



# JEE (Main)

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# 2021

## COMPUTER BASED TEST (CBT)

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### Memory Based Questions & Solutions

Date: 20 July, 2021 (SHIFT-2) | TIME : (3.00 p.m. to 6.00 p.m)

Duration: 3 Hours | Max. Marks: 300

#### SUBJECT: MATHEMATICS

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

**HIGHEST No. of Classroom Selections**

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



AIR-2  
(GEN-EWS)

**AIR-15**

DHANANJAY



Zonal Topper  
IIT-Kharagpur

**AIR-25**

SAMARTH



2nd Rank in  
IIT-Kharagpur Zone

**AIR-29**

SANKALP



AARYAN K.

**AIR-30**



UTKARSH P.

**AIR-41**

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Total Selections in JEE (Advanced) 2020

**4505**

Classroom: 3441 | Distance: 1064

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

**14755**

Classroom: 11047 | Distance: 3708

NEET 2020

**2646**

Classroom: 1633 | Distance: 813

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JEE MAIN-2021 | DATE : 20-07-2021 (SHIFT-2) | PAPER-1 | MEMORY BASED | MATHEMATICS

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- 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

Ans. (3)

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

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

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

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

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

$$= 4$$

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

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

Q. If  $\vec{OA}$  is parallel to  $\vec{OB}$ ,  $\vec{OC}$  is perpendicular to  $\vec{OA}$  and  $\vec{OD}$  is perpendicular to  $\vec{OC}$ , then the value of  $n$  is

2. In a  $\triangle ABC$ , if  $|AB| = 7$ ,  $|BC| = 5$ , and  $|CA| = 3$ . If projection of  $\overrightarrow{BC}$  on  $\overrightarrow{CA}$  is  $\left(\frac{1}{2}\right)$ , then the value of  $\theta$  is:

Ans. 05.00

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



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

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

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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.  $\tan\left(\tan^{-1}\frac{6}{5} + \tan^{-1}\frac{5}{12}\right)$

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

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

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

$$a+b=17$$

$$\text{Variance} = \frac{20}{3}$$

$$49 + 100 + 121 + 225 + a^2 + b^2 = 20$$

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

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

$$ab = 72$$

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

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

$$|a-b| = 1$$

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

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

Ans. (1)

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

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$$= \left( 2^{-n+1} \right)_0^\infty = 2^{-1} = 2 \text{ ANS.}$$

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x is :

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

Ans. (3)

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

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

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

$$= 252 \log_9 x$$

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

$$\Rightarrow x = 9$$

- (1) -2

- (2) 1

- (3) 0

- (4) -1

Ans. (3)

$$\text{Sol. } I = \int_{-\frac{\pi}{2}}^{\frac{\pi}{2}} [x] - [\sin x] dx$$

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

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

$$\alpha x e^x - \beta / n (1+x) + \gamma x^2 e^{-x}$$

Ans. (3)

$$\text{Sol. } \lim_{x \rightarrow 0} \frac{\alpha x \left( 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \dots \right) - \beta \left( x - \frac{x^2}{2} + \frac{x^3}{3} + \dots \right) + \gamma x^2 \left( 1 - x + \frac{x^2}{2!} - \frac{x^3}{3!} + \dots \right)}{x^3} = 10$$

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

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

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

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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 :

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**Ans. (2)**

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

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

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

$$\therefore 1 + t + \frac{2}{t} = 4$$

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

$$t = 1, t = 2$$

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  $(\alpha, \beta)$  is the point on  $y^2 = 6x$  such that is closest to  $(3, 3)$  then find  $\alpha/\beta + \beta$ .

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(1) 6

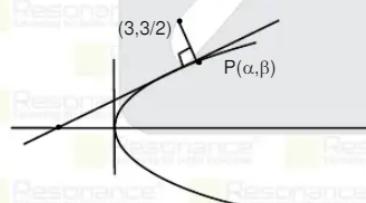
(2) 9

(3) 7

(4) 5

**Ans. (2)**

**Sol.**



$$y^2 = 6x$$

$$2yy' = 6$$

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

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$$-\frac{1}{3} = \frac{1}{\alpha - 3}$$

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

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

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

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

$$\therefore \beta^2 = 6\alpha$$

$$\frac{81}{4\alpha^2} = 6\alpha$$

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

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

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

4 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  $(3\cos\theta - 1, 3\sin\theta - 2)$

$\Rightarrow$  radius of circle is

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

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

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

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

$$\Rightarrow a + b = 3$$

12. If  $\triangle ABC$  is right angled triangle with sides  $a, b$  &  $c$  and smallest angle  $\theta$ . 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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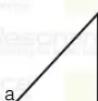
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**Ans. (1)**

**Sol.** Let  $a > b > c$



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

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

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

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

$$1 = \frac{c^2}{a^2} + \frac{c^2}{a^2 - c^2} [As a^2 = b^2 + c^2]$$

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

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

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

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

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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

$$(1) a = 2, b = 3 \quad (2) a = 1, b = 1 \quad (3) b = 1, a = R \setminus \{0\} \quad (4) a = 3, b = 2$$

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$$\text{Sol. } \frac{x}{1} = \frac{y - \frac{1}{a}}{\frac{1}{3}} = \frac{z - 2}{1}, \quad x = \frac{y - \frac{2}{b}}{\frac{1}{3}} = \frac{z - 2}{\frac{1}{b}}$$

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

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

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

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

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

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

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

Then the value of  $P(\text{at least one of } A, B, C)$  is:

$$(1) > \frac{1}{2}$$

$$(2) \left[ \frac{1}{2}, \frac{1}{4} \right]$$

$$(3) < \frac{1}{2}$$

$$(4) \frac{1}{2}$$

Ans. (1)

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Sol.

$$P(A) + P(B) - 2P(A \cap B) = 1 - K$$

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

$$P(B) + P(C) - 2P(B \cap C) = 1 - K$$

$$P(A \cup B \cup C) = P(A) + P(B) + P(C) - P(A \cap B) - P(B \cap C) - P(A \cap C) + P(A \cap B \cap C)$$

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∴ The value of  $2k^2 - 4k + 3$  is greater than 1

$$\therefore P(A \cup B \cup C) > \frac{1}{2}$$

16. If  $f(x) = \frac{5x+3}{6x+a}$  and  $f(f(x)) = x$  then the value of a is :

(1) -5

(2) 5

(3) 6

(4)-6

Ans. (1)

Sol.  $f(f(x)) = \frac{5f(x)+3}{6f(x)+a} = x \Rightarrow 5f(x)+3 = 6xf(x)+ax$

$$\Rightarrow \frac{25x+15}{6x+a} + 3 = 6x\left(\frac{5x+3}{6x+a}\right) + ax$$

$$\Rightarrow 25x+15+18x+3a = 30x^2+18x+6ax^2+a^2x$$

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$$\Rightarrow (a+5)x^2 + (a-5)x - 3(a+5) = 0, \quad \forall x$$

$$\Rightarrow a+5 = 0 \Rightarrow a = -5$$

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 :

(1) 1

(2) 3

(3) 2

(4) 4

Ans. (2)

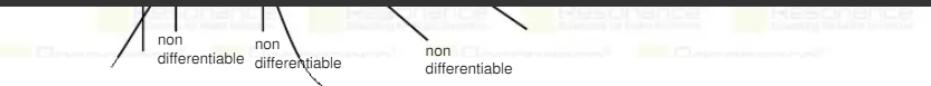
Sol.  $y = t^3 - 6t^2 + 9t - 3$

$$y' = 3t^2 - 12t + 9$$

$$= 3(t^2 - 4t + 3)$$



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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

(3) C is true, A and B are false

(2) B is true, A and C are false

(4) B is false, A and C are true

Ans. (4)

Sol. Truth table  $p \rightarrow q$

p	q	$p \rightarrow q$
T	T	T
T	F	F
F	T	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)<sup>2</sup>

(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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