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ESE 2023 : Mains Test Series

UPSC ENGINEERING SERVICES EXAMINATION

Electronics & Telecommunication Engineering

Test-5 : Computer Organization and Architecture + Materials Science [All topics]

Electronic Devices & Circuits-1 + Advanced Communications Topics-1 [Part Syllabus]

Analog & Digital Communication Systems-2 [Part Syllabus]

Name :

Roll No :

Test Centres				Student's Signature
Delhi ☐	Bhopal ☐	Jaipur ☐		
Pune ☑	Kolkata ☐	Bhubaneswar ☐	Hyderabad ☐	

Instructions for Candidates

1. Do furnish the appropriate details in the answer sheet (viz. Name & Roll No).
2. There are Eight questions divided in TWO sections.
3. Candidate has to attempt FIVE questions in all in English only.
4. Question no. 1 and 5 are compulsory and out of the remaining THREE are to be attempted choosing at least ONE question from each section.
5. Use only black/blue pen.
6. The space limit for every part of the question is specified in this Question Cum Answer Booklet. Candidate should write the answer in the space provided.
7. Any page or portion of the page left blank in the Question Cum Answer Booklet must be clearly struck off.
8. There are few rough work sheets at the end of this booklet. Strike off these pages after completion of the examination.

FOR OFFICE USE

Question No.	Marks Obtained
Section-A	
Q.1	
Q.2	
Q.3	
Q.4	
Section-B	
Q.5	
Q.6	
Q.7	
Q.8	
Total Marks Obtained	177

Signature of Evaluator ....

Cross Checked by ....

IMPORTANT INSTRUCTIONS

CANDIDATES SHOULD READ THE UNDERMENTIONED INSTRUCTIONS CAREFULLY. VIOLATION OF ANY OF THE INSTRUCTIONS MAY LEAD TO PENALTY.

DONT'S

1. Do not write your name or registration number anywhere inside this Question-cum-Answer Booklet (QCAB).
2. Do not write anything other than the actual answers to the questions anywhere inside your QCAB.
3. Do not tear off any leaves from your QCAB, if you find any page missing do not fail to notify the supervisor/invigilator.
4. Do not leave behind your QCAB on your table unattended, it should be handed over to the invigilator after conclusion of the exam.

DO'S

1. Read the Instructions on the cover page and strictly follow them.
2. Write your registration number and other particulars, in the space provided on the cover of QCAB.
3. Write legibly and neatly.
4. For rough notes or calculation, the last two blank pages of this booklet should be used. The rough notes should be crossed through afterwards.
5. If you wish to cancel any work, draw your pen through it or write "Cancelled" across it, otherwise it may be evaluated.
6. Handover your QCAB personally to the invigilator before leaving the examination hall.

Section A : Computer Organization and Architecture + Materials Science

Q.1 (a) (i) Suppose that execution time for a program is directly proportional to instruction access time and that access to an instruction in the cache is 20 times faster than access to an instruction in the main memory. Assume that a requested instruction is found in the cache with probability 0.96, and also assume that if an instruction is not found in the cache, it must first be fetched from the main memory to the cache and then fetched from the cache to be executed. Compute the ratio of program execution time without the cache to program execution time with the cache.

(ii) If the size of the cache is doubled, assume that the probability of not finding a requested instruction there is cut in half. Repeat part (i) for a doubled cache size.

[6 + 6 marks]

i) Suppose time of execution without cache $= I$ sec. $= T_{non\ cache}$ — (A)

With use of cache this time will be $\frac{I}{20}$ sec

as cache is 20 times faster

As hit ratio of cache is 0.96. total access time $T = h_{cache} \times T_{cache} + (1 - h_{cache}) \times T_{Main\ mem.}$

$T_{cache} = 0.96 \times \frac{I}{20} + 0.04\left(I + \frac{I}{20}\right)$ — (I)

since first instruction has to brought in cache from main memory it will take I sec & after that to read from cache it will take $\frac{I}{20}$ sec

so from (I), $T_{cache} = 0.09 I$. — (B)

$\frac{T_{non\ cache}}{T_{cache}} = \frac{I}{0.09 I}$ from (A) & (B)

$= 11.11$

ii) As cache is doubled its access time will be half $= \frac{I}{40}$

Hit ratio $= 1 - \frac{1}{2}(1 - 0.96) = 0.98$

$T = \frac{I}{40}$ & $h = 0.98$

6

$$\text{i.e. } T_{cache} = 0.98 \times \frac{I}{40} + 0.02\left(I + \frac{I}{40}\right)$$

$$= 0.045 I \cdot \text{sec}$$

$$\frac{T_{non\ cache}}{T_{cache}} = \frac{I}{0.045} = \underline{\underline{22.22}}$$

Q.1 (b) Draw the flow chart explaining the Round Robin scheduling algorithm. Find out the average waiting time for the processes listed in the following process table assuming Round Robin scheduling with time quantum equal to 3 nsec.

P_{id}	Arrival time (nsec)	Burst time (nsec)
P_1	0	8
P_2	5	2
P_3	1	7
P_4	6	3
P_5	8	5
P_6	2	3

[12 marks]

Flow chart →

At given arrival time check all the processes arrived

↓

The process which comes first is placed 1st in waiting queu

↓

That process is executed for given time quantum & preempted after that

↓

while previous instruction is getting executed waiting que is continously updated

↓

After preemption of previous process if that process is not terminated that process again enters in queu

↓

Based on waiting queu all the processes are executed till they are terminated

Pid	AT	BT	CT	TAT (CT−AT)	WT (TAT−BT)
P1	0	8 5 2 0	25	25	17
P2	5	2 0	14	9	7
P3	1	7 4 1 0	26	25	18
P4	6	3 0	17	11	8
P5	8	5 2 0	28	20	15
P6	2	3 0	9	7	4

Gatt chart

P1	P3	P6	P1	P2	P4	P3	P5	P1	P3	P5
0–3	3–6	6–9	9–12	12–14	14–17	17–20	20–23	23–25	25–26	26–28

Waiting queu

P1 | P3 | P6 | P1 | P2 | P4 | P3 | P5 | P1 | P3 | P5

Avg waiting time $= \frac{17+7+18+8+15+4}{6}$

$= \frac{69}{6}$

$= 11.5$ nsec

12

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Q.1 (c) Calculate the angles of diffraction for red and green light incident on diffraction grating that has 500 lines per mm. The wavelength of red and green light are 7×10^{-7} m and 5.38×10^{-7} m respectively. Assume first order diffraction ($n = 1$). Can the contents of any incident light wave be examined by diffraction?

[12 marks]

$n\lambda = 2d\sin\theta$

As $n = 1$. $\lambda = 2d\sin\theta$

$\theta = \sin^{-1}\left(\frac{\lambda}{2d}\right)$ - angle of diffraction

500 lines for 1 mm $= 10^{-3}$ m

1 line for $\frac{10^{-3}}{500} = d$

$\therefore d = 2 \times 10^{-6}$ m

$\lambda_{red} = 7 \times 10^{-7}$ m

$\theta_{red} = \sin^{-1}\left(\frac{7 \times 10^{-7}}{2 \times 2 \times 10^{-6}}\right) = 10.08°$

$\lambda_{green} = 5.38 \times 10^{-7}$ m

$\theta_{green} = \sin^{-1}\left(\frac{5.38 \times 10^{-7}}{2 \times 2 \times 10^{-6}}\right) = 7.73°$

As diffraction angle is not too small content of incident light can be examined by diffraction.

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Q.1 (d) Germanium forms a substitutional solid solution with silicon. Compute the weight percent of germanium that must be added to silicon to yield an alloy that contains 2.43×10^{21} Ge atoms per cubic centimeter. The densities of pure Ge and Si are 5.32 and 2.33 g/cm^3, respectively. Assume the atomic weights for Germanium and Silicon as 72.59 and 28.09 g/mol respectively.

[12 marks]

Q.1 (e) A computer has a cache, main memory, and a disk used for virtual memory. If a referenced word is in the cache, 15 nsec are required to access it. If it is in main memory but not in the cache, 50 nsec are needed to load it into the cache, and then the reference is started again. If the word is not in main memory, 10 msec are required to fetch the word from disk, followed by 50 nsec to copy it to the cache, and then the reference is started again. The cache hit ratio is 0.9 and the main memory hit ratio is 0.5. What is the average time in nsec required to access a referenced word in this system?

[12 marks]

$T_{cache} = 15$ nsec

$T_{main\ mem}$ = time to load into cache + T_{cache}

$T_{MM} = 50 + 15 = 65$ nsec

T_{disk} = time to load in main memory + T_{MM}

$= 10$ msec $+ 65$ nsec

$= \sout{10 \times 10^{6}}$ $10 \times 10^{-3} \times 10^{-6}$ nsec $\times 10^{6} + 65$ nsec

$= 10 \times 10^{-9} \times 10^{6}$ sec $+ 65$ nsec

$= 10^{7}$ nsec $+ 65$ nsec

$h_{cache} = 0.9$ $h_{main\ mem} = 0.5$

$T_{avg} = h_{cache} \times T_{cache} + (1 - h_{cache})\, h_{main\ mem} \times (T_{cache} + T_{MM})$
$+ (1 - h_{cache})(1 - h_{main\ mem}) \times 1 \times (T_{cache} + T_{MM} + T_{disk})$

$= 0.9 \times 15 + 0.1 \times 0.5 \times 80 + 0.1 \times 0.5 \times 1 \times (80 + 10^{7} + 65)$

$= 5.00024 \times 10^{5} \times 10^{-9}$ sec

$= 5.00024 \times 10^{-4}$ sec

$= 0.5$ msec

6

Q.2 (a) Consider two different machines, with two different instruction sets, both of which have a clock rate of 200 MHz. The following measurements are recorded on the two machines running a given set of benchmark programs.

Instruction Type	Instruction Count (millions)	Cycles per instruction
Machine A		
Arithmetic and logic	8	1
Load and store	4	3
Branch	2	4
Others	4	3
Machine B		
Arithmetic and logic	10	1
Load and store	8	2
Branch	2	4
Others	4	3

(i) Determine the effective CPI, MIPS rate and execution time for each machine.

(ii) Comment on results.

[15 + 5 marks]

i) For machine A,

Total no. of cycles = $8\times1+4\times3+2\times4+4\times3$

$= 8+12+8+12$

$= 40\times10^6$

effective CPI = $\frac{\text{Total no. of cycles}}{\text{Total no. of instructions}}$

$= \frac{40\times10^6}{18\times10^6}$

$= 2.22$

MIPS $= \frac{(8+4+2+4)}{40} = 0.45$ MIPS

Execution time = Total CPI × Total no. of instructions × cycle time

$= \frac{2.22\times18\times10^6}{200\times10^6} = 0.2$ sec

For Machine B,

$$\text{effective CPI} = \frac{\text{Total no. of cycles}}{\text{Total no. of instructions}}$$

$$= \frac{(10\times1 + 8\times2 + 2\times4 + 4\times3)\times10^6}{(10+8+2+4)\times10^6}$$

$$= \frac{10+16+8+12}{24}$$

$$= \underline{1.92}$$

$$\text{MIPS} = \frac{10+8+2+4}{46}$$

$$= \underline{0.52}$$

Execution time = effective CPI × Total no. of instructions × cycle time

$$= \frac{1.92\times24\times10^6}{200\times10^6}$$

$$= \underline{0.23 \text{ sec}}$$

ii) Execution time for machine B is greater than machine A.

- This is because CPI for machine B is is less than machine A & machine B has to execute more instructions than machine A. Machine B executes 6×10^6 instructions more than machin A so it is taking more time than machine A for same clock cycle time.

18

Q.2 (b) **(i)** Addition of 0.3 atomic % nickel and 0.4 atomic % silver into copper at 298 K increases the resistivity by 0.012 mΩ cm and 0.00018 mΩ m respectively. If the resistivity of copper is 0.025 mΩ cm at 298 K, determine the conductivity of the resulting alloy in $(\Omega\ m)^{-1}$.

(ii) Explain with graphical representation, how mobility varies with temperature?

[10 + 10 marks]

i) Due to addition of impurity resistivity of alloy increases linearly.

resistivity of Alloy = resistivity of Cu + increase in resistivity by nickel & silver

$= 0.025\ m\Omega + 0.012 + 0.00018\ m\Omega$

$= 0.03718\ m\Omega\ cm.$

$= 0.03718 \times 10^{-3}\ \Omega \times 10^{-2}\ m$

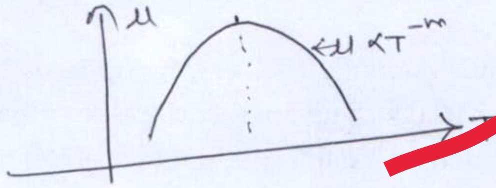
$= 0.03718 \times 10^{-5}\ \Omega m.$

$\text{Conductivity} = \dfrac{1}{\text{resistivity}}$

$= \dfrac{1}{0.03718 \times 10^{-5}}\ (\Omega m)^{-1}$

$= 2.69 \times 10^{6}\ (\Omega m)^{-1}$

ii)
- In metal mobility of electrones decreases with increase in temperature
- This is because at high temp. electrones gain high energy & they collide with each other more frequently. so resistivity increases.
- For semiconductor relation with temperature can be shown as follows



- As temperature increases more energy is acquired by electrones to break covalent bond & then they breaks those bonds & sea of free electrones increases by resulting into increased conductivity. Because of this mobility increases.
- At higher temperature beyond certain limit mobility starts decreasing with temperature.
- This is because by increasing temperature lattice vibration increases & free electrones get collided frequently with these vibrating lattices. This increases resistance to electrones flow & their mobility decreases.

Q.2 (c) **(i)** Enumerate the differences between Carbon Dots and Quantum Dots.

(ii) At 100°C, copper (Cu) has a lattice constant of 3.655 Å. What is the density at this temperature? (Assume atomic weight of Cu as 63.55 g/mole).

[10 + 10 marks]

ii) Cu has fcc structure 6 atoms at 6 lattice faces & 8 atoms at 8 corners of lattice.

No. of atoms per lattice $= 6 \times \frac{1}{2} + \frac{1}{8} \times 8$

$= 3 + 1 = \underline{\underline{4}}$

$a = 3.655\,A^\circ = 3.655 \times 10^{-10}$ m $= 3.655 \times 10^{-8}$ cm

$M = 63.55$ g/mole

Density $\rho = \frac{nM}{N_A a^3}$

$= \frac{4 \times 63.55}{6.023 \times 10^{23} \times (3.655 \times 10^{-8})^3}$

$= 8.643 \frac{gm}{cm^3}$

10

i) Carbon dots

1. Carbon dots are structure of nano scale carbon.
2. Due to their active nature these are used in catalyst, surface passivation.
3. Its properties - mechanical, electrical, magnetic are quite different than bulk material

Quantum Dots.

1. Quatum dots are made from semi-conductor material
2. These are used in display technology
3. Their properties depends on their size & excitation provided to them

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Q.3 (a) Consider a pure Si crystal that has $\varepsilon_r = 11.9$.

(i) What is the electronic polarizability due to valence electrons per Si atom?

(ii) Assume that a Si crystal sample electroded on opposite faces and has a voltage applied across it. By how much is the local field greater than the applied field?

(iii) What is the resonant frequency f_0 corresponding to ω_0?

Consider the density of the Si crystal, the number of Si atoms per unit volume, N is given as $5 \times 10^{28}\ m^{-3}$.

[6 + 8 + 6 marks]

i) $\varepsilon_r = 11.9 \qquad N = 5 \times 10^{28}\ m^{-3}$

We know that

$$\frac{N\alpha_e}{3\varepsilon_0} = \frac{\varepsilon_r - 1}{\varepsilon_r + 2}$$

$$\alpha_e = \frac{3\varepsilon_0}{N} \times \frac{\varepsilon_r - 1}{\varepsilon_r + 2}$$

$$= \frac{3 \times 8.85 \times 10^{-12}}{5 \times 10^{28}} \times \frac{(11.9 - 1)}{11.9 + 2}$$

$$= 4.164 \times 10^{-40}\ \frac{F}{m^2}$$

6

ii) $E_{local} = E_i + E_o$

E_{local} = local electric field

E_i = internal — " —

E_o = applied — " —

~~E_i~~ = $E = \frac{\gamma P}{\varepsilon_o}$ $\qquad$ P – polarization $= \varepsilon_o(\varepsilon_r - 1)E_o$

$\gamma = \frac{1}{3}$

$$\therefore E_{local} = \frac{P}{3\varepsilon_o} + E_o$$

$$\frac{\varepsilon_o(\varepsilon_r - 1)E_o}{3\varepsilon_o} + E_o$$

$$= \left(\frac{\varepsilon_r - 1}{3} + 1\right)E_o$$

$$= \left(\frac{11.9 - 1}{3} + 1\right)E_o$$

$$\boxed{E_{local} = 4.63\ E_o}$$

6

iii) For Si $Z = 4$.

$$\omega_0 = \sqrt{\frac{Ze^2}{m\alpha_e}}$$

$$= \sqrt{\frac{4\times(1.6\times10^{-19})^2}{9.1\times10^{-31}\times4.164\times10^{-40}}}$$

$$= 1.643\times10^{16} \text{ rad}$$

$$f_0 = \frac{\omega_0}{2\pi}$$

$$f_0 = 2.62\times10^{15} \text{ Hz}$$

6

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Q.3 (b) **(i)** **1.** What is superconductivity and how the superconductors are classified?

2. The superconducting state of a lead specimen has critical temperature of T_c. It has critical magnetic field of 8.2×10^5 A/m at 0 K. If the critical field at 5 K for this specimen is 4.1×10^5 A/m, then find value of T_c at 5 K.

(ii) Calculate the first three energy levels for an electron in a quantum well of width 10 Å with infinite walls.

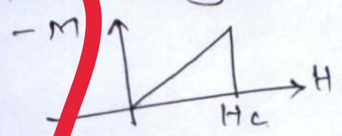
(Assume, Plank's constant, $h = 6.63 \times 10^{-34}$ J.s, depth of well, $L = 1$ nm, mass of electron, $m = 9.11 \times 10^{-31}$ kg)

[10 + 10 marks]

i) Superconductivity is having infinite conductivity
- Super conductors show zero resistance to flow of current under curie temperatu
- If magnetic field is increased beyond certain value Hc or if temperature is increased beyond critical temperature then superconductor converts into normal conductor.

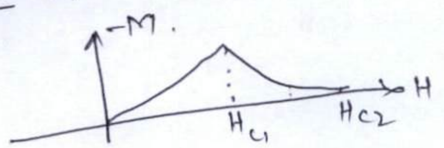
Classification

Type I →
- These shows sudden transistion from super conductor to normal conductor above critical magnetic field. Hc.



- They exhibit perfect silsbee rule, & meisners effect.

Type II →



- They exhibit week silsbee rule & meisners effect.
- Transition from superconductor to normal state is not sudden.

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- They slowly transit to normal state
- so in vortex region there are 2 critical magnetic field values.

2. $H_c = 8.2\times10^5$ A/m

$T_c = 5K$

$H = 4.1\times10^5$ A/m

$T = ?$

$$H = H_c\left[1-\left(\frac{T}{T_c}\right)^2\right]$$

$$\frac{T}{T_c} = \sqrt{1-\frac{H}{H_c}}$$

$$T = T_c\sqrt{1-\frac{H}{H_c}}$$

$$= 5\times\sqrt{1-\frac{4.1\times10^5}{8.2\times10^5}}$$

$$= 3.54\ K$$

Q.3 (c) **(i)** A process has been allocated 3 page frames. Assume that none of the pages of the process are available in memory initially. The process makes the following sequence of page references (reference string) : 1, 2, 1, 3, 7, 4, 5, 6, 3, 1.

If optimal page replacement policy is used, how many page faults occur for the above reference string?

(ii) Least recently used (LRU) page replacement policy is a practical approximation to optimal page replacement. For the above reference string, how many more page faults occur with LRU than with the optimal page replacement policy?

[10 + 10 marks]

i) optimal page policy.

1	2	1	3	7	4	5	6	3	1
			3	3	3	3	3	3	3
	2	2	2	7	4	5	6	6	6
1	1	1	1	1	1	1	1	1	1
M	M	H	M	M	M	M	M	H	H

No. of page faults = 7.

ii) LRU

1	2	1	3	7	4	5	6	3	1
			3	3	3	5	5	5	1
	2	2	2	7	7	7	6	6	6
1	1	1	1	1	4	4	4	3	3
M	M	H	M	M	M	M	M	M	M

No. of page faults = 9.

2 more page faults occurs in LRU than optimal page replacement policy

Q.4 (a) Consider zero, one, two and three address machines. Write programs to compute

$$X = (A + B \times C)/(D - E \times F)$$

for each of the four machines. The instructions available for use are as follows:

'0' address	'1' address	'2' address	'3' address
PUSH M	LOAD M	MOV $(X \leftarrow Y)$	MOV $(X \leftarrow Y)$
POP M	STORE M	ADD $(X \leftarrow X + Y)$	ADD $(X \leftarrow Y + Z)$
ADD	ADD M	SUB$(X \leftarrow X - Y)$	SUB $(X \leftarrow Y - Z)$
SUB	SUB M	MUL$(X \leftarrow X \times Y)$	MUL $(X \leftarrow Y \times Z)$
MUL	MUL M	DIV$(X \leftarrow X/Y)$	DIV $\left(X \leftarrow \frac{Y}{Z}\right)$
DIV	DIV M		

[20 marks]

Q.4 (b) **(i)** Define the following:

1. Translators **2.** Assemblers **3.** Compilers

4. Converters **5.** Interpreters

(ii) **1.** Consider a magnetic material of 20 cm length carries a 1 Amp current. If the magnetic susceptibility of the material is 0.5×10^{-2}, calculate the flux density in the material in Tesla.

2. Distinguish between hard and soft magnetic material.

[10 + 10 marks]

Q.4 (c) **(i)** What is lossless join decomposition property in DBMS? If a relation 'R' is decomposed into two relations R_1 and R_2, then what are the conditions if it is lossless decomposition?

(ii) Find out which one of the given below decomposition of $R(VWXYZ)$ are lossless decomposition and lossy decomposition.

$R(VWXYZ)$

$Z \rightarrow Y, \quad Y \rightarrow Z, \quad X \rightarrow YV, \quad VW \rightarrow X$

1. $R_1(VWX), R_2(XYZ)$
2. $R_1(VWX), R_2(YZ)$
3. $R_1(VW), R_2(WXYZ)$

[8 + 12 marks]

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Section B : Electronic Devices & Circuits-1 + Advanced Communications Topics-1 + Analog & Digital Communication Systems-2

Q.5 (a) A new semiconductor has density of states $N_C = 10^{19}$ cm^{-3}, $N_V = 5 \times 10^{18}$ cm^{-3} and energy gap, $E_g = 2$ eV. If it is doped with 10^{17} donors (fully ionized), calculate electron, hole and intrinsic carrier concentrations at 627°C. (Assume E_g, N_C and N_V are independent of temperature.)

[12 marks]

$n_i = \sqrt{N_C N_V}\, e^{\frac{-E_g}{2kT}}$

$kT = 1.38 \times 10^{-23} \times 900 = 1.242 \times 10^{-20}$ J

$= \frac{1.242 \times 10^{-20}}{1.6 \times 10^{-19}}$ eV

$= 0.078$ eV.

$n_i = \sqrt{10^{19} \times 5 \times 10^{18}}\, e^{-\frac{2}{0.155}} = 1.798 \times 10^{13}$ cm^{-3}

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~~electrone conc $n = N_c e^{-\frac{(E_C - E_F)}{kT}}$~~

As $N_d >> n_i$ electrones concentration

$n = 10^{17}\ cm^{-3}$

Hole concentration $= \frac{n_i^2}{N_D}$

$= \frac{(1.798 \times 10^{13})^2}{10^{17}}$

$= 3.23 \times 10^{9}\ cm^{-3}$

Q.5 (b) Draw the following data formats for the bit stream 1100110:

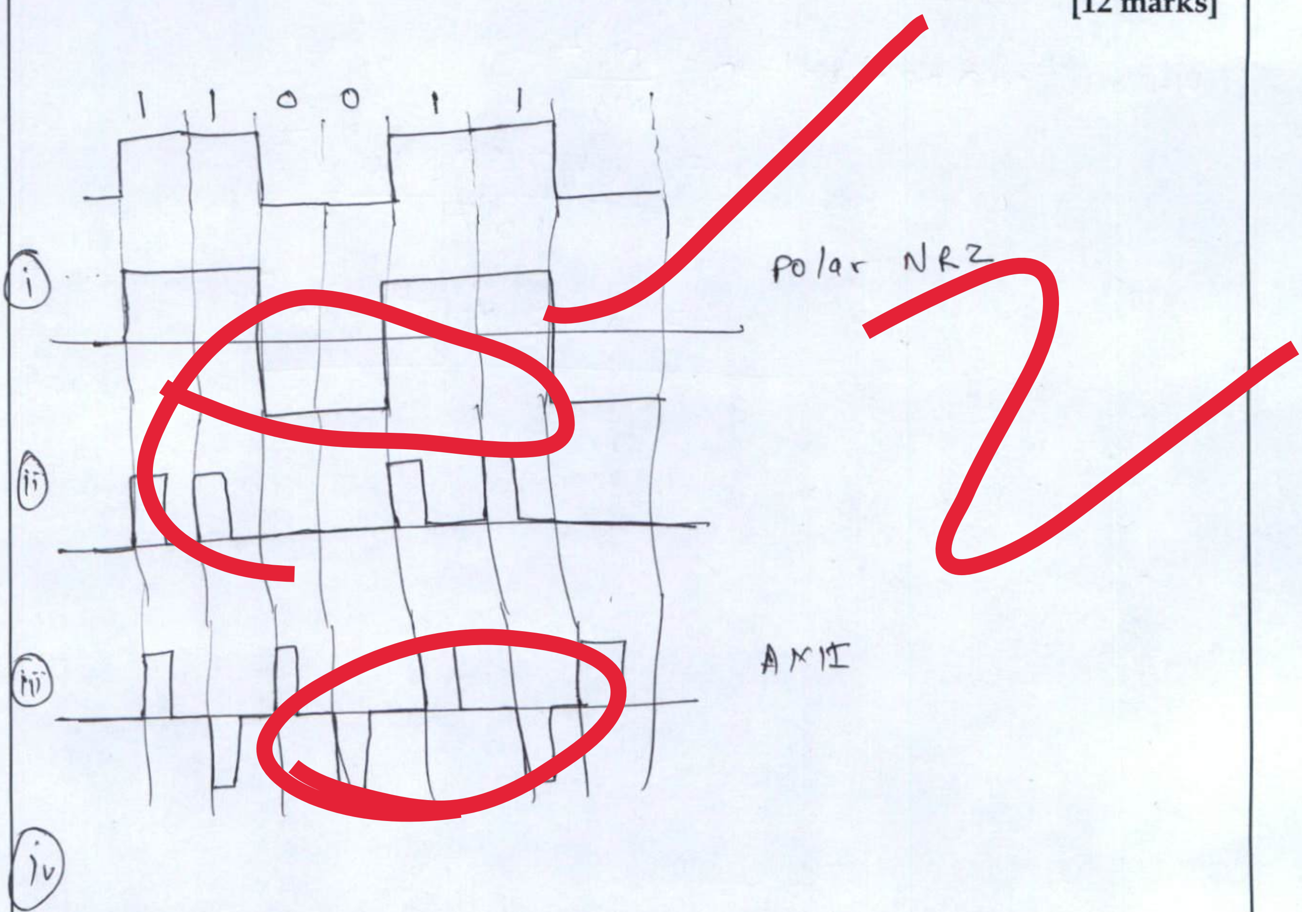
(i) Polar NRZ

(ii) Unipolar RZ

(iii) Alternate Mark inversion (AMI)

(iv) Manchester

[12 marks]



Q.5 (c) The cell-site transmitted power increased by 3 dB (or doubled). For the same minimum acceptable received signal power and all other parameters remaining unchanged, prove that the coverage area is increased by $\sqrt{2}$ times. Assume mobile radio operating environment conditions.

[12 marks]

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Q.5 (d) Consider the two 8-point QAM signal constellation shown in figure below. The minimum distance between adjacent points is 2A. Determine the average transmitted power for each constellation assuming that the signal points are equally probable. Which constellation is more power efficient?

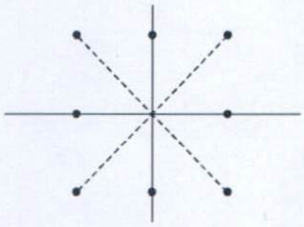


Fig. (a)

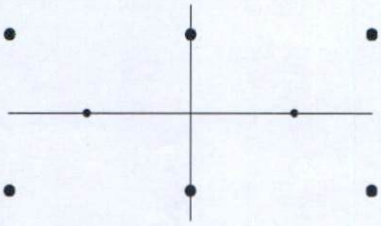
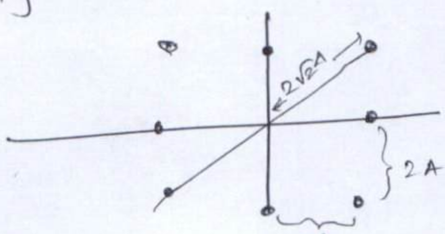


Fig. (b)

[12 marks]

$E = d^2$ Joules.

For fig. a



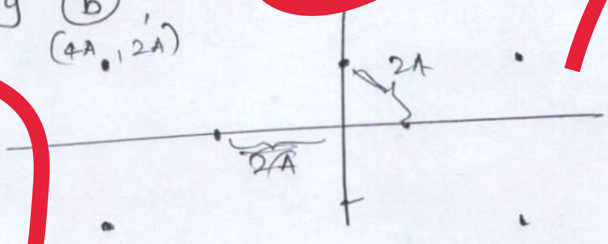
$$\text{Avg. energy} = \frac{1}{8}\left[4\times(2A)^2 + 4\times 8A\right]$$

$$= \frac{1}{8}\left[4\times 4 + 32\right]$$

$$= \frac{1}{8}\left[48\right]$$

$$= 6A.$$

fig (b)



$2x^2 = 4A^2$

$x^2 = 2A^2$

$x_d = \sqrt{2}$

$$\text{Avg power} = \frac{1}{8}\left[4\times 2 + (20)\right]$$

$$= \frac{1}{8}\left[28\right]$$

$$= 3.5A.$$

2^{nd} constellation is more power efficient as it is consuming less

4

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power

Q.5 (e) Describe some methods to reduce co-channel interference and can the value of cluster size be increased more than 7 to minimise the effect of co-channel interference in cellular communication?

[12 marks]

1. To reduce co-channel interference filter design should be proper so that unwanted ~~filt~~ frequencies will be filtered out properly
2. In another method using directional antennas co-channel interference can be minimized because signal will not be directed in unwanted direction.
3. Lowering ~~f~~ base ~~of~~ station antenna output power will also reduce co-channel interference

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Q.6 (a) (i) Explain TCP/IP reference model briefly.

(ii) Define cryptography and its type briefly.

[14 + 6 marks]

ii) Cryptography

- To avoid unwanted party to intercept & modify messages in communication cryptography is used.
- Here data to be sent is encrypted using keys & same data is decrypted using key which is shared with receiver

Symmetric cryptography -

- Here same key is used for encryption & decryption of messages

Asymmetric cryptography -

- Here different keys are used

4

at sender & receiver end,

Ex. Aadhar card

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Q.6 (b) A city with a coverage area of 500 sq. km is covered with a 12-cell system each with a radius of 1.241 km. The total spectrum allocated is 36 MHz with a full duplex channel bandwidth is 30 kHz. Assume a GoS of 0.02 for an Erlang B system is specified and the offered traffic per user is 0.05 Erlangs.

Compute

(i) The number of cells in the service area.

(ii) The number of channels per cell.

(iii) Traffic intensity of each cell.

(iv) The maximum carried traffic.

(v) The total number of users that can be served for 2% GoS.

Use the Erlang B chart as given below:

No. of channels 'C'	Capacity (Erlangs) for GoS		
	0.02	0.005	0.002
5	1.36	1.13	0.9
10	4.46	3.96	3.43
20	12	11.1	10.1
40	29.0	27.3	25.7
70	56.1	53.7	51.0
100	84.0	80.9	77.4

[20 marks]

i) Area of cell $= 2.59 R^2$

$= 2.59 \times (1.241)^2$

$= 3.99$ sq. km.

No. of cells $= \dfrac{\text{Total area}}{\text{Area of single cell}}$

$= \dfrac{500}{3.99}$

≈ 125 cells

ii) Total no. of channels $= \dfrac{\text{Total spectrum}}{\text{channel bandwidth}}$

$= \dfrac{36 \times 10^6}{30 \times 10^3}$

$= 1200$ channels

No of channels per cell $= \dfrac{\text{total channels}}{\text{total cell in system}}$

$= \frac{1200}{12}$

= 100 channels / cell.

iii) For 100 channels / cell with GoS 2%.

traffic intencity for each cell

= 84 Erlangs.

iv) maximum traffic carried = 84 × 12

= 1008 Erlangs

v) For 1 cell max. traffic intenity = 84 erlangs

for 1 user traffic intencity = 0.05 Erlangs

No. of users in 1 cell = $\frac{84}{0.05}$

= 1680 users

total no. of users = 12 × 1680

= 20160 users

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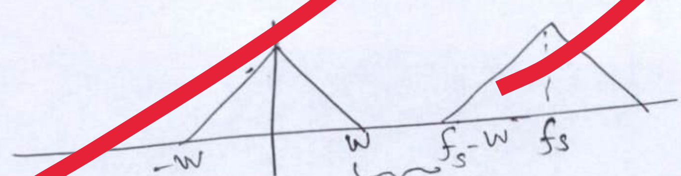
Q.6 (c) **(i)** Consider a binary memoryless source X with two symbols x_1 and x_2. Show that $H(X)$ is maximum when both x_1 and x_2 are equiprobable.

(ii) An analog message signal bandlimited to 2.8 kHz is sampled above Nyquist rate to have a guard band of half of message signal bandwidth. The samples are quantized into 4 levels. The quantization levels Q_1, Q_2, Q_3 and Q_4 are assumed to be independent and occur with equal probabilities. Determine the information rate of the source.

[10 + 10 marks]

ii) $P(Q1) = P(Q2) = P(Q3) = P(Q4) = \frac{1}{4}$.

$\therefore H(Q)\big|_{max} = \log_2 4 = 2$ bits / symbol.



By given condition guard band $= \frac{W}{2}$

$\therefore f_s - W - W = \frac{W}{2}$

$f_s = 2.5W = 2.5 \times 2.8$ KHz

$f_s = \underline{7 \text{ KHz}}$

As quantized levels = 4.

no. of bits required = $\log_2 4 = 2$ bits.

Bit rate = nf_s

= 2×7

= 14 Kbps.

Information rate = r H.

= 2×14

= 28 Kbps.

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Q.7 (a) **(i)** **1.** A Si sample is doped with 10^{17} boron atoms/cm^3. What is the electron concentration, n_0 at 300 K? What is the resistivity?

2. A Ge sample is doped with 3×10^{13} Sb atoms/cm^3. Using the requirements of space charge neutrality, calculate the electron concentration n_0 at 300 K.

[Assume, $n_i = 1.5 \times 10^{10}\ \text{cm}^{-3}$ for Si and $n_i = 2.5 \times 10^{13}\ \text{cm}^{-3}$ for Ge, $\mu_p = 250 \dfrac{\text{cm}^2}{\text{Vs}}$]

(ii) The total current in a semiconductor is constant and is composed of electron drift current and hole diffusion current. The electron concentration is constant and equal to $10^{16}\ \text{cm}^{-3}$. The hole concentration is given by

$$p(x) = 10^{15} \exp\left(\frac{-x}{L}\right) \text{cm}^{-3}; x \geq 0$$

where, $L = 12\ \mu\text{m}$. The hole diffusion coefficient, $D_p = 12\ \text{cm}^2/\text{s}$ and electron mobility

$\mu_n = 1000 \dfrac{\text{cm}^2}{\text{V-s}}$. The total current density is $J = 4.8\ \text{A/cm}^2$. Calculate:

1. hole diffusion current density for $x > 0$.
2. electron current density for $x > 0$.
3. electric field for $x > 0$.

[10 + 10 marks]

Q.7 (b) An n-type Si sample of thickness L is inhomogeneously doped with phosphorus donor whose concentration profile is given by $N_D(x) = N_0 + (N_L - N_0)\left(\frac{x}{L}\right) \text{cm}^{-3}$. Find:

(i) Electric potential across the sample at thermal equilibrium.

(ii) Electric potential when $\frac{N_L}{N_0} = 0.75$ (Assume: $D_n = 12\ \text{cm}^2/\text{s}$; $\mu_n = 3000\ \frac{\text{cm}^2}{\text{V-s}}$)

[15 + 5 marks]

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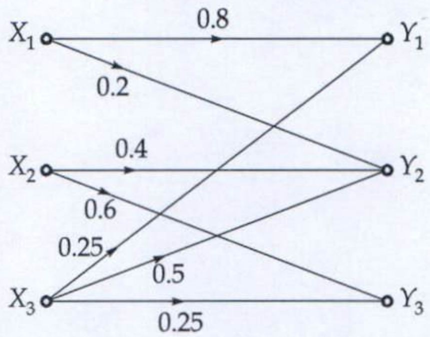
Q.7 (c) **(i)** Consider the discrete source transmit messages X_1, X_2 and X_3 with the probabilities 0.25, 0.5 and 0.25 respectively. The source is connected to the channel as given in below figure. Determine the value of $H\left(\frac{X}{Y}\right)$.



(ii) Consider a linear block code with generator matrix shown below:

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

Determine maximum and minimum hamming weight.

[14 + 6 marks]

Q.8 (a) **(i)** Derive equation for the maximum output signal to quantization noise ratio of the Delta modulation system for a sinusoidal input.

(ii) Consider a low-pass signal with a bandwidth of 3 kHz. A linear delta modulation system, with step size $\Delta = 0.1$ V, is used to process this signal at a sampling rate ten times the Nyquist rate. For 1 V amplitude of a test sinusoidal signal of frequency 1 kHz, evaluate the output signal to noise ratio in dB under (a) prefiltered, (b) postfiltered conditions.

[14 + 6 marks]

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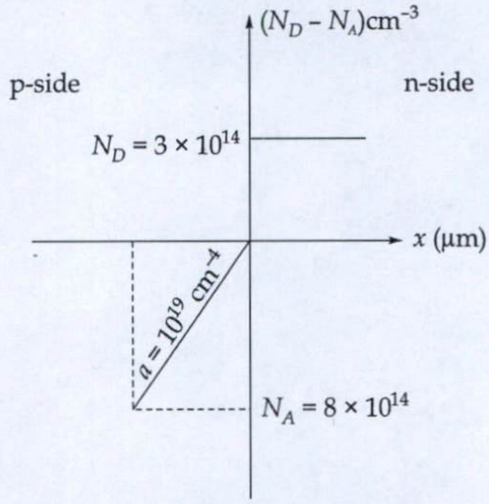
Q.8 (b) A diffused silicon p-n junction has a linearly graded junction on *p*-side and a uniform doping on *n*-side as shown below:



If the depletion width on the *p*-side is 0.8 μm at zero bias. Find:

(i) total depletion layer width.

(ii) maximum E-field on *p*-side and *n*-side at zero bias.

(iii) draw built-in potential on *p*-side and *n*-side.

(Assume, $\epsilon_s = 11.9\epsilon_0$)

[20 marks]

Q.8 (c) An ISP is granted a block of addresses starting with 190.100.0.0/16 [65,536 addresses]. The ISP needs to distribute these addresses to three groups of customers as follows:

(a) The first group has 64 customers; each needs 256 addresses.

(b) The second group has 128 customers; each needs 128 addresses.

(c) The third group has 128 customers; each needs 64 addresses.

Design the subblocks and find out how many addresses are still available after these allocations.

[20 marks]

OOOO

Space for Rough Work

Space for Rough Work