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# Questions to be Challenged in

# GATE 2020

# Electrical Engineering


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# Date of Exam : 08/02/2020

## SECTION A : GENERAL APTITUDE

**Q.3** In four-digit integer numbers from 1001 to 9999, the digit group "37" (in the same sequence) appears ______ times.

(a) 299 (b) 270
(c) 280 (d) 279

**Ans.** (c)

$10 \times 10 + 9 \times 10 + 9 \times 10 = 280$

Question is asking 37 appears how many times and not how many numbers.

**GATE Ans. Key (b)**

*End of Solution*

## SECTION B : TECHNICAL

**Q.1** $x_R$ and $x_A$ are, respectively, the rms and average values of $x(t) = x(t - T)$, and similarly, $y_R$ and $y_A$ are, respectively, the rms and average values of $y(t) = kx(t) \cdot k$, $T$ are independent of $t$. Which of the following is true?

(a) $y_A = kx_A$ ; $y_R = kx_R$ (b) $y_A = kx_A$ ; $y_R \neq kx_R$
(c) $y_A \neq kx_A$ ; $y_R \neq kx_R$ (d) $y_A \neq kx_A$ ; $y_R = kx_R$

**Ans.** (a, b)

Given, $y(t) = Kx(t)$ ...(1)

then, Average of $y(t) = K \times$ Average of $x(t)$

$\Rightarrow Y_A = KX_A$

From equation (1),

$$\text{Power of } y(t) = |K|^2 \cdot \text{power of } x(t)$$

$$\Rightarrow Y_R^2 = |K|^2 \cdot X_R^2 \quad [\because \text{Power} = \text{Rms}^2]$$

$$\Rightarrow Y_R = |K| \cdot X_R$$

**Case (i):** When $K$ is real and positive then,

$$|K| = K$$

and $Y_R = KX_R$

Thus option (a) is satisfied.

**Case (ii):** When $K$ is imaginary or complex or real and negative then,

$$|K| \neq K$$

and $Y_R \neq KX_R$

Thus option (b) is satisfied, option (a) and (b) both satisfies the given condition.

**GATE Ans. Key (a)**

*End of Solution*

**Q.4** Which of the following is true for all possible non-zero choices of integers $m$, $n$; $m \neq n$. or all possible non-zero choices of real numbers $p$, $q$ ; $p \neq q$, as applicable?

(a) $\frac{1}{\pi}\int_0^{\pi} \sin m\theta \sin n\theta \, d\theta = 0$

(b) $\frac{1}{2\pi}\int_{-\pi}^{\pi} \sin p\theta \cos q\theta \, d\theta = 0$

(c) $\frac{1}{2\pi}\int_{-\pi/2}^{\pi/2} \sin p\theta \sin q\theta \, d\theta = 0$

(d) $\lim\limits_{\alpha\to\infty} \frac{1}{2a}\int_{-\alpha}^{\alpha} \sin p\theta \sin q\theta \, d\theta = 0$

**Ans.** (a, b, d)

1. $$\int_{-l}^{l} \cos\left(\frac{n\pi x}{l}\right)\cos\left(\frac{m\pi x}{l}\right)dx = \begin{cases} 2l & \text{if } n=m=0 \\ l & \text{if } n=m\neq 0 \\ 0 & \text{if } m\neq n \end{cases}$$

2. $$\int_{0}^{l} \cos\left(\frac{n\pi x}{l}\right)\cos\left(\frac{m\pi x}{l}\right)dx = \begin{cases} l & \text{if } n=m=0 \\ l/2 & \text{if } n=m\neq 0 \\ 0 & \text{if } m\neq n \end{cases}$$

3. $$\int_{-l}^{l} \sin\left(\frac{n\pi x}{l}\right)\sin\left(\frac{m\pi x}{l}\right)dx = \begin{cases} l & \text{if } m=n \\ 0 & \text{if } m\neq n \end{cases}$$

4. $$\int_{0}^{l} \sin\left(\frac{n\pi x}{l}\right)\sin\left(\frac{m\pi x}{l}\right)dx = \begin{cases} l/2 & \text{if } n=m \\ 0 & \text{if } n\neq m \end{cases}$$

5. $$\int_{-l}^{l} \sin\left(\frac{n\pi x}{l}\right)\cos\left(\frac{m\pi x}{l}\right)dx = 0$$

(A): $$\frac{1}{\pi}\int_0^{\pi} \sin m\theta \cos n\theta = 0$$

Put $l = \pi$ in rule 4

$$\int_0^{\pi} \sin\left(\frac{n\pi x}{\pi}\right)\sin\left(\frac{m\pi x}{\pi}\right)dx$$

Given that, $m \neq n$

$$\frac{1}{\pi}\int_0^{\pi} \sin nx \sin mx \, dx = 0$$

(B): $$\frac{1}{2\pi}\int_{-\pi}^{\pi} \sin p\theta \cos q\theta \, d\theta = 0$$

Put $l = \pi$ in rule 5

$$\int_{-\pi}^{\pi} \sin\left(\frac{n\pi x}{\pi}\right)\cos\left(\frac{m\pi x}{\pi}\right)dx$$

Given that, $m \neq n$

$$\int_{-\pi}^{\pi} \sin nx \cos mx \, dx = 0$$

(C): $$\underset{\alpha\to\infty}{Lt}\ \frac{1}{2\alpha}\int_{-\alpha}^{\alpha}\sin p\theta\ \sin q\theta\ d\theta = 0$$

When, $\alpha \to \infty$,

$$\frac{1}{2\infty}\int_{-\infty}^{\infty}\sin p\theta \sin q\theta\, d\theta = \frac{1}{\infty}(\text{finite}) = 0$$

## GATE Ans. Key (d)

**End of Solution**

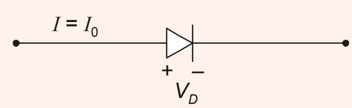
**Q.34** A non-ideal Si-based pi: junction diode is tested by sweeping the bias applied across its terminals from —5 V to +5 V. The effective thermal voltage, $V_T$, for the diode is measured to be (29 ± 2) mV. The resolution of the voltage source in the measurement range is 1 mV. The percentage uncertainty (rounded off to 2 decimal plates) in the measured current at a bias voltage of 0.02 V is _______.

**Ans.** (5.87)

$$V_T = (29 \pm 2)\text{ mV}$$

$$= \left(\underset{V_T}{\underset{\downarrow}{0.029}} \pm \underset{W_{V_T}}{\underset{\downarrow}{(0.002)}}\right)\text{V} \quad \left| \begin{array}{l} V_D = 0.02\text{ V} \\ W_{V_D} = 1\text{ mV} = 0.001\text{ V}\end{array}\right.$$

$$I_D = I = I_0 \cdot e^{\frac{V_D}{\eta V_T}}$$




Applying log on both sides,

$$\ln(I) = \ln(I_0) + \frac{V_D}{\eta V_T}$$

Differentiating w.r.t. '$V_T$',

$$\frac{\partial I}{I} = 0 + \left(\frac{V_D}{\eta}\right)\left(1 - \frac{1}{V_T^2} \times \partial V_T\right) \Rightarrow \frac{\partial I}{\partial V_T} = -\frac{V_D I}{\eta V_T^2}$$

For $$\eta = 1 \Rightarrow \frac{\partial I}{\partial V_T} = -\frac{V_D I}{V_T^2}$$

Differentiating w.r.t. '$V_D$',

$$\frac{\partial I}{I} = 0 + \frac{1}{\eta V_T}\cdot \partial V_D \Rightarrow \frac{\partial I}{\partial V_D} = -\frac{I}{\eta V_T}$$

$\Rightarrow$ $$\frac{\partial I}{\partial V_D} = \frac{I}{V_T}; \quad \text{for } \eta = 1$$

$$W_{\text{res}} = \sqrt{\left(\frac{\partial I}{\partial V_T}\right)^2 W_{V_T}^2 + \left(\frac{\partial I}{\partial V_D}\right)^2 W_{V_D}^2}$$

$$= \sqrt{\left(-\frac{V_D I}{V_T^2}\right)^2 W_{V_T}^2 + \left(\frac{I}{V_T}\right)^2 W_{V_D}^2}$$

$$= \sqrt{\frac{V_D^2 \cdot I^2}{V_T^4} \times W_{V_T}^2 + \left(\frac{I}{V_T}\right)^2 \times W_{V_D}^2}$$

$$W_{res} = \sqrt{\frac{I^2 \times (0.02)^2}{(0.029)^4} \times (0.002)^2 + \frac{I^2}{(0.029)^2} \times (0.001)^2}$$

$$= I \times \sqrt{2.262 \times 10^{-3} + 1.189 \times 10^{-3}}$$

$$= 0.0587 \times I$$

$$\% \frac{W_{res}}{I} = \pm 0.0587 \times 100$$

$$\Rightarrow \quad \% \frac{W_I}{I} = \pm 5.87\%$$

## GATE Ans. Range (11.50 to 12.00)

*End of Solution*

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**Q.55** The number of purely real elements in a lower triangular representation of the given $3 \times 3$ matrix, obtained through the given decomposition is

$$\begin{bmatrix} 2 & 3 & 3 \\ 3 & 2 & 1 \\ 3 & 1 & 7 \end{bmatrix} = \begin{bmatrix} a_{11} & 0 & 0 \\ a_{12} & a_{22} & 0 \\ a_{13} & a_{23} & a_{33} \end{bmatrix} \begin{bmatrix} a_{11} & 0 & 0 \\ a_{12} & a_{22} & 0 \\ a_{13} & a_{23} & a_{33} \end{bmatrix}^T$$

(a) 6
(b) 5
(c) 8
(d) 9

**Ans.** **(d)**

$$\begin{bmatrix} 2 & 3 & 3 \\ 3 & 2 & 1 \\ 3 & 1 & 7 \end{bmatrix} = \begin{bmatrix} l_{11} & 0 & 0 \\ l_{21} & l_{22} & 0 \\ l_{31} & l_{32} & l_{33} \end{bmatrix} \begin{bmatrix} u_{11} & u_{12} & u_{13} \\ 0 & u_{22} & u_{23} \\ 0 & 0 & u_{33} \end{bmatrix}$$

Consider $u_{11} = u_{22} = u_{33} = 1$

$$\begin{bmatrix} 2 & 3 & 3 \\ 3 & 2 & 1 \\ 3 & 1 & 7 \end{bmatrix} = \begin{bmatrix} l_{11} & 0 & 0 \\ l_{21} & l_{22} & 0 \\ l_{31} & l_{32} & l_{33} \end{bmatrix} \begin{bmatrix} 1 & u_{12} & u_{13} \\ 0 & 1 & u_{23} \\ 0 & 0 & 1 \end{bmatrix}$$

$$\begin{bmatrix} 2 & 3 & 3 \\ 3 & 2 & 1 \\ 3 & 1 & 7 \end{bmatrix} = \begin{bmatrix} l_{11} & l_{11}u_{12} & l_{11}u_{13} \\ l_{21} & l_{21}u_{12} + l_{22} & l_{21}u_{13} + l_{22}u_{23} \\ l_{31} & l_{31}u_{12} + l_{32} & l_{31}u_{13} + l_{32}u_{23} + l_{33} \end{bmatrix}$$

$$l_{11} = 2 \qquad l_{11}u_{12} = 3 \qquad l_{11}u_{13} = 3$$

$$l_{21} = 3 \qquad 2u_{12} = 3 \qquad 2u_{13} = 3$$

$$l_{31} = 3 \qquad u_{12} = \frac{3}{2} \qquad u_{13} = \frac{3}{2}$$

$$l_{21}u_{12} + l_{22} = 2 \qquad l_{21}u_{13} + l_{22}u_{23} = 1$$

$$(3)\left(\frac{3}{2}\right) + l_{22} = 2 \qquad (3)\left(\frac{3}{2}\right) + \left(-\frac{5}{2}\right)u_{23} = 1$$

$$l_{22} = -\frac{5}{2} \qquad u_{23} = \frac{7}{5}$$

$$l_{31}u_{12} + l_{32} = 1 \qquad l_{31}u_{13} + l_{32}u_{23} + l_{33} = 7$$

$$(3)\left(\frac{3}{2}\right) + l_{32} = 1 \qquad (3)\left(\frac{3}{2}\right) + \left(-\frac{7}{2}\right)\left(\frac{7}{5}\right) + l_{33} = 7$$

$$l_{32} = -\frac{7}{2} \qquad l_{33} = \frac{74}{10}$$

$$L = \begin{bmatrix} 2 & 0 & 0 \\ 3 & -5/2 & 0 \\ 3 & -7/2 & 74/10 \end{bmatrix}$$

The number of purely real elements of lower triangular matrix are 9.

## GATE Ans. Key (c)

*End of Solution*

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