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# ESE 2025 : Mains Test Series

UPSC ENGINEERING SERVICES EXAMINATION

## Electronics & Telecommunication Engineering

**Test-6 : Advanced Electronics + Computer Organization and Architecture + Advanced Communication [All topics]**

Name : ....................

Roll No :

| Test Centres | | | | Student's Signature |
|---|---|---|---|---|
| Delhi ☑ | Bhopal ☐ | Jaipur ☐ | Pune ☐ | |
| Kolkata ☐ | 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 | 34 |
| Q.2 | 19 |
| Q.3 | — |
| Q.4 | — |
| Section-B | |
| Q.5 | 30 |
| Q.6 | 20 |
| Q.7 | — |
| Q.8 | 40 |
| **Total Marks Obtained** | 143 |

Signature of Evaluator: Chaitanya · A · M ·

Cross Checked by ....................

* Good Performance, keep it up.
* Avoid calculation mistakes.

## 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 : Advanced Electronics + Computer Organization and Architecture + Advanced Communication**

**(a)** A 0.6 μm layer of silicon dioxide on a Si substrate to be etched down to the Si substrate. Assume that the normal oxide etch rate is 0.4 μm/minute. There is a ±4% variation in the oxide thickness and a ±5% variation in the oxide etch rate.

**(i)** How much overetch is required (in % time) in order to ensure that all the oxide is etched?

**(ii)** If the overetch obtained in part (i) is used, then what etch selectivity of the oxide with respect to the Si is required so that a maximum of 0.5 nm of Si is etched?

**[12 marks]**

Sol^n

i)

~~$x_0^2 + x_0 =$~~

~~Ead~~

Etching rate (E) = $\frac{\text{Thickness}}{\text{Time}}$

$\Rightarrow$ Time (t) = $\frac{\text{Thickness}(x)}{\text{Etching rate}(E)}$

$$\frac{\Delta t}{t}\times 100 = \frac{\Delta x}{x}\times 100 + \frac{\Delta E}{E}\times 100$$

$$= 4 + 5 = 9\%$$

$\therefore$ 9% overetch is required ~~to~~ ensure all oxide is etched.

1

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**(b)** 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]**

Sol^n

```
#include <stdio.h>

int main( )                          // array of size 100
{ int f[100];
  f[0]= 0;   f[1] = 1;               // initialized
  int f2 = 1;

for(int i = 2 ; i < 100 ; i++)
  {   f[i] = f[i-1] + f[i-2];
                                      // Filling entries
                                      of array with
   }                                  Fibonacci series
for(int i=0; i<100; i++)
 {  Printf ("%d", f[i]);             // Printing the
                                      Fibonacci
  }                                   numbers
                                      by traversing
return 0;                             array f.

}
```

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**Q.1 (c)** In the transmission and reception of signals to and from moving vehicles, the transmitted signal frequency is shifted in direct proportion to the speed of the vehicle. The so-called Doppler frequency shift imparted to a signal that is received in a vehicle travelling at a velocity $v$ relative to a (fixed) transmitter is given by the formula

$$f_D = \pm\frac{v}{\lambda}$$

where $\lambda$ is the wavelength, and the sign depends on the direction (moving toward or moving away) that the vehicle is travelling relative to the transmitter. Suppose that a vehicle is travelling at a speed of 100 km/h relative to a base station in a mobile cellular communication system. The signal is a narrowband signal transmitted at a carrier frequency of 1 GHz.

**(i)** Determine the Doppler frequency shift.

**(ii)** What should be the bandwidth of a Doppler frequency tracking loop if the loop is designed to track Doppler frequency shifts for vehicles travelling at speeds up to 100 km/h?

**(iii)** Suppose the transmitted signal Bandwidth is 2 MHz centered at 1 GHz. Determine the Doppler frequency spread between the upper and lower frequencies in the signal.

**[12 marks]**

Sol^n

(i) $\lambda = \frac{c}{f}$

$= \frac{3\times 10^8}{10^9}$

$\boxed{\lambda = 30\text{ cm}}$

$\therefore$ Doppler shift $(f_d) = \pm\frac{V}{\lambda}$

$= \pm\frac{10^5}{3600\times 0.3}$

$= \pm\ 92.59\text{ Hz}$

ii) Bandwidth $= 2\times 92.59$

$\simeq 185.18\text{ Hz}$

(iii)


~~$f_H$ = 4000~~

$f_H = 1002$ MHz

∴ ~~$f_D$~~

$f_D = \frac{v}{\lambda}$

$\Rightarrow f_D = \frac{v f}{c}$

$\Delta f_D = \frac{v}{c} \Delta f$

$= \frac{10^5}{3600 \times 3 \times 10^8} \times 2 \times 10^6$

$= \frac{10}{54}$ Hz

$= 0.185$ Hz

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**Q.1 (d)** A low earth orbit satellite is in a circular polar orbit with an altitude, $h$ of 1200 km. A transmitter on the satellite has a frequency of 3.56 GHz. [GM = $3.98 \times 10^{11}$ Nm$^2$ kg]

**(i)** Find the velocity of the satellite in orbit.

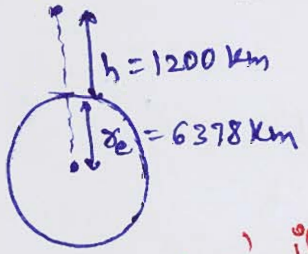
**(ii)** Find the component of velocity toward an observer at an earth station as the satellite appears over the horizon, for an observer who is in the plane of the satellite orbit.

**(iii)** Hence, find the Doppler shift of the received signal at the earth station. Use a mean earth radius value, $r_e$ of 6378 km.

**(iv)** The satellite also carries a Ka-band transmitter at 25 GHz. Find the Doppler shift for this signal when it is received by the same observer. What type of receiver will be needed for this?

**[12 marks]**

Sol$^n$




i) Radius of circular orbit

$r = h + r_e$

$= 7578$ km

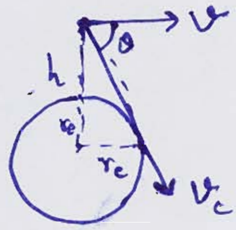
velocity of Satellite $(v) = \sqrt{\frac{GM}{r}}$

$= \sqrt{\frac{3.98 \times 10^{11}}{7578 \times 10^3}}$

$= 229.17$ m/s ✗

'r' in km

ii) Component of velocity towards observer




$v_c = v \cos\theta$

$\tan\theta = \frac{h + r_e}{r_e}$

$= \frac{1200 + 6378}{6378}$

$\tan\theta = \frac{7578}{6378}$

$\therefore V_c = 229.17 \times 0.6439$

$V_c = 147.57$ m/s ✗

(iii) Doppler Shift $= \pm \frac{\Delta V}{\lambda}$

$= \pm \frac{(229.17 - 147.57)}{\lambda}$

$\lambda = \frac{3 \times 10^8}{3.56 \times 10^9}$

$\lambda = 0.0843 \, m$

[ Doppler shift $= 967.97$ HZ
$= 0.97$ KHZ ]

6

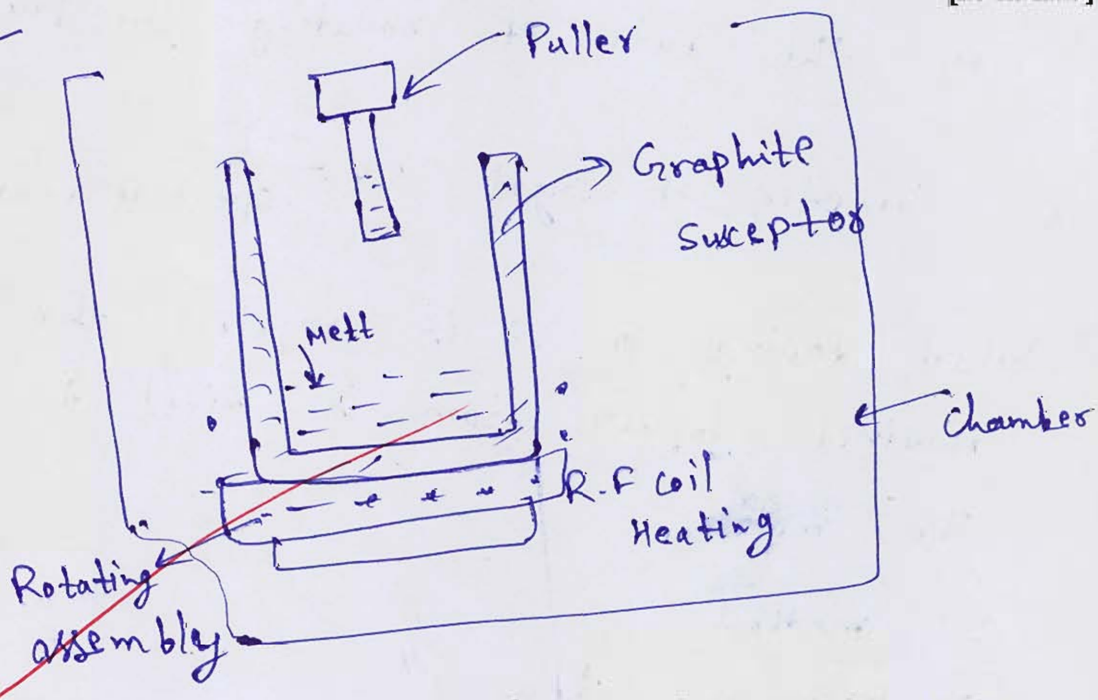
(iv) Dopper shift $\propto f$

$\therefore$ New Dopper shift $= \frac{25}{3.56} \times 0.97$

$= 6.81$ KHZ

1 (e) Explain Czochralski Technique for growing single crystals of silicon with a neat diagram.
**[12 marks]**

Solⁿ




The Electronic Grade Silicon is used in melted form in the Graphite susceptor and the chamber is ~~heating~~ heated using RF coil.

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The puller contains single Silicon crystal.

The puller is rototed in opposite direction.

When the temperature is increased, the silicon from the melt starts attaching to the puller, as the single silicon crystal (acting as seed). has dangling bonds.

This process continues and the single crystal silicon on the puller keeps on growing to form a big INGOT.

The size of of the ingot depends on the rate of rotating the puller.

10

$$\text{Diameter of Ingot} \propto \frac{1}{\text{speed of puller}}$$

When doping of si is required then required dopant atom is mixed in the melt.

CZ method

→ Easy and cheap

→ Large diameter ingot can be formed.

(a) A p-n junction is to be formed at a depth of 0.5 μm from the surface of an n-type Si substrate, which has a doping concentration of $10^{17}$ phosphorus atoms/$cm^3$. The junction is formed by a two-step diffusion of boron: the solid-solubility limited pre-deposition at 1100°C and the drive-in at 1200°C.

After the drive-in step, the surface concentration of boron is $5 \times 10^{19}$ atoms/$cm^3$. Find out the appropriate diffusion times required for both the steps (pre-deposition and drive-in)

Assume the following data:

Diffusion constant for boron ($D_0$) = 11.8 $cm^2$/sec.

The activation energy for boron diffusion ($E_a$) = 4.36 eV.

The solid solubility limit of boron in silicon at 1000°C = $2.6 \times 10^{20}$ atoms/$cm^3$.

**[20 marks]**

Sol$^n$

$N_d = 10^{17} / cm^3$

6

$C(x,t) = C_0 \, erfc\left[\frac{x}{2\sqrt{Dt}}\right]$

$D = D_0 e^{-E_A/KT}$

At $T = 1100°C$

$D = 11.8 \, e^{-\frac{4.36 \times 1.6 \times 10^{-19}}{1.38 \times 10^{-23} \times 1373}}$

$= 11.8 \, e^{-3.68}$

$= 0.297 \, cm^2/s$

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After drive-in at 1200 °C

Surface Conc. = $5 \times 10^{19}$ /cm$^3$

$$\frac{Q}{\sqrt{\pi D t_2}} = 5 \times 10^{19}$$

$$\text{Dosage } (Q) = 2 C_0 \sqrt{\frac{D t_1}{\pi}}$$

$t_1 \rightarrow$ Pre-deposition time.

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**Q.2 (b)** **(i)** Explain what is meant by the gyro frequency and why frequencies in the region of the gyro frequency are not suitable for ionosphere transmission. Calculate the maximum range obtainable in a single hop transmission utilizing F2 layer, situated at 400 km above the earth's surface. Assume earth radius as 6370 km.

**(ii)** Assume that reflection take place at a height of 350 km and that the maximum density in the ionosphere corresponds to a 0.8 refractive index at 15 MHz. What will be the range (assume flat earth) for which the MUF is 20 MHz?

**[14 + 6 marks]**

Sol^n

ii) $\mu = \sqrt{1 - \frac{81N}{f^2}}$ [μ → refractive index, N → ionic density]

Critical frequency $(f_c) = 9\sqrt{N_{max}}$

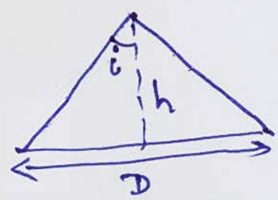
$$\mu = \sqrt{1 - \left(\frac{f_c}{f}\right)^2}$$

$$0.8 = \sqrt{1 - \left(\frac{f_c}{f}\right)^2} \Rightarrow 0.64 = 1 - \left(\frac{f_c}{f}\right)^2$$

$$\Rightarrow \left(\frac{f_c}{f}\right) = 0.6 \Rightarrow f_c = 0.6 \times 15 = 9\ MHz$$

6

$f_{MUF} = f_c \sec i$




$$\Rightarrow \sec i = \frac{20}{9}$$

$$\frac{\sqrt{\left(\frac{D}{2}\right)^2 + h^2}}{h} = \frac{20}{9}$$

$$\left(\frac{D}{2}\right)^2 + h^2 = \frac{400}{81} h^2$$

~~$\left(\frac{D}{2}\right)^2 = \frac{16}{9}h^2 \Rightarrow \frac{D}{2} = \frac{4}{3}h$~~

~~$D = \frac{8h}{3}$~~ $\Rightarrow$

$$\left(\frac{D}{2}\right)^2 = \frac{319}{81}h^2 \Rightarrow \frac{D}{2} = \frac{\sqrt{319}}{9}h$$

$$D = \frac{2\sqrt{319}}{9}h$$

$$\Rightarrow \boxed{D = 1389.1\ km}$$

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Q.2 (c) (i) A hard disk with a transfer rate of 1 kbps is constantly transferring data to memory using DMA burst mode. The size of the data transfer is 16 bytes. The processor runs at 400 kHz clock frequency. The DMA controller requires 10 cycles for initialization of operation and transfer takes 2 cycles to transfer one byte of data from the device to the memory. What is the percentage of time for which the CPU is blocked during this DMA operation?

(ii) Consider a 4 block cache memory (Initially empty) with the following main memory block references 4, 5, 7, 12, 4, 5, 13, 4, 5, 7. Find the hit ratio for the following page replacement algorithms:

1. FIFO 2. LRU

**[10 + 10 marks]**

Sol^n.

(i) Total cycle taken by DMA to transfer one byte = 10 + 2
= 12 cycles

Size of data = 16 bytes

∴ Total cycle = 16 × 12
= 192 cycles

~~Transfer speed = 1000~~

Time for which CPU is blocked

$= \frac{192}{400\,k} = 0.48\ ms$

4

Time required for transfer of data

$= \frac{16 \times 8}{1\,k}$

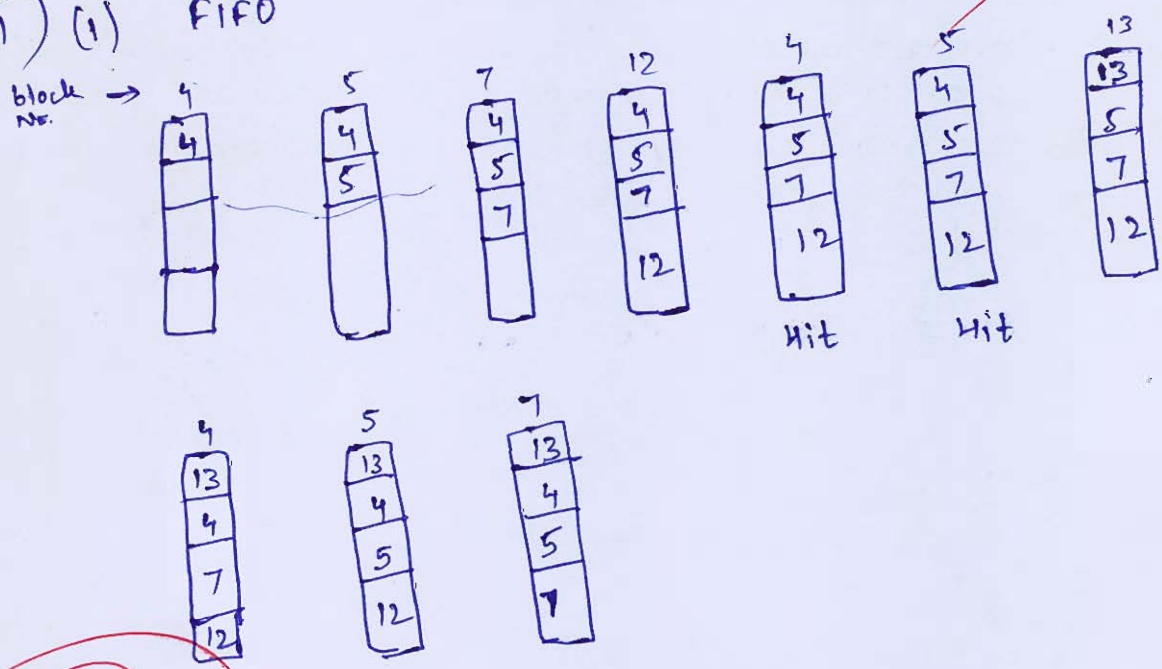
$= 128\ ms$

Percentage of time CPU is blocked

$= \frac{0.48}{128} \times 100$

$= 0.375\%$

ii) (1) FIFO

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Hit ratio $= \frac{2}{10}$

$= 0.2$

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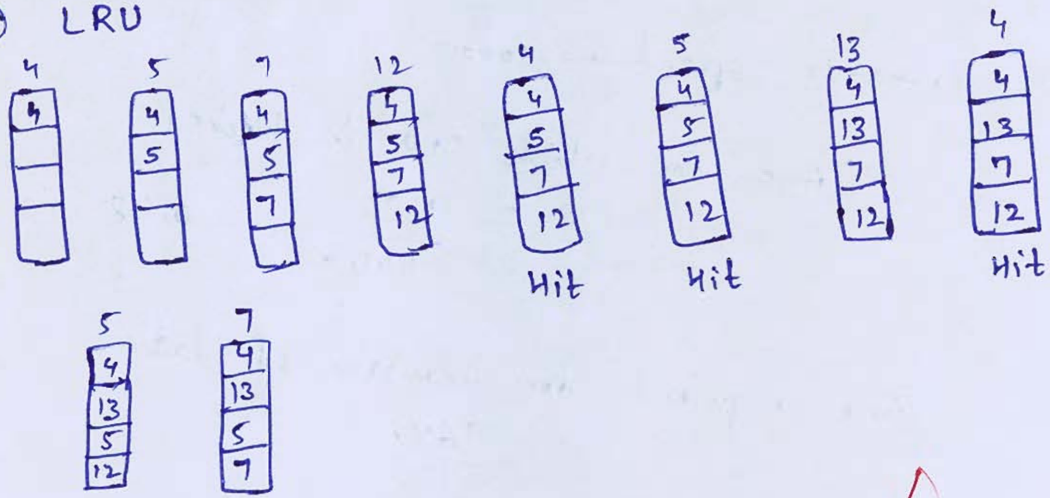
② LRU




Number of Hits = 3

[ Hit ratio $= \frac{3}{10}$
$= 0.3$ ]

**Q.3 (a)** **(i)** A digital computer has a memory unit with 32 bits per word. The instruction set size is 250. All instructions supported by computer have one mode field to support 10 addressing modes and an address field; apart from opcode field. What is the maximum allowable size of memory if each instruction is stored in one word?

**(ii)** Consider a system with instruction set that uses a fixed 19 bits instruction length and length of address is 8 bits. There are 6 two address instructions.

What is the maximum number of one address instructions if the number of zero address instructions are 65536?

**[8 + 12 marks]**

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Q.3 (b) Explain in detail how the digital signature works and the assurances provided by digital signature.

[20 marks]

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**Q.3 (c)** (i) Bismuth is implanted in a p-type silicon sample with a uniform doping concentration of $10^{18}$ atoms/cm$^3$. If the beam current density is 5 μA/cm$^2$ and the implantation is carried out for 20 minutes, calculate the implantation dose. Also, find the peak impurity concentration.
Assume, $R_p = 2$ μm and $\Delta R_p = 0.5$ μm.

(ii) Use frequency sampling method, design a bandpass filter with the following specifications:

$f_{c1} = 2$ kHz

$f_{c2} = 4$ kHz

$f_s = 8$ kHz

Find the filter coefficients for $N = 5$.

**[8 + 12 marks]**

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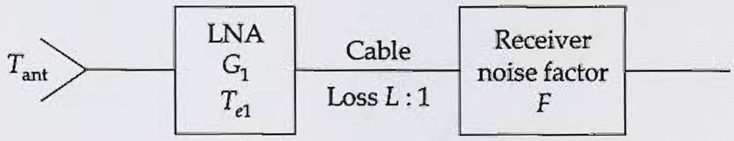
**Q.4 (a)** A receiver in a urban cellular radio system detects a 1 mW at $d = d_0 = 1.5$ m from the transmitter. In order to mitigate co-channel interference effects, it is required that the signal received at any base station receiver from another base station transmitter which operates with the same channel must be below '–100 dBm'. A measurement team has determined that the average path loss exponent in the system is $n = 4$. Determine the minimum radius of each cell if a seven-cell reuse pattern is used. What is the minimum radius if a four-cell reuse pattern is used?

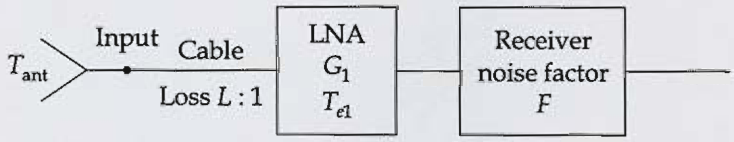
**[20 marks]**

Do not write in this margin

Q.4 (b) (i) For the system shown in figure below, the receiver noise figure is 12 dB, the cable loss is 8 dB, the LNA gain is 60 dB, and its noise temperature 150 K. The antenna noise temperature is 45 K. Calculate the noise temperature referred to the input.




Repeat the calculation when the system of figure (a) is arranged as shown in figure below.




(ii) Explain Bridgman method used for growth of crystals from molten material with neat diagram.

**[10 + 10 marks]**

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(c) (i) Consider a disk with an average seek time of 4 ms, rotation speed of 15000 rpm, and 512-byte sectors with 500 sectors per track. Suppose that we wish to read a file consisting of 2500 sectors for a total of 1.28 Mbytes. Explain and estimate the total time for the transfer in case of

1. Sequential access.
2. Random access.

(ii) Explain the functions of following CPU registers:

1. MAR
2. MDR

**[16 + 4 marks]**

**Section B : Advanced Electronics + Computer Organization and Architecture + Advanced Communication**

5 (a) (i) Explain the types of Cache Misses.

(ii) Consider a pipeline system with 6 segments. Segment delays are 5 ns, 8 ns, 6 ns, 9 ns, 7 ns and 8 ns. Intermediate register delay is 1 ns which is used after each segment. In the given system, 1000 instructions are to be executed. Among 1000 instructions, 20% are branch instructions each of which incurs 3 pipeline stall cycles. 30% of total 1000 instructions causes resource conflict because of which 1 stall cycles is incurred for such instructions.

Determine the speed-up of this pipeline as compared to the corresponding non-pipeline system.

**[4 + 8 marks]**

Sol^n

ii) Total Delay in non-pipeline system

$= 1000 \times (5+8+6+9+7+8+5)$

$= 1000 \times 48$

$T_d = 48\ \mu s$

Branch instruction = 200

~~Speed up~~

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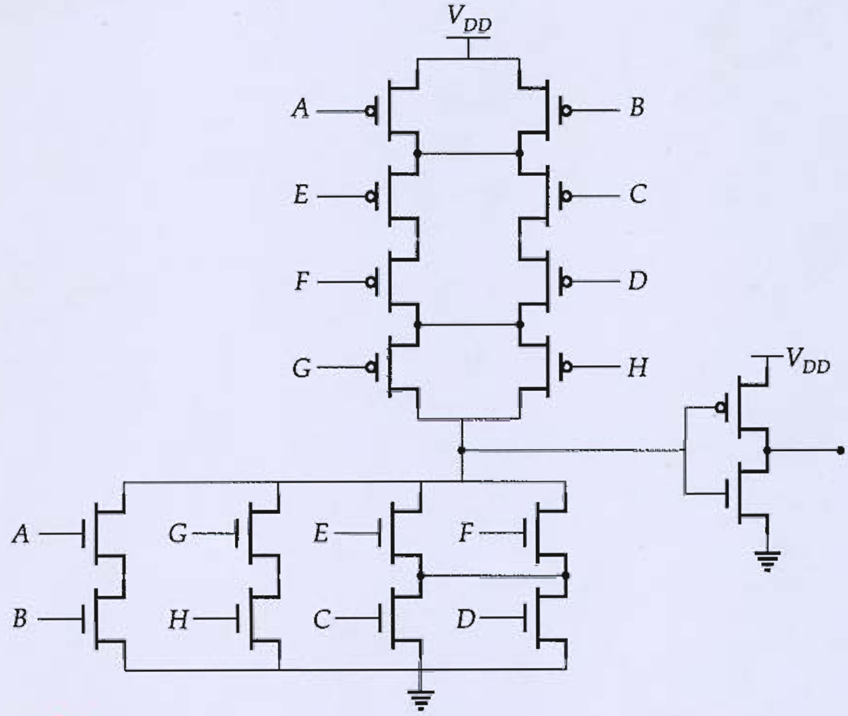
.5 (b) Explain Domino logic. Draw the domino CMOS logic version of the given conventional CMOS logic.




[12 marks]

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.5 (c) (i) Show that the total broadening of a light pulse $\Delta T$ due to intermodal dispersion in a multimode step index fibre may be given by:

$$\Delta T = \frac{L(NA)^2}{2n_1 c}$$

where $L$ is the fibre length, NA is the numerical aperture of the fibre, $n_1$ is the core refractive index and $c$ is the velocity of light in vacuum.

(ii) A multimode fibre is having a core refractive index of 1.5 and a relative index difference of 3%. Determine the critical radius of curvature at which large bending loss occur if the operating wavelength is 1.3 μm.

**[6 + 6 marks]**

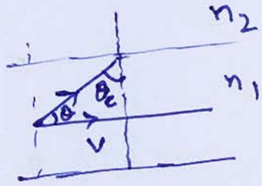
Sol^n

(i)

~~$dt = \frac{dl}{v_1 \cos\theta} = \frac{dl}{v_1}$~~

$$T_1 = \frac{L}{v} = \frac{n_1 L}{c}$$

$$T_2 = \frac{L}{v\cos\theta} = \frac{L}{\frac{c}{n_1}\cos\theta} = \frac{n_1 L}{c \sin\theta_c}$$




$n_1 \sin\theta_c = n_2$

$$\Delta T = \frac{n_1 L}{c \sin\theta_c} - \frac{n_1 L}{c}$$

$$= \frac{n_1 L}{c}\left[\frac{1}{\sin\theta_c} - 1\right]$$

$$= \frac{n_1 L}{c}\left[\frac{n_1}{n_2} - 1\right]$$

$$\simeq \frac{n_1 L}{c}\left[\frac{n_1 - n_2}{n_2}\right]$$

$$\simeq \frac{n_1 L}{c}\Delta$$

5

$$NA = n_1^2 - n_2^2 \simeq n_1\sqrt{2\Delta}$$

$$\therefore \Delta T = \frac{n_1 L}{c} \cdot \frac{(NA)^2}{2n_1^2} = \frac{L(NA)^2}{2n_1 c}$$

$$\therefore \Delta T = \frac{L(NA)^2}{2n_1 C}$$

ii) $R_c = \frac{3 n_1^2 \lambda}{4\pi (n_1^2 - n_2^2)^{3/2}}$ , $\Delta = 0.03$ (given)

6

$$\Delta = \frac{n_1^2 - n_2^2}{2n_1^2}$$

$$\Rightarrow n_1^2 - n_2^2 = 2n_1^2 \Delta$$

$$\therefore R_c = \frac{3 \times (1.5)^2 \times 1.3\,\mu m}{4\pi (2n_1^2 \Delta)^{3/2}}$$

$$= \frac{3 \times (1.5)^2 \times 1.3}{0.6233}\ \mu m$$

$$R_c = 14.07\ \mu m$$

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Q.5 (d) (i) A glass fibre exhibits material dispersion given by $\left|\lambda^2 \frac{d^2 n}{d\lambda^2}\right|$ of 0.03 and fibre is used with a light source having rms spectral width of 15 nm.

Determine:

1. Material dispersion coefficient at a wavelength of 1.3 μm.
2. rms pulse broadening per kilometer due to material dispersion.

(ii) 1. Prove that the maximum value of $a/\lambda$ is approximately 1.4 times larger for a parabolic refractive index profile single-mode fibre than for a single-mode step index fibre. ($a$ is the core radius)

2. If the refractive index of the core of a single-mode step index fiber is 1.49 and refractive index of the cladding is 1.48, find the fiber core diameter to enable single-mode transmission at a wavelength of 1.5 μm.

**[6 + 3 + 3 marks]**

Soln

ii) (1) For single-mode fibre

Normalized frequency $(V) = 2.405\left[1+\frac{2}{\alpha}\right]^{1/2}$

$V = \frac{2\pi}{\lambda} a\,(NA)$ NA → numerical aperture.

For Parabolic Profile, $\alpha = 2$

$$\Rightarrow \quad V_1 = 2.405\left[1+\frac{2}{2}\right]^{1/2}$$

$$= 2.405\sqrt{2}$$

For step index fibre, $\alpha \to \infty$

$$V_2 = 2.405$$

$$\therefore \quad \frac{V_1}{V_2} = \sqrt{2}$$

$$\frac{2\pi a_1 (NA)}{\lambda_1 \cdot 2\pi \frac{a_2}{\lambda_2}(NA)} = \sqrt{2}$$

$$\Rightarrow \quad \boxed{\frac{a_1}{\lambda_1} = \sqrt{2} \times \frac{a_2}{\lambda_2}}$$

(2) For single-mode transmission

$$V = 2.405$$

$$\frac{2\pi a_1 (NA)}{\lambda_1} = 2.405$$

$$\frac{2\pi a_1 \times \sqrt{(1.49)^2-(1.48)^2}}{1.5(\mu m)} = 2.405$$

$$\Rightarrow \quad a_1 = \frac{2.405 \times 1.5}{2\pi \times \sqrt{(1.49)^2-(1.48)^2}} \ \mu m$$

$$a_1 = 3.33 \ \mu m$$

$$\boxed{\text{Fibre core diameter} = 2a_1 = 6.66 \ \mu m}$$

7

(i) (1) Material dispersion coefficient

$$= \frac{0.03}{(1.3)^2}$$

$$= 0.01775 \,/\mu m^2$$

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**Q.5 (e)** (i) Consider a hierarchial memory system that uses cache memory having access time of 80 ns, main memory with an access time of 200 ns and secondary memory with an access time of 800 ns. Hit ratio of cache memory is 80% and main memory hit ratio is 90%. Find the average memory access time of the memory system.

(ii) Explain the Memory Hierarchy Design.

**[8 + 4 marks]**

Soln

(i) Cache memory access time $(t_c) = 80$ ns

Main memory access time $(t_m) = 200$ ns

Secondary memory access time $(t_s) = 800$ ns

$H_c \rightarrow$ Hit ratio of cache memory $= 0.8$

$H_m \rightarrow$ Hit ratio of main memory $= 0.9$

$H_s = 1$ (Hit ratio of secondary memory)

8

Average Memory access time $(t_{av})$

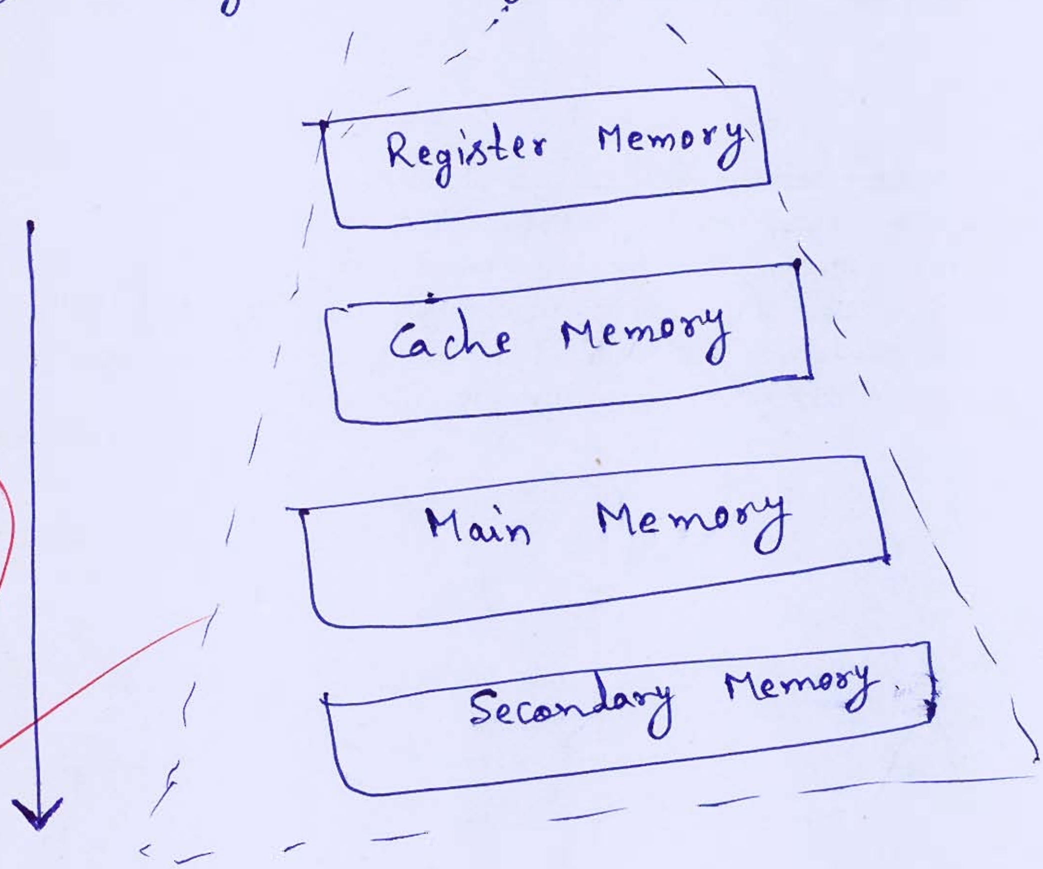
$$= H_c t_c + (1-H_c) H_m (t_m + t_c) + (1-H_c)(1-H_m)(t_c + t_m + t_s)$$

$$= 0.8 \times 80 + 0.2 \times 0.9 (80 + 200) + 0.2 \times 0.1 \times (80 + 200 + 800)$$

$$= 64 + 50.4 + 21.6$$

$$t_{av} = 136 \text{ ns}$$

(ii) Memory Hierarchy Design




3

~~Access time~~ →

Access Speed → Decreases along the arrow

Memory size → Increases along the arrow

Access time → Increases along the arrow

Cost → Increases along the arrow

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**Q.6 (a)** The downlink $C/N_0$ ratio in a direct broadcast satellite (DBS) system is estimated to be 85 dB-Hz.

The specifications of the link are:

Satellite $EIRP$ = 57 dBW,

Downlink carrier frequency = 12.5 GHz,

Data rate = 10 Mb/s,

Required $E_b/N_0$ at the receiving earth terminal = 10 dB,

Distance of satellite from the receiving earth terminal = 41000 km.

Calculate the minimum diameter of the dish antenna needed to provide a satisfactory TV reception, assuming that the dish has an efficiency of 55 percent and it is located alongside the home where the temperature is 310 K. For this calculation, assume that the operation of the DBS system is essentially downlink limited.

**[20 marks]**

Solⁿ

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Q.6 (b) (i) Explain in detail the types of scaling used in VLSI technology.

(ii) What is the oxide thickness after dry oxidation at 1500°C carried out for 2 hours? By assuming initial oxide thickness is zero.
[Given; $A = 0.2\ \mu m$, $B = 0.5\ \mu m^2/hr$]

**[12 + 8 marks]**

Sol$^n$

(i) Scaling in VLSI technology

a) Constant voltage scaling, Length scaled by 'S'

Length $\rightarrow \frac{1}{S}$

Area $\rightarrow \frac{1}{S^2}$

(b) Voltage scaled by 'u', Length scaled by 'S'

Length $\rightarrow \frac{1}{S}$

Area $\rightarrow 1/S$

~~Electric~~

$V \rightarrow \frac{V}{u}$

Capacitance $\rightarrow S$

3

(ii) Using, $x_o^2 + Ax_o = B(t+\tau)$

$\tau = 0$ as initial thickness is zero.

$x_o^2 + 0.2x_o = 0.5 \times 2$ [$x_o$ in $\mu m$]

$x_o^2 + 0.2x_o = 1$

$x_o = 0.9$, $x_o = -1.1$ (neglected)

$\therefore$ [Oxide thickness after 2 hours $= 0.9\ \mu m$]

**Q.6 (c)** **(i)** Consider the following set of processes, with the arriving time and length of the CPU burst given 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?

**[15 + 5 marks]**

Sol$^n$

(i) Ready ~~Queue~~ state

$t = 0 \rightarrow P_1(6)$

$t = 1 \rightarrow P_1(5), P_2(4)$

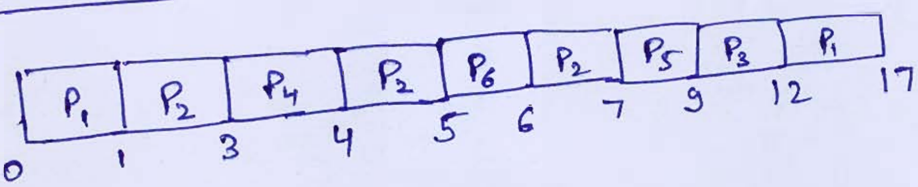
$t = 2 \rightarrow P_1(5), P_2(3), P_3(3)$

$t = 3 \rightarrow P_1(5), P_2(2), P_3(3), P_4(1)$

$t = 4 \rightarrow P_1(5), P_2(2), P_3(3), P_5(2)$

$t = 5 \rightarrow P_1(5), P_2(1), P_3(3), P_5(2), P_6(1)$

Gantt chart:




| Process | Arrival Time | Burst Time | Completion Time | Turn around Time | Waiting Time |
|---|---|---|---|---|---|
| $P_1$ | 0 | 6 | 17 | 17 | 11 |
| $P_2$ | 1 | 4 | 7 | 6 | 2 |
| $P_3$ | 2 | 3 | 12 | 10 | 7 |
| $P_4$ | 3 | 1 | 4 | 1 | 0 |
| $P_5$ | 4 | 2 | 9 | 5 | 3 |
| $P_6$ | 5 | 1 | 6 | 1 | 0 |

Average waiting Time = 3.83 ms

7 (a) (i) Explain the following two priority based interrupt handling methods:

1. Polling
2. Daisy chaining

(ii) Find whether the given schedules are conflict serializable or not.

$S_1 : W_2(x), W_1(x), R_3(x), W_2(y), R_3(y), R_3(z), R_2(x)$

$S_2 : R_3(z), W_2(x), W_2(y), R_1(x), R_3(x), R_2(x), R_3(y), W_1(z)$

**[12 + 8 marks]**

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7 (b) (i) Explain briefly about following terms related to design quality in VLSI Chip Design:

1. Testability
2. Yield
3. Manufacturability
4. Reliability

(ii) Consider a cellular system which consists of 34 cells with the cell radius as 1.4 km. A total frequency bandwidth is capable of supporting 343 traffic channels. Find what geographical area (in km) can be covered and the number of channels available per cell. What is the total number of concurrent calls that can be handled? [Assume reuse factor of $N = 7$]

**[10 + 10 marks]**

Do not write in this margin

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

**[20 marks]**

(a) (i) Implement a Binary to Gray code converter using PLA.

(ii) Define the following parameters related to Testability of a circuit:

1. Controllability
2. Observability

**[14 + 6 marks]**

Soln

(i) Binary to Gray code :

binary → $b_0$ $b_1$ $b_2$ $b_3$

↓ ↓ ↓ ↓

Gray code → $b_0$ $b_0 \oplus b_1$ $b_1 \oplus b_2$ $b_2 \oplus b_3$

$(c_0)$ $(c_1)$ $(c_2)$ $(c_3)$

$c_0 = b_0$

$c_1 = b_0\bar{b}_1 + \bar{b}_0 b_1$

$c_2 = b_1\bar{b}_2 + \bar{b}_1 b_2$

$c_3 = b_2\bar{b}_3 + \bar{b}_3 b_2$

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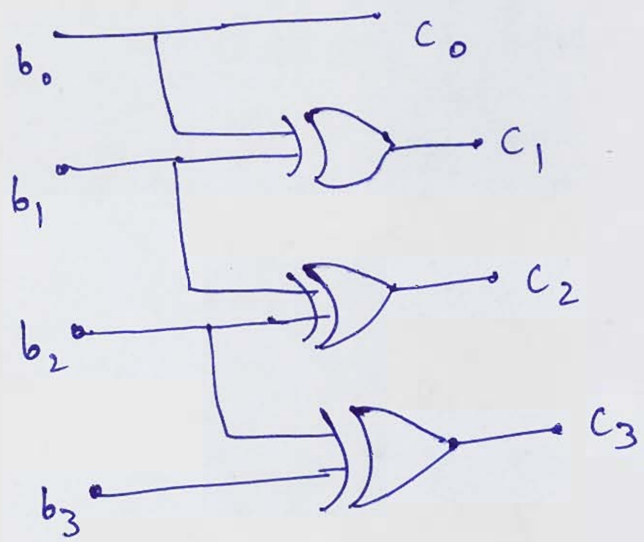


4

PLA → Programable OR and AND

ii) <u>Controllability</u>

If the output of the circuit can be controlled using the testing input to the desired value then it is known as controllable circuit.

3

<u>Observability</u>

If the system internal state can be determined by observing the output of the system then it is known as observable system.

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Q.8 (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 a 32B blocks. CPU generates 28 bit physical address to access the data. The cache controller contains tag information along 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]**

Sol^n

(i) (1.) Entity : An object having certain characteristic.

(2) Attributes : These the are characteristics Posses by an entity.

(3) Relationship : It specifies the relation between two entities.

(4) Domain : This represents the overall region in which the entity will exist & perform its function

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ii) Byte offset = 5 bits

(as 1 Block = 32 B = $2^5$ B)

Number of cache memory block = $\frac{64 KB}{32 B}$

= 2 K

~~No~~ Number of sets = $\frac{2K}{8} = \frac{2^{11}}{2^3} = 2^8$

⇒ Set-offset = 8 bits

| Tag bits | set offset | Byte offset |
|---|---|---|

← 28 bits →

∴ Tag bits = 28 − 5 − 8 = 15

∴ [Cache controller tag bits = 15 + 2 + 2 + 3
= 22 bits]

Tag directory size = No. of cache memory block × cache controller bits

= $2^{11}$ × 22 bits

= ~~22~~ 45056 bits

Tag directory size = 5632 B

Do not write in this margin

Q.8 (c) (i) Obtain the binary notation and also determine the network address for the following classful IP addresses (Assume that subnetting is not being used):

1. 23.56.89.12
2. 133.45.78.65
3. 201.150.47.19

(ii) Determine and explain clearly the address class for the following IP addresses:

1. Binary: 11000000 10101000 00000001 00000001
2. Hexadecimal : 8F 7C 2A 1B
3. Dotted Decimal: 172.31.0.1

**[10 + 10 marks]**

Sol^n

(i) 1) 23.56.89.12

00010111.00111000.01011001.00001100

⇒ Class A address [24 bits network Id, 8 bits Host id]

Network address: 23.56.89.0

Do not write in this margin

(2) 133. 45. 78. 65

10000101. 00101101 . 01001110 . 01000001

10 → denotes Class B addressing

⇒ 16 bits for network & 16 bits for Host

Network address → 133. 45. 0. 0

(3) 201. 150. 47. 19

11001001. 10010110. 00101111. 00010011

110 → denotes class-C addressing

⇒ 8 bits for Network 24 bits for host

Network address → 133. 0. 0. 0

18

ii) 1) 11000000 10101000 00000001 00000001

Starting with 11 ⇒ class-C addressing

(2) 8F 7C 2A 1B

10001111 0111 00101100 00011011

Starting with 10 ⇒ Class B addressing

(3) 172. 31. 0. 1

10101100. 00011111 . 00000000 . 00000001

Starting with 10 ⇒ Class-B addressing

**Space for Rough Work**

$\Delta = \frac{n_1 - n_2}{n_1}$

$NA^2 = n_1^2 - n_2^2$

$n_1 \sqrt{2\Delta} = (NA)$

$\frac{(n_1 - n_2)(n_1 + n_2)}{(n_2)(n_1 + n_2)}$

$n_1 \sin\theta_c = n_2$

$\Delta = \frac{n_1 - n_2}{n_1}$

$\frac{n_1 L}{c}\left[\frac{1}{\cos\theta} - 1\right]$ $\frac{n_1 L}{c \cos\theta}$

$\frac{n_1 L}{c}\left[\frac{n_1}{n_2} - 1\right]$

$\frac{n_1^2 L}{c\, n_2} - \frac{n_1 L}{c}$

$n_2^2 - n_1^2 = (NA)^2$

$\frac{n_1 L}{c}\left[\frac{n_1 - n_2}{n_2}\right]$

$\Delta = \frac{n_1 - n_2}{n_1}$

$\frac{n_1^2 L \Delta}{n_2 c}$

$n_1 \sqrt{2\Delta}$

$n_1^2 2\Delta = NA$

## Space for Rough Work