General Aptitude

Q. No. 1 – 5 Carry One Mark Each

1. An apple costs Rs. 10. An onion costs Rs. 8.

Select the most suitable sentence with respect to grammar and usage.

(A) The price of an apple is greater than an onion.

(B) The price of an apple is more than onion.

(C) The price of an apple is greater than that of an onion.

(D) Apples are more costlier than onions.

Key: (C)

2. The Buddha said, "Holding on to anger is like grasping a hot coal with the intent of throwing it at someone else; you are the one who gets burnt."

Select the word below which is closest in meaning to the word underlined above.

(A) burning (B) igniting (C) clutching (D) flinging

Key: (C)

3. M has a son Q and a daughter R. He has no other children. E is the mother of P and daughter-in-law of M. How is P related to M?

(A) P is the son-in-law of M.
(B) P is the grandchild of M.
(C) P is the daughter-in law of M.
(D) P is the grandfather of M.

Key: (B)

4. The number that least fits this set: (324, 441, 97 and 64) is ________.

(A) 324 (B) 441 (C) 97 (D) 64

Key: (C)

Exp: $324 = 18^2; 441 = 21^2; 64 = 8^2$ but $97 \neq x^2$ for any positive integer

i.e. 97 is odd man out

5. It takes 10 s and 15 s, respectively, for two trains travelling at different constant speeds to completely pass a telegraph post. The length of the first train is 120 m and that of the second train is 150 m. The magnitude of the difference in the speeds of the two trains (in m/s) is ____________.

(A) 2.0 (B) 10.0 (C) 12.0 (D) 22.0

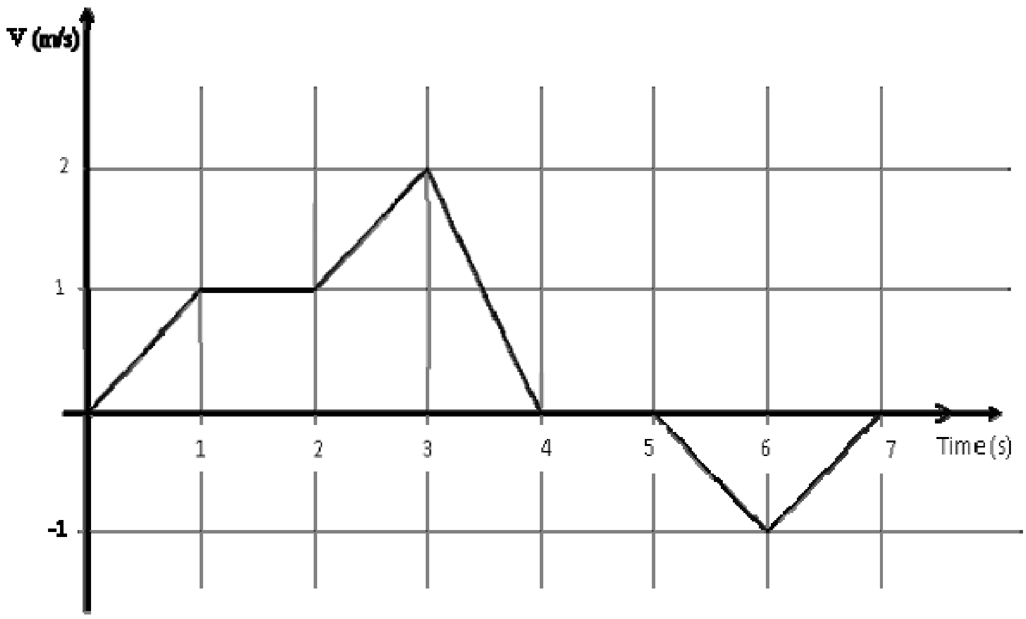
Key: (A)

Exp: $\text{Speed} = \frac{\text{length}}{\text{time}} \Rightarrow \text{length} = \text{speed} \times \text{time}$

$$120 = 10 \times s_1 \Rightarrow s_1 = 12$$
$$150 = 15 \times s_2 \Rightarrow s_2 = 10$$
$$|s_1 - s_2| = 2$$

Q. No. 6 – 10 Carry Two Marks Each

6. The velocity V of a vehicle along a straight line is measured in m/s and plotted as shown with respect to time in seconds. At the end of the 7 seconds, how much will the odometer reading increase by (in m)?



(A) 0 (B) 3 (C) 4 (D) 5

Key: (D)

7. The overwhelming number of people infected with rabies in India has been flagged by the World Health Organization as a source of concern. It is estimated that inoculating 70% of pets and stray dogs against rabies can lead to a significant reduction in the number of people infected with rabies.

Which of the following can be logically inferred from the above sentences?

(A) The number of people in India infected with rabies is high.

(B) The number of people in other parts of the world who are infected with rabies is low.

(C) Rabies can be eradicated in India by vaccinating 70% of stray dogs

(D) Stray dogs are the main sources of rabies worldwide.

Key: (A)

8. A flat is shared by four first year undergraduate students. They agreed to allow the oldest of them to enjoy some extra space in the flat. Manu is two months older than Sravan, who is three months younger than Trideep. Pavan is one month older than Sravan. Who should occupy the extra space in the flat?

(A) Manu (B) Sravan (C) Trideep (D) Pavan

Key: (C)

9. Find the area bounded by the lines 3x+2y=14, 2x-3y=5 in the first quadrant.

(A) 14.95 (B) 15.25 (C) 15.70 (D) 20.35

Key: (B)

Exp $A=\left(\frac{14}{3},0\right)$

$B=(0,7)$

$C=\left(\frac{5}{2},0\right)$

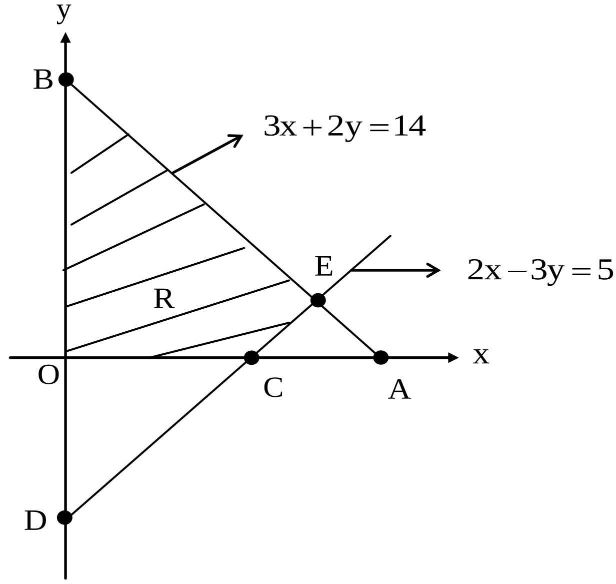
$D=\left(0,\frac{-5}{3}\right)$

$E=(4,1)$

Required area is area of

Δ OAB − area of Δ CEA

$=\frac{1}{2}\left(\frac{14}{3}\right)(7)-\frac{1}{2}\left(\frac{13}{6}\right)(1)=15.25$ sq.units



10. A straight line is fit to a data set (ln *x*, *y*). This line intercepts the abscissa at ln *x* = 0.1 and has a slope of −0.02. What is the value of *y* at *x* = 5 from the fit?

(A) −0.030 (B) −0.014 (C) 0.014 (D) 0.030

Key: (A)

Exp: $y=a+bx,$ where $x=l_n\,x$ and $\frac{-a}{b}=0.1,\ b=-0.02$

$=a-0.02(x) \qquad \Rightarrow a=0.002$

$=0.002-0.02(x)$

at $x=5,\ y=0.002-0.02(1.609)=-0.03018$

$\simeq -0.030$

Instrumentation Engineering

Q. No. 1 – 25 Carry One Mark Each

1. A straight line of the form $y = mx + c$ passes through the origin and the point $(x, y) = (2, 6)$. The value of m is ____________.

Key: 3

Exp: y=mx+c passing through $(0,0)\Rightarrow 0=0+c\Rightarrow c=0$

y=mx+c passing through $(2,6)\Rightarrow 6=2m\Rightarrow m=3$

2. $\lim\limits_{n\to\infty}\left(\sqrt{n^2+n}-\sqrt{n^2+1}\right)$ is ____________.

Key: 0.5

Exp: $\ell im_{n\to\infty}\left(\sqrt{n^2+n}-\sqrt{n^2+1}\right)\times\frac{\sqrt{n^2+n}+\sqrt{n^2+1}}{\sqrt{n^2+n}+\sqrt{n^2+1}}$

$$= \lim_{n\to\infty} \frac{n^2+n-n^2-1}{\sqrt{n^2+n}+\sqrt{n^2+1}} = \lim_{n\to\infty} \frac{\left(1-\frac{1}{n}\right)}{\sqrt{1+\frac{1}{n}}+\sqrt{1+\frac{1}{n^2}}} = \frac{1}{2}$$

3. A voltage V_1 is measured 100 times and its average and standard deviation are 100 V and 1.5 V respectively. A second voltage V_2, which is independent of V_1, is measured 200 times and its average and standard deviation are 150 V and 2 V respectively. V_3 is computed as: $V_3 = V_1 + V_2$. Then the standard deviation of V_3 in **volt** is ____________.

Key: 2.5

Exp: $\mathrm{Var}(V_3) = \mathrm{Var}(V_1+V_2) = \mathrm{Var}(V_1)+\mathrm{Var}(V_2) = 2.25+4 = 6.25$

Standard deviation of $V_3 = +\sqrt{\mathrm{Var}(V_3)} = +\sqrt{6.25} = 2.5$

4. The vector that is **NOT** perpendicular to the vectors $(i+j+k)$ and $(i+2j+3k)$ is _.

(A) $(i-2j+k)$ (B) $(-i+2j-k)$ (C) $(0i+0j+0k)$ (D) $(4i+3j+5k)$

Key: (D)

Exp: We know that if $\vec{a}\cdot\vec{b}=0$ then $\vec{a}$ and $\vec{b}$ are perpendicular

Verify options (a) , (b), (c) are perpendicular Option (d) is not perpendicular

5. In the neighborhood of $z = 1$, the function $f(z)$ has a power series expansion of the form $f(z) = 1+(1-z)+(1-z)^2+$ ………..

Then f(z) is

(A) $\frac{1}{z}$ (B) $\frac{-1}{z-2}$ (C) $\frac{z-1}{z+1}$ (D) $\frac{1}{2z-1}$

Key: (A)

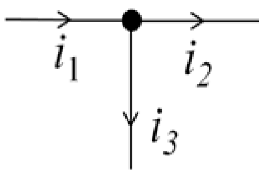
Exp: $1+(1-z)+(1-z)^3+---$

put $w=1-z$, then the given series becomes

$=1+w+w^2+w^3+---$

$=\frac{1}{1-w}=\frac{1}{1-(1-z)}=\frac{1}{z}$

6. Three currents i_1, i_2 and i_3 meet at a node as shown in the figure below. If $i_1 = 3\cos(\omega t)$ ampere, $i_2 = 4\sin(\omega t)$ ampere and $i_3 = I_3\cos(\omega t+\theta)$ ampere, the value of I_3 in **ampere** is _.



Key: 5

Exp: By KCL $i_1(t) = i_2(t) + i_3(t)$

$$\Rightarrow i_3(t) = i_1(t) - i_2(t)$$

By phasor $I_3 = \bar{I}_1 - \bar{I}_2$

$$= [3 < 0] - [4 < -90^o] = 5\angle 53.13$$

$$\Rightarrow i_3(t) = 5\cos(\omega t + 53.13)$$

So by comparison $I_3 = 5.$

7. An air cored coil has a Q of 5 at a frequency of 100 kHz. The Q of the coil at 20 kHz (neglecting skin effect) will be ________ .

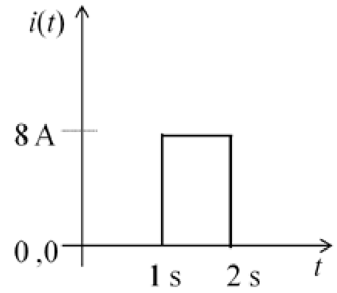
Key: 1

Exp: $Q = \frac{\omega L}{R}$

$$\text{at } 100\text{kHz}, \; 5 = \frac{\omega L}{R} = \frac{2\pi \times 100 \times 10^3 \times L}{R} \Rightarrow \frac{L}{R} = 7.9577 \times 10^{-6}$$

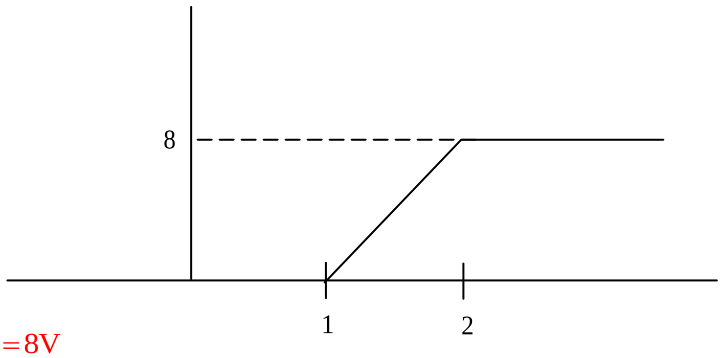
$$\text{at } 20\text{kHz}, \; Q = \frac{\omega L}{R} = 2\pi \times 20 \times 10^3 \times 7.9577 \times 10^{-6} = 1$$

8. A current $i(t)$ shown in the figure below is passed through a 1 F capacitor that had zero initial charge. The voltage across the capacitor for $t > 2$ s in **volt** is ____________



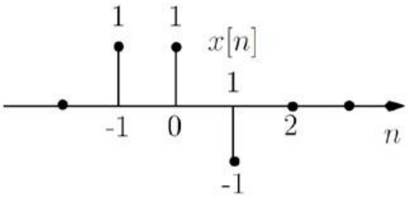
Key: 8

Exp: $V_c = \frac{1}{C}\int idt = \frac{1}{1}\int 8[u(t-1) - u(t-2)]dt = 8[r(t-1) - r(t-2)]$



$V_c(t > 2) = 8V$

9. The signal x[n] shown in the figure below is convolved with itself to get y[n]. The value of y[-1] is __________.

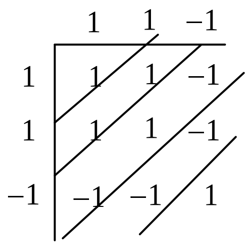


Key: 2

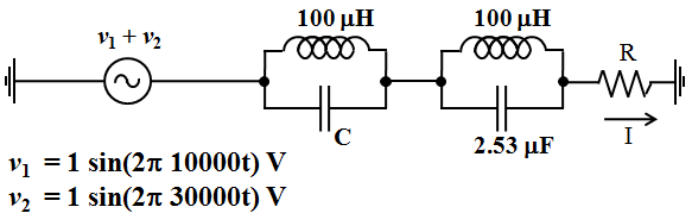
Exp: $x(n)=\{1,1,-1\}\ (-1\le n\le 1)$
$\uparrow$

$y(n)=x(n)*x(n)=\{1,2,-1,-2,1\}$

$y(-1)=2$



10. In the circuit shown below $(v_1+v_2)=[1\sin(2\pi 10000t)+1\sin(2\pi 30000t)]$V. The RMS value of the current through the resistor R will be minimum if the value of the capacitor C in **microfarad** is _________.



Key: 0.28 to 0.283

11. If X(s), the Laplace transform of signal $x(t)$ is given by $X(s)=\frac{(s+2)}{(s+1)(s+3)}$, then the value of x(t) as $t\to\infty$ is ______.

Key: 0

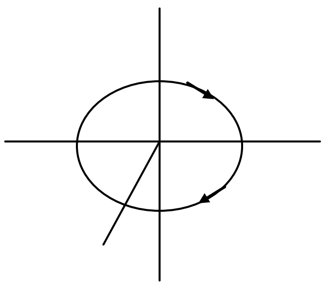
Exp: $\underset{t\to\infty}{\ell t}\ f(t)=\underset{s\to 0}{\ell t}\ s\frac{s+2}{(s+1)(s+2)}=0$

12. The number of times the Nyquist plot of $G(s)=\frac{s-1}{s+1}$ will encircle the origin clockwise is ______.

Key: 1

Exp: $G(s)=\frac{s-1}{s+1}$

$|G(s)|=\frac{\sqrt{1+\omega^2}}{\sqrt{1+\omega^2}}=1$



$\underline{|G(s)} = 180 - 2\tan^{-1}(\omega)$

$G(s) = 1\underline{|180^o - 2\tan^{-1}(\omega)}$

$\rightarrow G(0) = 1\underline{|180^o}$

$G(\infty) = 1\underline{|0^o}$

$G(1) = 1\underline{|90^o}$

Using G(0), G(1), G $G(\infty)$ information, the plot will look like

$\rightarrow$ Hence it encircle the origin only 1 time in clockwise direction

13. The value of a_0 which will ensure that the polynomial $s^3 + 3s^2 + 2s + a_0$ has roots on the left half of the s-plane is

(A) 11 (B) 9 (C) 7 (D) 5

Key: (D)

Exp:

$$\begin{array}{c|cc} S^3 & 1 & 2 \\ S^2 & 3 & a_0 \\ S1 & \frac{6-a_0}{3} & \\ S^0 & a_0 & \end{array}$$

For Stability $\frac{6-a_0}{3} > 0 \Rightarrow a_0 < 6$

14. The input $i(t) = 2\sin(3t+\pi)$ is applied to a system whose transfer function $G(s) = \frac{8}{(s+10)^2}$.

The amplitude of the output of the system is_.

Key: 0.1467

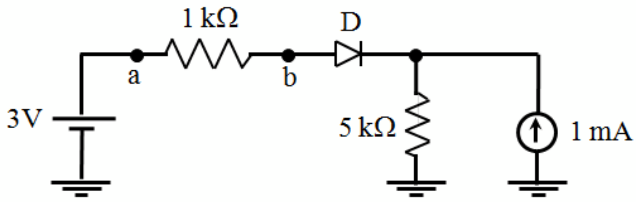
Exp: $G(s) = \frac{8}{(s+10)^2} + \frac{8}{s^2+20s+100} = \frac{8}{(100-\omega^2)+j(20\omega)}$

$G(s) = \frac{8}{\sqrt{(100-\omega^2)^2+3600}}\underline{|-\tan^{-1}\frac{60}{91}} = \frac{8}{109}\underline{|-33.4^o}$

$y(t) = \left(2\times\frac{8}{109}\right)\sin(3t+\pi-33.4^o) = 0.1467\sin(3t+146.6^o)$

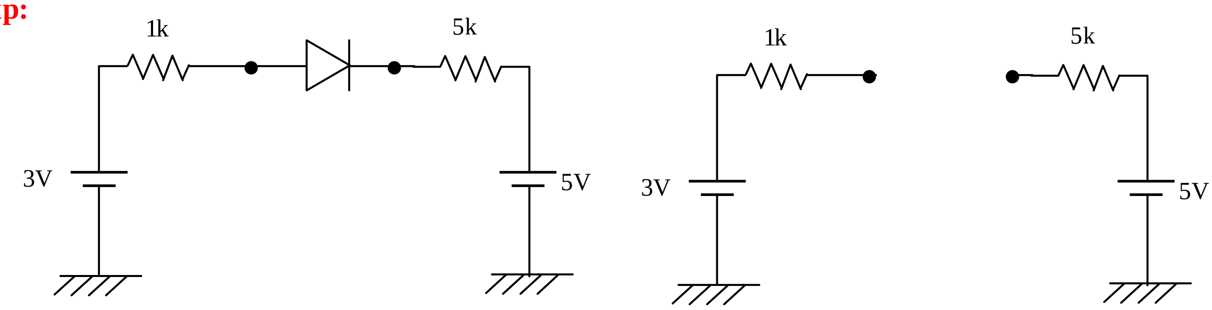
So amplitude is 0.1467.

15. The diode D used in the circuit below is ideal. The voltage drop V_{ab} across the $1k\Omega$ resistor in **volt** is____________.



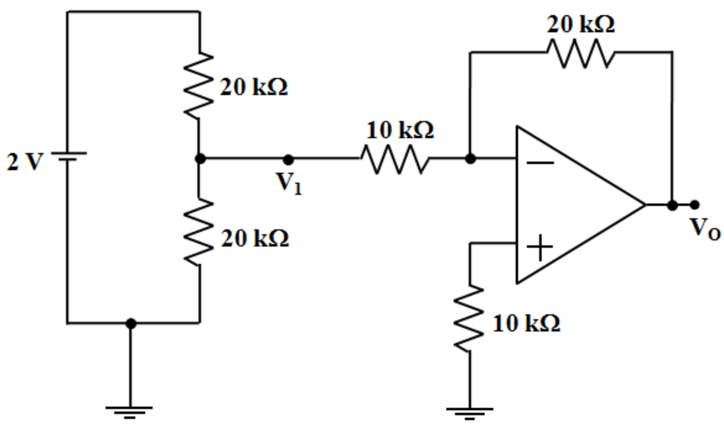
Key: 0

Exp:



Since $V_P < V_N$ diode is open circuit and no current flow through 1k, So $V_{1k\Omega} = 0V$.

16. In the circuit given below, the op-amp is ideal. The output voltage V_O in **volt** is _____.



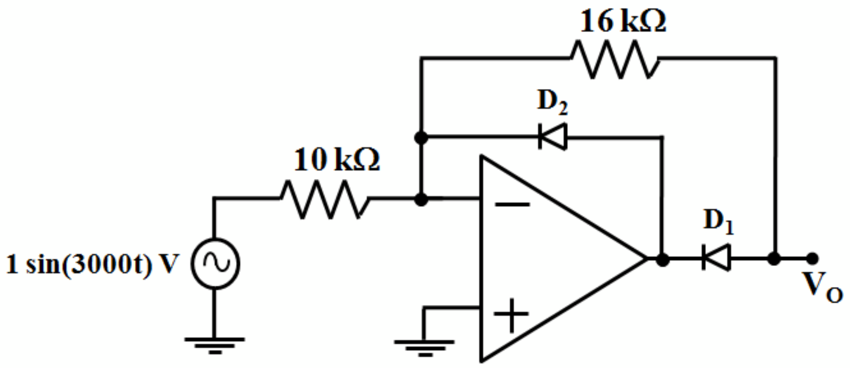
Key: -1

Exp: $\frac{V_x-2}{20}+\frac{V_x}{20}+\frac{V_x}{10}=0 \Rightarrow V_x\left(\frac{1}{20}+\frac{1}{20}+\frac{1}{10}\right)=\frac{2}{20} \Rightarrow V_x(1+1+2)=2$

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

$V_0 = \frac{-R_f}{R}V_x = -\left(\frac{20}{10}\right)\frac{1}{2} = -1V$

17. In the circuit given below, the diodes D_1 and D_2 have a forward voltage drop of 0.6 V. The op-amp used is ideal. The **magnitude** of the negative peak value of the output V_O in **volt** is ______.



Key: 1.6

18. The Boolean expression $XY+(X'+Y')Z$ is equivalent to

(A) $XYZ'+X'Y'Z$ (B) $X'Y'Z'+XYZ$ (C) (X+Z) (Y+Z) (D) $(X'+Y)(Y'+Z)$

Key: (C)

Exp: $F=XY+\bar{X}Z+\bar{Y}Z$

The min term of F are

$$\begin{array}{ccccccccc} X & Y & - & \bar{X} & - & Z & - & \bar{Y} & Z \\ =1 & 1 & 0 & 0 & 0 & 1 & 0 & 0 & 1 \\ 1 & 1 & 1 & 0 & 1 & 1 & 1 & 0 & 1 \end{array}$$

$F=\sum m(1,3,5,6,7)$

If we go for option B

$F=(x+z)(y+z)=z+xy$

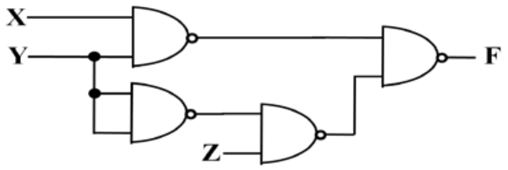
$\rightarrow$ Its minterms are

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

$F=\sum m(1,3,5,6,7)$

Since minterms are same these two functions are equal

19. In the digital circuit given below, F is



(A) $XY+Y\overline{Z}$ (B) $XY+\overline{YZ}$ (C) $\overline{X}\overline{Y}+Y\overline{Z}$ (D) $XZ+\overline{Y}$

Key: (B)

Exp: From the circuit

$$F=\overline{\overline{XY}.\overline{YZ}}=XY+\overline{YZ}$$

20. A 3 ½ digit DMM has an accuracy specification of $\pm 1\%$ of full scale (accuracy class 1). A reading of 100.0 mA is obtained on its 200 mA full scale range. The worst case error in the reading in **milliampere** is ± ____________.

Key: 2

Exp: Since all information are given n in mA unit assume the scale in mA unit.

→ Since it is given that error is $\pm 1\%$ of full scale

So, error $=\pm 1\%$ of 200mA $=\pm 2$mA.

→ So if it measures 100mA then the reading will be in the range (100 ± 2)mA

→ the worst source error is ± 2mA.

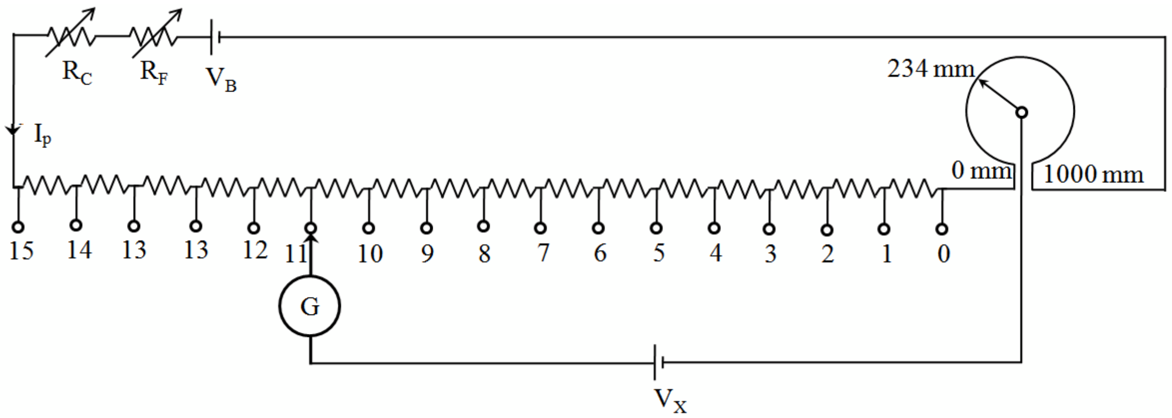
1	0	0	0

mA

↓

200 mA range decimal point

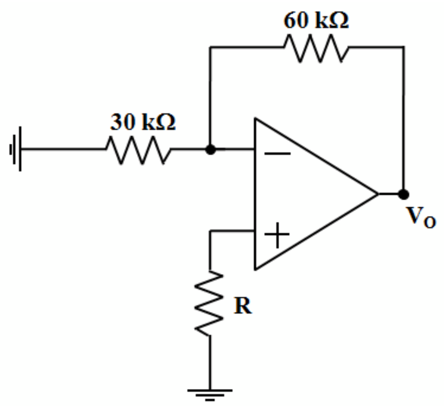
21. A dc potentiometer, shown in figure below, is made by connecting fifteen 10Ω resistors and a 10Ω slide wire of length 1000 mm in series. The potentiometer is standardized with the current I_p = 10.0000 mA. Balance for an unknown voltage is obtained when the dial is in position 11 (11 numbers of the fixed 10Ω resistor are included) and the slide wire is on the 234th mm position. The unknown voltage (up to four decimal places) in **volt** is ______.



Key: 1.1234

Exp: $V_x = (10\times10^{-3})\left[11\times10 + 234\text{mm}\times\frac{10}{1000\text{mm}}\right] = 1.1234\text{V}$

22. In the circuit given below, each input terminal of the op-amp draws a bias current of 10 nA. The effect due to these input bias currents on the output voltage V_0 will be zero, if the value of R chosen in **kilo-ohm** is ________.



Key: 20

Exp: $R = (60/30) = 20\text{k}\Omega$

23 A peizo-electric type pressure sensor has a sensitivity of 1 mV/kPa and a bandwidth of 300 Hz to 300 kHz. For a constant (dc) pressure of 100 kPa, the steady state output of the sensor in **mllivolt** is __________.

Key: 0

Exp: Piezoelectric transducer produces output for changing input, but here input is constant, So output is 0.

24. The signal $m(t) = \cos(\omega_m t)$ is SSB (single side-band) modulated with a carrier $\cos(\omega_c t)$ to get *s*(*t*). The signal obtained by passing *s*(*t*) through an ideal envelope detector is

(A) $\cos(\omega_m t)$

(B) $\sin(\omega_m t)$

(C) $\cos(\omega_m t) + \sin(\omega_m t)$

(D) 1

Key: (D)

Exp: $\delta(t) = X_{SSB}(t)$

$X_{SSB}(t) = m(t)\cos\omega_c t \pm \hat{m}(t)\text{Sin}\omega_c t$

$\hat{m}(t) = \text{hilbert transform of } \hat{m}(t)$

$m(t) = \cos\omega_n t$

$\hat{m}(t) = \sin\omega_n t$

$\delta(t) = \cos\omega_m \cos\omega_c t + \sin\omega_m t \sin\omega_c t = \cos(\omega_c \pm \omega_m)t$

$|\delta(t)| = 1$

25. Let $s(t)=\text{rect}\left(\frac{t-3}{3}\right)$ be a signal passed through an AWGN (additive white Gaussian noise) channel with noise power spectral density (PSD) $\frac{N_0}{2}$ to get $v(t)$. If $v(t)$ is passed through a matched-filter that is matched to s(t), then output signal-to noise ratio (SNR) of the matched-filter

(A) $\frac{1}{N_0}$ (B) $\frac{2}{N_0}$ (C) $\frac{3}{N_0}$ (D) $\frac{4}{N_0}$

Key: (B)

Q. No. 26 – 55 carry Two Marks Each

26. Let $f:[-1,1]\rightarrow R$, where $f(x)=2x^3-x^4-10$. The minimum value of $f(x)$ is________.

Key: -13

Exp: $f(x)=2x^3-x^4-10$

$f'(x)=6x^2-4x^3$

$f''(x)=12x-12x^2$

$f'(x)=0\Rightarrow 6x^2-4x^3=0$

$x^2(6-4x)=0$

$\Rightarrow x=0,\ x=\frac{3}{2}$ are stationary points

$f''(0)=0$ neither maxima nor minima at x= 0

$x=\frac{3}{2}\notin[-1,\ 1]$

$\therefore$ minimum of $f(x)=\text{minimum}\ \{f(-1),\ f(1)\}$

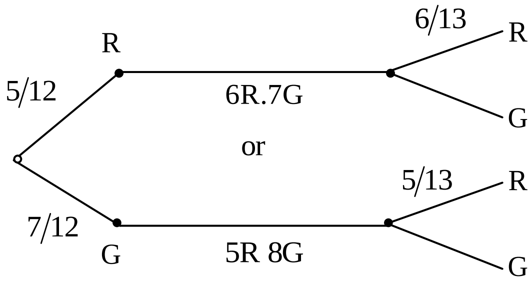
$=\text{minimum}\{-13,-9\}=-13$

27. An urn contains 5 red and 7 green balls. A ball is drawn at random and its colour is noted. The ball is placed back into the urn along with another ball of the same colour. The probability of getting a red ball in the next draw is

(A) $\frac{65}{156}$ (B) $\frac{67}{156}$ (C) $\frac{79}{156}$ (D) $\frac{89}{156}$

Key: (A)

Exp: $\frac{5}{12}\times\frac{6}{13}+\frac{7}{12}\times\frac{5}{13}=\frac{65}{12\times13}=\frac{65}{156}$



28. Consider the matrix $A = \begin{pmatrix} 2 & 1 & 1 \\ 2 & 3 & 4 \\ -1 & -1 & -2 \end{pmatrix}$ whose eigenvalues are 1, -1 and 3. Then Trace of $\left(A^3 - 3A^2\right)$ is _______.

Key: -6

Exp: eigen values of $A^3 - 3A^2$ corresponding to – 1, 1, 3 are -4, - 2, 0 respectively.

$\therefore$ Trace of $\left(A^3 - 3A^2\right) = -4 - 2 + 0 = -6$

29. The relationship between the force $f(t)$ and the displacement $x(t)$ of a spring-mass system (with a mass M, viscous damping D and spring constant K) is

$$M\frac{d^2x(t)}{dt^2} + D\frac{dx(t)}{dt} + Kx(t) = f(t).$$

$X(s)$ and $F(s)$ are the Laplace transforms of $x(t)$ and $f(t)$ respectively. With $M = 0.1$, $D = 2$, $K = 10$ in appropriate units, the transfer function $G(s) = \frac{X(s)}{F(s)}$ is

(A) $\frac{10}{s^2 + 20s + 100}$

(B) $s^2 + 20s + 100$

(C) $\frac{10s^2}{s^2 + 20s + 100}$

(D) $\frac{s}{s^2 + 20s + 100}$

Key: (A)

Exp: $M\frac{d^2x(t)}{dt^2} + D\frac{dx(t)}{dt} + kx(t) + f(t)$

Taking Laplace both side of above we get

$$\frac{X(s)}{F(s)} = \frac{1}{MS^2 + DS + k}$$

Using M=0.1, D=2 and k=0 then the function becomes

$$\frac{1}{0.1s^2 + 2s + 10} = \frac{10}{s^2 + 20s + 100}$$

30. The value of the integral $\frac{1}{2\pi j}\oint_C \frac{z^2+1}{z^2-1}dz$ where z is a complex number and C is a unit circle with center at 1+0j in the complex plane is _______.

Key: 1

Exp: Given $\frac{1}{2\pi j}\oint_c \frac{z^2+1}{z^2-1}dz = \frac{1}{2\pi j}\oint_c \frac{z^2+1}{(z-1)(z+1)}dz$

Poles are z = 1, - 1

Given C is $(x-1)^2+y^2=1$

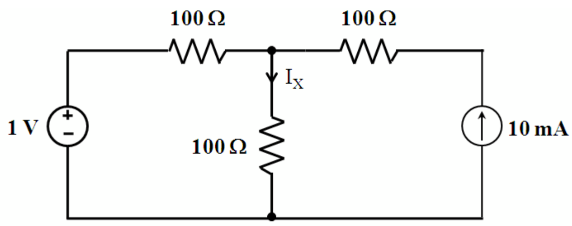
Clearly 1 lies inside of C and -1 outside of C

$$\left[\operatorname{Res} f(z)\right]_{z=1} = \underset{z\to 1}{\ell t}\,(z-1)\,\frac{z^2+1}{(z-1)(z+1)} = 1$$

$\therefore$ By Cauchy's Residue theorem

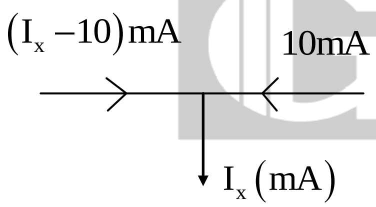
$$\frac{1}{2\pi j}\oint_C \frac{z^2+1}{z^2-1}\,dz = \frac{1}{2\pi j}\times 2\pi j\times 1 = 1$$

31. The current I_X in the circuit given below in **milliampere** is ____________.



Key: 10

Exp:

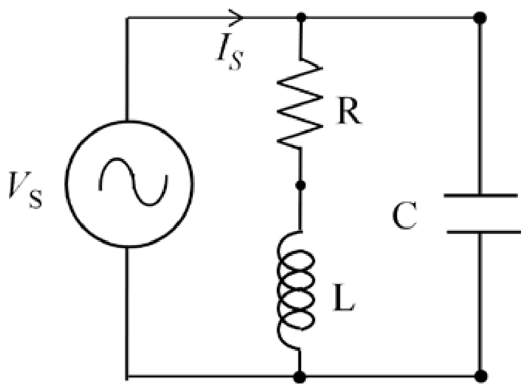


$$\text{By KVL, } 1=\left[100(I_x-10)+100\,I_x\right]10^{-3}$$

$$1000 = 200\,I_x - 1000$$

$$I_x = 10\,\text{mA}$$

32. In the circuit shown below, $V_S = 101\angle 0V$, $R = 10\Omega$ and $\omega L = 100\Omega$. The current I_S is in phase with V_S. The magnitude of I_S in **milliampere** is _________.



Key: 100

Exp: In phase means circuit is under resonance and the admittance seen by source must be real i.e. imaginary part of $Y_{eq} = 0$

$$\Rightarrow Y_{eq} = \frac{1}{R + j\omega L} + \frac{1}{(1/j\omega c)}$$

$$= \frac{R - j\omega l}{R^2 + (\omega L)^2} + j\omega L$$

$$\rightarrow \text{Real}(y) = \frac{R}{R^2 + (\omega L)^2} = \frac{10}{100 + (100)^2} = \frac{1}{1010}$$

$$I = VY = \frac{101}{1010} = 0.1 = 100\text{mA}$$

33. A symmetrical three-phase three-wire RYB system is connected to a balanced delta-connected load. The RMS values of the line current and line-to-line voltage are 10 A and 400 V respectively. The power in the system is measured using the two wattmeter method. The first wattmeter connected between R-line and Y-line reads zero. The reading of the second wattmeter (connected between B- line and Y-line) in watt is ________.

Key: 3464.1

Exp: $W_1 = V_L I_L \cos(30 - \phi)$

$W_2 = V_L I_L \cos(30 + \phi)$

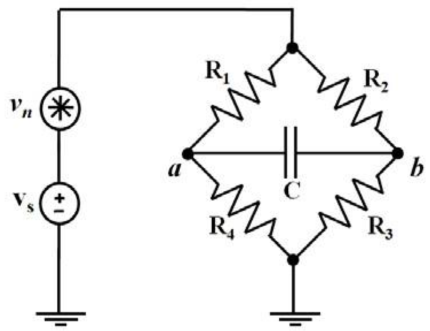
When $\cos\phi = 0.5$

$\phi = 60$

$W_2 = V_L I_L \cos(30 + 60) = V_L I_L \cos 90 = 0$

$\therefore \quad W_1 = 10 \times 400 \cos(30 - 60) = 3464.1\text{W}$

34. In the strain gauge bridge circuit given below, $R_1 = R_3 = R(1-x)$ and $R_2 = R_4 = R(1+x)$, where **R** is 350Ω. The voltage sources $\mathbf{v_S}$ and v_n represent the dc excitation and the undesired noise/interference, respectively. The value of capacitor C in **microfarad** that is required to ensure that the output across *a* and *b* is low-pass filtered with a cutoff frequency of 150 Hz is ______.



Key: 3.02

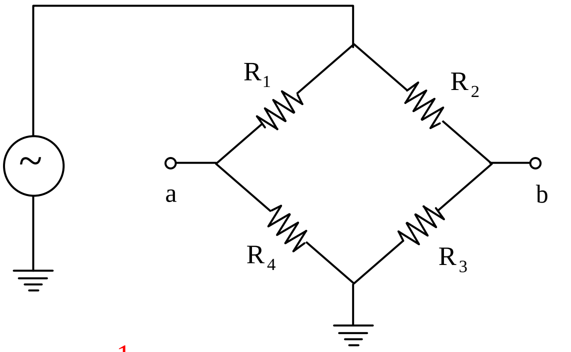
Exp: For DC excitation, C is open

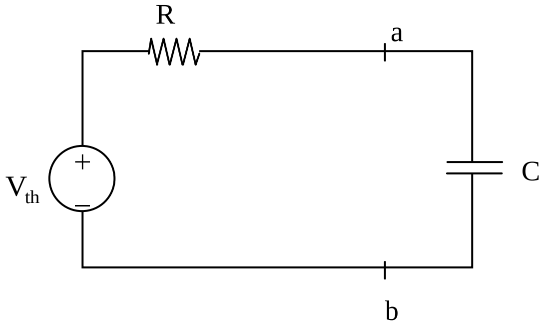
$R_1R_3 = R_2R_4$

$[R(1-x)]^2 = [R(1+x)]^2 \Rightarrow x = 0$

For AC excitation

Across a and, $R_{th} = R_1 | R_4 + R_2 | R_3 = R$



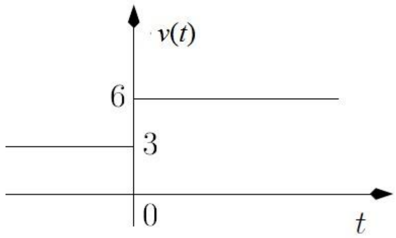


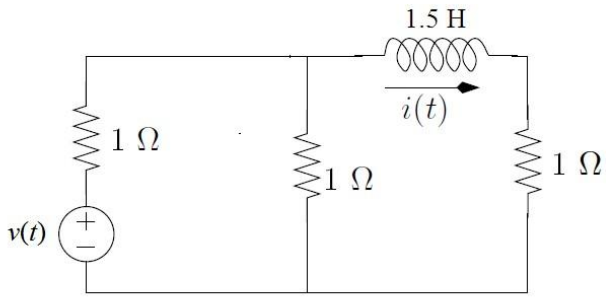
$f = \frac{1}{2\pi R_C}$

$150 = \frac{1}{2\pi \times 350 \times C}$

$C = 3.02\mu F$

35. The voltage v(t) shown below is applied to the given circuit. v(t) = 3V for t < 0 and v(t)= 6V for t > 0. The value of current i(t) at t = 1s, in **ampere** is ______ .

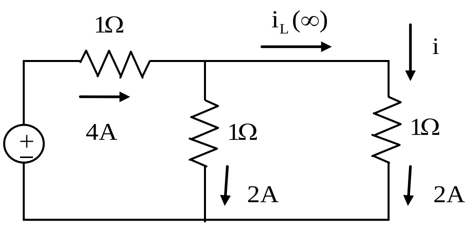




Key: 1.632

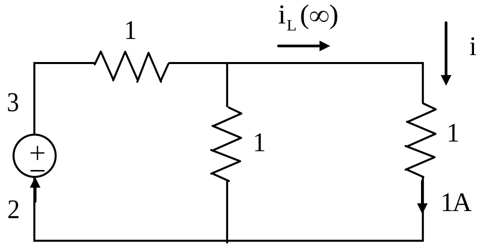
Exp: $i_L(t) = i_L(\infty) + \left[i_L(0^-) - i_L(\infty)\right] e^{-\frac{t}{\tau}}$

at $t = \infty$, supply is 6V



$i_L(\infty) = 2A$

$\rightarrow$ at $t = 0^-$



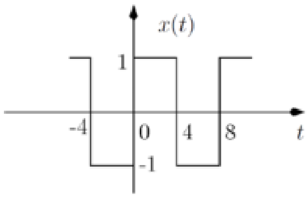
$i_L(0^-) = 1A$

$\rightarrow \tau = \frac{L}{R_{in}} = \frac{1.5}{1.5} = 1$

$\rightarrow i_L(t) = 2 - e^{-t}$

$i_L(t) = 2 - e^{-1} = 1.632$

36. For the periodic signal x(t) shown below with period T = 8 s, the power in the 10^{th} harmonic is



(A) 0 (B) $\frac{1}{2}\left(\frac{2}{10\pi}\right)^2$ (C) $\frac{1}{2}\left(\frac{4}{10\pi}\right)^2$ (D) $\frac{1}{2}\left(\frac{4}{5\pi}\right)^2$

Key: (A)

Exp: The given square wave satisfy odd and half wave symmetry so it does not have any eigen harmonic. Since 10^{th} harmonic amplitude is 0. So Re also 0

37. The fundamental period N_0 of the discrete-time sinusoid $x[n]=\sin\left(\frac{301}{4}\pi n\right)$ is ______.

Key: 8

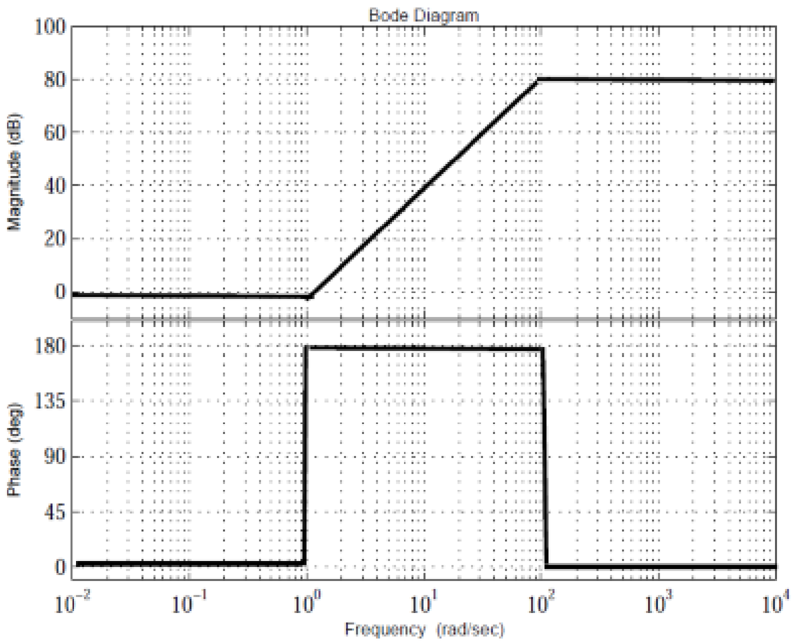
Exp: In discrete case $\omega_0 N = 2\pi m \Rightarrow N = \frac{2\pi}{\omega_0}m$

Where m is the smallest positive integer that makes integer.

$\rightarrow N = 2\pi \times \frac{4}{301\pi} \times m = \left[\frac{8}{301}m\right]$

If $m = 301$, then $N = 8$

38. The transfer function G(s) of a system which has the asymptotic Bode plot shown below is

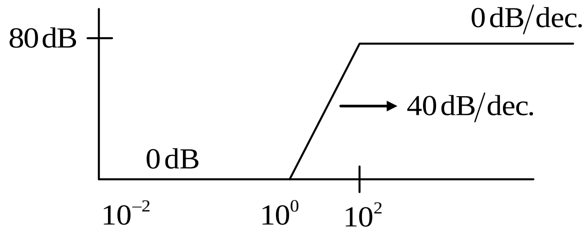


(A) $10^4\frac{(s-1)^2}{(s+100)^2}$ (B) $10^4\frac{(s+1)^2}{(s+100)^2}$ (C) $10^4\frac{(s+1)}{(s+100)^2}$ (D) $10^4\frac{(s-1)^2}{(s-100)^2}$

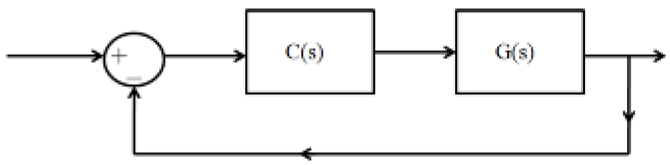
Key: (B)

Exp: $TF = k.\dfrac{\left(1+\frac{S}{1}\right)^2}{\left(1+\frac{S}{100}\right)^2}$ $\quad 20\log_{10} k = 0 \quad k = 1$

$= \dfrac{10^4 (s+1)^2}{(s+100)^2}$



39. For the feedback system given below, the transfer function $G(s) = \dfrac{1}{(s+1)^2}$. The system **CANNOT** be stabilized with



(A) $C(s) = 1+\dfrac{3}{s}$ (B) $C(s) = 3+\dfrac{7}{s}$ (C) $C(s) = 3+\dfrac{9}{s}$ (D) $C(s) = \dfrac{1}{s}$

Key: (C)

Exp: The characteristic equation of system is 1+G(S)(S) = 0

$\Rightarrow 1+\dfrac{C(S)}{S^2+2S+1} = 0$

$\Rightarrow S^2+2S+1+C(S) = 0$

if we take $C(S) = 3+\dfrac{9}{5}$ then

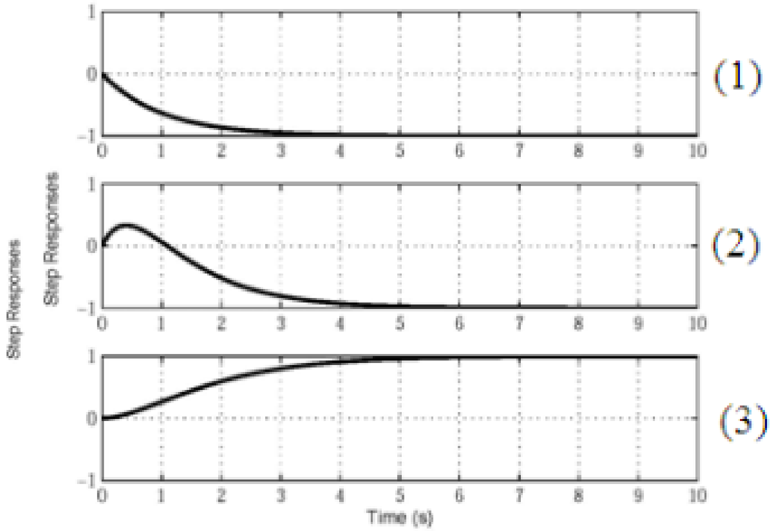
$S^2+2S+1+3+\dfrac{9}{S} = 0$

$\Rightarrow S^3+2S^2+4S+9 = 0$

S^3	1	4
S^2	2	9
S^1	$-1/2$	
S^0	9	

So system is unstable, remaining options gives stable.

40. Match the unit-step responses (1), (2) and (3) with the transfer functions P(s), Q(s) and R(s), given below.



$$P(s) = \frac{-1}{(s+1)}$$

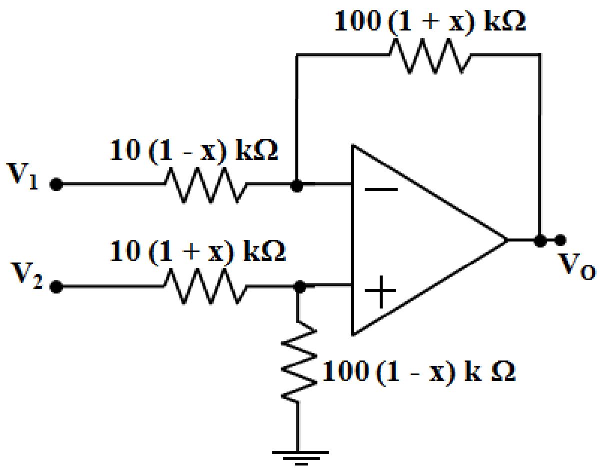
$$Q(s) = \frac{2(s-1)}{(s+10)(s+2)}$$

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

(A) P(S)-(3), Q(S)-(2), R(S)-(1)
(B) P(S)-(1), Q(S)-(2), R(S)-(3)
(C) P(S)-(2), Q(S)-(1), R(S)-(3)
(D) P(S)-(1), Q(S)-(3), R(S)-(2)

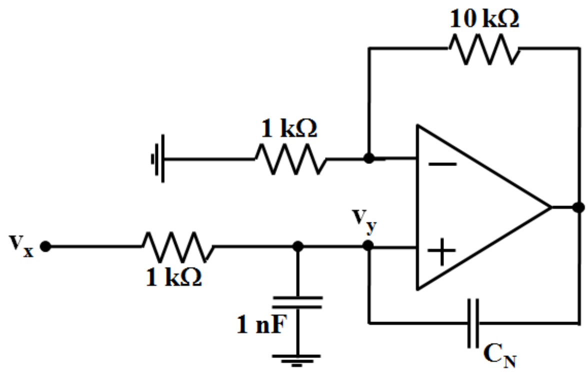
Key: (B)

41. An ideal op-amp is used to realize a difference amplifier circuit given below having a gain of 10. If x = 0.025, the CMRR of the circuit in **dB** is ________.



Key: 40 to 41

42. In the circuit given below, the op-amp is ideal. The input v_X is a sinusoid. To ensure $v_Y = v_X$, the value of C_N in **picofarad** is __________ .



Key: 100

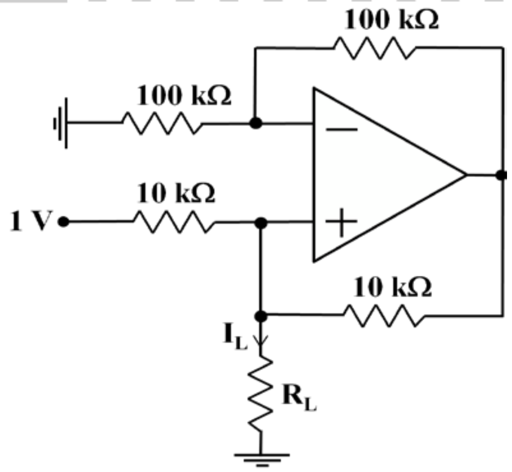
Exp: when $V_x = V_y$

$$\frac{V_y}{\frac{1}{10^{-9}S}} + \frac{V_y - V_0}{\frac{1}{C_N S}} = 0$$

$$V_y(10^{-9} + C_N) = V_0 C_N = 11 C_N V_y$$

$$10C_N = 10^{-9} \Rightarrow C_N = 10^{-10} = 100\text{pF}$$

43. In the circuit given below, the op-amp is ideal. The value of current I_L in **microampere** is ______.

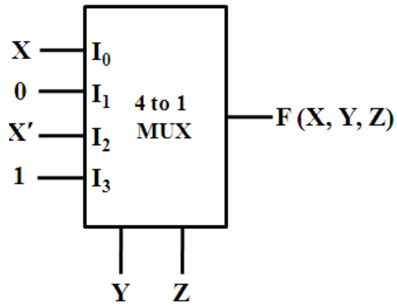


Key: 100

Exp: It is standard V to I converter, where [100k × 10k] = [10k × 100] i.e. the balanced bridge is formed so the current.

$$I_L = \frac{1}{10 \times 10^3} = 100\,\mu A$$

44. A 4 to 1 multiplexer to realize a Boolean function F (X, Y, Z) is shown in the figure below. The inputs Y and Z are connected to the selectors of the MUX (Y is more significant). The canonical sum-of-product expression for F (X, Y, Z) is



(A) $\Sigma m(2,3,4,7)$ (B) $\Sigma m(1,3,5,7)$ (C) $\Sigma m(0,2,4,6)$ (D) $\Sigma m(2,3,5,6)$

Key: (A)

Exp: $F = x\bar{y}\bar{z} + o\bar{y}z + \bar{x}y\bar{z} + 1.yz$

$= x\bar{y}\bar{z} + \bar{x}y\bar{z} + yz$

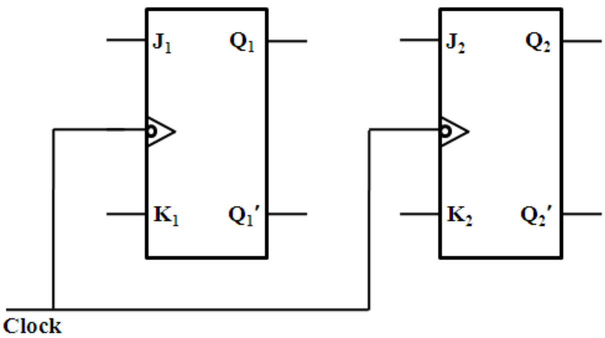
$= 100 \quad 100 \quad -11$

011

111

$F(x,y,z) = \Sigma m = (2,3,4,7)$

45. A synchronous counter using two J - K flip flops that goes through the sequence of states: $Q_1Q_2 = 00 \rightarrow 10 \rightarrow 01 \rightarrow 11 \rightarrow 00...$ is required. To achieve this, the inputs to the flip flops are



(A) $J_1 = Q_2, K_1 = 0; J_2 = Q_1', K_2 = Q_1$ (B) $J_1 = 1, K_1 = 1; J_2 = Q_1, K_2 = Q_1$

(C) $J_1 = Q_2, K_1 = Q_2'; J_2 = 1', K_2 = 1$ (D) $J_1 = Q_2', K_1 = Q_2; J_2 = Q_1, K_2 = Q_1'$

Key: (B)

Exp:

Present	State	Next	State	Flip flop Input			
Q_1	Q_2	Q_1^+	Q_2^+	J_1	K_1	J_2	K_2
0	0	1	0	1	X	0	X
1	0	0	1	X	1	1	X
0	1	1	1	1	X	X	0
1	1	0	0	X	1	X	1

From the column of $J_1\ K_1\ J_2\ K_2$

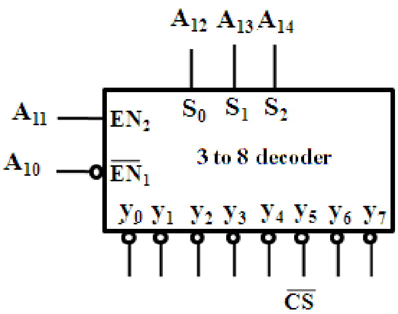
We can say $J_1 = 1$

$K_1 = 1$

And $T_2 = Q_1$

$K_2 = Q_1$

46. A 1 Kbyte memory module has to be interfaced with an 8-bit microprocessor that has 16 address lines. The address lines A_0 to A_9 of the processor are connected to the corresponding address lines of the memory module. The active low chip select $\overline{CS}$ of the memory module is connected to the y_5 output of a 3 to 8 decoder with active low outputs. S_0, S_1, and S_2 are the input lines to the decoder, with S_2 as the MSB. The decoder has one active low $\overline{EN_1}$ and one active high EN_2 enable lines as shown below. The address range(s) that gets mapped onto this memory module is (are)



(A) 3000_H to $33FF_H$ and $E000_H$ to $E3FF_H$ (B) 1400_H to $17FF_H$

(C) 5300_H to $53FF_H$ and $A300_H$ to $A3FF_H$ (D) 5800_H to $5BFF_H$ and $D800_H$ to $DBFF_H$

Key: (D)

Exp: $\rightarrow$ 1kB memory means 10 adress lines A_9 to A_0

$\rightarrow$ Since A_{15} line is missing it should be taken as don't care.

$\rightarrow$ 5^{th} output of decoder should be activated means $A_{14} = 1; A_{13} = 0; A_{12} = 1$

$\rightarrow$ $A_{11} = 1$ since active high enable

$\rightarrow A_{10} = 0$ since active low enable

	A_{15}	A_{14}	A_{13}	A_{12}	A_{11}	A_{10}	A_9	A_8	A_7	A_6	A_5	A_4	A_3	A_2	A_1	A_0
$\rightarrow$		1	0	1	1	0	0	0	0	0	0	0	0	0	0	0
		1	0	1	1	0	1	1	1	1	1	1	1	1	1	1

$\rightarrow$ If $A_{15} = 0$ then the range is 5800 to 5BFF

$\rightarrow$ If $A_{15} = 1$ then the range is D800 to DBFF.

47. A coil is tested with a series type Q-meter. Resonance at a particular frequency is obtained with a capacitance of 110 pF. When the frequency is doubled, the capacitance required for resonance is 20 pF. The distributed capacitance of the coil in **pico farad** is __________.

Key: 10

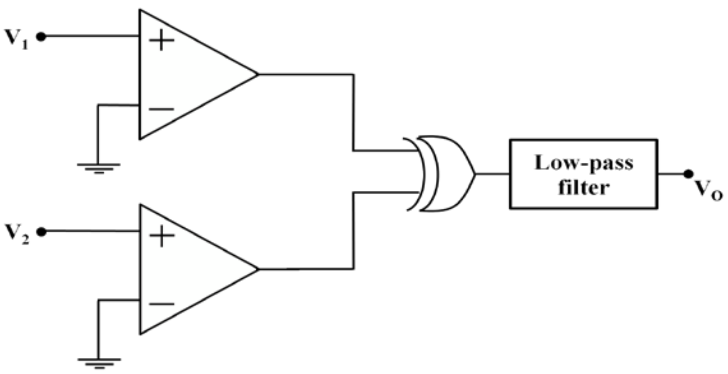
Exp: $C_d = \dfrac{C_1 - n^2C_2}{n^2 - 1} \Rightarrow \dfrac{110-(4\times 20)}{4-1} = 10\,\text{pf}$

here $C_1 = 110\,\text{pf}$

$C_2 = 20\,\text{pf}$

$\dfrac{f_2}{f_1} = n = 2$

48. The comparators (output = '1', when input ≥ 0 and output ='0', when input < 0), exclusive-OR gate and the unity gain low-pass filter given in the circuit are ideal. The logic output voltages of the exclusive-OR gate are 0 V and 5 V. The cutoff frequency of the low-pass filter is 0.1 Hz. For $V_1 = 1\sin(3000t + 36°)\,V$ and V_2 = 1 sin (3000t) V, the value of V_O in **volt** is ______.



Key: 1

49. A 200 mV full scale dual-slope 3 ½ digit DMM has a reference voltage of 100 mV and a first integration time of 100 ms. For an input of $\left[100+10\cos(100\pi t)\right]$mV, the conversion time (without taking the auto-zero phase time into consideration) in **millisecond** is ________.

Key: 200

Exp: In dual slope converter total conversion time

T= 1[st] integration period + 2[nd] integration period

$=T_1+T_2=100\,\text{msec}+T_2.$

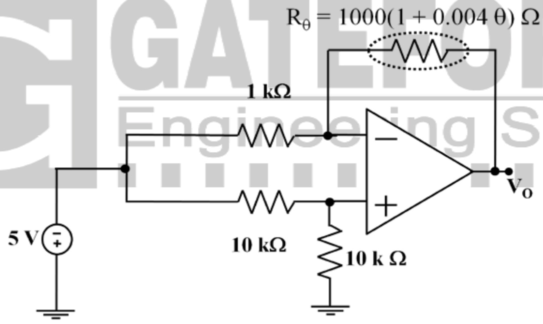
To obtain T_2 we can use $V_{in}T_1=V_{ref}T_2$

$\Rightarrow 100\text{mv}\times 100\,\text{m.sec}=100\text{mv}\times T_2$

$\Rightarrow T_2=100\text{msec}$

$\rightarrow T=100+100=200\text{msec}.$

50. In the circuit below, the op-amp is ideal and the sensor is an RTD whose resistance $R_\theta=1000(1+0.004\theta)\Omega$, where θ is temperature in °C. The output sensitivity in **mV/□C** is ______.



Key: 10

Exp: $V_+=\dfrac{V_{in}}{2}=V_-$

$$\frac{V_{in}-V_-}{1k}=\frac{V_--V_o}{R\theta}=\frac{V_--V_o}{\left(1+\frac{\theta}{250}\right)k}$$

$$\left(1+\frac{\theta}{250}\right)\left(V_{in}-\frac{V_{in}}{2}\right)=\frac{V_{in}}{2}-V_o$$

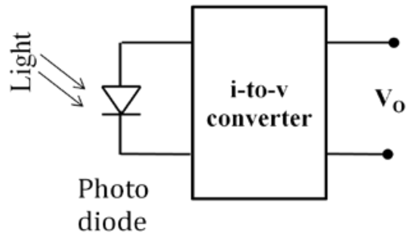
$$\left(1+\frac{\theta}{250}\right)\frac{V_{in}}{2}=\frac{V_{in}}{2}-V_o$$

$$\frac{V_{in}}{2}+\frac{\theta.V_{in}}{500}=\frac{V_{in}}{2}-V_o$$

$$V_{in}=-5V,\qquad V_o=+\frac{0.5}{500}=+\frac{\theta}{100}$$

$$\frac{dV_o}{d\theta}=\frac{1}{100}=10\text{ mV}/^\circ\text{C}$$

51. The photo diode in the figure below has an active sensing area of 10 mm^2, a sensitivity of 0.5 A/W and a dark current of $1\mu A$. The i-to-v converter has a sensitivity of $100\,mV/\mu A$. For an input light intensity of 4 W/m^2, the output V_O in **volt** is.



Key: 2

Exp: $A = 10\times10^{-6}\,m^2$

$S = 0.5\,A|W = \frac{1}{2}A|W \to 1A \to 2W$

$I = 1\mu A \qquad\qquad 1\mu A \to 2\mu W$

$S = 100\,mV/\mu A$

$I = 4W\times10\times\mu = 40\mu W$

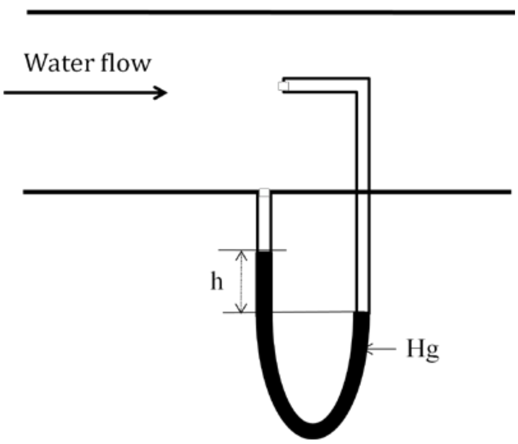
$2\mu W \to 1\mu A$

$\therefore 40\mu W \to 20\mu A$

$1\mu A \to 100\,mV$

$20\mu A \to 2V$

52. The velocity of flow of water (density 1000 kg/m^3) in a horizontal pipe is measured using the Pitot tube shown below. The fluid in the U-tube manometer is mercury with a density of 13534 kg/m^3. Assume g = 9.81 m/s^2. If the height difference (h) is measured as 94.1 mm, the velocity of flow of water in **m/s** is ________.



Key: 4.81

Exp: $V = \sqrt{2gh}$

$$h = x\left[\frac{s_g}{s_0} - 1\right] = 94.1\times10^{-3}\left[\frac{13534}{1000} - 1\right] = 1.18$$

$$V = \sqrt{2\times9.81\times1.18} = 4.81\,\text{m/sec}$$

53. The band gap in **eV** of a semiconductor material required to construct an LED that emits peak power at the wavelength of 620 nm is ________.
(Plank constant $h = 4.13567\times10^{-15}\,\text{eV s}$ and speed of light $c = 2.998\times10^{8}\,\text{m/s}$).

Key: 2

Exp: $E = \dfrac{hC}{\lambda} = \dfrac{4.13567\times10^{-15}\times2.998\times10^{8}}{620\times10^{-9}} = 2\text{eV}$

54. The signal $m(t) = \dfrac{\sin(100\pi t)}{100\pi t}$ is frequency modulated (FM) with an FM modulator of frequency deviation constant of 30 kHz/V. Using Carson's rule, the approximate bandwidth of the modulated wave in **kilohertz** is _____.

Key: 60

Exp: $k_f = 30\text{KHz/V}$

$$(\Delta f)_{max} = 30\times10^{3}\times1 = 30\text{KHz}$$

$$f_{max} = 50\text{Hz}$$

$$\beta = \frac{30\text{KHz}}{50\text{Hz}} >> 1$$

$$BW = 2(\Delta f + f_m) \approx 2(\Delta f)_{max} = 60\text{ kHz}$$

55. A signal *m*(*t*) varies from -3.5V to + 3.5 V with an average power of 3 W. The signal is quantized using a midtread type quantizer and subsequently binary encoded. With the codeword of length 3, the signal to quantization noise ratio in **dB** is ______.

Key: 16.72

Exp: n= 3bits

$$A_m = 3.5\text{V}$$

$$P_{avg} = 3.5\text{V}$$

$$\text{SNR} = \frac{\text{Signal power}}{\text{Noise powder}}$$

$$\text{Quantization noise power} = \frac{\Delta^2}{12} = \frac{7^2}{12} = \frac{7^2}{L^2.12} = \frac{7\times7}{64\times12}$$

$$L = 2^3 = 8,\ \Delta\frac{2A_m}{L}$$

$$(\text{SNR})_{dB} = 10\log\left(\frac{0.3\times12\times64}{49}\right) = 16.72\text{dB}$$