PRE-GATE-2020

Instrumentation Engineering

(Questions with Detailed Solutions)

GENERAL APTITUDE

Q. 1 – Q. 5 carry one mark each.

01. **Fill in the blank with an appropriate phrase**

Jobs are hard to _____ these days

(A) Come by (B) Come down

(C) Come of (D) Come from

01. Ans: (A)

Sol: 'Come by' means to manage to get something.

02. ***The question below consists of a pair of related words followed by four pairs of words. Select the pair that best expresses the relation in the original pair.***

MONKEY : TROOP :

(A) sheep : hard

(B) elephant : Parliament

(C) bacteria : Colony

(D) wolves : School

02. Ans: (C)

Sol: Troop consists of monkeys just as a colony consists of bacteria.

03. ***Choose the most appropriate word from the options given below to complete the following sentence:***

If you had gone to see him, he _______ delighted.

(A) Would have been

(B) Will have been

(C) Had been

(D) Would be

03. Ans: (A)

Ans: 'A" conditional tense type 3 grammatical code is

If +had+V3, would +have+V3

04. Which of the following options is closest in meaning to the underlined word?

European intellectuals have long debated the consequences of the **hegemony** of American popular culture around the world.

(A) regimen (B) vastness

(C) dominance (D) popularity

04. Ans: (C)

Sol: Dominance means influence or control over another country, a group of people etc.

05. How many one-rupee coins, 50 paise coins, 25 paise coins in total of which the numbers are proportional to 5, 7 and 12 are together work ₹115?

(A) 50, 70, 120 (B) 60, 70, 11
(C) 70, 80, 90 (D) None of these

05. Ans: (A)

Sol: $(5 \times 1 + 7 \times 0.5 + 12 \times 0.25)x = 115$

$(5 + 3.5 + 3)x = 115$

$11.5x = 115$

$x = 10$

$\therefore$ Number of one rupee coin = 5x

$= 5 \times 10 = 50$

Number of 5-paise coin = $7x = 7 \times 10 = 70$

Number of 25-paise coin = 12x

$= 12 \times 10 = 120$

Q. 6 – Q. 10 carry Two marks each.

06. Critical reading is a demanding process. To read critically, you must slow down your reading and, with pencil in hand, perform specific operations on the text mark up the text with your reactions, conclusions, and questions, then you read, become an active participant.

This passage best supports the statement that

(A) Critical reading is a slow, dull but essential process.

(B) The best critical reading happens at critical times in a person's life.

(C) Readers should get in the habit of questioning the truth of what they read.

(D) Critical reading requires thoughtful and careful attention.

06. Ans: (D)

Sol: Choice (A) is incorrect because the author never says that reading is dull.

Choice (B) and (C) are not support by the paragraph.

Choice (D) is correct as it is implied in the entire passage.

07. Anil's house faces east from the back-side of the house, he walks straight 50 metres, then turns to the right and walks 50m again finally, he turns towards left and stops after walking 25 m. Now Anil is in which direction from the starting point?

(A) South-east

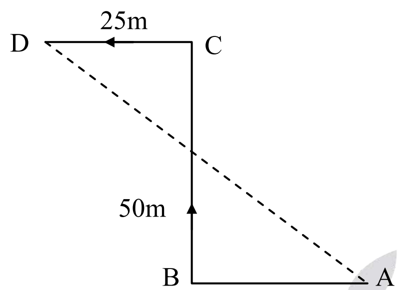
(B) South-west

(C) North-east

(D) North- west

07. Ans: (D)

Sol: The movement of Anil are shown in the adjoining figure



He starts walking from back of his house (i.e) towards west now, the final position is D, which is to the north west of his starting point A.

08. A and B enter into a partnership, A puts in ₹50 and B puts in ₹45. At the end of 4 months, A withdraws half his capital and at the end of 5 months B withdraws $\frac{1}{2}$ of his, C then enters with a capital of ₹70 at the end of 12 months, the profit of concern is ₹254, how can the profit be divided among A, B and C ?

(A) ₹76, ₹80 and ₹98

(B) ₹80, ₹76 and ₹98

(C) ₹76, ₹98 and ₹80

(D) ₹80, ₹98 and ₹76

08. Ans: (B)

Sol:

A's share	: B's share	: C's share
(50×4+25×8)	: (45×5+22.5×7)	: (70×7)
400	: 382.5	: 490
800	: 765	: 980
160	: 153	: 196

Total profit = ₹254

$$\text{Profit of A} = \frac{160}{160+153+196}\times 254$$

$$= \frac{160}{509}\times 254$$

$$= ₹79.8 \approx ₹80$$

$$\text{Profit of B} = \frac{153}{509}\times 254$$

$$= ₹76.34$$

$$\approx ₹76$$

$$\text{Profit of C} = \frac{196}{509}\times 254$$

$$= ₹97.8$$

$$\approx ₹98$$

∵ Hence option 'B' is correct.

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09. A sum of ₹25400 was lent out in two parts, one of 12% and the other at $12\frac{1}{2}$%. If the total annual income is ₹3124.2, the money lent at 12% is _____.

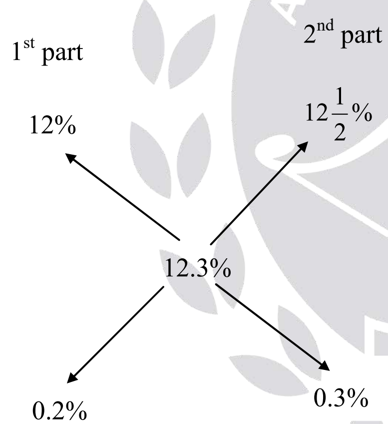
(A) ₹15240 (B) ₹25400

(C) ₹10160 (D) ₹31242

09. Ans: (C)

Sol: Overall rate of interest

$$\frac{3124.2}{25400}\times 100 = 12.3\%$$



∴ The sum will be divided in the ratio 0.2:0.3 (or) 2:3

∴ The sum lent at 12% = $25400\times\frac{2}{5}$

= ₹10160.

10. The following question is to be answered on the basis of the table given below.

Category of personnel	Number of staff in the year-1990	Number of staff in the year-1995
Data preparation	18	25
Data control	5	8
Operators	18	32
Programmers	21	26
Analysts	15	31
Managers	3	3
Total	80	135

What is the increase in the sector angle for operators in the year 1995 over the sector angle for operators in the year 1990?

(A) 4° (B) 3°

(C) 2° (D) 1°

10. Ans: (A)

Sol: Sector angle for operators in the year 1990

$$= \frac{18}{80}\times 360° = 81°$$

Sector angle for operators in the year 1995

$$= \frac{32}{135}\times 360°$$

= 85.33

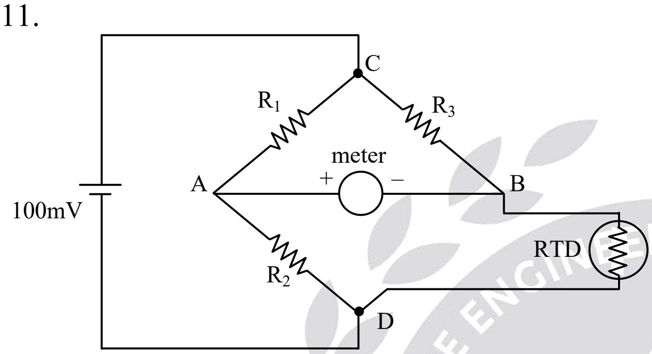
≃ 85%

∴ Required difference = 85°– 81° = 4°

INSTRUMENTATION ENGINEERING

Q. 11 – Q. 35 carry one mark each.

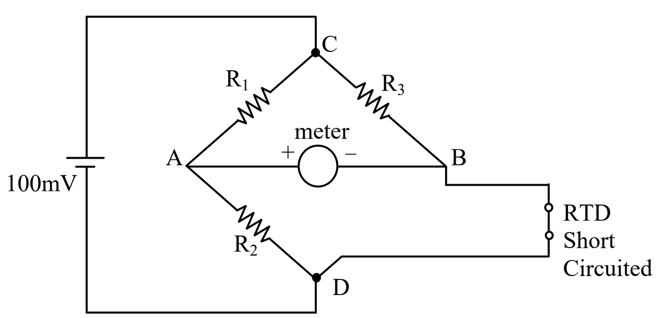
11.



Suppose the meter in given Wheatstone bridge circuit is "pegged" even when the RTD is at 0°C (When the bridge should be balanced) with the polarity across the indicating voltmeter terminals as shown. Using digital multi meter we measured voltage between test point C and B. If RTD failed shorted then the magnitude reading of digital multi meter in mV is

11. Ans: 100 [Range: 99.9 to 100.1]

Sol:



From above diagram we can say that all supply voltage will come across resistance R_3 so digital multi meter connected between test point C and B measure 100 mV.

12. A 1 kΩ strain gauge having gauge factor G_f = 2.0 is attached to a load cell (E = 100×10^3 MPa). The cross sectional area of the load cell A is 200 mm^2. The change in resistance ΔR (in Ω), when the load cell supports a 1000 kg load (Consider g = 10 m/s^2)

12. Ans: 1 [Range: 0.9 to 1.1]

Sol: We know

$\Delta R = G_f \varepsilon R$ ___(1)

$$\varepsilon = \frac{\text{stress}}{E} = \frac{F/A}{E} = \frac{F}{AE}$$

$$\varepsilon = \frac{Mg}{AE}$$

Equation (1) becomes

$$\Delta R = G_f \times \frac{Mg}{AE} \times R$$

$$= 2 \times \frac{1000\times10}{200\times10^{-6}\times100\times10^{3}\times10^{6}} \times 1000$$

$\Delta R = 1\Omega$

13. If directional derivative of $\phi = 2xz - y^2$, at the point (1, 3, 2) becomes maximum in the direction of $\bar{a}$, then magnitude of $\bar{a}$ is ________

13. Ans: 7.48 [Range: 7.4 to 7.5]

Sol: Given $\phi = 2xz - y^2$

$$\nabla\phi = \frac{\partial\phi}{\partial x}\bar{i} + \frac{\partial\phi}{\partial y}\bar{j} + \frac{\partial\phi}{\partial z}\bar{k}$$

$$= 2z\bar{i} - 2y\bar{j} + 2x\bar{k}$$

$\therefore$ Required direction vector = $\bar{a}$ = ($\nabla\phi$) at (1, 3, 2) = $(4\bar{i} - 6\bar{j} + 2\bar{k})$

Magnitude of $\bar{a} = \sqrt{16+36+4}$

$= \sqrt{56}$

$= 7.48$

14. A sinusoidal carrier is frequency modulated by a sinusoidal signal with the frequency deviation of 10 kHz. If the message signal frequency is 5 kHz, then the fraction of carrier power P_{f_c} to the total power P_t is _______

(Given that $J_0(2) = 0.224$, $J_0(5) = -0.178$ & $J_0(8) = 0.172$)

14. Ans: 0.0501 [Range: 0.0490 to 0.0510]

Sol: Given $\Delta f = 10\text{kHz}$ and $f_m = 5\text{kHz}$

$$\beta = \frac{\Delta f}{f_m} = \frac{10k}{5k} = 2$$

$\beta = 2$

$$P_{f_c} = \frac{A_C^2}{2} J_0^2(2)$$

$$P_t = \frac{A_C^2}{2}$$

$$\frac{P_{f_c}}{P_t} = J_0^2(2) = 0.0501$$

15. A photomultiplier has a current gain of 3×10^6. A weak light beam produces 50 electrons per second at the photocathode. The anode to ground resistance (in kΩ) must be used to get 12 μV voltage from this light source (The charge on an electron is 1.6×10^{-19} C).

15. Ans: 500 [Range: 495 to 505]

Sol: The current is found from the gain of the PMT and the charge of an electron as:

$$I = 3\times10^6 \times 50\left(\frac{e}{sec}\right)\times 1.6\times10^{-19}\left(\frac{C}{e}\right)$$

$$= 3\times10^6\times50\times1.6\times10^{-19}\left(\frac{C}{sec}\right)$$

$= 24(\text{pA})$

Anode to ground resistance $= \dfrac{12\times10^{-6}}{24\times10^{-12}}$

$= 0.5\times10^6$

$= 500\ \text{k}\Omega$

16. A numerical solution of the equation $f(x) = x + \sqrt{x} - 3 = 0$ can be obtained using Newton - Raphson method. If the starting value is $x = 2$ for the iteration then the value of x that is to be used in the next step is _____

16. Ans: 1.69 [Range: 1.4 to 1.8]

Sol: Given $f(x) = x + \sqrt{x} - 3 = 0$ and $x_0 = 2$

$$f^1(x) = 1 + \frac{1}{2\sqrt{x}}$$

Newton - Raphson formula is

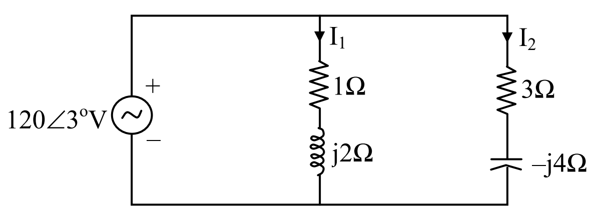
$$x_{n+1} = x_n - \frac{f(x_n)}{f^1(x_n)}$$

$$\Rightarrow x_1 = x_0 - \frac{f(x_0)}{f^1(x_0)}$$

$$= 2 - \frac{(2 + \sqrt{2} - 3)}{\left(1 + \frac{1}{2\sqrt{2}}\right)}$$

$$= 1.6939$$

17. Consider the following circuit. The behaviour of parallel circuit with the power factor of _____ lagging



17. Ans: 0.8 [Range: 0.77 to 0.83]

Sol: Total admittance

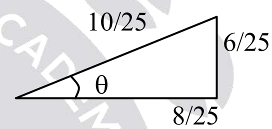
$$Y = Y_1 + Y_2 = \frac{1}{Z_1} + \frac{1}{Z_2}$$

$$= \frac{1}{1 + j2} + \frac{1}{3 - j4} = \frac{1 - j2}{5} + \frac{3 + j4}{25}$$

$$Y = \frac{5 - j10 + 35 + j4}{25} = \frac{(8 - j6)}{25} \, \mho$$

$$Y = \left(\frac{8}{25}\right) - j\left(\frac{6}{25}\right)$$

$Y = G - jB$



$\cos\theta = 0.8$

0.8 lagging power factor.

18. Given $X(z) = \frac{z^2 + z}{z^3 - 3z^2 + 3z - 1}; |z| > 1$, then x(n) value at n = 2 is ______

18. Ans: 4

Sol: $X(z) = \frac{z^{-1} + z^{-2}}{1 - 3z^{-1} + 3z^{-2} - z^{-3}}$

$$1 - 3z^{-1} + 3z^{-2} - z^{-3}) z^{-1} + z^{-2} (z^{-1} + 4z^{-2} + \text{-----}$$
$$\underline{z^{-1} - 3z^{-2} + 3z^{-3} - z^{-4}}$$
$$4z^{-2} - 3z^{-3} + z^{-4}$$
$$\underline{4z^{-2} - 12z^{-3} + 12z^{-4} - 4z^{-5}}$$
$$\vdots$$

$X(z) = z^{-1} + 4z^{-2} + \text{------}$

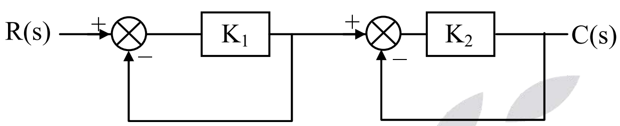
Apply inverse z-transform

$\delta(n - n_0) \leftrightarrow z^{-n_0}$

$x(n) = \delta(n - 1) + 4\delta(n - 2) + \text{------}$

$x(2) = 4$

19. A control system is represented by the block diagram shown in figure. The nominal values of the parameters are $K_1 = 1$ and $K_2 = 10$. Then Sensitivity of the transfer function with respect to K_1 is _____



19. Ans: 0.5

Sol: Transfer function,

$$\frac{C(s)}{R(s)} = \left(\frac{K_1}{1+K_1}\right)\left(\frac{K_2}{1+K_2}\right) = \left(\frac{10K_1}{11+11K_1}\right)$$

$$S_{K_1}^{T} = \left(\frac{\partial T / T}{\partial K_1 / K_1}\right) = \left(\frac{K_1}{T}\right)\left(\frac{\partial T}{\partial K_1}\right)$$

$$= \frac{K_1}{\left(\frac{10K_1}{11+11K_1}\right)} \times \left[\frac{10(11+11K_1) - 10K_1(11)}{(11+11K_1)^2}\right]$$

$$= \left(\frac{11}{11+11K_1}\right) \Rightarrow \left(S_{K_1}^{T}\right)_{K_1=1} = \frac{11}{22} = 0.5$$

20. A butter worth LPF is to meet the following specifications pass band ripple = 1dB for $\Omega \le$ 4rad/sec and stop band attenuation $\ge$ 20 dB for $\Omega \ge$ 8 rad/sec.

The minimum order required for butterworth filter is ______

20. Ans: 5

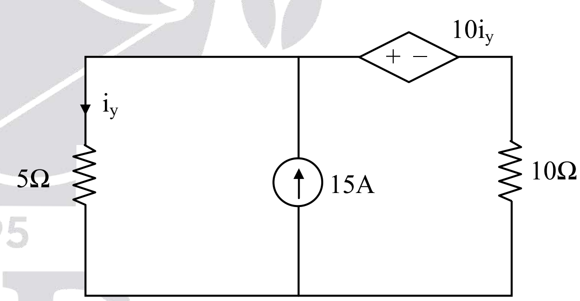
Sol: Given δ_p = 1dB, Ω_p = 4rad/sec, δ_s = 20dB and Ω_s = 8 rad/sec

$$n = \frac{1}{2}\frac{\log\left[\frac{10^{0.1\delta_s dB} - 1}{10^{0.1\delta_p dB} - 1}\right]}{\log\left(\frac{\Omega_s}{\Omega_p}\right)}$$

$$= \frac{1}{2}\frac{\log\left[\frac{10^{0.1(20)} - 1}{10^{0.1(1)} - 1}\right]}{\log\left(\frac{8}{4}\right)}$$

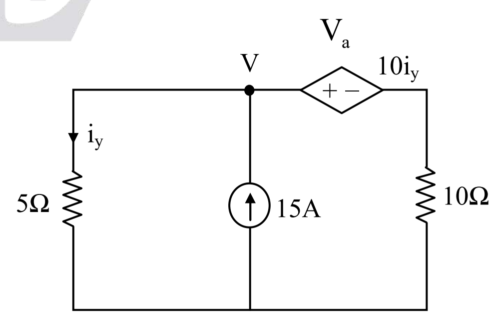
$$= 4.289 \approx 5$$

21. In the given circuit, the power (in kiloWatts) delivered by the dependent source is_______



21. Ans: 4.5

Sol:



By KCL at node 'V'

$$\frac{V}{5} + \frac{V - 10i_y}{10} = 15 \Rightarrow 2V + V - 10i_y = 150$$

$3V - 10i_y = 150$

$$3V - 10\left(\frac{V}{5}\right) = 150 \Rightarrow V = 150\,\text{Volts}$$

$$\text{and } i_y = \frac{V}{5} = 30\,\text{A}$$

Power delivered by the dependent source

$$P_d = V_a I_d = (10i_y)\left(\frac{10i_y - V}{10}\right)$$

$$= 10 \times 30\left(\frac{10(30) - 150}{10}\right)$$

$= 300(15) = 4500$ Watts

$= 4.5$kW

22. Simplify the following Boolean expression $F = \overline{X\overline{Y} + XYZ + X(Y + X\overline{Y})}$ and the number of literals in the simplified expression are______

22. Ans: 0

Sol: $F = \overline{X\overline{Y} + XYZ + X(Y + X\overline{Y})}$

$$= \overline{X(\overline{Y} + YZ) + X(Y + X)(Y + \overline{Y})}$$

[$\because$ distributive law $A + BC = (A + B)(A + C)$]

$$= \overline{X(\overline{Y} + Z) + X(X + Y)}$$

$$= \overline{X(\overline{Y} + Z)}.\overline{X(1 + Y)} \qquad [\because A + \overline{A} = 1]$$

$$= \overline{X(\overline{Y} + Z)}.\overline{X(1 + Y)} \qquad [\because \overline{\overline{A}} = A]$$

$$= \overline{X(\overline{Y} + Z)}.\overline{X} = 0$$

[$\because$ A(1+B) = A, $A.\overline{A} = 0$]

23. A base band signal band limited to 5 MHz is to be transmitted using VSB modulation. The percentage of vestige bandwidth allowed is 20% of USB bandwidth. The bandwidth saving (in MHz) due to VSB modulation when compared to DSB-SC modulation is ________

23. Ans: 4

Sol: Given W = 5 MHz

BW of USB is 5 MHz

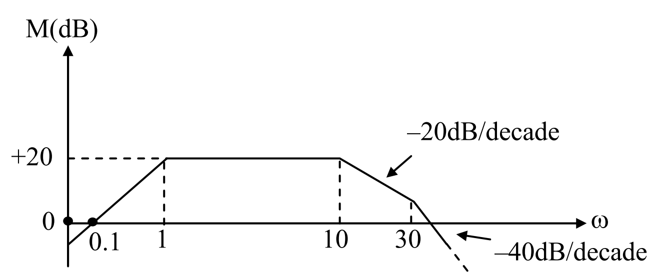
BW of vestige is 20% of 5 MHz = 1 MHz

BW of VSB signal = 5MHz + 1MHz
= 6 MHz

BW of the DSB-SC signal = 2W
= 10 MHz

So, the BW saving is 4 MHz.

24. The asymptotic magnitude plot of a minimum phase system is shown in figure. The transfer function of a given system is



(A) $\frac{10s}{(s+1)(s+10)(s+30)}$

(B) $\frac{3000s}{(s+1)(s+10)(s+30)}$

(C) $\frac{3000s^2}{(s+1)^2(s+10)(s+30)}$

(D) $\frac{300s}{(s+1)(s+10)(s+30)}$

24. Ans: (B)

Sol: Calculations for initial slope

$$\Rightarrow S = \frac{M_2 - M_1}{\log\omega_2 - \log\omega_1} \Rightarrow S = \frac{20-0}{\log 1 - \log 0.1}$$

$$\Rightarrow S = \frac{20}{0+1} = +20\ dB/dec$$

Transfer function,

$$G(s)H(s) = \frac{K\ s}{(1+s)(1+s/10)(1+s/30)}$$

Calculations for K:

$$M|_{\omega=0.1} = 20\log K + 20\log\omega$$

$0 = 20\log K - 20\log 0.1$

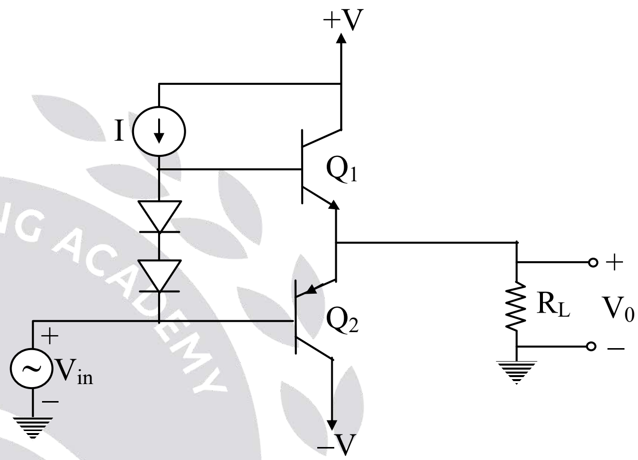
$0 = 20\log K - 20$

$20 = 20\log K \Rightarrow K = 10$

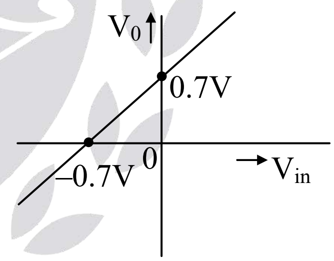
$$G(s)H(s) = \frac{10\,s}{(1+s)(1+s/10)(1+s/30)}$$

$$= \frac{3000\,s}{(s+1)(s+10)(s+30)}$$

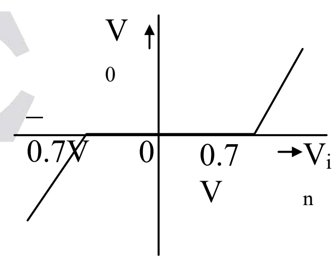
25. Consider the following circuit. The diode forward drop and base-to-emitter forward drop is considered to be 0.7V. $[V_{BE\,(ON)} = V_{D\,(ON)} = 0.7V]$. Sketch the transfer characteristics?



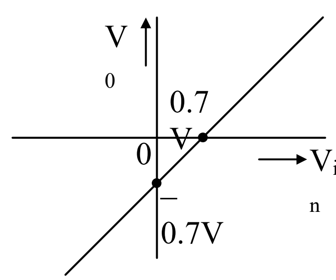
(A)



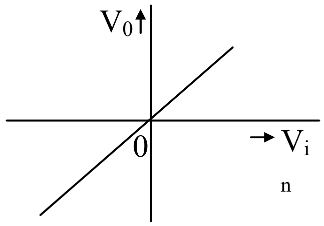
(B)



(C)



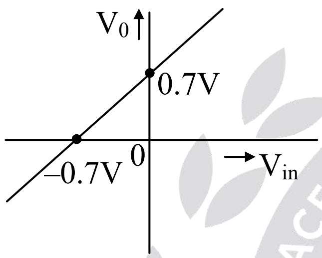
(D)



25. Ans: (A)

Sol:

V_{in}	V_{B1}	V_0
0V	1.4V	0.7V
–0.7V	0.7V	0V



26. For the function $f(x, y) = x^2 - y^2$, the point (0, 0) is

(A) a local minimum

(B) a saddle point

(C) a local maximum

(D) not a stationary point

26. Ans: (B)

Sol: Given $f(x,y) = x^2 - y^2$

$\Rightarrow f_x = 2x,\ f_y = -2y$ and

$f_{xx} = 2,\ f_{xy} = 0,\ f_{yy} = -2$

Consider $f_x = 0$ and $f_y = 0$

$\Rightarrow 2x = 0$ and $-2y = 0$

$\Rightarrow (0,0)$ is a stationary point

At (0, 0), $f_{xx} f_{yy} - (f_{xy})^2 = -4 < 0$

$\therefore$ f(x, y) has neither a maximum nor minimum at (0, 0).

27. A synchronous counter built using T flip-flops, the flip-flop inputs are $T_2 = Q_2 \oplus Q_1$; $T_1 = Q_1 \oplus Q_0$; $T_0 = Q_2 \odot Q_0$. Determine the counter state after 2 pulses if the present state is 110.

(Assume Q_2 as MSB, Q_0 as LSB)

(A) 000 (B) 110

(C) 100 (D) None

27. Ans: (A)

Sol: $T_2 = Q_2 \oplus Q_1$; $T_1 = Q_1 \oplus Q_0$;

$T_0 = Q_2 \odot Q_0$

CLK	P.S	FF Inputs	N.S
	$Q_2\ Q_1\ Q_0$	$T_2\ T_1\ T_0$	$Q_2\ Q_1\ Q_0$
1	1 1 0	0 1 0	1 0 0
2	1 0 0	1 0 0	0 0 0

28. A system is described by the impulse response $h(n) = (-1)^n u(n)$. The difference equation of the inverse of this system is

(A) y(n) + y(n–1) = x(n)

(B) y(n) – y(n–1) = x(n)

(C) y(n) = x(n) + x(n–1)

(D) y(n) = x(n) – x(n–1)

28. Ans: (C)

Sol: Given $h(n) = (-1)^n u(n)$

$$(a)^n u(n) \xleftrightarrow{Z.T} \frac{1}{1 - az^{-1}} \quad H(z) = \frac{1}{1 + z^{-1}}$$

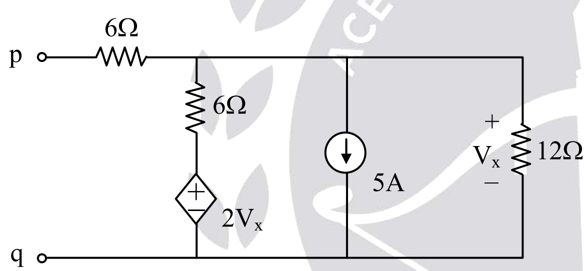
$$H_{inv}(z) = \frac{1}{H(z)} = 1 + z^{-1} = \frac{Y(z)}{X(z)}$$

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

Apply inverse z-transform

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

29. In the following circuit, the thevenin's voltage and resistance looking into terminals p & q respectively are.

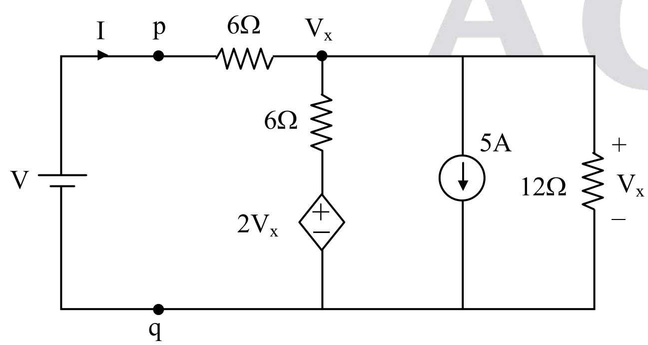


(A) 40V, 6Ω (B) 60V, 12Ω

(C) 40V, –12Ω (D) 60V, –6Ω

29. Ans: (D)

Sol: V-I method



By KCL at V_x

$$I = \frac{V_x - 2V_x}{6} + 5 + \frac{V_x}{12}$$

$$I = \frac{-V_x}{6} + 5 + \frac{V_x}{12} = \frac{-2V_x + 60 + V_x}{12}$$

$12I = 60 - V_x$

$12I = 60 - (V - 6I)$ $\left(I = \frac{V - V_x}{6} \right)$

$12I = 60 - V + 6I$ $V_x = V - 6I$

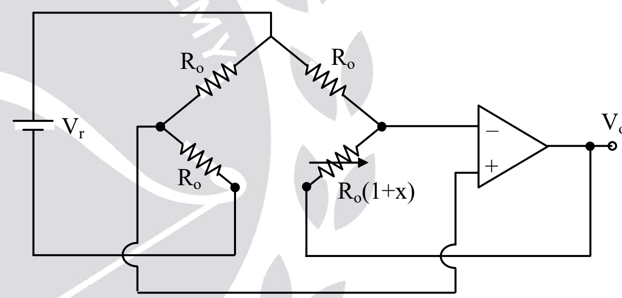
$V = -6I + 60$

$V = R_{th}I + V_{th}$

$V_{th} = 60$ Volts

$R_{th} = -6\Omega$

30. A modified bridge circuit includes a single linear sensor $R_o(1 + x)$.



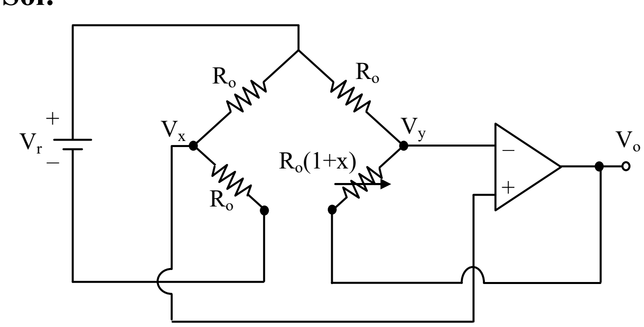
The output voltage V_o is

(A) $-\frac{V_r}{2}$ (B) $-\frac{V_r x}{2}$

(C) $\frac{V_r x}{2}$ (D) 0

30. Ans: (B)

Sol:



Apply voltage division rule at V_x

$$V_x = \frac{V_r}{2}$$

By VG, $V_y = V_x = \frac{V_r}{2}$

Apply KCL at V_y

$$\frac{V_y - V_r}{R_o} + \frac{V_y - V_o}{R_o(1+x)} = 0$$

$$V_o = -\frac{V_r}{2}x$$

31. An LED with an external quantum efficiency of 0.012 is coupled to an optical fiber of NA = 0.15 (with air between them). The overall source-fiber coupling efficiency is

(A) 2.25×10^{-2} (B) 2.7×10^{-4}
(C) 1.2×10^{-2} (D) 1.8×10^{-3}

31. Ans: (B)

Sol: Overall source fiber coupling efficiency

= External quantum efficiency × optical fiber efficiency

$= 0.012 \times (NA)^2$

$= 0.012 \times (0.15)^2$

$= 2.7\times10^{-4}$

32. A continuous random variable X has a probability density function $f(x) = e^{-x}$, $0 < x < \infty$. Then $P(X > 2)$ is

(A) 0.1353 (B) 0.2354
(C) 0.2343 (D) 1.1353

32. Ans: (A)

Sol: $P(X > 2) = \int_2^\infty f(x)\cdot dx$

$$= \int_2^\infty e^{-x}dx = \left.\frac{e^{-x}}{-1}\right|_2^\infty$$

$$= e^{-2} = 0.1353$$

33. A time varying voltage signal V(t) = $X + Y \sin\omega t$ is measured by a single channel Analog CRO (operated with coupling mode set to DC) and also by Dual slope integrating DMM (operated with voltage Range set to AC). After measurement, DMM and CRO will display ____ and ___ respectively.

(A) $\sqrt{\left(\frac{X}{\sqrt{2}}\right)^2 + \left(\frac{Y}{\sqrt{2}}\right)^2}$ & $X + Y\sin\omega t$

(B) X & X+Y sinωt

(C) $\sqrt{X^2 + \left(\frac{Y}{\sqrt{2}}\right)^2}$ & $Y\sin\omega t$

(D) X & Y sinωt

33. Ans: (B)

Sol:
* DMM measures average value. Therefore displays X)
* In DC coupling, the sensed signal as it is reaches to Y-input of CRO and hence displayed as X+Y sinωt.

34. In a counter type ADC the clock frequency is 1 MHz and threshold voltage is 10 mV. The DAC has full scale output of 20.46V and resolution of 10 bits. Find the conversion time for analog input of 3.728V.

(A) 1023μs (B) 511.5μs
(C) 190μs (D) 187μs

34. Ans: (D)

Sol: Step size $= \frac{20.46}{2^{10}-1} = \frac{20.46}{1023} = 20\text{mV}$.

Given V_{in} = 3.728V, then V_d has to be = 3.728 + 10mV

$V_d = 3.728 + 0.01 = 3.738\text{V}$

$= \frac{3.738}{20\times10^{-3}} = 186.9 = 187_{10}$

$= 010111011_2$

Conversion time is ⇒ 187×1μs = 187μs.

35. The solution to $x^2y^{11} + xy^1 - y = 0$ is

(A) $y = C_1x^2 + C_2\,x^{-3}$

(B) $y = C_1 + C_2x^{-2}$

(C) $y = C_1\,x + \frac{C_2}{x}$

(D) $y = C_1\,x + C_2\,x^4$

35. Ans: (C)

Sol: Put $ln\,x = t$ so that $x = e^t$ and

let $x\frac{dy}{dx} = Dy$, $x^2\frac{d^2y}{dx^2} = D(D-1)\,y$

where $D = \frac{d}{dt}$

Given differential equation is

$x^2y^{11} + xy^1 - y = 0$

⇒ $D(D-1)y + Dy - y = 0$

⇒ $(D^2 - 1)\,y = 0$

Consider Auxiliary equation f(D) = 0

⇒ $D^2 - 1 = 0$

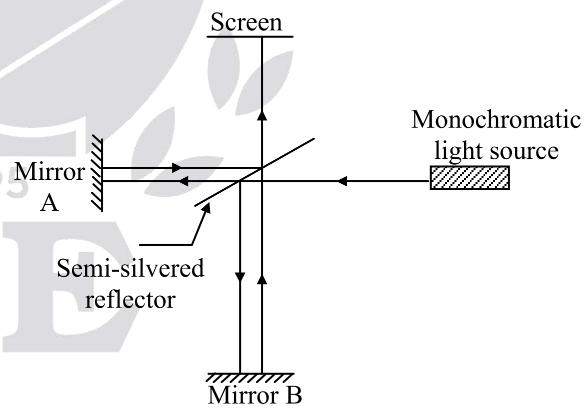
⇒ D = 1, –1 are different real roots

∴ The general solution of given equation is

$y = C_1e^t + C_2e^{-t} = C_1\,x + \frac{C_2}{x}$

Q. 36 – Q. 65 carry Two marks each.

36.



The interferometer as shown in the above figure. Two monochromatic light rays that are initially coming from same source (and hence being initially in phase) travel the two different paths and finally we look at them on the screen and find an interference pattern.

Suppose we change the position of one of the mirrors (mirror A in the figure) by 0.0125 mm & find that the bright and dark fringes change into each other 100 times during this process.

The frequency of the light ray in THz is

36. Ans: 600 [Range: 592 to 610]

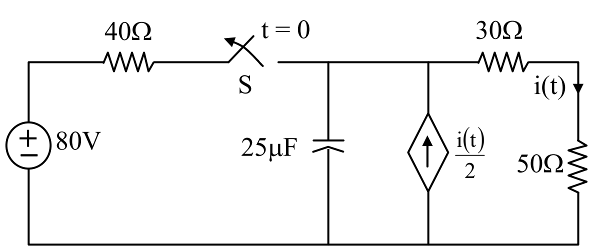
Sol: Let we change position of one of the mirrors by d such that $2d = \frac{\lambda}{2}$, then a bright fringe changes into dark fringe and dark fringe change into bright fringe. The dark & bright fringes change into each other 100 times during the process, then the distance D by which mirror has been displaced must be 100 times d.

$$D = 100d = 100 \times \frac{\lambda}{4} = 25\lambda$$

$$\lambda = \frac{D}{25} = \frac{1.25\times10^{-5}}{25} = 500\text{nm}$$

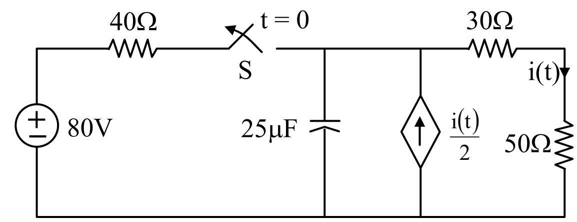
We know $f = \frac{C}{\lambda} = \frac{3\times10^{8}}{5\times10^{-7}} = 6\times10^{14}\,\text{Hz}$
$= 600\times10^{12}\text{Hz} = 600 \text{ THz}$

37. The circuit is under steady state for t < 0, the switch is opened at t = 0. The value of i(t) (in milliamperes) at t = 4msec is ________.



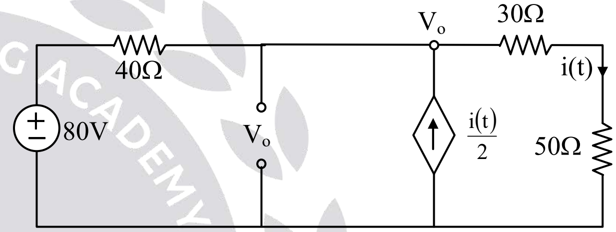
37. Ans: 294.303 [Range: 292 to 296]

Sol:



For t < 0, S is closed at t = 0^-

Circuit is in steady state condition and capacitor acts as open circuit



By KCL at V_0,

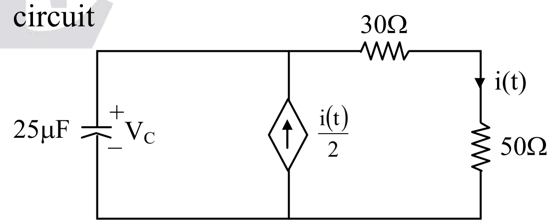
$$\frac{V_0 - 80}{40} + i(t) = \frac{i(t)}{2} \Rightarrow \frac{V_0 - 80}{40} + \frac{i(t)}{2} = 0$$

$$\Rightarrow \frac{V_0 - 80}{40} + \frac{1}{2}\left(\frac{V_0}{80}\right) = 0$$

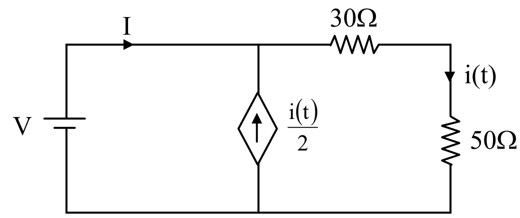
$4V_0 - 320 + V_0 = 0 \Rightarrow 5V_0 = 320$ V

$V_0 = 64$ Volts

For t > 0, S is opened, R-C source free circuit



For Req



$\tau = R_{eq}C$

$$I + \frac{i(t)}{2} = i(t)$$

$$\Rightarrow \frac{i(t)}{2} = I$$

$$\Rightarrow \frac{V}{80 \times 2} = I$$

$$\Rightarrow R_{eq} = \frac{V}{I} = 160\Omega$$

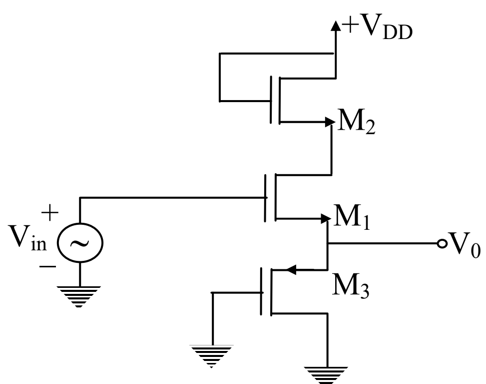
Voltage across capacitor is given by,

$$V_C(t) = V_0 e^{\frac{-t}{\tau}} = 64e^{-250t}$$

$$i(t) = \frac{V_C(t)}{80} = \frac{64e^{-250t}}{80}$$

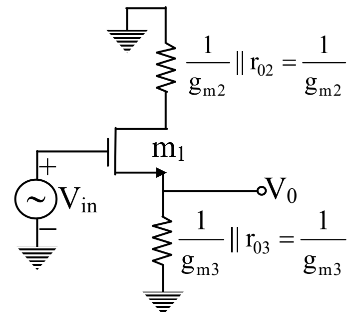
$$\Rightarrow \; i(t)|_{t=4\,m\sec} = 0.8e^{-1} = 294.303\,mA$$

38. In the following circuit, the MOSFETs used are of enhancement mode and operating in saturation region. If all the MOSFETs are identical and by neglecting the channel length modulation, the low frequency small signal gain $\left(\frac{V_0}{V_{in}}\right)$ is ______



38. Ans: 0.5 [Range: 0.49 to 0.51]

Sol:

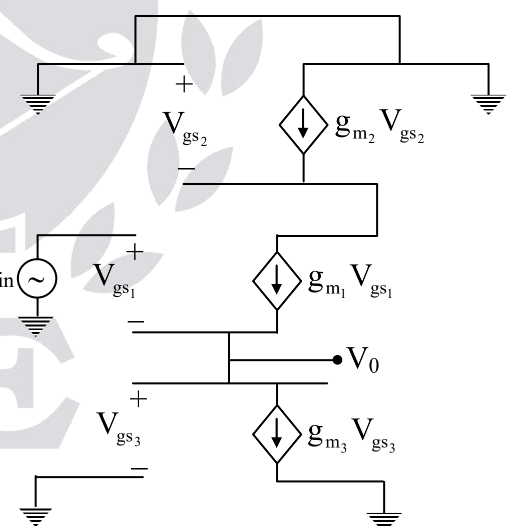


$$\frac{V_0}{V_{in}} = \frac{i_{d_1}(1/g_{m3})}{V_{gs1} + i_{d1}(1/g_{m3})}$$

$$= \frac{i_{d_1}(1/g_m)}{i_{d_1}(1/g_m) + i_{d_1}(1/g_m)} = \frac{1}{2}$$

$$= 0.5$$

(OR)



From the above diagram

$$g_{m_1}V_{gs_1} = g_{m_3}V_{gs_3}$$

$$\Rightarrow V_{gs_1} = V_{gs_3} \left(\because g_{m_1} = g_{m_2} = g_{m_3} = g_m\right) \_\_\_\_(1)$$

By KVL, $V_{gs_1} = V_{in} - V_0$ ________(2)

$V_0 = V_{gs_3}$ _____(3)

Apply Equation (2) and (3) in equation (1)

$V_{in} - V_0 = V_0$

$\Rightarrow V_{in} = 2V_0$

$\Rightarrow \frac{V_0}{V_{in}} = \frac{1}{2} = 0.5$

39. Photons of wavelength 900 nm are incident on a photodiode at the rate of 50×10^{10} s^{-1} and an average, electrons are collected at the terminals of the diode at the rate of 11×10^{10} s^{-1}. The responsivity of the given photodiode at 900 nm wavelength is

$$\begin{bmatrix} \text{Take} & h = 6.6\times10^{-34} \\ & e = 1.6\times10^{-19} \\ & c = 3\times10^{8} \end{bmatrix}$$

39. Ans: 0.16 [Range: 0.155 to 0.165]

Sol: We know

$$\eta = \frac{\text{Electron current rate}}{\text{Photon current rate}}$$

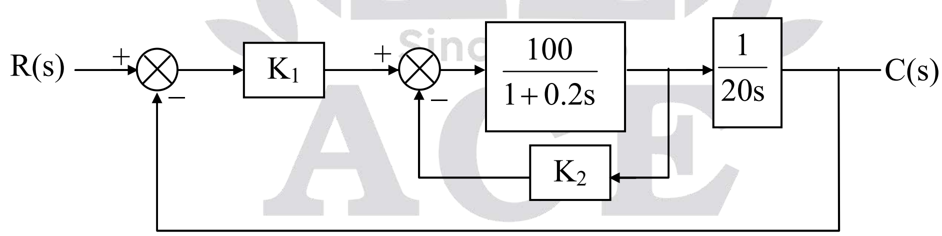
$$= \frac{11\times10^{10}}{50\times10^{10}} = 0.22$$

Responsivity

$$R = \frac{\eta e\lambda}{hc} = \frac{0.22\times1.6\times10^{-19}\times900\times10^{-9}}{6.6\times10^{-34}\times3\times10^{8}}$$

$= 0.16$

40. The system shown below has second order response with a damping ratio of 0.5 and a settling time with ± 2% tolerance is 0.5 sec. Then the value of K_1 is ____



40. Ans: 10.24 [Range: 10 to 11]

Sol:
$$\frac{C(s)}{R(s)} = \frac{100K_1/(20s(1+0.2s))}{1+\frac{100K_2}{(1+0.2s)}+\frac{100K_1}{20s(1+0.2s)}} = \frac{100K_1}{20s(1+0.2s)+100K_2(20s)+100K_1}$$

$$\frac{C(s)}{R(s)} = \frac{100K_1}{20s+4s^2+2000K_2 s+100K_1} = \frac{100K_1}{4s^2+s(2000K_1+20)+100K_1}$$

$\underrightarrow{CE}$ $4s^2 + s(2000K_1 + 20) + 100K_1 = 0$

$\underrightarrow{CE}$ $s^2 + S(500K_1 + 5) + 25K_1 = 0$

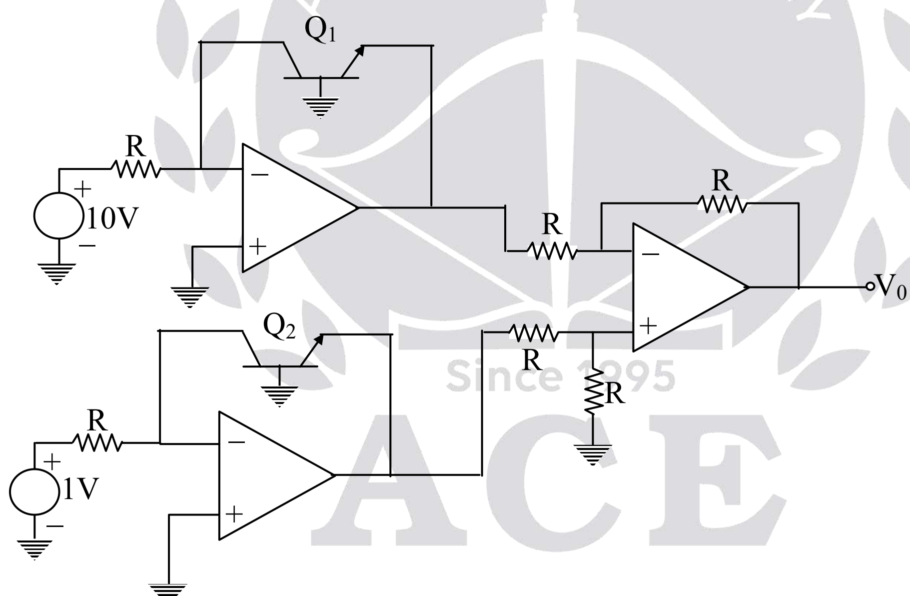
Given Data: $\xi = 0.5$, $t_s = 0.5$ sec

$\pm 2\%$ $t_s = \dfrac{4}{\xi\omega_n} \Rightarrow 0.5 = \dfrac{4}{0.5\times\omega_n}$

$\Rightarrow \omega_n = 16$ rad/sec

$\omega_n^2 = 25K_1 \Rightarrow K_1 = \dfrac{256}{25} = 10.24$

41. The transistors shown obey a non linear relation $I_C = I_S\, e^{\frac{V_{be}}{V_T}}$ where V_T is the thermal voltage equal to 25mV and I_S is the reverse saturation current. If β is large, then the value of output voltage V_0 (in milli volt) is ______



41. Ans: 57.56 [Range: 57 to 58]

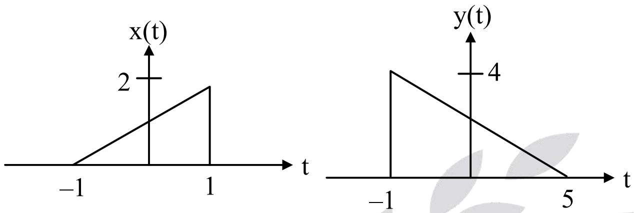
Sol: Here $V_{e2} = -V_{BE2}$, $V_{e1} = -V_{BE1}$

$V_0 = V_{e2} - V_{e1} = V_{be1} - V_{be2} = V_T \ln\left[\dfrac{I_{C1}}{I_{C2}}\right]$

$= V_T \ln\left[\dfrac{10/R}{1/R}\right] = 25m \ln[10]$

$V_0 = 57.56$ mV

42. Consider the signals x(t) & y(t) as shown below. Then y(t) expression interms of x(t) as $y(t) = Ax\left(\frac{t}{B} + C\right)$. Then the value of A + B + C is _____



42. Ans: –0.333 [Range: – 0.30 to –0.35]

Sol: y(t) is amplitude scaled by 2 it is also folded, expanded & shifted version of x(t)

y(t) can be expressed as y(t) = Ax(αt + β)

t = –1 of x(t) corresponds to t = 5 of y(t)

t = 1 of x(t) corresponds to t = –1 of y(t)

$$\left.\begin{aligned} 5\alpha + \beta &= -1 \\ -\alpha + \beta &= 1 \end{aligned}\right\} \alpha = -\frac{1}{3} \;\&\; \beta = \frac{2}{3}$$

$$\therefore y(t) = 2x\left(\frac{-t}{3} + \frac{2}{3}\right)$$

But, given $y(t) = Ax\left(\frac{t}{B} + C\right)$

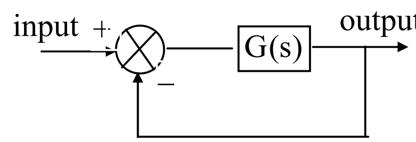
Then A = 2

B = –3

$C = \frac{2}{3}$

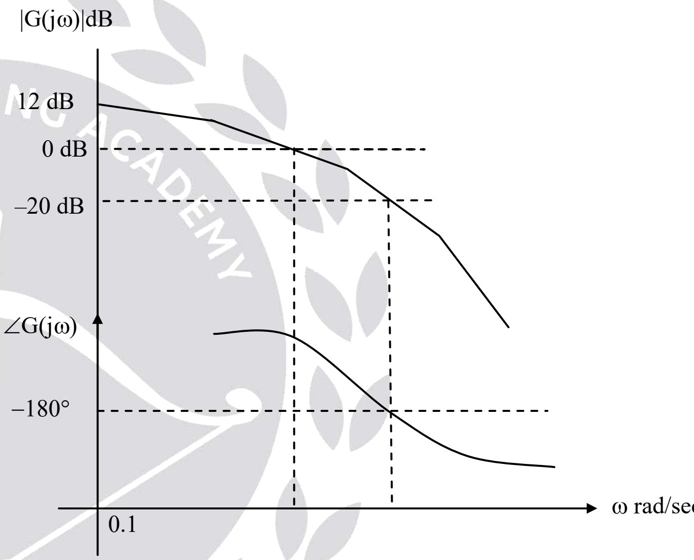
$A + B + C = \frac{-1}{3} = -0.333$

43. Consider the feedback control system shown in figure below.



where $G(s) = \frac{k}{s(1+sT_1)(1+sT_2)(1+sT_3)}$,

whose Bode plot is given below.



Then the maximum value of 'k' for stability of the system is _____ .

43. Ans: 4 [Range: 3.9 to 4]

Sol: For maximum value of k, system should be marginally stable. So, GM = 0 dB.

⇒ Magnitude plot has to shift up by +20 dB

$20 \log k - 20 \log \omega|_{\omega = 0.1} = 12 + 20$

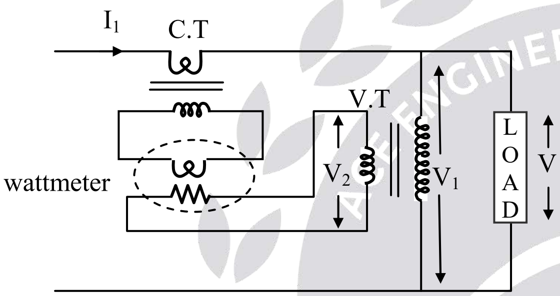
$= 32$ dB

20 log k = 12 dB

k = 4

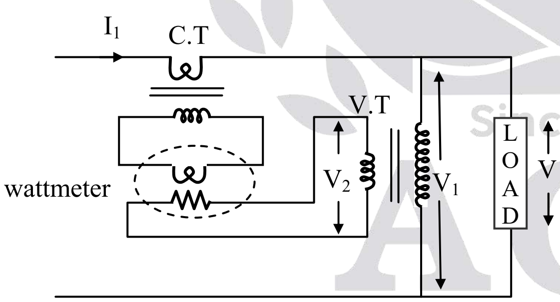
44. An electro dynamic wattmeter with maximum voltage & current ranges of 115 V & 1A respectively it's range extended by C.T & V.T. shown in figure transformer ratio are $\frac{V_1}{V_2} = 2$, & $\frac{I_1}{I_2} = 5$.

If the load voltage is 220 V, load current is 5 A lagging voltage by 25°. The wattmeter indication in watts is



44. Ans: 99.7 [Range: 99 to 100]

Sol:



$$I_2 = \frac{I_1}{\left(\frac{I_1}{I_2}\right)} = \frac{5A}{5} = 1A,$$

$$V_2 = \frac{V_1}{\left(\frac{V_1}{V_2}\right)} = \frac{220V}{2} = 110V$$

Wattmeter reading = 110 V ×1A ×cos25

= 99.7W

45. Consider the differential equation $\frac{dy}{dx} + 2xy = e^{-x^2}$ with initial condition $y(0) = 1$. The value of $y(1)$ is _____.

45. Ans: 0.7357 [Range 0.73 to 0.74]

Sol: Given $\frac{dy}{dx} + 2xy = e^{-x^2}$ …….. (1)

with $y(0) = 1$ …….. (2)

$\therefore$ I. F. = $e^{\int 2x\,dx} = e^{x^2}$

Now, the general solution of (1) is

$\Rightarrow y.\ e^{x^2} = \int e^{x^2} .\ e^{-x^2} dx + c$

$\Rightarrow y.\ e^{x^2} = x + c$ …….. (3)

Using (2), (3) becomes

$\Rightarrow 1 = 0 + c \Rightarrow c = 1$

$y = x\ e^{-x^2} + e^{-x^2}$

$y = (x + 1)\ e^{-x^2}$

$\therefore\ y(1) = 2 \times e^{-1} = 0.7357$

46. The surface integral $\iint_s (\overline{F}.\overline{n})\,dS$ over the surface S of the sphere $x^2 + y^2 + z^2 = 9$, where $F = (x+y)\bar{i} + (x+z)\bar{j} + (y+z)\bar{k}$ and $\bar{n}$ is the unit outward surface normal, yields ________.

46. Ans: 226.08 [Range: 226 to 227]

Sol: $\vec{F} = (x+y)\vec{i} + (x+z)\vec{j} + (y+z)\vec{k}$

$\text{div}\ \vec{F} = 1+1 = 2$

$$\iint_S \vec{F}.\vec{n}\,dS = \iiint_V \text{div}\,\vec{F}\,dx\,dy\,dz$$

(By Gauss divergence theorem)

$$= \iiint 2\,dx\,dy\,dz$$

$= 2 \times$ volume of the sphere

$$= 2\times\frac{4}{3}\pi(3)^3 = 72\,\pi = 226.08$$

47. Consider a control system with $G(s) = \frac{K(s+40)}{s(s+10)}$, $H(s) = \frac{1}{(s+20)}$.

The value of 'k' for which the system will oscillate is ______

47. Ans: 600

Sol: $\underrightarrow{CE}\ \ 1+G(s)H(s) = 0$

$$\underrightarrow{CE}\ \ 1+\frac{K(s+40)}{s(s+10)}.\frac{1}{(s+20)} = 0$$

$$\underrightarrow{CE}\ \ s(s+10)(s+20)+K(s+40) = 0$$

$$\underrightarrow{CE}\ \ s^3+30s^2+s(K+200)+40K = 0$$

CE:- $s^3 + 30s^2 + s(K + 200) + 40K = 0$

s^3	1	K+200
s^2	30	40K
s^1	$\left(\frac{30(K+200)-40K}{30}\right)$	
s^0	40K	

For marginal stable

$\Rightarrow (30K + 6000 - 40K) = 0$

$10K = 6000$

$K = 600$

48. The value of the double integral $\int_0^8\left(\int_{y/2}^{(y/2)+1}\left(\frac{2x-y}{2}\right)dx\right)dy$, using the substitution $u = \left(\frac{2x-y}{2}\right)$ and $v = \frac{y}{2}$ is ______.

48. Ans: 4

Sol: Given $u = \frac{2x-y}{2}$ and $v = \frac{y}{2}$

$\Rightarrow du = dx,\ dv = \frac{dy}{2}$ and $dy = 2\,dv$

If $x = \frac{y}{2}$ then $u = 0$

If $x = \frac{y}{2}+1$ then $u = 1$

If $y = 0$ then $v = 0$

If $y = 8$ then $v = 4$

$$\int_0^8\left[\int_{\frac{y}{2}}^{\frac{y}{2}+1}\left(\frac{2x-y}{2}\right)dx\right]dy = \int_{v=0}^{4}\int_{u=0}^{1} 2u\,du\,dv = 4$$

49. Given F.T of x(t) is X(f) = 8Sinc(2f)Sinc(4f). Then the value of x(t) at t = 0 is _____

49. Ans: 2

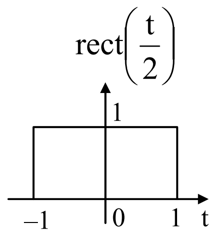
Sol: Using plancheral's theorem

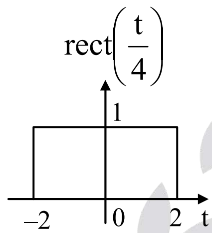
$$\int_{-\infty}^{\infty} x_1(t)x_2(t)dt = \int_{-\infty}^{\infty} X_1(f)X_2(f)df$$

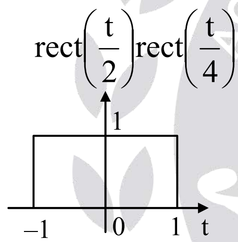
$$A\,\text{rect}\left(\frac{t}{T}\right) \leftrightarrow AT\ \text{Sinc}(fT)$$

8Sinc(2f)Sinc(4f)= [2 Sinc(2f)][4Sinc(4f)]

$$\int_{-\infty}^{\infty}(2\text{Sinc}(2f))(4\text{Sinc}(4f))df = \int_{-\infty}^{\infty}\text{rect}\left(\frac{t}{2}\right)\text{rect}\left(\frac{t}{4}\right)dt$$

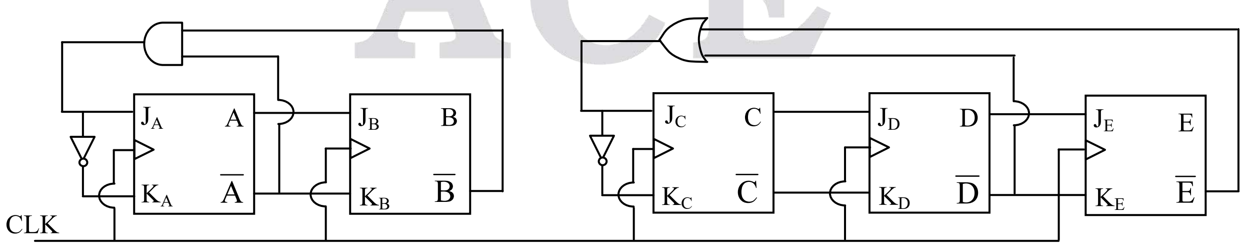






$$\int_{-\infty}^{\infty}\text{rect}\left(\frac{t}{2}\right)\text{rect}\left(\frac{t}{4}\right)dt = \int_{-1}^{1}(1)dt = 2$$

50. Two Johnson counters of 2-bit and 3-bit are connected parallely as shown in the following figure. The initial value of the counter is ABCDE = 00001. The modulus of the counter is _____



50. Ans: 15

Sol: In the given figure

$J_A = \overline{A}.\overline{B} = \overline{A+B}$ $\quad J_B = A$ $\quad J_C = \overline{D}+\overline{E} = \overline{DE}$ $\quad J_D = C$ $\quad J_E = D$

$K_A = A+B$ $\quad K_B = \overline{A}$ $\quad K_C = DE$ $\quad K_D = \overline{C}$ $\quad K_E = \overline{D}$

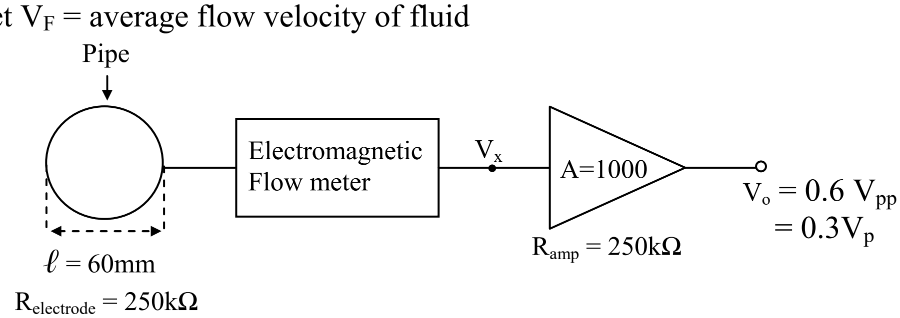
CLK	J_A	K_A	J_B	K_B	J_C	K_C	J_D	K_D	J_E	K_E	A	B	C	D	E
0											0	0	0	0	1
1	1	0	0	1	1	0	0	1	0	1	1	0	1	0	0
2	0	1	1	0	1	0	1	0	0	1	0	1	1	1	0
3	0	1	0	1	1	0	1	0	1	0	0	0	1	1	1
4	1	0	0	1	0	1	1	0	1	0	1	0	0	1	1
5	0	1	1	0	0	1	0	1	1	0	0	1	0	0	1
6	0	1	0	1	1	0	0	1	0	1	0	0	1	0	0
7	1	0	0	1	1	0	1	0	0	1	1	0	1	1	0
8	0	1	1	0	1	0	1	0	1	0	0	1	1	1	1
9	0	1	0	1	0	1	1	0	1	0	0	0	0	1	1
10	1	0	0	1	0	1	0	1	1	0	1	0	0	0	1
11	0	1	1	0	1	0	0	1	0	1	0	1	1	0	0
12	0	1	0	1	1	0	1	0	0	1	0	0	1	1	0
13	1	0	0	1	1	0	1	0	1	0	1	0	1	1	1
14	0	1	1	0	0	1	1	0	1	0	0	1	0	1	1
15	0	1	0	1	0	1	0	1	1	0	0	0	0	0	1

So, the modulus of the counter is 15

51. Consider an electromagnetic flow meter which is used to measure volumetric flow of a process fluid in a pipe of 60 mm diameter. The velocity profile is symmetrical and can be assumed uniform. The flux density in the fluid is 0.1 Wb/m^2. The output from the flow meter is given to an amplifier of gain 1000 and impedance between the electrodes is 250 kΩ. The input impedance of the amplifier is 250 kΩ. The average velocity (in m/sec) of the liquid when the peak to peak voltage at the amplifier output is 0.6 V.

51. Ans: 0.1

Sol: Let V_F = average flow velocity of fluid



Voltage generated by electromagnetic flow meter

$e = B\ell V_F$

$e = 0.1 \times 60\times10^{-3}V_F \quad = 6\times10^{-3}V_F \quad (V_F = \text{velocity})$

Voltage at the input of op-amp

$$V_x = \frac{R_{amp}}{R_{amp} + R_{electrode}} \times e = \frac{250k}{250k + 250k} \times 6\times10^{-3} V_F = 3mV\times V_F$$

Voltage at output of op-amp

$V_o = 3mV \times V_F \times A = 0.3$

$$V_F = \frac{0.3}{3\times10^{-3}\times1000} = 0.1(m/sec)$$

52. An RTD has $\alpha(20^oC) = 0.004(1/^oC)$ RTD has resistance of 106Ω at 20^oC. The RTD has a dissipation constant of $25(mW/^oC)$ and is used in a circuit that puts 8mA through the sensor. If the RTD is placed in a bath at 100^oC, then RTD indicated temperature in ^oC is

(A) 100.00 (B) 99.64 (C) 100.63 (D) 100.36

52. Ans: (D)

Sol: $\alpha(20^oC) = 0.004(1/^oC)$

RTD = 106Ω at $T = 20^oC$

$P_D = 25(mW/^oC)$

R_2 is RTD resistance at 100^oC

$R_2 = 106\,[1 + 0.004(100 - 20)] = 139.92\ \Omega$

P = power dissipation in RTD due to 8mA current = $(8mA)^2\times139.92\Omega$

$= 8.95(mW)$

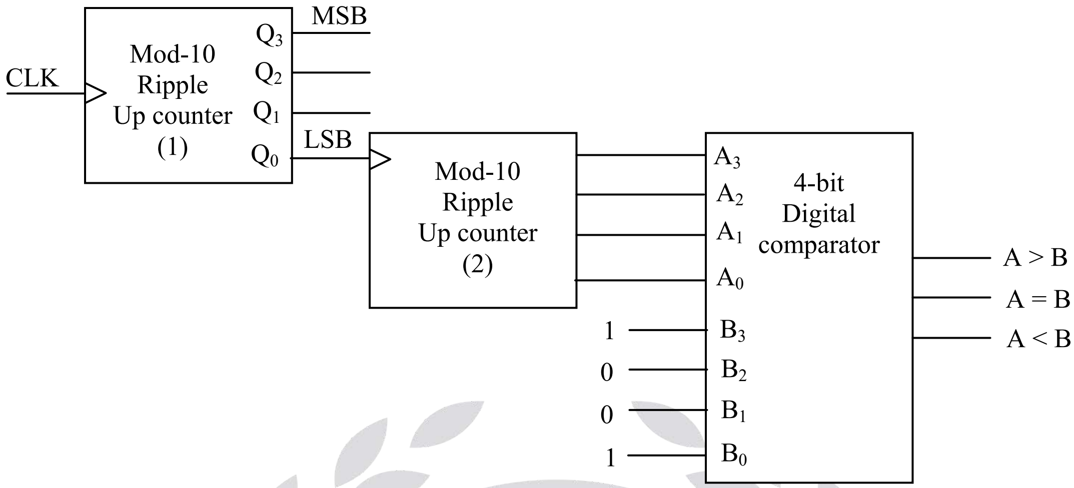
So rise in temperature = $\dfrac{P}{P_D} = \dfrac{8.95(mW)}{25(mW/^oC)}$

$\Delta T = 0.36(^oC)$

So the RTD indicated temperature = $100^oC + \Delta T = 100 + 0.36 = 100.36^oC$

53. In the following logic circuit, find the minimum number of clock pulses required to obtain the A = B output HIGH of digital comparator.

Initially both counters are cleared and A < B output is high.



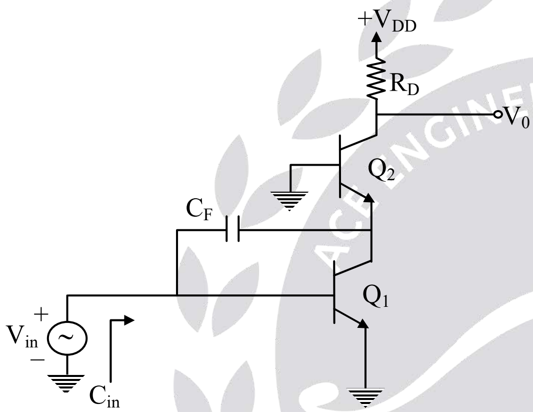
(A) 9 (B) 17 (C) 18 (D) 88

53. Ans: (B)

Sol: Here CLK of up counter (2) is Q_0 of up counter(1).

CLK	$Q_3\ Q_2\ Q_1\ Q_0$	$A_3\ A_2\ A_1\ A_0$	$B_3\ B_2\ B_1\ B_0$	A = B
0	0 0 0 0	0 0 0 0	1 0 0 1	0
1	0 0 0 1 →	0 0 0 1	1 0 0 1	0
2	0 0 1 0	0 0 0 1	1 0 0 1	0
3	0 0 1 1 →	0 0 1 0	1 0 0 1	0
4	0 1 0 0	0 0 1 0	1 0 0 1	0
5	0 1 0 1 →	0 0 1 1	1 0 0 1	0
6	0 1 1 0	0 0 1 1	1 0 0 1	0
7	0 1 1 1 →	0 1 0 0	1 0 0 1	0
8	1 0 0 0	0 1 0 0	1 0 0 1	0
9	1 0 0 1 →	0 1 0 1	1 0 0 1	0
10	0 0 0 0	0 1 0 1	1 0 0 1	0
11	0 0 0 1 →	0 1 1 0	1 0 0 1	0
12	0 0 1 0	0 1 1 0	1 0 0 1	0
13	0 0 1 1 →	0 1 1 1	1 0 0 1	0
14	0 1 0 0	0 1 1 1	1 0 0 1	0
15	0 1 0 1 →	1 0 0 0	1 0 0 1	0
16	0 1 1 0	1 0 0 0	1 0 0 1	0
(17)	0 1 1 1 →	[1 0 0 1]	1 0 0 1	1
18	1 0 0 0			

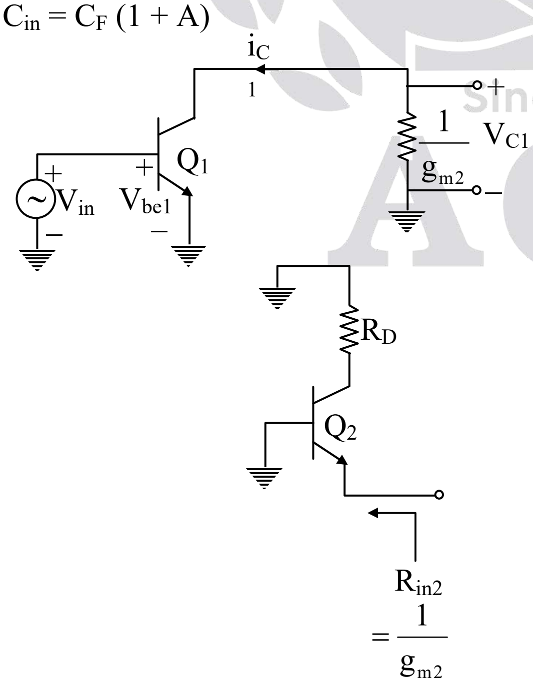
54. The transistors Q_1 and Q_2 are similar and neglect early effect. The small signal voltage gain $\left(\frac{V_0}{V_{in}}\right)$ is –100. Using miller's approximation, find the input capacitance C_{in} (Neglect all other capacitances). Assume the transistors operate with the same bias current.



(A) C_F (B) $2C_F$ (C) $11C_F$ (D) $101C_F$

54. Ans: (B)

Sol: $C_{in} = C_F(1 + A)$



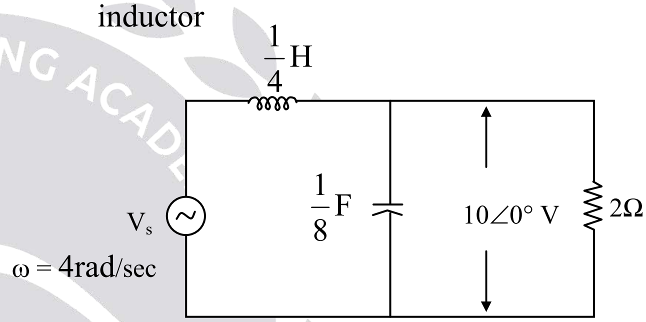
$$\frac{V_{C1}}{V_{in}} = -A = \frac{i_{C1}[1/g_{m2}]}{i_{C1}[1/g_{m1}]} = \frac{-1/g_m}{1/g_m} = -1$$

$$-A = -1$$

$$\therefore A = 1$$

$C_{in} = C_F(1 + A) = C_F(1 + 1) = 2C_F$

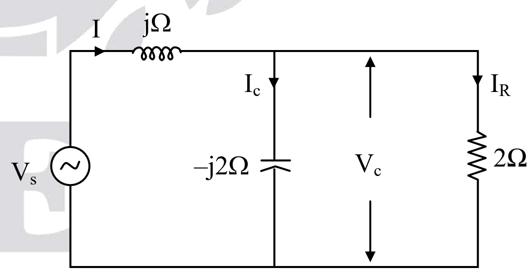
55. For an AC circuit as shown in figure, what is the phase angle of voltage across capacitor lags the voltage across the inductor



(A) 45° (B) –45°
(C) 135° (D) –135°

55. Ans: (C)

Sol:



$I_R = 5A$

$I_C = j\omega CV_C = 5\angle 90^o$

$I_L = I = I_R + I_C = 5 + j5 = 5\sqrt{2}\angle 45^o$

$V_L = j\omega LI_L = j5\sqrt{2}\angle 45^o = 5\sqrt{2}\angle 135^o$

$V_C = 10\angle 0^o$

⇒ Voltage across capacitor lags the voltage across inductor by 135°.

56. Given matrix $[A] = \begin{bmatrix} 4 & 2 & 1 & 3 \\ 6 & 3 & 4 & 7 \\ 2 & 1 & 0 & 1 \end{bmatrix}$, then the system AX = O, where $X = \begin{bmatrix} x_1 \\ x_2 \\ x_3 \\ x_4 \end{bmatrix}$ has

(A) no solution

(B) a unique solution

(C) only one independent solution

(D) two linearly independent solutions

56. Ans: (D)

Sol: Given $A = \begin{bmatrix} 4 & 2 & 1 & 3 \\ 6 & 3 & 4 & 7 \\ 2 & 1 & 0 & 1 \end{bmatrix}$

$R_2 \to 4R_2 - 6R_1$;

$R_3 \to 2R_3 - R_1$

$$\sim \begin{bmatrix} 4 & 2 & 1 & 3 \\ 0 & 0 & 10 & 10 \\ 0 & 0 & -1 & -1 \end{bmatrix}$$

$R_3 \to (10)R_3 + R_2$

$$\sim \begin{bmatrix} 4 & 2 & 1 & 3 \\ 0 & 0 & 10 & 10 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$\therefore \rho(A) = 2$

$\therefore$ Number of linearly independent solutions

= Number of variables – Rank of A

= 4 – 2 = 2

57. A temperature transmitter has a calibrated range of –80 to 150 °F & its output signal range is 4 to 20mA. Assuming the perfect calibration (zero error) then the correct table is

(A)

Measured temperature °F	% Span	Output Signal (mA)
120	86.96	17.91
–45	15.22	6.435

(B)

Measured temperature °F	% Span	Output signal (mA)
120	57.14	13.14
–45	–178.57	–24.57

(C)

Measured temperature °F	% Span	Output signal (mA)
120	86.96	17.91
–45	54.35	6.435

(D)

Measured temperature °F	% Span	Output signal (mA)
120	15.22	17.91
–45	86.96	6.435

57. Ans: (A)

Sol:

Temp (°F)	–80	150
Current (mA)	4	20

T = measured temperature, I = output current signal, S = span percent

$$\frac{T+80}{150+80} = \frac{I-4}{20-4}$$

$$I = \left(\frac{T+80}{230}\right)\times 16 + 4$$

$$T = 120^{o}F \rightarrow I = \left(\frac{120+80}{230}\right)\times 16+4$$
$$= 17.91mA$$

$$T = -45^{o}F \rightarrow I = \left(\frac{-45+80}{230}\right)\times 16+4$$
$$= 6.735mA$$

Percent of span $S = \frac{T - T_{min}}{T_{max} - T_{min}} \times 100$

$$T = 120^{o}F \rightarrow S = \frac{120+80}{150+80}\times 100 = 86.96\%$$

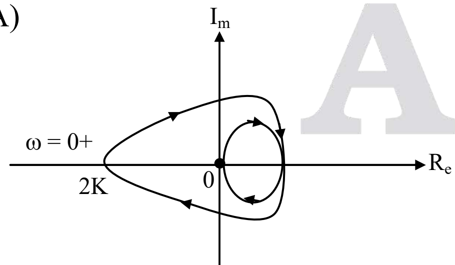
$$T = -45^{o}F \rightarrow S = \frac{-45+80}{150+80}\times 100 = 15.22\%$$

So the correct option is (a).

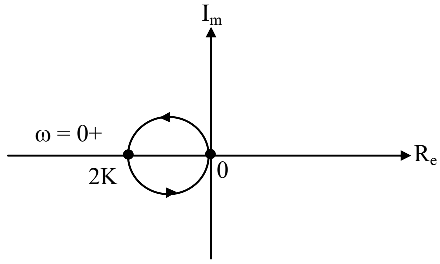
58. The open loop transfer function of a system is $G(s)H(s) = \frac{K(s-2)}{(s+1)^2}$

The Nyquist plot for this system is

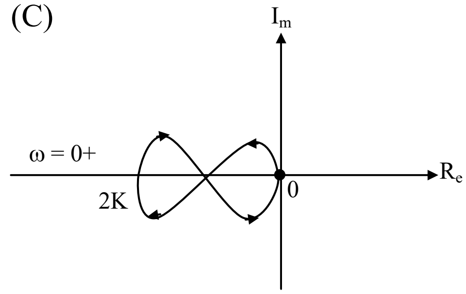
(A)



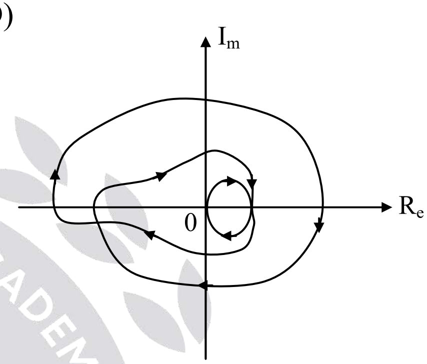
(B)



(C)



(D)



58. Ans: (A)

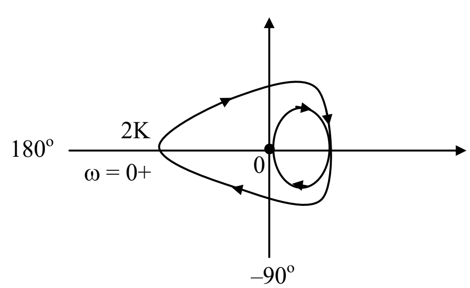
Sol: $G(j\omega)H(j\omega) = \frac{K(j\omega-2)}{(j\omega+1)^2}$

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

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

$$\angle\phi = 180° - \tan^{-1}\left(\frac{\omega}{2}\right) - 2\tan^{-1}(\omega)$$

$$\left.\begin{matrix}\omega = 0\ ;\ 2K\angle 180° \\ \omega = \infty\ ;\ 0\angle -90°\end{matrix}\right\}\text{Direction is clockwise}$$



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to our GATE-2019 Top Rankers

- AIR 1 PRAKHAR SINGH CE
- AIR 1 SURYANARYANA PI
- AIR 1 RAJAT SONI EC
- AIR 1 PRANAV SHARMA CSIT
- AIR 1 SHASHANK MANGAL IN

- AIR 2 KUNAL G EE
- AIR 2 MUKESH POONIA EE
- AIR 2 ANAND JERRY GEORGE EC
- AIR 2 PRIYANKA GUPTA IN
- AIR 2 VINAY SEELAM PI
- AIR 3 ANKIT KULHARI ME
- AIR 3 IDRIS MANAQIBWALA CE

- AIR 3 SHUBHAM MAURYA EC
- AIR 3 PRATEEK AGARWAL CSIT
- AIR 3 VINEET GOSWAMI IN
- AIR 3 ROHIT KHANNA PI
- AIR 4 CHETAN HANAKANAHALLI EC
- AIR 4 CHAITANYA KUMAR EC
- AIR 4 ARJUNDAS K IN

- AIR 4 RAJ BHAWANI SINGH IN
- AIR 4 SIDDARTH WADHWA ME
- AIR 5 SAYANTAN BHATTACHARYA EE
- AIR 5 PRADEEP KUMAR VERMA EE
- AIR 5 CHARMIN PATEL ME
- AIR 5 AYUSH JHAM PI
- AIR 5 RUTVIK LATHIA XE

- AIR 6 PRIYANSHU SHARMA EC
- AIR 6 HARI SHRAWGI CSIT
- AIR 6 RAMESH KAMULLA IN
- AIR 6 RAJ ZUNKE PI
- AIR 7 CHIRAG RATHI CE
- AIR 7 SHREYANS MEHTA CE
- AIR 7 ANKIT KUMAR EC

- AIR 7 SAIKIRAN CHOLLETI EC
- AIR 7 DEEPITA ROY EE
- AIR 7 SHUBHAM MITTAL EE
- AIR 7 SAISH KALASKAR IN
- AIR 7 SHWETA YADAV IN
- AIR 7 AMIT LAL SHAH PI
- AIR 7 ANUJ MEENA PI

- AIR 9 RAVI SHANKAR MISHRA CSIT
- AIR 9 ARKA RAY CSIT
- AIR 9 RANJIT KUMAR SINGH EC
- AIR 9 DEEP ADHVARYU IN
- AIR 9 B. SREEKAR IN
- AIR 9 ATULYA JYOTI PI
- AIR 10 GEETH GEORGE EE

- AIR 10 ASIF KHAN CE
- AIR 10 MAHESH SINGH YADAV ME
- AIR 10 GARVIT GUPTA XE
- AIR 10 MANMOHAN ARORA PI
- AIR 10 SHUBHAM PANDE PI

and many more...

	TOP 10	TOP 100
CE	5	44
ME	6	60
EE	7	71
EC	9	74
CS	5	28
IN	10	74
PI	10	49

59. Let $x(n) = \{3,4,\underset{\uparrow}{5},6\}$. The step interpolated signal $h(n) = x(0.5n-1)$ is ______

(A) $\{3,0,\underset{\uparrow}{4},0,5,0,6,0\}$

(B) $\{3,3,\underset{\uparrow}{4},4,5,5,6,6\}$

(C) $\{3,3,4,4,\underset{\uparrow}{5},5,6,6\}$

(D) $\{3,4,5,\underset{\uparrow}{6},3,4,5,6\}$

59. Ans: (B)

Sol: $x(n-1) = \{3,\underset{\uparrow}{4},5,6\} = y(n)$

$$h(n) = y\left(\frac{n}{2}\right) = \{3,3,\underset{\uparrow}{4},4,5,5,6,6\}$$

if we apply step interpolation

60. A 700nm beam with a power of 0.2mW and 5cm diameter strikes a detector with a 0.2cm diameter. The number of photons strike the detector per second is

(A) 0.1128×10^{13} (B) 0.704×10^{15}

(C) 70.63×10^{13} (D) 43.962×10^{16}

60. Ans: (A)

Sol: $\lambda = 700$ nm

D = 5 cm

d = 0.2 cm

P = 0.2 mW

$$A_1 = \frac{\pi}{4}D^2 = \frac{\pi}{4}\times(5\times10^{-2})^2$$
$$= 1.96\times10^{-3}(m^2)$$

$$A_2 = \frac{\pi}{4}d^2 = \frac{\pi}{4}\times(0.2\times10^{-2})^2$$
$$= 3.14\times10^{-6}(m^2)$$

Intensity in the beam

$$I = \frac{P}{A_1} = \frac{0.2\times10^{-3}}{\frac{\pi}{4}\times(5\times10^{-2})^2} = 0.102\left(\frac{W}{m^2}\right)$$

Energy of each photon

$$= \frac{hc}{\lambda} = \frac{6.62\times10^{-34}\times3\times10^{8}}{700\times10^{-9}}$$
$$= 2.84\times10^{-19}(J)$$

The numbers of photons strike the detector per second

$$N = I\left(\frac{W}{m^2}\right)\times A_2\times\frac{1}{E}$$
$$= I\left(\frac{J}{\sec m^2}\right)\times A_2(m^2)\times\frac{1}{E(J)}$$
$$= 0.102\times3.14\times10^{-6}\times\frac{1}{2.84\times10^{-19}}$$

$N = 0.1128\times10^{13}$(photons per second).

61. A current transformer has a bar primary & 200 secondary winding turns. The secondary winding burden is an ammeter of resistance 1.2 Ω and reactance 0.5 Ω. The secondary winding has a resistance of 0.2 Ω & reactance 0.3 Ω. The core requires the equivalent of an mmf of 100 AT for magnetization and 50 A for core losses the ammeter connected in the secondary winding circuit indicates 5A, The ratio error and the number of turns to be reduced in the secondary winding in order that ratio error zero for this condition are respectively

(A) – 8.5 %, 16 (B) +9.8%, 16

(C) – 8.5 %, 19 (D) +9.3%, 19

61. Ans: (C)

Sol: Total secondary circuit resistance

$= 1.2 + 0.2 = 1.4\ \Omega$

Total secondary circuit resistance

$= 0.5 + 0.3 = 0.8\ \Omega$

Total secondary circuit impedance angle $(\delta) = \tan^{-1}\left(\frac{0.8}{1.4}\right) = 29.74\ \Omega$

$\cos\delta = 0.8686$, $\sin\delta = 0.4955$, $N_p = 1$, $N_s = 200$, $n = \frac{N_s}{N_p} = 200$

$N_pI_m = 100$ AT $\Rightarrow$ $K_n = 200$, $n = K_n$

$$I_m = \frac{100}{1} = 100A, N_pI_e = 50AT$$

$$\Rightarrow I_e = \frac{50}{1} = 50A, I_s = 5A$$

$$R = n + \frac{I_e\cos\delta + I_m\sin\delta}{I_s}$$

$$= 200 + \frac{(50\times0.8686) + (100\times0.4955)}{5}$$

$$= 218.6$$

% Ratio error (%σ)

$$= \frac{K_n - R}{R}\times100 = \left(\frac{200-218.6}{218.6}\right)\times100$$

$$= -8.5\%$$

∗ To make ratio error zero, for this $K_n = R$

$$200 = n + \frac{(50\times0.8686) + (100\times0.4955)}{5}$$

$200 = n + 18.6$

$n = 181.4$,

$N_s = nN_p \Rightarrow N_s = 181.4\times1 = 181.4$

Reduction in secondary winding long turns $= 200 - 181.4 \simeq 19$

62. The annual precipitation data of a city is normally distributed with mean and standard deviation as 1000 mm and 200 mm, respectively. The probability that the annual precipitation will be more than 1200 mm is

(A) 0.1587 (B) 0.3174

(C) 0.3456 (D) 0.2345

62. Ans: (A)

Sol: Let X = annual precipitation

We know area under normal curve in the interval $(\mu - \sigma, \mu + \sigma) = 0.6826$

where μ is mean and σ is standard deviation

$\Rightarrow P(800 < X < 1200) = 0.6826$

Required probability $= P(X > 1200)$

$$= \frac{1-0.6826}{2}$$

$$= 0.1587$$

63. In the following 2-bit synchronous up/down counter using T-flip flops

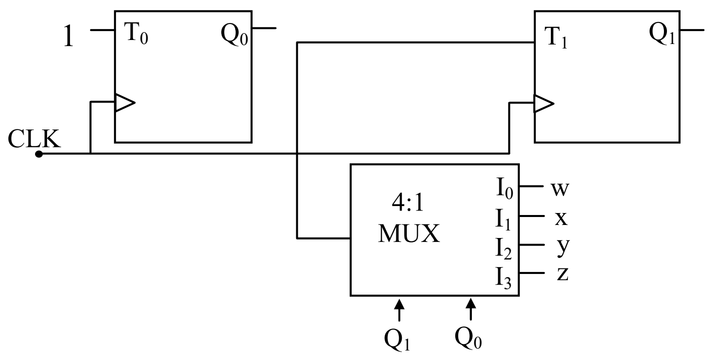
if m = 1

⇒ It should act as an ‘up counter”

if m = 0

⇒ it should act as a “down counter”

w, x, y, z are functions of m ,which of the following is correct.



(A) $w = y = m$, $x = z = \overline{m}$
(B) $w = y = \overline{m}$, $x = z = m$
(C) $w = y = 0$, $x = z = m$
(D) $w = y = m$, $x = z = 1$

63. Ans: (B)

Sol:

P.S		Input	N.S		FF Inputs	
Q_1	Q_0	m	Q_1	Q_0	T_1	T_0
0	0	0	1	1	1	1
0	0	1	0	1	0	1
0	1	0	0	0	0	1
0	1	1	1	0	1	1
1	0	0	0	1	1	1
1	0	1	1	1	0	1
1	1	0	1	0	0	1
1	1	1	0	0	1	1

$\Rightarrow T_0 = 1$

$T_1 = Q_0 \odot m$

i.e if $Q_0 = 0 \Rightarrow T_1 = \overline{m}$

if $Q_0 = 1 \Rightarrow T_1 = m$.

Then $I_o = I_2 = \overline{m}$ i.e $w = y = \overline{m}$

$I_1 = I_3 = m$ i.e $x = z = m$

64. We wish to sample a signal of 1 sec duration, band-limited to 50Hz & compute the DFT of the sampled signal with spectral spacing Δf. The number of zeros needed to be Padded to reduce the spacing to 0.5Δf, using the minimum sampling rate to avoid aliasing if we use radix-2 FFT are

(A) 100 (B) 156
(C) 28 (D) 256

64. Ans: (B)

Sol: Given signal duration = 1 sec

$f_m = 50$ Hz & $f_s = 2f_m = 100$ Hz

and N = (f_s) (signal duration) = 100 × 1 = 100

and $\Delta f = \frac{f_s}{N} = 1$ Hz

To reduce spectral spacing to $\frac{\Delta f}{2} = 0.5\text{Hz}$, we require 200 samples.

So, N = 256 (for FFT)

Available number of samples = 100

∴ Number of Padding zeros = 256 – 100 = 156

65. Negative feedback is employed in a control system then which one of the following statement (s) is/are true.

1. Gain increases

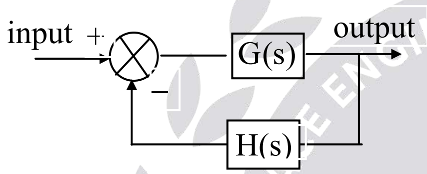
2. Bandwidth increases

3. Sensitivity of the output with respect to parameter changes in the forward path decreases.
4. Time constant of the system decreases

(A) 1, 2, 3, 4
(B) Only 2, 3, 4
(C) Only 3, 4
(D) Only 2, 4

65. Ans: (B)

Sol:



- $\text{CLTF} = \dfrac{G(s)}{1+G(s)H(s)}$

  Negative feedback reduces gain of system

- $S_G^M = \dfrac{1}{1+G(s)H(s)}$ is less than unity

  i.e less sensitive to the forward path parameter variations.

- Bandwidth increases hence rise time decreases, speed increases, time constant decreases.

Hearty Congratulations to our ESE-2019 Top Rankers

AIR 1 KARTIKEYA SINGH EE

AIR 1 RAJAT SONI E&T

AIR 1 HARSHAL BHOSALE ME

AIR 1 ABUZAR GAFFARI CE

AIR 2 SHAMBHAVI T EE

AIR 2 ANKUSH MANGLA E&T

AIR 2 SAHIL GOYAL ME

AIR 3 ABHISHEK ANAND EE

AIR 3 ROHIT KUMAR E&T

AIR 3 KUMAR CHANDAN ME

AIR 3 AMARJEET CE

AIR 4 ANKIT TAYAL EE

AIR 4 AMIR KHAN E&T

AIR 4 SAURAV ME

AIR 4 AMAN GULIA CE

AIR 5 KUMAR MAYANK EE

AIR 5 AYUSH CHANDRA CE

AIR 6 RITESH LALWANI EE

AIR 6 PUSHPAK ME

AIR 6 KABIL BHARGAVA CE

AIR 7 KARTIKEY SINGH EE

AIR 7 RAHUL JAIN E&T

AIR 7 MANISH RAJPUT ME

AIR 8 KULDEEP KUMAR E&T

AIR 8 HEMANT KUMAR SINGH ME

AIR 8 YOGESH KUMAR CE

AIR 9 DEEPITA ROY EE

AIR 9 SHUBHAM KARNANI E&T

AIR 9 DWEEP SABAPARA ME

AIR 9 ANKIT KUMAR CE

AIR 10 ANKITA SHARMA EE

AIR 10 GAURAV SRIVASTAVA E&T

AIR 10 SUMIT BHAMBOO ME

and many more...

Total Selections in **Top 10: 33** | **EE : 9** | **E&T : 8** | **ME : 9** | **CE : 7**