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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	40
Q.3	21
Q.4	—
Section-B	
Q.5	27
Q.6	41
Q.7	—
Q.8	—
Total Marks Obtained	163

Signature of Evaluator: Chaithra. 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.

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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]

$t_{ox} = 0.6\,\mu m \pm 4\%$, etch rate $R_e = 0.4\,\mu m/\text{minutes} \pm 5\%$.

$(t_{ox})_{max} = 1.04 \times 0.6\,\mu m = 0.624\,\mu m$

$R_{e\,min} = 0.95 \times 0.4\,\mu m/min = 0.38\,\mu m/min$

original etch time $= \dfrac{t_{ox}}{R_e} = \dfrac{0.6\,\mu m}{0.4\,\mu m/\text{minute}} = 1.5\text{ min} = 90\text{ sec}$

max^m etch time $= \dfrac{t_{ox\,max}}{R_{e\,min}} = \dfrac{0.624\,\mu m}{0.38\,\mu m/min} = 1.6421\text{ min} \simeq 98.5\text{ sec}$

% overetch time :→ $= \dfrac{98.5 - 90}{90} \times 100 = 9.44\%$

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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]

```
void main(){
    int a = 0;          // store fib(i-2)  } → variable initialization
    int b = 1;          // store fib(i-1)
    int c = 0;
    printf("%d", a);  printf("%d", b);   // initial 2 values
    for (i=0 ; i<98 ; i++)   → loop 98 times
    {                         [i< 100]
        c = a+b;           → Calculating next result
        printf("%d", c);   } → printing Results
        a = b;
        b = c;             } → updation of a & b
    }
```

Result :- 0 1 1 2 3 5 8 - - - - - - - -

7

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 λ 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]

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 = 3.98×10^{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]

(i) $h = 1200$ km, $f = 3.56$ GHz, $GM = 3.98 \times 10^{11}$ Nm^{2}kg

velocity of satellite $v = \sqrt{\frac{GM}{r}}$

$r = h + R$ (R → Radius of earth)

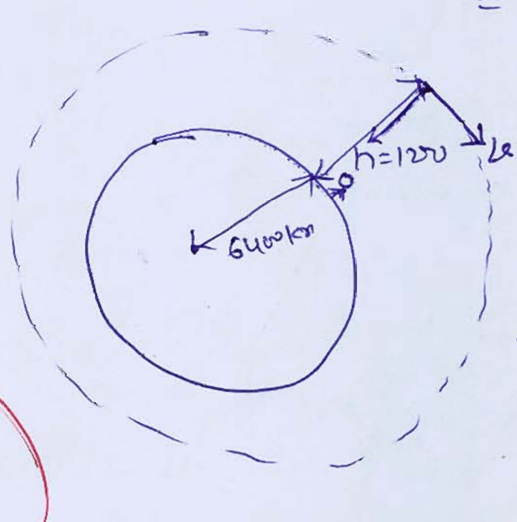
$= 1200 + 6400 = 7600$ km

$$= \sqrt{\frac{3.98 \times 10^{11}}{7600}}$$

$$= \sqrt{5.23 \times 10^{7}}$$

$$= 7.23 \times 10^{3} \text{ m/sec.}$$

(ii)



→ The velocity v is always tangent to the orbit, so there is no component of velocity along the observer

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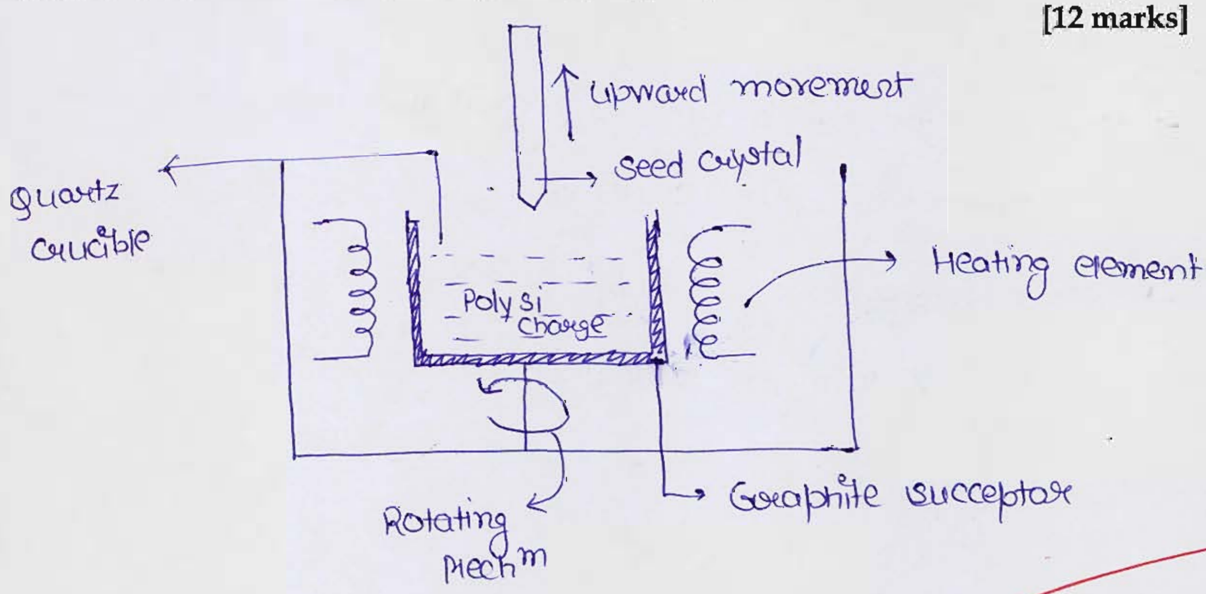
1 (e) Explain Czochralski Technique for growing single crystals of silicon with a neat diagram.
[12 marks]



Working Principle :→

→ A Quartz crucible is taken & Poly si balls are placed inside it & is heated using the Heating element so that polysi convert to Molten state

→ Quartz crucible melting pt. is higher than that of polysi, so that it is preferred

→ Graphite succeptor is used so that the Heating is Homogeneous throughout.

→ A seed crystal Rod is taken & a pulliy Mechⁿ is employed with it which pull it upwards

→ The portion of Polysi in contact with seed crystal takes the orientation of the seed crystal & successively cool down.

→ This process continues & thus a Pure Si Ingot is formed.

→ This method may lead to some oxide impurities because of the heatiy of quartz which releases oxygen.

→ For n type or p-type si, suitable impurities are added to the crucible.

→ This process is mainly suitable for formiy large diameter Si Ingots.

11

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2 (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 5×10^{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 = 2.6×10^{20} atoms/cm^3.

[20 marks]

Junction depth $t_j = 0.5\ \mu m$

$N_B = N_D = 10^{17}$ $\quad N_0|_{T=1000°C} = 2.6 \times 10^{20}$

Pre - deposition :→

$$N(x,t) = N_0 \, erfc\left(\frac{x}{2\sqrt{Dt}}\right)$$

Drive - In :→

Surface Concn → $N = \frac{Q}{2\sqrt{Dt}}$ $\quad N = 5 \times 10^{19}\ cm^{-3}$

Also $D = D_0 e^{-E_A/kT}$

kT :→ 0.026 eV at 300 K

So at 1200°C = 1473 K → $kT|_{1473K} = 0.127$ eV

$$D|_{1473K} = D_0 e^{-E_a/kT}$$

$$= 11.8\, e^{-4.36/0.127} = 1.45\times10^{-14}\ cm^2/sec$$

Drive In :→ $N = \frac{Q}{2\sqrt{D_{1473} t_{drive in}}}$

↓ surface conc.

$$5\times10^{19} \times 2\sqrt{D_{1473} \times t_{drive in}} = Q$$

$$t_{drive-in} = \frac{Q^2}{(5\times10^{19}\times 2)^2 \times 1.45\times10^{-14}} \quad -①$$

Pre-deposition at $x = x_j$, $N(x,t) = N_D$

$$kT|_{1373} = 0.118\ eV$$

$$D|_{1373K} = D_0 e^{-E_a/kT}$$

$$D|_{1373K} = 11.8\, e^{-4.36/0.118} = 1.05\times10^{-15}$$

$$N(x,t) = N_0\, erfc\left(\frac{x}{2\sqrt{Dt_{pre}}}\right)$$

At $x = x_j$, $N(x,t) = N_B = 10^{17}$
$= 0.5\,\mu m$

$$10^{17} = 2.6\times10^{20}\ erfc\left(\frac{0.5\times10^{-4}}{2\sqrt{1.05\times10^{-15} \times t_{pre}}}\right) \quad -②$$

using ① & ②, t_{pre} & $t_{drive-in}$ can out be found when we know certain erfc constant values.

[N_0 is used constant with temp. for simplification]

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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]

(ii) $h = 350$ km

$N_{max} \rightarrow \mu = 0.8$, $f = 15$ MHz

$f_c = 9\sqrt{N_{max}}$

$\mu = \sqrt{1 - \frac{81 N}{f^2}}$

$\Rightarrow 0.8 = \sqrt{1 - \frac{81 N_{max}}{(15 \times 10^6)^2}}$

$0.36 = \frac{81 N_{max}}{225 \times 10^{12}} \Rightarrow N_{max} = 10^{12}$

$f_c = 9\sqrt{10^{12}} = 9$ MHz

$f_{MUF} = f_c \sqrt{1 + \left(\frac{D}{2h}\right)^2}$ (assumed flat earth as given)

$20 = 9\sqrt{1 + \left(\frac{D}{700}\right)^2}$

$D^2 = 49 \times 10^4 \times 3.93$

$D = 13.89 \times 10^2 \approx 1389$ km Ans.

6

(i) Gyro frequency :- These are the frequencies at which the electromagnetic rays are Txed through the Ionosphere without refraction i.e. they scatter the Gas particles in Ionosphere & pass through.

$h = 400$ km , $R = 6370$ km

6

$$f_{MUF} = f_c \sqrt{1 + \left[\frac{D}{2\left(h + \frac{D^2}{8R}\right)}\right]^2}$$

$$\frac{D}{2\left(400 + \frac{D^2}{8 \times 6370}\right)} = \sqrt{\left(\frac{f_{MUF}}{f_c}\right)^2 - 1}$$

Let it be a

$$D = 800a + \frac{D^2}{4 \times 6370} a$$

$$\boxed{D^2 a + 25480 D + 20384000 a = 0}$$

⇓

Solving this eq^n gives D if a is known.

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]

(i) Data size = 16 bytes Transfer Rate = 1kbps

⇓

For 1 byte ⇒ 2 cycle

So, For 16 bytes ⇒ 16×2 cycles = 32 cycles

5

T_c = Cycle time = $\frac{1}{\text{cycle freq}} = \frac{1}{400 \times 10^3} = 0.25 \times 10^{-5}$ s

Actual Data Transfer time = 32 cycle = 32 T_c

$= 32 \times 0.25 \times 10^{-5} = 8 \times 10^{-5}$ s

~~CPU block time = 10 cycles = 10 Tc~~

~~Total time = 32 Tc + 10 Tc = 42 Tc~~

~~CPU block time = 10 Tc / 42 Tc~~

Hard disk Transfer Rate = 1 Kbps

CPU Transfer Rate = $\frac{8 \text{ bit}}{2 \times 0.25 \times 10^{-5}}$ = 16×10^5 bps.

As we can see, Transfer Rate of CPU >> Hard disk Transfer Rate, CPU remain idle for sometime.

Hard disk transfer time of 16 bytes = $\frac{16 \times 8 \text{ bit}}{2^{10} \text{ bit/sec}} = 2^{-3}$ sec.

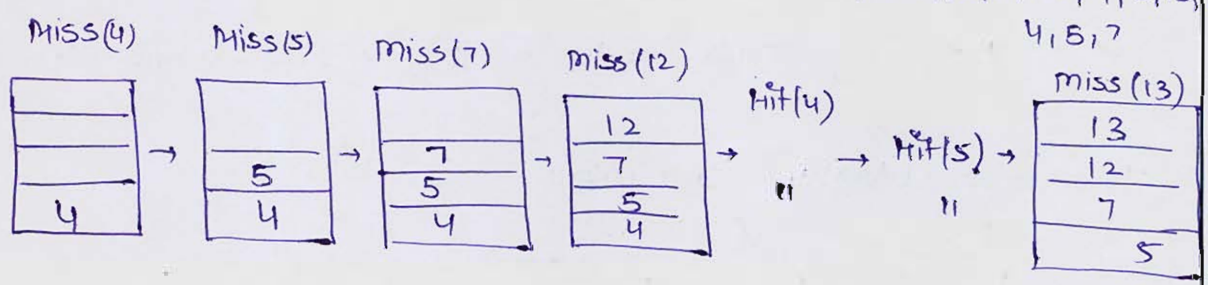
Cycle block time = $(2^{-3} \text{ sec} + 10\, T_c) - (8 \times 10^{-5})$ sec.

$= (0.125 + 2.5 \times 10^{-5} - 8 \times 10^{-5})$ sec

$= (0.125 - 5.5 \times 10^{-5})$ sec.

% of CPU block = $\frac{0.125 - 5.5 \times 10^{-5}}{0.125 + 2.5 \times 10^{-5}} \simeq 100\%$.

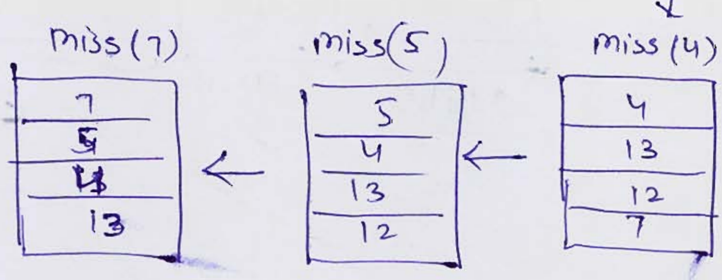
(ii) FIFO :→ First In First out , 4, 5, 7, 12, 4, 5, 13, 4, 5, 7



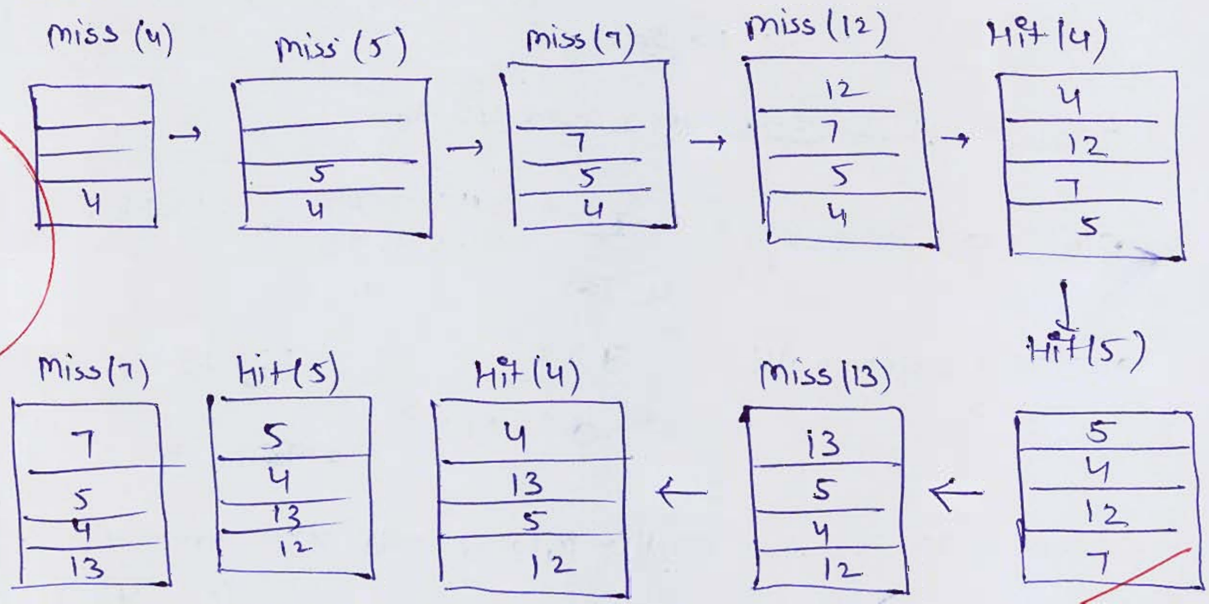
Hit Ratio = $\frac{\text{Total Hits}}{\text{Total Ref.}}$

$= \frac{2}{10} = \frac{1}{5}$

$= 0.2$



LRU :→ Least Recently used



10

Hit Ratio = $\frac{\text{Total Hits}}{\text{Total Ref}} = \frac{4}{10} = 0.4$

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?

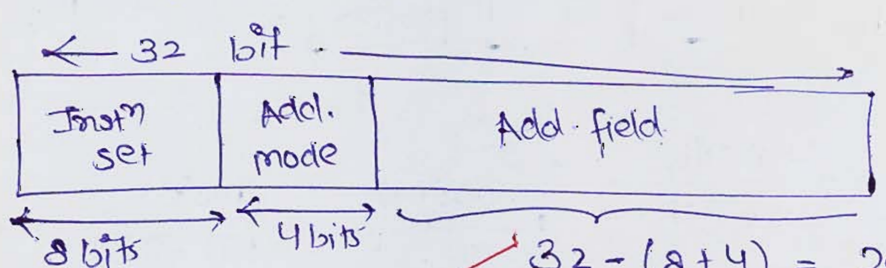
[8 + 12 marks]

(i) Instruction set = 250 ⇒ $\log_2 250 \simeq 7.9$

For Instruction Set ⇒ 8 bits Reqd.

Addressing Modes ⇒ 10 ⇒ $\log_2 10$ ⇒ 4 bits Reqd.

Instruction Length = one word = 32 bits



$32 - (8+4) = 20$ bits
⇓
address

Total no. of Possible Inst^{n}s

$$= 250 \times 10 \times 2^{20} = 2500 \times 2^{20}$$

↑ Inst^n set ↑ Add. modes ⇓ max^m no. of addressing. Consider all are Compatible with the Inst^n

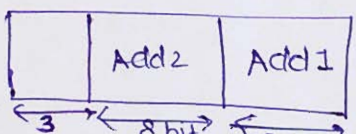
Total size of memory = Total Poss Inst^n × Inst^n size

$$= 250 \times 10 \times 32 \times 2^{20}$$

$$= 80000 \text{ MB.}$$

(ii) Inst^n Length = 19 bits

Two address



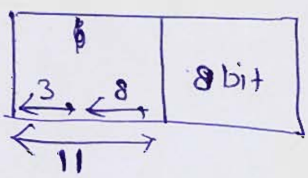
Total Possible 2 Add Instruction $= 2^3$

Total 2-add = 8

used = 6

Remaining Unused = 2

1 address

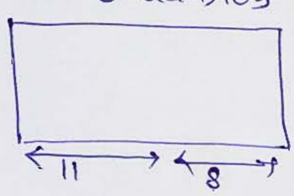


Total Possible $= 2 \times 2^8$

Used $= x$

Unused $= 2^9 - x$

0 address



Total Possible 0 add. Inst $= (2^9 - x) \times 2^8$

But Given, Total Possible zero add. Inst^n = 65536

$$(2^9 - x)\, 2^8 = 65536$$

$$(2^9 - x)\, 2^8 = 2^{16}$$

$$2^9 - x = 2^8$$

$$x = 2^9 - 2^8 = 2^8 = 256 \text{ Ans}$$

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]

(i) $J = 5\ \mu A/cm^2$, $t = 20$ min , $Q = ?$ → Implantation dose

$$Q = \frac{Jt}{q} = \frac{5\times10^{-6}\times 20\times 60}{1.6\times10^{-19}}\ cm^{-2}$$

$$= 3.75\times10^{3}\times10^{-6}\times10^{9}\ cm^{-2}$$

$$Q = 3.75\times10^{16}\ cm^{-2}$$

$$N(x) = \frac{1}{\Delta R_p \sqrt{2\pi}} e^{-\frac{(x - R_p)^2}{2\Delta R_p^2}}$$

↓ Impurity concn.

N_{max} at $x = R_p$ ⇒

$$N(x)_{max} = \frac{1}{\Delta R_p \sqrt{2\pi}} = \frac{1}{0.5 \times 10^{-4} \times \sqrt{2\pi}}$$

$$= 0.79 \times 10^{4} \text{ cm}^{-3}$$

5

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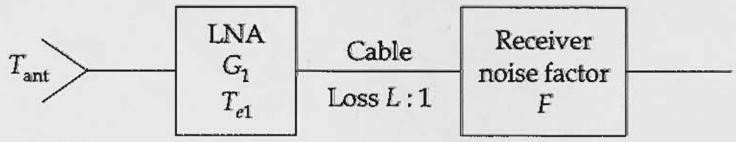
Q.4 (a) A receiver in a urban cellular radio system detects a 1 mW at $d = d_0 = 1.5$ m from the transmitter. In order to mitigate co-channel interference effects, it is required that the signal received at any base station receiver from another base station transmitter which operates with the same channel 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]

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]

(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]

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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]

(ii)

S1		S2		S3		S4		S5		S6
5ns	1s	8ns	1s	6ns	1s	9ns	1s	7s	1s	8ns

⇒ with pipelining, one Inst^n execution time

= max (5, 8, 6, 9, 7, 8) + 1 = 10 ns

⇒ Total 1000 Inst^{n}s

- 20% = 200 ⇓ 3 stalls each
- 30% = 300 ⇓ 1 stall each
- 50% = 500 ⇓ no stalls

⇒ Total stalls for 1000 Inst^n = (200×3) + (300×1)

= 900 stall cycles

⇒ total time to execute 1000 Inst^{n}s ⇒

(1000 + 900) × 10ns = 19000 ns

(1000 ⇓ Regular cycles; 900 ⇑ stall cycles)

⇒ Time with pipeling = 19000 ns for 1000 Inst^n — (1)

8

without Pipelining :→

Time for 1 instn execution = (5+8+6+9+7+8) ns

= 43 ns

Time reqd for 1000 Instn = 43 X 1000 = 43000 ns

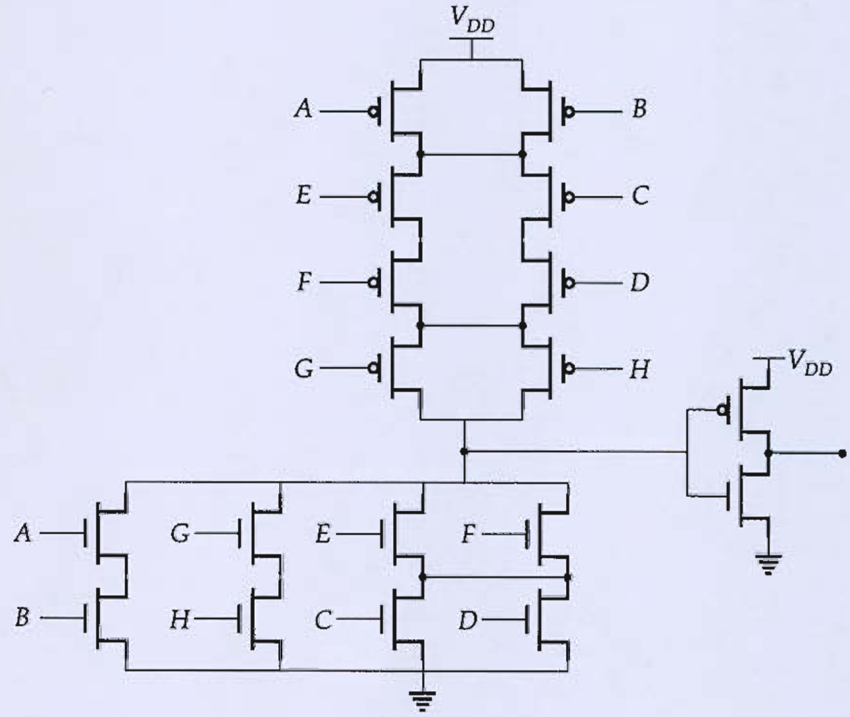
Time without pipelining for 1000 Instn = 43000 ns

-(2)

Speedup = $\frac{\text{Time without pipelining}}{\text{Time with pipelining}}$

= $\frac{43000}{19000}$ = 2.263 Ans.

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



[12 marks]

~~The Domino logic refers~~

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

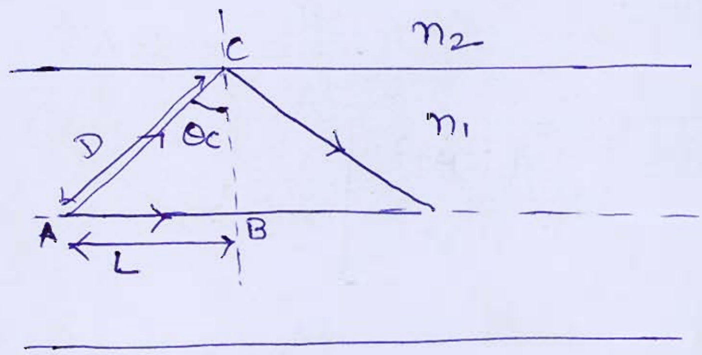
$$\Delta T = \frac{L(NA)^2}{2n_1 c}$$

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]

(i)



Time taken by axial ray to reach from pt

$$A \text{ to } B = \frac{L}{c} = \Delta t_1$$

Time taken by the meridional ray shown from

$$A \text{ to } C = \frac{D}{c} = \Delta t_2$$

From Figure, $\sin\theta_c = \frac{L}{D}$

$$\Delta t_2 = \frac{L}{c\sin\theta_c}$$

Pulse broadening → $\Delta T = \Delta t_2 - \Delta t_1$

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

We know, $\sin\theta_c = \frac{n_2}{n_1}$

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

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

$$\Delta T = \frac{L}{C}\left[\frac{n_1 - n_2}{n_2}\right]$$

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

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$$\Delta T = \frac{n_1 L}{C}\Delta \quad \text{—} (1)$$

Also, $NA = n_1\sqrt{2\Delta} \Rightarrow \frac{(NA)^2}{n_1^2} = 2\Delta$

Substitute Δ,

we get, $\boxed{\Delta T = \frac{L(NA)^2}{2n_1 C}}$

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/λ 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]

(ii) (1) For SMSI fibre :-

$$V = 2.405 = \left(\frac{2\pi a}{\lambda}\right)_{SMSI} (NA) \quad \text{—(1)}$$

For Graded R.I. profile (parabolic) single mode

MMGI → SMGI

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

$$V = 2.405\sqrt{2} = \left(\frac{2\pi a}{\lambda}\right)_{Parabolic} (NA) \quad \text{—(2)}$$

For parabolic

$\alpha = 2$

⇓

$V = 2.405\sqrt{2}$

Divide ① by ②

$$\frac{1}{\sqrt{2}} = \frac{(a/\lambda)_{SMSI}}{(a/\lambda)_{parabol.}}$$

$$\boxed{\left(\frac{a}{\lambda}\right)_{parabolic} = (1.4)\left(\frac{a}{\lambda}\right)_{SMSI}}$$

(ii) SMSI, $\eta_1 = 1.49$

$\eta_2 = 1.48$ $\lambda = 1.5\ \mu m$

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Single Mode → $V = 2.405$

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

$$= \sqrt{(1.49)^2 - (1.48)^2} = 0.172$$

$$V = \frac{2\pi a}{\lambda}(NA)$$

$$2a = \frac{V\lambda}{\pi (NA)} = \frac{2.405 \times 1.5 \times 10^{-6}}{\pi \times 0.172}$$

↓ diameter ↓

$$\boxed{d = 6.676\ \mu m}$$

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(i) $\Delta t = \lambda^2 \frac{d^2 n}{d\lambda^2} = 0.03$

$D_{mat} = \left| \frac{\lambda}{c} \frac{d^2 n}{d\lambda^2} \right|$

(2) $\sigma_s \rightarrow$ RMS pulse broadening

$\sigma_s = \frac{\Delta t}{2\sqrt{3}} = \frac{0.03}{2\sqrt{3}} = 8.66 \times 10^{-3}$

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]

(i) $h_{t\,cache} = 0.8$ $t_{cache} = 80\,ns$

$h_{t\,mm} = 0.9$ $t_{mm} = 200\,ns$

$t_{sm} = 800\,ns$

⇒ Avg. memory access time depend on the type / method by which cache is accessed.

⇒ Assuming parallel access of all 3 memory i.e. all 3 goes simultaneously for searching.

1

$$t_{avg} = \underbrace{h_{t\,cache} \times t_{cache}}_{\text{Cache is hit}} + \underbrace{(1 - h_{t\,cache})}_{\text{Cache miss}} \times t_{mm} \times \underbrace{h_{t\,mm}}_{\text{mm hit}}$$

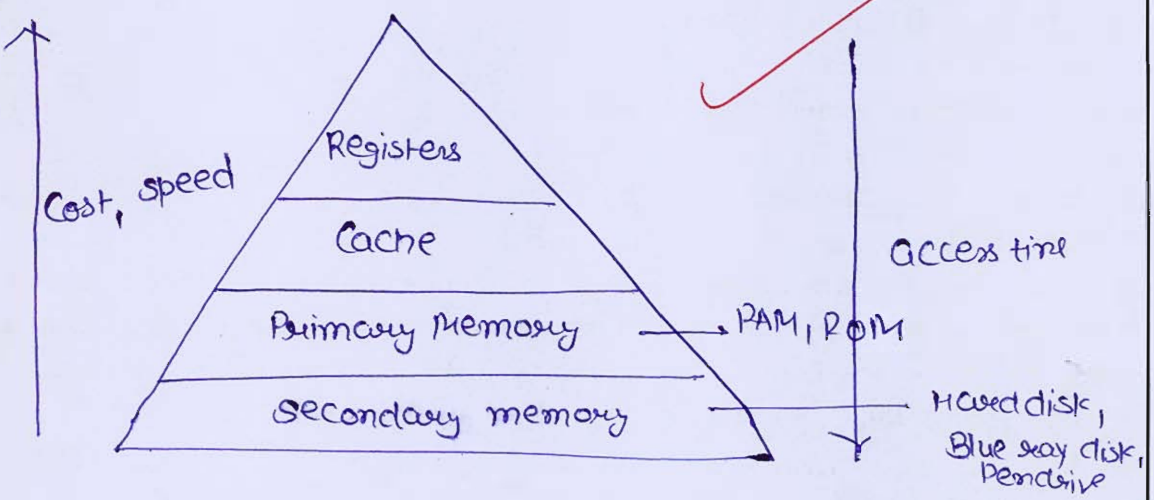
$$+ \underbrace{(1 - h_{t\,cache})(1 - h_{t\,mm})}_{\text{both miss}} \times t_{secondary}$$

$$= 0.8 \times 80 + (1 - 0.8) \times 200 \times 0.9 + (1 - 0.8)(1 - 0.9) \times 800 \; ns$$

$t_{avg} = 116\,ns$ ✗

If cache memory is used, use Hierarchical memory organization

(ii)



Above figure shows the memory Hierarchy diagm.

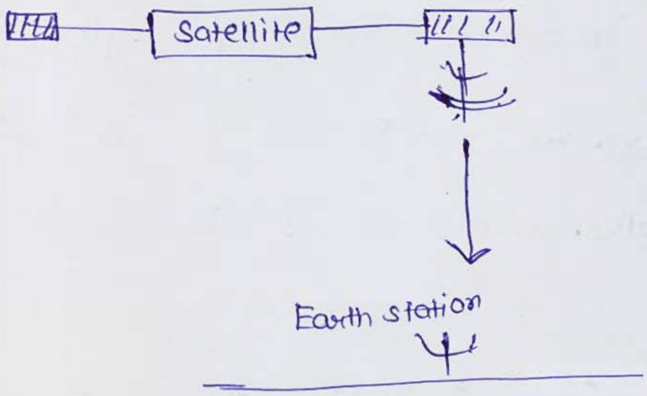
→ Registers are the fastest or max^m speed providing memories followed by cache, primary & secondary Memories.

→ As we move up, cost increases, access time decreases, speed increases.

→ whereever small amount of memory is reqd for real time process, we choose faster costly memory while for large permanent storage, we choose primary or secondary Memory

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]



$d = 41000$ km

$\left(\frac{C}{N_o}\right)_{downlink} = 85$ dB-Hz

$(EIRP) = 57$ dBW

$f = 12.5$ GHz

$R_b = 10$ Mb/s

$\left(\frac{E_b}{N_o}\right)_{ES} = 10$ dB

$$\left(\frac{C}{N_o}\right)_{downlink} = \frac{P_t G_t G_r}{L_s K T_e B} \quad (B = 1\text{ Hz})$$

Let $G_r = G$

$$\left(\frac{C}{N_o}\right)(dB) = \underbrace{10\log_{10} P_t G_t}_{EIRP} + 20\log_{10} G - 10\log_{10} L_s - 10\log_{10} k - 10\log_{10} T_e$$

$$L_s = 92.5 + 20\log 41000 + 20\log_{10} 12.5$$
$$= 206.69 \text{ dB}$$

$85 = 57 dB + 20 \log_{10} G - 206.69 dB + 228.6 dB - 24.91$

$10 \log_{10} G = 31$

~~$88 = 10 \log_{10} P_t G$ — (1)~~

~~$88 = 10 \log_{10} P_t + 20 \log_{10} G$ — (1)~~

$G = 1258.92$ — (1)

$G = \eta \cdot (\pi^2) \left(\frac{D}{\lambda}\right)^2 \rightarrow G = 0.55 \times 10 \times \frac{D^2}{5.76 \times 10^{-4}}$

$\lambda = \frac{c}{f} = \frac{3 \times 10^8}{12.5 \times 10^9}$

$G = 0.954 \times 10^4 D^2$ — (2)

~~$\frac{E_b}{N_0} = 10$, $R_B = 10 \times 10^6 = 10^7$ bps~~

~~$N_0 = kT = 1.38 \times 10^{-23} \times 310 = 427.8 \times 10^{-23}$~~

~~$P_r = E_b R_b = 10 \times 427.8 \times 10^{-23} \times 10^7$~~

~~$P_r = 4.278 \times 10^{-13}$ W~~

~~$10 \log_{10} P_r = 10 \log_{10} P_t + 20 \log_{10} G - L_s$~~

(1) in (2) :→

$1258.92 = 0.954 \times 10^4 D^2$

$D = 0.3634$ m

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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; $A = 0.2$ µm, $B = 0.5$ µm^2/hr]

[12 + 8 marks]

(ii) $t_{ox}^2 + A t_{ox} = B(t + \tau)$

Initial oxide thickness = 0 i.e. at $t = 0$, $t_{ox} = 0$

⇓

i.e. $\tau = 0$

$t_{ox}^2 + A t_{ox} = Bt$

$t = 2$ hrs, $A = 0.2$ µm, $B = 0.5$ µm^2/hr

$t_{ox}^2 + 0.2 t_{ox} = 0.5 \times 2$

$t_{ox}^2 + 0.2 t_{ox} - 1 = 0$

$\boxed{t_{ox} = 0.904 \text{ µm}}$

8

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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]

(i) t = 0 ⇒ P_1 (6)
→ P_1 execute

t = 1 ⇒ P_1 (5), P_2 (4)
→ P_2 execute

t = 2 ⇒ P_1 (5), P_2 (3), P_3 (3)
→ P_2 execute

t = 3 ⇒ P_1 (5), P_2 (2), P_3 (3), P_4 (1)
→ P_4 execute

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t=4 ⇒ P1(5), P2(2), P3(3), P5(2)

⟶ P2 execute

t=5 ⇒ P1(5), P2(1), P3(3), P5(2), P6(1)

⟶ P2 execute

t=6 ⇒ P1(5), P3(3), P5(2), P6(1)

⟶ P6 execute

t=7 ⇒ P1(5), P3(3), P5(2)

⟶ P5 execute

t=9 ⇒ P1(5), P3(3)

⟶ P3 execute

t=12 → P1(5)

⟶ P1 execute

t=17 → Complete

Gantt chart :-

P1	P2	P2	P4	P2	P2	P6	P5	P3	P1

0 1 2 3 4 5 6 7 9 12 17

Process	AT	CT	TAT	BT	WT
P1	0	17	17	6	11
P2	1	6	5	4	1
P3	2	12	10	3	7
P4	3	4	1	1	0
P5	4	9	5	2	3
P6	5	7	2	1	1

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Avg. WT = $\frac{11+1+7+0+3+1}{6} = \frac{23}{6} = 3.83$ ms

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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]

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]

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

[20 marks]

8 (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]

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]

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]

Space for Rough Work

Space for Rough Work

$$I = \frac{Q}{t}$$

$$I = \frac{Q \cdot q}{t}$$