ESE - 2025

MAINS EXAMINATION

QUESTIONS WITH DETAILED SOLUTIONS

ELECTRONICS & TELECOMMUNICATION ENGINEERING

(Paper-2)

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ELECTRONICS & TELECOMMUNICATION ENGINEERING

ESE_MAINS_2025_PAPER – II

Questions with Detailed Solutions

SUBJECT WISE WEIGHTAGE

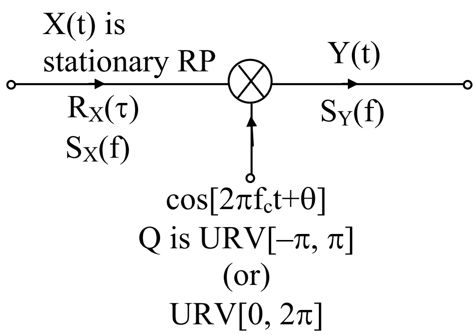
S.No	NAME OF THE SUBJECT	Marks
01	COMMUNICATION SYSTEMS	90
02	(a) CONTROL SYSTEMS (b) SIGNALS & SYSTEMS	80+30
03	COMPUTER ORGANIZATION AND ARCHITECTURE	100
04	ELECTROMAGNETICS	80
05	(a) ADVANCED ELECTRONICS (b) MICROPROCESSORS & MICROCONTROLLERS + Digital	20 20+20
06	ADVANCED COMMUNICATIONS	40
	Total Marks	480

SECTION - A

01. (a) A random process Y(t) is obtained by multiplication of a stationary process X(t) with a sinusoidal wave $\cos(2\pi f_c t + \theta)$ where the phase θ is a random variable that is uniformly distributed over the interval $[0, 2\pi]$.

Express the power spectral density of random process Y(t) in terms of power spectral density of X(t). Assume that random variable θ is independent of X(t). (10 M)

Sol:



x(t) and θ are independent

$$R_Y(\tau) = E\{Y(t)\,Y(t-\tau)\}$$

$$= E\{x(t)\cos(2\pi f_c t + \theta)x(t-\tau)\cos(2\pi f_c t - 2\pi f_c\tau + \theta)\}$$

$$= E\{x(t)\,x(t-\tau)\}\,E\{\cos(2\pi f_c t + \theta)\cos(2\pi f_c t - 2\pi f_c\tau + \theta)\}$$

$$R_Y(\tau) = R_X(\tau)\times\frac{1}{2}\cos(2\pi f_c\tau)$$

$$S_Y(f) = S_X(f) * \left[\frac{1}{4}\Delta(f-f_c) + \frac{1}{4}\Delta(f+f_c)\right]$$

$$S_Y(f) = \frac{1}{4}S_X(f-f_c) + \frac{1}{4}S_X(f+f_c)$$

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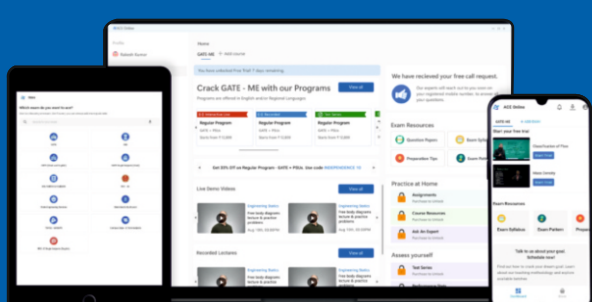

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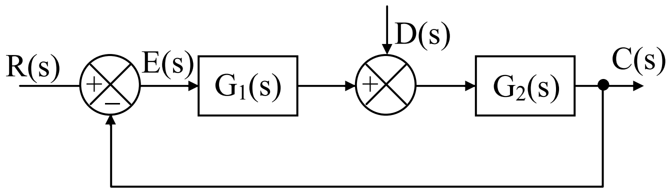
01. (b) Consider the system shown below :



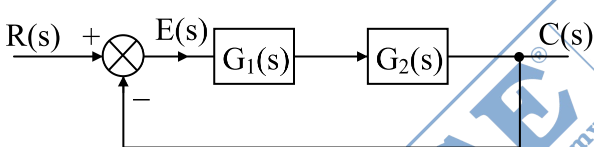
Here $G_1(s) = \dfrac{100(s+5)}{s+2}$

$$G_2(s) = \frac{5}{s(s+4)}$$

Determine the steady state error due to unit step input and a step disturbance of 10 unit.

(10 M)

Sol: **Steady state error due to unit step input [D(s) = 0]:**



$$\frac{E(s)}{R(s)} = \frac{1}{1+G_1(s).G_2(s)}$$

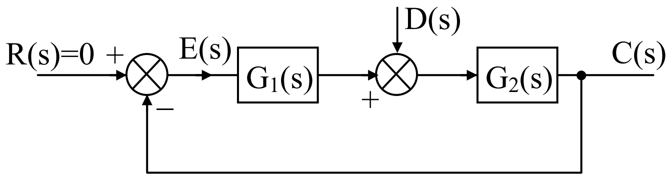
$$= \frac{1}{1+\dfrac{100(s+5)}{(s+2)}\cdot\dfrac{5}{s(s+4)}}$$

$$E(s) = \left(\frac{s(s+2)(s+4)}{s(s+2)(s+4)+500(s+5)}\right)R(s)$$

$$e_{ss} = \underset{s\to 0}{Lt}\, sE(s) = \underset{s\to 0}{Lt}\, s\left[\frac{\cancelto{0}{s}(s+2)(s+4)}{\cancelto{0}{s}(s+2)(s+4)+500(s+5)}\right]\times\left(\frac{1}{s}\right) = 0$$

Steady state error due to step disturbance:

$$\Rightarrow D(s) = \left(\frac{10}{s}\right), R(s) = 0$$



$$\frac{E(s)}{R(s)} = \frac{-G_2(s)}{1+G_1(s).G_2(s)} = \frac{\dfrac{-5}{s(s+4)}}{1+\dfrac{500(s+5)}{s(s+2)(s+4)}}$$

$$E(s) = \left(\frac{-5(s+2)}{s(s+2)(s+4)+500(s+5)}\right).D(s)$$

$$e_{ss} = \underset{s\to 0}{\text{Lt}}\, sE(s) = \underset{s\to 0}{\text{Lt}}\, s\left[\frac{-5(s+2)}{s(s+2)(s+4)+500(s+5)}\right]\times\left(\frac{10}{s}\right)$$

$$= \frac{-100}{2500} = \frac{-1}{25}$$

01. (c) Find out the time complexity of the following code segment:

```
for (i = n/2;  i < n;  i++)
    for (k = 1; k < i;  k * = 2)
        count + = n * n ;
```

(10 M)

Sol: Time Complexity Analysis – Detailed Solution

Problem

Find the time complexity of the following code segment:

```
for (i = n/2; i < n; i++)
  for (k = 1; k < i; k *= 2)
  count += n * n;
```

Analysis

Step 1 — Outer loop

The variable i runs from n/2 to n−1. Therefore, the outer loop executes exactly n/2 times, which is Θ(n).

Step 2 — Inner loop

For a fixed i, the variable k takes the values 1, 2, 4, … while k < i. The number of iterations is the

smallest t such that 2^t ≥ i, i.e., $\lceil \log_2 i \rceil = \Theta(\log i)$.

Step 3 — Total work

The body "count += n * n;" is constant-time. The total number of executions of the body is:

The total iterations of the innermost statement: $\sum_{i=n/2}^{n-1} \theta(\log i)$

Since for all $i \in [n/2, n)$, $\log(n/2) \le \log i < \log n$, and there are n/2 terms.

$$\frac{n}{2}\log\left(\frac{n}{2}\right) \le \sum_{i=n/2}^{n-1} \log i < \frac{n}{2}\log n \text{ is} \Rightarrow \theta(n \log n)$$

01. (d) Determine the divergence of the vector field $\vec{A}$ and evaluate them at the specified point :

$\vec{A} = \rho z \sin\phi\, \hat{a}_\rho + 3\rho z^2 \cos\phi\, \hat{a}_\phi$ **at (5, π/2, 1).** **(5 + 5 M)**

Sol:

$$\nabla.\bar{A} = \frac{1}{\rho}\left[\frac{\partial}{\partial\rho}(\rho\ \rho z \sin\phi) + \frac{\partial}{\partial\phi}(3\rho\ z^2 \cos\phi) + \frac{\partial}{\partial z}(\rho.0)\right]$$

$$\nabla.\bar{A} = \frac{1}{\rho}\left[2\rho z \sin\phi - 3\rho\ z^2 \sin\phi\right]$$

$$\nabla.\bar{A} = 2 z \sin\phi - 3\ z^2 \sin\phi$$

At $(\rho, \phi, z) = (5,\ \pi/2, 1)$

$$\nabla.\bar{A} = 2\times1\times1 - 3\times1^2\times1$$

$$\nabla.\bar{A} = 2 - 3 = -1$$

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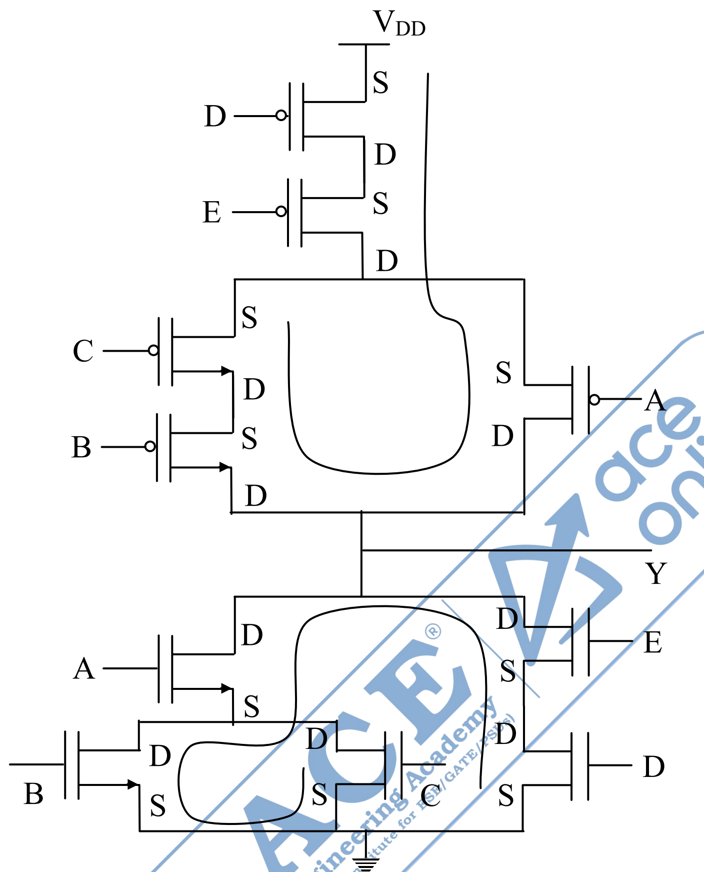
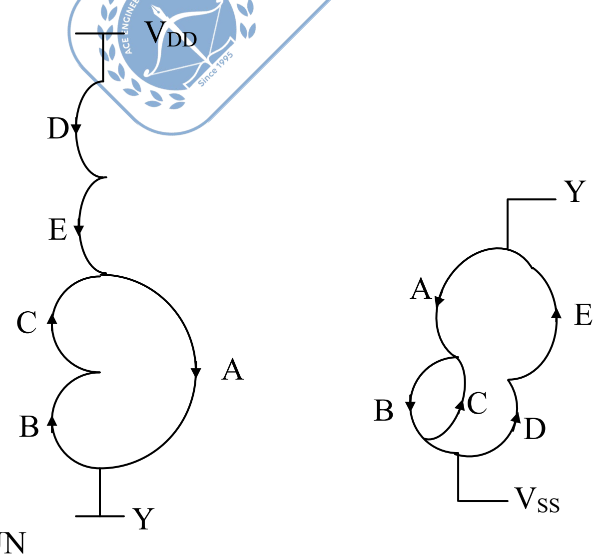
01. (e) Use Euler path method to find out optimal gate ordering for the stick diagram and layout of CMOS implementation of the Boolean expression $\overline{A(B+C)+DE}$. (10 M)

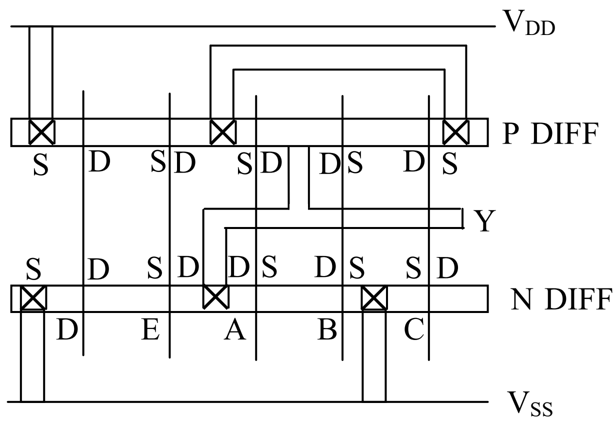
Sol:



Euler's Graph:



Stick Diagram:



01. (f) A bit stream 10011101 is received (LSB is received first). The transmitter is using standard CRC method with the generator polynomial $x^3 + 1$. Show the actual bit stream transmitted. Show that the error is detectable at the receiver's side. (5 + 5 M)

Sol: Generator polynomial = $x^3 + 1 \rightarrow 1001$

Received code word is 10011101

At receiver:

```
1 0 0 1) 1 0 0 1  1 1 0 1 (1 0 0 0 1
         1 0 0 1
         0)0 0 0 1
           0 0 0 0
           0)0 0 1 1
             0 0 0 0
             0)0 1 1 0
               0 0 0 0
               0)1 1 0 1
                 1 0 0 1
                 0) 1 0 0
```

Checksum bits are not zero. Hence error occurred.

At transmitter: No of parity bits added at end of data bits = 3

Initially all are zero

```
1 0 0 1) 1 0 0 1  1 0 0 0 (1 0 0 0 1
         1 0 0 1
         0)0 0 0 1
           0 0 0 0
           0)0 0 1 0
             0 0 0 0
             0)0 1 0 0
               0 0 0 0
               0)1 0 0 0
                 1 0 0 1
                 0) 0 0 1
```

∴ Parity bits are 001

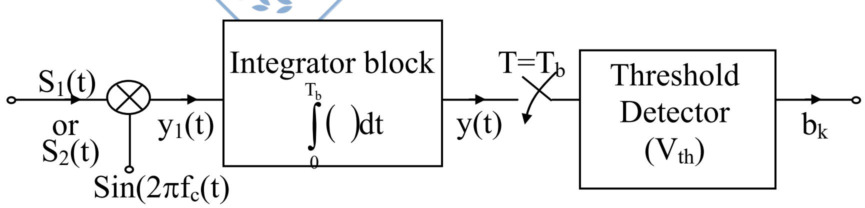
T_X code word is 10011001

02. (a) Consider that, two input signals of a Binary Phase Shift Keying (BPSK) receiver are $\pm \sin 2\pi f_c t$ (Where f_c carrier frequency). Draw the functional block diagram of a BPSK receiver to recover the bit stream of '0' and '1'. Give the necessary mathematical interpretation of the signals. (20 M)

Sol: $S_1(t) = \sin(2\pi f_c t),\ 0 \le t \le T_b$

$S_2(t) = -\sin(2\pi f_c t),\ 0 \le t \le T$

Considering coherent receiver



For $S_1(t)$ received

$$y_1(t) = \sin^2(2\pi f_c t) = \frac{1}{2} - \frac{1}{2}\cos(4\pi f_c t)$$

$$y(t) = \int_0^{T_b}\left[\frac{1}{2} - \frac{1}{2}\cos(4\pi f_c t)dt\right] = \frac{T_b}{2}\,(\text{volts})$$

For $S_2(t)$ received

$y_1(t) = -\sin^2(2\pi f_c t),\ 0 \le t \le T_b$

$$y_1(t) = -\frac{1}{2} + \frac{1}{2}\cos(4\pi f_c t), 0 \le t \le T_b$$

$$y(t) = \int_0^{T_b}\left[-\frac{1}{2} + \frac{1}{2}\cos(4\pi f_c t)\right]dt = \frac{-T_b}{2}(\text{volts})$$

At threshold detector the decision is taken

If $V_{th} \ge 0$ (volts) $\rightarrow$ Bit 1 is decoded

If $V_{th} < 0$ (volts) $\rightarrow$ Bit 0 is decoded

02. (b) Show that the maximum phase lead of a lead compensator occurs at frequency $\sqrt{ab}$, where (–a) and (–b) are the locations of zero and pole respectively of the lead compensator.

(20 M)

Sol: $\Rightarrow$ TF of Lead compensator $= \dfrac{(s+a)}{(s+b)}$ [Given]

"s" replace by "jω"

$$G_C(j\omega) = \frac{(j\omega + a)}{(j\omega + b)}$$

Phase angle $\angle\phi = \tan^{-1}\left(\frac{\omega}{a}\right) - \tan^{-1}\left(\frac{\omega}{b}\right)$

$\Rightarrow$ To get maximum phase, differentiate ϕ with respect to ω and make equal to zero.

i.e. $\dfrac{d\phi}{d\omega} = 0$

$$\frac{d\phi}{d\omega} \Rightarrow \left[\frac{1}{1+\left(\frac{\omega}{a}\right)^2}\left(\frac{1}{a}\right) - \frac{1}{1+\left(\frac{\omega}{b}\right)^2}\left(\frac{1}{b}\right)\right] = 0$$

$$\Rightarrow \left[\frac{a^2}{a^2+\omega^2}\left(\frac{1}{a}\right) - \frac{b^2}{\omega^2+b^2}\left(\frac{1}{b}\right)\right] = 0$$

$$\Rightarrow \frac{a}{a^2+\omega^2} - \frac{b}{\omega^2+b^2} = 0$$

$\Rightarrow a(\omega^2 + b^2) - b(a^2 + \omega^2) = 0$

$\Rightarrow a\omega^2 + ab^2 - a^2b - b\omega^2 = 0$

$\Rightarrow \omega^2 (a - b) = a^2b - ab^2 \Rightarrow \omega^2 (a - b) = ab(a - b)$

$\Rightarrow \omega^2 = ab\left(\frac{a-b}{a-b}\right) \Rightarrow \omega^2 = ab$

$\Rightarrow \omega = \sqrt{ab}$ rad/sec ---(1)

$\Rightarrow$ Equation (1) is the frequency at which maximum phase lead occurs $\Rightarrow \omega_m = \sqrt{ab}$ rad/sec

02. (c) A system has 512 mega bytes of main memory and 128 kilo bytes of cache memory: Memory is word addressable with 32 bit word size. Cache memory is 8 way associative with 128 byte block size. Calculate the number of tag bis required or this set associative cache mapping scheme. (20 M)

Sol: The given memory is word addressable

One word = 32 bits = 4 B

$MM = 512\ MB \Rightarrow MM = \frac{512\ MB}{4B} = 128\ M$ words $= 2^{27}$ words

$CM = 128\ KB \Rightarrow CM = \frac{128KB}{4B} = 32K$ words $= 2^{15}$ words

K = 8

$BS = 128$ byte $= \frac{128}{4} = 32$ words $= 2^5$ words

TAG bits = ?

Number of memory blocks; $MB = \frac{MM}{BS} = \frac{2^{27}}{2^5} = 2^{22}$

Number of cache lines; $CL = \frac{CM}{BS} = \frac{2^{15}}{2^5} = 2^{10}$

- Number of sets $= \frac{2^{10}}{k=8} = 2^7$

  Set offset = 7 bits

- Block offset = $\log_2 32 = 5\,\text{bits}$

$\longleftarrow$ 27 $\longrightarrow$

TAG	Set offset	Block offset
	7 bits	5 bits

TAG bits $= 27 - (7 + 5) = 15$ bits

03. (a) (i) Amplitude Modulation (AM) transmitter with a carrier power of 900 W, transmits a power of 1.1 kW, when modulated with a single sine wave. Calculate the percentage of modulation.

If the same carrier is simultaneously modulated with one more sine wave of 50% modulation, calculate the total transmitted power. (4 + 6 = 10 M)

Sol: $P_c = 900(\text{W})$

$P_t = 1.1(\text{kW})$

$$P_t = P_c\left[1+\frac{\mu^2}{2}\right]$$

$$1.1\times10^3 = 900\left[1+\frac{\mu^2}{2}\right]$$

$\therefore\ \mu = 0.666$ (or) 66.63%

Considering $\mu_1 = 0.666$

$\mu_2 = 0.5$

$\mu_t^2 = \mu_1^2 + \mu_2^2 = 0.694$

$$\therefore\ P_t = P_c\left[1+\frac{\mu_t^{\,2}}{2}\right] = 900\left[1+\frac{0.694}{2}\right] = 1.2123(\text{kW})$$

03. (a) (ii) Frequency modulation (FM) broadcast system is having a maximum frequency deviation of 75 kHz and modulating frequency of 15 kHz. Calculate the modulation Index and the required bandwidth using Carson's rule. Discuss whether this FM broadcast system is narrowband or wideband. Justify your answer. (10 M)

Sol: $\Delta f_{max} = 75(\text{kHz})$

$f_{max} = 15(\text{kHz})$

$$\beta = \frac{\Delta f_{max}}{f_{max}} = 5$$

$BW = 2(\beta + 1)f_{max} = 2[5 + 1]\ 15 \times 10^3 = 180(\text{kHz})$

As $\beta = 5$ $[\beta > 1]$ this is WBFM signal.

03. (b) (i) The forward path transfer function of a negative unity feedback system is given by $G(s) = \dfrac{K}{s(s+T)}$. Determine the values of K and T such that all the roots of characteristic equation are in the left-half plane of the vertical line passing through $s = -a$. (10 M)

Sol: $G(s) = \dfrac{K}{s(s+\tau)}, H(s) = 1$

CE: $s^2 + Ts + K = 0$

"s" replace by $(z - a)$

CE: $(z - a)^2 + T(z - a) + K = 0$

CE: $z^2 - 2az + a^2 + Tz - aT + K = 0$

CE: $z^2 + z(T - 2a) + (a^2 - aT + K) = 0$

$$\begin{array}{c|cc} z^2 & 1 & (a^2 - aT + K) \\ z^1 & (T - 2a) & \\ z^0 & (a^2 - aT + K) & \end{array}$$

To lie all the roots to the left half s = – a, all the coefficients in the first column should be positive.

$\Rightarrow (T - 2a) > 0 \Rightarrow T > 2a$

$\Rightarrow (a^2 - aT + K) > 0 \Rightarrow K > (Ta - a^2)$

If $T = 2A \Rightarrow K > (2a^2 - a^2) \Rightarrow K > a^2$

$\Rightarrow$ If $T = 2a$ and $K > a^2$, the poles lies on line $s = -a$

$\Rightarrow$ If $T > 2a$ and $K > (Ta - a^2)$, the poles lies left half of vertical line $s = -a$.

03. (b) (ii) A negative feedback control system has the forward path transfer function $G(s) = \dfrac{K(s+0.5)}{s^2(s+12)}$ and feedback transfer function H(s) = 1. Find the value of K at the breakaway points. (10 M)

Sol: $G(s) = \dfrac{K(s+0.5)}{s^2(s+12)}, H(s) = 1$

CE $\Rightarrow 1 + G(s) = 0$

CE $\Rightarrow 1 + \dfrac{K(s+0.5)}{s^2(s+12)} = 0$

$$K = -\left[\frac{s^3 + 12s^2}{(s+0.5)}\right]$$

$\Rightarrow$ For break point $\dfrac{dK}{ds} = 0$

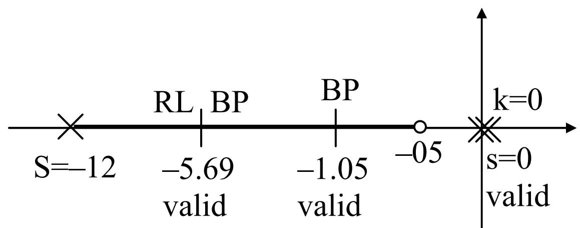
$$\frac{dK}{ds} = -\left[\frac{(3s^2 + 24s)(s+0.5) - (s^3 + 12s^2)1}{(s+0.5)^2}\right] = 0$$

$\Rightarrow 3s^3 + 24s^2 + 1.5s^2 + 12s - s^3 - 12s^2 = 0$

$\Rightarrow 2s^3 + 13.5s^2 + 12s = 0$

$\Rightarrow s(2s^2 + 13.5s + 12) = 0$

$\Rightarrow s = 0, s = -1.05$ and $s = -5.69$



Valid break points are 0, –1.05, –5.69

K value at BP:

At $s = 0 \Rightarrow K = 0$

At $s = -1.05 \Rightarrow M = 1 \Rightarrow \left|\dfrac{K(s+0.5)}{s^2(s+12)}\right| = 1$

$$\left|\frac{K(-1.05+0.5)}{(-1.05)^2(-1.05+12)}\right| = 1$$

$K = 21.95$

At $s = -5.69 \Rightarrow \left|\dfrac{K(s+0.5)}{s^2(s+12)}\right| = 1$

$$\left|\frac{K(-5.69+0.5)}{(-5.69)^2(-5.69+12)}\right| = 1$$

$K = 39.36$

03. (c) An embedded system for a plant contol uses two processes P1 and P2. High priority process P1 reads temperatures from two sensors at regular interval t and updates the latest temperature values in two fixed memory locations T1 and T2 sequentially. Low priority process P2 uses the values stored in locations T1 an T2 to calculate the average of this set of values. If the average of any set of values happens to be more than 50, then P2 calls a function to sound an alarm. The loop time of P2 is variable, but is ensured to be always less than t,

(i) Write an indicative pseudocode describing the above situation and mention what can go wrong in this case.

(ii) Suggest appropriate operating system mechanism for solving the possible code problem with appropriate modifications in the pseudocode for part (i) above. (10 + 10 M)

Sol: We have:

- **Process P1 (High Priority)**
  - Reads temperature from two sensors at fixed interval ttt.
  - Writes these readings to memory locations **T1** and **T2** sequentially.
- **Process P2 (Low Priority)**
  - Reads **T1** and **T2** from memory.
  - Calculates their average.
  - If average > 50 → triggers an alarm.
  - Runs more often than ttt, but not exactly fixed.

(i) Indicative pseudocode (without synchronization)

```
Process P1: // High priority
loop every t second:
   T1 = ReadSensor1()
   T2 = ReadSensor2()

Process P2: // Low priority
loop:
   temp1 = T1
   temp2 = T2
```

```
avg = (temp1 + temp2) / 2
if avg > 50:
    SoundAlarm()
```

This is a **race condition** problem:

- **P1** writes T1 and T2 sequentially.
- **P2** may run in between these writes, reading a **new T1** and an **old T2** (or vice versa).
- This leads to an **inconsistent average** (values from different sampling times).
- Could cause:
  - **False alarms** (avg > 50 when it shouldn't be).
  - **Missed alarms** (avg ≤ 50 when it should be > 50).

(ii) OS mechanism to fix this

Appropriate OS mechanism: Mutual Exclusion

We can use:

- **Semaphore / Mutex** to ensure P1 and P2 don't access T1 and T2 simultaneously.
- Or **disable interrupts** in small embedded systems while updating both variables (critical section).
- In real-time systems, **priority inheritance** may be needed to avoid priority inversion.

```
Semaphore mutex = 1
Process P1: // High priority
loop every t seconds:
 wait(mutex)
T1 = ReadSensor1()
T2 = ReadSensor2()
 signal(mutex)

Process P2: // Low priority
loop:
  wait(mutex)
   temp1 = T1
   temp2 = T2
    signal(mutex)
    avg = (temp1 + temp2) / 2
```

```
        if avg > 50:
            SoundAlarm()
```

- wait**(mutex)** ensures only one process is reading/writing T1 & T2 at a time.
- No possibility of partial update being read.
- Data consistency is guaranteed.

04. (a) (i) Plot the entropy function of a Binary Memoryless Source (BMS). List the important observations: from the drawn plot. (10 M)

Sol: Binary Memory Less source has only two outcomes.

S_1 and S_2

Let $P(s_1) = P$

Then $P(s_2) = 1 - P$

$\therefore$ Entropy of this source is

$$H(s) = -[P\log_2(P) + (1-P)\log_2(1-P)]$$

Considering $\frac{d}{dp}[H(s)] = 0$, to determine at value of 'P' entropy is maximized

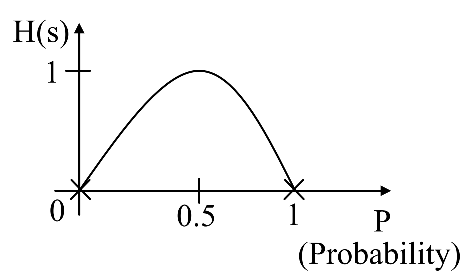
$$\Rightarrow -\left[P\times\frac{1}{P}\log_2(P) + (1-P)\frac{-1}{(1-P)} + \log_2(1-P)(-1)\right] = 0$$

$\Rightarrow \log_2(P) = \log_2(1-P)$

$\therefore 2P = 1$

$P = 1/2$

Hence H(s) is maximum when both S_1 and S_2 occur with equal probability



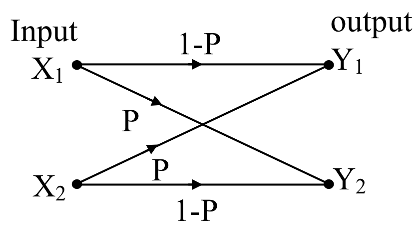
$H(s)_{at\ p=0} = 0$ (bit/symbol)

$H(s)_{at\ p=1} = 0$ (bit/symbol)

$H(s)_{at\ p=1/2} = 1$ (bit/symbol)

04. (a) (ii) Plot the curve of transition probability versus Channel capacity for a Binary Symmetric Channel (BSC). List the significant observation from the drawn plot. (10 M)

Sol: Considering BSC as shown in the figure below.



Transition probability is $P\left[\frac{Y_1}{X_2}\right] = P\left[\frac{Y_2}{X_1}\right] = P$

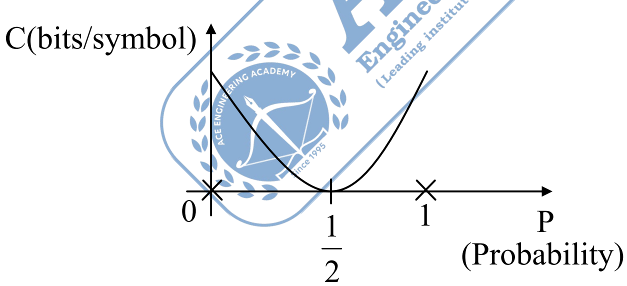
Line probability is $P\left[\frac{Y_1}{X_1}\right] = P\left[\frac{Y_2}{X_2}\right] = 1 - P$

Channel capacity, $C = 1 + P\log_2(P) + (1 - P)\log_2(1 - P)$ (bits/symbol)

At $P = 0$, $c = 1$(bit/symbol)

At $P = 1$, $c = 1$(bit/symbol)

At $P = \frac{1}{2}$, $c = 0$(bit/symbol)



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04. (b) (i) Sketch the polar plot for $G(s)H(s)=\dfrac{1}{s^4(s+2)}$

(ii) How do you count the number of encirclement of the

(A) Origin

(B) (–1 + j0)

points? Use examples to justify the answer **(12+4×2 = 20)**

Sol:

(i) $G(s)H(s)=\dfrac{1}{s^4(s+2)}$

$S \to j\omega \Rightarrow GH(j\omega)=\dfrac{1}{(j\omega)^4(j\omega+2)}$

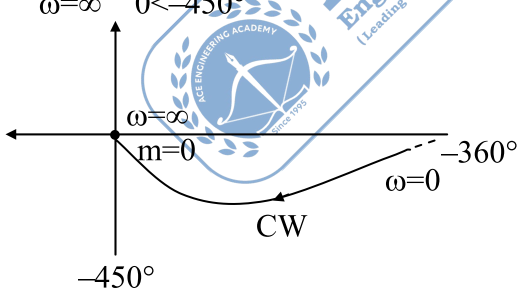
$M=\dfrac{1}{\omega^4\sqrt{\omega^2+4}}$

$<\phi = -360° - \tan^{-1}\left(\dfrac{\omega}{2}\right)$

⇒ Negative "tan" term push the polar plot in clockwise direction.

ω=0 ∞<–360°

ω=∞ 0<–450°



(ii)

(A) Counting Encirclements of the origin:

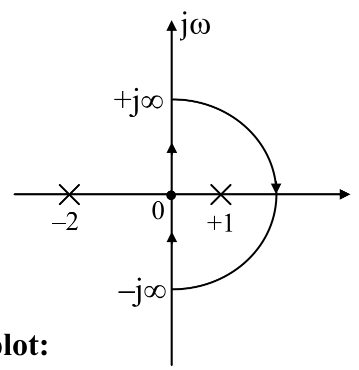
→ The number of encirclements about the origin of the nyquist plot of G(s)H(s) relates to the number of open loop poles and open loop zeros in the right half of the s-plane.

$N_{(origin)}$ = (open loop poles RHS) – (open loop zeros RHS)

Ex: $G(s)H(s) = \left(\dfrac{s+2}{s-1}\right)$

Verification : $\Rightarrow N_{origin} = 1 - 0 = 1$ (Once encirded origin)

Nyquist Contour



Nyquist plot:

$$M = \sqrt{\frac{\omega^2 + 4}{\omega^2 + 1}}$$

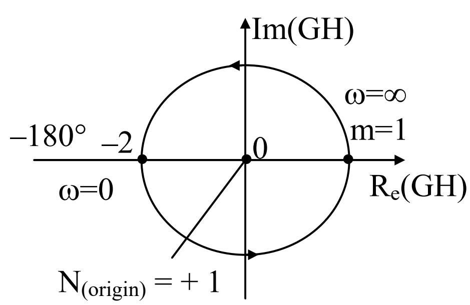
$$< \phi = -\left[180^\circ - \tan^{-1}(\omega)\right] + \tan^{-1}\left(\frac{\omega}{2}\right)$$

$$= -180^\circ + \tan^{-1}(\omega) + \tan^{-1}\left(\frac{\omega}{2}\right)$$

$\omega = 0$ $\quad$ $2 < -180^\circ$

$\omega = \infty$ $\quad$ $1 < 0^\circ$

$\Rightarrow$ Positive "tan" push the plot in anticlockwise direction



$\Rightarrow N_{(origin)} = \pm 1$ (once encircled origin). Hence verified.

(B) Counting encirclements of the critical point (–1 + j0):

→ The point (–1 + j0) is the critical point for closed loop stability analysis in the nyquist criterion.

$N(-1, j0) = (P - Z)$

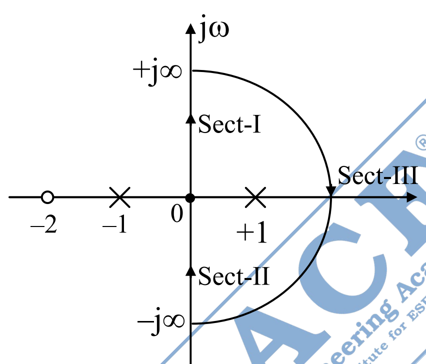
Where P → OL poles lies in the RHS

Z → CL poles lies in the RHS

Ex: $G(s)H(s) = \dfrac{(s+2)}{(s+1)(s-1)}$

OL poles RHS P = 1

Nyquist contour:



$$M = \frac{\sqrt{\omega^2 + 4}}{(\omega^2 + 1)}$$

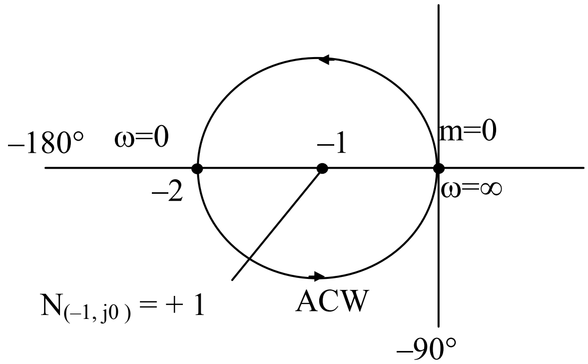
$$<\phi = -\tan^{-1}(\omega) - [180^\circ - \tan^{-1}(\omega)] + \tan^{-1}\left(\frac{\omega}{2}\right)$$

$$<\phi = -180^\circ + \tan^{-1}\left(\frac{\omega}{2}\right)$$

→ Anticlock wise direction

$\omega = 0$ $\quad$ $2 < -180^\circ$

$\omega = \infty$ $\quad$ $0 < -90^\circ$



$N(-1) = (P - Z) \Rightarrow +1 = +1 - z \Rightarrow z = 0 \Rightarrow$ no closed loop pole RHS CL system stable.

04. (c) A demand paged virtual memory system uses 4 page frames. Consider following string of memory references:

1 2 4 0 5 7 4 3 4 0

Indicate the page frames for the reference string and determine the number of page faults for

(i) FIFO (Fist In First Out) page replacement algorithm

(ii) LRU (Least Recently Used) page replacement algorithm (10 + 10 M)

Sol:

(i) FIFO: Number of page faults = 7

	1	2	4	0	5	7	4	3	4	0
				0	0	0	0	3	3	3
			4	4	4	4	4	4	4	4
		2	2	2	2	7	7	7	7	7
	1	1	1	1	5	5	5	5	5	0
	×	×	×	×	×	×	✓	×	✓	×

(ii) LRU:

				0	0	0	0	3	3	3
			4	4	4	4	4	4	4	4
		2	2	2	2	7	7	7	7	7
	1	1	1	1	5	5	5	5	5	0
	×	×	×	×	×	×	✓	×	✓	×

$\therefore$ Number of page faults = 7

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SECTION - B

05. (a) Consider a telephone channel having a bandwidth of 3 kHz and the channel capacity of 30 kbps. Calculate the Signal-to-Noise ratio of this digial telephone communication system.

(10 M)

Sol: BW = 3 (kHz)

C = 30(kbps)

$$C = B\log_2\left(1+\frac{S}{N}\right)$$

$$30\times10^3 = 3\times10^3\log_2\left(1+\frac{S}{N}\right)$$

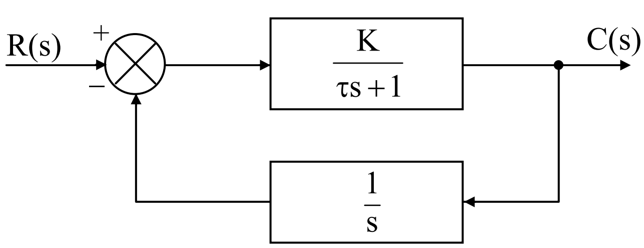
$$\therefore\ 1+\frac{S}{N} = 2^{10} = 1024$$

$$\frac{S}{N} = 1023 = 10\log_{10}(1023) = 30.098(\text{dB})$$

05. (b) Figure approximately represents a differentiator, Its transfer function

$$\frac{C(s)}{R(s)} = \frac{Ks}{s(\tau s+1)+K}.\ \textbf{Note that}\ \lim_{\tau\to0,K\to\infty}\frac{C(s)}{R(s)} = s.$$

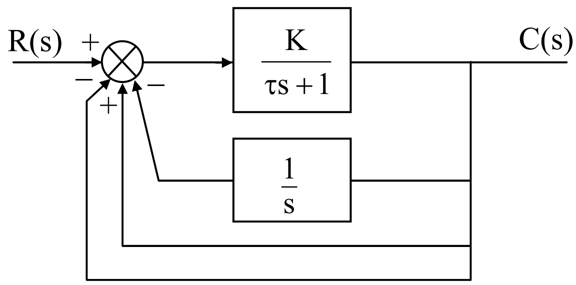
Find the step, ramp and parabolic error constants for this system, where the ideal system is assumed to be a differentiator.

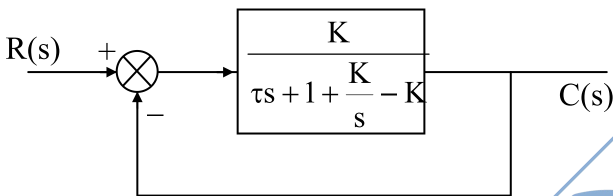


(10 M)

Sol: $\text{CLTF} = \dfrac{Ks}{s(s\tau+1)+K}$

OLTF:- add one positive and one negative unity feedback





$$G(s) = \left(\frac{Ks}{s(s\tau+1)+K-Ks}\right), H(s) = 1$$

$$G(s) = \frac{Ks}{s^2\tau+s(1-K)+K}, H(s) = 1$$

Step error constant:

$$K_p = \underset{s\to 0}{\text{Lt}}\, G(s) = \underset{s\to 0}{\text{Lt}}\left(\frac{K\cancel{s}^{\,0}}{s^2\tau+s(1-K)+K}\right) = 0$$

Ramp error constant:

$$K_v = \underset{s\to 0}{\text{Lt}}\, sG(s) = \underset{s\to 0}{\text{Lt}}\, \cancel{s}^{\,0}\left(\frac{Ks}{s^2\tau+s(1-K)+K}\right) = 0$$

Parabolic error constant:

$$K_a = \underset{s\to 0}{\text{Lt}}\, s^2G(s) = \underset{s\to 0}{\text{Lt}}\, \cancel{s}^{2\,0}\left(\frac{Ks}{s^2\tau+s(1-K)+K}\right) = 0$$

$\Rightarrow$ The error constants for all the inputs is 0.

$\Rightarrow$ This implies that the given system is differentiator. The steady state error becomes very large for all the inputs.

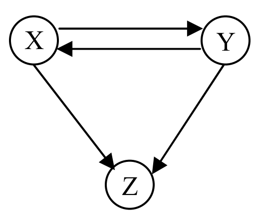
05. (c) Draw precedence graph for the schedule of transactions X, Y, and Z shown below and find if the schedule is conflict serializable ?

X	Y	Z
Read (A)		
Write (B)		
	Read (C)	
	Write (A)	
	Write (C)	
	Commit	
Read (B)		
Write (A)		
Commit		
		Write (A)
		Commit

↓ time

(10 M)

Sol: The precedence graph for the schedule given is



As the precedence graph has a cycle from X → Y and Y→Z then the given schedule is not conflict serializable.

05. (d) Find the maximum effective area of a λ/2 wire dipole operating at 300 MHz. How much power is received with an incident plane wave of strength 2 mV/m ?

(5 + 5 = 10 M)

Sol: $$D = \frac{4\pi}{\lambda^2} A_e$$

$$\Rightarrow A_e = \frac{1.64\lambda^2}{4\pi}$$

$$\lambda = \frac{3\times10^8}{300\times10^6} = 1\text{m}$$

$$A_e = \frac{1.64\lambda^2}{4\pi} m^2$$

$$S = \frac{|E|^2}{2\eta_0} = \frac{(2\times10^{-3})^2}{2\times120\pi}$$

$$A_e = \frac{P_r}{S}$$

$$P_r = SA_e = \frac{4\times10^{-6}}{2\times120\pi}\times\frac{1.64}{4\pi} = 0.69\times10^{-9}$$

$$P_r = 0.69\,\text{nW}$$

05. (e) Show that the accumulator is the inverse system of a backward difference system. (10 M)

Sol: Backward difference equation is

$$y[n] = x[n] - x[n-1] \qquad\qquad x[n-n_0] \xrightarrow{Z.T} z^{-n_0}X(z)$$

$$\downarrow \text{Z.T}$$

$$Y(z) = X(z)(1-z^{-1})$$

$$\text{T.F} \quad H(z) = \frac{Y(z)}{X(z)} = 1 - z^{-1}$$

$$h[n] * h_{inv}[n] = \delta[n]$$

$$\downarrow \text{Z.T}$$

$$H(z)\,H_{inv}(z) = 1 \Rightarrow H_{inv}(z) = \frac{1}{H(z)} = \frac{1}{1-z^{-1}}$$

$$\downarrow \text{I.Z.T}$$

$$h_{inv}[n] = u[n] = \sum_{k=-\infty}^{n} \delta[k]$$

$$y[n] = \sum_{k=-\infty}^{n} x[k] \rightarrow \text{Accumulator}$$

$$\longrightarrow \boxed{y[n] = x[n] - x[n-1]} \longrightarrow \boxed{y[n] = \sum_{k=-\infty}^{n} x[k]} \longrightarrow$$

05. (f) A double-heterojunction InGaAsP light emitting diode (LED) used in a Fiber optic communication system emitting a peak wavelength of 1310 nm has radiative and non radiative recombination times of 30 ns and 100 ns respectively. The drive current is 40 mA. Calculate :

(i) Bulk recombination life time

(ii) Internal Quantum efficiency

(iii) Internal power of the LED **(3 + 3 + 4 = 10 M)**

Sol:

(i) Bulk recombination lifetime (τ_b):

1. The bulk recombination lifetime is given by the formula:

$$\frac{1}{\tau_b} = \frac{1}{\tau_r} + \frac{1}{\tau_{nr}}$$

Where τ_r is the radiative recombination time and τ_{nr} is the non-radiative recombination time

2. Given $\tau_r = 30$ ns and $\tau_{nr} = 100$ ns

3. Substitute the values:

$$\frac{1}{\tau_b} = \frac{1}{30\times10^{-9}} + \frac{1}{100\times10^{-9}}$$

$$\frac{1}{\tau_b} = \frac{100\times10^{9}+30\times10^{9}}{3000\times10^{-18}\times10^{9}} = \frac{130\times10^{9}}{3000\times10^{-9}}$$

$$\frac{1}{\tau_b} = \frac{130}{3000}\times10^{9} = \frac{13}{300}\times10^{9}$$

$$\tau_b = \frac{300}{13}\times10^{-9}\text{ s} \approx 23.08\text{ ns}$$

The bulk recombination lifetime is approximately 23.08 ns.

(ii) Internal Quantum Efficiency (η_{int}):

1. The internal quantum efficiency is given by the formula:

$$\eta_{int} = \frac{\tau_b}{\tau_r}$$

2. Given $\tau_b \approx 23.08$ ns and $\tau_r \approx 30$ ns

3. Substitute the values:

$$\eta_{int} = \frac{23.08 \times 10^{-9}}{30 \times 10^{-9}} \approx 0.769$$

The internal quantum efficiency is approximately 0.769 or 76.9 %.

(iii) Internal Power of the LED (P_{int}):

1. The internal power of the LED is given by the formula:

$$P_{int} = \eta_{int} \times \frac{hc}{\lambda} \times \frac{I}{e}$$

Where h is Planck's constant (6.626×10^{-34} J.s), c is the speed of light (3×10^{8} m/s), λ is the peak wavelength (1310 nm), I is the drive current (40 mA) and e is the elementary charge (1.602×10^{-19} C).

2. Substitute the values:

$$P_{int} = 0.769 \times \frac{6.626 \times 10^{-34} \times 3 \times 10^{8}}{1310 \times 10^{-9}} \times \frac{40 \times 10^{-3}}{1.602 \times 10^{-19}}$$

$$P_{int} = 0.769 \times (1.517 \times 10^{-19}) \times (2.497 \times 10^{17})$$

$$P_{int} = 0.769 \times 0.0378$$

$$P_{int} = 0.029\,\text{W} \quad \text{or} \quad 29\,\text{mW}$$

The internal power of the LED is approximately 29 mW.

06. (a) The z-component of magnetic field for the dominant mode propagating in air-filled waveguide in the z-direction at 10 GHz is given by the following expression:

$H_z(x\ z) = 10\cos(43.74\,\pi x)e^{-j\beta_z z}$, **A/m**

Find:

(i) the cutoff wave number

(ii) the broader dimension of the guide

(iii) the phase velocity

(iv) the wave impedance **(5 + 5 + 5 + 5 = 20 M)**

Sol: Given: $H_z(x\ z) = 10\cos(43.74\,\pi x)e^{-j\beta_z z}$ A / m

$f = 10$ GHz

$\frac{m\pi}{a} = 43.74\pi,\ f = 10$ GHz

TE_{10} mode:

$$\frac{\pi}{a} = 43.74\pi$$

$$a = \frac{1}{43.74} = 2.28\,\text{cm}$$

$$\eta_{TE_{10}} = \frac{120\pi}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}} \quad \text{where } f_c = \frac{1}{2\sqrt{\mu_0\varepsilon_0}} \times \frac{1}{2.2\times10^{-2}} = \frac{3\times10^8\times10^2}{4.4} = 6.8\,\text{GHz}$$

$$= \frac{120\pi}{\sqrt{1-\left(\frac{6.8}{10}\right)^2}} = \frac{120\pi}{\sqrt{0.53}} = 517.83\,\Omega$$

$$v_p = \frac{3\times10^8}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}} = \frac{3\times10^8}{\sqrt{0.53}} = 4.12\times10^8\ \text{m/s}$$

$$\overline{\lambda} = \frac{c/f}{\sqrt{0.53}} = \frac{(3\times10^8/10\times10^9)}{\sqrt{0.53}} = \frac{0.03}{\sqrt{0.53}}$$

$$\overline{\lambda} = 4.12\,\text{cm}$$

$$\overline{\beta} = \frac{2\pi}{\overline{\lambda}} = \frac{2\pi}{4.12\times10^{-2}} = 152.5\,\text{rad/m}$$

06. (b) Using overlap add method of block filtering find the output of a filter with impulse response $h[n] = \{\underset{\uparrow}{2}, \ 2, \ 0, \ 0......\}$ and input $x[n] = \{\underset{\uparrow}{1}, \ -2, \ 3, \ 0, \ -1 \ \ 2\}$.

Take L(value of non-overlapping blocks) = 3. (20 M)

Sol: Total length of the input sequence x[n] is 6 and length of I.R is m = 2.

Let the length of each section $x_r[n]$ is N = 3

Since h[n] is of length m = 2 and $x_r[n]$ is of length N= 3, linear convolution of length (N + m – 1) = (3 + 2 – 1) = 4. We have to pad each section by (m – 1) = (2 – 1) = 1 zero and h[n] by (N –1) = (3 – 1) = 2 zeros so that their lengths will be equal to length of results of linear convolution. Thus the sections (or blocks) of input sequence are

$x_0[n] = \{1, -2, 3, \underbrace{0}_{\text{1 zero}}\}$

$x_1[n] = \{0, -1, 2, \underbrace{0}_{\text{1 zero}}\}$

Now we will compute linear convolution using 4 points circular convolution of each section $x_r[n]$ with h[n] to get $y_r[n]$

$y_0[n] = h[n] \otimes x_0[n] = \{2, -2, 2, 6, \underset{\text{added}}{0}\}$

$$
\begin{array}{lccccc}
 & 1 & -2 & 3 & 0 & \\
 & 2 & 2 & & & \\
\hline
 & 2 & -4 & 6 & 0 & \\
 & & 2 & -4 & 6 & 0 \\
\hline
y_0[n] \rightarrow & 2 & -2 & 2 & 6 & 0
\end{array}
$$

$y_1[n] = h[n] \otimes x_1[n]$

$$
\begin{array}{lccccc}
 & 0 & -1 & 2 & 0 & \\
 & 2 & 2 & & & \\
\hline
 & 0 & -2 & 4 & 0 & \\
 & & 0 & -2 & 4 & 0 \\
\hline
y_1[n] \rightarrow & \underset{\text{added}}{0} & -2 & 2 & 4 & \underset{\text{added}}{0}
\end{array}
$$

The filtered output sections will overlap by (m – 1) = 1 sample and there overlap samples must be added to get correct final result

y[n] = {2, –2, 2, (6 +0), –2, 2, 4}

06. (c) (i) The loss computed for a single-mode optical fiber cable is given as 0.25 dB/km. Determine the optical power at a distance 100 km from a light source of 0.1 mW. (10 M)

Sol: Loss = 0.25 dB/km

Total distance = 100 kms

$\therefore$ Total loss = 25 dB

$P_T = 0.1\text{ mW} = 10^{-4}$ Watts

$$P_R = \frac{10^{-4}}{10^{2.5}} = 0.3162\ (\mu W)$$

06. (c) (ii) Consider that 6 GHz is the receiving frequency at satellite transponder from the earth station and 4 GHz is the output frequency of the satellite transponder. Draw the block diagram of the satellite transponder and explain the functionality of each block. (10 M)

Sol: Transponder:

- A typical satellite transponder consists of an input bandlimiting device (BPF), an input low-noise amplifier (LNA), a frequency translator, a low-level power amplifier, and an output bandpass filter.
- The below figure shows a simplified block diagram of a satellite transponder. This transponder is an RF-to-RF repeater. Other transponder configurations are IF and baseband repeaters similar to those used in microwave repeaters.

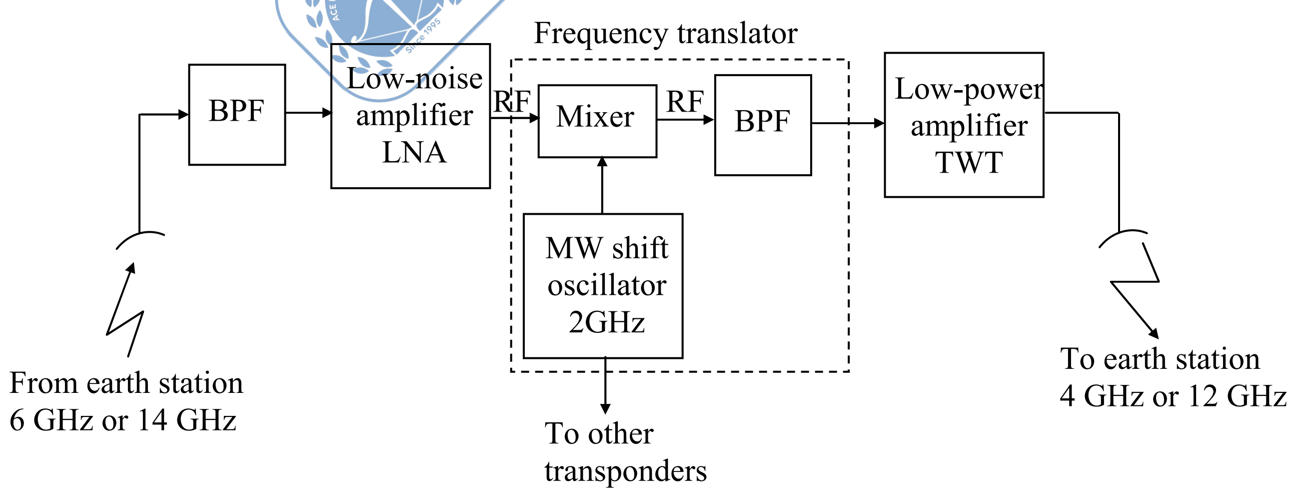


Fig. Satellite transponder

- In above figure the input BPF limits the total noise applied to the input of the LNA. (A common device used as an LNA is a tunnel diode).
- The output of the LNA is fed to a frequency translator (a shift oscillator and BPF), which converts the high-band uplink frequency to the low-band downlink frequency.
- The low-level power amplifier, which is commonly a travelling-wave tube, amplifies the RF signal for transmission through the downlink to earth station receivers.
- Each RF satellite channel requires a separate transponder.

07. (a) Given a uniform plane wave in air as

$\vec{E}_i = 40\cos(\omega t - \beta z)\hat{a}_x + 30\sin(\omega t - \beta z)\hat{a}_y$ **, V/m**

Find $\vec{H}_i$. If the wave encounters a perfectly conducting plate normal to the z-axis at z = 0, find the reflected wave $\vec{E}_r$ and $\vec{H}_r$. Assume $\epsilon_r = 1$. **(20 M)**

Sol: $\overline{E}_i = 40\cos(\omega t - \beta z)\hat{x} + 30\sin(\omega t - \beta z)\hat{y}$

(1) AIR | **(2) PERFECT CONDUCTOR**

$\eta_1 = \eta_0 = 120\pi$ $\quad (\sigma \to \infty) \quad \eta_2 = \sqrt{\dfrac{j\omega\mu}{\sigma + j\omega\varepsilon}} = 0$

$$\Gamma = \frac{\eta_2 - \eta_1}{\eta_2 + \eta_1} = -1 = \frac{E_r}{E_i}$$

$$\overline{E}_r = -\overline{E}_i = -[40\cos(\omega t + \beta z)\hat{x} + 30\sin(\omega t + \beta z)\hat{y}]$$

UPW (–ve z-direction)

$$-\frac{E_x}{H_y} = +\frac{E_y}{H_x} = \eta_1 = 120\pi$$

$$H_y = -\left(\frac{-40\cos(\omega t + \beta z)}{120\pi}\right) = \frac{1}{3\pi}\cos(\omega t + \beta z)$$

$$H_x = \frac{-30\sin(\omega t + \beta z)}{120\pi} = -\frac{1}{4\pi}\sin(\omega t + \beta z)$$

$$\overline{H} = -\frac{1}{4\pi}\sin(\omega t + \beta z)\hat{x} + \frac{1}{3\pi}\cos(\omega t + \beta z)\hat{y}$$

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MEGA MOCK TEST
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RANK 7 EE
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RANK 20 CE
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MEGA MOCK TEST
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AND MANY MORE...

500+ SELECTIONS

CE : 434 | EE : 61 | ME : 20

07. (b) A light bulb L turns ON and OFF depending on the positions of two switches P and Q. P and Q never change positions simultaneously. L is OFF when P is in OFF position irrespective of the position of switch Q. L tums ON when Q toggles its position while P is in ON position, and then remains ON until P goes to OFF position.

Design an asynchronous circuit to implement the above logic. Derive the minimal-sum Boolean expressions for the output and next state variables in terms of the inputs and present state variables. (20 M)

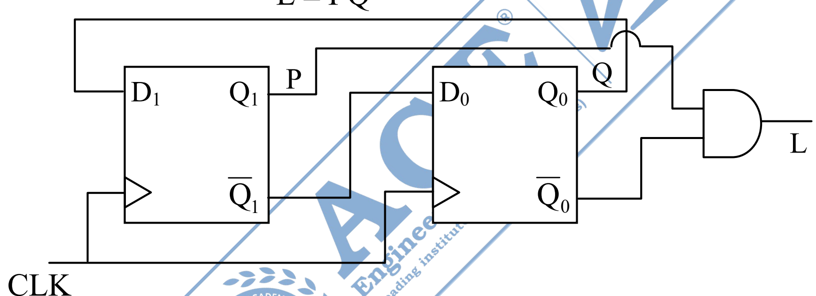
Sol:

PS	NS	FF i/p's	o/p(L)
PQ	PQ	D_1D_0	L
00	01	01	0
01	11	11	0
11	10	10	0
10	00	00	1

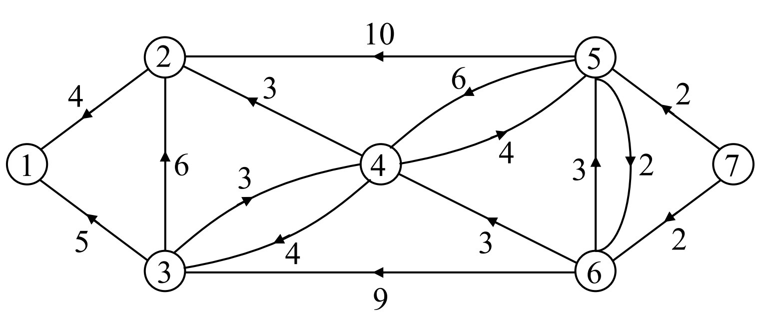
$$D_1 = Q$$

$$D_0 = \overline{P}$$

$$L = P\overline{Q}$$



07. (c) Find the shortest path tree from every node to node 1 for the graph of figure shown using the Bellman-Ford and Dijkstra algorithms.

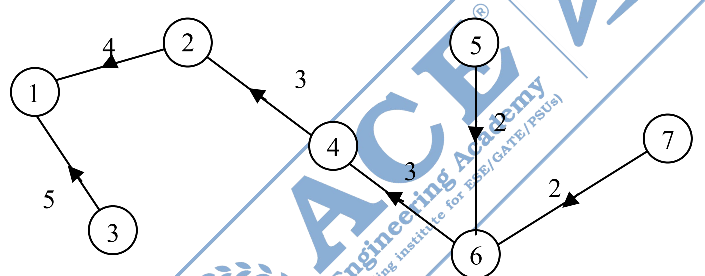


(10 + 10 = 20)

Sol:

	1	2	3	4	5	6	7
S = {1}	0*	∞	∞	∞	∞	∞	∞
S = {1, 2}	0*	4*	5	∞	∞	∞	∞
S = {1, 2, 3}	0*	4*	5*	7	14	∞	∞
S = {1, 2, 3, 4}	0*	4*	5*	7*	14	14	∞
S = {1, 2, 3, 4, 6}	0*	4*	5*	7*	13	10*	∞
S = {1, 2, 3, 4, 6, 5}	0*	4*	5*	7*	12*	10*	12
S = {1, 2, 3, 4, 6, 5, 7}	0*	4*	5*	7*	12*	10*	12*

Shortest path tree: (Both Bellman ford, Dijkstra provide the same DFS Tree



Source	**Destination**	**Shortest path**	**Path cost**
1	2	2 → 1	: 4
3	1	3 → 1	: 5
4	1	4 → 2 → 1	: 7
6	1	6 → 4 → 2 → 1	: 10
5	1	5 → 6 → 4 → 2 → 1	: 12
7	1	7 → 6 → 4 → 2 → 1	: 14

Hearty Congratulations

To our students CIVIL ENGINEERING

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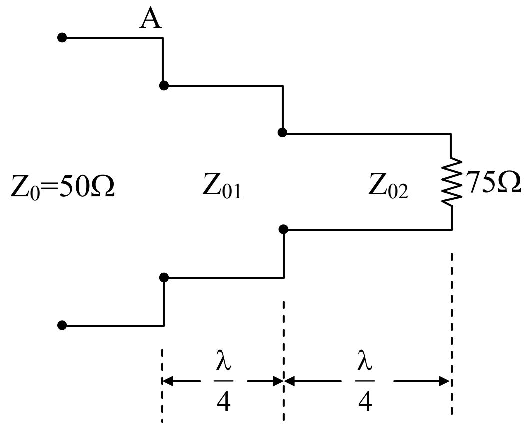
& many more..

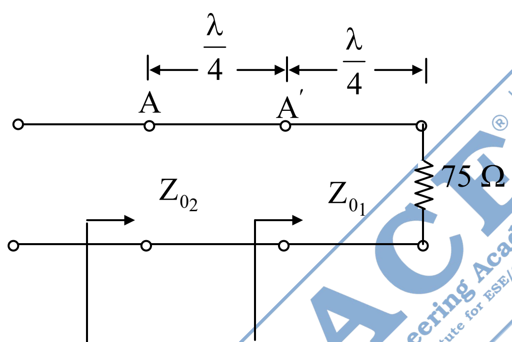
Total 150+ Selections | **CE-98** | **EE-29** | **ME-24**

08. (a) (i) Two λ/4 transformers in tandem are to connect a 50 Ω line to a 75 Ω load as given below:



Determine the characteristic impedance Z_{o1} if Z_{o2} = 30 Ω and there is no reflected wave to the left of A. (10 M)

Sol:



$$Z_A = \frac{(Z_{02})^2}{Z_{A'}} \qquad Z_{A'} = \frac{(Z_{01})^2}{75}$$

$$\Rightarrow Z_A = Z_0 = 50 = \frac{(Z_{02})^2}{Z_{A'}} \qquad \text{where} \quad Z_{A'} = \frac{(Z_{02})^2}{75}$$

$$Z_{02} = \sqrt{Z_{A'}\,50}$$

$$Z_{02} = \sqrt{\frac{(Z_{01})^2}{75} \times 50} = Z_{01}\sqrt{\frac{2}{3}}$$

$$30 = Z_{01}\sqrt{\frac{2}{3}}$$

$$Z_{01} = 30\sqrt{\frac{3}{2}}$$

$$Z_{01} = 30\sqrt{1.5} = 36.74\ \Omega$$

08. (a) (ii) A distortionless transmission line operating at 250 MHz has R = 30 Ω/m, L = 200 nH/m and C = 80 pF/m. After how many meters travelling along the line, will the voltage wave get reduced to 30% of its initial value. (10 M)

Sol: Given transmission line is distortionless

$$\Rightarrow \frac{R}{L} = \frac{G}{C}$$

$R = 30\Omega/m$, $f = 250\times10^{6}$ Hz

$L = 200\,nH/m$

$C = 80\,pF/m$

$$Z_0 = \sqrt{\frac{L}{C}} = \sqrt{\frac{200\times10^{-9}}{80\times10^{-12}}} = 50\Omega$$

Propagation Constant,

$$\gamma = \alpha + j\beta = \sqrt{(R+j\omega L)(G+j\omega C)}$$

$$= \sqrt{(R+j\omega L)\left(\frac{RC}{L}+j\omega C\right)} = \sqrt{(R+j\omega L)\left(\frac{RC+j\omega LC}{L}\right)}$$

$$= \sqrt{\frac{1}{L}(R+j\omega L)\; C(R+j\omega L)} = \sqrt{\frac{C}{L}(R+j\omega L)^2}$$

$$= \sqrt{\frac{C}{L}}(R+j\omega L)$$

$$= R\sqrt{\frac{C}{L}} + j\omega\sqrt{LC}$$

$$= 30\sqrt{\frac{80\times10^{-12}}{200\times10^{-9}}} + j2\pi\times250\times10^{6}\times\sqrt{200\times10^{-9}\times80\times10^{-12}}$$

$$= \frac{3}{5} + j2\pi$$

$$= (0.6 + j6.283)\ /m$$

So, $\alpha = 0.6$ Np/m & $\beta = 6.283$ rad/m

Now $V_0 e^{-\alpha d} = 0.3 V_0$

$$\Rightarrow e^{-\alpha d} = 0.3 \Rightarrow -\alpha d = \ln(0.3)$$


Hearty Congratulations
to our students GATE - 2025
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AIR 3 PI Sadhan Anumala
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AIR 8 IN Pushpendra Payal
AIR 8 CS Rishi Sharma
AIR 9 EC Sai Charan Chilukuri
AIR 9 ME Rahul Paliwal
AIR 9 PI Anish Vanapalli
AIR 10 EE Neelava Mukherjee
AIR 10 ME Ashutosh kumar
AIR 10 ME Jetti Ganateja
AIR 10 ME Pitchika Kumar Vasu
AIR 10 CE Adnan Quasain
& mamy more....

$$\Rightarrow d = \frac{1}{\alpha} \times \ln\left(\frac{1}{0.3}\right)$$

$$d = \frac{1}{0.6} \times \ln\left(\frac{1}{0.3}\right) = 2\text{ m}$$

So after traveling 2 m along the line, the voltage wave get reduced to 30 % of its initial value.

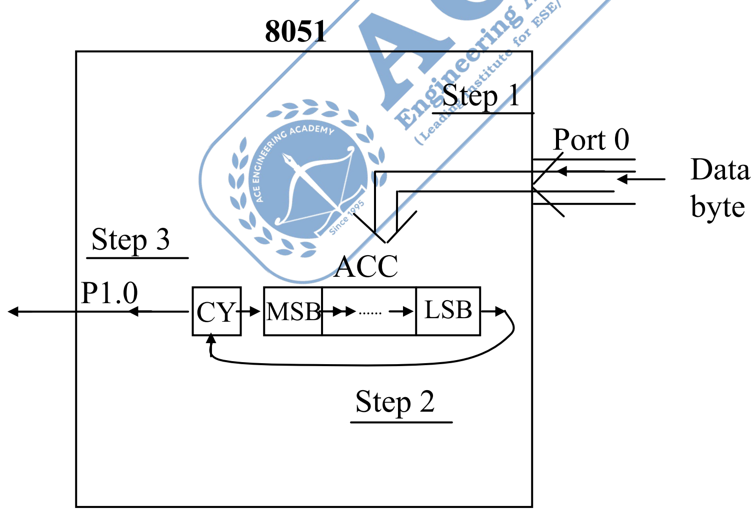
08. (b) A data byte read from port 0 of 8051 microcontroller is to be sent out serially from bit 0 of port 1. Each bit duration for serial transmission is 2 milliseconds and least significant bit goes out first. Write assembly language program using timer 0 for the delay. Assume crystal clock frequency to be 12 MHz. (20 M)

Sol:

- Data byte read from port 0 of 8051 microcontroller is to be sent serially out via P1.0 Pin.
- There are 2 dedicated serial port pins TXD and RXD in port 3 and corresponding SFRs like, SBUF, SCON and PCON.

  But it is given that we need to send the data bit via a port pin.

  Therefore, let's use logic of shifting the byte to isolate each bit and then sending it out.
- Ruff idea



Step 1: Receive data byte into ACC.

Step 2: Isolate each bit starting from LSB by rotating into CY.

Step 3: Move CY to P1.0 and call for 2ms delay

Step 4: Repeat for 8 times

- Timer 0 is to be used for creating 2ms Time delay.
- Time frequency = $\frac{f_{clock}}{12}$

$$= \frac{12\,\text{MHz}}{12} \quad (\because \text{ given that 12 MHz clock frequency})$$

$$= 1\text{ MHz}$$

- Timer clock = $\frac{1}{1\,\text{MHz}} = 1\ \mu s$
- 2 ms delay is required

  2 ms = Timer count × 1 μs

  $$\Rightarrow \quad \text{Timer count} = \frac{2\,\text{ms}}{1\,\mu s} \text{ i.e., } \frac{\text{Delay}}{\text{tick}}$$

  $$= 2000$$

- Let's use Timer 0 as 16 bit Timer (mode 1)
- We need to initialize TMOD register for Timer mode configuration and also TH0, TL0 to be initialized with timer count.
- Timer run control bit TR0 and timer over flow flag bit TF0 of TCON will be used to start/stop timer 0 and to check overflow respectively in delay subroutine.

- Timer "Counts up" from the initial timer count loaded into TH0 and TL0 until it overflows.

  $$\text{Timer Count} = 65536 - \frac{\text{Delay}}{\text{tick}}$$

  $$= 65536 - \frac{2\,\text{ms}}{1\,\mu s}$$

  $$= 65536 - \frac{2000\,\mu s}{1\,\mu s}$$

  $$= 65536 - 2000$$

  $$= 63536 \text{ in decimal}$$

  $$= \text{F8A0H}$$

Hearty Congratulations to our students ESE - 2024

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AIR 1
Himanshu T

AIR 1
Rajan Kumar

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AIR 9
KRISHNA KUMAR D

AIR 10
RAJESH BADUGU

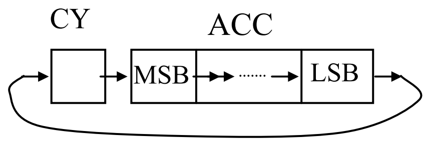
AIR 10
RAJVARDHAN SHARMA

AIR 10
AKSHAY VIDHATE

TOTAL 36 SELECTIONS IN TOP 10 CE: 09 | ME: 10 | EE: 08 | E&T: 09

```
          MOV A, P0       ;  (A) ← data byte at port 0
          MOV R7, #08H ;  (R7) = 08H for count of shifting

LOOP:  RRC A              ;  Rotate Right (A) through carry
```

; 

This is for isolating each bit

```
          MOV P0.1, C       ; (P0.1) ← (CY)
          ACALL DELAY ; 2ms Time delay subroutine called
          DJNZ R7, LOOP ; Decrement counter R7 and
                              ;  Jump if (R7) ≠ 00H to LOOP LABEL
                              ;  first isolating next bit into carry

HERE: SJMP HERE          ;  for putting 8051 in infinite LOOP
                              ; and also for separating sub routine
                              ; from main program

DELAY: MOV TMOD, #01H  ; Timer 0 is mode, Gate bit = 0 , C/T̅  = 0
            MOV TH0, #0F8H  ; Timer Count for 2ms delay
            MOV TL0, #0A0H  ; is F8A0H
            SETB TR0               ; Start timer 0
AGAIN: JNB TF0, AGAIN    ; Continue to be in this loop till
                                ; TF0 = 0 and break as TF0 = 1
           CLR TR0                ; Clear Timer 0 Run control bit
           CLR TF0                ; Clear Timer 0 Over flow bit
           RET                      ; Return to Main program
```

08. (c) (i) The downlink of a satellite communication operated at 4 GHz, the receiving antenna is a parabolic reflector with a diameter of 3.6 m and efficiency is 0.7. Calculate the gain of the receiving antenna in dB. (10 M)

Sol: $f = 4\times10^9$ Hz

Diameter = 3.6 mts

$\eta = 0.7$

$$\lambda = \frac{3\times10^8}{4\times10^9} = 0.075\,\text{mts}$$

$$G = \eta\times\frac{4\pi\times A_e}{\lambda^2}$$

$$\text{Where } A_e = \frac{\pi D^2}{4} = \frac{\pi(3.6)^2}{4} = 3.24\pi$$

$$G = \frac{0.7\times4\pi\times3.24\times\pi}{(0.075)^2} = 15917.698 = 42.018\text{ dB}$$

08. (c) (ii) The numerical aperture of an optical fiber is 0.3. Calculate the acceptance angle for the meridional rays. Further calculate the acceptance angle for the skew rays which change direction by 90° at each reflection.
(Assume that refractive index, n_a of air is 1) (10 M)

Sol: NA = 0.3

For meridional Rays

Acceptance angle $\theta_m = \sin^{-1}(NA) = \sin^{-1}(0.3) = 17.457^\circ$

For Skew Rays

$$\text{Acceptance angle } \theta_s = \sin^{-1}\left[\frac{NA}{\cos(Y)}\right]$$

Where Y is the angle of reflection for the Skew rays at the core-cladding interface.

Given $Y = 90^\circ$

$\therefore\ \theta_s$ is undefined