PRE-GATE-2019

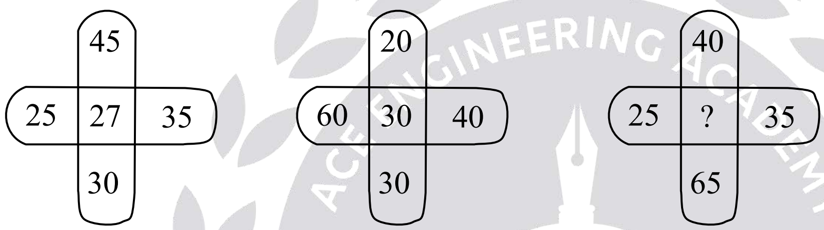
Instrumentation Engineering

(Questions with Detailed Solutions)

The GA section consists of 10 questions. Questions 1 to 5 are of 1 mark each, and Questions 6 to 10 are of 2 marks each.

Q. 1 – Q. 5 carry one mark each.

01. Find the missing number from the given alternatives



(A) 36 (B) 33 (C) 45 (D) 60

01. Ans: (B)

Sol: As, $25 + 45 + 35 + 30 = 135 = \dfrac{135}{5} = 27$

And $60 + 20 + 40 + 30 = 150 = \dfrac{150}{5} = 30$

Similarly $25 + 40 + 35 + 65 = 165$

$$\therefore \frac{165}{5} = 33$$

Hence option (B) is correct.

02. Identify the correct sentence as per the standard English

(A) I taught the dog to lay down and roll over.

(B) I taught the dog to lie down and roll over.

(C) I taught the dog to laid down and roll over.

(D) I taught the dog to lied down and roll over.

02. Ans: (B)

03. Fill in the blank with an appropriate phrase

The gardens were ___ with lawns and flower beds.

(A) laid about (B) laid out (C) laid off (D) laid by

03. Ans: (B)

04. Out of the following four sentences, select the most suitable sentence with respect to grammar and usage

(A) I will not leave the place until the minister will not meet me.

(B) I will not leave the place until the minister doesn't meet me.

(C) I will not leave the place until the minister meet me.

(D) I will not leave the place until the minister meets me.

04. Ans: (D)

05. Which of the following options is the closest meaning to the underlined part of below sentence?

There was a <u>homogeneity</u> of outlook.

(A) diversity (B) unspoiled freshness

(C) similarity (D) stubbornness

05. Ans: (C)

Q. 6 – Q. 10 carry Two marks each.

06. Nine men and seven women can complete a piece of work in five days. The same work can be completed by seven men and eleven women in four days. Which of the following statements is true regarding the efficiency of the men and women?

(A) Men are more efficient than women by $88\frac{8}{9}\%$

(B) Women are more efficient than men by $88\frac{8}{9}\%$

(C) Men are more efficient than women by $18\frac{8}{9}\%$

(D) Women are more efficient than men by $18\frac{8}{9}\%$

06. Ans: (B)

Sol: 9 men and 7 women complete $\frac{1}{5}$th of the work in 1 day

$\therefore$ 45 men and 35 women can complete the work in 1 day

7 men and 11 women can complete $\frac{1}{4}$th of the same work in 1 day

$\therefore$ 28 men and 44 women can complete the work in 1 day

$\therefore$ 45 men + 35 women

$\Rightarrow$ 28 men + 44 women

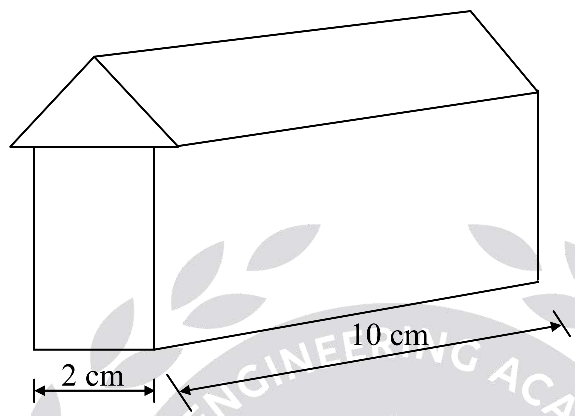
$\Rightarrow$ 17 men = 9 women

$\Rightarrow \frac{\text{women}}{\text{men}} = \frac{17}{9} = 1\frac{8}{9}$

$\therefore$ Women are more efficient by $\frac{8}{9} \times 100 = 88\frac{8}{9}\%$

Hence option (B) is correct

07. What is the approximate volume of the piece shown in the given figure which has a rectangular prism surrounded by a triangular prism (of cross-section equilateral triangle)? The height of the entire piece is 13 cm and that of the rectangular piece is 10 cm



(A) 252 cm^3 (B) 400 cm^3 (C) 216 cm^3 (D) 236 cm^3

07. Ans: (A)

Sol: The total height of the piece is 13 cm and the height of the rectangular piece is 10 cm, the height of the triangular piece = 13 – 10 = 3 cm since the triangular piece is an equilateral triangle, from its height 3 cm, we get the side of the triangle as $2\sqrt{3}$ cm.

Volume of the top portion = Area × length = $\frac{\sqrt{3}}{4}\times(\text{side})^2\times\text{length}$

$$= \frac{\sqrt{3}}{4}\times\left(2\sqrt{3}\right)^2\times 10 = 30\sqrt{3} = 52\text{cm}^3$$

Volume of the bottom portion = 10 × 10 × 2 = 200 cm^3

$\therefore$ Total volume = 252 cm^3

$\therefore$ Hence option (A) is correct

08. In a primary school, the average weight of male students is 65.9 kg and the average weight of female students is 57 kg. If the average weight of all the students (both male and female) is 60.3 kg and the number of male students in the school is 66, then what is the number of female students in the school?

(A) 152 (B) 162 (C) 168 (D) 112

08. Ans: (D)

Sol: Average weight of male students = 65.9 kg

Average weight of female students = 57.0 kg

Average weight of total students = 63.3 kg

Let the total number of students be 'x'

Then, $\dfrac{65.9\times 66+(x-66)\times 57}{x} = 60.3$

$65.9 \times 66 + 57x - 57 \times 66 = 60.3x$

$(65.9 - 57) \times 66 = 3.3\ x$

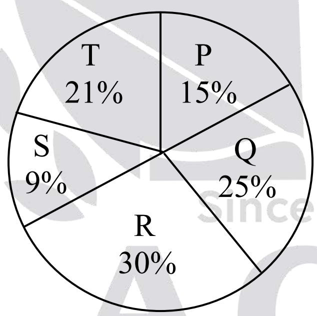
$8.9 \times 66 = 3.3\ x$

$x = 178$

$\therefore$ Number of female students = 178 – 66 = 112

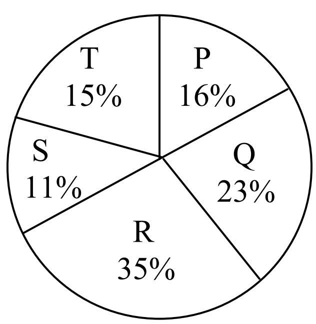
Hence option (D) is correct

09. Study the following pie charts and answer the given question. Distribution of total number of Dell laptops sold by 5 stores



Total number = 2400

Distribution of number of Laptops (both Dell and Lenovo) sold by 5 stores in 2011



Total number = 4500

What is the difference between number of Laptops (both Dell and Lenovo) sold by store Q and total number of Lenovo Laptops sold by store 'R' and 'S' together?

(A) 185 (B) 99 (C) 91 (D) 119

09. Ans: (B)

Sol: Number of laptops (Dell and Lenovo) sold by store Q = $4500 \times \frac{23}{100} = 45 \times 23 = 1035$

Now, total number of Laptops (Lenovo and Dell) sold by R and S together = $4500 \times \frac{46}{100} = 2070$

Number of Dell laptops sold by 'R' and 'S' together = $2400 \times \frac{39}{100} = 936$

Number of Lenovo laptops = 2070 – 936 = 1134

$\therefore$ Required difference = 1134 – 1035 = 99

10. Stronger patent laws are needed to protect inventions from being pirated. With that protection manufacturers would be encouraged to invest in the development of new products and technologies. Such investment frequently results in an increase in manufacturer's productivity.

Which of the following conclusions can most properly be drawn from the information above?

(A) Stronger patent laws tend to benefit financial institutions as well as manufacturers.

(B) Increased productivity in manufacturing is likely to be accompanied by the creation of more manufacturing jobs.

(C) Manufacturers will decreases investment in the development of new products and technologies unless there are stronger patent laws.

(D) Stronger patent laws would stimulate improvements in productivity for many manufacturers.

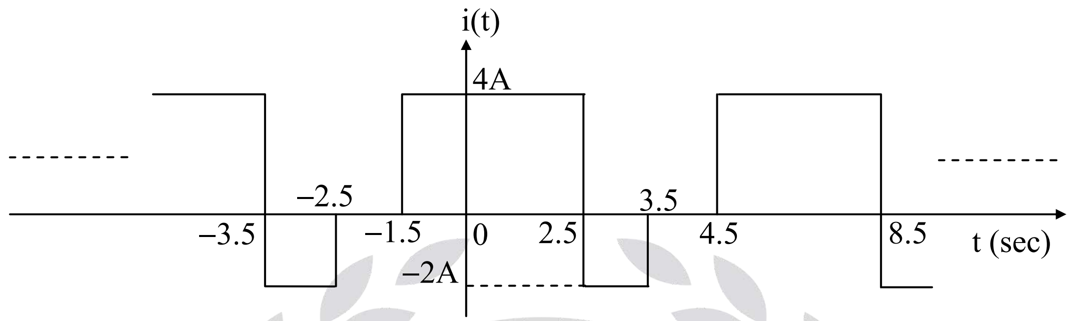
10. Ans: (D)

Sol: Stronger patent laws increase protection; protection encourages investment; investment often raises productivity. Thus, stronger patent laws initiate a chain of events that often culminates in improved productivity. Choice D expresses that and is, therefore, the best answer.

Choice A is inappropriate because the role, if any, that financial institutions would play in investments is left open. The increased productivity mentioned in B may mean fewer hours of labour for a given level of output, and may, thus, threaten jobs. Investments of the sort described in C may already be at the lowest possible level.

Q. 11 – Q. 35 carry one mark each.

11. The root mean square value of the given current waveform is _____ (in Amperes)



11. Ans: 3.366 (Range: 3.3 to 3.4)

Sol: The time period for a given waveform = 6sec

$$\left.\begin{aligned} i(t) &= 4A(-1.5 < t < 2.5 \to 4\text{sec}) \\ &= -2A\ (2.5 < t < 3.5 \to 1\text{sec}) \\ &= 0\ (3.5 < t < 4.5 \to 1\text{sec}) \end{aligned}\right\} 6\text{sec} = T$$

Root mean square value

$$I_{rms} = \sqrt{\frac{(4)^2(4) + (-2)^2(1) + (0)^2(1)}{6}}$$

$$= \sqrt{\frac{64+4}{6}} = \sqrt{11.33} = 3.36\,\text{Amps}$$

$$I_{rms} = 3.36\,\text{Amps}$$

12. The forward path transfer function of a unity feedback system is $G(S) = \frac{K}{S(S+1)^2}$. If a unit ramp input is applied, the minimum possible steady state error is _________

12. Ans: 0.5 (no range)

Sol: The steady state error is minimum to the largest value of K for which the closed loop system is stable.

RH criterian : $CE \Rightarrow 1+G(S)=0 \Rightarrow 1+\frac{K}{S(S+1)^2}=0$

$$CE \Rightarrow S^3 + 2S^2 + S + K = 0$$

$$\begin{array}{c|ll} S^3 & 1 & 1 \\ S^2 & 2 & K \\ S^1 & \left(\frac{2-K}{2}\right) > 0\,(S) & \\ S^0 & K > 0 \quad (S) & \end{array}$$

$0 < K < 2 \rightarrow$ CL stable

Largest K for CL system stable is 2

$$G(S) = \frac{2}{S(S+1)^2}, H(S) = 1$$

For unit Ramp input

$$e_{ss} = \frac{A}{K_v} \qquad A = 1$$

$$K_v = \underset{S\to 0}{\text{Lt}}\, SG(S) = \underset{S\to 0}{\text{Lt}}\, S\left(\frac{2}{S(S+1)^2}\right) = 2$$

$$e_{ss} = \frac{1}{2} = 0.5$$

13. A turbine flow meter coupled to an electric voltage generator produces 4 mV for each lit/s of flow. The output quantity (in lit/sec), when 1 V produced is _________

13. Ans: 250 (no range)

Sol: We know that flow meter output voltage (e_0) generated by turbine flow meter is directly proportional to the quantity of flow (Q)

$e_0 \propto Q$

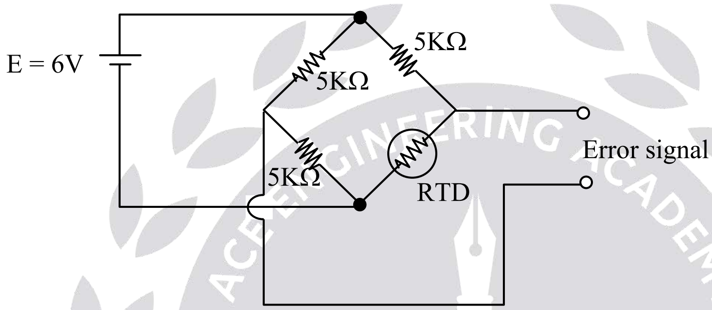
Q (lit/sec)	1	Q_2
e_0 (V)	4×10^{-3}	1

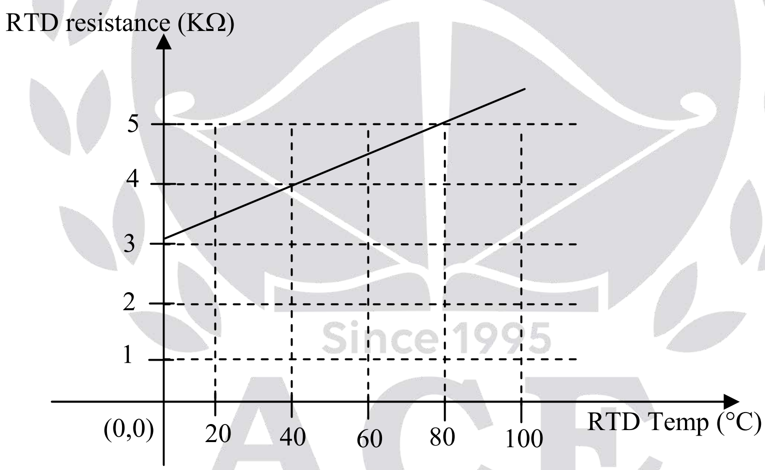
$$\frac{e_{01}}{e_{02}} = \frac{Q_1}{Q_2}$$

$$Q_2 = \frac{Q_1 e_{02}}{e_{01}} = \frac{1\times1}{4\times10^{-3}} = 0.25 \times 10^3$$

Q_2 = 250 (lit/sec)

14. Circuit shown in which RTD is connected in bridge circuit, also RTD and temperature relation shown in the corresponding graph. The amplitude (magnitude) of the error signal in V at 40°C is





14. Ans: 0.33 (Range: 0.29 to 0.36)

Sol: By graph we can say that Resistance RTD′ at 40°C is 4 KΩ

So error signal is

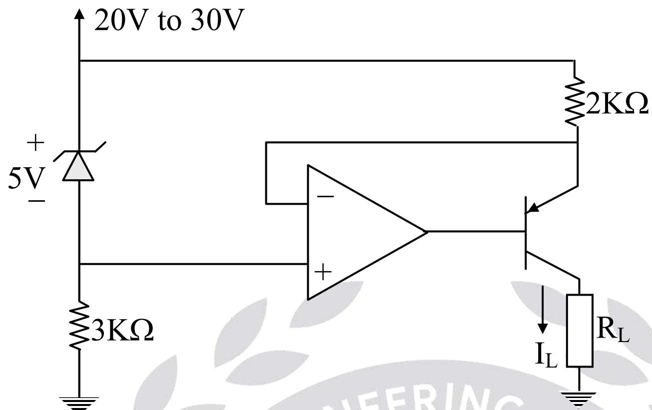
$$e = E\left[\frac{RTD'}{RTD'+5K} - \frac{5K}{5K+5K}\right]$$

$$= 6\times\left[\frac{4K}{9K} - \frac{1}{2}\right]$$

$$e = -0.33 \text{ V}$$

Error signal magnitude = 0.33 V

15. For the regulator circuit given, load current (I_L) is ________ mA. Assume that the Op-amp is ideal



15. Ans: 2.5 (No range)

Sol: KVL

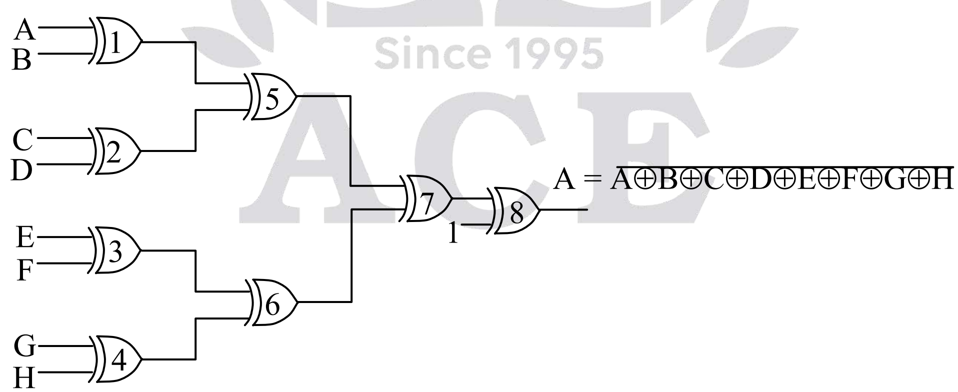
$5 + 0 - I_L\,(2K) = 0$

$I_L = 2.5$ mA

16. The number of 2 input Ex-OR gates required to construct an 8-input EX-NOR gate are ____

16. Ans: 8 (no range)

Sol:



Total number of two input Ex-OR gates are 8

17. In a 4-bit ripple carry adder, the full adder takes 3ns and 2ns to produce sum and carry outputs respectively. The inputs to this adder are F_H and 1_H and are applied at time t = 0. At ____ nsec, the output of the adder is 8_H.

17. Ans: 7 (no range)

Sol:

$$\begin{array}{cccc} 1 & 1 & 1 & 1 \\ 0_0 & 0_0 & 0_0 & 1 \\ \hline 0 & 0 & 0 & 0 \end{array}$$

At 3ns $\Rightarrow$ 1 1 1 $0_2 = E_H$ and $C_2 = 1$ at 2ns

At 5ns $\Rightarrow$ 1 1 0 $0_2 = C_H$ and $C_3 = 1$ at 4ns

At 7ns $\Rightarrow$ 1 0 0 $0_2 = 8_H$ and $C_4 = 1$ at 6ns

18. In 8085 microprocessor, the Accumulator is loaded with -1_{10} in 2's complement form. 'CY' flag is '0' initially.

```
LOOP: RAL
   CMC
   JNC LOOP
```

Then LOOP executes for _______ times.

18. Ans: 9 (no range)

Sol: Initially [A] = -1_{10} = 1111 1111_2 and CY = 0

(1) Loop : RAL ; [A] = 1111 1110, CY = 1
CMC; CY = 0
JNC Loop; So Loop will be executed

(2) Loop : RAL ; [A] = 1111 1100, CY = 1
CMC; CY = 0
JNC Loop

(3) Loop : RAL; [A] = 1111 1000, CY = 1
CMC ; CY = 0
JNC Loop

(4) Loop : RAL ; [A] = 1111 0000, CY = 1

CMC; CY = 0

JNC Loop

(5) Loop : RAL ; [A] = 1110 0000, CY = 1

CMC; CY = 0

JNC Loop

(6) Loop : RAL ; [A] = 1100 0000, CY = 1

CMC; CY = 0

JNC Loop

(7) Loop : RAL ; [A] = 1000 0000, CY = 1

CMC; CY = 0

JNC Loop

(8) Loop : RAL ; [A] = 0000 0000, CY = 1

CMC; CY = 0

JNC Loop ;

(9) Loop : RAL ; [A] = 0000 0000, CY = 0
CMC; CY = 1

JNC Loop; Loop gets terminated here

$\therefore$ LOOP executes for 9 times.

19. In an electrodynamometer type ammeter a current of 60 A required a deflection of 90^o. The current required for 180^o deflection is ______ A. (Give answer up to two decimal places).

19. Ans: 84.85 (Range: 84 to 85)

Sol: $\theta \propto I^2$

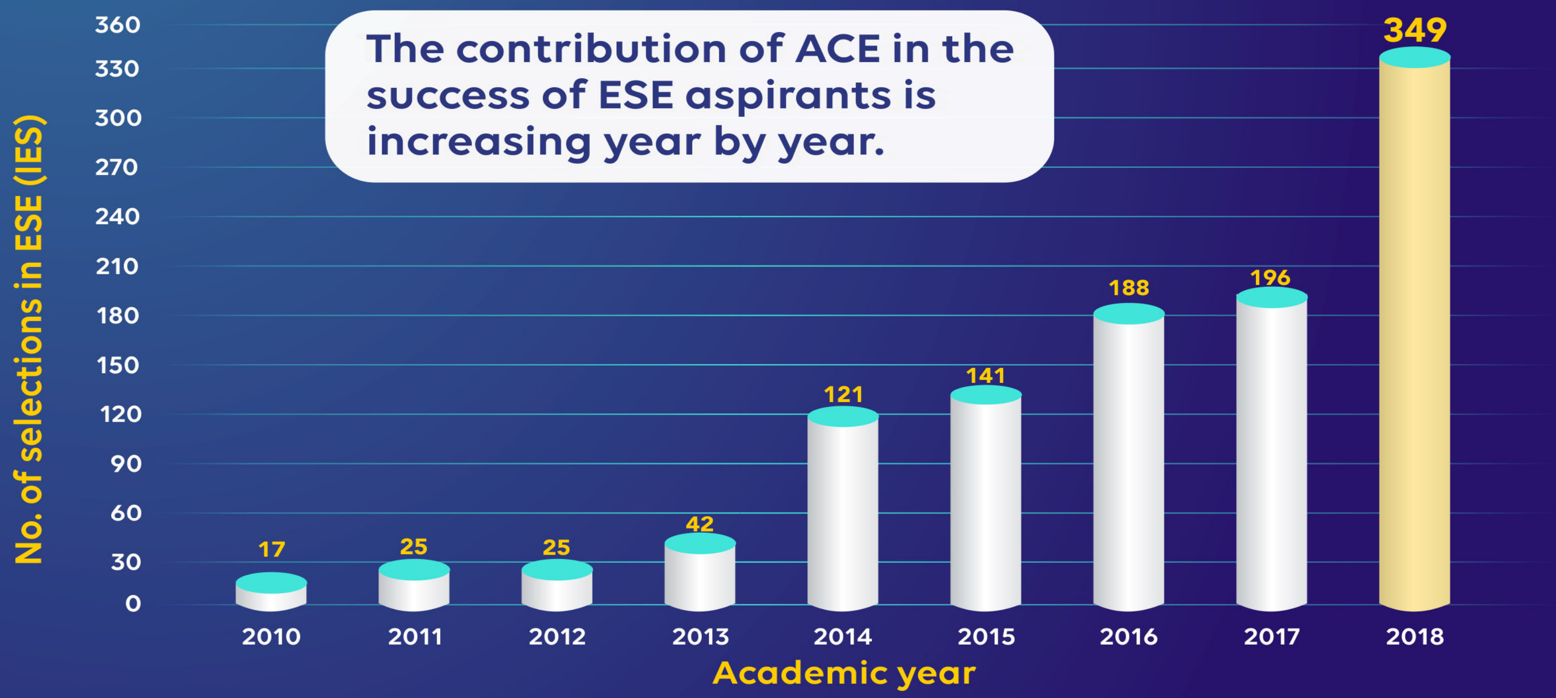
$I \propto \sqrt{\theta}$

$$\frac{I_2}{I_1} = \sqrt{\frac{\theta_2}{\theta_1}}$$

$$\frac{I_2}{60} = \sqrt{\frac{180}{90}}$$

$I_2 = 60\sqrt{2} = 84.85$ A

The current required for 180^o deflection is 84.85 A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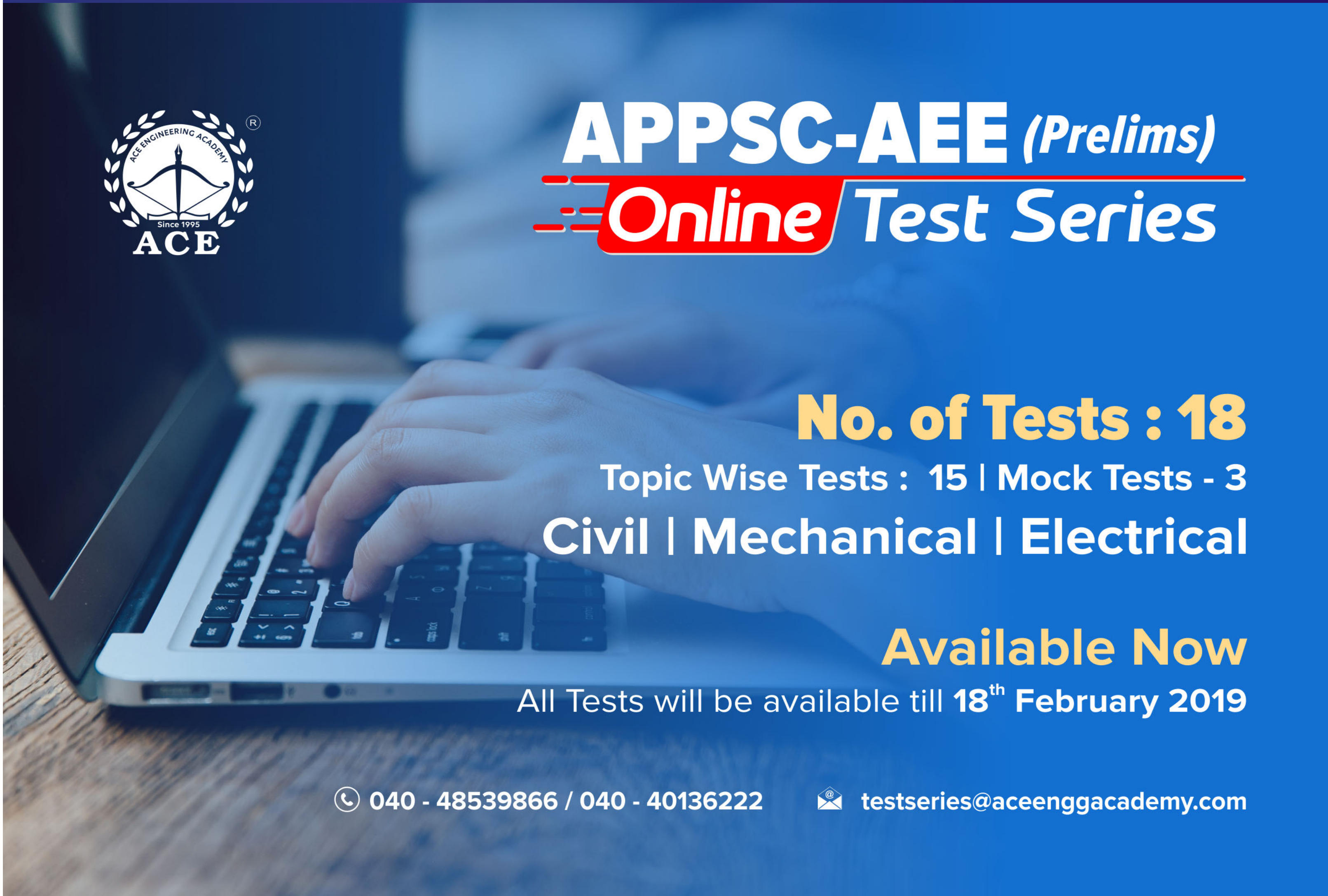
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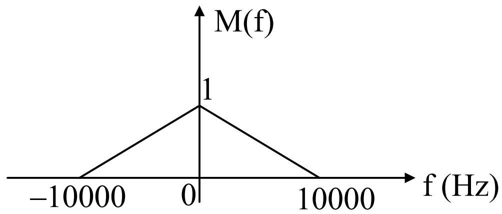
20. Consider a message signal m(t) having Fourier transform M(f) as shown in the figure below:



It is known that the signal is normalized meaning that $-1 \le m(t) \le 1$. If an FM signal with $k_f = 60$kHz is used. The bandwidth of the modulated signal is _____ kHz.

20. Ans: 140 (no range)

Sol: $\beta_{FM} = \dfrac{\Delta f}{f_m} = \dfrac{k_f A_m}{f_m} = \dfrac{60\times10^3\times1}{10\times10^3} = 6$

$\therefore$ $s(t)_{FM}$ is WBFM signal

As per Carson's rule of BW

$BW = 2(\beta + 1)\, f_m$

$\therefore$ $BW = 2(6+1)\times10^3\times10 = 140$ kHz

21. Consider the angle modulated signal $s(t) = 10\cos[2000\pi t + 100\pi t^2]$.

The instantaneous frequency of the signal at t = 2 sec is _____ Hz.

21. Ans: 1200 (no range)

Sol: The instantaneous frequency is

$$f_i = \frac{1}{2\pi}\frac{d}{dt}[2000\pi t + 100\pi t^2]$$

$$f_i = \frac{1}{2\pi}[2000\pi + 200\pi t]$$

$$f_i = 1000 + 100t$$

where t = 2

$f_i = 1000 + 200$

$f_i = 1200$ Hz

22. Let $A=\begin{bmatrix} 2 & -3 \\ a & 5 \end{bmatrix}$. If one of the eigen values of A is 3, then a = _____.

22. Ans: 0.6667 (Range: 0.65 to 0.67)

Sol: Let λ be the second eigen value of A.

We know that, sum of the eigen values of A = Trace of A

$\Rightarrow 3 + \lambda = 2 + 5$

$\Rightarrow \lambda = 4$

Again, product of the eigen values of A = |A|

$\Rightarrow 12 = 10 + 3a$

$\Rightarrow a = \dfrac{2}{3} = 0.6667$

23. If f(x) = x^2 and g(x) = x^3 then, the mean value C satisfying Cauchy's Mean Value theorem in the interval (1, 2) is ______.

23. Ans: 1.555 (Range: 1.5 to 1.6)

Sol: Here, f(x) and g(x) satisfy the conditions of Cauchy's mean value theorem.

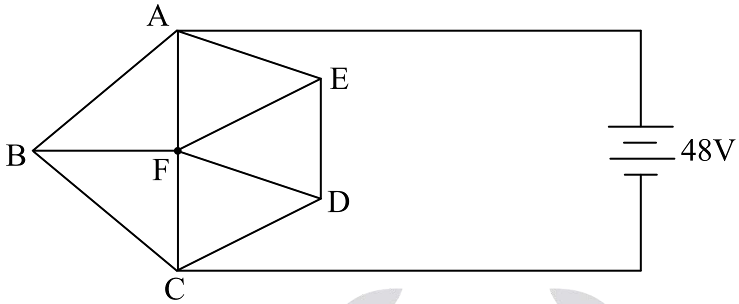
By Cauchy's mean value theorem, there exists a value $C \in (1, 2)$ such that

$$\frac{f'(C)}{g'(C)} = \frac{f(2)-f(1)}{g(2)-g(1)} \text{ .... (1)}$$

$$\Rightarrow \quad \frac{2C}{3C^2} = \frac{4-1}{8-1}$$

$$\therefore \quad C = \frac{14}{9} = 1.555$$

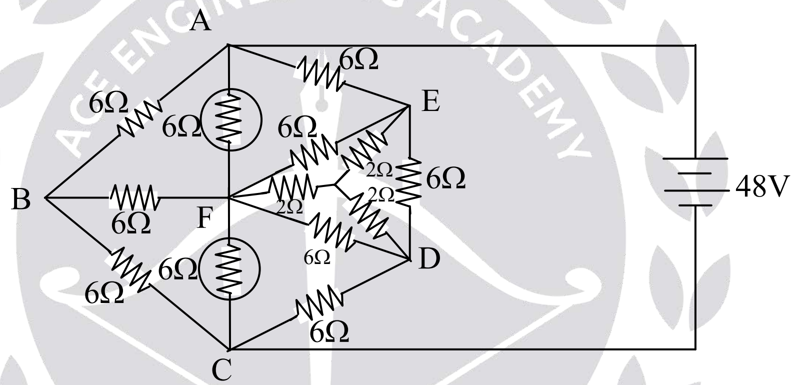
24. A pentagonal pyramid build up of ten wires with each 6Ω resistance as shown in figure is fed from 48V battery at the terminals A&C. Find the current passing through AB



(A) 7A (B) 4A (C) $\frac{4}{7}$A (d) $\frac{7}{4}$A

24. Ans: (B)

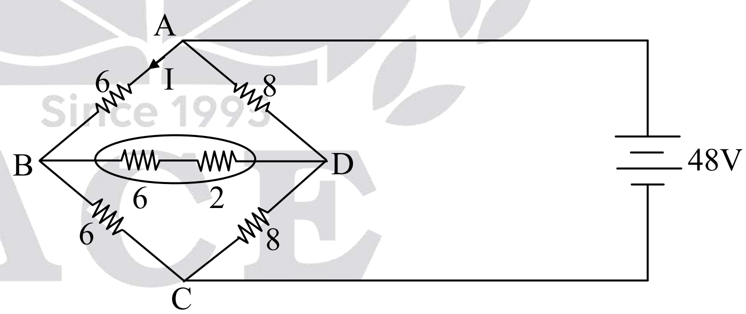
Sol:



$$R_{eq} = 12 \parallel 16$$

$$= \frac{12 \times 16}{28}$$

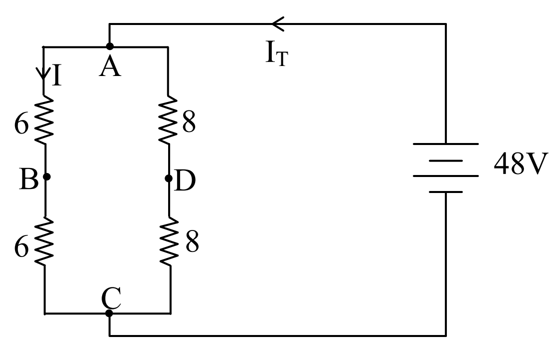
$$= \frac{48}{7} \Omega$$



$$I_T = \frac{V}{R_{eq}} = \frac{48}{\frac{48}{7}} = 7 \text{ Amps}$$

By Current Division Rule current through AB(I)

$$I = \frac{7 \times 16}{16 + 12} = 4 \text{ Amps}$$



Distractor Logic:

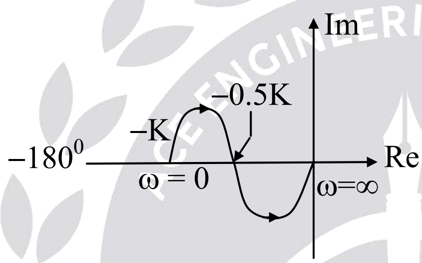
(a) The total current $I_T = \frac{V}{R_{eq}} = \frac{48}{48/7} = 7A$

(b) Option (B) is correct

(c) Option (C) are not possible

(d) Option (D) are not possible

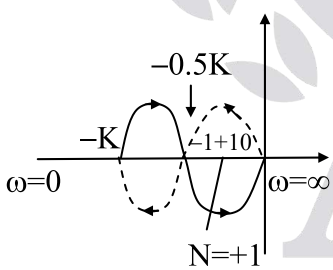
25. The Nyquist plot over the frequency range 0 to ∞ is shown in figure. For which the OLTF has one pole in the RHS-plane. The range of K for which closed loop system is stable



(A) K < 1 (B) 1 < K < 2 (C) K > 2 (D) K < 1 or K > 2

25. Ans: (C)

Sol:



N=+1
P=+1
N=P
CL Stable

For CL stability

$\Rightarrow 0.5\text{ K} > 1$

K > 2 CL stable

Distractor Logic:

(a) If critical point (−1, j0) consider outside the loop, then option A is possible but CL system is unstable

(b) If critical point (−1, j0) consider between −0.5k to −K, then option B is possible but CL system is unstable

(c) Option (C) is correct

(d) If critical point consider in two regions then two different range of K values are possible. In this case CL system is unstable.

26. Two slits in Young's experiment have widths in the ratio 81:1. The ratio of the amplitudes of light waves coming from them is

(A) 9:1 (B) 81:1 (C) 1:81 (D) 1:9

26. Ans: (A)

Sol: Given:

$$\frac{W_1}{W_2} = \frac{81}{1}$$

To find:

$$\frac{a_1}{a_2} = ?$$

Formula:

$$\frac{W_1}{W_2} = \frac{I_1}{I_2} = \frac{a_1^2}{a_2^2}$$

$$\therefore \frac{81}{1} = \frac{a_1^2}{a_2^2}$$

$$\therefore \frac{a_1}{a_2} = \frac{9}{1}$$

$\therefore a_1 : a_2 = 9 : 1$

Destructor Logic:

(a) Correct option

(b) We get this option

If we take formula as:

$$\frac{W_1}{W_2} = \frac{a_1}{a_2}$$

then we get

$a_1 : a_2 = 81 : 1$

(c) We get this option if we take formula as:

$$\frac{W_1}{W_2} = \frac{a_2}{a_1}$$

$a_1 : a_2 = 1 : 81$

(d) We get this option if we take formula as:

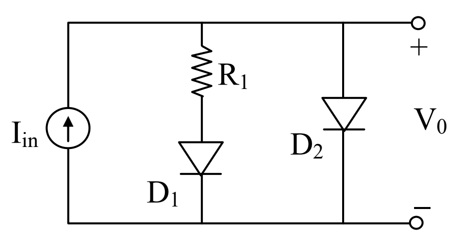
$$\frac{W_1}{W_2} = \frac{a_2^2}{a_1^2}$$

So, $a_1 : a_2 = \sqrt{W_2} : \sqrt{W_1}$

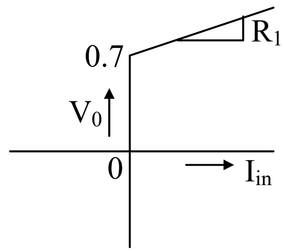
$= \sqrt{1} : \sqrt{81}$

$= 1 : 9$

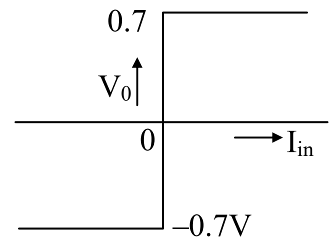
27. Identify the Transfer characteristics of the circuit given if $V_{D_{(ON)}} = 0.7V$



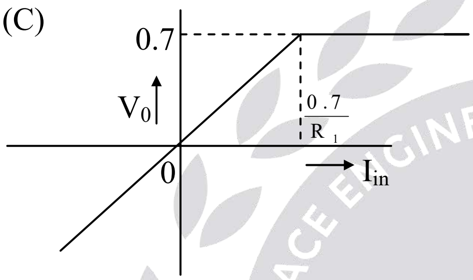
(A)



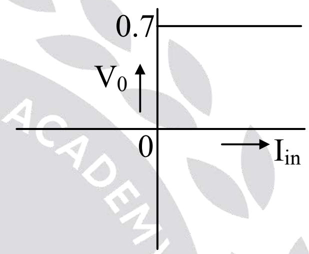
(B)



(C)



(D)



27. Ans: (D)

Sol: I_{in} Positive $\rightarrow$ Diode ON $\Rightarrow V_0 = V_{D(ON)} = 0.7V$

I_{in} Negative $\rightarrow$ Diode OFF $\Rightarrow V_0 = 0$ V

Distractor Logic:

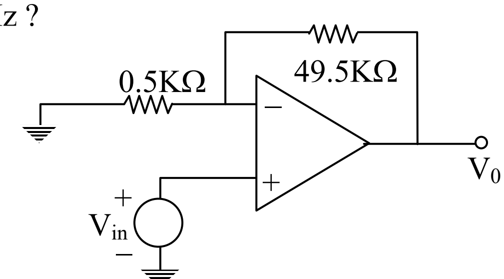
Option A: If D_2 is ignored, then the transfer characteristics is shown

Option B: If R_1 is ignored and diodes D_2 is reversed

Option C: If D_1 is neglected

Option D: Right answer

28. The unity gain frequency of an Op-amp is 10kHz. Find the gain of the amplifier for a sinusoidal input of 50kHz ?



(A) 19.6 (B) 70.7 (C) 55.55 (D) 100

28. Ans: (A)

Sol: $G = 1 + \frac{49.5}{0.5} = 100$

$$\frac{V_0}{V_{in}} = \frac{100}{1 + \frac{jf}{10^4}}$$

$$\left.\frac{V_0}{V_{in}}\right|_{50K} = \frac{100}{\sqrt{1 + \left(\frac{50K}{10K}\right)^2}} = 19.6$$

Distractor Logic:

Option A: Right answer

Option B: If you calculate the 3dB gain

Option C: Gain at 15kHz instead of 50kHz

Option D: DC Gain

29. The system is represented by the following state model

$$\dot{X} = AX + BU$$
$$Y = CX$$

If there are no pole zero cancellation in the transfer function $C[sI–A]^{-1}B$, then the system is

(A) Controllable and Observable

(B) Controllable but not observable

(C) Observable but not controllable

(D) neither controllable nor observable

29. Ans: (A)

Sol: Let us consider the state variable formulation of a system is

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -1 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 0 \\ 1 \end{bmatrix} u \; ; \quad y = \begin{bmatrix} 1 & 0 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$$

$$TF = C[sI - A]^{-1} B$$

$$sI - A = \begin{bmatrix} s & -1 \\ 1 & s+1 \end{bmatrix}$$

$$TF = \frac{[1 \quad 0]\begin{bmatrix} s+1 & 1 \\ -1 & s \end{bmatrix}\begin{bmatrix} 0 \\ 1 \end{bmatrix}}{s(s+1)+1} = \frac{1}{s^2 + s + 1}$$

TF having no pole zero cancellation

Controllability $|M| \neq 0$

M = [B AB]

$$AB = \begin{bmatrix} 0 & 1 \\ -1 & -1 \end{bmatrix}\begin{bmatrix} 0 \\ 1 \end{bmatrix} = \begin{bmatrix} 1 \\ -1 \end{bmatrix}$$

$$|B \ \ AB| = \left|\begin{bmatrix} 0 & 1 \\ 1 & -1 \end{bmatrix}\right| = -1 \neq 0$$

$\therefore$ Above system is controllable

Observability $|N| \neq 0$

$$N = \begin{bmatrix} C \\ CA \end{bmatrix}$$

$$CA = [1 \ \ 0] \begin{bmatrix} 0 & 1 \\ -1 & -1 \end{bmatrix} = [\ 0 \ \ 1]$$

$$\begin{vmatrix} C \\ CA \end{vmatrix} = \begin{vmatrix} 1 & 0 \\ 0 & 1 \end{vmatrix} = 1 \neq 0$$

$\therefore$ Above system is observable.

Destructor Logic:

Option (A): Option (A) is correct

Option (B): Let us consider the state variable formulation of a system is

$$\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} -2 & 0 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 1 \\ 1 \end{bmatrix} u,$$

and $y = [1 \quad 0] \begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$

TF of above system $= \dfrac{Y(s)}{U(s)} = C[sI - A]^{-1} B$

$$\frac{Y(s)}{U(s)} = \frac{s+1}{(s+2)(s+1)} = \frac{1}{s+2}$$

TF having pole zero cancellation

Controllability $|M| \neq 0$

$M = [\,B \;\; AB\,]$

$$AB = \begin{bmatrix} -2 & 0 \\ 0 & -1 \end{bmatrix} \begin{bmatrix} 1 \\ 1 \end{bmatrix}$$

$$= \begin{bmatrix} -2 \\ -1 \end{bmatrix}$$

$$|B \;\; AB| = \left| \begin{bmatrix} 1 & -2 \\ 1 & -1 \end{bmatrix} \right| = 1 \neq 0$$

$\therefore$ Above system is controllable

Observability $|N| \neq 0$

$$N = \begin{bmatrix} C \\ CA \end{bmatrix}$$

$$CA = [1 \;\; 0] \begin{bmatrix} -2 & 0 \\ 0 & -1 \end{bmatrix} = [-2 \;\; 0]$$

$$\begin{vmatrix} C \\ CA \end{vmatrix} = \begin{vmatrix} 1 & 0 \\ -2 & 0 \end{vmatrix} = 0$$

$\therefore$ Above system is not observable.

Option (C): Let us consider the state variable formulation of a system is

$$\begin{bmatrix}\dot{x}_1\\ \dot{x}_2\end{bmatrix}=\begin{bmatrix}-2 & 0\\ 0 & -1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}+\begin{bmatrix}1\\ 0\end{bmatrix}u, \text{ and } y=\begin{bmatrix}1 & 1\end{bmatrix}\begin{bmatrix}x_1\\ x_2\end{bmatrix}$$

TF of above system $= \dfrac{Y(s)}{U(s)} = C[sI-A]^{-1}B$

$$\frac{Y(s)}{U(s)}=\frac{s+1}{(s+2)(s+1)}=\frac{1}{s+2}$$

TF having pole zero cancellation

Controllability $|M| \neq 0$

$M = [\,B \;\; AB\,]$

$$AB=\begin{bmatrix}-2 & 0\\ 0 & -1\end{bmatrix}\begin{bmatrix}1\\ 0\end{bmatrix}$$

$$=\begin{bmatrix}-2\\ 0\end{bmatrix}$$

$$|B \;\; AB| = \left|\begin{bmatrix}1 & -2\\ 0 & 0\end{bmatrix}\right| = 0$$

$\therefore$ Above system is not controllable

Observability $|N| \neq 0$

$$N=\begin{bmatrix}C\\ CA\end{bmatrix}$$

$$CA=[1 \;\; 1]\begin{bmatrix}-2 & 0\\ 0 & -1\end{bmatrix}=[-2 \;\; -1]$$

$$\begin{vmatrix}C\\ CA\end{vmatrix}=\begin{vmatrix}1 & 1\\ -2 & -1\end{vmatrix}=1\neq 0$$

$\therefore$ Above system is observable.

Option (D): Let us consider the state variable formulation of a system is

$$\dot{X}=\begin{bmatrix}-1 & 0 & 0\\ 0 & -2 & 0\\ 0 & 0 & -3\end{bmatrix}X+\begin{bmatrix}1\\ 1\\ 0\end{bmatrix}U \qquad Y=\begin{bmatrix}1 & 0 & 2\end{bmatrix}X$$

TF of above system $= \dfrac{Y(s)}{U(s)} = C[sI - A]^{-1} B$

$$sI - A = \begin{bmatrix} s+1 & 0 & 0 \\ 0 & s+2 & 0 \\ 0 & 0 & s+3 \end{bmatrix}$$

$$[sI-A]^{-1} = \begin{bmatrix} \frac{(s+2)(s+3)}{(s+1)(s+2)(s+3)} & 0 & 0 \\ 0 & \frac{(s+1)(s+3)}{(s+1)(s+2)(s+3)} & 0 \\ 0 & 0 & \frac{(s+1)(s+2)}{(s+1)(s+2)(s+3)} \end{bmatrix}$$

$$TF = \frac{(s+2)(s+3)}{(s+1)(s+2)(s+3)} = \frac{1}{(s+1)}$$

TF having pole zero cancelation

Controllability $|M| \neq 0$

$M = [B \;\; AB \;\; A^2B]$

$$A^2 = \begin{bmatrix} 1 & 0 & 0 \\ 0 & 4 & 0 \\ 0 & 0 & 9 \end{bmatrix} \quad \text{and} \quad A^2B = \begin{bmatrix} 1 \\ 4 \\ 0 \end{bmatrix}$$

$$|M| = \begin{vmatrix} 1 & -1 & 1 \\ 1 & -2 & 4 \\ 0 & 0 & 0 \end{vmatrix} = 0$$

Above system is un controllable

For Observability $|N| \neq 0$

$$N = \begin{bmatrix} C \\ CA \\ CA^2 \end{bmatrix}$$

$CA = [-1 \;\; 0 \;\; -6]$ and $CA^2 = [1 \;\; 0 \;\; 18]$

$$|N| = \begin{vmatrix} 1 & 0 & 2 \\ -1 & 0 & -6 \\ 1 & 0 & 18 \end{vmatrix} = 0$$

Above system is un observable

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AIR 10  MILAN KRISHNA EE

AIR 10  SRICHAND POONIYA CE

TOTAL SELECTIONS in Top 10	34

	E&T	EE	CE	ME
TOP 10	10	10	8	6

and many more...

30. Given $X(z) = 2z^2 - 5z + 5z^{-1} - 2z^{-2}$. Then the signal x(n) is _____

(A) Non-Causal & Odd symmetric (B) Causal & Odd symmetric

(C) Non-Causal & Even symmetric (D) Causal & Even symmetric

30. Ans: (A)

Sol: $\delta(n-n_0) \xleftrightarrow{Z.T} z^{-n0}$

$X(z) = 2z^2 - 5z + 5z^{-1} - 2z^{-2}$

Apply inverse z-transform

$x(n) = 2\delta(n+2) - 5\delta(n+1) + 5\delta(n-1) - 2\delta(n-2)$

$x(n) = \{2, -5, \underset{\uparrow}{0}, 5, -2\}$

$x(n) \neq 0$ for $n < 0$. So, non-causal

$x(-n) = -x(n)$. So, odd symmetric

Distractor Logic:

Option (A): Option (A) is correct

Option (B): As no arrow mark is given misinterpretation of feeling signal starts from n = 0

Option (C): As the sample amplitudes are having alternate sign misconception of even symmetry

Option (D): As the sample amplitudes are having alternate sign misconception of even symmetry

31. The inverse F.T of $X(f) = \dfrac{j\,2\pi f}{1+6j\pi f - 8\pi^2 f^2}$ is _____

(A) $\frac{1}{2}e^{-4t}u(t) - \frac{1}{2}e^{-2t}u(t)$ (B) $\left[e^{-t} - \frac{1}{2}e^{-t/2}\right]u(t)$

(C) $\left[\frac{1}{2}e^{-t} - e^{-t/2}\right]u(t)$ (D) $\left[e^{-t} + \frac{1}{2}e^{-t/2}\right]u(t)$

31. Ans: (B)

Sol: $X(f) = \dfrac{j\,2\pi f}{(1+4j\pi f)(1+2j\pi f)} = \dfrac{1}{1+2j\pi f} - \dfrac{1}{1+4j\pi f} = \dfrac{1}{1+j\,2\pi f} - \dfrac{1/2}{\frac{1}{2}+2j\pi f}$

Use $e^{-at}u(t) \leftrightarrow \dfrac{1}{a+j2\pi f}$

So, $x(t) = \left[e^{-t} - \frac{1}{2}e^{-t/2}\right]u(t)$

Distractor Logic:

Option (A): If you feel like by missing j2πf in the numerator

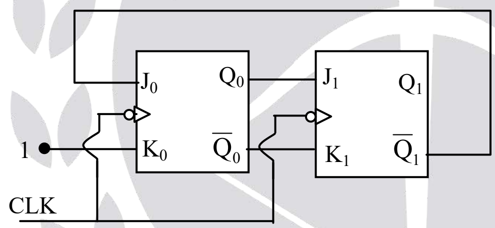
$$X(\omega)=\frac{-1}{(4+j\omega)(2+j\omega)}=\frac{\frac{1}{2}}{(4+j\omega)}-\frac{\frac{1}{2}}{(2+j\omega)}$$

Option (B): Option (B) is correct

Option (C): If you adjust given form like $X(\omega)=\dfrac{1}{(1+j\omega)\left(1+\dfrac{j\omega}{2}\right)}$

Option (D): If $X(\omega)=\dfrac{1}{(1+j\omega)\left(1+\dfrac{j\omega}{2}\right)}$ is not doing partial fraction expansion correctly

32. Find the value of the following counter after 730 clock pulses. Initially $Q_0 = Q_1 = 0$.



(A) $Q_0\,Q_1 = 00$ (B) $Q_0\,Q_1 = 01$ (C) $Q_0\,Q_1 = 10$ (D) $Q_0\,Q_1 = 11$

32. Ans: (C)

Sol: It is a 2 bit synchronous counter. Given $J_0 = \overline{Q}_1$; $K_0 = 1$; $J_1 = Q_0$; $K_1 = \overline{Q}_0$

	Present state		Flip Flop Inputs				Next state		
	Q_0	Q_1	J_0	K_0	J_1	K_1	Q_0	Q_1	
⓪	0	0	1	1	0	1	1	0	②
②	1	0	1	1	1	0	0	1	①
①	0	1	0	1	0	1	0	0	⓪

Counting sequence is 00, 10, 01, 00,……….. it is a Mod-3 counter.

Counter value after 730 clock pulses is same value of the counter after 1 pulse i.e., $Q_0\,Q_1 = 10$

Distractor Logic:

Option (A): It might be mistaken as 2-bit Johnson counter which is a 4:1 counter. Thus value after 730 pulses is same as initial value i.e., $Q_0\,Q_1 = 00$

Option (B): The counting sequence of the counter may be mistaken as 00, 01, 10, 00, ……… Then its solution is taken as 01

Option (C): Option (C) is correct

Option (D): Mistakenly chosen as 11

33. The general solution of $x^2\dfrac{d^2y}{dx^2} - 5x\dfrac{dy}{dx} + 9y = 0$ is

(A) $(C_1 + C_2x)e^{3x}$

(B) $(C_1 + C_2\, l\text{n}x)x^3$

(C) $(C_1 + C_2x)x^3$

(D) $(C_1 + C_2\, l\text{n}x)\,e^{x^3}$

(Here, C_1 & C_2 are arbitrary constants)

33. Ans: (B)

Sol: Given $x^2\dfrac{d^2y}{dx^2} - 5x\dfrac{dy}{dx} + 9y = 0$

Put $z = \log x$ or $x = e^z$ and $D = \dfrac{d}{dz}$

The given equation becomes,

$$D(D-1)y - 5Dy + 9y = 0$$

$$(D^2 - 6D + 9)y = 0$$

The Auxiliary equation is $D^2 - 6D + 9 = 0$

Roots are 3, 3

The general solution is $y = (C_1 + C_2\,z)e^{3z}$

$$\therefore\ y = (C_1 + C_2\, l\text{n}x)x^3$$

Hence, option (B) is correct.

34. When a fair coin is tossed 200 times then mean and standard deviation are

(A) 100, 50 (B) 100, $\sqrt{50}$ (C) 50, 100 (D) $\sqrt{100}$, 50

34. Ans: (B)

Sol: $n = 200,\ p = \frac{1}{2},\ q = \frac{1}{2}$

Mean = E(X) = np = $200 \times \frac{1}{2} = 100$

Variance = V(X) = npq = $200 \times \frac{1}{2} \times \frac{1}{2} = 50$

Standard deviation = $\sqrt{50}$

35. The Recursion relation to solve $x = e^x$ using Newton-Raphson method is ______.

(A) $x_{n+1} = e^{x_n}$

(B) $x_{n+1} = x_n - e^{x_n}$

(C) $x_{n+1} = \frac{(1-x_n)e^{x_n}}{1-e^{x_n}}$

(D) $x_{n+1} = \frac{(1+x_n)e^{x_n}}{1-e^{x_n}}$

35. Ans: (C)

Sol: Given equation $x = e^x$

Let $f(x) = x - e^x$

$\Rightarrow f'(x) = 1 - e^x$

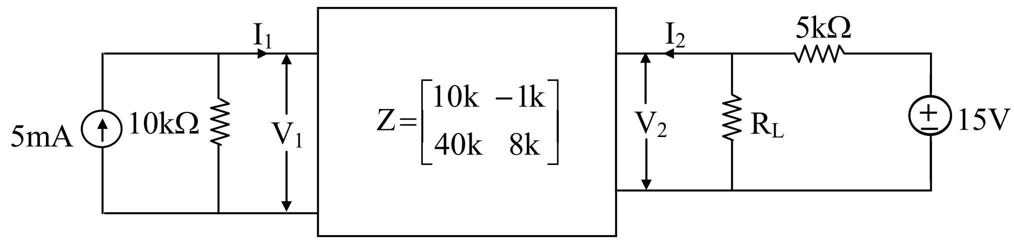
By Newton-Raphson Formula

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)} = x_n - \frac{(x_n - e^{x_n})}{1-e^{x_n}} = \frac{x_n - x_n e^{x_n} - x_n + e^{x_n}}{1-e^{x_n}}$$

$$x_{n+1} = \frac{(1-x_n)e^{x_n}}{1-e^{x_n}}$$

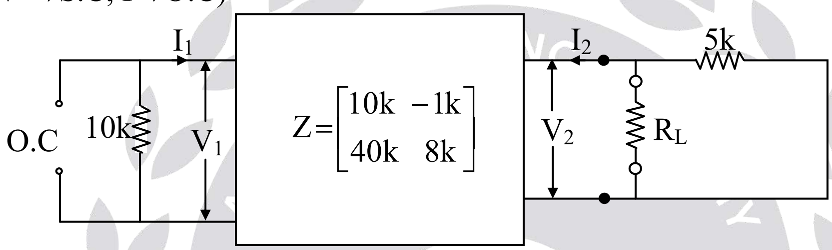
Q. 36 – Q. 65 carry Two marks each.

36. The following two-port network described by Z-parameters matrix. Then the Thevenin's equivalent resistance across load R_L in kilo ohms is ______



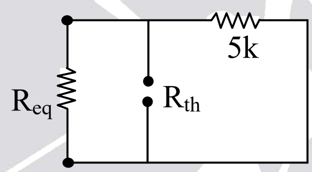
36. Ans: 3.33 (Range: 3.2 to 3.5)

Sol: For R_{th} (V →S.C, I→O.C)



R_{eq} across output terminals of two-port network

$R_{eq} = \dfrac{V_2}{I_2}$ then



$R_{th}=R_{eq}||5k$

For R_{eq} From input port & Z-parameters

$V_1 = -10kI_1$ ––––– (1)

Z-parameters

$V_1 = 10kI_1 - 1kI_2$ ––––– (2)

$V_2 = 40kI_1 + 8kI_2$ ––––– (3)

From 1 & 2 $-10kI_1 = 10kI_1 - kI_2$

$I_2 = 20I_1 \Rightarrow I_1 = \dfrac{I_2}{20}$

From 3

$$V_2 = 40K\left(\frac{I_2}{20}\right) + 8kI_2$$

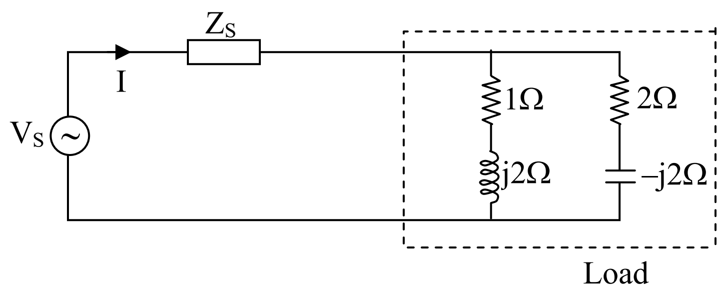
$$V_2 = 10kI_2 \Rightarrow R_{eq} = \frac{V_2}{I_2} = 10k\Omega$$

$$R_{th} = R_{eq} || 5k = 10k || 5k = \frac{10}{3}k = 3.33k\Omega$$

ESE / GATE / PSUs - 2020
ADMISSIONS OPEN

CENTER	COURSE	BATCH TYPE	DATE
HYDERABAD - DSNR	GATE + PSUS – 2020	Regular Batches	26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
HYDERABAD - DSNR	ESE + GATE + PSUs - 2020	Regular Batches	21st March, 26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
HYDERABAD - DSNR	GATE + PSUs - 2020	Short Term Batches	29th April, 6th, 11th, 18th May 26th May, 2nd June, 2019
HYDERABAD - DSNR	GATE + PSUs - 2020	Morning/Evening Batch	21st Jan 2019
HYDERABAD - DSNR	ESE – 2019 STAGE-II (MAINS)	Regular Batch	17th Feb 2019
HYDERABAD - Abids	GATE + PSUS – 2020	Regular Batches	26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
HYDERABAD - Abids	GATE + PSUs - 2020	Short Term Batches	29th April, 6th, 11th, 18th May 26th May, 2nd June, 2019
HYDERABAD - Abids	ESE + GATE + PSUs - 2020	Morning Batch	21st Jan 2019
HYDERABAD - Abids	ESE – 2019 STAGE-II (MAINS)	Regular Batch	17th Feb 2019
HYDERABAD - Abids	GATE + PSUs - 2020	Weekend Batch	19th Jan 2019
HYDERABAD - Abids	ESE+GATE + PSUs - 2020	Spark Batches	11th May, 09th June 2019
HYDERABAD - Kukatpally	GATE + PSUs - 2020	Morning/Evening Batch	21st Jan 2019
HYDERABAD - Kukatpally	GATE + PSUS – 2020	Regular Batches	17th May, 1st, 16th June, 1st July 2019
HYDERABAD - Kukatpally	GATE + PSUs - 2020	Short Term Batches	29th April, 6th, 11th, 18th May 26th May, 2nd June, 2019
HYDERABAD - Kothapet	ESE + GATE + PSUS – 2020	Regular Batches	21st March, 26th April, 11th, 25th May, 09th, 24th June, 8th July 2019
HYDERABAD - Kothapet	ESE+GATE + PSUs - 2020	Spark Batches	11th May, 09th June 2019
DELHI	ESE+GATE+PSUs - 2020	Weekend Batches	13th Jan, 2nd Feb 2019
DELHI	ESE+GATE+PSUs - 2020	Regular Evening Batch	18th Feb 2019
DELHI	ESE+GATE+PSUs - 2020	Regular Day Batch	11th May 2019
DELHI	ESE+GATE+PSUs - 2020	Spark Batch	11th May 2019
DELHI	ESE+GATE+PSUs - 2021	Weekend Batch	13th Jan 2019
DELHI	GATE+PSUs - 2020	Short Term Batches	11th, 23rd May 2019
BHOPAL	ESE + GATE+PSUs - 2020 & 21	Evening Batch	09th Jan 2019
BHOPAL	ESE+GATE+PSUs - 2020	Regular Day Batch	01st Week of June 2019
PUNE	GATE+PSUs - 2020	Weekend Batch	19th Jan 2019
PUNE	ESE+GATE+PSUs - 2021	Weekend Batch	26th Jan 2019
BHUBANESWAR	GATE+PSUs - 2020 & 21	Weekend Batch	12th Jan 2019
BHUBANESWAR	GATE+PSUs - 2020	Regular Batch	02nd Week of May 2019

37. An input voltage $V_S(t) = 50\sqrt{2}$ Cosωt volts with an internal impedance $Z_S = (1 + j\,3.33)\Omega$ feeds a load circuit as shown in figure below. The reactive power consumed by a load is _______ VAR



37. Ans: 66.67 (Range: 65 to 68)

Sol: The load impedance $Z_L = (1+j2) \parallel (2-j2)$

$$Z_L = \frac{(1+j2)(2-j2)}{3} = \frac{2+4+j4-j2}{3}$$

$$Z_L = \left(2 \pm j\frac{2}{3}\right)\Omega$$

Total impedance $Z_T = Z_S + Z_L = (1+j\,3.33) + (2+j\,0.67)$

$$Z_T = (3 + j4)\Omega$$

$$I = \frac{V_s}{Z_T} = \frac{50(\text{rms})}{(3+j4)} = \frac{50\angle 0^\circ}{5\angle 53.14^\circ} = 10\angle -53.14^\circ$$

The Reactive power absorbed by the load circuit

$Q_L = I^2 X_{Load}$

$$Q_L = 10^2\left(\frac{2}{3}\right) = \frac{200}{3}\text{VAR} = 66.67\,\text{VAR}$$

38. The system and its unit step response are shown in figure a & b. The value of K/τ is______

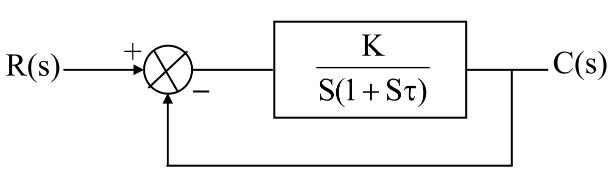


Figure (a)

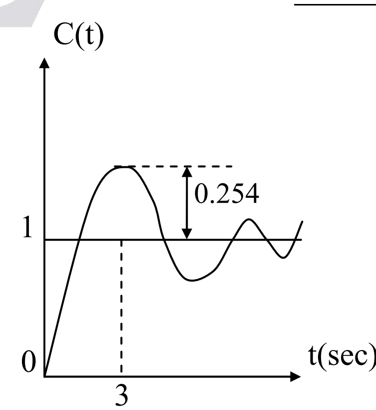


Figure (b)

38. Ans: 1.3 (Range: 1.2 to 1.4)

Sol: CLTF $\frac{C(s)}{R(s)} = \frac{K}{S^2\tau + S + K} = \frac{K/\tau}{S^2 + S/\tau + K/\tau}$

$\underrightarrow{CE}$ $S^2 + S/\tau + K/\tau = 0$ ---(1)

Given $m_p = 0.254$

$0.254 = e^{-\pi\xi/\sqrt{1-\xi^2}}$

$+1.37 = +\left(\pi\xi/\sqrt{1-\xi^2}\right)$

$\xi = 0.399 \approx 0.4$

Given $t_p = 3$ sec

$3 = \frac{\pi}{\omega_n\sqrt{1-\xi^2}}$

$\omega_n = 1.14$ rad/sec

CE = $S^2 + 2\xi\omega_n S + \omega_n^2 = 0$

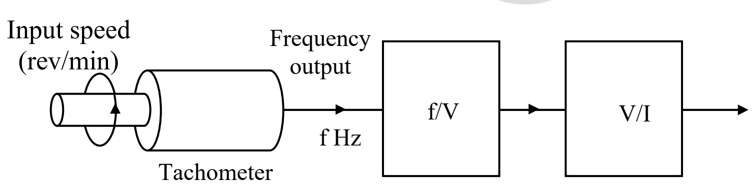
CE = $S^2 + 2\times0.4\times1.14S + 1.14^2 = 0$

CE = $S^2 + 0.912S + 1.3 = 0$ ---(2)

Compare equation (1) and (2)

$\frac{1}{\tau} = 0.912$ & $\frac{K}{\tau} = 1.3$

39. The diagram shows a system for measuring rotational speed.



The tachometer produces one cycle of electricity for every revolution. The f/V converter converts the frequency into mV such that a V = 0.6 f. The V/I converter produces an output of 0.8 mA/mV. The output current (in mA) when the tachometer is turned at 3000 rev/min is

39. Ans: 24

Sol: Given data:

f/V converter relation $\Rightarrow V = 0.6f$ (mV)

V/I converter relation $\Rightarrow I = 0.8V$ (mA)

Tachometer turned at 3000 (rev/min)

3000 (rpm) = pulses per second $\times$ 60

Pulses per second = frequency f = 50Hz

So output of f/V converter $V = 0.6f$ (mV)

$= 0.6 \times 50$ (mV)

$V = 30$ (mV)

Now output of V/I converter = 0.8 (mA/mV) $\times$ V

= 0.8 (mA/mV) $\times$ 30 (mV)

= 24 (mA)

40. An Iron vs Constantan thermocouple is to be used to measure temperature between 0°C and 300°C. The e.m.f. values are as given in table with respect to 0°C as:

Type	Temp (°C)	emf (μV)
J (Iron-Constantan)	100	5269
	200	10779
	300	16327
	500	27393

The non-linearity at 100°C as a percentage of full scale is

40. Ans: – 1.06 (Range: –0.85 to –1.20)

Sol: $E_{300,0} = 16327\ \mu V$

T (°C)	0	300
E (μV)	0	16327

$$\frac{T-0}{300-0} = \frac{E-0}{16327-0}$$

$$E = \frac{16327}{300}T$$

At T = 100°C, $E = \frac{16327}{300} \times 100 = 5442.3\ \mu V$

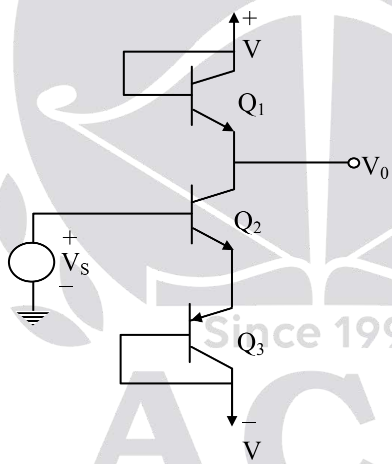
$E_{true} = 5442.3\ \mu V$

From table $E_{measured} = 5269\ \mu V$

So non linearity at 100°C as a % of full scale $= \frac{(E_{measured} - E_{true})}{16327} \times 100$

$$= \frac{(5269 - 5442.3)}{16327} \times 100 = -1.06$$

41. If g_m is the transconductance, r_0 is the output resistance and r_π is the base to emitter dynamic resistance then the approximate small signal voltage gain $\left(\frac{V_0}{V_S}\right)$ is _______.

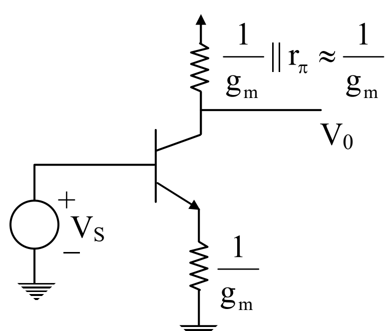


41. Ans: –0.5 (no range)

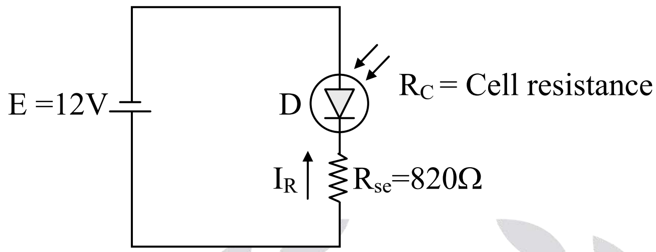
Sol:

$$\frac{V_0}{V_S} = \frac{-\frac{1}{g_m}}{\frac{1}{g_m} + \frac{1}{g_m}} = -0.5$$

$$\frac{V_0}{V_S} = \frac{-1}{2} = -0.5$$



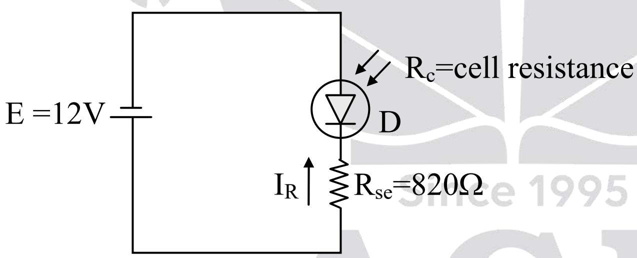
42. A photoconductive cell with characteristics as shown in figure is connected in series with an 820 Ω resistor and a 12 V supply. The cell illumination level (in lx) when the circuit current is approximately 1.1 mA is



R_C (in kΩ)	Illumination in (lx)
0.100	200
1.890	15
5.700	12
10.089	1

42. Ans: 1 (no range)

Sol:



Given I_R = 1.1 mA

$$R_c + R_{se} = \frac{12}{I_R}$$

$$R_c + 820 = \frac{12}{1.1\times10^{-3}}$$

R_c = 10089.1Ω = 10.089 kΩ

From given photoconductive cell characteristics we say that cell resistance (R_c) 10.089kΩ corresponds to illumination level of 1 lx.

43. A system has an impulse response $h(t) = 10\ \text{rect}\left(\frac{t-0.01}{0.02}\right)$. The null-to-null B.W. is _____ Hz

43. Ans: 50 (no range)

Sol: $A\ \text{rect}(t/T) \leftrightarrow ATSa\left(\frac{\omega T}{2}\right)$

Given $h(t) = 10\ \text{rect}\left(\frac{t-0.01}{0.02}\right)$

$H(\omega) = 0.2\ Sa(0.01\omega)\ e^{-j\omega(0.01)} = 0.2\ Sa\left(\frac{\omega}{100}\right)e^{-j\omega(0.01)}$

Zero crossing frequencies are $\frac{\omega}{100} = \pm n\pi$

$\omega = \pm 100 n\pi$

Null to null bandwidth = 100π rad/sec = 50Hz

44. A system with input x(n) and output y(n) are related as $y(n) - 0.2y(n-1) = x(n) - 5x(n-1)$. The magnitude of the d.c & high frequency gain of this filter are α and β respectively. Then the value of $\alpha + \beta$ is _______

44. Ans: 10 (no range)

Sol: $y(n) - 0.2y(n-1) = x(n) - 5x(n-1)$

Apply z-transform

$Y(z) - 0.2\ z^{-1}\ Y(z) = X(z) - 5z^{-1}\ X(z)$

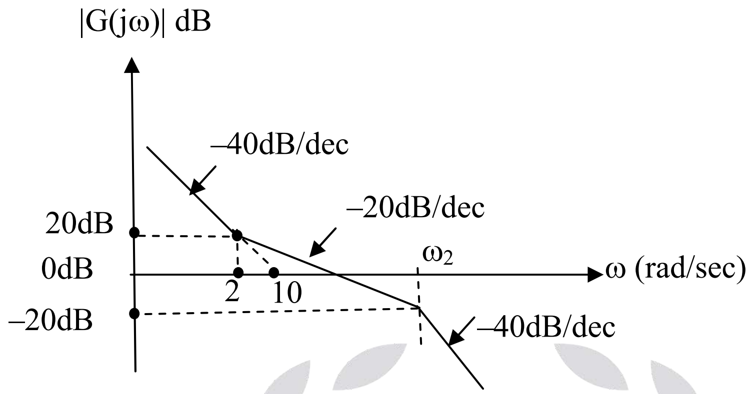
Transfer Function is $H(z) = \frac{Y(z)}{X(z)} = \frac{1-5z^{-1}}{1-0.2z^{-1}} \Rightarrow H(e^{j\omega}) = \frac{1-5e^{-j\omega}}{1-0.2e^{-j\omega}}$

D.C. gain = $\left|H(e^{j0})\right| = \left|\frac{1-5}{1-0.2}\right| = 5 = \alpha$

H.F. gain = $\left|H(e^{j\pi})\right| = \left|\frac{1+5}{1+0.2}\right| = 5 = \beta$

$\alpha + \beta = 10$

45. The Bode plot of a minimum phase unity feedback system is given below.



Then the ratio of acceleration error coefficient (K_a) to ω_2 is ______ .

45. Ans: 0.5 (no range)

Sol: $TF = G(s) = \dfrac{k\left(1+\dfrac{s}{2}\right)}{s^2\left(1+\dfrac{s}{\omega_2}\right)}$

For calculation of ω_2,

$$\frac{-20-20}{\log\omega_2 - \log 2} = -20$$

$$2 = \log\frac{\omega_2}{2}$$

$$\omega_2 = 200 \text{ rad/sec}$$

$$\left|\frac{k}{s^2}\right| = \frac{k}{\omega^2} = 1 \text{ at } \omega = 10$$

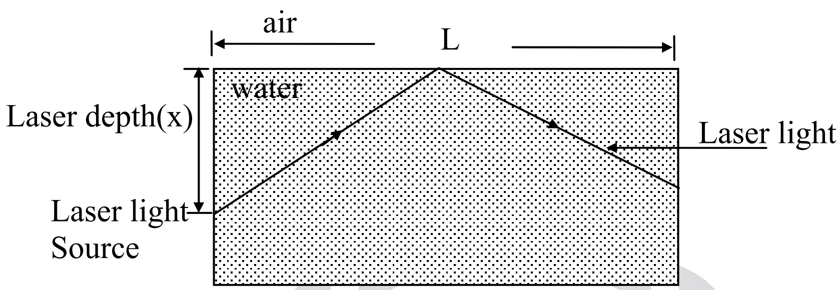
$$\therefore\ k = \omega^2 = 100$$

$$K_a = \underset{s\to 0}{\text{Lt}}\ s^2\, G(s) = k$$

$$K_a = k = 100$$

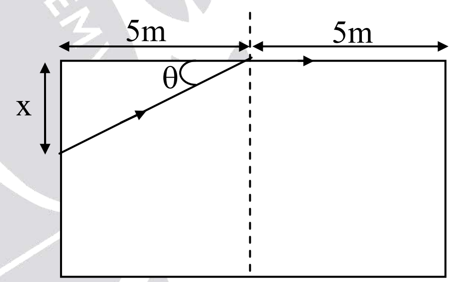
$$\frac{K_a}{\omega_2} = \frac{100}{200} = 0.5$$

46. A submerged laser at one end of a swimming pool is aimed at the surface of the water ($n_w = 1.33$) at the midpoint along the pool's length (L=10m) if the light is to undergo total internal reflection back into the water, the maximum depth x (in m) that the laser can be situated is



46. Ans: 4.38 (Range: 4.30 to 4.40)

Sol: The angle of incidence beyond which ray of light passing through a denser medium to the surface of less dense medium are no longer refracted but totally reflected.



$$i_c = \sin^{-1}\left(\frac{n_2}{n_1}\right) = \sin^{-1}\left(\frac{n_{air}}{n_{water}}\right) = \sin^{-1}\left(\frac{1}{1.33}\right)$$

$i_c = 48.75°$

Since value of x is required we find out θ using i_c value.

$\theta = 90 - i = 41.25°$

$x = 5\tan(41.25°) = 4.38$ m

47. On the average 15 cars pass a certain point on a road per hour. What is the probability that exactly four cars pass through the point in a 12 minute period?

47. Ans: 0.168 (Range: 0.16 to 0.17)

Sol: Let we use Poisson distribution.

Average number of cars passing through the point in a 12 minute period $= \dfrac{15}{\left(\dfrac{60}{12}\right)} = 3$

$\therefore \lambda = 3$

By Poisson distribution,

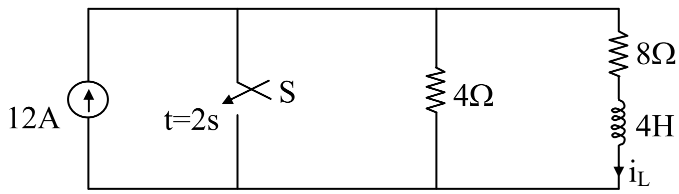
$$P(X = k) = \frac{e^{-\lambda}.\lambda^k}{k\,!}$$

$\therefore$ The Required probability $= P(X = 4) = \dfrac{e^{-3}.3^4}{4\,!} = 0.168$

48. Consider the following circuits as shown in figure.

Switch is opened for a longtime it is closed at t = 2 sec.

Determine the value of i_L at t = 3 sec.



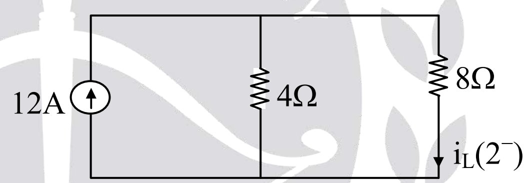
(A) $\frac{4}{e^2}$ A (B) $\frac{4}{e^6}$ A (C) $\frac{4}{e^{10}}$ A (D) $\frac{4}{e^3}$ A

48. Ans: (A)

Sol: For $t < 2$, 'S' is opened

$t = 2^-$ – (steady state) L→S.C for initial value of 'L'

By Current Division Rule

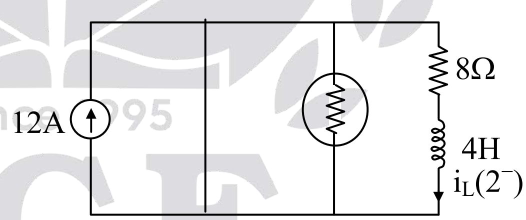


$$i_L(2^-) = \frac{12\times 4}{4+8} = 4A$$

$$= i_L(2^+) = I_0$$

For $t > 2$, 'S' is closed

It is RL source free circuit



$$\tau = \frac{L}{R} = \frac{4}{8} = \frac{1}{2}$$

$$i_L(2^+) = I_o e^{-t/\tau}$$

$$i_L(t) = 4e^{\frac{-(t-2)}{\frac{1}{2}}}$$

$$i_L(t) = 4e^{-2(t-2)} A$$

At $t = 3$ Sec

$$i_L(t) = 4\,e^{-2(3-2)}$$

$$i_L(t) = \frac{4}{e^2} \text{ Amps}$$

Distractor Logic:

(a) Option (A) is correct

(b) If $i_L(t) = 4\,e^{-2t}$

At t = 3 sec $i_L(t) = 4\,e^{-2(3)}$

$$i_L(t) = \frac{4}{e^6}\,A$$

(c) If $i_L(t) = 4\,e^{-2(t+2)}$

At t = 3 sec $i_L(t) = 4\,e^{-2(3+2)}$

$= 4\,e^{-10}$

$$i_L(t) = \frac{4}{e^{10}}\,A$$

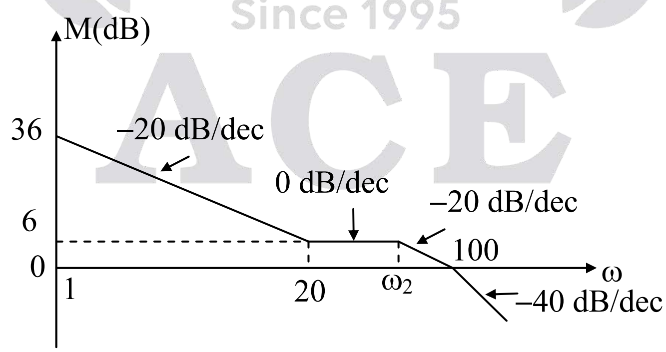
(d) If $i_L(t) = 4\,e^{-t}$

At t = 3 sec $i_L(t) = 4\,e^{-(3)}$

$i_L(t) = 4e^{-3}$

$$i_L(t) = \frac{4}{e^3}\,A$$

49. The asymptotic magnitude plot of a minimum phase system is shown in figure. The approximate phase margin of the system is



(A) 45° (B) 50° (C) 55° (D) 60°

49. Ans: (D)

Sol: Select line from ω_2 rise to 100 rad/sec.

$$\text{Slope} = \left(\frac{M_2 - M_1}{\log\omega_2 - \log\omega_1}\right) \qquad \Rightarrow -20 = \left(\frac{0-6}{\log 100 - \log\omega_2}\right)$$

$$\Rightarrow \log 100 - \log\omega_2 = \frac{-6}{-20} = 0.3$$

$-\log\omega_2 = 0.3-2$

$\log\omega_2 = 1.7$

$\omega_2 = 50.11 \approx 50$ rad/sec

$$\Rightarrow \text{TF } G(s)H(s) = \frac{K(1+S/20)}{S(1+S/50)(1+S/100)}$$

$\omega_{gc} = 100$rad/sec [from figure]

$$PM = 180^0 + \angle G(j\omega)H(j\omega)|_{\omega_{gc}} = 180^0 + \left[-90^0 + \tan^{-1}\left(\frac{\omega_{gc}}{20}\right) - \tan^{-1}\left(\frac{\omega_{gc}}{50}\right) - \tan^{-1}\left(\frac{\omega_{gc}}{100}\right)\right]$$

$$PM = 180^0 + \left[-90^0 + \tan^{-1}\left(\frac{100}{20}\right) - \tan^{-1}\left(\frac{100}{50}\right) - \tan^{-1}\left(\frac{100}{100}\right)\right] = 60^0$$

Distractor Logic:

(a) If $\omega_2 = 20$ rad/sec, then PM = 45^0

(b) If $\omega_2 = 30$ rad/sec, then PM = 50^0

(c) If $\omega_2 = 40$ rad/sec, then PM = 55^0

(d) Correct ans: if $\omega_2 = 50$ rad/sec, then PM = 60^0

50. A linear time invariant system is described by the state equation

$$\dot{X} = \begin{bmatrix} -1 & 2 \\ -1 & -3 \end{bmatrix} X + \begin{bmatrix} 0 \\ 1 \end{bmatrix} U$$

The state transition matrix is

(A) $\begin{bmatrix} e^{-2t}[\cos(t) - \sin(t)] & -2e^{-2t}\sin(t) \\ e^{-2t}\sin(t) & e^{-2t}[\cos(t)+\sin(t)] \end{bmatrix}$

(B) $\begin{bmatrix} +e^{-2t}[\cos(t) + \sin(t)] & 2e^{-2t}\sin(t) \\ -e^{-2t}\sin(t) & e^{-2t}[\cos(t)-\sin(t)] \end{bmatrix}$

(C) $\begin{bmatrix} e^{-2t}[\cos(t)+\sin(t)] & -2e^{-2t}\sin(t) \\ +e^{-2t}\sin(t) & e^{-2t}[\cos(t)-\sin(t)] \end{bmatrix}$

(D) $\begin{bmatrix} e^{-2t}[\cos(t)-5\sin(t)] & -2e^{-2t}\sin(t) \\ e^{-2t}\sin(t) & e^{-2t}[\cos(t)-3\sin(t)] \end{bmatrix}$

50. Ans: (B)

Sol: $[SI-A]=\begin{bmatrix} S+1 & -2 \\ +1 & S+3 \end{bmatrix}$

$$\text{STM}\,\phi(t)=L^{-1}\left[[SI-A]^{-1}\right]=L^{-1}\left[\frac{\text{Adj}[SI-A]}{|SI-A|}\right]$$

$$\phi(t)=L^{-1}\begin{bmatrix} \dfrac{S+3}{(S+2)^2+1} & \dfrac{2}{(S+2)^2+1} \\ \dfrac{-1}{(S+2)^2+1} & \dfrac{S+1}{(S+2)^2+1} \end{bmatrix}=L^{-1}\begin{bmatrix} \dfrac{(S+2)+1}{(S+2)^2+1^2} & \dfrac{2}{(S+2)^2+1^2} \\ \dfrac{-1}{(S+2)^2+1^2} & \dfrac{(S+2)-1}{(S+2)^2+1^2} \end{bmatrix}$$

$$=\begin{bmatrix} e^{-2t}[\cos(t)+\sin(t)] & 2e^{-2t}\sin(t) \\ -e^{-2t}\sin(t) & e^{-2t}[\cos(t)-\sin(t)] \end{bmatrix}$$

Distractor Logic:

(a) If $\text{Adj}[SI-A]=\begin{bmatrix} \dfrac{S+1}{(S+2)^2+1} & \dfrac{-2}{(S+2)^2+1} \\ \dfrac{1}{(S+2)^2+1} & \dfrac{S+3}{(S+2)^2+1} \end{bmatrix}$, then $\phi(t)$ becomes option (A)

(b) Option (B) is correct

(c) If $\text{Adj}[SI-A]=\begin{bmatrix} \dfrac{S+3}{(S+2)^2+1} & \dfrac{2}{(S+2)^2+1} \\ \dfrac{-1}{(S+2)^2+1} & \dfrac{S+1}{(S+2)^2+1} \end{bmatrix}$, then $\phi(t)$ becomes option (C)

(d) If [SI–A] is written wrong, then $\phi(t)$ becomes option (D)

51. The volume flow rate of a liquid is calculated by allowing the liquid to flow into a cylindrical tank (stood on its flat end) and measuring the height of the liquid surface before and after the liquid has flow for 10 minutes. The volume collected after 10 minutes is given by

Volume = $(h_2 - h_1)\ \pi(d/2)^2$

Here h_1 and h_2 are the starting and finishing surface heights and d is the measured diameter of the tank. If h_1 = 2m, h_2 = 3m, d = 2m, the volume flow rate (in m^3/min) is

(A) $\frac{\pi}{10}$ (B) $\frac{\pi}{5}$ (C) $\frac{2\pi}{5}$ (D) π

51. Ans: (A)

Sol: Volume collected in 10 minutes $= \frac{(h_2 - h_1)\pi d^2}{4}$

Now volume at $h_1 = 2m$

$h_2 = 3m$

$d = 2m$

$$\text{Volume collected in 10 minutes} = \frac{(3-2)\times\pi\times(2)^2}{4}$$

$$\text{Volume collected in 10 minutes} = \pi$$

Now the volume flow rate (in m^3/min) is

$$Q = \frac{\text{Volume collected in 10 min}}{10\,\text{min}} = \frac{\pi}{10} \quad (m^3/\text{min})$$

Destructor Logic:

(a) This is correct option

(b) This option will be correct choice if we take

$$\text{Volume} = \frac{(h_2 - h_1)\pi d^2}{2} = \frac{(3-2)\pi(2)^2}{2} = 2\pi$$

$$Q = \frac{2\pi}{10} = \frac{\pi}{5}$$

(c) This option will be correct choice if we take

$$\text{Volume} = (h_2 - h_1)\pi d^2 = (3-2)\pi(2)^2 = 4\pi$$

$$Q = \frac{4\pi}{10} = \frac{2\pi}{5}$$

(d) This option will be correct choice if we take volume collected in option (a) taken as flow rate then $Q = \pi$

52. A 230 V, 1-ϕ, watt hour meter has a constant load of 4A passing through it for 6 hours at unity power factor. If the meter disc makes 2208 revolutions during this period. What is the meter constant in revolutions /kWh. Calculate the power factor of the load if the number of revolutions made by the meter is 1472 when operating at 230 V, 5A for 4 hrs

(A) 400, 0.8 (B) 400, 0.96 (C) 320, 1.5 (D) 400, 1

52. Ans: (A)

Sol: Energy supplied $= \text{VI}\cos\phi t = \frac{230\times4\times1}{1000}\times6 = 5.52$ kWh

$\therefore$ Meter constant, $K = \frac{2208}{5.52} = 400$ rev/kWh

Energy consumed when the meter makes 1472 revolutions

$$= \frac{1472}{400} = 3.68 \text{ kWh}$$

$\therefore$ Energy consumed = VI $\cos\phi \times t$

$$3.68 \text{ kWh} = \frac{230\times5\times\cos\phi}{1000}\times4$$

$\therefore$ $\cos\phi = 0.8$

Destructor Logic:

Option (A): Option (A) is correct

Option (B): Energy supplied $= \frac{230\times4\times1\times6}{1000} = 5.52$ kWh

Meter constant, $K = \frac{\text{rev}}{\text{kWh}} = \frac{2208}{5.52} = 400$ rev/kWh

Energy consumed = VI$\cos\phi$t

$$5.52 \text{ kWh} = \frac{230\times5\times\cos\phi}{1000}\times5$$

$\cos\phi = 0.96$

Option (C): Energy supplied $= \frac{230\times5\times1}{1000}\times6 = 6.9$ kWh

$$K = \frac{2208}{6.9} = 320 \text{ rev/kWh}$$

$$\text{Energy consumed} = \frac{230\times5\times\cos\phi}{1000}\times4$$

$$6.9 = \frac{230\times5\times\cos\phi}{1000}\times4$$

$$\cos\phi = 1.5$$

Option (D): Energy supplied $= \frac{230\times5\times1}{1000}\times6 = 5.52$ kWh

$$K = \frac{2208}{5.52} = 400 \text{ rev/kWh}$$

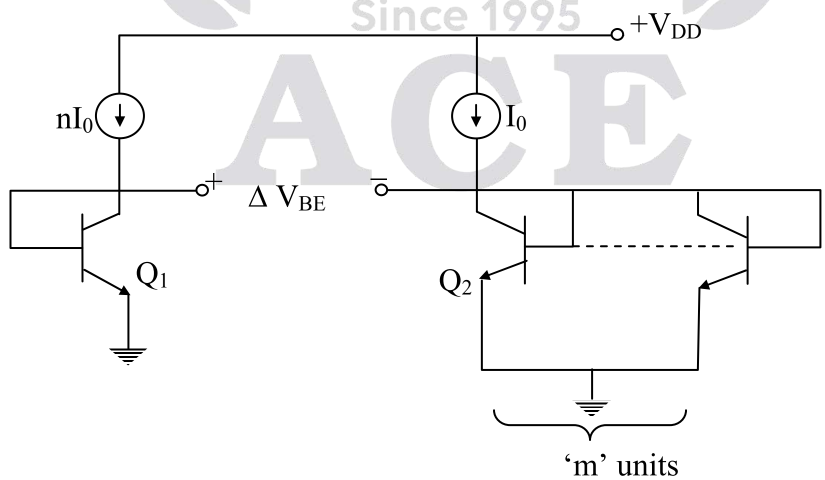
Energy consumed for 1472 rev

$$= \frac{1472}{400} = 3.68 \text{ kWh}$$

$$3.68 = \frac{230\times4\times\cos\phi}{1000}\times4$$

$$\cos\phi = 1$$

53. Calculate ΔV_{BE} in the following circuit where Q_2 is formed as the parallel combination of "m" units each identical to Q_1 [V_t is the thermal voltage]



(A) $V_t \ln [n\, m]$ (B) $V_t \ln \left[\frac{n}{m}\right]$ (C) $V_t \ln \left[\frac{m}{n}\right]$ (D) $V_t \ln \left[\frac{1}{nm}\right]$

53. Ans: (A)

Sol: $\Delta V_{BE} = V_B - V_E$

$$= V_t \ln\left[\frac{I_{C1}}{I_S}\right] - V_t \ln\left[\frac{I_{C2}}{I_S}\right]$$

$$= V_t \ln\left[\frac{nI_0}{I_S}\right] - V_t \ln\left[\frac{I_o/m}{I_S}\right]$$

$$= V_t \ln [n\,m]$$

Distractor Logic:

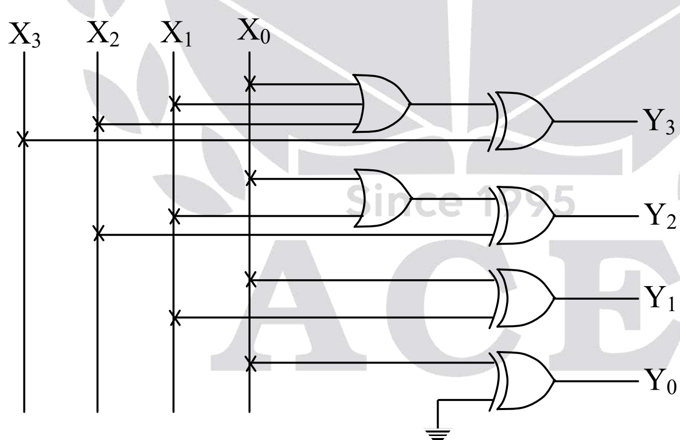
Option A: Right answer

Option B: If current division is not applied in Q_2

Option C: If current division is applied in Q_1

Option D: If ΔV_{EB} is considered

54. A combinational circuit has 4 inputs X_3, X_2, X_1, X_0 (LSB) and 4 outputs Y_3, Y_2, Y_1, Y_0 (LSB) and its implementation is as shown below. Find the function of the circuit.



(A) Binary to Gray code converter

(B) Gray to Binary code converter

(C) 2's complement of Binary input

(D) BCD to Ex-3 code converter

54. Ans: (C)

Sol: From given combinational circuit

$\Rightarrow Y_3 = (X_2 + X_1 + X_0) \oplus X_3$

$Y_2 = (X_1 + X_0) \oplus X_2$

$Y_1 = X_0 \oplus X_1$

$Y_0 = 0 \oplus X_0 = X_0$

It is 2's complement of binary input $X_3\, X_2\, X_1\, X_0$

Distractor logic:

(A): If output expressions are taken as $Y_3 = X_3$

$$Y_2 = X_2 \oplus X_3$$

$$Y_1 = X_1 \oplus X_2$$

$$Y_0 = X_0 \oplus X_1$$

Then it acts as "Binary to Gray" code converter

(B): If output expressions are taken as $Y_3 = X_3$

$$Y_2 = X_3 \oplus X_2$$

$$Y_1 = Y_2 \oplus X_1$$

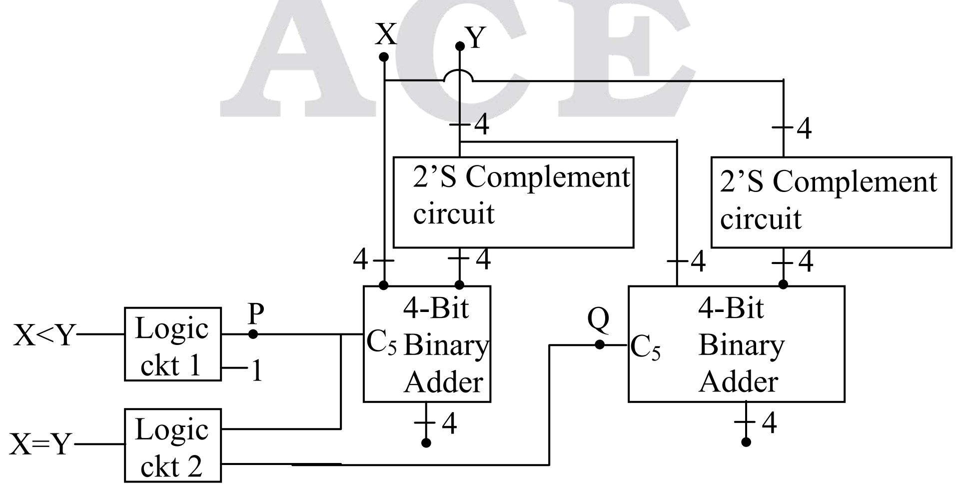
$$Y_0 = Y_1 \oplus X_0$$

Then it acts as "Gray to Binary" code converter

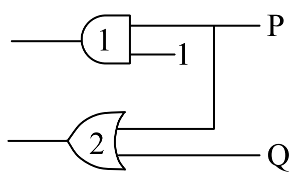
(C): Option (C) is correct

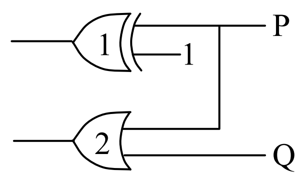
(D): Possibility to pick it as "BCD to Ex-3 code converter".

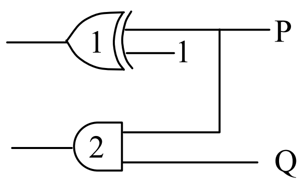
55. A 4-Bit Digital comparator with X<Y and X=Y outputs is built using two 4-Bit Binary subtractors as shown in the following figure, where P and Q indicates the End Around Carry(EAC) value

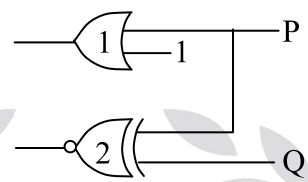


Which of the following is suitable for implementation of logic circuit 1 and 2

(A)


(B)


(C)


(D)


55. Ans: (C)

Sol: If EAC = 0 i.e., P = 0 then X < Y output is $P \oplus 1 = 0 \oplus 1 = 1$

X = Y only if P = 1, Q = 1 then X = Y output is P.Q

Distractor logic

(A) If P is mistaken for carry and equality occurs if either P or Q is 1.

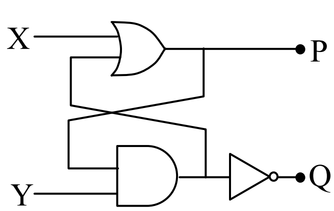
(B) If outputs P, Q are taken as carries after subtraction.

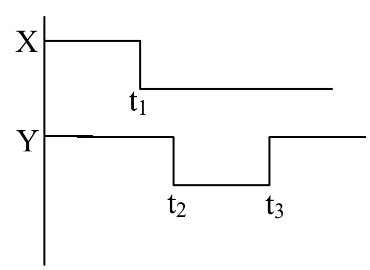
(C) Option (C) is correct

(D) If output P is mistaken for carry instead of EAC.

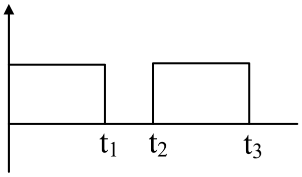
56. An XY latch is constructed using OR, AND and inverter gates as shown below. The values of P and Q must be complement to each other.

Find the output waveform, for the following inputs

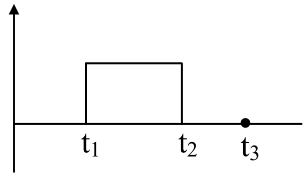




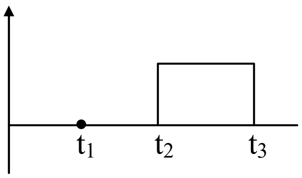
(A)



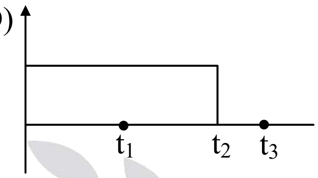
(B)



(C)



(D)



56. Ans: (D)

Sol: XY latch function table is

X	Y	P	Q
0	0	0	1
0	1	No Change	
1	0	Not Allowed	
1	1	1	0

Sketch the waveform at 'P' based on X, Y inputs according to the above table.

Destruction logic

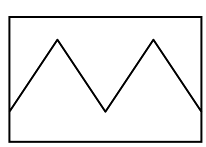
(a) If 01 and 00 input response is taken as 0 and 1 respectively

(b) If 11, 01, 00 Input responses are taken as 0, 1, 0 respectively

(c) If 11, 01, 00 input response is taken as 0, 0, 1 respectively

(d) Option (D) is correct

57. A single channel analog CRO is used to sense an unknown signal whose waveform is displayed as given below



This signal has peak amplitude of 5V and frequency of 10 kHz. The screen dimensions are 10 div × 8 div. The displayed wave occupies 5 div from peak to peak. What are the values of vertical deflection sensitivity and horizontal time base setting?

(A) 2 V/div & 20 μs/div (B) 0.5 V/div & 10 μs/div

(C) 0.5 div/V & 20 μs/div (D) 2 div/V & 10 μs/div

57. Ans: (C)

Sol: We know:

V_{p-p} = Number of vertical divisions × Volt/div

$\Rightarrow 2 \times 5V = 5 \text{ div} \times \text{Volt/div}$

$$\Rightarrow \frac{\text{Volt}}{\text{div}} = \frac{10\,\text{volt}}{5\,\text{div}} = 2\frac{\text{volt}}{\text{div}}$$

$$S = \frac{1}{2\frac{\text{volt}}{\text{div}}} = 0.5 \text{ div/volt}$$

We know,

$$T_{signal} = \text{Number of horizontal divisions per 1cycle} \times \frac{\text{Time}}{\text{div}}$$

$$\frac{1}{10\,\text{kHz}} = 5\frac{\text{div}}{\text{cycle}} \times \frac{\text{Time}}{\text{div}}$$

$$\Rightarrow \frac{\text{Time}}{\text{div}} = \frac{1}{10\,\text{kHz} \times 5\frac{\text{div}}{\text{cycle}}} = 0.02 \text{ ms/div} = 20\ \mu\text{s/div}$$

Distractor Logic:

Option (a): We know:

V_{p-p} = Number of vertical divisions × volt/div

$\Rightarrow 2 \times 5V = 5 \text{ div} \times \text{volt/div}$

$$\Rightarrow \frac{\text{Volt}}{\text{div}} = \frac{10\,\text{volt}}{5\,\text{div}}$$

$$S = 2\frac{\text{volt}}{\text{div}}$$

$$T_{signal} = \text{Number of horizontal divisions per 1cycle} \times \frac{\text{Time}}{\text{div}}$$

$$\frac{1}{10\,\text{kHz}} = 5\frac{\text{div}}{\text{cycle}} \times \frac{\text{Time}}{\text{div}}$$

$$\Rightarrow \frac{\text{Time}}{\text{div}} = \frac{1}{10\,\text{kHz} \times 5\frac{\text{div}}{\text{cycle}}} = 0.02 \text{ ms/div} = 20\ \mu\text{s/div}$$

Option (b): We know:

V_{p-p} = Number of vertical divisions × volt/div

$\Rightarrow 2 \times 5V = 5 \text{ div} \times \text{volt/div}$

$$\Rightarrow \frac{\text{Volt}}{\text{div}} = \frac{10\,\text{volt}}{5\,\text{div}} = 2\frac{\text{volt}}{\text{div}}$$

$$S = \frac{1}{2\frac{\text{volt}}{\text{div}}} = 0.5 \text{ div/volt}$$

We know,

$$T_{signal} = \text{Number of horizontal divisions per 1cycle} \times \frac{\text{Time}}{\text{div}}$$

$$\frac{1}{10\,\text{kHz}} = \frac{\text{div}}{\text{cycle}} \times \frac{\text{Time}}{\text{div}}$$

$$\Rightarrow \frac{\text{Time}}{\text{div}} = \frac{1}{10\,\text{kHz} \times \frac{\text{div}}{\text{cycle}}} = 0.01 \text{ ms/div} = 10\ \mu\text{s/div}$$

Option (c): Option (C) is correct

Option (d): We know:

V_{p-p} = Number of vertical divisions × Volt/div

$\Rightarrow 2 \times 5V = 5 \text{ div} \times \text{Volt/div}$

$$\Rightarrow \quad \frac{\text{Volt}}{\text{div}} = \frac{10\,\text{volt}}{5\,\text{div}}$$

$$S = 2\frac{\text{volt}}{\text{div}}$$

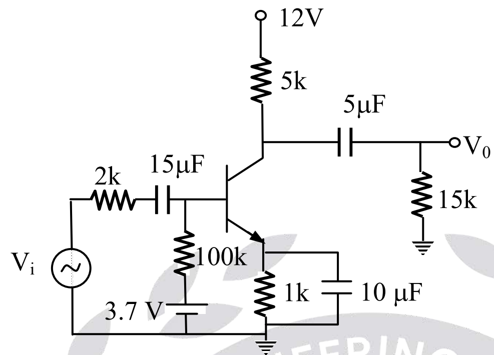
We know,

$$T_{signal} = \text{Number of horizontal divisions per 1cycle} \times \frac{\text{Time}}{\text{div}}$$

$$\frac{1}{10\,\text{kHz}} = \frac{\text{div}}{\text{cycle}} \times \frac{\text{Time}}{\text{div}}$$

$$\Rightarrow \frac{\text{Time}}{\text{div}} = \frac{1}{10\,\text{kHz} \times \frac{\text{div}}{\text{cycle}}} = 0.01 \text{ ms/div} = 10\ \mu\text{s/div}.$$

58. For the amplifier circuit shown, the transistor has $\beta = 100$, $V_{BE} = 0.7$ V and $V_T = 25$ mV. Then the approximate value of $A = \left(\frac{V_0}{V_i}\right)$ is



(A) – 102 (B) – 135 (C) – 302 (D) – 226

58. Ans: (A)

Sol: Apply DC analysis to calculate r_e :

Apply KVL to B-E loop:

$3.7 - 100\times10^3 I_B - 0.7 - 10^3 I_E = 0$

$3 = 100\times10^3 I_B + 10^3(1+\beta)I_B$

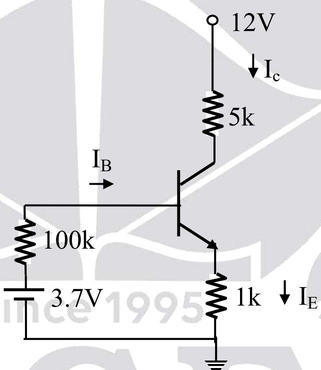
$= I_B \times 10^3[100+101]$

$I_B = \frac{3}{201\times10^3} = 14.925\ \mu A$

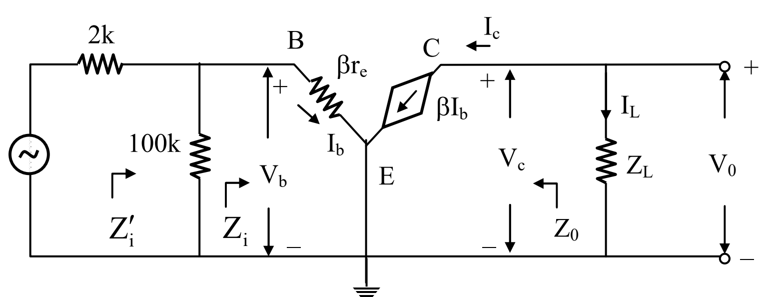
$I_C = \beta I_B = 1.4925$ mA

$I_E = (1+\beta)\ I_B = 1.5074$ mA

Then $r_e = \frac{V_T}{I_E} = \frac{25}{1.5074} = 16.584\ \Omega$



Apply AC analysis to calculate voltage gain 'A'



Z_L = 5k//15k = 3.75 k

$A_I = -\beta = -100$

$Z_i = \beta\, r_e = 1658.4\ \Omega$

$$A_V = \frac{A_I.Z_L}{Z_i} = \frac{-100\times 3.75\times 10^3}{1658.4} = -226.12$$

$$Z_i' = 100k\ //\ Z_i = \frac{(100\text{ k})(1.6584\text{ k})}{101.6584\text{ k}} = 1.6313\text{ k}\Omega$$

$$A = \left(\frac{V_0}{V_i}\right) = A_V\left(\frac{Z_i'}{Z_i' + R_s}\right) = -226.12\left(\frac{1.6313}{1.6313+2}\right) = -101.58 \approx -102$$

Distractor logic:

Option (A): Option (A) is correct

Option (B): By taking the load resistance as 5kΩ only, $A_V = \frac{A_I Z_L}{Z_i} = \frac{-100\times 5k}{1.6554k} = -301.49$

$$A = \left(\frac{V_0}{V_i}\right) = A_V\left(\frac{Z_i'}{Z_i' + R_s}\right)$$

$$= -301.49\left(\frac{1.6313}{3.6313}\right)$$

$$A = -135.44$$

Option (C): By taking the load resistance as 5kΩ only, then

$$A_V = \frac{A_I Z_L}{Z_i} = -301.49$$

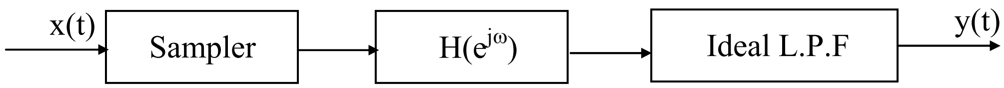
By considering voltage gain as voltage amplification, $A = A_V = -\ 301.49$

Option (D): By taking the load resistance as 5k//15k and considering voltage gain as voltage amplification.

$$A_V = \frac{A_I Z_L}{Z_i} = \frac{-100\times 3.75K}{1.6584K} = -226.12$$

$A = A_V = -226.12$

59. An analog signal x(t) = cos(0.25πt) is passed through the following system.



The sampler is ideal and operates at f_s = 1Hz. The cut-off frequency of the ideal low pass filter is f_c = 0.5 Hz. The frequency response of the digital filter is $H(e^{j\omega}) = \text{rect}(\omega/\pi)\, e^{-j\omega/4}$. The relation between y(t) and x(t) is _______

(A) y(t) = x(t)   (B) y(t) = x(t – 0.25)
(C) y(t) = x(t – 0.5)   (D) y(t) = x(t + 0.5)

59. Ans: (B)

Sol: Given x(t) = cos(πt/4) with f_s = 1Hz

Resultant discrete time signal is $x(n) = \cos\left(\frac{\pi n}{4}\right)$

$$\omega_o = \pi/4$$

$H(e^{j\omega}) = \text{rect}(\omega/\pi)\, e^{-j\omega/4}$

$$H(e^{j\omega}) = e^{-j\frac{\omega}{4}} \quad -\frac{\pi}{2} < \omega < \frac{\pi}{2}$$

Thus, $y(n) = \cos\left(\frac{n\pi}{4} - \frac{\pi}{16}\right)$

$$\therefore\ y(t) = \cos\left(\frac{\pi t}{4} - \frac{\pi}{16}\right) = \cos\left(\frac{\pi}{4}(t-0.25)\right) = x(t-0.25)$$

Distractor logic:

Option (A): If we feel $|H(e^{j\omega})| = 1$ acting like all pass filter, we may think y(t) = x(t)

Option (B): Option (B) is correct

Option (C): If we are not taking common multiplier $\frac{\pi}{4}$ in the output term correctly, it may be treated as option (C).

Option (D): If we feel time advance, may be choosing option (D)

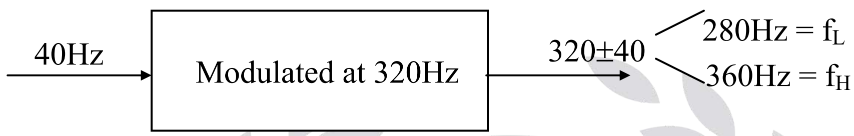
60. A signal x(t) is band–limited to 40Hz & modulated by a 320Hz carrier to generate modulated signal y(t). The minimum sampling rate for y(t) to prevent aliasing is ______

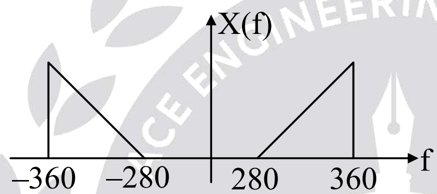
(A) > 80 Hz (B) 160 Hz

(C) $180 < f_s < 186.67$ Hz (D) $360 < f_s < 373$ Hz

60. Ans: (C)

Sol:





$$N = \text{int}\left(\frac{f_H}{f_H - f_L}\right) = \text{int}\left(\frac{360}{80}\right) = 4$$

we require $\frac{2f_H}{m} \le f_s \le \frac{2f_L}{m-1}$; m = 1,2,----N

= 1,2,3,4

For minimum f_s, m = 4 $\Rightarrow \frac{2f_H}{4} \le f_s \le \frac{2f_L}{3}$

$180 \le f_s \le 186.67$ Hz

Distractor logic:

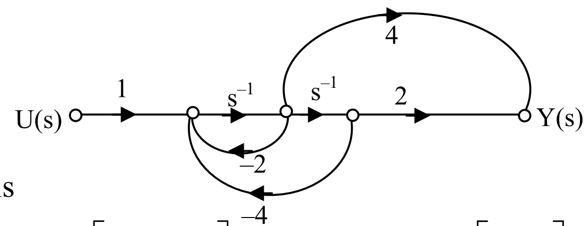
Option (A): Assuming y(t) as band limited signal taking $f_s > 80$ Hz

Option (B): As carrier frequency is 320 Hz, you may feel $\frac{320}{2} = 160\,\text{Hz}$

Option (C): Option (C) is correct

Option (D): If you feel least value of m = 2, you may choose option (D)

61. System with the state space representation $\dot{X} = AX + BU, Y = CX + DU$ has the following state diagram



Then the matrix A is

(A) $\begin{bmatrix} 0 & 1 \\ -4 & -2 \end{bmatrix}$ (B) $\begin{bmatrix} 0 & 1 \\ -2 & -4 \end{bmatrix}$ (C) $\begin{bmatrix} 0 & 1 \\ 4 & 2 \end{bmatrix}$ (D) $\begin{bmatrix} 0 & 1 \\ 2 & 4 \end{bmatrix}$

61. Ans: (A)

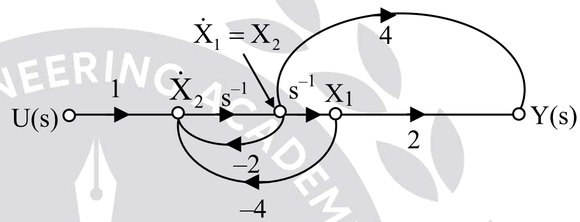
Sol: $\dot{X}_1 = X_2$

$\dot{X}_2 = -4X_1 - 2X_2 + U$

$Y = 2X_1 + 4X_2$

$\dot{X} = \begin{bmatrix} 0 & 1 \\ -4 & -2 \end{bmatrix} X + \begin{bmatrix} 0 \\ 1 \end{bmatrix} U$

$Y = [2 \quad 4]X$



Method 2:

$$\text{T.F} = \frac{Y(s)}{U(s)} = \frac{2(s^{-1})^2 + 4(s^{-1})}{1 - \left[-2s^{-1} - 4(s^{-1})^2\right]} = \frac{\frac{2}{s^2} + \frac{4}{s}}{1 - \left[-\frac{2}{s} - \frac{4}{s^2}\right]} = \frac{4s+2}{s^2+2s+4} = \frac{(4s+2)}{s^2+2s+4} = \frac{b(c_1 s + c_0)}{s^2 + a_1 s + a_0}$$

By controllable canonical form $A = \begin{bmatrix} 0 & 0 \\ -a_0 & -a_1 \end{bmatrix} = \begin{bmatrix} 0 & 1 \\ -4 & -2 \end{bmatrix}$

Distractor Logic:

Option (A): Option (A) is correct

Option (B): If we assume

$A = \begin{bmatrix} 0 & 1 \\ -a_1 & -a_0 \end{bmatrix}$ then option (B)

Option (c): If we assume

$A = \begin{bmatrix} 0 & 1 \\ a_0 & a_1 \end{bmatrix}$ then option (C)

Option (d): If we assume

$A = \begin{bmatrix} 0 & 1 \\ a_1 & a_0 \end{bmatrix}$ then option (D)

62. The values of constants a and b for which the vector

$\vec{F} = \left[x^2 + y + (a-b)z\right]\vec{i} + \left[(a+b)x - y^2 - z\right]\vec{j} + \left[2x - y + z^2\right]\vec{k}$ is irrotational, then which of the following is correct ?

(A) $a = \frac{3}{2}, b = \frac{1}{2}$ (B) $a = \frac{1}{2}, b = \frac{3}{2}$

(C) $a = \frac{-1}{2}, b = \frac{3}{2}$ (D) $a = \frac{3}{2}, b = \frac{-1}{2}$

62. Ans: (D)

Sol: $\text{curl}\,\vec{F} = \nabla \times \vec{F} = 0$

$$\begin{vmatrix} \vec{i} & \vec{j} & \vec{k} \\ \frac{\partial}{\partial x} & \frac{\partial}{\partial y} & \frac{\partial}{\partial z} \\ x^2 + y + (a-b)z & (a+b)x - y^2 - z & 2x - y + z^2 \end{vmatrix} = 0$$

$\Rightarrow \vec{i}(-1+1) - \vec{j}(2-(a-b)) + \vec{k}[(a+b)-1] = 0$

$\Rightarrow 0\,\vec{i} + \vec{j}[(a-b)-2] + \vec{k}[(a+b)-1] = 0\,\vec{i} + 0\,\vec{j} + 0\,\vec{k}$

$a - b - 2 = 0;\ a + b - 1 = 0$

$a - b = 2$

$a + b = 1$

on solving these two equations, we get $a = \frac{3}{2}, b = \frac{-1}{2}$

$\therefore$ Option (D) is correct.

63. For an n×n matrix consisting of all ones, which of the following is true?

(A) the distinct eigen values are 0 and 1

(B) the distinct eigen values are 1 and n

(C) the distinct eigen values are 1, 2, ..., n

(D) the distinct eigen values are 0 and n

63. Ans: (D)

Sol: Let $A = \begin{bmatrix} 1 & 1 & .... & 1 \\ 1 & 1 & .... & 1 \\ ... & .... & .... & ... \\ 1 & 1 & .... & 1 \end{bmatrix}_{n\times n}$

$|A - \lambda I| = 0$

$$\begin{bmatrix} 1-\lambda & 1 & .... & 1 \\ 1 & 1-\lambda & .... & 1 \\ ... & .... & .... & ... \\ 1 & 1 & .... & 1-\lambda \end{bmatrix}_{n\times n} = 0$$

$C_1 \to C_1 + C_2 + ... + C_n$

$$\begin{vmatrix} n-\lambda & 1 & .... & 1 \\ n-\lambda & 1-\lambda & .... & 1 \\ ... & .... & .... & ... \\ n-\lambda & 1 & .... & 1-\lambda \end{vmatrix} = 0$$

$R_2 - R_1, R_3 - R_1, ..., R_n - R_1$

$$\begin{vmatrix} n-\lambda & 1 & .... & 1 \\ 0 & -\lambda & .... & 0 \\ ... & .... & .... & ... \\ 0 & 0 & .... & -\lambda \end{vmatrix} = 0$$

$\Rightarrow \lambda = n, 0, 0, ..., 0 \qquad [(n-1) \text{ zeros}]$

$\therefore$ The distinct eigen values are 0 and n

64. The solution of the initial value problem $\frac{dy}{dx} = \left(y + y^2\right)\cot x$, $y\left(\frac{\pi}{2}\right) = 1$, is

(A) y cosx – (1 – y) sinx = 0 (B) y = sinx

(C) y = sinx + cosx (D) 2y – (1 + y) sinx = 0

64. Ans: (D)

Sol: Given $\frac{dy}{dx} = \left(y + y^2\right)\cot x$

$$\frac{dy}{y + y^2} = \cot x \; dx$$

$$\frac{dy}{y(1 + y)} = \cot x \, dx$$

$$\left(\frac{1}{y} - \frac{1}{1 + y}\right)dy = \cot x \, dx$$

Integrating both sides, we get

$\ell n\, y - \ell n\,(1 + y) = \ell n\; \sin x + \ell n\, C$

$$\ell n\left(\frac{y}{1 + y}\right) = \ell n\left(C \sin x\right)$$

$$\frac{y}{1 + y} = C \sin x$$

$\therefore$ y = C(1 + y) sinx .... (1) is the general solution.

$y\left(\frac{\pi}{2}\right) = 1$, (1) $\Rightarrow 1 = C(1 + 1)\sin\left(\frac{\pi}{2}\right)$

$\Rightarrow 1 = 2C$

$\Rightarrow C = \frac{1}{2}$

$\therefore\; y = \frac{1}{2}(1 + y)\sin x$

$2y = (1 + y) \sin x$

$2y - (1 + y)\sin x = 0$

Hence, option (D) is correct.

65. The value of the integral $\oint_C \left(\frac{e^{\frac{z^2}{2}}}{z^3}\right) dz$, where C = {z: |z| = 1}, is equal to

(A) 0 (B) 0.5 πi (C) πi (D) 2πi

65. Ans: (C)

Sol: $$\frac{e^{\frac{z^2}{2}}}{z^3} = \frac{1}{z^3}\left\{1+\left(\frac{z^2}{2}\right)+\frac{\left(\frac{z^2}{2}\right)^2}{2!}+\ldots\ldots\ldots\right\}$$

$$= \frac{1}{z^3}\left\{1+\left(\frac{z^2}{2}\right)+\frac{z^4}{8}+\ldots\ldots\ldots\right\} \quad = \frac{1}{z^3}+\frac{1}{2z}+\frac{z}{8}+\ldots\ldots$$

At $z = 0$, residue of $f(z)$ = coefficient of $\frac{1}{z}$ in the above expansion = $\frac{1}{2}$

$\therefore$ By Cauchy residue theorem, we have

$$\oint_C \left(\frac{e^{\frac{z^2}{2}}}{z^3}\right) dz = (2\pi i)\left(\frac{1}{2}\right) = \pi i\text{ss}$$