_x=\sqrt{\frac{1}{n}\sum X^2-\bar{X}^2}=2.121$ (2M)
- $\sigma_y=\sqrt{\frac{1}{n}\sum Y^2-Y^2}=2.345$ (2M)

	• $r(X,Y)=\frac{Cov(X,Y)}{\sigma_x.\sigma_y}=0.6031$ (2M)
11	**Let X and Y be discrete random variables with pdf** $f(x,y)=\frac{x+y}{21}, x=1,2,3; y=1,2$ **. Find** $\rho(X,Y)$ **(8M)** BTL5 **Answer : Pg. 2.78- Dr. A. Singaravelu** • $E(X)=\sum x\, f(x)=\frac{46}{21}$ (1M) • $E(Y)=\sum y\, f(y)=\frac{33}{21}$ (1M) • $E(X^2)=\sum x^2\, f(x)=\frac{114}{21}$ (1M) • $E(Y^2)=\sum y^2\, f(y)=\frac{57}{21}$ (1M) • $Var\,X=\sigma_x^2=E(X^2)-[E(X)]^2=\frac{278}{441}$ (1M) • $Var\,Y=\sigma_y^2=E(Y^2)-[E(Y)]^2=\frac{108}{441}$ (1M) • $E(XY)=\sum xy\, f(x,y)=\frac{72}{21}$ (1M) • $r(X,Y)=\frac{Cov(X,Y)}{\sigma_x.\sigma_y}=\frac{-6}{173.20}=-0.035$ (1M)
12	**If the joint pdf of (X,Y) is given by** $f(x,y)=x+y, 0\le x,y\le 1$**. Find** ρ_{xy} **.(8 M) (May/June 2014)** BTL3 **Answer : Page : 2.99 – Dr. A. Singaravelu** • $f(x)=\int_0^1 (x+y)dy=x+\frac{1}{2}, 0<x<1$ (1M) • $f(y)=\int_0^1 (x+y)dx=y+\frac{1}{2}, 0<y<1$ (1M) • $E(X)=\int x\, f(x)dx=\int_0^1 x\left(x+\frac{1}{2}\right)dx=\frac{7}{12}$ (1M) • $E(Y)=\int y\, f(y)dy=\int_0^1 y\left(y+\frac{1}{2}\right)dy=\frac{7}{12}$ (1M) • $E(X^2)=\int x^2\, f(x)dx=\frac{5}{12},\ E(Y^2)=\int y^2\, f(y)dy=\frac{5}{12}$ (1M) • $Var\,X=\sigma_x^2=E(X^2)-[E(X)]^2=\frac{11}{144},\ Var\,Y=\sigma_y^2=E(Y^2)-[E(Y)]^2=\frac{11}{144}$ (1M) • Cov(X,Y) = E(XY) – E(X). E(Y) = $\frac{-1}{144}$ (1M)

	• $r(X,Y)=\frac{Cov(X,Y)}{\sigma_x.\sigma_y}=\frac{-1}{11}$ (1M)
13	**Two independent random variables X and Y are defined by,** $f(x)=\begin{cases}4ax,0\le x\le 1\\ 0\quad ,otherwise\end{cases}$ $f(y)=\begin{cases}4by,0\le y\le 1\\ 0\quad ,otherwise\end{cases}$**. Show that U=X + Y and V=X – Y are uncorrelated. (8 M)(May/June 2013)** BTL4 **Answer : Page: 2.105 – Dr. A. Singaravelu** • $\int_0^1 f(x)dx=1\Rightarrow a=\frac{1}{2};\int_0^1 f(y)dy=1\Rightarrow b=\frac{1}{2}$ (1M) • $E(U)=E(X)+E(Y)=\frac{2}{3}+\frac{2}{3}=\frac{4}{3}.$ (2M) • $E(V)=E(X)-E(Y)=\frac{2}{3}-\frac{2}{3}=0.$ (2M) • $E(UV)=E(X^2)-E(Y^2)=\frac{1}{2}-\frac{1}{2}=0.$ (2M) • Cov(U,V) = E(UV) – E(U).E(V) =0. (1M)
14	**If X and Y are two random variables having joint pdf** $f(x,y)=\frac{1}{8}(6-x-y)$**, 0<x<2, 2<y<4. Find (i)** r_{xy} **(ii)P(X<1 /Y<3) (8 M)** BTL5 **Answer : Page : 2.109 – Dr. A. Singaravelu** • $f(x)=\int_2^4\frac{1}{8}(6-x-y)dy=\frac{6-2x}{4}$ (1M) • $f(y)=\int_0^2\frac{1}{8}(6-x-y)dy=\frac{10-2y}{8}$ (1M) • $E(X)=\int x\,f(x)dx=\frac{5}{6}$ (1M) • $E(Y)=\int y\,f(y)dy=\frac{17}{6}$ (1M) • $E(X^2)=\int x^2\,f(x)dx=1$ (1M) • $E(Y^2)=\int y^2\,f(y)dy=\frac{25}{3}$ (1M) • $E(XY)=\int\int x\,f(x)dx=\frac{7}{3}$ (1M) • $\sigma_x^2=\frac{11}{36},\ \sigma_y^2=\frac{11}{36}$ (1M)

	• $r_{xy}=\frac{Cov(X,Y)}{\sigma_x.\sigma_y}=-\frac{1}{11}$ (1M)
15	**The two lines of regression are *8x – 10y +66 = 0; 40x -18y -214 = 0.* The variance of 'x' is 9. Find th4e mean values of 'x' and 'y'. Also find the correlation coefficient between 'x' and 'y'.(8 M) (Apr/May 2015, May/June 2016)** BTL4 **Answer: Page : 2.129 – Dr.A. Singaravelu** • $\bar{x}=13$, $\bar{y}=17$ • From first equation $x=\frac{10}{8}y-\frac{66}{8}\Rightarrow b_{xy}=\frac{10}{8}$. (2M) • From the second equation $y=\frac{40}{18}x-\frac{214}{18}\Rightarrow b_{yx}=\frac{40}{18}$. (1M) • Correlation coefficient $r=1.66$ which is not less than 1. (1M) • Now, From first equation $y=\frac{8}{10}x+\frac{66}{10}\Rightarrow b_{yx}=\frac{8}{10}$. (1M) • From the second equation $x=\frac{18}{40}y-+\frac{214}{40}\Rightarrow b_{yx}=\frac{18}{40}$. (1M) • Correlation coefficient $r=\pm 0.6$. (2M)
16	**If the pdf of a two dimensional random variable (X,Y) is given by** $f(x,y)=x+y,;0\le(x,y)\le 1$**. Find the pdf of U=XY.(8 M) (Apr/May 2015, Nov/Dec 2017)** BTL4 **Answer : Page : 2.156 – Dr.A.Singaravelu** • Take $u=xy$and $v=y$. • $J=\frac{\partial(x,y)}{\partial(u,v)}=\begin{vmatrix}\frac{\partial x}{\partial u} & \frac{\partial x}{\partial v}\\ \frac{\partial y}{\partial u} & \frac{\partial y}{\partial v}\end{vmatrix}=\frac{1}{v}$. (2M) • $f(u,v)=\lvert J\rvert\, f(x,y)=1+\frac{u}{v^2}$. (3M) • $f(u)=\int_u^1\left(1+\frac{u}{v^2}\right)dv=2-2u$. (3M)
17	**Let (X,Y) be a two-dimensional non-negative continuous random variable having the joint density** $f(x,y)=\begin{cases}4xye^{-(x^2+y^2)} & , x,y\ge 0\\ 0 & ,elsewhere\end{cases}$**. Find the density function of** $U=\sqrt{X^2+Y^2}$**. (8 M) (May/June 2016, Apr/May 2018)** BTL5 **Answer : Page : 2.179 – Dr.A. Singaravelu** • Take $u^2=x^2+y^2$, $v=x$ • $J=\frac{\partial(x,y)}{\partial(u,v)}=\begin{vmatrix}\frac{\partial x}{\partial u} & \frac{\partial x}{\partial v}\\ \frac{\partial y}{\partial u} & \frac{\partial y}{\partial v}\end{vmatrix}=\frac{u}{\sqrt{u^2-v^2}}$. (2M) • $f(u,v)=\lvert J\rvert\, f(x,y)=4uve^{-u^2}$. (3M)

	• $f(u)=\int_0^u \left(4uve^{-u^2}\right)dv=2u^3e^{-u^2}$. (3M)
18	**If X and Y are independent random variables with pdf $e^{-x}, x\ge 0\,; e^{-y}, y\ge 0$ respectively. Find the density function of $U=\frac{X}{X+Y}$ and $V=X+Y$. Are X and Y independent? (8 M) (Nov/Dec 2013, Apr/May 2017, Nov/Dec 2017)** BTL5 **Answer : Page : 2.176- Dr. A. Singaravelu** • Take $U=\frac{X}{X+Y}$ and $V=X+Y$. • $J=\frac{\partial(x,y)}{\partial(u,v)}=\begin{vmatrix}\frac{\partial x}{\partial u} & \frac{\partial x}{\partial v}\\ \frac{\partial y}{\partial u} & \frac{\partial y}{\partial v}\end{vmatrix}=v$. (2M) • $f(u,v)=\lvert J\rvert\, f(x,y)=ve^{-v}$. (1M) • $f(u)=\int_0^\infty \left(ve^{-v}\right)dv=1$ (2M) • $f(v)=\int_0^\infty \left(ve^{-v}\right)du=ve^{-v}$. (2M) • $f(u).f(v)=1.\,ve^{-v}=ve^{-v}=f(u,v)$. (1M)
19	**If X_1, X_2, …, X_n are Poisson variables with parameter $\lambda=2$, use the central limit theorem to estimate P(120 < S_n< 160) where S_n = X_1+ X_2+ …+X_n and n=75. (8M)** BTL5 **Answer:Page: 2.187-Dr.A. Singaravelu** • $n\mu=150; n\sigma=\sqrt{150}$. (1M) • $z=\frac{S_n-n\mu}{\sigma\sqrt{n}}$; If $S_n=120, z=\frac{-30}{\sqrt{150}}$. (2M) • If $S_n=160, z=\frac{10}{\sqrt{150}}$. (2M) • $P(120<S_n<160)=P(-2.45\le S_n\le 0.85)=P(-2.45\le S_n\le 0)+P(0\le S_n\le 0.85)=0.7866$. (3M)

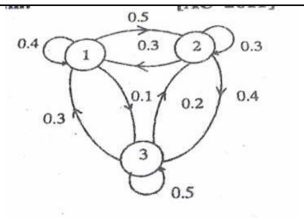
	UNIT III – Random Proccesses
	Classification – Stationary process – Markov process - Markov chain - Poisson process – Random telegraph process.
	PART *A

Q.No	Questions
1.	**Define a random process and give an example. (May/June 2016)** BTL1 A random process is a collection of random variables {X(s,t)} that are functions of a real variable, namely time 't' where $s \in S$ (Sample space) and $t \in T$ (Parameter set or index set). Example: $X(t) = A\cos(\omega t + \theta)$ where θ isuniformly distributed in $(0, 2\pi)$, where 'A' and 'ω' are constants.
2	**State the two types of stochastic processes.** BTL1 The four types of stochastic processes are Discrete random sequence, Continuous random sequence, Discrete random process and Continuous random process.
3	**Define Stationary process with an example.(May/June 2016)** BTL1 If certain probability distribution or averages do not depend on 't', then the random process {X(t)} is called stationary process. Example: A Bernoulli process is a stationary process as the joint probability distribution is independent of time.
4	**Define first Stationary process.(Nov/Dec 2015)** BTL1 A random process {X(t)} is said to be a first order stationary process if $E[X(t)] = \mu$ is a constant.
5	**Define strict sense and wide sense stationary process.(Nov/Dec 2015, Apr/May 2017, Nov/Dec 2017)** BTL1 A random process is called a strict sense stationary process or strongly stationary process if all its finite dimensional distributions are invariant under translation of time parameter. A random process is called wide sense stationary or covariance stationary process if its mean is a constant and auto correlation depends only on the time difference.
6	**In the fair coin experiment we define {X(t)} as follows** $X(t) = \begin{cases} \sin \pi t & ,if\ \ head\ \ shows \\ 2t & ,if\ \ tail\ \ shows \end{cases}$ **.Find E[X(t)] and find F(x,t) for t = 0.25. (Nov/Dec 2016)** BTL3 $P[X(t) = \sin \pi t] = \frac{1}{2}$, $P[X(t) = 2t] = \frac{1}{2}$ $E[X(t)] = \sum X(t) P[X(t)] = \sin \pi t\left(\frac{1}{2}\right) + 2t\left(\frac{1}{2}\right) = \frac{1}{2}\sin \pi t + t$ $When\ t = 0.25$, $P[X(0.25) = \sin \pi(0.25)] = P\left[X(0.25) = \frac{1}{\sqrt{2}}\right] = \frac{1}{2}$ $P[X(t) = 2(0.25)] = P\left[X(t) = \frac{1}{2}\right] = \frac{1}{2}$ Hence F(x,t) for t= 0.25 is given by $F(x,t) = \begin{cases} 0 & ,x < 0 \\ \frac{1}{2} & ,\frac{1}{2} \le x < \frac{1}{\sqrt{2}} \\ 1 & ,x \ge \frac{1}{\sqrt{2}} \end{cases}$
7	**Prove that a first order stationary random process has a constant mean. (Apr/May 2011)** BTL3 f[X(t)] = f[X(t+h)] as the process is stationary.

	$E[X(t)]=\int X(t)\, f[X(t+h)]d(t+h)$ $t+h=u \Rightarrow d(t+h)=du$ Put $=\int X(u)\, f[X(u)]du$ $=E[X(u)]$ Therefore, E[X(t+h)] = E[X(t)] Therefore, E[X(t)] is independent of 't'. Therefore , E[X(t)] is a constant.
8	**What is a Markov process. Give an example.(Nov/Dec 2014, Apr/May 2015, May/June 2016,Apr/May 2018)** BTL1 Markov process is one in which the future value is independent of the past values, given the present value. (i.e.,)A random process X(t) is said to be a Markov process if for every $t_0 < t_1 < t_2 < \ldots t_n$, $P\{X(t_n) \le x_n / X(t_{n-1}) = x_{n-1}, X(t_{n-2}) = x_{n-2}, \ldots, X(t_0) = x_0\} \Rightarrow P\{X(t_n) \le x_n / X(t_{n-1}) = x_{n-1}\}$. Example: Poisson process is a Markov process. Therefore, number of arrivals in (0,t) is a Poisson process and hence a Markov process.
9	**Define Markov chain. When it is called homogeneous? Also define one-step transition probability. (Apr/May 2010)** BTL1 • If $\forall n, P[X_n = a_n / X_{n-1} = a_{n-1}, X_{n-2} = a_{n-2}, \ldots, X_0 = a_0] = P[X_n = a_n / X_{n-1} = a_{n-1}]$ then the process $\{X_n\}$ n = 0,1,2,… is called a Markov chain. • In a Markov chain if the one-step transition probability $P[X_n = a_n / X_{n-1} = a_{n-1}] = P_{ij}(n-1,n)$ independent of the step 'n'. (i.e.,) $P_{ij}(n-1,n) = P_{ij}(m-1,m)$ for all m,n and I,j. Then the Markov chain is said to be homogeneous. • The conditional probability $P[X_n = a_j / X_{n-1} = a_i]$ is called the one step transition probability from state a_i to state a_j at the nth step.
10	**Define Poisson process.(Nov/Dec 2017)** BTL1 If X(t) represents the number of occurrences of a certain event in (0,t), then the discrete process {X(t)} is called the Poisson process provided the postulates are satisfied: $P[1\ occurrence\ in\ (t,t+\Delta t)] = \lambda\Delta t + 0(\Delta t)$ $P[0\ occurrence\ in\ (t,t+\Delta t)] = 1 - \lambda\Delta t + 0(\Delta t)$ $P[2\ occurrence\ in\ (t,t+\Delta t)] = 0(\Delta t)$ X(t) is independent of the number of occurrences of the event in any interval prior and after the interval (0,t) The provability that the event occurs a specified number of times in (t_0, t_0+t) depends only on 't', but not on 't_0'.
11	**State any two properties of Poisson process. (Nov/Dec 2015, Apr/May 2018)** BTL1 • The Poisson process is a Markov process • Sum of two different Poisson process is a Poisson process • Difference of two different Poisson process is not a Poisson process
12	**If the customers arrive at a bank according to a Poisson process with mean rate 2 per minute, find the probability that during a 1-minute interval no customers arrive. (Apr/May 2017)** BTL3 Mean arrival rate = λ = 2

	The probability of Poisson process is $P[X(t)=n]=\frac{e^{-\lambda t}(\lambda t)^n}{n!}$ $P[X(t)=0]=\frac{e^{-2}(2)^0}{0!}=e^{-2}=0.1353$.
13	**Prove that the sum of two independent Poisson process is a Poisson process.(Nov/Dec 2012, Apr/May 2015, Apr/May 2017)** BTL5 $Let\ \ X(t)=[X_1(t)+X_2(t)]$ $E[X(t)]=E[X_1(t)+X_2(t)]=E[X_1(t)]+E[X_2(t)]$ $=\lambda_1 t+\lambda_2 t=(\lambda_1+\lambda_2)t$ $E[X^2(t)]=E[X_1(t)+X_2(t)]^2=E[X_1{}^2(t)+2X_1(t)X_2(t)+X_2{}^2(t)]$ $=E[X_1{}^2(t)]+2E[X_1(t)]E[X_2(t)]+E[X_2{}^2(t)]$ $=\lambda_1^2t^2+\lambda_1t+2(\lambda_1t)(\lambda_2t)+\lambda_2^2t^2+\lambda_2t$ $=(\lambda_1+\lambda_2)^2t^2+(\lambda_1+\lambda_2)t$ Therefore $X(t)=[X_1(t)+X_2(t)]$is a Poisson process.
14	**Prove that the sum of two independent Poisson process is a Poisson process.** BTL5 $Let\ \ X(t)=[X_1(t)-X_2(t)]$ $E[X(t)]=E[X_1(t)+-X_2(t)]=E[X_1(t)]-E[X_2(t)]$ $=\lambda_1 t-\lambda_2 t=(\lambda_1-\lambda_2)t$ $E[X^2(t)]=E[X_1(t)-X_2(t)]^2=E[X_1{}^2(t)-2X_1(t)X_2(t)+X_2{}^2(t)]$ $=E[X_1{}^2(t)]-2E[X_1(t)]E[X_2(t)]+E[X_2{}^2(t)]$ $=\lambda_1^2t^2+\lambda_1t-2(\lambda_1t)(\lambda_2t)+\lambda_2^2t^2+\lambda_2t$ $=(\lambda_1-\lambda_2)^2t^2+(\lambda_1+\lambda_2)t$ $\neq(\lambda_1-\lambda_2)^2t^2+(\lambda_1-\lambda_2)t$ Therefore $X(t)=[X_1(t)-X_2(t)]$is nota Poisson process.
15	**Patients arrive randomly and independently at a doctor's consulting room form 8 A.M at an average rate of 1 for every 5 minutes. The waiting room can hold 12 persons. What is the probability that the room will be full when the doctor arrives at 9 A.M?. (Nov/Dec 2016)** BTL3 Given $\lambda=\frac{1}{5}\,per\ \min=\frac{1}{5}\times 60=12\,per\ hour$ The probability law of Poisson process is $P[X(t)=n]=\frac{e^{-\lambda t}(\lambda t)^n}{n!}$ $P[X(1)=12]=\frac{e^{-12}(12)^{12}}{12!}=0.1144$
16	**Define Semi- Random telegram signal process. (Apr/May 2015)** BTL1

	If N(t) represents the number of occurrences of a specified event in (0,t) and X(t) = $(-1)^{N(t)}$, then {X(t)} is called a semi-random telegraph signal process.
17	**Define Random telegraph process.** BTL1 A random telegraph process is a discrete random process X(t) satisfying the following conditions: • X(t) assumes only one of the two possible values 1 or -1 at any time ‘t’, randomly • X(0) = 1 or -1 with equal probability ½. • The number of level transitions or flips, $N(\tau)$, from one value to another occurring in any interval of length τ is a Poisson process with rate λ so that the probability of exactly ‘r’ transitions is $P[N(\tau)=r]=\frac{e^{-\lambda\tau}(\lambda\tau)^r}{r!},\ r=0,1,2,...$
18	**Write the properties of Random telegraph process.** BTL1 • P[X(t)=1] = $\frac{1}{2}$ = P[X(t)= - 1] for any t >0 • E[X(t)] = 0 and Var[X(t)] = 1 • X(t) is a WSS process
19	**Consider the random process** $X(t)=\cos(t+\phi)$ **where** ϕ **is a random variable with density function** $f(\phi)=\frac{1}{\pi},\ -\frac{\pi}{2}<\phi<\frac{\pi}{2}$ **. Check whether or not the process is stationary.**BTL3 $E[X(t)]=\int_{-\infty}^{\infty} X(t)\, f(\phi)\, d\phi$ $=\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} \cos(t+\phi)\,\frac{1}{\pi}\,d\phi$ $=\frac{1}{\pi}\int_{-\frac{\pi}{2}}^{\frac{\pi}{2}}\cos(t+\phi)\,d\phi$ $=\frac{1}{\pi}[\sin(t+\phi)]_{-\frac{\pi}{2}}^{\frac{\pi}{2}}$ $=\frac{1}{\pi}\left[\sin(\frac{\pi}{2}+t)-\sin(-\frac{\pi}{2}+t)\right]$ $=\frac{1}{\pi}[\cos(t)+\cos(t)]=\frac{2}{\pi}\cos(t)$ Therefore E[X(t)] is not a constant. Hence X(t) is not stationary.
20	**Find the transition probability matrix of the process represented by the transition diagram. (Apr/May 2011)** BTL3



$$\begin{array}{c} 1 \\ 2 \\ 3 \end{array}\begin{bmatrix} 0.4 & 0.5 & 0.1 \\ 0.3 & 0.3 & 0.4 \\ 0.3 & 0.2 & 0.5 \end{bmatrix}$$

21

If the tpm of the markov chain is $\begin{bmatrix} 0 & 1 \\ \frac{1}{2} & \frac{1}{2} \end{bmatrix}$**, find the steady-state distribution of the chain.** BTL5

Given : P= $\begin{bmatrix} 0 & 1 \\ \frac{1}{2} & \frac{1}{2} \end{bmatrix}$

Let the steady- state probability distribution be $\pi = (\pi_1 \quad \pi_2)$ we have

$\pi P = \pi$ ....(1)

$\pi_1 + \pi_2 = 1$...........(2)

$$(1) \Rightarrow (\pi_1 \quad \pi_2)\begin{bmatrix} 0 & 1 \\ \frac{1}{2} & \frac{1}{2} \end{bmatrix} = (\pi_1 \quad \pi_2)$$

$$\left[\pi_1(0) + \pi_2\left(\frac{1}{2}\right) \quad \pi_1(1) + \pi_2\left(\frac{1}{2}\right)\right] = (\pi_1 \quad \pi_2)$$

$$\Rightarrow \left[\pi_2\left(\frac{1}{2}\right) \quad \pi_1 + \pi_2\left(\frac{1}{2}\right)\right] = (\pi_1 \quad \pi_2)$$

$$\Rightarrow \frac{1}{2}\pi_2 = \pi_1 \text{............(3)}$$

$$\pi_1 + \pi_2\left(\frac{1}{2}\right) = \pi_2 \text{..........(4)}$$

$Now\ (2) \Rightarrow \pi_1 + \pi_2 = 1,\ substitute\ (3)\ in\ (2)$

$$\Rightarrow \frac{1}{2}\pi_2 + \pi_2 = 1 \Rightarrow \frac{3}{2}\pi_2 = 1 \Rightarrow \pi_2 = \frac{2}{3}$$

$Sub\ \pi_2\ in\ (3),\ \frac{1}{2}.\frac{2}{3} = \pi_1 \Rightarrow \pi_1 = \frac{1}{3}$

The steady state distribution of the chain is $\pi = \begin{pmatrix} \frac{1}{3} & \frac{2}{3} \end{pmatrix}$

22

Let $A = \begin{pmatrix} 0 & 1 \\ \frac{1}{2} & \frac{1}{2} \end{pmatrix}$ **be a stochastic matrix. Check if it is regular. (Nov/Dec 2016)** BTL4

$$A^2 = \begin{pmatrix} 0 & 1 \\ \frac{1}{2} & \frac{1}{2} \end{pmatrix} \begin{pmatrix} 0 & 1 \\ \frac{1}{2} & \frac{1}{2} \end{pmatrix} = \begin{pmatrix} \frac{1}{2} & \frac{1}{2} \\ \frac{1}{4} & \frac{3}{4} \end{pmatrix}$$

Since all the entries of A^2 are positive , 'A' is regular.

23 **What is the autocorrelation function of the Poisson process. Is Poisson process stationary?** BTL2

Let X(t) be a Poisson process then $P[X(t)=n] = \frac{e^{-\lambda t}(\lambda t)^n}{n!}$ n=0,1,2,…

Autocorrelation function $R_{xx}(t_1,t_2) = \lambda^2 t_1 t_2 + \lambda \min\{t_1,t_2\}$

Since $R_{xx}(t_1,t_2)$ is not a function of time difference t_1-t_2, Poisson process is not stationary.

24 **When is a Random process said to be evolutionary. Give an example. (Apr/May 2015)** (BTL1)

A random process that is not stationary at any sense is called evolutionary process.

Semi-random telegraph signal process is an example of evolutionary random process.

25 **Define irreducible Markov chain and state Chapman-Kolmogorov theorem.** BTL1

A Markov chain is said to be irreducible if every state can be reached from every other state, where $p_{ij}^{(n)} > 0$ for some 'n' and for all 'i' and 'j'.

If 'P' is the tpm of a homogeneous Markov chain, then the n-step tpm $P^{(n)}$ is equal to P^n.

(i.e.,) $\left[P_{ij}^{(n)}\right] = \left[P_{ij}\right]^n$.

Part*B

1 **The process {X(t)} whose probability distribution under certain conditions is given by,**

$$P\{X(t)=n\} = \frac{(at)^{n-1}}{(1+at)^{n+1}}, n = 1,2...$$

$$= \frac{at}{1+at}, n = 0$$

Show that it is not stationary(evolutionary). (8M)(Nov/Dec 2014, Nov/Dec 2016, Apr/May 2018) BTL5

Answer: Page: 3.33 –Dr. A. Singaravelu

- $E[X(t)] = \sum_{n=0}^{\infty} n\, p_n = 0 + (1)\frac{1}{(1+at)^2} + (2)\frac{at}{(1+at)^3} + ... = 1.$ (3M)
- $E[X^2(t)] = \sum_{n=0}^{\infty} n^2 P_n = \sum_{n=0}^{\infty} ([n(n+1)-n]P_n = 1+2at$. (3M)
- $Var[X(t)] = E[X^2(t)] - E[X(t)] = 2at \neq cons\tan t$. (2M)

2 **If the random process X(t) takes the value -1 with probability $\frac{1}{3}$ and takes the value 1 with probability $\frac{2}{3}$, find whether X(t) is a stationary process or not. (6M)(Apr/May 2017)** BTL4

Answer:Page: 3.12 – Dr. G. Balaji

X(t)=n	-1	1
P_n	1/3	2/3

	• $E[X(t)]=\sum_{n=-1}^{1} n\,P_n=\frac{1}{3}$(2M) • $E[X^2(t)]=\sum_{n=-1}^{1} n^2\,P_n=1$ (2M) • $Var[X(t)]=E[X^2(t)]-E[X(t)]=\frac{8}{9}$ = constant. (2M)
3	**Show that the process $X(t)=A\cos(\omega t+\theta)$ where A, ω are constants, θ is uniformly distributed in $(-\pi,\pi)$ is wide sense stationary. (8M) (May/June 2016, Nov/Dec 2016)** BTL5 **Answer:Page: 3.15-Dr. A. Singaravelu** • $E[X(t)]=\int_{-\infty}^{\infty} X(t)\,f(\theta)\,d\theta=\int_{-\pi}^{\pi} A\cos(\omega t+\theta)\frac{1}{2\pi}\,d\theta=0=cons\tan t$ (2M) • $R_{XX}(t,t+\tau)=E[X(t)X(t+\tau)]=E[A\cos(\omega t+\theta).A\cos(\omega(t+\tau)+\theta)]$ (1M) • $E[A\cos(\omega t+\theta).A\cos(\omega(t+\tau)+\theta)]=\frac{A^2}{2}\{E(\cos\omega\tau)+E[\cos(2\omega t+2\theta+\omega\tau)]\}$ (2M) • $E[\cos(2\omega t+2\theta+\omega\tau)]=0$ (2M) • $R_{XX}(t,t+\tau)=\frac{A^2}{2}\cos\omega\tau$ =a function of τ. (1M)
4	**Show that the process $X(t)=A\cos(\omega t+\theta)$ where A, ω are constants, θ is uniformly distributed in $(0,2\pi)$ is WSS. (8M) (Nov/Dec 2017)** BTL5 **Answer:Page: 3.24-Dr. G. Balaji** • $E[X(t)]=\int_{-\infty}^{\infty} X(t)\,f(\theta)\,d\theta=\int_{0}^{2\pi} A\cos(\omega t+\theta)\frac{1}{2\pi}\,d\theta=0=cons\tan t$ (2M) • $R_{XX}(t,t+\tau)=E[X(t)X(t+\tau)]=E[A\cos(\omega t+\theta).A\cos(\omega(t+\tau)+\theta)]$ (1M) • $E[A\cos(\omega t+\theta).A\cos(\omega(t+\tau)+\theta)]=\frac{A^2}{2}\{E(\cos\omega\tau)+E[\cos(2\omega t+2\theta+\omega\tau)]\}$ (2M) • $E[\cos(2\omega t+2\theta+\omega\tau)]=0$ (2M) • $R_{XX}(t,t+\tau)=\frac{A^2}{2}\cos\omega\tau$ =a function of τ. (1M)
5	**Show that the process $X(t)=A\cos\lambda t+B\sin\lambda t$ is strict sense stationary of order 2. A and B are random variables if E[A] = E[B] = 0 ; E[A^2] = E[B^2]; E[AB] = 0.** **(OR)** **If $X(t)=A\cos\lambda t+B\sin\lambda t$, $t\geq 0$ is a random process where A and B are independent $N(0,\sigma^2)$ random variables. Examine the WSS process of X(t). (8M) (Apr/May 2015, Apr/May 2017)** BTL5 **Answer:Page: 3.13-Dr. A. Singaravelu** • $E\{X(t)\}=E\{A\cos\lambda t+B\sin\lambda t\}=0=cons\tan t$ (2M) • $R_{XX}(t,t+\tau)=E[X(t)X(t+\tau)]=E\{[A\cos\lambda t+B\sin\lambda t][A\cos\lambda(t+\tau)+B\sin\lambda(t+\tau)]\}$ (2M) • $R_{XX}(t,t+\tau)=K^2[\cos\lambda t\cos\lambda(t+\tau)+\sin\lambda t\sin\lambda(t+\tau)]=K^2\cos\lambda\tau$ (4M)
6	**A random variable {X(t)} is defined by $X(t)=A\cos t+B\sin t,-\infty<t<\infty$ where A and B are independent random variables each of which has a value -2 with probability $\frac{1}{3}$ and a value 1 with probability $\frac{2}{3}$. Show**

	that X(t) is wide sense stationary. (8M) (Nov/Dec 2015, Apr/May 2017, Apr/May 2018) BTL5 **Answer:Page: 3.44-Dr. G. Balaji** • $E[A]=\sum A_i\,P(A_i)=0$ (1M) • $E[B]=\sum B_i\,P(B_i)=0$ (1M) • $E[A^2]=\sum A_i^{\,2}\,P(A_i)=2$ (1M) • $E[B^2]=\sum B_i^{\,2}\,P(B_i)=2$ (1M) • $E[X(t)]=E[Y\cos t+Z\sin t]=0=cons\tan t$ (2M) • $R_{XX}(t,t+\tau)=E\left[X(t)X(t+\tau)\right]=E\left[(Y\cos t_1+Z\sin t_1)(Y\cos t_2+Z\sin t_2)\right]=2\cos\tau$ (2M)
7	**The transition probability matrix of a Markov chain {X_n}, n=1,2,… having 3 states 1,2 and 3 is** $P=\begin{bmatrix}0.1 & 0.5 & 0.4\\ 0.6 & 0.2 & 0.2\\ 0.3 & 0.4 & 0.3\end{bmatrix}$ **and the initial distribution is** $P^{(0)}=\begin{pmatrix}0.7 & 0.2 & 0.1\end{pmatrix}$. **Find (i)** $P\{X_2=3\}$ **and (ii)** $P\{X_3=2, X_2=3, X_1=3, X_0=2\}$. **Answer:Page: 3.60-Dr. A. Singaravelu** • $P^{(1)}=P^{(0)}P=\begin{bmatrix}0.7 & 0.2 & 0.1\end{bmatrix}\begin{bmatrix}0.1 & 0.5 & 0.4\\ 0.6 & 0.2 & 0.2\\ 0.3 & 0.4 & 0.3\end{bmatrix}=\begin{bmatrix}0.22 & 0.43 & 0.35\end{bmatrix}$ (2M) • $P^{(2)}=P^{(1)}P=\begin{bmatrix}0.22 & 0.43 & 0.35\end{bmatrix}\begin{bmatrix}0.1 & 0.5 & 0.4\\ 0.6 & 0.2 & 0.2\\ 0.3 & 0.4 & 0.3\end{bmatrix}=\begin{bmatrix}0.385 & 0.336 & 0.279\end{bmatrix}$ (2M) • $P\{X_2=3\}=0.279$ (1M) • $P\{X_3=2, X_2=3, X_1=3, X_0=2\}=P_{32}^{1}\,P_{33}^{1}\,P_{23}^{1}\,P[X_0=2]=0.0048$ (3M)
8	**A man either drives a car or catches a train to office each day. He never goes 2 days in a row by train but if he drives one day, then the next day he is just as likely to drive again as he is to travel by train. Now suppose that on the first day of the week, the man tossed a fair die and drive to work if and only if a 6 appeared. Find (i) The probability that he drives to work in the long run and (ii) The probability that he takes a train on the third day. (8M) (May/June 2016, Nov/Dec 2017)** BTL4 **Answer:Page: 3.71-Dr. A. Singaravelu** • $P=\begin{bmatrix}0 & 1\\ \frac{1}{2} & \frac{1}{2}\end{bmatrix}$ (2M) • $\pi=(\pi_1 \quad \pi_2)=\begin{pmatrix}\frac{1}{3} & \frac{2}{3}\end{pmatrix}$ (3M) • $P^{(2)}=P^{(1)}P=\begin{pmatrix}\frac{1}{12} & \frac{11}{12}\end{pmatrix}$ (1M) • $P^{(3)}=P^{(2)}P=\begin{pmatrix}\frac{11}{24} & \frac{13}{22}\end{pmatrix}$ (2M)

9	**If {X$_n$; n=1,2,3…} be a Markov chain on the space S={1,2,3} with one-step** $\begin{bmatrix}0 & 1 & 0\\ \frac{1}{2} & 0 & \frac{1}{2}\\ 1 & 0 & 0\end{bmatrix}$**.Sketch the transition diagram. Is the chain irreducible? Explain. Is the chain ergodic? Explain. (8M) (May/June 2013, Nov/Dec 2014)** BTL4 **Answer:Page:3.141-Dr. G. Balaji** - $P^4 = P^3P = P.P = P^2$ (1M) - $P^5 = P^4P = P^2.P = P^3 = P$ (1M) - 1st state $P_{00}^{(2)} > 0, P_{00}^{(4)} > 0, P_{00}^{(6)} > 0 \;....\Rightarrow d_i = GCD(2,4,6,...) = 2$ (1M) - 2nd state $P_{11}^{(2)} > 0, P_{11}^{(4)} > 0, P_{11}^{(6)} > 0 \;....\Rightarrow d_i = GCD(2,4,6,...) = 2$ (1M) - 3rd state $P_{22}^{(2)} > 0, P_{22}^{(4)} > 0, P_{22}^{(6)} > 0 \;....\Rightarrow d_i = GCD(2,4,6,...) = 2$ (1M) - The states are aperiodic with period 2. - We find $P_{ij}^{(n)} > 0$. So the Markov chain is irreducible (2M) - The chain is finite and irreducible so it is non- null persistant. But not ergodic. (1M)
10	**Find the mean, variance and auto correlation of Poisson process. (8M) (May/June 2014, Apr/May 2015)** BTL2 **Answer: Page:3.93- Dr. A. Singaravelu** - The probability of Poisson distribution is $P\{X(t) = n\} = \frac{e^{-\lambda t}(\lambda t)^n}{n!}$, n=0,1,2,… (1M) - $E[X(t)] = \sum_{x=0}^{\infty} x \frac{e^{-\lambda t}(\lambda t)^n}{n!} = \lambda t$ (2M) - $E[X^2(t)] = \sum_{x=0}^{\infty} x^2 \frac{e^{-\lambda t}(\lambda t)^n}{n!} = (\lambda t)^2 + \lambda t$ (2M) - $Var[X(t)] = \lambda t$ (1M) - $R_{xx}(t_1, t_2) = E[X(t_1)X(t_2)] = \lambda^2 t_1 t_2 + \lambda \min(t_1, t_2)$ (2M)
11	**(i) Prove that the interval between two successive occurrences of a Poisson process with parameter λ has an exponential distribution.** **(ii)Show that Poisson process is a Markov process. (8M) (Apr/May 2018)**BTL5 **Answer: Page:3.98- Dr. A. Singaravelu** (i) - P(T > t) = P(E$_{i+1}$ did not occur in (t$_i$, t$_{i+1}$)= P(X(t)=0) = $e^{-\lambda t}$ **(**1M) - $F(t) = P(T \le t) = 1 - P(T > t) = 1 - e^{-\lambda t}$ (2M) - The pdf of T is given by $\lambda e^{-\lambda t}$ which is an exponential distribution. (1M) (ii) - $P[X(t_3) = n_3 / X(t_2) = n_2; X(t_1) = n_1] = \frac{e^{-\lambda(t_3 - t_2)}\lambda^{n_3 - n_2}(t_3 - t_2)^{n_3 - n_2}}{(n_3 - n_2)!}$ (3M) - $P[X(t_3) = n_3 / X(t_2) = n_2; X(t_1) = n_1] = P[X(t_3) = n_3 / X(t_2) = n_2]$ which is Markov process. (1M)

12	**Suppose that customers arrive at a bank according to a Poisson process with mean rate of 3 per minute; find the probability that during a time interval of 2 min (i) exactly 4 customers arrive and (ii) more than 4 customers arrive. (iii) fewer than 4 customers arrive. (8M) (Nov/Dec 2015)** BTL5 **Answer: Page:3.100- Dr. A. Singaravelu** • The probability of Poisson distribution is $P\{X(t)=n\}=\frac{e^{-\lambda t}(\lambda t)^n}{n!}$, n=0,1,2,… (1M) • P[4 customers arrive in 2 min time interval] = P{X(2)=4} = 0.1339 (2M) • P[More than 4 customers arrive in 2 min interval] =P{X(2)>4} = $1-P[X(2)\le 4]$= 0.715(3M) • P[Fewer than 4 customers arrive in 2 min interval] = P{X(2)<4} = 0.1512. (2M)
13	**A fisherman catches a fish at a Poisson rate of 2 per hour from a large lake with lots of fish. If he starts fishing at 10.00 a.m. What is the probability that he catches one fish by 10.30 a.m and three fishes by noon? (8M) (Apr/May 2017)**BTL5 **Answer: Classwork** • The probability of Poisson distribution is $P\{X(t)=n\}=\frac{e^{-\lambda t}(\lambda t)^n}{n!}$, n=0,1,2,… (2M) • P[He catches one fish by 10.30 a.m] =P[X(0.5)=1] $=\frac{e^{-1}(1)^1}{1!}$ =0.3679 (3M) • P[He catches three fishes by noon] = P[X(2) = 3] = $\frac{e^{-4}(4)^3}{3!}$ =0.1954 (2M)
14	**A hard disk fails in a computer system and it follows Poisson process with mean rate of 1 per week. Find the probability that 2 weeks have elapsed since the last failure. If there are 5 extra hard disks and the next supply is not due in 10 weeks, find the probability that the machine will not be out of order in the next 10 weeks. (8M) (Nov/Dec 2017)** BTL5 **Answer: Page:3.102- Dr. A. Singaravelu** • The probability of Poisson distribution is $P\{X(t)=n\}=\frac{e^{-\lambda t}(\lambda t)^n}{n!}$, n=0,1,2,… (2M) • P[No failure in 2 weeks since last failure] = P[X(2)=0] = e^{-2} = 0.135 (3M) • $P[X(10)\le 5]=P[X(10)=0]+[X(10)=1]+[X(10)=2]+[X(10)=3]+[X(10)=4]+[X(10)=5]=0.067$ (3M)
15	**If customers arrive at a counter in accordance with a Poisson process with a mean rate of 2 per minute, find the probability that the interval between 2 consecutive arrivals is (i) more than 1 minute, (ii) between 1 min and 2 min and (iii) 4 min or less. (8M) (May/June 2012)** BTL5 **Answer: Page: 3.100- Dr. A. Singaravelu** • Using inter arrival property of Poisson process, $f(t)=\lambda e^{-\lambda t}$ (1M) • $P(T>1)=\int_1^\infty 2e^{-2t}dt=0.135$ (2M) • $P(1<T<2)=\int_1^2 2e^{-2t}dt=0.117$ (2M) • $P(T\le 4)=\int_0^4 2e^{-2t}dt=1$ (3M)

16 **If {X₁(t)} and {X₂(t)} are two independent Poisson process with parameter λ_1 and λ_2 respectively, show that P[X₁(t) =x / X₁(t)+ X₂(t) = n] is Binomial where $P=\frac{\lambda_1}{\lambda_1+\lambda_2}$.(8M) (Apr/May 2018)** BTL5

Anwer: Page: 3.84-Dr G. Balaji

- $P\left[X_1(t)=x/X_1(t)+X_2(t)=n\right]=\frac{P\left[\left\{X_1(t)=x\right\}\cap\left\{X_1(t)+X_2(t)=n\right\}\right]}{P\left(X_1(t)+X_2(t)=n\right)}$ (3M)
- $P\left[X_1(t)=x/X_1(t)+X_2(t)=n\right]=\frac{\frac{e^{-\lambda_1 t}(\lambda_1 t)^x}{x!}\cdot\frac{e^{-\lambda_2 t}(\lambda_2 t)^{n-x}}{(n-x)!}}{\frac{e^{-(\lambda_1+\lambda_2)t}((\lambda_1+\lambda_2)t)^n}{n!}}$ (3M)
- $P\left[X_1(t)=x/X_1(t)+X_2(t)=n\right]=nC_x P^x q^{n-x}$ where $P=\frac{\lambda_1}{\lambda_1+\lambda_2}$ and $q=\frac{\lambda_2}{\lambda_1+\lambda_2}$ (2M)

17 **Define semi-random telegraph signal process and random telegraph signal process and prove that the former is evolutionary and the latter is wide sense stationary(Covariance stationary process). (16M) (Nov/Dec 2013, Nov/Dec 2017, Apr/May 2015, Apr/May 2017)** BTL5

Answer: 3.106- -Dr.A. Singaravelu

- A random telegraph process is a discrete random process X(t) satisfying the following conditions:
  X(t) assumes only one of the two possible values 1 or -1 at any time ‘t’, randomly
  X(0) = 1 or -1 with equal probability ½.

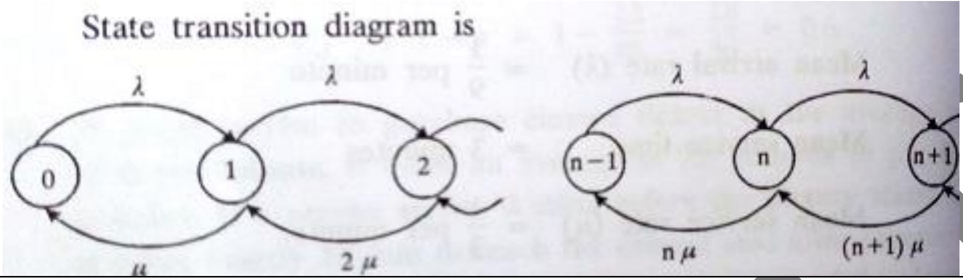
The number of level transitions or flips, $N(\tau)$, from one value to another occurring in any interval of length τ is a Poisson process with rate λ so that the probability of exactly ‘r’ transitions is $P\left[N(\tau)=r\right]=\frac{e^{-\lambda\tau}(\lambda\tau)^r}{r!}$, $r=0,1,2,...$ (2M)

- If N(t) represents the number of occurrences of a specified event in (0,t) and X(t) = $(-1)^{N(t)}$, then {X(t)} is called a semi-random telegraph signal process. (2M)
- $\mathrm{P}\{\mathrm{X(t)}=1\}=\mathrm{P}\{\mathrm{N(t)\ is\ even}\}=\mathrm{e}^{-\lambda t}\cosh\lambda t$ (1M)
- $\mathrm{P}\{\mathrm{X(t)}=-1\}=\mathrm{P}\{\mathrm{N(t)\ is\ odd}\}=\mathrm{e}^{-\lambda t}\,Sinh\,\lambda t$ (1M)
- $E[X(t)]=e^{-2\lambda t}$ (1M)
- $P\left[X(t_1)=1,X(t_2)=1\right]=P\left[X(t_1)=1/X(t_2)=1\right]\times P\left[X(t_2)=1\right]=e^{-\lambda\tau}\cosh\lambda\tau\,e^{-\lambda t_2}\cosh\lambda t_2$ (1M)
- $P\left[X(t_1)=-1,X(t_2)=-1\right]=e^{-\lambda\tau}\cosh\lambda\tau\,e^{-\lambda t_2}\,Sinh\,\lambda t_2$ (1M)
- $P\left[X(t_1)=1,X(t_2)=-1\right]=e^{-\lambda\tau}\sinh\lambda\tau\,e^{-\lambda t_2}\,Sinh\,\lambda t_2$ (1M)
- $P\left[X(t_1)=-1,X(t_2)=1\right]=e^{-\lambda\tau}\sinh\lambda\tau\,e^{-\lambda t_2}\cosh\lambda t_2$ (1M)
- $P\left[X(t_1)\times X(t_2)=1\right]=e^{-\lambda\tau}\cosh\lambda\tau$ (1M)
- $P\left[X(t_1)\times X(t_2)=-1\right]=e^{-\lambda\tau}\sinh\lambda\tau$
- $R(t_1,t_2)=E[X(t_1)X(t_2)]=e^{-2\lambda(t_2-t_1)}$ (1M)

	- {X(t)} is evolutionary - For Random telegraph signal process Y(t), $P(\alpha=1)=\frac{1}{2}$,$P(\alpha=-1)=\frac{1}{2}$ (1M) - $E(\alpha)=0, E(\alpha^2)=1$ (1M) - $R_{YY}(t_1,t_2)=E[Y(t_1)Y(t_2)]=E[\alpha^2 X(t_1)X(t_2)]=e^{-2\lambda(t_2-t_1)}$ which is WSS. (1M) -

	UNIT IVQUEUEINGMODELS
	Markovian queues – Birth and death processes – Single and multiple server queuing models – Little's formula - Queues with finite waiting rooms – Queues with impatient customers : Balking andreneging
	PART * A
Q.No.	**Questions**
1.	**In a given M/M/1/∞/FCFS queue $\rho=0.6$, what is the probability that the queue contains 5 or more customers.** BTL3 The probability that the queue contains 5 or more customers is given by $P(N\geq 5)=\rho^5$ $\Rightarrow (0.6)^5=0.0778$

2.	**Discuss the term: (1) Reneging , (2) Jockeying (APR/MAY 2015)**BTL 1 (1) RENEGING: This occurs when a waiting customers leaves the queue due to impatience. (2) JOCKEYING: Customers may Jockey from one waiting line to another. This is most common in a " Supermarket".
3.	**Define Balking.(APR/MAY 2015)** BTL 1 A customers who leaves the queue because the queue is too long and he has no time or has no sufficient waiting space.
4	**What is the probability that a customer has to wait more than 15 minutes to get his service completed in (M/M/1) : (∞ / FIFO) queue system if $\lambda = 6$ per hour and $\mu = 10$ per hour? (NOV/DEC 2003, 2004, APR/MAY 2009, 2011, 2013, 2015)**BTL3 The probability that the waiting time of a customer in the system exceeds $t = e^{(\mu-\lambda)t}$ Given that $\lambda = 6$ per hour $\mu = 10$ per hour $t = 15\min = \frac{1}{4}hr$ The requires probability = $e^{-(10-6)\frac{1}{4}=e^{-1}}$ =0.3679
5	**What is the basic characteristics of a queuing system? (MAY/JUNE 2006, 2013)** BTL2 The basic characteristics of the queuing system are 1) Arrival pattern of customers 2) Service pattern of servers 3) Queue discipline and 4) System capacity.
6	**Write the basic characteristics of a queuing process. (NOV/DEC 2006, 2010)** BTL1 The basic queuing process describes how customers arrive at and proceed through the queuing system. This means that the basic queuing process describes the operation of a queuing system. 1) The calling population 2) The arrival process 3) The queue configuration 4) The queue discipline and 5) The service mechanism.
7	**Define transient state and steady state queuing system.** BTL1 STEADY STATE: If the characteristics of a queuing system are independent of time. TRANSIENT STATE: If the characteristics of a queuing system are dependent of time.
8	**What do the letters in the symbolic representation (a/b/c): (d/e) of a queuing model represent? (NOV/DEC 2011, 2015)** BTL1 Usually a queuing model is specified and represented symbolically in the form (a/b/c):(d/e), where a – the type of distribution of the number of arrivals per unit time; b – the type of distribution of the service time; c – The number of serves d – The capacity of the system, viz., the maximum queue size e – The queue discipline.
9	**Draw the state transition rate diagram for M/M/C queuing model. (MAY/JUNE 2009, 2011,**

	2015)BTL1 Self-service model: Here all units are taken into service on arrival and there is no queue $\lambda_n = \lambda$ $\mu_n = n\mu$. $for \quad n =,1,2,...$ State transition diagram is 
10	**Define effective arrival rate with respect at to an (M/M/1):(k/FIFO) queuing model.(APR/MAY 2011)** BTL1 The effective arrival rate is denoted by $\lambda' \; or \; \lambda_{eff}$ and defined by $\frac{\lambda'}{\mu} = 1 - P_0 \quad or \quad \lambda' = \mu(1-P_0)$
11	**Define Morkovian Queuing models**. BTL1 Queuing models in which both inter-arrival time and service time which are exponentially distributed are called Markovian queuing models.
12	**Explain the term" TRAFFIC INTENSITY".** BTL2 Utilization factor or traffic intensity is the average function of time tat the serves are being utilized while serving customers. $\rho = \frac{Mean \quad arrival \quad rate \quad (\lambda)}{Mean \quad Service \quad rate \quad (\mu)}$
13	**In (M/M/S):(∞/FIFO), $\lambda = 10/hr$, $\mu = 15$/hr, s=2 Calculate P_0.** BTL3 $P_0 = \frac{1}{\left[\sum_{n=0}^{s-1}\frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n\right]+\left[\frac{1}{s!\left(1-\frac{\lambda}{\mu s}\right)}\left(\frac{\lambda}{\mu}\right)^s\right]} = \boldsymbol{\frac{1}{2}}$
14	**Define Little's formula**. BTL1 $W_s = \frac{1}{\mu - \lambda}$ $W_q = W_s - \frac{1}{\mu}$ $L_S = \lambda W_s$ $L_q = \lambda W_q$
15	**For (M/M1) : (∞ / FIFO) models, write the little's formula.** BTL1

	$W_s = \frac{1}{\lambda} L_S$ $W_q = \frac{1}{\lambda} L_q$ $L_S = \frac{\rho}{1-\rho}$ $L_q = L_S - \rho$
16	**Write down the Little's formulas that hold good for the infinite capacity Poisson queue models.** BTL1 $W_s = \frac{1}{\mu - \lambda}$ $W_q = W_s - \frac{1}{\mu}$ $L_S = \lambda W_s$ $L_q = \lambda W_q$
17	**Write the relation among** $L_s, L_q, W_s \& W_q$ **.** BTL1 $W_s = \frac{1}{\lambda} L_S$ $W_q = \frac{1}{\lambda} L_q$ $L_S = \frac{\rho}{1-\rho}$ $L_q = L_S - \rho$
18	**In the usual notation of an M/M/1 queuing system, if** λ **=12 per hour and** μ **=24 per hour, find the average number of customers in the system. (MAY/JUNE 2007)**BTL3 $\lambda = 12, \mu = 24$ $L_s = \frac{\lambda}{\mu - \lambda} = \frac{12}{24-12} = 1$
19	**Suppose, customers arrive at a Poisson rate of one per every 12 minutes and that the service time is exponential at a rate of one service per 8 minutes. What is (a) The average number of customers in the system. (b) The average time a customer spends in the system.**BTL5 (a) $L_S = \frac{\rho}{1-\rho}$ =2 (b) $W_s = \frac{1}{\lambda} L_S$ =24 minute.
20	**If** λ, μ **are the rates of arrivals and departure in a M/M/1 queue respectively, give the**

	formula for the probability that there are *n* customers in the queue at any time in steady state.BTL1 $P_n = \left(\frac{\lambda}{\mu}\right)^n \left[1-\frac{\lambda}{\mu}\right]$
21	**Arrival rate of telephone calls at a telephone booth is according to Poisson distribution with an average time of 9 minutes between two consecutive arrivals. The length of a telephone call is assumed to be exponentially distributed with mean 3 minutes. Determine the probability that a person arriving at the booth will have to wait.**BTL3 Given : Telephone booth – single server Telephone calls – Infinite capacity The given problem is (M/M/1): (∞ /FIFO) Mean arrival rate (λ)= 1/9 per minute Mean service rate (μ) = 1/3 per minute $\rho = \frac{\lambda}{\mu}$ =0.33
22	**What is the probability that there are no customers in the (M/M/S): (∞ / FIFO) queuing system? (APR/MAY 2011)**BTL1 $P_0 = \frac{1}{\left[\sum_{n=0}^{s-1}\frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n\right]+\left[\frac{1}{s!\left(1-\frac{\lambda}{\mu s}\right)}\left(\frac{\lambda}{\mu}\right)^s\right]}$
23	**Trains arrive at the yard every 15 minutes and the service time is 33 minutes. If the line capacity of the yard is limited to 4 trains find the probability that the yard is empty.** BTL3 Given : Yard- single server Trains- Finite capacity Hence this problem comes under the model: (M/M/1):(K/FIFO) Mean arrive rate = $\frac{1}{15}$ per minute Mean service rate = $\frac{1}{33}$ per minute k = 4 $\rho = \frac{\lambda}{\mu}$ =($\frac{33}{15}$) The probability that the yard is empty (P_0) = $\frac{1-\rho}{1-\rho^{k+1}}$ 0.0237
24	**Write down Little's formulas for the averages waiting time in the system and in the queue for an (M/M/s):(k/FIFO) queuing model.**BTL1 Average waiting time in the system and in the queue

	$W_S = E[W_s] = \frac{1}{\lambda'}E[N]$ $W_q = E[W_q] = \frac{1}{\lambda'}E[N_q]$
25	**If people arrive to purchase cinema tickets at the average rate of 6 per minute, it takes an average of 7.5 seconds to purchase a tickets. If a person arrives 2 mins before the picture starts and it takes exactly 1.5 min to reach the correct seat after purchasing the ticket. Can he expect to be seated for the start of the picture?**BTL3 Given: $\lambda = 6/\min$ $\mu = 8/\min$ $W_s = \frac{1}{\mu - \lambda} = \frac{1}{2}\min$ $E[total\ \ time\ \ required\ \ to\ \ purchase\ \ the\ \ ticket\ \ and\ \ to\ \ reach\ \ the\ \ seat] = 2\min$
	Part*B
1	**Customers arrive at one-man barber shop according to a poisson process with a mean inter arrival time of 12 min. customers spend an average of 10 min. in the barber's chair.** **a) What is the expected number of customers in the barber shop and in the queue?** **b) Calculate the % of time of arrival; can walk straight into the barber's chair without having to wait?** **c) How much time can customer expect to spend in the barber's shop?** **d) Management will provide another chair and here another barber. When a customer's waiting time in the shop exceeds 1.25h. How much the average rate of arrivals increase to warrant a second barber?** **e) What is the average time customers spend in the queue?** **f) What is the probability that the waiting time in the system is greater than 30 min?** **g) Calculate the % of customers who have to wait prior to getting into the barber's chair?** **h) What is the probability that more than 3 customers are in the system?(APR/MAY 2011, 2015)(16M)**BTL5 **Answer: Page : 3.6 - Dr. G. Balaji** one man barber shop- single server customers- infinite capacity The given problem is (M/M/1) : (∞/FIFO) model Mean arrival rate (λ)= 1/12 per minute Mean service rate (μ) = 1/10 per minute

$$\rho = \frac{\lambda}{\mu} = \frac{5}{6}$$

$$P_0 = 1 - \rho = 1 - \frac{5}{6} = \frac{1}{6}$$

$$L_s = \frac{\rho}{1-\rho} = 5$$

$$L_q = L_s - \rho = 4.17$$

$$W_s = \frac{1}{\lambda} L_s = 60$$

$$W_q = \frac{1}{\lambda} L_q = 50$$

(a)(i) The expected number of customer in the system = $L_s = 5$ (2M)

(ii)The expected number of customer in the queue = $L_q = 4.17$ (2M)

(b)P[a customer walk straight into the barber's chair without having to wait]= P_0 =0.1667

(c) Expected time a customer spends in the (barber shop) system= $W_s = 60$ (2M)

(d) Given $W_s > 1.25h \Rightarrow \lambda_R > \frac{13}{150}$. Hence the arrival rate should increase by $\frac{1}{300}$per min. (2M)

(e) Average waiting time per customer in the queue = W_q =50 min. (2M)

(f) P[waiting time in the system > 30 minutes]=P[W>30] = $e^{-(\mu-\lambda)t} = e^{-0.5} = 0.6065$ (2M)

(g) P[a customer has to wait]= $1 - P_0 = \rho = \frac{5}{6} \Rightarrow 83.33\%$. (2M)

(h) P[more than 3 customer in the system]= P[N>3]= $\rho^4 = 0.4823$. (2M)

2

If people arrive to purchase cinema tickets at the average rate of 6 per minute, it takes an average of 7.5 seconds to purchase a ticket. If a person arrives 2 min before the picture starts and if it takes exactly 1.5 min to reach the correct seat after purchasing the ticket.

- **a) Can he expect to be seated for the start of the picture?**
- **b) What is the probability that he will be seated for the start of the picture?**
- **c) How early must he arrive in order to be 99% of sure of being seated for the start of the picture?(NOV/DEC 2010,2014)(16M)**BTL5

Answer: Page : 4.30 - Dr. G. Balaji

Ticket counter – Single server

People – infinite capacity

The given problem is (M/M/1) : (∞/FIFO) model

Mean arrival rate (λ)= 6 per minute

Mean service rate (μ) = $\frac{1}{7.5}$ per second = 8 per minute.

$$\rho = \frac{\lambda}{\mu} = \frac{6}{8}$$

$$P_0 = 1 - \rho = 1 - \frac{6}{8} = \frac{2}{8}$$

$$L_s = \frac{\rho}{1-\rho} = 3$$

$$L_q = L_s - \rho = \frac{9}{4}$$ (6M)

$$W_s = \frac{1}{\lambda} L_s = \frac{1}{2} \text{min}$$

$$W_q = \frac{1}{\lambda} L_q = 3/8$$

a) E[Total time required to purchase the ticket and to reach the seat]=[$W_s + 1.5 = \frac{1}{2}\text{min} + 1.5$ =2 min (4M)

(b) P[he will be seated for the start of the picture]= P[Total time ≤2 min]=0.632. (2M)

(c) Given: P[W≤t]=0.99

$P[W > t] = 1 - 0.99 = 0.01$

$t = 2.3\text{min}$

Therefore, P[Ticket purchasing time<2.3] = 0.99

P[Total time to get the ticket and to go the seat < (2.3+1.5)]=0.99

Hence, the person must arrive atleast 3.8 minutes early, so as to be 99% sure of seeing the start of the picture. (4M)

3 **A duplicating machine maintained for office use is operated by an office assistant who earns Rs. 5 per hour. The time to complete each job varies according to an exponential distribution with mean 6 min. Assume a poisson input with an average arrival rate of 5 jobs per hour. If an 8 hour day is used as a base, determine**

- **a) The % idle time of the machine.**
- **b) The average time a job is in the system and**
- **c) The average earning per day of the assistant. (NOV/DEC 2008)(16M)**BTL5

Answer: Page : 4.35- Dr. G. Balaji

Duplicating machine- single server.

Job varies- infinite capacity

The given problem is (M/M/1) : (∞/FIFO) model

Mean arrival rate (λ)= 5 per hour

Mean service rate (μ) = $\frac{1}{6}$per minute = 10 per hour.

	$\rho = \frac{\lambda}{\mu} = \frac{5}{10} = \frac{1}{2}$ $P_0 = 1-\rho = 1-\frac{1}{2} = \frac{1}{2}$ $L_s = \frac{\rho}{1-\rho} = 1$ $L_q = L_s - \rho = \frac{1}{2}$ (6M) $W_s = \frac{1}{\lambda} L_s = \frac{1}{5} hour$ $W_q = \frac{1}{\lambda} L_q = \frac{1}{10}$ a) P[the machine is idle] = $\frac{1}{2}$ (3M) b) Average time a job in the system $= W_s = \frac{1}{\lambda} L_s = \frac{1}{5} hour$ (3M) c) E[earning per day] = E[number of jobs done per day] × earning per job = Rs.40/- (4M)
4	**A T.V repairman finds that the time spent on his job has an exponential distribution with mean 30 minutes. If he repairs cars in the order in which they come, which follow a poisson arrival pattern with average rate of 10 per 8 hour day.** **i. What is the repairman's expected idle time each day?** **ii. How many cars are ahead of an average car brought in?** **iii. What is the average number of cars in a non- empty queue? (MAY/JUNE2012, NOV DEC 2013)(16M)**BTL5 **Answer: Page : 4.24 - Dr. G. Balaji** A T.V repairmen – single server Sets –infinite capacity The given problem is (M/M/1) : (∞/FIFO) model Mean arrival rate (λ)= 10 per (8 hour) day Mean service rate (μ) = $\frac{\mathbf{8}}{\mathbf{1/2}}$ = 16 sets per (8 hour) day. (4M) $\rho = \frac{\lambda}{\mu} = \frac{5}{8}$

	$P_0 = 1-\rho = 1-\frac{5}{8} = \frac{3}{8}$ $L_s = \frac{\rho}{1-\rho} = \frac{5}{3}$ $L_q = L_s - \rho = \frac{25}{24} = 1.042$ (5M) $W_s = \frac{1}{\lambda} L_s = \frac{1}{6}$ $W_q = \frac{1}{\lambda} L_q = 0.10$ i. P[repairman id idle] = $P_0 = 1-\rho = 1-\frac{5}{8} = \frac{3}{8}$. (3M) ii. Average number of jobs ahead of an average set brought in $L_s = \frac{\rho}{1-\rho} = \frac{5}{3}$. (2M) iii. Average number of jobs in a non-empty queue = $L_W = \frac{L_q}{\rho^2} = 2.667$. (2M)
5	**There are 3 typists in an office. Each typist can type an average of 6 letters per hour. If letters arrive for being typed at the rate of 15 letters per hour:** 1) **What fraction of the time all the typists will be busy?** 2) **What is the average number of letters waiting to be typed?** 3) **What is the average time a letter has to spend for waiting and for being typed?** 4) **What is the probability that a letter will take longer than 20 min. waiting to be typed and being typed?(NOV/DEC 2004, 2010, 2011, MAY/JUNE 2007,2009,2012,2013)**(16M) BTL5 **Answer: Page : 4.56 - Dr. G. Balaji** Typists – Multiple Server Letters – infinite capacity

$the \quad given \quad problem \quad is\,(M/M/s) \quad : \quad (\infty/FIFO)\,\mathrm{mod}\,el$

$mean \quad arrival \quad rate \quad (\lambda) = 15\,per \quad hour$

$mean \quad service \quad rate \quad (\mu) = 6\,per \quad hour$

$s = 3$

$$\frac{\lambda}{\mu} = \frac{15}{6} = 2.5$$

$$\rho = \frac{\lambda}{s\mu} = 0.83$$

$$P_0 = \left[\sum_{n=0}^{s-1} \frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n + \frac{\left(\frac{\lambda}{\mu}\right)^s}{s!(1-\rho)} \right]^{-1} = [6.625 + 15.32]^{-1} = 0.046$$

$$L_s = \frac{1}{ss!}\frac{\left(\frac{\lambda}{\mu}\right)^{s+1}}{(1-\rho)^2}P_0 + \frac{\lambda}{\mu} = 5.95 \cong 6$$

$$L_q = L_s - \frac{\lambda}{\mu} = 6 - 2.5 = 3.5$$

$$W_s = \frac{1}{\lambda}L_s = 0.4h$$

(6M)

$$W_q = \frac{1}{\lambda}L_q = 0.2333$$

$$P[N \geq s] = \frac{\left(\frac{\lambda}{\mu}\right)^s P_0}{s!(1-\rho)} \Rightarrow P[N \geq 3] = 0.70$$

1) P(all the typists are busy) = $P[N \geq 3] = 0.70$. (3M)
2) The average number of letters waiting to be typed $L_q = L_s - \frac{\lambda}{\mu} = 6 - 2.5 = 3.5$. (3M)
3) The average time a letter has to spend for waiting and for being typed = $W_s = \frac{1}{\lambda}L_s = 0.4h$ =24min. (2M)
4) $$P(W > t) = e^{-\mu t}\left\{1 + \frac{\left(\frac{\lambda}{\mu}\right)^s\left[1 - e^{-\mu t(s-1-\frac{\lambda}{\mu})}\right]}{s!\left(1 - \frac{\lambda}{\mu s}\right)\left(s - 1 - \frac{\lambda}{\mu}\right)}P_0\right\}$$ (2M)

$$P(W > 20\,\mathrm{min}) = P(W > \frac{1}{3}hr) = 0.4616.$$

6	**A petrol pump station has 4 pumps. The service times follow the exponential distribution with a mean of 6 min. and cars arrive for service in a Poisson process at the rate of 30 cars per hour.** **1) What is the probability that an arrival would have to wait in line?** **2) Find the average waiting time, average time spent in the system and the average number of cars in the system.** **3) For what % of time would a pump be idle on an average?(MAY/JUNE 2010,2011,2012, NOV/DEC 2018)(16M)**BTL5 **Answer: Page :4.52- Dr. G. Balaji** Petrol pumps – multiple server Cars – infinite capacity s = 4

$$the \quad given \quad problem \quad is\,(M/M/s) \;:\; (\infty/FIFO)\,\text{mod}\,el$$

$$mean \quad arrival \quad rate \quad (\lambda) = 30\,per \quad hour$$

$$mean \quad service \quad rate \quad (\mu) = \frac{1}{6}\,per \quad \min = 10\,per \quad hour$$

$$s = 4$$

$$\frac{\lambda}{\mu} = \frac{30}{10} = 3$$

$$\rho = \frac{\lambda}{s\mu} = \frac{30}{4(10)} = 0.75$$

$$1-\rho = 0.25$$

$$P_0 = \left[\sum_{n=0}^{s-1}\frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n + \frac{\left(\frac{\lambda}{\mu}\right)^s}{s!(1-\rho)}\right]^{-1} = [13+13.5]^{-1} = 0.0377$$

$$L_s = \frac{1}{ss!}\frac{\left(\frac{\lambda}{\mu}\right)^{s+1}}{(1-\rho)^2}P_0 + \frac{\lambda}{\mu} = 4.5269$$

$$L_q = L_s - \frac{\lambda}{\mu} = 4.53 - 3 = 1.53$$

$$W_s = \frac{1}{\lambda}L_s = 0.151h = 9.06\min$$

$$W_q = \frac{1}{\lambda}L_q = 0.0.51h = 3.06\min$$

(6M)

$$P[N \ge s] = \frac{\left(\frac{\lambda}{\mu}\right)^s P_0}{s!(1-\rho)} \Rightarrow P[N \ge 4] = 0.509$$

1) P [an arrival has to wait] =P [W>0] = $P[N \ge 4] = 0.509$. (2M)

2) (a) The average waiting time in the queue $= W_q = \frac{1}{\lambda}L_q = 0.0.51h = 3.06\min$. (2M)

   (b) The average time spend in the system = $W_s = \frac{1}{\lambda}L_s = 0.151h = 9.06\min$. (2M)

   (c) The average number of cars in the system= $L_s = \frac{1}{ss!}\frac{\left(\frac{\lambda}{\mu}\right)^{s+1}}{(1-\rho)^2}P_0 + \frac{\lambda}{\mu} = 4.5269$ =4.53 cars.

3) The fraction of time when the pumps are busy $= 1-\rho = 0.25$ =25%. (4M)

7 **Patients arrive at a clinic according to Poisson distribution at a rate of 30 patients per hour.**

The waiting room does not accommodate more than 14 patients. Examination time per patient is exponential with mean rate of 20 per hour. (1) find the effective arrival rate at the clinic. (2) what is the probability that an arriving patient will not wait? (3) What is the expected waiting time until a patient is discharged from the clinic?(MAY/JUNE 2007, 2010, 2012, NOV/DEC 2009)(16M)BTL5

Answer: Page : 4.75- Dr. G. Balaji

Clinic – Single server

15 Patients – Finite Capacity

Hence, this problem comes under the model (M/M/1) : (k/FIFO) (3M)

$$Mean \quad arrival \quad rate \quad (\lambda) = 30\, per \quad hour$$
$$Mean \quad service \quad rate \quad (\mu) = 20\, per \quad hour$$
$$k = 14 + 1 = 15$$
$$\rho = \frac{\lambda}{\mu} = \frac{30}{20} = 1.5$$
$$here \quad \lambda \neq \mu$$
$$P_0 = \frac{1-\rho}{1-\rho^{k+1}} = 0.00076 \approx 0.001$$
$$\lambda^{'} = \mu(1-P_0) = 19.98 \approx 20$$
$$L_s = \frac{\rho}{1-\rho} - \frac{(k+1)\rho^{k+1}}{1-\rho^{k+1}} = 13.02$$
$$L_q = L_s - \frac{\lambda^{'}}{\mu} = 12.02$$
$$W_s = \frac{1}{\lambda^{'}} L_s = 0.651$$ (6M)
$$W_q = \frac{1}{\lambda^{'}} L_q = 0.601$$

(1) The effective arrival rate = 20 per hour. (2M)
(2) P(a patient will not wait) = P_0 = 0.001. (2M)
(3) To find W_s = 0.65 h = 39 min. (3M)

8 **At a railway station, only one train is handled at a time. The railway yard is sufficient only for 2 trains to wait, while the other is given signal to leave the station. Trains arrive at the station at an average rate of 6 per hour and the railway station can handle them on an average of 6 per hour. Assuming Poisson arrivals and exponential service distribution, find the probabilities for the numbers of trains in the system. Also find the average waiting time of a new train coming into the yard. If the handling rate is doubled, how will the above**

results are modified?(16M)BTL5

Answer: Page : 4.80- Dr. G. Balaji

One yard – single server

Trains – finite capacity

$$Mean \quad arrival \quad rate \quad (\lambda) = 6\, per \quad hour$$

$$Mean \quad service \quad rate \quad (\mu) = 6\, per \quad hour$$

$$k = 3$$

$$\rho = \frac{\lambda}{\mu} = \frac{6}{6} = 1$$

$$here \quad \lambda = \mu$$

$$P_0 = \frac{1}{k+1} = \frac{1}{4} = 0.25$$

$$\lambda' = \mu(1 - P_0) = 4.5$$

$$L_s = \frac{k}{2} = 1.5$$

$$W_s = \frac{1}{\lambda'} L_s = \frac{1}{3} h = 20 \min$$

$$Now, \quad average \quad number \quad of \quad trains \quad in \quad the \quad railway \quad station \quad is\,(L_s) = 1.5$$

$$Average \quad waiting \quad time \quad in \quad the \quad station \quad of \quad the \quad new \quad train \quad co\min g \quad \text{int}\, o$$

$$the \quad yard \quad is\,(W_s) = 20 \min$$

(8M)

$$If \quad the \quad handling \quad rate \quad is \quad doubled,$$

$$\lambda = 6$$

$$\mu = 12$$

$$k = 3$$

$$\rho = \frac{\lambda}{\mu} = \frac{6}{12} = \frac{1}{2} = 0.5$$

$$Here \quad \lambda \neq \mu$$

(8M)

$$P_0 = \frac{1-\rho}{1-\rho^{k+1}} = 0.533$$

$$\lambda^{'} = \mu(1 - P_0) = 5.604$$

$$L_s = \frac{\rho}{1-\rho} - \frac{(k+1)\rho^{k+1}}{1-\rho^{k+1}} = 0.733$$

$$W_s = \frac{1}{\lambda^{'}} L_s = 7.86 \min$$

9 **Trains arrive at the yard every 15 minutes and the service time is 33 minutes. If the line capacity of the yard is limited to 5 trains, find the probability that the yard is empty and the average number of trains in the system, given that the inter arrival time and service**

	time are following exponential distribution. (MAY/JUNE 2011,2012)(10M)BTL5 **Answer: Page : 4.84 - Dr. G. Balaji** One yard – single server Trains- finite capacity Hence this problem comes under the model (M/M/1) : (k/FIFO)model (2M) $Mean \quad arrival \quad rate \quad (\lambda) = \frac{1}{15} per \quad \min$ $Mean \quad service \quad rate \quad (\mu) = \frac{1}{33} per \quad \min$ $k = 5$ $\rho = \frac{\lambda}{\mu} = \frac{33}{15} = 2.2$ $here \quad \lambda \neq \mu$ $P_0 = \frac{1-\rho}{1-\rho^{k+1}} = 0.011$ $\lambda^{'} = \mu(1-P_0) = 0.03$ $L_s = \frac{\rho}{1-\rho} - \frac{(k+1)\rho^{k+1}}{1-\rho^{k+1}} = 4.22$ The probability of yard is empty = P_0=0.011. Average number of trains in the system = L_s= 4.22. (8M)
10	**A two person barber shop has 5 chairs to accommodate waiting customers. Potential customers, who arrive when all 5 chairs are full leave without entering barber shop. Customers arrive at the average rate of 4 per hour and spend an average of 12 min. in the barber's chair compute P_0, P_1, P_7, $E(L_q)$ and E(W). (NOV/DEC 2013)(16M)**BTL5 **Answer: Page : 4.92- Dr. G. Balaji** 2 Person barber shop – multiple server Chairs – finite capacity Hence, this problem comes under the model (M/M/s): (k/FIFO) (2M) Here, s=2 K=2+5 =7

	$\lambda = 4 \, per \quad hour$ $\mu = 5 \, per \quad hour$ $\frac{\lambda}{\mu} = \frac{4}{5} = 0.8$ $\rho = \frac{\lambda}{\mu s} = 0.4$ $to \quad find \quad P_0 = \left[\sum_{n=0}^{s-1}\frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n + \frac{1}{s!}\left(\left(\frac{\lambda}{\mu}\right)^s \sum_{n=s}^{k}\rho^{(n-s)}\right)\right]^{-1} = 0.429$ $P_n = \frac{1}{n!}\left(\frac{\lambda}{\mu}\right)^n P_0, n \le s$ $\lambda' = \mu\left[s - \sum_{n=0}^{s-1}(s-n)P_n\right]$ $here \quad s = 2$ $\lambda' = 5[2-(2P_0+P_1)]$ $P_1 = 0.343$ $\lambda' = 3.994$ $L_s = \frac{P_0}{s!}\left(\frac{\lambda}{\mu}\right)^s\left[\frac{\rho(1-\rho^{k-s})}{(1-\rho)^2} - \frac{(k-s)\rho^{k-s+1}}{1-\rho}\right] + \frac{\lambda'}{\mu} = 0.9452$ $L_q = L_s - \frac{\lambda'}{\mu} = 0.15 customer$ (14M) $W_s = \frac{L_s}{\lambda'} = 14.20 \min$ $W_q = \frac{L_q}{\lambda'} = 0.34$ $s = 2, n = 7, k = 7$ $P_7 = 0.0014.$
11	**Explain Morkovian Birth Death process and obtain the expressions for steady state probabilities.(APR/MAY 2015) (16M)**BTL5 **Answer: Page : 4.8 - Dr. G. Balaji** Let N(t) denotes the total number of individuals at approach '*t*' starting from *t=0*. Consider the interval 0 to *t+h*. Suppose this is split into 2 periods 0 to *t* and *t+h*. (3) A_{ij} : *(n-i+j)* individuals by approach *t, i* – birth and *j* – death between *t &t+h, i,j=0,1.* (2)

	$P_n(t) = P[N(t) = n]$ (2) $P_n(t+h) = P_n(t)[1-(\lambda_n+\mu_n)h] + P_{n-1}(t)[\lambda_{n-1}h] + P_{n+1}(t)[\mu_{n-1}(h)] + O(h)$ (3) $as \quad h \to 0 \quad we \quad have$ $P_0{}^1(t) = -\lambda_0 P_0(t) + \mu_1 P_1(t)$ (2) If at approach t=0 there were *i* individuals, then the initial condition is $P_n(0) = 0$, for $n\neq1$, (2) $P_1(0) = 1$ (2) Its known as equation of birth and death process.
12	**Customers arriving at a watch repair shop according to Poisson process at a rate of one per every 10 minutes and the service time is an exponential random variable with mean 8 minutes.** **(i) Find the average number of customers Ls in the shop.** **(ii) Find the average time a customer spends in the shop.** **(iii) Find the average number of customer in the queue.** **(iv) What is the Probability that the server is idle? (NOV/DEC 2005,2010)(16M)**BTL5 **Answer: Page : 4.21 - Dr. G. Balaji** The watch repair shop – single server Customer – infinite capacity The given problem is (M/M/1) : (∞/FIFO) model Mean arrival rate (λ)= $\frac{1}{10}$ customers per min. Mean service rate (μ) = $\frac{1}{8}$ per min. (2M) $\rho = \frac{\lambda}{\mu} = \frac{4}{5}$ $P_0 = 1-\rho = 1-\frac{4}{5} = \frac{1}{5}$ $L_s = \frac{\rho}{1-\rho} = 4$ $L_q = L_s - \rho = \frac{16}{5} = 3.2$ (6M) $W_s = \frac{1}{\lambda}L_s = 40$ $W_q = \frac{1}{\lambda}L_q = 32$ (i) $L_s = \frac{\rho}{1-\rho} = 4$ customers (2M)

(ii) $W_s = \frac{1}{\lambda} L_s = 40$ min. (2M)

(iii) $L_q = L_s - \rho = \frac{16}{5} = 3.2$ customers. (2M)

(v) P [server is idle] = $\frac{1}{5}$. (2M)

13 **A supermarket has a single cashier. During peak hours, customers arrive at a rate of 20 per hour. The average number of customers that can be proceed by the cashier is 24 per hour. Calculate**

1) **The probability that the cashier is idle.**
2) **The average number of customers in the Queuing system.**
3) **The average time a customer spends in the system,**
4) **The average number of customers in the queue.**
5) **The average time a customer spends in the queue waiting for service.(APR/MAY 2014)(16M)**BTL5

Answer: Page : 4.19 - Dr. G. Balaji

Single cashier – single server

Customers – infinite capacity.

The given problem is (M/M/1) : (∞/FIFO) model. (3M)

Mean arrival rate (λ)= 20 per hour.
Mean service rate (μ) =24 per hour.

$\rho = \frac{\lambda}{\mu} = \frac{20}{24}$. (3M)

$$P_0 = 1 - \rho = 1 - \frac{20}{24} = \frac{4}{24}$$

$$L_s = \frac{\rho}{1-\rho} = 5$$

$$L_q = L_s - \rho = \frac{25}{6} = 4.1667$$ (4M)

$$W_s = \frac{1}{\lambda} L_s = \frac{1}{4} h$$

$$W_q = \frac{1}{\lambda} L_q = 0.2083h$$

1) The probability that the cashier is idle: $P_0 = 1 - \rho = 1 - \frac{20}{24} = \frac{4}{24}$. (2M)
2) The average number of customers in the system = $L_s = \frac{\rho}{1-\rho} = 5$. (2M)
3) The average time a customer spends in the system = $W_s = \frac{1}{\lambda} L_s = \frac{1}{4} h$

4) The average number of customers waiting in the queue = $L_q = L_s - \rho = \frac{25}{6} = 4.1667$

5) The average time a customer spends in the queue = $W_q = \frac{1}{\lambda} L_q = 0.2083h$

14

A supermarket has 2 girls attending to sales at the counters. If the service time for each customer is exponential with mean 4 min and if people arrive in Poisson fashion at the rate of 10 per hour,

(1) What is the probability that a customer has to wait for service?

(2) What is the expected % of idle time for each girl?

(3) If the customer has to wait in the queue, what is the expected length of his waiting time? (APR/MAY 2011,2015)BTL5

Answer: Page : 4.58– G. Balaji

Girls – multiple server

People – infinite capacity

$$the \quad given \quad problem \quad is\,(M/M/s) \quad : \quad (\infty/FIFO)\,\mathrm{mod}\,el$$

$$mean \quad arrival \quad rate \quad (\lambda) = 10\,per \quad hour = \frac{1}{6}\,per \quad \min$$

$$mean \quad service \quad rate \quad (\mu) = \frac{1}{4}\,per \quad \min$$

$$s = 2$$

$$\frac{\lambda}{\mu} = \frac{1/6}{1/4} = 0.67$$

$$\rho = \frac{\lambda}{s\mu} = 0.33$$

$$1 - \rho = 0.67$$

$$P_0 = \left[\sum_{n=0}^{s-1} \frac{1}{n!} \left(\frac{\lambda}{\mu} \right)^n + \frac{\left(\frac{\lambda}{\mu} \right)^s}{s!(1-\rho)} \right]^{-1} = [1.67 + 0.355]^{-1} = 0.5$$

(1) P[a customer has to wait] =

$$P[N \geq s] = \frac{\left(\frac{\lambda}{\mu} \right)^s P_0}{s!(1-\rho)} \Rightarrow P[N \geq 2] = 0.168$$

(2) The fraction of time when the girls are busy = $\frac{\lambda}{s\mu} = \frac{1}{3}$.

(3) $E(W_q / W_s > 0) = \frac{1}{\mu s - \lambda} = 3\min$.

15

Derive the governing equations for the (M/M/1) : (GD/N/∞) queuing model and hence obtain the expression for the steady state probability and the average number of customers in the system.

(or)

Derive the steady- state probability of the number of customers in M/M/1queueing system from the birth and death processes and hence deduce that the average measures such as expected system size, expected queue size, expected waiting time in system and expected waiting time in queue. (NOV/DEC 2011,2013, NOV/DEC 2018) (16M) BTL5

Answer: Page : 4.15 - Dr. G. Balaji

Let 'N' denotes the number of customers in the queuing system and the number of customer in the queue is (N-1)

λ – Mean arrival rate

μ- Mean service rate

ρ- Traffic intensity $= \frac{\lambda}{\mu}$

$P_0 = 1 - \rho$;

P$_n$= $\rho^n(1-\rho), \rho < 1, n = 0,1.2....$

(1) Average number of customers in the system: $L_s = \frac{\rho}{1-\rho}$

(2) Average number of customer in the queue: $L_q = L_s - \rho$

(3) The Average waiting time of a customer in the system: $W_s = \frac{1}{\lambda} L_s$

(4) The average waiting time of a customer in the queue: $W_q = \frac{1}{\lambda} L_q$

(5) Average number of customer in non-empty queues: $L_W = \frac{L_q}{P(n>1)} = \frac{L_q}{\rho^2}$

(6) The probability density function of the waiting time in the system:

$$f(W) = \mu\left(\frac{\mu-\lambda}{\mu}\right)e^{-\mu W}e^{\lambda W} = (\mu-\lambda)e^{-(\mu-\lambda)}W$$

Which is the p.d.f of an exponential distribution with parameter $(\mu - \lambda)t$.

	UNIT V - ADVANCED QUEUEINGMODELS
	Finite source models - M/G/1 queue – Pollaczek Khinchin formula - M/D/1 and $M/E_K/1$ as special cases – Series queues – Open Jackson networks.
Q.No	**Part * A**
1.	**Write down Pollaczek- Khintchine formula and explain the notation.(NOV/DEC 2011,2013)**BTL1 If T is the random service time, the average number of customers in the system $L_s = E_n = \lambda E(T) + \frac{\lambda^2[E^2(T)+V(T)]}{2[1-\lambda E(T)]}$ Where E(T) is mean of T and V(T) is variance of T.
2	**M/G/1 queuing system is Markovian. Comment on this statement.**BTL2 M/G/1 queuing system is a non-Markovian queue model. Since the service time follows general distribution. In the M/G/1queuing system under study, we consider a single-server queuing system with infinite capacity, Poisson arrivals and general service discipline. The model has arbitrary service time, and it is not necessary to be memoryless (i.e) it is not exponential.
3	**Write down the Pollaczek – Khintchine transform formula**.BTL1 The Pollaczek- Khintchine Transform formula: $V(s) = \frac{(1-\rho)(1-s)B^*(\lambda-\lambda_S)}{B^*(\lambda-\lambda_S)-s}$
4	**In M/G/1 model write down the formula for the average number of customers in the system.**BTL1 The average number of customers in the system is $W_s = \frac{\lambda^2\sigma^2+\rho^2}{2\lambda(1-\rho)}+\frac{1}{\mu}$
5	**Write the classification of Queuing Networks.(MAY/JUNE 2010)**BTL1 1) Open Networks. 2) Closed Networks. 3) Mixed Networks.

6	**State Arrival theorem. (MAY/JUNE 2010)**BTL1 In the closed network system with *m* customers, the system as seen by arrivals to server *j* is distributed as the stationary distribution in the same network system when there are only *m-1* customers.
7	**Distinguish between open and closed network.(APR/MAY 2010,2011,2014,NOV/DEC 2015)**BTL2 Open Network: Arrivals from outside to the node *i* is allowed. Once a customer gets the service completed at node *i*, he joins the queue at node *j* with probability P_{ij} or leaves the system with Probability P_{i0}. Closed Network: New customers never enter in to the system. Existing customers never depart from the system (i.e)., $P_{i0} = 0$ and $r_i = 0$ for all *i* (OR)No customer may leave the system.
8	**Explain (Series queue) tandem queue model.(NOV/DEC 2010,2011)**BTL2 A series queue model or a tandem queue or a tandem queue model is satisfies the following characteristics. 1) Customers may arrive from outside the system at any node and may leave the system from any node. 2) Customers may enter the system at some node, traverse from node to node in the system and leave the system from some node, necessarily following the same order of nodes. 3) Customers may return to the nodes already visited, skip some nodes and even choose to remain in the system forever.
9	**Define an open Jackson network. (APR/ MAY 2015, NOV/DEC 2013, 2014)**BTL1 Suppose a queuing network consists of *k* nodes is called an open Jackson network, if it satisfied the following characteristics. 1) Customers arriving at node *k* from outside the system arrive in a Poisson pattern with the average arrival rate r_i and join the queue at *i* and wait for his turn for service. 2) Service times at the channels at node *i* are independent and each exponentially distributed with parameter μ . 3) Once a customer gets the service completed at node *i*, he joins the queue at node *j* with probability P_{ij} when $i=1, 2,\ldots,k$ and $j=0,1,2,\ldots k$. P_{i0}represents the probability that a customer leaves the system from node *i* after getting the service at *i*. 4) The utilization of all the queues is less than one.
10	**What is meant by queue network?** BTL1 A network of queues is a collection of service centers, which represent system resources, and customers, which represent users or transaction.
11	**Define Closed queuing network.(MAY/JUNE 2013)** BTL1 In a closed queuing network, jobs neither enter nor depart from the network. If the network has multiple job classes then it must be closed for each class of jobs.
12	**Define Open queuing network.(APR/MAY 2015)** BTL1 An open queuing network is characterized by one or more sources of job arrivals and corresponding

	one or more sinks that absorb jobs departing from the network. If the network has multiple job classes then it must be open for each class of jobs.
13	**What do you mean by bottleneck of a network? (NOV/DEC 2010)**BTL2 As the arrival rate λ in a 2-state tandem queue model increases, the node with the larger value of $\rho_i = \frac{\lambda}{\mu_i}$ will introduce instability. Hence the node with the larger value ρ_i is called the bottleneck of the system.
14	**Consider a service facility with two sequential stations with respective service rate of 3/min and 4/min. The arrival rate is 2/min. What is the average service time of the system, if the system could be approximated by a two stage Tandem queue? (NOV/DEC 2010)**BTL3 $\lambda = 2$ $\mu_1 = 3$ Given $\mu_2 = 4$ *The average service time of the system* $= \frac{1}{\mu_1 - \lambda} + \frac{1}{\mu_2 - \lambda} = 1 + \frac{1}{2} = \frac{3}{2} / \min$.
15	**What do you mean by series queue with blocking?(APR/MAY 2011)**BTL2 This is a sequential queue model consisting of two service points S_1 and S_2 at each of which there is only one server and where no queue is allowed to form at either point.
16	**Define a two Stage tandem queues. (APR/MAY 2011)**BTL1 Consider a two- server system in which customers arrive at a Poisson rate λ at server 1. After being served by server 1 then they join the queue in front of server 2. We suppose there is infinite waiting space at both servers. Each server one customer at a time with server *i* taking an exponential time with rate μ_i for service $i=1,2,\ldots$ such a system is called a tandem or sequential system.
17	**Write down the balance equation for 2- stage series queue model.**BTL1 $\lambda p(0,0) = \mu_2 p(0,1)$ $(\lambda + \mu_1) p(m,0) = \lambda p(m-1,0) + \mu_2 p(m,1), [m > 0]$ $(\lambda + \mu_2) p(0,n) = \lambda p(1,n-1) + \mu_2 p(0,n+1), [n > 0]$ $(\lambda + \mu_1 + \mu_2) p(m,n) = \lambda p(m-1,n) + \mu_1 p(m+1,n-1) + \mu_2 p(m,n+1), [m > 0]$ $\sum_m \sum_n p(m,n) = 1$
18	**Write down the (flow balance) traffic equation for an open Jackson network.(MAY/JUNE 2016)**BTL1 Jackson's flow balance equation for this open model are $\lambda_j = r_j + \sum_{i=1}^{k} \lambda_i P_{ij},\ j = 1,2,..,k$

19	**Given any two examples for series queuing situation. (APR/MAY 2015)**BTL2 1) A master health check-up programme in a hospital where a patient has to undergo a series of test. 2) An admission process in a school where the student has to visit a series of officials. 3) Manufacturing or assembly line process. 4) Registration process in university. 5) Clinic physical examination procedure.
20	**Define a Tandem Queue**. BTL1 A series queue in which the series facilities are arranged in sequence and the flow is always in a single direction.
21	**When a M/G/1 queuing model will become a classic M/M/1 queuing model?(MAY/JUNE 2012)**BTL2 In the M/G/1 model, G stands for the general service time distribution. If G is replaced by exponential service time distribution then the M/G/1 model become the classic M/M/1 model.
22	**Consider a tandem queue with 2 independent Markovian servers. The situation at server 1 is just as in an M/M/1model. What will be the type of queue in server 2? Why?**BTL2 The type of queue in server 2 is also a M/M/1 model. Since output of M/M/1 is another M/M/1 queue.
23	**Define series queues.(NOV/DEC 2013)**BTL1 A series queue is one in which customers may arrive from outside the system at any node and may leave the system from any node.
24	**What does the letter in the symbolic representation M/G/1 of a queuing model representation M/G/1 of a queuing model represent?(APR/MAY 2015)**BTL1 M- Inter arrival time is exponential distribution. G- Service time is general distribution 1-Number of server.
25	**How queuing theory could be used to study computer network. (APR/MAY 2010)**BTL2 1) Jackson's open network concept can be extended when the nodes are multi server nodes. In this case the network behaves as if each node is an independent M/M/S model. 2) Consider a system of *k* servers. Customers arrive from outside the system to server *i, i=1,2,3…k* in accordance with independent Poisson processes then they join the queue at i until their turn at service comes. Once a customer is served by server *i*, then he joins the queue in front of server *j* , *j=1, 2, …, k* with probability P_{ij}. Hence $\sum_{j=1}^{k} P_{ij} \leq 1$ and 1-$\sum_{j=1}^{k} P_{ij}$ represents the probability that a customer departs the system after being served by server *i*. if we let λ_j denote the total arrival rate of customers to server *j*, then the λ_j can be obtained as the solution of $\lambda_j = r_j + \sum_{i=1}^{k} \lambda_i P_{ij}, j = 1,2,..,k$.
	Part * B

1

Derive Pollaczek – Khintchine formula.

(OR)

Derive Pollaczek – Khintchine formula for M/G/1 queue. Hence deduce the result for the result for the queues M/D/1 and M/E$_K$/1 as special cases. (APR/MAY 2010,2011, NOV/DEC 2010,2011,2012, 2013,2014,2015, NOV/DEC 2018) (16M) BTL5

Answer: Page : 5.2 - Dr. G. Balaji

Let $n' = n - 1 + \delta + k$

n →Number of customers in the system at time$'t'$.

n' →number of customers in the system $'t + T'$

T → random service time

k →Number of arrivals during the service time.

$$\delta = \begin{cases} 1 & if\ n = 0 \\ 0 & if\ n > 0 \end{cases}$$

$$n' = \begin{cases} k & if\ n = 0 \\ (n-1) + k & if\ n > 0 \end{cases}$$

$\delta^2 = \delta$ [for values of $\delta = 0$ and $\delta = 1$]

$$n\delta = 0 \quad [\because n = 0, \delta = 1 \Longrightarrow n\delta = 0; n > 0, \delta = 0 \Longrightarrow n\delta = 0]$$

$$n' = n + \delta - (1 - k)$$

$$E[n'^2] - E[n^2] + 2E[n][1 - E(k)] = -E[\delta] + 1 - E[k] + E[k^2] - E[k] + 2E[\delta]E[k]$$

$$E[n] = E(k) + \frac{E[k^2] - E[k]}{2[1 - E(k)]} \qquad (6M)$$

$$E[k] = E[\lambda T] = \lambda E[T]$$

$$E[n] = \lambda E[T] + \frac{\lambda^2 V(T) + \lambda^2 [E(T)]^2}{2[1 - \lambda E(T)]}$$

$$L_s = \rho + \frac{\rho^2}{2(1 - \rho)}$$

M → arrival time follows Poisson distribution

E_k → service time follows Erlang distribution with k phases

1→ Siingle server model

	Here, $\mu = \frac{1}{km}$, $\sigma^2 = \frac{1}{k\mu^2}, \rho = \frac{\lambda}{\mu}$ Hence, from P-K formula, we get $L_s = \frac{\lambda}{\mu} + \left(\frac{k+1}{2k}\right)\frac{\lambda^2}{\mu(\mu-\lambda)}$. (10M)
2	**In a heavy machine shop, the overhead crane is 75% utilized. Time study observation gave the average slinging time as 10.5 min with a standard deviation of 8.8 min.** **(1) What is the average calling rate for the service of the crane?** **(2) What is the average delay in getting service?** **(3) If the average service time is cut to 8.0 min, with a standard deviation of 6.0 min, how much reduction will occur, on average, in the delay of getting served? (16M)** BTL3 **Answer: Page : 5.6 - Dr. G. Balaji** This is a (M/G/1) : (∞/FIFO) Process Utilization rate = 75%= $\frac{3}{4}$ $\rho = \frac{\lambda}{\mu} = \frac{3}{4}$ Mean service time = 10.5 min $\lambda = \frac{3}{4}\mu$ λ= 0.0714 per min $\mu = \frac{1}{10.5}$ $\rho = 0.75$ $\sigma = 8.8$ $L_s = \rho + \frac{\rho^2}{2(1-\rho)} = 2.6646$

	$L_q = L_s - \frac{\lambda}{\mu} = 1.9146$ $W_s = \frac{1}{\lambda} L_s = 37.32$ (10M) $W_q = \frac{1}{\lambda} L_s = 26.815$ (1) The average calling rate for the services of the crane = λ= 0.0714 per min. (2M) (2) The average delay in getting service = $W_q = \frac{1}{\lambda} L_s = 26.815$. (2M) (3) The reduction will occur on average, in the delay of getting served = 26.815 - 8.325 = 18.5 min. (2M)
3	**In a big factory, there are a large number of operating machines and two sequential repair shops, which do the service of the damaged machines exponentially with respective rates of 1/hour and 2/hour. If the cumulative failure rate of all the machines in the factory is 0.5/hour, find (i) the probability that both repair shops are idle, (ii) the average number of machines in the service section of the factory and (iii) the average repair time of a machine. (NOV/DEC 2010) (10M)** BTL3 **Answer: Page : 5.49 - Dr. G. Balaji** $\lambda = 0.5/hour = \frac{1}{2}\, per \quad hour$ $\mu_1 = 1\, per \quad hour$ $\mu_2 = 2\, per \quad hour$ $P(both \quad the \quad service \quad stations \quad are \quad idle)$ $P(0,0) = \left(\frac{\lambda}{\mu_1}\right)^0 \left(1 - \frac{\lambda}{\mu_1}\right)\left(\frac{\lambda}{\mu_2}\right)^0 \left(1 - \frac{\lambda}{\mu_2}\right) = \frac{3}{8}$ (5M) $The \quad average \quad number \quad of \quad machines \quad in \quad service$ $= \frac{\lambda}{\mu_1 - \lambda} + \frac{\lambda}{\mu_2 - \lambda} = \frac{4}{3}$ $The \quad average \quad repair \quad time = \frac{1}{\mu_1 - \lambda} + \frac{1}{\mu_2 - \lambda} = \frac{8}{3}$ (5M)
4	**A TVS company in Madurai containing repair facility shared by a large number of machines has 2 sequential stations with respective rates of 2per hour and 3per hour. The cumulative failure rate of all the machines is 1 per hour. Assuming that the system behavior may be approximated by the 2-stage tandem queue, find** **(1) the average repair time including the waiting time.** **(2) the probability that both the service stations are idle** **(3) the bottleneck of the repair facility.** **(OR)** **A repair facility shared by a large number of machines has 2- sequential stations ith respective service rates of 2 per hour and 3 per hour. The cumulative failure rate of all the machines is 1 per**

	hour. Asuming that the system behavior may be approximated by the 2-stage tandem queue, find **(1) The average repair time including the waiting time,** **(2) The probability that both the service stations are idle and** **(3) The bottleneck of the repair facility. (APR/MAY 2015) (10M)** BTL3 **Answer: Page : 5.15 - Dr. G. Balaji** $\lambda = 1$ $\mu_1 = 2$ $\mu_2 = 3$ $(1) The \quad average \quad number \quad of \quad machines \quad in \quad service$ (5M) $= \frac{\lambda}{\mu_1 - \lambda} + \frac{\lambda}{\mu_2 - \lambda} = \frac{3}{2}$ $(2) The \quad average \quad repair \quad time = \frac{1}{\mu_1 - \lambda} + \frac{1}{\mu_2 - \lambda} = \frac{8}{3}$ $(3) P(0,0) = \left(\frac{\lambda}{\mu_1}\right)^0 \left(1 - \frac{\lambda}{\mu_1}\right) \left(\frac{\lambda}{\mu_2}\right)^0 \left(1 - \frac{\lambda}{\mu_2}\right) = \frac{3}{8}$ (5M)
5	**An average of 120 students arrive each hour (inter arrival times are exponential) at the controller office to get their hall tickets. To complete the process, a candidate must pass through three counters. Each counter consists of a single server; service times at each counter are exponential with the following mean times: counter 1, 20 seconds; counter 2, 15 seconds and counter 3, 12 seconds. On the average how many students will be present in the controller's office. (MAY/JUNE 2012, APR/MAY 2014)(8M)** BTL3 **Answer: Page : 5.61- Dr. G. Balaji**

	$\lambda = 120/hr$ $\mu_1 = \frac{1}{20}/\sec = 180/hr$ $\mu_2 = \frac{1}{15}/\sec = 240/hr$ $\mu_3 = \frac{1}{12}/\sec = 300/hr$ $L_{s1} = \frac{\lambda}{\mu_1 - \lambda} = 2$ $L_{s2} = \frac{\lambda}{\mu_2 - \lambda} = 1$ (4M) $L_{s3} = \frac{\lambda}{\mu_3 - \lambda} = \frac{2}{3}$ $Average \quad number \quad of \quad students = L_{s1} + L_{s2} + L_{s3} = \frac{11}{3}$ (4M)
6	**Consider a system of two servers where customers from outside the system arrive at server 1 at a Poisson rate 4 and at server 2 at a Poisson rate 5. The service rates 1 and 2 are respectively 8 and 10. A customer upon completion of service at server 1 is equally likely to go to server 2 or to leave the system (i.e., P_{11} = 0, P_{12} = ½); whereas a departure from server 2 will go 25 percent of the time to server 1 and will depart the system otherwise (i.e., P_{21} = 1/4, P_{22} = 0). Determine the limiting probabilities, Ls and Ws. [MAY/JUNE 2013] (8M)** BTL3 **Answer: Page : 5.65 - Dr. G. Balaji**

	$r_1 = 4; r_2 = 5$ $\mu_1 = 8; \mu_2 = 10$ *The Jackson's flow balance equations are* $\lambda_j = r_j + \sum_{i=1}^{2} \lambda_i P_{ij}, j = 1,2$ *For* $j = 1$ *we get* $\lambda_1 = 4 + \frac{\lambda_4}{4}$ *For* $j = 2$ *we get* $\lambda_2 = r_2 + \lambda_1 P_{12} + \lambda_2 P_{22}$ $\Rightarrow \lambda_1 = 6; \lambda_2 = 8.$ $L_s = \frac{\lambda_1}{\mu_1 - \lambda_1} + \frac{\lambda_2}{\mu_2 - \lambda_2} = 3 + 4 = 7.$ $W_s = \frac{1}{\lambda} L_s = \frac{7}{9}. \quad [\because \lambda = 4 + 5]$ (8M)
7	**Consider two servers. An average of 8 customers per hour arrive from outside at server 1 and an average of 17 customers per hour arrive from outside at server 2. Inter arrival times are exponential. Server 1 can serve at an exponential rate of 20 customers per hour and server 2 can serve at an exponential rate of 30 customers per hour. After completing service at server 1, half of the customers leave the system, and half go to server 2. After completing service at server 2, ¾ of the customers complete service, and ¼ return to server 1. (i) What fraction of the time is server 1 idle? (ii) Find the expected number of customers at each server. (iii) Find the average time a customer spends in the system. (iv) How would the answers to parts (i) – (iii) change if server 2 could server only an average of 20 customers per hour? [NOV/DEC 2012, 2014] (8M)** BTL3 **Answer: Page : 5.70 - Dr. G. Balaji**

	$r_1 = 8; r_2 = 17;$ $\mu_1 = 20; \mu_2 = 30$ *The Jackson's flow balance equations are* $\lambda_j = r_j + \sum_{i=1}^{2} \lambda_i P_{ij}, j = 1,2$ *For* $j = 1$ *we get* $\lambda_1 = 8 + \frac{\lambda_2}{4}$ *For* $j = 2$ *we get* $\lambda_2 = r_2 + \lambda_1 P_{12} + \lambda_2 P_{22}$ $\Rightarrow \lambda_1 = 14; \lambda_2 = 24,$ $(i) P_0 = 1 - \rho = 1 - \left(\frac{\lambda}{\mu}\right) = 0.3$ $(ii) L_s = \frac{\lambda_1}{\mu_1 - \lambda_1} + \frac{\lambda_2}{\mu_2 - \lambda_2} = \frac{7}{3} + 4 = \frac{19}{3}.$ $(iii) W_s = \frac{1}{\lambda} L_s = \frac{19}{75}. \quad [\because \lambda = 8 + 17 = 25].$ (8M) $(iv) S_2 \mu_2 = 20 < \lambda_2$, *so no steady state exists.*
8	**In a network of 3 service stations 1, 2, 3 customers arrive 1, 2, 3 from outside, in accordance with Poisson process having rates 5, 10, 15 respectively. The service times at the 3 stations are exponential with respective rates 10, 50, 100. A customer competing service at station 1 is equally like to (1) go to station 2, (2) go to station 3 and (3) leave the system. A customer departing from service at station 2 always goes to station 3. A departure from service at station 3 is equally like to go to station 2 or leave the system. (A) What is the average number of customers in the system consisting of all the tree stations? (B) What is the average time a customer spends in the system? [NOV/DEC 2010, 2011] (8M)** BTL3 **Answer: Page : 5.76 - Dr. G. Balaji** $r_1 = 5; r_2 = 10; r_3 = 15$ $\mu_1 = 10; \mu_2 = 50; \mu_3 = 100;$ *The Jackson's flow balance equations are* $\lambda_j = r_j + \sum_{i=1}^{3} \lambda_i P_{ij}, j = 1,2,3$ (4M) *For* $j = 1$ *we get* $\lambda_1 = 5$ *For* $j = 2$ *we get* $\lambda_2 = r_2 + \lambda_1 P_{12} + \lambda_2 P_{22} + \lambda_3 P_{32}$

	For $j = 3$ we get $\lambda_3 = r_3 + \lambda_1 P_{13} + \lambda_2 P_{23} + \lambda_3 P_{33}$ $\Rightarrow \lambda_1 = 5; \lambda_2 = 40, \lambda_3 = \left(\frac{170}{3}\right),$ (4M) $L_s = \frac{\lambda_1}{\mu_1 - \lambda_1} + \frac{\lambda_2}{\mu_2 - \lambda_2} + \frac{\lambda_3}{\mu_3 - \lambda_3} = \frac{82}{13} = 6.3077.$ $W_s = \frac{1}{\lambda} L_s = \frac{41}{195} = 0.2103.$
9	**A one man barber shop takes exactly 25 minutes to complete one haircut. If customer arrive at the barber shop in a Poisson fashion at an average rate of one every 40 minutes, how long on the average a customer spends in the shop? Also find the average time a customer must wait for service.(NOV/DEC 2013) (8M)** BTL3 **Answer: Page : 4.15 - Dr. G. Balaji** $\lambda = \frac{1}{40}$per min $\mu = \frac{1}{25}$per min $\rho = \frac{\lambda}{\mu} = \frac{5}{8}$ $L_s = \rho + \frac{\rho^2}{2(1-\rho)} = \frac{55}{48}$ (4M) $L_q = L_s - \frac{\lambda}{\mu} = \frac{25}{48}$ $W_s = \frac{1}{\lambda} L_s = 45.833$ $W_q = \frac{1}{\lambda} L_s = 20.833$ Hence, a customer has to spend 45.8 minutes in the shop and has to wait for 20.8 minutes on the average. (4M)
10	**An automatic car wash facility operates with only one bay. Cars arrive according to a Poisson distribution with a mean of 4 cars/hr. and may wait in the facility's parking lot if the bay is busy. Find L_s, L_q, W_s, W_q if the service time.** **(1) Follows uniforms distribution between 8 and 12 minutes.** **(2) Follows normal distribution with mean 12 minutes and S.D 3 minutes** **(3) Follows a discrete distribution with values 4,8 and 15 minutes with corresponding probability 0.2, 0.6 and 0.2. (16M)** BTL3 **Answer: Page : 5.16 - Dr. G. Balaji** This is an M/G/1 queue model. (a) Mean $=\lambda = \frac{4}{60}$per minute.

$E(T)$=mean of the uniform distribution =$\frac{1}{2}(a+b)$=10

$Var(T)=\frac{1}{12}(b-a)^2$=$\frac{4}{3}$.

By the Pollazek- Knichine formula,

L_s=$\frac{302}{225}$= 1.342 cars.

L_q =0.675 cars≅ 1 car. (by Little's formula) (5M)

(b) Mean =$\lambda=\frac{1}{15}$.

$E(T)$=12min

$Var(T)=9$.

$\mu=\frac{1}{E(T)}$=$\frac{1}{12}$

By the Pollazek- Knichine formula,

L_s= 2.5 cars.

L_q =1.7 cars≅ 2 cars.(by Little's formula) (5M)

(C)

T:	4	8	15
$P(T)$:	0.2	0.6	0.2

$E(T)=\sum TP(T)=8.6$min

$var(T)=E(T^2)$-$[E(T)]^2$ =12.64

By the Pollazek- Knichine formula,

L_s= 1.021≅1 car.

L_q =0.45cars (by Little's formula) (6M)

11

Jackson network with three facilities that have the parameters given below

$P_{11}=0, P_{12}=0.6, P_{13}=0.3,$

$P_{21}=0.1, P_{22}=0, P_{23}=0.3,$

$P_{31}=0.4, P_{32}=0.4, P_{33}=0,$

$\mu_1=10, \mu_2=10, \mu_3=10,$

$c_1=1, c_2=2, c_3=1,$

$r_1=1, r_2=4, r_3=3$

1) **Find the total arrival rate at each facility**
2) **Find** $P(n_1, n_2, n_3)$
3) **Find the expected number of customers in the entire system**
4) **Find the expected time a customer spends in the system. [MAY/JUNE 2012, APR/MAY 2014]**

(OR)

For an open queuing network with three nodes 1, 2, and 3, let customers arrive from outside the system to node j according to a Poisson input process with parameters $r_j$and let P_{ij} denote the proportion of customers departing from facility i to facility$j$. Given (r_1, r_2, r_3) = (1, 4, 3) and $P_{ij}=\begin{pmatrix} 0 & 0.6 & 0.3 \\ 0.1 & 0 & 0.3 \\ 0.4 & 0.4 & 0 \end{pmatrix}$. Determine the average arrival rate λ_j to the node j for $j=1,2,3$.

(16M) BTL3

Answer: Page : 5.84 - Dr. G. Balaji

$$P_{11} = 0, P_{12} = 0.6, P_{13} = 0.3,$$

$$P_{21} = 0.1, P_{22} = 0, P_{23} = 0.3,$$

$$P_{31} = 0.4, P_{32} = 0.4, P_{33} = 0,$$

$$\mu_1 = 10, \mu_2 = 10, \mu_3 = 10,$$

$$c_1 = 1, c_2 = 2, c_3 = 1,$$

$$r_1 = 1, r_2 = 4, r_3 = 3$$

$$r_1 = 5; r_2 = 10; r_3 = 15$$

$$\mu_1 = 10; \mu_2 = 50; \mu_3 = 100;$$

The Jackson's flow balance equations are

$$\lambda_j = r_j + \sum_{i=1}^{3} \lambda_i P_{ij}, \ j = 1,2,3$$

For $j = 1$ *we get*

$$\lambda_1 = 1 + (0.1)\lambda_2 + (0.4)\lambda_3$$

For $j = 2$ *we get*

$$\lambda_2 = 4 + (0.6)\lambda_1 + (0.4)\lambda_3$$

For $j = 3$ *we get*

$$\lambda_3 = 3 + (0.3)\lambda_1 + (0.3)\lambda_2$$

$$\Rightarrow \lambda_1 = 5; \lambda_2 = 10, \lambda_3 = 7.5,$$

Facility 1 *is an* $(M/M/1)$ mod*el*

(10M)

$$P_{n1} = \left(\frac{\lambda_1}{\mu_1}\right)^{n_1}\left(1 - \frac{\lambda_1}{\mu_1}\right) = \left(\frac{1}{2}\right)^{n_1}\left(\frac{1}{2}\right)$$

$$L_{s_1} = \frac{\lambda_1}{\mu_1 - \lambda_1} = 1$$

Facility 2 is an (M/M/2) model

$$P_{n_2} = \begin{cases} \frac{1}{n_2!}\left(\frac{\lambda_2}{\mu_2}\right)^{n_2} P_{0,} & If\ n_2 < 2 \\ \frac{1}{C_2! C_2{}^{n_2 - C_2}}\left(\frac{\lambda_2}{\mu_2}\right)^{n_2} P_{0,} & If\ n_2 \geq 2 \end{cases}$$

$$P_0 = \left[\sum_{n=0}^{1} \frac{1}{n!}\left(\frac{\lambda_2}{\mu_2}\right)^n + \frac{\frac{1}{2!}\left(\frac{\lambda_2}{\mu_2}\right)^2}{\left(1 - \frac{\lambda_2}{2\mu_2}\right)}\right]^{-1} = \frac{1}{3}$$

$$P_1 = \frac{1}{1!}\left(\frac{\lambda_2}{\mu_2}\right)^1 P_0 = \frac{1}{3}$$

	$P_{n_2} = \left\{ \begin{matrix} \frac{1}{3} if \quad n_2 = 0 \\ \frac{1}{3} if \quad n_2 = 1 \\ \frac{1}{3}\left(\frac{1}{2}\right)^{n_2-1} \quad if \quad n_2 \geq 0 \end{matrix} \right\}$ $L_{s_2} = \frac{\left(\frac{\lambda_2}{\mu_2}\right)^{C_2+1}}{c_2 c_2!\left(1-\left(\frac{\lambda_2}{c_2\mu_2}\right)\right)^2} P_0 + \frac{\lambda_2}{\mu_2} = \frac{4}{3}$ $Facility \quad 3 \quad is \quad an \quad (M/M/1) \quad \text{mod}\, el$ $P_{n_3} = \left(\frac{\lambda_3}{\mu_3}\right)^{n_3}\left(1-\frac{\lambda_3}{\mu_3}\right) = \left(\frac{7.5}{10}\right)^{n_3}\left(\frac{2.5}{10}\right)$ $L_{s_3} = \frac{\lambda_3}{\mu_3 - \lambda_3} = 3$ $L_s = L_{s_1} + L_{s_2} + L_{s_3} = \frac{16}{3}$ (6M) $W_s = \frac{L_s}{\lambda} = \frac{2}{3}$
12	**For a 2-stage (service point) sequential queue model with blockage, compute L_s and W_s, if $\lambda = 1, \mu_1 = 1$ and $\mu_2 = 2$. (16M)** BTL3 **Answer: Class Work Note** Given $\lambda = 1, \mu_1 = 1$ **and** $\mu_2 = 2$ The balanced equation are (0,0) $\lambda P_{00} = \mu P_{01}$ (1,0) $\mu_1 P_{10} = \lambda P_{00} + \mu_2 P_{11}$ (0,1) $(\lambda + \mu_1)P_{01} = \mu_1 P_{10} + \mu_2 P_{b1}$ (1,1) $(\mu_1 + \mu_2)P_{11} = \lambda P_{01}$ (b,1) $\mu_2 P_{b1} = \mu_1 P_{11}$ (4M) $P_{00} = 3P_{01}$ $P_{10} = P_{00} + 3P_{11}$ $4P_{01} = P_{10} + 3P_{b1}$ $4P_{11} = P_{01}$ $3P_{b1} = P_{11}$ $P_{00} + P_{10} + P_{01} + P_{11} + P_{b1} = 1$ (4M) From above equations we have $P_{10} = \frac{4}{3}P_{00}$ $P_{00} = \frac{12}{37}$

	$P_{01} = \frac{6}{37}$ $P_{11} = \frac{2}{37}$ $P_{b1} = \frac{1}{37}$ $P_{10} = \frac{16}{37}$ Therefore, $L = P_{01} + P_{10} + 2(P_{11} + P_{b1}) = \frac{65}{97}$. (6M) $W = \frac{L}{\lambda(P_{00}+P_{01})} = \left(\frac{65}{48}\right)$. (6M)
13.	**Explain Queuing network. (8M)** BTL2 **Answer: Class Work Note** In a closed queuing network, jobs neither enter nor depart from the network. If the network has multiple job classes then it must be closed for each class of jobs. (3M) An open queuing network is characterized by one or more sources of job arrivals and corresponding one or more sinks that absorb jobs departing from the network. If the network has multiple job classes then it must be open for each class of jobs.. Suppose a queuing network consists of *k* nodes is called an open Jackson network, if it satisfied the following characteristics. 1) Customers arriving at node *k* from outside the system arrive in a Poisson pattern with the average arrival rate r_i and join the queue at *i* and wait for his turn for service. 2) Service times at the channels at node *i* are independent and each exponentially distributed with parameter μ . 3) Once a customer gets the service completed at node *i*, he joins the queue at node *j* with probability P_{ij} when $i=1, 2,…,k$ and $j=0,1,2,…k$. P_{i0}represents the probability that a customer leaves the system from node *i* after getting the service at *i*. The utilization of all the queues is less than one. (5M)

CS8491 COMPUTER ARCHITECTURE L T P C 3 0 0 3

- To learn the basic structure and operations of a computer.
- To learn the arithmetic and logic unit and implementation of fixed-point and floating point arithmetic unit.
- To learn the basics of pipelined execution.
- To understand parallelism and multi-core processors.
- To understand the memory hierarchies, cache memories and virtual memories.
- To learn the different ways of communication with I/O devices

UNIT I BASIC STRUCTURE OF A COMPUTER SYSTEM 9

Functional Units – Basic Operational Concepts – Performance – Instructions: Language of the Computer – Operations, Operands – Instruction representation – Logical operations – decision making – MIPS Addressing.

UNIT II ARITHMETIC FOR COMPUTERS 9

Addition and Subtraction – Multiplication – Division – Floating Point Representation – Floating Point Operations – Subword Parallelism

UNIT III PROCESSOR AND CONTROL UNIT 9

A Basic MIPS implementation – Building a Datapath – Control Implementation Scheme – Pipelining – Pipelined datapath and control – Handling Data Hazards & Control Hazards – Exceptions.

UNIT IV PARALLELISIM 9

Parallel processing challenges – Flynn‘s classification – SISD, MIMD, SIMD, SPMD, and Vector Architectures – Hardware multithreading – Multi-core processors and other Shared Memory Multiprocessors – Introduction to Graphics Processing Units, Clusters, Warehouse Scale Computers and other Message-Passing Multiprocessors.

UNIT V MEMORY & I/O SYSTEMS 9

Memory Hierarchy – memory technologies – cache memory – measuring and improving cache performance – virtual memory, TLB‘s – Accessing I/O Devices – Interrupts – Direct Memory Access – Bus structure – Bus operation – Arbitration – Interface circuits – USB.

TOTAL : 45 PERIODS

OUTCOMES:

On Completion of the course, the students should be able to:

Understand the basics structure of computers, operations and instructions.

Design arithmetic and logic unit.

Understand pipelined execution and design control unit.

Understand parallel processing architectures.

Understand the various memory systems and I/O communication.

TEXT BOOKS:

1. David A. Patterson and John L. Hennessy, Computer Organization and Design: The Hardware/Software Interface, Fifth Edition, Morgan Kaufmann / Elsevier, 2014.
2. Carl Hamacher, Zvonko Vranesic, Safwat Zaky and Naraig Manjikian, Computer Organization and Embedded Systems, Sixth Edition, Tata McGraw Hill, 2012.

REFERENCES:

1. William Stallings, Computer Organization and Architecture – Designing for Performance, Eighth Edition, Pearson Education, 2010.
2. John P. Hayes, Computer Architecture and Organization, Third Edition, Tata McGraw Hill, 2012.
3. John L. Hennessey and David A. Patterson, Computer Architecture – A Quantitative Approach‖, Morgan Kaufmann / Elsevier Publishers, Fifth Edition, 2012.

DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING
QUESTION BANK

SUBJECT : CS8491 COMPUTER ARCHITECTURE
SEM /YEAR : IV/II

UNIT -1- BASIC STRUCTURE OF A COMPUTER SYSTEM

Functional Units – Basic Operational Concepts – Performance – Instructions: Language of the Computer – Operations, Operands – Instruction representation – Logical operations – decision making – MIPS Addressing.

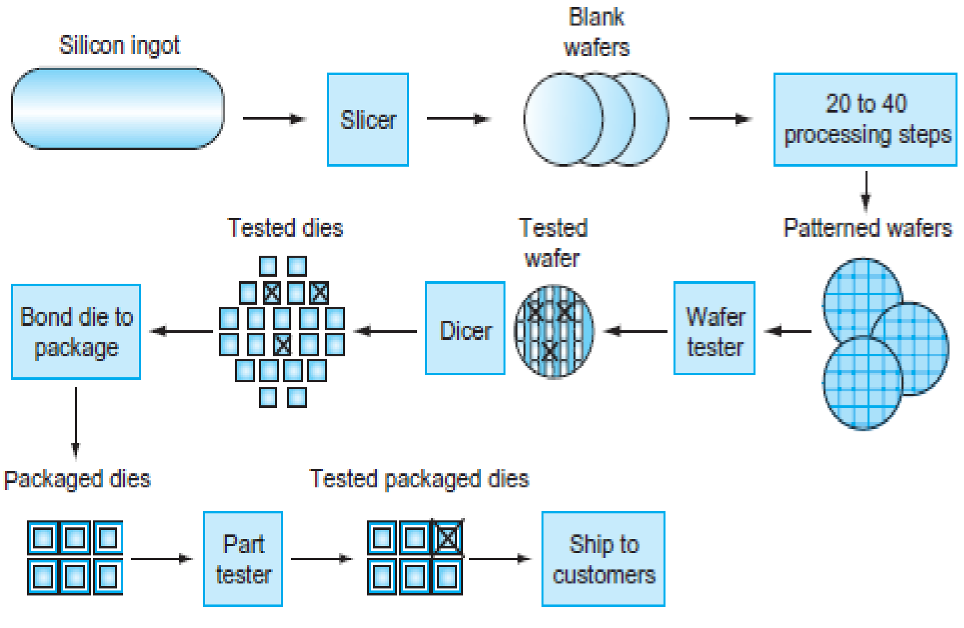
PART A

Q.No	QUESTIONS
1.	**Define computer architecture BTL1** Computer architecture is defined as the functional operation of the individual h/w unit in a computer system and the flow of information among the control of those units.
2.	**Define computer h/w BTL1** Computer h/w is the electronic circuit and electro mechanical equipment that constitutes the Computer
3.	**What are the functions of control unit? BTL2** • The memory arithmetic and logic, and input and output units store and process information and perform i/p and o/p operation • The operation of these unit must be coordinate in some way this is the task of control unit the cu is effectively the nerve center that sends the control signal to other units and sense their states.
4.	**What is an interrupt? BTL2** An interrupt is an event that causes the execution of one program to be suspended and another program to be executed.
5.	**What are the uses of interrupts? BTL2** • Recovery from errors • Debugging • Communication between programs • Use of interrupts in operating system
6.	**What is the need for reduced instruction chip? BTL2** • Relatively few instruction types and addressing modes. • Fixed and easily decoded instruction formats. • Fast single-cycle instruction execution. • Hardwired rather than microprogrammed control.
7.	**Explain the following the address instruction? BTL3** • Three-address instruction-it can be represented as add a,b,c operands a,b are called source operand and c is called destination operand. • Two-address instruction-it can be represented as add a,b • One address instruction-it can be represented as add a • Zero address instruction-it can be represented as Push down stack
8.	**Differentiate between RISC and CISC BTL4** RISC & CISC reduced instruction set computer 1. complex instruction set computer simple instructions take one cycle per operation complex instruction take multiple cycles per operation. few instructions and address

	modes are used. many instruction and address modes. fixed format instructions are used. variable format instructions are used instructions are compiled and then executed by hardware. instructions are interpreted by the microprogram and then executed. RISC machines are multiple register set. CISC machines use single register set.
9.	**Specify three types of data transfer techniques. BTL1** - Arithmetic data transfer - Logical data transfer - Programmed control data transfer
10.	**What is absolute addressing mode? BTL1** The address of the location of the operand is given explicitly as a part of the instruction. Eg. move a , 2000
11.	**What is the role of MAR and MDR? BTL1** - The MAR (memory address register) is used to hold the address of the location to or from which data are to be transferred - The MDR(memory data register) contains the data to be written into or read out of the addressed location.
12.	**Define CPI BTL1** - The term clock cycles per instruction which is the average number of clock cycles each instruction takes to execute, is often abbreviated as CPI. CPI= CPU clock cycles/instruction count.
13.	**Define throughput and throughput rate. BTL1** - throughput -the total amount of work done in a given time. - throughput rate-the rate at which the total amount of work done at a given time.
14.	**State and explain the performance equation? BTL2** Suppose that the average number of basic steps needed to execute one machine instruction is S,where each basic step is completed in one clock cycle. if the clock cycle rate is R cycles per second, the program execution time is given by T = (N x S) / R this is often referred to as the basic performance equation.

15.	**What are the various types of operations required for instructions? BTL1** • Data transfers between the main memory and the CPU registers • Arithmetic and logic operation on data • Program sequencing and control • I/O transfers
16.	**What are the various units in the computer? BTL1** • Input unit • Output unit • Control unit • Memory unit • Arithmetic and logical unit
	PART B
1	**Explain in detail, the eight ideas in computer architecture. (13m) BTL4** **Answer**: U-1 in refer notes **Definition(2m)** **Diagram(4m)** **Explanation(7m)** • Design for Moore's Law • Use Abstraction to simplify design • Make the common case fast • Performance via parallelism • Performance via pipelining • Performance via prediction • Hierarchy of memories • Dependability via redundancy
2	**Explain in detail, the components of a computer system. (13m) (Apr/may 2018) BTL4** **Answer**: U-1 Refer notes **Explanation(8m)** **Diagram(5m)** The five classic components of a computer are input, output, memory, datapath, and control.
3	**Explain in detail, the technologies for building processor and memory. (13m) BTL4** **Technologies. (3m)** **Answer**: U-1 Refer notes **The manufacturing process for integrated circuits: (7m)** • The manufacture of a chip begins with silicon, a substance found in sand. Because silicon does not conduct electricity well, it is called a semiconductor. With a special chemical process, it is possible to add materials to silicon that allow tiny areas to transform into one of three devices: • Excellent conductors of electricity (using either microscopic copper or aluminum wire) • Excellent insulators from electricity (like plastic sheathing or glass) • Areas that can conduct or insulate under special conditions (as a switch) Transistors fall in the last category. • A VLSI circuit, then, is just billions of combinations of conductors, insulators, and switches manufactured in a single small package. The manufacturing process for integrated circuits is critical to the cost of the chips and hence important to computer designers. • The process starts with a silicon crystal ingot, which looks like a giant sausage. Today, ingots are 8–12 inches in diameter and about 12–24 inches long. An ingot is finely sliced into wafers no more than 0.1 inches thick.

- These wafers then go through a series of processing steps, during which patterns of chemicals are placed on each wafer, creating the transistors, conductors, and insulators discussed earlier.
- Today's integrated circuits contain only one layer of transistors but may have from two to eight levels of metal conductor, separated by layers of insulators.



The chip manufacturing process:

- After being sliced from the silicon ingot, blank wafers are put through 20 to 40 steps to create patterned wafers.
- These patterned wafers are then tested with a wafer tester, and a map of the good parts is made. Then, the wafers are diced into dies.
- The yield of good dies are then bonded into packages and tested one more time before shipping the packaged parts to customers. One bad packaged part was found in this final test.

Defect: A microscopic flaw in a wafer or in patterning steps that can result in the failure of the die containing that defect.

Die: The individual rectangular sections that are cut from a wafer, more informally known as chips.

Yield: The percentage of good dies from the total number of dies on the wafer.

The cost of an integrated circuit rises quickly as the die size increases, due both to the lower yield and the smaller number of dies that fit on a wafer. To reduce the cost, using the next generation process shrinks a large die as it uses smaller sizes for both transistors and wires.

$$\text{Cost per die} = \frac{\text{Cost per wafer}}{\text{Dies per wafer} \times \text{yield}}$$

$$\text{Dies per wafer} \approx \frac{\text{Wafer area}}{\text{Die area}}$$

$$\text{Yield} = \frac{1}{(1 + (\text{Defects per area} \times \text{Die area}/2))^2}$$

Diagram(3m)

4 **Explain in detail, the performance of a computer. (13m) BTL4**

Defining Performance:

- If you were running a program on two different desktop computers, you'd say that the faster one is the desktop computer that gets the job done first. If you were running a datacenter that had several servers running jobs submitted by many users, you'd say that the faster computer was the one that completed the most jobs during a day.

- As an individual computer user, you are interested in reducing response time—the time between the start and completion of a task—also referred to as execution time. Datacenter managers are often interested in increasing throughput or bandwidth—the total amount of work done in a given time
- Hence, in most cases, we will need different performance metrics as well as different sets of applications to benchmark personal mobile devices, which are more focused on response time, versus servers, which are more focused on throughput. To maximize performance, we want to minimize response time or execution time for some task. Thus, we can relate performance and execution time for a computer X:

$$\text{Performance}_X = \frac{1}{\text{Execution time}_X}$$

This means that for two computers X and Y, if the performance of X is greater than the performance of Y, we have

$$\text{Performance}_X > \text{Performance}_Y$$

$$\frac{1}{\text{Execution time}_X} > \frac{1}{\text{Execution time}_Y}$$

$$\text{Execution time}_Y > \text{Execution time}_X$$

- That is, the execution time on Y is longer than that on X, if X is faster than Y. To relate the performance of two different computers quantitatively. We will use the phrase “X is n times faster than Y”—or equivalently “X is n times as fast as Y”—to mean

$$\frac{\text{Performance}_X}{\text{Performance}_Y} = n$$

If X is n times as fast as Y, then the execution time on Y is n times as long as it is on X:

$$\frac{\text{Performance}_X}{\text{Performance}_Y} = \frac{\text{Execution time}_Y}{\text{Execution time}_X} = n$$

Measuring Performance: Time is the measure of computer performance:

- The computer that performs the same amount of work in the least time is the fastest. Program execution time is measured in seconds per program. However, time can be defined in different ways, depending on what we count.
- The most straightforward definition of time is called wall clock time, response time, or elapsed time. These terms mean the total time to complete a task, including disk accesses, memory accesses, input/output (I/O) activities, operating system overhead—everything.
- CPU execution time also called CPU time: The actual time the CPU spends computing for a specific task. user CPU time The CPU time spent in a program itself. system CPU time the CPU time spent in the operating system performing tasks on behalf of the program.
- A simple formula relates the most basic metrics (clock cycles and clock cycle time) to CPU time:

$$\begin{matrix}\text{CPU execution time} \\ \text{for a program}\end{matrix} = \frac{\text{CPU clock cycles for a program}}{\text{Clock rate}}$$

Instruction Performance : One way to think about execution time is that it equals the number of instructions executed multiplied by the average time per instruction.

Therefore, the number of clock cycles required for a program can be written as

$$\text{CPU clock cycles} = \text{Instructions for a program} \times \begin{matrix}\text{Average clock cycles} \\ \text{per instruction}\end{matrix}$$

clock cycles per instruction (CPI) Average number of clock cycles per instruction for a program or program

The Classic CPU Performance Equation: The basic performance equation in terms of instruction count (the number of instructions executed by the program),
CPI, and clock cycle time:

$$\text{CPU time} = \text{Instruction count} \times \text{CPI} \times \text{Clock cycle time}$$

or, since the clock rate is the inverse of clock cycle time:

$$\text{CPU time} = \frac{\text{Instruction count} \times \text{CPI}}{\text{Clock rate}}$$

The basic components of performance and how each is measured. These factors are combined to yield execution time measured in seconds per program:

$$\text{Time} = \text{Seconds/Program} = \frac{\text{Instructions}}{\text{Program}} \times \frac{\text{Clock cycles}}{\text{Instruction}} \times \frac{\text{Seconds}}{\text{Clock cycle}}$$

Instruction mix: A measure of the dynamic frequency of instructions across one or many programs. The performance of a program depends on the algorithm, the language, the compiler, the architecture, and the actual hardware.

PART-C

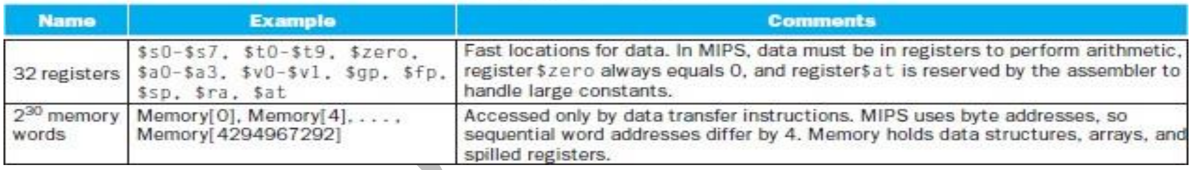
1

Write short notes on : i) Operations and operands ii) Representing instructions iii) Logical and control operations (15m) BTL2

Operations of the Computer Hardware:

- Every computer must be able to perform arithmetic. The MIPS assembly language Notation add a, b, c instructs a computer to add the two variables b and c and to put their sum in a.

MIPS operands



Name	Example	Comments
32 registers	\$s0-\$s7, \$t0-\$t9, \$zero, \$a0-\$a3, \$v0-\$v1, \$gp, \$fp, \$sp, \$ra, \$at	Fast locations for data. In MIPS, data must be in registers to perform arithmetic, register \$zero always equals 0, and register\$at is reserved by the assembler to handle large constants.
2^{30} memory words	Memory[0], Memory[4], . . . , Memory[4294967292]	Accessed only by data transfer instructions. MIPS uses byte addresses, so sequential word addresses differ by 4. Memory holds data structures, arrays, and spilled registers.

- The natural number of operands for an operation like addition is three: the two numbers being added together and a place to put the sum. Requiring every instruction to have exactly three operands, no more and no less, conforms to the philosophy of keeping the hardware simple: hardware for a variable number of operands is more complicated than hardware for a fixed number.

- Three underlying principles of hardware design:

Design Principle 1: Simplicity favors regularity.

Design Principle 2: Smaller is faster.

Design Principle 3: Good design demands good compromises.

operands of the Computer Hardware:

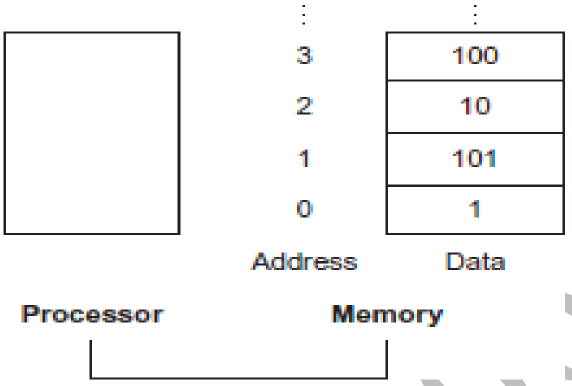
- Unlike programs in high-level languages, the operands of arithmetic instructions are restricted; they must be from a limited number of special locations built directly in hardware called registers.

- Registers are primitives used in hardware design that are also visible to the programmer when the computer is completed, so you can think of registers as the bricks of computer construction.

- The size of a register in the MIPS architecture is 32 bits; groups of 32bits occur so frequently that they are given the name word in the MIPS architecture.

- One major difference between the variables of a programming language and registers is the limited number of registers, typically 32 on current computers, like MIPS.
- The reason for the limit of 32 registers is due to design principles of hardware technology: Smaller is faster.
- A very large number of registers may increase the clock cycle time simply because it takes electronic signals longer when they must travel farther

Memory Operands:



- Data transfer instruction is a command that moves data between memory and registers. Address A value used to delineate the location of a specific data element within a memory array.

Memory addresses and contents of memory at those locations.

- The data transfer instruction that copies data from memory to a register is traditionally called load. The actual MIPS name for this instruction is lw, standing for load word.

lw $t0,8($s3) # Temporary reg $t0 gets A[8]

- The instruction complementary to load is traditionally called store; it copies data from a register to memory. The actual MIPS name is sw, standing for store word.

sw $t0,48($s3) # Stores h + A[8] back into A[12]

- Load word and store word are the instructions that copy words between memory and registers in the MIPS architecture.

Constant or Immediate Operands:

- Many times a program will use a constant in an operation—for example, incrementing an index to point to the next element of an array.
- This quick add instruction with one constant operand is called add immediate or addi. To add 4 to

```
addi    $s3,$s3,4          # $s3 = $s3 + 4
```

  register $s3,

- Computer programs calculate both positive and negative numbers, so we need a representation that distinguishes the positive from the negative.
- The most obvious solution is to add a separate sign, which conveniently can be represented in a single bit; the name for this representation is sign and magnitude.

Signed and Unsigned Numbers:

- Signed versus unsigned applies to loads as well as to arithmetic. The function of a signed load is to copy the sign repeatedly to fill the rest of the register—called sign extension—but its purpose is to place a correct representation of the number within that register.

- Unsigned loads simply fill with 0s to the left of the data, since the number represented by the bit pattern is unsigned.

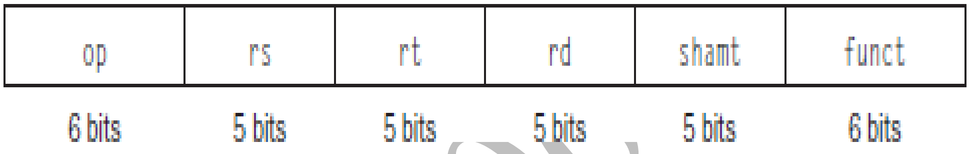
i) Representing instructions

- Instructions are kept in the computer as a series of high and low electronic signals and may be represented as numbers.
- In fact, each piece of an instruction can be considered as an individual number, and placing these numbers side by side forms the instruction.

Instruction format: A form of representation of an instruction composed of fields of binary numbers.

Machine language: Binary representation used for communication within a computer system. Hexa decimal Numbers in base 16.

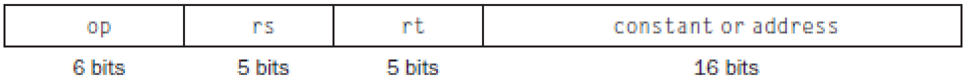
MIPS Fields:



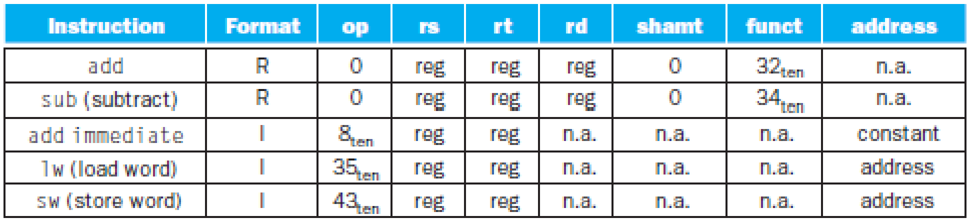
op	rs	rt	rd	shamt	funct
6 bits	5 bits	5 bits	5 bits	5 bits	6 bits

Here is the meaning of each name of the fields in MIPS instructions:

- op: Basic operation of the instruction, traditionally called the opcode.
- rs: The first register source operand.
- rt: The second register source operand.
- rd: The register destination operand. It gets the result of the operation.
- shamt: Shift amount. (Section 2.6 explains shift instructions and this term; it will not be used until then, and hence the field contains zero in this section.)



op	rs	rt	constant or address
6 bits	5 bits	5 bits	16 bits



Instruction	Format	op	rs	rt	rd	shamt	funct	address
add	R	0	reg	reg	reg	0	32_{ten}	n.a.
sub (subtract)	R	0	reg	reg	reg	0	34_{ten}	n.a.
add immediate	I	8_{ten}	reg	reg	n.a.	n.a.	n.a.	constant
lw (load word)	I	35_{ten}	reg	reg	n.a.	n.a.	n.a.	address
sw (store word)	I	43_{ten}	reg	reg	n.a.	n.a.	n.a.	address

of the operation in the

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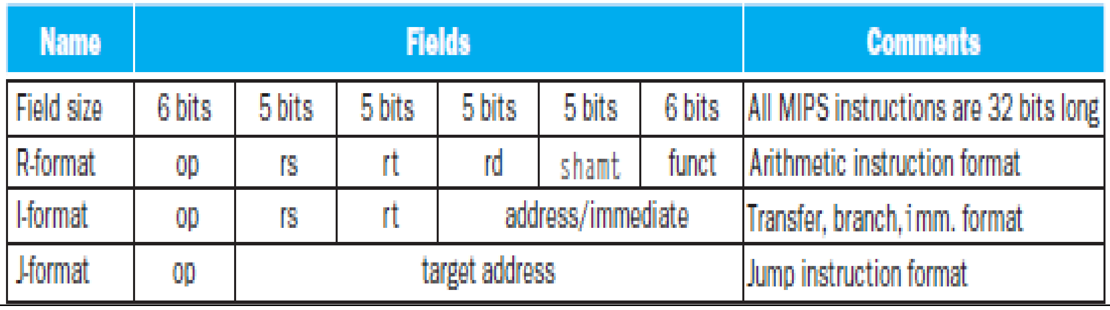
MIPS instruction encoding.

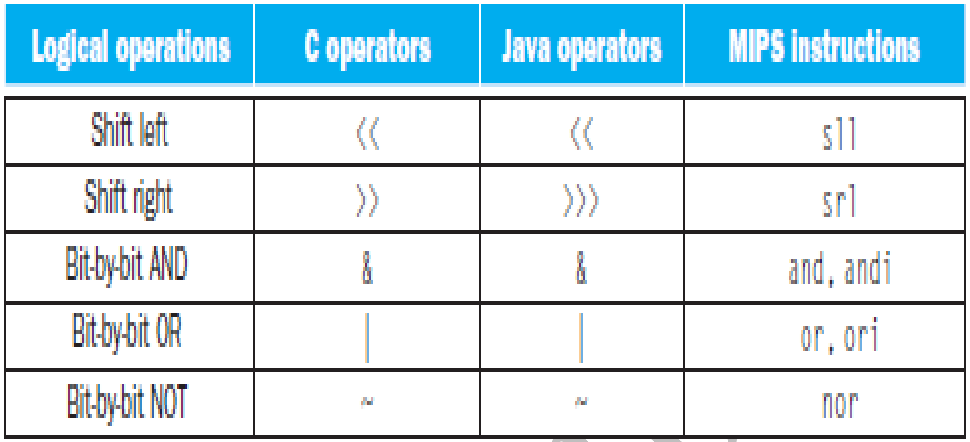


Name	Fields						Comments
Field size	6 bits	5 bits	5 bits	5 bits	5 bits	6 bits	All MIPS instructions are 32 bits long
R-format	op	rs	rt	rd	shamt	funct	Arithmetic instruction format
I-format	op	rs	rt	address/immediate			Transfer, branch, imm. format
J-format	op	target address					Jump instruction format

MIPS instruction formats.

(iii) Logical Operations

- The instructions used for the packing and unpacking of bits into words are called logical operations.
- The first class of such operations is called shift s. They move all the bits in a word to the left or right, filling the emptied bits with 0s. For example, if register $s0 contained



Logical operations	C operators	Java operators	MIPS instructions
Shift left	<<	<<	sll
Shift right	>>	>>>	srl
Bit-by-bit AND	&	&	and, andi
Bit-by-bit OR	|	|	or, ori
Bit-by-bit NOT	~	~	nor

0000 0000 0000 0000 0000 0000 0000 1001two = 9ten and the instruction to shift left by 4 was executed, the new value would be: 0000 0000 0000 0000 0000 0000 1001 0000two = 144ten

- The dual of a shift left is a shift right. The actual name of the two MIPS shift instructions are called shift left logical (sll) and shift right logical (srl).

AND: A logical bit by- bit operation with two operands that calculates a 1 only if there is a 1 in both operands. And $t0,$t1,$t2 # reg $t0 = reg $t1 & reg $t2

OR: A logical bit-by bit operation with two operands that calculates a 1 if there is a 1 in either operand.

or $t0,$t1,$t2 # reg $t0 = reg $t1 | reg $t2

NOT: A logical bit-by bit operation with one operand that inverts the bits; that is, it replaces every 1 with a 0, and every 0 with a 1.

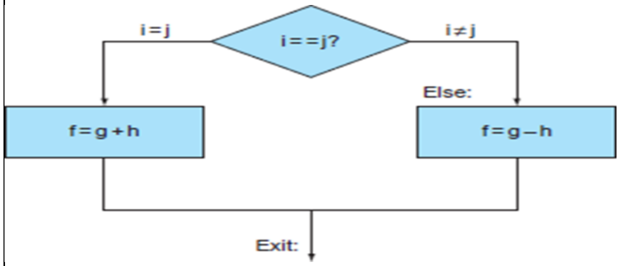
NOR: A logical bit-by bit operation with two operands that calculates the NOT of the OR of the two operands. That is, it calculates a 1 only if there is a 0 in both operands.

Instructions for Making Decisions:

- MIPS assembly language includes two decision-making instructions, similar to an if statement with a go to. The first instruction is

beq register1, register2, L1

- This instruction means go to the statement labeled L1 if the value in register1 equals the value in register2. The mnemonic beq stands for branch if equal.
- The second instruction is bne register1, register2, L1 It means go to the statement labeled L1 if the value in register1 does not equal the value in register2.
- The mnemonic bne stands for branch if not equal. These two instructions are traditionally called conditional branches.

	the compiled MIPS code for this C if statement if (i == j) f = g + h; else f = g – h; is given as bne $s3,$s4,Else # go to Else if i ≠ j conditional branch • An instruction that requires the comparison of two values and that allows for a subsequent transfer of control to a new address in the program based on the outcome of the comparison. **Loops:** • Decisions are important both for choosing between two alternatives—found in ifstatements—and for iterating a computation—found in loops. Eg1: Loop: sll $t1,$s3,2 # Temp reg $t1 = i * 4 Eg 2: j Loop # go to Loop Exit:  **Case/Switch Statement:** • Most programming languages have a case or switch statement that allows the programmer to select one of many alternatives depending on a single value. • Jump address table also called jump table. A table of addresses of alternative instruction sequences.
2	**Explain in detail, the Addressing & Addressing Modes. (15m) (Apr/may 2018) BTL4** **Answer: U-1**Refer notes **Carl hamacher book Pageno:48 (10m)** Immediate addressing, where the operand is a constant within the instruction itself 1. Register addressing, where the operand is a register 2. Base or displacement addressing, where the operand is at the memory location whose address is the sum of a register and a constant in the instruction 3. PC-relative addressing, where the branch address is the sum of the PC and a constant in the instruction 4. Pseudodirect addressing, where the jump address is the 26 bits of the instruction concatenated with the upper bits of the PC. **Diagram(5m)** • Immediate Addressing Mode • Absolute(Direct) Addressing Mode • Indirect Addressing Mode • Register Addressing Mode • Base with index Addressing Mode • Base with index & offset Addressing Mode • Additional Modes(Increment & Decrement Addressing Mode)

UNIT 2- ARITHMETIC FOR COMPUTERS

Addition and Subtraction – Multiplication – Division – Floating Point Representation – Floating Point Operations – Subword Parallelism

PART A

1 **State the principle of operation of a carry look-ahead adder. BTL2**

- The input carry needed by a stage is directly computed from carry signals obtained from all the preceding stages i-1,i-2,…..0, rather than waiting for normal carries to supply slowly from stage to stage.
- An adder that uses this principle is called carry look-ahead adder.

2 **What are the main features of booth's algorithm? BTL1**

- It handles both positive and negative multipliers uniformly.
- It achieves some efficiency in the number of addition required when the multiplier has a few large blocks of 1s.

3 **How can we speed up the multiplication process? BTL3**

There are two techniques to speed up the multiplication process:

- The first technique guarantees that the maximum number of summands that must be added is n/2 for n-bit operands.
- The second technique reduces the time needed to add the summands.

4 **What is bit pair recoding? give an example. BTL1**

- Bit pair recoding halves the maximum number of summands.
- Group the booth-recoded multiplier bits in pairs and observe the following: the pair (+1 -1) is equivalent to the pair (0 +1)that is instead of adding -1 times the multiplicand m at shift position i to +1 the same result is obtained by adding +1

5 **What is the advantage of using booth algorithm? BTL1**

- It handles both positive and negative multiplier uniformly.
- It achieves efficiency in the number of additions required when the multiplier has a few large blocks of 1's.
- The speed gained by skipping 1's depends on the data.

6 **Write the algorithm for restoring division BTL3**

Do the following for n times:

- shift a and q left one binary position.
- subtract m and a and place the answer back in a.
- if the sign of a is 1, set q0 to 0 and add m back to a.

where a- accumulator, m- divisor, q- dividend.

7 **Write the algorithm for non restoring division. BTL3**

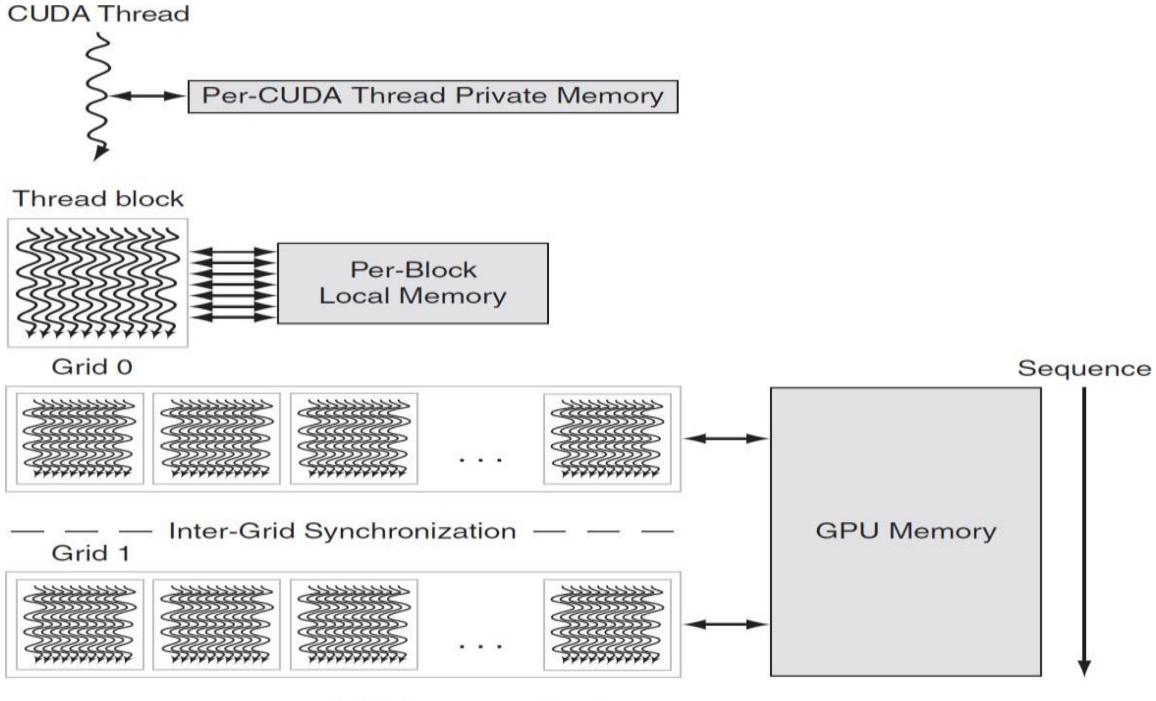
Do the following for n times:

	step 1: do the following for n times: • If the sign of a is 0, shift a and q left one bit position and subtract m from a; otherwise, shift a and q left and add m to a. • Now, if the sign of a is 0, set q0 to 1; otherwise, set q0 to0. step 2: if the sign of a is 1, add m to a.
8	**Explain about the special values in floating point numbers. BTL2** The end values 0 to 255 of the excess-127 exponent e are used to represent special values such as: when e= 0 and the mantissa fraction m is zero the value exacts 0 is represented. when e= 255 and m=0, the value is represented. when e= 0 and m=0, denormal values are represented. when e= 2555 and m=0, the value represented is called not a number.
9	**Write the add/subtract rule for floating point numbers. BTL3** • Choose the number with the smaller exponent and shift its mantissa right a number of steps equal to the difference in exponents. • Set the exponent of the result equal to the larger exponent. • Perform addition/subtraction on the mantissa and determine the sign of the result • Normalize the resulting value, if necessary.
10	**Write the multiply rule for floating point numbers. BTL3** • Add the exponent and subtract 127. • Multiply the mantissa and determine the sign of the result. • Normalize the resulting value , if necessary.
11	**What is the purpose of guard bits used in floating point arithmetic BTL1** Although the mantissa of initial operands are limited to 24 bits, it is important to retain extra bits, called as guard bits
12	**What are generate and propagate function? BTL1** • The generate function is given by Gi=XiYi • The propagate function is given as Pi=Xi+Yi.
13	**What is floating point numbers? BTL1** • In some cases, the binary point is variable and is automatically adjusted as computation proceeds. • In such case, the binary point is said to float and the numbers are called floating point numbers.

14	**In floating point numbers when so you say that an underflow or overflow has occurred? BTL5** • In single precision numbers when an exponent is less than -126 then we say that an underflow has occurred. • In single precision numbers when an exponent is less than +127 then we say that an overflow has occurred.
15	**In floating point numbers when so you say that an underflow or overflow has occurred? BTL5** • In single precision numbers when an exponent is less than -126 then we say that an underflow has occurred. • In single precision numbers when an exponent is less than +127 then we say that an overflow has occurred.
PART B	

1	**Summarize about the sub word parallelism. (13m) BTL2**
	• Since every desktop microprocessor by definition has its own graphical displays, as transistor budgets increased it was inevitable that support would be added for graphics operations.
	• Many graphics systems originally used 8 bits to represent each of the three primary colors plus 8 bits for a location of a pixel. The addition of speakers and microphones for teleconferencing and video games suggested support of sound as well. Audio samples need more than 8 bits of precision, but 16 bits are sufficient.
	• Every microprocessor has special support so that bytes and halfwords take up less space when stored in memory (see Section 2.9), but due to the infrequency of arithmetic operations on these data sizes in typical integer programs, there was little support beyond data transfers. Architects recognized that many graphics and audio applications would perform the same operation on vectors of this data.
	• By partitioning the carry chains within a 128-bit adder, a processor could use parallelism to perform simultaneous operations on short vectors of sixteen 8-bit operands, eight 16-bit operands, four 32-bit operands, or two 64-bit operands. The cost of such partitioned adders was small.
	• Given that the parallelism occurs within a wide word, the extensions are classified as subword parallelism. It is also classified under the more general name of data level parallelism. They have been also called vector or SIMD, for single instruction, multiple data (see Section 6.6). The rising popularity of multimedia applications led to arithmetic instructions that support narrower operations that can easily operate in parallel.
	• For example, ARM added more than 100 instructions in the NEON multimedia instruction extension to support subword parallelism, which can be used either with ARMv7 or ARMv8. It added 256 bytes of new registers for NEON that can be viewed as 32 registers 8 bytes wide or 16 registers 16 bytes wide. NEON supports all the subword data types you can imagine except 64-bit floating point numbers:
	  • 8-bit, 16-bit, 32-bit, and 64-bit signed and unsigned integers
	  • 32-bit floating point numbers

Figure shows the memory structures of an NVIDIA GPU. We call the onchip memory that is local to each multithreaded SIMD processor Local Memory.



GPU Memory structures.

- It is shared by the SIMD Lanes within a multithreaded SIMD processor, but this memory is not shared between multithreaded SIMD processors.
- We call the off -chip DRAM shared by the whole GPU and all thread blocks GPU Memory.
- Rather than rely on large caches to contain the whole working sets of an application, GPUs traditionally use smaller streaming caches and rely on extensive multithreading of threads of SIMD instructions to hide the long latency to DRAM, since their working sets can be hundreds of megabytes.
- Thus, they will not fit in the last level cache of a multicore microprocessor.
- Given the use of hardware multithreading to hide DRAM latency, the chip area used for caches in system processors is spent instead on computing resources and on the large number of registers to hold the state of the many threads of SIMD instructions

2

Explain in detail, the multiplication algorithm, with a neat diagram.(13m) (Apr/may2018)

BTL4

Answer: U-2 Refer notes **carl hamacher book-page no:376**

Explanation:(5m) &Algorithm:(5m)

Step 1: bit=0, shift right C,A &Q

Step 2: bit=1, C,A<-A+B shift right C,A, &Q

Step 3:Check Q0 bit

Diagram:(3m)

3	**Explain in detail, the division algorithm, with a neat diagram. (13m) (Apr/may 2018) BTL4** **Answer: U-2** Refer notes **carl hamacher book-page no:390** **Explanation:(5m) & Algorithm:(5m)** **Step 1: Shift A&Q left 1 binary bit position** **Step 2: Subtract Divisor A<-A-B** **Step 3: Check Sign bit of A & Set Q0** **Diagram:(3m)**
4	**Explain in detail, the flow chart of floating-point multiplication. (13m) BTL4** **Answer: U-2** Refer notes **carl hamacher book-page no:398** **Explanation:(5m) &Algorithm:(5m),** **Step 1: If either multiplicand or multiplier is 0, result will be 0** **Step 2: Add the exponents & subtract bias.** **Step 3: Multiply the mantissas & determine the sign of the result** **Step 4: Result must be normalized** **Diagram:(3m)**
PART C	
1	**Explain in detail, the block diagram of an arithmetic unit for floating-point addition & subtraction. (15m) (Apr/may 2018) BTL4** **Answer: U-2** Refer notes **carl hamacher book-page no:393** **Explanation & Algorithm:(10m),** **Step 1: Change the sign of Q for subtraction & check zero.** **Step 2: Align mantissa** **Step 3: Addition** **Step 4: Normalization** **Diagram:(5m)**
2	**Explain in detail, the addition and subtraction operation. (15m) BTL4** **Answer: U-2** Refer notes **Explanation:(10m),** • **Half adder** • **Full adder** • **Subtractor** • **ALU** • **Examples** **Diagram:(5m)**

UNIT-3 PROCESSOR AND CONTROL UNIT

A Basic MIPS implementation – Building a Datapath – Control Implementation Scheme – Pipelining – Pipelined datapath and control – Handling Data Hazards & Control Hazards – Exceptions.

PART A

1 **Define MIPS. BTL1**

MIPS: one alternative to time as the metric is MIPS (million instruction per second)
MIPS=instruction count/ (execution time x1000000).
This MIPS measurement is also called native MIPS to distinguish it from some alternative definitions of MIPS.

2 **Define MIPS rate. BTL1**

The rate at which the instructions are executed at a given time

3 **Define Pipelining. BTL1**

Pipelining is a technique of decomposing a sequential process into sub operations with each sub process being executed in a special dedicated segment that operates concurrently with all other segments.

4 **Define Instruction pipeline. BTL1**

- The transfer of instructions through various stages of the CPU instruction cycle, including fetch opcode, decode opcode, compute operand addresses.
- Fetch operands, execute instructions and store results. this amounts to realizing most (or) all of the CPU in the form of multifunction pipeline called an instruction pipelining.

5 **What are Hazards? BTL1**

- A hazard is also called as hurdle.
- The situation that prevents the next instruction in the instruction stream from executing during its designated clock cycle. stall is introduced by hazard. (ideal stage).

6 **State different types of hazards that can occur in pipeline. BTL1&2**

The types of hazards that can occur in the pipelining were,

- Data hazards.
- Instruction hazards.
- Structural hazards.

7 **Define Data hazards. BTL1**

A data hazard is any condition in which either the source or the destination operands of an instruction are not available at the time expected in pipeline, as a result some operation has to be delayed, and the pipeline stalls.

8 **Define Instruction hazards. BTL1**

- The pipeline may be stalled because of a delay in the availability of an instruction.
- For example, this may be a result of miss in cache, requiring the instruction to be fetched from the main memory. such hazards are called as instruction hazards or control hazards

9 **Define Structural hazards. BTL1**

- The structural hazards is the situation when two instructions require the use of a given hardware resource at the same time.
- The most common case in which this hazard may arise is access to memory.

10	**How data hazard can be prevented in pipelining? BTL5** Data hazards in the instruction pipelining can prevented by the following techniques. • Operand forwarding • Software approach
11	**How addressing modes affect the instruction pipelining? BTL5** • Degradation of performance is an instruction pipeline may be due to address dependency where operand address cannot be calculated without available information needed by addressing mode. • For e.g. an instruction with register indirect mode cannot proceed to fetch the operand if the previous instructions is loading the address into the register. hence operand access is delayed degrading the performance of pipeline.
12	**How compiler is used in pipelining? BTL5** • A compiler translates a high level language program into a sequence of machine instructions. • To reduce n, we need to have suitable machine instruction set and a compiler that makes good use of it. • An optimizing compiler takes advantages of various features of the target processor to reduce the product n*s, which is the total number of clock cycles needed to execute a program. • The number of cycles is dependent not only on the choice of instruction, but also on the order in which they appear in the program. • The compiler may rearrange program instruction to achieve better performance of course, such changes must not affect of the result of the computation.
13	**List out the methods used to improve system performance. BTL1** The methods used to improve system performance are • Processor clock • Basic performance equation • Pipelining • Clock rate • Instruction set • Compiler
14	**How the interrupt is handled during exception? BTL5** • CPU identifies source of interrupt

	- CPU obtains memory address of interrupt handles - PC and other CPU status information are saved - PC is loaded with address of interrupt handler and handling program to handle it.
15	**What is branch delay slot? BTL1** The location containing an instruction that may be fetched and then discarded because of the branch is called branch delay slot.
16	**List out the advantages of pipelining Apr/May 2016 BTL1** 1. The Instruction cycle time of the processor is reduced increasing, instruction throughput. **2.** Increase in pipeline stages increase number of instructions that can be processed at once which reduces delay between completed instructions.
17	**Define Exception. Apr/May 2016 BTL1** Exceptions are internally generated unscheduled events that disrupt program execution & they are used to detect overflow. On the other hand, interrupt comes from outside of the processor.
18	**Web server is to be enhanced with a new CPU which is 10 times faster on computation than old CPU The original CPU spent 40% its time processing and 60% of its time waiting for I/O. What will be the overall speedup? Nov/Dec 2018 BTL1** Overall speedup= $\frac{0.4*10+0.6}{0.4+0.6}$ = 4.6
19	**List the types of Exception BTL1** Precise Exception- partially executed instructions are discarded. Imprecise Exception- instructions executed to completion
20	**List out the common steps to implement any type of instruction Nov/Dec 2018 BTL1** Fetch & Decode
	PART B
1	**Explain in detail, the basic implementation of MIPS. (13m) BTL4** **Answer: U-3** refer notes pageno:3 Explanation:8m The Basic MIPS Implementation An Overview of the Implementation Diagram:5m
2	**Explain in detail, the steps involved in building a data path unit. (13m) (Apr/May 2018) BTL4** **Answer: U-3 Refer** Notes pageno:1 Explanation:8m

	• Building a datapath • Types of Elements in the Datapath • Datapath Segment for ALU, LW & SW, Br. Instructions Diagram:5m
3	**Explain in detail about the operation of datapath & Control Nov/Dec2017 BTL4** **Building a datapath/Operation (7)** • Building a datapath • Types of Elements in the Datapath • Datapath Segment for ALU, LW & SW, Br. Instructions • Diagram **Control (6)** • Control Implementation scheme • ALU Control • Designing the main control unit • Format for R, L&S, Br. Instructions • Important observations about this Ins. Format • Table/Cmp- Functions of Seven Single bit control Lines • Diagram
4	**Explain in detail, the design of the main control unit. (13m) BTL4** **Answer: U-3** Refer Notes Explanation(8m) • Control Implementation scheme • ALU Control • Designing the main control unit • Format for R, L&S, Br. Instructions • Important observations about this Ins. Format • Table/Cmp- Functions of Seven Single bit control Lines Diagram:(5m)
5	**Explain in detail, the pipelined data path and control. (13m) (Apr/May 2018) BTL5** **Answer: U-3** Refer Notes **carl hamacher book-page no:479** **Explanation(8m)** • Implementation of 2 stage instruction pipelining • Organization of CPU with 4 stage Instruction pipelining • Implementation of MIPS Instruction Pipeline **The Pipelined Control & datapath(5m)** • Instruction fetch: • Instruction decode and register file read:

	• Execute or address calculation • Memory access: • Write-back: Diagram
6	**Discuss the modified datapath to accommodate pipelined executions with a diagram Apr/ May 2017 (13m) BTL2** **Explanation (8m)** • Data Hazard • Operand Forwarding **Diagram (5m)**
7	(i)**Discuss the hazards caused by unconditional branching statements (6m) Apr/ May 2017 BTL2** Explanation (3) Control Hazards Unconditional Branching- Effect of Branching in 2- stage pipelining Branch penalty Diagram(3) (ii**) Describe operand forwarding in a pipeline processor with a diagram (6m)** Explanation (4) • Data Hazard • Operand Forwarding Diagram(3m)
8	**Explain in detail, the instruction hazards. (13m) BTL4** **Answer**: U-3 Refer Notes, **Carl hamacher book pageno:465** **Explanation(10m)** **Diagram(3m)**
9	**Why is branch prediction algorithm needed? Differentiate between the static & dynamic techniques Nov/dec 2016 BTL2&3** **Explanation (10)** • Branch Prediction • Branch prediction strategies • Difference between the static & dynamic branch strategy • A typical state diagram used in dynamic branch prediction **Diagram (3)**
10	**Explain in detail how exceptions are handled in MIPS Architecture Apr/May 2015 BTL4** **Explanation (11)** • Example of Except & Interrupt(2m) • types of Exception • Response to an Exception • Methods used to communicate the reason for an Exception • Exceptions & Interuppts are classified into two types • Precise • Imprecise
PART C	
1.	**Explain the overview of pipelining. (15m) BTL4** **Answer: u-3** Refer Notes **carl hamacher book-page no:454** Explanation(10m) Diagram(5m) An Overview of Pipelining:

Designing Instruction Sets for Pipelining:
Pipeline Hazards:

2. **(i) Explain in detail, the pipeline hazards. (9m) BTL4**

Answer : U-3Refer notes
Explanation(7m)
Pipeline Hazards
Structural Hazards
Data Hazards
Control Hazards
Diagram(2m)

(ii) **A pipelined processor uses delayed branch technique. Recommend any one of the following possibilities for the design of the processor. In the 1st possibility, the processor has a 4- stage pipeline and one delay slots. In the 2nd possibility, it has a 6- stage pipeline & two delay slots. Compare the performance of these two alternatives, taking only the branch penalty into account. Assume that 20% of the instructions are branch instructions and that an optimizing compiler has an 80% success rate in filling in the single delay slot. For the Second alternative, the compiler is able to fill the second slot 25% of the time.** Apr/May 2017 BTL4

Answer: Given 20% of ins. Are br. Ins. & compiler can fill 80% of 1st delay slot & 25% of 2nd delay slot.

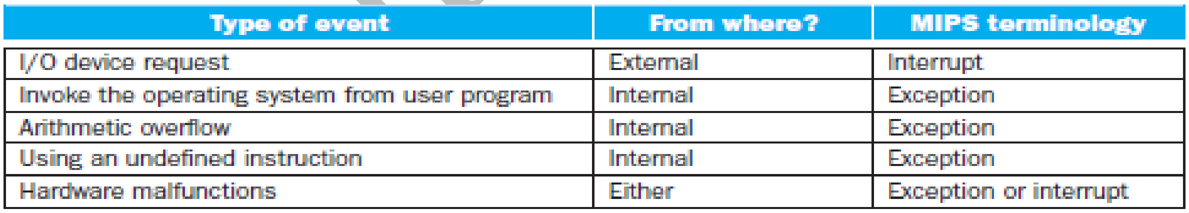
Throughput improvement due to pipeline is n, where n is the number of pipeline stages.

Stage	**No. of cycles needed to execute one instruction**	**Throughput**
4-Stage	1+0.2-0.8*0.2=1.04	4/1.04 = 3.85
6-Stage	1+(0.2*2)-0.8*0.2-0.25*0.2=1.19	6/1.19 = 5.04

3. **Summarize about the exceptions. (15m) (Apr/May 2018) BTL2**

Answer: U-3 Refer Notes, **carl hamacher book-page no:218**

Explanation (10m)



Type of event	From where?	MIPS terminology
I/O device request	External	Interrupt
Invoke the operating system from user program	Internal	Exception
Arithmetic overflow	Internal	Exception
Using an undefined instruction	Internal	Exception
Hardware malfunctions	Either	Exception or interrupt

Example of Except & Interrupt(2m)

- types of Exception
- Response to an Exception
- Methods used to communicate the reason for an Exception
- Exceptions & Interuppts are classified into two types
- Precise
- Imprecise

Diagram(3m)

4. **Interpret a processor has 5 individual stages, namely. IF, ID, EX, MEM, WB and their latencies are 250ps, 350ps, 150ps, 300ps & 200ps respectively. The frequency of the instructions executed by the processor are as follows: ALU: 40%, branch 25%, Load 20% and store 15%. What is the clock cycle time in a pipelined & non-pipelined processor? If you can split one stage of the pipelined datapath into two new stores,**

each with half the latency of the original stage, which stage would you split & what is the new clock cycle time of the processor? Assuming there are no stalls or hazards, what is the utilization of the write-register port of the "Registers" unit? Nov/Dec 2018 BTL3

Answer

(a) **Clock cycle tome in a pipelined processor=350ps**
Clock cycle time in non-pipelined processor= 250+350+150+300+200=1250ps

(b) **We have to split one stage of the pipelined datapath which has a maximum latency i.e, ID**
After splitting ID stage with latencies ID1=175ps
ID2=175ps
We have new clock cycle time of the processor equal to 300ps

(c) **Assuming there are no stalls or hazards, the utilization of the**
data memory= 20% to 15%=35%

(d) **Assuming there are no stalls or hazards, the utilization of the write reg. port of the reg. Unit** = 40%+25% = 65%

5 **Summarize the following sequence of instructions are executed in the basic 5- stage pipelined processor Apr/May 2018 BTL3/4 (14m)**

OR r1, r2, r3

OR r2, r1, r4

OR r1, r1, r2

(i) **Indicate dependences & their type**

Answer:

RAW- dependency in r1 between Instruction 1,2 & 3

RAW- dependency in r2 between Instruction 2 & 3

WAR- in r2 from Instructions 1 to 2

WAR- in r1 from Instructions 2 to 3

WAR- in r1 from Instructions 1 to 3

(ii) **Assume there is no forwarding in this pipelined processor. Indicate hazards & add NOP instructions to eliminate them.**

Answer:

No hazards form WAR, WAW, Since there are 5 stages RAW cause data Hazards

OR r1, r2, r3
NOP
NOP
OR r2, r1, r4
NOP
NOP
OR r1, r1, r2

(iii) **Assume there is full forwarding. Indicate hazards & add NOP instructions to eliminate**

	them. **Answer:** In full forwarding the data hazards above are eliminated, thus there is no need for NOP instructions.
7	**Explain about the Parallelism via Instructions. (15m) BTL4** **Answer: U-3** Refer Notes Pageno:11 **Explanation(13m)** ILP Implementing a Multiple Issue Processor Speculation Static Multiple Issue Dynamic Multiple Issue ➢ True Data dependency ➢ Procedural Dependency ➢ Resource Conflict ➢ Output dependency ➢ Antidependency Recovery mechanism Instruction- Issue Policy ➢ In-order issue with In-order completion ➢ In-order issue with Out-order completion ➢ Out-order issue with Out-order completion Register Renaming Branch Prediction Diagram(2m)

UNIT 4- PARALLELISM

Parallel processing architectures and challenges, Flynn's Classification, Hardware multithreading, Multicore and shared memory multiprocessors, Introduction to Graphics Processing Units, Clusters and Warehouse scale computers – Other Message passing Multiprocessors

PART A

1	**What is instruction level parallelism? BTL1** Pipelining is used to overlap the execution of instructions and improve performance. this potential overlap among instructions is called instruction level parallelism (ILP).
2	**List various types of dependences in ILP. BTL1** • Data dependences • Name dependences • Control dependences
3	**What is Multithreading? BTL1** Multithreading allows multiple threads to share the functional units of a single processor in an overlapping fashion.to permit this sharing, the processor must duplicate the independent state of each thread.
4	**What are multiprocessors? mention the categories of multiprocessors? BTL1** Multiprocessor are used to increase performance and improve availability. the different categories are SISD, SIMD, MISD, MIMD.
5	**What are two main approaches to multithreading? BTL1** • fine-grained multithreading • coarse-grained multithreading
6	**What is the need to use multiprocessors? BTL2** • Microprocessors as the fastest CPUs collecting several much easier than redesigning • Complexity of current microprocessors do we have enough ideas to sustain 1.5x/yr? can we deliver such complexity on schedule? • Slow (but steady) improvement in parallel software (scientific apps, databases, os) • Emergence of embedded and server markets driving microprocessors in addition to desktops embedded functional parallelism, producer/consumer model server figure of merit is tasks per hour vs. latency
7	**Write the software implications of a multicore processor? BTL2** • Multi-core systems will deliver benefits to all software, but especially multi-threaded programs. • All code that supports the technology or multiple processors, for example, will benefit automatically from multicore processors, without need for modification. most server-side enterprise packages and many desktop productivity tools fall into this category
8	**Define parallel processing. BTL1** Processing data concurrently is known as parallel processing
9	**Define multiprocessor system. BTL1** A computer system with atleast two processor is called multiprocessor system
10	**Define parallel processing program. BTL1** A single program that runs on multiple processors simultaneously
11	**What is cluster? BTL1** A set of computers connected over a local area network that function as single large multiprocessor is

	called cluster
12	**What is multicore? BTL1** A multicore is an architectural design that places multiple processors on a single computer chip to enhance performance and allow simultaneous process of multiple tasks more efficiently. Each processor is called core
13	**List the Flynn's Classification BTL1 Dec2014** SISD SIMD MISD MIMD
13	**Differentiate between Strong Scaling & weak Scaling BTL2 Dec-17** Strong scaling: Speedup achieved on a multiprocessor without increasing the size of the problem. Weak Scaling: Speedup achieved on a multiprocessor while increasing the size of the problem proportionally to the increase in the number of processors.
14	**Compare UMA and NUMA multiprocessor BTL2 Dec-15** **UMA:** A multiprocessor in which latency to any word in main memory is about the same no matter which processor requests the access. **NUMA:** A type of single address space multiprocessor in which some memory accesses are much faster than others depending on which processor asks for which word
15	**What is Fine grained multithreading? BTL1 May-16** A version of hardware multithreading that suggests switching between threads after every instruction is called fine-grained multithreading
16	**Distinguish implicit multithreading and explicit multithreading BTL2 May-17** Implicit multithreading refers to the concurrent execution of multiple threads extracted from a single sequential program. Explicit Multithreading refers to the concurrent execution execution of instructions from different explicit threads, either by interleaving instructions from different threads on shared pipelines or by parallel execution on parallel pipelines
17	**State the Amdahl's law? BTL1 Dec-14** It states that the performance improvement to be gained from using some faster mode of execution is limited by the fraction of the time the faster mode can be used
18	**What is SaaS(Software as a Service)** Saas is a software that runs at a remote site and made available over the internet typically via a Web interface to customers. SaaS customers are charged based on use versus on ownership.
19	**Protein string matching code has 4 days execution time on current machine doing integer instructions in 20% of time, doing I/O in 35% of time and other operations in the remaining time.**

Which is better tradeoff among the following two proposals? First: Compiler optimization that reduces number of integer instructions by 25%(assume each integer instruction takes the same amount of time); Second: Hardware optimization that reduces the latency of each I/O operations from 6µs to 5µs. BTL2 May-18

Solution:

If we can speed up X of the program by S times, Amdahl's law gives the total speedup, $S_{tot.}$

S_{tot}=1/(X/S+(1-X)

First case: Speed integer instruction time

X=0.2

S=1/(1-0.25)=1.33

S_{INT}=1/[(0.2/1.33)+(1-0.2)]

= 1.052

Second case: Speedup I/O operation time.

X=0.35

S=**6µs/5µs**

= 1.2

S_{IO}=1/[(0.35/1.2)+(1-0.35)]

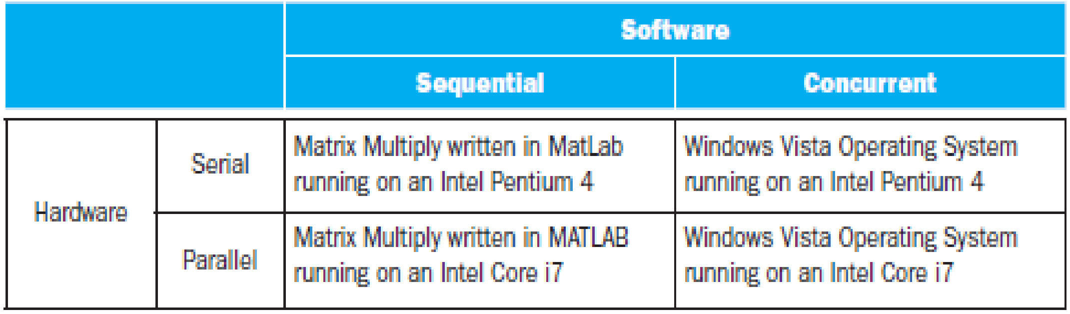
= 1.062

Thus, speeding up I/O operations is done.

PART B

1 **Explain the challenges in parallel processing. (13m) (Apr/May 2018) BTL4**

- The tall challenge facing industry is to create hardware and software that will make it easy to write correct parallel processing programs that will execute efficiently in performance and energy as number of cores per chip scales.
- Only challenge of parallel revolution is figuring out how to make naturally sequential software have high performance on parallel hardware, but it is also to make concurrent programs have high performance on multiprocessors as number of processors increases.
- The difficulty with parallelism is not hardware; it is that too few important application programs have been rewritten to complete tasks sooner on multiprocessors.
- It is difficult to write software that uses multiple processors to complete one task faster, and problem gets worse as number of processors increases.
- The first reason is that you must get better performance or better energy efficiency from a parallel processing program on a multiprocessor; why is it difficult to write parallel processing programs that are fast, especially as number of processors increases



		Software	
		Sequential	Concurrent
Hardware	Serial	Matrix Multiply written in MatLab running on an Intel Pentium 4	Windows Vista Operating System running on an Intel Pentium 4
	Parallel	Matrix Multiply written in MATLAB running on an Intel Core i7	Windows Vista Operating System running on an Intel Core i7

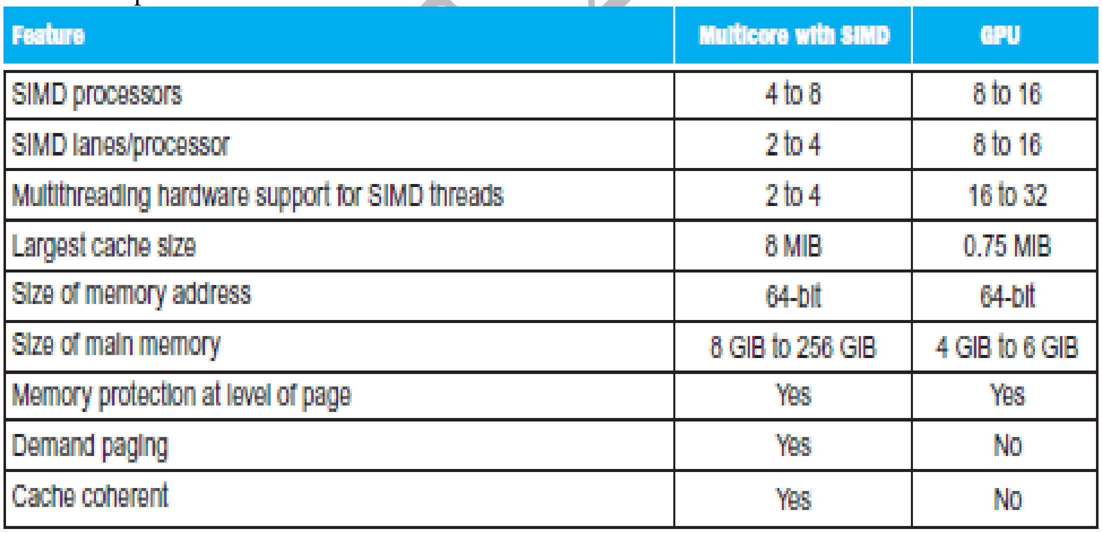
- For both analogy and parallel programming, challenges include scheduling, partitioning work into parallel pieces, balancing load evenly between workers, time to synchronize, and overhead for communication between parties.
- The challenge is stiffer with more reporters for a newspaper story and with more processors for parallel programming.
- Another obstacle, namely Amdahl's Law. It reminds us that even small parts of a program

	must be parallelized if program is to make good use of many cores.Speed-up Challenge: • Suppose you want to achieve a speed-up of 90 times faster with100 processors. • What percentage of original computation can be sequential? Amdahl's Law in terms of speed-up versus original execution time: $\text{Speed-up} = \dfrac{\text{Execution time before}}{(\text{Execution time before} - \text{Execution time affected}) + \dfrac{\text{Execution time affected}}{\text{Amount of improvement}}}$ 0.1% **Speed-up Challenge: Balancing Load** $\text{Speed-up} = \dfrac{1}{(1 - \text{Fraction time affected}) + \dfrac{\text{Fraction time affected}}{\text{Amount of improvement}}}$ • Example demonstrates importance of balancing load, for just a single processor with twice load of the others cuts speed-up by a third, and five times load on just one processor reduces speed-up by almost a factor of three.
2	**Explain in detail, hardware multithreading unit. (13m) (Apr/May 2018) BTL4** **Answer: U-5** Refer Notes Pageno:5 **Explanation(10m)** • Interleaved • Blocked • Simultaneous(SMT) • Chip processing • Scalar • Superscalar • VLSW **Diagram(3m)**
3	**Summarize about the Introduction to Graphics Processing Units (GPU) (13m) BTL2** • The original justification for adding SIMD instructions to existing architectures was that many microprocessors were connected to graphics displays in PCs and workstations, so an increasing fraction of processing time was used for graphics. • As Moore's Law increased number of transistors available to microprocessors, it therefore made sense to improve graphics processing. • A major driving force for improving graphics processing was computer game industry, both on PCs and in dedicated game consoles such as Sony PlayStation. • The rapidly growing game market encouraged many companies to make increasing investments in developing faster graphics hardware, and positive feedback loop led graphics processing to improve at a faster rate than general-purpose processing in mainstream microprocessors. • Given that graphics and game community had different goals than microprocessor development community, it evolved its own style of processing and terminology. • As graphics processors increased in power, they earned name Graphics Processing Units or GPUs to distinguish themselves from CPUs. For a few hundred dollars, anyone can buy a GPU today with hundreds of parallel floating-point units, which makes high-performance computing more accessible. • The interest in GPU computing blossomed when potential was combined with a

programming language that made GPUs easier to program. Hence, many programmers of scientific and multimedia applications today are pondering whether to use GPUs or CPUs.

Here are some of key characteristics as to how GPUs vary from CPUs:

- GPUs are accelerators that supplement a CPU, so y do not need be able to perform all tasks of a CPU.
- This role allows m to dedicate all their resources to graphics. It's fine for GPUs to perform some tasks poorly or not at all, given that in a system with both a CPU and a GPU, CPU can do m if needed.
- The GPU problems sizes are typically hundreds of megabytes to gigabytes, but not hundreds of gigabytes to terabytes. These differences led to different styles of architecture:
- Perhaps biggest difference is that GPUs do not rely on multilevel caches to overcome long latency to memory, as do CPUs.
- Instead, GPUs rely on hardware multithreading (Section 6.4) to hide latency to memory. That is, between time of a memory request and time that data arrives, GPU executes hundreds or thousands of threads that are independent of that request.
- The GPU memory is thus oriented toward bandwidth rather than latency. There are even special graphics DRAM chips for GPUs that are wider and have higher bandwidth than DRAM chips for CPUs.
- In addition, GPU memories have traditionally had smaller main memories than conventional microprocessors. In 2013, GPUs typically have 4 to 6 GiB or less, while CPUs have 32 to 256 GiB.
- Finally, keep in mind that for general-purpose computation, you must include time to transfer data between CPU memory and GPU memory, since GPU is a coprocessor.
- Given reliance on many threads to deliver good memory bandwidth, GPUs can accommodate many parallel processors (MIMD) as well as many threads.
- Hence, each GPU processor is more highly multithreaded than a typical CPU, plus y have more processors.



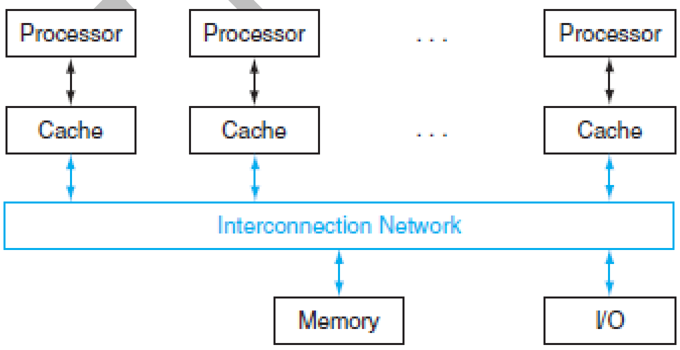
Feature	Multicore with SIMD	GPU
SIMD processors	4 to 8	8 to 16
SIMD lanes/processor	2 to 4	8 to 16
Multithreading hardware support for SIMD threads	2 to 4	16 to 32
Largest cache size	8 MiB	0.75 MiB
Size of memory address	64-bit	64-bit
Size of main memory	8 GiB to 256 GiB	4 GiB to 6 GiB
Memory protection at level of page	Yes	Yes
Demand paging	Yes	No
Cache coherent	Yes	No

- Similarities and differences between multicore with Multimedia SIMD extensions and recent GPUs.
- At a high level, multicore computers with SIMD instruction extensions do share similarities with GPUs.
- Both are MIMDs whose processors use multiple SIMD lanes, although GPUs have more processors and many more lanes.
- Both use hardware multithreading to improve processor utilization, although GPUs have hardware support for many more threads.
- Both use caches, although GPUs use smaller streaming caches and multicore

	computers use large multilevel caches that try to contain whole working sets completely. • Both use a 64-bit address space, although physical main memory is much smaller in GPUs. While GPUs support memory protection at page level, y do not yet support demand paging. • SIMD processors are also similar to vector processors. • The multiple SIMD processors in GPUs act as independent MIMD cores, just as many vector computers have multiple vector processors.
4.	**Explain in detail about the multicore & shared memory multiprocessors with a neat diagram(13m) BTL4** **Answer:** Refer notes • Introduction • Type1, Type2, Type3 • Diagram • Shared memory • UMA • NUMA • Diagram
5	**Describe about the Flynn's classification with a neat diagram (13m) BTL2** **Answer:** Refer notes Explanation- 9m Diagram – 4m • Introduction • SISD • SIMD • MISD • MIMD
	PART C
1	**Explain in detail, the GPA with a neat diagram. (15m) BTL4** **Answer: U-5** refer notes Explanation (12m) • Introduction • GPU vs CPU • Connection between CPU & GPU • GPU Architecture • An Introduction to the NVIDIA GPU Architecture Diagram (3m)
2	**Explain in detail about the introduction to Multiprocessor network topologies. (15m) BTL1** **Answer: Carl Hamacher book pageno:624** Explanation(10m) • Time shared Bus or common bus • Crossbar Switch • Multiport memory • Multistage Switching networks • Hypercube Interconnection Diagram(5m)

3 **Explain in detail, the shared memory multiprocessor, with a neat diagram. (15m) (Apr/May 2018) BTL4**

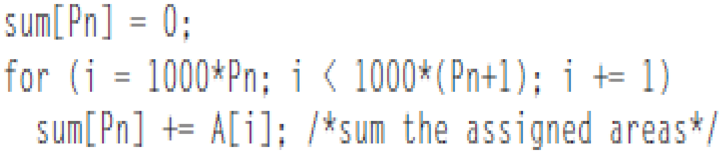
- Shared memory multiprocessor (SMP) is one that offers programmer a single physical address space across all processors-which is nearly always case for multicore chips
- Although a more accurate term would have been shared-address multiprocessor. Processors communicate through shared variables in memory, with all processors capable of accessing any memory location via loads and stores.
- Note that such systems can still run independent jobs in their own virtual address spaces, even if y all share a physical address space.
- Single address space multiprocessors come in two styles. In first style, latency to a word in memory does not depend on which processor asks for it.
- Such machines are called uniform memory access (UMA) multiprocessors. In second style, some memory accesses are much faster than others, depending on which processor asks for which word, typically because main memory is divided and attached to different microprocessors or to different memory controllers on same chip.
- Such machines are called non uniform memory access (NUMA) multiprocessors. As you might expect, programming challenges are harder for a NUMA multiprocessor than for a UMA multiprocessor, but NUMA machines can scale to larger sizes and NUMAs can have lower latency to nearby memory.
- As processors operating in parallel will normally share data, you also need to coordinate when operating on shared data; otherwise, one processor could start working on data before another is finished with it.
- This coordination is called synchronization, When sharing is supported with a single address space, there must be a separate mechanism for synchronization. One approach uses a lock for a shared variable.
- Only one processor at a time can acquire lock, and or processors interested in shared data must wait until original processor unlocks variable.



Classic organization of a shared memory multiprocessor

- OpenMP An API for shared memory multiprocessing in C, C++, or Fortran that runs on UNIX and Microsoft platforms. It includes compiler directives, a library, and runtime directives.
- A Simple Parallel Processing Program for a Shared Address Space Suppose we want to sum 64,000 numbers on a shared memory multiprocessor computer with uniform memory access time. Let's assume we have 64 processors.
- The first step is to ensure a balanced load per processor, so we split set of numbers into subsets of same size. We do not allocate subsets to a different memory space, since re is a single memory space for machine; we just give different starting addresses to each processor.

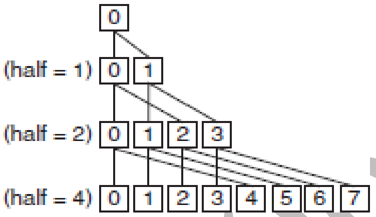
- Pn is number that identifies processor, between 0 and 63. All processors start program by running a loop that sums their subset of numbers:



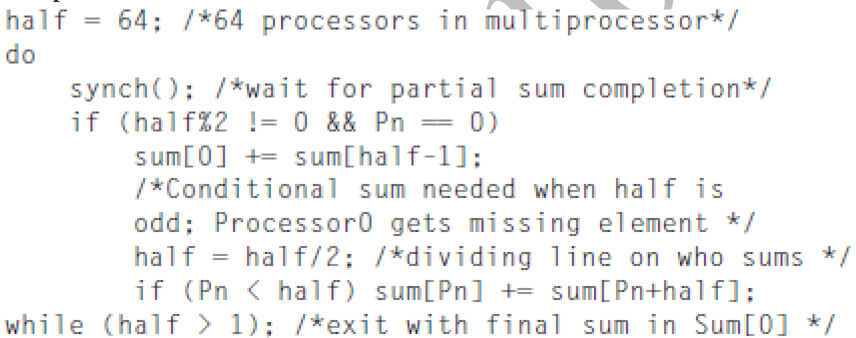
```
sum[Pn] = 0;
for (i = 1000*Pn; i < 1000*(Pn+1); i += 1)
  sum[Pn] += A[i]; /*sum the assigned areas*/
```

- The next step is to add se 64 partial sums.
- This step is called a reduction, where we divide to conquer.
- Half of processors add pairs of partial sums, and n a quarter add pairs of new partial sums,

and so on until we have single, final sum.



- Each processor to have its own version of loop counter variable i, so we must indicate that it is a private variable. Here is the code,



```
half = 64; /*64 processors in multiprocessor*/
do
    synch(); /*wait for partial sum completion*/
    if (half%2 != 0 && Pn == 0)
        sum[0] += sum[half-1];
        /*Conditional sum needed when half is
        odd; Processor0 gets missing element */
        half = half/2; /*dividing line on who sums */
        if (Pn < half) sum[Pn] += sum[Pn+half];
while (half > 1); /*exit with final sum in Sum[0] */
```

- Some writers repurposed acronym SMP to mean symmetric multiprocessor, to indicate that latency from processor to memory was about same for all processors

UNIT 5- MEMORY AND I/O SYSTEM

Memory Hierarchy – memory technologies – cache memory – measuring and improving cache performance – virtual memory, TLB's – Accessing I/O Devices – Interrupts – Direct Memory Access – Bus structure – Bus operation – Arbitration – Interface circuits – USB.

PART A

1	**Define memory access time. BTL1** • The time that elapses between the initiation of an operation and completion of that operation, for example, the time between the read and the MFC signals. • This is referred to as memory access time.
2	**Define memory cycle time. BTL1** • The minimum time delay required between the initiations of two successive memory operations, for example, the time between two successive read operations.
3	**Define Static memories. BTL1** Memories that consist of circuits capable of retaining the state as long as power is applied are known as static memories.
4	**What is locality of reference? What are its types? May 14 BTL1** • Many instructions in localized area of the program are executed repeatedly during some time period and the remainder of the program is accessed relatively infrequently. • This is referred as locality of reference. • Two types they are, Temporal & Spatial Locality
5	**Explain virtual memory technique. BTL2** Techniques that automatically move program and data blocks into the physical memory, when they are required for execution are called virtual memory technique
6	**What are virtual and logical addresses? BTL1** The binary addresses that the processor issues for either instruction or data are called virtual or logical addresses.
7	**Define translation buffer. BTL1** • Most commercial virtual memory systems incorporate a mechanism that can avoid the bulk of the main memory access called for by the virtual to physical addresses translation buffer. • This may be done with a cache memory called a translation buffer.
8	**What is optical memory? BTL1** • Optical or light based techniques for data storage, such memories usually employ optical

	disk which resemble magnetic disk in that they store binary information in concentric tracks on an electromechanically rotated disks. • The information is read as or written optically, however with a laser replacing the read write arm of a magnetic disk drive. optical memory offer high storage capacities but their access rate is are generally less than those of magnetic disk
9	**What are static and dynamic memories? BTL1** static memory are memories which require periodic no refreshing. dynamic memories are memories, which require periodic refreshing.
10	**What are the components of memory management unit? BTL1** • A facility for dynamic storage relocation that maps logical memory references into physical memory addresses. • A provision for sharing common programs stored in memory by different users .
11	**What are the multimedia applications which use caches? BTL2** Some multimedia application areas where cache is extensively used are • Multimedia entertainment • Education • Office systems • Audio and video mail
12	**What do you mean associative mapping technique? BTL1** • The tag of an address received from the CPU is compared to the tag bits of each block of the cache to see • If the desired block is present. this is called associative mapping technique.
13	**What is an i/o channel? BTL1** An i/o channel is actually a special purpose processor, also called peripheral processor.the main processor initiates a transfer by passing the required information in the input output channel. the channel then takes over and controls the actual transfer of data.
14	**Why program controlled i/o is unsuitable for high-speed data transfer? BTL5** • In program controlled i/o considerable overhead is incurred, because several program instruction have to be executed for each data word transferred between the external devices and main memory. • Many high speed peripheral; devices have a synchronous modes of operation, that is data transfer are controlled by a clock of fixed frequency, independent of the CPU.
15	**what is the function of i/o interface? BTL1 Dec-06/07 May-07/09** The function is to coordinate the transfer of data between the CPU and external devices. **What is the necessity of an interface?** Handle data transfer between much slower peripherals & CPU or memory Match signal levels of different I/O protocols with computer signal levels

	Provides necessary driving capabilities – sinking & sourcing currents
16	**What is the need to implement memory as a hierarchy May 15 BTL1** Ideally, computer memory should be fast, large and inexpensive. Unfortunately, it is impossible to meet all the three of these requirements using one type of memory.
17	**Name some of the IO devices. BTL1** • Video terminals • Video displays • Alphanumeric displays • Graphics displays • Flat panel displays • Printers • Plotters
18	**What is an interrupt?** An interrupt is an event that causes the execution of one program to be suspended and another program to be executed
19	**What is the difference between Serial interface & Parallel interface Dec15 BTL2** **Serial Interface** It transfer data one bit at a time Lower data transfer rate. Needs less number of wires to connect devices in the system Well suited for long distances, because fewer wires are used as compared to a parallel bus. **Parallel Interface** It can transmit more than one data bit at a time. Faster data transfer rate. Needs more number of wires to connect devices in the system. The interconnection penalty increases as distances increase.
20	**What is DMA? Or What is DMA operation? State its advantages or why we need DMA Dec 16/May 15/Dec 17 BTL1** A Special control unit may be provided to enable transfer a block of data directly between an external device and memory without contiguous intervention by the CPU. This approach is called DMA. The data transfer using such approach is called DMA operation. Two main Advantages of DMA operation are: The data transfer is very fast. Processor is not involved in the data transfer operation and hence it is free to execute other tasks.
21	**What is the use of DMA controller Dec15 BTL1** DMA is used to connect a high speed network to the computer bus. The DMA control handles the data transfer between high speed network & the computer system. It is also used to transfer data between processor & floppy disk with the help of Floppy disk controller
22	**What is meant by interleaved memory? May 13&17 BTL1** The memory interleaving is a technique to reduce memory access time by dividing memory into a number of memory modules and the addresses are arranged such that the successive words in the address space are placed in different modules. Most of the times CPU access consecutive memory locations. In such situations accesses will be to the different modules. Since these modules can be accessed in parallel, the average access time of fetching word from the main memory can be reduced
23	**What is meant by address mapping?** The virtually addressed memory with pages mapped to main memory. This process is called address

mapping or address translation

24 **Define hit rate/hit ratio Dec 15 BTL1**

The percentage of accesses where the processor finds the code or data word it needs in the ache memory is called the hit rate or hit ratio

25 **How DMA can improve I/O speed. May 15 BTL1**

DMA is a hardware controlled data transfer. It doesn't spend testing I/O device status and executing a number of instructions for I/O data transfer.

In DMA transfer, data is transferred directly from the disk controller to the memory location without passing through the processor or the DMA controller

26 **What is the purpose of dirty/Modified bit in cache memory Dec 14 BTL1**

The data in the cache is called dirty data, if it is modified within cache but not modified in main memory. Whereas, dirty bit(modified bit) is a cache line condition(status)identifier, its purpose is to indicate whether contents of a particular cache line are different to what is stored in operating memory.

27 **How many total bits are required for a direct-mapped cache with 16kb of data and 4-word blocks, assuming a 32-bit address? Dec 17 BTL2**

Solution:
16kb=4k words=2^12 words
Block size of 4 words= 2^10 blocks
Each block has 4*32=128 bits of data + tag + valid bit
Tag + Valid bit= (32 – 10 – 2 - 2) +1=19
Total cache size= 2^10 (128 + 19) = 2^10 * 147

PART B

1 **Differentiate programmed I/O from memory mapped I/O. (13m) (Apr/May 2018) BTL4**

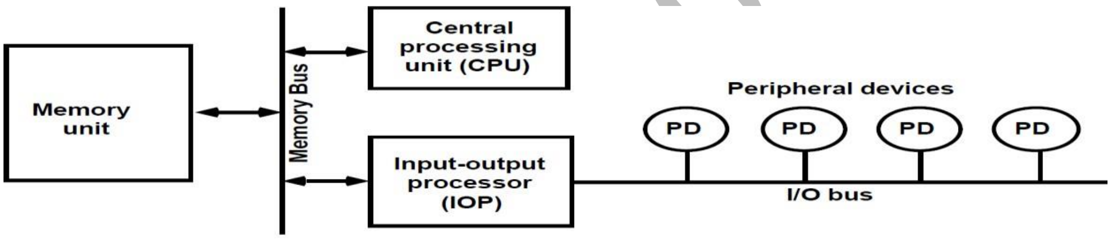
	Isolated-mapped I/O	**Memory-mapped I/O**
1.	Each port is treated as an independent unit.	Each port is treated as an independent unit.
2.	Separate address spaces for memory and input/output ports.	CPU's memory address space is divided between memory and input/output ports.
3.	Usually, processor provides less address lines for accessing I/O. Therefore, less decoding is required.	Usually, processor provides more address lines for accessing memory. Therefore more decoding is required control signals.
4.	I/O control signals are used to control read and write operations.	Memory control signals are used to control read and write I/O operations.
5.	I/O address bus width is smaller than memory address bus width.	Memory address bus width is greater than I/O address bus width.
6.	Two instructions are necessary to transfer data between memory and port.	Single instruction can transfer data between memory and port.
7.	Data transfer is by means of instruction like MOVE.	Each port can be accessed by means of IN or OUT instructions.
8.	I/O bus shares only I/O address range.	Memory address bus shares entire address range.

2 **Explain in detail, the architecture of I/O Processors. (13m) BTL4**

- The I/O processor (IOP) has an ability to execute I/O instructions and it can have complete control over I/O operation.
- The I/O instructions are stored in main memory. When I/O transfer is required, the CPU initiates an I/O transfer by instructing the I/O channel to execute an I/O program stored in the main memory.
- The I/O program specifies the device or devices, the area of memory storage, priority and actions to be taken for certain error conditions.

Features and Functions of IOP

1. An IOP can fetch and execute its own instructions.
2. Instructions are specially designed for I/O processing.
3. In addition to data transfer, IOP can perform arithmetic and logic operations, branches, searching and translation.
4. IOP does all work involved in I/O transfer including device setup, programmed I/O, DMA operation.
5. IOP can transfer data from an 8-bit source to 16-bit destination and vice versa.
6. Communication between IOP and CPU is through memory based control blocks. CPU defines tasks in the control blocks to locate a program sequence, called a channel program.
7. IOP supports multiprocessing environment. IOP and CPU can do processing simultaneously. This distributed processing approach improves system performance and flexibility.

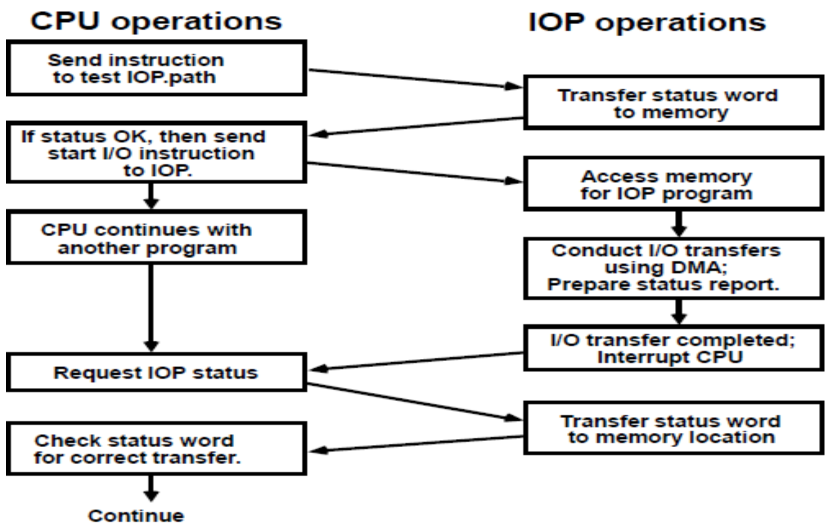


Block diagram of a computer with I/O processor

- The Figure shows the block diagram of computer system with an I/O processor.
- The CPU and I/O processor work independently and communicate with each other using centrally located memory and DMA.
- The CPU does the processing of needed in the solution of computational tasks and IOP does the data transfer between various peripheral devices and the memory unit.

CPU and IOP Communication

- The communication between CPU and IOP may be different for different processor and IOP configurations. However, in most of cases the memory based control blocks are used to store the information about the task to be performed.
- The processor uses these blocks to leave information in it for the other processor. The memory control block are linked, i.e., the address of the next memory based control blocks is available in the previous memory based control block.



CPU and IOP communication

- The figure shows the flowchart of sequence of operations that are carried out during the CPU and IOP communication. The sequence of operations carried out during CPU and IOP communication are:
    1. CPU checks the existence of I/O path by sending an instruction.
    2. In response to this IOP puts the status word in the memory stating the condition f IOP and I/O device (Busy, ready, etc.)
    3. CPU checks the status word and if all conditions are OK, it sends the instruction to start I/O transfer along with the memory address where the IOP program is stored.
    4. After this CPU continues with another program.
    5. IOP now conducts the I/O transfer using DMA and prepares status report.
    6. On completion of I/O transfer, IOP sends an interrupt request to the CPU.The CPU responds to the interrupt by issuing an instruction to read the status from the IOP. The status indicates whether the transfer has been completed or is any errors occurred during the transfer.

3 **Compare & Design the mapping techniques & functions in involved in cache memory (13m) (Apr/May2018) BTL4&6**

Answer: U-4 Refer Notes, **Carl hamacher book Pageno:316**

Explanation(8m)

- Direct mapping
- Associative mapping(Fully Associative)
- Set- Associative mapping

Diagram(5m)

4 **Explain about the mass storage. (13m) BTL4**

Answer: U-4 Refer notes, **Carl hamacher book Pageno:358**

Explanation(8m)

- **Magnetic** disk
- **Floppy disk**
- RAID Disk arrays
- Magnetic tapes
- Optical Disk

	Diagram(5m)
5	**Expain about Interuppt Handling / Write the sequence of operations carried out by a processor. When interrupted by a peripheral device connected to it. /Design & Explain a parallel priority interrupt hardware for a system with 8 interuupt sources. Dec 15/May 17 BTL4** **Answer:** Explanation (10m) Interrupt Driven I/O • Enabling & disabling interrupts • Vectored Interuppts • Interuppt Nesting • Interuppt Priority Recognition of interrupt & Response to interrupt Diagram (3m) • Response to an interrupt with the flowchart & diagram
6	**Explain about virtual memory & steps involved in Virtual Memory address translation BTL2** **Answer:** Explanation (10m) • Virtual memory • Concept of paging • Virtual to Physical Address Translation • Segment Translation • Page Translation Diagram (3m)
7	**Explain memory technologies in detail May17 BTL4** **Answer:** Explanation: (10m) RAM & ROM Technologies • Static RAM cell • Read operation • Write operation • CMOS Cell • Read operation • Write operation • DRAM • ROM, PROM, EPROM, EEPROM Diagram (3m)
8	**Explain Bus Arbitration techniques in DMA Dec 14/ May 17** **Answer:** Explanation (10m) Approaches to Bus Arbitration • Centralized bus arbitration ➢ Daisy Chaining ➢ Polling method ➢ Independent request • Distributed bus arbitration Diagram (3m)
9	**Describe about the i/p & o/p devices in detail with a neat diagram. (15m) BTL1**

	Answer: U-4 Refer notes, **Carl hamacher book Pageno:554-558** Explanation:10m Diagram:5m **I/P devices:** Keyboard, Mouse,… **O/P devices:** Printer, Plotter,…
PART C	
1	**Explain in detail, the concepts of virtual memory. (15m) (Apr/May 2018) BTL4** **Answer: U-4** Refer Notes, **Carl hamacher book Pageno:337** Explanation:10m Diagram:5m
2	**Explain in detail, the methods to improve cache performance. (15m) BTL4** **Answer: U-4** Refer Notes, **Carl hamacher book Pageno:329** Explanation:10m Diagram:5m
3	**Explain in detail, the cache memory and the accessing methods (15m) BTL4** **Answer: U-4** Refer Notes, **Carl hamacher book Pageno:314** Explanation:10m Diagram:5m
4	**Explain about DMA/ DMA Operations/ DMA Controller** **Answer:** **Explanation (10m)** • DMA Operation • DMA Block diagram • Cycle stealing mode(Single transfer mode) • Block transfer mode • Demand transfer mode
5	(i) Consider web browsing application assuming both client & server are involved in the process web browsing application, where can caches be placed to speed up the process design a memory hierarchy for the system show the typical size & the latency at various levels of the hierarchy. What is the relationship between cache size & its access latency? What are the units of data transfers between hierarchies? What is the relationship between the data location, data size & transfer latency? Answer: a) Assuming both client & server are involved in the process of web browsing application, caches can be placed on both sides-Web browser & server b) Memory hierarchy for the system is as follows: 1. Browser cache, size=fraction of client computer disk, latency= local disk latency 2. Proxy cache, size-proxy disk, Latency= LAN + proxy disk latencies 3. Server-side cache= fraction of server disk, Latency= WAN + server disk 4. Server storage, size= server storage, latency= WAN + server storage. Latency is not directly related to cache size. (C) The units of data transfers between hierarchies are pages. (d) Latency grows with page size as well as distance (ii) The following sequence of instructions are executed in the basic 5-stage pipelined processor I1: lw $1, 40($6) I2: add $6, $2, $2 I3: sw $6, 50($1)

Indicate dependencies & their type, Assuming there is no forwarding in pipelined processor. Indicate hazards & add NOP instructions to eliminate them.

Answer:

(a) I1: RAW Dependency on **\$1 from I1 to I3**

I2: RAW Dependency on **\$6 from I2 to I3**

I3: RAW Dependency on **\$6 from I1 to I2 to I3**

(b) If register read happens in the second half of the clock & the register write happens in the first half. The code that eliminates these hazards by inserting nop instruction is:

```
I1: lw $1, 40($6)
I2: add $6, $2, $2
nop; delay I3 to avoid RAW hazard on $1 from I1
I3: sw $6, 50($1)
```

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6 Assume the miss rate of an instruction cache is 2% & miss rate of data cache is 4% If a processor has a CPI of 2 without any memory stalls & miss penalty 100 cycles for all misses, determine how much faster a processor would run with a perfect cache that never missed. Assume the frequency of all loads & stores is 36%

Solution: The number of memory miss cycles for instructions in terms of the instruction count(I) is

Instruction miss cycle=I*2% * 100 = 2.00*I

As the frequency of all loads & stores is 36%, we can find the number of memory miss cycles for data refernces:

Data miss cycles= I*36%*4%*100=1.44 *I

The total number of memory-stall cycles is 2.00 I + 1.44 I = 3.44 I. This is move then 3 cycles of memory stall per instruction. Accordingly, the total CPI including memory stalls is 2+3.44 = 5.44. Since there is no change in instruction count or clock rate, the ratio of the CPU execution times is

CPU time with stalls/CPU time with perfect cache = $I*CPI_{stall}$ * Clock cycle/ $I*CPI_{perfect}$ * Clock cycle

$= CPI_{stall} / CPI_{perfect}$

$= 5.44/2$

The performance with the perfect cache is better by 2.72

Hit time is the time to access the upper level of the memory hierarchy, which includes the time needed to determine whether the access is a hit or miss.

If a larger cache is used, there is increase in the access time i.e, the hit time. But at a certain point, the increase in hit time due to larger cache results into decrease in miss rate i.e, the hit rate increases and so the cache performance also increases.

AMAT(Average Memory Access Time) is the average time to access memory considering both hits & misses & the frequency of different accesses

AMAT= Time for a hit + Miss rate * Miss penalty

CS8492 DATABASE MANAGEMENT SYSTEM LTPC
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OBJECTIVES

- To learn the fundamentals of data models and to represent a database system using ER diagrams.
- To study SQL and relational database design.
- To understand the internal storage structures using different file and indexing techniques which will help in physical DB design.
- To understand the fundamental concepts of transaction processing- concurrency control techniques and recovery procedures.
- To have an introductory knowledge about the Storage and Query processing Techniques

UNITI RELATIONAL DATABASES 10

Purpose of Database System – Views of data – Data Models – Database System Architecture – Introduction to relational databases – Relational Model – Keys – Relational Algebra – SQL fundamentals – Advanced SQL features – Embedded SQL– Dynamic SQL

UNIT II DATABASE DESIGN 8

Entity-Relationship model – E-R Diagrams – Enhanced-ER Model – ER-to-Relational Mapping – Functional Dependencies – Non-loss Decomposition – First, Second, Third Normal Forms, Dependency Preservation – Boyce/Codd Normal Form – Multi-valued Dependencies and Fourth Normal Form – Join Dependencies and Fifth Normal Form

UNITIII TRANSACTIONS 9

Transaction Concepts – ACID Properties – Schedules – Serializability – Concurrency Control – Need for Concurrency – Locking Protocols – Two Phase Locking – Deadlock – Transaction Recovery - Save Points – Isolation Levels – SQL Facilities for Concurrency and Recovery.

UNIT IV IMPLEMENTATION TECHNIQUES 9

RAID – File Organization – Organization of Records in Files – Indexing and Hashing –Ordered Indices – B+ tree Index Files – B tree Index Files – Static Hashing – Dynamic Hashing – Query Processing Overview – Algorithms for SELECT and JOIN operations – Query optimization using Heuristics and Cost Estimation.

UNIT V ADVANCED TOPICS 9

Distributed Databases: Architecture, Data Storage, Transaction Processing – Object-based Databases: Object Database Concepts, Object-Relational features, ODMG Object Model, ODL, OQL - XML Databases: XML Hierarchical Model, DTD, XML Schema, XQuery – Information Retrieval: IR Concepts, Retrieval Models, Queries in IR systems.

TOTAL: 45 PERIODS

OUTCOMES:

Upon completion of the course, the students will be able to:

- Classify the modern and futuristic database applications based on size and complexity
- Map ER model to Relational model to perform database design effectively
- Write queries using normalization criteria and optimize queries
- Compare and contrast various indexing strategies in different database systems
- Appraise how advanced databases differ from traditional databases.

TEXT BOOKS:

1. 3, Henry F. Korth, S. Sudharshan, -Database System Concepts‖, Sixth Edition, Tata McGraw Hill,2011.
2. Ramez Elmasri, Shamkant .Navathe,-Fundamentals of Database Systems‖, Sixth Edition, Pearson Education,2011.

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1. C.J.Date,A.Kannan,S.Swamynathan,-An Introduction to Database Systems‖, Eighth Edition, Pearson Education,2006.
2. RaghuRamakrishnan,―DatabaseManagementSystems‖,FourthEdition,McGraw-Hill College Publications,2015.
3. G.K.Gupta, "Database Management Systems‖, Tata McGraw Hill,2011.

Subject Code: CS8492 **Year/Semester: II/04**
Subject Name: DATABASE MANAGEMENT SYSTEM **Subject Handler: M. SUGANYA**

UNIT-I RELATIONAL DATABASES

Purpose of Database System – Views of data – Data Models – Database System Architecture – Introduction to relational databases – Relational Model – Keys – Relational Algebra – SQL fundamentals – Advanced SQL features – Embedded SQL– Dynamic SQL

PART * A

Q.No.	Questions
1.	**What is database?** BTL 2 A database is logically coherent collection of data with some inherent meaning, representing some aspect of real world and which is designed, built and populated with data for a specific purpose.
2	**Define DBMS.** BTL 1 A Database-management system consists of a collection of interrelated data and a set of programs to access those data. The collection of data, usually referred to as the database, contains information about one particular enterprise. The primary goal of a DBMS is to provide an environment that is both convenient and efficient to use in retrieving and storing database information.
3	**List the purpose of Database System** BTL 2 Problems with File Processing System: 1. Data redundancy and inconsistency 2. Difficulty in accessing data 3. Difficulty in data isolation 4. Integrity problems 5. Atomicity problems 6. Concurrent-access anomalies 7. Security problems
4	**What are the disadvantages of file processing system?** BTL 2 Data redundancy & inconsistency 1. Difficult in accessing data 2. Data isolation 3. Data integrity 4. Concurrent access is not possible. 5. Security problem
5	**Who is a DBA? What are the responsibilities of a DBA? April/May-2011** BTL 2 A database administrator (short form DBA) is a person responsible for the design, implementation, maintenance and repair of an organization's database. They are also known by the titles Database Coordinator or Database Programmer, and is closely related to the Database Analyst, Database Modeler, Programmer Analyst, and Systems Manager.
6	**What is data model? April/May-2011** BTL 2 A database model is the theoretical foundation of a database and fundamentally determines in which manner data can be stored, organized, and manipulated in a database system. It thereby defines the infrastructure offered by a particular database system. The most popular example of a database model is the relational model.

7	**List the types of data model used.** BTL 2 Types of data model used 1. Hierarchical model 2. Network model 3. Relational model 4. Entity-relationship 5. Object-relational model 6. Object model
8	**List any eight applications of DBMS.** BTL 2 1. Banking 2. Airlines 3. Universities 4. Credit card transactions 5. Tele communication 6. Finance g) Sales 7. Manufacturing 8. Human resources
9	**Write the levels of data abstraction.**BTL 2 1. Physical level 2. Logical level 3. View level
10	**Define instance and schema?** BTL 1 Instance: Collection of data stored in the data base at a particular moment is called an Instance of the database. The overall design of the data base is called the data base schema.
11	**What is storage manager?** BTL 2 A storage manager is a program module that provides the interface between the low level datastored in a database and the application programs and queries submitted to the system.
12	**What are the components of storage manager?** BTL 2 The storage manager components include 1. Authorization and integrity manager 2. Transaction manager 3. File manager 4. Buffer manager
13	**What are the purpose of storage manager?** BTL 2 The storage manager is responsible for the following 1. Interaction with the file manager 2. Translation of DML commands in to low level file system commands 3. Storing, retrieving and updating data in the database
14	**What is data dictionary?** BTL 2 A data dictionary is a data structure which stores meta data about the structure of the databaseie. the schema of the database traversal
15	**What is an entity relationship model?** BTL 2 The entity relationship model is a collection of basic objects called entities and relationship among those objects. An entity is a thing or object in the real world that is distinguishable fromother objects.
16	**What are attributes? Give examples.** BTL 2 An entity is represented by a set of attributes. Attributes are descriptive properties possessed byeach member of an entity set.

	Example: possible attributes of customer entity are customer name, customer id, Customer Street, customer city.
17	**What is relationship? Give examples.**BTL 2 A relationship is an association among several entities. Example: A depositor relationship associates a customer with each account that he/she has.
18	**Define the terms relationship set.**BTL 1 The set of all relationships of the same type is termed as a relationship set.
19	**Define single valued and multivalued attributes.** BTL 1 Single valued attributes: attributes with a single value for a particular entity are called singlevalued attributes. Multivalued attributes: Attributes with a set of value for a particular entity are calledmultivalued attributes.
20	**What are stored and derived attributes?** BTL 2 Stored attributes: The attributes stored in a data base are called stored attributes. Derived attributes: The attributes that are derived from the stored attributes are called derived attributes.
21	**Define the terms i) Entity type ii) Entity set** BTL 1 Entity type: An entity type defines a collection of entities that have the same attributes. Entity set: The set of all entities of the same type is termed as an entity set.
22	**Define weak and strong entity sets.** BTL 1 Weak entity set: entity set that do not have key attribute of their own are called weak entity sets. Strong entity set: Entity set that has a primary key is termed a strong entity set.
23	**What does the cardinality ratio specify?** BTL 2 Mapping cardinalities or cardinality ratios express the number of entities to which another entitycan be associated. Mapping cardinalities must be one of the following: 1. One to one 2. One to many 3. Many to one
24	**What is meant by lossless-join decomposition? APRIL/MAY-2011** BTL 2 1. Let R be a relation schema. 2. Let F be a set of functional dependencies on R. 3. Let R1and R2 form a decomposition of R. 4. The decomposition is a lossless-join decomposition of R if at least one of the following functional dependencies are in : a. R1∩ R2→ R1 b. R1∩ R2→ R2
25	**What are the uses of functional dependencies?** BTL 2 To test relations to see whether they are legal under a given set of functional dependencies. To specify constraints on the set of legal relations.
26	**Define Relational Algebra.** BTL 1 A general expression in the relational algebra is constructed out of smaller sub expressions. Let E1 and E2 be relational algebra expressions. Then, the following are all relational algebra expressions: • E1 U E2 • E1 – E2 • E1 * E2 • (E1), where P is a predicate on attribute in E1. • (E1), where S is a list consisting of some of the attributes in E1 • (E1), where x is the new name for the result of E1.

27	**Define Data Independence.** BTL 1 The ability to modify a schema definition in one level without affecting a schema definition in the next higher level is called data independence. There are two levels of data independence: Physical data independence, and Logical data independence.
28	**What is embedded SQL? What are its advantages? April/May-2011** BTL 2 Embedded SQL is a method of combining the computing power of a programming language and the database manipulation capabilities of SQL. Embedded SQL statements are SQL statements written in line with the program source code of the host language. The embedded SQL statements are parsed by an embedded SQL preprocessor and replaced by host-language calls toa code library. The output from the preprocessor is then compiled by the host compiler. This allows programmers to embed SQL statements in programs written in any number of languages such as: C/C++, COBOL and Fortran.
PART * B	
1	**What is file processing system? What are the disadvantages of a file-processing system that led to the development of the database system? (13M)** BTL 2 **Answer: Page 10 - 16 -** Abraham Silberschatz • File processing system (4M) • Data redundancy (3M) • Data consistency (3M) • Example (3M)
2	**Discuss the advantages of database system. Explain the various cost and risk factors involved in implementing a database system. (13M)** BTL 4 **Answer: Page 10 - 16 -** Abraham Silberschatz • Controlled data redundancy (3M) • Enforcing data integrity (2M) • Data sharing (2M) • Data security (2M) • Multiple user interface (2M) • Backup and recovery (2M)
3	**Explain the different criteria on the basics of which DBMS is classified into different categories. (13M) BTL3** **Answer: Page 04 - 06 -** Abraham Silberschatz • Based on data model (4M) • Based on number of errors (3M) • Based on number of sites (3M) • Based on the purpose (3M)
4	**What is the goal of designing a database? Explain the overall database(13M) (May 2015) BTL2** **Answer: Page 50 - 56 -** Abraham Silberschatz • Requirement collection and analysis (2M) • Conceptual database design (2M) • Choice of a DBMS (2M) • Logical database design (2M) • Physical database design (2M)

	• Database system architecture (2M) • Testing and evaluation (1M)
5	**Explain with neat diagram about database system architecture. (13M) (Dec'2016) BTL3** **Answer: Page 18 - 20 -** Abraham Silberschatz • Diagram (2M) • Data definition (2M) • DDL compiler (2M) • Data manipulation (2M) • DML compiler (2M) • Data security and integrity (1M) • Concurrency and data recovery (1M) • Performance optimization (1M)
6	**What is entity-relationship? Explain with an example about major components of entity-relationship diagrams (13M) BTL2** **Answer: Page 10 - 16 -** Abraham Silberschatz • Entity: concrete entity, abstract entity (5M) • Attributes: Simple, Composite, derived (4M) • Relationship: Unary, Binary, Ternary (4M)
7	**Explain different data models.(13M)** BTL 3 **Answer: Page 10 - 16 -** Abraham Silberschatz • Data model (2M) • Conceptual data model (2M) • Representation data model (2M) • Hierarchical data model (2M) • Network data model (2M) • Relational data model (2M) • Example for online book database (1M)
	PART – C

1	**Draw ER diagram for Online Book database. (15M) BTL** 4 **Answer: Page 25 - 26 -** Abraham Silberschatz • Entity: Book Edition, Author, Publisher, Reviews, Feedback (8M) • Relationship: Published by, Has, Writes (7M)
2	**Explain about three-schema architecture and schemas, mapping and instances. (15M) BTL** 3 **Answer: Page 30 - 36 -** Abraham Silberschatz • Internal level (4M) • Conceptual level (4M) • External level (4M) • Mapping (3M)
3	**What do you understand by an embedded SQL? How are variables declared and used in an embedded SQL? Explain with examples.(15M)**BTL 2 **Answer: Page 37 - 39 -** Abraham Silberschatz • Embedded SQL: SQL statements, application program, host language. (5M) • Variables: Host variables, commands (5M) • Application programs (5M)

Subject Code: CS8492 **Year/Semester: II/04**
Subject Name: DATABASE MANAGEMENT SYSTEM **Subject Handler: N.GLADISS MERLIN**

UNIT II DATABASE DESIGN

Entity-Relationship model – E-R Diagrams – Enhanced-ER Model – ER-to-Relational Mapping – Functional Dependencies – Non-loss Decomposition – First, Second, Third Normal Forms, Dependency Preservation – Boyce/Codd Normal Form – Multi-valued Dependencies and Fourth Normal Form – Join Dependencies and Fifth Normal Form

PART * A

Q.No.	Questions
1	**What are the parts of SQL language?** BTL 2 1. The SQL language has several parts: 2. data - definition language 3. Data manipulation language 4. View definition 5. Transaction control

	6. Embedded SQL 7. Integrity 8. Authorization
2	**What are the categories of SQL command?** BTL 2 1. SQL commands are divided in to the following categories: 2. Data - Definition Language 3. Data Manipulation language 4. Data Query Language 5. Data Control Language 6. Data Administration Statements 7. Transaction Control Statements
4	**What are the three classes of SQL expression?** BTL 2 SQL expression consists of three clauses: 1. Select 2. From 3. Where
5	**Give the general form of SQL query.**BTL 1 Select A1, A2…………., An From R1, R2……………, Rm Where P
6	**What is the use of rename operation?** BTL 2 Rename operation is used to rename both relations and attributes. It uses the as clause, taking the form: Old-name as new-name
7	**List the string operations supported by SQL.** BTL 2 1. Pattern matching Operation 2. Concatenation 3. Extracting character strings 4. Converting between uppercase and lower case letters.
8	**List the set operations of SQL.**BTL 2 1. Union 2. Intersect operation 3. The except operation
9	**What is the use of Union and intersection operation?**BTL 2 Union: The result of this operation includes all tuples that are either in r1 or in r2 or in both r1 and r2.Duplicate tuples are automatically eliminated. Intersection: The result of this relation includes all tuples that are in both r1 andr2
10	**What is the use of Union and intersection operation?** BTL 1 Union: The result of this operation includes all tuples that are either in r1 or in r2 or in both r1 and r2.Duplicate tuples are automatically eliminated. Intersection: The result of this relation includes all tuples that are in both r1 andr2
11	**What is the use of group by clause?** BTL 2 Group by clause is used to apply aggregate functions to a set of tuples. The attributes given in the group by clause are used to form groups. Tuples with the same value on all attributes in the group by clause are placed in one group.

12	**What is view in SQL? How is it defined?** BTL 2 Any relation that is not part of the logical model, but is made visible to a user as a virtual relation is called a view. We define view in SQL by using the create view command. The form of the create view command is Create view v as
13	**What is the use of with clause in SQL?** BTL 2 The ‘with’ clause provides a way of defining a temporary view whose definition is available only to the query in which the ‘with’ clause occurs.
14	**List the table modification commands in SQL. BTL 2** 1. Deletion 2. Insertion 3. Updates 4. Update of a view
15	**List the SQL domain types. BTL 2** SQL supports the following domain types. 1. Char(n) 2. varchar(n) 3. int 4. numeric(p,d) 5. float(n) 6. date
16	**What is the use of integrity constraints?** BTL 2 Integrity constraints ensure that changes made to the database by authorized users do not result in a loss of data consistency. Thus integrity constraints guard against accidental damage to the database.
17	**Mention the 2 forms of integrity constraints in ER model.**BTL 4 1. Key declarations 2. Form of a relationship
18	**What is trigger?** BTL 2 Triggers are statements that are executed automatically by the system as the side effect of a modification to the database.
19	**What are domain constraints?** BTL 2 A domain is a set of values that may be assigned to an attribute .all values that appear in a column of a relation must be taken from the same domain.
20	**What are referential integrity constraints?** BTL 2 A value that appears in one relation for a given set of attributes also appears for a certain set of attributes in another relation.
21	**What is assertion? Mention the forms available.** BTL 2 An assertion is a predicate expressing a condition that we wish the database always to satisfy.
22	**What is the need for triggers?** BTL 2 Triggers are useful mechanisms for alerting humans or for starting certain tasks automatically when certain conditions are met.
23	**List the requirements needed to design a trigger.** BTL 2 The requirements are 1. Specifying when a trigger is to be executed. 2. Specify the actions to be taken when the trigger executes.
24	**Give the forms of triggers.**BTL 1

	1. The triggering event can be insert or delete. 2. For updated the trigger can specify columns. 3. The referencing old row as clause 4. The referencing new row as 5. The triggers can be initiated before the event or after the event.
25	**What does database security refer to?** BTL 2 Database security refers to the protection from unauthorized access and malicious destruction or alteration.
26	**List some security violations (or) name any forms of malicious access.** BTL 2 1. Unauthorized reading of data 2. Unauthorized modification of data 3. Unauthorized destruction of data.
27	**Give the limitations of SQL authorization.** BTL 2 The code for checking authorization becomes intermixed with the rest of the application code. Implementing authorization through application code rather than specifying it declaratively in SQL makes it hard to ensure the absence of loopholes
28	**What do you mean by “Query Optimization”?** BTL 2 Improving of the strategy for processing a query is called “Query Optimization”. It is the responsibility of the system to transform the query as entered by the user into an equivalent query which can be computed more efficiently.
29	**What are the steps involved in query processing?** BTL 2 The basic steps are: 1. parsing and translation 2. optimization 3. Evaluation
30	**What is called a query –execution engine?** BTL 2 The query execution engine takes a query evaluation plan, executes that plan, and returns the answers to the query.
31	**What is called a query evaluation plan?** BTL 2 A sequence of primitive operations that can be used to evaluate a query is a query evaluation plan or a query execution plan.
	PART -B
1	**What are the various operation in relation algebra? Explain with examples. (13M)** BTL 2 **Answer: Page 113 - 116 -** Abraham Silberschatz • Union operation (4M) • Interaction operation (3M) • Difference operation (3M) • Cartesian product operation (3M)
2	**What is the use of constraint? Explain the different type of constraint that can be specified.(13M)** BTL 2 **Answer: Page 160 - 165 -** Abraham Silberschatz 1. Primary key (3M)

	2. Unique constraint (3M) 3. Check constraint (3M) 4. NOT null constraint (2M) 5. Foreign key constraint (2M)
3	**Explain Normalization with the help of an example. (13M)** BTL 3 **Answer: Page 157 - 159 -** Abraham Silberschatz 1. Insert anomaly (2M) 2. Deletion anomaly (2M) 3. Update anomaly (2M) 4. First normal form(1NF) (1M) 5. Second normal form(1NF) (1M) 6. Third normal form(1NF) (1M) 7. Fourth normal form(1NF) (1M) 8. Fifth normal form(1NF) (1M) 9. Example (2M)
4	**Write the inference rules for multi-valued dependencies (13M)** BTL 2 **Answer: Page 148 - 149 -** Abraham Silberschatz 1. Complementation rule (3M) 2. Augmentation rule (3M) 3. Transitive rule (3M) 4. Replication rule (2M) 5. Coalescence rule (2M)
5	**Explain inference rules for functional dependencies. (13M)** BTL 3 **Answer: Page 145 - 146 - C** Abraham Silberschatz • Reflexivity rule (3M) • Augmentation rule (2M) • Transitivity rule (2M) • Decomposition rule (2M) • Union rule (2M) • Pseudo transitivity rule (2M)
6	**What are the role of join operations in relational algebra(13M)**BTL 2 **Answer: Page 130 - 136 -** Abraham Silberschatz • Equijoin operation (3M) • Natural join operation (3M) • Left outer join operation (3M) • Right outer join operation (2M) • Full outer join operation (2M)
	PART - C
1	**Discuss the various update operations that can be performed on a relation and its integrity (15M)**BTL 4 **Answer: Page 210 - 216 -** Abraham Silberschatz

	• Insert operation (3M) • Delete operation (2M) • Update operation (2M) • Domain integrity (2M) • Entity integrity (2M) • Referential integrity (2M) • Semantic integrity (2M)
2	**Explain the characteristics of relations and mapping relation scheme.(15M)**BTL 3 **Answer: Page 220 -226 -** Abraham Silberschatz • Ordering of tuples in a relation (3M) • Ordering of values within a tuple (2M) • Values and nulls in the tuples (2M) • Interpretation of a relation (2M) • Many-to- many (2M) • One-to-many (2M) • Many-to-One (2M)

Subject Code: CS8492 **Year/Semester: II/04**
Subject Name: DATABASE MANAGEMENT SYSTEM **Subject Handler: N.GLADISS MERLIN**

UNIT-III TRANSACTIONS

Transaction Concepts – ACID Properties – Schedules – Serializability – Concurrency Control – Need for Concurrency – Locking Protocols – Two Phase Locking – Deadlock – Transaction Recovery - Save Points – Isolation Levels – SQL Facilities for Concurrency and Recovery.

PART * A

Q.No.	Questions
1	**What are the ACID properties? APRIL/MAY-2011** BTL 2 ACID properties is a set of properties that guarantee database transactions are processed reliably. In the context of databases, a single logical operation on the data is called a transaction. For example, a transfer of funds from one bank account to another, even though that might involve multiple changes (such as debiting one account and crediting another), is a single transaction.
2	**What is transaction?** BTL 2 Collections of operations that form a single logical unit of work are called transactions.
4	**What are the two statements regarding transaction?** BTL 2 The two statements regarding transaction of the form: 1. Begin transaction 2. End transaction

5	**What are the properties of transaction?** BTL 2 The properties of transactions are: 1. Atomicity 2. Consistency 3. Isolation 4. Durability
6	**What is recovery management component?** BTL 2 Ensuring durability is the responsibility of a software component of the base system called as recovery management component.
7	**When is a transaction rolled back?** BTL 2 Any changes that the aborted transaction made to the database must be undone. Once the changes caused by an aborted transaction have been undone, then the transaction has been rolled.
8	**What are the states of transaction?** BTL 2 The states of transaction are 1. Active 2. Partially committed 3. Failed 4. Aborted 5. Committed 6. Terminated
9	**List out the statements associated with a database transaction.**BTL 2 1. Commit work 2. Rollback work
10	**Give the reasons for allowing concurrency.**BTL 3 The reasons for allowing concurrency is if the transactions run serially, a short transaction may have to wait for a preceding long transaction to complete, which can lead to unpredictable delays in running a transaction. So concurrent execution reduces the unpredictable delays in running transactions.
11	**What is average response time?** BTL 2 The average response time is that the average time for a transaction to be completed after it hasbeen submitted.
12	**What are the two types of Serializability?** BTL 2 The two types of Serializability is 1. Conflict serializability 2. View serializability
13	**Define lock.**BTL 1 Lock is the most common used to implement the requirement is to allow a transaction to access a data item only if it is currently holding a lock on that item.
14	**Define the phases of two phase locking protocol.**BTL 1 Growing phase: a transaction may obtain locks but not release any lock. Shrinking phase: a transaction may release locks but may not obtain any new locks.
15	**Define upgrade and downgrade.**BTL 1 It provides a mechanism for conversion from shared lock to exclusive lock is known as upgrade. It provides a mechanism for conversion from exclusive lock to shared lock is known as downgrade.
16	**What are the two methods for dealing deadlock problem?** BTL 2 The two methods for dealing deadlock problem is deadlock detection and deadlock recovery.
17	**What is a recovery scheme?** BTL 2 An integral part of a database system is a recovery scheme that can restore the database to the consistent state that existed before the failure.

18	**When is a transaction rolled back?** BTL 2 Any changes that the aborted transaction made to the database must be undone. Once the changes caused by an aborted transaction have been undone, then the transaction has been rolled back.
19	**Give the reasons for allowing concurrency.**BTL 3 The reasons for allowing concurrency is if the transactions run serially, a short transaction may have to wait for a preceding long transaction to complete, which can lead to unpredictable delays in running a transaction. So concurrent execution reduces the unpredictable delays in running transactions.
20	**Define upgrade and downgrade.**BTL 1 1. It provides a mechanism for conversion from shared lock to exclusive lock is known as upgrade. 2. It provides a mechanism for conversion from exclusive lock to shared lock is known as downgrade
21	**What is a database graph?** BTL 2 The partial ordering implies that the set D may now be viewed as a directed acyclic graph, called a database graph.
22	**What are the two methods for dealing deadlock problem?** BTL 2 The two methods for dealing deadlock problem is deadlock detection and deadlock recovery.
23	**What is meant by log-based recovery?** BTL 2 The most widely used structures for recording database modifications is the log. The log is a sequence of log records, recording all the update activities in the database. There are several types of log records
24	**What are uncommitted modifications?** BTL 2 The immediate-modification technique allows database modifications to be output to the database while the transaction is still in the active state. Data modifications written by active transactions are called uncommitted modifications.
25	**Differentiate strict two phase locking protocol and rigorous two phase locking protocol.** BTL 3 1. Strict two phase locking protocol all exclusive mode locks taken by a transaction is held until that transaction commits. 2. Rigorous two phase locking protocol requires that all locks be held until the transaction commits.
26	**How the time stamps are implemented?** BTL 4 1. Use the value of the system clock as the time stamp. That is a transaction's time stamp is equal to the value of the clock when the transaction enters the system. 2. Use a logical counter that is incremented after a new timestamp has been assigned; that is the time stamp is equal to the value of the counter.
27	**What are the time stamps associated with each data item?** BTL 2 1. W-timestamp (Q) denotes the largest time stamp if any transaction that executed WRITE (Q) successfully. 2. R-timestamp (Q) denotes the largest time stamp if any transaction that executed READ (Q) successfully.
28	**When is a transaction rolled back?** BTL 2 Any changes that the aborted transaction made to the database must be undone. Once the changes caused by an aborted transaction have been undone, then the transaction has been rolled back.
	PART -B
1	**Explain state transition diagram. Explain when a transaction is said to be failed. (13M)**BTL 3 **Answer: Page 60 - 63 -** Abraham Silberschatz • State transition diagram (3M)

	• Active (2M) • Partially committed (2M) • Committed (2M) • Failed (2M) • Terminated (2M)
2	**Discuss the two different forms of schedule equivalence. (13M)**BTL 4 **Answer: Page 70 - 76 -** Abraham Silberschatz • Conflict equivalence (4M) • Conflict serializability (3M) • View equivalence (3M) • Conflict serializability (3M)
3	**How is locking implemented? What is the role of the lock table in implementation? How are the requests to lock and unlock a data item handled? (13M)**BTL 3 **Answer: Page 85 - 86 -** Abraham Silberschatz • Lock manager (4M) • Lock table (3M) • Lock request (3M) • Unlock request (3M)
4	**What do you understand by lock upgrade and lock downgrade? Explain the graph –based locking technique. (13M)**BTL 2 **Answer: Page 80 - 84 -** Abraham Silberschatz • Lock conversion (3M) • lock upgrade (3M) • lock downgrade (3M) • Database graph (2M) • Tree-locking (2M)
5	**Discuss deadlock prevention and how it is detected. (13M)**BTL 4 **Answer: Page 97 - 98 -** Abraham Silberschatz • Wait-die (3M) • Wound-wait (2M) • Wait – for graph (2M) • Conservation 2PL (2M) • Assigning data item (2M) • Timestamp lock (2M)
6	**Explain two-phase locking protocol. (13M)**BTL 3 **Answer: Page 90- 96 -** Abraham Silberschatz • Growing or expanding phase (3M) • Shrinking phase (3M)

	• Lock point (3M) • Strict two - phase locking (2M) • Rigorous two- phase locking (2M)
	PART -C
1	**How are optimistic concurrency control technique different from other concurrency control technique? (15M) BTL3** **Answer: Page 100- 106 -** Abraham Silberschatz • Validation (3M) • Read phase (3M) • Write phase (3M) • System clock (2M) • Logical counter (2M) • Blocking (2M)
2	**What are intension locking? How does it provide a higher degree of concurrency? (15M)**BTL2 **Answer: Page 110 - 116 -** Abraham Silberschatz • Intention lock (3M) • Intension shared (3M) • Intension exclusive mode (3M) • Shared- exclusive mode (3M) • Multiple granularity lock (3M)

Subject Code: CS8492 **Year/Semester: II/04**
Subject Name: DATABASE MANAGEMENT SYSTEM **Subject Handler: N.GLADISS MERLIN**

UNIT-IV IMPLEMENTATION TECHNIQUES

RAID – File Organization – Organization of Records in Files – Indexing and Hashing –Ordered Indices – B+ tree Index Files – B tree Index Files – Static Hashing – Dynamic Hashing – Query Processing Overview – Algorithms for SELECT and JOIN operations – Query optimization using Heuristics and Cost Estimation.

PART * A

Q.No.	Questions
1	**What are the storage types?** BTL 2 The storage types are: 1. Volatile storage 2. Nonvolatile storage
2	**Define blocks.**BTL 1 The database system resides permanently on nonvolatile storage, and is into fixed-length storage units called blocks.

3	**What is meant by Physical blocks?** BTL 2 The input and output operations are done in block units. The blocks residing on the disk are referred to as physical blocks.
4	**What is meant by buffer blocks?** BTL 2 The blocks residing temporarily in main memory are referred to as buffer blocks.
5	**What is meant by disk buffer?** BTL 2 The area of memory where blocks reside temporarily is called the disk buffer.
6	**Define garbage collection.** BTL 1 Garbage may be created also as a side effect of crashes. Periodically, it is necessary to find all the garbage pages and to add them to the list of free pages. This process is called garbage collection.
7	**What is an index?** BTL 2 An index is a structure that helps to locate desired records of a relation quickly,without examining all records
8	**Define query optimization.** BTL 1 Query optimization refers to the process of finding the lowest –cost method of evaluating a given query.
9	**What are the types of storage devices?** BTL 2 1. Primary storage 2. Secondary storage 3. Tertiary storage 4. Volatile storage 5. Nonvolatile storage
10	**What is called remapping of bad sectors?** BTL 2 If the controller detects that a sector is damaged when the disk is initially formatted, or when an attempt is made to write the sector, it can logically map the sector to a different physical location.
11	**Define access time.** BTL 1 Access time is the time from when a read or write request is issued to when data transfer begins.
12	**Define seek time.** BTL 1 The time for repositioning the arm is called the seek time and it increases with the distance that the arm is called the seek time.
13	**Define average seek time.** BTL 1 The average seek time is the average of the seek times, measured over a sequence of random requests.
14	**What is meant by data-transfer rate?** BTL 2

	The data-transfer rate is the rate at which data can be retrieved from or stored to the disk.
15	**What is meant by mean time to failure?** BTL 2 The mean time to failure is the amount of time that the system could run continuously without failure.
16	**What is a block and a block number?** BTL 2 A block is a contiguous sequence of sectors from a single track of one platter.Each request specifies the address on the disk to be referenced. That address is in the form of a block number.
17	**What are called journaling file systems?** BTL 2 File systems that support log disks are called journaling file systems.
18	**What is the use of RAID?** BTL 2 A variety of disk-organization techniques, collectively called redundant arrays of independent disks are used to improve the performance and reliability
19	**What is called mirroring?** BTL 2 The simplest approach to introducing redundancy is to duplicate every disk. This technique is called mirroring or shadowing.
20	**What is called bit-level striping?** BTL 2 Data striping consists of splitting the bits of each byte across multiple disks. This is called bit-level striping.
21	**What is called block-level striping?** BTL 2 Block level striping stripes blocks across multiple disks. It treats the array of disks as a large disk, and gives blocks logical numbers
22	**What are the two main goals of parallelism?** BTL 2 1. Load –balance multiple small accesses, so that the throughput of such accesses increases. 2. Parallelize large accesses so that the response time of large accesses is reduced
23	**What are the factors to be taken into account when choosing a RAID level?** BTL 2 1. Monetary cost of extra disk storage requirements. 2. Performance requirements in terms of number of I/O operations 3. Performance when a disk has failed. 4. Performances during rebuild.
24	**What is meant by software and hardware RAID systems?** BTL 2 RAID can be implemented with no change at the hardware level, using only software modification. Such RAID implementations are called software RAID systems and the systems with special hardware support are called hardware RAID systems.
25	**What are the ways in which the variable-length records arise in database systems?** BTL 2 1. Storage of multiple record types in a file.

	2. Record types that allow variable lengths for one or more fields. 3. Record types that allow repeating fields.
26	**What is the use of a slotted-page structure and what is the information present in the header?** BTL 2 The slotted-page structure is used for organizing records within a single block. The header contains the following information. 1. The number of record entries in the header. 2. The end of free space 3. An array whose entries contain the location and size of each record.
27	**What are the two types of blocks in the fixed –length representation? Define them.** BTL 2 Anchor block: Contains the first record of a chain. Overflow block: Contains the records other than those that are the first record of a chain.
28	**What is hashing file organization?** BTL 2 In the hashing file organization, a hash function is computed on some attribute of each record. The result of the hash function specifies in which block of the file the record should be placed.
29	**What are called index-sequential files?** BTL 2 The files that are ordered sequentially with a primary index on the search key, are called index-sequential files.
30	**What is a B+-Tree index?** BTL 2 A B+-Tree index takes the form of a balanced tree in which every path from the root of the root of the root of the tree to a leaf of the tree is of the same length
31	**What is a hash index?** BTL 2 A hash index organizes the search keys, with their associated pointers, into a hash file structure.
32	**What is called as recursive partitioning?** BTL 2 The system repeats the splitting of the input until each partition of the build input fits in the memory. Such partitioning is called recursive partitioning.
33	**What is called as an N-way merge?** BTL 2 The merge operation is a generalization of the two-way merge used by the standard in memory sort-merge algorithm. It merges N runs, so it is called an N-way merge.
	PART-B
1	**List the different types of storage media available in the company system. Also explain how they are classified into different categories?** BTL 2 **Answer: Page 312 - 316 -** Abraham Silberschatz • Primary storage: cache memory, main memory, flash memory (5M)

	• Secondary memory: magnetic disk (4M) • Tertiary memory: optical disc, tape storage (4M)
2	**Give hardware description of magnetic disk and steps involved in accessing data from a magnetic disk.** BTL 2 **Answer: Page 300 - 309 -** Abraham Silberschatz • Single-sided disk (3M) • Double-sided disk (2M) • Head –disk assemblies (2M) • Seek time (2M) • Rotate (2M) • Data transfer (2M)
3	**How can be reliability and performance of disk be improved using RAID? Explain different RAID levels.** (13M) BTL 3 **Answer: Page 330 - 336 -** Abraham Silberschatz • Data stripping (3M) • Bit-level data stripping (2M) • Block-level stripping (2M) • Mirroring and shadowing (2M) • RAID level 0 and RAID level 1 (1M) • RAID level 2 and RAID level 3 (1M) • RAID level 4 and RAID level 5 (1M) • RAID level 6 (1M)
4	**Explain the polices used by the buffer manager to replace a page.** (13M) BTL3 **Answer: Page 337 - 338 -** Abraham Silberschatz • Lase Recently Used(LRU) (4M) • Most Recently Used(MRU) (4M) • Clock Replacement (5M)
5	**Discuss the importance of file organization in database and various types of file organization available**. (13M) BTL4 **Answer: Page 340 - 346 -** Abraham Silberschatz • File organization (4M) • Heap file organization (3M) • Sequential file organization (3M) • Hash file organization (3M)
	PART – C
1	**What are the main problem associated with most of the hash function and how can it be resolved?**(15M) BTL2 **Answer: Page 290 - 296 -** Abraham Silberschatz

	• Cut key hashing (3M) • Folded key (2M) • Division remainder hashing (2M) • Collision (2M) • Open addressing (2M) • Multiple hashing (2M) • Chained overflow (2M)
2	**Explain the various algorithms for implementing the select operation involving complex condition?** (15M) BTL3 **Answer: Page 300 - 306 -** Abraham Silberschatz • Conjunctive selective using one index (4M) • Conjunctive selection using composite index (4M) • Conjunctive selection by intersection of record pointers (4M) • Conjunctive union of intersection of record pointers (3M)

Subject Code: CS8492 Year/Semester: II/04
Subject Name: DATABASE MANAGEMENT SYSTEM Subject Handler: N.GLADISS MERLIN

UNIT V ADVANCED TOPICS	
Distributed Databases: Architecture, Data Storage, Transaction Processing – Object-based Databases: Object Database Concepts, Object-Relational features, ODMG Object Model, ODL, OQL - XML Databases: XML Hierarchical Model, DTD, XML Schema, XQuery – Information Retrieval: IR Concepts, Retrieval Models, Queries in IR systems.	
PART * A	
Q.No.	Questions
1	**Define Data mining.** BTL 1 Data mining - knowledge discovery in database. Data mining is the process of semi automatically analyzing large databases to find useful patterns.
2	**What is meant by Data warehouse?** BTL 2 A data warehouse is a repository (archive) of information gathered from multiple sources, stored under a unified schema at a single site. ¬ Greatly simplifies querying, permits study of historical trends ¬ Shifts decision support query load away from transaction processing systems
3	**List out the functionalities of Data warehouse.** BTL 2 1. Data cleaning 2. Data transformation 3. Data integration 4. Data loading 5. Periodic data refreshing
4	**List the types of security mechanisms.** BTL 2

	1. Discretionary security mechanisms 2. Mandatory security mechanisms
5	**What are the database design issues?** BTL 2 1. Legal and ethical issues 2. Policy issues 3. System related issues
6	**List the actions performed by DBA?** BTL 2 1. Account creation 2. Privilege granting 3. Privilege revocation 4. Security level assignment
7	**What are the steps for designing a warehouse?** BTL 2 1. Choose a business process to model 2. Choose the grain of the business process 3. Choose the dimension that will apply to each fact table record 4. Choose the measures that will populate each fact table record
8	**What are the issues in data warehouse design?** BTL 2 1. When and how to gather data 2. What schema to use 3. Data cleansing 4. How to propagate updates 5. What data to summarize
9	**What are the goals of data mining?** BTL 2 1. Prediction 2. Identification 3. Classification 4. Optimization
10	**List out the types of Discovered knowledge.** BTL 2 1. Association rules 2. Classification Hierarchies 3. Sequential patterns 4. Patterns within time series 5. Clustering
11	**What is meant by Association rule?** BTL 2 An association rule is of the form X→Y, where X={x1, x2,…….xn} and Y={y1, y2,……. yn} are set of items with xi and yi being distinct items of all i and j. It must satisfy a minimum support and confidence.
12	**What is meant by Confidence rule?** BTL 2

	Given a rule of the form A→B, rule confidence is the conditional probability that B is true when A is known to be true.
13	**Define Apriori algorithm.** BTL 1 The Apriori algorithm was the first algorithm used to generate association rules. It uses the general algorithm for creating association rules together with downward closure and ant monotonicity
14	**Define Sampling algorithm.** BTL 1 The Sampling algorithm selects samples from the database of transactions that individually fit into memory. Frequent itemsets are then formed for each sample.
15	**What is meant by frequent pattern tree algorithm?** BTL 2 The Frequent pattern tree algorithm reduces the total number of candidate itemsets by producing a compressed version of the database in terms of an FP-tree. The FP-tree stores relevant information and allows for the efficient description of frequent item sets. The algorithm consists of 2 steps: 1. Build FP-tree 2. Use the tree to find frequent itemsets.
16	**What is meant by Classification?** BTL 2 Classification is the process of learning a model that is able to describe different classes of data.
17	**List the applications of data mining.** BTL 2 1. Marketing 2. Finance 3. Resource optimization 4. Image Analysis 5. Fraud detection
	PART- B
1	**Discuss various security issues and threats.** (13M) BTL 4 **Answer: Page 400 - 406 -** Abraham Silberschatz • Privacy (3M) • Database integrity (2M) • Database availability (2M) • Accidental threats (2M) • Managing user accounts (2M) • Database audit (2M)
2	**What is the role of access matrix? Discuss with the help of an example**. (13M) BTL 2 **Answer: Page 407 - 416 -** Abraham Silberschatz • Authorizer (4M) • Select and modify (3M) • Reference and drop (3M)

	• Alter and propagate access control (3M)
3	**What are the various technique that can be used to authenticate a user and two approaches for access control in DBMS?** (13M) BTL 2 **Answer: Page 417 - 426 -** Abraham Silberschatz • Password Authentication (3M) • Physical characteristics (2M) • Smart card (2M) • Discretionary access control (2M) • Mandatory access control (2M) • Star property (2M)
4	**Discuss various locking technique that can be applied in distributed system along with their advantages and disadvantages.** (13M) BTL 4 **Answer: Page 430 - 436 -** Abraham Silberschatz • Single lock manager (3M) • Distributed lock manager (2M) • Primary copy (2M) • Majority locking (2M) • Advantages (2M) • Disadvantages (2M)
5	**Discuss the three layers of three-tier client/server architecture used in developing distributed system.**(13M) BTL 4 **Answer: Page 450 - 456 -** Abraham Silberschatz • Presentation layer (4M) • Application layer (3M) • Database layer (3M) • Sever layer (3M)
	PART C
1	**Explain various indexing and ranking technique.(15M)** BTL 3 **Answer: Page 490 - 496 -** Abraham Silberschatz • Stemming (3M) • Inverted index (2M) • Posting file (2M) • Signature files (2M) • Signature width (2M) • TF/IDF based ranking (2M) • Similarity based ranking (2M)
2	**Write a on the ODMG object model.(15M)**BTL 2 **Answer: Page 500 - 506 -** Abraham Silberschatz • Objects: state, behavior, identifier, name, lifetime, structure. (3M)

	• Literals : collection and structural literals (3M) • Atomic objects : atomic objects (3M) • Interface (2M) • Inheritance: interface inheritance (2M) • Extents (2M)
3	**Discuss the spatial database in detail.(15M)**BTL 4 **Answer: Page 510 - 516 -** Abraham Silberschatz • Spatial data model (2M) • Elements (2M) • Geometry (2M) • Layer (2M) • Spatial query (2M) • Range query (2M) • Nearest neighbor query (2M) • Spatial join query (1M)

CS8451 DESIGN AND ANALYSIS OF ALGORITHMS L T P C

3 0 0 3

OBJECTIVES:

- To understand and apply the algorithm analysis techniques.
- To critically analyze the efficiency of alternative algorithmic solutions for the same problem
- To understand different algorithm design techniques.
- To understand the limitations of Algorithmic power.

UNIT I INTRODUCTION 9

Notion of an Algorithm – Fundamentals of Algorithmic Problem Solving – Important Problem Types – Fundamentals of the Analysis of Algorithmic Efficiency –Asymptotic Notations and their properties. Analysis Framework – Empirical analysis – Mathematical analysis for Recursive and Non-recursive algorithms – Visualization

UNIT II BRUTE FORCE AND DIVIDE-AND-CONQUER 9

Brute Force – Computing an – String Matching – Closest-Pair and Convex-Hull Problems – Exhaustive Search – Travelling Salesman Problem – Knapsack Problem – Assignment problem. Divide and Conquer Methodology – Binary Search – Merge sort – Quick sort – Heap Sort – Multiplication of Large Integers – Closest-Pair and Convex – Hull Problems.

UNIT III DYNAMIC PROGRAMMING AND GREEDY TECHNIQUE 9

Dynamic programming – Principle of optimality – Coin changing problem, Computing a Binomial Coefficient – Floyd ‘s algorithm – Multi stage graph – Optimal Binary Search Trees – Knapsack Problem and Memory functions. Greedy Technique – Container loading problem – Prim ‘s algorithm and Kruskal’s Algorithm – 0/1 Knapsack problem, Optimal Merge pattern – Huffman Trees.

UNIT IV ITERATIVE IMPROVEMENT 9

The Simplex Method – The Maximum-Flow Problem – Maximum Matching in Bipartite Graphs, Stable marriage Problem.

UNIT V COPING WITH THE LIMITATIONS OF ALGORITHM POWER 9

Lower – Bound Arguments – P, NP NP- Complete and NP Hard Problems. Backtracking – n-Queen problem – Hamiltonian Circuit Problem – Subset Sum Problem. Branch and Bound – LIFO Search and FIFO search – Assignment problem – Knapsack Problem – Travelling Salesman Problem – Approximation Algorithms for NP-Hard Problems – Travelling Salesman problem – Knapsack problem.

TOTAL: 45 PERIODS

OUTCOMES:

At the end of the course, the students should be able to:

- Design algorithms for various computing problems.
- Analyze the time and space complexity of algorithms.
- Critically analyze the different algorithm design techniques for a given problem.
- Modify existing algorithms to improve efficiency.

TEXT BOOKS:

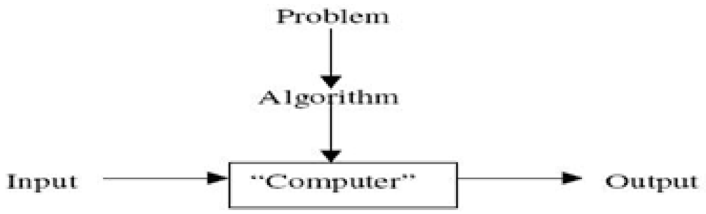
1. Anany Levitin, ―Introduction to the Design and Analysis of Algorithms‖, Third Edition, Pearson Education, 2012.
2. Ellis Horowitz, Sartaj Sahni and Sanguthevar Rajasekaran, Computer Algorithms/ C++, Second Edition, Universities Press, 2007.

REFERENCES:

1. Thomas H. Cormen, Charles E.Leiserson, Ronald L. Rivest and Clifford Stein, ―Introduction to Algorithms‖, Third Edition, PHI Learning Private Limited, 2012.
2. Alfred V. Aho, John E. Hopcroft and Jeffrey D. Ullman, ―Data Structures and Algorithms‖, Pearson Education, Reprint 2006.
3. Harsh Bhasin, ―Algorithms Design and Analysis‖, Oxford university press, 2016.
4. S. Sridhar, ―Design and Analysis of Algorithms‖, Oxford university press, 2014.

Subject Code: CS8451 Subject Name – Design and Analysis of Algorithms

Subject Handler: Mr.S.Sudha Mercy Sem / Year: IV/Second Year

UNIT I –INTRODUCTION	
Notion of an Algorithm – Fundamentals of Algorithmic Problem Solving – Important Problem Types – Fundamentals of the Analysis of Algorithmic Efficiency –Asymptotic Notations and their properties. Analysis Framework – Empirical analysis – Mathematical analysis for Recursive and Non-recursive algorithms – Visualization	
Q.NO	**PART A**
1.	**What is the need of studying algorithms?** BTL1 From a practical standpoint, a standard set of algorithms from different areas of computing must be known, in addition to be able to design them and analyze their efficiencies. From a theoretical standpoint the study of algorithms is the cornerstone of computer science.
2.	**What is an algorithm? (May/June 2017)**BTL1 An algorithm is a sequence of unambiguous instructions for solving a problem, i.e., for obtaining a required output for any legitimate input in finite amount of time. An algorithm is step by step procedure to solve a problem.
3.	**Give the diagram representation of Notion of algorithm.** BTL2 
4.	**What is the formula used in Euclid's algorithm for finding the greatest common divisor of two numbers?(May/June 2016, May/June 2017)**BTL1 Euclid 's algorithm is based on repeatedly applying the equality Gcd(m, n)=gcd (n,m mod n) until m mod n is equal to 0, since gcd(m,0) =m.
5.	**List the three different algorithms used to find the gcd of two numbers.** BTL1 The three algorithms used to find the gcd of two numbers are • Euclid 's algorithm • Consecutive integer checking algorithm • Middle school procedure
6.	**Show the fundamental steps involved in algorithmic problem solving.**BTL2 The fundamental steps are: • Understanding the problem • Ascertain the capabilities of computational device • Choose between exact and approximate problem solving

	• Decide on appropriate data structures • Algorithm design techniques • Methods for specifying the algorithm • Proving an algorithms correctness • Analyzing an algorithm.
7.	**What is an algorithm design technique?** BTL 1 An algorithm design technique is a general approach to solving problems algorithmically that is applicable to a variety of problems from different areas of computing.
8.	**What is pseudocode?** BTL1 A pseudocode is a mixture of a natural language and programming language constructs to specify an algorithm. A pseudocode is more precise than a natural language and its usage often yields more concise algorithm descriptions.
9.	**List the types of algorithm efficiencies.**BTL1 The algorithm efficiencies: *Time efficiency:* indicates how fast the algorithm runs *Space efficiency:* indicates how much extra memory the algorithm needs
10.	**List some of the important problem types.** BTL1 • Sorting • Searching • String processing • Graph problems • Combinatorial problems • Geometric problems • Numerical problems
11.	**What are the classical geometric problems?** BTL1 *The closest pair problem:* given n points in a plane find the closest pair among them *The convex hull problem:* find the smallest convex polygon that would include all the points of agiven set.

12.	**List the steps involved in the analysis framework?** BTL1 • Measuring the input ‘s size • Units for measuring running time • Orders of growth • Worst case, best case and average case efficiencies
13.	**What do you mean by worst case efficiency of an algorithm? (Nov/Dec 2017)**BTL1 The **worst-case complexity of an algorithm** should be contrasted with its average-**case complexity**, which is an average measure of the amount of resources the **algorithm** uses on a random input.
14.	**Define O-notation, Ω-notation, θ notations. (May/June 2012)**BTL1 A function t(n) is said to be in O(g(n)), denoted by t(n) ε O(g(n)), if t(n) is bounded above by some constant multiple of g(n) for all large n, i.e., if there exists some positive constant c and some non-negative integer n_0 such that T (n) <=cg (n) for all n >= n_0 A function t(n) is said to be in θ (g(n)), denoted by t(n) ε θ (g(n)), if t(n) is bounded both above & below by some constant multiple of g(n) for all large n, i.e., if there exists some positive constants c1 & c2 and some nonnegative integer n0 such that c_2g (n) <= t (n) <= c_1g (n) for all n >= n0 A function t(n) is said to be in Ω (g(n)), denoted by t(n) ε Ω (g(n)), if t(n) is bounded below by some constant multiple of g(n) for all large n, i.e., if there exists some positive constant c and some non-negative integer n_0 such that T (n) >=cg (n) for all n >=n_0
15.	**Mention the useful property, which can be applied to the asymptotic notations and its use?** BTL1 If $t_1(n)$ ε $O(g_1(n))$ and $t_2(n)$ ε $O(g_2(n))$ then $t_1(n)+t_2(n)$ ε max {$g_1(n)$, $g_2(n)$} this property is also true for Ω and θ notations. This property will be useful in analyzing algorithms that comprise of two consecutive executable parts.
16.	**What is average case efficiency?(May/June 2014)** BTL1 The average case efficiency of an algorithm is its efficiency for an average case input of size n. It provides information about an algorithm behavior on a ―typical‖ or ―random‖ input.
17.	**What is amortized efficiency?** BTL1 In some situations a single operation can be expensive, but the total time for the entire sequence of n such operations is always significantly better that the worst case efficiency of that single operation multiplied by n. this is called amortized efficiency.
18.	**What are the basic asymptotic efficiency classes?**BTL1 The basic efficiency classes are: Constant: 1 Logarithmic: log n Linear: n N-log-n: nlog n Quadratic: n2 Cubic: n3 Exponential: 2n Factorial : n!
19.	**What is algorithm visualization?** BTL1 Algorithm visualization is a way to study algorithms. It is defined as the use of images to convey some useful information about algorithms. That information can be a visual illustration of algorithm‘s operation, of its performance on different kinds of inputs, or of its execution speed versus that of other algorithms for the same problem.

20. **What are the two variations of algorithm visualization?** BTL1

The two principal variations of algorithm visualization‖. Static *algorithm visualization*: It shows the algorithm 's progress through a series of still images. *Dynamic algorithm visualization*: Algorithm animation shows a continuous movie like presentation of algorithms operation,

PART B

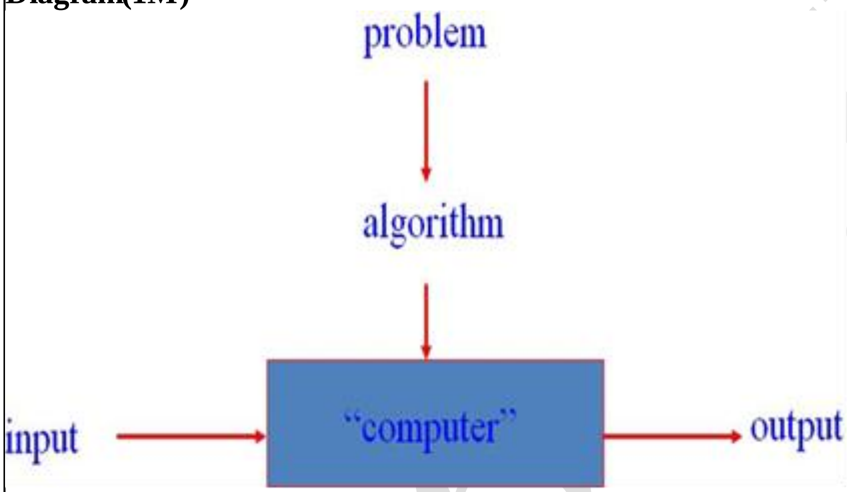
1 **Explain about algorithm with suitable example (Notion of algorithm). (13M)**BTL4

Definition (2M)

An algorithm is a sequence of unambiguous instructions for solving a computational problem, i.e., for obtaining a required output for any legitimate input in a finite amount of time.

Answer: Page : 1-12 - Technical Publications

Diagram(1M)



Algorithms – Computing the Greatest Common Divisor of Two Integers (gcd (m, n): the largest integer that divides both m and n.) **(5M)**

Euclid's algorithm: gcd (m, n) = gcd (n, m mod n)

Step1: If n = 0, return the value of m as the answer and stop; otherwise, proceed to Step 2.

Step2: Divide m by n and assign the value of the remainder to r.

Step 3: Assign the value of n to m and the value of r to n. Go to Step 1.

```
Algorithm Euclid (m, n)
//Computes gcd (m, n) by Euclid 's algorithm
//Input: Two nonnegative, not-both-zero integers m and n
//Output: Greatest common divisor of m and n
while n ≠ 0 do
        r ← m mod n
        m ← n
        n ← r
return m
```

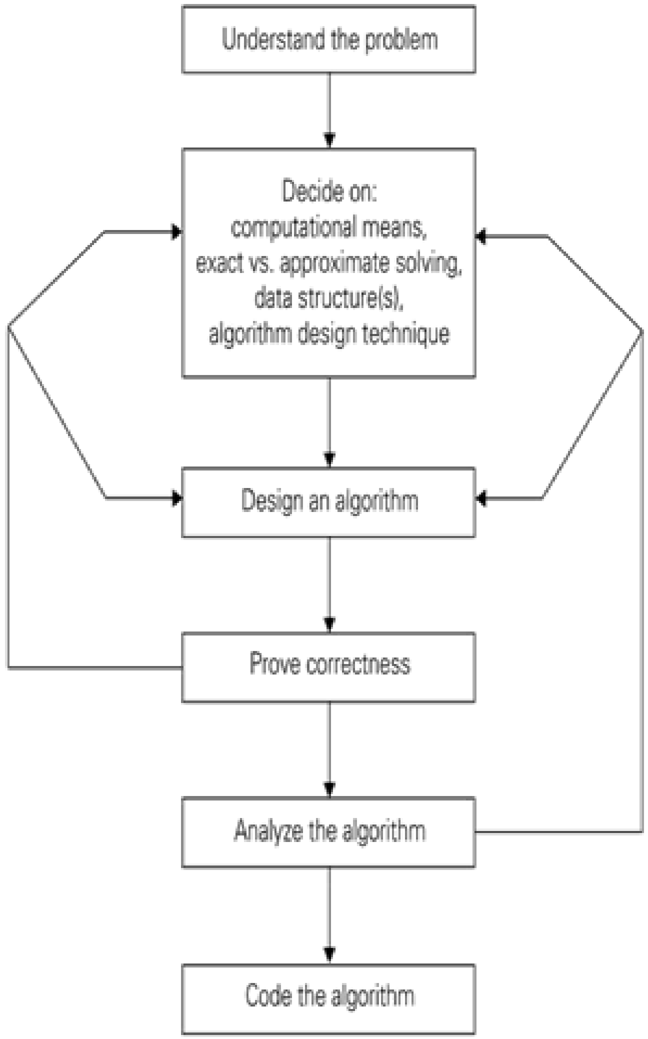
Consecutive Integer Algorithm (3M)

Step1: Assign the value of min {m, n} to t.

Step2: Divide m by t. If the remainder of this division is 0, go to Step3; otherwise, go to Step 4.

Step3: Divide n by t. If the remainder of this division is 0, return the value of t as the answer and stop; otherwise, proceed to Step4.

	Middle-school procedure (2M) Step1: Find the prime factors of m. Step2: Find the prime factors of n. Step3: Identify all the common factors in the two prime expansions found in Step1 and Step2. (If p is a common factor occurring Pm and Pn times in m and n, respectively, it should be repeated in min {Pm, Pn} times.) Step4: Compute the product of all the common factors and return it as the gcd of the numbers given.
2	**Write short note on Fundamentals of Algorithmic Problem Solving . (13M)[APRIL/MAY 2019]** BTL3 **Answer: Page : 1-12 - Technical Publications** **Explanation(10M)** • Understanding the problem(1M) • Deciding on Exact vs. approximate problem solving(2M) • Appropriate data structure(1M) • Design an algorithm(2M) • Proving correctness(2M) • Analyzing an algorithm(2M) **Diagram of Fundamentals of Algorithmic Problem Solving (3M)**



Time efficiency: how fast the algorithm runs
Space efficiency: how much extra memory the algorithm need Coding an algorithm

3 **Discuss important problem types that you face during Algorithm Analysis. (13M)** BTL2

Answer: Page : 1-18- Technical Publications

<u>Problem Types</u>

- **Sorting**
- **Searching**
- **String Processing**
- **Graph Problems**

SORTING(4M)
Rearrange the items of a given list in ascending order.
Input: A sequence of n numbers <a1, a2, …, an>

	Output: A reordering <a´1, a´2, …, a's> of the input sequence such that a´1≤a´2 ≤… ≤a's. A specially chosen piece of information used to guide sorting. I.e., sort student records by names. **Examples of sorting algorithms** Selection sort Bubble sort Insertion sort Merge sort Heap sort. Stability: A sorting algorithm is called stable if it preserves the relative order of any two equal elements in its input. In place: A sorting algorithm is in place if it does not require extra memory, except, possibly for a few memory units. **SEARCHING (3M)** Find a given value, called a search key, in a given set. Examples of searching algorithms Sequential searching Binary searching. **STRING PROCESSING (3M)** A string is a sequence of characters from an alphabet. Text strings: letters, numbers, and special characters. String matching: searching for a given word/pattern in a text. **GRAPH PROBLEMS (3M)** A graph is a collection of points called vertices, some of which are connected by line segments called edges. Modeling real-life problems Modeling WWW communication networks Project scheduling.
4	**Discuss Fundamentals of the analysis of algorithm efficiency elaborately[APRIL/MAY 2019]. (13M) (Nov/Dec 2017).** BTL2 **Answer: Page : 1-21- Technical Publications** **Definition(2M)** Analysis of algorithms means to investigate an algorithm's efficiency with respect to resources: running time and memory space. Time efficiency: how fast an algorithm runs. Space efficiency: the space an algorithm requires. • Measuring an input 's size • Measuring running time • Orders of growth (of the algorithm 's efficiency function) • Worst-base, best-case and average efficiency **Measuring Input Sizes (3M)** Efficiency is defined as a function of input size. Input size depends on the problem. Example 1: what is the input size of the problem of sorting n numbers? Example 2: what is the input size of adding two n by n matrices?

Units for Measuring Running Time(3M)

Measure the running time using standard unit of time measurements, such as seconds, minutes

Depends on the speed of the computer.

count the number of times each of an algorithm 's operations are executed.

count the number of times an algorithm 's basic operation is executed.

Basic operation: the most important operation of the algorithm, the operation contributing the most to the total running time.

For example, the basic operation is usually the most time-consuming operation in the algorithm 's innermost loop.

Orders of Growth(2M)

consider only the leading term of a formula

Ignore the constant coefficient.

Worst-Case, Best-Case, and Average-Case Efficiency (3M)

Algorithm efficiency depends on the input size n

For some algorithm's efficiency depends on type of input.

Example: Sequential Search

5 **Explain the Asymptotic Notations and properties.[APRIL/MAY 2019][NOV/DEC 2020](Nov/Dec 2019 (13M) (May/June 2016 May/June 2017)** BTL3

Answer: Page : 1-27 - Technical Publications

Three notations used to compare orders of growth of an algorithm 's basic operation count:

a. $O(g(n))$: class of functions $f(n)$ that grow *no faster* than $g(n)$ **(4M)**

b.$\Omega(g(n))$: class of functions $f(n)$ that grow *at least as fast* as $g(n)$**(3M)**

c.Θ (g(n)): class of functions f(n) that grow at same rate as g(n)**(3M)**

Property[3M]

6 **List out the Steps in Mathematical Analysis of non-recursive Algorithms and recursive algorithms. (13M)(Nov/Dec 2017 May/June 2014) (Nov/Dec 2019).** BTL4

Answer: Page : 1-66 and 1-80- Technical Publications

Non-Recursive Algorithms (6M)

```
MaxElement (A [0...n-1])
//Determines the value of the largest element in a given array
//Input: An array A[0...n-1] of real numbers //Output: The value
of the largest element in A
maxvalA [0]
for i 1 to n-1 do
if A[i] >maxval
maxval A[i]
return maxval
```

Recursive Algorithms(7M)

Decide on parameter *n* indicating *input size*

Identify algorithm 's *basic operation*

Determine *worst*, *average*, and *best* case for input of size *n*

Set up a recurrence relation and initial condition(s) for $C(n)$-the number of times the basic operation will be executed for an input of size n (alternatively count recursive calls)
Solve the recurrence or estimate the order of magnitude of the solution

$$F(n) = \begin{cases} 1 & \text{if } n = 0 \\ n * (n-1) * (n-2) \ldots 3 * 2 * 1 & \text{if } n > 0 \end{cases}$$

Recursive definition

$$F(n) = \begin{cases} 1 & \text{if } n = 0 \\ n * F(n-1) & \text{if } n > 0 \end{cases}$$

Algorithm(6m)

Algorithm

```
F(n)
if n=0
    return 1
else
    return F (n -1) * n
```

PART C

1 **Describe in detail about linear search. (15M) (Nov/Dec 2013).** BTL3

Answer: Page : 1-60 - Technical Publications

Definition(2M)

Sequential Search searches for the key value in the given set of items sequentially and returns the position of the key value else returns -1.

Algorithm of linear search(7M)

Time Complexity analysis(6M)

Average Case Analysis:

$$\begin{aligned} C_{avg}(n) &= [1 \cdot \frac{p}{n} + 2 \cdot \frac{p}{n} + \cdots + i \cdot \frac{p}{n} + \cdots + n \cdot \frac{p}{n}] + n \cdot (1 - p) \\ &= \frac{p}{n}[1 + 2 + \cdots + i + \cdots + n] + n(1 - p) \\ &= \frac{p}{n}\frac{n(n+1)}{2} + n(1 - p) = \frac{p(n+1)}{2} + n(1 - p). \end{aligned}$$

the average number of key comparisons will be n because the algorithm will inspect all n elements on all such inputs.

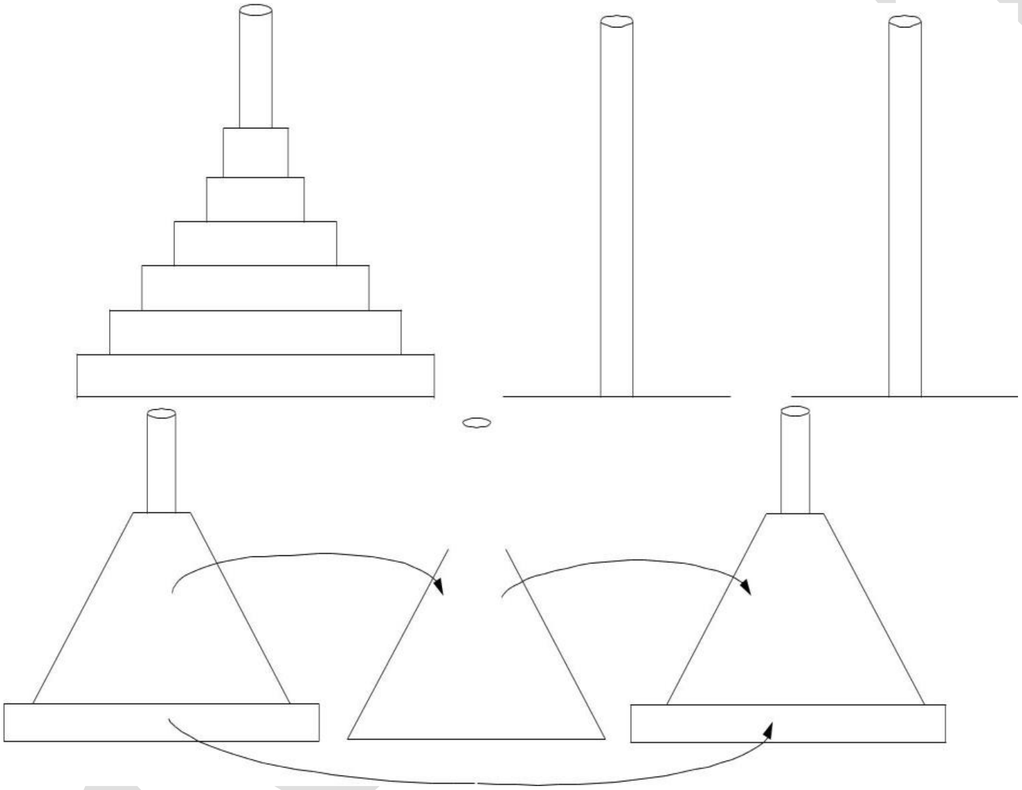
2 **Explain in detail about Tower of Hanoi.(15M) (May/June 2014).** BTL3

Explanation(7M)

In this puzzle, there are *n* disks of different sizes and three pegs. Initially, all the disks are on the first peg in order of size, the largest on the bottom and the smallest on top.
The goal is to move all the disks to the third peg, using the second one as an auxiliary, if necessary.

Answer: Page : 1-66 - Technical Publications

Diagram(4M)



The number of disks *n* is the obvious choice for the input's size indicator, and so is moving one disk as the algorithm's basic operation. Clearly, the number of moves *M(n)* depends on *n* only, and we get the following recurrence equation for it:

$$M(n) = M(n-1) +1+M(n-1)$$

With the obvious initial condition M (1) = 1, the recurrence relation for the number of moves M(n) is:

$$M(n) = 2M (n- 1) + 1 \text{ for } n> 1, M (1) = 1.$$

The total number of calls made by the Tower of Hanoi algorithm: ***n-1***

Time Complexity Analysis(4m)

$$C(n) = \sum_{i=0}^{n-1} 2^i$$

= 2n-1

UNIT 2- BRUTE FORCE AND DIVIDE-AND-CONQUER

Brute Force – Computing an – String Matching – Closest-Pair and Convex-Hull Problems – Exhaustive Search – Travelling Salesman Problem – Knapsack Problem – Assignment problem. Divide and Conquer Methodology – Binary Search – Merge sort – Quick sort – Heap Sort – Multiplication of Large Integers – Closest-Pair and Convex – Hull Problems.

PART A

1 **What is brute force algorithm?** BTL1

A straightforward approach, usually based directly on the problem‘s statement and definitions of the concepts involved.

2 **List the strength and weakness of Brute Force Algorithm.** BTL1

Strength

- wide applicability,
- simplicity
- yields reasonable algorithms for some important problems (e.g., matrix multiplication, sorting, searching, string matching)

Weakness:

- rarely yields efficient algorithms
- some brute-force algorithms are unacceptably slow not as constructive as some other design techniques

3 **Define exhaustive search.** BTL1

A brute force solution to a problem involving search for an element with a special property, usually among combinatorial objects such as permutations, combinations, or subsets of a set.

4 **Give the general plan of exhaustive search Method.** BTL2

- Generate a list of all potential solutions to the problem in a systematic manner.
- evaluate potential solutions one by one, disqualifying infeasible ones.
- For an optimization problem, keeping track of the best one found so far when search ends, announce the solution(s) found

5 **Give the general plan for divide-and-conquer algorithms. (Nov/Dec 2017 May/June 2016).** BTL2

- A problems instance is divided into several smaller instances of the same problem, ideally about the same size
- The smaller instances are solved, typically recursively
- If necessary the solutions obtained are combined to get the solution of the original problem Given a function to compute on _inputs the divide-and-conquer strategy suggests splitting the inputs in to ‘k ‘distinctsubsets, 1<k <n, yielding _k ‘sub problems. The sub problems must be solved, and then a method must be found to combine sub solutions into a solution of the whole. If the sub problems are still relatively large, then the divide-and conquer strategy can possibly be reapplied.

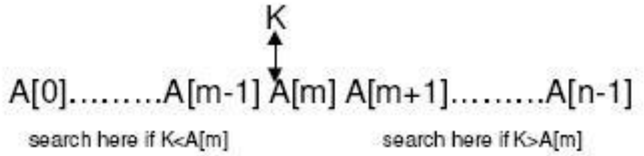
6 **List the advantages of Divide and Conquer Algorithm. BTL**1

Solving difficult problems, Algorithm efficiency, Parallelism, Memory access, Round off control.

7 **Define of feasibility.** BTL1

A feasible set (of candidates) is promising if it can be extended to produce not merely a

	solution, but an optimal solution to the problem.
8	**Define Hamiltonian circuit.**BTL1 A Hamiltonian circuit is defined as a cycle that passes through all the vertices of the graph exactly once.
9	**State the Master theorem and its use [APRIL/MAY 2019].**BTL2 If f(n) θ(n^d) where d ³ 0 in recurrence equation T(n) = aT(n/b)+f(n), then (n^d) if a<b^d T(n) θ (n^dlog n) if a=b^d (nlogb^a) if a>b^d The efficiency analysis of many divide-and-conquer algorithms is greatly simplified by the use of Master theorem.
10	**What is the general divide-and-conquer recurrence relation?** BTL1 An instance of size n can be divided into several instances of size n/b, with a of them needing to be solved. Assuming that size n is a power of b, to simplify the analysis, the following recurrence for the running time is obtained: T(n) = aT(n/b)+f(n) Where f(n) is a function that accounts for the time spent on dividing the problem into smaller ones and on combining their solutions.
11	**Define merge sort and its time and space complexity [APRIL/MAY 2019].**BTL1 Merge sort sorts a given array A[0..n-1] by dividing it into two halves a[0..(n/2)-1] and A[n/2..n-1] sorting each of them recursively and then merging the two smaller sorted arrays into a single sorted array. Time complexity O(nlogn) Space Complexity O(nlogn)
12	**List the Steps in Merge Sort.** BTL1 a. **Divide Step:** If given array A has zero or one element, return S; it is already sorted. Otherwise, divide A into two arrays, A1 and A2, each containing about half of the elements of A. b. **Recursion Step:** Recursively sort array A1 and A2. **Conquer Step:** Combine the elements back in A by merging the sorted arrays A1 and A2
13	**List out Disadvantages of Divide and Conquer Algorithm.**BTL1 • Conceptual difficulty • Recursion overhead • Repeated sub problems
14	**Define Quick Sort.** BTL1 Quick sort is an algorithm of choice in many situations because it is not difficult to implement, it is a good \"general purpose\" sort and it consumes relatively fewer resources during execution.
15	**List out the Advantages in Quick Sort.** BTL1 • It is in-place since it uses only a small auxiliary stack. • It requires only n log(n) time to sort n items. • It has an extremely short inner loop • This algorithm has been subjected to a thorough mathematical analysis, a very precise statement can be made about performance issues.
16	**List out the Disadvantages in Quick Sort.** BTL1 a. It is recursive. Especially if recursion is not available, the implementation is extremely complicated.

	b. It requires quadratic (i.e., n2) time in the worst-case. c. It is fragile i.e., a simple mistake in the implementation can go unnoticed and cause it to perform badly.
17	**What is the difference between quicksort and merge sort?** BTL1 Both quicksort and merge sort use the divide-and-conquer technique in which the given array is partitioned into subarrays and solved. The difference lies in the technique that the arrays are partitioned. For merge sort the arrays are partitioned according to their position and in quicksort they are partitioned according to the element values.
18	**What is binary search?** BTL1 Binary search is a remarkably efficient algorithm for searching in a sorted array. It works by comparing a search key K with the arrays middle element A[m]. If they match the algorithm stops; otherwise the same operation is repeated recursively for the first half of the array if K < A[m] and the second half if K > A[m]. 
19	**List out the 4 steps in Strassen's Method.** BTL1 • Divide the input matrices A and B into n/2 * n/2 submatrices, as in equation (1). • Using Θ(n2) scalar additions and subtractions, compute 14 n/2 * n/2 matrices A1, B1, A2, B2, …, A7, B7. • Recursively compute the seven matrix products Pi =AiBi for i =1, 2, 7. • Compute the desired submatrices r, s, t, u of the result matrix C by adding and/or subtracting various combinations of the Pi matrices, using only Θ(n2) scalar additions and subtractions
	PART B
1	**Explain n briefly about Divide and Conquer Method. (13M)** BTL3 **Answer: Page : 2-20 - Technical Publications** **Definition(2M)** • The most well-known algorithm design strategy is Divide and Conquer Method. It • Divide the problem into two or more smaller sub problems. • Conquer the sub problems by solving them recursively. • Combine the solutions to the sub problems into the solutions for the original problem. **Explanation(11M)** **Divide and Conquer Examples** Sorting: merge sort and quicksort**(4M)** binary search**(4M)** Matrix Multiplication-Strassen 's algorithm**(3M)**
2	**Explain Merge Sort with suitable example. (13M). (Nov/Dec 2017May/June 2014) (May/June 2019) BTL3** **Answer: Page : 2-52 - Technical Publications** **Definition(2M)**

Example for merge sort(4M)

Merge sort sorts a given array A[0...n-1] by dividing it into two halves a[0.(n/2)-1] and A[n/2..n-1] sorting each of them recursively and then merging the two smaller sorted arrays into a single sorted one.

Algorithm for merge sort(5M)

Time complexity(2M)

3 **Discuss Quick Sort. (13M) (May/June 2019).** BTL2

Answer: Page : 2-67 - Technical Publications

Quick Sort definition(2M)

Quick sort is an algorithm of choice in many situations because it is not difficult to implement, it is a good \"general purpose\" sort and it consumes relatively fewer resources during execution.

Explanation with Algorithm (11m)

ALGORITHM Quicksort(A[l..r])

```
        //Sorts a subarray by quicksort
        //Input: A subarray A [l... r] of A [0...n-1], defined by its left and right
        indices l and r
        //Output: The subarray A [l... r]
        sorted in no decreasing order if l <r
            s <- Partition (A [l... r]) // s is a split position
            Quicksort (A [l... s-1])
            Quicksort (A [s+1...r]
```

ALGORITHM Partition (A [l ...r])

```
        //Partitions a subarray by using its first element as a pivot
        //Input: A subarray A [l... r] of A [0...n-1], defined by its left and right
        indices l and r (l < r)
        //Output: A partition of A [l... r], with the split position
        returned as this function 's value P  A[l]
        i<-l; j<-r + 1;
        Repeat
            repeat i<-i + 1 until A[i]>=p //left-right scan
            repeat j <-j – 1 until A[j] <= p//right-left scan
            if (i< j)                    //need to continue with the scan
                swap(A[i], a[j])
        until i>= j               //no need to scan
        swap(A[l], A[j])
            return j
```

5

Explain Binary Search. (13M) (Nov/Dec 2016) (April/May 2019). BTL3

Answer: Page : 2-24 - Technical Publications

Definition(2M)

Definition: Search a *sorted array* by repeatedly dividing the search interval in half.

Begin with an interval covering the whole array. If the value of the search *key* is less than the item in the middle of the interval, narrow the interval to the lower half. Otherwise narrow it to the upper half. Repeatedly check until the value is found or the interval is empty.

Algorithm with example(9M)

Algorithm:

```
function binary search (A, n, T):
L: = 0
R: = n − 1
while L <= R:
m: =floor ((L + R) / 2)
if A[m] < T:
L: = m + 1
else if A[m] > T:
R: = m - 1
else:
return m
return unsuccessful
```

Time complexity(2m)

Time complexity:

T(N) = O(log(N))

6 **Explain Strassen's Algorithm. (13M) (May/June 2016).** BTL3

Answer: Page : 2-81 - Technical Publications

Definition:

Strassen's Matrix multiplication can be performed only on **square matrices** where **n** is a **power of 2**. Order of both of the matrices are **n × n**.

Algorithm Explanation with example(9M)

Strassen's Algorithm:

M1: =(A+C) ×(E+F) M1: =(A+C) ×(E+F)
M2: =(B+D) ×(G+H) M2: =(B+D) ×(G+H)
M3: =(A−D) ×(E+H) M3: =(A−D) ×(E+H)
M4: =A×(F−H) M4: =A×(F−H)
M5: =(C+D) ×(E)M5: =(C+D) ×(E)
M6: =(A+B) ×(H)M6: =(A+B) ×(H)
M7: =D×(G−E) M7: =D×(G−E)

Then,

I: =M2+M3−M6−M7I: =M2+M3−M6−M7
J: =M4+M6J: =M4+M6
K: =M5+M7K: =M5+M7
L: =M1−M3−M4−M5L: =M1−M3−M4−M5

Time complexity analysis(2M)

PART C

1 **Explain in detail about Travelling Salesman Problem using exhaustive search. (15M) (Nov/Dec 2019)**BTL2.

Answer: Page : 2-16 - Technical Publications

Traveling Salesman Problem (TSP)2M

- Find the shortest tour through a given set of n cities that visits each city exactly once before returning to the city where it started
- Can be conveniently modeled by a weighted graph; vertices are cities and edge weights are distances

Algorithm Explanation with example(8m)

Algorithm: Traveling-Salesman-Problem

```
C ({1}, 1) = 0
for s = 2 to n do
  for all subsets S Є {1, 2, 3, …, n} of size s and containing 1
    C (S, 1) = ∞
  for all j Є S and j ≠ 1
    C (S, j) = min {C (S – {j}, i) + d (i, j) for i Є S and i ≠ j}
Return min C ({1, 2, 3, …, n}, j) + d (j, i)
```

Time complexity analysis(3M)

Time complexity Analysis:

There are at the most 2^n. n sub-problems and each one takes linear time to solve. Therefore, the total running time is O (2^n. n^2) O (2^n. n^2).

2 **Explain in detail about Knapsack problem. (15M)(May/June 2014).** BTL3

Knapsack Problem(2M)

Answer: Page : 2-17 - Technical Publications

Given a set of items, each with a weight and a value, determine a subset of items to include in a collection so that the total weight is less than or equal to a given limit and the total value is as large as possible.

Algorithm Explanation with example(10m)

Algorithm: Greedy-Fractional-Knapsack (w [1...n], p [1...n], W)

```
for i = 1 to n
  do x[i] = 0
weight = 0
for i = 1 to n
```

```
  if weight + w[i] ≤ W then
    x[i] = 1
    weight = weight + w[i]
  else
    x[i] = (W - weight) / w[i]
    weight = W
    break
return x
```

Time complexity analysis(3m)

Efficiency: $\Omega(2^n)$

3

Explain in detail about closest pair problem. (15M) (Nov/Dec 2017)(Nov/Dec 2019). BTL3

Answer: Page : 2-18 - Technical Publications

Definition(2m)

The brute force algorithm checks the distance between every pair of points and keep track of the min. The cost is $O(n(n-1)/2)$, quadratic.

Algorithm Explanation with example(10M)

Algorithm Closest Pair

- Initially sort the n points, $P_i = (x_i, y_i)$ by their x dimensions.

- Then recursively divide the n points, $S_1 = \{P_1 \ldots, P_{n/2}\}$ and $S_2 = \{P_{n/2+1} \ldots, P_n\}$
- so that S_1 points are two the left of $x = x_{n/2}$ and S_2 are to the right of $x = x_{n/2}$.

- Recursively find the closest pair in each set, d_1 of S_1 and d_2 for S_2, $d = \min(d_1, d_2)$.

- We must check all the S_1 points lying in this strip to every S_2 points in the strip, and get closest distance $d_{between}$

- To efficiently do the above, need to sort the points along the y dimensions, using a merge sort approach.

- Then the minimum distance is minimum distance is $\min(d, d_{between})$

Time complexity analysis (3M)

Efficiency: Θ(n^2)

UNIT 3 DYNAMIC PROGRAMMING AND GREEDY TECHNIQUE

Dynamic programming – Principle of optimality – Coin changing problem, Computing a Binomial Coefficient – Floyd ‘s algorithm – Multi stage graph – Optimal Binary Search Trees – Knapsack Problem and Memory functions. Greedy Technique – Container loading problem – Prim ‘s algorithm and Kruskal’s Algorithm – 0/1 Knapsack problem, Optimal Merge pattern – Huffman Trees.

PART A

1 **Define dynamic programming.(May/June 2017).** BTL1

Dynamic programming is an algorithm design method that can be used when a solution to the problem is viewed as the result of sequence of decisions.

Dynamic programming is a technique for solving problems with overlapping sub problems. These sub problems arise from a recurrence relating a solution to a given problem with solutions to its smaller sub problems only once and recording the results in a table from which the solution to the original problem is obtained. It was invented by a prominent U.S Mathematician, Richard Bellman in the 1950s.

2 **What are the features of dynamic programming?(May/June 2014).** BTL1

- Optimal solutions to sub problems are retained so as to avoid recomputing their values.
- Decision sequences containing subsequences that are sub optimal are not considered.
- It definitely gives the optimal solution always.

3 **What are the drawbacks of dynamic programming?**BTL1

- Time and space requirements are high, since storage is needed for all level.
- Optimality should be checked at all levels.

4 **Write the general procedure of dynamic programming.**BTL2

The development of dynamic programming algorithm can be broken into a sequence of 4 steps. They are:

- Characterize the structure of an optimal solution.
- Recursively define the value of the optimal solution.
- Compute the value of an optimal solution in the bottom-up fashion.
- Construct an optimal solution from the computed information.

5 **Define principle of optimality.(Nov/Dec 2017 May/June 2014).** BTL1

It states that an optimal sequence of decisions has the property that whenever the initial stage or decisions must constitute an optimal sequence with regard to stage resulting from the first decision.

6 **Write the difference between the Greedy method and Dynamic programming.(May/June 2012).**BTL2

- Greedy method

Only one sequence of decision is generated.
It does not guarantee to give an optimal solution always.

- Dynamic programming

Many numbers of decisions are generated.
It definitely gives an optimal solution always

7	**What is greedy technique?**BTL1 Greedy technique suggests a greedy grab of the best alternative available in the hope that a sequence of locally optimal choices will yield a globally optimal solution to the entire problem. The choice must be made as follows Feasible: It has to satisfy the problem's constraints Locally optimal: It has to be the best local choice among all feasible choices available on that step. Irrevocable: Once made, it cannot be changed on a subsequent step of the algorithm
8	**What is the Greedy choice property?**BTL1 • The first component is greedy choice property (i.e.) a globally optimal solution can arrive at by making a locally optimal choice. • The choice made by greedy algorithm depends on choices made so far but it cannot depend on any future choices or on solution to the sub problem. • It progresses in top down fashion.
9	**List the steps required to develop a greedy algorithm.(May/June 2017).** BTL1 • Determine the optimal substructure of the problem. • Develop a recursive solution. • Prove that at any stage of recursion one of the optimal choices is greedy choice. Thus it is always safe to make greedy choice. • Show that all but one of the sub problems induced by having made the greedy choice are empty. • Develop a recursive algorithm and convert into iterative algorithm.
10	**What are the labels in Prim's algorithm used for?**BTL1 Prim 's algorithm makes it necessary to provide each vertex not in the current tree with the information about the shortest edge connecting the vertex to a tree vertex. The information is provided by attaching two labels to a vertex. • The name of the nearest tree vertex. • The length of the corresponding edge
12	**How are the vertices not in the tree are split into?**BTL2 The vertices that are not in the tree are split into two sets: • Fringe: It contains the vertices that are not in the tree but are adjacent to at least one tree vertex. • Unseen: All other vertices of the graph are called unseen because they are yet to be affected by the algorithm.
13	**What are the operations to be done after identifying a vertex u* to be added to the tree?**BTL1 After identifying a vertex u* to be added to the tree, the following two operations need to be performed: • Move u* from the set $V-V_T$ to the set of tree vertices V_T. • For each remaining vertex u in $V-V_T$ that is connected to u* by a shorter edge than the u 's current distance label, update its labels by u* and the weight of the edge between u* and u, respectively.

14	**Give the use of Dijkstra'salgorithm.** BTL2 Dijkstra 's algorithm is used to solve the single-source shortest-paths problem: for a given vertex called the source in a weighted connected graph, find the shortest path to all its other vertices. The single-source shortest-paths problem asks for a family of paths, each leading from the source to a different vertex in the graph, though some paths may have edges in common.
15	**Define Spanning tree.**BTL1 *Spanning tree* of a connected graph *G*: a connected acyclic subgraph of *G* that includes all of *G*'svertices
16	**What is minimum spanning tree?**BTL1 *Minimum spanning tree* of a weighted, connected graph *G*: a spanning tree of *G* of the minimum totalweight
17	**What does a Floyd algorithm do? (Nov/Dec 2017).** BTL1 The Floyd-Warshall algorithm works based on a property of *intermediate* vertices of a shortest path. An *intermediate* vertex for a path p = <v_1, v_2, ..., vj> is any vertex other than v_1 or v_j.
17	**What is closest pair problem? (May/June 2016 May/june 2017).** BTL1 The closest pair problem is finding the two closest points from the set of n points.

PART B

2 **Explain Kruskal's algorithm. (13M) (May/June 2014).**BTL3

Answer: Page : 3-152 - Technical Publications
Kruskal's algorithm(2M)

It is a minimum spanning tree algorithm that takes a graph as input and finds the subset of the edges of that graph which

- form a tree that includes every vertex
- It has the minimum sum of weights among all the trees that can be formed from the graph

The steps for implementing Kruskal's algorithm are as follows:

1. Sort all the edges from low weight to high
2. Take the edge with the lowest weight and add it to the spanning tree. If adding the edge created a cycle, then reject this edge.
3. Keep adding edges until we reach all vertices.

Algorithm(9M)

```
KRUSKAL(G):
A =∅
```

```
For each vertex v ∈ G.V:
    MAKE-SET(v)
For each edge (u, v)∈ G.E ordered by increasing order byweight (u, v):
if FIND-SET(u)≠ FIND-SET(v):
    A = A ∪{(u, v)}
UNION (u, v)
return A
```

Time complexity analysis(2M)

Time complexity analysis:

Kruskal's algorithm can be shown to run in O (E log E) **time**, or equivalently, O (E log V) **time**, where E is the number of edges in the graph and V is the number of vertices,

3 **Discuss Prim's Algorithm(13M) (Nov/Dec 2017).** BTL3

Answer: Page : 3-140 - Technical Publications

Definition(2M)

Prim's algorithm, in contrast with Kruskal's algorithm, treats the nodes as a single tree and keeps on adding new nodes to the spanning tree from the given graph.

Algorithm Explanation with example(9M)

Algorithm:

```
T =∅;
U ={1};
while(U ≠ V)
let(u, v) be the lowest cost edge such that u ∈ U and v ∈ V - U;
    T = T ∪{(u, v)}
    U = U ∪{v}
```

Time complexity analysis(2M)

The time complexity is O(Vlog + ElogV) = O(ElogV), making it the same as Kruskal's algorithm

4 **Write short note on Greedy Method. (13M)**BTL2

Answer: Page : 3-134 - Technical Publications

A greedy algorithm makes a locally optimal choice in the hope that this choice will lead to a globally optimal solution.**(2M)**

The choice at each step must be:

- Feasible**(1M)**
  Satisfy the problem ‘s constraints
- locally optimal**(1M)**
  Be the best local choice among all feasible choices

- Irrevocable**(1M)**
  Once made, the choice can ‘t be changed on subsequent steps.

Applications of the Greedy Strategy

- Optimal solutions**(4M)**

change making
Minimum Spanning Tree (MST)
Single-source shortest paths.
Huffman codes

- Approximations**(4M)**
  Traveling Salesman Problem (TSP)
  Knapsack problem

PART C

2

Explain how Floyd’s Algorithm works.(15M) (April/May 2019). BTL3

Answer: Page : 3-49 - Technical Publications

Definition(2M)

Floyd-Warshall Algorithm

The Floyd-Warshall algorithm works based on a property of *intermediate* vertices of a shortest path. An *intermediate* vertex for a path $p = <v_1, v_2, ..., vj>$ is any vertex other than v_1 or v_j.

Algorithm(11M)

```
Floyd (W [1...n, 1...n]) // W is the weight distances

    $D^{(0)} \leftarrow W$
    for $k \leftarrow 1$ to $n$ do // iteration through distance matrices
        for $i \leftarrow 1$ to $n$ do
            for $j \leftarrow$ to $n$ do
                $D^{(k)}[i, j] \leftarrow \min(D^{(k-1)}[i, j], (D^{(k-1)}[i, k] + D^{(k-1)}[k, j]))$
    return $D^{(n)}$
```

Time complexity analysis(2M)

Time complexity of **Floyd Warshall algorithm**. The Floyd-Warshall all-pairs shortest path runs in $O(n^3)$ time

3

Explain Memory Function algorithm for the Knapsack problem. (15M).BTL1

Answer: Page : 3-115 - Technical Publications
Definition(2M)

Memory Function algorithm for the Knapsack problem:
The technique uses a top-down approach, recursive algorithm, with table of sub-problem solution. Before determining the solution recursively, the algorithm checks if the sub problem has already been solved by checking the table. If the table has a valid value, then the algorithm uses the table value else it proceeds with the recursive solution.

Algorithm (13M)

```
Knapsack (i, j) // i, j represents the sub problem
    if V [i, j] < 0 // meaning not already calculated
        if j < Weights[i] then
            value ← Knapsack (i-1, j)
        else
            value ← max (Knapsack (i-1, j), Values[i] + Knapsack (i-1, j-Weights[i])
        V [i, j] ← value // put valid value in the table for both cases
    return V [i, j]
```

4

Explain in detail about Huffman tree. (15M)(May/June 2017) (April/May 2019). BTL2

Answer: Page : 3-175 - Technical Publications

Definition(2m)

Huffman coding tree or **Huffman tree** is a full binary tree in which each leaf of the tree corresponds to a letter in the given alphabet.

Define the weighted path length of a leaf to be its weight times its depth. The Huffman tree is the binary tree with minimum external path weight, i.e., the one with the minimum sum of weighted path lengths for the given set of leaves. So the goal is to build a tree with the minimum external path weight.

Letter frequency table

Letter	Z	K	M	C	U	D	L	E
Frequency	2	7	24	32	37	42	42	120

Huffman code

Letter	Freq	Code	Bits
E	120	0	1
D	42	101	3
L	42	110	3
U	37	100	3
C	32	1110	4
M	24	11111	5
K	7	111101	6
Z	2	111100	6

Algorithm Explanation with example(13M)

Algorithm:

```
Begin
  define a node with character, frequency, left and right child of the node forHuffman tree.
  create a list 'freq' to store frequency of each character, initially, all are 0
  for each character c in the stringdo
    increase the frequency for character ch in freq list.
  done

  for all type of character ch do
    if the frequency of ch isnon-zerothen
      add ch and its frequency as a node of priority queue Q.
  done

 while Q isnot empty do
    remove item from Q and assign it to left child of node
    remove item from Q and assign to the right child of node
    traverse the node to find the assigned code
  done
End
```

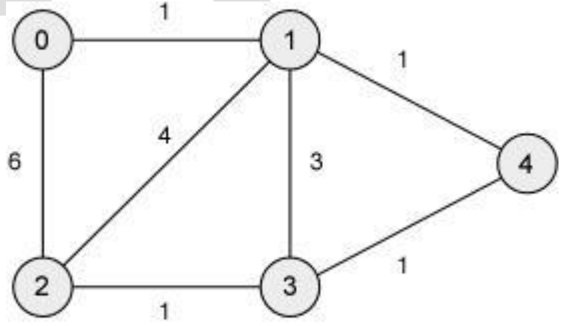
UNIT-4 ITERATIVE IMPROVEMENT

The Simplex Method – The Maximum-Flow Problem – Maximum Matching in Bipartite Graphs, Stable marriage Problem.

PART A

1	**What do you mean by optimal solution?**BTL1 Given a problem with n inputs, we obtain a subset that satisfies come constraints. Any subset that satisfies these constraints is called a feasible solution. A feasible solution, which either maximizes or minimizes a given objective function is called optimal solution. •
2	**What is feasible solution?**BTL1 It is obtained from given n inputs Subsets that satisfies some constraints are called feasible solution. It is obtained based on some constraints
3	**Compare feasible and optimal solution. (Nov/Dec 2017 May/June 2014).** BTL2 **Feasible solution** A solution (set of values for the decision variables) for which all of the constraints in the Solver model are satisfied is called a feasible solution. In some problems, a feasible solution is already known; in others, finding a feasible solution may be the hardest part of the problem. **Optimal solution** An optimal solution is a feasible solution where the objective function reaches its maximum (or minimum) value – for example, the most profit or the least cost. A globally optimal solution is one where there are no other feasible solutions with better objective function values. A locally optimal solution is one where there are no other feasible solutions "in the vicinity" with better objective function values.
4	**Recall LPP.**BTL1 *Linearprogrammingproblem* (LPP) is to optimize a linear function of several variables subject to linear constraints: Maximize (or minimize) $c_1x_1 + ...+ c_nx_n$ Subject to $a_{i1}x_1 + ... + a_{in}x_n$ ≤ (or ≥ or =)b_i, i =1,..., m $x_1 \geq 0, ... , x_n \geq 0$ The function $z = c_1x_1 + ... + c_nx_n$ is called the *objective function*; Constraints $x_1 \geq 0, ... , x_n \geq 0$ are called *nonnegativity constraints*
5	**What is Simplex Method?**BTL1 The classic method for solving Linear programming problem (LPP.One of the most important algorithms ever invented to solve LPP.Invented by George Danzig in 1947.Based on the iterative improvement idea. **Generates a sequence of adjacent points of the problem's feasible region with** improving values of the objective function until no further improvement is possible.
6	**Write the steps to solve LPP problems by Simplex Method / Procedure for Simplex Method.**BTL2 • **Step 0** [Initialization] Present a given LP problem in standard form and set upinitial tableau.

	• **Step 1** [Optimality test] If all entries in the objective row are nonnegative thenstop: the tableau represents an optimal solution. • **Step 2** [Find entering variable] Select the most negative entry in the objectiverow. Mark its column to indicate the entering variable and the **pivot column**. • **Step 3** [Find departing (leaving) variable] For each positive entry in the pivotcolumn, calculate the **θ-**ratio by dividing that row's entry in the rightmost column (solution) by its entry in the pivot column. (If there are no positive entries in the pivot column then stops: the problem is unbounded.) Find the row with the smallest **θ-**ratio, mark this row to indicate the departing variable and the **pivotrow.** • **Step 4** [Form the next tableau] Divide all the entries in the pivot row by its entryin the pivot column. Subtract from each of the other rows, including the objective row, the new pivot row multiplied by the entry in the pivot column of the row in question. Replace the label of the pivot row by the variable's name of the pivot column and go back to Step 1.
7	**Mention the time complexity of the Simplex Method.**BTL2 • Finding an initial basic feasible solution may pose a problem. • Theoretical possibility of cycling. • Typical number of iterations is between m and 3m, where m is the number of equality constraints in the standard form. Worse-case efficiency is **exponentia**l.
8	**Write the Standard form of LP problem.**BTL2 Must be a **maximization** problem All constraints (except the nonnegativity constraints) must be in the form of linear equations All the variables must be required to be nonnegative Thus, the general linear programming problem in standard form with *m* constraints and *n* unknowns ($n \geq m$) is Maximize $c_1x_1 + ... + c_nx_n$ Subject to $a_{i1}x_1 + ... + a_{in}x_n = b_i,\ i = 1,..., m,$ $x_1 \geq \mathbf{0}, ... , x_n \geq$
9	**Give the possible outcomes in solving an LP problem.**BTL2 • has a finite optimal solution, which may not be unique • *unbounded*: the objective function of maximization (minimization) LP problem isunbounded from above (below) on its feasible region • *infeasible*: there are no points satisfying all the constraints, i.e. the constraints arecontradictory
10	**Solve the LPP by algebraic geometry technique.**BTL1 Maximize: 60c + 90s Subject to 50c + 100s = 20000 (1) 100c + 40s = 19200 (2) (1)/50 => c + 2s = 400 (2)/20 => 5c + 2s = 960 (2) – (1) => 4c = 560 C= 140 Substitute c = 140 in (1) then s = 130 Profit: p = 60c + 90s = 60(140) + 90(130) = 20,100

11	**How will you calculate new pivot row and remaining rows in new iteration of simplex method?** BTL2 Pivot row: New Pivot Row = Current Pivot Row / Pivot Element All other rows including z: New Row = Current Row – (Its Pivot column coefficient)* New Pivot Row
12	**Convert the given primal problem into dual problem.** BTL3 The Primal problem Minimize $4x_1 + 2x_2 - x_3$ subject to $x_1 + x_2 + 2x_3 \geq 3$ $2x_1 - 2x_2 + 4x_3 \leq 5$ $x_1, x_2, x_3 \geq 0.$ The dual problem Maximize $3y_1 + 5y2$ subject to $y_1 + 2y_2 \leq 4$ $y_1 - 2y_2 \leq 2$ $2y_1 + 4y_2 \leq -1$ $y_1 \geq 0, y_2 \geq 0$
13	**Compare Explicit and Implicit Constraints.(May/June 2014).** BTL2 1) Explicit constraints: Explicit constraints are rules that restrict each Xi to take values only from a given set. Some examples are, Xi >0 or Si = {all non-negative real nos.} Xi =0 or 1 or Si= {0,1}. Li Xi Ui or Si= {a: Li a Ui} All tupules that satisfy the explicit constraint define a possible solution space. 2) Implicit constraints: The implicit constraint determines which of the tuples in the solution space can actually satisfy the criterion functions.
14	**Define weighted graph.**BTL2 A weighted graph is a graph in which a number (the weight) is assigned to each edge. such weights might represent for example costs, lengths or capacities, depending on the problem at hand. Some authors call such a graph a network. 
15	**Define multistage graph.**BTL1 A <u>multistage graph</u> is a graph **G= (V, E)**with**V**partitioned into**K >= 2**disjoint subsets such that if**(a, b)**is in**E**, then **a** is

	in **V_i**, and **b** is in **V_{i+1}** for some subsets in the partition; and **$\| V_1\| = \| V_K\| = 1$**. The vertex **s** in **V_1** is called the source; the vertex **t** in **V_K** is called the sink. **G** is usually assumed to be a **weighted graph**. The cost of a path from node v to node w is sum of the costs of edges in the path. The "multistage graph problem" is to find the minimum cost path from s to t.
17	**Define source and sink node of graph.**BTL1 A Flow graph contains 1 source node and 1 sink node. Source node: Unique vertex with no entering edges. Sink node: Unique vertex with no leaving edges.
18	**What is bipartite graph?(Nov/Dec 2017).**BTL1 A **bipartite graph**, also called a bigraph, is a set of **graph** vertices decomposed into two disjoint sets such that no two **graph** vertices within the same set are adjacent. A **bipartite graph** is a special case of a k-partite **graph**
19	**What is Maximum Flow Problem?** BTL1 • Problem of maximizing the flow of a material through a transportation network (e.g., pipeline system, communications or transportation networks) • Formally represented by a connected weighted digraph with *n* vertices numbered from 1 to *n* with the following properties: • contains exactly one vertex with no entering edges, called the *source* (numbered 1) • contains exactly one vertex with no leaving edges, called the *sink* (numbered *n*) • has positive integer weight u_{ij} on each directed edge (*i.j*), called the *edge capacity*, indicating the upper bound on the amount of the material that can be sent from *i* to *j* through this edge. • A digraph satisfying these properties is called a **flow network** or simply a network.
20.	**What is state space tree?(May/June 2016).** BTL2 Backtracking and branch bound are based on the construction of a state space tree, whose nodes reflect specific choices made for a solution's component. Its root represents an initial state before the search for a solution begins. The nodes of the first level the tree represent the made for the first component of solution, the nodes of the second level represent the Choices for the second components & so on
	PART B
1	**Describe stable marriage problem with example.(13M) (Nov/Dec 2017).** BTL3 **Answer: Page : 4-36 - Technical Publications** **Definition(2M)** A ***marriage matching M*** is a set of ***n (m, w)*** pairs whose members are selected from disjoint-element sets ***Y*** and ***X*** in a one-one fashion, i.e., each man ***m*** from is paired with exactly one-woman ***w*** from ***X*** and vice versa. (If we represent and ***X*** as vertices of a complete bipartite graph with edges connecting possible marriage partners, then a marriage matching is a perfect matching in such a graph.) **Algorithm and explanation(11M)**

Algorithm

```
function stable Matching {
   Initialize all m∈ M and w∈ W to free
while∃free man m who still has a woman w to propose to {
      w = first woman on m’s list to whom m has not yet proposed
if w is free
        (m, w) become engaged
else some pair (m', w) already exists
if w prefers m to m'
          m' becomes free
         (m, w) become engaged
else
         (m', w) remain engaged
   }
}
```

2 **Explain Simplex method with example. (13M) (Nov/Dec 2017 May/June 2016) (April/May 2019).** BTL3

Answer: Page : 4-2 - Technical Publications
Definition(2M)
Algorithm and explanation(11M)

The classic method for solving LP problems. Invented by George Dantzig in 1947.

- Based on the iterative improvement idea.
- Generates a sequence of adjacent points of the problem’s feasible region with improving
- values of the objective function until no further improvement is possible.

Simplex method steps

Step 0 [Initialization] Present a given LP problem in standard form and set up initial tableau.

Step 1 [Optimality test] If all entries in the objective row are nonnegative then stop: the tableau represents an optimal solution.

Step 2 [Find entering variable] Select the most negative entry in the objective row. Mark its column to indicate the entering variable and the pivot column.

Step 3 [Find departing (leaving) variable] For each positive entry in the pivot column, calculate the θ

3. **Explain Maximum Flow Problem (13M). (Nov/Dec 2016) (April/May 2019).** BTL3

Answer: Page : 4-14 - Technical Publications
Definition(2M)

Maximum Flow Problem Problem of maximizing the flow of a material through a transportation network (e.g., pipeline system, communications or transportation networks)

Formally represented by a connected weighted digraph with n vertices numbered from 1 to n with the following properties:

• Contains exactly one vertex with no entering edges, called the source (numbered 1)

- Contains exactly one vertex with no leaving edges, called the sink (numbered n)
- Has positive integer weight uij on each directed edge (i.j), called the edge capacity, indicating the upper bound on the amount of the material that can be sent from i to j through this edge.
- A digraph satisfying these properties is called a flow network or simply a network.

Algorithm and explanation(11M)

Ford-Fulkerson Algorithm:

It was developed by L. R. Ford, Jr. and D. R. Fulkerson in 1956. A pseudocode for this algorithm is given below,

Inputs required are network graph G, source node S and sink node T.

```
function:Ford Fulkerson (GraphG, Node S,Node T):
Initialise flow in all edges to 0
while(there exists an augmenting path(P) between S and T in residual network graph):
Augment flow between S to T along the path P
Update residual network graph
return
```

4 **Explain Maximum MatchingBipartite graph.(Nov/Dec 2019) (13M) (Nov/Dec 2016).** BTL2

Answer: Page : 4-24 - Technical Publications

Definition(2M)

A **matching** in a graph is a sub set of edges such that no two edges share a vertex. The **maximum matching** of a graph is a matching with the maximum number of edges.

Algorithm and explanation(11m)

```
Algorithm MaximumBipartiteMatching(G)
    initialize set M of edges // can be the empty set
    initialize queue Q with all the free vertices in V
    while not Empty(Q) do
        w ← Front(Q)
        if w ε V then
            for every vertex u adjacent to w do // u must be in U
                if u is free then // augment
                    M ← M union (w, u)
                    v ← w
                    while v is labeled do // follow the augmenting path
                        u ← label of v
                        M ← M - (v, u) // (v, u) was in previous M
                        v ← label of u
                        M ← M union (v, u) // add the edge to the
                        path
                    // start over
                    remove all vertex labels
                    reinitialize Q with all the free vertices in V
```

```
                break // exit the for loop
            else // u is matched
                if (w, u) not in M and u is unlabeled then
                    label u with w // represents an edge in E-M
                    Enqueue(Q, u)
                    // only way for a U vertex to enter the queue

    else // w ε U and therefore is matched with v
        v ← w's mate // (w, v) is in M
        label v with w // represents in M
        Enqueue(Q, v) // only way for a mated v to enter Q
```

PART C

1. **Explain 2 colorable graph problem(15M) (May/June 2014 Nov/Dec 2012) (Nov/Dec 2019)** BTL3

Answer: Page : 4-24 - Technical Publications
Definition(2M)

A bipartite graph is also called 2 colorable. A bipartite graph is possible if the graph coloring is possible using two colors such that vertices in a set are colored with the same color. Note that it is possible to color a cycle graph with even cycle using two colors. For example, see the following graph.

Algorithm and explanation(11M)
Algorithm to check if a graph is Bipartite:

One approach is to check whether the graph is 2-colorable or not using backtracking algorithm m coloring problem.

Following is a simple algorithm to find out whether a given graph is Bipartite or not using Breadth First Search (BFS).

1. Assign RED color to the source vertex (putting into set U).
2. Color all the neighbors with BLUE color (putting into set V).
3. Color all neighbor's neighbor with RED color (putting into set U).
4. This way, assign color to all vertices such that it satisfies all the constraints of m way coloring problem where m = 2.
5. While assigning colors, if we find a neighbor which is colored with same color as current vertex, then the graph cannot be colored with 2 vertices (or graph is not Bipartite)

UNIT 5- COPING WITH THE LIMITATIONS OF ALGORITHMPOWER

Lower – Bound Arguments – P, NP NP- Complete and NP Hard Problems. Backtracking – n-Queen problem – Hamiltonian Circuit Problem – Subset Sum Problem. Branch and Bound – LIFO Search and FIFO search – Assignment problem – Knapsack Problem – Travelling Salesman Problem – Approximation Algorithms for NP-Hard Problems – Travelling Salesman problem – Knapsack problem.

PART A

1	**Analyse the limitations of algorithm power.** BTL2 There are many algorithms for solving a variety of different problems. They are very powerful instruments, especially when they are executed by modern computers. The power of algorithms is because of the following reasons: • There are some problems cannot be solved by any algorithm. • There are some problems can be solved algorithmically but not in polynomial time. • There are some problems can be solved in polynomial time by some algorithms, but there are usually lower bounds on their efficiency. • Lower-Bound Arguments • Decision Trees • P, NP and NP-Complete Problems
2	**What are lower-bound arguments? May/june 2016.**BTL1 Lower bounds mean estimating the minimum amount of work needed to solve the problem. We present several methods for establishing lower bounds and illustrate them with specific examples. • Trivial Lower Bounds • Information-Theoretic Arguments • Adversary Arguments • Problem Reduction In analyzing the efficiency of specific algorithms in the preceding, we should distinguish between a lower-bound class and a minimum number of times a particular operation needs to be executed.
3	**Define Trivial Lower Bounds.**BTL1 The simplest method of obtaining a lower-bound class is based on counting the **number of items in the problem's input that must be processed and the number of output** items that need to be produced. Since any algorithm must at least "read" all the items it needs to process and "write" all its outputs, such a count yields a **trivial lower bound**.
4	**Define Information-Theoretic Arguments.**BTL1 The information-theoretical approach seeks to establish a lower bound based on the amount of information it has to produce by algorithm.
5	**Define Adversary Arguments.**BTL1 Adversary Argument is a method of proving by playing a role of adversary in which algorithm has to work more for adjusting input consistently.

	Consider the Game of guessing number between positive integer 1 and n by asking a person (Adversary) with yes/no type answers for questions. After each question at least one-half of the numbers reduced. If an algorithm stops before the size of the set is reduced to 1, the adversary can exhibit a number. Any algorithm needs $\log_2 n$ iterations to shrink an n-element set to a one-element set by halving and rounding up the size of the remaining set. Hence, at least $\log_2 n$ questions need to be asked by any algorithm in the worst case. This example illustrates the ***adversarymethod*** for establishing lower bounds.
6	**Discuss Problem Reduction.**BTL2 Problem reduction is a method in which a difficult unsolvable problem P is reduced to another solvable problem B which can be solved by a known algorithm. A similar reduction idea can be used for finding a lower bound. To show that problem P is at least as hard as another problem Q with a known lower bound, we need to reduce Q to P (not P to Q!). In other words, we should show that an arbitrary instance of problem Q can be transformed to an instance of problem P, so any algorithm solving P would solve Q as well. Then a lower bound for Q will be a lower bound for P.
7	**Define decision trees.**BTL1 Important algorithms like sorting and searching are based on comparing items of their inputs. The study of the performance of such algorithm is called a **decision tree**. As an example, Each internal node of a binary decision tree represents a key comparison indicated in the node.
8	**Define tractable and intractable.**BTL1 Problems that can be solved in polynomial time are called ***tractable***, and problems that cannot be solved in polynomial time are called ***intractable***
9	**Give the importance of Hamiltonian circuit problem. Nov/Dec 2013.**BTL2 Determines whether a given graph has a Hamiltonian circuit—a path that starts and ends at the same vertex and passes through all the other vertices exactly once.
10	**Illustrate Traveling salesman problem.**BTL1 Find the shortest tour through n cities with known positive integer distances between them (find the shortest Hamiltonian circuit in a complete graph with positive integer weights). ***Applications*** Vehicle routing. Discrete optimization Computer network problem Airport tour. Sonnet ring Power cable
11	**What is the use of Knapsack problem?**BTL1 Find the most valuable subset of n items of given positive integer weights and values that fit into a knapsack of a given positive integer capacity.
12	**Write about Partition problem.**BTL1 Given n positive integers, it determines whether it is possible to partition them into two disjoint subsets with the same sum.
13	**Define Bin-packing problem.**BTL1 Given n items whose sizes are positive rational numbers not larger than 1, put

	them into the smallest number of bins of size 1.
14	**Define Graph-coloring problem.** For a given graph, find its chromatic BTL1number, which is the smallest number of colors **that need to be assigned to the graph's vertices s**o that no two adjacent vertices are assigned the same color. Every Planner graph is 4 colorable.
15	**Define Integer linear programming problem.**BTL1 Find the maximum (or minimum) value of a linear function of several integer-valued variables subject to a finite set of constraints in the form of linear equalities and inequalities.
16	**Mention the use of deterministic and nondeterministic algorithm.**BTL2 **A nondeterministic algorithm** is a two-stage procedure that takes as its input an instance Iof a decision problem and does the following. **Nondeterministic ("guessing") stage:** An arbitrary string S is generated that can bethought of as a candidate solution to the given instance. **Deterministic ("verification") stage:** A deterministic algorithm takes both I and S asits input and outputs yes if S represents a solution to instance I. (If S is not a solution to instance I , the algorithm either returns no or is allowed not to halt at all.) Finally, a nondeterministic algorithm is said to be ***nondeterministic polynomial*** if the time efficiency of its verification stage is polynomial.
17	**Define Class P.** BTL1 **Class *P***is a class of decision problems that can be **solved in polynomial time by deterministic algorithms.** This class of problems is called***polynomial class***. **Examples:** Searching Element uniqueness Graph connectivity Graph acyclicity Primality testing
18	**Recall Class NP.** BTL1 **Class *NP***is the class of decision problems that can be solved by nondeterministicpolynomial algorithms. This class of problems is called ***nondeterministic polynomial***. Examples: Integer factorization problem, graph isomorphism problem, All NP-complete problem (travelling salesman problem, Boolean satisfiability problem).
19	**State the use of Class NP-Hard. / List out the properties of NP-Hard Problems. (May/June 2014).** BTL2 A problem is NP-hard if an algorithm for solving it can be translated into one for solving any NP-problem (nondeterministic polynomial time) problem. Therefore, NP-hard means "at least as hard as any NP-problem," although it might, in fact, be harder. There are no polynomial-time algorithms for NP-hard problems. Traveling salesman and knapsack problems are NP-hard problems.
20	**Define NP-complete.(May/June 2014 Nov/Dec 2013). BTL**1 A decision problem *D* is said to be ***NP-complete*** if it is hard as any problem in NP. • It belongs to class *NP* • Every problem in *NP* is polynomial reducible to *D*

PART B

1

Describe Briefly about Np-hard and Np-Completeness(13m) (Nov/Dec 2016).(NOV/DEC 2019) BTL2

Answer: Page : 5-11 - Technical Publications

Definition (3M)

A problem is in the class NPC if it is in NP and is as **hard** as any problem in NP. A problem is **NP-hard** if all problems in NP are polynomial time reducible to it, even though it may not be in NP itself.

A language **B** is ***NP-complete*** if it satisfies two conditions

- **B** is in NP
- Every **A** in NP is polynomial time reducible to **B**.

NP-Complete Problems (5M)

Following are some NP-Complete problems, for which no polynomial time algorithm is known.

- Determining whether a graph has a Hamiltonian cycle
- Determining whether a Boolean formula is satisfiable, etc.

NP-Hard Problems (5M)

The following problems are NP-Hard

- The circuit-satisfiability problem
- Set Cover
- Vertex Cover
- Travelling Salesman Problem

2

Describe about Assignment Problem and extend how job assignment problems could be solved.(13M) (Nov/Dec 2017). BTL2

Answer: Page : 5-60 - Technical Publications

Definition(3m)

Assignment problem is a special type of linear programming **problem** which deals with the allocation of the various resources to the various activities on one to one basis. It **does** it in such a way that the cost or time involved in the process is minimum and profit or sale is maximum.

	J1	*J2*	*J3*	*J4*
W1	82	83	69	92
W2	77	37	49	92
W3	11	69	5	86
W4	8	9	98	23

Each worker should perform exactly one job and the objective is to minimize the total time required to perform all jobs.

It turns out to be optimal to assign worker 1 to job 3, worker 2 to job 2, worker 3 to job 1 and worker 4 to job 4. The total time required is then 69 + 37 + 11 + 23 = 140 minutes. All other assignments lead to a larger amount of time required.

Solution 1: Brute Force (2M)

Solution 2: Hungarian Algorithm(3M)

Solution 3: DFS/BFS on state space tree(2M)

Solution 4: Finding Optimal Solution using Branch and Bound(2M)

1. .

3 **Discuss the 8-Queens problem & discuss the possible solutions. (13M) (May/June 2014)[NOV/DEC 2019].** BTL3

Answer: Page : 5-34 - Technical Publications

Definition (3M)

The eight queen’s problem is the problem of placing eight queens on an 8×8 chessboard such that none of them attack one another (no two are in the same row, column, or diagonal). More generally, the n queen’s problem places in queens on an n×n chessboard. solutions for the problemBacktracking Algorithm

Algorithm(10M)

The idea is to place queens one by one in different columns, starting from the leftmost column. When we place a queen in a column, we check for clashes with already placed queens. In the current column, if we find a row for which there is no clash, we mark this row and column as part of the solution. If we do not find such a row due to clashes, then we backtrack and return false.

1) Start in the leftmost column

2) If all queens are placed

return true

3) Try all rows in the current column. Do following for every tried row.

a) If the queen can be placed safely in this row then mark this [row, column] as part of the solution and recursively check if placing queen here leads to a solution.

b) If placing the queen in [row, column] leads to a solution then return true.

c) If placing queen doesn't lead to a solution then mark this [row, column] (Backtrack) and go to step (a) to try other rows.

4) If all rows have been tried and nothing worked, return false to trigger backtracking.

PART C

1 **Describe about Branch and Bound Problem(15M) (May/June 2014).** BTL2

Answer: Page : 5-59 - Technical Publications

Definition (3M)

The selection rule for the next node in BFS and DFS is "blind". i.e. the selection rule does not give any preference to a node that has a very good chance of getting the search to an answer node quickly. The search for an optimal solution can often be speeded by using an "intelligent" ranking function, also called an approximate cost function to avoid searching in sub-trees that do not contain an optimal solution.

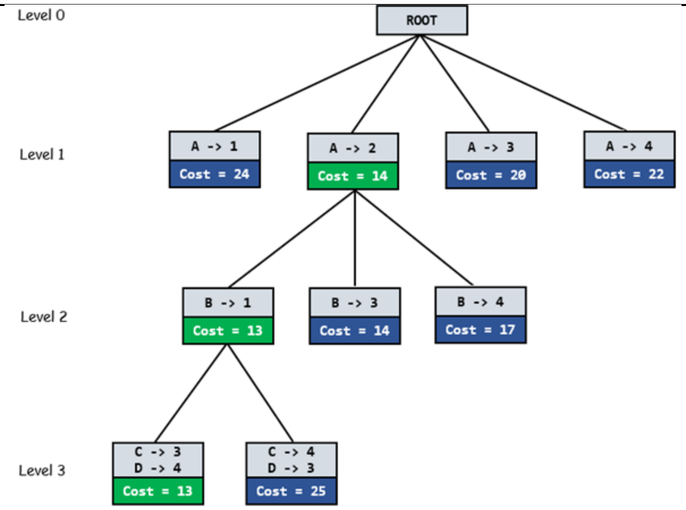
Finding Optimal Solution using Branch and Bound(7M)

It is similar to BFS-like search but with one major optimization. Instead of following FIFO order, we choose a live node with least cost. We may not get optimal solution by following node with least promising cost, but it will provide very good chance of getting the search to an answer node quickly.

There are two approaches to calculate the cost function:

1. For each worker, we choose job with minimum cost from list of unassigned jobs (take minimum entry from each row).
2. For each job, we choose a worker with lowest cost for that job from list of unassigned workers (take minimum entry from each column).

Example(5M)



2 **Illustrate about Hamiltonian Circuit Problem (15M) (Nov/Dec 2017 May/June 2014Nov/Dec 2016).** BTL3

Answer: Page : 5-46 - Technical Publications
Definition (3M)
Hamiltonian Path in an undirected graph is a path that visits each vertex exactly once. A **Hamiltonian cycle** (or Hamiltonian circuit) is a Hamiltonian Path such that there is an edge (in graph) from the last vertex to the first vertex of the Hamiltonian Path.Determine whether a given graph contains Hamiltonian Cycle or not. If it contains, then print the path.
Explanation with example(12M)
Following are the input and output of the required function.
A 2D array graph[V][V] where V is the number of vertices in graph and graph[V][V] is adjacency matrix representation of the graph. A value graph[i][j] is 1 if there is a direct edge from i to j, otherwise graph[i][j] is 0.

Output:
An array path[V] that should contain the Hamiltonian Path. path[i] should represent the ith vertex in the Hamiltonian Path. The code should also return false if there is no Hamiltonian Cycle in the graph.
For example, a Hamiltonian Cycle in the following graph is {0, 1, 2, 4, 3, 0}.

```
(0) --(1) --(2)

 |  / \  |

 | /   \ |

 |/     \|

(3) -------(4)
```

And the following graph doesn’t contain any Hamiltonian Cycle.

```
(0) --(1) --(2)

 |  / \  |
```

	| / \ | |/ \\| (3) (4)

REGULATION: 2017 ACADEMIC YEAR: 2019-2020

CS8493 OPERATING SYSTEMS L T P C

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UNIT I OPERATING SYSTEM OVERVIEW 7

Computer System Overview-Basic Elements, Instruction Execution, Interrupts, Memory Hierarchy, Cache Memory, Direct Memory Access, Multiprocessor and Multicore Organization. Operating system overview-objectives and functions, Evolution of Operating System.- Computer System Organization Operating System Structure and Operations- System Calls, System Programs, OS Generation and System Boot.

UNIT II PROCESS MANAGEMENT 11

Processes - Process Concept, Process Scheduling, Operations on Processes, Inter-process Communication; CPU Scheduling - Scheduling criteria, Scheduling algorithms, Multiple-processor scheduling, Real time scheduling; Threads- Overview, Multithreading models, Threading issues; Process Synchronization - The critical-section problem, Synchronization hardware, Mutex locks, Semaphores, Classic problems of synchronization, Critical regions, Monitors; Deadlock - System model, Deadlock characterization, Methods for handling deadlocks, Deadlock prevention, Deadlock avoidance, Deadlock detection, Recovery from deadlock.

UNIT III STORAGE MANAGEMENT 9

Main Memory – Background, Swapping, Contiguous Memory Allocation, Paging, Segmentation, Segmentation with paging, 32 and 64 bit architecture Examples; Virtual Memory – Background, Demand Paging, Page Replacement, Allocation, Thrashing; Allocating Kernel Memory, OS Examples.

UNIT IV FILE SYSTEMS AND I/O SYSTEMS 9

Mass Storage system – Overview of Mass Storage Structure, Disk Structure, Disk Scheduling and Management, swap space management; File-System Interface - File concept, Access methods, Directory Structure, Directory organization, File system mounting, File Sharing and Protection; File System Implementation- File System Structure, Directory implementation, Allocation Methods, Free Space Management, Efficiency and Performance, Recovery; I/O Systems – I/O Hardware, Application I/O interface, Kernel I/O subsystem, Streams, Performance.

UNIT V CASE STUDY 9

Linux System - Design Principles, Kernel Modules, Process Management, Scheduling, Memory Management, Input-Output Management, File System, Inter-process Communication; Mobile OS - iOS and Android - Architecture and SDK Framework, Media Layer, Services Layer, Core OS Layer, File System.

TOTAL : 45 PERIODS

TEXT BOOK: 1. Abraham Silberschatz, Peter Baer Galvin and Greg Gagne, "Operating System Concepts",9th Edition, John Wiley and Sons Inc., 2012.

REFERENCES:

1. RamazElmasri, A. Gil Carrick, David Levine, ―Operating Systems – A Spiral Approach‖, Tata McGraw Hill Edition, 2010.

2. Achyut S.Godbole, Atul Kahate, ―Operating Systems‖, Mc Graw Hill Education, 2016. 3. Andrew S. Tanenbaum, ―Modern Operating Systems‖, Second Edition, Pearson Education, 2004.

4. Gary Nutt, ―Operating Systems‖, Third Edition, Pearson Education, 2004.

5. Harvey M. Deitel, ―Operating Systems‖, Third Edition, Pearson Education, 2004.

6. Daniel P Bovet and Marco Cesati, ―Understanding the Linux kernel‖, 3rd edition, O'Reilly, 2005.

7. Neil Smyth, ―iPhone iOS 4 Development Essentials – Xcode‖, Fourth Edition, Payload media, 2011.

OUTCOMES:

At the end of the course, the students should be able to:

- Analyze various scheduling algorithms.
- Understand deadlock, prevention and avoidance algorithms.
- Compare and contrast various memory management schemes.
- Understand the functionality of file systems.
- Perform administrative tasks on Linux Servers.
- Compare iOS and Android Operating Systems.

REGULATION: 2017 ACADEMIC YEAR: 2019-2020

Subject Code:CS8493 Year/Semester: II /04
Subject Name: OPERATING SYSTEMS Subject Handler: Dr.J.FARITHA BANU

UNIT I– OPERATING SYSTEM OVERVIEW

Computer System Overview-Basic Elements, Instruction Execution, Interrupts, Memory Hierarchy, Cache Memory, Direct Memory Access, Multiprocessor and Multicore Organization. Operating system overview-objectives and functions, Evolution of Operating System. - Computer System Organization Operating System Structure and Operations- System Calls, System Programs, OS Generation and System Boot.

PART * A

Q.No.	Questions
1	**What is an Operating system?** BTL2 An operating system is a program that manages the computer hardware. It also provides a basis for application programs and act as an intermediary between a user of a computer and the computer hardware. It controls and coordinates the use of the hardware among the various application programs for the various users.
2	**List the services provided by an Operating System.**BTL2 • I/O Operation • File -System manipulation Communications • Error detection
3	**What is the Kernel?** BTL2 A more common definition is that the OS is the one program running at all times on the computer, usually called the kernel, with all else being application programs.
4	**What is meant by Mainframe Systems?** BTL2 Mainframe systems are the first computers developed to tackle many commercial and scientific applications. These systems are developed from the batch systems and then multiprogramming system and finally time sharing systems.
5	**What is meant by Batch Systems?** BTL2 Operators batched together jobs with similar needs and ran through the computer as a group .Th operators would sort programs into batches with similar requirements and as system becom available, it would run each batch.
6	**Define Multiprogramming**. BTL1 Several users simultaneously compete for system resources (i.e) the job currently waiting for I/O will yield the CPU to another job which is ready to do calculations, if another job is waiting. Thus it increases CPU utilization and system throughput.
7	**What can you say about Time-sharing Systems?** BTL2 Time Sharing is a logical extension of multiprogramming.Here, CPU executes multiple jobs by switching among them, but the switches occur so frequently that the users can interact with each program while it is running.
8	**What are the Components of a Computer System?** BTL2

	• Application Programs • System Program • Operating System • Computer Hardware
9	**What are the advantages of Multiprogramming**? BTL2 • Increased System Throughput • Increased CPU utilization
10	**Define Multiprocessor System.**BTL1 Multiprocessor systems have systems more than one processor for communication, sharing the computer bus, the memory, clock & peripheral devices.
11	**What are the advantages of multiprocessors?** BTL2 • Increased throughput • Economy of scale • Increased reliability
12	**What are Multiprocessor Systems & give their advantages?** BTL2 Multiprocessor systems also known as parallel systems or tightly coupled systems are systems that have more than one processor in close communication, sharing the computer bus, the clock and sometimes memory & peripheral devices.
13	**What are the different types of Multiprocessing?** BTL2 Symmetric multiprocessing (SMP): In SMP each processor runs an identical copy of the OS & these copies communicate with one another as needed. Asymmetric multiprocessing: Each processor is assigned a specific task. A master processor controls the system; the other processors look to the master for instructions or predefined tasks. It defines a master-slave relationship.
14	**What is meant by clustered system?** BTL2 Clustered systems are collection of multiple CPUs to accomplish computational work. Those systems share storage and are closely linked via LAN networking.
15	**What are the types of clustering?** BTL2 • Asymmetric Clustering • Symmetric Clustering • Clustering over a WAN
16	**What is meant by Asymmetric Clustering?** BTL2 In this clustering, one machine is in hot standby mode, while the other is running the application. The hot standby machine just monitors the active server. If that server fails, hot standby host become the active server.
17	**Define Symmetric clustering.** BTL1 Two or more hosts are running applications and they are monitoring each other. This clustering requires more than one application be available to run and it uses all of the available hardware.
18	**Define parallel clusters.** BTL1 Parallel clusters allow multiple hosts to access the same data on the shared storage. Each machine has full access to all data in the database.
19	**What is meant by Real time system?** BTL2 Real time systems are systems that have their in-built characteristics as supplying immediate response. In real time system, each process is assigned a certain level of priority according to the relative importance of the events to be processed.
20	**What are the advantages of distributed systems?** BTL2 • Resource sharing

	• Load balancing • Reliability • Communication link easy
21	**What are the applications of real-time systems?** BTL2 Controlling the machines Instruments Industrial process Landing & tasking off aero planes Real time simulations Military applications.
22	**What are the types of Real time systems?** BTL2 • Hard Real Time System • Soft Real Time System
23	**What is meant by Hard Real time systems?** BTL2 They are generally required to and they guarantee that the critical tasks are completed in given amount of time.
24	**Define soft real time system**. BTL1 It provides priority to the tasks based on their criticality. It does not guarantee completion of critical tasks in time.
25	**What are the disadvantages of distributed systems?** BTL2 • Security weakness Over dependence on performance • Reliability Maintenance • control become complex
	PART – B
1	**What are the different types of Operating System Services? (13M)** BTL2 **AnswerPage:55 - Silberschatz, Galvin** **Definition (2M)** An Operating System provideservices to both the users and to the programs. It provides programs an environment to execute. It provides users the services to execute the programs in a convenient manner.Normally, an operating system provides certain services to programs and to the users of those programs. Some of them are: **Operating Services(11M)** i. Program Execution. (3M) ii. I/O operations (2M) iii. File-system manipulation (2M) iv. Communications (2M) v. Error Detection (2M)
2	**Explain different types of System Programs.(13M)** BTL2 **AnswerPage:74 - Silberschatz, Galvin** **Definition(2M)** System programs provide a convenient environment for program development and execution. Some of these programs are user interfaces to system calls and others are more complex. Some of them are: **Types of System Programs(11M)** i. File Management (2M) ii. Status Information (1M) iii. File modification (1M) iv. Programming Language support (2M) v. Program loading and Execution (2M)

	vi. Communication.(1M) vii. Application Programs (2M)
3	**What are System Calls?What are the five major categories of System Calls?(13M)** BTL2 **Answer: Page:62 Silberschatz, Galvin** **Definition (2M)** System calls provide the interface between a process and the operating system. These calls are generally available as assembly-language instructions. i. Process Control (2M) ii. File-management (2M) iii. Device-management (2M) iv. Information maintenance (2M) v. Communications (3M)
4	**Explain different types of Operating System Components. (13M)** BTL2 **AnswerPage:66 -Silberschatz, Galvin.** **Definition (2M)** The parts of an operating system all exist so as to make the various parts of a computer system work together. All user software program has to undergo the operating system in order to utilize any of the hardware, whether it be as basic as a mouse or keyboard or as complicated as an Internet component. i. Process management (1M) ii. I/O-system management (2M) iii. Secondary-storage management (2M) iv. Networking (2M) v. Protection system (2M) vi. Command-interpreter system(2M)
	PART – C
1	**Explain with the features of Operating System Structures(13M)** BTL2 **Answer: Page:78 Silberschatz, Galvin** **Definition(2M)** A system as large and complex as a modern operating system must be engineered carefully if it isto function properly and be modified easily. A common approach istopartitionthe taskintosmallcomponents, ormodules, rather than have one monolithic system. Each of these modules should be a well-defined portion of the system, with carefully defined inputs, outputs, and functions. Types of Structures • Simple Structure (4M) • Layered Approach (4M) • Microkernel (3M)
2	**Explain basic Elements Operating Systems(15M)** BTL2 **Answer: Page:74 Silberschatz, Galvin.** **Definition (2M)**

	An operating system is a software that controls your computer. There are a few elements that make up an operating system. The first element of an operating system is the kernel. The kernel ensures that every running process has adequate time to execute. • Instruction Execution (2M) • Interrupts (2M) • Memory Hierarchy (3M) • Cache Memory (2M) • Direct Memory Access (2M) • Multiprocessor and Multicore Organization (2M)

REGULATION: 2017 ACADEMIC YEAR: 2019-2020

Subject Code:CS8493 Year/Semester: II /04
Subject Name: OPERATING SYSTEMS Subject Handler: Dr.J.FARITHA BANU

UNIT II – PROCESS MANAGEMENT

Processes - Process Concept, Process Scheduling, Operations on Processes, Inter-process Communication; CPU Scheduling - Scheduling criteria, Scheduling algorithms, Multiple-processor scheduling, Real time scheduling; Threads- Overview, Multithreading models, Threading issues; Process Synchronization - The critical-section problem, Synchronization hardware, Mutex locks, Semaphores, Classic problems of synchronization, Critical regions, Monitors; Deadlock - System model, Deadlock characterization, Methods for handling deadlocks, Deadlock prevention, Deadlock avoidance, Deadlock detection, Recovery from deadlock.

PART * A

Q.No.	Questions
1	**Define process.** BTL1 A process is more than a program code, which is sometime known as the text section. IT also includes the current activity, as represented by the value of the program counter and the processor's registers.
2	**What is meant by the state of the process?** BTL2 The state of the process is defined in part by the current activity of that process. Each process may be in one of the following states. x New: The process is being created. x Running: Instruction are being executed x Waiting: The process is waiting for some event to occur. x Ready: The process is waiting to be assigned to a processor x Terminated: The process has finished execution
3	**Define process control block.** BTL1 Each process is represented in the operating system by a process control block (PCB) – also called as task control block. The PCB simply serves as the repository for any information that may vary from process to process.
4	**What does PCB contain?** BTL2 • Process state • Program counter • CPU registers • CPU scheduling information • Memory management information • Accounting information
5	**What are the three different types of scheduling queues?** BTL2 **i).Job Queue:** As process enters the system they are put into job queue. **ii). Ready Queue:** The processes that are residing in the main memory and are ready and waiting t execute are kept in the queue **iii).Device Queue**: The list of processes waiting for particular I/O device is called a device queue.
6	**Define schedulers.** BTL1 A process migrates between the various scheduling throughout its lifetime. The operating system must select, for scheduling purposes, processes from these queues in some fashion. The selection process is carried out by the appropriate scheduler.

7	**What are the types of scheduler?** BTL2 Long term scheduler or job scheduler selects processes from the pool and load them into the memory for execution. Short term scheduler or CPU scheduler, select among the processes that are ready to execute and allocates the CPU to one of them.
8	**Define critical section.** BTL1 If a system consist on n processes {P0, P1,……., Pn-1}.Each process has a segment of code called a critical section, in which the process may be changing common variables, updating a table , writing a file. The important feature of this system is that, when one process is in its critical section, no other process is to be allowed to execute in its critical section.
9	**What requirement is to be satisfied for a solution of a critical section problem?** BTL2 A solution to the critical section problem must satisfy the following 3 requirements. • Mutual exclusion • Progress • Bounded waiting
10	**Define semaphores.** BTL1 Semaphore is a synchronization toll. A semaphore S is an integer variable that apart from initialization is accessed only through 2 standard atomic operations. x Wait x Signal
11	**Define Starvation in deadlock.** BTL1 A problem related to deadlock is indefinite blocking or starvation, a situation where processes wait indefinitely within a semaphore. Indefinite blocking may occur if we add and remove processes from the list associated with a semaphore in LIFO order.
12	**List out the classic problem of synchronization.** BTL1 • The Bounded – Buffer Problem • The Reader – Writer Problem • The Dining –Philosophers Problem
13	**Define deadlock.** BTL1 A process request resources; if the resource are not available at that time, the process enters a wait state. Waiting processes may never change state, because the resources they are requested are held by other waiting processes. This situation is called deadlock.
14	**What is the sequence of operation by which a process utilizes a resource?** BTL2 Under the normal mode of operation, a process may utilize a resource in only the following sequence: x Request: If the request cannot be granted immediately, then the requesting process must wait until it can acquire the response. x Use: The process can operate on the resource. x Release: The process releases the resource
15	**Give the condition necessary for a deadlock situation to arise?** BTL3 A deadlock situation can arise if the following 4 condition hold simultaneously in a system. • Mutual Exclusion • Hold and Wait • No preemption • Circular Wait
16	**Define 'Safe State".** BTL1 A state is safe if the system allocates resources to each process in some order and still avoid deadlock.
17	**Define deadlock-avoidance algorithm.** BTL1 A deadlock-avoidance algorithm dynamically examines the resource allocation state to ensure that a circular wait condition can never exist. The resource allocation state is defined by the number of available and allocated resources, and the maximum demand of the processes.

18	**What are the benefits of multithreaded programming?** BTL2 • Responsiveness • Resource sharing • Economy • Utilization of multiprocessor architecture
19	**Define deadlock detection diction.** BTL1 If a system does not employ either a deadlock-prevention or a deadlock avoidance algorithm, then a deadlock situation may occur. In this environment, the system must provide: • An algorithm that examines the state of the system to determine whether a deadlock has occurred. • An algorithm to recover from the deadlock.
20	**Define race condition.** BTL1 When several process access and manipulate same data concurrently, then the outcome of the execution depends on particular order in which the access takes place is called race condition. To avoid race condition, only one process at a time can manipulate the shared variable
21	**What is critical section problem?** BTL2 Consider a system consists of ‘n‘processes. Each process has segment of Code called a critical section, in which the process may be changing common variables, updating a table, writing a file. When one process is executing in its critical section, no other process can allowed to execute in its critical section.
22	**Define busy waiting and spinlock.** BTL1 When a process is in its critical section, any other process that tries to enter its critical section must loop continuously in the entry code. This is called as busy waiting and this type of semaphore is also called a spinlock, because the process while waiting for the lock.
23	**What are the requirements that a solution to the critical section problem must satisfy?** BTL2 The three requirements are • Mutual Exclusion • Progress • Bounded waiting
24	**Define entry section and exit section.** BTL1 The critical section problem is to design a protocol that the processes can use to cooperate. Each process must request permission to enter its critical section. The section of the code implementing thisrequest is the entry section. The critical section is followed by an exit section. The remaining code is the remainder section.
25	**What are conditions under which a deadlock situation may arise?** BTL2 A deadlock situation can arise if the following four conditions hold Simultaneously in a system: • Mutual exclusion • Hold and wait • No pre-emption • Circular wait
26	**What is a resource-allocation graph?** BTL2 Deadlocks can be described more precisely in terms of a directed graph called a system resource allocation graph. This graph consists of a set of vertices V and a set of edges E. The set of vertices V is partitioned into two different types of nodes; P the set consisting of all active processes in the system and R the set consisting of all resource types in the system.

	PART – B
1	**Explain different types of scheduler. (13M)** BTL2 **Answer Page:206 - Silberschatz, Galvin.** **Definition (2M)** The process scheduling is the activity of the process manager that handles the removal of the running process from the CPU and the selection of another process on the basis of a particular strategy. Process scheduling is an essential part of a Multiprogramming operating systems. The objective of multiprogramming is to have some process running at all times, so as to maximize CPU utilization. **Types of Schedulers (11M)** • Long-term scheduler(4M) • Medium-term scheduler(4M) • Short-term scheduler(3M)
2	**Explain about process operation in detail. (13M)** BTL1 **Answer Page: 115 - Silberschatz, Galvin.** **Definition (2M)** In computing, a process is an instance of a computer program that is being executed. It contains the program code and its activity. Depending on the operating system (OS), a process may be made up of multiple threads of execution that execute instructions concurrently.Each CPU (core) executes a single task at a time. **Process operation (11M)** • Process Creation (4M) • Process Termination(4M) • Cooperating Process(3M)
3	**Explain interprocess communication (IPC)with example. (13M)** BTL1 **Answer Page:122 - Silberschatz, Galvin.** **Definition (2M)** Operating systems provide the means for cooperating processes to communicate with each other via an interprocess communication (PC) facility. IPC provides a mechanism to allow processes to communicate and to synchronize their actions.IPC is best provided by a message passing system. **IPC Operation (10M)** • Directcommunication (2M) • Indirect communication (2M) • Shared Memory systems(2M) • Message Passing systems(2M) • Buffering (2M) • Synchronization(1M)
4	**What is critical section problem? Can you explain the solution to solve it?(13M) BTL1** **Answer Page:206 -Silberschatz, Galvin.**

Definition (2M)

Only one process in the group can be allowed to execute in their critical section at any one time. If one process is already executing their critical section and another process wishes to do so, then the second process must be made to wait until the first process has completed their critical section work.

Solution (5M)

- Mutual Exclusion
- Progress
- Bounded waiting

Example (6M)

5

Briefly describe the deadlock operation with example. (13M) BTL2

Answer Page: 317 - Silberschatz, Galvin.

Definition (2M)

A process requests resources. If the resources are not available at that time ,the process enters a wait state. Waiting processes may never change state again because the resources they have requested are held by other waiting processes. This situation is called a deadlock.

Deadlock Operation (11M)

- Deadlock Characterization(3M)
- Methods for handling Deadlocks(3M)
- Deadlock Avoidance(3M)
- Deadlock Prevention(3M)

6

What are the different types of scheduling algorithms used in Operating System.(13M) BTL2

Answer Page: 266 -Silberschatz, Galvin.

Definition (2M)

A scheduling system allows one process to use the CPU while another is waiting for I/O, thereby making full use of otherwise lost CPU cycles.The challenge is to make the overall system as "efficient" and "fair" as possible, subject to varying and often dynamic conditions, and where "efficient" and "fair" are somewhat subjective terms, often subject to shifting priority policies.

Types of Scheduling Algorithms (11M)

- First-Come, First-Served Scheduling (3M)
- Shortest Job First Scheduling (3M)
- Priority Scheduling (3M)
- Round Robin Scheduling (3M)

PART *C

1

Consider the following set of processes, with the length of the CPU-burst time given in milliseconds:

Process	Burst Time	Priority
*P*1	10	3
*P*2	1	1
*P*3	2	3

*P*4	1	4
*P*5	5	2

The processes are assumed to have arrived in the order P1, P2, P3, P4, P5, all at time 0.

a. Draw four Gantt charts illustrating the execution of these processes using FCFS,SJF,A non pre-emptive priority (a smaller priority number implies a higher priority), and RR (quantum = 1) scheduling. (10M)BTL4

b. What is the turnaround time of each process for each of the scheduling algorithms in part a? (5M). BTL2

Answer: Page:301 -Silberschatz, Galvin.

- FCFS – 13.4 TAT and 9.6 WT
- SJF- 7 TAT and 3.2 WT
- A non pre-emptive priority – 13.4 TAT and 8.2 WT
- Round Robin – 9.2 TAT and 5.4 WT

2

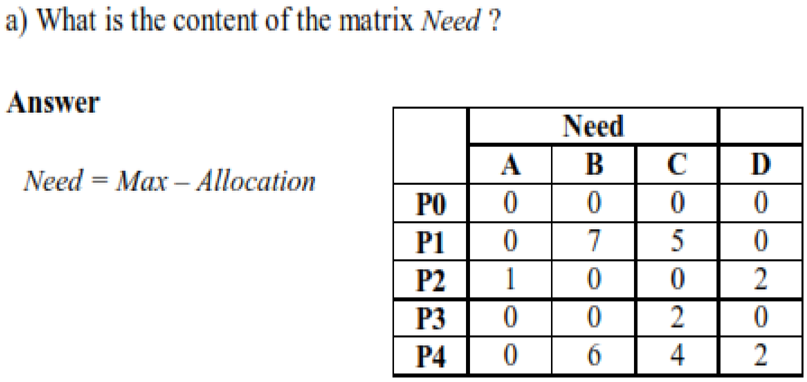
Consider the following snapshot of a system:

Process	**Allocation**	**Max**	**Available**
	A B C D	A B C D	A B C D
P0	0 0 1 2	0 0 1 2	1 5 2 0
P1	1 0 0 0	1 7 5 0	
P2	1 3 5 4	2 3 5 6	
P3	0 6 3 2	0 6 5 2	
P4	0 0 1 4	0 6 5 6	

Answer the following questions using the banker's algorithm: a. What is the content of the matrix Need? Is the system in a safe state? (10M) BTL4

If a request from process P1 arrives for (0, 4, 2, 0), can the request be granted immediately?(5M) BTL4

Answer Page:333 - Silberschatz, Galvin.



a) What is the content of the matrix *Need* ?

Answer

Need = Max – Allocation

	Need			
	A	**B**	**C**	**D**
P0	0	0	0	0
P1	0	7	5	0
P2	1	0	0	2
P3	0	0	2	0
P4	0	6	4	2

b) Is the system in a safe state? Explain why?

Answer

Work = Available = 1 5 2 0, then if Need ≤ Work, then Work = Work + Allocation.

	Work			
	A	B	C	D
P0	1	5	3	2
P2	2	8	8	6
P3	2	14	11	8
P4	2	14	12	12
P1	3	14	12	12

The system is in a safe state since the sequence < P0, P2, P3, P4, P1> satisfies safety criteria.

c) If a request from P1 arrives for (0,4,2,0), can the request be granted immediately? Explain why?

Answer

Check Request ≤ Available → (0,4,2,0) ≤ (1,5,2,0) , then

	Allocation				Need				Available			
	A	B	C	D	A	B	C	D	A	B	C	D
P0	0	0	1	2	0	0	0	0	1	1	0	0
P1	1	4	2	0	0	3	3	0				
P2	1	3	5	4	1	0	0	2				
P3	0	6	3	2	0	0	2	0				
P4	0	0	1	4	0	6	4	2				

Now, check if the system is in a safe state.

Work = Available = 1 1 0 0, then if Need ≤ Work, then Work = Work + Allocation.

	Work			
	A	B	C	D
P0	1	1	1	2
P2	2	4	6	6
P3	2	10	9	8
P4	2	10	10	12
P1	3	14	12	12

The system is in a safe state since the sequence < P0, P2, P3, P4, P1> satisfies safety criteria. . So the request can be granted immediately.

REGULATION: 2017 ACADEMIC YEAR: 2019-2020

Subject Code:CS8493 Year/Semester: II /04
Subject Name: OPERATING SYSTEMS Subject Handler: Dr.J.FARITHA BANU

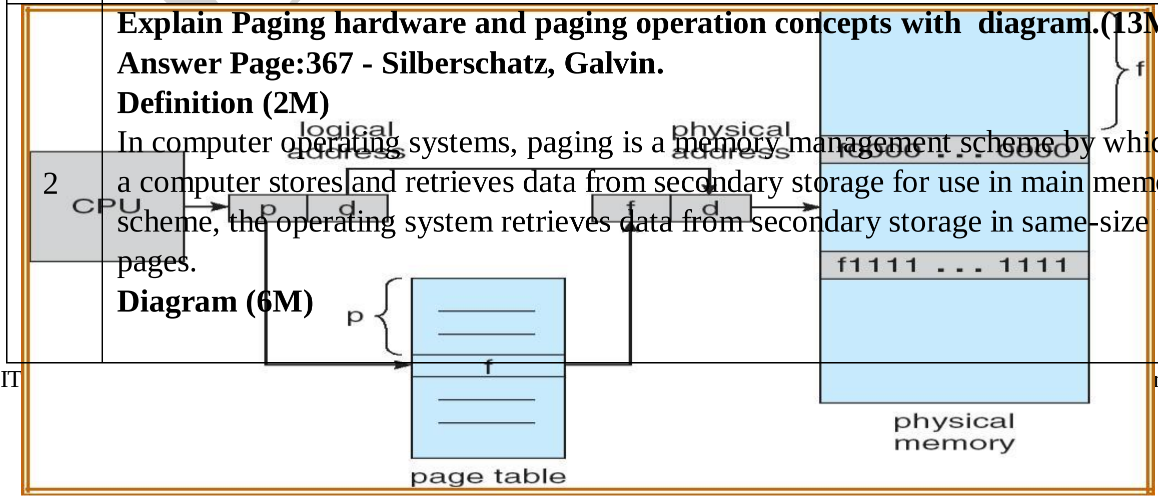
UNIT III – STORAGE MANAGEMENT

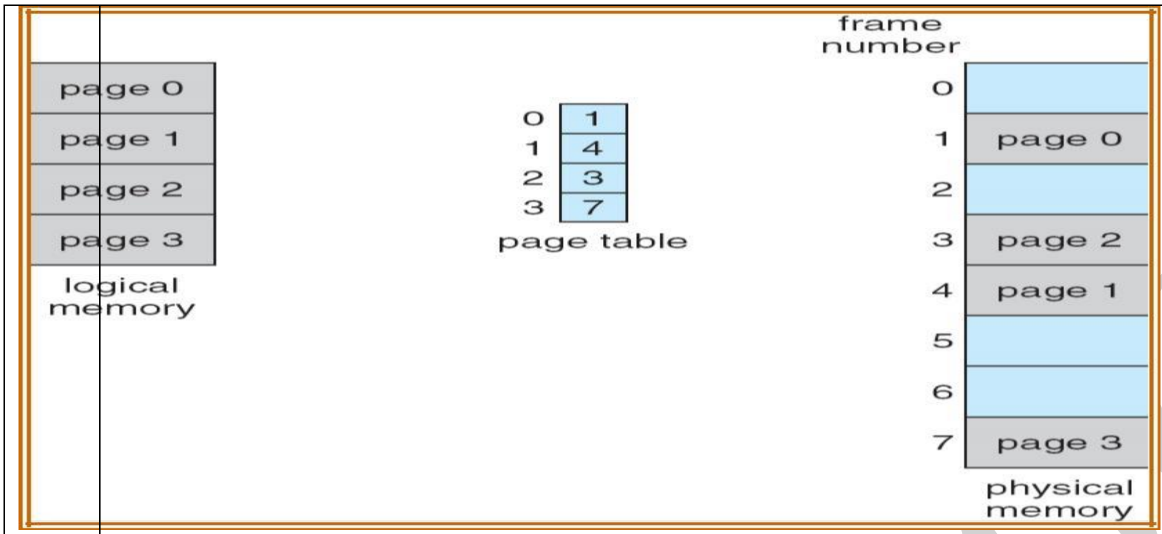
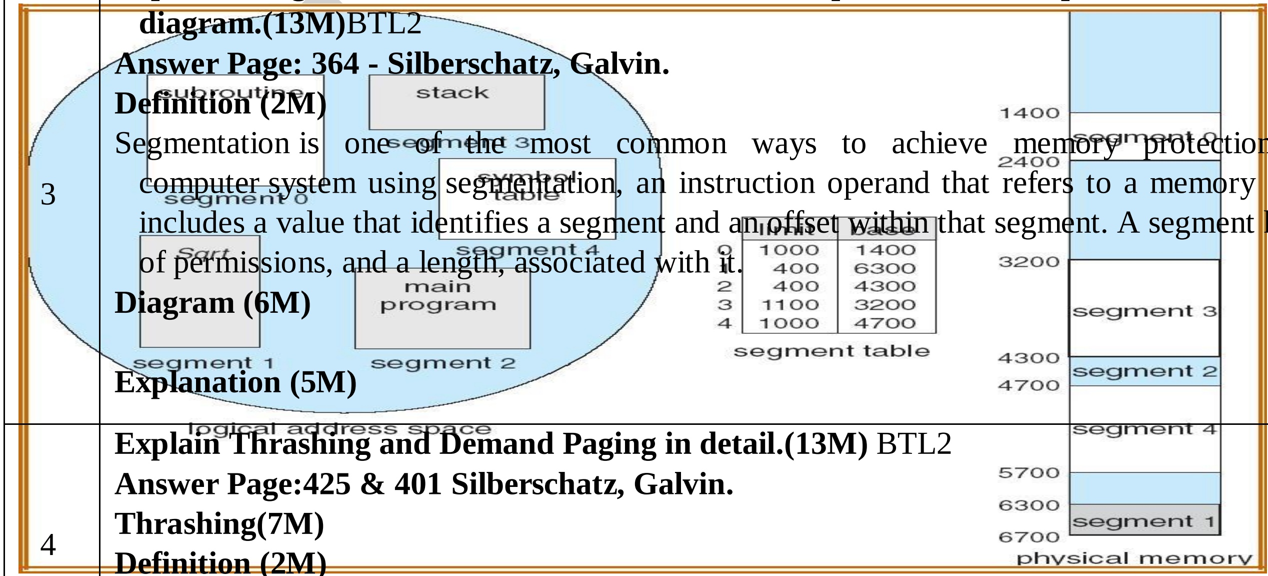
Main Memory – Background, Swapping, Contiguous Memory Allocation, Paging, Segmentation, Segmentation with paging, 32- and 64-bit architecture Examples; Virtual Memory – Background, Demand Paging, Page Replacement, Allocation, Thrashing; Allocating Kernel Memory, OS Examples.

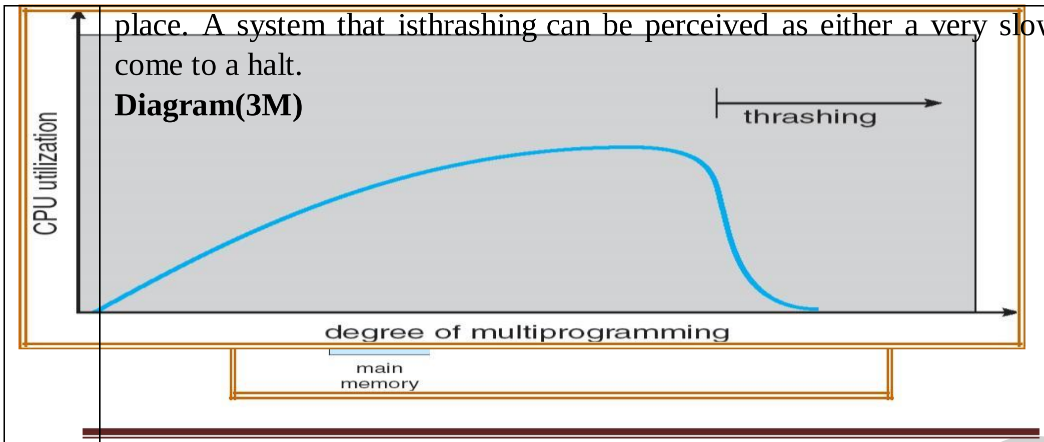
PART * A

Q.No.	Questions
1	**Define Dynamic Loading.** BTL1 To obtain better memory-space utilization dynamic loading is used. With dynamic loading, a routine is not loaded until it is called. All routines are kept on disk in a relocatable load format. The main program is loaded into memory and executed. If the routine needs another routine, the calling routine checks whether the routine has been loaded. If not, the relocatable linking loader is called to load the desired program into memory.
2	**Define Dynamic Linking.**BTL1 Dynamic linking is similar to dynamic loading, rather that loading being postponed until execution time, linking is postponed. This feature is usually used with system libraries, such as language subroutine libraries. A stub is included in the image for each library-routine reference. The stub is a small piece of code that indicates how to locate the appropriate memory-resident library routine, or how to load the library if the routine is not already present.
3	**What are Overlays?** BTL2 To enable a process to be larger than the amount of memory allocated to it, overlays are used. The idea of overlays is to keep in memory only those instructions and data that are needed at a given time. When other instructions are needed, they are loaded into space occupied previously by instructions that are no longer needed.
4	**Define Swapping.** BTL2 A process needs to be in memory to be executed. However a process can be swapped temporarily out of memory to a backing store and then brought back into memory for continued execution. This process is called swapping.
5	**What do you mean by Best Fit?** BTL2 Best fit allocates the smallest hole that is big enough. The entire list has to be searched, unless it i sorted by size. This strategy produces the smallest leftover hole.
6	**What do you mean by First Fit?** BTL2 First fit allocates the first hole that is big enough. Searching can either start at the beginning of the set of holes or where the previous first-fit search ended. Searching can be stopped as soon as a free hole that is big enough is found.
7	**How is memory protected in a paged environment?** BTL2 Protection bits that are associated with each frame accomplish memory protection in a paged environment. The protection bits can be checked to verify that no writes are being made to a read-only page.

8	**What is External Fragmentation?** BTL2 External fragmentation exists when enough total memory space exists to satisfy a request, but it is not contiguous; storage is fragmented into a large number of small holes.
9	**What is Internal Fragmentation?** BTL2 When the allocated memory may be slightly larger than the requested memory, the difference between these two numbers is internal fragmentation.
10	**Define Compaction.** BTL1 Compaction is a solution to external fragmentation. The memory contents are shuffled to place al free memory together in one large block. It is possible only i f relocation is dynamic, and is done a execution time.
11	**What are Pages and Frames?** BTL2 Paging is a memory management scheme that permits the physical -address space of a process to be non-contiguous. In the case of paging, physical memory is broken into fixed-sized blocks called frames and logical memory is broken into blocks of the same size called pages.
12	**State the use of Valid-Invalid Bits in Paging?** BTL2 When the bit is set to valid, this value indicates that the associated page is in the process's logical address space, and is thus a legal page. If the bit is said to invalid, this value indicates that the page is not in the process's logical address space. Using the valid-invalid bit traps illegal addresses.
13	**What is the basic method of Segmentation?** BTL1 Segmentation is a memory management scheme that supports the user view of memory. A logical address space is a collection of segments. The logical address consists of segment number and offset. If the offset is legal, it is added to the segment base to produce the address in physical memory of the desired byte.
14	**How Virtual Memory is used in Operating systems?** BTL4 Virtual memory is a technique that allows the execution of processes that may not be completely in memory. It is the separation of user logical memory from physical memory. This separation provides an extremely large virtual memory, when only a smaller physical memory is available.
15	**Why Demand Paging is needed?**BTL4 Virtual memory is commonly implemented by demand paging. In demand paging, the pager brings only those necessary pages into memory instead of swapping in a whole process. Thus it avoids reading into memory pages that will not be used anyway, decreasing the swap time and the amount of physical memory needed.
16	**Define Lazy Swapper.** BTL1 Rather than swapping the entire process into main memory, a lazy swapper is used. A lazy swapper never swaps a page into memory unless that page will be needed.
17	**What is a Pure Demand Paging?** BTL2 When starting execution of a process with no pages in memory, the operating system sets the instruction pointer to the first instruction of the process, which is on a non-memory resident page, the process immediately faults for the page. After this page is brought into memory, the process continues to execute, faulting as necessary until every page that it needs is in memory. At that point, it can execute with no more faults. This schema is pure demand paging.
18	**Define Effective Access Time.** BTL1 Let p be the probability of a page fault close to 0; that is, there will be only a few page faults. The effective access time is, Effective access time = (1-p)*ma+p*page fault time ma: memory access time
19	**Define Secondary Memory.** BTL1

	This memory holds those pages that are not present in main memory. The secondary memory is usually a high speed disk. It is known as the swap device, and the section of the disk used for this purpose is known as swap space
20	**What is the basic approach of Page Replacement?** BTL2 If no frame is free is available, find one that is not currently being used and free it. A frame can be freed by writing its contents to swap space, and changing the page table to indicate that the page is no longer in memory. Now the freed frame can be used to hold the page for which the process faulted.
21	**What is the various Page Replacement Algorithms used for Page Replacement?** BTL2 • FIFO page replacement • Optimal page replacement • LRU page replacement • LRU approximation page replacement • Counting based page replacement
22	**What are the major problems to implement Demand Paging?** BTL2 The two major problems to implement demand paging is developing, Frame allocation algorithm Page replacement algorithm
23	**Define Reference String.** BTL1 An algorithm is evaluated by running it on a particular string of memory references and computing the number of page faults. The string of memory reference is called a reference string.
25	**Define secondary memory.** BTL1 This memory holds those pages that are not present in main memory. The secondary memory is usually a high speed disk. It is known as the swap device, and the section of the disk used for this purpose is known as swap space.
	PART – B
1	**Explain contiguous memory allocation detail. (13M)** BTL2 **Answer Page:360 - Silberschatz, Galvin.** **Definition (2M)** Contiguous memory allocation is a classicalmemory allocation model that assigns a process consecutive memory blocks (that is, memory blocks having consecutive addresses). Contiguous memory allocation is one of the oldest memory allocation schemes. When a process needs to execute, memory is requested by the process. **Types of Memory Allocation (11M)** • First Fit Allocation (4M) • Best Fit Allocation (4M) • Worst Fit Allocation (3M)
2	**Explain Paging hardware and paging operation concepts with diagram.(13M)** BTL2 **Answer Page:367 - Silberschatz, Galvin.** **Definition (2M)** In computer operating systems, paging is a memory management scheme by which a computer stores and retrieves data from secondary storage for use in main memory. In this scheme, the operating system retrieves data from secondary storage in same-size blocks called pages. **Diagram (6M)** 

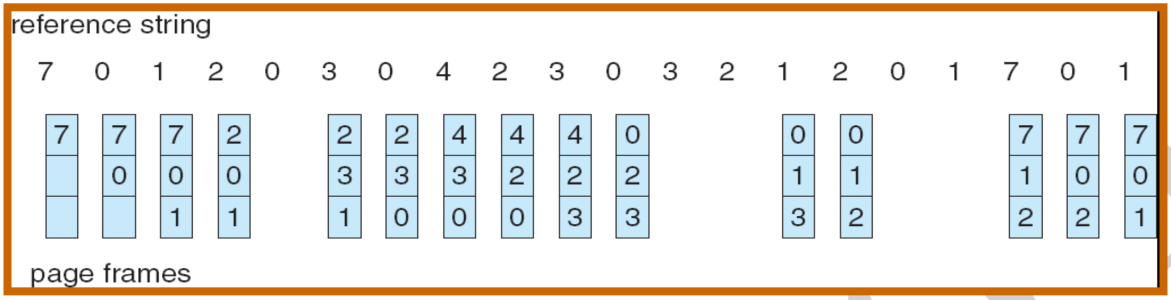
	 **Explanation (5M)**
3	**Explain Segmentation hardware and its operation concepts with necessary diagram.(13M)**BTL2 **Answer Page: 364 - Silberschatz, Galvin.** **Definition (2M)** Segmentation is one of the most common ways to achieve memory protection. In a computer system using segmentation, an instruction operand that refers to a memory location includes a value that identifies a segment and an offset within that segment. A segment has a set of permissions, and a length, associated with it. **Diagram (6M)**  **Explanation (5M)**
4	**Explain Thrashing and Demand Paging in detail.(13M)** BTL2 **Answer Page:425 & 401 Silberschatz, Galvin.** **Thrashing(7M)** **Definition (2M)** In a virtual storage system (an operating system that manages its logical storage or memory in units called pages), thrashing is a condition in which excessive paging operations are taking

	place. A system that isthrashing can be perceived as either a very slow system or one that has come to a halt. **Diagram(3M)**  **Explanation(2M)** **Demand Paging (6M)** Demand Paging. Demand paging is a type of swapping done in virtual memory systems. In demand paging, the data is not copied from the disk to the RAM until they are needed or being demanded by some program. The data will not be copied when the data is already available on the memory. **Diagram (3M)** **Explanation(3M)**
	PART *C
1	**Consider the following page reference string: 7, 0,1,2,0,3,0,4,2,3,0,3,2,1,2,0,1,7,0,1 Calculate thenumber of page faults would occur for the following page replacement algorithm with frame size of 3 .i)FIFO ii)LRU iii) Optimal (15M)** BTL6 **Answer Page:409 -Silberschatz, Galvin.** **Definition (2M)** Page replacement algorithm. In a computer operating system that uses paging for virtual memory management, page replacement algorithms decide which memory pages to page out, sometimes called swap out, or write to disk, when a page of memory needs to be allocated. **Page Replacement Algorithms (4M)**

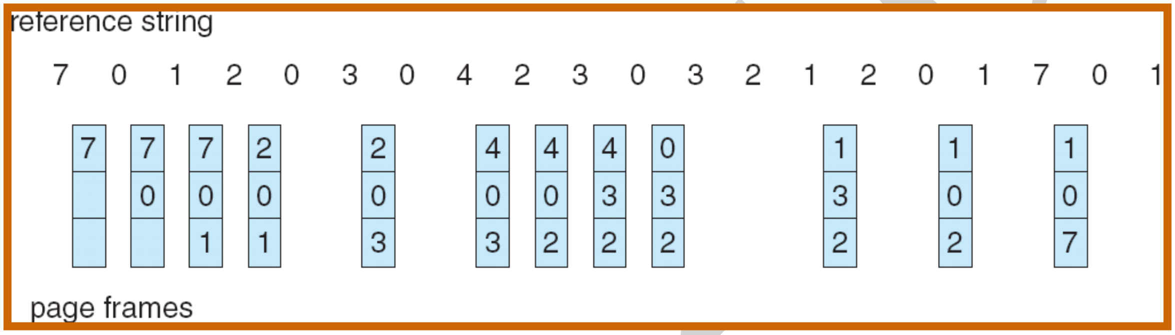
- FIFO – 15 Page Faults
- LRU – 12 Page Faults
- Optimal - 9 Page Faults

Diagram (9M)

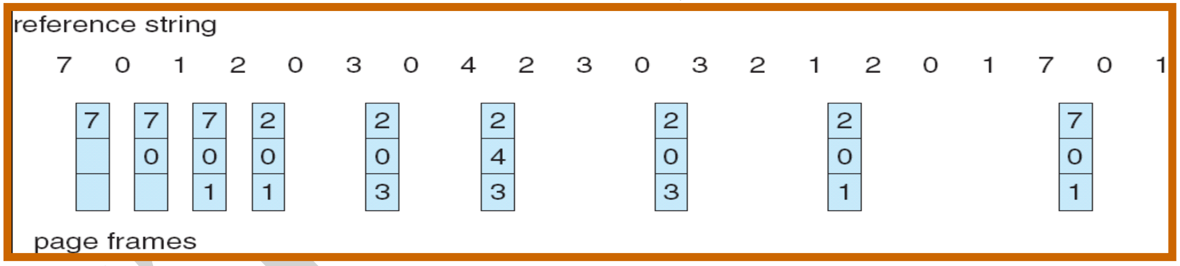
- FIFO – 15 Page Faults



- LRU – 12 Page Faults



- Optimal - 9 Page Faults



REGULATION: 2017 ACADEMIC YEAR: 2019-2020

Subject Code:CS8493 **Year/Semester: II /04**
Subject Name: OPERATING SYSTEMS **Subject Handler: Dr.J.FARITHA BANU**

UNIT IV – FILE SYSTEMS AND I/O SYSTEMS

Mass Storage system – Overview of Mass Storage Structure, Disk Structure, Disk Scheduling and Management, swap space management; File-System Interface - File concept, Access methods, Directory Structure, Directory organization, File system mounting, File Sharing and Protection; File System Implementation- File System Structure, Directory implementation, Allocation Methods, Free Space Management, Efficiency and Performance, Recovery; I/O Systems – I/O Hardware, Application I/O interface, Kernel I/O subsystem, Streams, Performance.

PART * A

Q.No.	Questions
1	**What is a File?** BTL2 A file is a named collection of related information that is recorded on secondary storage. A file contains either programs or data. A file has certain "structure" based on its type. File attributes: Name, identifier, type, size, location, protection, time, date File operations: creation, reading, writing, repositioning, deleting, truncating, appending, renaming File types: executable, object, library, source code etc.
2	**List the various File Attributes.** BTL1 A file has certain other attributes, which vary from one operating system to another, but typically consist of these: Name, identifier, type, location, size, protection, time, date and user identification.
3	**What are the various File Operations?** BTL2 The basic file operations are, Creating a file • Writing a file • Reading a file • Repositioning within a file • Deleting a file • Truncating a file

4	**What is the information associated with an Open File?** BTL2 Several pieces of information are associated with an open file which may be: • File pointer • File open count • Disk location of the file • Access rights
5	**What are the different Accessing Methods of a File?** BTL2 The different types of accessing a file are: Sequential access: Information in the file is accessed sequentially Direct access: Information in the file can be accessed without any particular order. Other access methods: Creating index for the file, indexed sequential access method
6	**Define Directory.**BTL1 The device directory or simply known as directory records information- such as name, location, size, and type for all files on that particular partition. The directory can be viewed as a symbol table that translates file names into their directory entries.
7	**What are the operations that can be performed on a Directory?** BTL2 The operations that can be performed on a directory are, Search for a file • Create a file • Delete a file • Rename a file • List directory • Traverse the file system
8	**How to define the Logical Structure of a Directory?** BTL1 The most common schemes for defining the logical structure of a directory Single -Level Directory Two -level Directory Tree-Structured Directories Acyclic -Graph Directories General Graph Directory
9	**State the use of UFD and MFD.** BTL1 In the two-level directory structure, each user has own user file directory Each UFD has a similar structure, but lists only the files of a single user. When a job starts the system's master file directory(MFD) will monitor the file handling process.
10	**What is a Path Name?** BTL2 A pathname is the path from the root through all subdirectories to a specified file. In a two-leve directory structure a user name and a file name define a path name.
11	**What is Access Control List?** BTL1 The most general scheme to implement identity-dependent access is to associate with each file and directory an access control unit.
12	**Define Equal Allocation.** BTL1 The way to split „m' frames among „n' processes is to give everyone an equal share, m/n frames. For instance, if there are 93 frames and 5 processes, each process will get 18 frames. The leftover

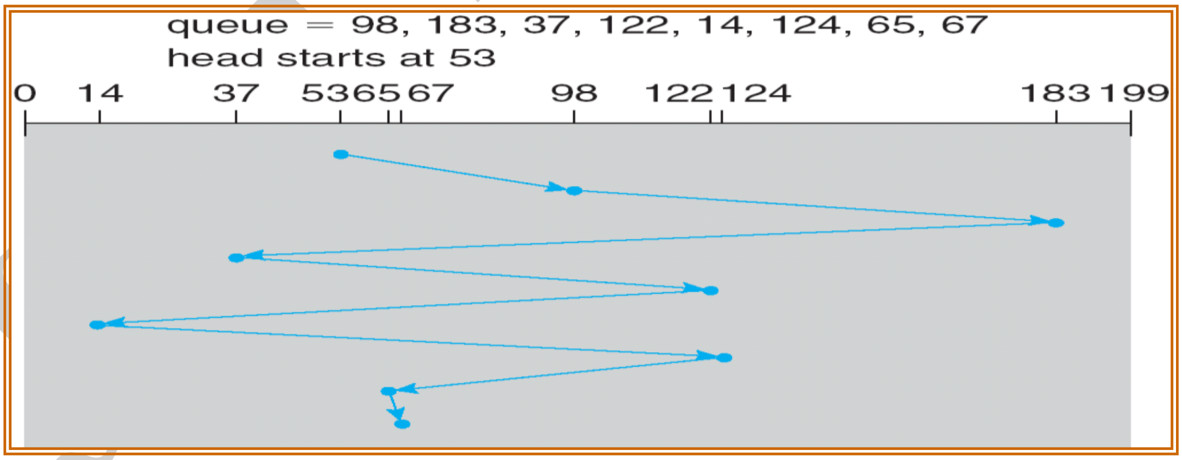
	3 frames could be used as a free-frame buffer pool. This scheme is called equal allocation.
13	**How would you solve thrashing problem?** BTL3 Thrashing is caused by under allocation of the minimum number of pages required by a process, forcing it to continuously page fault. The system can detect thrashing by evaluating the level of CPU utilization as compared to the level of multiprogramming. It can be eliminated by reducing the level of multiprogramming.
14	**What is Belady's Anomaly?** BTL2 For some page replacement algorithms, the page fault rate may increase as the number of allocated frames increases.
15	**List out the types of Path Names.** BTL1 Path names can be of two types. Absolute path name: Begins at the root and follows a path down to the specified file, giving the directory names on the path. Relative path name: Defines a path from the current directory.
16	**What is meant by Locality of Reference?** BTL2 The locality model states that, as a process executes, it moves from locality to locality. Locality is of two types. • Spatial locality • Temporal locality.
17	**Define Seek Time and Latency Time.** BTL1 The time taken by the head to move to the appropriate cylinder or track is called seek time. Once the head is at right track, it must wait until the desired block rotates under the read- write head. This delay is latency time.
18	**What are the Allocation Methods of a Disk Space?** BTL2 Three major methods of allocating disk space which are widely in use are • Contiguous allocation • Linked allocation • Indexed allocation
19	**What are the advantages of Contiguous Allocation?**BTL1 The advantages are, • Supports direct access • Supports sequential access • Number of disk seeks is minimal.
20	**List out the drawbacks of Contiguous Allocation of Disk Space.**BTL1 The disadvantages are, • Suffers from external fragmentation • Suffers from internal fragmentation • Difficulty in finding space for a new file • File cannot be extended • Size of the file is to be declared in advance
21	**What are the advantages of Linked Allocation?**BTL2 The advantages are, • No external fragmentation • Size of the file does not need to be declared

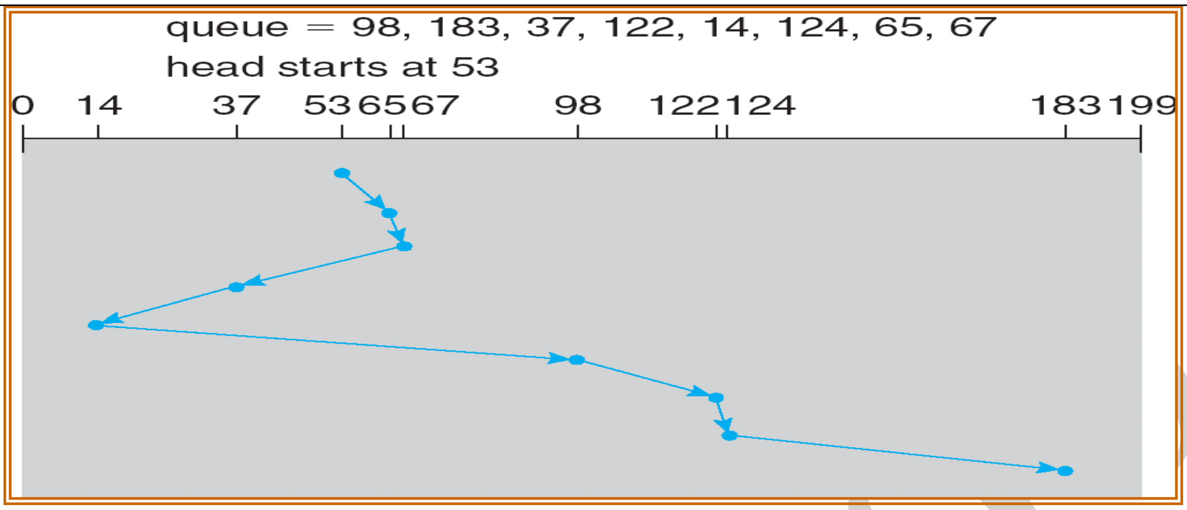
22	**What are the disadvantages of Linked Allocation?**BTL2 The disadvantages are, Used only for sequential access of files. • Direct access is not supported • Memory space required for the pointers. • Reliability is compromised if the pointers are lost or damaged
23	**How many types of Disk-Scheduling Algorithms used in operating systems?** BTL1 The various disk-scheduling algorithms are, • First Come First Served Scheduling • Shortest Seek Time First Scheduling • SCAN Scheduling • C -SCAN Scheduling • LOOK scheduling
24	**What are the techniques used for performing I/O?**BTL2 • Programmed I/O • Interrupt driven I/O • Direct Memory Access
25	**Give an example of an application in which data in a file should be accessed in the following order**: BTL3 Sequentially - Print the content of the file. Randomly - Print the content of record i. This record can be found using hashing or index techniques
26	**What problems could occur if a system allowed a file system to be mounted simultaneously at more than one location?** BTL2 There would be multiple paths to the same file, which could confuse users or encourage mistakes. (Deleting a file with one path deletes the file in all the other).
	PART – B
1	**Explain different types of storage media used in operating systems. (13M).** BTL2 **Answer Page: 467 - Silberschatz, Galvin.** **Definition (3M)** A computer storage device is any type of hardware that stores data.These types of drives are often used for backing up internal hard drives, storing video or photo libraries, or for simply adding extra storage. **Types of Storage Media (10M)** • Primary Storage (2M) • Secondary Storage (3M) • Tertiary Storage (3M) • Off-line Storage (2M)
2	**Explain various Directory Structure management in detail. (13M).** BTL2 **Answer Page: 515 - Silberschatz, Galvin.** **Definition (3M)** A directory is defined as an organizational unit, or container, used to organize folders and files into a hierarchical structure. You can think of a directory as a file cabinet that contains folders that contain files.

	There are five directory structures. (10M) • Single-level directory (2M) • Two-level directory (2M) • Tree-Structured directory (2M) • Acyclic Graph directory (2M) • General Graph directory (2M)
3	**Explain the different types of File Allocation methods in detail. (13M).** BTL2 **Answer Page: 553 - Silberschatz, Galvin.** **Definition (3M)** A file allocation table (FAT) is a file system developed for hard drives that originally used 12 or 6 bits for each cluster entry into the file allocation table. It is used by the operating system (OS) to managefiles on hard drives and other computer systems. **Types of File Allocation (10M)** • Contiguous Allocation (4M) • Linked Allocation (3M) • Indexed Allocation (3M)
4	**Explain the FCFS, SSTF, SCAN, C-SCAN disk scheduling algorithms. (13M)** BTL2 **Answer Page: 472 - Silberschatz, Galvin.** **Definition (3M)** Disk scheduling is done by operating systems to schedule I/O requests arriving for disk. Disk scheduling is also known as I/O scheduling. ... Hard drives are one of the slowest parts of computer system and thus need to be accessed in an efficient manner. **Types disk scheduling algorithms (10M)** • FCFS scheduling • SSTF scheduling • SCAN scheduling • C-SCAN scheduling • LOOK scheduling • C-LOOK scheduling
5	**How would you classify the File concepts and Access Methods with an example.(13M)** BTL2 **Answer Page: 512 - Silberschatz, Galvin.** **Definition (3M)** **File Concepts (5M)** • File Attribute. • File operation. • File Types. • File Sharing&Protection. **File Access Methods (5M)** • Sequential Access. • Direct Access.

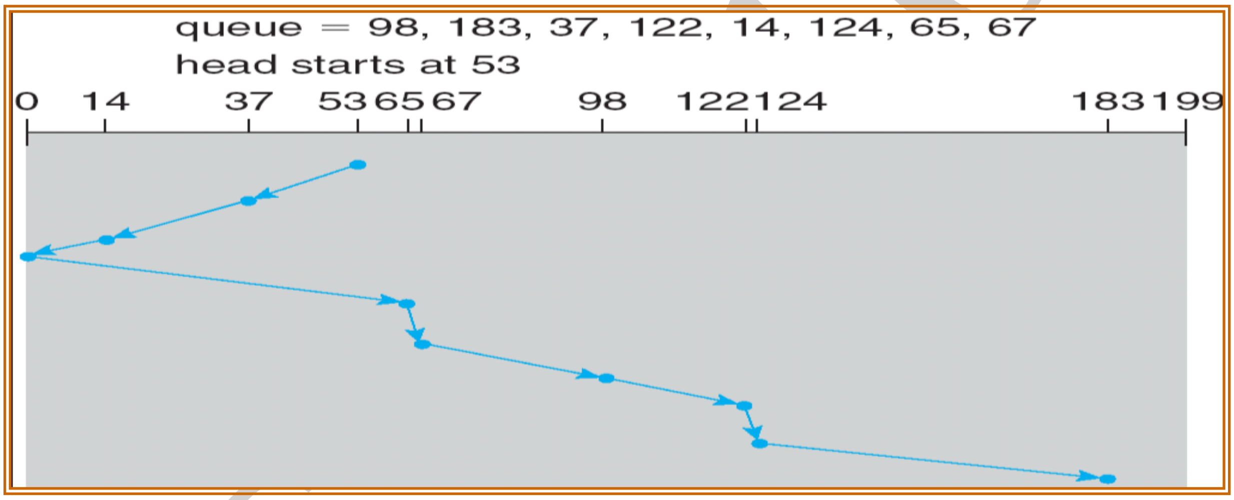
	• Other Access.
6	**Explain Free space Management with example. (13M)** BTL2 **Answer Page: 561 - Silberschatz, Galvin.** **Definition (2M)** The system keeps tracks of thefree disk blocks for allocating space to files when they are created. Also, to reuse the space released from deleting the files, free space management becomes crucial. **Free Space Management (11M)** • Bit Vector (3M) • Linked List (3M) • Grouping (3M) • Counting (2M)

PART *C

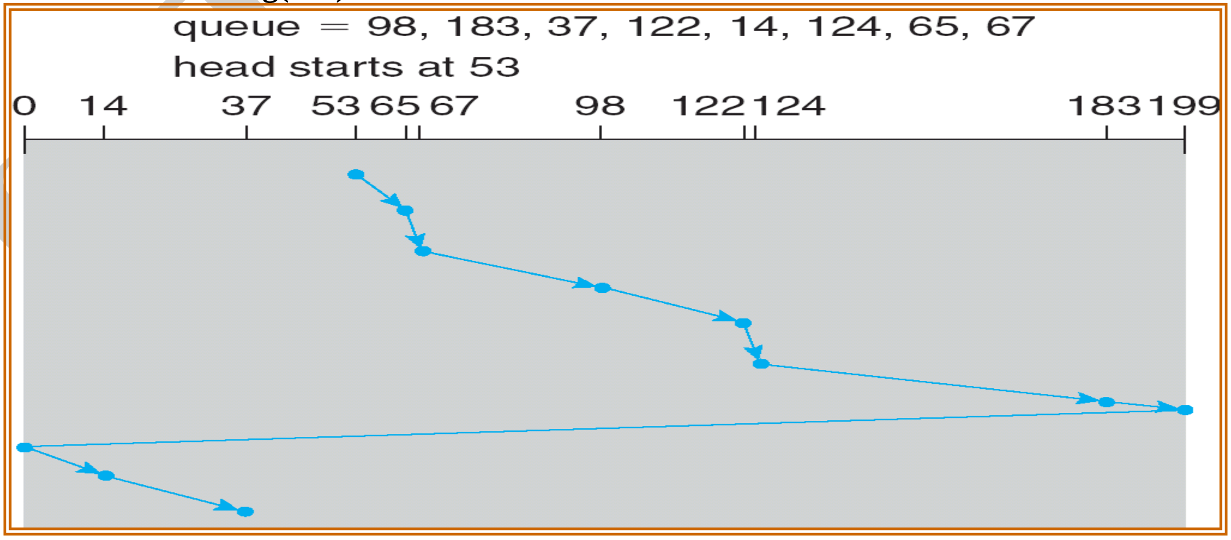
1	**Draw the FCFS, SSTF, SCAN and C-SCAN disk scheduling algorithms graph forthe following example. A request queues. 98, 183, 37, 122, 14, 124, 65, 67 , Total tracks (0-199) and Assume that initial position of R/W Head at 53. ? (15M)** BTL4 **Answer Page: 472 - Silberschatz, Galvin.** **Definition (3M)** Disk scheduling is done by operating systems to schedule I/O requests arriving for disk. Disk scheduling is also known as I/O scheduling. Disk scheduling is important because: Multiple I/O requests may arrive by different processes and only one I/O request can be served at a time by disk controller. **FCFS scheduling (3M)**  **SSTF scheduling(3M)**



SCAN scheduling(3M)



C-SCAN scheduling(3M)



2	**How would you classify the RAID levels with example?(15M)** BTL4 **Answer Page: 484 - Silberschatz, Galvin.**

	Definition (3M) RAID (Redundant Array of Independent Disks, originally Redundant Array of Inexpensive Disks) is a data storage virtualization technology that combines multiple physical disk drive components into one or more logical units for the purposes of data redundancy, performance improvement, or both. **RAID Levels (12M)** - RAID Level 0 (2M) - RAID Level 1 (2M) - RAID Level 2 (2M) - RAID Level 3 (2M) - RAID Level 4 (2M) - RAID Level 5 (2M)

Subject Code:CS8493 **Year/Semester: II /04**
Subject Name: OPERATING SYSTEMS **Subject Handler: Dr.J.FARITHA BANU**

UNIT VCase Study	
Linux System - Design Principles, Kernel Modules, Process Management, Scheduling, Memory Management, Input-Output Management, File System, Inter-process Communication; Mobile OS - iOS and Android - Architecture and SDK Framework, Media Layer, Services Layer, Core OS Layer, File System.	
PART * A	
Q.No.	**Questions**
1	**What are the Components of a Linux System?** BTL2 Linux System composed of three main modules. They are: - Kernel - System libraries - System utilities
2	**What are the main supports for the Linux modules?** BTL2 The Module support under Linux has three components. They are: - Module Management - Driver Registration. - Conflict Resolution mechanism.
3	**What is meant by Process Personality?** BTL2 Process Personalities are primarily used by emulation libraries to request that system call be compatible with certain versions of UNIX.
4	**Define Buffer cache.**BTL1 It is the kernel's main cache for block-oriented devices such as disk drives and is the main mechanism through which I/O to these devices is performed.

5	**What is the Disadvantage of Static Linking?** BTL2 The main disadvantage of static linking is that every program generated must contain copies o exactly the same common system library functions.
6	**What is meant by Kernel in Linux system?** BTL2 Kernel is responsible for maintaining all the important abstractions of the operating system including such things as virtual memory and processes.
7	**Define System Libraries.**BTL1 System Libraries define a standard set of functions through which applications can interact with the kernel and that implement much of the operating -system functionality that doesn‟tneed the full privileges of kernel code.
8	**Define System Utilities.**BTL1 System Utilities are system programs that perform individual, specialized management tasks. Some of the System utilities may be invoked just to initialize and configure some aspect of the system and others may run permanently, handling such tasks as responding to incoming network connections, accepting logon requests from terminals or updating log files.
9	**State the Role of Module management.**BTL1 The module management allows modules to be loaded into memory and to talk to the rest of the kernel.
10	**What is the function of Driver registration?** BTL2 Driver Registration allows modules to tell the rest of the kernel that a new driver has become available.
11	**What is the function of Conflict Resolution mechanism?** BTL2 This mechanism allows different device drivers to reserve hardware resources and to protect those resources from accidental use by another driver.
12	**Can you list out some functions of Device drivers?** BTL2 Device drivers include • Character devices such as printers, terminals • Block devices including all disk drives • Network interface devices.
13	**What is Linux distribution?**BTL2 A Linux distribution includes all the standard components of the Linux system, plus a set of administrative tools to simplify the initial installation and subsequent upgrading of Linux and manage installation and removal of other packages on the system.
14	**What is the use of User mode?**BTL2 Under Linux, no user code is built into the kernel. Any operating-system-support code that does notneed to run in kernel mode is placed into the system libraries and runs in user mode.
15	**Define process Identity.** BTL1 Each process has a unique identifier. The PID is used to specify the process to the operating system when an application makes a system call to signal, modify, or wait for the process. Additional identifiers associate the process with a process group (typically, a tree of processes forked by a singleuser command and login session.
16	**Define DNS.** BTL1 The domain name system(DNS) provides host-name-to-network-address translations for the entire Internet. Before DNS became widespread, files containing the same informationwere sent via e-mailor ftp between all networked hosts.

17	**What is virtualization?**BTL2 Virtualization, in computing, refers to the act of creating a virtual (rather than actual) version of something, including but not limited to a virtual computer hardware platform, operating system (OS),storage device, or computer network resources.
18	**What is meant by Mobile Operating System?**BTL2 A mobile operating system, also called a mobile OS, is software that is specifically designed to run on mobile devices such as mobile phones, smartphones, PDAs, tablet computers and other handheld devices. Much like the Linux or Windows operating system controls your desktop or laptop computer, a mobile operating system is the software platform on top of which other programs can run on mobile devices.
19	**List out various Mobile Operating Systems**. BTL1 • There are many mobile operating systems. The followings demonstrate the most important ones: • Java ME Platform • Palm OS • Symbian OS • Linux OS • Windows Mobile OS • BlackBerry OS • iPhone OS • Google Android Platform
20	**Do FAT file system is advantageous? Why?**BTL3 FAT File System is best for cross-compatibility with other platforms. There are NTFS file system drivers for Linux, but not really for Windows. FAT, however, can be read more or less transparently by both operating systems. There is also a slight speed gain in FAT.
21	**What is the responsibility of kernel in Linux operating system?**BTL2 Kernel is the core part of Linux. It is responsible for all major activities of this operating system. It is consisting of various modules and it interacts directly with the underlying hardware. Kernel provides the required abstraction to hide low level hardware details to system or application programs.
22	**Why Virtualization is required?** BTL3 Virtualization reduces the number of physical servers, reducing the energy required to power and cool them. Save time. With fewer servers, you can spend less time on the manual tasks required for server maintenance. It's also much faster to deploy a virtual machine than it is to deploy a new physical server.
23	**Define Android SDK.**BTL1 Android SDK is a software development kit that enables developers to create applications for the Android platform. The Android SDK includes sample projects with source code, development tools, an emulator, and required libraries to build Android applications.
	PART - B
1	**Explain Linux operating systemsand its operations. (13M)** BTL2 **Answer Page: 781 - Silberschatz, Galvin.** **Definition (3M)** Linux looks and feels much like any other UNIX system; indeed, UNIX compatibility has been a major design goal of the Linux project. However, Linux is much younger than most UNIX

	systems. Its development began in 1991, when a Finnish university student, Linus Torvalds, began developing a small but self-contained kernel for the 80386 processor, the first true 32-bit processorinIntel'srangeof PC-compatible CPUs. **Operations (10M)** • Linux Systems. (2M) • Linux Distributions (3M) • Linux Licensing(2M) • Linux Modules (3M)
2	**Describe Process management systems in Linux OS. (13M)** BTL2 **Answer Page: 792 - Silberschatz, Galvin.** **Definition (3M)** A process is the basic context in which all user-requested activity is serviced withintheoperatingsystem.TobecompatiblewithotherUNIXsystems,Linux must use a process model similar to those of other versions of UNIX. Linux operates differently from UNIX in a few key places.They are • Process Models (3M) • Processes and Threads(3M) • Process Environment(2M) • Process Identity (2M)
3	**How to manage the Memory system in Linux and explain its components?(13M)** BTL2 **Answer Page: 801 - Silberschatz, Galvin.** **Definition (3M)** Memory management under Linux has two components. The first deals with allocating and freeing physical memory—pages, groups of pages, and small blocksofRAM.Thesecondhandlesvirtualmemory,whichismemory-mapped into the address space of running processes. **Components (10M)** • Management of Physical Memory • Virtual Memory • Swapping and Paging • Kernel Virtual Memory • Execution and Loading of user programs
4	**Explain different types of File systems used in Linux operating systems. (13M)** BTL2 **Answer Page: 809 - Silberschatz, Galvin.** **Definition (3M)** Linuxretains UNIX's standard file-systemmodel.In UNIX, afile doesnothave to be an object stored on disk or fetched over a network from a remote file server. Rather, UNIX files can be anythingcapable of handling the input or outputofastreamofdata.Devicedriverscanappearasfiles andinterprocesscommunication channels or network connections also look like files to the user. • Virtual File Systems (3M) • Linux ext3 File systems (3M)

	- Journaling(2M) - Linux Process File systems(2M)
5	**What are the advantages and disadvantages of Android Mobile OS? (13M)** BTL2 **Answer Page: 902 - Silberschatz, Galvin.** **Definition (3M)** Android is a mobile operating system developed by Google, based on a modified version of the Linux kernel and other open source software and designed primarily for the touchscreen mobile devices such as smartphones and tablets. **Advantages(5M)** - Large number of devices using Android - Frequent Enhancement - Larger number of applications availability - Excellent UI - Multi-tasking - Free developer tools - No restrictions on applications - Phones are available from every service **Disadvantages (5M)** - Some device manufacturers add alternative UI front-ends which reduces OS consistency - Updates are controlled by device manufacturers and may be slow or nonexistent - Applications are not validated
	PART *C
1	**What are the advantages and disadvantages of AppleiOS and BlackBerry OS? (15M)** BTL2 **Answer Page: 903 - Silberschatz, Galvin.** **Definition (3M)** Apple iOS is a proprietary mobile operating system that runs on the iPhone, iPad and iPod Touch.Apple iOS is based on the Mac OS X operating system for desktop and laptop computers. The iOSdeveloper kit provides tools that allow for iOS app development. **Apple iOS Advantages& Disadvantages(5M)** Advantages - Excellent UI - Larger number of applications availability - Apple validates applications - Consistent UI across devices - Frequent free OS updates Disadvantages - Closed Architecture - Limited number of devices to choose from – all from apple - No multi-tasking for applications - Applications must be approved by Apple before being made available via the Marketplace - Can’t be unlocked

BlackBerry OS(2M)

BlackBerry OS is a proprietary mobile operating system developed by Research In Motion (RIM) for its BlackBerry line of smartphones. BlackBerry 10 OS is a QNX-based operating system, similar to the one found on RIM's Playbook tablet. It will replace the BlackBerry OS on smartphones and tablets in 2013.

Blackberry OS Advantages& Disadvantages(5M)

Advantages

- Secure send and receive email using proprietary encryption
- Multi-tasking
- Phones available form most service providers

Disadvantages

- Closed Architecture
- Limited number of devices to choose from – all from Research In Motion
- Limited number of applications available
- Application development is more complex and difficult than other Operating Systems
- Applications tend to be more costly

Regulation: 2017 **Academic year: 2019-2020**

Subject Code: CS8494 **Year/Semester: II /04**

Subject Name: SOFTWARE ENGINEERING **Subject Handler: S.DEEPAN**

CS8494 SOFTWARE ENGINEERING L T P C

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OBJECTIVES:

- To understand the phases in a software project
- To understand fundamental concepts of requirements engineering and Analysis Modeling.
- To understand the various software design methodologies
- To learn various testing and maintenance measures

UNIT I SOFTWARE PROCESS AND AGILE DEVELOPMENT 9

Introduction to Software Engineering, Software Process, Perspective and Specialized Process Models –Introduction to Agility- Agile process-Extreme programming-XP Process.

UNIT II REQUIREMENTS ANALYSIS AND SPECIFICATION 9

Software Requirements: Functional and Non-Functional, User requirements, System requirements, Software Requirements Document – Requirement Engineering Process: Feasibility Studies, Requirements elicitation and analysis, requirements validation, requirements management-Classical analysis: Structured system Analysis, Petri Nets- Data Dictionary.

UNIT III SOFTWARE DESIGN 9

Design process – Design Concepts-Design Model– Design Heuristic – Architectural Design - Architectural styles, Architectural Design, Architectural Mapping using Data Flow- User Interface Design: Interface analysis, Interface Design –Component level Design: Designing Class based components, traditional Components.

UNIT IV TESTING AND MAINTENANCE 9

Software testing fundamentals-Internal and external views of Testing-white box testing - basis path testing-control structure testing-black box testing- Regression Testing – Unit Testing – Integration Testing – Validation Testing – System Testing And Debugging –Software Implementation Techniques: Coding practices-Refactoring-Maintenance and Reengineering-BPR model-Reengineering process model-Reverse and Forward Engineering.

UNIT V PROJECT MANAGEMENT 9

Software Project Management: Estimation – LOC, FP Based Estimation, Make/Buy Decision COCOMO I & II Model – Project Scheduling – Scheduling, Earned Value Analysis Planning – Project Plan, Planning Process, RFP Risk Management – Identification, Projection - Risk Management-Risk Identification-RMMM Plan-CASE TOOLS

TOTAL :45 PERIODS

OUTCOMES:

On Completion of the course, the students should be able to:

- Identify the key activities in managing a software project.
- Compare different process models.
- Concepts of requirements engineering and Analysis Modeling.
- Apply systematic procedure for software design and deployment.
- Compare and contrast the various testing and maintenance.

- Manage project schedule, estimate project cost and effort required.

TEXT BOOKS:

1. Roger S. Pressman, ―Software Engineering – A Practitioner‟s Approach‖, Seventh Edition, Mc Graw-Hill International Edition, 2010.
2. Ian Sommerville, ―Software Engineering‖, 9th Edition, Pearson Education Asia, 2011.

REFERENCES:

1. Rajib Mall, ―Fundamentals of Software Engineering‖, Third Edition, PHI Learning PrivateLimited, 2009.
2. Pankaj Jalote, ―Software Engineering, A Precise Approach‖, Wiley India, 2010.
3. Kelkar S.A., ―Software Engineering‖, Prentice Hall of India Pvt Ltd, 2007.
4. Stephen R.Schach, ―Software Engineering‖, Tata McGraw-Hill Publishing Company Limited,2007.
5. http://nptel.ac.in/.

SUBJECT CODE :CS 8494 **SUBJECT HANDLER: Mr. S. DEEPAN**
SUBJECT NAME: SOFTWARE ENGINEERING **YEAR/SEM:II/04**

UNIT -1- SOFTWARE PROCESS AND AGILE DEVELOPMENT

Introduction to Software Engineering, Software Process, Perspective and Specialized Process Models – Introduction to Agility-Agile process-Extreme programming-XP Process.

PART * A

Q.NO	QUESTIONS
1	**What is software engineering?(APR MAY 2010)** BTL 1 Software engineering is a discipline in which theories, methods and tools are applied to develop professional software.
2	**What are the merits of incremental model?** BTL 1 • The incremental model can be adopted when there are less number of people involved in the project • Technical risks can be managed with each increment. • For a very small time span at least core product can be delivered to the customer
3	**What are the umbrella activities of a software process?(APR/MAY 2012)** BTL 1 Software project tracking and control. Risk management. Software Quality Assurance. Formal Technical Reviews. **Software Configuration Management.** Work product preparation and production. Reusability management. Measurement.

4	**Write down the fundamental activities of a software process.** BTL 2 Specification Design and implementation Validation Evolution
5	**Define software process.** BTL 2 Software process is defined as the structured set of activities that are required to develop the software system.
6	**What are the challenges in software?** BTL 1 Copying with legacy systems. Heterogeneity challenge Delivery times challenge
7	**List various categories of software (NOV/DEC 2014)** BTL 2 System software Application software Engineering/Scientific software Embedded software Web Applications Artificial Intelligence software
8	**What are the characteristics of the software? (APR/MAY 2013)** BTL 1 Software is engineered, not manufactured. Software does not wear out. Most software is custom built rather than being assembled from components.
9	**What is Software?(NOV/DEC 2010)** BTL 1 Software is nothing but a collection of computer programs that are related documents that are indented to provide desired features, functionalities and better performance.
10	**What is System Engineering?** BTL 1 System Engineering means designing, implementing, deploying and operating systems which include hardware, software and people
11	**List the process maturity levels in SEIs CMM.** BTL 2 Level 1:Initial – Few processes are defined and individual efforts are taken. Level 2:Repeatable – To track cost schedule and functionality basic project management processes areestablished.
12	**Describe effector process.** **(**BTL 2) The effector process is a process that verifies itself. The effector process exists in certain criteria.
13	**What does Validation represent?** **(**BTL 1) Validation represents the set of activities that ensure that the software that has been built is satisfying thecustomer requirements.
14	**What does Verification represent?** **(**BTL 1) Verification represents the set of activities that are carried out to confirm that the software correctlyimplements the specific functionality.
15	**Define the computer based system.** **(**BTL 1) The computer based system can be defined as **“**a set or an arrangement of elements that are organized toaccomplish some predefined goal by processing information**”**.

16 **Name the Evolutionary process Models. (**BTL 3)

- Incremental model
- Spiral model
- WIN-WIN spiral model
- Concurrent Development

17 **What is Agile Methodology? (**BTL 2)

AGILE methodology is a practice that promotes continuous iteration of development and testing throughout the software development lifecycle of the project. Both development and testing activities are concurrent unlike the Waterfall model.

18 **Distinguish between Agile and Waterfall Method (**BTL 2)

Agile method proposes incremental and iterative approach to software design.	Development of the software flows sequentially from start point to end point.
The agile process is broken into individual models that designers work on	The design process is not broken into an individual models
Agile model is considered unstructured compared to the waterfall model	Waterfall model are more secure because they are so plan oriented
Testers and developers work together	Testers work separately from developers

19 **Write some agile principles. (**BTL 2)

- Satisfy customer through early and continuous increments.
- Deploy first increment within couple of weeks and the whole software within couple of months.
- Customer and agile teams must work jointly daily throughout the project.
- Agile team and customer must have face-to-face meetings.

20 **List agile software methods (**BTL 1)

- Extreme Programming (XP),
- Agile Modeling (AM),
- Scrum
- Adaptive Software Development (ASD)

21 **What is extreme programming** (XP)? (BTL 2)

Extreme Programming is one of the most widely adopted agile methodologies. The XP methodology was created by Kent Beck. The XP improves a software project in four essential ways which are communication, simplicity, feedback and courage.

22 **Describe scrum. (**BTL 3)

It is an agile, iterative, incremental developing method which assumes that changes and chaos exist through entire life-circle of the project crum is designed to add energy, focus, clarity and transparency to project teams development software systems

23 **List 4 phases of the Adaptive Software Development process Model.** (BTL 3)

	• Communication and planning • Analysis • Design and development • Testing and deployment
24	**How is scrum different from waterfall?** BTL 3 The major differences are: The feedback from customer is received at an early stage in Scrum than waterfall, where the feedback from customer is received towards the end of development cycle. To accommodate the new or changed requirement in scrum is easier than waterfall. Scrum focuses on collaborative development than waterfall where the entire development cycle is divided into phases. At any point of time we can roll back the changes in scrum than in waterfall. Test is considered as phase in waterfall unlike scrum.
25	**What is Agility?** **(**BTL 1) Agility is the ability to balance flexibility and stability. In an uncertain and turbulent world, success belongs to companies that have the capacity to create change, and maybe even chaos, for their competitors. Creating change disrupts competitors; responding to change guards against competitive thrusts.

	PART *B
1	**Explain iterative waterfall and spiral model for software life cycle and various activities in each (APR/MAY 2012) .(APR/MAY 2015) (13M)** BTL 1 **Answer: Page:79 - Roger S Pressman** **Water fall model and spiral model Communication (3M)** **Planning** - Proper planning of model (2M) **Modeling** -Modeling of the software development(2M) **Construction** -code generation and testing (2M) **Deployment** -Installation and evaluation (2M) **Advantages and disadvantages (**2M)
2	**Explain about the incremental model. (NOV/DEC 2014) (13 M)** BTL 1 **Answer: Page:80 in Roger S Pressman** Combination of linear + prototype (2M) • Rather than deliver the system as a single delivery, the development and delivery is broken down into increments with each increment delivering part of the required functionality (3M) • User requirements are prioritized and the highest priority requirements are included in early increments (3M) • Once the development of an increment is started, the requirements are frozen though requirements for later increments can continue to evolve(2M) **Incremental development advantages:** (3M) • The customer is able to do some useful work after release • Lower risk of overall project failure • The highest priority system services tend to receive the most testing
3	**Explain in detail about the software process. (NOV/DEC 2014) (13M)** BTL 2 **Answer: Page:80 in Roger S Pressman** • A structured set of activities required to develop a software system (3M) – Specification; – Design; – Validation; – Evolution. • A software process model is an abstract representation of a process. It presents a description of a process from some particular perspective. • **Systems Engineering** (2M) – Software as part of larger system, determine requirements for all system elements, allocate requirements to software. • **Software Requirements Analysis** (2M) – Develop understanding of problem domain, user needs, function, performance, interfaces, ...

	– Software Design – Multi-step process to determine architecture, interfaces, data structures, functional detail. Produces (high-level) form that can be checked for quality, conformance before coding. • **Coding** (2M) – Produce machine readable and executable form, match HW, OS and design needs. • **Testing** (2M) – Confirm that components, subsystems and complete products meet requirements, specifications and quality, find and fix defects. • **Maintenance** (2M) – Incrementally, evolve software to fix defects, add features, adapt to new condition. Often 80% of effort spent here
4	**Illustrate Agile process in detail** **(13 M)** BTL 2 **Answer: Page:106 in Roger S Pressman** **Definition (2M)** **The politics of Agile Development (5M)** There is no substitute for rapid feedback, both on the development process and on the product itself. **Human Factors (6M)** ▪ Competence ▪ Common focus ▪ Collaboration ▪ Decision Making ▪ Self organization
5	**Write the difference between Agile andWaterfall method** **(13M)** BTL 4 **Answer: Page:79 - 80 in Roger S Pressman**

Agile Model	Waterfall Model
Agile method proposes incremental and iterative approach to software design	Development of the software flows sequentially from start pointto end point.
The agile process is broken into individual models that designers work on	The design process is not broken into an individual models
The customer has early and frequent opportunities to look at the product and make decision and changes to the project	The customer can only see the product at the end of the project
Agile model is considered unstructured compared to the waterfall model	Waterfall model are more secure because they are so plan oriented
Small projects can be implemented very quickly. For large projects, it is difficult to estimate the development time.	All sorts of project can be estimated and completed.
Error can be fixed in the middle of the project.	Only at the end, the whole product is tested. If the requirement error is found or any changes have to be made, the project has to start from the beginning
Development process is iterative, and the project is executed in short (2-4) weeks iterations. Planning is very less.	The development process is phased, and the phase is much bigger than iteration. Every phase ends with the detailed description of the next phase.
Documentation attends less priority than software development	Documentation is a top priority and can even use for training staff and upgrade the software with another team
Every iteration has its own testing phase. It allows implementing regression testing every time new functions or logic are released.	Only after the development phase, the testing phase is executed because separate parts are not fully functional.

In agile testing when an iteration end, shippable features of the product is delivered to the customer. New features are usable right after shipment. It is useful when you have good contact with customers.	All features developed are delivered at once after the long implementation phase.
Testers and developers work together	Testers work separately from developers
At the end of every sprint, user acceptance is performed	User acceptance is performed at the end of the project.
It requires close communication with developers and together analyze requirements and planning	Developer does not involve in requirement and planning process. Usually, time delays between tests and coding

PART* C

1 **Explain Extreme Programming in detail (15M) BTL 4**

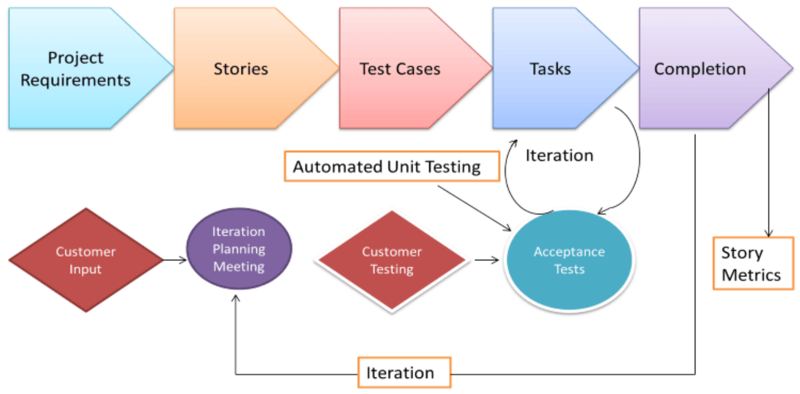
Answer: Page:110 in Roger S Pressman

Definition (2M)

Extreme Programming technique is very helpful when there is constantly changing demands or requirements from the customers or when they are not sure about the functionality of the system

Phases of eXtreme programming:

- Planning (3M)
- Analysis(3M)
- Design (2M)
- Execution(2M)
- Wrapping(2M)
- Closure(2M)



Extreme Programming (XP)

UNIT 2- REQUIREMENTS ANALYSIS AND SPECIFICATION

Software Requirements: Functional and Non-Functional, User requirements, System requirements, Software Requirements Document – Requirement Engineering Process: Feasibility Studies, Requirements elicitation and analysis, requirements validation, requirements management-Classical analysis: Structured system Analysis, Petri Nets- Data Dictionary.

PART * A

1. **Define software prototyping.** BTL 1

Software prototyping is defined as a rapid software development for validating the requirements.

2. **What are the benefits of prototyping? (APR/MAY 2012)** BTL 1

- Prototype serves as a basis for deriving system specification.
- Design quality can be improved.
- System can be maintained easily.
- Development efforts may get reduced.
- System usability can be improved.

3. **List the prototyping approaches in software process? (APR/MAY 2015)** BTL 1

- Evolutionary prototyping – In this approach of system development, the initial prototype is prepared and it is then refined through number of stages to final stage.
- Throw-away prototyping – Using this approach a rough practical implementation of the system is produced.
- The requirement problems can be identified from this implementation. It is then discarded.
- System is then developed using some different engineering paradigm.

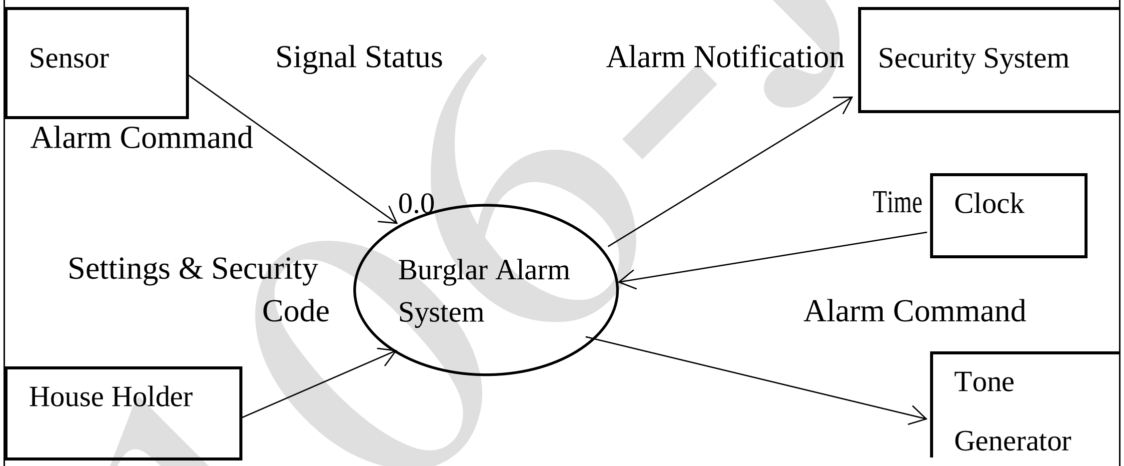
4. **What are the advantages of evolutionary prototyping? (APR/MAY 2012)** BTL 1

- Fast delivery of the working system.
- User is involved while developing the system.
- More useful system can be delivered.
- Specification, design and implementation work in co-ordinated manner.

5. **What are the various Rapid prototyping techniques (NOV/DEC2014)** BTL 1

- Dynamic high level language development.
- Database programming.
- Component and application assembly.

6.	**What is the use of User Interface prototyping? (APR/MAY 2012)** BTL 1 This prototyping is used to pre-specify the look and feel of user interface in an effective way.
7.	**What are the characteristics of SRS?** BTL 1 • Correct – The SRS should be made up to date when appropriate requirements are identified. • Unambiguous – When the requirements are correctly understood then only it is possible to write an unambiguous software. • Complete – To make SRS complete, it should be specified what a software designer wants to create software. • Consistent – It should be consistent with reference to the functionalities identified. • Specific – The requirements should be mentioned specifically. • Traceable – What is the need for mentioned requirement? This should be correctly identified.
8.	**Write down the objectives of Analysis modeling.** BTL2 • To describe what the customer requires. • To establish a basis for the creation of software design. • To devise a set of valid requirements after which the software can be built.
9.	**What is data modeling? (APR/MAY 2012)** BTL 1 Data modeling is the basic step in the analysis modeling. In data modeling the data objects are examined independently of processing. The data model represents how data are related with one another.
10.	**What is a data object? ((NOV/DEC 2014)** BTL 1 Data object is a collection of attributes that act as an aspect, characteristic, quality, or descriptor of the object.
11.	**Give details about attributes.** BTL 2 Attributes are the one, which defines the properties of data object.
12	**What is cardinality in data modeling?** BTL 2 Cardinality in data modeling, cardinality specifies how the number of occurrences of one object is related to the number of occurrences of another object.
13	**What does modality in data modeling indicates? ? .(APR/MAY 2015)** BTL 1 Modality indicates whether or not a particular data object must participate in the relationship.
14	**What is ERD? (NOV/DEC 2014)** BTL 1 Entity Relationship Diagram is the graphical representation of the object relationship pair. It is mainly used in database applications.
15	**Illustrate DFD.** BTL 2 Data Flow Diagram depicts the information flow and the transforms that are applied on the data as it moves from input to output.
16	**What does Level0 DFD represent?** BTL 1 Level0 DFD is called as **„fundamental system model‟ or „context model‟. In the context model** the entire software system is represented by a single bubble with input and output indicated by incoming and outgoing arrows
17	**What is a state transition diagram?** BTL 1

	State transition diagram is basically a collection of states and events. The events cause the system to change its state. It also represents what actions are to be taken on the occurrence of particular event
18	**Describe Data Dictionary.** BTL 2 The data dictionary can be defined as an organized collection of all the data elements of the system with precise and rigorous definitions so that user and system analyst will have a common understanding of inputs, outputs, components of stores and intermediate calculations.
19	**Write down the elements of Analysis model.** BTL 2 • Data Dictionary • Entity Relationship Diagram • Data Flow Diagram • State Transition Diagram • Control Specification • Process specification
20	**Draw the context diagram for burglar alarm system.** BTL 4 
21	**List the good features of a SRS. (APR/May 2016)** BTL 2 • Correct • Unambiguous • Complete • Consistent • Specific • Traceable
22	**Write the types of prototypes briefly.** BTL 2 **Rapid prototyping** is a group of techniques used to quickly fabricate a scale model of a physical part or assembly using three-dimensional computer aided design (CAD) data. **Evolutionary Prototyping** (also known as breadboard prototyping) is quite different from Throwaway Prototyping. The main goal when using Evolutionary Prototyping is to build a very robust prototype in a structured manner and

constantly refine it.

Incremental prototyping we can reduce the time gap between user and software developer.

Extreme Prototyping as a development process is used especially for developing web applications

23 **How the requirements are validated? (APR/May 2015)** BTL 3

Requirement validation is a process in which it is checked that whether the gathered requirements represent the same system that customer really wants. Requirement checking can be done in following manner: Validity, Consistency, Completeness, and Realism

24 **What are functional requirements?** BTL 2

Functional requirements are" statements of services the system should provide how the system should react to particular input and how the system should behave in particular situation.

25 **What are non functional requirements?** BTL 1

Non functional requirements are constraints on the services or functions offered by the system such as timing constraints, constraints on the development process, standards, etc.

PART B

1 **Explain in detail about Functional and nonfunctional requirements. (APR/MAY 2012)** (13 M) BTL2

Answer: Page:175 in Roger S Pressman

Introduction about requirements (4M)

Requirement engineering is the process of establishing the services that the customer requires from system and the constraints under which it operates and is developed. The requirements themselves are the descriptions of the system services and constraints that are generated during the requirements engineering process. A requirement can range from a high-level abstract statement of a service or of a system constraint to a detailed mathematical functional specification.

Types of requirements (4 M)

Functional requirements
Non Functional requirements

Examples: (5 M)
Library System

2 **Explain in detail about user requirements. (APR/MAY 2015) (13 M) BTL2**

Answer: Page:176 in Roger S Pressman

Specification user requirements (6M)

- Capability and constraint requirements
- Methods for user requirement capture
- Interviews and surveys

	- Studies of existing systems and system requirements - Feasibility study - Prototyping Methods for user requirement Specification - Natural language - Mathematical formalism - Structured English - Tables **Example** (7M)
3	Write about the following Requirements Engineering activities. (Apr/May 15) (13 M) BTL2 Answer: Page:177 in Roger S Pressman **i) Inception (2 M)** Inception is a task where the requirement engineering asks a set of questions to establish a software process. **ii) Elicitation (2 M)** It is related to the various ways used to gain knowledge about the project domain and requirements **iii) Elaboration (2 M)** In this task, the information taken from user during inception and elaboration and are expanded and refined in elaboration. **iv) Negotiation (2 M)** In negotiation task, a software engineer decides the how will the project be achieved with limited business resources. **v) Specification (2 M)** This activity is used to produce formal software requirement models. **vi) Validation (2 M)** It refers to a different set of tasks that ensure that the software that has been built is traceable to customer requirements. **vii) Requirements Management (1 M)** Requirement management is the process of analyzing, documenting, tracking, prioritizing and agreeing on the requirement and controlling the communication to relevant stakeholders.
4	**What is requirement engineering? Give the importance of feasibility study. State its process and explain requirements elicitation problem. (APR/May 08,16)** BTL4 **Answer: Page:174 in Roger S Pressman** **Requirement Engineering Process (3M)** The requirements engineering process includes a feasibility study, requirements elicitation and analysis, requirements specification and requirements management . **Feasibility Studies (6M)**

	A feasibility study is a study made to decide whether or not the proposed system is worthwhile. **Elicitation and analysis (4M)** The systems operational constraints May involve end-users, managers, engineers involved in maintenance, domain experts, trade union.
5	**What are the components of the standard structure for the software requirements document? (APR/May 14,16)** BTL2 **Answer**: Page:208 in Roger S Pressman book **DeMarco (3M)** A top-down approach The analyst maps the current physical system onto the current logical data-flow model The approach can be summarized in four steps: Analysis of current physical system Derivation of logical model Derivation of proposed logical model **Modern structured analysis (3M)** Distinguishes between user‘s real needs and those requirements that represent the external behavior satisfying those needs Includes real-time extensions Other structured analysis approaches include: Structured Analysis and Design Technique (SADT) Structured Systems Analysis and Design Methodology (SSADM) **Method weaknesses (3M)** They do not model non-functional system requirements. They do not usually include information about whether a method is appropriate for a given problem. The may produce too much documentation. The system models are sometimes too detailed and difficult for users to understand. **CASE workbenches (2M)** • A coherent set of tools that is designed to support related software process activities such as analysis, design or testing. • Analysis and design workbenches support system modeling during both requirements engineering and system design. • These workbenches may support a specific design method or may provide support for a creating several different types of system model. **Data Dictionary (2M)** • Data dictionaries are lists of all of the names used in the system models. Descriptions of the entities, relationships and attributes are also included **Advantages**

- Support name management and avoid duplication
- Store of organizational knowledge linking analysis, design and implementation
- Many CASE work benches support data dictionaries.

6 **Explain Petri nets and data dictionary. (13 M)** BTL3

Answer: Page:185 in Roger S Pressman book

Definition (2M)

A Petri Nets (PN) comprises places, transitions, and arcs

Places are system states

– Transitions describe events that may modify the system state

– Arcs specify the relationship between places

- Tokens reside in places, and are used to specify the state of a PN

Data Dictionary Entries (4M)

Name	Description	Typed
has-labels	1:N relation between entities of type Node or Link and entities of type Label	Relation
Label	Holds structured of unstructured information about nodes or links Labels are represented by an icon.	Entity
Link	A 1:1 relation between design entities represented as node, Links are types and may be named	Relation
Name	Each label has a name which identifies the type of label the name must be unique within the set of label types used in a design.	Attribute

Examples (7M)

EFTPOS example is a Petri net representation of a finite state machine (FSM).

It consists of three types of components: places (circles), transitions (rectangles) and arcs (arrows):

– Places represent possible states of the system;

– Transitions are events or actions which cause the change of state.

Every arc simply connects a place with a transition or a transition with a place is denoted by a movement of token(s) (black dots) from place(s) to place(s); and is caused by the firing of a transition. The firing represents an occurrence of the event or an action taken. The firing is subject to the input conditions, denoted by token availability.

A transition is firable or enabled when there are sufficient tokens in its input places.

After firing, tokens will be transferred from the input places (old state) to

	the output places, denoting the new state.
PART C	
1	**Tamilnadu electricity Board (TNEB) would like to automate its billing process. Customers apply for a connection. EB staff take readings and update the system each customer is required to pay charges bi-monthly according to the rates set for the types of connection. Customers can choose to pay either by cash / card** BTL 4 A bill is generated on payment i)Give a name for the system. (5M) ii)Draw the Level – 0 DFD (5M) iii)Draw the Level-1 DFD (5M)
2	**A software is to be built that will control an Automated Teller Machine(ATM) . The ATM machine services cutomers 24 X 7. ATM has a magnetic stripe reader for reading an ATM card, a keyboard and display for interaction with the customer, a slot for depositing envelopers , a customers for cash, a printer for printing receipts and a switch that allows an operator to start / stop a machine.** **The ATM services one customer at a time. When a customer inserts an ATM card and enters the personal identification number (PIN) the details are validated for each transaction. A customer can perform one or more transactions. Transactions made against each account are recorded so as to ensure validity of transactions.** **If PIN is invalid, customer is required to re-enter PIN before making a transaction. If customer is unable to successfully enter PIN after three tries, card is retained by machine and customer has to contact bank.** **The ATM provides the following services to the customer:** **Withdraw cash in multiples of 100.** **Deposti cash in multiples of 100** **Transfer amount between any two accounts.** **Make balance enquiry** **Print receipt.** (BTL 5) 1. Stakeholders Bank customer , Service operator , Hardware and software maintenance engineers , Database administrators , Banking regulators, Security administrator (3M) 2. **Functional requirements (6M)** • There should be the facility for the customer to insert a card.

- The system should first validate card and PIN.
- The system should allow the customer to deposit amount in the bank.
- The system should dispense the cash on withdraw.
- The system should provide the printout for the transaction.
- The system should make the record of the transactions made by particular customer.
- The cash withdrawal is allowed in multiple of 100 The cash deposition is allowed in multiple of 100.
- The customer is allowed to transfer amount between the two accounts.
- The customer is allowed to know the balance enquiry.

3. Non functional requirements. (6M)

- Each of the transaction should be made within 60 seconds. If the time limit is exceeded , then cancel the transaction.
- If there is no response from the bank computer after request is made within the minutes then the card is rejected with error message.
- The bank dispenses money only after the processing of withdrawl form the bank. That means if sufficient fund is available in user‘s account then only the withdrawal request is processed.
- Each bank should process the transactions from several ATM centress at the same time.
- The machine should be loaded with sufficient fund in it.

UNIT 3- SOFTWARE DESIGN

Design process – Design Concepts-Design Model– Design Heuristic – Architectural Design - Architectural styles, Architectural Design, Architectural Mapping using Data Flow- User Interface Design: Interface analysis, Interface Design –Component level Design: Designing Class based components, traditional Components.

PART * A

1 **What are the elements of design model? (APR/MAY 2015)** BTL 1

i. Data design
ii. Architectural design
iii. Interface design
iv. Component-level design

2 **Define design process.** BTL 1

Design process is a sequence of steps carried through which the requirements are translated into a system or software model.

3	**List the principles of a software design. (NOV/DEC 2014)** BTL 2 • The design process should not suffer from “tunnel vision” • The design should be traceable to the analysis model. • The design should exhibit uniformity and integration. • Design is not coding. • The design should not reinvent the wheel.
4	**What is the benefit of modular design?** BTL 1 Changes made during testing and maintenance becomes manageable and they do not affect other modules.
5	**Define SCM. (APR/MAY 2012)** BTL 1 Software Configuration Management is a set of activities carried out for identifying, organizing and controlling changes throughout the lifecycle of computer software.
6	**What is SCI? (APR/MAY 2012)** BTL 1 Software Configuration Item is information that is carried as part of the software engineering process.
7	**Give brief about cohesive module. (NOV/DEC 2014)** BTL 2 A cohesive module performs only “one task” in software procedure with little interaction with other modules. In other words cohesive module performs only one thing.
8	**What are the different types of Cohesion?** BTL 1 • Coincidentally cohesive - The modules in which the set I\of tasks are related with each other loosely. • Logically cohesive – A module that performs the tasks that are logically related with each other. • Temporal cohesion – The module in which the tasks need to be executed in some specific time span. • Procedural cohesion – When processing elements of a module are related with one another and must be executed in some specific order. • Communicational cohesion – When the processing elements of a module share the data then such module is called communicational cohesive.
9	**What is coupling? (APR/MAY 2012)** BTL 1 Coupling is the measure of interconnection among modules in a program structure. It depends on the interface complexity between modules
10	**Write down the various types of coupling.** BTL 2 • Data coupling – The data coupling is possible by parameter passing or data interaction. • Control coupling – The modules share related control data in control coupling. • Common coupling – The common data or a global data is shared among modules. • Content coupling – Content coupling occurs when one module makes use of data or control information maintained in another module.
11	**What are the common activities in design process? (APR/MAY 2015)** BTL 1 • System structuring – The system is subdivided into principle subsystems components and communications between these subsystems are identified.

	• Control modeling – A model of control relationships between different parts of the system is established. • Modular decomposition – The identified subsystems are decomposed into modules.
12	**List the benefits of horizontal partitioning.** BTL 1 • Software that is easy to test. • Software that is easier to maintain. • Propagation of fewer side effects. • Software that is easier to extend.
13	**Describe vertical partitioning (APR/MAY 2012)** BTL 2 Vertical partitioning often called factoring suggests that the control and work should be distributed top-down in program structure.
14	**What are the advantages of vertical partitioning?** BTL 1 • These are easy to maintain changes. • They reduce the change impact and error propagation.
15	**Illustrate various elements of data design.** BTL 3 • Data object – The data objects are identified and relationship among various data objects can be represented using ERD or data dictionaries. • Databases – Using software design model, the data models are translated into data structures and data bases at the application level. • Data warehouses – At the business level useful information is identified from various databases and the data warehouses are created.
16	**List the guidelines for data design. (NOV/DEC 2014)** BTL 2 • Apply systematic analysis on data. • Identify data structures and related operations. • iii Establish data dictionary. • iv Use information hiding in the design of data structure.
17	**Name the commonly used architectural styles.** BTL 4 • Data centered architecture. • Data flow architecture. • Call and return architecture. • Object-oriented architecture. • v. Layered architecture.
18	**What is Transform mapping?** BTL 1 The transform mapping is a set of design steps applied on the DFD in order to map the transformed flow characteristics into specific architectural style.
19	**What is a Real time system?** BTL 1 Real time system is a software system in which the correct functionalities of the system are dependent upon results produced by the system and the time at which these results are produced.

20	**What are the objectives of Analysis modeling?** BTL 1 To describe what the customer requires. To establish a basis for the creation of software design. To devise a set of valid requirements after which the software can be built.
21	**Describe an Architectural design.** BTL 1 The architectural design defines the relationship between major structural elements of the software, the “design patterns” that can be used to achieve the requirements that have been defined for the system.
22	**What is data design?** BTL 1 The data design transforms the information domain model created during analysis into the data structures that will be required to implement the software.
23	**What is interface design?** BTL 1 The interface design describes how the software communicates within itself, with systems that interoperate with it, and with humans who use it.
24	**Illustrate component level design.** BTL 2 The component level design transforms structural elements of the software architecture into a procedural description of software components.
25	**Describe software design** BTL 3 Software design is an iterative process through which the requirements are translated into a “blueprint” for constructing the software.
26	**What is user interface design?** BTL 1 User interface design creates an effective communication medium between a human and a computer.
27	**What is system design?** BTL 1 System design process involves deciding which system capabilities are to be implemented in software and which in hardware.

	PART * B
1	**Explain about the various design process & design concepts considered during design. (Apr/May 2003.2006,2007,2008,Nov/ Dec 2005) (13M) BTL 3** **Answer**: Page:265 in Roger S Pressman book **Software design-** blueprint‖ for constructing the software **Quality Attributes (4M)** • usability • reliability • performance • supportability **Design concepts (4M)** • Abstraction • Software architecture **Design classes (5M)** • User interface classes • Business domain classes

- Process classes
- Persistent classes
- System classes

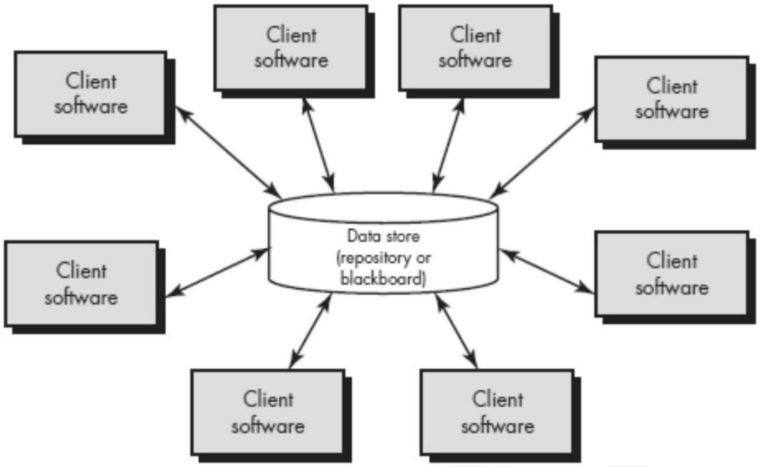
2

Explain in detail about architectural styles and design. APR/May 2007,APR/MAY 2014 (13M) BTL 3

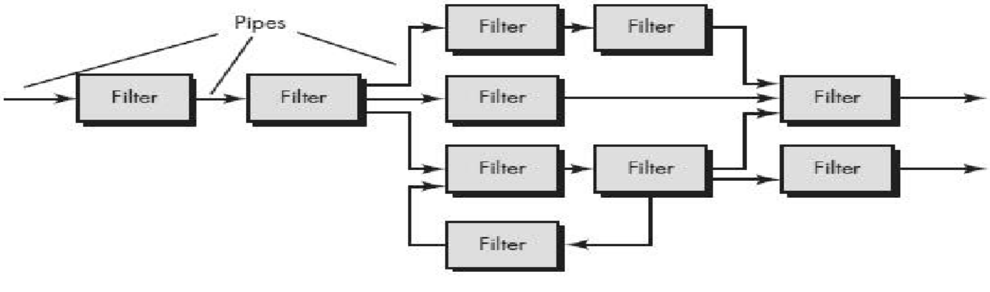
Answer: Page:275 in Roger S Pressman book

Architectural model or style is a pattern for creating the system architecture for given problem. (2M)

Data-centered architectures (4M)

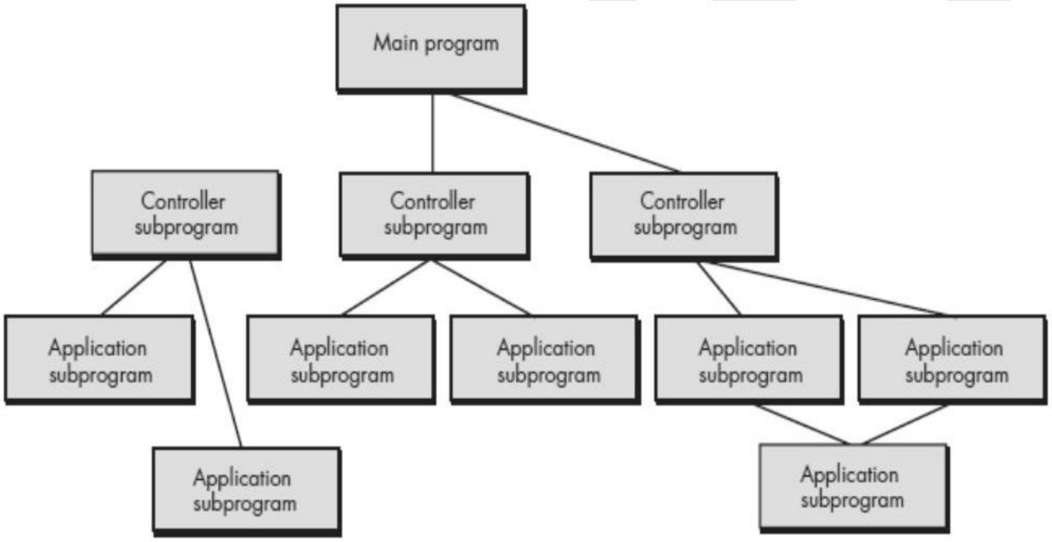


Data-flow architectures (4M)



Pipes and filters

Call and return architectures (3M)



3 **Describe the concepts of cohesion and coupling. State difference between cohesion and coupling with a suitable examples.APR/May 2003,2008 2015,2016. (13M)** BTL 4

Answer: Page:335 in Roger S Pressman book

Cohesion (7 M)

Cohesion is the ―single-mindedness‘ of a component

Kinds of cohesion

- **Sequential cohesion**
- **Procedural cohesion**
- **Temporal cohesion**
- **Utility cohesion**

Coupling (6 M)

- qualitative measure of the degree to which operations and classes are connected to one another

The objective is to keep coupling as low as possible

The kinds of coupling can be ranked in order from lowest (best) to highest (worst)

- **Data coupling**
- **Stamp coupling**
- **Control coupling**
- **Common coupling**
- **content coupling**
- **Subroutine call coupling**

4 **Discuss the design heuristics for effective modularity design May/June 2013, 16. (13 M)** BTL 3

Answer: Page:364 in Roger S Pressman book

<u>**Design Heuristics**</u> **(7M)**

Evaluate the —first iteration of the program Structure to reduce coupling and improve cohesion. The task is to improve module independence, once the program structure has been developed.

Attempt to minimize structures with fan-out. Strive for fan-in as depth increases.

Keep the scope of effect of a module within the slope of control of that module. (6 M)

If module **e** makes a decision that affects module **r**, then the heuristic is violated, because module **r** lies outside the scope of control of module **e**.

Evaluate module interfaces to reduce complexity and redundancy to improve consistency.

Define modules whose function is predictable. But avoid modules that are overly restrictive.

5 **Explain interface design activities. What steps do we perform to accomplish interface design? APR/May 2007,Nov/Dec 2008 (13M)** BTL 3

Answer: Page:356 in Roger S Pressman book

Three golden rules: (3M)

Place the user in control.

Reduce the user‛s memory load.

Make the interface consistent.

Place the User in Control (2M)

Mandel defines a number of design principles that allow the user to maintain control:

Define interaction modes in a way that does not force a user into unnecessary or undesired actions.

Provide for flexible interaction

Allow user interaction to be interruptible and undoable.

Streamline interaction as skill levels advance and allow the interaction to be customized.

Reduce the User‟s Memory Load (2M)

Make the Interface Consistent (2M)

Interface analysis, Interface Design (2M)

User Interface design activities: (2M)

User interface analysis and design process begins at the interior of the spiral and encompasses four distinct framework activities:

Interface analysis and modeling,

interface design,

Interface construction, and

Interface validation.

PART * C

1 **What are the characteristics of good design? Describe the types of coupling and cohesion. How is design evaluation performed (APR/MAY/2010) (or) Which is a measure of interconnection among modules in a program structure? Explain (NOV/DEC/2011)** BTL 4

Answer: Page:175 in Roger S Pressman book

Purpose of Design (5M)

Design is where customer requirements, business needs, and technical considerations all come together in the formulation of a product or system

The design model provides detail about the software data structures, architecture, interfaces, and components

The design model can be assessed for quality and be improved before code is generated and tests are conducted

- Does the design contain errors, inconsistencies, or omissions?
- Are there better design alternatives?
- Can the design be implemented within the constraints, schedule, and cost that have been established?

Goals of a Good Design -three characteristics that serve as a guide for the evaluation of a good design: (5M)

- The design must implement all of the explicit requirements contained in the analysis model
  - – It must also accommodate all of the implicit requirements desired by the customer
- The design must be a readable and understandable guide for those who generate code, and for those who test and support the software
- The design should provide a complete picture of the software, addressing the data, functional, and behavioral domains from an implementation perspective

Technical criteria for good design (5M)

- A design should exhibit an architecture that
  - Has been created using recognizable architectural styles or patterns
  - Is composed of components that exhibit good design characteristics
  - Can be implemented in an evolutionary fashion, thereby facilitating implementation and testing
- A design should be modular; that is, the software should be logically partitioned into elements or subsystems
- A design should contain distinct representations of data, architecture, interfaces, and components
- A design should lead to data structures that are appropriate for the classes to be implemented and are drawn from recognizable data patterns
- A design should lead to components that exhibit independent functional

	characteristics A design should lead to interfaces that reduce the complexity of connections between components and with the external environment
2	**Explain about component level design with example. Nov 2016 (13 M)** BTL 3 **Component Definitions (3M)** **Answer**: Page:325 in Roger S Pressman book Component is a modular, deployable, replaceable part of a system that encapsulates implementation and exposes a set of interfaces Object-oriented view is that component contains a set of collaborating classes **Class-based Component Design (4M)** **Component-Level Design Guidelines (4M)** **Coupling (4M)** Content coupling – occurs when one component surreptitiously modifies internal data in another component Common coupling – occurs when several components make use of a global variable Control coupling – occurs when one component passes control flags as arguments to another Stamp coupling – occurs when parts of larger data structures are passed between components Data coupling – occurs when long strings of arguments are passed between components Routine call coupling – occurs when one operator invokes another

UNIT-4 TESTING AND MAINTENANCE

Software testing fundamentals-Internal and external views of Testing-white box testing - basis path testing-control structure testing-black box testing- Regression Testing – Unit Testing – Integration Testing – Validation Testing – System Testing And Debugging –Software Implementation Techniques: Coding practices-Refactoring-Maintenance and Reengineering-BPR model-Reengineering process model-Reverse and Forward Engineering.

PART A

1	**Define software testing. (APR/MAY 2015)** BTL 1 Software testing is a critical element of software quality assurance and represents the ultimate review of specification, design, and coding.
2	**What are the objectives of testing? (APR/MAY 2015)** BTL 3 • Testing is a process of executing a program with the intend of finding an error. • A good test case is one that has high probability of finding an undiscovered error. • A successful test is one that uncovers as an-yet undiscovered error.

3	**What are the testing principles the software engineer must apply while performing the software testing?** BTL 1 • All tests should be traceable to customer requirements. ii. Tests should be planned long before testing begins. • The pareto principle can be applied to software testing-80% of all errors uncovered during • testing will likely be traceable to 20% of all program modules. • Testing should begin **“**in the small**”** and progress toward testing **“**in the large**”**. v. Exhaustive testing is not possible. • vi. To be most effective, an independent third party should conduct testing.
4	**Give in brief about two levels of testing? (APR/MAY 2012)** BTL 3 i. Component testing Individual components are tested. Tests are derived from developer’s experience. ii. System Testing The group of components are integrated to create a system or sub-system is done.These tests are based on the system specification.
5	**What are the various testing activities?**(**APR/MAY 2012)** BTL 1 • Test planning • Test case design • Test execution • Data collection • Effective evaluation
6	**Write short note on black box testing.** BTL 2 The black box testing is also called as behavioral testing. This method fully focuses on the functional requirements of the software. Tests are derived that fully exercise all functional requirements.
7	**What is equivalence partitioning? (NOV/DEC 2014)** BTL 1 Equivalence partitioning is a black box technique that divides the input domain into classes of data. From this data test cases can be derived. Equivalence class represents a set of valid or invalid states for input conditions.
8	**What is a boundary value analysis? (APR/MAY 2012)** BTL 1 A boundary value analysis is a testing technique in which the elements at the edge of the domain are selected and tested. It is a test case design technique that complements equivalence partitioning technique. Here instead of focusing on input conditions only, the test cases are derived from the output domain.
9	**What are the reasons behind to perform white box testing?** BTL 1 There are three main reasons behind performing the white box testing. • Programmers may have some incorrect assumptions while designing or implementing some functions. Due to this there are chances of having logical errors in the program. To detect and correct such logical errors procedural details need to be examined. • Certain assumptions on flow of control and data may lead programmer to make design errors. To uncover the errors on logical path, white box testing is must. • There may be certain typographical errors that remain undetected even after syntax and type checking mechanisms. Such errors can be uncovered during white box testing.

10	**What is cyclomatic complexity? .(APR/MAY 2015)** BTL 1 Cyclomatic complexity is a software metric that gives the quantitative measure of logical complexity of the program. The Cyclomatic complexity defines the number of independent paths in the basis set of the program that provides the upper bound for the number of tests that must be conducted to ensure that all the statements have been executed at least once.
11	**How to compute the cyclomatic complexity?(APR/MAY 2012)** BTL 2 The cyclomatic complexity can be computed by any one of the following ways. 1. The numbers of regions of the flow graph correspond to the cyclomatic complexity. 2. Cyclomaticcomplexity,V(G),for the flow graph,G,is defined as: V(G)=E-N+2, 3. V(G)=P+1 Where P is the number of predicate nodes contained in the flow graph.
12	**Distinguish between verification and validation.** BTL 2 Verification refers to the set of activities that ensure that software correctly implements a specific function. Validation refers to a different set of activities that ensure that the software that has been built is traceable to the customer requirements. According to Boehm, Verification:" Are we building the product right?" Validation:" Are we building the right product?"
13	**What are the various testing strategies for conventional software?** BTL 1 • Unit testing • Integration testing. • Validation testing. • iv. System testing.
14	**Write about drivers and stubs.(APR/MAY 2015)** BTL 2 Drivers and stub software need to be developed to test incompatible software. The " driver" is a program that accepts the test data and prints the relevant results. The " stub" is a subprogram that uses the module interfaces and performs the minimal data manipulation if required.
15	**What are the approaches of integration testing?** BTL 1 The integration testing can be carried out using two approaches. 1. The non-incremental testing. 2. Incremental testing.
16	**What are the advantages and disadvantages of big-bang? (APR/MAY 2012)** BTL 1 Advantages: This approach is simple. Disadvantages: It is hard to debug. It is not easy to isolate errors while testing. In this approach it is not easy to validate test results. After performing testing, it is impossible to form an integrated system

17	**What are the benefits of smoke testing? (APR/MAY 2012)** BTL 1 Integration risk is minimized. The quality of the end-product is improved. Error diagnosis and correction are simplified. Assessment of program is easy.
18	**What are the conditions exists after performing validation testing? (NOV/DEC 2014)** BTL 1 After performing the validation testing there exists two conditions. The function or performance characteristics are according to the specifications and are accepted. The requirement specifications are derived and the deficiency list is created. The deficiencies then can be resolved by establishing the proper communication with the customer.
19	**Define debugging. (APR/MAY 2012)** BTL 1 Debugging is defined as the process of removal of defect. It occurs as a consequence of successful testing.
20	**What are the various types of system testing? (NOV/DEC 2014)** BTL 1 1. Recovery testing – **is intended to check the system‟ s ability to recover from failures.** 2. Security testing – verifies that system protection mechanism prevent improper penetration or data alteration. 3. Stress testing – Determines breakpoint of a system to establish maximum service level. 4. Performance testing – evaluates the run time performance of the software, especially real-time software.
21	**Distinguish between alpha and beta testing. (NOV/DEC 2013)** BTL 2 Alpha and beta testing are the types of acceptance testing. Alpha test: The alpha testing is attesting in which the version of complete software is tested by the customer under the supervision of developer. This testing is performed at developer's site. Beta test: The beta testing is a testing in which the version of the software is tested by the customer without the developer being present. This testing is performed at customer's site.
22	**What are the common approaches in debugging? ((NOV/DEC 2013)** BTL 1 Brute force method: The memory dumps and run-time tracks are examined and program with write statements is loaded to obtain clues to error causes. Back tracking method: The source code is examined by looking backwards from symptom to potential causes of errors. Cause elimination method: This method uses binary partitioning to reduce the number of locations where errors can exists.
23	**Write about the types of project plan.** BTL 2 Quality plan – This plan describes the quality procedures and standards that will be used in a Project. Validation plan – This plan describes the approach, resources and schedule required for system validation. Configuration management plan – This plan focuses on the configuration management

	procedures and structures to be used. Maintenance plan – The purpose of maintenance plan is to predict the maintenance requirements of the system, maintenance cost and efforts required
24	**What is meant by regression testing?** BTL 1 Regression testing is used to check for defects propagated to other modules by changes made to existing program. Thus, regression testing is used to reduce the side effects of the changes.
25	**What is meant by unit testing?** BTL 1 The unit testing focuses verification effort on the smallest unit of software design, the software component or module.
26	**Define structural testing.** BTL 1 In structural testing derivation of test cases is according to program structure. Hence knowledge of the program is used to identify additional test cases.
	PART * B
1	**(i). Illustrate white box testing in detail** APR/**May 2004,2007, Nov/Dec 2007, May 2015 (13M)** BTL 3 **Definition (2M)** White-box testing of software is predicated on close examination of procedural detail. The "status of the program" may be examined at various points. **Methods:** Flow graph notation - Start with simple notation **(2M)** Independent program paths or Cyclomatic complexity **(2M)** Deriving test cases **(2M)** Graph Matrices **(2M)**
2	**Explain the various types of black box testing methods. Dec 2007 ,2016 May 2015 (13 M)** BTL 2 **Answer**: Page:434 in Roger S Pressman book **Definition (2M)** ✓ **BLACK BOX TESTING**, also known as Behavioral Testing, is a software testing method in which the internal structure/design/implementation of the item being tested is not known to the tester. These tests can be functional or non-functional, though usually functional. **Example (2M)** A tester, without knowledge of the internal structures of a website, tests the web pages by using a browser; providing inputs (clicks, keystrokes) and verifying the outputs against the expected outcome. **Techniques (4M)** Following are some techniques that can be used for designing black box tests. • *Equivalence Partitioning:* It is a software test design technique that involves dividing input values into valid and invalid partitions and selecting representative values from each partition as test data. • *Boundary Value Analysis:* It is a software test design technique that involves the determination of boundaries for input values and selecting values that are at the

boundaries and just inside/ outside of the boundaries as test data.

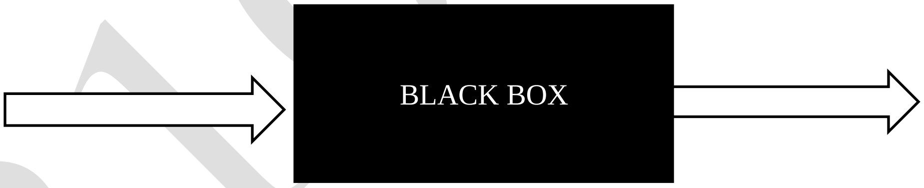
- *Cause-Effect Graphing:* It is a software test design technique that involves identifying the cases (input conditions) and effects (output conditions), producing a Cause-Effect Graph, and generating test cases accordingly.

Advantages (3M)

- Tests are done from a user's point of view and will help in exposing discrepancies in the specifications.
- Tester need not know programming languages or how the software has been implemented.
- Tests can be conducted by a body independent from the developers, allowing for an objective perspective and the avoidance of developer-bias.
- Test cases can be designed as soon as the specifications are complete.

Disadvantages (2M)

- Only a small number of possible inputs can be tested and many program paths will be left untested.
- Without clear specifications, which is the situation in many projects, test cases will be difficult to design.
- Tests can be redundant if the software designer/developer has already run a test case.
- Ever wondered why a soothsayer closes the eyes when foretelling events? So is almost the case in Black Box Testing.



3 **Explain about various testing strategy May 2005,2006, Dec 2008, May: 2010, 2013 (13M)** BTL 3

Answer: Page:421 in Roger S Pressman book

1. Unit Testing: (2M)

In unit testing the individual components are tested independently to ensure their quality. The focus is to uncover the errors in design and implementation.

2. Integration Testing: (2M)

Integration testing tests integration or interfaces between components, interactions to different parts of the system such as an operating system, file system and hardware or

	interfaces between systems **3.Top-Down Integration Testing: (2M)** Is an incremental approach in which modules are integrated by moving down through the control structure **4.Bottom-Up Integration: (1M)** **-** In Bottom-Up Integration the modules at the lowest levels are integrated first, then integration is done by moving upward through the control structure **5.Regression Testing: (1M)** Is a kind of integration testing technique used for time critical projects wherein the projects needs to be assessed on frequent basis **6.Smoke Testing (1M)** Ensure that each function or performance characteristic conforms to its specification. **7.Acceptance Testing (1M)** **-** Is a kind of testing conducted to ensure that the software works correctly for intended user in his or her normal work environment **8.System Testing (1M)** The system test is a series of tests conducted to fully the computer based system **9.Performance testing (2M)** **-** Performance testing evaluates the run-time performance of software
4	**Why does software testing need extensive planning ? Explain. May : 2016** BTL 2 1. Testing is the process of exercising a software component using a selected set of test cases, with the intent of (i) revealing defects, and (ii) evaluating quality. (2M) 2.Test results should be inspected meticulously. (1M) 3.A test case must contain the expected output or result. (1M) 4.Test cases should be developed for both valid and invalid input conditions. (1M) 5.The probability of the existence of additional defects in a software component is proportional to the number of defects already detected in that component. (1M) 6.Testing should be carried out by a group that is independent of the development group. 7.Tests must be repeatable and reusable (1M) 8.Testing should be planned. (1M) 9.Testing activities should be integrated into the software life cycle. (1M) 10.Testing is a creative and challenging task. (1M) 11.When the test objective is to detect defects, then a good test case is one that has a high Probability of revealing a yet undetected defect(s). (2M)

5

i) Explain validation testing in detail (8 M) BTL 3

Requirements are validated against the constructed software (4M)

Validation testing follows integration testing
The distinction between conventional and object-oriented software disappears
Focuses on user-visible actions and user-recognizable output from the system
Demonstrates conformity with requirements
Designed to ensure that
All functional requirements are satisfied
All behavioral characteristics are achieved
All performance requirements are attained
Documentation is correct

configuration have been properly developed, cataloged, and have the necessary detail for entering the support phase of the software life cycle

Alpha testing (2M)

– Conducted at the developer‘s site by end users

– Software is used in a natural setting with developers watching intently

– Testing is conducted in a controlled environment

Beta testing (2M)

– Conducted at end-user sites

– Developer is generally not present

– It serves as a live application of the software in an environment that cannot be controlled by the developer

– The end-user records all problems that are encountered and reports these to the developers at regular intervals

After beta testing is complete, software engineers make software modifications and prepare for release of the software product to the entire customer base.

(ii) Explain the debugging process in detail (8)

Debugging (2M)

Debugging occurs as a consequence of successful testing

Coding Process (1M)

It is the phase where the designed software project is implemented as coded program

Coding standards(1M)

"Establish programming conventions before you begin programming. It's nearly impossible to change code to match them later."

Commenting(1M)

Due to time restrictions or enthusiastic programmers who want immediate results for their code

Naming conventions(1M)

Use of proper naming conventions is considered good practice. Sometimes programmers tend to use X1, Y1, etc

Keep the code simple (1M)

The code that a programmer writes should be simple

Keep the code simple

The code that a programmer writes should be simple

Code Development(1M)

Code building

A best practice for building code involves daily builds and testing, or better still continuous integration, or even continuous delivery.

Testing

Testing is an integral part of software development that needs to be planned. It is also important that testing is done proactively

6

Compare and contrast alpha and beta Testing. May /June 2016 (13M)

BTL 4

Answer: Page:442 in Roger S Pressman book

1	It is always performed by the developers at the software development site.	It is always performed by the customers at their own site
2	Sometimes it is also performed by Independent Testing Team.	It is not performed by Independent Testing Team.
3	Alpha Testing is not open to the market and public	Beta Testing is always open to the market and public.
4	It is conducted for the software application and project.	It is usually conducted for software product.
5	It is always performed in Virtual Environment.	It is performed in Real Time Environment.
6	It is always performed within the organization.	It is always performed outside the organization.
7	It is the form of Acceptance Testing.	It is also the form of Acceptance Testing.

8	Alpha Testing is definitely performed and carried out at the developing organizations location with the involvement of developers.	Beta Testing (field testing) is performed and carried out by users or you can say people at their own locations and site using customer data.
9	It comes under the category of both White Box Testing and Black Box Testing.	It is only a kind of Black Box Testing.
10	Alpha Testing is always performed at the time of Acceptance Testing when developers test the product and project to check whether it meets the user requirements or not.	Beta Testing is always performed at the time when software product and project are marketed.
11	It is always performed at the developer‘s premises in the absence of the users.	It is always performed at the user‘s premises in the absence of the development team.
12	Alpha Testing is not known by any other different name.	Beta Testing is also known by the name Field Testing means it is also known as field testing.
13	It is considered as the User Acceptance Testing (UAT) which is done at developer‘s area.	It is also considered as the User Acceptance Testing (UAT) which is done at customers or users area.

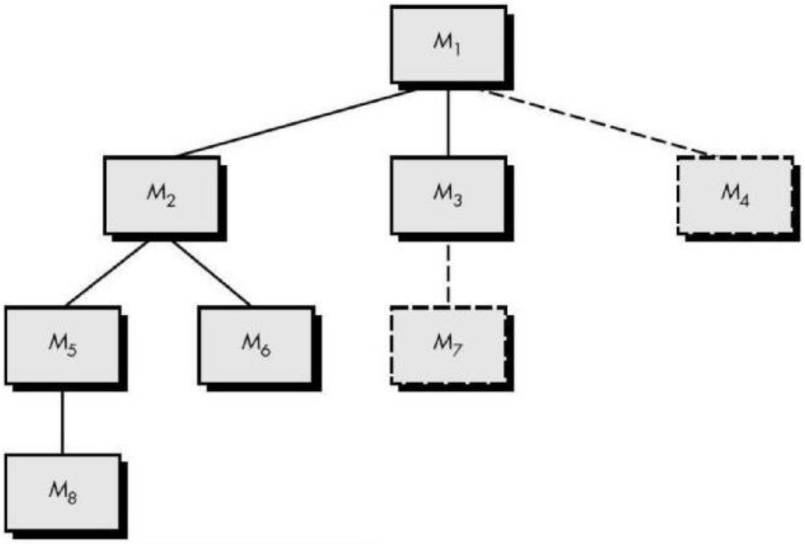
PART C

1. **Explain in detail about top-down and bottom-up integration (13M)** BTL 3

Top-down integration (7M)

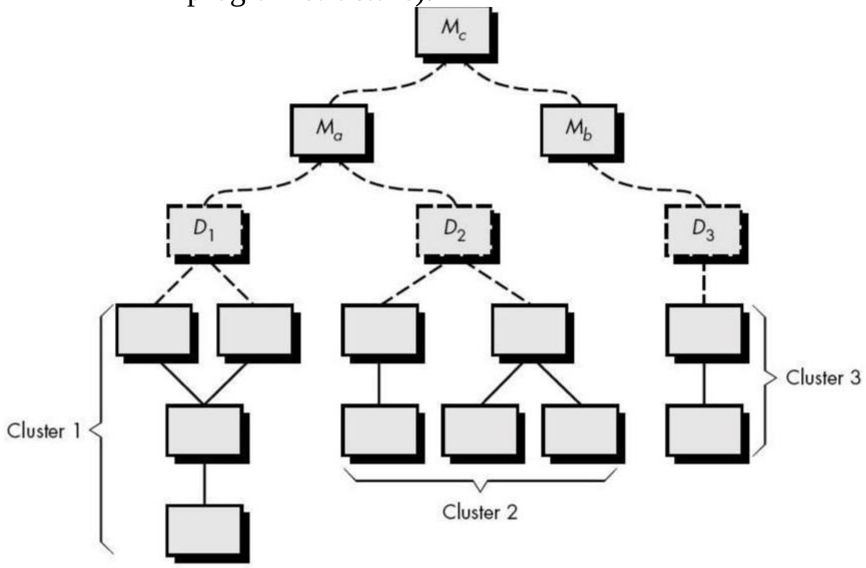
Answer: Page:455 in Roger S Pressman book

Top-down integration testing is an incremental approach to construction of program structure.



Bottom-up Integration (8M)

Bottom-up integration testing, as its name implies, begins construction and testing with atomic modules (i.e., components at the lowest levels in the program structure).



Top-Down Integration	Bottom-up integration
A top-down approach is essentially the breaking down of a system to gain insight into its compositional sub-systems.	A bottom-up approach is the piecing together of systems to give rise to grander systems, thus making the original systems sub-systems of the emergent system.
An overview of the system is not formulated, specifying but Dealing any first-level subsystems.	The individual base elements of the system are first specified in great detail. These elements are then linked together to form larger subsystems.
It is often specified with the Assistance of ―black boxes‖, these make it easier to manipulate.	It is often resembles a ―seed model‖, whereby the beginnings are small but eventually grow in complexity and completeness.
It emphasize planning and A complete understanding of the system.	Zero redundancy
Easy to visualize functionality	Good unit test case can be written to validate changes.

Sense of completeness in the requirement	Developer has only option to use unit testing tools to test the logic.
Easy to show the progress of development	Easy to manage changes and modification.
High possibility of redundancy	Effort involved writing cases.

2. **Explain in detail about Integration testing. (May/Jun 2014)** BTL 3

Answer: Page:460 in Roger S Pressman book

A group of dependent components are tested together to ensure their quality of their integration unit. (3M)

The objective is to take unit tested components and build a program structure that has been dictated by software design. (5M)

- The focus of integration testing is to uncover errors in
- Design and construction of software architecture.
- Integrated functions or operations at subsystem level.
- Interfaces and interactions between them.
- Resource integration and/or environment integration. The

integration testing can be carried out using two approaches.

The non-incremental integration

Incremental integration Integration

Advantage of big-bang: (3M)

This approach is simple.

Disadvantages: (4M)

i) It is hard to debug.

ii) It is not easy to isolate errors while testing.

In this approach it is not easy to validate test results.

An incremental construction strategy includes

Top down integration

Bottom up integration

Regression testing

Smoke testing

UNIT 5- PROJECT MANAGEMENT

Software Project Management: Estimation – LOC, FP Based Estimation, Make/Buy Decision COCOMO I & II Model – Project Scheduling – Scheduling, Earned Value Analysis Planning – Project Plan, Planning Process, RFP Risk Management – Identification, Projection - Risk Management-Risk Identification-RMMM Plan-CASE TOOLS.

	PART * A
1	**Define measure.** BTL 1 Measure is defined as a quantitative indication of the extent, amount, dimension, or size of some attribute of a product or process.
2	**Define metrics. (APR/MAY 2015)** BTL 1 Metrics is defined as the degree to which a system component, or process possesses a given attribute.
3	**What are the types of metrics? (APR/MAY 2012)** BTL 1 Direct metrics – It refers to immediately measurable attributes. Example – Lines of code, execution speed. Indirect metrics – It refers to the aspects that are not immediately quantifiable or measurable. Example – functionality of a program.
4	**What are the advantages and disadvantages of size measure? (NOV/DEC 2014)** BTL 1 **Advantages:** Artifact of software development which is easily counted. Many existing methods use LOC as a key input. A large body of literature and data based on LOC already exists. **Disadvantages:** This method is dependent upon the programming language. This method is well designed but shorter program may get suffered. It does not accommodate non procedural languages. In early stage of development it is difficult to estimate LOC.
5	**Write short note on the various estimation techniques. (APR/MAY 2012)** BTL 2 Algorithmic cost modeling – the cost estimation is based on the size of the software. Expert judgment – The experts from software development and the application domain use their experience to predict software costs. Estimation by analogy – The cost of a project is computed by comparing the project to a similar project in the same application domain and then cost can be computed. Parkinson's law – The cost is determined by available resources rather than by objective assessment. Pricing to win – The project costs whatever the customer ready to spend it
6	**What is COCOMO model? (NOV/DEC 2014)** BTL 2 COnstructiveCOstMOdel is a cost model, which gives the estimate of number of man-months it willtake to develop the software product
7	**What is the purpose of timeline chart? (NOV/DEC 2012)** BTL 1 The purpose of the timeline chart is to emphasize the scope of the individual task. Hence set of tasks are given as input to the timeline chart
8	**Give the procedure of the Delphi method. (NOV/DEC 2013)** BTL 3 1. The co-ordinator presents a specification and estimation form to each expert. 2. Co-ordinator calls a group meeting in which the experts discuss estimation issues with the coordinator and each other. 3. Experts fill out forms anonymously. 4. Co-ordinator prepares and distributes a summary of the estimates.

	5. The Co-ordinator then calls a group meeting. In this meeting the experts mainly discuss the points where their estimates vary widely. 6. The experts again fill out forms anonymously. 7. Again co-ordinator edits and summarizes the forms, repeating steps 5 and 6 until the co-ordinator is satisfied with the overall prediction synthesized from experts.
9	**What is EVA? (APR/MAY 2012)** BTL 3 Earned Value Analysis is a technique of performing quantitative analysis of the software Project. It provides a common value scale for every task of software project. It acts as a measure for software project progress.
10	**What is architectural evolution? (APR/MAY 2012)** BTL 1 Architectural evolution is the process of changing a system from a centralized architecture to a distributed architecture like client server.
11	**What are the types of software maintenance? ((NOV/DEC 2014)** BTL 1 Corrective maintenance – Means the maintenance for correcting the software faults. Adaptive maintenance – Means maintenance for adapting the change in environment. Perfective maintenance – Means modifying or enhancing the system to meet the new requirements. Preventive maintenance – Means changes made to improve future maintainability.
12	**Define maintenance.** BTL 1 Maintenance is defined as the process in which changes are implemented by either modifying the **existing system‟ s architecture or by adding new components to the system.**
13	**What is software maintenance?** BTL 1 Software maintenance is an activity in which program is modified after it has been put into use.
14	**Write about software change strategies**. BTL 2 The software change strategies that could be applied separately or together are: Software maintenance – The changes are made in the software due to requirements. Architectural transformation – It is the process of changing one architecture into another form. Software re-engineering – New features can be added to existing system and then the system is reconstructed for better use of it in future
15	**Why software change occurs? .(APR/MAY 2015)** BTL 2 Software change occurs because of the following reasons. New requirements emerge when the software is used. The business environment changes. Errors need to be repaired. New equipment must be accommodated. The performance or reliability may have to be improved.
16	**What are the metrics computed during error tracking activity?** BTL 1 Errors per requirement specification page. Errors per component-design level Errors per component-code level DRE-requirement analysis DRE-architectural analysis DRE-

	component level design DRE-coding.
17	**How the CASE tools are Classified?** BTL 2 CASE tools can be classified by a. By function or use b. By user type(e.g. manager, tester),or c. By stage in software engineering process (e.g.requirements,test).
18	**What are the types of static testing tools? .(APR/MAY 2015)** BTL 1 There are three types of static testing tools. Code based testing tools – These tools take source code as input and generate test cases. Specialized testing tools – Using this language the detailed test specification can be written for each test case. Requirement-based testing tools – These tools help in designing the test cases as per user
19	**What is meant by CASE tools?** BTL 2 The computer aided software engineering tools automatic the project management activities, manage all the work products. The CASE tools assist to perform various activities such as analysis, design, coding and testing.
20	**What is meant by software evolution?** BTL 1 Software evolution is a process of managing the changes in the software.
21	**What is meant by risk management?** BTL 1 Risk management is an activity in which risks in the software projects are identified.
22	**Write about software change strategies.** BTL 2 The software change strategies that could be applied separately or together are: Software maintenance – The changes are made in the software due to requirements. Architectural transformation – It is the process of changing one architecture into another form. Software re-engineering – New features can be added to existing system and then the system is reconstructed for better use of it in future.
23	**What is meant by software project scheduling?** BTL 2 Software project scheduling is an activity that distributes estimated effort across the planned project duration by allocating the effort to specified software engineering tasks.
24	**What is software configuration management (SCM)?** BTL 1 Software configuration management is the art of identifying, organizing, and controlling modifications to the software being built by a programming team.
25	**Derive ZIP‟s law.** BTL 4 ZIP‟s first law of the form, fr r = C (or) $n_{r = Cn /\ r}$ C = constant

r =rank for tokens
fr = frequency of occurrence

PART B

1 **Describe two metrics which have been used to measure the software. May 04,05 (13m)** BTL4

Answer: Page:472 in Roger G.Pressman

Definition(2m)

Software process and project metrics are quantitative measures. The software measures are collected by software engineers and software metrics are analyzed by software managers

Metric in Process Domain: (4M)

Process metrics are collected across all projects and over long periods of time.

They are used for making strategic decisions.

The intent is to provide a set of process indicators that lead to long-term software process improvement.

The only way to know how/where to improve any process is to

Measure specific attributes of the process

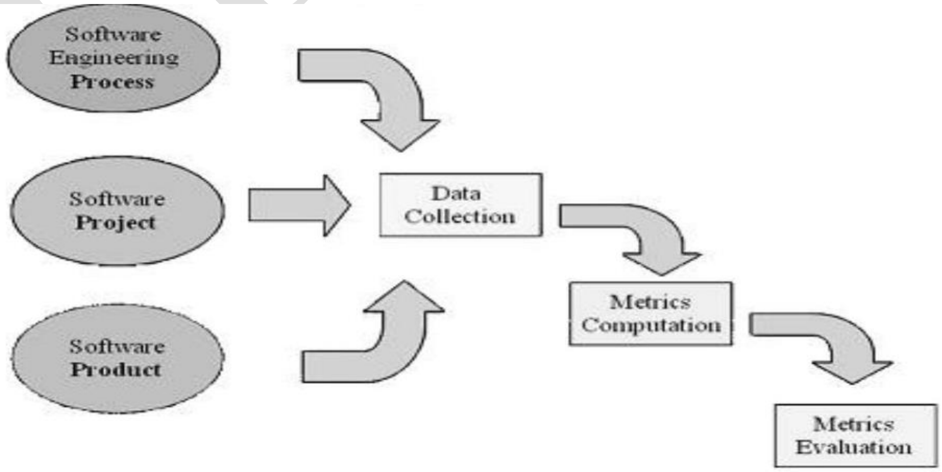
Develop a set of meaningful metrics based on these attributes

Use the metrics to provide indicators that will lead to a strategy for improvement

Metrics in Project Domain (4M)

Project metrics enable a softw are project manager to
– Assess the status of an ongoing project
– Track potential risks
– Uncover problem areas before their status becomes critical
– Adjust work flow or tasks
– Evaluate the project team‘s ability to control quality of software work products
- Many of the same metrics are used in both the process and project domain
- Project metrics are used for making tactical decisions
– They are used to adapt project workflow and technical activities

Diagram(3m)



2 **What are the categories of software risks? Give an overview about risk management.(May 14) (13m)** BTL2

Answer: Page:731 in Roger G.Pressman

Risk is a potential problem – it might happen and it might not conceptual definition of risk **(2M)**

o Risk concerns future happenings

o Risk involves change in mind, opinion, actions, places, etc

Risk Categorization (6M)

1) Project risks

They threaten the project plan. If they become real, it is likely that the project schedule will slip and that costs will increase

2) Technical risks

They threaten the quality and timeliness of the software to be produced. If they become real, implementation may become difficult or impossible

3) Business risks

They threaten the viability of the software to be built. If they become real, they jeopardize the project or the product

Sub-categories of Business risks

Market risk – building an excellent product or system that no one really wants

Strategic risk – building a product that no longer fits into the overall business strategy for the company

iii)Sales risk – building a product that the sales force doesn't understand how to sell

Management risk – losing the support of senior management due to a change in focus or a change in people

Budget risk – losing budgetary or personnel commitment

4. Known risks

Those risks that can be uncovered after careful evaluation of the project plan, the business and technical environment in which the project is being developed, and other reliable information sources (e.g., unrealistic delivery date)

5. Predictable risks

Those risks that are extrapolated from past project experience (e.g., past turnover)

6. Unpredictable risks

Those risks that can and do occur, but are extremely difficult to identify in advance

Risk Identification (2M)

Risk identification is a systematic attempt to specify threats to the project plan. By identifying known and predictable risks, the project manager takes a first step toward avoiding them when possible and controlling them when necessary Generic risks

Risk Table (3M)

Risk Summary	Risk Category	Probability	Impact (1-4)	RMMM

3

Describe function point analysis with a neat example.(Dec 2006 Nov 2010) (8M)
BTL 3
Answer: Page:656 in Roger G.Pressman

. Function-oriented metrics use a measure of the functionality delivered by the application as a normalization value

Calculate Function Point

The data for following information domain characteristics are collected.

Number of user inputs – Each user input which provides distinct application data to the software is counted.

Number of user outputs – Each user output that provides application data to the user is counted, e.g –Screens, reports, error messages.

Number of user inquiries – An on-line input that results in the generation of some immediate software response in the form of an output.

Number of files – Each logical master file, i.e a logical grouping of data that may be part of a database or a separate file.

Number of external interfaces – All machine readable interfaces that are used to transmit information to another system are counted.

Domain Characteristics	**Count**		**Weighting Factor**			**Count**
			Simple	Average	Complex	
Number of user input		X	3	4	6	
Number of user output		X	4	3	7	
Number of user inquiries		X	3	4	6	
Number of fiels		X	7	10	15	
Number of external interfaces		X	5	7	10	
Count totals						

Consider the following function point components and their complexity. If the total degree of influence is 52,find the estimated function points. (Nov / Dec 2016)

Function Type	**Estimated Count**	**Complexity**
ELF	**2**	**7**
ILF	**4**	**10**
EQ	**22**	**4**
EO	**16**	**5**

EI	**24**	**4**

Solution :

FP = UFC x VAF

Where , FP = Function Point

UFC = FP Count Total

VAF = Value Adjustment Factor

UFC = 2x7+4x10+22x4+16x5+24x4 = 318

VAF = (0.65 + (0.01 x ∑(Fi)))

(0.65 + (0.01 x 52))

1.17

So, FP Estimated = (318 x 1.17) =372

4 **(i). Explain in detail the COCOMO II Model** (**May2008,Dec2013,May2014,2016) (7m)** BTL2

Answer: pg.no692 in Roger G.Pressman

Constructive **CO**st **Mo**del II (COCOMO® II) is a model that allows one to estimate the cost, effort, and schedule when planning a new software development activity.

The 5 Scale Drivers are:

- Precedentedness
- Development Flexibility
- Architecture / Risk Resolution
- Team Cohesion
- Process Maturity

COCOMO II Effort Equation

The COCOMO II model makes its estimates of required effort (measured in Person-Months ï¿½ PM) based primarily on your estimate of the software project's size (as measured in thousands of SLOC,KSLOC)):

Effort = 2.94 * EAF * (KSLOC)E

Effort Adjustment Factor

The Effort Adjustment Factor in the effort equation is simply the product of the effort multipliers corresponding to each of the cost drivers for your project.

For example, if your project is rated Very High for Complexity (effort multiplier of 1.34), and Low for Language & Tools Experience (effort multiplier of 1.09), and all of the other cost drivers are rated to be Nominal (effort multiplier of 1.00), the EAF is the product of 1.34 and 1.09.

Effort Adjustment Factor = EAF = 1.34 * 1.09 = 1.46

Effort = 2.94 * (1.46) * (8)1.0997 = 42.3 Person-Months

COCOMO II Schedule Equation

The COCOMO II schedule equation predicts the number of months required to complete your software project. The duration of a project is based on the effort predicted by the effort equation:

Duration = 3.67 * (Effort) SE

5 **Explain Software Project Planning May2005,2006, Dec2006, 2007, May2015 (13m)**
BTL1

Answer: Page:725 in Roger G.Pressman

Definition(2m)

Software project planning encompasses five major activities

Estimation, scheduling, risk analysis, quality management planning, and change management planning.

Explanation(3m)

Estimation determines how much money, effort, resources, and time it will take to build a specific system or product

The software team first estimates

– The work to be done

– The resources required

– The time that will elapse from start to finish

Then they establish a project schedule that

– Defines tasks and milestones

– Identifies who is responsible for conducting each task

– Specifies the inter-task dependencies

Task Set for Project Planning (3M)

1) Establish project scope

2) Determine feasibility

3) Analyze risks

4) Define required resources

Activities associated with project planning (5M)

Software
scope
resources
Project
estimation
Decomposition

Plan	Description
Quality plan	Describes the quality procedures and standards that will be used in a project.
Validation plan	Describes the approach, resources and schedule used for system validation.
Configuration management plan	Describes the configuration management

	procedures and structures to be used.
Maintenance plan	Predicts the maintenance requirements of the system, maintenance costs and effort required.
Staff development plan.	Describes how the skills and experience of the project team members will be developed.

PART* C

1 **Write shot notes on i) Project Scheduling ii) Timeline Charts** (**May: 2005, 2006,Dec 2006,2007,May 2015) (15m)** BTL6

Answer: Page:706 in Roger G.Pressman

i) Project Scheduling

Definition (2M)

Software project scheduling is an action that distributes estimated effort across the planned project duration by allocating the effort to specific software engineering tasks.

Basic Principles (4M)

Compartmentalization

Interdependency

Time allocation

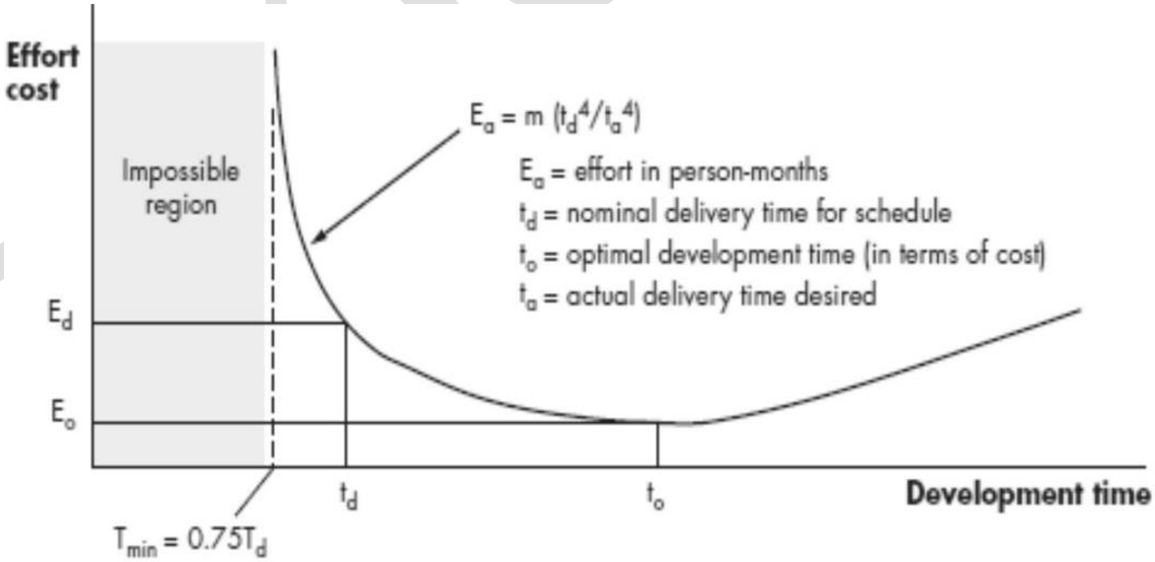
Effort validation

Define responsibilities

Define outcomes

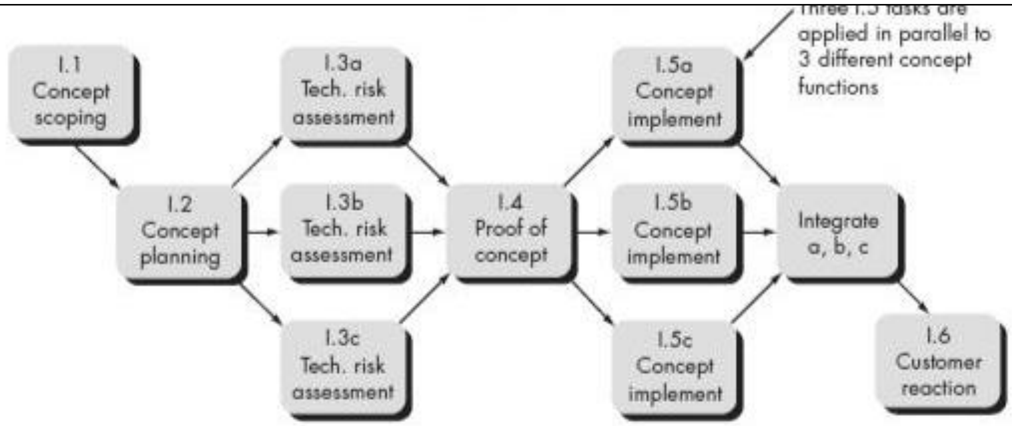
Defined Milestone

The Relationship between People and Effort(2M)



Defining a task network (1M)

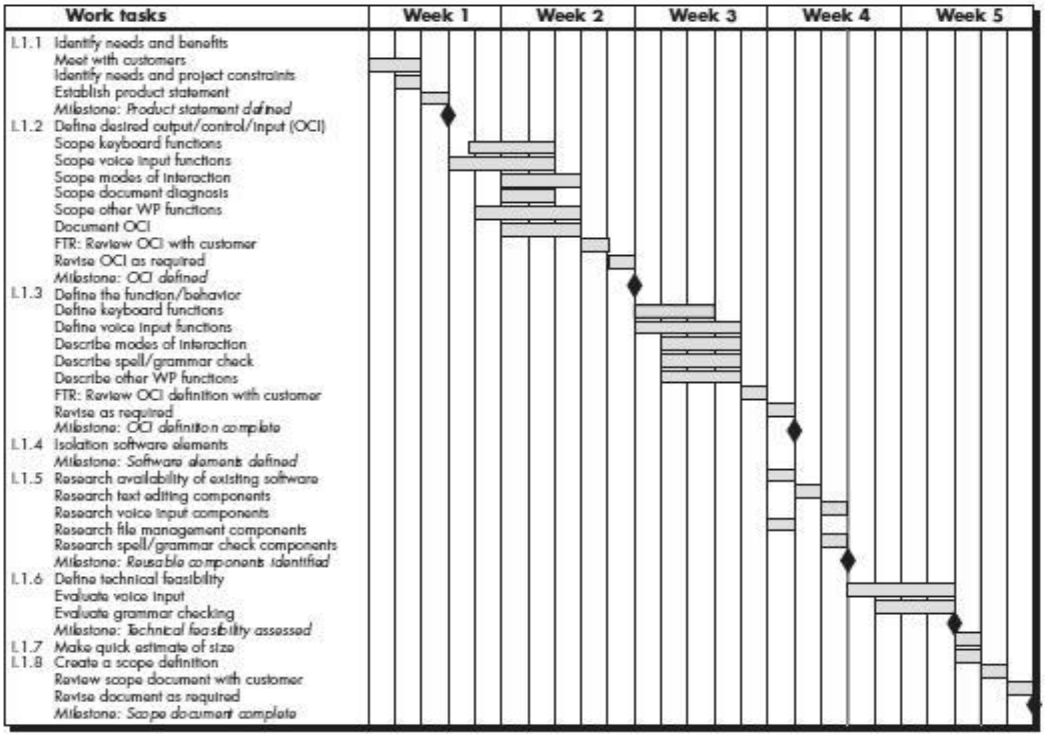
ii) Timeline Charts Time



Timeline Charts

Definition (2M)

Time-line chart, also called a Gantt chart, is generated. A time-line chart can be developed for the entire project. Alternatively, separate charts can be developed for each project function or for each individual



Earned value analysis (2M)

EVA is a technique of performing quantitative analysis of the software project.

It provides a common value scale for every task of software project.

Effort Distribution (2M)

A recommended distribution of effort across the software process is often referred to as the 40–20–40 rule

2

Elaborately explain Problem-Based Estimation. May 2005,2006, 2007, Dec 2007,10. (15m) BTL5

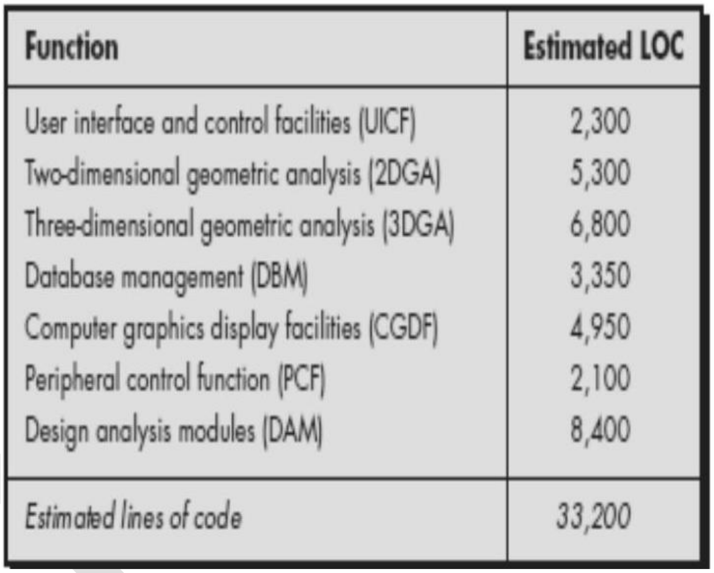
Answer: Page:682 in Roger G.Pressman

Problem-Based Estimation (3M)

LOC and FP data are used in two ways during software project estimation:

An Example of LOC-Based Estimation (3M)

Following the decomposition technique for LOC, an estimation table is developed. A range of LOC estimates is developed for each function. For example, the range of LOC estimates for the 3D geometric analysis function is optimistic, 4600 LOC; most likely, 6900 LOC; and pessimistic, 8600 LOC

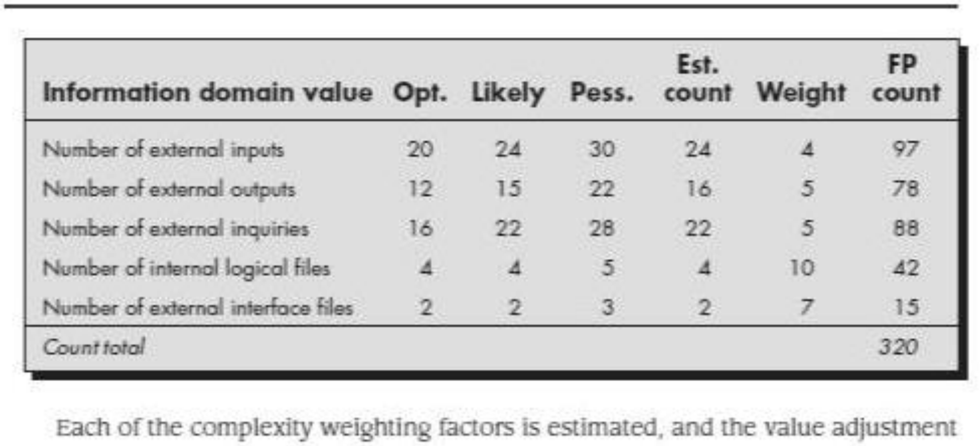


Function	Estimated LOC
User interface and control facilities (UICF)	2,300
Two-dimensional geometric analysis (2DGA)	5,300
Three-dimensional geometric analysis (3DGA)	6,800
Database management (DBM)	3,350
Computer graphics display facilities (CGDF)	4,950
Peripheral control function (PCF)	2,100
Design analysis modules (DAM)	8,400
Estimated lines of code	*33,200*

An Example of FP-Based Calculation(6m)

Decomposition for FP-based estimation focuses on information domain values rather than software functions. Referring to the table we would estimate inputs, outputs, inquiries, files, and external interfaces for the CAD software. An FP value is computed using the technique

Diagram(3m)



Information domain value	Opt.	Likely	Pess.	Est. count	Weight	FP count
Number of external inputs	20	24	30	24	4	97
Number of external outputs	12	15	22	16	5	78
Number of external inquiries	16	22	28	22	5	88
Number of internal logical files	4	4	5	4	10	42
Number of external interface files	2	2	3	2	7	15
Count total						*320*

Each of the complexity weighting factors is estimated, and the value adjustment

3

Analyze the Unit, Integration, and system testing for currency converter application. (15m) BTL4

Answer: Page:394 in Roger G.Pressman

Explanation(10m)

The currency converter has the following requirements:

- The user can input an amount into an input box
- The user can select the currency to convert to
- When selecting a currency, a flag is displayed for that currency
- Clicking a 'compute' button outputs the equivalent amount into an output box
- There is no limit on the number of conversions that can be performed

Diagram(5m)