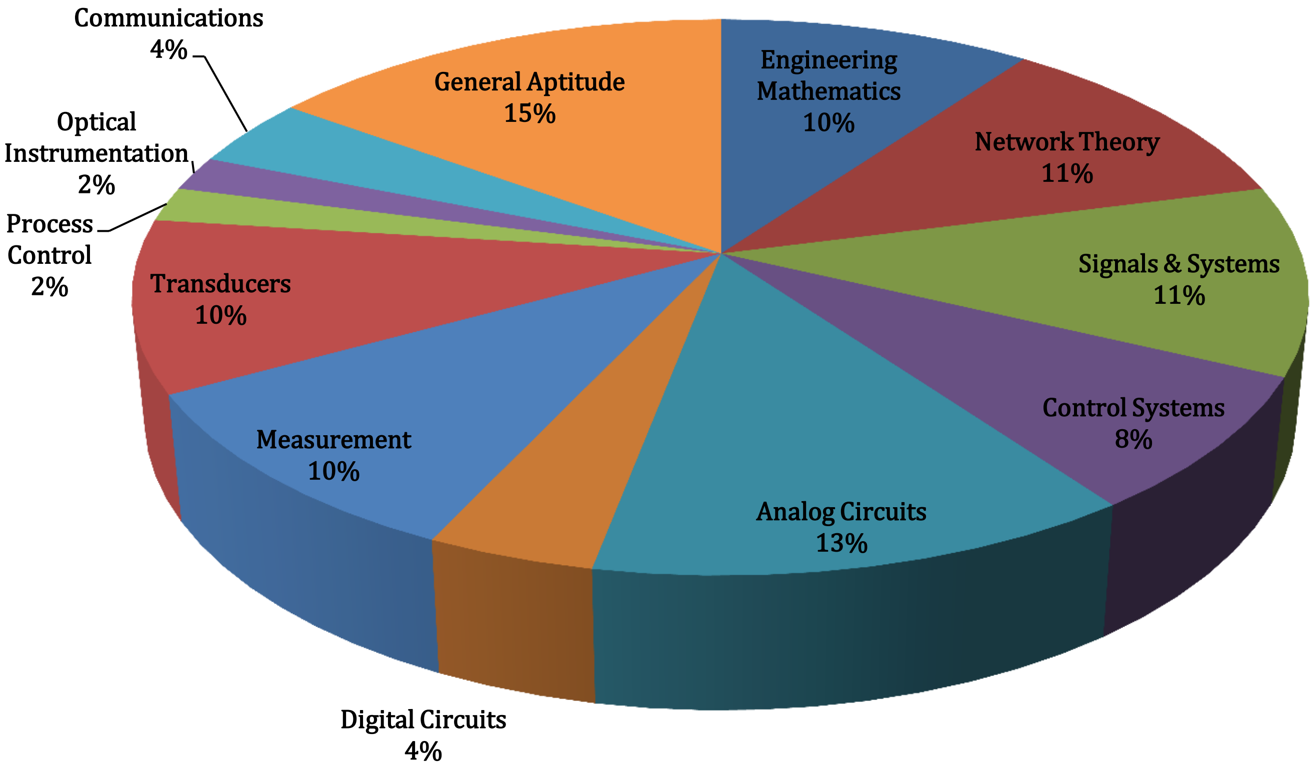
ANALYSIS OF GATE 2017*

Instrumentation Engineering



IN ANALYSIS-2017_12-Feb

SUBJECT	No. of Ques.	Topics Asked in Paper	Level of Ques.	Total Marks
Engineering Mathematics	1 Marks: 4 2 Marks: 3	Linear Algebra; Complex variables; Calculus Numerical Methods; Probability and Distribution	Easy	10
Network Theory	1 Marks: 3 2 Marks: 4	RLC Circuits to DC Input; Two Port Networks Network Solution Methodology; Sinusoidal Steady State Analysis	Easy	11
Signals & Systems	1 Marks: 5 2 Marks: 3	Laplace Transform; Z-Transform; Linear Time Invariant(LTI) Systems ; Introduction to Signals & Systems; Fourier Representation of Signals	Easy	11
Control Systems	1 Marks: 0 2 Marks: 4	Basics of Control System; Root; Locus Technique; Stability & Routh Hurwitz Criterion; Frequency Response Analysis	Easy	8
Analog Circuits	1 Marks: 5 2 Marks: 4	Diode Circuits-Analysis and Application Feedback & Oscillator Circuits; Operational Amplifiers & Its Applications; Miscellaneous	Tough	13
Digital Circuits	1 Marks: 2 2 Marks: 1	Introduction to Microprocessor; Logic Gates Combinational and Sequential Digital Circuits	Medium	4
Measurement	1 Marks: 2 2 Marks: 4	Measurements of Basic Electrical Quantities 1 and 2(Dynamometer type ammeter; Wein bridge and AC Bridge);Electronic Measuring Instruments 1 and 2(PMMC; Voltmeter Instrument Transformer)	Tough	10
Transducers	1 Marks: 2 2 Marks: 4	Mechanical Transducers in Instrumentation Measurement of Non Electrical Quantities	Medium	10
Process Control	1 Marks: 2 2 Marks: 0	Introduction (ON/OFF controller; Range of Controller)	Medium	2
Optical Instrumentation	1 Marks: 0 2 Marks: 1	Optical Sources and Detectors	Medium	2
Communications	1 Marks: 0 2 Marks: 2	Angle Modulation; Amplitude Modulation	Easy	4
General Aptitude	1 Marks:5 2 Marks:5	Verbal Ability; Numerical Ability	Medium	15
Total	**65**			**100**
Faculty Feedback	Majority of the question were concept based. Network, Signals, Maths, Measurement, Transducers and Analog weightage was comparatively high. GA was medium as compared to the last year.			

GATE 2017 Examination*
Instrumentation Engineering

Test Date: 12/02/2017
Test Time: 2:00 PM 5:00 PM
Subject Name: Instrumentation Engineering

Section I General Aptitude

1. What is the value of x when $81 \times \left(\frac{16}{25}\right)^{x+2} \div \left(\frac{3}{5}\right)^{2x+4} = 144$?

(A) 1
(B) −1
(C) −2
(D) Cannot be determined

[Ans. B]

$$81 \times \left(\frac{16}{25}\right)^{x+2} \div \left(\frac{3}{5}\right)^{2x+4} = 144$$

$$\frac{\left(\frac{16}{25}\right)^{x+2}}{\left(\frac{3}{5}\right)^{2x+4}} = \frac{144}{81} = \frac{(12)^2}{(9)^2} = \left(\frac{12}{9}\right)^2$$

$$\frac{\left(\frac{4}{5}\right)^{2x+4}}{\left(\frac{3}{5}\right)^{2x+4}} = \left(\frac{12}{9}\right)^2$$

$$\frac{(4)^{2x+4}}{(5)^{2x+4}} \times \frac{(5)^{2x+4}}{(3)^{2x+4}} = \left(\frac{12}{9}\right)^2$$

$$\frac{(4)^{2x+4}}{(3)^{2x+4}} = \left(\frac{12}{9}\right)^2 = \left(\frac{4}{3}\right)^2$$

$$\left(\frac{4}{3}\right)^{2x+4} = \left(\frac{4}{3}\right)^2$$

$2x + 4 = 2$

$2x = -2$

$x = -1$

2. There was no doubt that their work was <u>thorough</u>
Which of the words below is closet in meaning to the underlined word above?

(A) pretty
(B) complete
(C) sloppy
(D) haphazard

[Ans. B]

Thorough means including every possible detail, parts or complete or absolute.

3. Two dice are thrown simultaneously. The probability that the product of the numbers appearing on the top faces of the dice is a perfect square is

(A) 1/9
(B) 2/9
(C) 1/3
(D) 4/9

[Ans. B]

Total chances = $6\times 6 = 36$ events

Product of numbers on 2 dice have to perfect square = Favorable chances

= (1,1), (2,2), (1,4), (3,3), (4,1), (5,5), (4,4), (6,6) = 8

$$\text{Probability} = \frac{\text{Favourable chances}}{\text{Totalchances}} = \frac{8}{36} = \frac{2}{9}$$

4. Four cards lie on a table. Each card has a number printed on one side and a colour on the other.
The faces visible on the cards are 2,3, red, and blue.
Proposition: If a card has an even value on one side, then its opposite face is red.
The cards which MUST be turned over to verify the above proposition are
(A) 2, red
(B) 2, 3, red
(C) 2, blue
(D) 2 red, blue

[Ans. C]

Total number of cards = 4

Visible numbers on the cards = 2 and 3

Visible colours on the cards = red and blue

If numbers on the cards = 1,2,3 and 4 then possible colours are blue, red, blue and red respectively.

In order to verify the proposition, we have to turn to card 2 then opposite must be red. In all options except 'C' 2 and red are present

5. The event would have been successful if you ________ able to come.
(A) are
(B) had been
(C) have been
(D) Would have been

[Ans. B]

Conditional tense type (3 had+V3 +would have +V3)

6. A map shows the elevation of Darjeeling, Gangtok, Kalimpong, Pelling, and Siliguri. Kalimpong is at a lower elevation than Gangtok. Pelling is at a lower elevation than Gangtok. Pelling is at a higher elevation than siliguri. Darjeeling is at a higher elevation than Gangtok. Which of the following statements can be inferred from the paragraph above?
   i. Pelling is at a higher elevation than Kalimpong
   ii. Kalimpong is at a lower elevation than Darjeeling
   iii. Kalimpong is at a higher elevation than Siliguri
   iv. Siliguri is at lower elevation than Gangtok

(A) Only ii
(B) Only ii and iii
(C) Only ii and iv
(D) Only iii and iv

[Ans. C]

7. Bhaichung was observing the pattern of people entering and leaving a car service centre. There was a single window where customers were being served. He saw that people

inevitably came out of the centre in the order that they went in. However, the time they spent inside seemed to vary a lot:

Some people came out in a matter of minutes while for others it took much longer.

From this, what can one conclude?

(A) The centre operates on a first-come –first-served basis, but with variable service times, depending on specific customer needs.

(B) Customers were served in an arbitrary order, since they took varying amounts of time for service completion in the centre.

(C) Since some people came out within a few minutes of entering the centre, the system is likely to operate on a last-come-first-served basis.

(D) Entering the centre early ensured that one would have shorter service times and most people attempted to do this.

[Ans. A]

The key sentence is "the order that they went in"

8. P, Q, R, S, T and U are seated around a circular table, R is seated two places to the right of Q, P is seated three places to the left of R.S is seated opposite U. If P and U now switch seats, which of the following must necessarily be true?

(A) P is immediately to the right of R

(B) T is immediately to the left of P

(C) T is immediately to the left of P or P is immediately to the right of Q

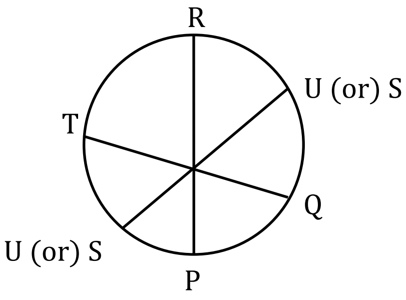
(D) U is immediately to the right of R or P is immediately to the left of T

[Ans. C]

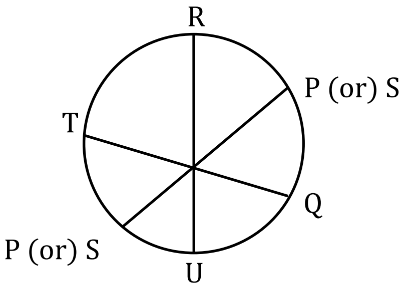
From the given data, all are seated around a circular table as follows

P Q – R

S is opposite to U

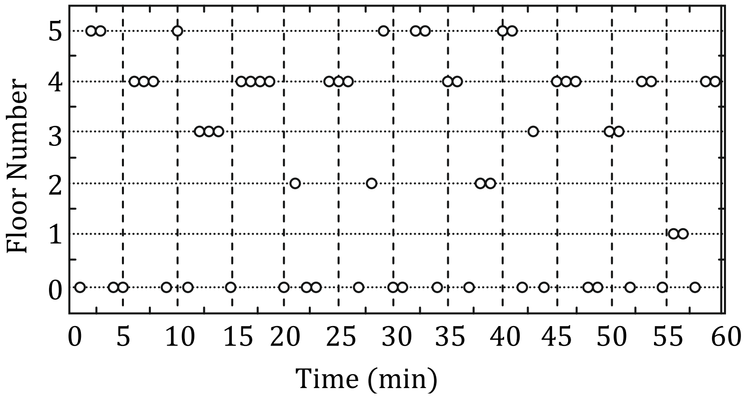


P and U are switch seated means, they are interchange their places



In option (C), before interchange T is immediately to the left of P and after interchange P is immediately to the right of Q

9. The points in the graph below represent the halts of a lift for durations of 1 minute, over a period of 1 hour.



Which of the following statements are correct?

i. The elevator never moves directly from any non-ground floor to another non-ground floor over the one hour period

ii. The elevator stays on the fourth floor for the longest duration over the one hour period

(A) Only i
(B) Only ii
(C) Both i and ii
(D) Neither i nor ii

[Ans. D]

i. is in correct as it has move directly

ii. is incorrect as it stayed for maximum duration on the ground floor

10. Budhan covers a distance of 19 km in 2 hours by cycling one fourth of the time and walking the rest. The next day he cycles (at the same speed as before) for half the time and walks the rest (at the same speed as before) and covers 26 km in 2 hours. The speed in km/h at which Budhan walks is

(A) 1
(B) 4
(C) 5
(D) 6

[Ans. D]

$$19 \text{ km} \rightarrow 2 \text{ hours} \begin{cases} \text{Cycling} \Rightarrow \frac{1}{4}\text{th} = 2 \times \frac{1}{4} = \frac{1}{2} \\ \text{Walking} \Rightarrow \frac{3}{4}\text{th} = 2 \times \frac{3}{4} = \frac{3}{2} \end{cases}$$

Let cycling speed = C

Walking speed = W

$$\frac{C}{2} + \frac{3W}{2} = 19 \ldots\ldots\ldots (1)$$

$$26 \text{ km} \rightarrow 2 \text{ hours} \begin{cases} \text{Cycling} \Rightarrow \frac{1}{2}\text{th} = 2 \times \frac{1}{2} = 1 \\ \text{Walking} \Rightarrow \frac{1}{2}\text{th} = 2 \times \frac{1}{2} = 1 \end{cases}$$

$$C + W = 26 \ldots\ldots\ldots (2)$$

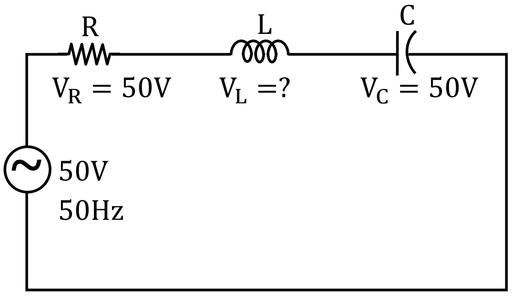
By solving equation number (1) and (2)

W = 6 km/hr

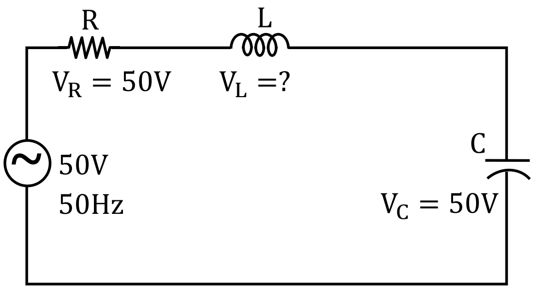
∴ The speed at which Budhan walks = 6 kmph

Section II Technical

1. A series R-L-C circuit is excited with a 50V, 50Hz sinusoidal source. The voltages across the resistance and the capacitance are shown in the figure. The voltage across the inductor V_L is ___________V.



[Ans. *] Range: 50 to 50



$$50 = \sqrt{V_R^2 + (V_L - V_S)^2}$$

$V_L = 50V$

2. Identify the instrument that does not exist:
(A) Dynamometer-type ammeter
(B) Dynamometer-type wattmeter
(C) Moving-iron voltmeter
(D) Moving-iron wattmeter

[Ans. D]

Moving-iron wattmeter does not exist

3. An 8-bit microcontroller with 16 address lines has 3 fixed interrupts i.e., Int1, Int2 and Int3 with corresponding interrupt vector addresses as 0008H, 0010H and 0018H. To execute a 32-byte long interrupt service subroutine for Int1 staring at the address ISS1, the location 0008H onwards should ideally contain
(A) a CALL to ISS1
(B) an unconditional JUMP to ISS1
(C) a condition JUMP to ISS1
(D) only ISS1

[Ans. B]

4. For a first order low pass filter with unity d.c. gain and -3 dB corner frequency of $2000\,\pi$ rad/s, the transfer function $H(j\omega)$ is

(A) $\dfrac{1}{1000+j\omega}$ (C) $\dfrac{2000\pi}{2000\pi+j\omega}$

(B) $\dfrac{1}{1+j1000\omega}$ (D) $\dfrac{1000\omega}{1+j1000\omega}$

[Ans. C]

For -3dB corner frequency

We equate

$$\left.\frac{2000\pi}{\sqrt{(2000\pi)^2+\omega^2}}\right|_{\omega=2000\pi}=\frac{1}{\sqrt{2}}\ldots\ldots\ldots.\text{①}$$

$$\text{LHS}=\frac{2000\pi}{\sqrt{(2000\pi)^2+(2000\pi)^2}}=\frac{1}{\sqrt{2}}$$

RHS=LHS

Hence option (C) is the required LPF

5. If V is a non-zero vector of dimension 3×1, then the matrix $A=VV^T$ has a rank =__________

[Ans. *] Range: 1 to 1

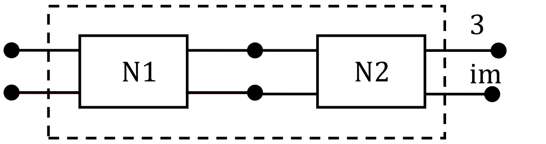
Let $V=\begin{bmatrix}X_1\\X_2\\X_3\end{bmatrix}_{3\times1}$ be a non-zero vector $\rho(V)^T=1, \rho\left(V^T\right)=1$

$A=\left(V\,V^T\right)_{3\times3}$

$\rho(A)=\rho\left(V\,V^T\right)=1$

6. The connection of two 2-port networks is shown in the figure. The ABCD parameter of N1 and N2 networks are given as

$\begin{bmatrix}A & B\\C & D\end{bmatrix}_{N1}=\begin{bmatrix}1 & 5\\0 & 1\end{bmatrix}$ and $\begin{bmatrix}A & B\\C & D\end{bmatrix}_{N2}=\begin{bmatrix}1 & 0\\0.2 & 1\end{bmatrix}$

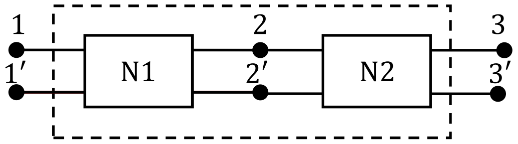


The ABCD parameters of the combined 2-port network are

(A) $\begin{bmatrix}2 & 5\\0.2 & 1\end{bmatrix}$ (C) $\begin{bmatrix}5 & 2\\0.5 & 1\end{bmatrix}$

(B) $\begin{bmatrix}1 & 2\\0.5 & 1\end{bmatrix}$ (D) $\begin{bmatrix}1 & 2\\0.5 & 5\end{bmatrix}$

[Ans. A]



$[T]=[T_1]\times[T_2]$

$\begin{bmatrix}A & B\\C & D\end{bmatrix}=\begin{bmatrix}1 & 5\\0 & 1\end{bmatrix}\times\begin{bmatrix}1 & 0\\0.2 & 1\end{bmatrix}=\begin{bmatrix}2 & 5\\0.2 & 1\end{bmatrix}$

7. The Region of Convergence (ROC) of the Z-transform of a causal unit step discrete-time sequence is

(A) $|Z| < 1$
(B) $|Z| \leq 1$
(C) $|Z| > 1$
(D) $|Z| \geq 1$

[Ans. C]

Given x(n)=u(n)

$$X(z) = \sum_{n=-\infty}^{\infty} x(n)z^{-n} = \sum_{n=0}^{\infty} z^{-n} = \sum_{n=0}^{\infty}(Z^{-1})^n = \frac{1}{1-2^{-1}}|z^{-1}| < 1$$

ROC=$|z| > 1$

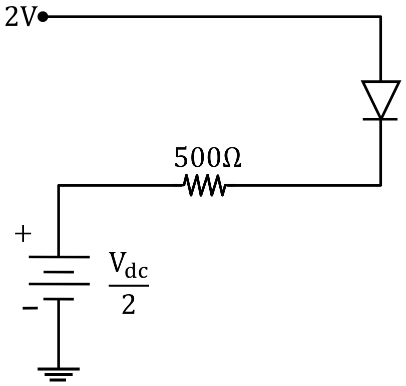
8. The term hysteresis is associated with

(A) ON-OFF control
(B) P-I control
(C) Feed-forward control
(D) Ratio control

[Ans. A]

Hysteresis term is associated with ON-OFF controller only.

9. The silicon diode, shown in the figure, has a barrier potential of 0.7 V. There will be no forward current flow through the diode, if V_{dc}, in volt, is greater than



(A) 0.7
(B) 1.3
(C) 1.8
(D) 2.6

[Ans. D]

$$2 - \frac{V_{dc}}{2} \geq 0.7$$

$V_{dc_{min}}$=2.6V

10. If a continuous-time signal $x(t) = \cos(2\pi t)$ is sampled at 4Hz, the value of the discrete time sequence x(n) at n = 5 is

(A) −0.707
(B) −1
(C) 0
(D) 1

[Ans. C]

The distance time signal obtained by sampling continuous time signal $x(t) = \cos(2\pi t)$ is

$x(nT_s) = \cos(2\pi \times n \times T_s)$

Given $f_s = 4Hz$

$$T_s = \frac{1}{f_s} = \frac{1}{4}$$

$$x(n) = \cos\left(2\pi \times n \times \frac{1}{4}\right) = \cos\left(\frac{n\pi}{2}\right)$$

$$x(5) = \cos\left(\frac{5\pi}{2}\right) = \cos\left(\frac{\pi}{2}\right) = 0$$

11. A System is described by the following differential equation: $\frac{dy(t)}{dt} + 2y(t) - \frac{dx(t)}{dt} + x(t)$, x(0)=y(0)=0 Where x(t) and y(t) are the input and output variables respectively. The transfer function of the inverse system is

(A) $\frac{s+1}{s-2}$ (C) $\frac{s+1}{s+2}$

(B) $\frac{s+2}{s+1}$ (D) $\frac{s-1}{s-2}$

[Ans. B]

Given $\frac{dy(t)}{dt} + 2y(t) = \frac{dx(t)}{dt} + x(t)$

Apply Laplace transform to above equation

$SY(s) + 2Y(s) = SX(s) + X(s)$

$Y(s)[s+2] = X(s)(s+1)$

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

$H_{inv(s)} = \frac{s+2}{s+1}$

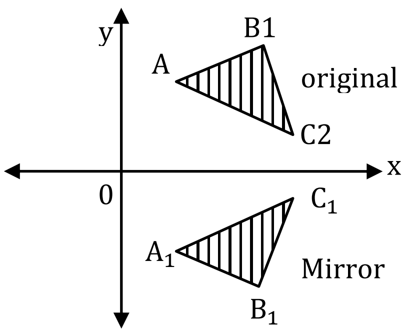
12. The condition for oscillation in a feedback oscillator circuit is that at the frequency of oscillation, initially the loop gain is greater than unity while the total phase shift around the loop in degree is

(A) 0 (C) 180

(B) 90 (D) 270

[Ans. A]

13. The figure shows a shape ABC and its mirror image $A_1B_1C_1$ across the horizontal axis (x-axis).The coordinate transformation matrix that maps ABC to $A_1B_1C_1$ is



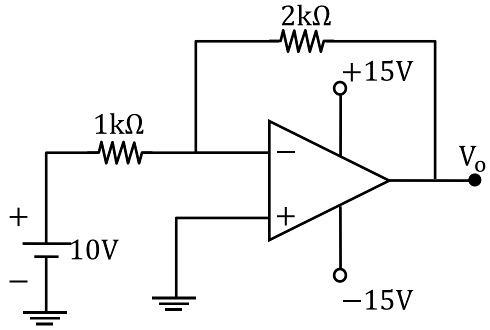
(A) $\begin{bmatrix} 0 & 1 \\ 1 & 0 \end{bmatrix}$ (C) $\begin{bmatrix} -1 & 0 \\ 0 & 1 \end{bmatrix}$

(B) $\begin{bmatrix} 0 & 1 \\ -1 & 0 \end{bmatrix}$ (D) $\begin{bmatrix} 1 & 0 \\ 0 & -1 \end{bmatrix}$

[Ans. D]

The required transformation matrix for reflection of given original image about x-axis is $\begin{bmatrix}1 & 0\\0 & -1\end{bmatrix}$, $[x \;\; y]\begin{bmatrix}1 & 0\\0 & -1\end{bmatrix} = [x \;\; -y]$

14. The output V_0 shown in the figure, in Volt, is close to



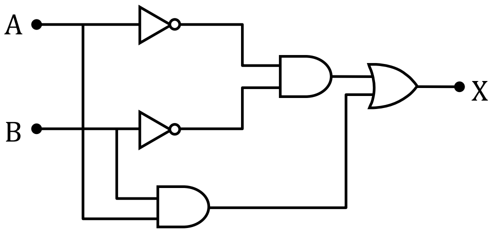
(A) −20
(B) −15
(C) −5
(D) 0

[Ans. B]

$V_o = \left(\frac{-2k}{1k}\right) 10 = -20$

Since op-amp is saturated $V_0 = -15V$

15. A and B are the logical inputs and X is the logical output shown in the figure. the output X is related to A and B by

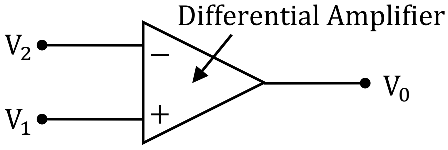


(A) $X = \bar{A}B + \bar{B}A$
(B) $X = AB + \bar{B}A$
(C) $X = AB + \bar{A}\bar{B}$
(D) $X = \bar{A}\bar{B} + \bar{B}A$

[Ans. C]

$X = AB + \bar{A}\bar{B}$

16. The differential amplifier, shown in the figure, has a differential gain of $A_d = 100$ and common mode gain of $A_c = 0.1$. If $V_1 = 5.01$ V and, $V_2 = 5.00$ V then V_0, in Volt (up to one decimal place) is ________



[Ans. *] Range: 1.4 to 1.6

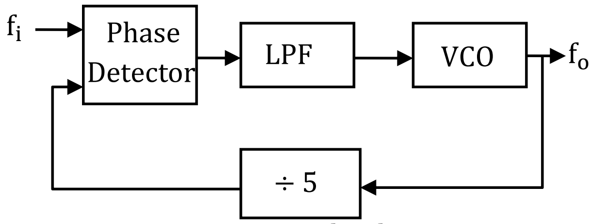
$V_0 = A_d V_d + A_{cm} V_{cm}$

$= 100(0.01) + 0.1\,(5.005)$

$= 1 + 0.5005$

$= 1.5005$

17. The figure shows a phase locked loop. The output frequency is locked at $f_0 = 5\text{kHz}$. The value of f_i in kHz is ____________



Frequency divider

[Ans. *] Range: 1 to 1

$$f_i = \frac{f_o}{n} = \frac{5}{5} = 1\text{ kHz}$$

18. The eigen values of the matrix $A = \begin{bmatrix} 1 & -1 & 5 \\ 0 & 5 & 6 \\ 0 & -6 & 5 \end{bmatrix}$ are

(A) $-1, 5, 6$
(B) $1, -5 \pm j6$
(C) $1,5 \pm j6$
(D) $1, 5, 5$

[Ans. C]

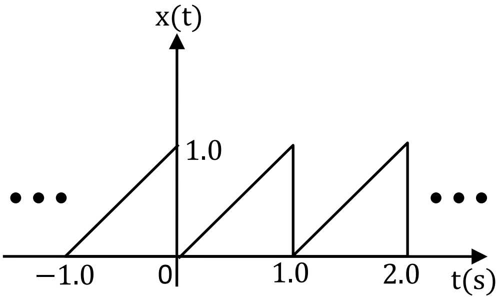
Given $A = \begin{bmatrix} 1 & -1 & 5 \\ 0 & 5 & 6 \\ 0 & -6 & 5 \end{bmatrix}$

tr (A)=11

det (A) $= (25 + 36) + (0) + 5(0) = 61$ =product of eigen value

only option (C) Satisfies these conditions

19. A periodic signal x(t) is shown in the figure. The fundamental frequency of the signal x(t) in Hz is ___________.

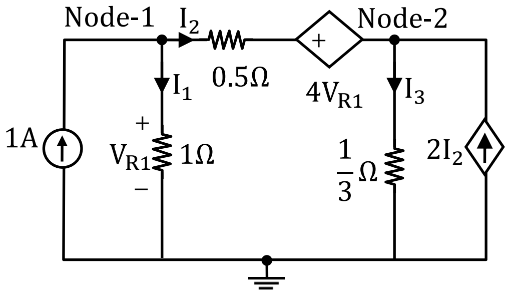


[Ans. *] Range: 1 to 1

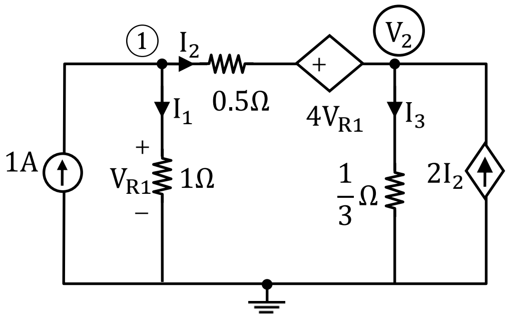
The fundamental period of given signal is $T_0 = 1$ sec

Fundamental frequency $f_0 = \frac{1}{T_0} =$ Hz

20. A circuit consisting of dependent and independent sources is shown in the figure. If the voltage at Node-1 is –1V, then the voltage at Node-2 is __________ V.



[Ans. *] Range: 2 to 2



Given that $V_1 = -1$ volts then find V_2

By KCL at (1) $V_{R1} = V_1 = -1$

$$1 = \frac{V_{R1}}{1} + \frac{V_{R1} - 4V_{R1} - V_2}{0.5}$$

$$1 = V_{R1} - 6V_{R1} - 2V_2$$

$$1 = -5V_{R1} - 2V_2$$

$$1 = -5(-1) - 2V_2$$

$$2V_{R2} = 4$$

$$\Rightarrow V_{R2} = 2 \text{ Volts}$$

21. The pressure drop across an orifice plate for a particular flow rate is 5Kg/m^2. If the flow rate is doubled (within the operating range of the orifice), the corresponding pressure drop in $\text{kg/m}^2$is

(A) 2.5
(B) 5.0
(C) 20.0
(D) 25.0

[Ans. C]

We know for orifice plate

$$Q\alpha\sqrt{\Delta P}$$

$$\frac{Q_1}{Q_2} = \sqrt{\frac{\Delta P_1}{\Delta P_2}}$$

$$Q_2 = 2Q_1, \Delta P_1 = 5(\text{kg/m}^2)$$

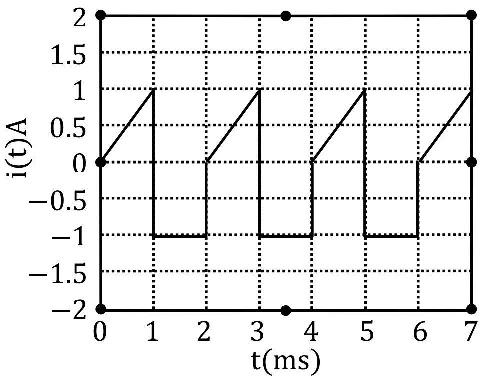
$$\frac{Q_1}{2Q_1} = \sqrt{\frac{5}{\Delta P_2}}$$

$$\frac{1}{2} = \sqrt{\frac{5}{\Delta P_2}}$$
$$\frac{1}{4} = \frac{5}{\Delta P_2}$$
$$\Delta P_2 = 20(\text{kg/m}^2)$$

22. The standard for long distance analog signal transmission in process control industry is
(A) 4 − 20 mV
(B) 0 − 20 mA
(C) 4 − 20 mA
(D) 0 − 5 V
[Ans. C]
4–20mA is the standard for long distance analog signal transmission in process control industry.

23. Let z = x + iy where $j = \sqrt{-1}$. Then $\overline{\cos z}$=
(A) cos z
(B) $\cos \bar{z}$
(C) sin z
(D) $\sin \bar{z}$
[Ans. B]
$$\overline{\cos z} = \overline{\cos(x + \imath y)} = \overline{\cos x \cos \imath y - \sin x \sin \imath y}$$
$$= \overline{\cos x \cos hy - \imath \sin x \sin hy}$$
$$= \cos x \cos hy + i \sin x \sin hy$$
$$= \cos x \cos iy + \sin x \sin iy = \cos(x - iy) = \cos \bar{z}$$

24. A current waveform, i(t), shown in the figure, is passed through a Permanent Magnet Moving Coil (PMMC) type ammeter. The reading of the ammeter up to two decimal places is



(A) −0.25 A
(B) −0.12 A
(C) 0.37 A
(D) 0.5 A
[Ans. A]
PMMC always measures average value
$$I_{avg} = \frac{\text{Area}}{|T}$$
$$= \frac{1}{2m} \times \left[\left(\frac{1}{2} \times 1m \times 1\right) + (-1 \times 1m)\right]$$
$$= \frac{1}{2}\left[\frac{1}{2} - 1\right]$$

$= \frac{1}{2}\left[\frac{1}{2}\right]$

$= -\frac{1}{4}$

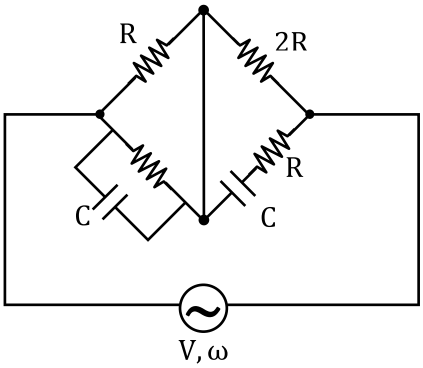
$= -0.25(A)$

25. The most suitable pressure gauge to measure pressure in the range of 10^{-4} to 10^{-3} torr is
(A) Bellows
(B) Barometer
(C) Strain gauge
(D) Pirani gauge

[Ans. D]

Gauge is the suitable pressure gauge to measure vacuum pressure up to the range of 10^{-4} torr

26. In the a.c bridge shown in the figure, $R = 10^3\ \Omega$ and $C = 10^{-7}$F. If the bridge is balanced at a frequency ω_0, the value of ω_0 in rad/s is __________



[Ans. *] Range: 10000 to 10000

$$\omega_0 = \frac{1}{RC} = \frac{1}{10^3 \times 10^{-7}}$$

$$= \frac{1}{10^{-4}} = 10000(\text{rad/sec})$$

27. The power delivered to a single phase inductive load is measured with a dynamometer type wattmeter using a potential transformer (PT) of turns ratio 200:1 and the current transformer (CT) of turns ratio 1:5. Assume both transformers to be ideal. The power factor of the load is 0.8. If the wattmeter reading is 200 W, then the apparent power of the load in kVA is ____

[Ans. *] Range: 250 to 250

Given,

Turns ratio of potential transformer (PT) $\left(\frac{N_1}{N_2}\right)_{PT} = 200:1$

Turns ratio of current transformer (CT) $\left(\frac{N_1}{N_2}\right)_{CT} = 1:5$

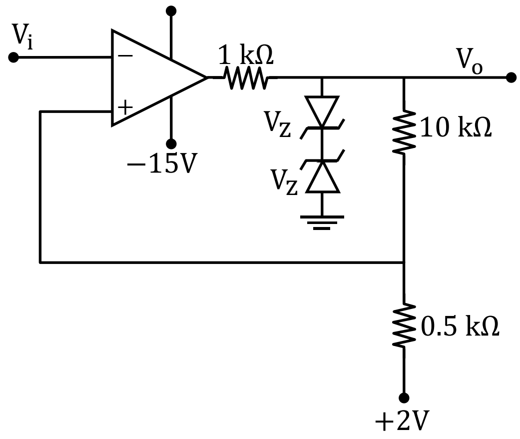
Let 'V' be the voltage across the given load.

'I' be the current through the given load.

Similarly let V_d be the voltage across the wattmeter and I_d be the current through the wattmeter

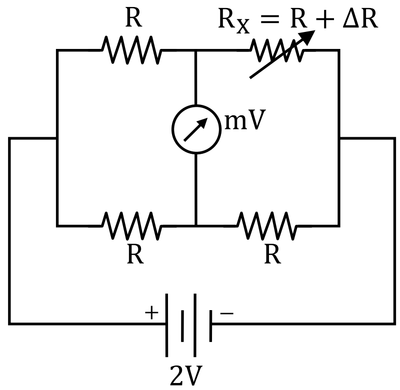
Given power factor = 0.8 lag [∵inductive load]
Given wattmeter reading = W1 = 200W
But,
$W_1 = V_d I_d \times \text{power factor}$
$200 = V_d I_d \times 0.8$
$\Rightarrow V_d I_d = 250 V_A \ldots\ldots\ldots. ①$
From the turns ratio of PT,
$$\frac{V}{V_d} = \left(\frac{N_1}{N_2}\right)_{PT} = \frac{200}{1}$$
$$\Rightarrow V_d = \frac{V}{200} \ldots\ldots\ldots. ②$$
From the turns ratio of CT_1
$$\frac{I}{I_d} = \left(\frac{N_2}{N_1}\right)_{CT} = \frac{5}{1}$$
$$\Rightarrow I_d = \frac{1}{5} \ldots\ldots\ldots. ③$$
Substituting ② and ③ in ① we get,
$$\left(\frac{V}{100}\right)\left(\frac{I}{5}\right) = 250\text{ VA}$$
$VI = 250 \times 10^3$ VA
∴apparent power of load = 250KVA

28. The circuit of a Schmitt trigger is shown in the figure. The zener-diode combination maintains the output between ±7V. The width of the hysteresis band is ____________ V.



[Ans. *] Range: 0.6 to 0.7
$$UTP = \frac{7 \times 0.5 + 2 \times 10}{10.5} = \frac{23.5}{10.5} = 2.238$$
$$LTP = \frac{-7 \times 0.5 + 2 \times 10}{10.5} = 1.57142$$
Hysteresis width= $V_{UTP} - V_{LTP}$
=0.667V

29. The unbalanced voltage of the Wheatstone bridge, shown in the figure, is measured using a digital voltmeter having infinite input impedance and a resolution of 0.1 mV. If R = 1000 Ω. Then the minimum value of ΔR in Ω to create a detectable unbalanced voltage is ____________



[Ans.*] Range: 0.17 to 0.23

$$0.1 \times 10^{-3} = 2 \times \left(\frac{R+\Delta R}{2R+\Delta R} - \frac{R}{2R}\right)$$

$$= 2 \times \left(\frac{1}{1+\frac{R}{R+\Delta R}} - \frac{1}{2}\right)$$

$$= 2 \times \left(\frac{1}{1+\frac{1000}{1000+\Delta R}} - \frac{1}{2}\right)$$

Let $\frac{1000}{1000+\Delta R} = x$

$$0.5 \times 10^{-4} = \left(\frac{1}{1+x} - \frac{1}{2}\right)$$

$$0.50005 = \frac{1}{1+x}$$

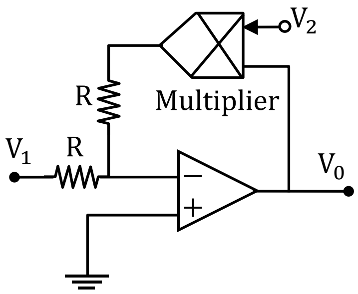
$1 + x = 1.9998$

$x=0.9998$

$$\frac{1000}{1000+\Delta R} = 1000.2$$

$\Delta R = 0.2\Omega$

30. The two-input voltage multiplier, shown in the figure, has a scaling factor of 1 and produces voltage output. If $V_1 = +15V$ and, $V_2 = +3V$ the value of V_0 in volt is _______



[Ans.*] Range: −5 to − 5

Given $V_1 = +15V, V_2 = +3V$

KCL at inverting terminal

$$0 - \frac{V_1}{R} + \frac{0 - (1.V_2\, V_0)}{R} = 0$$

$$V_0 = -\frac{V_1}{V_2} = -5V$$

31. The angle between two vectors $x_1 = [2 \quad 6 \quad 14]^T$ and $x_2 = [-12 \quad 8 \quad 16]^T$ in radian is ______

[Ans.*] Range: 0.65 to 0.8

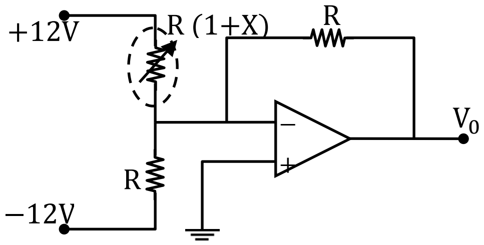
Given $X_1 = \begin{bmatrix} 2 \\ 6 \\ 14 \end{bmatrix}$ & $X_2 = \begin{bmatrix} -12 \\ 8 \\ 16 \end{bmatrix}$ angle between two vector is

$$\cos\theta = \frac{X_1\, X_2}{|X_1||X_2|} = \frac{-24 + 48 + 224}{\sqrt{4 + 36 + 196}\,\sqrt{144 + 64 + 256}} = \frac{248}{\sqrt{236}\sqrt{466}} = \frac{248}{\sqrt{109976}}$$

$$= \frac{248}{331.626} = 0.74783$$

$\theta = 41.45° = 0.7235$ rad

32. A resistance temperature detector (RTD) is connected to a circuit, as shown in the figure. Assume the op-amp to be ideal. If $V_0 = +2.0V$, then the value of x is __________



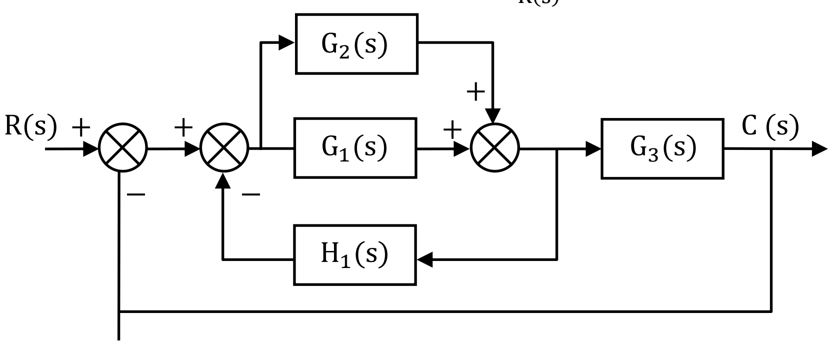
[Ans.*] Range: 0.19 to 0.21

KCL at inverting terminal:-

$$\frac{0 - 12}{R(1 + X)} + \frac{0 + 12}{R} + \frac{0 - V_0}{R} = 0 \;\{\text{Given } V_0 = +2\}$$

$X = 0.2$

33. The overall closed loop transfer function $\frac{C(s)}{R(s)}$, represented in the figure, will be



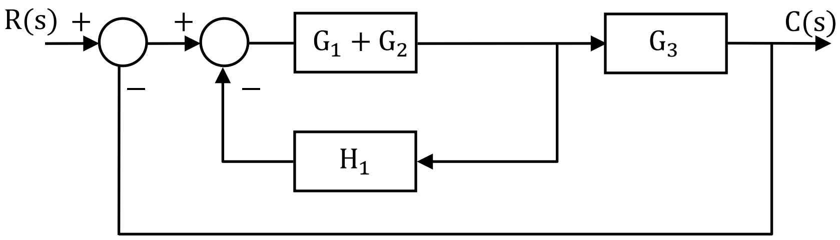
(A) $\dfrac{(G_1(s) + G_2(s))G_3(s)}{1 + (G_1(s) + G_2(s))(H_1(s) + G_3(s)))}$

(B) $\dfrac{(G_1(s) + G_3(s))}{1 + (G_1(s)(H_1(s) + G_2(s)G_3(s)}$

(C) $\dfrac{(G_1(s) - G_2(s))H_1(s)}{1 + (G_1(s) + G_3(s))(H_1(s) + G_1(s))}$

(D) $\dfrac{G_1(s)G_2(s)H_1(s)}{1 + G_1(s)H_1(s) + G_1(s)G_3(s)}$

[Ans. A]



$$\frac{C(s)}{R(s)}=\frac{G_3(G_1+G_2)}{[1-(-H_1(G_1+G_2)-G_3(G_1+G_2)))]}$$

$$=\frac{G_3(G_1+G_2)}{1+H_1(G_1+G_2)+G_3(G_1+G_2)}$$

$$=\frac{G_3(G_1+G_2)}{1+(G_1+G_2)(1+1+G_3)}$$

34. An angle modulated signal with carrier frequency $\omega_c = 2\pi \times 10^6$ rad/s is given by $\varphi_m(t) = \cos(\omega_c t + 5\sin(1000\pi t) + 10\sin(2000\pi t)$. The maximum deviation of the frequency in the angle modulated signal from that of the carriers is ______ kHz

[Ans.*]Range: 12 to 13

$\phi(t) = \cos[\omega_c t + 5 \sin 1000 \pi t + 10 \sin 2000 \pi t]$

$\phi(t) = \cos[\omega_c t + \beta_1 \sin 2\pi f_1 t + \beta_2 \sin 2\pi f_2 t]$

$\beta_1 = 5, f_1 = 500$ Hz

$\beta_2 = 10, f_2 = 1000$ Hz

The maximum frequency deviation is

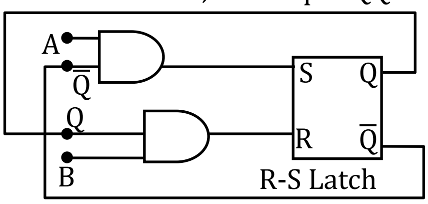
$(\Delta f)_{max} = \beta_1 f_1 + \beta_2 f_2$

$= 5 \times 500 + 10 \times 1000$

$= 2500 + 10{,}000$

$= 12.5$ kHz

35. The two inputs A and B connected to an R-S latch via two AND gates as shown in the figure. If A = 1 and B = 0, the output $Q\overline{Q}$ is

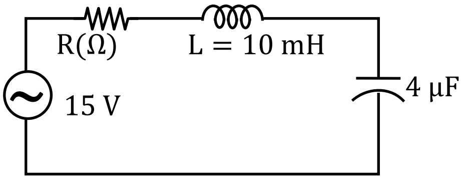


(A) 00
(B) 10
(C) 01
(D) 11

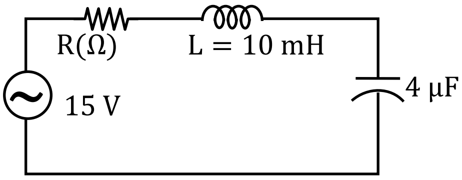
[Ans. B]

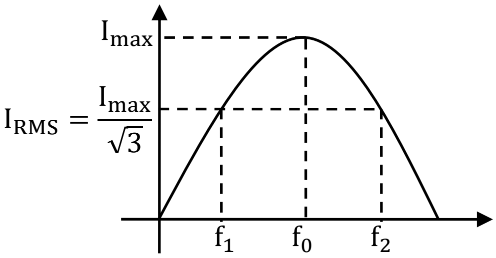
It is similar to JKFF where A = J, B = K

36. A series R-L-C circuit is excited with an a. c. voltage source. The quality factor (Q) of the circuit is given as Q = 30. The amplitude of current in ampere at upper half-power frequency will be ______



[Ans.*] Range: 6 to 7





$$Q = \frac{1}{R}\sqrt{\frac{L}{C}}$$

$$30 = \frac{1}{R}\sqrt{\frac{10 \times 10^{-3}}{4 \times 10^{-6}}}$$

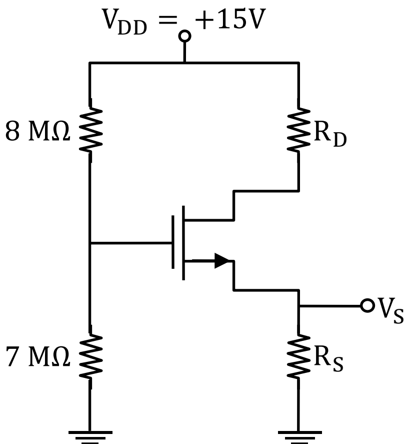
$$30 = \frac{1}{R}\sqrt{\frac{1000}{4}} = \frac{50}{R} \Rightarrow R = \frac{5}{3}\Omega$$

$$f_2 \& f_1 \rightarrow I = I_{RMS} = \frac{I_{max}}{\sqrt{2}}$$

$$I = \frac{V}{\sqrt{2}R} = \frac{15}{\sqrt{2} \times \frac{5}{3}} = \frac{9}{\sqrt{2}}$$

$$I = 6.365A$$

37. In the circuit, shown in the figure, the MOSFET is operating in the saturation zone. The characteristics of the MOSFET is given by $I_D = \frac{1}{2}(V_{GS} - 1)^2$mA, where V_{GS} is in V. If $V_s = +5V$, then the value of R_s in kΩ is ________



[Ans.*] Range: 9.9 to 10.1

$$I_D = \frac{1}{2}(V_{GS} - 1)^2$$

$V_G = \frac{15 \times 7}{15} = 7V$

$V_S = +5V; V_{GS} = 2V$

$I_D = \frac{1}{2}(1) = 0.5mA$

$V_s = I_D R_s$

$R_S = 10k\Omega$

38. When the voltage across a battery is measured using a d .c. potentiometer, the reading shows 1.08 V. But when the same voltage is measured using a Permanent Magnet Moving Coil (PMMC) voltmeter, the voltmeter reading shows 0.99 V. If the resistance of the voltmeter is 1100 Ω,the internal resistance of the battery, in Ω, is _______

[Ans.*]Range: 100 to 100

$0.99 = 1.08 \frac{R_V}{R_V + R_m}$

$R_V =$ voltmeter resistance

$R_m =$ battery internal resistance

$0.99 = 1.08 \times \frac{1100}{1100 + R_m}$

$1100 + R_m = 1200$

$R_m = 100\Omega$

39. The magnetic flux density of an electromagnetic flow meter is 100 mWb/m^2. The electrodes are wall-mounted inside the pipe having a diameter of 0.25 m. A voltage of 1V is generated when a conducting fluid is passed through the flow meter. The volumetric flow rate of the fluid in m^3/s is__________.

[Ans.*] Range: 1.9 to 2.0

$e = \frac{B}{V} = 100 \times 10^{-3} \times 0.25 \times V$

$1 = 0.25 \times 10^{-1} V$

$V = 40\ (m/sec)$

$Q = AV = \frac{\pi}{4} d^2 \times V = \frac{\pi}{4} \times (0.25)^2 \times 40 = 1.9634 (m^3/sec)$

40. The following table lists an n^{th} order polynomial $f(x) = a_n x^n + a_{n-1} x^{n-1} + \cdots + a_1 x + a_0$ and the forward differences evaluated at equally spaced values of x. The order of the polynomial is

x	f(x)	Δf	$\Delta^2 f$	$\Delta^3 f$
−0.4	1.7648	−0.2965	0.089	−0.03
−0.3	1.4683	−0.2075	0.059	−0.0228
−0.2	1.2608	−0.1485	0.0362	−0.0156
−0.1	1.1123	−0.1123	0.0206	−0.0084
0	1	−0.0917	0.0122	−0.0012
0.1	0.9083	−0.0795	0.011	0.006
0.2	0.8288	−0.0685	0.017	0.0132

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

[Ans. D]

A, B, are eliminated as $\Delta^3 f = 0$ for first 8 second order

Check for third order

$f(x) = a_3\, x^3 + a_2 x^2 + a_1 x + a_0$

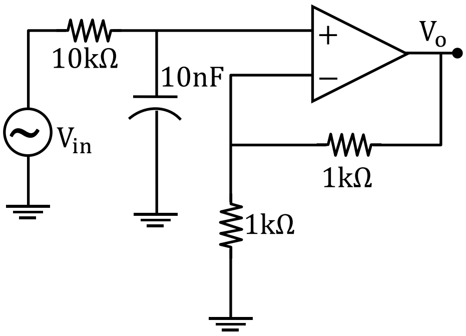
$f'''(r) = 6a_3$

Constant irrespective of x

Given $f'''(x)$ is not constant

∴ C is eliminated

41. Assuming the op-amp shown in the figure to be ideal , the frequency at which the magnitude of V_o will be 95% of the magnitude of V_{in} is _______ kHz



[Ans.*] Range: 2.9 to 3

$V_o = 2V_+$

$= \dfrac{2V_{in}}{1 + SCR}$

$\dfrac{V_o}{V_{in}} = \dfrac{2}{1 + j\omega 10^4 10^{-8}} = 0.95$

$0.95V_i = 2V_i \dfrac{1}{\sqrt{1 + (2\pi fRC)^2}}$

$\sqrt{1 + (2\pi fRC)^2} = \dfrac{2}{0.95} = 2.10526$

$1 + (2\pi fRC)^2 = 4.432$

$(2\pi fRC)^2 = 3.432$

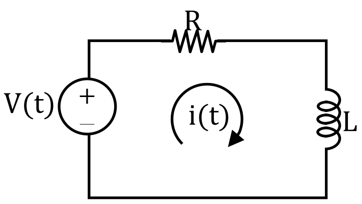
f=2.9485 kHz

42. The current response of a series R-L circuit to a unit step voltage is given in the table. The value of L is ____________H.

t in s	0	0.25	0.5	0.75	1.0	⋯	∞
i(t) in A	0	0.197	0.316	0.388	0.432	⋯	0.5

[Ans.*]Range: 1 to 1

The current response of a series R-L to a unit step voltage



$i(t) = \frac{V}{R}(1 - e^{-t/\tau})$

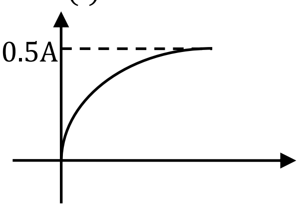
$\tau = \frac{L}{R}$

From the table $t = \infty$

$i(\infty) = \frac{V}{R} = 0.5$

$R = \frac{1}{0.5} = 2\Omega$

At $t = \tau$



At $t = \tau$;

$i(t) = 0.5\,(1 - e^{-1})$

$= 0.5(0.632)$

$= 0.316$

From the table $\tau = 0.5$

$\Rightarrow i(t) = 0.316$

$\frac{L}{R} = 0.5$

L=1H

43. The hot junction of a bare thermocouple, initially at room temperature (30°C) is suddenly dipped in molten metal at $t = 0$ s. The cold junction is kept at room temperature. The thermocouple can be modeled as first-order instrument with a time constant of 1.0 s and a static sensitivity of 10 μV/°C. If the voltage across the thermocouple indicates 10.0 mV at $t = 1.0$ s, then the temperature of the molten metal in °C is ______________

[Ans.*]Range: 1605 to 1618

Initially $(t < 0)$

Hot junction temperature.

So, $T_H(0^-) = 30°C$

$\forall t > 0$

A sudden step change is applied to the thermocouple hot junction and the amount of step change is equal to "Molten steel temperature".

So, for thermocouple,

$T_H(0) = 30°C$

$T_H(\infty) = T_m$(Molten steel temperature)

And $T_C(t) = 30°\ (\forall t \geq 0)$

Where, T_C = Cold junction temperature

Given that time constant of thermocouple is 1 sec.

⇒ The step response of first order system is given as

$T_H(t) = T_H(\infty) + [T_H(0) - T_H(\infty)]e^{-t/\tau}$

at t = 1 sec

$T_H(1) = T_m + (30 - T_m)e^{-1} \dots\dots\dots (1)$

Thermo couple output voltage at any time is

Given as

$e_0(t) = k \times \left(T_H(t) - T_C(t)\right)\ (\forall t \geq 0)$

$k = 10\ \mu v/°C$ (Static sensitivity)

at t = 1 sec

$e_0(1) = k\left(T_H(1) - T_C(1)\right)$

$10 \times 10^{-3} = 10 \times 10^{-6}\ [T_m - T_m e^{-1} + 11.036 - 30]$

$1000 = T_m(1 - e^{-1}) - 18.9631$

$$\frac{1018.9636}{(1 - e^{-1})} = T_m$$

$$T_m = \frac{1018.9636}{0.632} = 1612.2844°C$$

44. In a sinusoidal amplitude modulation scheme (with carrier) the modulated signal is given by $A_m(t) = 100\cos(\omega_c t) + 50\cos(\omega_m t)\cos(\omega_c t)$, where ω_c is the carrier frequency an ω_m is the modulation frequency. The power carried by the sidebands in % of total power is ______ %

[Ans.*]Range: 11 to 11.2

$S(t) = 100\cos\omega_c t + 50\cos\omega_m t\ \cos\omega_c t$

$= 100[1 + 0.5\cos\omega_m t]\cos\omega_c t$

$$\eta = \frac{P_{SB}}{P_t} = \frac{\mu^2}{2 + \mu^2} = \frac{0.25}{2.25}$$

$$\frac{P_{SB}}{P_t} = 11.1\%$$

$P_{SB} = 11.1\%\ P_t$

45. Three DFT coefficients, out of five DFT coefficients of a five-point real sequence are given as: X (0) = 4, X (1) = 1– j1 and X (3) = 2 + j2. The zero-th value of the sequence x (n), x(0), is

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

[Ans. B]

Given N = 5

X(n) is real, so X(k) = X(N–k)

Given that X(0) = 4, X(1) = 1–j1, X(3) = 2 + j2

X(4) = X(5–4) = X(1) = 1+j1

X(2) = X(5–2) = X(3) = 2 – j2

$$x(0)\frac{1}{N}\sum_{K=0}^{4} X(k) = \frac{1}{5}[4 + 1 - j1 + 2 - j2 + 2 + j2 + 1 + j1]$$

$$X(0) = \frac{1}{5}[10] = 2$$

46. The Laplace transform of a causal signal y(t) is $Y(s) = \frac{s+2}{s+6}$. The value of the signal y(t) at t = 0.1s is __________ unit.

[Ans.*]Range: −2.4 to − 2.0

The laplace transform $Y(s) = \dfrac{s+2}{s+6}$ then y(t)at t = 0.1 is

$$Y(s) = \frac{s+2}{s+6} = \frac{s+6-4}{s+6}$$

$$y(t) = L^{-1}\left[1 - \frac{4}{S+6}\right]; \quad y(t) = [\delta(t) - 4e^{-6t}]$$

$$t = 0.1 \; y(0.1) = \delta(0.1) - 4e^{-6(0.1)}$$

$$y(0.1) = -2.19$$

47. Quantum efficiency of a photodiode (ratio between the number of liberated electrons and the number of incident photons) is 0.75 at 830 nm. Given Planck's constant $h = 6.625 \times 10^{34}$J, the charge of an electron $e = 1.6 \times 10^{-19}$C and the velocity of light in the photodiode $C_m = 2 \times 10^8$m/s For an incident optical power of 100μW at 830 nm, the photocurrent in μA is ________

[Ans.*]Range: 74.5 to 75.5

$$\frac{I}{P} = \frac{\eta e\lambda}{hc}; \quad I = \frac{\eta e\lambda}{hc} \times P$$

$$= \frac{0.75 \times 1.6 \times 10^{-19} \times 830 \times 10^{-9} \times 100 \times 10^{-6}}{6.624 \times 10^{-34} \times 2 \times 10^{8}}$$

$$I = 75.18\mu A$$

48. The probability that a communication system will have high fidelity is 0.81 . The probability that the system will have both high fidelity and high selectivity is 0.18. The probability that a given system with high fidelity will have selectivity is

(A) 0.181
(B) 0.191
(C) 0.222
(D) 0.826

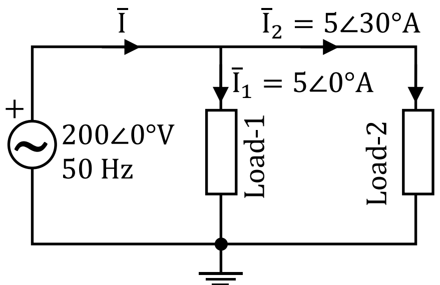
[Ans. C]

$P(HF) = 0.81, P(HF \cap HS) = 0.18$

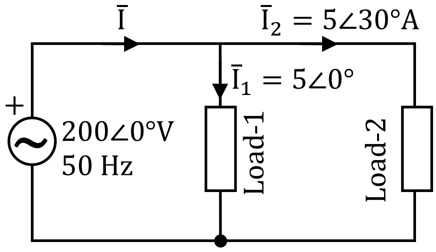
$$P(HS|\,HF) = \frac{P(HS \cap HF)}{P(HF)}$$

$$= \frac{2}{9} = 0.222$$

49. For the circuit, shown in the figure, the total real power delivered by the source to the loads is ____ kW



[Ans.*]Range: 1.75 to 1.96



$I = I_1 + I_2$

$= 5\angle 0° + 5\angle 30°$

$= 5 + 5\frac{\sqrt{3}}{2} + j\frac{5}{2}$

$I = 5\left(1 + \frac{\sqrt{3}}{2}\right) + j\frac{5}{2}$

$= 5(1.866) + j\frac{5}{2}$

So, $S = VI^*$

$= (200\angle 0°)(9.33 - j2.5)$

$P + jQ = 1866 - j5000$

Real power $P = 1866\text{ W} = 1.866\text{kW}$

50. The loop transfer function of a closed-loop system is given by $G(s)H(s) = \frac{k(s+6)}{S(s+2)}$.The breakaway point of the root-loci will be

[Ans.*] Range: -1.2 to -1.0

$G(s) = \frac{k(s+6)}{s(s+2)}$

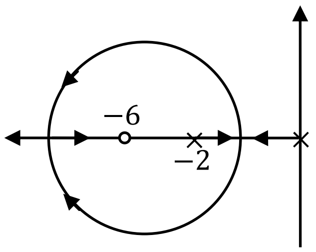
$\frac{k(s+6)}{s(s+2)} = -1$

$k = \frac{-s^2 + 2s}{s + 6}$

$\frac{dk}{ds} = \frac{\left((s+6)(2s+2) - (s^2+2s)\right)}{(s+6)^2}$

$2s^2 + 2s + 12s + 12 - s^2 - 2s = 0$

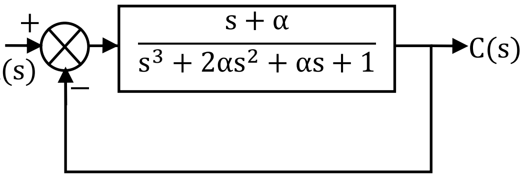
$s^2 + 12s + 12 = 0$



$s = -1.01;\ s = -10.8$

The breakaway point $s = -1.01$

51. A closed-loop system is shown in the figure. The system parameter α is not known. The condition for asymptotic stability of the closed loop system is



(A) $\alpha < -0.5$
(B) $-0.5 < \alpha < 0.5$
(C) $0 < \alpha < 0.5$
(D) $\alpha > 0.5$

[Ans. D]

Characteristics equation

C. E $= s^3 + 2\alpha s^2 + (\alpha + 1)s + 1 + \alpha = 0$

Condition for stability

$2\alpha(\alpha + 1) > 1 + \alpha$

$2\alpha^2 + 2\alpha - \alpha - 1 > 0$

$2\alpha^2 + \alpha - 1 > 0$

$2\alpha^2 + 2\alpha - \alpha - 1 > 0$

$(2\alpha - 1)(\alpha + 1) > 0$

$2\alpha - 1 > 0$

$\alpha + 1 > 0$

$\alpha > \frac{1}{2}$

$\alpha > -1$

$\alpha > 0.5$

52. Consider two discrete-time signals

$x_1(n) = \{1, 1\}$ and $x_2(n) = \{1, 2\}$, for $n = 0, 1$

The Z – transform of the convoluted sequence $x(n) = x_1(n) * x_2(n)$ is

(A) $1 + 2z^{-1} + 3z^{-1}$
(B) $z^2 + 3z + 2$
(C) $1 + 3z^{-1} + 2z^{-2}$
(D) $z^{-2} + 3z^{-3} + 2z^{-4}$

[Ans. C]

$x_1(n) = [1, 1]$

$x_2(n) = [1, 2]$

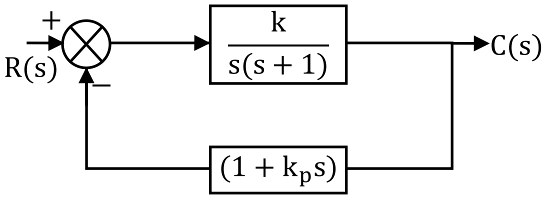
$x(n) = x1\ (n) * x_2(n)$

	1	2
1	1	2
1	1	2

$x(n) = [1,3,2]$

$$X(z) = \sum_{n=-\infty}^{\infty} = 1 + 3z^{-1} + 2z^{-2}$$

53. The block diagram of a closed-loop control system is shown in the figure. The values of k and k_p are such that the system has a damping ratio of 0.8 and an undamped natural frequency ω_n of 4 rad/s respectively. The value of k_p will be ______



[Ans.*] Range: 0.32 to 0.4

$$\frac{C(s)}{R(s)} = \frac{\frac{k}{s(s+1)}}{1+\frac{k(1+k_p s)}{s(s+1)}}$$

$$\frac{C(s)}{R(s)} = \frac{k}{s^2 + s + kk_p s + k}$$

By comparing with standard second order system

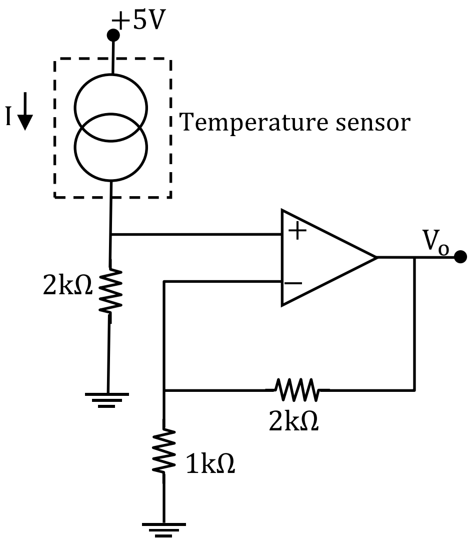
$k = \omega_n^2 = 16$

$(1 + kk_p) = 2\xi\omega_n$

$1 + 16(k_p) = 2(0.8)4$

$k_p = 0.3375$

54. The junction semiconductor temperature sensor shown in the figure is used to measure the temperature of hot air. The output voltage V_0 is 2.1 V. The current output of the sensor is given by $I = T\mu A$ where T is the temperature in K. Assuming the op-amp to be ideal, the temperature of the hot air in °C is approximately ____________



[Ans.*]Range: 76 to 78

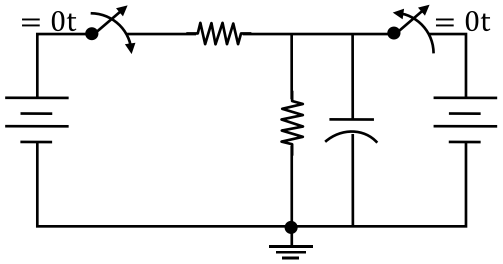
$$V_0\left(\frac{1k}{2k+1k}\right) = \frac{V_0}{3} = \frac{2.1}{3} = 0.7 = V_+ \text{(Virtual and concept)}$$

$$I = \frac{V_+}{2k} = 0.35mA = T\mu A$$

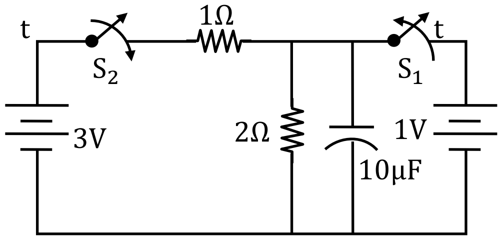
T=350K

T = 77°C

55. In the circuit diagram, shown in the figure, S_1 was closed and S_2 was open for a very long time. At $t = 0$, S_1 is opened and S_2 is closed. The voltage across the capacitor, in voltage, at $t = 5\ \mu s$ is ____

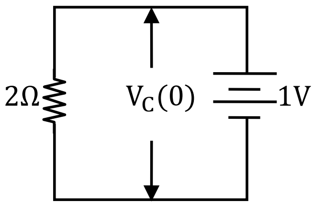


[Ans.*] Range: 1.43 to 1.63



For $t < 0$, S_1 is closed &S_2 is opened

$C \rightarrow 1V$ source at $t = 0$, (steady state) $C \rightarrow O.C$

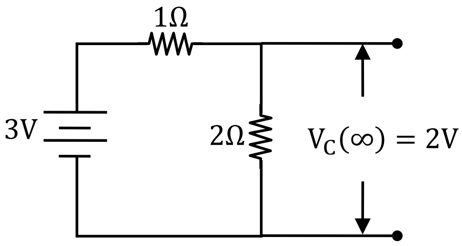


$V = V_C(0^{-1}) = V_C(0^{+}) = V_0(\text{Initial value})$

For $t > 0$, S_1 is opened & S_2 is closed

$C \rightarrow 3V$ source $t = \infty$, (steady state)$C \rightarrow O.C$

For final value



$$\tau = R_{eq}C = \frac{2 \times 1}{2 + 1} \times 10\mu F = \frac{20}{3}\ \mu sec$$

$$V_C(t) = V_C(\infty) + (V_C(0) - V_C(\infty))e^{-\frac{t}{\tau}}$$

$$= 2 + (1 - 2)e^{-\frac{3t}{20 \times 10^{-6}}}$$

$$V_C(t) = \left(2 - e^{-\frac{3t}{20 \times 10^{-6}}}\right)$$

$t = 5\mu sec$

$$V_C(t) = \left(2 - e^{-\frac{3(5 \times 10^{-6})}{20 \times 10^{-6}}}\right) = 2 - e^{-3/4}$$

$V_C(t) = 1.5276$ Volts