Sample Paper

aglasem.com

IN: Instrumentation Engineering

Q.No. 1 In a control system with unity gain feedback, the plant has the transfer function p(s)=3/s.Assuming that a controller of the form C(s)= K/(s+p) is used, where *K* is a positive constant, the value of p for which the root-locus of the closed-loop system passes through the points -3± j3√3 where j=√-1 , is

(A) 3

(B) 3√3

(C) 6

(D) 9

Answer: (C)

Q.No. 2 Consider the matrix $M = \begin{bmatrix} 1 & -1 & 0 \\ 1 & -2 & 1 \\ 0 & -1 & 1 \end{bmatrix}$ .One of the eigenvectors of M is

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

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

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

(D) $\begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix}$

Answer: (D)

Q.No. 3 Two bags *A* and *B* have equal number of balls. Bag *A* has 20% red balls and 80% green balls. Bag *B* has 30% red balls, 60% green balls and 10% yellow balls. Contents of Bags *A* and *B* are mixed thoroughly and a ball is randomly picked from the mixture. What is the chance that the ball picked is red?

(A) 20%

(B) 25%

(C) 30%

(D) 40%

Answer: (B)

Q.No. 4 A straight line drawn on an x-y plane intercepts the x-axis at -0.5 and the y-axis at 1. The equation that describes this line is ___ .

(A) y = -0.5 x + 1

(B) y = x - 0.5

(C) y = 0.5x - 1

(D) y = 2x + 1

Answer: (D)

Q.No. 5 For the sequence $x[n] = \{1, -1, 1, -1\}$, with $n = 0,1,2,3$, the DFT is computed as $X(k) = \sum_{n=0}^{3} x[n] e^{-j\frac{2\pi}{4}nk}$,for $k = 0,1,2,3$. The value of k for which $X(k)$ is not zero is

(A) 0

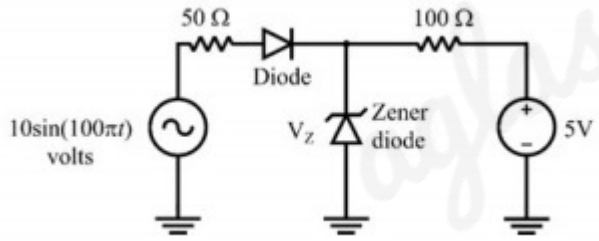
(B) 1

(C) 2

(D) 3

Answer: (C)

Q.No. 6 If the diodes in the circuit shown are ideal and the breakdown voltage Vz of the Zener diode is 5 V, the power dissipated in the 100Ω resistor (in watts) is



(A) 0

(B) 1

(C) 25/100

(D) 225/100

Answer: (A)

Q.No. 7 A set of linear equations is given in the form Ax b, where A is a 2 x 4 matrix with real number entries and b≠0. Will it be possible to solve for x and obtain a unique solution by multiplying both left and right sides of the equation by A^T (the super script T denotes the transpose) and inverting the matrix $A^T A$? Answer

(A) Yes, it is always possible to get a unique solution for any 2 x 4 matrix A.

(B) No, it is not possible to get a unique solution for any 2 x 4 matrix A.

(C) Yes, can obtain a unique solution provided the matrix $A^T A$ is well conditioned

(D) Yes, can obtain a unique solution provided the matrix A is well conditioned

Answer: (B)

Q.No. 8 Let N be a 3 by 3 matrix with real number entries. The matrix N is such that $N^2 = 0$. The eigen values of N are

(A) 0, 0, 0

(B) 0,0,1

(C) 0,1,1

(D) 1,1,1

Answer: (A)

Q.No. 9 A complex function $f(z) = u(x, y) + i\, v(x, y)$ and its complex conjugate $f^*(z) = u(x, y) - i\, v(x, y)$ are both analytic in the entire complex plane, where $z = x + i\, y$ and $i = \sqrt{-1}$. The function f is then given by

(A) $f(z) = x + i\, y$

(B) $f(z) = x^2 - y^2 + i\, 2xy$

(C) $f(z)$ = constant

(D) $f(z) = x^2 + y^2$

Answer: (C)

Q.No. 10 A differentiator has a transfer function whose

(A) phase increases linearly with frequency

(B) magnitude remains constant

(C) magnitude increases linearly with frequency

(D) magnitude decreases linearly with frequency

Answer: (C)

Q.No. 11 The representation of the decimal number (27.625)10 in base-2 number system is

(A) 110110

(B) 11101.101

(C) 110101

(D) 101110

Answer: (C)

Q.No. 12 Let $y[n] = x[n] * h[n]$, where $*$ denotes convolution and $x[n]$ and $h[n]$ are two discrete time sequences. Given that the z-transform of $y[n]$ is $Y(z) = 2 + 3z^{-1} + z^{-2}$, the z-transform of $p[n] = x[n] * h[n - 2]$ is

(A) $2 + 3z + z^{-2}$

(B) $3z + z^{-2}$

(C) $2z^2 + 3z + 1$

(D) $2z^{-2} + 3z^{-3} + z^{-4}$

Answer: (D)

Q.No. 13 Consider the following equations $\frac{\partial V(x,y)}{\partial x} = px^2 + y^2 + 2xy$ $\frac{\partial V(x,y)}{\partial y} = x^2 + qy^2 + 2xy$ where p and q are constants. *V*(*x*, *y*) that satisfies the above equations is

(A) $p\frac{x^3}{3} + q\frac{y^3}{3} + 2xy + 6$

(B) $p\frac{x^3}{3} + q\frac{y^3}{3} + 5$

(C) $p\frac{x^3}{3} + q\frac{y^3}{3} + x^2y + xy^2 + xy$

(D) $p\frac{x^3}{3} + q\frac{y^3}{3} + x^2y + xy^2$

Answer: (D)

Q.No. 14 A piezoelectric transducer with sensitivity of 30 mV/kPa is intended to be used in the range of 0 kPa to 100 kPa. The readout circuit has a peak noise amplitude of 0.3 mV and measured signals over the full pressure range are encoded with 10 bits. The smallest pressure that produces a non-zero output, in units of Pa, is approximately

(A) 10

(B) 100

(C) 240

(D) 300

Answer: (B)

Q.No. 15 A Q meter is best suited for the measurement of the

(A) Quality factor of a capacitance.

(B) Distributed capacitance of a coil.

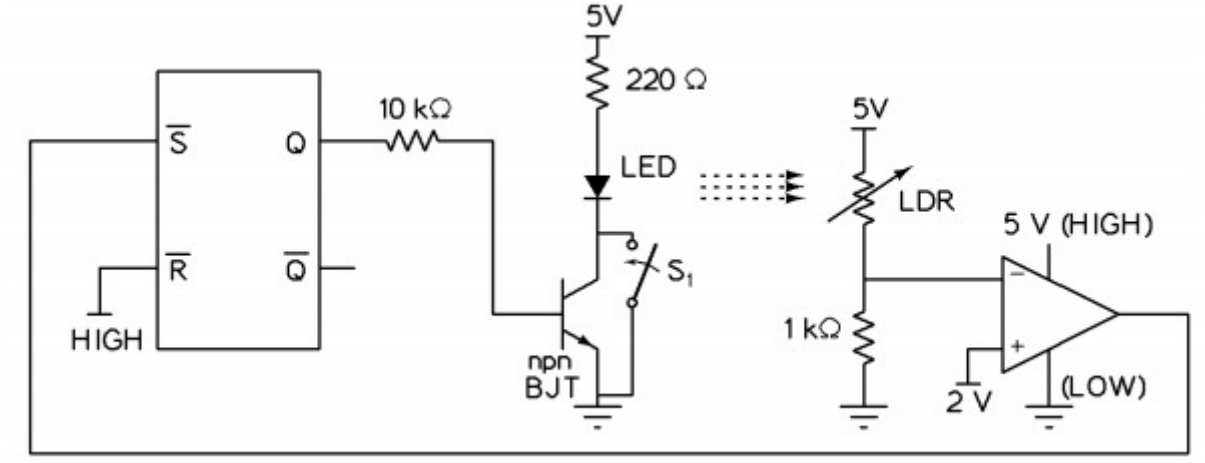
(C) Quality factor of piezoelectric sensor.

(D) Turns-ratio of a transformer

Answer: (B)

Q.No. 16 In the circuit below, the light dependent resistor (LDR) receives light from the LED. The LDR has resistances of 5 kΩ and 500Ω under dark and illuminated conditions, respectively. The LED is OFF at time $t < 0$. At time t=0s, the switch S_1 is closed for 1 ms and then kept open thereafter. Assuming zero propagation

delay in the devices, the LED



(A) turns ON when S_1 is closed and remains ON after S_1 is opened

(B) turns ON when S_1 is closed and turns OFF after S_1 is opened

(C) turns ON when S_1 is closed and toggles periodically from ON to OFF after S_1 is opened

(D) remains OFF when S_1 is closed and continues to remain OFF after S_1 is opened

Answer: (A)

Q.No. 17 The dynamics of the state $\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$ of a system is governed by the differential equation $\begin{bmatrix} \dot{x}_1 \\ \dot{x}_2 \end{bmatrix} = \begin{bmatrix} 1 & 2 \\ -3 & -4 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \end{bmatrix} + \begin{bmatrix} 20 \\ 10 \end{bmatrix}$ Given that the initial state is $\begin{bmatrix} 0 \\ 0 \\ 0 \end{bmatrix}$, the steady state value of $\begin{bmatrix} x_1 \\ x_2 \end{bmatrix}$ is

(A) $\begin{bmatrix} -30 \\ -40 \end{bmatrix}$

(B) $\begin{bmatrix} -20 \\ -10 \end{bmatrix}$

(C) $\begin{bmatrix} 5 \\ -15 \end{bmatrix}$

(D) $\begin{bmatrix} 50 \\ -35 \end{bmatrix}$

Answer: (D)

Q.No. 18 The Thevenin equivalent circuit representation across terminals p-q of the circuit shown in the

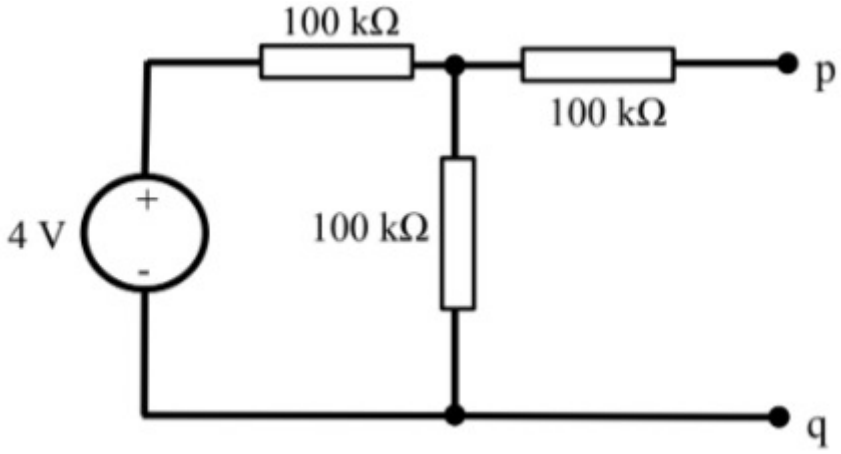


figure is a

(A) 1 V source in series with 150 kΩ

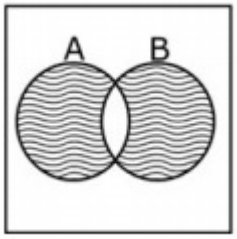
(B) 1 V source in parallel with 100 kΩ

(C) 2 V source in series with 150 kΩ

(D) 2 V source in parallel with 200 kΩ

Answer: (C)

Q.No. 19 The Boolean expression for the shaded regions as shown in the figure is ____ .



(A) (A+B).($\bar{A}$+ $\bar{B}$)

(B) (A+$\bar{B}$).($\bar{A}$+ B)

(C) ($\bar{A}$+B).($\bar{A}$+ $\bar{B}$)

(D) ($\bar{A}$+ $\bar{B}$).(A+ $\bar{B}$)

Answer: (A)

Q.No. 20 Consider signal $x(t) = \begin{cases} 1, & |t| \leq 2 \\ 0 & |t| > 2 \end{cases}$. Let $\delta(t)$ denote the unit impulse (Dirac-delta) function. The value of the integral /(\int_{0}^{5} 2 x(t-3) \delta(t-4) d t/) is

(A) 2

(B) 1

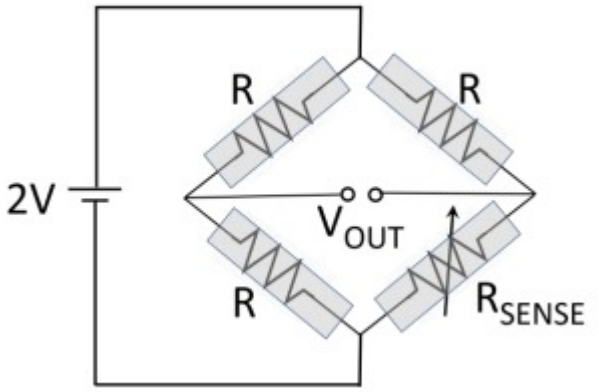
(C) 0

(D) 3

Answer: (A)

aglasem.com

Q.No. 21 Four identical resistive strain gauges with gauge factor of 2.0 are used in a Wheatstone bridge as shown in the figure below. Only one of the strain gauges R_{SENSE} changes its resistance due to strain. If the output voltage V_{OUT} is measured to be 1 mV, the magnitude of strain, in units of microstrain, is



(A) 1

(B) 10

(C) 100

(D) 1000

Answer: (D)

Q.No. 22 A phase lead network has the transfer function $G(s) = \frac{1+0.2s}{1+0.05s}$ The angular frequency at which the maximum phase shift for the network occurs is

(A) 10 rad/s

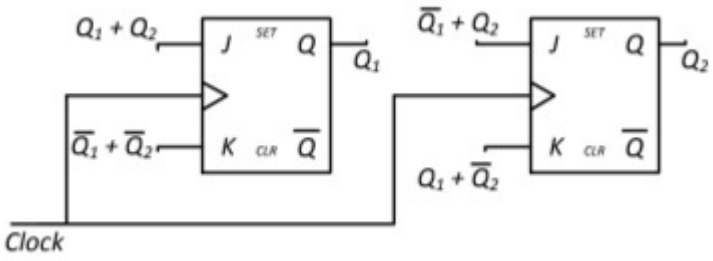
(B) 20 rad/s

(C) 100 rad/s

(D) 200 rad/s

Answer: (A)

Q.No. 23 A 2-bit synchronous counter using two J-K flip flops is shown. The expressions for the inputs to the J-K flip flops are also shown in the figure. The output sequence of the counter starting from $Q_1Q_2 = 00$ is



(A) 00 → 11 → 10 → 01 → 00 □□□

(B) 00 → 01 → 10 → 11 → 00 □□□

(C) 00 → 01 → 11 → 10 → 00 □□□

(D) 00 → 10 → 11 → 01 → 00 □□□

Answer: (C)

aglasem.com

Q.No. 24 Consider the Signal $x[n] = \sin(2\pi n)u[n]$ Where $u[n] = \begin{cases} 1 & n = 0, 1, 2, 3, \ldots \\ 0 & \text{otherwise} \end{cases}$ The period of this signal X[n] is _____ .

(A) 4

(B) 3

(C) 2

(D) 1

Answer: (D)

Q.No. 25 The function $p(x)$ is given by $p(x) = A/x^{\mu}$ where A and μ are constants with $\mu > 1$ and $1 \le x < \infty$ and $p(x) = 0$ for $-\infty < x < 1$. For $p(x)$ to be a probability density function, the value of A should be equal to

(A) $\mu - 1$

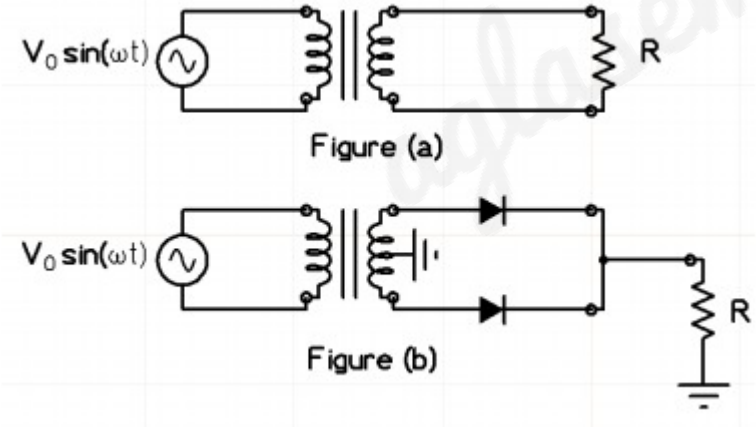
(B) $\mu + 1$

(C) $1/(\mu - 1)$

(D) $1/(\mu + 1)$

Answer: (A)

Q.No. 26 In the Figures (a) and (b) shown below, the transformers are identical and ideal, except that the transformer in Figure (b) is centre-tapped. Assuming ideal diodes, the ratio of the root- mean-square (RMS) voltage across the resistor R in Figure (a) to that in Figure (b) is



(A) √2:1

(B) 2:1

(C) 2√2:1

(D) 4:1

Answer: (B)

Q.No. 27 Consider the differential equation $\frac{dx}{dt} = \sin(x)$ with the initial condition x(0) = 0. The solution to this ordinary differential equation is ____ .

(A) x(t) = 0

(B) x(t) = sin(t)

(C) x(t) = cos(t)

(D) x(t) = sin(t) - cos(t)

Answer: (A)

Q.No. 28 Thermocouples measure temperature based on

(A) Photoelectric effect

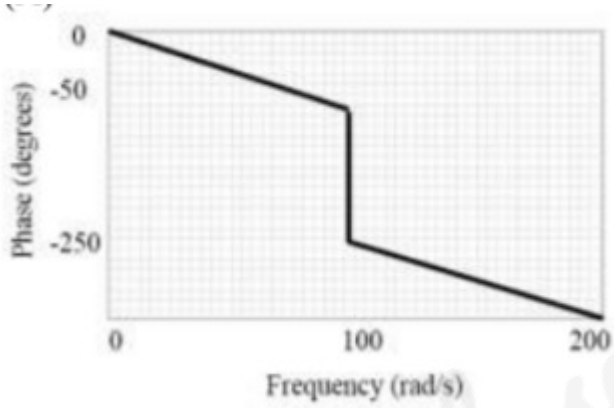
(B) Seebeck effect

(C) Hall effect

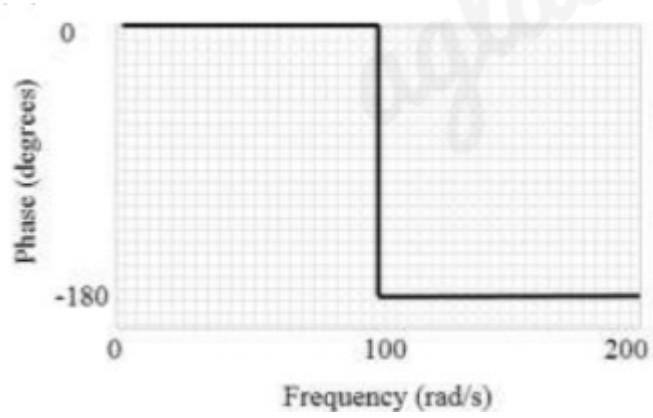
(D) Thermal expansion

Answer: (B)

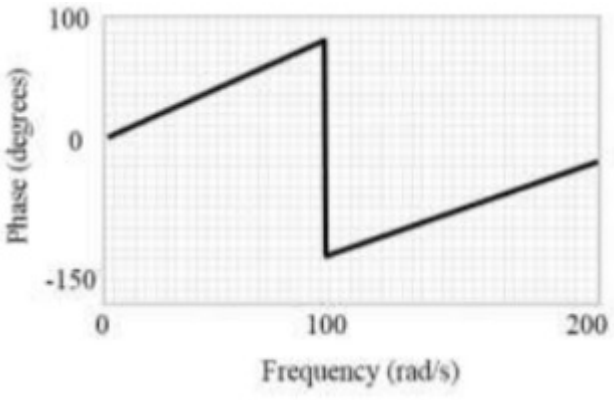
Q.No. 29 The approximate phase response of $\frac{100^2 e^{-0.01s}}{s^2+0.2s+100^2}$



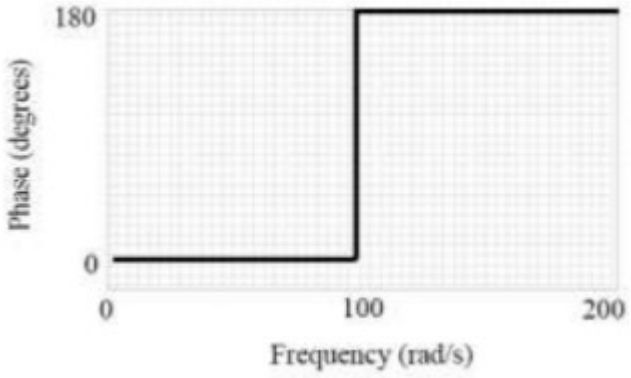
(A)



(B)



(C)



(D)

Answer: (A)

Q.No. 30 Consider the following system of linear equations: $3x + 2ky = -2$ $kx + 6y = 2$ Here x and y are the unknowns and k is a real constant. The value of k for which there are infinite number of solutions is

(A) 3

(B) 1

(C) −3

(D) −6

Answer: (C)

Q.No. 31 A pulsed laser emits rectangular pulses of width 1 nanosecond at a repetition rate of 1 kHz. If the average power output is 1 mW, the average power over a single pulse duration, in watts,is

(A) 1

(B) 10

(C) 100

(D) 1000

Answer: (D)

Q.No. 32 The correct biasing conditions for typical operation of light emitting diodes, photodiodes, Zener diodes are, respectively

(A) forward bias, reverse bias, reverse bias

(B) reverse bias, reverse bias, forward bias

(C) forward bias, forward bias, reverse bias

(D) reverse bias, forward bias, reverse bias

Answer: (A)

Q.No. 33 The input $x[n]$ and output $y[n]$ of a discrete-time system are related as $y[n] = \alpha y[n - 1] + x[n]$. The condition on α for which the system is Bounded-Input Bounded-Output (BIBO) stable is

(A) $|\alpha| < 1$

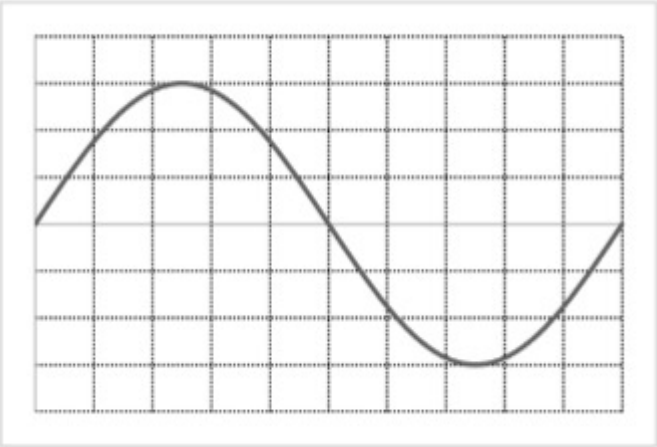
(B) $|\alpha| = 1$

(C) $|\alpha| > 1$

(D) $|\alpha| < 3/2$

Answer: (A)

Q.No. 34 A voltage of 6 cos(100πt) V is fed as y-input to a CRO. The waveform seen on the screen of the CRO is shown in the figure. The Y and X axes settings for the CRO are respectively



(A) 1 V/div and 1 ms/div

(B) 1 V/div and 2 ms/div

(C) 2 V/div and 1 ms/div

(D) 2 V/div and 2 ms/div

Answer: (D)

Q.No. 35 The unit vectors along the mutually perpendicular x, y and : axes are $\hat{i}$, $\hat{j}$ and $\hat{k}$ respectively. Consider the plane z = 0 and two vectors $\vec{a}$ and $\vec{b}$ on that plane such that $\vec{a} \neq \alpha \vec{b}$ for any scalar α. A vector perpendicular to both $\vec{a}$ and $\vec{b}$ is ____ .

(A) $\hat{k}$

(B) $\hat{i} - \hat{j}$

(C) $-\hat{j}$

(D) $\hat{i}$

Answer: (A)

Q.No. 36 Given $f(A, B, C, D) = \sum m(0, 1, 2, 6, 8, 9, 10, 11) + \sum d(3, 7, 14, 15)$ is a Boolean function, where m represents min-terms and d represents don't-cares. The minimal sum of products expression for f is

(A) $f = A\bar{B} + CB$

(B) $f = \bar{B} + C$

(C) $f = \bar{D} + A$

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

Answer: (B)

Q.No. 37 $X = X_1X_0$ and $Y = Y_1Y_0$ are 2-bit binary numbers. The Boolean function S that satisfies the condition "If $X > Y$, then $S = 1$", in its minimized form, is

(A) $X_1Y_1 + X_0Y_0$

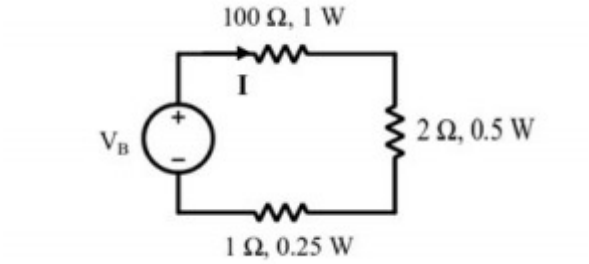
(B) $X_1\overline{Y}_1 + X_0\overline{Y}_0\overline{Y}_1 + X_0\overline{Y}_0X_1$

(C) $X_1\overline{Y}_1X_0\overline{Y}_0$

(D) $X_1Y_1 + X_0\overline{Y}_0Y_1 + X_0\overline{Y}_0\overline{X}_1$

Answer: (B)

Q.No. 38 In the circuit shown below, the safe maximum value for the current I is _____



(A) 1.0 A

(B) 0.5 A

(C) 0.1 A

(D) 0.05 A

Answer: (C)

Q.No. 39 The forward path transfer functionL(s) of the control system shown in Figure (a) has the asymptotic Bode plot shown in Figure (b). If the disturbance d(t) is given by d(t)=0.1sin(ωt) where ω=5rad/s , the steady-state amplitude of the output y(t) is

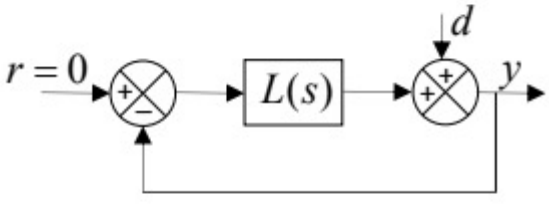


Figure (a)

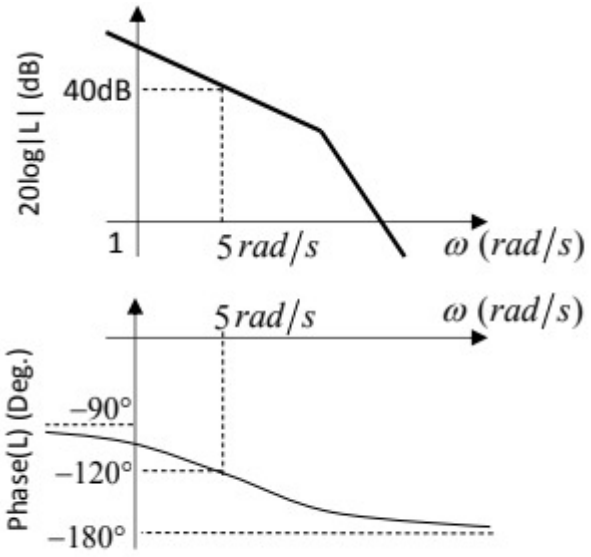


Figure (b)

(A) 1.00×10^{-3}

(B) 2.50×10^{-3}

(C) 5.00×10^{-3}

(D) 10.00×10^{-3}

Answer: (A)

Q.No. 40 $\vec{a}, \vec{b}, \vec{c}$ are three orthogonal vectors. Given that $\vec{a} = \hat{i} + 2\hat{j} + 5\hat{k}$ and $\vec{b} = \hat{i} + 2\hat{j} - \hat{k}$,the vector $\vec{c}$ is parallel to

(A) $\hat{i} + 2\hat{j} + 3\hat{k}$

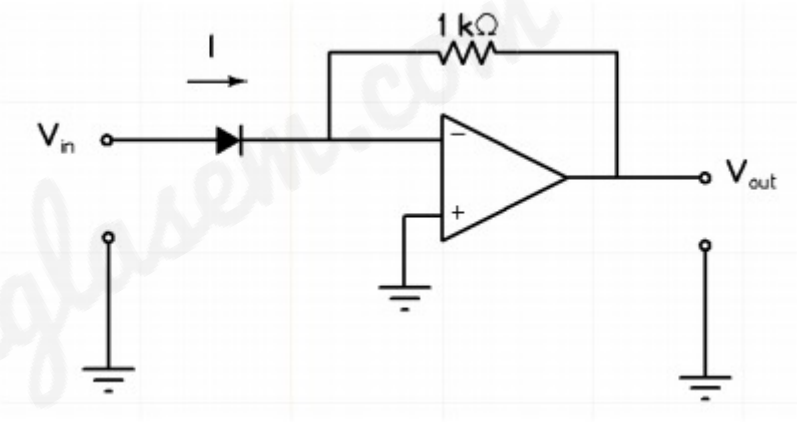
(B) $2\hat{i} + \hat{j}$

(C) $2\hat{i} - \hat{j}$

(D) $4\hat{k}$

Answer: (C)

Q.No. 41 In the circuit shown below, the input voltage *Vin* is positive. The current (*I*) - voltage (*V*) characteristics of the diode can be assumed to be $I = I_0 e^{V/VT}$ under the forward bias condition, where V_T is the thermal voltage and I_0 is the reverse saturation current. Assuming an ideal op-amp, the output voltage



Vout of the circuit is proportional to

(A) $\log_e(V_{in}/V_T)$

(B) 2*Vin*

(C) e^{V_{in}/V_T}

(D) V_{in}^2

Answer: (C)

Q.No. 42 The curve y=f(x) is such that the tangent to the curve at every point (*x*, *y*) has a *Y*-axis intercept *c*, given by $c = -y$. Then, ( )f x is proportional to

(A) x^{-1}

(B) x^2

(C) x^3

(D) x^4

Answer: (B)

Q.No. 43 Let $f(z) = \frac{1}{z+a}$, $a > 0$. The value of the integral $\oint f(z)\,dz$ over a circle C with center (-a, 0) and radius R > 0 evaluated in the anti-clockwise direction is ____ .

(A) 0

(B) 2πi

(C) -2πi

(D) 4πi

Answer: (B)

Q.No. 44 Given $\vec{F} = (x^2 - 2y)\,\vec{i} - 4yz\,\vec{j} + 4xz^2\vec{k}$, the value of the line integral $\int_c \vec{F} \cdot d\vec{l}$. along the straight line c from (0,0,0) to (1,1,1) is

(A) 3/16

(B) 0

(C) -5/12

(D) -1

Answer: (D)

Q.No. 45 Unit step response of a linear time invariant (LTI) system is given by $y(t) = (1 - e^{-2t})u(t)$. Assuming zero initial condition, the transfer function of the system is

(A) $1/s+1$

(B) $2/(s+1)(s+2)$

(C) $1/s+2$

(D) $2/s+2$

Answer: (D)

Q.No. 46 If I is the current flowing through a Hall effect sensor and B is the magnetic flux density perpendicular to the direction of the current (in the plane of the Hall effect sensor), the Hall voltage generated is ____ .

(A) Directly proportional to I and inversely proportional to B

(B) Directly proportional to both I and B

(C) Inversely proportional to both I and B

(D) Inversely proportional to I and directly proportional to B

Answer: (B)

Q.No. 47 A piezoelectric pressure sensor has a bandpass characteristic with cut-off frequencies of 0.1 Hz and 1 MHz, and a sensitivity of 100 mV/kPa. The sensor is subjected to a static constant pressure of 100 kPa. Its steady-state output will be

(A) 0 V

(B) 0.1 V

(C) 1 V

(D) 10 V

Answer: (A)

Q.No. 48 The number of comparators required for implementing an 8-bit flash analog-to-digital converter is

(A) 8

(B) 128

(C) 255

(D) 256

Answer: (C)

Q.No. 49 The product of sum expression of a Boolean function $F(A, B, C)$ of three variables is given by F(A, B, C) = (A + B + $\overline{C}$) · (A + $\overline{B}$ + $\overline{C}$) · ($\overline{A}$+ B + C) · ($\overline{A}$+ $\overline{B}$ + $\overline{C}$) The canonical sum of product expression of $F(A, B, C)$ is given by

(A) $\overline{A}\overline{B}$ C + $\overline{A}$B C + A $\overline{B}$ $\overline{C}$+ A B C

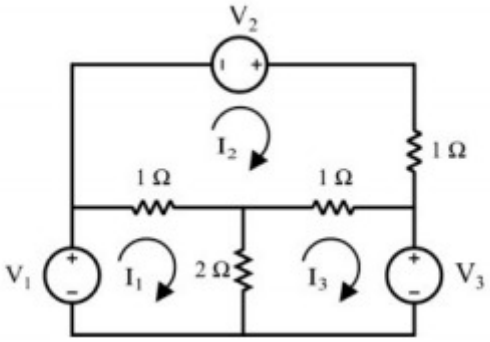
(B) $\overline{A}\overline{B}$ $\overline{C}$+ $\overline{A}$B $\overline{C}$+ A$\overline{B}$ C + A B $\overline{C}$

(C) A B $\overline{C}$+ A $\overline{B}$ $\overline{C}$+ $\overline{A}$B C + $\overline{A}\overline{B}$ $\overline{C}$

(D) $\overline{A}\overline{B}$ $\overline{C}$+ $\overline{A}$B C + A B $\overline{C}$+ A B C

Answer: (B)

Q.No. 50 I_1, I_2 and I_3 in the figure below are mesh currents. The correct set of mesh equations for these



currents, in matrix form, is _____ .

(A) $\begin{bmatrix} 3 & -1 & -2 \\ -1 & 3 & -1 \\ -2 & -1 & 3 \end{bmatrix} \begin{bmatrix} \mathbf{I}_1 \\ \mathbf{I}_2 \\ \mathbf{I}_3 \end{bmatrix} = \begin{bmatrix} \mathrm{V}_1 \\ \mathrm{V}_2 \\ -\mathrm{V}_3 \end{bmatrix}$

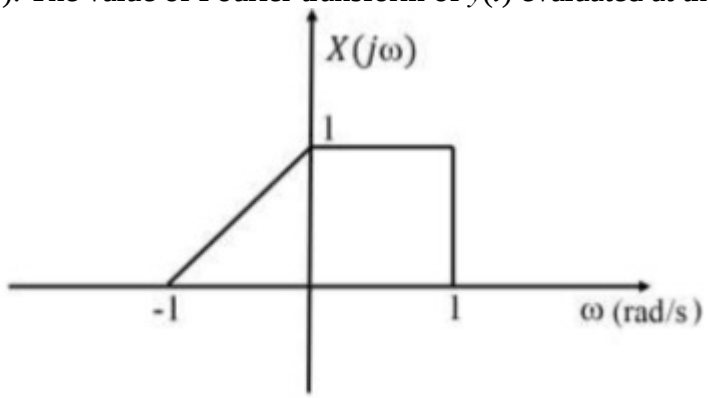
(B) $\begin{bmatrix} 3 & -1 & -2 \\ -1 & 3 & -1 \\ -2 & -1 & -3 \end{bmatrix} \begin{bmatrix} \mathbf{I}_1 \\ \mathbf{I}_2 \\ \mathbf{I}_3 \end{bmatrix} = \begin{bmatrix} \mathrm{V}_1 \\ \mathrm{V}_2 \\ \mathrm{V}_3 \end{bmatrix}$

(C) $\begin{bmatrix} -3 & -1 & -2 \\ -1 & 3 & -1 \\ -2 & -1 & 3 \end{bmatrix} \begin{bmatrix} \mathbf{I}_1 \\ \mathbf{I}_2 \\ \mathbf{I}_3 \end{bmatrix} = \begin{bmatrix} \mathrm{V}_1 \\ \mathrm{V}_2 \\ -\mathrm{V}_3 \end{bmatrix}$

(D) $\begin{bmatrix} 1 & -1 & -2 \\ -1 & 2 & -1 \\ -2 & -1 & 3 \end{bmatrix} \begin{bmatrix} \mathbf{I}_1 \\ \mathbf{I}_2 \\ \mathbf{I}_3 \end{bmatrix} = \begin{bmatrix} \mathrm{V}_1 \\ \mathrm{V}_2 \\ \mathrm{V}_3 \end{bmatrix}$

Answer: (A)

Q.No. 51 The Fourier transform of a signal $x(t)$, denoted by □(□□), is shown in the figure. Let $y(t) = x(t) + ejtx(t)$. The value of Fourier transform of $y(t)$ evaluated at the angular frequency □= 0.5 rad/s is



(A) 0.5

(B) 1

(C) 1.5

(D) 2.5

Answer: (C)

Q.No. 52 Two periodic signals $x(t)$ and $y(t)$ have the same fundamental period of 3 seconds. Consider the signal $z(t) = x(-t) + y(2t + 1)$. The fundamental period of $z(t)$ in seconds is

(A) 1

(B) 1.5

(C) 2

(D) 3

Answer: (D)

Q.No. 53 In a cascade control system, the closed loop transfer function of the inner loop may be assumed to have a single time-constant $\tau 1$. Similarly, the closed loop transfer function of the outer loop may be assumed to have a single time-constant $\tau 2$. The desired relationship between τ_1 and τ_2 in a well-designed control system is

(A) τ_1 is much less than τ_2

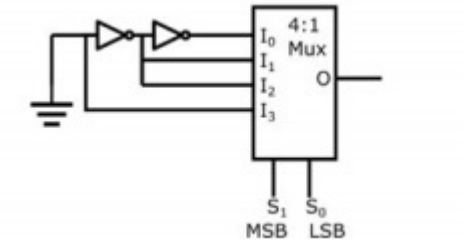
(B) τ_1 is equal to τ_2

(C) τ_1 is much greater than τ_2

(D) τ_1 is independent of τ_2

Answer: (A)

Q.No. 54 The Boolean operation performed by the following circuit at the output O is ___ .



(A) $O = S_1 \oplus S_0$

(B) $O = S_1.\overline{S}_0$

(C) $O = S_1 + S_0$

(D) $O = S_0.\overline{S}_1$

Answer: (A)

Q.No. 55 X and Y are two independent random variables with variances 1 and 2, respectively. Let $Z = X - Y$. The variance of Z is

(A) 0

(B) 1

(C) 2

(D) 3

Answer: (D)

aglasem.com