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GATE 2019

Electronics Engineering

Memory Based Questions and Solutions

Date of Exam : 9/2/2019

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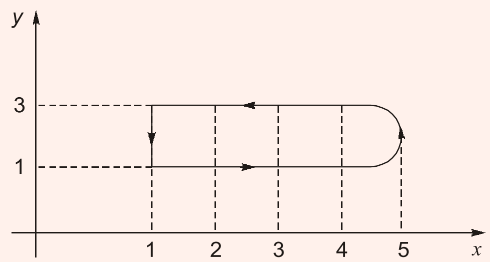
Q.1 The correct relation between the responsivity (R), quantum efficiency (η) and wavelength in micrometers (λ) is

Sol.

$$R = \frac{n\lambda}{1.24}$$

End of Solution

Q.2 The value of $\int_c xdy - ydx$ is ___. Where c is shown below.



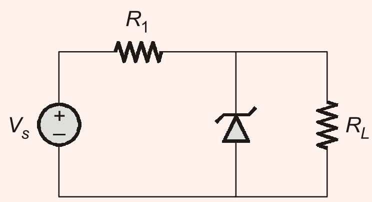
Sol.

$$\int_c xdy - ydx = \int_{<R>} 2dxdy = 2(\text{area under curve})$$

$$= 2\left[(2\times 3) + \frac{1}{2}\pi(1)^2\right] = 12 + \pi$$

End of Solution

Q.3 $R_1 = 200\ \Omega$, $R_L = 1\ \text{k}\Omega$, $V_z = 20$ V and $I_{z(\max)} = 60$ mA. Find the range of V_s for which Zener diode operates in reverse breakdown region?



Sol.

$$V_{s(\min)} = 20\text{ V} + \left(\frac{20\text{ V}}{1\text{k}\Omega} \times 200\ \Omega\right) = 24\text{ V}$$

$$V_{s(\max)} = 20\text{ V} + \left(\frac{20\text{ V}}{1\text{k}\Omega} + 60\ \Omega\right)(200\ \Omega) = 36\text{ V}$$

End of Solution

Q.4 The value of $\frac{1}{2\pi i}\oint_c \left(z+\frac{1}{z}\right)^2 dz$ is ______. Where c is the unit circle in z-plane.

Sol. (0)

End of Solution

Q.5 The number of distinct eigen values are possible for the following matrix is ____.

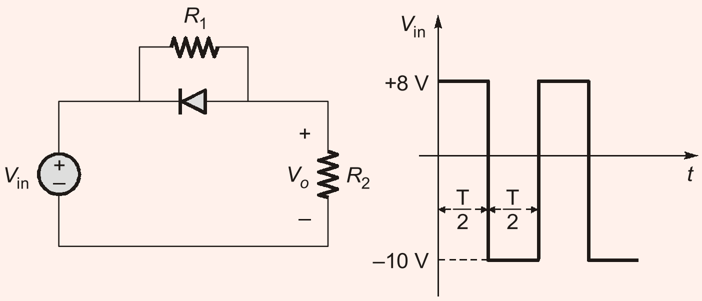
$$A = \begin{bmatrix} 2 & 2 & 3 & 4 \\ 0 & 3 & 5 & 6 \\ 0 & 0 & 1 & 7 \\ 0 & 0 & 0 & 2 \end{bmatrix}$$

Sol. Eigen values = Diagonal values = 2, 3, 1, 2

Number of distinct eigen values = 3

End of Solution

Q.6 Diode is ideal and $R_1 = R_2 = 500\ \Omega$.



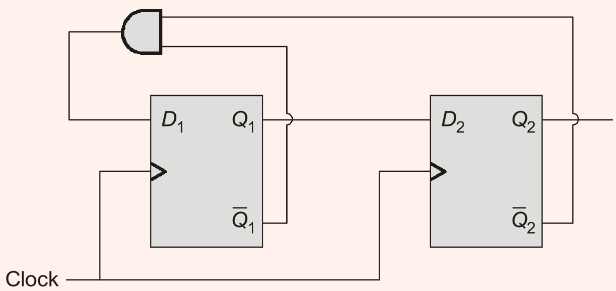
Average value of output voltage is ______ V.

Sol.

$$V_{o\,(avg)} = \frac{4-10}{2} = -3\text{ V}$$

End of Solution

Q.7 Input clock frequency is 12 kHz. Find the frequency of Q_2?



Sol.

PS		D_2	D_1	NS	
Q_2	Q_1			Q_2^+	Q_1^+
0	0	0	1	0	1
0	1	1	0	1	0
1	0	0	0	0	0

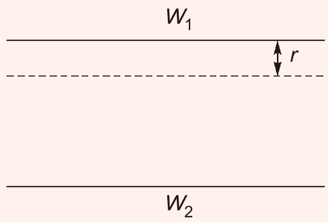
$$D_1 = \bar{Q}_2\bar{Q}_1 = \overline{Q_2 + Q_1}$$

$$\text{MOD} = 3$$

$$f_{Q2} = \frac{f_{clk}}{3} = \frac{12}{3}\text{ kHz} = 4\text{ kHz}$$

End of Solution

Q.8 Two wires W_1 and W_2 are separated by a distance of "$4r$" and carrying current I and $2I$ respectively in opposite direction. The magnitude of magnetic flux density at a distance of "r" from W_1 is ____________.



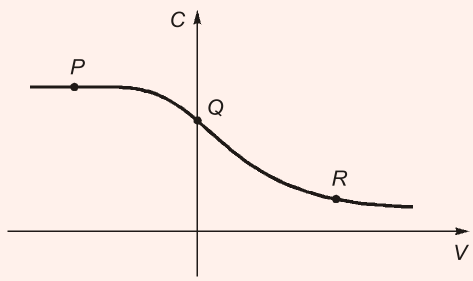
Sol.

$$H_1 = \frac{I}{2\pi r}\ ;\ H_2 = \frac{2I}{2\pi(3r)}$$

$$B = \mu_0(H_1 + H_2) = \frac{I\mu_0}{2\pi r}\left(1 + \frac{2}{3}\right) = \frac{5I\mu_0}{6\pi r}$$

End of Solution

Q.9 The high frequency C-V plot of an n-channel MOSFET is given below:



The flat band, inversion and accumulation situations are depicted by respectively

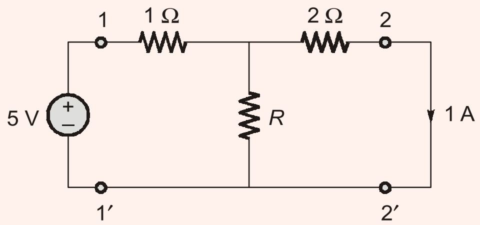
(a) P, Q, R (b) Q, R, P

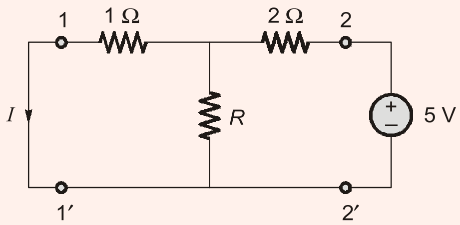
(c) R, Q, P (d) Q, P, R

Sol. (b)

End of Solution

Q.10 Consider the figures shown in the circuit below.





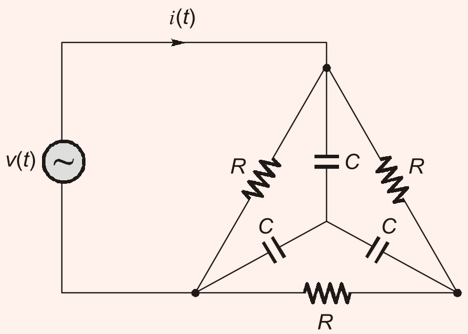
Find the value of current I?

Sol. According to reciprocity theorem,

$$I = 1 \text{ A}$$

End of Solution

Q.11 $R = 1 \text{ k}\Omega$; $C = 1 \text{ μF}$; $v(t) = 3\sin(1000t)$ V.



Find the steady state current $i(t)$.

End of Solution

Q.12 X and Y are two random variables and

$$E[2X + Y] = 0$$
$$E[X + 2Y] = 33$$

The value $E[X + Y]$ is ______.

Sol.

$$E[2X + Y] = 2\overline{X} + \overline{Y} = 0 \quad \text{...(i)}$$

$$E[X + 2Y] = \overline{X} + 2\overline{Y} = 33 \quad \text{...(ii)}$$

Adding equations (i) and (ii)

$$3\overline{X} + 3\overline{Y} = 33 \quad \Rightarrow \quad \overline{X} + \overline{Y} = 11$$

So, $E[X + Y] = \overline{X} + \overline{Y} = 11$

End of Solution

Q.13 Match the below two lists:

1.	$\nabla \cdot \vec{D}$	P.	0
2.	$\nabla \times \vec{E}$	Q.	ρ
3.	$\nabla \cdot \vec{B}$	R.	$-\dfrac{\partial \vec{B}}{\partial t}$
4.	$\nabla \times \vec{H}$	S.	$\sigma \vec{E} + \dfrac{\partial \vec{D}}{\partial t}$

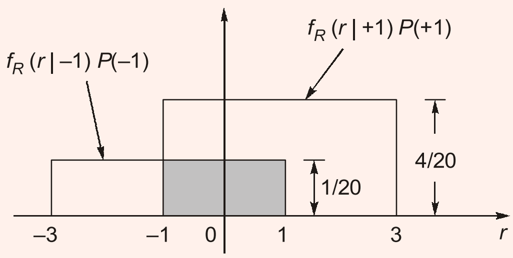
Sol.

1. $\nabla \cdot \vec{D} = \rho$
2. $\nabla \times \vec{E} = -\dfrac{\partial \vec{B}}{\partial t}$
3. $\nabla \cdot \vec{B} = 0$
4. $\nabla \times \vec{H} = \sigma \vec{E} + \dfrac{\partial \vec{D}}{\partial t}$

End of Solution

Q.14 X is a random variable, which takes the values –1 and +1 with probabilities 0.2 and 0.8 respectively. It is passed through a noisy channel such that the received signal at the output is $X + N$, where N is independent of X and uniformly distributed over [–2, 2]. If optimum threshold is selected to minimise the probability of error, then the minimum error probability will be __________.

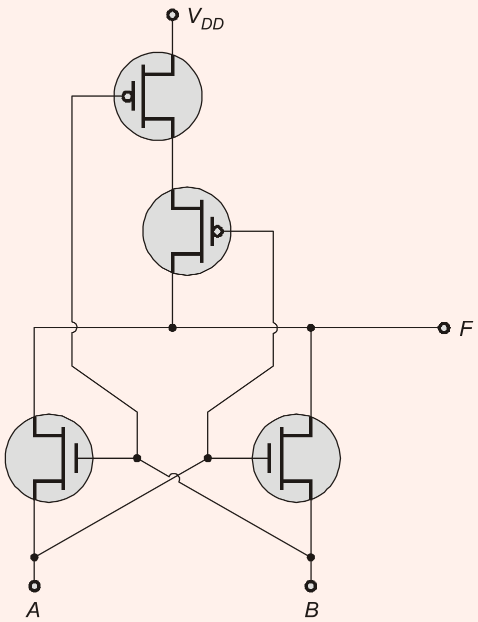
Sol.



$$\text{Ans} = \text{Shaded area} = 2 \times \frac{1}{20} = 0.10$$

End of Solution

Q.15 The following circuit works as

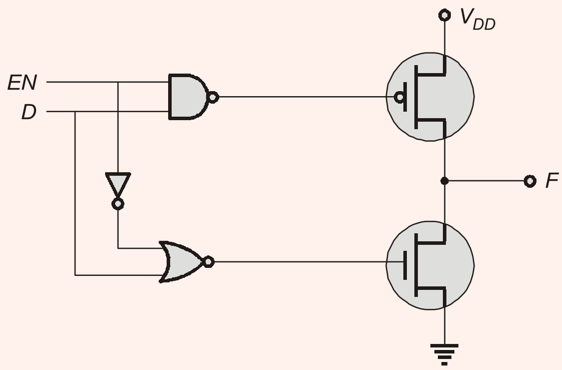


(a) XNOR
(b) Latch
(c) XOR
(d) SRAM cell

Sol. (a)

End of Solution

Q.16 When EN = 0 and EN = 1, the state of F will be respectively.



Sol. $\left.\begin{array}{l} EN = 0 \Rightarrow \text{ High-Z} \\ EN = 1 \Rightarrow \; F = D \end{array}\right\}$ It acts as a tristate buffer

End of Solution

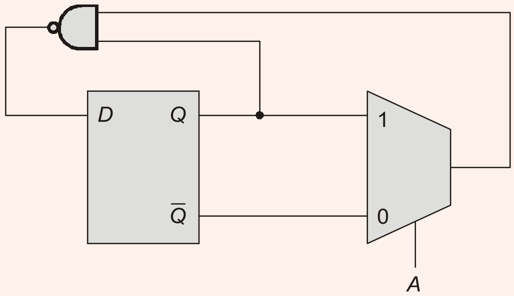
Q.17 A message signal, having frequencies in the range 5 to 15 kHz, is amplitude modulated with a carrier frequency of 600 kHz. The resultant signal is sampled with 1.2 times the Nyquist rate and quantized using a 256-level quantizer. The final data rate will be ____ Mbps.

Sol.

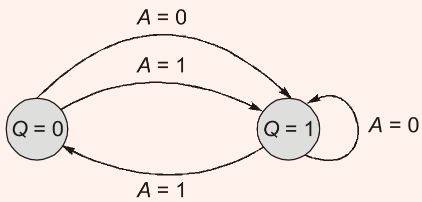
$$f_{max} = 600 + 15 = 615 \text{ kHz}$$
$$f_s = 1.2 \times 2 \times 615 = 1476 \text{ kHz}$$
$$R_b = 8f_s = 11808 \text{ kbps} = 11.808 \text{ Mbps}$$

End of Solution

Q.18 Select the correct state diagram representation of this logic circuit.

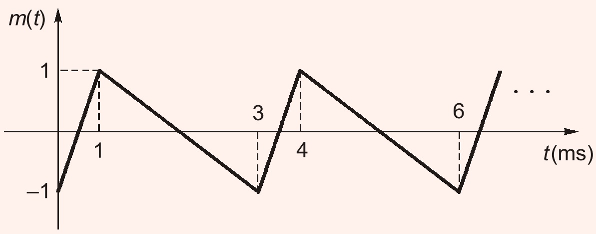


Sol.



End of Solution

Q.19 The following message signal is applied to a phase modulator with $K_p = 10\pi$.



If f_c = 50 kHz and maximum instantaneous frequency of the modulated signal is f_{max} and minimum instantaneous frequency is f_{min}, then the ratio of f_{max} to f_{min} is _____.

Sol.

$$\frac{f_{max}}{f_{min}} = \frac{60}{45} = 1.33$$

End of Solution

Q.20 An exponential random variable is given, such that its cumulative distribution function (CDF) is given by,

$$F_Z(x) = \begin{cases} (1-e^{-x}) \;; & x \ge 0 \\ 0 \;; & \text{otherwise} \end{cases}$$

Find the probability $P\{z > 2 \mid z > 1\}$.

Sol. Required probability $= \dfrac{P[(z>2)\cap(z>1)]}{P[z>1]} = \dfrac{P[z>2]}{P[z>1]}$

$$P(z \le 2) = 1 - e^{-2} \Rightarrow P(z > 2) = e^{-2}$$
$$P(z \le 1) = 1 - e^{-1} \Rightarrow P(z > 1) = e^{-1}$$

So, Required probability $= \dfrac{e^{-2}}{e^{-1}} = e^{-1} \simeq 0.37$

End of Solution

Q.21 An infinite line carrying a charge density of Q. The value of $\int \vec{E}\cdot\vec{da}$ over the surface formed by a quarter cylinder of height H and radius R.

Sol.

$$2\pi RHD = QH$$
$$D = \frac{Q}{2\pi R}$$
$$E = \frac{Q}{2\pi\epsilon_o R}$$
$$\int \vec{E}\cdot\vec{da} = \int_{<\pi/2>}\int_{<H>} E\,R\,d\phi\,dz = \frac{Q}{2\pi\epsilon_o}\times\frac{\pi}{2}\times H = \frac{QH}{4\epsilon_o}$$

End of Solution

Q.22 The value of $\int_0^{\pi}\int_y^{\pi} \frac{\sin(x)}{x}\,dx\,dy$ is ______.

End of Solution

Q.23 $\dfrac{dy}{dx} = -\left(\dfrac{x}{y}\right)^n$

For $n = -1$ and $n +1$, the solution of the above given differential equation respectively represent

(a) parabola and circle
(b) hyperbola and circle
(c) hyperbola and parabola
(d) circle and hyperbola

End of Solution

Q.24 One machine can complete a work in 4 hours, another machine can complete the same work in 2 hours. If both the machines work together, the same work can be completed in

(a) 1 hour
(b) 3 hours
(c) 4/3 hours
(d) 2 hours

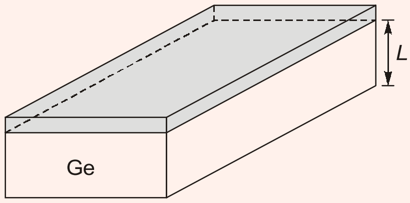
End of Solution

Q.25 When he did not come to home, she ______ him died at roadside somewhere.

(a) noticed
(b) looked
(c) pictured
(d) concluded

End of Solution

Q.26 Consider the SiO_2 layer on a Ge sample as shown below.



A Laser light, with a wavelength of 600 nm is falling on the surface of SiO_2 layer. Half of the incident power is reflected by the SiO_2 surface and remaining half reached the interface of SiO_2-Ge. One third of the remaining power is reflected by the SiO_2-Ge interface, one third is absorbed by Ge sample and remaining one third comes out from the sample. The absorption coefficient of the Ge is 3×10^4 cm^{-1}. The thickness of the Ge sample is ___________ μm.

Sol.

$$\frac{2}{3}e^{-\alpha L} = \frac{1}{3}$$

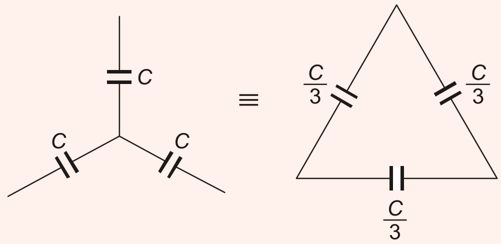
$$\alpha = 3 \times 10^4 \text{ cm}^{-1}$$

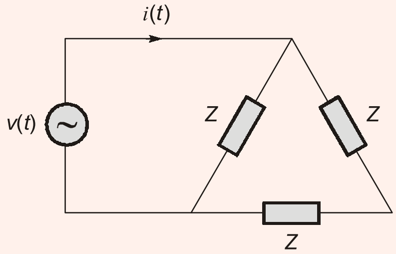
$$L = \frac{1}{\alpha}\ln(2)\text{ cm} = \frac{0.693}{3}\,\mu\text{m} = 0.231\,\mu\text{m}$$

End of Solution

Q.27 A rectangular waveguide with dimension width (w) and height (h has cut-off frequency of TE_{10} and TM_{11} mode with a ratio of 1 : 2. The aspect ratio (w/h) of the waveguide is ______.

Sol.





$$Z = R \parallel \left(\frac{3}{j\omega C}\right) = (1 \parallel -j3)\ \text{k}\Omega = \frac{-j3}{1-j3}\ \text{k}\Omega$$

$$Z_{\text{total}} = 2Z \parallel Z = \frac{2Z}{3} = \frac{-j2}{1-j3}\ \text{k}\Omega$$

$$i(t) = \frac{v(t)}{Z_{\text{total}}} = \frac{3\angle 0^\circ}{\frac{-j2}{(1-j3)}}\ \text{mA} = \frac{3(1-j3)}{-j2}\ \text{mA}$$

$$= \frac{3}{2}(3-j)\ \text{mA} = (4.5 - j1.5)\ \text{mA}$$

$$i(t) = 4.5\sin(1000t) + 1.5\cos(1000t)\ \text{mA}$$

End of Solution

Q.28 A block diagram has been given in the question, whose close-loop transfer function will be,

$$T(s) = \frac{K}{s^3 + 3s^2 + 2s + K}$$

The value of K for which two of its poles lie on the imaginary axis in s-plane is ___.

Sol. $K_{mar} = 2 \times 3 = 6$

End of Solution

Q.29 For a diode with η = 1, the magnitude of reverse biased voltage needed to reach 75% of its reverse saturation current is ________ mV.

Sol.

$$I_o\,(e^{V_{BE}/V_T} - 1) = -\frac{3}{4} I_o \quad (\text{Take } V_T = 25.9 \text{ mV})$$

On solving, $V_{BE} = -35.9$ mV

$\Rightarrow$ $V_R = |V_{BE}| = 35.9\,\text{mV}$

End of Solution

Q.30 The transfer function of a system is,

$$\frac{Y(s)}{U(s)} = \frac{1}{s^3 + 3s^2 + 2s + 1}$$

Its state space representation is,

$$\dot{x} = Ax + Bu$$

$$y = Cx$$

If $B = [0\ 0\ 1]^T$, then the correct representation of matrices A and C is

Sol.

$$A = \begin{bmatrix} 0 & 1 & 0 \\ 0 & 0 & 1 \\ -1 & -2 & -3 \end{bmatrix}; C = [1\ \ 0\ \ 0]$$

End of Solution

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