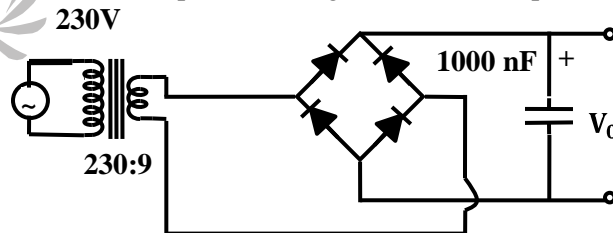


**Q. 1 – Q.30 carry one mark each**

1. Let A be a  $3 \times 3$  matrix with rank 2. Then  $AX = 0$  has  
 (A) only the trivial solution  $X = 0$  (C) two independent solutions  
 (B) one independent solution (D) three independent solutions
2. Identify which one of the following is an eigenvector of the matrix  $A = \begin{bmatrix} 1 & 0 \\ -1 & -2 \end{bmatrix}$   
 (A)  $[-1 \ 1]^T$  (C)  $[1 \ -1]^T$   
 (B)  $[3 \ -1]^T$  (D)  $[-2 \ 1]^T$
3. If  $f = a_0x^n + a_1x^{n-1}y + \dots + a_{n-1}xy^{n-1} + a_ny^n$ , where  $a_i$  ( $i = 0$  to  $n$ ) are constants, then  $x \frac{\partial f}{\partial x} + y \frac{\partial f}{\partial y}$  is  
 (A)  $\frac{f}{n}$  (C)  $nf$   
 (B)  $\frac{n}{f}$  (D)  $n\sqrt{f}$
4. If a vector  $\vec{R}(t)$  has a constant magnitude, then  
 (A)  $\vec{R} \cdot \frac{d\vec{R}}{dt} = 0$  (C)  $\vec{R} \cdot \vec{R} = \frac{d\vec{R}}{dt}$   
 (B)  $\vec{R} \times \frac{d\vec{R}}{dt} = 0$  (D)  $\vec{R} \times \vec{R} = \frac{d\vec{R}}{dt}$
5. The value of the integral  $\int_{-1}^1 \frac{1}{x^2} dx$  is  
 (A) 2 (C)  $-2$   
 (B) does not exist (D)  $\infty$
6. The probability that there are 53 Sundays in a randomly chosen leap year is  
 (A)  $\frac{1}{7}$   
 (B)  $\frac{1}{14}$   
 (C)  $\frac{1}{28}$   
 (D)  $\frac{2}{7}$
7. A mass of 10 kg is measured with an instrument and the readings are normally distributed with respect to the mean of 10 kg. Given that  $\frac{2}{\sqrt{2\pi}} \int_0^{0.84} \exp\left(-\frac{\eta^2}{2}\right) d\eta = 0.6$  and that 60 per cent of the readings are found to be within 0.05 kg from the mean, the standard deviation of the data is  
 (A) 0.02 (C) 0.06  
 (B) 0.04 (D) 0.08
8. The measurements of a source voltage are 5.9V, 5.7V and 6.1V. The sample standard deviation of the readings is  
 (A) 0.013 (B) 0.04

- (C) 0.115 (D) 0.2
9. The diameter of an aluminium sphere is found to be 50 mm at an atmospheric pressure of  $10^5$  Pa. The bulk modulus for aluminium is 68.6 GPa. The change in the diameter of the sphere in microns, when placed in vacuum is  
 (A) 0.018 (C) 0.032  
 (B) 0.024 (D) 0.038
10. In a flyball-type angular speed magnitude measuring device, the centrifugal force, given  $10^{-6} \omega^2$ , where  $\omega$  is the angular speed in rad/s, is transmitted to a spring with the non-linear characteristic  $F = 16 \pi^2 x^2$ , where  $F$  is the applied force and  $x$  is the spring compression in meters. The sensitivity of the device in mm.s is  
 (A)  $\frac{1}{\pi}$  (C)  $\frac{1}{3\pi}$   
 (B)  $\frac{1}{2\pi}$  (D)  $\frac{1}{4\pi}$
11. In a variable-area flowmeter (rotameter), the inlet tube diameter is the same as that of the effective float diameter and the tube taper is small. When the volume flow rate of a fluid is  $Q_1$ , the float stands at a height of 70 mm from the inlet and when the volume flow rate of the fluid  $Q_2$ , the float moves to a height of 20 mm from the inlet. The ratio of the flow rates  $Q_1/Q_2$  is  
 (A) 3.5 (C) 0.082  
 (B) 0.29 (D) 12.3
12. In a falling-ball viscometer, the ball attains terminal velocities of 0.01 m/s for oil A and 0.002 m/s for oil B. Assuming the oils have the same density and oil A has kinematic viscosity of  $5 \times 10^{-3}$  m<sup>2</sup>/s, the kinematic viscosity of oil B in m<sup>2</sup>/s is  
 (A)  $15 \times 10^{-3}$  (C)  $25 \times 10^{-3}$   
 (B)  $20 \times 10^{-3}$  (D)  $30 \times 10^{-3}$
13. The peak value of the output voltage  $V_0$  across the capacitor shown in the figure for a 230:9 transformer and a 230 V, 50 Hz, input, assuming 0.7 V diode drop and an ideal transformer, is

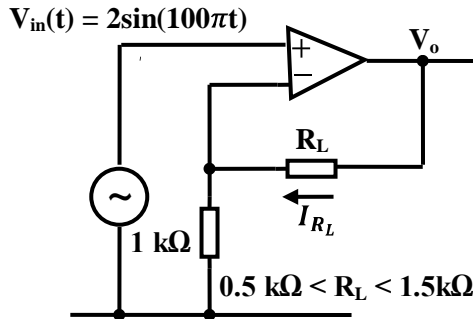


- (A) 12.73 (C) 7.6  
 (B) 11.33 (D) 9.0
14. Identify the transfer function corresponding to an all-pass filter from the following  
 (A)  $\frac{1-st}{1+st}$  (C)  $\frac{1}{1+st}$   
 (B)  $\frac{1+st_1}{1+st_2}$  (D)  $\frac{st}{1+st}$

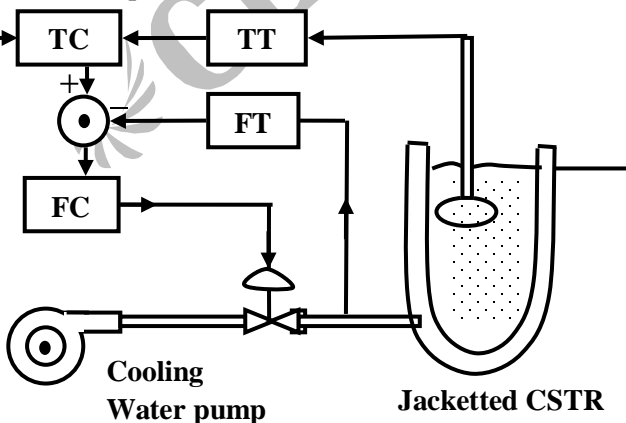
15. Given the discrete-time sequence  $x[n] = [2, 0, -1, -3, 4, 1, -1]$ ,  $X(e^{j\pi})$  is
- (A) 8  
(B)  $6\pi$   
(C)  $8\pi$   
(D) 6
16. A voltage signal  $V(t) = A + B \sin \omega t$  is fed to an oscilloscope with the coupling mode set to DC, other settings being appropriate. The displayed wave can be expressed as
- (A)  $A + B \sin \omega t$   
(B)  $B \sin \omega t$   
(C) A  
(D)  $|A + B \sin \omega t|$
17. An 8-bit 2's complement representation of an integer is FA (hex). Its decimal equivalent is
- (A) -10  
(B) -6  
(C) +6  
(D) +10
18. For N-bit Successive Approximation ADCs, other parameters such as clock frequency remaining constant, the conversion time is proportional to
- (A)  $N^2$   
(B)  $\sqrt{N}$   
(C)  $\log N$   
(D) N
19. The time period of a square wave in the audio frequency range is measured using an 8085 microprocessor by feeding the square wave to one of the four interrupts, namely, RST 7.5, RST 6.5, RST 5.5, or INT. The algorithm used starts a timer at the beginning of a time period, stops the timer at the beginning of the next time period and reads the timer values for time measurement. Which of the following interrupts should be selected for this application?
- (A) INTR  
(B) RST 5.5  
(C) RST 6.5  
(D) RST 7.5
20. An 8-bit microcontroller has an external RAM is the memory map from 8000H to 9FFFH. The number of bytes this RAM can store is
- (A) 8193  
(B) 8191  
(C) 8192  
(D) 8000
21. In an 8085 microprocessor, which one of the following is the correct sequence of the machine cycles for the execution of the DCR M instruction?
- (A) op-code fetch  
(B) op-code fetch, memory read, memory write  
(C) op-code fetch memory read  
(D) op-code fetch memory write, memory write
22. A thermometer at room temperature  $30^\circ\text{C}$  is dipped suddenly into a bath of boiling water at  $100^\circ\text{C}$ . It takes 30 seconds to reach  $96.5^\circ\text{C}$ . The time required to reach a temperature of  $98^\circ\text{C}$  is
- (A) 32.5 s  
(B) 34.6 s

- (C) 35.6 s (D) 38.6 s

23. In the circuit shown in the given figure the input voltage  $V_{in}(t)$  is given by  $2 \sin(100\pi t)$ . For  $R_L$  in the range  $0.5 \text{ k}\Omega$  to  $1.5 \text{ k}\Omega$ , the current through  $R_L$  is



- (A)  $+2 \sin(100\pi t)$  mA  
 (B)  $-2 \sin(100\pi t)$  mA  
 (C)  $+0.5 \sin(100\pi t)$  mA  
 (D)  $1.5 \sin(100\pi t)$  mA
24. A single input single output linear system is described by the equations  $\frac{dx}{dt} = Ax + bu$  and  $y = cx + du$ , where  $A$  is an  $[n \times n]$  matrix and  $x$  and  $b$  are  $[n \times 1]$  vectors. The transfer function is given by
- (A)  $c[sI - A]^{-1}b$  (C)  $c[sI - A]b$   
 (B)  $c[sI - A]^{-1}b + d$  (D)  $c[sI - A]b + d$
25. A control loop structure is shown in the figure with FC, FT, TC and TT denoting Flow Controller, Flow Transmitter, Temperature Controller and Temperature Transmitter respectively. This loop is an example of



- (A) Ratio Control (C) Split Range Control  
 (B) Feed forward Control (D) Cascade Control

26. The P wave, QRS complex and T wave in one heart cycle of the ECG waveform correspond respectively to
- (A) polarization of atria; depolarization of ventricles and repolarization of atria  
 (B) polarization of atria; polarization of ventricles and repolarization of atria  
 (C) depolarization of atria; depolarization of ventricles and repolarization of atria  
 (D) depolarization of atria; repolarization of ventricles and depolarization of atria

27. Choose the correct match for signals and biological activity

P. EEG	1. Eye movement
Q. EOG	2. Gastric motility
R. EMG	3. Muscle activity
S. EGG	4. Brain activity
	5. Heart activity
	6. Bladder activity

The matching pairs are

- (A) P-4, Q-5, R-4, S-3  
 (B) P-4, Q-1, R-3, S-2  
 (C) P-3, Q-2, R-6, S-1  
 (D) P-2, Q-3, R-1, S-6
28. A cranial generator has a peak-to-peak voltage of  $100 \mu\text{V}$  and a source resistance of  $10 \text{ k}\Omega$ . If the electrode resistances are  $20 \text{ k}\Omega$ , the voltage across the amplifier terminals with an input impedance of  $10 \text{ M}\Omega$ , is
- (A)  $93.5 \mu\text{V}$   
 (B)  $95.5 \mu\text{V}$   
 (C)  $97.5 \mu\text{V}$   
 (D)  $99.5 \mu\text{V}$
29. The longitudinal mode separation in a gas laser with a cavity length of  $0.4 \text{ m}$  (given velocity of light  $= 3 \times 10^8 \text{ m/s}$ ) is
- (A)  $374 \text{ MHz}$   
 (B)  $375 \text{ MHz}$   
 (C)  $748 \text{ MHz}$   
 (D)  $750 \text{ MHz}$

30. The continuous-time signal  $x(t) = \frac{1}{a^2+t^2}$  has the Fourier transform  $\frac{\pi}{a} \exp(-a|\omega|)$ . The signal  $x(t) \cos bt$  has the Fourier transform
- (A)  $\frac{\pi}{2a} [\exp(-a|\omega - b|) + \exp(-a|\omega + b|)]$   
 (B)  $\frac{\pi}{2a} [\exp(-a|\omega|) + \exp(-a|\omega|)]$   
 (C)  $\frac{\pi}{a} [\exp(-a|\omega|) \cos b\omega]$   
 (D)  $\frac{\pi}{2a} [\exp(-a|\omega - b|) - \exp(-a|\omega + b|)]$

**Q. 31 to Q. 80 carry two marks each**

31. Using the given data points tabulated below, a straight line passing through the origin is fitted using least square method. The slope of the line is

x	1.0	2.0	3.0
y	1.5	2.2	2.7

- (A) 0.9  
(B) 1.0  
(C) 1.1  
(D) 1.5
32. Consider the circle  $|z - 5 - 5i| = 2$  in the complex plane  $(x,y)$  with  $z = x + iy$ . The minimum distance from the origin to the circle is  
(A)  $5\sqrt{2} - 2$   
(B)  $\sqrt{54}$   
(C)  $\sqrt{34}$   
(D)  $5\sqrt{2}$
33. Let  $z^3 = \bar{z}$ , where  $z$  is a complex number not equal to zero. Then  $z$  is a solution of  
(A)  $z^2 = 1$   
(B)  $z^3 = 1$   
(C)  $z^4 = 1$   
(D)  $z^9 = 1$
34. Given a real-valued continuous function  $f(t)$  defined over  $[0,1]$ ,  $\lim_{t \rightarrow 0} \frac{1}{t} \int_0^t f(x) dx$  is  
(A)  $\infty$   
(B) 0  
(C)  $f(1)$   
(D)  $f(0)$
35. The curves, for which the curvature  $\rho$  at any point is equal to  $\cos^3\theta$ , where  $\theta$  is the angle made by the tangent at that point with the positive direction of the  $x$ -axis, are (given  $\rho = y'' \sqrt{1 + (y')^2}^{3/2}$ , where  $y'$  and  $y''$  are the first and second derivatives of  $y$  with respect to  $x$ )  
(A) circles  
(B) parabolas  
(C) ellipses  
(D) hyperbolas
36. The general solution of the differential equation  $(D^2 - 4D + 4)y = 0$ , is of the form (given  $D = d/dx$ ), and  $C_1$  and  $C_2$  are constants  
(A)  $C_1 e^{2x}$   
(B)  $C_1 e^{2x} + C_2 e^{-2x}$   
(C)  $C_1 e^{2x} + C_2 x e^{2x}$   
(D)  $C_1 e^{2x} + C_2 x e^{-2x}$

37. A scalar field is given by  $f = x^{2/3} + y^{2/3}$ , where  $x$  and  $y$  are the Cartesian coordinates. The derivative of  $f$  along the line  $y = x$  directed away from the origin, at the point  $(8,8)$  is
- (A)  $\frac{\sqrt{2}}{3}$  (C)  $\frac{2}{\sqrt{3}}$   
(B)  $\frac{\sqrt{3}}{2}$  (D)  $\frac{3}{\sqrt{2}}$
38. A temperature sensor having a range of  $0-100^\circ\text{C}$  has a worst case accuracy specification of  $\pm 1.0\%$  of true value or  $\pm 0.3\%$  of full scale, whichever is higher. The sensitivity of the sensor is experimentally obtained by taking its readings at true temperatures  $25^\circ\text{C}$  and  $75^\circ\text{C}$ . The maximum error in sensitivity, expressed as percentage of its ideal value is
- (A)  $\pm 0.105\%$  (C)  $\pm 1.05\%$   
(B)  $\pm 0.21\%$  (D)  $\pm 2.1\%$
39. Position sensor units having a constant sensitivity of  $1\text{V/mm}$  are used for feedback in number of position controlled system units, each having an overall forward path dc gain of 50. If the random dc bias errors in the outputs of various sensor units are characterized as normal with mean 0 and standard deviation ( $\sigma$ )  $0.01\text{V}$ , for a constant set point of  $5\text{V}$ , the true position outputs of the various controlled system units can be characterized as normal with
- (A) mean of 5.0,  $\sigma$  of 0.01 (C) mean of 5.0,  $\sigma$  of 0.0098  
(B) mean of 0.0,  $\sigma$  of 0.01 (D) mean of 4.902,  $\sigma$  of 0.0098
40. A surface height profile is given by,  $y = a + b \sin \frac{2\pi x}{l} (0 \leq x \leq l)$  where  $a, b, l$  are constants and  $x$  is the horizontal coordinate. The roughness of the surface, based on absolute deviation, is
- (A)  $\frac{2b}{\pi}$  (C)  $\frac{6b}{\pi}$   
(B)  $\frac{4b}{\pi}$  (D)  $\frac{8b}{\pi}$
41. A mercury barometer reads  $h$  mm Hg with the temperature of the mercury at  $T^\circ\text{C}$ . The barometer reading corrected for the standard temperature  $0^\circ\text{C}$  with  $\beta$  denoting the volumetric expansion coefficient of mercury in  $0^\circ\text{C}^{-1}$ , is
- (A)  $\frac{h}{1+\beta T}$   
(B)  $h(\beta + T)$   
(C)  $h(1+\beta T)$   
(D)  $h(\beta - T)$
42. The fundamental period of the sequence  $x[n] = 3 \sin(1.3 \pi n + 0.5 \pi) + 5 \sin(1.2 \pi n)$  is
- (A) 20 (B)  $\frac{2\pi}{1.3\pi}$

(C)  $\frac{2\pi}{1.2\pi}$

(D) 10

43. An analog low-pass filter is needed with the following specifications:

Pass-band:  $0.9 \leq |H(j\omega)| \leq 1, 0 \leq \omega \leq 2\pi \times 1000$ ;

Stop-band:  $|H(j\omega)| \leq 0.2, \omega \geq 2\pi \times 1500$ .

The minimum order  $N$  of the Butterworth filter to approximate the above is

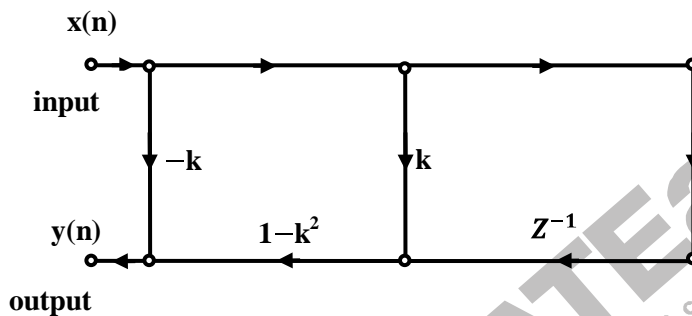
(A) 6

(C) 12

(B) 11

(D) 15

44. A discrete-time system is shown in the figure. The system function,  $H(z)$ , of the network is given by



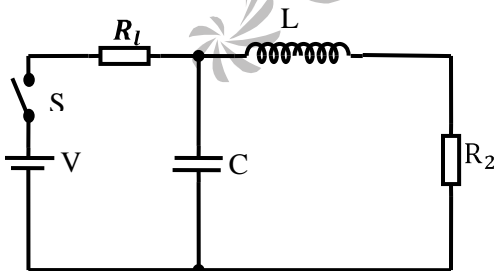
(A)  $\frac{-k+z^{-1}}{1-(1-k^2)z^{-1}}$

(C)  $\frac{1-(1-k^2)z^{-1}}{1-kz^{-1}}$

(B)  $\frac{(1-k^2)+z^{-1}}{1-kz^{-1}}$

(D)  $\frac{-k+z^{-1}}{1-kz^{-1}}$

45. In the circuit shown in the figure, the switch  $S$  is closed at time  $t = 0$ . The supply current at  $t = 0^+$  and the capacitor voltage at  $t \rightarrow \infty$  are, respectively



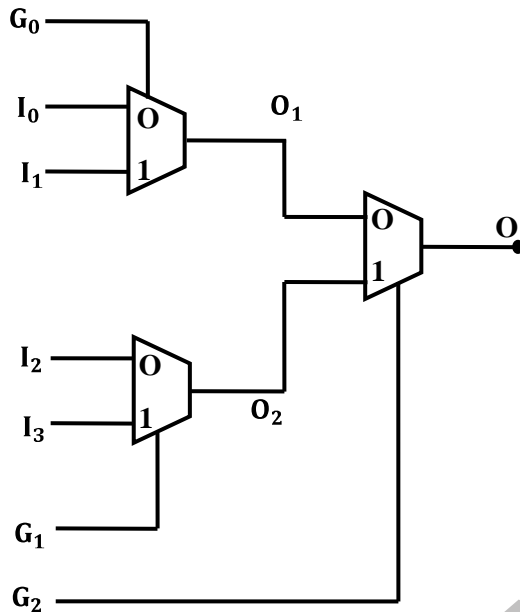
(A) 0 and  $V$

(B)  $\frac{V}{R_1}$  and  $\frac{VR_2}{R_1+R_2}$

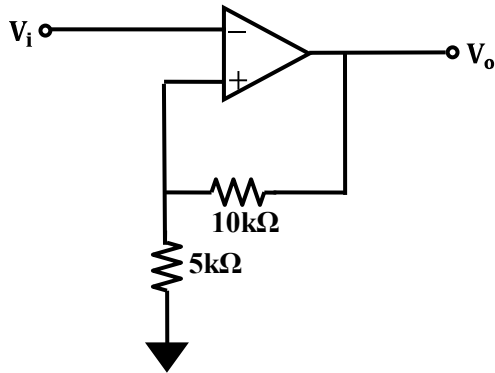
(C)  $\frac{V}{R_1+R_2}$  and  $\frac{VR_2}{R_1+R_2}$

(D)  $\frac{V}{R_1}$  and  $V$

46. The cell of a Field Programmable Gate Array is shown in the figure. It has three 2-to-1-multiplexers with their select lines  $G_0, G_1, G_2$  and 4 digital signal input lines  $I_0, I_1, I_2$  and  $I_3$ . The logical function that relates the output  $O$  to the select and signal input lines is

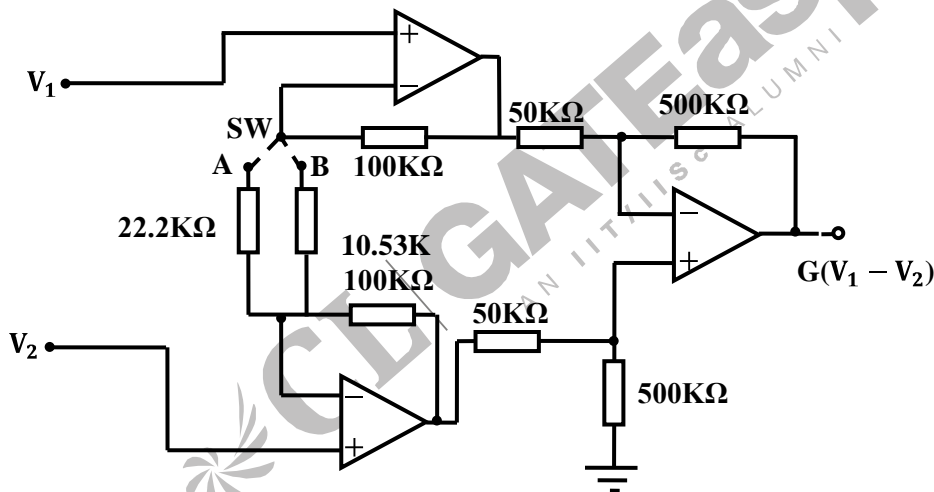


- (A)  $\overline{G_0} \overline{G_1} I_2 + \overline{G_0} G_1 I_3 + \overline{G_2} \overline{G_1} I_0 + \overline{G_2} G_1 I_1$  (C)  $\overline{G_0} \overline{G_2} I_0 + G_0 \overline{G_2} I_1 + G_2 G_1 I_2 + G_2 G_1 I_3$   
 (B)  $\overline{G_0} I_2 + \overline{G_0} G_1 + \overline{G_2} I_0 + \overline{G_2} G_1 I_1 + G_0$  (D)  $G_2 G_1 \overline{I_2} + \overline{G_2} \overline{G_1} \overline{I_3} + G_2 \overline{G_0} I_0 + G_0 \overline{G_2} \overline{I_1}$
47. The input-output characteristic of a Schmidt trigger has a hysteresis band of  $\pm 0.1V$ . If the input voltage is  $5 \sin(1000 \pi t)$ , the delay between the corresponding zero cross-over points of the output and input signals is
- (A)  $6.37 \mu s$  (C)  $63.7 \mu s$   
 (B)  $0.02 \mu s$  (D)  $2.0 \mu s$
48. In the circuit shown in the figure the input voltage  $V_i$  is a symmetrical saw-tooth wave of average value zero, positive slope and peak-to-peak value  $20V$ . The average value of the output, assuming an ideal operational amplifier with peak-to-peak symmetrical swing of  $30V$ , is



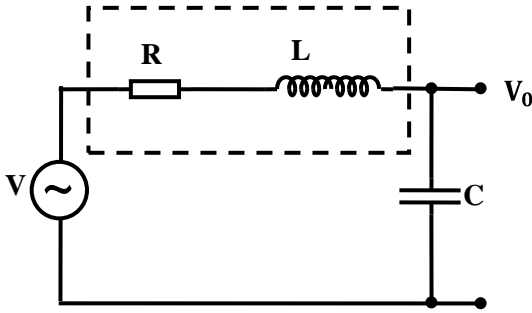
- (A) 5 V  
 (B) 10 V  
 (C) -5 V  
 (D) 7.5 V

49. In the instrumentation amplifier shown in the figure if the switch SW is changed from position A to B, the values of the amplifier gain  $G$  before and after changing the switch respectively are



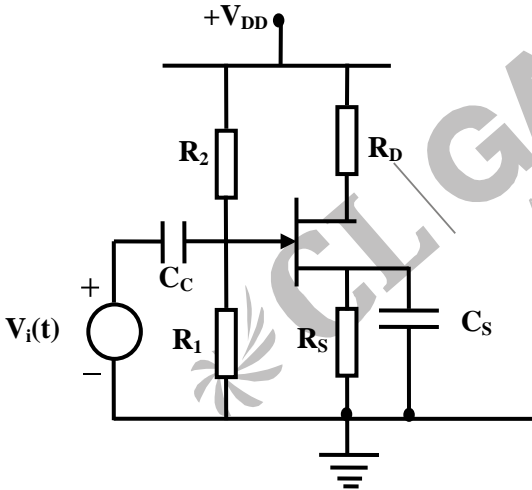
- (A) 45, 95  
 (B) 50, 100  
 (C) 100, 200  
 (D) 90, 180

50. Figure shows a circuit which has a coil of resistance  $R$  and inductance  $L$ . At resonance, the  $Q$ -factor of the coil is given by



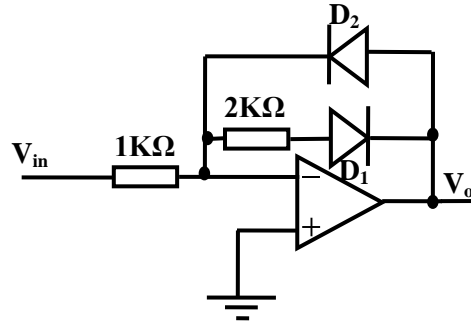
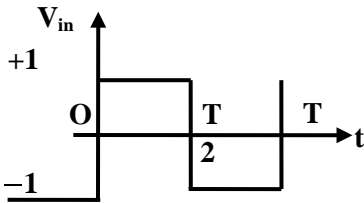
- (A)  $\left(\frac{V-V_0}{V}\right)$  (C)  $\left(\frac{V-V_0}{V_0}\right)$   
 (B)  $\frac{V_0}{V}$  (D)  $\frac{V}{V_0}$

51. For the circuit shown in the figure,  $I_{DSQ}$  (in mA) and  $V_{GSQ}$  (in V) are related through  $2I_{DSQ} = (4 + V_{GSQ})^2$ . The following data is given:  
 $V_{DD} = 15$  V,  $R_1 = 1.0$  M $\Omega$ ,  $R_2 = 6.5$  M $\Omega$ ,  
 $R_D = 2.0$  k $\Omega$ ,  $R_S = 1.0$  k $\Omega$ ,  $I_{DSS} = 8$  mA.  
 The value of  $I_{DSQ}$ , assuming the gate current is negligible, is approximately equal to



- (A) 5 mA (C) 2.3  $\mu$ A  
 (B) 2.0 nA (D) 3.4 mA

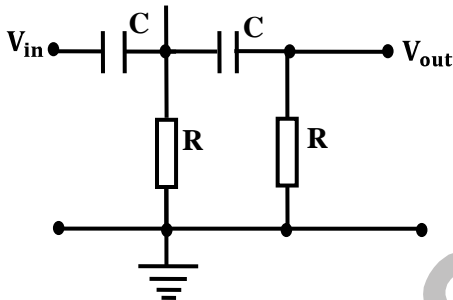
52. In the circuit shown in the figure, assuming ideal diode characteristics with zero forward resistance and 0.7V forward drop, the average value of  $V_0$  when the input wave form is as shown, is



- (A)  $-0.7\text{ V}$
- (B)  $-1.0\text{ V}$

- (C)  $-2.0\text{ V}$
- (D)  $-2.7\text{ V}$

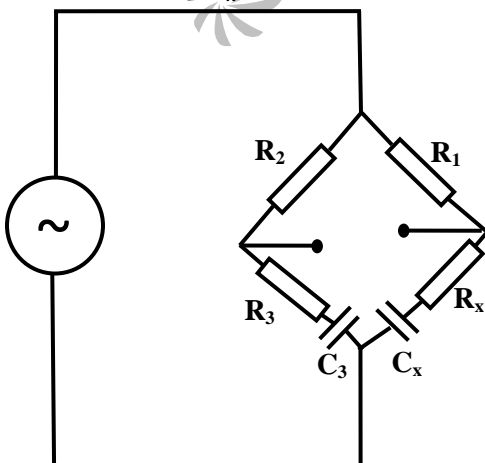
53. For the RC circuit shown in the figure, the condition for obtaining an attenuation,  $|V_{out}/V_{in}|$ , of  $1/3$  at a frequency  $\omega$  rad/s is



- (A)  $3\omega CR - 1 = 0$
- (B)  $2\omega CR - 1 = 0$

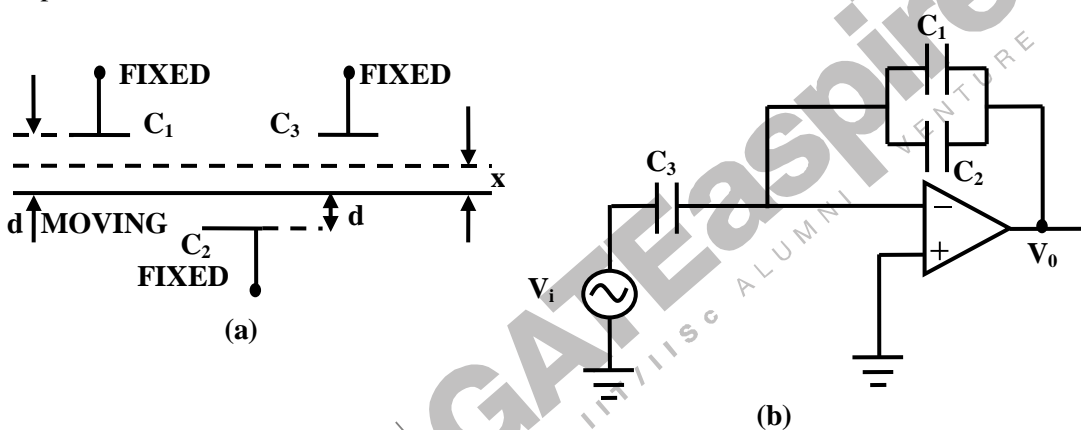
- (C)  $3\omega CR - 2 = 0$
- (D)  $\omega CR - 1 = 0$

54. The bridge shown in Fig. Q. 54 is balanced. The dissipation factor for the unknown lossy capacitor  $R_x + \frac{1}{j\omega C_x}$  is



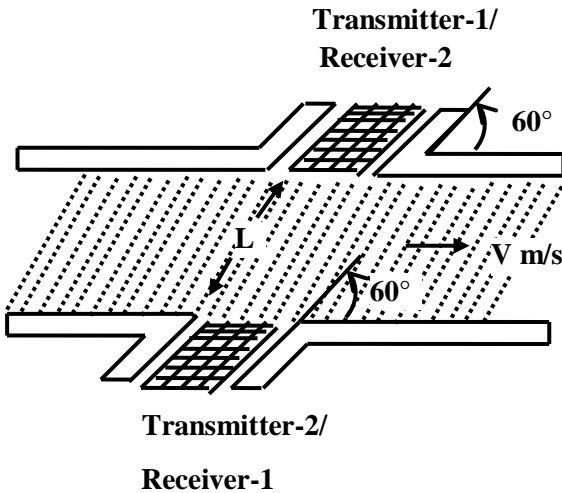
- (A)  $\omega R_2 C_3$  (C)  $\omega R_3 C_3$   
 (B)  $\frac{\omega R_1^2 C_3}{R_2}$  (D)  $\frac{R_1}{R_2}$

55. Three parallel-plate air capacitors of equal plate area  $A$  are formed, as shown in the Fig.  $a$ , for measuring zero mean vibrational displacement. The capacitors have three separate fixed plates and one common moving plate, which are connected as shown in Fig.  $b$ . When the displacement,  $x$ , is zero, the distance separating the fixed plates from the common moving plate is the same, equal to  $d$ . The circuit is excited by a sinusoidal voltage  $V_i \sin \omega t$ . Neglecting fringe effects and the possibility of saturation of the opamp output, the output voltage  $V_0$  normalised by  $V_i$  for a displacement  $x$  is



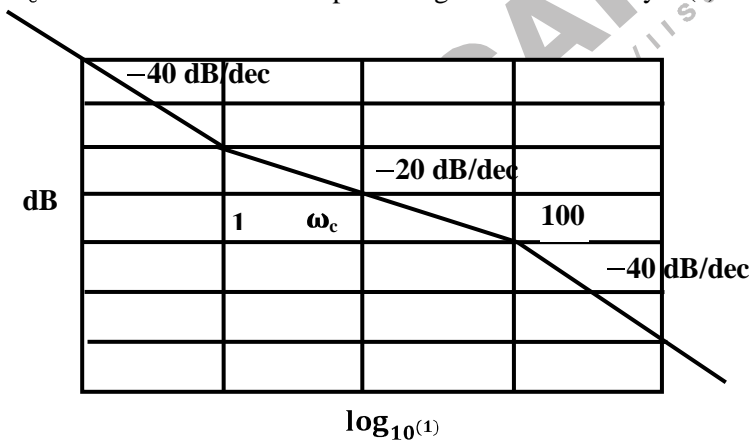
- (A)  $\frac{1}{2} + \frac{x}{d}$  (C)  $-\frac{2x}{d^2} - x^2$   
 (B)  $\frac{1}{2} + \frac{x}{2d}$  (D)  $\frac{1}{2}$

56. Figure given below shows an ultrasound flowmeter with the transducers separated by a distance  $L = 25$  mm with the line joining the transducers making an angle  $60^\circ$  with the direction of the flow. The transit time difference between upstream and downstream measurements is 10 ns with the sound velocity in the medium being 1000 m/s. Assuming that the size of the transducers is very small as compared to the diameter of the pipe, the flow velocity is



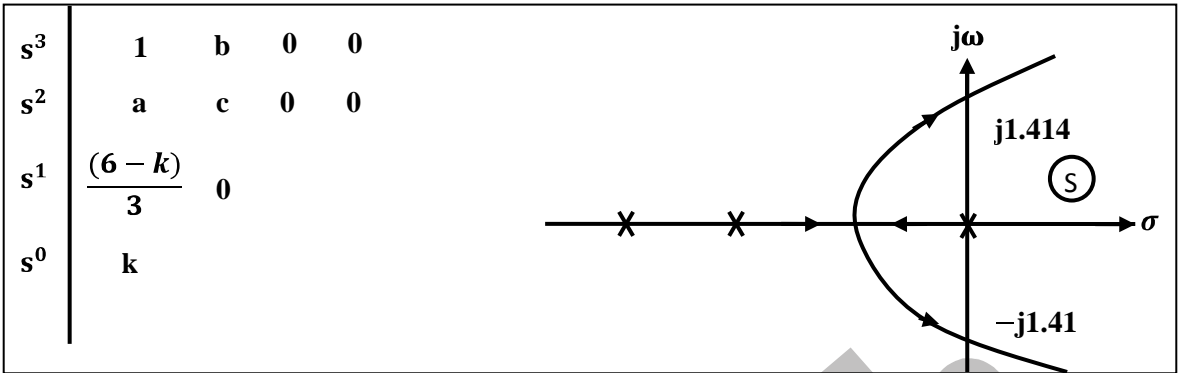
- (A) 0.2 m/s
- (B) 2 m/s
- (C) 0.4 m/s
- (D) 40 m/s

57. The asymptotic magnitude Bode plot of an open loop system  $G(s)$  with  $K > 0$  and all poles and zeros on the left hand side of the  $s$ -plane is shown in the figure. It is completely symmetric about  $\omega_c$ . The minimum absolute phase angle contribution by  $G(s)$  is given by



- (A)  $78.6^\circ$
- (B)  $90^\circ$
- (C)  $101.4^\circ$
- (D)  $180^\circ$

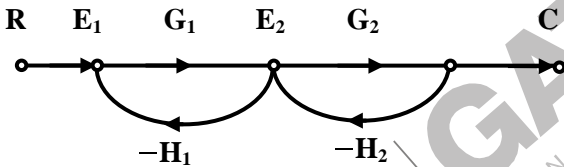
58. The Routh-Hurwitz array is given for a third order characteristic equation.



The coefficients  $a$ ,  $b$ ,  $c$ , and  $k$  are such that  $a = 3$ ,  $b > 0$ ,  $k > 0$ ,  $c > 0$  and  $c$  is a function of  $k$ . The root locus for the corresponding characteristic equation is as shown in the given figure. The values of  $k$  and  $c$  for critical stability respectively are

- (A) 6 and 6  
 (B) 6 and 2  
 (C) 3 and 2  
 (D) 3 and 3

59. The transfer function of the open loop system  $G(s)$  which is represented by the signal flow graph shown the figure below is



- (A)  $\frac{G_1 G_2}{1 + G_1 H_1 + G_2 H_2}$   
 (B)  $\frac{G_1 G_2}{1 + G_1 H_1 G_2 H_2}$   
 (C)  $\frac{G_1 G_2}{(1 + G_1 H_1)(1 + G_2 H_2)}$   
 (D)  $\frac{G_1 G_2}{1 + (G_1 + H_1)(G_2 + H_2)}$

60. The open loop part of a unity feed back control system  $G(s)$  is unstable and has two poles on the right hand side of the  $s$ -plane. However, the closed loop system is stable. The number of encirclements made by the Nyquist plot of the  $(-1, 0)$  point in the  $G(s)$  plane is

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

61. Consider a unity feedback control system whose forward path transfer function  $G(s) = K/s^2$ . The steady state error, for a step input is

- (A) 1.0  
 (B)  $\infty$   
 (C) 0.0  
 (D) does not exist

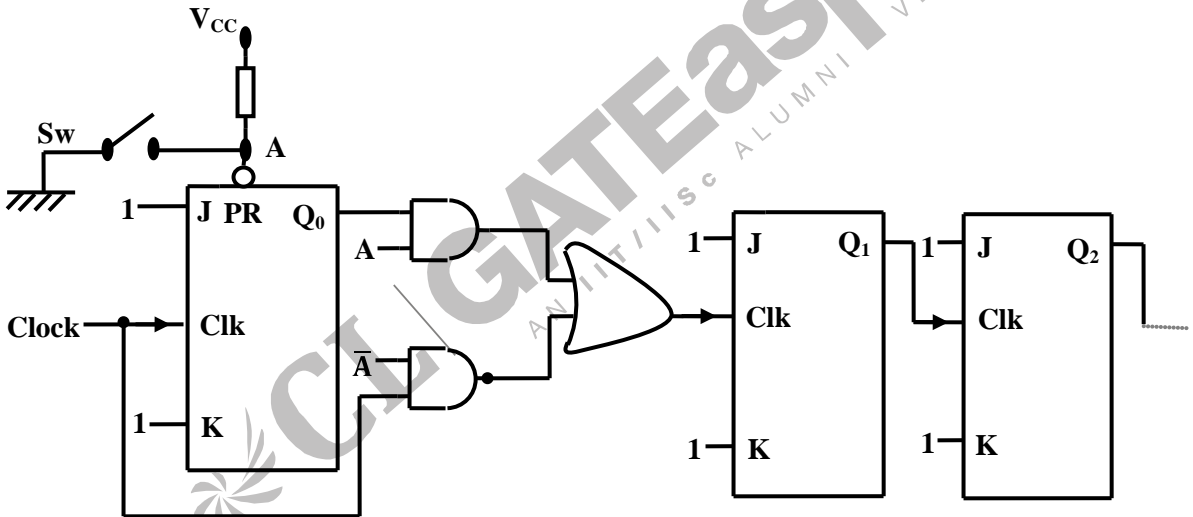
62. A single stack stepper motor has 4-stator slots and 18 permanent magnet type rotor pole faces. The step size under half stepping scheme is
- (A)  $5^\circ$  (C)  $15^\circ$   
(B)  $10^\circ$  (D)  $20^\circ$
63. Two ionic species A and B of masses in the ratio 1:2 and of equal charge are simultaneously accelerated in a time of flight mass-spectrometer. When ion A reaches the end of a 1 m drift tube, ion B would be at a distance of
- (A)  $\sqrt{2}m$   
(B)  $\sqrt{2} - 1m$   
(C)  $\frac{1}{\sqrt{2}}m$   
(D)  $\frac{1}{2}m$
64. A spectrophotometer is used to measure concentration of a molecule in a solution based on Beer's law using a cuvette of path length 10 mm and detectable absorbance of 0.01. The molar absorptivity of the solution is  $10^4$  litres/mol/cm. The minimum concentration of the solution that can be detected is
- (A)  $1 \mu\text{ mol/litre}$  (C)  $5 \mu\text{ mol/litre}$   
(B)  $2 \mu\text{ mol/litre}$  (D)  $10 \mu\text{ mol/litre}$
65. The maximum solid angle of acceptance of light coupled into a step index fibre having core and cladding refractive indices of 1.48 and 1.45 respectively, is
- (A) 0.28 steradians (C) 0.32 steradians  
(B) 0.30 steradians (D) 0.34 steradians
66. A microprocessor has an instruction XOR ( $r_p, r_2$ ), which performs an Exclusive OR operation of registers  $r_p$   $r_2$  and stores the result in  $r_1$ . After the following instructions are executed
- XOR ( $r_2, r_1$ )  
XOR ( $r_1, r_2$ )  
XOR ( $r_2, r_1$ )
- Which one of the following is true?
- (A) Content of register  $r_1$  is half sum of  $r_1$  and  $r_2$   
(B) Content of register  $r_2$  is half sum of  $r_1$  and  $r_2$   
(C) Content of register  $r_1$  and  $r_2$  remain unaltered  
(D) Content of register  $r_1$  and  $r_2$  are swapped

67. In a 8085 microprocessor the value of the stack pointer (SP) is 2010H and that of DE register pair is 1234H before the following code is executed. The value of the DE register pair after the following code is executed is

```
LXI H,      0000H
PUSH       H
PUSH       H
POP        B
DAD        SP
XCHG
```

- (A) 200 EH
- (B) 200 CH
- (C) 2010 H
- (D) 1232 H

68. For the digital counter shown in the figure with outputs  $Q_0, Q_1, Q_2, \dots, Q_n$  where  $Q_0$  indicates the LSB of the count value, the correct statement when the switch Sw is closed, is



- (A) Counter outputs are both even and odd numbers
- (B) Counter outputs are only odd numbers
- (C) Counter outputs are only even numbers
- (D) Counter stops counting

69. A combinational logic circuit has three inputs A, B and C and one output Y. The output  $Y = 1$  when at least two inputs are 1. Otherwise,  $Y = 0$ . In its minimized SOP realization, the maximum number of two-input terms is

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

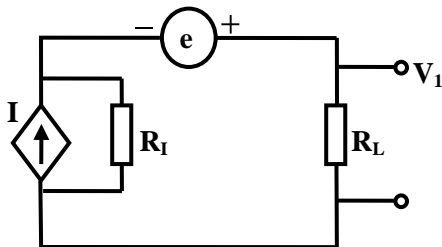
70. Notwithstanding overflow, the addition and subtraction of K-bit signed binary numbers can be realized using

One K-bit full adder and

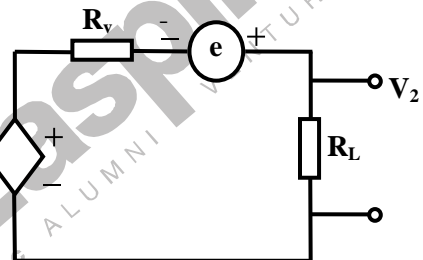
- (A) K2 – Input AND Gates  
(B) K2 – Input NOR Gates

- (C) K2 – Input OR Gates  
(D) K2 – Input XOR Gates

71. Figs. (a) and (b) depict a simplified representation of the effect of series mode voltage noise on 2-wire transmission of analog signals. I and V represent information sources transmitting in voltage and current modes,  $R_L$  is the load resistance and  $R_1$  and  $R_V$  are the corresponding source resistances. For comparable full scale readings, let  $V = IR_L$ . Also let  $R_1 = 100R_L$  and  $R_V = R_L/100$ . For a given noise voltage magnitude e, the errors caused by e are  $V_{e1}$  and  $V_{e2}$  in the displayed voltages  $V_1$  and  $V_2$  respectively. The ratio  $V_{e1}/V_{e2}$  is



(a)



(b)

- (A) 0.01  
(B) 1

- (C) 100  
(D)  $0^{-4}$

72. The output from a 633 nm He-Ne laser comes out from the mirror with a beam diameter of 1 mm and diverges to the far field. It is brought to a focus by a convex lens of focal length of 17 mm. The spot size diameter of the beam at the focal point is

- (A)  $20 \mu m$   
(B)  $26 \mu m$

- (C)  $52 \mu m$   
(D)  $13 \mu m$

73. The exact diffusion potential across an electrochemical cell membrane due to  $\text{Na}^+$  ion concentration is 60mV. In Case I, two silver electrodes are used to measure the potential and in Case II, one silver electrode and one gold electrode are used. In Case I, the diffusion potential is measured as 60 mV without error. The concentration ratio of  $\text{Na}^+$  ions across the membrane, and the voltage error in Case II are respectively

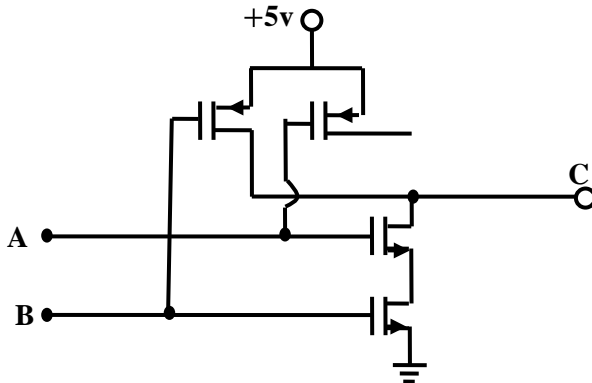
- (A) 10; 0 mV  
(B) 10; 1150 mV

- (C) 10; 700 mV  
(D) 10; 2300 mV

74. The two-wattmeter method is used to measure power in a balanced 3-phase circuit, drawing lagging current. The power factor if one of the wattmeters reads zero is

- (A) 0.5 (C) 1.0  
(B) 0.8 (D) 0.0

75. Identify the logic gate given in the figure.



- (A) NOR (C) AND  
(B) NAND (D) OR

**Common Data for Questions 76, 77, 78:**

The temperature – emf characteristics of iron– constantan and copper–constantan junctions, with the reference junctions at  $0^{\circ}\text{C}$ , are given by  $E_{IC} = 53T\mu\text{V}$  and  $E_{CC} = 43T\mu\text{V}$ , over an appropriate temperature range, where  $T$  is in  $^{\circ}\text{C}$ . It is known that AD 590 is an IC temperature sensor which can drive a current of  $(273+T)\mu\text{A}$  at  $T^{\circ}\text{C}$  into an appropriate load resistance.

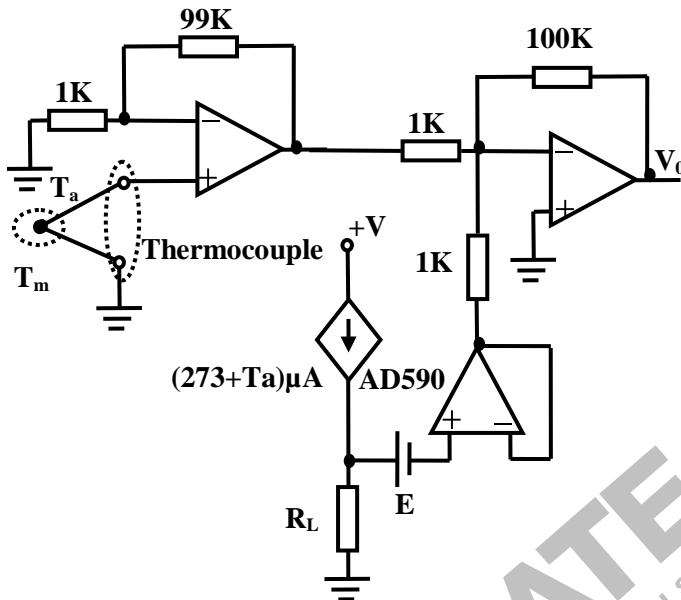
76. An iron-constantan thermocouple has its measuring junction in a both whose temperature can vary between  $100^{\circ}\text{C} - 200^{\circ}\text{C}$ . The reference junction is maintained at ambient temperature. If the emf developed is to correspond to that with the reference junction at  $0^{\circ}\text{C}$ , the maximum error, expressed as a percentage of the emf developed, due to ambient temperature variation in the range  $0^{\circ}\text{C} - 45^{\circ}\text{C}$ , is

- (A) 8.182 (C) 45  
(B) 22.5 (D) 81.82

77. A thermocouple is made using a copper and an iron wire. Its measuring junction is kept at a temperature of  $100^{\circ}\text{C}$  and the reference junction is kept at the ambient temperature of  $30^{\circ}\text{C}$ . The emf developed would be

- (A)  $700\mu\text{V}$  (C)  $3010\mu\text{V}$   
(B)  $1000\mu\text{V}$  (D)  $5300\mu\text{V}$

78. A voltage generated using a AD590 sensor is used to compensate for ambient temperature error for the iron-constantan thermocouple in the circuit shown in the figure such that the output voltage  $V_0$  is proportional to the measuring junction temperature  $T_m$ . The values of  $R_L$  and  $E$  for exact compensation, assuming ideal components, are



- (A) 1 k $\Omega$ , 273 mV  
 (B) 4.3 k $\Omega$ , 1.174 V  
 (C) 5.3 k $\Omega$ , 1.447V  
 (D) 1 k $\Omega$ , 303 mV

**Common Date for Questions 79, 80**

A bonded metal strain gauge has the following specifications:

Gauge factor = 2.0

Unstrained resistance = 120  $\Omega$  at 0  $^{\circ}\text{C}$

Maximum operating temperature = 150 $^{\circ}\text{C}$

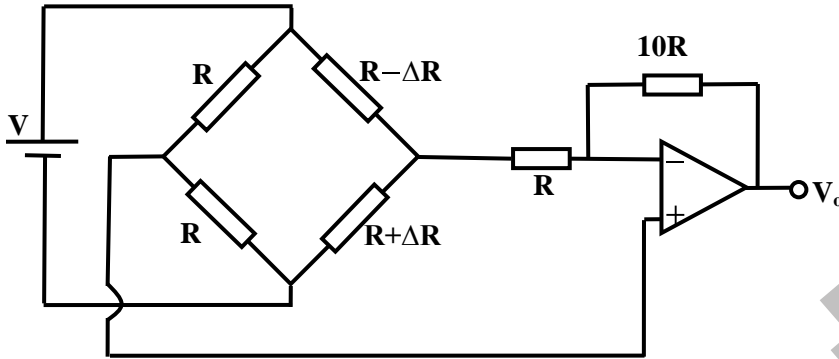
Temperature coefficient of resistance =  $(2 \times 10^{-5})$   $^{\circ}\text{C}^{-1}$

Maximum tensile and compressive strain =  $2 \times 10^{-2}$

79. The temperature induced resistance error at the maximum operating temperature expressed as the percentage of resistance change due to maximum tensile strain only, assuming self-heating effects to be negligible, is
- (A) 0.0625  
 (B) 0.625  
 (C) 6.26  
 (D) 7.5

80. Two strain gauges, with the specifications given above are mounted on a structural member in a push-pull configuration, connected in a bridge along with two standard resistances, whose output

is fed to an amplifier as shown in the figure. The output voltage  $V_0$  per unit battery voltage, under maximum loading, is



- (A)  $-0.4V$  (C)  $0.37$   
 (B)  $-0.37V$  (D)  $0.4V$

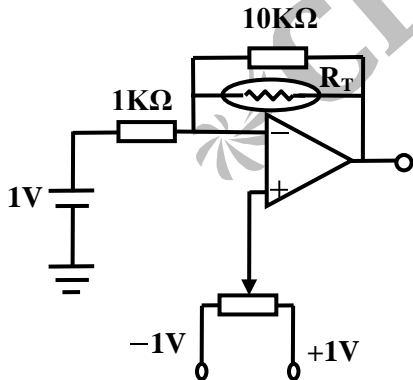
**Linked Answer Questions: Q. 81a to Q. 85b carry two marks each.**

**Statement for Linked Answer Questions 81a & 81b**

In the amplifier circuit shown in the figure, a  $10\text{ k}\Omega$  resistance is connected in parallel to a negative temperature coefficient thermistor to reduce non-linearity in the range  $298-232\text{K}$ . The thermistor specifications are:

$R_{298} = 10\text{ k}\Omega$ , the characteristic constant  $\beta = 4000\text{K}$ ,

$$R_T = R_{298} \exp \left[ \beta \left( \frac{1}{T} - \frac{1}{298} \right) \right]$$



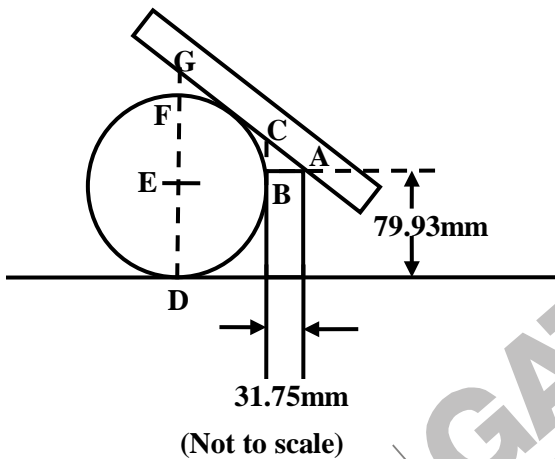
81. a. The magnitudes of the resistance change, between the temperatures  $298\text{ K}$  and  $323\text{ K}$ , when the thermistor is used alone and when it is used in parallel combination with the resistance, are

- (A)  $6.5\text{k}\Omega, 2.4\text{k}\Omega$  (C)  $6.1\text{k}\Omega, 2.0\text{k}\Omega$   
 (B)  $5.7\text{k}\Omega, 1.6\text{k}\Omega$  (D)  $5.3\text{k}\Omega, 1.2\text{k}\Omega$

81. b. In the given figure the potentiometer is adjusted so that the output voltage  $V_0$  is 0 at  $T = 298$  K, the voltage output at 323 K is
- (A) 500 mV (C) 2.4 V  
(B) 400 mV (D) 2.6 V

**Statement for Linked Answer Questions 82a & 82b**

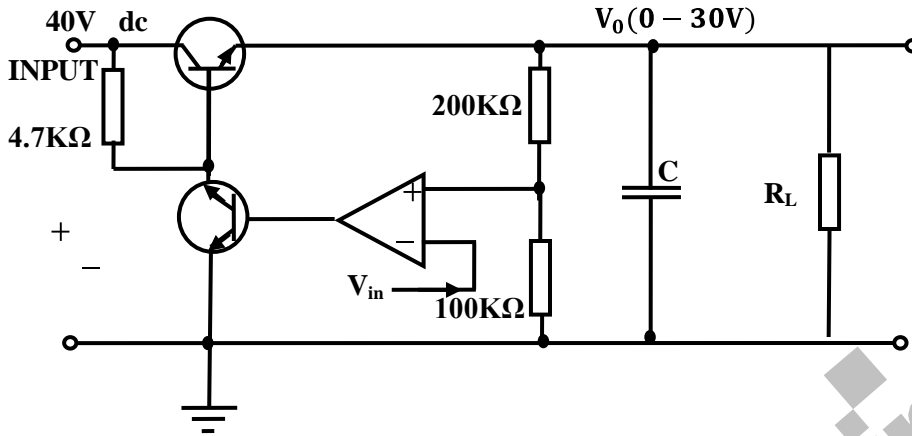
In order to find the diameter of a cylinder, an optical flat is placed over a combination of the cylinder and a gauge block which are in contact with each other as shown in the figure. When the portion AB is examined with a coherent light source of wavelength  $0.589 \mu\text{m}$  from above, 20 fringes are found in the field of view.



82. a. The height BC is
- (A)  $2.945 \mu\text{m}$  (C)  $8.835 \mu\text{m}$   
(B)  $5.890 \mu\text{m}$  (D)  $11.78 \mu\text{m}$
82. b. The length of the segment DG, which approximates the diameter of the cylinder, is
- (A) 79.94 mm (C) 79.98 mm  
(B) 79.96 mm (D) 80.20 mm

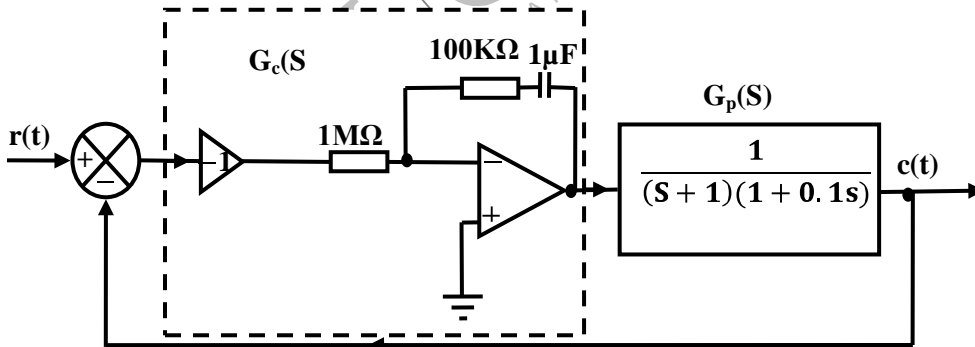
**Statement for Linked Answer Questions 83a & 83b**

Given figure shows a transistor circuit with feedback



83. a. In the circuit, in order to get  $V_0$  in the range of  $0.30V$ , the range of  $V_{in}$  is  
 (A)  $0 - 30 V$  (C)  $0 - 15 V$   
 (B)  $0.20 V$  (D)  $0.10 V$
83. b. If  $V_{in}$  is generated using an n-bit DA converter, the minimum value of n required, so that the value of  $V_0$  can be set within an accuracy of less than  $20 mV$  is,  
 (A) 9 (C) 11  
 (B) 10 (D) 12

**Statement for Linked Answer Questions 84a & 84b**



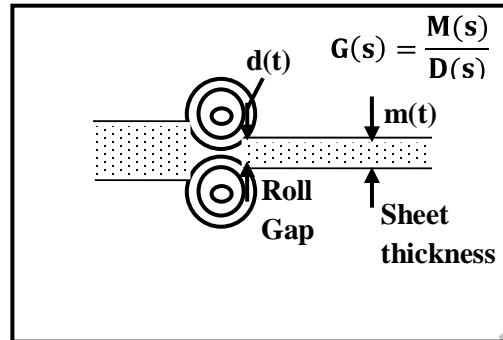
Given figure shows a closed loop unity feedback system. The controller block has a transfer function denoted by  $G_c(s)$ . The controller is cascaded to the plant, which is denoted by  $G_p(s)$ .

84. a. The transfer function  $G_c(s)$  is  
 (A)  $\frac{1+0.1s}{s}$  (C)  $-\frac{s}{s+1}$   
 (B)  $-\frac{1+0.1s}{s}$  (D)  $\frac{s}{s+1}$

84. b. The peak percentage overshoot of the closed loop system is

- (A) 5.0% (C) 16.3%  
 (B) 10.0% (D) 1.63%

**Statement for Linked Answer Questions 85a & 85b**



(a)



(b)

The thickness of a metal sheet from a rolling mill is manipulated by controlling the roll gap  $d(t)$  and measuring the sheet thickness  $m(t)$  at a certain distance from the rolls as shown in the figure. The thickness of the sheet at the roll out point is equal to the roll gap  $d(t)$  as shown and remains invariant during transit.

85. a. Given the distance at which the thickness is measured is 0.5m from the roll gap and the velocity of the sheet 0.2 m/s, the transfer function system,  $G(s) = M(s)/D(s)$ , is
- (A)  $\exp(-2.5s)$  (C)  $\exp(+0.4s)$   
 (B)  $\exp(+2.5s)$  (D)  $\exp(-0.4s)$
85. b. The gap  $d(t)$  is controlled by a proportional controller along with a hydraulic actuator of combined gain  $K$  and a unity feedback loop exists around  $K.G(s)$  (Fig. b). Increasing  $K$  beyond a certain value causes the system to become unstable. The frequency of oscillations at the critical value of  $K$  is
- (A)  $\omega = \pi$  (C)  $\omega = 0.4\pi$   
 (B)  $\omega = 2.5\pi$  (D)  $\omega = \frac{\pi}{2.5}$