Q. No. 1 – 25 Carry One Mark Each

1. The dimension of the null space of the matrix $\begin{bmatrix} 0 & 1 & 1 \\ 1 & -1 & 0 \\ -1 & 0 & -1 \end{bmatrix}$ is

(A) 0 (B) 1 (C) 2 (D) 3

Answer: (B)

Exp: $A = \begin{bmatrix} 0 & 1 & 1 \\ 1 & -1 & 0 \\ -1 & 0 & -1 \end{bmatrix} \Rightarrow \text{Rank } A = 2$

$\therefore$ Dimension of the null space of A=3-2=1

2. If the A- matrix of the state space model of a SISO linear time invariant system is rank deficient, the transfer function of the system must have

(A) a pole with positive real part (B) a pole with negative real part
(C) a pole with positive imaginary part (D) a pole at the origin

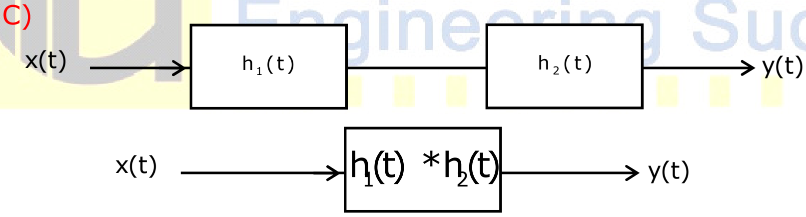
Answer: (D)

3. Two systems with impulse responses $h_1(t)$ and $h_2(t)$ are connected in cascade. Then the overall impulse response of the cascaded system is given by

(A) a product of $h_1(t)$ and $h_2(t)$ (B) sum of $h_1(t)$ and $h_2(t)$
(C) convolution of $h_1(t)$ and $h_2(t)$ (D) subtraction of $h_2(t)$ from $h_1(t)$

Answer: (C)

Exp:



4. The complex function tanh (s) is analytic over a region of the imaginary axis of the complex s-plane if the following is TRUE everywhere in the region for all integers n

(A) $\text{Re}(s) = 0$ (B) $\text{Im}(s) \neq n\pi$

(C) $\text{Im}(s) \neq \frac{n\pi}{3}$ (D) $\text{Im}(s) \neq \frac{(2n+1)\pi}{2}$

Answer: (D)

Exp: $\text{Tanh}s = \frac{e^s - e^{-s}}{e^s + e^{-s}}$ is analytic

if $e^s + e^{-s} \neq 0$

$\Rightarrow e^{2s} \neq -1 \Rightarrow s \neq i\frac{(2n+1)}{2}\pi$

$\therefore I_m(s) \neq \frac{(2n+1)}{2}\pi$

5. For a vector E, which one of the following statements is NOT TRUE?

(A) If $\nabla \cdot E=0$, E is called solenoidal

(B) If $\nabla \times E=0$, E is called conservative

(C) If $\nabla \times E=0$, E is called irrotational

(D) If $\nabla \cdot E=0$, E is called irrotational

Answer: (D)

Exp: $\nabla.E = 0$, E is called irrotational, which is not true

6. For a periodic signal $v(t) = 30\sin 100t + 10\cos 300t + 6\sin\left(500t + \frac{\pi}{4}\right)$, the fundamental frequency in rad/s is

(A) 100 (B) 300 (C) 500 (D) 1500

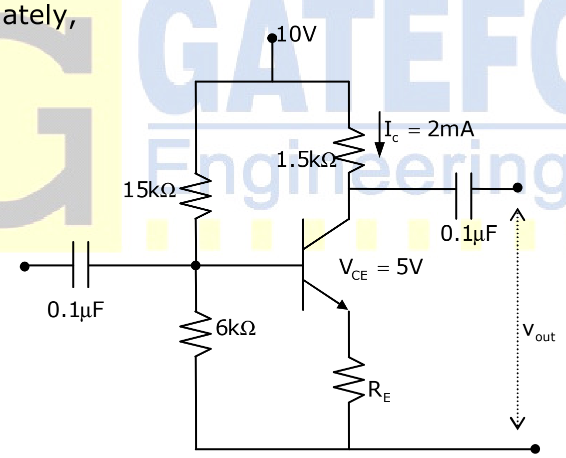
Answer: (A)

Exp: $\omega_o = 100\text{ rad / sec}$ fundamental

$3\omega_o = 300\text{ rad / sec}$ third harmonic

$5\omega_o = 500\text{ rad / sec}$ fifth harmonic

7. In the transistor circuit as shown below, the value of resistance R_E in $k\Omega$ is approximately,



(A) 1.0 (B) 1.5 (C) 2.0 (D) 2.5

Answer (A)

Exp: $V_B = 10 \times \frac{6k}{(6+15)k} = 2.8V$

$\Rightarrow V_E = 2.8 - 0.7 = 2.1\,V$

$\Rightarrow R_E = \frac{V_E}{I_E} = \frac{2.1}{2mA} = 1k\Omega$

8. A source $v_s(t) = V\cos 100\pi t$ has an internal impedance of $(4 + j3)\Omega$. If a purely resistive load connected to this source has to extract the maximum power out of the source, its value in Ω should be

(A) 3 (B) 4 (C) 5 (D) 7

Answer: (C)

Exp: For maximum power Transfer

$R_L = |Z_s|$

$= \sqrt{4^2 + 3^2}$

$= 5\Omega$

9. Which of the following statements is NOT TRUE for a continuous time causal and stable LTI system?

(A) All the poles of the system must lie on the left side of the $j\omega$-axis

(B) Zeroes of the system can lie anywhere in the s-plane

(C) All the poles must lie within $|s| = 1$

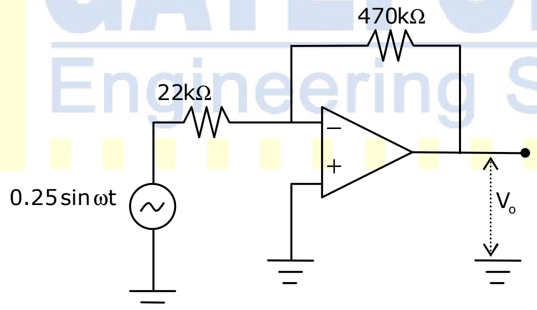
(D) All the roots of the characteristic equation must be located on the left side of the $j\omega$-axis.

Answer: (C)

Exp: For an LTI system to be stable and causal all poles or roots of characteristic equation must lie on LHS of s-plane i.e., left hand side of $j\omega -$ axis

[Refer Laplace transform].

10. The operational amplifier shown in the circuit below has a slew rate of $0.8V/\mu s$. The input signal is $0.25 \sin \omega t$. The maximum frequency of input in kHz for which there is no distortion in the output is



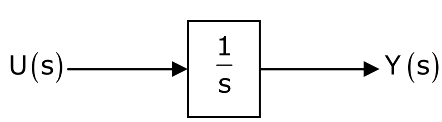
(A) 23.84 (B) 25.0 (C) 50.0 (D) 46.60

Answer: (A)

Exp: $f_{Max} = \frac{SR}{2\pi V_{opk}} = \frac{0.8}{2\pi \times 5.34 \times 10^{-6}}$; where $V_0 = \frac{470}{22} V_i = -5.34 \sin \omega t$

$= 23.84kHz$

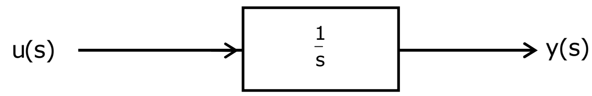
11. Assuming zero initial condition, the response $y(t)$ of the system given below to a unit step input $u(t)$ is



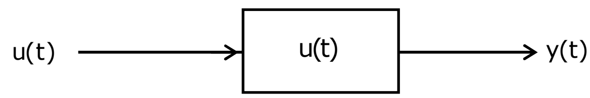
(A) $u(t)$ (B) $t\,u(t)$ (C) $\frac{t^2}{2} u(t)$ (D) $e^{-t} u(t)$

Answer: (B)

Exp: Integration of unit step function is ramp output

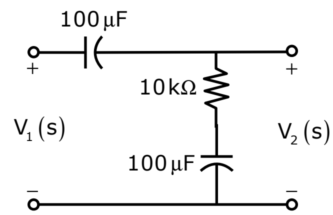


Writing in time domain



$y(t) = u(t) * u(t) = t\,u(t)$

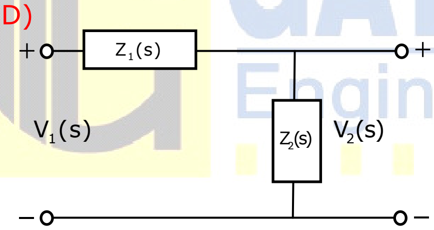
12. The transfer function $\frac{V_2(s)}{V_1(s)}$ of the circuit shown below is



(A) $\frac{0.5s+1}{s+1}$ (B) $\frac{3s+6}{s+2}$ (C) $\frac{s+2}{s+1}$ (D) $\frac{s+1}{s+2}$

Answer: (D)

Exp:



$z_1(s) = \frac{1}{10^{-4}s}, \quad z_2(s) = \frac{s+1}{10^{-4}s}$

$\frac{V_2(s)}{V_1(s)} = \frac{Z_q(s)}{Z_1(s)+Z_q(s)} = \frac{s+1}{s+2}$

13. The type of partial differential equation $\frac{\partial f}{\partial t} = \frac{\partial^2 f}{\partial x^2}$ is

(A) Parabolic (B) Elliptic (C) Hyperbolic (D) Nonlinear

Answer: (A)

Exp: $\frac{\partial f}{\partial t} = \frac{\partial^2 f}{\partial x^2}$ Here $B^2 - 4AC = 0$

$\therefore$ The equation is parabolic

14. The discrete-time transfer function $\frac{1-2z^{-1}}{1-0.5z^{-1}}$ is

(A) Non-minimum phase and unstable (B) Minimum phase and unstable

(C) Minimum phase and stable (D) Non-minimum phase and stable

Answer: (D)

Exp: $H(z) = \dfrac{1-2z^{-1}}{1-0.5z^{-1}}$

For minimum phase system, all poles and zeros must lie inside the unit circle.
For stable system, all poles must be inside the unit circle
For the given system, Zero is at 2, pole is at 0.5
This system is stable but non-minimum phase

15. Match the following biomedical instrumentation techniques with their application.

P.	Otoscopy	U.	Respiratory volume measurement
Q.	Ultrasound Technique	V.	Ear diagnostics
R.	Spirometry	W.	Echo-cardiography
S.	Thermodilution Technique	X.	Heart-volume measurement

(A) P-U;Q-V;R-X;S-W (B) P-V;Q-U;R-X;S-W
(C) P-V;Q-W;R-U;S-X (D) P-V;Q-W;R-X;S-U

Answer: (C)

16. A continuous random variable X has a probability density function $f(x) = e^{-x},\ 0<x<\infty$, then $P(X>1)$ is

(A) 0.368 (B) 0.5 (C) 0.632 (D) 1.0

Answer: (A)

Exp: $p(x>1) = \int_1^{\infty} e^{-x}dx = \left[-e^{-x}\right]_1^{\infty} = e^{-1} = 0.368$

17. A band limited signal with a maximum frequency of 5 kHz is to be sampled. According to the sampling theorem, the sampling frequency in kHz which is not valid is

(A) 5 (B) 12 (C) 15 (D) 20

Answer: (A)

Exp: Given: $f_m = 5kHz$

According to sampling frequency

$f_s \ge 2f_m;\ f_s \ge 10$ kHz

So, only in option (a) it is less than 10KHz ie., (5KHz)

18. A differential pressure transmitter of a flow meter using venture tube reads 2.5×10^5 Pa for a flow rate of $0.5\ m^3/s$. The approximate flow rate in m^3/s for a differential pressure of 0.9×10^5 Pa is

(A) 0.30 (B) 0.18 (C) 0.83 (D) 0.60

Answer: (A)

Exp: $Q \alpha \sqrt{p} \Rightarrow \dfrac{Q_2}{Q_1} = \sqrt{\dfrac{p_2}{p_1}}$

$\boxed{Q_2 = 0.30}$

19. A bulb in a staircase has two switches, one switch being at the ground floor and the other one at the first floor. The bulb can be turned ON and also can be turned OFF by any one of the switches irrespective of the state of the other switch. The logic of switching of the bulb resembles

(A) an AND gate (B) an OR gate (C) an XOR gate (D) a NAND gate

Answer: (C)

Exp: Let Switches = p_1, p_2

p_1,	p_2	Z(o / p)
OFF	OFF	OFF
OFF	ON	ON
ON	OFF	ON
ON	ON	OFF

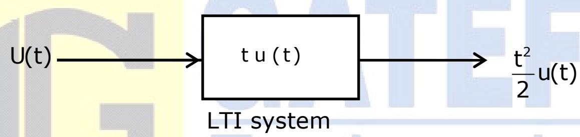
From Truth Table, it can be verified that Ex-OR logic is implemented.

20. The impulse response of a system is $h(t) = tu(t)$. For an input $u(t-1)$, the output is

(A) $\frac{t^2}{2}u(t)$ (B) $\frac{t(t-1)}{2}u(t-1)$ (C) $\frac{(t-1)^2}{2}u(t-1)$ (D) $\frac{t^2-1}{2}u(t-1)$

Answer: (C)

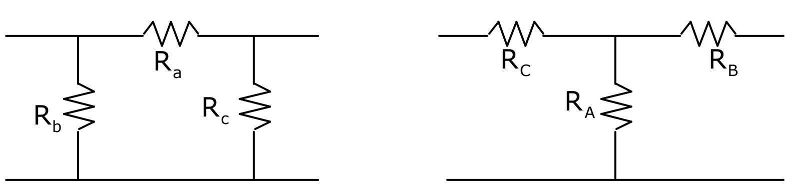
Exp:



For LTI system, if input gets delayed by one unit, output will also get delayed by one unit.

$$u(t-1) \rightarrow \frac{(t-1)^2}{2} \; u(t-1)$$

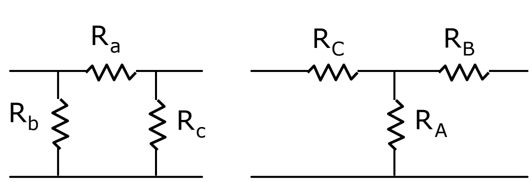
21. Consider a delta connection of resistors and its equivalent star connection as shown. If all elements of the delta connection are scaled by a factor k, k>0, the elements of the corresponding star equivalent will be scaled by a factor of



(A) k^2 (B) k (C) 1/k (D) $\sqrt{k}$

Answer: (B)

Exp: $R_C = \frac{R_a R_b}{R_a + R_b + R_c}$



$$R_B = \frac{R_a R_c}{R_a + R_b + R_c}$$

$$R_A = \frac{R_b R_c}{R_a + R_b + R_c}$$

Above expression shown that if R_a, R_b & R_c is scaled by k, R_A, R_B & R_C is scaled by k only.

22. An accelerometer has input range of 0-10g, natural frequency 30Hz and mass 0.001kg. The range of the secondary displacement transducer in mm required to cover the input range is

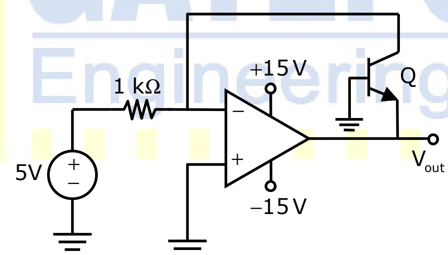
(A) 0 to 2.76 (B) 0 to 9.81 (C) 0 to 11.20 (D) 0 to 52.10

Answer: (A)

Exp: $a = w^2 x \Rightarrow x = \frac{a}{(2\pi f)^2}$

$\text{for } a = 0 - \log \Rightarrow x \Rightarrow 0 \text{ to } 2.76$

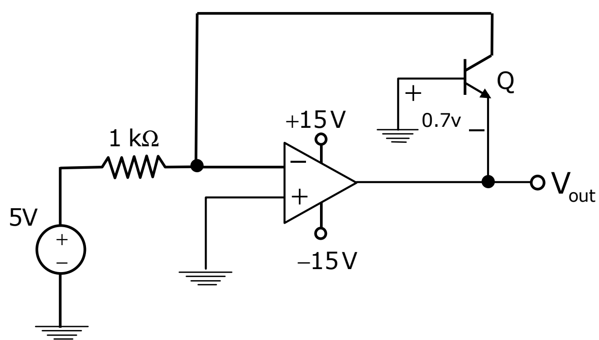
23. In the circuit shown below what is the output voltage (V_{out}) in Volts if a silicon transistor Q and an ideal op-amp are used?



(A) -15 (B) -0.7 (C) +0.7 (D) +15

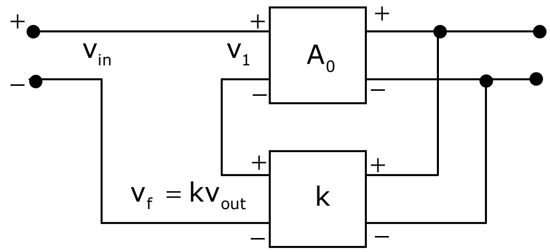
Answer: (B)

Exp:



$V_{out} = -0.7\,v$

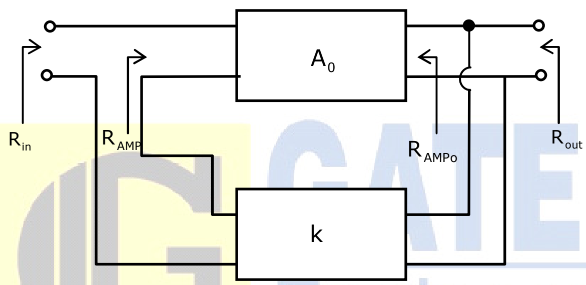
24. In the feedback network shown below, if the feedback factor k is increased, then the



(A) input impedance increases and output impedance decreases
(B) input impedance increases and output impedance also increases
(C) input impedance decreases and output impedance also decreases
(D) input impedance decreases and output impedance increases

Answer: (A)

Exp: In voltage-voltage feedback



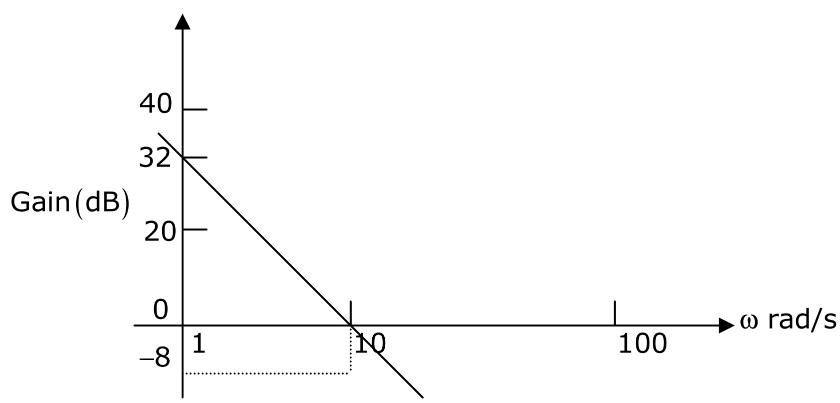
$$R_{in} = R_{AMP}(1 + A_0K)$$

$$R_{out} = \frac{R_{AMPo}}{1 + A_0K}$$

as $K\uparrow$

$R_{in}\uparrow$, $R_{out}\downarrow$

25. The Bode plot of a transfer function G(s) is shown in the figure below.

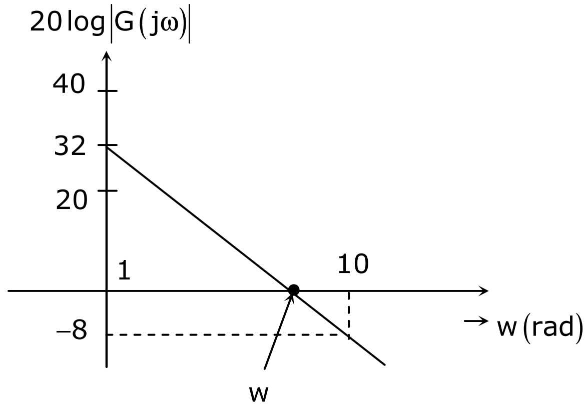


The gain $(20 \log |G(s)|)$ is 32dB and -8dB at 1 rad/s and 10 rad/s respectively. The phase is negative for all ω. Then $G(s)$ is

(A) $\frac{39.8}{s}$ (B) $\frac{39.8}{s^2}$ (C) $\frac{32}{s}$ (D) $\frac{32}{s^2}$

Answer: (B)

Exp: Any two paints on same line segment of Bode plot satisfies the equation of straight line.



i.e, $\frac{G_2 - G_1}{\log\omega_2 - \log\omega_1}$ = slope of the line segment.

For the initial straight line

$$\Rightarrow \frac{G_2 - G_1}{\log\omega_2 - \log\omega_1} = -40 \, dB/dec$$

$$\Rightarrow 0 - 32 = -40\log\left(\frac{\omega}{1}\right)$$

$$\Rightarrow \omega = 6.309 = k^{1/N}$$; Where N is type of system here initial slope is $-40 \, dB/dec$ Hence N = 2

$$\Rightarrow 6.309 = k^{1/2}$$

$$\Rightarrow k = (6.309)^2$$

$$k = 39.8$$

Hence $\boxed{G(s) = \frac{39.8}{s^2}}$

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26. While numerically solving the differential equation $\frac{dy}{dx} + 2xy^2 = 0,\ y(0) = 1$ using Euler's predictor– corrector (improved Euler–Cauchy) method with a step size of 0.2, the value of y after the first step is

(A) 1.00 (B) 1.03 (C) 0.97 (D) 0.96

Answer: (D)

Exp: $\frac{dy}{dx} = -2xy^2, x_0 = 0,\ y_0 = 1,\ h = 0.2$

$f(x,y)$; $y_1^p = y_0 + h.f(x_0, y_0) = 1 + (0.2)f(0,1) = 1$

and $y_1^c = y_o + \left[f(x_0, y_0) + f(x_1, y_1^p)\right] = 1 + (0.1)\left[f(0,1) + f(0.2,1)\right]$

= 0.96, is the value of y after first step, using Euler's predictor – corrector method.

27. One pair of eigen vectors corresponding to the two eigen values of the matrix $\begin{bmatrix} 0 & -1 \\ 1 & 0 \end{bmatrix}$ is

(A) $\begin{bmatrix} 1 \\ -j \end{bmatrix}, \begin{bmatrix} j \\ -1 \end{bmatrix}$ (B) $\begin{bmatrix} 0 \\ 1 \end{bmatrix}, \begin{bmatrix} -1 \\ 0 \end{bmatrix}$ (C) $\begin{bmatrix} 1 \\ j \end{bmatrix}, \begin{bmatrix} 0 \\ 1 \end{bmatrix}$ (D) $\begin{bmatrix} 1 \\ j \end{bmatrix}, \begin{bmatrix} j \\ 1 \end{bmatrix}$

Answer: (D)

Exp: $\lambda = j, -j$ are eigen values

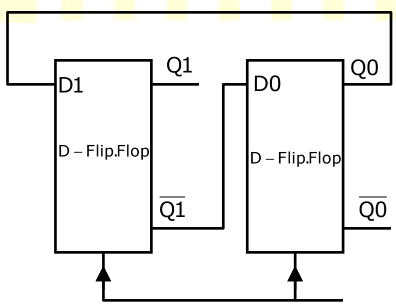
$(A - jI)x = 0 \Rightarrow \begin{bmatrix} -j & -1 \\ 1 & -j \end{bmatrix}\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$

$\therefore$ Eigen vector for j is $\begin{bmatrix} j \\ 1 \end{bmatrix}$

and $(A + jI)x = 0 \Rightarrow \begin{bmatrix} j & -1 \\ 1 & j \end{bmatrix}\begin{bmatrix} x \\ y \end{bmatrix} = \begin{bmatrix} 0 \\ 0 \end{bmatrix}$

$\therefore$ Eigen vector for $-j$ is $\begin{bmatrix} 1 \\ j \end{bmatrix}$

28. The digital circuit shown below uses two negative edge-triggered D-flip-flops. Assuming initial condition of Q1 and Q0 as zero, the output Q1Q0 of this circuit is



(A) 00, 01, 10, 11, 00... (B) 00, 01, 11, 10, 00....

(C) 00, 11, 10, 01, 00... (D) 00, 1, 11, 11, 00...

Answer: (B)

Exp:

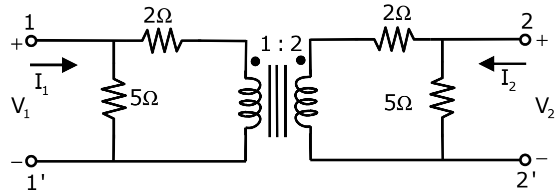
Q_1	Q_0	Q_{1next}	Q_{0next}
0	0	0	1
0	1	1	1
1	1	1	0
1	0	0	0

$D_1 = Q_0$

$D_0 = \bar{Q}_1$

The counter is 00, 01, 11, 10, 00,.......

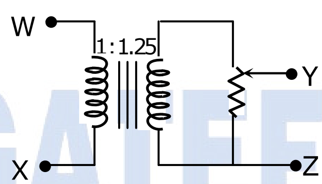
29. Considering the transformer to be ideal, the transmission parameter 'A' of the 2–port network shown in the figure below is



(A) 1.3 (B) 1.4 (C) 0.5 (D) 2.0

Answer: (A)

30. The following arrangement consists of an ideal transformer and an attenuator, which attenuates by a factor of 0.8. An ac voltage $V_{WX1} = 100V$ is applied across WX to get an open circuit voltage V_{YZ1} across YZ. Next, an ac voltage $V_{YZ2} = 100V$ is applied across YZ to get an open circuit voltage V_{WX2} across WX. Then, $V_{YZ1} / V_{WX1}, V_{WX2} / V_{YZ2}$ are respectively

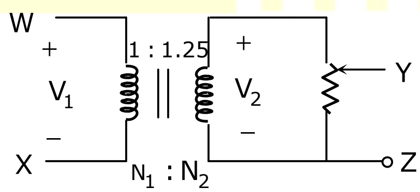


(A) 125 / 100 and 80 / 100 (B) 100 / 100 and 80 / 100

(C) 100 / 100 and 100 / 100 (D) 80 / 100 and 80 / 100

Answer: (C)

Exp:



For a transform

$$\frac{V_2}{V_1} = \frac{N_2}{N_1}$$

$$\Rightarrow V_2 = 1.125 \times V_1$$

The potentiometer gives an attenuation factor of 0.8 over υ_2

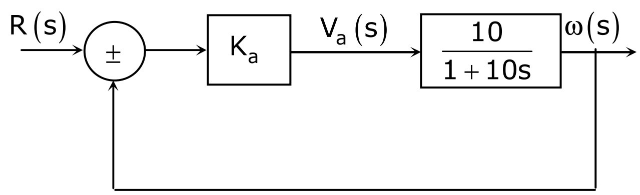
Hence $V_{yz} = 0.8\upsilon_2 \Rightarrow \frac{V_{yz}}{0.8} = \upsilon_2$

$$\Rightarrow \frac{V_{yz}}{0.8} = 1.125 \times V_{wx}$$

$$\Rightarrow V_{YZ} = V_{WX} \Rightarrow \frac{V_{YZ1}}{V_{WX1}} = \frac{100}{100}$$

Since potentiometer and transformer are bilateral elements. Hence $\frac{V_{wx2}}{V_{yz1}} = \frac{100}{100}$

31. The open–loop transfer function of a dc motor is given as $\frac{\omega(s)}{V_a(s)} = \frac{10}{1+10s}$. When connected in feedback as shown below, the approximate value of K_a that will reduce the time constant of the closed loop system by one hundred times as compared to that of the open–loop system is



(A) 1 (B) 5 (C) 10 (D) 100

Answer: (C)

Exp: $\tau_{\text{openloop}} = 10$

$$\tau_{\text{closedloop}} = \frac{10}{100} = \frac{10}{1+10k_a} \Rightarrow K_a = 9.9. \simeq 10.$$

$$\text{CLTF} = \frac{10k}{1+\frac{10K_a}{1+10s}} = \frac{10K_a}{1+\frac{10_s}{1+10k_a}(1+10k_a)}$$

$$= 10$$

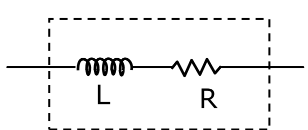
32. Two magnetically uncoupled inductive coils have Q factor q_1 and q_2 at the chosen operating frequency. Their respective resistances are R_1 and R_2. When "connected in series, the effective Q factor of the series combination at the same operating frequency is

(A) $q_1 + q_2$
(B) $(1/q_1)+(1/q_2)$
(C) $(q_1R_1 + q_2R_2)/(R_1 + R_2)$
(D) $(q_1R_2 + q_2R_1)/(R_1 + R_2)$

Answer: (C)

Exp: Q Factor of a inductive coil.

$$\boxed{\bar{Q} = \frac{wL}{R}} \Rightarrow Q_1 = \frac{wL_1}{R_2} \ \& \ Q_2 = \frac{wL_2}{R_2}$$



When such two coils are connected in series individual inductances and resistances are added.

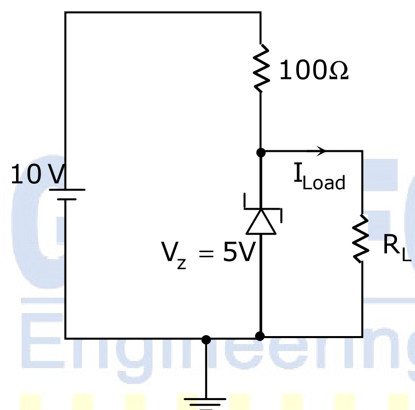
Hence, $L_{eq} = L_1 + L_2$

$$R_{eq} = R_1 + R_2$$

$$\text{Hence } Q_{eq} = \frac{\omega L_{eq}}{R_{eq}} = \frac{\omega(L_1 + L_2)}{(R_1 + R_2)} = \frac{\frac{\omega L_1}{R_1 R_2} + \frac{\omega L_2}{R_1 R_2}}{\frac{R_1}{R_1 R_2} + \frac{R_2}{R_1 R_2}}$$

$$= \frac{\frac{Q_1}{R_2} + \frac{Q_2}{R_1}}{\frac{1}{R_2} + \frac{1}{R_1}} = \frac{Q_1 R_1 + Q_2 R_2}{R_1 + R_2}$$

33. For the circuit shown below, the knee current of the ideal Zener diode is 10 mA. To maintain 5 V across R_L, the minimum value of the load resistor R_L in Ω and the minimum power rating of the Zener diode in mW, respectively, are



(A) 125 and 125 (B) 125 and 250 (C) 250 and 125 (D) 250 and 250

Answer: (B)

Exp $R_{L\,min} = \dfrac{5}{I_{L\,max}}$

$$I_{100} = \frac{10-5}{100} = \frac{5}{100} = 50 \text{ mA}$$

$$I_{LMax} = I_{100} - I_{knee} = 40 \text{ mA}$$

$$R_{L\,min} = \frac{5}{40} \times 1000 = 125\Omega$$

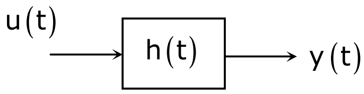
Minimum power rating of Zener should = 50 mA x 5V
= 250 mW

34. The impulse response of a continuous time system is given by $h(t) = \delta(t-1) + \delta(t-3)$. The value of the step response at $t = 2$ is

(A) 0 (B) 1 (C) 2 (D) 3

Answer: (B)

Exp: $h(t) = \delta(t-1) + \delta(t-)$



$y(t) = u(t-1) + u(t-3)$

$y(2) = u(1) + u(-1) = 1$

35. Signals from fifteen thermocouples are multiplexed and each one is sampled once per second with a16–bit ADC. The digital samples are converted by a parallel to serial converter to generate a serial PCM signal. This PCM signal is frequency modulated with FSK modulator with 1200 Hz as 1 and 960 Hz as 0. The minimum band allocation required for faithful reproduction of the signal by the FSK receiver without considering noise is

(A) 840 Hz to 1320 Hz (B) 960 Hz to 1200 Hz

(C) 1080 Hz to 1320 Hz (D) 720 Hz to 1440 Hz

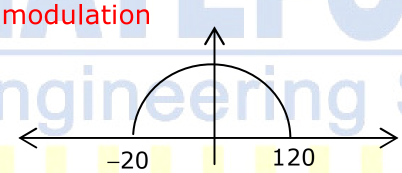
Answer: (A)

Exp: Data rate from ADC is 16 x 15 bits/second=240 bits/second

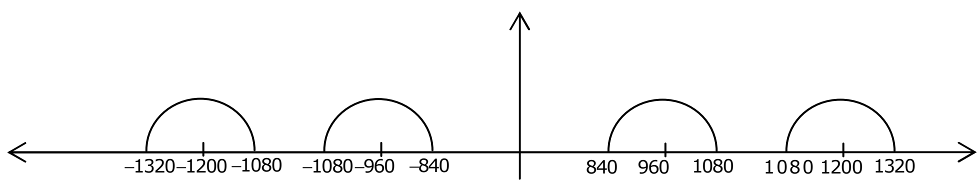
The bandwidth required for transmitting 240 bits/second = 120 Hz. (Half of bit rate).

Now when each pulse representing '1's and '0' s get FSK modulator with 960 Hz and 1200

Base band signal before modulation



The spectrum of signal after modulation



Thus all frequency from 840 to 1320 is required for allocation

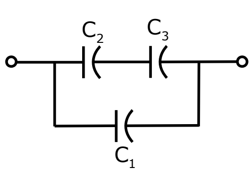
36. Three capacitors C_1, C_2 and C_3 whose values are $10\mu F, 5\mu F$ and $2\mu F$ respectively, have breakdown voltages of 10V, 5V, and 2V respectively. For the interconnection shown below, the maximum safe voltage in Volts that can be applied across the combination, and the corresponding total charge in μC stored in the effective capacitance across the terminals are, respectively

(A) 2.8 and 36

(B) 7 and 119

(C) 2.8 and 32

(D) 7 and 80



Answer: (C)

Exp: $\frac{Vc_3}{c_2+c_3} \le 5V \Rightarrow \frac{2V}{7} \le 5V$..................(1)

$\frac{Vc_2}{c_2+c_3} \le 2 \Rightarrow \frac{5V}{7} \le 2V$..................(2)

$V \le 10V \Rightarrow V \le 10V$......................(3)

From (1), $V \le 17.5$ Volts

From (2), $V \le 2.8$ Volts

From (3), $V \le 10$ Volts

To operate Circuit safe, V should be minimum of those =2.8V

$c_{eff} = c_1 + (c_2 \parallel C_3) = 10\mu F + \frac{10}{7}\mu F = \frac{80}{7}\mu F$

$Q = c_{eff} \times 2.8V = 32\mu c$

37. The maximum value of the solution y(t) of the differential equation $y(t) + \ddot{y}(t) = 0$ with initial conditions $\dot{y}(0) = 1$ and $y(0) = 2$, for $t \ge 0$ is

(A) 1 (B) 2 (C) π (D) $\sqrt{2}$

Answer:

Exp: $\ddot{y}(t) + y(t) = 0$

Taking Laplace on both sides, we get

$(s^2+1)y(s) = 2s+1 \Rightarrow y(s) = \frac{2s}{s^2+1} + \frac{1}{s^2+1}$

$\therefore y(t) = 2\cos t + \sin t$

$\therefore$ maximum value of y(t) is $\sqrt{2^2+1^2} = \sqrt{5}$

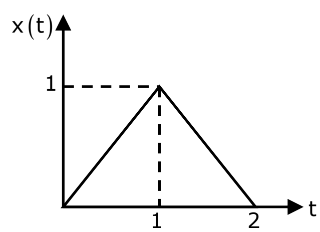
38. The Laplace Transform representation of the triangular pulse shown below is

(A) $\frac{1}{s^2}\left[1+e^{-2s}\right]$

(B) $\frac{1}{s^2}\left[1-e^{-s}+e^{-2s}\right]$

(C) $\frac{1}{s^2}\left[1-e^{-s}+2e^{-2s}\right]$

(D) $\frac{1}{s^2}\left[1-2e^{-s}+e^{-2s}\right]$



Answer: (D)

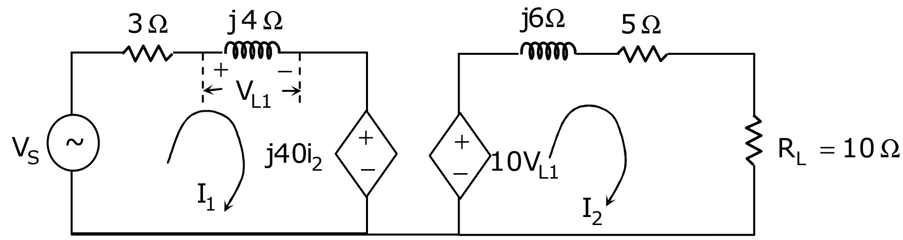
Exp: From the graph we have

$x(t) = t$ for $0 < t < 1$

$= 2 - t$ for $1 < t < 2$

$L\left[x(t)\right] = \int_0^1 e^{-st} \times t dt + \int_1^2 e^{-st}(2-t)dt = \frac{1}{s^2}\left[1-2e^{-s}+e^{-2s}\right]$

39. In the circuit shown below, if the source voltage $V_s = 100\angle 53.13^\circ$ Volts, then the Thevenin's equivalent voltage in Volts as seen by the load resistance R_L is



(A) $100\angle 90^\circ$ (B) $800\angle 0^\circ$ (C) $800\angle 90^\circ$ (D) $100\angle 60^\circ$

Answer: (C)

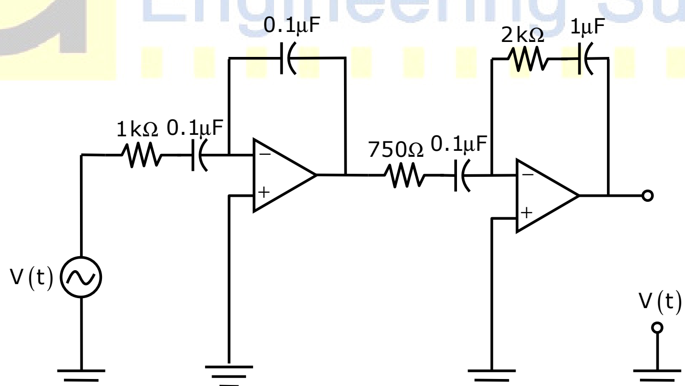
Exp: $V_{TH} = 10\,V_{L1}$

$$V_{L_1} = \frac{V_C}{3+j4} = \frac{100\angle 53.13}{5} - \mathrm{Tan}^{-1\left(\frac{4}{8}\right)} \times j4$$

$V_{L_1} = 80\angle 90^\circ$

$V_{TH} = 800\angle 90^\circ$

40. A signal $V_t(t) = 10 + 10\sin 100\pi t + 10\sin 4000\pi t + 10\sin 100000\pi t$ is supplied to a filter circuit (shown below) made up of ideal op–amps. The least attenuated frequency component in the output will be

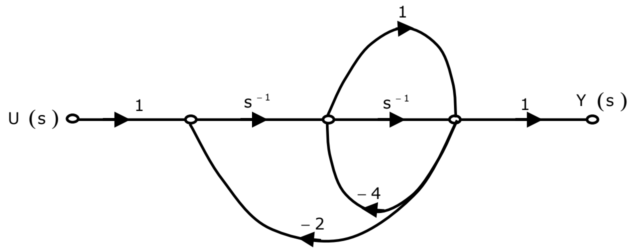


(A) 0 Hz (B) 50 Hz (C) 2 kHz (D) 50 kHz

Answer: (A)

Exp: Least attenuated signal frequency is 0 Hz

41. The signal flow graph for a system is given below. The transfer function $\frac{Y(s)}{U(s)}$ for this system is given as



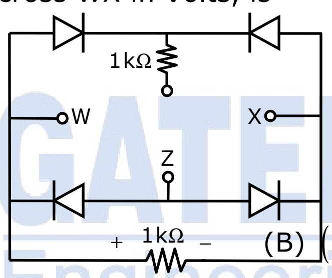
(A) $\dfrac{s+1}{5s^2+6s+2}$ (B) $\dfrac{s+1}{s^2+6s+2}$ (C) $\dfrac{s+1}{s^2+4s+2}$ (D) $\dfrac{1}{5s^2+6s+2}$

Answer: (A)

Exp: By using Mason's gain formula

$$\frac{y(s)}{u(s)} = \frac{s^{-2}+s^{-1}}{1-\left[-2s^{-2}-4s^{-1}-2s^{-1}-4\right]+0} = \frac{s^{-2}\left[s+1\right]}{25^2+6s^{-1}+5} = \frac{s+1}{5s^2+6s+2}$$

42. A voltage 1000 sin ωt Volts is applied across YZ. Assuming ideal diodes, the voltage measured across WX in Volts, is

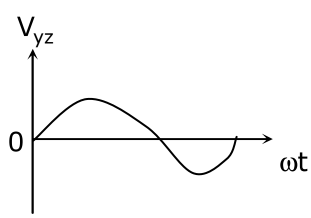


(A) $\sin\omega t$ (B) $\left(\sin\omega t+\left|\sin\omega t\right|\right)/2$

(C) $\left(\sin\omega t-\left|\sin\omega t\right|\right)/2$ (D) 0 for all t

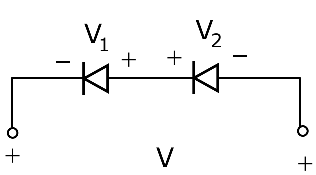
Answer: (D)

Exp:.



During the half cycle

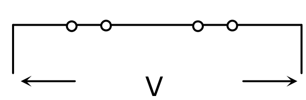
All Diodes OFF & Hence



$\left|V_1\right| = \left|V_2\right|$

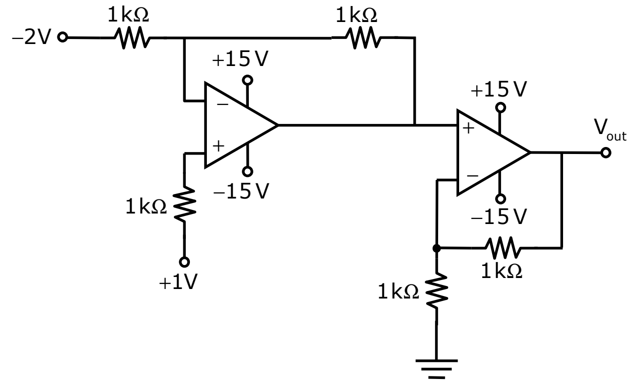
V = 0V

During −Ve half cycle



V = 0V.

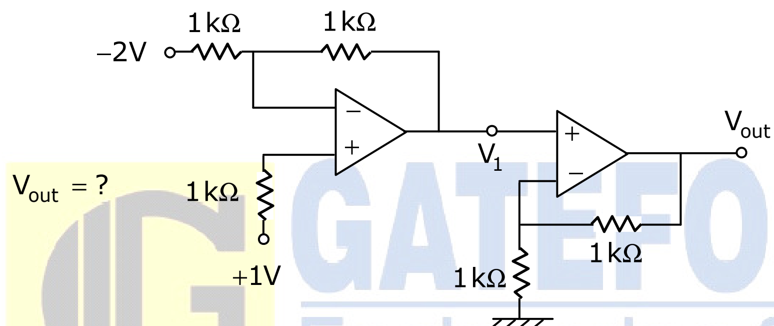
43. In the circuit shown below the op-amps are ideal. Then V_{out} in volts is



(A) 4 (B) 6 (C) 8 (D) 10

Answer: (C)

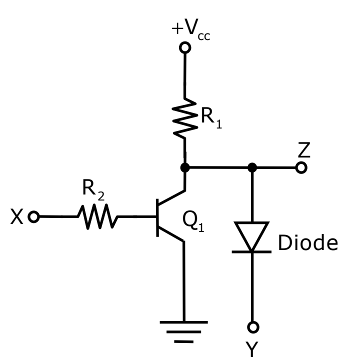
Exp:



$V_1 = 1(1+1) - 2(-1) = 4V$

$V_{out} = 2V_1 = 8V$

44. In the circuit shown below, Q_1 has negligible collector-to-emitter saturation voltage and the diode drops negligible voltage across if under forward bias. If V_{cc} is $+5V$, X and Y are digital signals with 0 V as logic 0 and V_{cc} as logic 1, then the Boolean expression for Z is



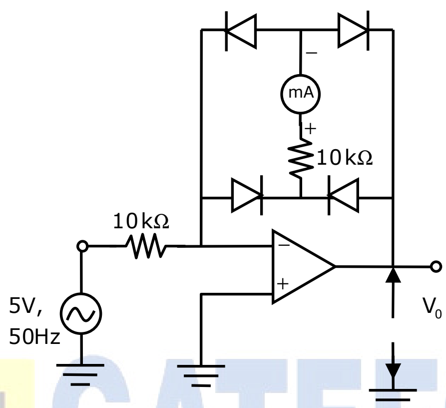
(A) XY (B) $\bar{X}Y$ (C) $X\bar{Y}$ (D) $\overline{XY}$

Answer: (B)

Exp: (B)

X	Y	Z
0	0	0
0	1	1
1	0	0
1	1	0

45. The circuit below incorporates a permanent magnet moving coil milli–ammeter of range 1 mA having a series resistance of $10\,k\Omega$. Assuming constant diode forward resistance of $50\,\Omega$ a forward diode drop of 0.7 V and infinite reverse diode resistance for each diode, the reading of the meter in mA is



(A) 0.45 (B) 0.5 (C) 0.7 (D) 0.9

Answer: (A)

46. Measurement of optical absorption of a solution is disturbed by the additional stray light falling at the photo-detector. For estimation of the error caused by stray light the following data could be obtained from controlled experiments.

Photo-detector output without solution and without stray light is $500\,\mu W$

Photo-detector output without solution and with stray light is $600\,\mu W$

Photo-detector output with solution and with stray light is $200\,\mu W$

The percent error in computing absorption coefficient due to stray light is

(A) 12.50 (B) 31.66 (C) 33.33 (D) 94.98

Answer: (B)

47. Two ammeters A_1 and A_2 measure the same current and provide readings I_1 and I_2 respectively. The ammeter errors can be characterized as independent zero mean Gaussian random variables of standard deviations σ_1 and σ_2 respectively. The value of the current is computed as:

$I = \mu I_1 + (1-\mu) I_2$. The value of V_1 which gives the lowest standard deviation of I is

(A) $\frac{\sigma_2^2}{\sigma_1^2+\sigma_2^2}$ (B) $\frac{\sigma_1^2}{\sigma_1^2+\sigma_2^2}$ (C) $\frac{\sigma_2}{\sigma_1+\sigma_2}$ (D) $\frac{\sigma_1}{\sigma_1+\sigma_2}$

Answer: (C)

Common Data for Questions: 48 & 49

A tungsten wire used in a constant current hot wire anemometer has the following properties:

Resistance at 0ºC is $10\,\Omega$, Surface area is $10^{-4}m^2$. Linear temperature coefficient of resistance of the tungsten wire is $4.8\times10^{-3}/^{o}C$, Convective heat transfer coefficient is $25.2W/m^2/^{o}C$, flowing air temperature is 30ºC, wire current is 100mA, mass specific heat product is $2.5\times10^{-5}J/^{o}C$

48. The thermal time constant of the hot wire under flowing air condition in ms is

(A) 24.5 (B) 12.25 (C) 6.125 (D) 3.0625

Answer: (B)

49. At steady state, the resistance of the wire in ohms is

(A) 10.000 (B) 10.144 (C) 12.152 (D) 14.128

Answer: (B)

Common Data for Questions: 50 & 51

A piezo electric force sensor, connected by a cable to a voltage amplifier has the following parameters:

Crystal properties: Stiffness $10^6 N/m$, Damping ratio 0.01, natural frequency 10^5 rad/s, Force-to-Charge sensitivity $10^{-9}C/N$, Capacitance $10^{-9}F$ with its loss angle assumed negligible.

Cable properties : capacitance $2\times10^{-9}F$ with its resistance assumed negligable

Amplifier properties: Input impedance $1M\Omega$, Bandwidth 1MHz, Gain 3

50. The maximum frequency of a force signal in Hz below the natural frequency within its useful midband range of measurement, for which the gain amplitude is less than 1.05 approximately is:

(A) 35 (B) 350 (C) 3500 (D) 16×10^3

Answer: (D)

51. The minimum frequency of a force signal in Hz within its useful mid-band range of measurement for which the gain amplitude is more than 0.95 approximately is:

(A) 16 (B) 160 (C) 1600 (D) 16×10^3

Answer: (B)

Linked Answer Questions: Q.52 to Q.55 Carry Two Marks Each

Statement for Linked Answer Questions: 52 & 53

Consider a plant with transfer function $G(s)=\frac{1}{(s+1)^3}$. Let K_u and T_u be the ultimate gain and ultimate period corresponding to the frequency response based closed loop Ziegler-Nichols cycling method respectively. The Ziegler-Nichols tuning rule for a P-controller is given as: $K = 0.5K_u$

52. The values of K_u and T_u respectively are:

(A) $2\sqrt{2}$ and 2π (B) 8 and 2π

(C) 8 and $2\pi/\sqrt{3}$ (D) $2\sqrt{2}$ and $2\pi/\sqrt{3}$

Answer: (C)

53. The gain of the transfer function between the plant output and an additive load disturbance input of frequency $\frac{2\pi}{T_u}$ in closed loop with a P-controller designed according to the Ziegler Nichols tuning rule as given above is

(A) -1.0 (B) 0.5 (C) 1.0 (D) 2.0

Answer: (B)

Statement for Linked Answer Questions: 54 & 55

A differential amplifier with signal terminals X, Y, Z is connected as shown in figure(a) below for CMRR measurement where the differential amplifier has an additional constant offset voltage in the output. The observations obtained are: when $V_i = 2V$, $V_o = 3mV$ and when $V_i = 3V, V_o = 4mV$

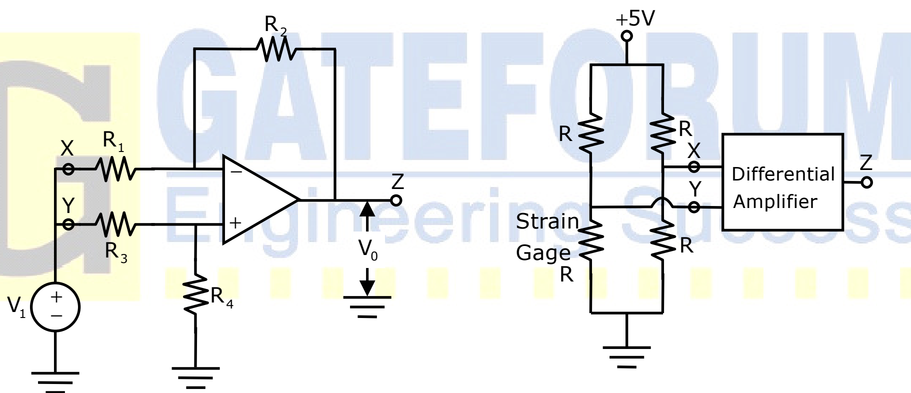


Figure : a Figure : b

54. Assuming its differential gain to be 10 and the op-amp to be otherwise ideal, the CMRR is

(A) 10^2 (B) 10^3 (C) 10^4 (D) 10^5

Answer: (C)

Exp:
$$\Delta V_0 = \frac{\Delta V_i}{CMRR}\left(1+\frac{R_2}{R_1}\right)$$
$$\Rightarrow CMRR = \frac{1V}{1mV}(10) = 10^4$$

55. The differential amplifier is connected as shown in the figure(b) above to a single strain gage bridge. Let the strain gage resistance vary around its no load resistance R by $\pm1\%$. Assume the input impedance of the amplifier to be high compared to the equivalent source resistance of the bridge, and the common mode characteristic to be as obtained above. The output voltage in mV varies approximately from

(A) +128 to -128 (B) +128 to -122 (C) +122 to -122 (D) +99 to -101

Answer: (B)

Q. No. 56 – 60 Carry One Mark Each

56. Statement: You can always give me a ring whenever you need.

Which one of the following is the best inference from the above statement?

(A) Because I have a nice caller tune

(B) Because I have a better telephone facility

(C) Because a friend in need in a friend indeed

(D) Because you need not pay towards the telephone bills when you give me a ring

Answer: (C)

57. Complete the sentence:

Dare ____________ mistakes.

(A) commit (B) to commit (C) committed (D) committing

Answer: (B)

58. Choose the grammatically CORRECT sentence:

(A) Two and two add four (B) Two and two become four

(C) Two and two are four (D) Two and two make four

Answer: (D)

59. They were requested not to quarrel with others.

Which one of the following options is the closest in meaning to the word quarrel?

(A) make out (B) call out (C) dig out (D) fall out

Answer: (D)

60. In the summer of 2012, in New Delhi, the mean temperature of Monday to Wednesday was 41°C and of Tuesday to Thursday was 43°C. If the temperature on Thursday was 15% higher than that of Monday, then the temperature in °C on Thursday was

(A) 40 (B) 43 (C) 46 (D) 49

Answer: (C)

Exp:- Let the temperature of Monday be T_M

Sum of temperatures of Tuesday and Wednesday = T and

Temperature of Thursday $=T_{Th}$

Now, $T_m + T = 41 \times 3 = 123$

& $T_{th} + T = 43 \times 3 = 129$

$\therefore T_{Th} - T_m = 6$, Also $T_{Th} = 1.15T_m$

$\therefore 0.15T_m = 6 \Rightarrow T_m = 40$

$\therefore$ Temperature of thursday $= 40 + 6 = 46^{O}C$

Q. No. 61 – 65 Carry Two Marks Each

61. Find the sum to n terms of the series 10 + 84 + 734 + …

(A) $\frac{9(9^n+1)}{10}+1$ (B) $\frac{9(9^n-1)}{8}+1$ (C) $\frac{9(9^n-1)}{8}+n$ (D) $\frac{9(9^n-1)}{8}+n^2$

Answer: (D)

Exp:-Using the answer options, substitute n = 2.

The sum should add up to 94

Alternative Solution:

The given series is 10+84+734+……………………….+n terms

$= (9+1) + (9^2+3) + (9^3+5) + (9^4+7) + \ldots\ldots\ldots\ldots n \text{ terms}$

$= (9 + 9^2 + 9^3 + \ldots\ldots\ldots n \text{ terms}) + (1 + 3 + 5 + 7 + \ldots\ldots\ldots n \text{ terms})$

$= \frac{9(9^n-1)}{9-1} + n^2 \quad \left(S_n = \frac{a(r^n-1)}{r-1} \; (r>1) \text{ and Sum of first n odd natural numbers is } n^2 \right)$

62. The set of values of p for which the roots of the equation $3x^2 + 2x + p(p-1) = 0$ are of opposite sign is

(A) $(-\infty, 0)$ (B) $(0,1)$ (C) $(1,\infty)$ (D) $(0,\infty)$

Answer: (B)

Exp: Since the roots are of opposite sign, the product of roots will be negative.

$\therefore \frac{p(p-1)}{3} < 0 \Rightarrow p(p-1) < 0 \Rightarrow (p-0)(p-1) < 0 \Rightarrow 0 < p < 1$

Thus the required set of values is $(0, 1)$

63. A car travels 8 km in the first quarter of an hour, 6 km in the second quarter and 16km in the third quarter. The average speed of the car in km per hour over the entire journey is

(A) 30 (B) 36 (C) 40 (D) 24

Answer: (C)

Exp :-Average speed $= \frac{\text{Total distance}}{\text{Total time}} = \frac{8+6+16}{\frac{1}{4}+\frac{1}{4}+\frac{1}{4}} = 40 \text{ km/hr}$

64. What is the chance that a leap year, selected at random, will contain 53 Sundays?

(A) 2/7 (B) 3/7 (C) 1/7 (D) 5/7

Answer: (A)

Exp:- There are 52 complete weeks in a calendar year $\simeq 852 \times 7 = 364$ days

Number of days in a leap year = 366

$\therefore$ Probability of 53 Saturdays = $\frac{2}{7}$

65. **Statement:** There were different streams of freedom movements in colonial India carried out by the moderates, liberals, radicals, socialists, and so on.

Which one of the following is the best inference from the above statement?

(A) The emergence of nationalism in colonial India led to our Independence

(B) Nationalism in India emerged in the context of colonialism

(C) Nationalism in India is homogeneous

(D) Nationalism in India is heterogeneous

Answer: (D)