MADE EASY

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Leading Institute for ESE, GATE & PSUs

ESE 2026 : 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-1 [Part Syllabus]
Analog & Digital Communication Systems-2 [Part Syllabus]

Name : ....

Roll No :

Test Centres			**Student's Signature**
Delhi ☑	Bhopal ☐	Jaipur ☐	
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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	20
Q.2	52
Q.3	54
Q.4	
Section-B	
Q.5	30
Q.6	29
Q.7	
Q.8	
Total Marks Obtained	185

Signature of Evaluator .... Cross Checked by ....

Good -- Keep it UP--

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.

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Section A : Computer Organization and Architecture + Materials Science

Q.1 (a) A 32-bit CPU is interfaced with a high speed I/O device having a data transfer rate of 100 MBps. The system employs a DMA controller operating in cycle stealing mode. The I/O device contains an internal buffer that initiates a DMA transfer only after it has accumulated 8 words of data. The CPU operates with a machine cycle time of 5 ns. Assuming each word transfer requires exactly one machine cycle of the CPU, calculate:

(i) The percentage of time the CPU remains consumed during the DMA operation.

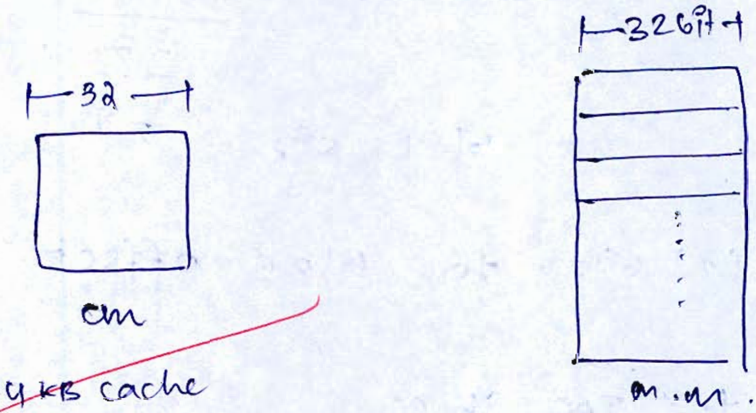
(ii) The percentage of time the CPU remains busy with its own processing.

[12 marks]

Q.1 (b) How many bits of storage are required for the tag array of a 64 KB cache with 128-byte cache lines and two-way set-associativity if the cache is write back but does not require any additional bits of data in the tag array to implement write-back policy? Assume that the system containing the cache uses 32-bit addresses.

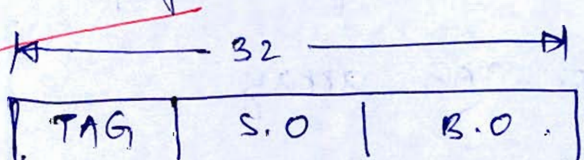
[12 marks]

Q1 (b) Given:



- 64 KB cache
- 128 B cache lines
- 2 way set associative

Statement: for a set associative cache memory, the field address is distributed as



s.o = set offset.

s.o = $\frac{\text{\# lines in cm}}{\text{P-way}} = \frac{2^7}{2} = 2^6$.

∴ (6) bits for set offset.

calculation for Block offset:

lines in cache memory = $\frac{\text{c.m size}}{\text{block size}}$

$128\,B = \frac{64\,KB}{\text{block size}}$.

block size = $\frac{2^6 \cdot 2^{10}}{2^7}$.

block size = 2^9.

∴ (9) bits for Block offset.

Hence, for TAG space,

TAG bits = 32 − (6+9)

TAG bits = 17

Hence 17 bits of TAG space is required for TAG array.

8

storage in tag ??

Q.1 (c) Write a C-program to print first hundred Fibonacci numbers' fib(i) given by,

fib(i) = fib(i – 1) + fib(i – 2)

It is given that, fib(0) = fib(1) = 1

[12 marks]

Q1 (c)

```
# include <iostream.h>
using namespace std;
int main ( )
{
 int x, y, z, count = 0;
 cout << "\n Program for first 100 fibonacci
             numbers:" ;

 x = 1;
 y = 1;
 z = 1;
 while ( count <= 100)
 {
    cout << "\n" << z;
    x = y;
    y = z;
    z = x+y;
    count ++;
 }
 return 0;
}.
```

Is it C??

C++ ??

0

<u>Assuming:</u> x & y as first numbers of series.

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Q.1 (d) (i) Calculate the density of BCC metal having atomic radius, 1.24 Å and atomic weight, 50 g/mol.

(ii) A plane cuts crystal axes at $a = 3$, $b = 2$ and $c = \infty$, find the Miller indices.

(iii) Find the interplanar spacing of (321) plane with Lattice parameter $a = 4$ Å.

[4 + 4 + 4 marks]

Q1. (d) i)

Given: $r = 1.24$ Å   BCC metal.

$A = 50$ g/mol.

Statements: ① Density is given as

$$\rho = \frac{n \cdot A}{N_A \cdot V_c}$$

for BCC, $n = 2$.

V_c: Volume $= (a)^3$.

for BCC, $r = \frac{\sqrt{3}}{4} a$.

$\therefore a = \frac{4r}{\sqrt{3}}$ $a = \frac{4}{\sqrt{3}} \times 1.24$ Å.

$a = 2.86$ Å

4 Good

$\therefore V_c = (2.86 \times 10^{-10})^3$

$V_c = 2.34 \times 10^{-29}$ /m³

$$\rho = \frac{2 \times 50}{6.023 \times 10^{23} \times 2.34 \times 10^{-29}}$$

$\rho = 7.095 \times 10^6$ g/m³ - ①

(ii) ② Miller indices can be calculated by taking reciprocal of plane,

[cuts] [3 2 ∞]

[reciprocal] [$\frac{1}{3}$ $\frac{1}{2}$ 0]

[miller indices] [2 3 0] - (2)

(iii) for interplanar spacing (d)

$$d = \frac{a}{\sqrt{h^2+k^2+l^2}}$$

substituting values,

$$d = \frac{4}{\sqrt{9+4+1}}$$

$$d = 1.06\times10^{-10} m$$

- (3)

Conclusion:

Hence (1), (2), (3) are respective answers.

Good (8)

Q.1 (e) Curie temperature of iron (Fe) is 1043 K. Assume that Fe atom when in metallic form have magnetic moment of two Bohr magneton per atom. Fe has body centered cubic structure with lattice parameter a = 0.286 nm. Calculate,

(i) Saturation magnetization

(ii) Curie constant

(iii) Weiss field constant

Given, magnetic moment, $\mu_B = 9.27 \times 10^{-24}$ A-m², $\mu_0 = 4\pi \times 10^{-7}$ Henry/meter, $K_B = 1.38 \times 10^{-23}$ Joule/Kelvin.

[12 marks]

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Q.2 (a) (i) Consider the following set of processes, with the arrival time and length of the CPU burst (in milliseconds):

Process	Arrival Time	Burst Time
P_1	0	6
P_2	1	4
P_3	2	3
P_4	3	1
P_5	4	2
P_6	5	1

Draw the Gantt chart and compute the average process waiting time using Shortest Remaining Time First (SRTF) scheduling algorithm.

(ii) What are the differences between concurrency and parallelism in the context of processes in operating systems?

[14 + 6 marks]

Q2 (a)(i) criteria: SRTF

mode: pre-emptive

Assumption: TQ (Time Quantum) = 1 msec.

Drawing the respective table again,

Pd	(A.T)	(B.T)
P_1	0	~~6~~ 5
P_2	1	~~4~~ ~~3~~ ~~2~~ ~~1~~ 0
P_3	2	3
P_4	3	~~1~~ 0
P_5	4	~~2~~ 0
P_6	5	~~1~~ 0

Gantt chart:

P_1	P_2	P_2	P_4	P_2	P_2	P_6	P_5	P_3	P_1

0 1 2 3 4 5 6 7 9 12 17

0 (start)	1	2	3	4	5	6	7	9	12	17
P_1	P_1	P_1	P_1	P_1	P_1	P_1	P_1	P_1	~~P_1~~	concluded
	P_2	P_2	P_2	P_2	~~P_2~~	P_3	P_3	~~P_3~~		
		P_3	P_3	P_3	P_3	P_5	P_5			
			~~P_4~~	P_5	P_5	~~P_6~~				
					P_6					

drawing table again:

Pd	A.T	B.T	C.T	TAT	W.T
P_1	0	6	17	17	11
P_2	1	4	6	5	1
P_3	2	3	12	10	3
P_4	3	1	4	1	0
P_5	4	2	9	5	3
P_6	5	1	7	2	1

statements : ① for a process,

$$TAT = CT - A.T$$

TAT = Turn around Time

$$W.T = TAT - B.T.$$

Average process waiting Time :

$$W.T_{avg} = \frac{11+1+3+0+3+1}{6}$$

$$= \frac{19}{6}$$

$$W.T_{avg} = 3.166 \text{ msec}$$

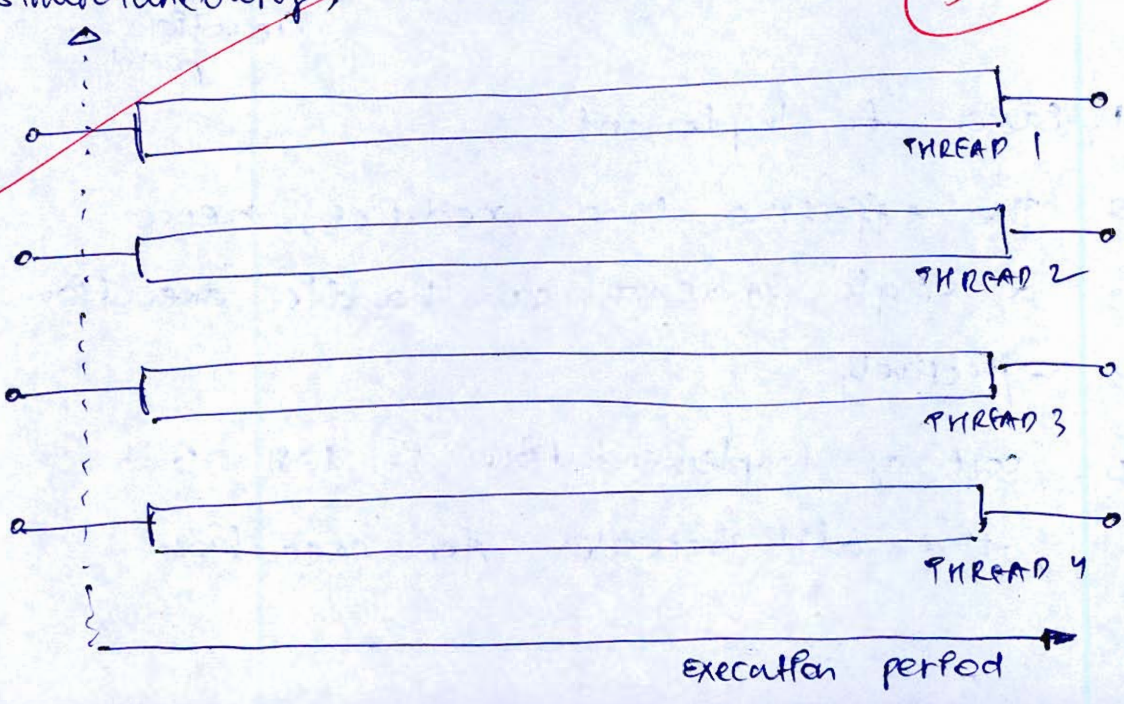
14

Q2 (a)

(ii) statements : In the context of processes in operating systems,

concurrency is handling multiple process simultaneously, as shown below,

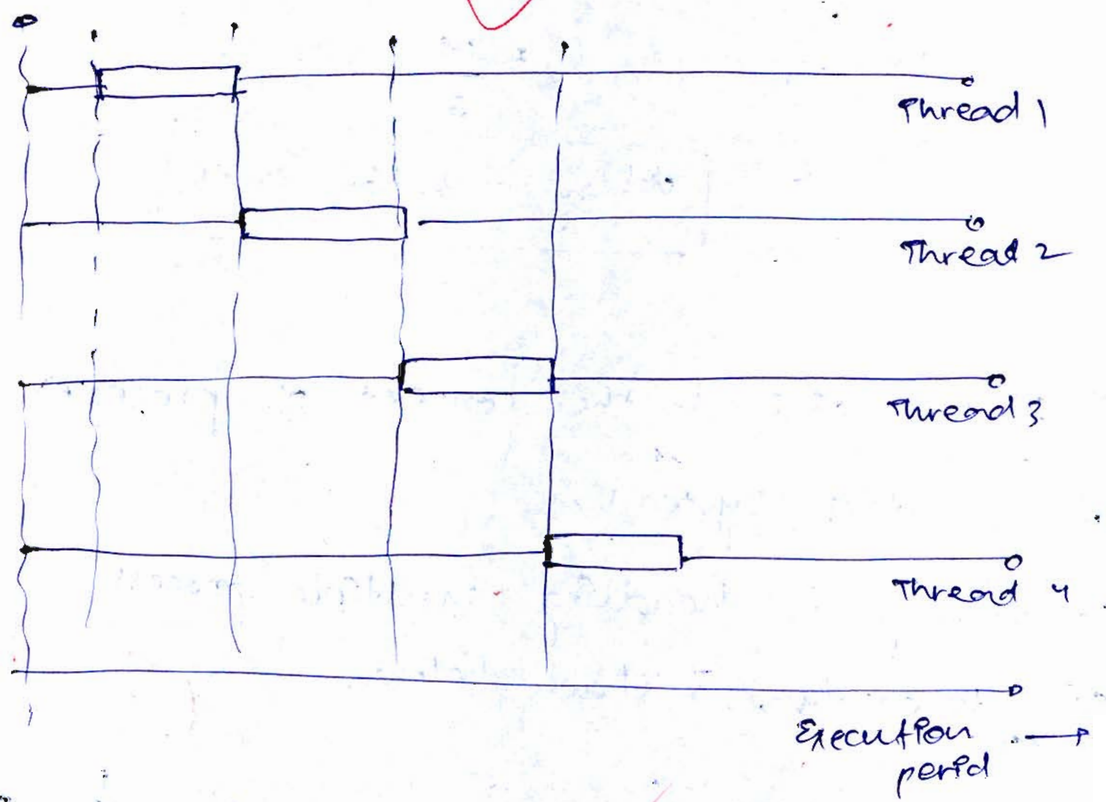
5



Differences w.r.t. parallelism:

1. load increases as multiple threads are processed simultaneously.
2. cost of implementation is high, as multiple cores are required for execution.
3. faster implementation of processes.

Parallelism:



1. Easier to implement.
2. The effective load reduces, hence a single processor can handle execution effectively.
3. cost of implementation is less but time also increases for execution.

Q.2 (b) **(i)** The demagnetization curve of a rare-earth alloy is of a parabolic shape given as $B = 1.1 - 4.4 \times 10^{-6} H^2$, where B is in Wb/m^2 and H is in kA/m.

Calculate:

1. Coercive field H_C
2. $(BH)_{max}$

(ii) A long narrow rod has an atomic density $5 \times 10^{28}/m^3$. Each atom has a polarizability of 10^{-40} F-m^2. Find the internal electric field when an axial field of 1 V/m is applied.

[10 + 10 marks]

Q2 (b)(i) Given curve characterstics.

$$B = 1.1 - 4.4 \times 10^{-6} H^2 \quad -(1)$$

B : wb/m^2 ; H : KA/m.

Statements : (a) coercive field (H_c) is the required field to make the residual flux density equal to zero.

Hence from (1),

$$B = 0.$$

$$1.1 = 4.4 \times 10^{-6} H^2$$

$$0.25 \times 10^6 = H^2$$

$$\therefore \boxed{H_c = 500 \text{ kA/m}} \quad -(A)$$

Statement (2) : maximum value of (BH) curve can be calculated by differentiating equation (1) w.r.t. "H" and equating it to zero.

$$\frac{dB}{dH} = -4.44 \times 10^{-6} \times 2H.$$

$$\frac{dB}{dH} = 0.$$

$$\therefore H = 0.$$

Hence $\boxed{(BH)_{max} = 1.1}$ - (B)

6

Q2 (b) (ii)

Given: atomic density $= 5 \times 10^{28} / m^3$.

$$\alpha = 10^{-40} \text{ F-m}^2.$$

$$E = 1 \text{ V/m}.$$

Statements: ① Relationship of internal field is as follows,

$$E_i = E + \frac{\gamma P}{\epsilon_0} \quad -①$$

E: External field.

P: Polarization.

γ: material structure constant.

② Also,

$$P = N\alpha E_i. \quad -②$$

substituting ① & ②,

$$E_i = E + \frac{P}{3\epsilon_0}$$ [let $\gamma = \frac{1}{3}$ for cubic system]

$$E_i = E + \frac{N\alpha E_i}{3\epsilon_0}$$

$$E_i\left[1 - \frac{N\alpha}{3\epsilon_0}\right] = E$$

$$\therefore E_i = \frac{E}{1 - \frac{N\alpha}{3\epsilon_0}}$$

substituting values,

$$E_i = \frac{1}{1 - \frac{5\times10^{28}\times10^{-40}}{3\times8.854\times10^{-12}}}$$

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$$\therefore \boxed{E_i = 1.23 \text{ V/m}} \text{ - ©}$$

Conclusion: Hence Ⓐ, Ⓑ & © are the respective answers.

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Q.2 (c) (i) Explain the sol-gel process of synthesis of Nanomaterials.

(ii) Explain mechanical properties of nano-materials along with their applications.

[15 + 5 marks]

Q2 (c) (i)

Nanomaterials are synthesized using two approaches.

1. Top-down Approach

2. Bottom-up Approach.

In Bottom-up approach, we start from the finest constituents such as atoms and proceed upwards to synthesize nanomaterials

- Sol-gel technique is hence, one of the bottom up approaches for synthesis of nano materials.

- In this technique, small constituents are added up under high temperatures, to create a desired nano material.

- The solute and solvent are in liquid phase and hence the term sol-gel.

Advantages:

1. The process is easier.
2. No need for chemical synthesis to remove impurities.

Disadvantages:

1. Bulk production is not feasable.
2. Higher temepratures leads to defects in the material.

Q2 (c)(ii) mechanical properties of nano materials

Nanomaterials are devices which have atleast one dimension in less than 100nm range.

This gives rise to extraordinary capabilities in nano materials, as the surface to volume ratio compared to a bulk material is comparitively higher.

for 2D nanomaterials such as Graphene, Excellent yield point (Yu, Ye) are observed.

- High resistance to wear and tear.
- High stress applications such as bullet vests.
- Carbon nanotubes (3D nano materials) are also used for their excellent mechanical strength over bulk counterparts.

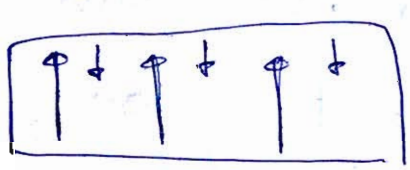
Q.3 (a) (i) What is the main advantage of Ferrimagnetic materials (ferrites) over ferromagnetic materials? Enumerate electric and magnetic properties of ferrites.

(ii) Write a short note on optical properties of semiconducting Nanoparticles.

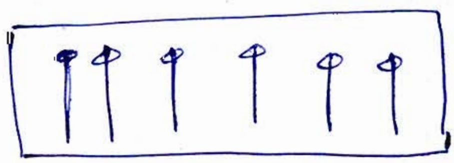
[10 + 10 marks]

Q3 (a) (i).

Ferrimagnetic materials: They constitute of dipoles opposite & not equal to each other.



Ferromagnetic materials: The dipoles tend to align with each other in ferromagnetic materials.



- Hence χ_m (susceptibility) of ferromagnetic material is higher.

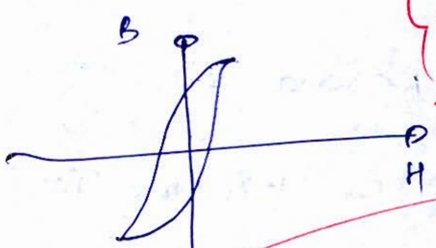
Under the Electrical properties,

- Ferrimagnetic materials provide higher resistivity over ferromagnetic counterparts.
- Hence they are prefered for high frequency applications.
- Eddy current losses are defined as

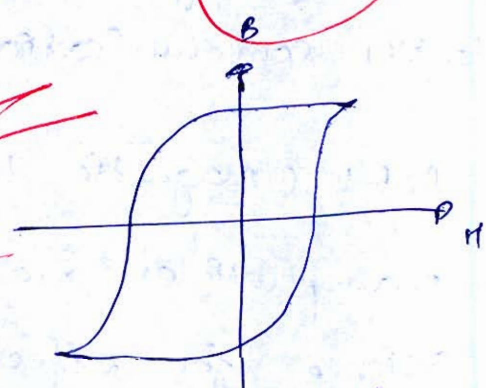
$$P_e \propto B^2 f^2 t^2$$

Since resistivity offered is high in ferrimagnetic materials, eddy current is also less in them.

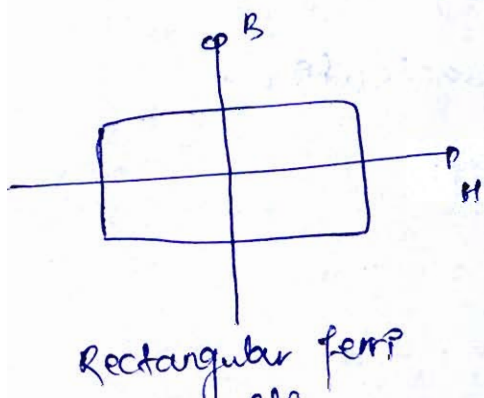
Some applications include:-



soft ferri-magnetic materials



Hard ferri-magnetic material.



Rectangular ferri magnetic.

- oxides of Yn G for magnetic storage capacaity.

Q3 (a)(ii) optical characterstics of semiconducting nano particles:

For nanomaterials, the effective surface/volume ratio is very high compared to bulk counterparts. This property gives rise to multiple applications in which we can design nano particles.

under optical characterstics:

1. These can be used at source and Receiving stations. For effective transmission, the freqency can be modulated for better communication.

2. MRI (magnetic Image Resonance)
   - Nanoparticles are used in bio-medical science for effective delivery of drug. Under Image resonance condition, they've been effetively used to identify medical characterstics.

Q.3 (b) (i) Explain the following components of Entity-Relationship Model (ER Model) of DBMS:

1. Entity
2. Attributes
3. Relationship
4. Domain

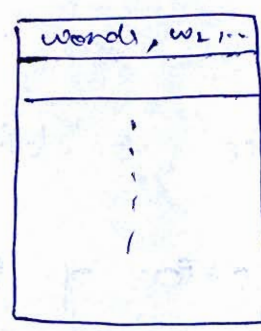
(ii) Consider 8-way set associative cache of 64 KB organised into 32B blocks. CPU generates 28 bit physical address to access the data. The cache controller contains tag information with 2 valid bits, 2 update bits and 3 replacement bits along with the bits needed to identify the memory block mapped in the cache. Find the tag space in the line and tag directory size.

[8 + 12 marks]

Q3 (b) (ii) given:

lines

cm

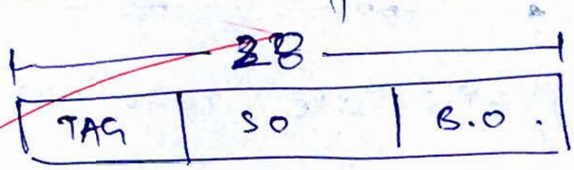


blocks

m.m

- 8-way set-associative
- 64KB
- 32 B blocks
- 2 valid, 2 update, 3 replacement bit.
- 28 bit physical address.

statements: ① for set associative mapping, the field address is as follows.



No. of lines in cache memory = $\frac{\text{cache memory size}}{\text{block size}}$

$$\# \text{ lines} = \frac{64KB}{32B} = \frac{2^6 \cdot 2^{10} B}{2^5 B}$$

$$= 2^{11} \text{ lines}.$$

S.O (set offset)

$$SO = \frac{\# \text{ lines}}{\text{f coay}}$$

$$S.O = \frac{2^{11}}{2^3} = 2^8.$$

Hence, 8 bits are needed for set offset.

Calculation of block offset:

Block size = 32B.

$= 2^5.$

$\therefore$ (5) bits for block offset

Hence field bits,

← 28 →

TAG	S.O	BO
15	8	5

Hence (15) bits are required for TAG space

TAG space = 15 bits

TAG directory size = # lines × (Total bits)

$= 2^{11} \times (15+2+2+3)$

$= 2^{11} \times 22 =$ **44KB**.

Q3 (b) (i) Considering file management system for easier explanation,

1. Entity : Component which is a specific file describing particular characteristic.
2. Attributes : Specific type / extension of file under a given directory.
3. Relationship : The interaction of file with sub system components.
4. Domain : The overall directory from which the file belongs.

4

Q.3 (c) Explain briefly the different types of polarization occurring in dielectric materials. If a dielectric material contains 3.2×10^{19} polar molecules/m^3 and the relative permittivity of material is $\epsilon_r = 2.4$ with applied external electric field $\vec{E} = 10^4 \vec{a_x}$ V/m, then calculate the value of polarization and dipole moment of each molecule. (Consider all molecules have same dipole moment)

[20 marks]

Q3 (c) Polarization in dielectric materials is of 4 types:

① Electronic polarization
② Ionic polarization
③ Orientational polarization
④ Space charge polarization.

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• At lower frequencies, existence of all are observed, but as frequencies increase, only electronic polarization prevails.

Electronic polarization: occurs due to difference in space changes inside an atom under the application of electric field.

Ionic polarization: observed between two different polarity ions constitutes in space resulting into an electric dipole.

Orientational polarization:

- This is dependent upon temperature.
- It observes because of the oriention of structure under application of field.

Observation,

$$P = N\alpha E$$

$$P = N\alpha_e E + N\alpha_i E + N\alpha_o E$$

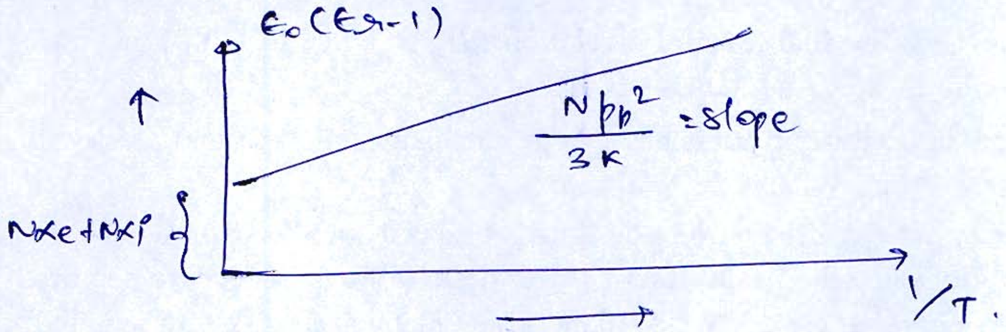
(electronic) (ionic) (orientational)

$$P = N\,4\pi\epsilon_0 R^3 E + N\alpha_i E + \frac{Np_p^2}{3KT}E \quad -(1)$$

also, $P = \epsilon_0(\epsilon_r - 1)E \quad -(2)$

Substituting (1) & (2)

$$\underbrace{\epsilon_0(\epsilon_r-1)}_{y} = \underbrace{N\,4\pi\epsilon_0 R^3 + N\alpha_i}_{c} + \underbrace{\frac{Np_p^2}{3KT}}_{mx}$$



(ϵ_r v/s 1/T graph)
for different polarization effects.

Given: $N = 3.2 \times 10^{19}$ polar molecules/m^3.

$\epsilon_r = 2.4$

$\vec{E} = 10^4 \hat{a}_x$ v/m.

Statement: $P = N\alpha E$ & $P = \epsilon_0(\epsilon_r - 1)E$

on substitution,

$$\alpha = \frac{\epsilon_0(\epsilon_r-1)}{N}.$$

(α: polarizability)

$$\alpha = \frac{8.854 \times 10^{-12}(2.4-1)}{3.2 \times 10^{-19}}.$$

$$\alpha = 38.73 \times 10^{6} \cdot F\text{-}m^2.$$

$\therefore$ $P = \alpha E$.

$P = \cancel{3.2 \times 10^{19}} \times 38.73 \times 10^6 \times 10^4$.

$$\boxed{P = 38.73 \times 10^{10}} \text{ C-m}.$$

Q.4 (a) **(i)** Find the highest normal form of a relation $R(A, B, C, D, E)$ with functional dependencies $(A \rightarrow D, B \rightarrow A, BC \rightarrow D, AC \rightarrow BE)$.

(ii) **1.** A hard disk with 20 platters has 4096 tracks/platter, 1024 sectors/track and 512 byte sectors. What is the total capacity?

2. An array of hard disk has to be designed of capacity of 512 GB or more. If the technology used to manufacture the disks allows 2048 byte sectors, 4096 sectors/track, 8192 tracks/platter, how many such disks are required, assuming 2 platters/disk.

[10 + 10 marks]

Q.4 (b) Show that in the mean field approximation, the magnetization of a ferromagnetic system of spin $\frac{1}{2}$ moments just below the curie temperature has the dominant temperature dependence $(T_C - T)^{1/2}$.

[20 marks]

Q.4 (c) Memory sub-system for a product has been designed with 3-level memory hierarchy within a budget of ₹ 22,000. The known and unknown parameters for the design are tabulated below:

Memory Type	Access Time	Capacity	Cost per kilobyte in ₹
Cache	5 ns	1 MB	1
Main Memory	–	128 MB	0.1
Solid State Drive (SSD)	5 μs	–	0.001

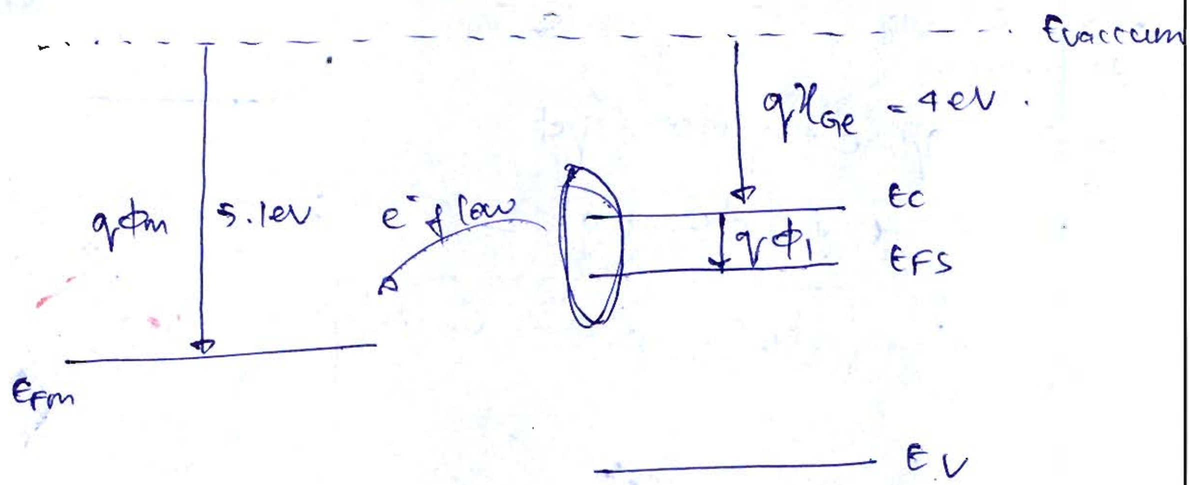
The design achieved an effective memory access time of 20 ns with cache hit ratio 0.95 and main memory hit ratio 0.99. The SSD can be only in integer power of 2 in GB.

Find out the missing parameters in the above table. **[20 marks]**

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

Q.5 (a) Find the height of the potential barrier of Au-n-Ge Schottky contact at room temperature (T = 293 K) if ρ_{Ge} = 1 Ω-cm, ϕ_{Au} = 5.1 eV and χ_{Ge} = 4.0 eV. Electron mobility in Ge is 3900 $cm^2 V^{-1} s^{-1}$, density of states in the conduction band is $N_C = 1.98 \times 10^{15} \times T^{3/2}$ cm^{-3}. (where ϕ_{Au}: work function of Gold: ϕ_{Au}, χ_{Ge} Electron affinity of Ge)

[12 marks]



Given: $\rho = 1\ \Omega\text{-cm}$.

$\mu_n = 3900\ cm^2/V\text{-sec}$,

$N_c = 1.98 \times 10^{15} \times T^{3/2}/cm^3$.

Statements: ① Calculation of Nc (effective density of states)

$$N_c = 1.98 \times 10^{15} \times (293)^{3/2}/cm^3$$

$$\therefore N_c = 9.983 \times 10^{18}/cm^3$$

② we know,

$$n = N_c e^{-(E_c - E_F)/KT}.$$

calculation of n:

$$\sigma = nq\mu_n.$$

$$n = \frac{1}{\sigma q \mu_n} = \frac{\rho}{q\mu_n}.$$

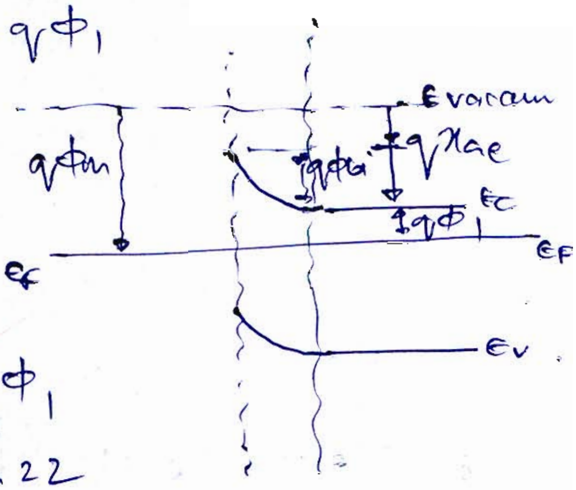
$$n = \frac{1}{1.6 \times 10^{-19} \times 3900} = 1.6024 \times 10^{15}/cm^3$$

$\cancel{f}\, 8.7317 \times KT = \cancel{f}(E_c - E_F)$

$\therefore \boxed{E_c - E_f = 0.22\,eV} = q\phi_1$

under Equilibrium:

from Energy band diagram,



$q\phi_m = q\chi_{ae} + q\phi_{bi} + q\phi_1$

$5.1 = 4 + q\phi_{bi} + 0.22$

$\therefore \boxed{\phi_{bi} = 0.88 \text{ volts}}$

Q.5 (b) Derive expressions of error probability for BPSK, BASK, and BFSK signalling schemes using signal constellation approach.

[9 marks]

Q5 (b) Statements: Probability of error for different signalling schemes depends upon the minimum distance between two signalling points, considering respective signalling schemes.

$$P_e = Q\left[\sqrt{\frac{d_{min}^2}{2N_0}}\right]$$

for BPSK scheme

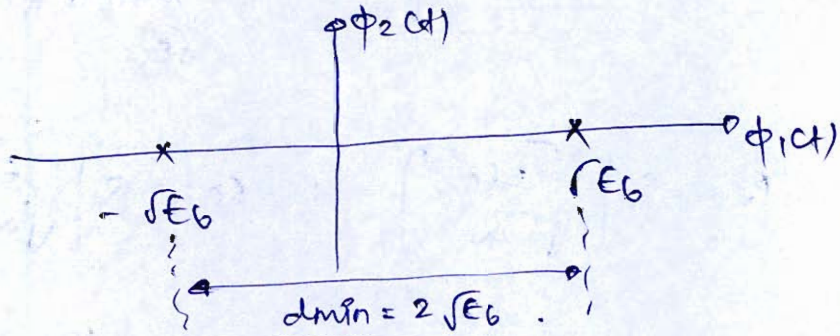
$S_1(t) = A_c \cos 2\pi f_c t \rightarrow Tx^n \rightarrow 1$

$S_2(t) = -A_c \cos 2\pi f_c t \rightarrow Tx^n \rightarrow 0.$

In terms of basis functions,

$\phi(t) = \pm\sqrt{E_b}$. where E_b: Energy per bit

Hence



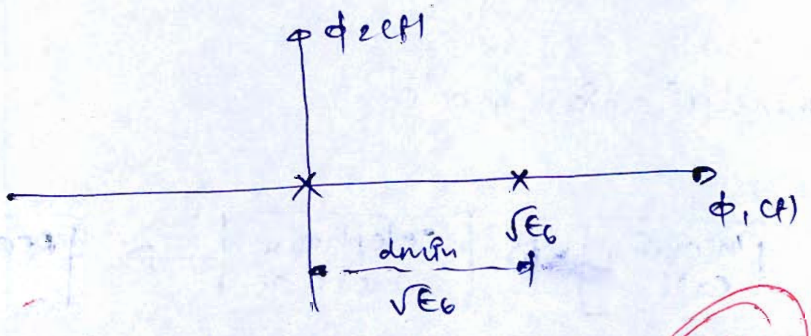
constellation diagram for BPSK scheme

$$P_e = Q\left[\sqrt{\frac{4E_b}{2N_0}}\right] = Q\left[\sqrt{\frac{2E_b}{N_0}}\right] \quad -①$$

for BASK scheme.

$s_1(t) = A_c\cos 2\pi f_c t \rightarrow Tx^n \rightarrow 1$

$s_2(t) = 0 \rightarrow Tx^n \rightarrow 0$.



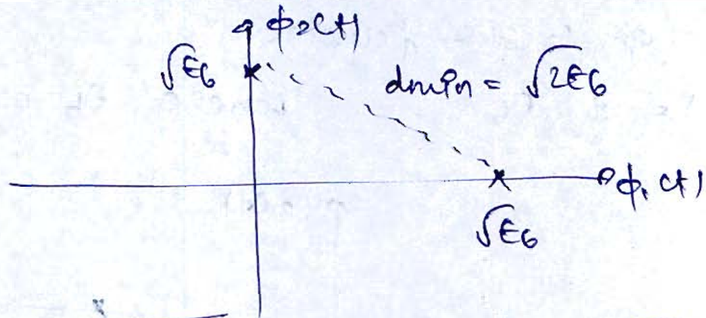
constellation for BASK scheme

$\therefore P_e = Q\left[\sqrt{\frac{E_b}{2N_0}}\right]$, $\rightarrow P_e$ for BASK scheme. $-②$

for BFSK scheme

$s_1(t) = A_c\cos 2\pi f_H t$

$s_2(t) = A_c\cos 2\pi f_L t$.



$$P_e = Q\left[\sqrt{\frac{2E_b}{2N_o}}\right] \quad ; \quad P_e = Q\left[\sqrt{\frac{E_b}{N_o}}\right] \quad -③$$

Conclusion: Hence ①, ② & ③ are the respective answers.

Q.5 (c) A common control device in a telephone exchange is required to commence operation within a average period of 10 msecs after receiving a calling signal.

(i) If the device is held, on average for 50 msecs per call, how many calls can it handle per hour?

(ii) If the device is required to handle 18,000 calls per hour, what is the maximum permissible average holding time?

[12 marks]

Q5 (c) Communication model:-

(i) Device held = 50 msec / call.

$$\text{call handling per hour} = \frac{50}{10} \times 3600$$

$$= 18000 \text{ calls.}$$

Q.5 (d) An n-type semiconductor has excess carrier holes 10^{14} cm^{-3}, a minority carrier life time 10^{-6} sec in the bulk material, and a minority carrier lifetime 10^{-7} sec at the surface. Assume zero applied electric field and let $D_p = 10$ cm^2/sec. Determine the steady-state excess carrier concentration as a function of distance from the surface ($x = 0$) of the semiconductor.

[12 marks]

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Q.5 (e) Given the data stream 1110010100, sketch the transmitted sequence of pulses for each of the following line codes:

(i) Unipolar nonreturn-to-zero

(ii) Polar nonreturn-to-zero

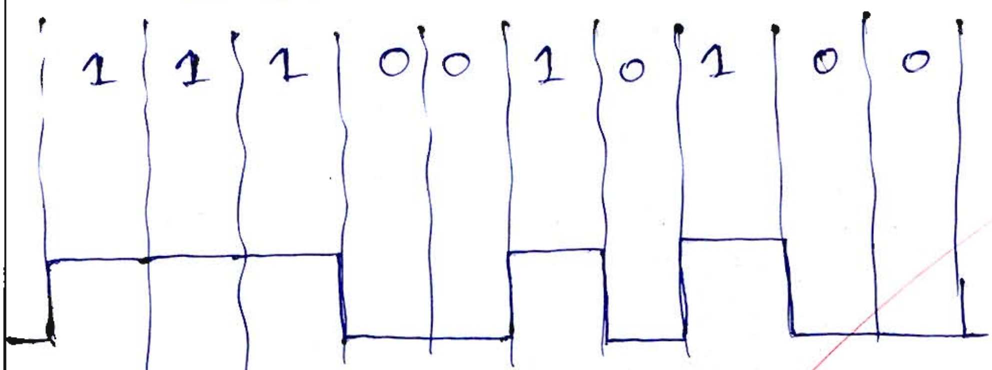
(iii) Unipolar return-to-zero

(iv) Bipolar return-to-zero

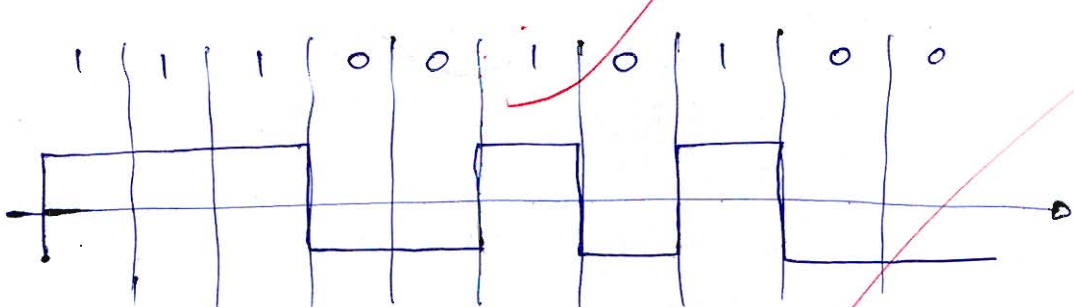
(v) Manchester code

[15 marks]

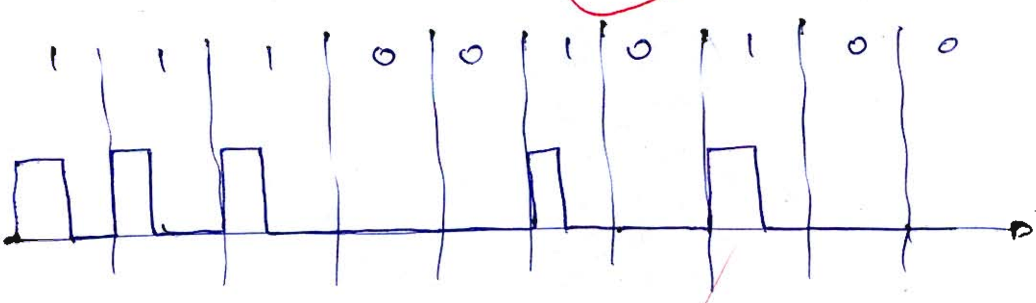
Q5 (e) (i) Given data stream: unipolar NRZ Scheme →



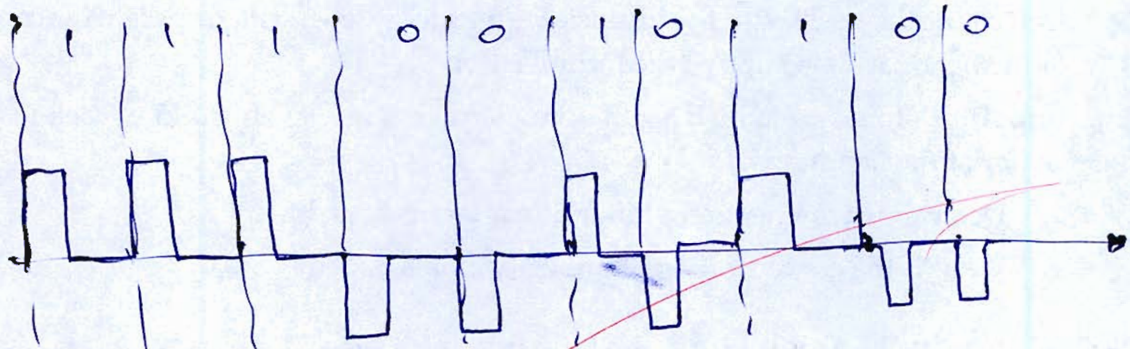
(ii) Polar NRZ :-



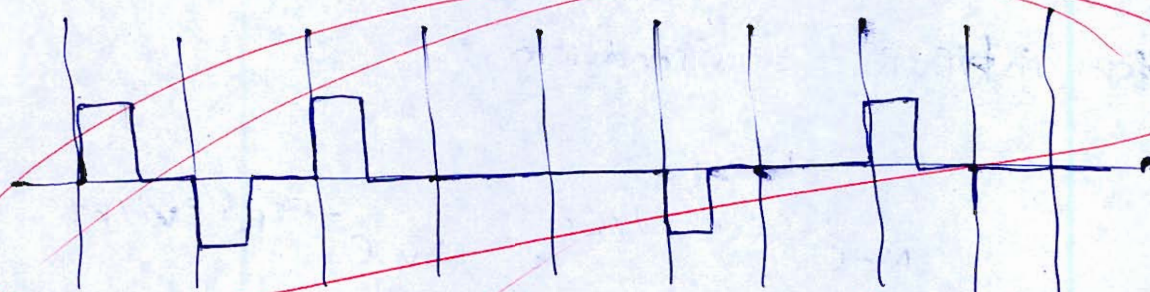
(iii) unipolar RZ :



(iv) Bipolar RZ →



(v) Manchester code →



8

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Q.6 (a) For a particular semiconductor, $E_g = 1.5$ eV, $m_p^* = 10m_n^*$, $T = 300$ K and $n_i = 1 \times 10^5/\text{cm}^3$.

(i) Determine the position of the intrinsic Fermi energy level with respect to the center of the bandgap. Also derive the formula used.

(ii) Impurity atoms are added so that the Fermi energy level is 0.45 eV below the center of the bandgap.

1. Determine whether acceptor or donor atoms are added.
2. What is the concentration of impurity atoms added?

[20 marks]

Q6 (a) Given: $E_g = 1.5eV$. $T = 300K$

$m_p^* = 10 m_n^*$ $n_i = 10^5/cm^3$.

(i) Position of fermi level with respect to Eg centre.

for intrinsic semiconductor,

$$n = p$$

$$N_c e^{-(E_c - E_F)/KT} = N_v e^{-(E_F - E_V)/KT}$$

$$\frac{N_c}{N_V} = \frac{e^{-(E_F - E_V)/KT}}{e^{-(E_c - E_F)/KT}}$$

$$\frac{N_c}{N_V} = e^{(-E_F + E_V + E_c - E_F)/KT}$$

Taking "ln" both sides,

$$\frac{-2E_F + E_c + E_V}{KT} = \ln\left(\frac{N_c}{N_V}\right)$$

$$-2E_F + E_c + E_V = KT \ln\left(\frac{N_c}{N_V}\right)$$

10

rearranging terms,

$$E_F = \frac{E_c + E_v}{2} - \frac{KT}{2} \ln\left(\frac{N_c}{N_v}\right).$$

we know, $N_c = 2\left(\frac{2\pi m_n^* KT}{h^2}\right)^{3/2}$.

$N_c \propto m_n^{*\,3/2}$, similarly N_v.

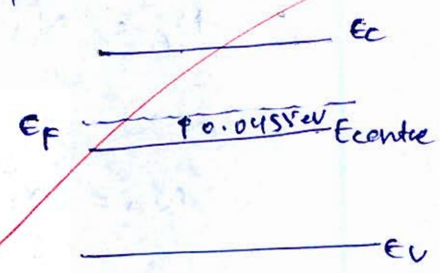
$$E_F = \frac{E_c + E_v}{2} - \frac{KT}{2} \ln\left(\frac{m_n^*}{m_p^*}\right)^{3/2}.$$

$$E_F = \frac{E_c + E_v}{2} - \frac{3KT}{4} \ln\left(\frac{m_n^*}{m_p^*}\right)$$

↑ this represents centre of bandgap.

$$E_F = \frac{E_c + E_v}{2} - \frac{3}{4} \times 0.0258 \ln[0.1].$$

$$E_F = \frac{E_c + E_v}{2} + 0.0445\,eV.$$



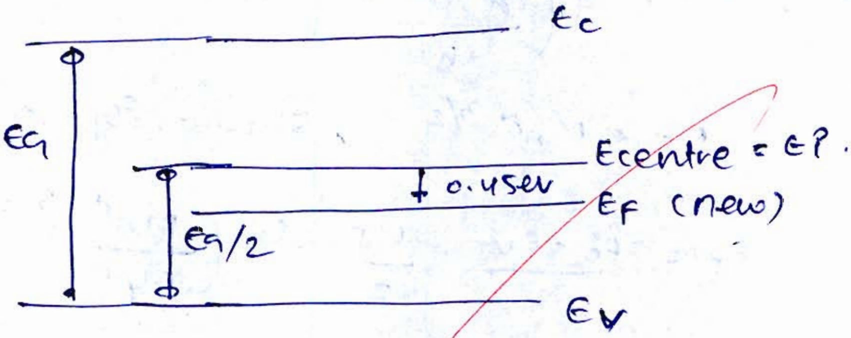
(Respective position)

(ii) ①. Since, the fermi level is shifted downwards,

- Hence we can conclude that the added impurity is of Acceptor in nature.
- The semiconductor becomes more p-type.

shift = 0.45 + 0.0455.

∴ Total shift = 0.4945 eV.



from observation, $E_F - E_V = \frac{E_g}{2} - 0.45$.

$= \frac{1.5}{2} - 0.45$

$= 0.3$ eV.

∴ $N_A = N_V e^{-(E_F - E_V)/KT}$.

(or)

$N_A = n_i e^{-(E_i - E_F)/KT}$.

$N_A = 10^5 e^{-(0.45)/0.0258}$

$$\boxed{N_A = 2.661 \times 10^{-3} /cm^3}$$

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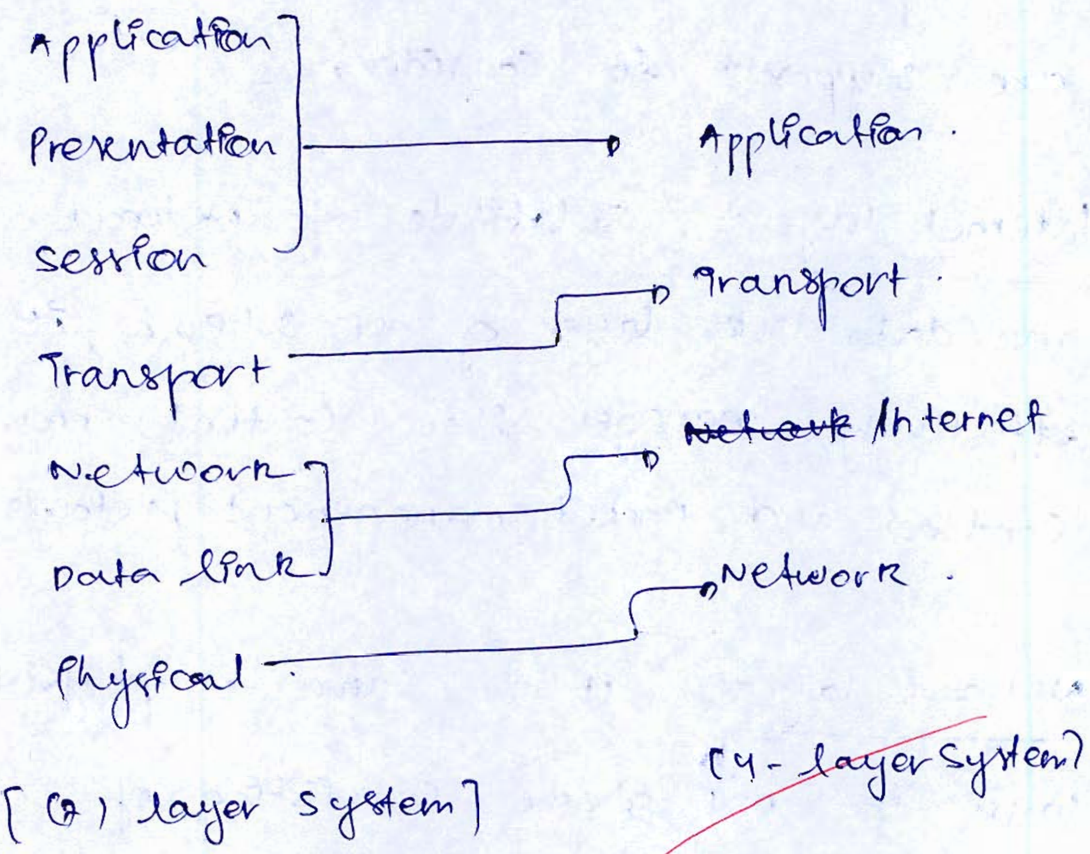
Q.6 (b) Describe in detail the layered architecture of TCP/IP protocol and define type of address used at each layer.

[20 marks]

Q6 (b) with reference from ISO/OSI model,

TCP layer can be defined as follows.



In TCP IP model, the layer of OSI model are merged to create a 4-layer system.

Application layer: constitute of application, presentation and session layer of OSI model.

- It is responsible for encryption/decryption, file transfer, Handshake, cryptography &

and many other functions.

Transport layer: It is the heart of the protocol model responsible for effective packet delivery between the nodes.

- It defines the route which the packets are supposed to consider.

Internet layer: Substitute of network and data link layer of OSI scheme, it effectively manages flow control, error control and packet management protocols.

Network layer: It is same as physical layer of OSI scheme consisting of physical nodes and mediums for transmission of data.

5

Q.6 (c) Compare the performance of a DPCM system with a μ-law companded PCM system ($\mu = 255$) for telephone-quality speech signals. The signal-to-quantization noise ratio (SNR) is given by:

$(SNR)_{dB} = \alpha + 6n$

where n is the number of bits per sample. For μ-law PCM, $\alpha \approx 4.77 - 20\log_{10}(\ln(1+\mu))$. For DPCM, α ranges from -3 dB to 15 dB.

Calculate:

(i) The SNR improvement (in dB) offered by DPCM over companded PCM for a constant bit rate.

(ii) The reduction in the number of bits per sample required by DPCM to achieve the same SNR as compared to PCM.

[20 marks]

Q6 (c) for μ law companding,

$$|v| = \frac{\ln[1+\mu|A|]}{\ln[1+\mu]}.$$

v : output voltage

A : normalized input voltage.

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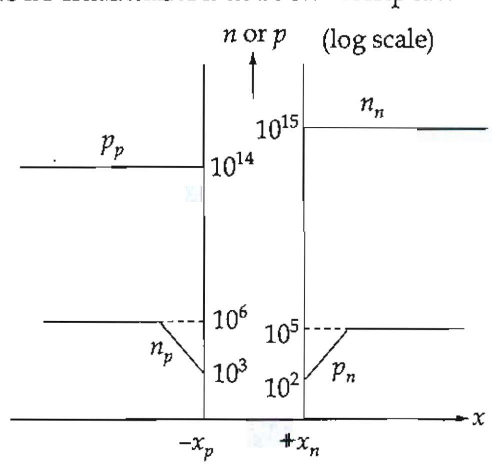
Q.7 (a) The figure below is a dimensioned plot of the steady state carrier concentrations inside a pn step junction diode maintained at room temperature.



(i) Is the diode forward or reverse biased? Explain how you arrived at your answer.

(ii) Do low-level injection conditions prevail in the quasineutral regions of the diode? Explain how you arrived at your answer.

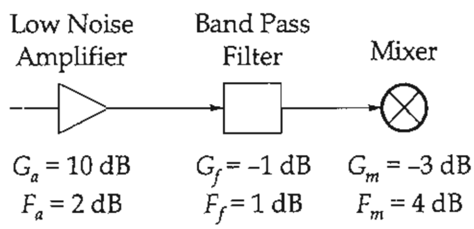
(iii) What are the p-side and n-side doping concentrations?

(iv) Determine the applied voltage, V_A.

(v) Determine the built-in potential, V_{bi}.

[20 marks]

Q.7 (b) The block diagram of a wireless receiver front end is shown below:



(i) Compute the overall Noise Figure of the sub-system.

(ii) Compute equivalent noise temperature (overall) assuming system temperature $T_0 = 290$ K.

(iii) Compute overall gain.

(iv) Compute output noise power assuming input noise power from the feeding antenna at 150 K temperature and IF bandwidth of 10 MHz.

(v) Compute input power if we require minimum signal to noise ratio of 20 dB.

(vi) Compute minimum signal voltage assuming characteristic impedance of 150 Ω.

[20 marks]

Q.7 (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:

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

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

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

Design the sub-blocks for allocation of IP addresses and find out how many addresses are still available after these allocations.

[20 marks]

Q.8 (a) **(i)** Explain the concept of frequency reuse in mobile cellular system and also write the relationship between frequency reuse distance '*D*', cell radius '*R*' and number of cells per cluster '*N*'.

(ii) A digital transmission system is required to transmit data at a bit rate of 8 kbps over a channel with an available bandwidth of 5 kHz.

1. Determine the minimum value of *M* required for an M-ary QAM system if rectangular pulses are used and also determine the minimum value of *M* required if Nyquist pulses are used.
2. If QPSK modulation is employed using Raised cosine pulses, calculate the maximum possible value of the roll-off factor (α) that can be supported by the channel.

[10 + 10 marks]

Q.8 (b) Using the drift-diffusion equation, derive the following equations for the 1-D electron current density, J_n and hole current density J_p:

$$J_n(x) = \sigma_n(x)\frac{d(E_{Fn}/q)}{dx};$$

$$J_p(x) = \sigma_p(x)\frac{d(E_{Fp}/q)}{dx}$$

where, E_{Fn} and E_{Fp} are electron and hole quasi-fermi levels, respectively.

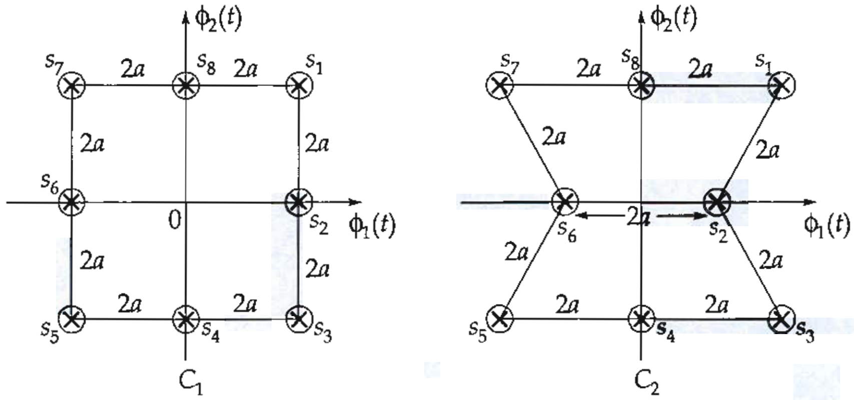
[20 marks]

Q.8 (c) Consider two 8-ary signal constellations, C_1 and C_2, shown in the figure below. The basis functions are $\phi_1(t)$ and $\phi_2(t)$. Assume all signal points are equiprobable and the minimum distance between any two adjacent signalling points is $d_{min} = 2a$.

(i) Calculate the average symbol energy (E_{avg}) for both constellations.

(ii) Compare the probability of symbol error (P_e) for C_1 and C_2 in an AWGN channel.

(iii) Determine which constellation is more power efficient and by how much (in dB).

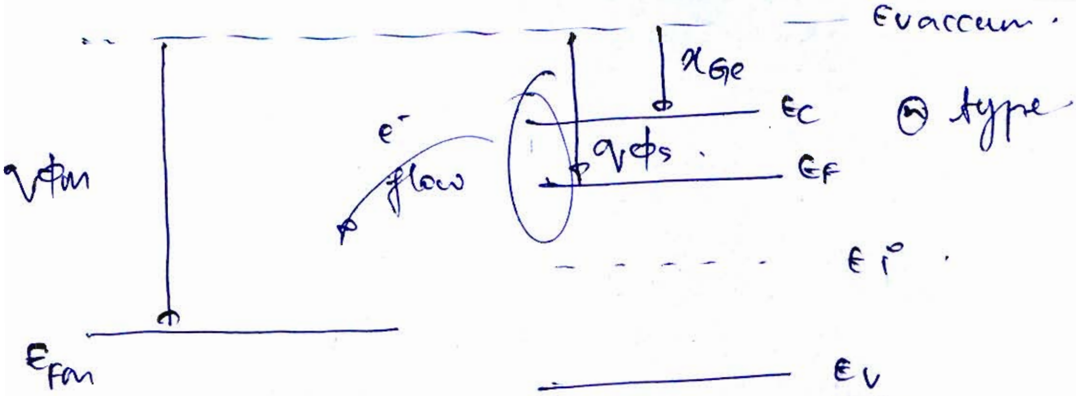


[20 marks]

OOOO

Space for Rough Work

Space for Rough Work



$\rho_{Ge} = 1\,\Omega\text{-cm}$. σ ✓

$\mu_n = 3900\ cm^2 V^{-1} s^{-1}$.

$\sigma = n q \mu_n$ ✓

$n \downarrow N_D$ ✓

$\vec{P} = \epsilon_0 (\epsilon_r - 1) \cancel{E}$

$P = N \alpha \cancel{E}$.

$$\boxed{\frac{\epsilon_0 (\epsilon_r - 1)}{N} = \alpha}$$

[redacted]

Space for Rough Work

Q1 (c) # include < iostream.h>   first hundered fib.
Series number.

using namespace std;

int main ( )

{

int i, x, y, z, count = 0 ;

cout " \n Program for first hundered fib. numbers";

1, 1, 2, 3, 5 ...

x = 1 ;

y = 1 ;

z = 1 ;

while (count <= 100)

{

cout << " \n " << z ;

x = y ;

y = z ;

z = x+y ;

count ++ ;

}.

return 0 ;

}.

x : 1

y : 1

z : 2

count : 0

0

1

1

1

1,

x : ~~1~~ ~~1~~ 1

y : ~~1~~ ~~1~~ 2

z : ~~1~~ ~~2~~ ~~2~~ z = 1 initially

count : 0

o/p

1 .

2

2

Space for Rough Work