IN INSTRUMENTATION ENGINEERING

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Q.1-Q.20 Carry one mark each

1) If v is a non-zero vector of dimension 3×1, then the matrix $A = vv^T$ has a rank = _____

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2) Fig. 1 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

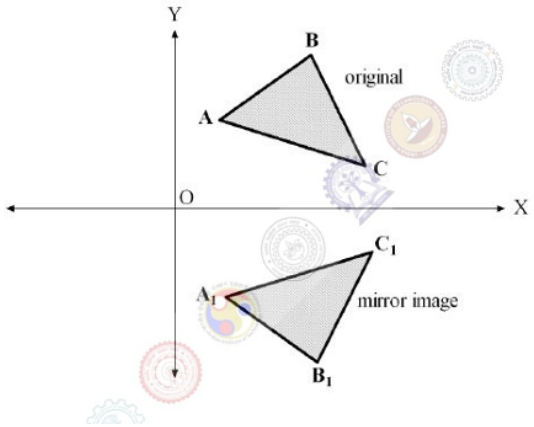

Fig. 1. Mirror Image across horizontal axis

(GATE IN 2017)

a) $\begin{pmatrix} 0 & 1 \\ 1 & 0 \end{pmatrix}$

b) $\begin{pmatrix} -1 & 0 \\ 1 & 0 \end{pmatrix}$

c) $\begin{pmatrix} 0 & 1 \\ -1 & 0 \end{pmatrix}$

d) $\begin{pmatrix} 0 & -1 \\ 1 & 0 \end{pmatrix}$

3) Let $z = x + jy$ where $j = \sqrt{-1}$. Then $\cos z =$

(GATE IN 2017)

a) $\cos z$ b) $\cos \bar{z}$ c) $\sin z$ d) $\sin \bar{z}$

4) The eigenvalues of the matrix $A = \begin{pmatrix} 1 & -1 & 5 \\ 0 & 5 & 6 \\ 0 & -6 & 5 \end{pmatrix}$ are

(GATE IN 2017)

a) $-1, 5, 6$ b) $1, -5 \pm j6$ c) $1, 5 \pm j6$ d) $1, 5, 5$

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

(GATE IN 2017)

a) $\frac{1}{1+j1000\omega}$ b) $\frac{2000\pi}{2000\pi+j\omega}$ c) $\frac{1}{1+j\omega/(2000\pi)}$ d) $\frac{1000}{1000+j\omega}$

6) 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 Fig. 2. The voltage across the inductor (V_L) is _____ V.

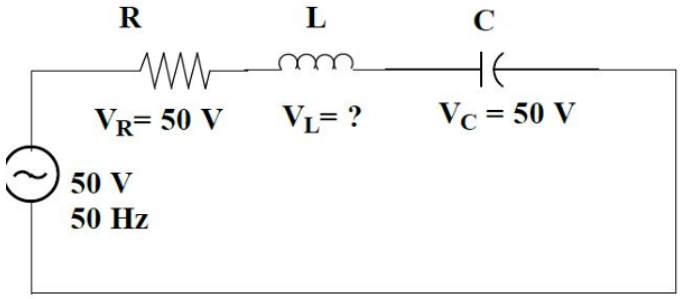

Fig. 2. R-L-C Circuit

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7) The connection of two 2-port networks is shown in Fig. 3. The ABCD parameters of N_1 and N_2 are

$$\begin{pmatrix} A & B \\ C & D \end{pmatrix}_{N1} = \begin{pmatrix} 1 & 5 \\ 0 & 1 \end{pmatrix}$$

and

$$\begin{pmatrix} A & B \\ C & D \end{pmatrix}_{N2} = \begin{pmatrix} 0.2 & 1 \\ 1 & 1 \end{pmatrix}$$

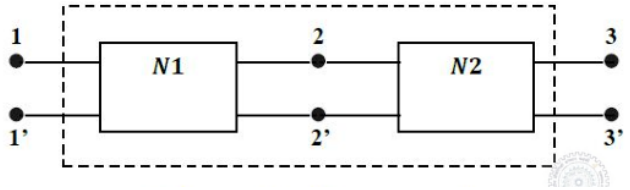

Fig. 3. Connection of 2-port networks

The ABCD parameters of the combined 2-port network are

(GATE IN 2017)

a) $\begin{pmatrix} 2 & 5 \\ 0.2 & 1 \end{pmatrix}$ b) $\begin{pmatrix} 0.5 & 1 \\ -0.5 & 1 \end{pmatrix}$ c) $\begin{pmatrix} 0.5 & 5 \\ 2 & 1 \end{pmatrix}$ d) $\begin{pmatrix} 0.5 & 5 \\ 1 & 2 \end{pmatrix}$

8) A circuit consisting of dependent and independent sources is shown in Fig. 4. If the voltage at Node-1 is -1 V, then the voltage at Node-2 is ——V

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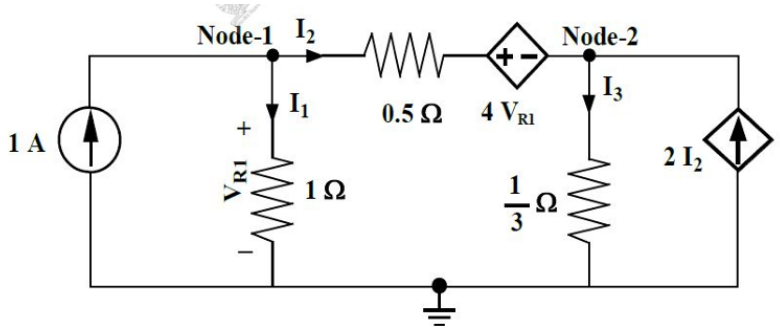

Fig. 4. Circuit Diagram for Question-8

9) A periodic signal $x(t)$) is shown in Fig. 5. The fundamental frequency of $x(t)$ in Hz is ——
(GATE IN 2017)

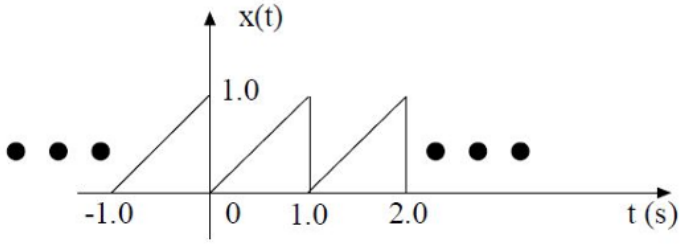

Fig. 5. Periodic Signal

10) A system is described by the following differential equation

$$\frac{dy(t)}{dt} + 2y(t) = \frac{dx(t)}{dt} + x(t), \quad x(0) = y(0) = 0$$

where $x(t)$ and $y(t)$ are the input and output variables respectively. The transfer function of the inverse system is
(GATE IN 2017)

a) $\frac{s+1}{s-2}$ b) $\frac{s+2}{s-1}$ c) $\frac{s+1}{s+1}$ d) $\frac{s+2}{s-2}$

11) 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
(GATE IN 2017)

a) -0.707 b) -1 c) 0 d) 1

12) The Region of Convergence (ROC) of the Z-transform of a causal unit step discrete-time sequence is
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a) $|z| < 1$ b) $|z| \leq 1$ c) $|z| > 1$ d) $|z| \geq 1$

13) The term hysteresis is associated with
(GATE IN 2017)

a) ON-OFF control
b) P-I control
c) Feed-forward control
d) Ratio control

14) The differential amplifier shown in Fig. 6, has A_d = 100 and common node gain of A_c = 0.1. If V_1 = 5.01V and V_2 = 5.00V, then V_o in volts (up to one decimal place) is _____

(GATE IN 2017)

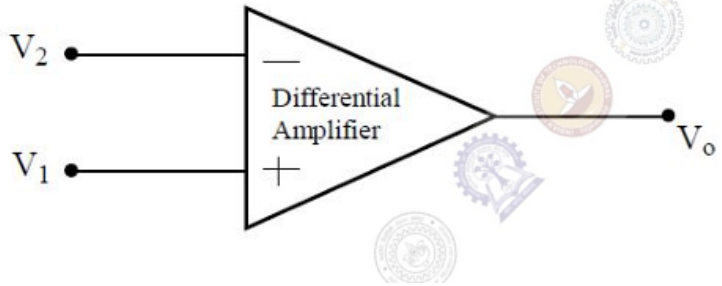

Fig. 6. Differential Amplifier

15) The silicon diode shown in Fig. 7 has a barrier potential of 0.7V. There will be no forward current if V_{dc} in volts is greater than

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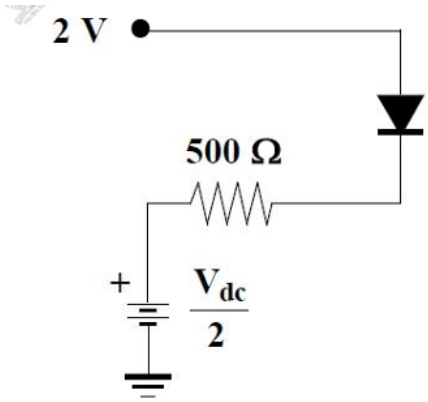

Fig. 7. Circuit Diagram for Question-15

a) 0.7 b) 1.3 c) 1.8 d) 2.6

16) Fig. 8 shows a phase locked loop with output frequency f_o = 5 kHz. The value of f_i in kHz is _____

(GATE IN 2017)

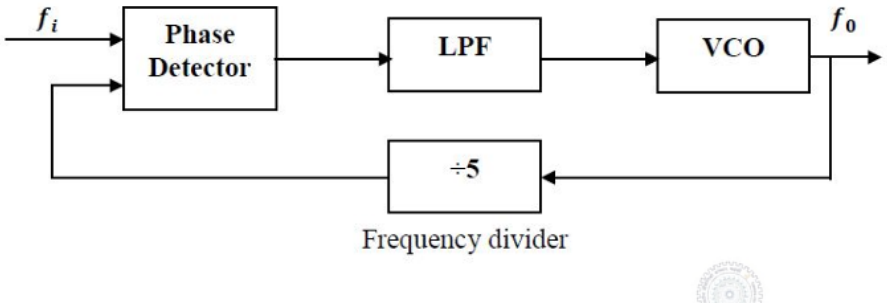

Fig. 8. Phase locked loop

17) The condition for oscillation in a feedback oscillator is that at the frequency pf oscillation, initially the loop gain is greater than unity while the total phase shift around the loop in degree is

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a) 0 b) 90 c) 180 d) 270

18) The output V_o shown in Fig. 9, in volt, is closest to

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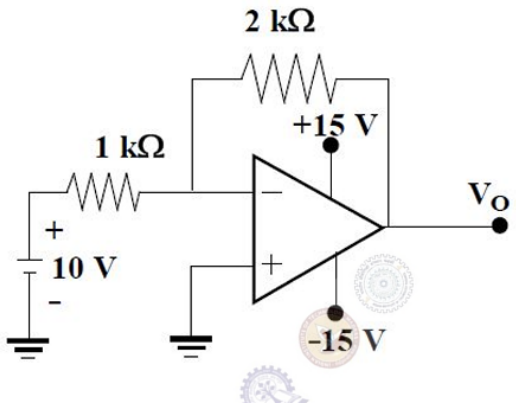

Fig. 9. Circuit Diagram for Question-18

a) −20 b) −15 c) −5 d) 0

19) An 8-bit microcontroller with 16 address lines has 3 fixed interrupts i.e. Int1, Int2 and Int3 with corresponding interrupt vector addresses as 008H, 0010H and 0018H. To execute a 32-byte long Interrupt Service Subroutine for Int1 starting at the address ISS1, the location 0008H onwards should ideally contain

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a) a CALL to ISS1
b) an unconditional JUMP to ISS1
c) a conditional JUMP to ISS1
d) only ISS1

20) A and B are the logical inputs and X is the logical output shown in Fig. 10. The output X is related to A and B by

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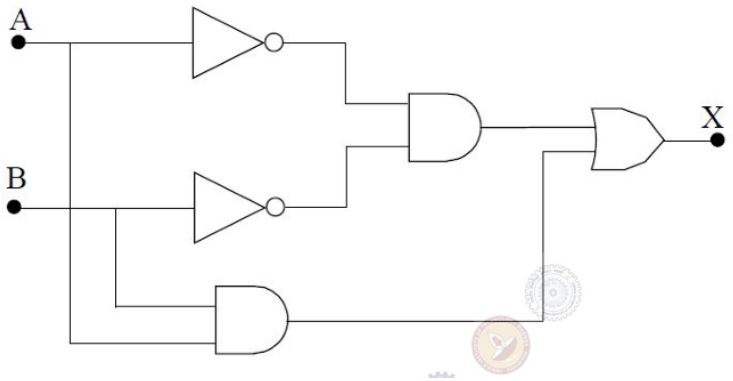

Fig. 10. Combination of Logic Gates

a) $X = \overline{A}B + B\overline{A}$ b) $X = AB + \overline{B}A$ c) $X = \overline{A}B + AB$ d) $X = AB + BA$

21) A current waveform, $i(t)$, shown in Fig. 11, is passed through a Permanent Magnet Moving Coil (PMMC) type ammeter. The reading of the ammeter up to two decimal places is
(GATE IN 2017)

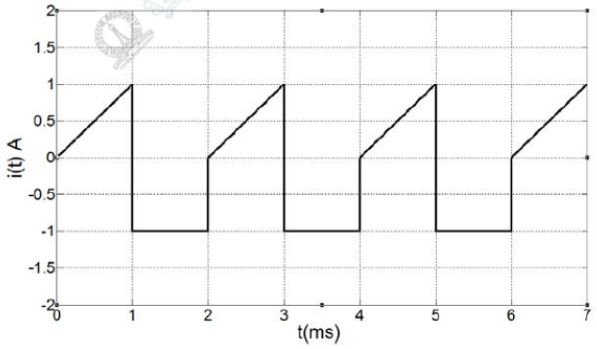

Fig. 11. Current Waveform

a) −0.25A b) −0.12A c) 0.37A d) 0.50A

22) Identify the instrument that does not exist
(GATE IN 2017)

a) Dynamometer-type ammeter
b) Dynamometer-type wattmeter
c) Moving-iron voltmeter
d) Moving-iron wattmeter

23) The most suitable pressure gauge to measure pressure in the range of 10^{-4} to 10^{-3} torr is
(GATE IN 2017)

a) Bellows b) Barometer c) Strain gauge d) Pirani gauge

24) The standard for long distance analog signal transmission in process control industry is
(GATE IN 2017)

a) 4 – 20mV b) 0 – 20mA c) 4 – 20mA d) 0 – 5V

25) The pressure drop across an orifice plate for a particular flow rate is 5kg/m^2. If the flow rate is doubled (withing the operating range of the orifice), the corresponding pressure drop in kg/m^2 is
(GATE IN 2017)

a) 2.5 b) 5.0 c) 20.0 d) 25.0

26) 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 high selectivity is

(GATE IN 2017)

a) 0.181 b) 0.191 c) 0.222 d) 0.826

27) The angle between two vectors $\mathbf{x}_1 = [2 \quad 6 \quad 14]^T$ and $x_2 = [-12 \quad 8 \quad 16]^T$ in radian is _____

(GATE IN 2017)

28) 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

(GATE IN 2017)

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

29) 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**.

(GATE IN 2017)

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

30) For the circuit shown in Fig. 12, the total real power delivered by the source to the loads is _____ **kW**.

(GATE IN 2017)

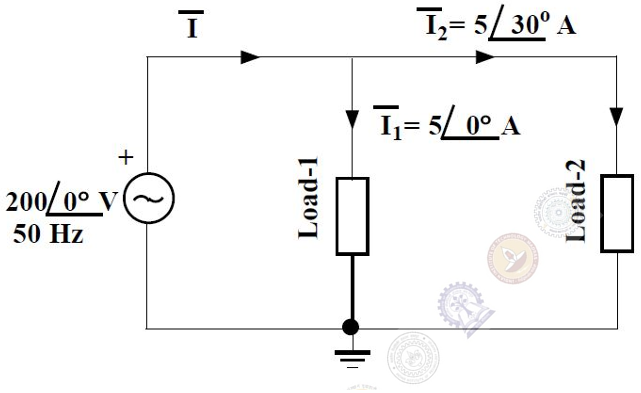

Fig. 12. Circuit Diagram for Question-30

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

(GATE IN 2017)

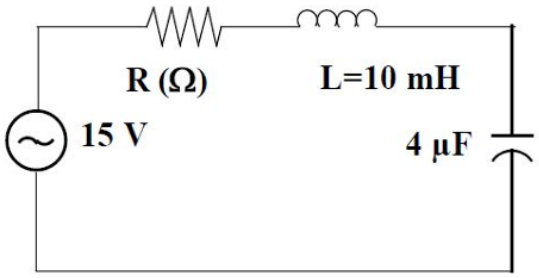

Fig. 13. R-L-C Circuit

32) In the circuit (Fig. 14 shown, 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 at $t = 5$ μs is _____ V.

(GATE IN 2017)

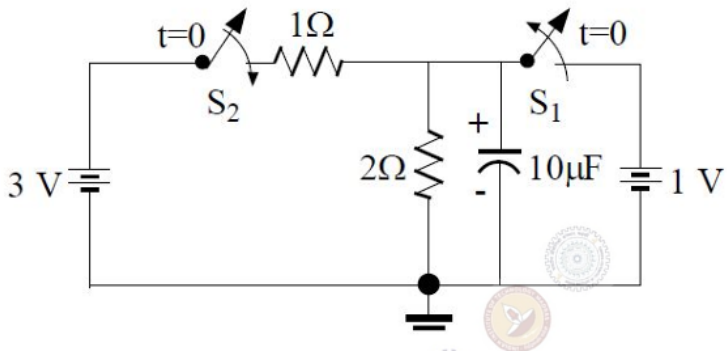

Fig. 14. Circuit Diagram for Question-32

33) Consider two discrete-time signals $x_1(n) = \{1, 1\}$ and $x_2(n) = \{1, 2\}$ for $n = 0, 1$.
The Z-transform of $x(n) = x_1(n) * x_2(n)$ is

(GATE IN 2017)

a) $1 + 2z^{-1} + 3z^{-2}$ b) $z^2 + 3z + 2$ c) $1 + 3z^{-1} + 2z^{-2}$ d) $z^{-2} + 3z^{-3} + 2z^{-4}$

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

(GATE IN 2017)

a) 1 b) 2 c) 3 d) 4

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

(GATE IN 2017)

36) The block diagram of a closed-loop control system is shown in Fig. 15. The values of k and k_p are such that the system has a damping ratio of 0.8 and an undamped frequency ω_n of 4rad/s respectively. The value of k_p will be _____.

(GATE IN 2017)

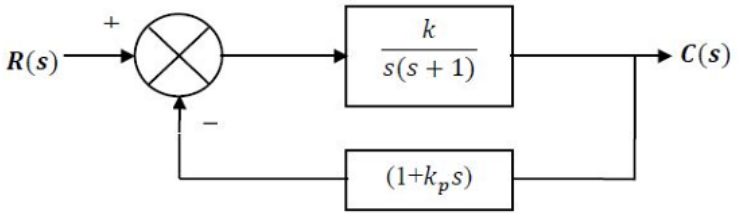

Fig. 15. Block diagram of a closed loop control system

37) 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 _____.

(GATE IN 2017)

38) The closed-loop system shown in Fig. 16. The system parameter α is not known. They condition for asymptotic stability of the closed loop system is

(GATE IN 2017)

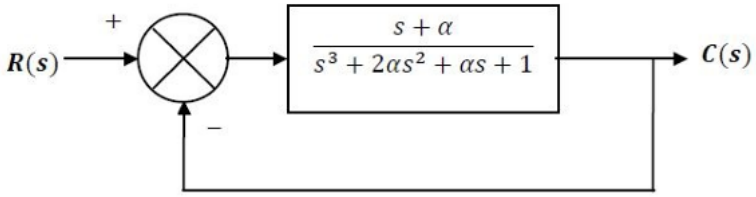

Fig. 16. Closed loop system

a) $\alpha < -0.5$ b) $-0.5 < \alpha < 0.5$ c) $0 < \alpha < 0.5$ d) $\alpha > 0.5$

39) The overall closed-loop transfer function $\frac{C(s)}{R(s)}$, represented in Fig. 17, will be

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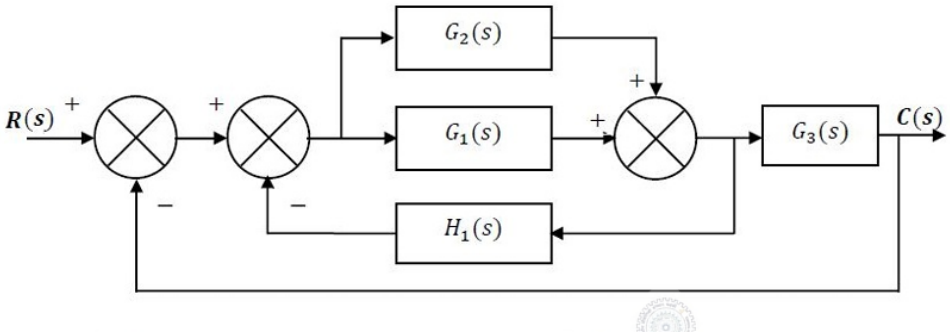

Fig. 17. Closed loop system

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

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

c) $\frac{(G_1(s)-G_2(s))H_1(s)}{1+(G_1(s)+G_3(s))(H_1(s)+G_1(s))}$

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

40) Assuming the op-amp shown in Fig. 18 to be ideal, the frequency at which $|V_0|$ will be 95% of V_{in} is _____ kHz.

(GATE IN 2017)

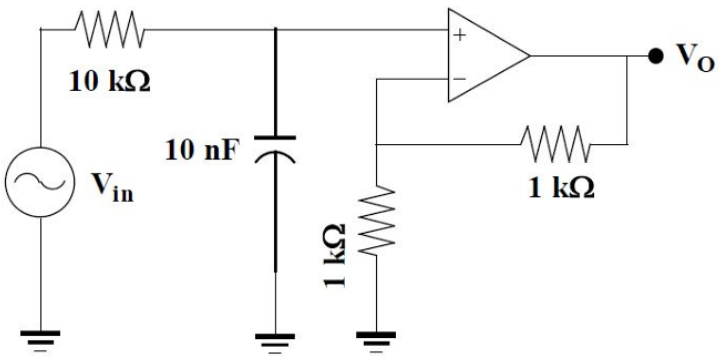

Fig. 18. Circuit Diagram for Question-40

41) In the circuit, shown in Fig. 19, The MOSFET operates in the saturation zone. The characteristics of the MOSFET is given by $I_D = \frac{1}{2}(V_{GS} - 1)^2$mA. For $V_S = +5$V, R_S in kΩ is _____.

(GATE IN 2017)

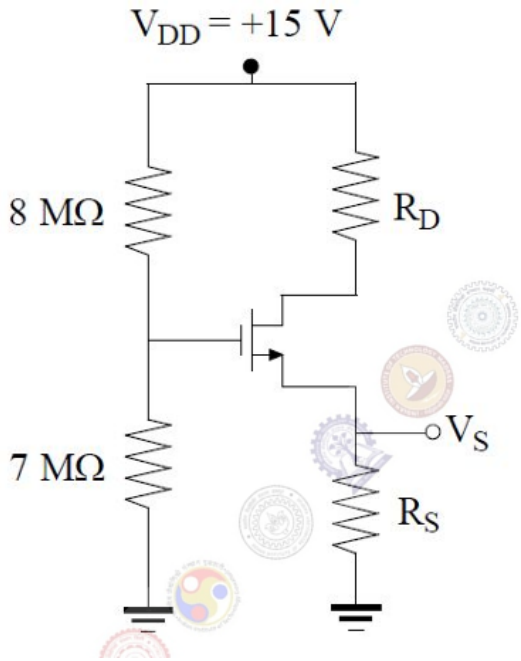

Fig. 19. Circuit Diagram for Question-41

42) The two-input voltage multiplier, shown in Fig. 20, has a scaling factor of 1 and produces voltage output. If $V_1 = +15$V and $V_2 = +3$V, the value of V_o in **volt** is _____.

(GATE IN 2017)

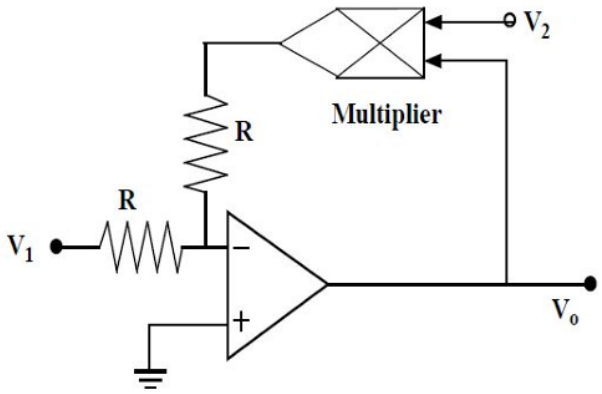

Fig. 20. Circuit Diagram for Question-42

43) The two inputs A and B are connected to an R-S latch via two AND gates as shown in Fig. 21. If A = 1 and B = 0, the output $Q\overline{Q}$ is

(GATE IN 2017)

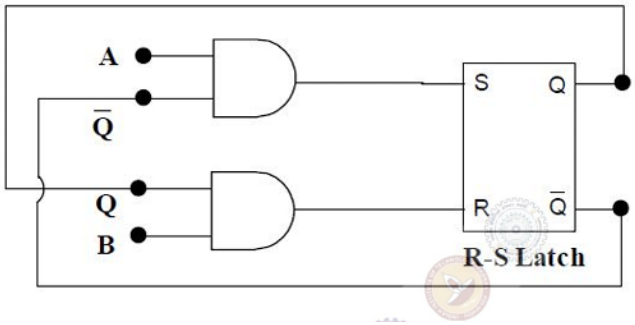

Fig. 21. Combination of AND Gates

a) 00 b) 10 c) 01 d) 11

44) The circuit of a Schmitt trigger is shown in Fig. 22. The zener-diode combination maintains the output between ±7V. The width of the hysteresis bandis _____ V.

(GATE IN 2017)

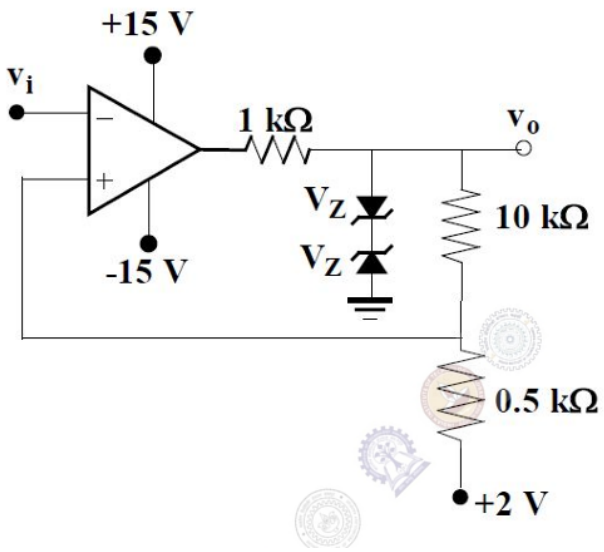

Fig. 22. Closed loop system

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

(GATE IN 2017)

46) 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 the transformers to be ideal. The power factor of the load is 0.8. If the wattmeter reading is 200W, then the apparent power of the load in **kVA** is _____.

(GATE IN 2017)

47) The unbalanced voltage of the Wheatstone bridge, shown in Fig. 23, is measured using a digital voltmeter having infinite input impedance and a resolution of 0.1**mV**. If R = 10000Ω, the minimum value of ΔR in Ω to create a detectable unbalanced voltage is _____.

(GATE IN 2017)

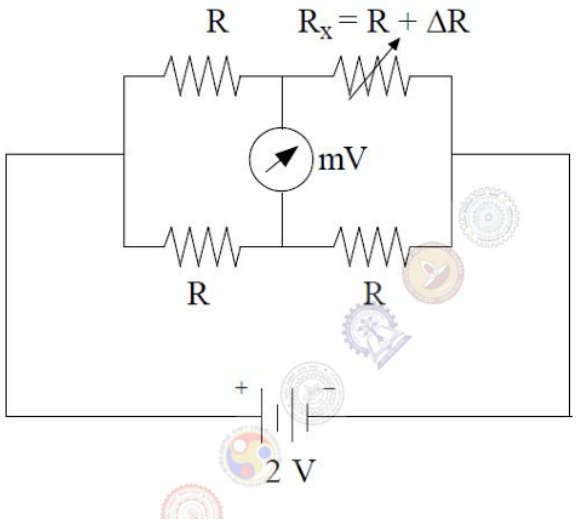

Fig. 23. Wheatstone Bridge

48) In the a.c. bridge, shown in Fig. 24, $R = 10^3\ \Omega$ and $C = 10^{-7}$F. If the bridge is balanced at a frequency ω_0, the value of ω_0 in rad/s is _____.

(GATE IN 2017)

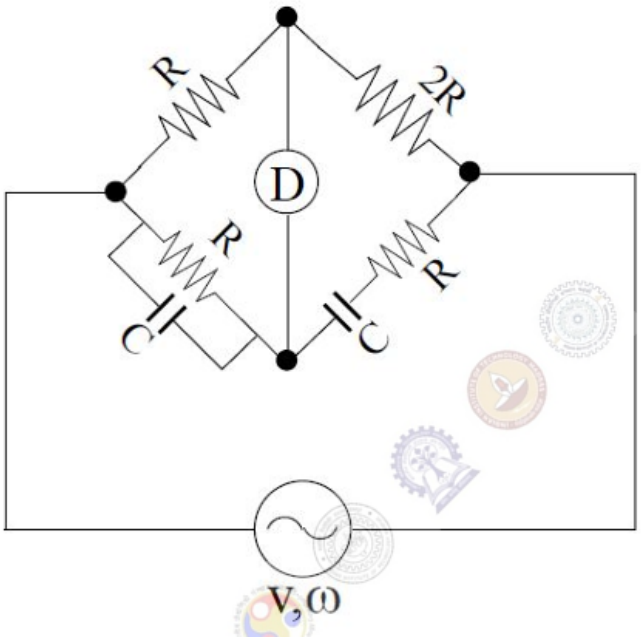

Fig. 24. AC Bridge

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

(GATE IN 2017)

50) A resistance temperature detector (RTD) is connected to a circuit, as shown in Fig. 25. Assume the opamp to be ideal. If $V = +2.0$V, then the value of x is _____.

(GATE IN 2017)

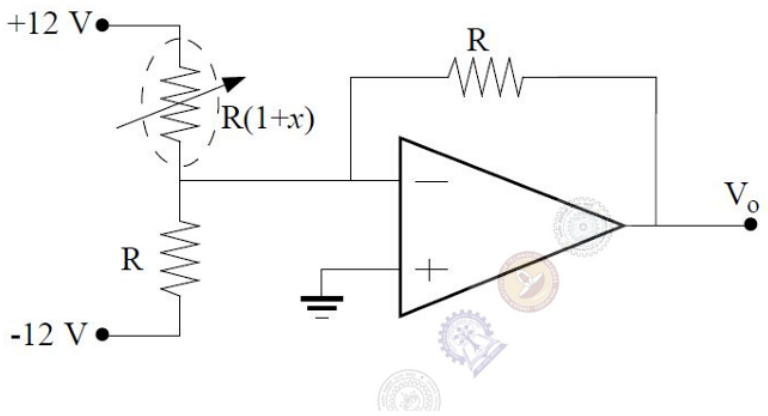

Fig. 25. Circuit Diagram for Question-50

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

(GATE IN 2017)

52) The junction semiconductor temperature sensor shown in Fig. 26 is used to measure the temperature of hot air. The output voltage V_o is 2.1V. The current output of the sensor is given by $I = T\mu$A where T is the temperature in K. Assuming the opamp to be ideal, the temperature of the hot air in °C is approximately _____.

(GATE IN 2017)

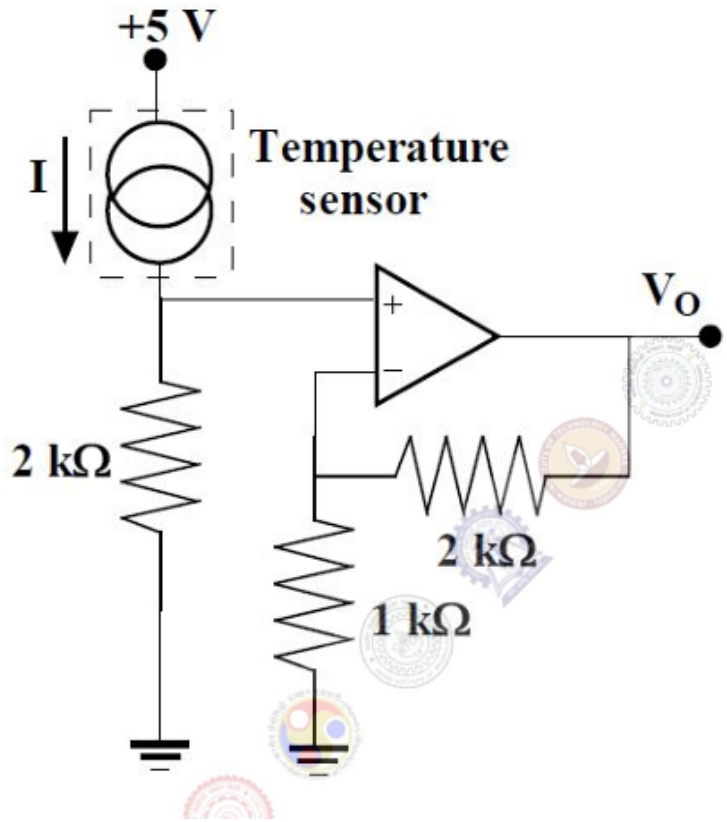

Fig. 26. Circuit Diagram for Question-52

53) Quantum efficiency of a photodiode (ratio between the number of liberated electrons and the number of incident photons) is 0.75 at 830nm. Given Planck's constant $h = 6.624 \times 10^{-34}$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 100 μW at 830nm, the photocurrent in μA is _____.

(GATE IN 2017)

54) 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 and ω_m is the modulation frequency. The power carried by the sidebands in % of total power is _____ %

(GATE IN 2017)

55) An angle modulated signal with carrier frequency $\omega_c = 2\pi\times10^6$rad/s is given by $4m(t) = \cos(\omega_c t + 5\sin(1000\pi t)$ The maximum deviation of the frequency in the angle modulated signal from that of the carrier is _____ kHz.

(GATE IN 2017)

56) The event would have been successful if you _____ able to come.

(GATE IN 2017)

a) are b) had been c) have been d) would have been

57) There was no doubt that their work was thorough. Which of the words below is closest in meaning to the underlined word above?

(GATE IN 2017)

a) pretty b) complete c) sloppy d) haphazard

58) 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

(GATE IN 2017)

a) 2, red b) 2, 3, red c) 2, blue d) 2, red, blue

59) What is the value of x when

$$81 \times \frac{x+2}{16} \div \frac{2x+4}{25} = 144 \ ?$$

(GATE IN 2017)

a) 1 b) -1 c) -2 d) Cannot be determined

60) 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

(GATE IN 2017)

a) $\frac{1}{9}$ b) $\frac{2}{9}$ c) $\frac{1}{3}$ d) $\frac{4}{9}$

61) 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?

(GATE IN 2017)

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.

62) A map shows the elevations 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 a lower elevation than Gangtok

(GATE IN 2017)

a) Only ii b) Only ii and iii c) Only ii and iv d) Only iii and iv

63) 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?

(GATE IN 2017)

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

64) 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

(GATE IN 2017)

a) 1 b) 4 c) 5 d) 6

65) The points in the graph below (Fig. 27) represent the halts of a lift for durations of 1 minute, over a period of 1 hour.

(GATE IN 2017)

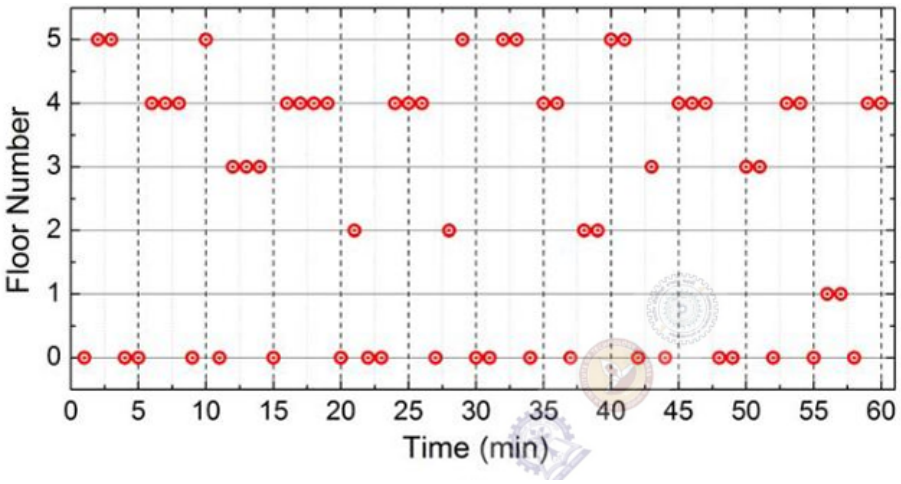

Fig. 27. Halts of a lift

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