JEE (Main) 2020

Computer Based Test (CBT)
Memory Based Questions & Solutions

Date: 04 September, 2020 (SHIFT-2) | Time: (03.00 p.m. to 06.00 p.m)

Duration: 3 Hours | Max. Marks: 300

Subject: Mathematics

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PART: MATHEMATICS

1. If \( a_1, a_2, a_3, \ldots, a_n \) are in Arithmetic Progression, whose common difference is an integer such that \( a_1 = 1 \), \( a_n = 300 \) and \( n \in [15, 50] \), then \((S_{n+2}, a_{n+2})\) is
   \[ \begin{align*}
   & (1) \quad (2491, 247) \\
   & (2) \quad (2490, 246) \\
   & (3) \quad (2590, 249) \\
   & (4) \quad (248, 2490)
   \end{align*} \]

   **Ans.**

   **Sol.**

   \( a_n = a_1 + (n-1)d \)

   \[ \begin{align*}
   \Rightarrow \quad d &= \frac{299}{n-1} = \frac{13 \times 23}{n-1} = \text{integer} \\
   \Rightarrow \quad n &= 14, 12, 24, 22, 300, -298, 2, 0
   \end{align*} \]

   But \( n \in [15, 50] \)

   \[ \Rightarrow \quad n &= 24 \Rightarrow \quad d = 13 \]

   Hence \( S_{n+2} = \frac{2}{2} \left[ (1) + (20 - 1)(13) \right] = 10(2 + 247) = 2490 \)

   \[ a_{n+2} = a_{22} = a_1 + 19d = 1 + 19 \times 13 = 1 + 247 = 248 \]

2. If \( \lim_{t \to x} \frac{x^2 + 2(1 - t^2) - 2t^2(x)}{t - x} = 0 \) and \( f(1) = e \) then solution of \( f(x) = 1 \) is
   \[ \begin{align*}
   & (1) \quad \frac{1}{e} \\
   & (2) \quad \frac{1}{2e} \\
   & (3) \quad e \\
   & (4) \quad 2e
   \end{align*} \]

   **Ans.**

   **Sol.**

   \[ \lim_{t \to x} \frac{x^2 + 2(1 - t^2) - 2t^2(x)}{t - x} = 0 \]

   using L'Hospital

   \[ \lim_{t \to x} \frac{x^2 + 2(f(1) - 2t^2(x))}{1} = 0 \]

   \[ \Rightarrow \quad x^2 \quad 2f(x) f'(x) - 2x f'(x) = 0 \]
2x f(x) [xf(x) - f(x)] = 0
f(1) = 0 so xf(x) = f(x)
x \frac{dy}{dx} + y = \frac{1}{x}dy = \frac{1}{dx}

Integration /my = /n + \lambda nc
y = cx \Rightarrow f(x) = cx
Now f(1) = c = e
so f(x) = ex
now f(x) = 1
ex = 1 \Rightarrow x = \frac{1}{e}

3. Minimum value of 2^{\sin x} + 2^{\cos x}
is

\begin{align*}
(1) & \quad 2 \cdot 2^{\frac{1}{2}} \\
(2) & \quad 2 \cdot 2^{\frac{1}{2}} \\
(3) & \quad 2^{\frac{1}{2}} \cdot 2 \\
(4) & \quad 2^{\frac{1}{2}} \\
\end{align*}

\text{Ans.} \quad (1)

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\textbf{Sol.} Using A.M. \geq G.M.
\[2^{\sin x} + 2^{\cos x} = 2 \cdot 2^{\frac{1}{2} \sin x + \cos x} \geq 2 \cdot 2^{\frac{1}{2} \cdot 2 \sin x + \cos x} \]
\[\geq 2 \cdot 2^{\frac{1}{2} \sin x + \cos x} \]
\[= 2^{\frac{1}{2}} \sin x + \cos x \]

Now \[\sin x + \cos x = \sqrt{2} \]
so \[= \frac{1}{2} \sin x + \cos x \leq \frac{1}{2} \]
minimum value of \[2^{\sin x} + 2^{\cos x} \]
so by (i)
minimum value of \[2^{\sin x} + 2^{\cos x} \]
minimum value of \[2^{\sin x} + 2^{\cos x} = 2^{\frac{1}{2} \cdot 2} \]

4. If \[a = i + j + 2k \] then the value of \[i \times [a \times j] + j \times [a \times k] + k \times [a \times i] \]
is
\text{Ans.} 18.00

\textbf{Sol.} Let \[a = i + j + 2k \]
\[i \times [a \times j] = (i)(a - [a \times j]) = j + 2k \]
similarly \[j \times [a \times k] = i + 2k \]
\[k \times [a \times i] = i + 2k \]
\[\|i \times [a \times j] + j \times [a \times k] + k \times [a \times i]\|
\[\|j \times [a \times k] + k \times [a \times i] + i \times [a \times j]\|
\[\|2[k^2 + i^2 + j^2 + i^2 + j^2 + k^2]\|
\[2 \cdot 4^2 = 2 \cdot 4 = 18 \]

5. \[\int_0^n x \ dx \]
\[\int_0^n x \ dx \text{ and } 10^n(n^2 - n) \text{ are in Geometric progression, where } [x] \text{ & } [\{x\}] \text{ represents fractional part function and greatest integral function respectively, find } n \text{ if } n > N \text{ and } n > 1 \]
\text{Ans.} 21.00

\textbf{Sol.} \[\int_0^n x \ dx = \int_0^{\frac{n}{2}} x \ dx + \int_{\frac{n}{2}}^n x \ dx = \frac{n^2}{2} - \frac{n^2}{2} = -n \]
and \[\int_0^n [x] \ dx = \int_0^{\frac{n}{2}} [x] \ dx + \int_{\frac{n}{2}}^n [x] \ dx = \frac{n}{2} \cdot \frac{n}{2} = \frac{n^2}{2} - \frac{n}{2}
\]
now \[\frac{n}{2} \cdot \frac{n^2}{2} \text{ and } 10^n(n^2 - n) \text{ are in Geometric progression}
\]
\[= \left(\frac{n^2 - n}{2}\right)^2 = \frac{n^2}{2} \cdot 10^n(n^2 - n) \Rightarrow \frac{n^2(n^2 - n)}{4} = 5n^2(n - 1) \Rightarrow n - 1 = 20 \Rightarrow n = 21 \]
6. The ratio of three consecutive terms in expansion of \((1 + x)^{10}\) is 5 : 10 : 4, then greatest coefficient is (1) 252 (2) 462 (3) 792 (4) 320

Ans. (2)

Sol. Let three consecutive terms are \(T_r, T_{r+1}, T_{r+2}\)

Hence \(\frac{T_r}{T_{r+1}} = \frac{5}{10}\) and \(\frac{T_{r+1}}{T_{r+2}} = \frac{10}{14}\)

\(\frac{nC_r}{nC_{r+1}} = \frac{5}{7}\)

\(\frac{nC_{r+1}}{nC_{r+2}} = \frac{7}{5}\)

\(\frac{nC_{r+2}}{nC_{r+3}} = \frac{5}{7}\)

\((n + 5) - r + 1 = 2\)

\(r = 5\)

\(n - r + 6 = 2r\)

\(n - 3r + 6 = 0\) ………(i)

Multiply equation (i) by 5

\(5n - 15r + 30 = 0\)

\(5n - 12r + 18 = 0\)

\(-3r + 12 = 0\)

\(r = 4\)

\(n = 6\)

hence greatest coefficient will be of middle term = \(nC_4 = 15C_6 = 462\)

7. There are 6 multiple choice questions in a paper each having 4 options of which only one is correct. In how many ways a person can solve exactly four correct, if he attempted all 6 questions.

(1) 134 (2) 135 (3) 136 (4) 137

Ans. (2)

Sol. No. of ways of giving wrong answer = 3

required no. of ways = \(6C_4(1)^4 \times (3)^2\)

\(= 15(9) = 135\)

8. Class

<table>
<thead>
<tr>
<th></th>
<th>0 – 10</th>
<th>10 – 20</th>
<th>20 – 30</th>
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<tbody>
<tr>
<td>(f)</td>
<td>2</td>
<td>x</td>
<td>2</td>
</tr>
</tbody>
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If variance of variable is 50 then \(x = \frac{\Sigma f}{\Sigma f} 10 + 15x + 50\)

\(\Sigma f = 60 + 15x = 15\)

Ans. (3)

Sol.

\(\bar{x} = \frac{\Sigma f x}{\Sigma f} = \frac{10 + 15x + 50}{4 + x}\)

\(= 15\)
9. Two persons A and B play a game of throwing a pair of dice until one of them wins. A will win if sum of numbers on dice appear to be 6 and B will win, if sum is 7. What is the probability that A wins the game if A starts the game.

(1) \( \frac{31}{61} \)  
(2) \( \frac{30}{61} \)  
(3) \( \frac{29}{61} \)  
(4) \( \frac{32}{61} \)

**Ans. (2)**

**Sol.**

sum 6 \( \rightarrow \) (1, 5), (5, 1), (3, 3), (2, 4), (4, 2)  
sum 4 \( \rightarrow \) (1, 6), (6, 1), (5, 2), (2, 5), (3, 4), (4, 3)

\[
P(\text{A wins}) = P(A) + P(\overline{A})P(B) + P(\overline{A})P(B) + P(\overline{A})P(\overline{B})P(A) + \ldots \]

This is infinite G.P. with common ratio \( P(\overline{A}) \times P(B) \)

Probability of A wins = \( \frac{P(A)}{1 - P(\overline{A})P(B)} \)

\( \frac{5}{36} \)  
\( = \frac{30}{61} \)

10. If \( \omega \) is an imaginary cube roots of unity such that \( (2 + \omega)^2 = a + b \omega, a, b \in \mathbb{R} \) then value of \( a + b \) is

(1) 7  
(2) 6  
(3) 8  
(4) 5

**Ans. (2)**

**Sol.**

\( 2 + \omega^2 = a + b \omega \)  
\( 4 + \omega^2 + 4 \omega = a + b \omega \)  
\( 3 = 3 \omega^2 = a + b \omega \)

\( a - 3 \)  
\( a - 3 + \frac{1}{2} + \frac{\sqrt{3}}{2} \)  
\( (b - 3) = 0 \)

\( a - 3 + \frac{1}{2} + \frac{\sqrt{3}}{2} \)  
\( (b - 3) = 0 \)

Compare real and imaginary part from both sides

\( a - 3 = 0 \)  
\( b - 3 = 0 \)  
\( \Rightarrow a = 3 \)  
\( b = 3 \)

Hence \( a + b = 6 \)

11. Centre of a circle S passing through the intersection points of circles \( x^2 + y^2 - 6x = 0 \) & \( x^2 + y^2 - 4y = 0 \) lies on the line \( 2x - 3y + 12 = 0 \) then circle S passes through

(1) \( (-3, 1) \)  
(2) \( (-4, -2) \)  
(3) \( (1, 2) \)  
(4) \( (-3, 6) \)

**Ans. (4)**

**Sol.**

By family of circle, passing through intersection of given circle will be member of

\( S_1 + \lambda S_2 = 0 \) family \( (\lambda = 1) \)

\( (x^2 + y^2 - 6x) + \lambda(x^2 + y^2 - 4y) = 0 \)

\( (\lambda + 1)x^2 + (\lambda + 1)y^2 - 6\lambda x - 4\lambda y = 0 \)

\( x^2 + y^2 - 6\lambda x + 4\lambda y = 0 \)

Centre \( \left( \frac{3}{\lambda + 1}, \frac{2\lambda}{\lambda + 1} \right) \)

Centre lies on \( 2x - 3y + 12 = 0 \)

\( 2 \left( \frac{3}{\lambda + 1} \right) - 3 \left( \frac{2\lambda}{\lambda + 1} \right) + 12 = 0 \)

\( 6\lambda + 18 = 0 \)

\( \lambda = -3 \)

Circle \( x^2 + y^2 - 3x - 6y = 0 \)

12. \( \int \tan^2 x \sin^2 3x \cdot 2 \sec^2 x \cdot \sin^2 3x \cdot 3 \tan x \cdot \sin 6x \cdot dx \)
13. From a pt 200 m above a lake, the angle of elevation of a cloud is 30° and the angle of depression of its reflection in lake is 60° then the distance of cloud from the point is

(1) 400 m  
(2) 400\sqrt{2} m  
(3) 400\sqrt{3} m  
(4) 200 m

Ans.  
Sol.

\[
\tan^4 x \sin^4 3x = \tan^4 x \sin^3 3x \sin 3x = \frac{1}{2} \int_{t=0}^{\infty} \left( \tan^4 x \sin^3 3x \right) dx
\]

14. The contrapositive of the statement:

If \( f(x) \) is continuous at \( x = a \) then \( f(x) \) is differentiable at \( x = a \)

(1) If \( f(x) \) is continuous at \( x = a \) then \( f(x) \) is not continuous at \( x = a \)

(2) If \( f(x) \) is not differentiable at \( x = a \) then \( f(x) \) is not continuous at \( x = a \)

(3) If \( f(x) \) is differentiable at \( x = a \) then \( f(x) \) is continuous at \( x = a \)

(4) If \( f(x) \) is differentiable at \( x = a \) then \( f(x) \) is not continuous

Ans.  
Sol. Contrapositive of \( \varphi \implies \neg q \implies \neg p \)

15. If equation of directrix of an ellipse \( \frac{x^2}{a^2} + \frac{y^2}{b^2} = 1 \) is \( x = 4 \), then normal to the ellipse at point

(1, \beta, (\beta > 0)) passes through the point (where eccentricity of the ellipse is \( \frac{1}{2} \))

(1) \( \left( \frac{3}{2} \right) \)  
(2) \( \left( \frac{3}{2} \right) \)  
(3) \( (-1, -3) \)  
(4) \( (-3, -1) \)

Ans.  
Sol. \( a = 4 \Rightarrow a = 2e \Rightarrow a = 2 \)

\( b^2 = a^2 (1-e^2) = 3 \)

(1, \beta) lies on \( \frac{x^2}{4} - \frac{y^2}{3} = 1 \)  
\( \beta^2 = \frac{9}{4} \Rightarrow \beta = \frac{3}{2} (\because \beta > 0) \)

Normal at \( (1, \beta) \)  
\( \frac{a^2 \beta}{\sqrt{1 + \beta^2}} = a^2 - b^2 \Rightarrow 4x - 3y = 1 \)

so equation of normal is \( 4x - 2y = 1 \)
16. If points $A$ and $B$ lie on $x$-axis and points $C$ and $D$ lie on the curve $y = x^2 - 1$ below the $x$-axis then maximum area of rectangle $ABCD$ is

\[ \text{Area} = \frac{4\sqrt{3}}{3} \]

\[ \text{Area} = \frac{4\sqrt{3}}{9} \]

\[ \text{Area} = \frac{4\sqrt{3}}{27} \]

\[ \text{Area} = \frac{8\sqrt{3}}{9} \]

**Ans.** (2)

**Sol.**

![Diagram of a curve with points A, B, C, and D labeled.]

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17. If $\alpha$, $\beta$ are roots of $x^2 - x + 2\lambda = 0$ and $\alpha$, $\gamma$ are roots of $3x^2 - 10x + 27\lambda = 0$ then value of $\frac{\beta\gamma}{\lambda}$ is

\[ (1) \ 27 \quad (2) \ 18 \quad (3) \ 9 \quad (4) \ 15 \]

**Ans.** (2)

**Sol.**

Given $3\alpha^2 - 10\alpha + 27\lambda = 0$ ——— (i)

$3\alpha^2 - 3\alpha + 6\alpha = 0$ ——— (ii)

Subtract $-7\alpha + 21\lambda = 0$

$3\lambda = \alpha$

by (ii) $9\lambda^2 - 3\lambda + 2\lambda = 0$

$\lambda = 0, \frac{1}{9}$

$\therefore$ given equation are $x^2 - x + \frac{2}{9} = 0$ and $3x^2 - 10x + 3 = 0$

$\alpha = \frac{1}{3}, \beta = \frac{2}{3}, \gamma = \frac{1}{3}$

$\therefore \frac{\beta\gamma}{\lambda} = \frac{2}{3} \times \frac{1}{9} = \frac{2}{27}$

18. $PQ$ is a diameter of circle $x^2 + y^2 = 4$. If perpendicular distances of $P$ and $Q$ from line $x + y = 2$ are $\alpha$ and $\beta$ respectively then maximum value of $\alpha \beta$ is

**Ans.** 2

**Sol.**

Let $P(2\cos\theta, 2\sin\theta) \cdot Q(-2\cos\theta, -2\sin\theta)$

given $x + y = 2$

$\therefore \alpha = \frac{2\cos\theta + 2\sin\theta - 2}{\sqrt{2}}$

$\beta = \frac{2\cos\theta - 2\sin\theta - 2}{\sqrt{2}}$

$\alpha \beta = \sqrt{2} (\cos\theta + \sin\theta - 1), \sqrt{2} (\cos\theta + \sin\theta + 1)$

$= 2(\cos\theta + \sin\theta + 2\sin\theta \cos\theta - 1) = 2\sin2\theta$

$\therefore$ maximum $\alpha \beta = 2$
19. If \( \frac{dy}{dx} \frac{y-3x}{n(y-3x)} = 3 \), then

\[
\begin{align*}
(1) \quad \frac{n(y-3x)}{2} &= x + c \\
(2) \quad \frac{n^2(y-3x)}{2} &= x + c \\
(3) \quad \frac{n(y-3x)}{2} &= x^3 + c \\
(4) \quad \frac{n^2(y-3x)}{2} &= x^3 + c
\end{align*}
\]

Ans. (2)

Sol. \( \frac{dy}{dx} \frac{y-3x}{n(y-3x)} = 3 \)

\[
\begin{align*}
\frac{dy}{dx} - 3 &= \frac{y-3x}{\ln(y-3x)} \\
\frac{d}{dx}(y-3x) &= \frac{y-3x}{\ln(y-3x)} \\
\int \frac{n(y-3x)}{(y-3x)} \, dx &= \int dx \\
\int \frac{dt}{t} &= \int dx \\
\frac{t^2}{2} &= x + c \\
\frac{(n(y-3x))^2}{2} &= x + c
\end{align*}
\]

20. The distance of point \((1, -2, -3)\) from plane \(x - y + z = 5\) measured parallel to the line \(\frac{x-2}{2} = \frac{y-3}{3} = \frac{z+6}{-6}\) is

\[
\begin{align*}
(1) \quad 7 & \quad (2) \quad \frac{1}{7} & \quad (3) \quad 1 & \quad (4) \quad 5
\end{align*}
\]

Ans. (4)

Sol.

Equation PQ

\[
\frac{x-1}{2} = \frac{y+2}{3} = \frac{z+3}{-6} = \lambda
\]
Let \( Q = (2\lambda + 1, 3\lambda, -6\lambda, -3) \)

\[ Q \text{ lies on } x - y + z = 5 \]

\[ (2\lambda + 1) - (3\lambda - 2) + (-6\lambda - 3) = 5 \]

\[ 2\lambda + 1 - 3\lambda + 2 - 6\lambda - 3 = 5 \]

\[ \lambda = -\frac{5}{7} \]

\[ Q = \left( -\frac{3}{7}, -\frac{29}{7}, \frac{9}{7} \right) \]

\[ PQ = \sqrt{\left( -\frac{3}{7} - \lambda \right)^2 + \left( -\frac{29}{7} - 2\lambda \right)^2 + \left( -\frac{9}{7} - 3\lambda \right)^2} \]

\[ = \sqrt{\frac{100}{49} + \frac{225}{49} + \frac{900}{49}} \]

\[ = \frac{1225}{49} \]

\[ = \frac{35}{7} = 5 \]

21. If \( f(x) = \begin{cases} \frac{1}{2} |x - 1|, & \text{if } |x| \leq 1 \\ \tan^{-1} x, & \text{if } |x| > 1 \end{cases} \)

then \( f(x) \) is

1. continuous for \( x \in R - (0) \)
2. continuous for \( x \in R - (0, 1,-1) \)
3. not continuous for \( x \in \{-1,0,1\} \)
4. \( f(x) \) is continuous for \( x \in R - \{1,-1\} \)

Ans. (4)

Sol.

\[ \begin{cases} \frac{1}{2} |x - 1|, & |x| > 1 \\ \tan^{-1} x, & |x| \leq 1 \end{cases} \]

Graph of \( f(x) \) is

\[ f(x) \text{ is not continuous at } x = -1, 1 \]

22. Suppose \( X_1, X_2, \ldots, X_n \) are 50 sets each having 10 elements and \( Y_1, Y_2, \ldots, Y_n \) are \( n \) sets each having 5 elements. Let \( \bigcup_{i=1}^{n} X_i = \bigcup_{i=1}^{n} Y_i \) and each element of \( Z \) belongs to exactly 25 of \( X_i \) and exactly 6 of \( Y_i \), then find \( n \) is

1. 20
2. 22
3. 24
4. 26

Ans. (3)

Sol.

\[ \bigcup_{i=1}^{n} X_i = \bigcup_{i=1}^{n} Y_i = Z \]

\[ \frac{10 \times 50}{25} = \frac{500}{6} \]

\[ n = 24 \]

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23. Let \( A \) is a \( 3 \times 3 \) matrix such that \( Ax_1 = B_1, Ax_2 = B_2, Ax_3 = B_3 \)

Where

\[ \begin{align*}
X_1 &= \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} & x_1 &= \begin{bmatrix} 0 \\ 2 \\ 1 \end{bmatrix} & \bar{x}_1 &= \begin{bmatrix} 0 \\ 0 \\ 1 \end{bmatrix} \\
B_1 &= \begin{bmatrix} 1 \\ 0 \\ 0 \end{bmatrix} & B_2 &= \begin{bmatrix} 0 \\ 2 \\ 0 \end{bmatrix} & B_3 &= \begin{bmatrix} 0 \\ 0 \\ 2 \end{bmatrix}
\end{align*} \]

then find \( |A| \)

1. 0
2. 1
3. 2
4. 3

Ans. (3)

Sol. Let \( A = \begin{bmatrix} a_{11} & a_{12} & a_{13} \\ a_{21} & a_{22} & a_{23} \\ a_{31} & a_{32} & a_{33} \end{bmatrix} \)
\[ \mathbf{A}x = \mathbf{b} \Rightarrow \begin{bmatrix} a_1 & a_2 & a_3 \\ b_1 & b_2 & b_3 \\ c_1 & c_2 & c_3 \end{bmatrix} \begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 1 \\ 1 \\ 1 \end{bmatrix} = \mathbf{s} \]

\[ a_1 + a_2 + a_3 = 1 \]
\[ b_1 + b_2 + b_3 = 0 \]
\[ c_1 + c_2 + c_3 = 0 \]

similar
\[ 2a_1 + a_3 = 0 \quad \text{and} \quad a_3 = 0 \]
\[ 2b_2 + b_3 = 2 \quad \text{and} \quad b_3 = 0 \]
\[ 2c_2 + c_3 = 2 \quad \text{and} \quad c_3 = 2 \]

\[ \therefore a_2 = 0, b_2 = 1, c_2 = -1, \]
\[ a_1 = 1, b_1 = -1, c_1 = -1 \]

\[ \mathbf{A} = \begin{bmatrix} 1 & 0 & 0 \\ -1 & 1 & 0 \\ -1 & -1 & 2 \end{bmatrix} \]

\[ |\mathbf{A}| = \frac{2}{2} = 2 \]
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