ACE
Engineering Academy

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ACE *Pre*-GATE 2017 Branch: ECE

Q.1 – Q.5 Carry One Mark Each

01. Reaching a place of appointment on Friday. I found that I was two days earlier than the scheduled day. If I had reached on the following Wednesday then how many days late would I have been?

(a) one (b) Two

(c) three (d) four

01. Ans: (c)

Sol: Friday $\rightarrow$ 2 days earlier

Therefore, scheduled day = Friday + 2 = Sunday

Sunday + 3 = Wednesday

Therefore, I would have been late by 3 days

02. Choose the most appropriate phrase from the options given below to complete the following sentence.

The bus stopped to _________ more passengers.

(a) Take in (b) Take on

(c) Take up (d) Take for

02. Ans: (b)

03. Choose the appropriate sentence from the following options.

(a) She has been discharged since.

(b) She has since been discharged.

(c) She has been since discharged.

(d) She since has been discharged.

03. Ans: (b)

04. Fill in the blank with an appropriate phrase.

The jet _________ into the air.

(a) Soared. (b) Soured.

(c) Sourced. (d) Sored.

04. Ans: (a)

05. Choose the most appropriate word from the options given below to complete the following sentence.

If I had known that you were coming, I ____________ you at the airport.

(a) Would meet (b) Would have met

(c) Will have met (d) Had met

05. Ans: (b)

Q.6 – Q.10 Carry two marks each

06. Which of the following can be logically inferred from the given statement.

"No other studied medicine except Helen"

(a) Helen only studied medicine

(b) Only Helen studied medicine

(c) Helen studied only medicine

(d) Helen studied medicine only

06. Ans: (b)

07. The average electricity bill of a household for January to June is ₹ 980, for July to September is ₹ 670, for October to December is ₹ 720. If the family goes on vacation for June and July and no electricity is used, what would be the average electricity bill for that year?

(a) ₹ 500 (b) ₹ 600

(c) ₹ 700 (d) ₹ 800

07. Ans: (c)

Sol: Average electricity bill from January to June = ₹ 980

$\therefore$ Total electricity bill from January to May = 980 × 5 = ₹ 4900

(As no electricity is used in June)

Similarly, total electricity bill from August to September (as no electricity is used in July) = 670 × 2 = ₹ 1340

And total electricity bill from October to December = 720 × 3 = ₹ 2160

Therefore, total electricity bill from January to December = 4900 + 1340 + 2160 = ₹8400

Thus, average electricity bill for the whole year $= \frac{8400}{12} = ₹700$

08. The following question has four statements of three segments each. Choose the alternative where the third segment in the statement can be deduced using both the preceding two but not just from one of them.

A. Sonia is an actress. Some actresses are pretty. Sonia is pretty.

B. All actors are pretty. Manoj is not an actor. Manoj is not pretty

C. Some men are cops. Some men are brave. Some brave people are cops.

D. All cops are brave. Some men are cops. Some men are brave.

(a) only C (b) only A

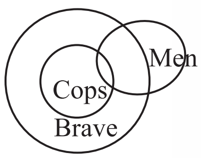
(c) only D (d) B and C

08. Ans: (c)

Sol: Statements:

All cops are brave

Some men are cops



Conclusion:

Some men are brave (True)

Hence, only D follows.

09. A contractor, who got the contract for building the flyover, failed to construct the flyover in the specified time and was supposed to pay ₹ 50,000 for the first day of extra time. This amount increased by ₹ 4,000 each day. If he completes the flyover after one month of stipulated time, he suffers a loss of 10% in the business. What is the amount he received for making the flyover in crores of rupee? (One month = 30 days)

(a) 3.1 (b)3.24

(c) 3.46 (d) 3.68

09. Ans: (b)

Sol: The sum of money that the contractor was supposed to pay for the period of an month over the stipulated time is

$$= S_n = \frac{n}{2}[2a + (n-1)d]$$

a = 50,000, n = 30, d = 4000

$$S_{30} = \frac{30}{2}[2\times 50{,}000 + (30-1)\times 4000] = 15[100{,}000 + 29\times 4000]$$

₹ 3240000 = ₹ 32.4 lakhs

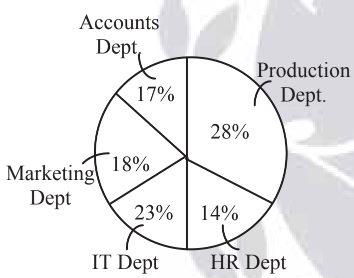
Loss in the business = 10%

$\therefore$ Amount he received for making the flyover = $\frac{3240000}{0.1} = 32400{,}000 =$ ₹ 3.24 crores

10. Study the following pie chart and table carefully to answer the following question that follow: Percentage break up of employees working in various departments of an organisation and the ratio of men to women in them.

Total number of employees = 1800

Percentage break up of employees:



Ratio of men to women

Department	Men	Women
Production	11	1
HR	1	3
IT	5	4
Marketing	7	5
Accounts	2	7

What is the number of men working in the marketing department?

(a) 132 (b) 174

(c) 126 (d) 189

10. Ans: (d)

Sol: Number of men working in the marketing department $= 1800 \times \frac{18}{100} \times \frac{7}{12} = 189$

Q.11 – Q.35 Carry one mark each.

11. The signal x(t) = cos(50πt) + cos(80πt) is sampled at 200Hz. The minimum number of samples required to prevent leakage is _______

11. Ans: 40

Sol: $\frac{\omega_1}{2\pi} = \frac{50\pi/200}{2\pi} = \frac{1}{8} = \frac{5}{40}$

$\frac{\omega_2}{2\pi} = \frac{80\pi/200}{2\pi} = \frac{1}{5} = \frac{8}{40}$

∴ The minimum number of samples required to prevent leakage is 40.

12. An n-channel JFET has a gate cut-off voltage of –10V. If –1V is applied at the gate terminal the minimum drain to source voltage required to obtain maximum drain resistance is ________ (V) (Neglect channel length modulation)

12. Ans: 9

Sol: Drain resistance will be maximum at saturation

Minimum voltage (V_{DS}) for saturation = $V_{GS} - V_P$

Given V_P = Gate cut-off voltage = –10 V

$V_{DS} = V_{GS} - V_P = -1 - (-10) = +9$ V

13. A fixed radar, used for navigational purpose, is operating at 3 GHz and transmitting 100 kW of power. If the smallest ocean going ship has a radar cross section of 200 m^2 and the radar antenna gain is 15dB, then the effective range of the radar is _____ (in km), if detection requires a minimum detectable signal power density of 1 nW/m^2 at the radar antenna.

13. Ans: 7.9 **Range : 7.8 to 8.1**

Sol: Given: 10logG = 15 ⇒ G = $10^{1.5}$ = 31.62

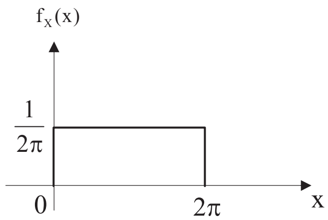
$$R_{max} = \left[\frac{P_t G A_e \times \sigma}{(4\pi)^2 \times S_{min}}\right]^{\frac{1}{4}} = \left[\frac{P_t G \sigma}{(4\pi)^2 \times \left(\frac{S_{min}}{A_e}\right)}\right]^{\frac{1}{4}} = \left[\frac{100\times 10^3 \times 31.62 \times 200}{(4\pi)^2 \times 1 \times 10^{-9}}\right]^{\frac{1}{4}}$$

∴ R_{max} = 7955.05m (or) 7.9km (or) ≅ 8km

14. X is a random variable which is uniformly distributed between $(0, 2\pi)$. Then $E[\cos X]$ = ______ .

14. Ans: 0

Sol:

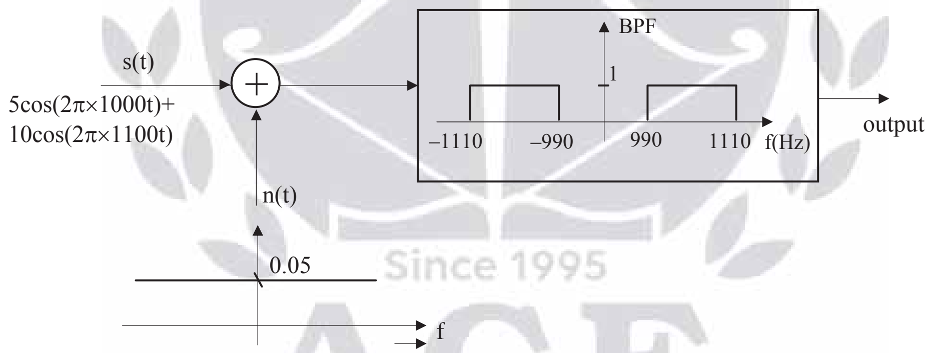


$$E[\cos X] = \int_0^{2\pi} \cos x \; f_X(x)\,dx = \int_0^{2\pi} \cos x \frac{1}{2\pi} dx$$

$$= \frac{1}{2\pi} \sin x \Big|_0^{2\pi}$$

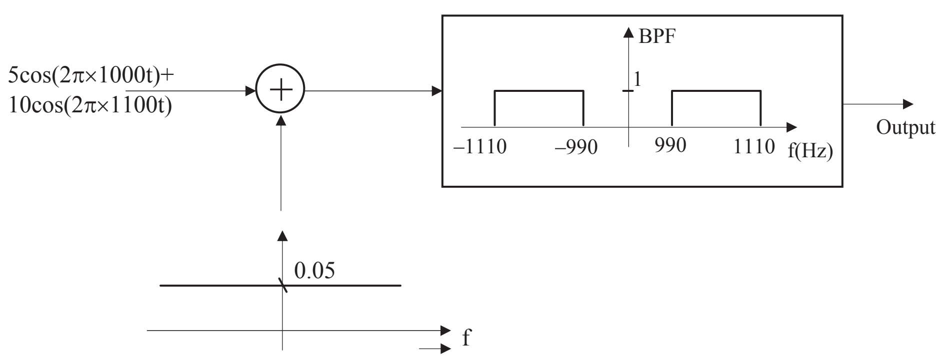
$$= 0$$

15. Consider the block diagram shown in figure. Find the signal to noise ratio at output.



15. Ans: 5.21 **Range: 5.1 to 5.3**

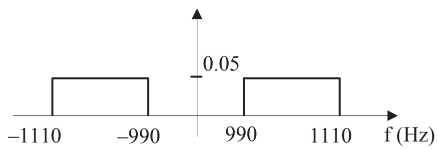
Sol:



s(t) contains frequencies 1000 Hz, 1100 Hz. Since BPF allows from 990 Hz to 1110 Hz.

Output contains both signals, so output signal power $= \frac{5^2}{2} + \frac{10^2}{2} = 62.5\text{W}$

Output Noise PSD is

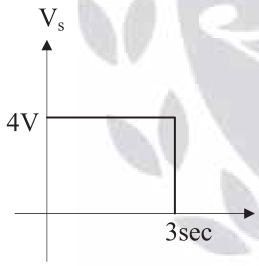


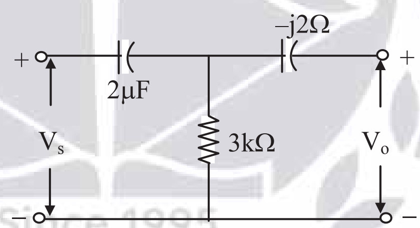
Area under PSD gives total power,

Output noise power = $2 \times 0.05 \times 120 = 12\text{W}$

Output signal to noise ratio $= \frac{62.5}{12} = 5.21$

16. A square pulse of 4V amplitude is applied to RC circuit shown in figure. The capacitor is initially uncharged. The output voltage V_o at time t = 3sec is ______ (in Volts).

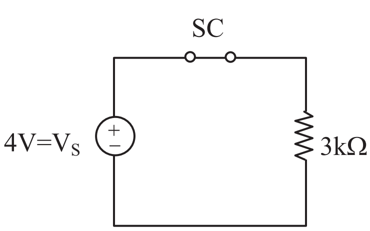




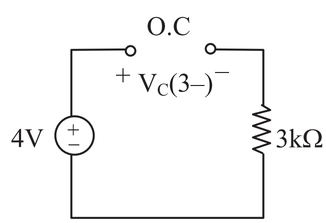
16. Ans: –4V

Sol:

At t = 0: C →Short Circuit

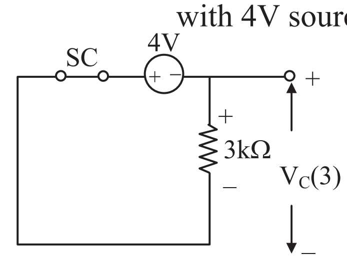


At t = (3–): C →Open Circuit



$V_C(3-) = V_C(3+) = 4\text{V}$

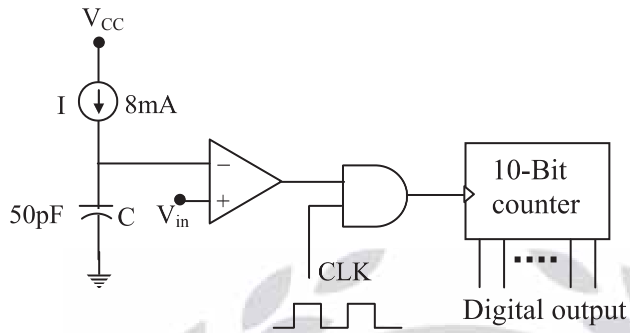
At t = 3: C →Short Circuit with 4V source



$V_C(3) = -4\text{V}$

Note: In the circuit –j2Ω capacitor Voltage is zero for all time since there is no current is flowing through that capacitor. Hence it acts as a Short Circuit.

17. A single slope ADC shown below is used to convert an analog input of 16V to digital. Determine the digital output (in decimal) if the clock frequency is 500 MHz. Initial voltage across capacitor is 0V



17. Ans: 50

Sol:

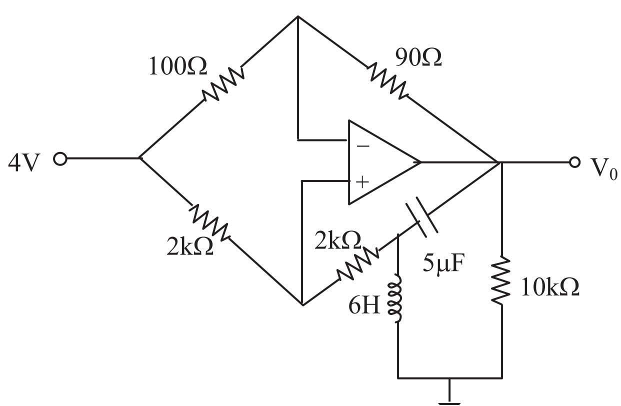
- Initially V_c = 0V; V_{in} = 16V ⇒ comparator output = 1 & clock pulses reach the Counter
- Time required for the capacitor to charge to 16V is It = CV

$$\Rightarrow t = \frac{CV}{I} = \frac{50\times10^{-12}\times16}{8\times10^{-3}} = 100\text{ns}$$

$$\text{Clock period T} = \frac{1}{500\times10^{6}} = 2\text{ ns}$$

$$\text{Digital output} = \frac{100\text{ ns}}{T} = \frac{100\text{ns}}{2\text{ns}} = (50)_{10}$$

18. If the Op-amp is ideal. Find the current (in Amp) across 90Ω resistor.



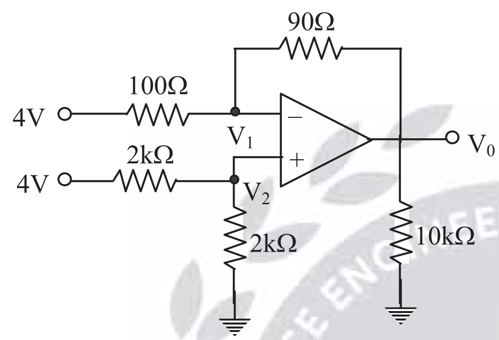
18. Ans: 0.02 **Range: 0.01 to 0.03**

Sol: Since, DC 4V is given as input, no switch (transient) is provided

$\Rightarrow$ we can proceed under steady state.

C $\rightarrow$ behaves as open & L $\rightarrow$ Acts as short

the circuit is $\rightarrow$



Hence the circuit behaves as a subtractor.

$\therefore$ From superposition,

$$V_0 = \frac{-90}{100}[4] + \left[1 + \frac{90}{100}\right]\left[\frac{4[2k]}{2k + 2k}\right] \text{Volts}$$

$= -3.6 + 3.8$

$= 0.2$ V

Hence, from circuit, as $V_2 = \dfrac{4(2k)}{2k + 2k} = V_1$

$\therefore$ $V_1 = 2V$

$$\therefore \; I_{90\Omega} = \frac{V_1 - V_0}{90} = 0.02A$$

19. If A, B & C are n × n matrices and | A | = 2, | B | = 3 & | C | = 5 then the value of $|A^2 B C^{-1}| = ?$

19. Ans: 2.4 **Range: 2 to 3**

Sol: $$\left|A^2 \; B \; C^{-1}\right| = \frac{|A||A||B|}{|C|} = \frac{2 \times 2 \times 3}{5} = \frac{12}{5}$$

$= 2.4$

20. What is the value of $\underset{x\to\infty}{\text{Lt}} \sqrt{(x^2+x+1)} - x$

20. Ans: 0.5 **Range: 0 to 1**

Sol: $\underset{x\to\infty}{\text{Lt}} \sqrt{(x^2+x+1)} - x = \underset{x\to\infty}{\text{Lt}} \left[\sqrt{x^2+x+1} - x\right]\left[\frac{\sqrt{x^2+x+1}+x}{\sqrt{x^2+x+1}+x}\right]$

$$= \frac{1+0}{\sqrt{1+0+0}+1} = \frac{1}{2} = 0.5$$

21. An Engineer applies the input r(t) = 2sin(t – 1.55) to a chemical process and measures the output as y(t) = 0.4sin(t – 1.55). What is the gain of the system?

21. Ans: 0.2 **Range: 0.1 to 0.3**

Sol: Input r(t) = 2sin(t–1.55)

Output y(t) = 0.4sin(t–1.55)

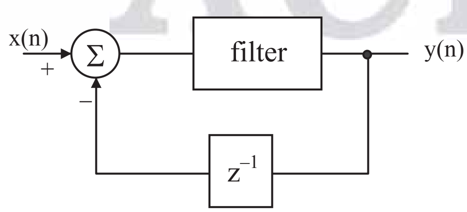
For sinusoidal input, the output is

$y(t) = A\times M \sin(t\pm\theta\pm\phi)$

$A\times M = 0.4$ ($A \rightarrow$ Amplitude of input), $A = 2$

$2M = 0.4 \Rightarrow M = 0.2$

22. Find the difference equation relating input x(n) and output y(n) for the realization shown in figure. If the filter impulse response is $h(n) = 0.5\delta(n) + 0.5\delta(n-1)$.



Option A: y(n) + y(n–1) + y(n–2) = x(n) + x(n–1)

Option B: y(n) + 0.5y(n–1) + 0.5y(n–2) = 0.5x(n) + 0.5x(n–1)

Option C: y(n) – 0.5y(n–1) – 0.5y(n–2) = 0.5x(n) + 0.5x(n–1)

Option D: 1.5y(n) + 0.5y(n–1) = 0.5x(n) + 0.5x(n–1)

22. Ans: (B)

Sol: Assume filter transfer function is $H_1(z)$.

$$H_1(z) = 0.5 + 0.5z^{-1}$$

$$H(z) = \frac{Y(z)}{X(z)} = \frac{H_1(z)}{1+z^{-1}H_1(z)} = \frac{0.5+0.5z^{-1}}{1+z^{-1}(0.5+0.5z^{-1})}$$

$$\frac{Y(z)}{X(z)} = \frac{0.5+0.5z^{-1}}{1+0.5z^{-1}+0.5z^{-2}}$$

$$Y(z)[1+0.5z^{-1}+0.5z^{-2}] = 0.5X(z) + 0.5z^{-1}X(z)$$

$$y(n) + 0.5y(n-1) + 0.5y(n-2) = 0.5x(n) + 0.5x(n-1)$$

Distractor Logic

Option A: If we miss 0.5 in filter impulse response.

Option B: Correct option

Option C: If we feel positive feedback system, wrong interpretation of taking negative coefficients.

Option D: In the feedback multiplier of $h_1(n)$ if we miss z^{-1}

23. An RC low pass filter has the impulse response $h(t) = e^{-t}\,u(t)$. The response of the system due to the input $x(t) = e^{2t}\,u(-t)$ is __________

Option A: $\frac{1}{3}e^{2t}u(-t)+\frac{1}{3}e^{-t}u(t)$

Option B: $\frac{-1}{3}e^{2t}u(t)-\frac{1}{3}e^{-t}u(-t)$

Option C: $-\frac{1}{3}e^{2t}u(-t)-\frac{1}{3}e^{-t}u(t)$

Option D: $e^{2t}u(-t)+e^{-t}u(t)$

23. Ans: (A)

Sol: $H(s) = \frac{1}{s+1}$; $\sigma > -1$

$X(s) = \frac{-1}{s-2}$; $\sigma < 2$

Output ROC = $(\sigma > -1) \cap (\sigma < 2) = -1 < \sigma < 2$

$$Y(s) = X(s)H(s) = \frac{-1}{(s-2)(s+1)} = \frac{-1/3}{s-2} + \frac{1/3}{s+1}$$

Based on the output ROC, take inverse Laplace transform $y(t) = \frac{1}{3}e^{2t}u(-t) + \frac{1}{3}e^{-t}u(t)$

Distractor Logic

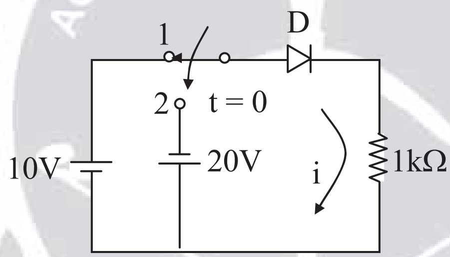
Option A: Correct Answer

Option B: In the partial fraction if we feel pole ‘2’ is right sided & pole ‘–1’ is left sided

Option C: In the partial fraction expansion if we take negative sign of Y(s) as it is

Option D: In the partial fraction expansion if we miss $\frac{1}{3}$ multipliers

24. The diode D shown in below figure is connected to 1 for a long time and is connected to 2 at t = 0. At t = 0+, the current (i) is __________. (Assume the forward drop of the diode to be 0V)



Option A: 0 A

Option B: 10 mA

Option C: –20 mA

Option D:–10 mA

24. Ans: (C)

Sol: The drop across the diode does not change for sudden change in applied voltage.

$\Rightarrow$ At t = 0+, $i = \frac{-20}{1k\Omega} = -20mA$

Distractor Logic

Option A: If the student assumes the diode reverse current is zero, he/she will go wrong.

Option B: If he/she assumes that diode current does not change, he/she will go wrong.

Option C: Correct option

Option D: If the diode forward current is just reversed, he/she will go wrong.

25. The electric field intensity is given inside a sphere of radius $R \le b$ m as $\vec{E} = 4R^2\hat{r}$ (N/C). If the sphere has permittivity 'ε', then the total electric displacement leaving the sphere $R = \frac{b}{2}$ m will be

Option A: $4\pi\varepsilon b^4$ Coulomb

Option B: $\pi\varepsilon b^4$ Coulomb

Option C: πb^4 Coulomb

Option D: $\frac{\pi b^4}{4}$ Coulomb

25. Ans: (B)

Sol: Given: $\vec{E} = 4R^2\hat{r}$ (N/C); $R \le b$

$\vec{D} = \varepsilon\vec{E}$

$= 4\,\varepsilon\,R^2\,\hat{r}\,C/m^2$

From Gauss's Law

$$\psi_{net} \equiv Q_{enc} = \oint_s \vec{D}.d\vec{S}$$

(or)

$$\psi_{net} = D_r \times \text{Area}$$

$$= 4\varepsilon R^2 \times 4\pi R^2$$

$$= 16\pi\varepsilon R^4$$

The net electric flux leaving the sphere of radius $R = \frac{b}{2}$ is given by

$$\psi_{net} = 16\pi\varepsilon\left(\frac{b}{2}\right)^4$$

$$\therefore\ \psi_{net} = \pi\varepsilon b^4\ C$$

Distractor Logic

Option A: Simplification mistake

$$\psi_{net} = 16\pi\varepsilon\left(\frac{b}{2}\right)^4 = 16\pi\varepsilon\frac{b^4}{4} = 4\pi\varepsilon b^4$$

Which is wrong answer

Option B: Correct option

Option C: If we take directly $\vec{E}$, while applying Gauss's law,

then $\psi_{net} = 4R^2 \times 4\pi R^2$

$$= 16\pi\left(\frac{b}{2}\right)^4 = \pi b^4$$

Which is wrong answer

Option D: $\psi_{net} = D_r \times \text{Area}$

If we take area $= \pi R^2$ then which results $\psi_{net} = \frac{\pi b^4}{4}$, which is wrong answer.

26. How deep does a radar wave at 3GHz propagate in seawater (σ = 4S/m, $\varepsilon = 24\varepsilon_0$, $\mu = \mu_0$) before its amplitude is reduced to 10^{-6} of its amplitude just below the surface?

Option A: 0.459cm

Option B: 3.41cm

Option C: 4.08cm

Option D: 9.86cm

26. Ans: (D)

Sol: $E_0\, e^{-\alpha z} = 10^{-6} \times E_0$

$$z = \frac{\ln 10^6}{\alpha}$$

$$\frac{\sigma}{\omega\varepsilon} = \frac{4}{2\pi\times 3\times 10^9 \times 24 \times \frac{10^{-9}}{36\pi}} = 1$$

$$\alpha = \omega\sqrt{\frac{\mu\varepsilon}{2}\left(\sqrt{1+\frac{\sigma^2}{\omega^2\varepsilon^2}}-1\right)}$$

$$= \frac{2\pi\times 3\times 10^9}{3\times 10^8}\sqrt{\frac{24}{2}\left(\sqrt{2}-1\right)}$$

α = 140.04Np/m

$$z = \frac{\ln 10^6}{140.04} = 0.0986\text{m}$$

$\therefore$ z = 9.86cm

Distractor Logic

Option A: If we calculate skin depth,

$$\delta = \sqrt{\frac{2}{\omega\mu\sigma}} = \sqrt{\frac{2}{2\pi\times 3\times 10^9 \times 4\pi\times 10^{-7}\times 4}}$$

= 0.459cm

Which is wrong answer.

Option B: If we forgot to substitute 'ε_r' value in α,

$\alpha = \frac{2\pi \times 3\times 10^9}{3\times 10^8}\sqrt{\left(\sqrt{2}-1\right)}$ which gives us z = 3.41cm, hence incorrect answer

Option C: $\alpha = \omega\sqrt{\frac{\mu\varepsilon}{2}\left(\sqrt{1+\frac{\sigma^2}{\omega^2\varepsilon^2}}+1\right)}$ $\rightarrow$ which is incorrect formulae.

$= 338.17$

$z = \frac{\ln 10^6}{338.17}$ = 4.08cm, which is wrong option

Option D: correct option.

27. Which of the following could not be the auto correlation function of a random process ?

Option A: $R(\tau) = \begin{cases} 1-|\tau|; & |\tau|<1 \\ 0; & |\tau|>1 \end{cases}$

Option B: $R(\tau) = 5\sin 3\tau$

Option C: $R(\tau) = \begin{cases} \cos\tau; & |\tau|\le \pi/2 \\ 0; & |\tau|>\pi/2 \end{cases}$

Option D: $R(\tau) = \frac{\sin\tau}{\tau}$

27. Ans: (B)

Sol: Auto correlation function is always even function, maximum value occurs at $\tau = 0$.

option (B) violating these two conditions

Distractor Logic

Option A: ACF satisfies $R_x(-\tau) = R_x(\tau)$

$|R_x(\tau)| \le R_x(0)$

$R(\tau) = \begin{cases} 1-|\tau|; & |\tau|<1 \\ 0; & |\tau|>1 \end{cases}$ satisfies both properties

So option A wrong

Option B: $R_x(-\tau) \ne R_x(\tau)$, $5\sin(3\tau)$ violates even condition

So option (B) Correct Answer

Option C: $\cos(\tau)$, $|\tau| \le \pi/2$ satisfies all properties

So option C is wrong

Option D: $\frac{\sin \tau}{\tau}$ satisfies all properties

So option D is wrongs

28. A network is composed of two sub-networks N_1 & N_2 as shown in figure

If the sub network N_1 contains only linear, bilateral, time invariant elements then it can be replaced by its Thevenin's equivalent even if the sub-network N_2 contains

Option A: A two-terminal element which is non linear

Option B: A non-linear inductance mutually coupled to an element in N_1

Option C: An element which is linear, but mutually coupled to same element in N_1

Option D: A dependent source the value of which depends upon the voltage (OR) current in any element of N_1

28. Ans: (A)

Sol: Network N_1 is passive network as per given data. Then network N_2 should be active element which should be independent. i.e., independent either voltage (OR) current source

Distractor Logic

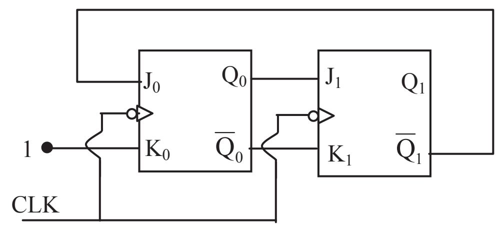
Option A: Correct option

Option B: Nonlinear inductance is not possible

Option C: If N_2 is linear element we can't replace the network by its Thevenin's equivalent

Option D: If N_2 contains dependent source then control variable should be in network N_2 only

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



Option A: $Q_0\,Q_1 = 00$

Option B: $Q_0\,Q_1 = 01$

Option C: $Q_0\,Q_1 = 10$

Option D: $Q_0\,Q_1 = 11$

29. 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., $Q_0Q_1 = 10$

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: Correct option

Option D: Mistakenly chosen as 11

30. In 8085 Microprocessor the Accumulator has a 2's complement number '11110100'. Determine the function of executing the following sequence of instructions RLC, RRC and RAR.

Assume 'carry' flag is cleared initially.

(A) It finds 1's complement representation of the given 2's complement number

(B) It converts the given 2's complement number to corresponding sign magnitude representation

(C) It divides the given 2's complement number by 2

(D) It multiplies the given 2's complement number by 2

Option A: It finds 1's complement representation of the given 2's complement number

Option B: It converts the given 2's complement number to corresponding sign magnitude representation

Option C: It divides the given 2's complement number by 2

Option D: It multiplies the given 2's complement number by 2

30. Ans: (C)

Sol: Given Accumulator value = -12_{10}

		ACC								cy
		1	1	1	1	0	1	0	0	0
RLC	⇒	1	1	1	0	1	0	0	1	1
RRC	⇒	1	1	1	1	0	1	0	0	1
RAR	⇒	1	1	1	1	1	0	1	0	0

Accumulator value is 11111010 = $\boxed{-6_{10}}$

Distractor Logic

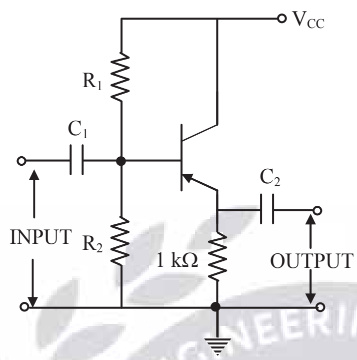
Option A: It may be mistaken as 1's complement form of given number

Option B: It may be mistaken as sign magnitude form of given number

Option C: Correct option

Option D: It may be mistaken as multiplication of 2's complement number

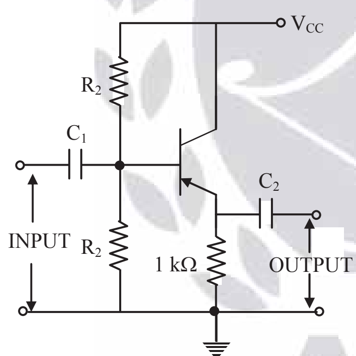
31. In the amplifier circuit shown in figure, the transistor parameters with usual notations are $g_m = 0.015$ S, $r_{b'e} = 1\,k\Omega$, $r_{bb'} = 90\,\Omega$, $C_{b'e} = 20$ pF and $C_{b'c} = 3$ pF. Neglecting the loading effect of biasing resistors, R_1 & R_2, the mid-frequency voltage gain of the amplifier is _____.



(A) – 13.76 (B) 0.9411 (C) 0.936 (D) 1

31. Ans: (C)

Sol:



Consider the parameters of BJT

$r_{b'e} = 1k\Omega$, $r_{bb'} = 90\Omega$ & $g_m = 0.015$ S,

Step(1) : $h_{ie} = r_{b'e} + r_{bb'} = 1090\,\Omega$

$$\text{Consider, } r_{b'e} = \frac{h_{fe}}{g_m} \Rightarrow h_{fe} = r_{b'e} \times g_m = 1k\Omega \times 0.015\,\mho = 15$$

Step(2): The given circuit is emitter follower (CC Amplifier)

$\therefore$ The mid-frequency voltage gain in a CC amplifier,

$$A_V = \frac{(1+h_{fe})R_E}{h_{ie} + (1+h_{fe})R_E} = \frac{16 \times 1k\Omega}{1.09k\Omega + 16 \times 1k\Omega} = \frac{16\,k\Omega}{17.09\,k\Omega}$$

$A_V = 0.936$

Distractor Logic

Option: A: If the given circuit is assumed as CE Amplifier, with a load resistance of

R_L=1k ; then,

Step (1): $h_{ie} = r_{b'e} + r_{bb'} = 1090\,\Omega$

$$\text{Consider, } r_{b'e} = \frac{h_{fe}}{g_m} \Rightarrow h_{fe} = r_{b'e} \times g_m = 1\text{k}\Omega \times 0.015\,\mho = 15$$

$$\text{Step (2): } A_V = -\frac{h_{fe}R_L}{h_{ie}} = -\frac{15\times 1\text{k}}{1.09\text{k}} = -13.76$$

Option: B

CC Amplifier: if we consider $h_{ie} = r_{b'e}$ [neglecting $r_{bb'}$ (base spreading resistance)]

$$A_V = \frac{(1+h_{fe})R_E}{h_{ie}+(1+h_{fe})R_E} = \frac{16\times 1\text{k}\Omega}{1\text{k}\Omega + 16\times 1\text{k}\Omega} = \frac{16\text{k}\Omega}{17\text{k}\Omega} = 0.9411$$

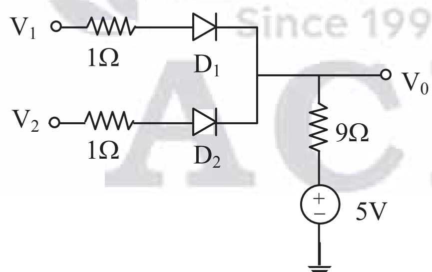
Option: C

CC Amplifier; $A_V = 0.936$

Option: D

The voltage gain in a CC amplifier ideally is ‘1’

32. Assume both the diodes to be precise, if $V_1 = -5V$ & $V_2 = 10V$, find V_0 ?



Option A: –4V

Option B: 8.87 V

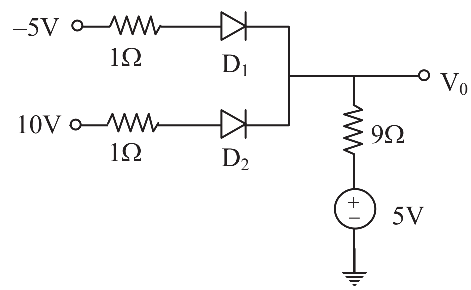
Option C: 9.5 V

Option D: –4.63 V

32. Ans: (C)

Sol: Assume D_1 OFF & D_2 ON,

$$\therefore V_0 = \frac{\left(\frac{10}{1}\right)+\left(\frac{5}{9}\right)}{\left(\frac{1}{1}\right)+\left(\frac{1}{9}\right)} = 9.5V$$



Now, check Assumption:

$$i_{D_2} = \frac{10-9.5}{1} = 0.5A > 0,$$

$\therefore$ $D_2 \rightarrow$ ON $\rightarrow$ True.

$$V_{D_1} = V_1 - V_0 = -5 - 9.5 = -14.5V < 0$$

$\therefore$ $D_1 \rightarrow$ OFF is True

Distractor Logic

Option A: –4 V $\rightarrow$ This is possible only when $D_1 \rightarrow$ short & $D_2 \rightarrow$ open

But from given biasing, this result is impossible

Option B: 8.87 V $\rightarrow$ is possible for $D_1 \rightarrow$ OFF & $D_2 \rightarrow$ ON, but if diodes are practical.

But given diodes are precise $\Rightarrow$ They are ideal

Option C: True

Option D: –4.63 V $\rightarrow$ This is possible only when $D_1 \rightarrow$short, $D_2 \rightarrow$open & diodes are practical

33. The general solution of $\frac{dy^4}{dx^4} - 6\frac{dy^3}{dx^3} + 12\frac{dy^2}{dx^2} - 8\frac{dy}{dx} = 0$ is

(A) $y = C_1 + (C_2 + C_3 x + C_4 x^2) e^{2x}$

(B) $y = (C_1 + C_2 x + C_3 x^2) e^{2x}$

(C) $y = (C_1 + C_2 x + C_3 x^2 + C_4 x^3) e^{2x}$

(D) $y = C_1 + C_2 x + C_3 x^2 + C_4 e^{2x}$

33. Ans: (A)

Sol: The given equation is $(D^4 - 6D^3 + 12D^2 - 8D)\, y = 0$

$D(D^3 - 6D^2 + 12D - 8)\, y = 0$

$D(D-2)^3 = 0$

$\therefore D = 0, 2, 2, 2$

$\therefore$ The required solution is (A)

34. $L\{e^{-2t}[1-u(t-1)]\} = ?$

(A) $\dfrac{1-e^{(s+2)}}{(s+2)}$ (B) $\dfrac{1+e^{(s+2)}}{(s+2)}$

(C) $\dfrac{1-e^{-(s+2)}}{(s+2)}$ (D) $\dfrac{1+e^{-(s+2)}}{(s+2)}$

34. Ans: (C)

Sol: $L\{e^{-2t}[1-u(t-1)]\} = L\{e^{-2t}\,g(t)\}$ (Where $g(t) = [1-u(t-1)]$)

$$= G(s+2) \quad \left(G(s) = L\{g(t)\} = \frac{1}{s} - \frac{e^{-s}}{s}\right)$$

$$= \frac{1-e^{-(s+2)}}{(s+2)}$$

35. The closed loop transfer function of a unity feedback system is $\frac{C(s)}{R(s)} = \left(\frac{30}{s^2+5s+36}\right)$. The steady state error due to a unit step input is

Option A: $\frac{36}{66}$

Option B: $\frac{1}{6}$

Option C: $\frac{36}{30}$

Option D: None

35. Ans: (B)

Sol: Given CLTF $\frac{C(s)}{R(s)} = \frac{30}{s^2+5s+36}$

Get OLTF $G(s) = \frac{30}{s^2+5s+6}$, H(s) = 1

Steady state error for unit step input $e_{ss} = \frac{1}{1+k} = \frac{1}{1+\frac{30}{6}}$

$$e_{ss} = \frac{6}{36} = \frac{1}{6}$$

Distractor Logic

Option A: If the given transfer function is considered as a OLTF then $e_{ss} = \frac{A}{1+k}$

$$e_{ss} = \frac{1}{1+\frac{30}{36}} = \frac{36}{66}$$

Option B: Correct Option

Option C: If the given transfer function is considered as OLTF and taken $e_{ss} = \frac{A}{k} = \frac{1}{\left(\frac{30}{36}\right)} = \frac{36}{30}$

Option D: If considered OLTF is unstable then e_{ss} is none (or) ∞

Q.36 – Q.65 carry two marks each.

36. Consider the filter $H(z)=\dfrac{z+2}{z+0.5}$. The input to this filter is x(n) = cos(nπ). The phase delay of this system is ________ (in secs)

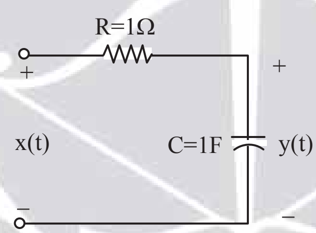
36. Ans: 1

Sol: $\omega_0=\pi\,(z=e^{j\omega_0}=-1)\Rightarrow H(e^{j\omega_0})=H(e^{j\pi})=H(-1)=\dfrac{-1+2}{-1+0.5}=-2=2e^{-j\pi}$

$x(n)=\cos(n\pi)\Rightarrow y(n)=2\cos(n\pi-\pi)$

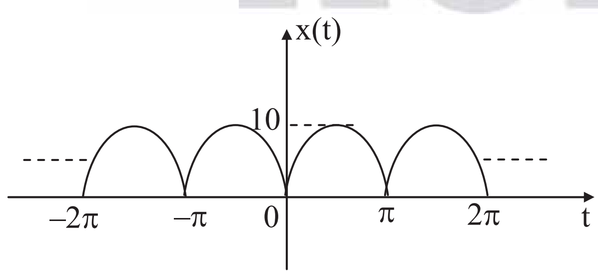
$t_p(\omega)=-\dfrac{\theta(\omega)}{\omega}=-\dfrac{(-\pi)}{\pi}=1\,\text{sec}$

37. Signal $x(t)=|10\sin t|$ Volts is applied to the circuit shown in figure. The Fourier series coefficient of the output has a dc value of ___________



37. Ans: 6.366 **Range: 6 to 7**

Sol: $x(t)=|10\sin t|$ is a Full-wave rectifier wave form



$T_0=\pi$

$\omega_0=\dfrac{2\pi}{T_0}=2$

The Exponential Fourier Series coefficients of Full Wave rectified wave form is

$$C_0 = \frac{1}{T_0}\int_0^{T_0} x(t)dt = \frac{1}{\pi}\int_0^{\pi} 10\sin t\, dt = \frac{10}{\pi}\left[-\cos t\Big|_0^{\pi}\right]$$

$$C_0 = \frac{20}{\pi}$$

$$C_n = \frac{1}{T_0}\int_0^{T_0} x(t)e^{-jn\omega_0 t}dt = \frac{1}{\pi}\int_0^{\pi} 10\sin(t)e^{-jn2t}dt = \frac{10}{\pi}\int_0^{\pi}\left[\frac{e^{jt}-e^{-jt}}{2j}\right]e^{-jn2t}dt$$

$$= \frac{10}{2\pi j}\left[\int_0^{\pi} e^{j(1-2n)t}dt - \int_0^{\pi} e^{-j(1+2n)t}dt\right]$$

$$= \frac{10}{2\pi j}\left[\frac{e^{j(1-2n)t}}{j(1-2n)}\Bigg|_0^{\pi} + \frac{e^{-j(1+2n)t}}{j(1+2n)}\Bigg|_0^{\pi}\right]$$

$$= \frac{10}{2\pi j}\left[\frac{e^{j\pi(1-2n)}-1}{j(1-2n)} + \frac{e^{-j\pi(1+2n)}-1}{j(1+2n)}\right] = \frac{10}{2j\pi}\left[\frac{-2}{j(1-2n)} - \frac{2}{j(1+2n)}\right]$$

$$= \frac{-20}{-2\pi}\left[\frac{1}{1-2n} + \frac{1}{1+2n}\right]$$

$$C_n = \frac{10}{\pi}\left[\frac{2}{1-4n^2}\right] = \frac{20}{\pi(1-4n^2)}$$

$$H(\omega) = \frac{1}{1+j\omega} \Rightarrow H(n\omega_0) = \frac{1}{1+jn\omega_0} = \frac{1}{1+j2n}$$

$$H(n\omega_0)\big|_{n=0} = 1$$

$\therefore$ dc component of output is $= C_0H(0) = \frac{20}{\pi} = 6.366$

38. A MOS capacitor with substrate doping of 10^{19} atoms/cm^3 of Boron and gate oxide thickness 1nm is operated in strong accumulation. If the permittivity of oxide is 3.5×10^{-11} F/m. The gate capacitance per unit area will be _____________ (mF/m^2). (Given permittivity of Si = 1.05×10^{-10} F/m and the maximum depletion width in Si can be 20 nm).

38. Ans: 35

Sol: $C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} = \frac{3.5\times10^{-11}}{1\times10^{-9}} = 0.035\ F/m^2 = 35\ mF/m^2$

39. An n-type silicon sample with donor doping concentration $N_D = 10^{16}/cm^3$ is steadily illuminated such that there is an additional generation rate (g') of $10^{21}\ cm^{-3}s^{-1}$. If $\tau_{n0} = \tau_{p0} = 10^{-6}$s, the position of quasi-Fermi level for holes with respect to intrinsic level is __________eV. (Assume intrinsic carrier concentration as $1.5\times10^{10}/cm^3$ and volt-equivalent temperature as 0.0259 V)

39. Ans: –0.2877 **Range: –0.2 to –0.3**

Sol: n-type

$\Delta n = \Delta p = g'\,\tau_{po} = 10^{21}10^{-6} = 10^{15}/cm^3$

We have $n_0 = N_D = 10^{16}/cm^3$

$$p_0 = \frac{n_i^2}{n_0} = \frac{(1.5\times10^{10})^2}{10^{16}} = 2.25\times10^4\ /\ cm^3$$

$$E_{Fp} - E_{Fi} = -kT\ln\left(\frac{p_0 + \Delta p}{n_i}\right)$$

$$= -0.0259\ln\left(\frac{2.25\times10^4 + 10^{15}}{1.5\times10^{10}}\right)$$

$$= -\,0.2877 \text{ eV}$$

40. A rectangular waveguide has a width to height ratio $\frac{a}{b} = 2$ and the ratio between operating frequency and the cutoff frequency is $\frac{f}{f_{c(10)}} = 2$ at f = 10GHz. What is the maximum time-averaged power (in Mega Watts) that can be transmitted in the waveguide in the TE_{10} mode without exceeding the breakdown electric field intensity of 30kV/cm in air?

40. Ans: 2.3 **Range: 2.1 to 2.5**

Sol: Given $\frac{a}{b} = 2$, E_0 = 30kV/cm = 3×10^6 V/m

$$\frac{f}{f_{c(10)}} = 2$$

f = 10GHz

$$f_c = \frac{f}{2}$$

$$\frac{c}{2a} = 5\text{GHz}$$

$$\Rightarrow \frac{3\times10^{10}}{2\times a} = 5\times10^9$$

$\therefore$ a = 3cm

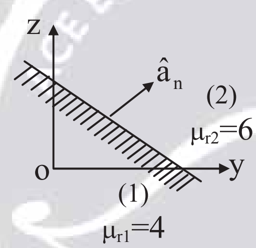
$$\eta_{TE_{10}} = \frac{\eta_0}{\sqrt{1-\left(\frac{f_c}{f}\right)^2}} = \frac{120\pi}{\sqrt{1-\left(\frac{1}{2}\right)^2}} = \frac{240\pi}{\sqrt{3}} \qquad [\because \text{for air filled } \eta_0 = 120\pi\Omega]$$

$$P_{total} = \frac{E_0^2}{\eta(TE_{10})}\frac{ab}{4}$$

$$= \frac{9\times10^{12}\times9\times10^{-4}}{\left(\frac{240\pi}{\sqrt{3}}\right)4\times2}$$

$\therefore$ $P_{total} = 2.325\times10^6$W (or) 2.32MW

41. Region 1, with $\mu_{r1} = 4$, is the side of the plane y + z =1 containing the origin (shown in figure). In region 2, $\mu_{r2} = 6$. If the magnetic flux density in region 1 is $\vec{B}_1 = 2\hat{a}_x + \hat{a}_y$ (Tesla), then the magnitude of magnetic flux density (in Tesla) in region 2 is ______.



41. Ans: 3.2 **Range: 3 to 3.4**

Sol: The unit vector normal to the plane y + z = 1 is given by

$$\hat{a}_n = \frac{\hat{a}_y + \hat{a}_z}{\sqrt{2}}$$

$$B_{n_1} = \vec{B}_1.\hat{a}_n = (2\hat{a}_x + \hat{a}_y).\left(\frac{\hat{a}_y + \hat{a}_z}{\sqrt{2}}\right)$$

$$B_{n1} = \frac{1}{\sqrt{2}}$$

$$\vec{B}_{n_1} = B_{n_1}\hat{a}_n = \frac{1}{\sqrt{2}}\left(\frac{\hat{a}_y + \hat{a}_z}{\sqrt{2}}\right)$$

$$\vec{B}_{n_1} = 0.5\hat{a}_y + 0.5\hat{a}_z$$

$$\vec{B}_{n2} = \hat{B}_{n_1} = 0.5\hat{a}_y + 0.5\hat{a}_z$$

$$\vec{B}_{t_1} = \vec{B}_1 - \vec{B}_{n_1}$$

$$= (2\hat{a}_x + \hat{a}_y) - (0.5\hat{a}_y + 0.5\hat{a}_z)$$

$$\vec{B}_{t_1} = 2\hat{a}_x + 0.5\hat{a}_y - 0.5\hat{a}_z$$

$$\frac{B_{t1}}{\mu_1} = \frac{B_{t2}}{\mu_2}$$

$$\Rightarrow \vec{B}_{t2} = \left(\frac{\mu_2}{\mu_1}\right)\vec{B}_{t1} = \left(\frac{3}{2}\right)\left[2\hat{a}_x + 0.5\hat{a}_y - 0.5\hat{a}_z\right]$$

$$\vec{B}_{t2} = 3\hat{a}_x + 0.75\hat{a}_y - 0.75\hat{a}_z$$

$$\vec{B}_2 = 3\hat{a}_x + 1.25\hat{a}_y - 0.25\hat{a}_z \quad [\because \vec{B}_2 = \vec{B}_{t2} + \vec{B}_{n2}]$$

$$\therefore \left|\vec{B}_2\right| = \sqrt{(3)^2 + (1.25)^2 + (-0.25)^2} = 3.259 \text{ Tesla}$$

42. Bandwidth of an Angle Modulated signal $10\cos(2\pi\times10^7t + 20\cos(1000\pi t))$ is ______ (kHz).

42. Ans: 21

Sol: $\theta_i = 2\pi\times10^7t + 20\cos(1000\pi t)$

$$\frac{d\theta_i}{dt} = 2\pi\times10^7 - 20\times1000\pi\sin(1000\pi t)$$

$$f_i = \frac{1}{2\pi}\frac{d\theta_i}{dt} = 10^7 - 10000\sin(1000\pi t)$$

$$\Delta f = f_{i,max} - f_c = 10000\text{ Hz}$$

$f_m = 500\text{Hz}$

$BW = 2\Delta f + 2f_m = 2\times10000 + 2\times 500$

$= 21$ kHz

43. Ten different signals are to be Time Division Multiplexed and transmitted using PCM. Four of these signals have a maximum frequency of 10kHz, two of them have maximum frequency of 15kHz, two other signals have a maximum frequency of 5kHz and remaining signals have a maximum frequency of 20kHz. The value of bit rate (in Mbps), if signals sampled at Nyquist rate and samples are represented using 10 bits is ______

43. Ans: 2.4 **Range: 2.3 to 2.5**

Sol: $r_{b,TDM} = n\, f_{s,TDM}$

$n = 10$

$f_{s,TDM} = 4f_{s_1} + 2f_{s_2} + 2f_{s_3} + 2f_{s_4}$

$W_1 = 10k\ ,\ f_{s_1} = 20k$

$W_2 = 15k\ ,\ f_{s_2} = 30k$

$W_3 = 5k\ ,\ f_{s_3} = 10k$

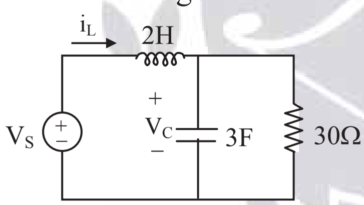
$W_4 = 20k\ ,\ f_{s_4} = 40k$

$f_{s,TDM} = 4\times 20k + 2\times 30k + 2\times 10k + 2\times 40k$

$= 240$ k samples/sec

$r_{b,TDM} = 10\times 240\text{k samples per sec} = 2400$ kbps $= 2.4$ Mbps

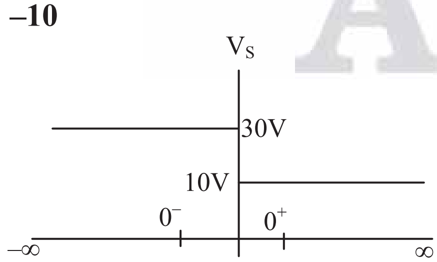
44. Consider the following network



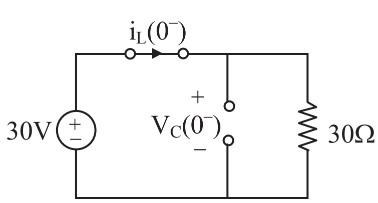
If $V_s = 10 + 20\,u(-t)$, then the value of $\dfrac{di_L(t)}{dt}$ at $t = 0^+$ in A/s is ________

44. Ans: –10

Sol:



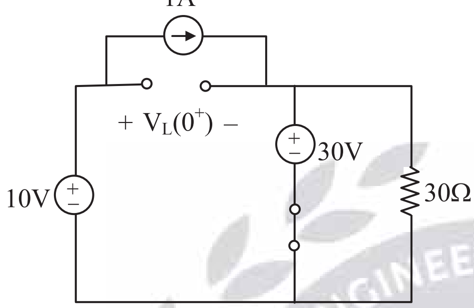
(i) At $t = 0^-$: Steady state



$$i_L(0^-) = \frac{30}{30} = 1A = i_L(0^+)$$

$$V_C(0^-) = 30V = V_C(0^+)$$

(ii) At $t = 0^+$



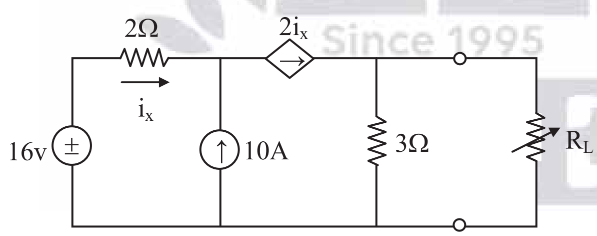
At $t = 0^+$: Transient state

By KVL $\Rightarrow 10 - V_L(0^+) - 30 = 0$

$$\Rightarrow V_L(t)\Big|_{t=0^+} = -20$$

$$\Rightarrow \frac{L di_L(t)}{dt}\Big|_{t=0^+} = -20 \Rightarrow \frac{di_L(t)}{dt}\Big|_{t=0^+} = \frac{-20}{L} = \frac{-20}{2} = -10A/s$$

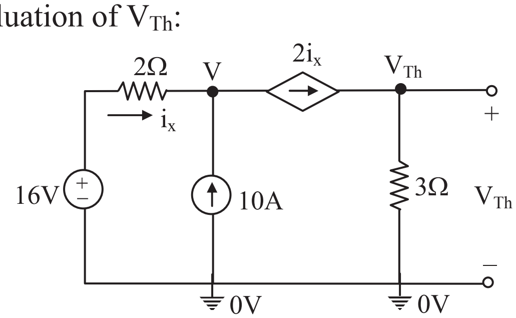
45. Consider the following network



The value of maximum power transferred to load 'R_L' (in watts) is ________

45. Ans: 300

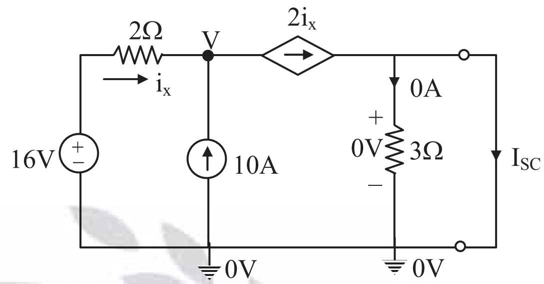
Sol: Evaluation of V_{Th}:



Nodal $\Rightarrow -i_x - 10 + 2i_x = 0 \Rightarrow i_x = 10A$

Nodal $\Rightarrow -2i_x + \frac{V_{Th}}{3} = 0 \Rightarrow V_{Th} = 6i_x = 60V$

Evaluation of I_{SC}:

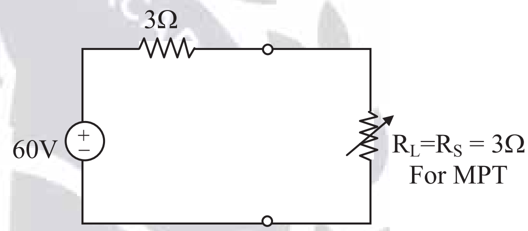


Nodal $\Rightarrow - i_x - 10 + 2i_x = 0 \Rightarrow i_x = 10$ A

So, $I_{SC} = 2i_x = 20A$

$$\Rightarrow R_{Th} = \frac{V_{Th}}{I_{SC}} = \frac{60}{20} = 3\Omega$$

$$\Rightarrow P_{max} = \frac{V_{Th}^2}{4 \times R_{Th}} = \frac{60^2}{4 \times 3} = 300W$$

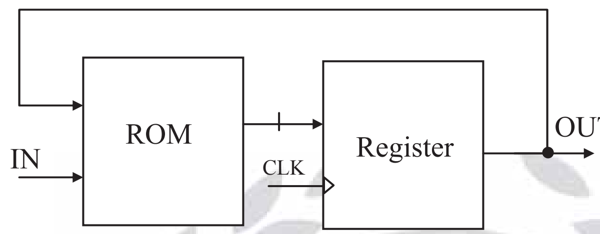


46. The maximum frequency of operation (in MHz) for the sequential circuit shown below is ______

The Propagation delays are as follows

t_{ROM} = 7.5 ns; t_{Reg} = 2.5 ns

t_{Setup} = 2.5 ns; t_{Hold} = 2.5 ns



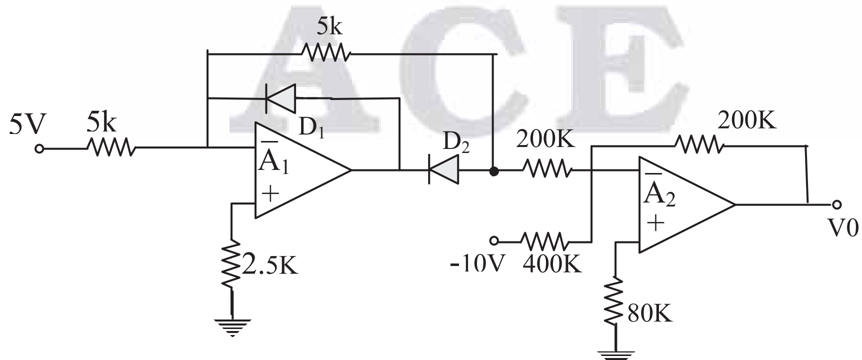
46. Ans: 80

Sol: The frequency of operation of the given sequential circuit is

$$f \le \frac{1}{t_{Rom} + t_{Reg} + t_{Setup}} \Rightarrow f \le \frac{1}{(7.5 + 2.5 + 2.5) \times 10^{-9}}$$

$$f_{max} = \frac{1 \times 10^9}{12.5} = 80\text{MHz}$$

47. Find the output voltage V_0 (in Volts) of op-amp circuit shown in figure assuming op-amp & diodes are as ideal.

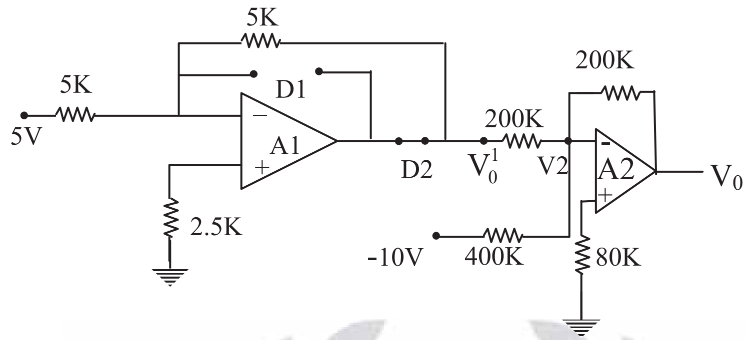


47. Ans: 10

Sol: Step (1) For the given input of 5v, D1 is off & D2 is ON

$$V_0^1 = \frac{-5k}{5k} \times 5v = -5v$$

Step (2) KCL at the inverting input, V_2 of op-amp2(A_2)



Op-amp 2 (A2)

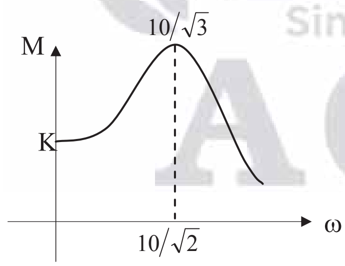
$$\frac{V_0^1}{200k} - \frac{10v}{400k} + \frac{V_0}{200k} = 0$$

$$V_0 = 200k\left[\frac{5V}{200k} + \frac{10V}{400k}\right] = 5\text{ V} + 5\text{ V}$$

$\therefore V_0 = 10$ V

48. Frequency response of a second order system is given below. The value of K is ____

$$G(s) = \frac{K \times 100}{s^2 + 10s + 100}$$



48. Ans: 5

Sol: $G(s) = \frac{K \times 100}{s^2 + 10s + 100}$

$s^2 + 10s + 100 \Rightarrow s^2 + 2s\xi\omega_n + \omega_n^2$

$\omega_n = 10$

$\xi = 1/2$

$$M = \frac{K}{2\xi\sqrt{1-\xi^2}} = \frac{10}{\sqrt{3}}$$

$$= \frac{K}{2(0.5)\sqrt{1-(0.5)^2}} = \frac{10}{\sqrt{3}}$$

K = 5

49. $y = e^{-x}\left(C_1 \cos\sqrt{3}\,x + C_2 \sin\sqrt{3}\,x\right) + C_3 e^{2x}$ is the general solution of

(A) $(D^3 + 4)\, y = 0$ (B) $(D^3 - 8)\, y = 0$

(C) $(D^3 + 8)\, y = 0$ (D) $(D^3 - 2D^2 + D - 2)\, y = 0$

49. Ans: (B)

Sol: The roots of AE are $\left(-1 \pm \sqrt{3}\, i\right)$ & 2

$\therefore$ The required equation is

$(D - 2)(D^2 + 2D + 4)\, y = 0$

i.e., $(D^3 - 8)\, y = 0$

50. Find the value of $\int_C \frac{z\cos z}{\left(z - \frac{\pi}{2}\right)^2} dz$, where 'C' is $|z - 1| = 1$

(A) $i\pi$ (B) $-i\pi$

(C) $i\pi^2$ (D) $-i\pi^2$

50. Ans: (D)

Sol: $z = \frac{\pi}{2} = \frac{3.14}{2} = 1.57$ is a pole of order '2' lies inside 'C'

$$\therefore \int_C \frac{z\cos z}{\left(z - \frac{\pi}{2}\right)^2} dz = 2\pi i\, f^1\left(\frac{\pi}{2}\right) \quad \text{(where } f(z) = z\cos z\text{)}$$

$$= 2\pi i\left(\frac{-\pi}{2}\right) = -\pi^2 i$$

51. $(a\alpha + b)\,x + ay + bz = 0$

$(b\alpha + c)\,x + by + cz = 0$

$(a\alpha + b)\,y + (b\alpha + c)\,z = 0$ have non-trivial solutions if

(i) a, b, c are in A. P

(ii) a, b, c are in G. P

(iii) a, b, c are in H. P

(iv) 'α' is a root of $(ax^2 + 2bx + c) = 0$

(A) both (i) & (iv) (B) both (ii) & (iv)

(C) both (iii) & (iv) (D) only (iv)

51. Ans: (B)

Sol: $$\begin{vmatrix} (a\alpha + b) & a & b \\ (b\alpha + c) & b & c \\ 0 & (a\alpha + b) & (b\alpha + c) \end{vmatrix} = 0$$

$R_3 \to R_3 - (\alpha R_1 + R_2)$

$$\Rightarrow \begin{vmatrix} a\alpha + b & a & b \\ b\alpha + c & b & c \\ -a\alpha^2 - 2b\alpha - c & 0 & 0 \end{vmatrix} = 0$$

i.e., $-(a\alpha^2 + 2b\alpha + c)\,(ac - b^2) = 0$

$\therefore$ 'α' is a root of $(ax^2 + 2bx + c) = 0$

or a, b, c are in G. P

52. Which one of the following statement is NOT TRUE about eigen signal?

Option A: Every signal is an eigen signal to the system described by $h(t) = A\delta(t)$

Option B: The signal $x(t) = e^{j\beta t}$ is an eigen signal of an LTI system given by $h(t) = e^{-\alpha t}u(t)$

Option C: The signal $x(t) = \cos\beta t$ is an eigen signal of an LTI system given by $\dot{y}(t) + \alpha y(t) = x(t)$

Option D: The signal $x(t) = \text{Sinc}(\alpha t)$ is an eigen signal of LTI system having $h(t) = \text{Sinc}(\beta t)$; $\beta \geq \alpha$

52. Ans: (C)

Sol: If $x(t) = \cos(\beta t)$ & $\dot{y}(t) + \alpha y(t) = x(t)$ then

$y(t) = A\cos(\beta t) + B\sin(\beta t) = C\cos(\beta t + \theta)$

Distractor Logic

Option A: $x(t)*A\delta(t) = Ax(t)$ but you may feel $A\delta(t)$

Option B: we may think of ‘α’ & ‘β’ nature

Option C: Correct option

Option D: Wrong option

Sinc(t)*Sinc(t) = Sinc(t)

$\text{Sinc}(t)*\text{Sinc}(2t) = \frac{1}{2}\text{Sinc}(t)$ but you may think Sinc(2t)

53. An ideal transistor has an emitter efficiency of 0.999 and collector-base leakage current of 10μA. The active region emitter current due to holes, if $I_B = 0$ is ____________

Option A: 0 A

Option B: 10 μA

Option C: –10 μA

Option D: 10 mA

53. Ans: (D)

Sol: For ideal transistor $\alpha_0 = \gamma = 0.999$; $\beta_0 = \frac{\alpha_0}{1-\alpha_0} = 999$

$I_{CB0} = 10\ \mu A$. Therefore $I_{CE0} = (1+\beta_0)\ I_{CB0}$

$= (1+999)\ 10 \times 10^{-6}$

$= 10\ mA$

Distractor Logic

Option A: I_B is given as zero

If student assumes the output current to be zero, he/she will go wrong

Option B: Since $I_B = 0$, if student assumes the reverse current to flow through emitter, he/she will go wrong.

Option C: If he/she assumes the reverse current to flow in opposite direction, they will go wrong

Option D: Correct option

54. If an n-type semiconductor is uniformly illuminated with light, producing a uniform excess generation rate G. Then find the change in semiconductor conductivity ($\Delta\sigma$). (Let μ_n = electron mobility, μ_p = hole mobility, n = electron concentration, p = hole concentration, τ_n = electron life time, τ_p = hole life time and q = electron charge).

Option A: $\Delta\sigma = qn\mu_n + qp\mu_p$

Option B: $\Delta\sigma = qn\mu_n + q\mu_p\tau_p G$

Option C: $\Delta\sigma = q\mu_n\tau_n G + qp\mu_p$

Option D: $\Delta\sigma = q\mu_n\tau_p G + q\mu_p\tau_p G$

54. Ans: (D)

Sol: $\sigma = q\mu_n n + q\mu_p p$; Before illumination $n_n = n_{no}$, $p_n = p_{no}$

after illumination, $n_n = n_{no} + \Delta n = n_{no} + \tau_p G$; $p_n = p_{no} + \Delta p = p_{no} + \tau_p G$

$$\Rightarrow \Delta\sigma = [q\mu_n(n_{no} + \Delta n) + q\mu_p(p_{no} + \Delta p)] - [q\mu_n n_{no} + q\mu_p p_{no}] = q(\mu_n + \mu_p)\tau_p G$$

Distractor Logic

Option A: This is the well known formula for conductivity. If a student just remembers formulas he/she will go wrong.

Option B: If a student assumes that there will be only excess minority carriers, he/she can go wrong

Option C: If a student assumes that there will be only excess majority carriers, he/she can go wrong

Option D: This is the correct option. There will be generation of both electrons and holes even if it is an n-type semiconductor.

55. If a plane wave of frequency 10MHz propagating in lake water ($\sigma = 4 \times 10^{-3}$ S/m $\varepsilon_r = 81$ and $\mu_r = 1$) and in seawater (σ = 4 S/m, ε_r = 81 and μ_r = 1), then the skin depths in both lake water and seawater will be

Option A: 12m and 8cm respectively

Option B: 2.51m and 8 cm respectively

Option C: 8cm and 12m respectively

Option D: 12m and 1.19cm respectively

55. Ans: (A)

Sol: $$\left[\frac{\sigma}{\omega\varepsilon}\right]_{\text{Lake}} = \frac{4\times10^{-3}}{2\pi\times10\times10^{6}\times81\times\frac{10^{-9}}{36\pi}} = 8.88\times10^{-2} << 1$$

Hence at f = 10MHz, lake water behaves as good dielectric

$$\text{skin depth, } \delta = \frac{1}{\alpha} = \frac{2}{\sigma}\sqrt{\frac{\varepsilon}{\mu}}$$

$$= \frac{2}{4\times10^{-3}}\sqrt{81}\times\frac{1}{120\pi} = 11.9\text{m} \cong 12\text{m}$$

$\therefore \delta \approx 12\text{m}$ (Lake water)

$$\left[\frac{\sigma}{\omega\varepsilon}\right]_{\text{Sea}} = \frac{4}{2\pi\times10\times10^{6}\times81\times\frac{10^{-9}}{36\pi}} = 88.8 >> 1$$

Hence at f = 10MHz, seawater behaves as good conductor.

$$\text{skin depth, } \delta = \frac{1}{\alpha} = \sqrt{\frac{2}{\omega\mu\sigma}}$$

$$= \sqrt{\frac{2}{2\pi\times10\times10^{6}\times4\pi\times10^{-7}\times4}}$$

$$\approx \frac{1}{4\pi}\text{m}$$

$\therefore \delta \approx 8\text{cm}$ (seawater)

Distractor Logic

Option A: correct option

Option B: For seawater, $\delta = \sqrt{\frac{2}{\omega\mu\sigma}} = \sqrt{\frac{2}{2\pi\times10\times10^{6}\times4\pi\times10^{-7}\times4}} = 8\text{cm}$

For lake water, $\delta = \sqrt{\frac{2}{\omega\mu\sigma}} = \sqrt{\frac{2}{2\pi\times10\times10^{6}\times4\pi\times10^{-7}\times4\times10^{-3}}} = 2.51\text{m}$

Which is incorrect result

Option C: As per the information given, we need to calculate the skin depths in both lake water and sea-water respectively. But in this option order is reversed.

Option D: For lake water $\delta = \frac{2}{\sigma}\sqrt{\frac{\varepsilon}{\mu}}$

If we take for seawater $\delta = \frac{2}{\sigma}\sqrt{\frac{\varepsilon}{\mu}} = \frac{2}{4}\sqrt{\frac{81\varepsilon_0}{\mu_0}}$ = 1.19cm

But which is incorrect answer

56. Parity check matrix of a particular (7, 4) code is $\begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 \end{bmatrix}$.

Then Generator matrix is _______.

Option A: $\begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 1 & 0 & 1 \end{bmatrix}$

Option B: $\begin{bmatrix} 1 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 0 & 0 & 1 \end{bmatrix}$

Option C: $\begin{bmatrix} 1 & 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 & 0 & 1 \end{bmatrix}$

Option D: $\begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 1 & 1 & 0 & 1 \end{bmatrix}$

56. Ans: (B)

Sol: (7, 4) code ;

n = 7; k = 4

p = n – k = 7 – 4 = 3

$H = \begin{bmatrix} I & P^T \end{bmatrix}$

$$H = \begin{bmatrix} 1 & 0 & 0 & 1 & 0 & 1 & 1 \\ 0 & 1 & 0 & 1 & 1 & 1 & 0 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 \end{bmatrix}$$

$$P^T = \begin{bmatrix} 1 & 0 & 1 & 1 \\ 1 & 1 & 1 & 0 \\ 0 & 1 & 1 & 1 \end{bmatrix}$$

$$P = \begin{bmatrix} 1 & 1 & 0 \\ 0 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 0 & 1 \end{bmatrix}$$

$$G = \left[P_{k\times n-k} \quad I_{k\times k}\right] = \begin{bmatrix} 1 & 1 & 0 & 1 & 0 & 0 & 0 \\ 0 & 1 & 1 & 0 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 & 0 & 0 & 1 \end{bmatrix}$$

Distractor Logic

Option A:

$H = [I \quad P^T]$

$G = [P \quad I]$ ($\because$ correct formula)

$G = [I \quad P]$ ($\because$ I ,P order wrong)

$$G = \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 1 & 0 & 1 \end{bmatrix}$$

So option A wrong

Option B: Correct answer

Option C: $G = [P \quad I]$

$$G = \begin{bmatrix} 1 & 0 & 1 & 1 & 1 & 0 & 0 \\ 1 & 1 & 1 & 0 & 0 & 1 & 0 \\ 0 & 1 & 1 & 1 & 0 & 0 & 1 \end{bmatrix} \quad [\because P^T \text{ missing, order of I wrong}]$$

So option C wrong

Option D: $G = [I \quad P]$

$$= \begin{bmatrix} 1 & 0 & 0 & 0 & 1 & 1 & 1 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 & 1 & 1 \\ 0 & 0 & 1 & 0 & 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 1 & 1 & 1 & 0 & 1 \end{bmatrix} \quad [\because \text{ order of G wrong}]$$

So Option D wrong

57. A signal is given by s(t) = 20cos(100πt) + 17cos(500πt). Find the minimum number of bits of quantization required so that the signal to quantization noise ratio is greater than 50dB.

Option A: 8

Option B: 7

Option C: 9

Option D: 10

57. Ans: (C)

Sol: s(t) = 20cos(100πt) + 17cos(500πt)

$$\text{Signal Power} = \frac{20^2}{2} + \frac{17^2}{2} = 344.5$$

$10\log SQNR \geq 50$ dB

$SQNR \geq 10^5$

$SQNR \geq 100000$

$$\frac{344.5}{QNP} \geq 100000$$

$$QNP \leq \frac{344.5}{100000}$$

$QNP \leq 3.445 \times 10^{-3}$

$$QNP = \frac{\Delta^2}{12} = \left(\frac{DR}{L}\right)^2 \times \frac{1}{12}$$

Dynamic range = $V_{max} - V_{min} = 37 - (-37) = 74$

$$\left(\frac{74}{L}\right)^2 \times \frac{1}{12} \leq 3.445 \times 10^{-3}$$

$\frac{1}{L^2} \leq \frac{3.445\times10^{-3}\times12}{74\times74}$

$\frac{1}{L^2} \leq 7.55\times10^{-6}$

$L^2 \geq 132450\ .331$

$L \geq 363.93$

$n \geq \log_2 363.93$

$n \geq 8.51 \Rightarrow n \geq 9$

Distractor Logic

Option A: s(t) = 20cos(100πt) + 17cos(500πt)

$\text{Signal Power} = \frac{20^2}{2} = 200$ [∵ maximum amplitude signal consider)

10 log SQNR ≥ 50

$SQNR \geq 10^5$

$\frac{200}{QNP} \geq 100000$

$\frac{QNP}{200} \leq \frac{1}{100000}$

$$QNP \leq \frac{200}{100000} \leq \frac{1}{500} \Rightarrow \frac{\Delta^2}{12} \leq \frac{1}{500} \Rightarrow \Delta^2 = 0.024 \Rightarrow \left(\frac{DR}{L}\right)^2 \leq 0.024 \Rightarrow \left(\frac{40}{L}\right)^2 \leq 0.024$$

$$\Rightarrow \left(\frac{L}{40}\right)^2 \leq 41.67$$

$L^2 \geq 66672$

$L \geq 258.21$, n = 8

So option A wrong

Option B: s(t) = 20cos(100πt) + 17cos(500πt)

$\text{Signal Power} = \frac{20^2}{2} + \frac{17^2}{2} = 344.5$

$SQNR \geq 10^5$

$$\frac{344.5}{QNP} \geq 100000$$

$QNP \leq 0.003445$

$$\frac{\Delta^2}{12} \leq 0.003445$$

$\Delta^2 \leq 0.04134$

$$\left(\frac{DR}{L}\right)^2 \leq 0.04134$$

$$\left(\frac{34}{L}\right)^2 \leq 0.04134 \qquad (\because \text{ dynamic range wrong})$$

$$L^2 \geq 34^2 \times \frac{1}{0.04134}$$

$L^2 \geq 27963.23174$

$L \geq 167.22$

$n \geq 7.38$

So option B wrong

Option C: Correct answer

Option D: If dynamic range is 40, n = 10

So option D wrong

58. For an RL series circuit R = 5Ω and X_L = 5Ω, the applied voltage $V(t) = 2\cos 3t + 4\sqrt{2}\cos(3t + 45^o) + 12\sin 3t$ Volts. Then find the resultant current RMS value of the circuit.

Option A: $\frac{3}{\sqrt{5}}$ A

Option B: 1A

Option C: $\sqrt{2}$ A

Option D: None

58. Ans: (B)

Sol: $V(t) = 2\cos 3t + 4\sqrt{2}\cos(3t + 45^{o}) + 12\sin 3t$

$$= 2\cos 3t + 4\sqrt{2}\left(\cos 3t\frac{1}{\sqrt{2}} - \sin 3t\frac{1}{\sqrt{2}}\right) + 12\sin 3t$$

$$= 6\cos 3t + 8\sin 3t$$

$$V_{RMS} = \sqrt{\frac{1}{2}\left(6^2 + 8^2\right)} = \sqrt{50} = 5\sqrt{2}\text{ Volts}$$

$$|I_{RMS}| = \left|\frac{V_{RMS}}{Z}\right| = \frac{5\sqrt{2}}{\sqrt{R^2 + X_L^2}} = \frac{5\sqrt{2}}{\sqrt{5^2 + 5^2}} = 1\text{Amps}$$

Distractor Logic

Option A: $V_{RMS} = \sqrt{\frac{1}{2}\left(2^2 + (4\sqrt{2})^2 + 12^2\right)} = \sqrt{90} = 3\sqrt{10}$ Volts

$$|I_{RMS}| = \left|\frac{V_{RMS}}{Z}\right| = \frac{3\sqrt{10}}{\sqrt{50}} = \frac{3}{\sqrt{5}}\text{Amps}$$

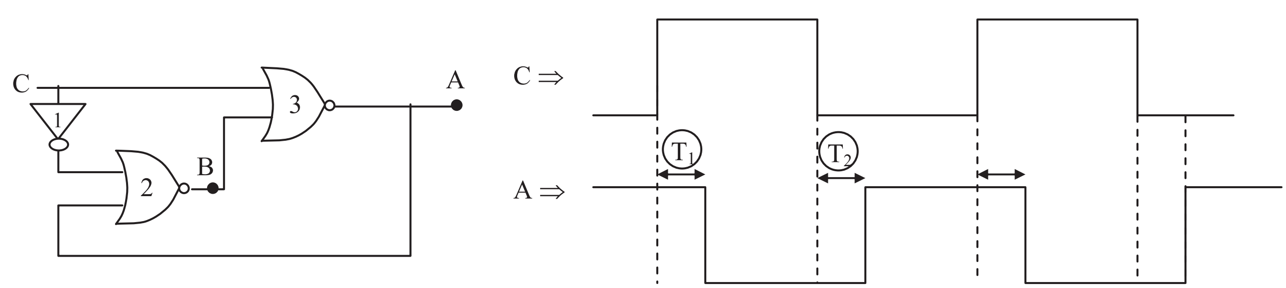
Option B: $I_{RMS} = 1A$

Option C: $V = 6\cos 3t + 8\sin 3t = 10\sin(3t + 36.86^{o}) = 10\angle 36.86^{o}$

$$I = \frac{V}{Z} = \frac{10}{\sqrt{5^2 + 5^2}} = \frac{10}{\sqrt{50}} = \sqrt{2}\text{Amps}$$

Option D: None

59. In the following circuit 'C' input is driven by a square wave with 50% Duty cycle. Each gate has a propagation delay of 1ns. Determine the values of T_1 and T_2, respectively for the output waveform is as shown below.



Option A: 3ns, 3ns

Option B: 1ns, 3ns

Option C: 1ns, 2ns

Option D: 2ns, 3ns

59. Ans: (B)

Sol: When C = 1, A becomes 0 after 1ns.

When C = 0, B becomes 0 after 2ns and A is 1 after 3ns

Distractor Logic

Option A: There is a possibility of adding propagation delays of all logic gates

Option B: Correct option

Option C: It is possible to take Gate-3 delay when C = 1 and propagation delays of Gate② and Gate③ when C = 0

Option D: Possible to take Gate②, ③ delays when C = 1 and Gate ①, ② and ③ delays when C = 0

60. In a 12-bit bipolar ADC, the digital output is in 2's complement form. Find the digital output for an analog input of –4V in 4 Hex digits.

The input voltage range is –4V to +4V

Option A: $FFFF_H$

Option B: 8000_H

Option C: $F800_H$

Option D: $FF00_H$

60. Ans: (C)

Sol: For –4V, the 12-bit digital output is 1000 0000 0000 = 800_H.

Then digital output in 4 Hex digits is = $F800_H$

Distractor Logic

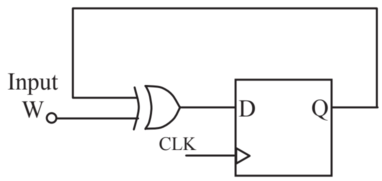
Option A: It is possible to select max negative output as 1111 1111 1111 which is $FFFF_H$ in 4 Hex digits

Option B: Max negative value using 12-bits is $1000\ 0000\ 0000_2$. i.e., 800_H. In 4 Hex digits it may be mistaken as 8000_H

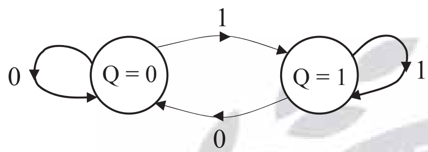
Option C: Correct option

Option D: Mistakenly it is taken as $F00_H$, which is in 4 Hex digits as $FF00_H$

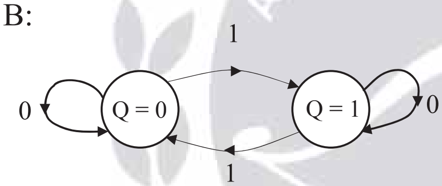
61. The state diagram for the sequential circuit shown below is



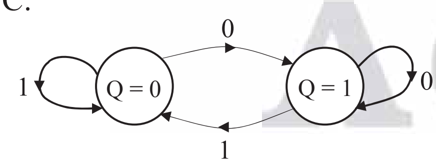
Option A:



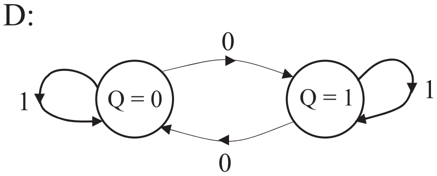
Option B:



Option C:



Option D:



61. Ans: (B)

Sol: Q(t+1) = D and output P =Q(t)

Where D = Q ⊕ W

i.e., Q(t+1) = Q(t) ⊕ W

If W = 0 ⇒ Q(t+1) = Q(t)

If W = 1 ⇒ Q(t+1) = $\overline{Q(t)}$

Distractor Logic

Option A: The output branches from each state are not assessed properly

Option B: Correct option

Option C: The output branches are not assessed properly

Option D: The output branches from each state are not assessed properly

62. In the circuit shown in figure , a silicon transistor with V_{BE} = 0.7V, β = 100 is used. Then find the collector current I_C.

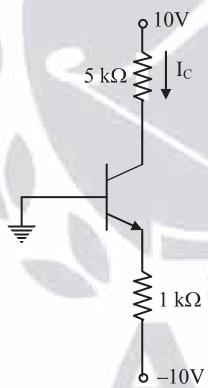


Fig.

(A) 9.2 mA (B) 2.1 mA (C) 1.86 mA (D) 0

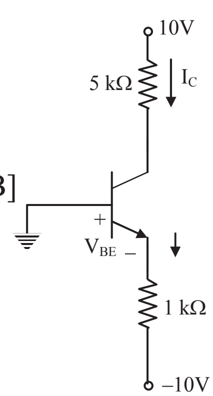
62. Ans: (B)

Sol: Step (1): KVL for BE loop of BJT

$$0 - 0.7V - I_E\,1K + 10V = 0 \text{ …….. (1)}$$

$$\Rightarrow I_E = \frac{9.3V}{1K} = 9.3mA \text{ …….. (2) [i.e } J_E \text{ is FB]}$$

$$\Rightarrow I_C = \left(\frac{\beta}{1+\beta}\right)I_E = 9.2mA \text{ ….. (3)}$$



Step (2): KVL for C-loop

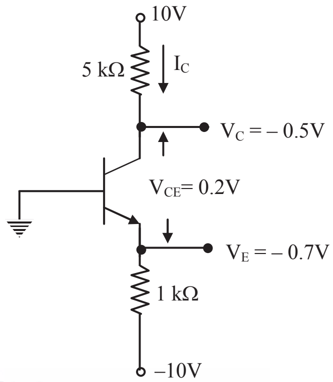
$10V - I_C \times 5K - V_C = 0$ …… (4)

$V_C = 10V - 9.2mA \times 5K = -36V$ ……. (5)

$\Rightarrow V_{CB} = V_C - V_B = -36V - 0 = -36V$ …… (6)

NOTE: $\because V_{CB}$ is –Ve, collector junctions is F.B

$\therefore$ BJT is operated in saturation region



Step (3): $\because$ BJT is in saturation, $V_{CE_{sat}} = 0.2V$

$$\Rightarrow V_C = V_{CE_{sat}} + V_E = -0.5V \text{ ……. (1)}$$

KVL for collector –loop:

$$I_C = \frac{10V - (-0.5V)}{5K} = 2.1mA \text{ …. (2)}$$

Distractor logic

Option: A: If the device(BJT) is in forward active region, KVL for BE loop of BJT

$0 - 0.7V - I_E\ 1K + 10V = 0$

$$I_E = \frac{9.3V}{1K} = 9.3mA$$

$$\therefore I_c = \left(\frac{\beta}{1+\beta}\right) I_E = \frac{100}{101} \times 9.3mA$$

$I_c = 9.2mA$

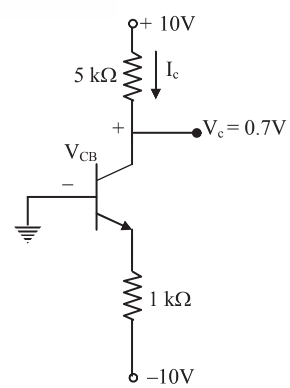
Option: B: $I_c = 2.1mA$ …… (1) ($\because$ Device is actually biased in saturation region)

Option: C: If the device is in inverse (or reverse) active region,

(i.e) E-B junction is R.B & C.B junction is F.B

Assuming $V_{CB} = 0.7V \Rightarrow V_c = 0.7V$ …… (1)

[$\because V_{CB} = V_C - V_B = V_C$]



KVL for collector loop of BJT

$10V - I_c\ 5K - 0.7V = 0$ …… (1)

$$I_c = \frac{9.3V}{5K} = 1.86mA \text{ …… (2)}$$

Option D: If the device is in cutoff region

$I_B = 0 \Rightarrow I_C = 0$ …… (1)

63. A bag contains (n + 1) coins. It is known that one of these coins shows heads on both sides where as the other coins are fair. One coin is selected at random and tossed. If the probability that the toss results in heads is $\frac{7}{12}$, then the value of 'n' is _________.

(A) 4 (B) 5 (C) 6 (D) 7

63. Ans: (B)

Sol: Let A = Event of selecting two headed coin

B = Event of selecting a fair coin

E = Event of coming head on selected coin

Given that P(A) P(E/A) + P(B) . P(E/B) = $\frac{7}{12}$

i.e., $\frac{1}{(n+1)}.1+\frac{n}{(n+1)}.\frac{1}{2}=\frac{7}{12}$

12 + 6n = 7n + 7

$\therefore$ n = 5

64. The characteristic equation of a feedback control system is given by $s^2+s(k-1)+k = 0$. Where k > 0. The break points on RLD are

Option A: –0.414, 2.414

Option B: 0.414, 2.414

Option C: 0.414, –2.414

Option D: –0.414, –2.414

Ans: (C)

Sol: Break point $\Rightarrow \frac{dk}{ds}=0$

Given, CE: $s^2 + sk - s + k = 0$

CE $\rightarrow (s^2-s)+k(s+1) = 0$

$$k=-\frac{(s^2-s)}{(s+1)}$$

$$\frac{dk}{ds}=-\left[\frac{(2s-1)(s+1)-(s^2-s)}{(s+1)^2}\right]=0$$

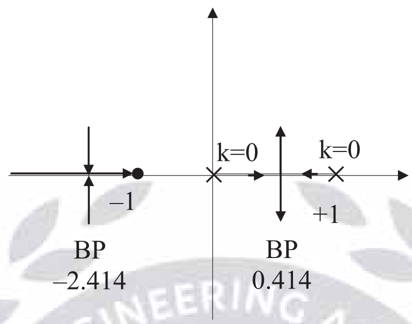
$\Rightarrow 2s^2 - s + 2s - 1 - s^2 + s = 0$

$\Rightarrow s^2 + 2s - 1 = 0$

$$s = \frac{-2 \pm \sqrt{4 - 4(1)(-1)}}{2} = \frac{-2 \pm \sqrt{8}}{2}$$

s = 0.414 and –2.414

$\Rightarrow G(s)H(s) = \frac{k(s+1)}{s(s-1)} \Rightarrow$



Distractor Logic

Option A: Given points are not on RLD.

Option B: One BP is valid and another is invalid.

Option C: Correct Option.

Option D: One BP is valid and another is invalid.

65. The state model of the system is given as

$$\dot{X} = \begin{bmatrix} 0 & 1 \\ -2 & -9 \end{bmatrix} X + \begin{bmatrix} 0 \\ 1 \end{bmatrix} U \ \ \& \ y = [1 \quad 0]x$$

Then find the poles of the system.

Option A: s = –0.22, –8.77

Option B: s = 0.216, –9.216

Option C: s = 0.22, 8.77

Option D: s = –0.216, 9.21

65. Ans: (A)

Sol: From the magnitude equation

$$[sI - A] = \begin{bmatrix} s & -1 \\ 2 & s+9 \end{bmatrix}$$

$$\text{Adj}[sI - A] = \begin{bmatrix} s+9 & 1 \\ -2 & s \end{bmatrix}$$

$$\text{TF} = \frac{C\,\text{Adj}[sI - A]B}{|sI - A|} + \cancel{D}^{\,0}$$

$$\text{TF} = \frac{[1\ \ 0]\begin{bmatrix} s+9 & 1 \\ -2 & s \end{bmatrix}\begin{bmatrix} 0 \\ 1 \end{bmatrix}}{s(s+9)+2} = \frac{[1\ \ 0]\begin{bmatrix} 1 \\ s \end{bmatrix}}{s^2+9s+2} = \frac{1}{s^2+9s+2}$$

CE $s^2 + 9s + 2 = 0$

$s = -0.22, -8.77$

Distractor Logic

Option A: Correct option

Option B: This option is constructed with wrong calculation of determinant as $|sI - A| = s^2 + 9s - 2 = 0$

Option C: While calculating determinant, the subtraction of last row and column element is wrong, then the equation is $|sI - A| = s^2 - 9s + 2 = 0$

Option D: This option is constructed with wrong calculation of determinant as $|sI - A| = s^2 - 9s - 2 = 0$