



JEE (Main)

PAPER-1 (B.E./B. TECH.)

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2021

COMPUTER BASED TEST (CBT) Memory Based Questions & Solutions

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Duration: 3 Hours | Max. Marks: 300

SUBJECT: MATHEMATICS

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**RESULT: JEE (Advanced),
JEE (Main), NEET**

HIGHEST No. of Classroom Selections
in JEE (Advanced) 2020 from any Institute of Kota

5 AIRs in TOP-50 in JEE (Adv.) 2020 from Classroom

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AIR-2 (GEN-EWS) AIR-15 DHANANJAY KEJRIWAL With us Since Class 9 th	Zonal Topper IIT-Kharagpur AIR-25 SAMARTH AGARWAL With us Since Class 11 th	2nd Rank in IIT-Kharagpur Zone AIR-29 SANKALP PARASHAR With us Since Class 11 th	AIR-30 AARYAN K. GUPTA With us Since Class 9 th	AIR-41 UTKARSH P. SINGH With us Since Class 10 th
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Total Selections in JEE (Advanced) 2020

1505

Eligible for JEE (Advanced) Through JEE (Main) 2020

11755

NEET 2020

2646

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CLASS 11, 12 & 12+

Target: JEE (Main+Adv.) | JEE (Main) | NEET

Scholarship Upto 90%*

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PART : MATHEMATICS

1. If element of matrix A is defined as $A = [a_{ij}]_{3 \times 3}$ where $A = \begin{cases} (-1)^{j-i} & i < j \\ 2 & i = j \\ (-1)^{i+j} & i > j \end{cases}$, then the value of $|3\text{Adj}(2A^{-1})|$ is:

(1) 72 (2) 36 (3) 108 (4) 48

Sol. $A = \begin{bmatrix} -1 & 2 & -1 \\ 1 & -1 & 2 \end{bmatrix}$

So, $|A| = \begin{vmatrix} 2 & -1 & 1 \\ -1 & 2 & -1 \\ 1 & -1 & 2 \end{vmatrix}$

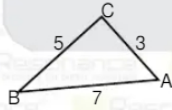
$= 2(4-1) + 1(-2+1) + 1(1-2)$
 $= 2(3) + 1(-1) + 1(-1)$
 $= 4$

$|3\text{Adj}(2A^{-1})| = 3^3 |\text{Adj}(2A^{-1})| = 3^3 \times |2A^{-1}|^2$
 $= 3^3 \times 2^6 \times |A^{-1}|^2 = 3^3 \times 2^6 \times \frac{1}{|A|^2} = 108$

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2. In a ΔABC , if $|AB|=7$, $|BC|=5$, and $|CA|=3$. If projection of BC on CA is $\left(\frac{5}{2}\right)$, then the value of $\sin A$ is

Sol. $|AB|=7$, $|BC|=5$, $|CA|=3$.



Projection of \vec{BC} on \vec{CA} is $= |\vec{BC}| \cos \angle BCA$

$$5 \left(\frac{3^2 + 5^2 - 7^2}{2 \cdot 3 \cdot 5} \right) = 5 \left(\frac{-15}{30} \right) = \frac{5}{2}$$

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3. The value of $\tan(2\tan^{-1}(3/5) + \sin^{-1}(5/13))$ is :

- (1) $\frac{220}{21}$ (2) $\frac{110}{21}$ (3) $\frac{55}{21}$ (4) $\frac{20}{11}$

Ans. (1)

Sol. $\tan \left(\tan^{-1} \frac{5}{12} + \tan^{-1} \frac{5}{12} \right)$

$$\tan \left(\tan^{-1} \left(\frac{15}{8} \right) + \tan^{-1} \left(\frac{5}{12} \right) \right) = \frac{\frac{15}{8} + \frac{5}{12}}{1 - \frac{15}{8} \cdot \frac{5}{12}} = \frac{220}{21}$$

4. Mean of 6 observations is 10 and their variance is $\frac{20}{3}$. If observations are 15, 11, 10, 7, a, b then

$|a - b|$ is equal to :

- (1) 2 (2) 1 (3) 3 (4) 4

Ans. (2)

Sol. Mean = 10

$$\frac{7+10+11+15+a+b}{6} = 10$$

$$a + b = 17 \quad \dots\dots\dots(1)$$

$$\frac{49+100+121+225+a^2+b^2}{6} - 100 = \frac{20}{3}$$

$$a^2 + b^2 = 145 \quad \dots\dots\dots(2)$$

$$(a + b)^2 = 289$$

$$ab = 72$$

$$(a - b)^2 = (a + b)^2 - 4ab$$

$$(a - b)^2 = 289 - 288 = 1$$

$$|a - b| = 1$$

5. If $f(x) = x + 1$, then find $\lim_{n \rightarrow \infty} \frac{1}{n} \left[f(0) + f\left(\frac{5}{n}\right) + f\left(\frac{10}{n}\right) + \dots\dots\dots + f\left(\frac{5(n-1)}{n}\right) \right]$

- (1) $\frac{7}{2}$ (2) $\frac{3}{2}$ (3) $\frac{5}{2}$ (4) $\frac{1}{2}$

Ans. (1)

Sol. $= \lim_{n \rightarrow \infty} \frac{1}{n} \sum_{r=0}^{n-1} f\left(\frac{5r}{n}\right) = \int_0^5 f(x) dx = \int_0^5 (x+1) dx$

$$= \left(\frac{5x^2}{2} + x \right)_0^7 = \frac{5}{2} + 1 = \frac{7}{2} \text{ Ans.}$$

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x is :

- (1) 7 (2) 243 (3) 9 (4) 81

Ans. (3)

Sol. $2 \log_9 x + 3 \log_9 x + 4 \log_9 x \dots 21$ terms

$$= (2 + 3 + 4 + 5 + \dots + 22) \log_9 x = \frac{21}{2} (2+22) \log_9 x$$

$$= 21 \times 12 \log_9 x$$

$$= 252 \log_9 x$$

$$\text{Given sum} = 252 \Rightarrow \log_9 x = 1$$

$$\Rightarrow x = 9$$

7. $\int_{\frac{1}{2}}^{\frac{1}{\sqrt{2}}} ([x] - [\sin x]) dx = ?$ (Where $[\cdot]$ represents G.I.F.)

Ans. (3)

$$\text{Sol. } I = \int_{\frac{1}{2}}^{\frac{1}{\sqrt{2}}} ([x] - [\sin x]) dx$$

$$\text{using property } \int_{-a}^a f(x) dx = \int_0^a f(x) dx + \int_0^a f(-x) dx$$

$$I = \int_0^{\frac{1}{\sqrt{2}}} ([x] + [-x]) dx - \int_0^{\frac{1}{\sqrt{2}}} ([\sin x] + [-\sin x]) dx = 0$$

8. If $\lim_{x \rightarrow 0} \frac{\alpha x e^x - \beta / n(1+x) + \gamma x^2 e^{-x}}{x^3} = 10$, then the value of $\alpha + \beta + \gamma$ is :

Ans. (3)

$$\text{Sol. } \lim_{x \rightarrow 0} \frac{\alpha x e^x - \beta / n(1+x) + \gamma x^2 e^{-x}}{x^3} = 10$$

$$\Rightarrow \alpha - \beta = 0, \Rightarrow \alpha = \beta$$

$$\Rightarrow \alpha + \frac{\beta}{2} + \gamma = 0 \Rightarrow \gamma = -\frac{3\beta}{2}$$

$$\Rightarrow \frac{\alpha}{2} - \frac{\beta}{3} - \gamma = 10$$

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$$\Rightarrow \frac{\beta}{2} - \frac{\beta}{3} + \frac{3\beta}{2} = 10 \Rightarrow \frac{3\beta - 2\beta + 9\beta}{6} = 10$$

$$\therefore \beta = 6, \alpha = 6, \gamma = -9$$

So, the value of $\alpha + \beta + \gamma = 3$

9. The value of x satisfying the equation $\log_{(x+1)}(2x^2 + 7x + 5) + \log_{(2x+5)}(x+1)^2 = 4$ is :

- (1) -2 (2) 2 (3) -4 (4) 4

Ans. (2)

Sol. $\log_{(x+1)}((2x+5)(x+1)) + \log_{(2x+5)}(x+1)^2 = 4$

$$1 + \log_{(x+1)}(2x+5) + 2\log_{(2x+5)}(x+1) = 4$$

$$\log_{(x+1)}(2x+5) + 2\log_{(2x+5)}(x+1) = 3$$

$$t^2 + t + 2 = 4t \Rightarrow t^2 - 3t + 2 = 0$$

$$t = 1, t = 2$$

For t = 1

$$2x + 5 = x + 1$$

$$\Rightarrow x = -4 \text{ (rejected)}$$

For t = 2

$$2x + 5 = (x + 1)^2$$

$$x = 2, x = -2 \text{ (rejected)}$$

10. If (α, β) is the point on $y^2 = 6x$, that is closest to $(3, \frac{3}{2})$ then find $2(\alpha + \beta)$

- (1) 6 (2) 9 (3) 7 (4) 5

Ans. (2)

Sol.

$(3, 3/2)$

$$y^2 = 6x$$

$$2yy' = 6$$

$$\frac{dy}{dx} = \frac{3}{\beta}$$

$$-\frac{\beta}{3} = \frac{\beta - 3/2}{\alpha - 3}$$

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$$-\frac{\beta}{3} = \frac{2\beta - 3}{2\alpha - 6}$$

$$-\beta(2\alpha - 6) = 6\beta - 9$$

$$6\beta - 2\alpha\beta = 6\beta - 9$$

$$\alpha\beta = \frac{9}{2} \Rightarrow \beta = \frac{9}{2\alpha}$$

$$4\alpha^2 = 9$$

$$\alpha^3 = \frac{27}{8} \quad \alpha = \frac{3}{2}, \beta^2 = 9 \Rightarrow \beta = \pm 3$$

$$\alpha = \frac{3}{2}, \beta = 3$$

$$2(\alpha + \beta) = 9$$

11. Two circles pass through $(-1, 4)$ and their centres lie on $x^2 + y^2 + 2x + 4y = 4$. If r_1 and r_2 are maximum and minimum radii and $\frac{r_1}{r_2} = a + b\sqrt{2}$ then the value of $a + b$ is

Ans. 3

Sol. Given circle

$$(x + 1)^2 + (y + 2)^2 = (3)^2$$

any point on this circle is $(3\cos\theta - 1, 3\sin\theta + 2)$ equation of circle having centre $(3\cos\theta - 1, 3\sin\theta + 2)$

$$r = \sqrt{(3\cos\theta - 1 + 1)^2 + (3\sin\theta + 2 - 4)^2}$$

$$= \sqrt{9\cos^2\theta + 9\sin^2\theta + 36 - 36\sin\theta}$$

$$\sqrt{45 - 36\sin\theta}$$

$$\Rightarrow r_{\max} = 9 = r_1 \text{ and } r_{\min} = 3 = r_2$$

$$\Rightarrow \frac{r_1}{r_2} = \frac{9}{3} = 3 = 3 + 0\sqrt{2}$$

$$\Rightarrow a + b = 3$$

12. If ΔABC is right angled triangle with sides a, b & c and smallest angle θ . If $\frac{1}{a}, \frac{1}{b}$ and $\frac{1}{c}$ are also the sides of right angled triangle then find $\sin\theta$

(1) $\sqrt{\frac{3-\sqrt{5}}{2}}$

(2) $\frac{3-\sqrt{5}}{2}$

(3) $\sqrt{\frac{3+\sqrt{5}}{2}}$

(4) $\frac{3+\sqrt{5}}{2}$

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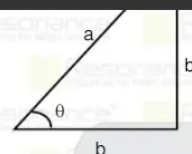
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Ans. (1)

Sol. Let $a > b > c$



$$\sin\theta = \frac{c}{a}$$

$$\frac{1}{a} < \frac{1}{b} < \frac{1}{c}$$

$$\frac{1}{c^2} = \frac{1}{a^2} + \frac{1}{b^2}$$

$$1 = \frac{c^2}{a^2} + \frac{c^2}{b^2}$$

$$1 = \sin^2\theta + \frac{1}{\frac{a^2}{c^2} - 1} = \sin^2\theta + \frac{1}{\operatorname{cosec}^2\theta - 1}$$

$$1 = \frac{1 - \sin^2 \theta + 1}{\operatorname{cosec}^2 \theta - 1} \Rightarrow \sin^2 \theta + \operatorname{cosec}^2 \theta = 3$$

13. If $\operatorname{Re} [(1 + \cos \theta + 2i \sin \theta)^{-1}] = 4$ then value of θ is :

- (1) $\frac{\pi}{2}$ (2) $\frac{\pi}{3}$ (3) $-\frac{\pi}{2}$ (4) π

Ans. (4)

$$\begin{aligned} \text{Sol. } & \frac{1}{1 + \cos^2 \theta + 2i \sin \theta} \times \frac{1 + \cos \theta - 2i \sin \theta}{1 + \cos \theta - 2i \sin \theta} \\ & = \frac{1 + \cos \theta - 2i \sin \theta}{(1 + \cos \theta)^2 + 4 \sin^2 \theta} \end{aligned}$$

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$$\begin{aligned} & \frac{1 + \cos \theta}{1 + \cos^2 \theta + 2 \cos \theta + 4 - 4 \cos^2 \theta} = 4 \\ & \Rightarrow \frac{1 + \cos \theta}{1 + \cos^2 \theta + 2 \cos \theta + 4 - 4 \cos^2 \theta} = 4 \end{aligned}$$

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$$\Rightarrow \frac{1 + \cos \theta}{5 + 2 \cos \theta - 3 \cos^2 \theta} = 4$$

$$\Rightarrow 1 + \cos \theta = 20 + 8 \cos \theta - 12 \cos^2 \theta$$

$$\Rightarrow 12 \cos^2 \theta - 7 \cos \theta - 19 = 0$$

$$\Rightarrow 12 \cos^2 \theta - 19 \cos \theta + 12 \cos \theta - 19 = 0$$

$$\Rightarrow \cos \theta (12 \cos \theta - 19) + 1 (12 \cos \theta - 19) = 0$$

$$\Rightarrow \cos \theta = -1 \text{ or } \cos \theta = \frac{19}{12} \text{ (rejected)}$$

$$\Rightarrow \theta = \pi$$

14. If $x = ay - 1 = z - 2$, and $x = 3y - 2 = bz - 2$ lie in same plane then the value of a, b , is

- (1) $a = 2, b = 3$ (2) $a = 1, b = 1$ (3) $b = 1, a \in \mathbb{R} - \{0\}$ (4) $a = 3, b = 2$

Ans. (3)

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$$\begin{vmatrix} 1 & \frac{1}{a} & 1 \\ \frac{1}{3} & \frac{1}{b} & 1 \end{vmatrix} = 0$$

$$(\vec{a}_1 - \vec{a}_2) \cdot (\vec{b}_1 \times \vec{b}_2) = 0$$

$$\begin{vmatrix} 0 & \frac{1}{a} - \frac{2}{3} & 2 - \frac{2}{b} \\ 1 & \frac{1}{a} & 1 \\ 1 & \frac{1}{3} & \frac{1}{b} \end{vmatrix} = 0$$

$$\Rightarrow \frac{1}{ab} - \frac{1}{a} = 0$$

$$b = 1, a \in \mathbb{R} - \{0\}$$

15. If $P(\bar{A} \cap B) + P(A \cap \bar{B}) = 1 - K$

$$P(\bar{A} \cap C) + P(A \cap \bar{C}) = 1 - 2K$$

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$$P(A \cap B \cap C) = K^2, K \in (0, 1)$$

Then the value of P (at least one of A, B, C) is:

- (1) $> \frac{1}{2}$ (2) $\left[\frac{1}{2}, \frac{1}{3} \right]$ (3) $< \frac{1}{2}$ (4) $\frac{1}{2}$

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Sol. $P(A) + P(B) - 2P(A \cap B) = 1 - K$
 $P(A) + P(C) - 2P(A \cap C) = 1 - 2K$
 $P(B) + P(C) - 2P(B \cap C) = 1 - K$
 $P(A \cup B \cup C) = P(A) + P(B) + P(C) - P(A \cap B) - P(B \cap C) - P(A \cap C) + P(A \cap B \cap C)$
 $= \frac{3-4k}{2} + k^2 = \frac{2k^2 - 4k + 3}{2}$
 \therefore The value of $2k^2 - 4k + 3$ is greater than 1
 $\therefore P(A \cup B \cup C) > \frac{1}{2}$

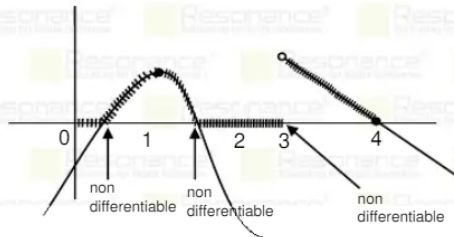
(1) -5 (2) 5 (3) 6 (4) -6

Ans. (1)

Sol. $f(f(x)) = \frac{5f(x)+3}{6f(x)+a} = x \Rightarrow 5f(x) + 3 = 6x f(x) + ax$
 $\Rightarrow \frac{25x+15}{6x+a} + 3 = 6x \left(\frac{5x+3}{6x+a} \right) + ax$
 $\Rightarrow 25x + 15 + 18x + 3a = 30x^2 + 18x + 6ax^2 + a^2x$
 $\Rightarrow (30+6a)x^2 + (a^2 - 25)x - (3a+15) = 0$
 $\Rightarrow 6(a+5)x^2 + (a-5)(a+5)x - 3(a+5) = 0, \quad \forall x$
 $\Rightarrow a+5 = 0 \Rightarrow a = -5$

17. If $g(t) = \begin{cases} \max(t^3 - 6t^2 + 9t - 3, 0), & t \in [0, 3] \\ 4 - t, & t \in (3, 4] \end{cases}$ then the number of points at which $g(t)$ is non differentiable is :

Sol. $y = t^3 - 6t^2 + 9t - 3$
 $y' = 3t^2 - 12t + 9$
 $= 3(t^2 - 4t + 3)$



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18. A : if $2 + 4 = 7$, then $3+4 = 8$
 B : if $3 + 5 = 8$, then earth is flat
 C : if A and B are true, then $5+4 = 11$
 (1) A is true, B and C are false (2) B is true, A and C are false
 (3) C is true, A and B are false (4) B is false, A and C are true

Ans. (4)

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p	q	$p \rightarrow q$
T	T	T
T	F	F
F	T	T
F	F	T

A is true, B is false, C is true .

19. If $A = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$, $B = \sum_{r=1}^{2021} A^r$ then value of $|B|$ is
 (1) 2021 (2) $(2021)^2$ (3) -2021 (4) 0

Ans. (2)

Sol. $A=I$, $B = I + I + \dots$ 2021 times

$$B = 2021 \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$$

$$|B| = (2021)^2$$

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