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

2022

COMPUTER BASED TEST (CBT) Memory Based Questions & Solutions

Date: 26 July, 2022 (SHIFT-1) | TIME : (9.00 a.m. to 12.00 p.m)
Duration: 3 Hours | Max. Marks: 300

SUBJECT: MATHEMATICS

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PART : MATHEMATICS

1. Value of $\tan\left(2\tan^{-1}\left(\frac{1}{5}\right) + \sec^{-1}\left(\frac{\sqrt{5}}{2}\right) + 2\tan^{-1}\left(\frac{1}{8}\right)\right)$ is

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

Ans. (3)

Sol. $\tan\left(2\tan^{-1}\left(\frac{1+1}{\frac{5-8}{1-\frac{1}{40}}}\right) + \sec^{-1}\left(\frac{\sqrt{5}}{2}\right)\right)$
 $= \tan\left(2\tan^{-1}\left(\frac{1}{3}\right) + \tan^{-1}\left(\frac{1}{2}\right)\right)$
 $= \tan\left(\tan^{-1}\left(\frac{3}{4}\right) + \tan^{-1}\left(\frac{1}{2}\right)\right)$
 $= \tan\left(\tan^{-1}\left(\frac{3+\frac{1}{2}}{\frac{4-\frac{1}{2}}{1-\frac{3}{8}}}\right)\right) = 2$

2. If the area enclosed by $y = 1$, $y = 3$, $x = 0$ and $x = y^a$ is $\frac{364}{3}$, then the value of a is
 (1) 3 (2) 5 (3) 7 (4) 9

Ans. (2)

Sol. Area = $\int_1^3 y^a dy$



$$= \left(\frac{y^{a+1}}{a+1}\right)_1^3 = \frac{364}{3}$$

$$= \frac{3^{a+1} - 1}{a+1} = \frac{364}{3}$$

$$\Rightarrow a = 5$$

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3. Suppose $a_1, a_2, a_3, \dots, a_n$ be a given sequence such that

$$a_1 = \{3\}$$

$$a_2 = \{6, 9, 12\}$$

$$a_3 = \{15, 18, 21, 24, 27\}$$

$$a_4 = \{30, 33, \dots, 48\} \text{ and so on. Now the sum of all the elements of } a_{11} \text{ is}$$

Ans. (6993)

Sol. Number of elements in $a_{11} = 1 + (11-1)2 = 21$

First term of $a_{11} = 303$

$$\text{Sum of all elements of } a_{11} = \frac{21}{2} [2 \times 303 + (21-1)2]$$

$$= 21 \times 303 + 21 \times 20$$

$$= 21 \times 323 = 6993$$

4. If $f(x)$ is a continuous and differentiable function satisfying $f(3x) - f(x) = x \forall x \in \mathbb{R} - \{0\}$ and $f(8) = 7$ then the value of $f(14)$ is

(1) 3

(2) 7

(3) 10

(4) 14

Ans. (3)

Sol. $\frac{f(3x) - f(x)}{3x - x} = \frac{1}{2}$

By LMVT

$$\Rightarrow f'(x) = \frac{1}{2} \Rightarrow f(x) = \frac{x}{2} + C$$

$$f(8) = 4 + 5 = 7 \Rightarrow C = 3$$

$$f(14) = 7 + 3 = 10$$

5. In the expansion of $(1+x)^p(1-x)^q$, when $p > 0, q > 0$ the coefficient of x and x^2 are -3 and -5 respectively, then the coefficient of x^3 is

Ans. (23)

Sol. $(1+x)^p(1-x)^q = \left(1 + px + \frac{p(p-1)}{2!}x^2 + \frac{p(p-1)(p-2)}{3!}x^3 + \dots\right) \left(1 - qx + \frac{q(q-1)}{2!}x^2 - \dots\right)$

$$p - q = -3 \dots (1) \text{ and } -pq + \frac{p(p-1)}{2} + \frac{q(q-1)}{2} = -5 \dots (2)$$

$$\Rightarrow p^2 + q^2 - 2pq - p - q = -10$$

$$\Rightarrow (p-q)^2 - (p+q) = -10$$

$$\Rightarrow -(p+q) = -10 - 9 = -19$$

$$\Rightarrow p+q = 19 \dots (3)$$

$$\Rightarrow p - q = -3 \dots (1)$$

$$\Rightarrow p = 8, \quad q = 11$$

Now coefficient of x^3 in $(1+x)^8(1-x)^{11} = (1-x^2)^8(1-x)^3 = (1-8x^2 + \dots)(1-3x + 3x^2 - x^3)$

so coefficient of $x^3 = -1 + 24 = 23$

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6. If the mean and variance of a binomial probability distribution are α and $\frac{\alpha}{3}$ respectively and

$$P(x = 1) = \frac{4}{243}, \text{ then the value of } P(x = 4 \text{ or } 5) \text{ is}$$

(1) $\frac{16}{27}$ (2) $\frac{64}{243}$ (3) $\frac{1}{27}$ (4) $\frac{64}{81}$

Ans. (1)

Sol. $n.p. = \alpha$

$$npq = \frac{\alpha}{3}$$

$$q = \frac{1}{3}, p = \frac{2}{3}$$

$$\Rightarrow n = \frac{3\alpha}{2}$$

$$P(x = 1) = {}^nC_1 \cdot p \cdot q^{n-1} = \frac{4}{243}$$

$$= \frac{2n}{3^n} = \frac{4}{243} \Rightarrow n = 6$$

$$P(X = 4 \text{ or } 5) = {}^6C_4 \cdot p^4 \cdot q^2 + {}^6C_5 \cdot p^5 \cdot q$$

$$= 15 \left(\frac{2}{3}\right)^4 \left(\frac{1}{3}\right)^2 + 6 \left(\frac{2}{3}\right)^5 \left(\frac{1}{3}\right) = \frac{80}{3^5} + \frac{64}{3^5}$$

$$= \frac{144}{243} = \frac{16}{27}$$

7. Statement $\sim(p \leftrightarrow q) \wedge q$ is equivalent to

(1) Tautology (2) contradiction (3) $(p \rightarrow q) \wedge q$ (4) $(p \rightarrow q) \wedge \sim p$

Ans. (4)

Sol. $\sim(p \leftrightarrow \sim q) \wedge q$

$$= (p \leftrightarrow q) \wedge q$$

p	q	$p \leftrightarrow q$	$(p \leftrightarrow q) \wedge q$	$(p \rightarrow q)$	$(p \rightarrow q) \wedge q$	$(p \rightarrow q) \wedge p$
T	T	T	T	T	T	T
T	F	F	F	F	F	F
F	T	F	F	T	T	F
F	F	T	F	T	F	F

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8. If $y(x)$ is the solution of differential equation $\frac{dy}{dx} + 2y \tan x = \sin x$, where $x \in \left(0, \frac{\pi}{2}\right)$ and $y\left(\frac{\pi}{2}\right) = 0$, then the maximum value of $y(x)$ is

- (1) $\frac{1}{16}$ (2) $\frac{1}{8}$ (3) $\frac{1}{4}$ (4) $\frac{1}{6}$

Ans. (2)

Sol. I.F. = $e^{\int 2 \tan x} = \sec^2 x$

$$\Rightarrow y(\sec^2 x) = \int \frac{\sin x}{\cos^2 x} dx + C \quad \text{Let } \cos x = t$$

$$\Rightarrow \frac{y}{\cos^2 x} = -\int \frac{1}{t^2} dt + C$$

$$\Rightarrow \frac{y}{\cos^2 x} = \frac{1}{\cos x} + C$$

$$\Rightarrow y(x) = \cos x + C \cos^2 x$$

$$\because y\left(\frac{\pi}{2}\right) = 0$$

$$\Rightarrow 0 = \frac{1}{2} + \frac{C}{4} \Rightarrow C = -2$$

$$\Rightarrow y(x) = \cos x - 2 \cos^2 x$$

$$\Rightarrow y(x) = -2 \left(\cos^2 x - \frac{1}{2} \cos x + \frac{1}{16} - \frac{1}{16} \right)$$

$$\Rightarrow y(x) = \frac{1}{8} - 2 \left(\cos x - \frac{1}{4} \right)$$

$$\Rightarrow y_{\max.} = \frac{1}{8} \text{ at } \cos x = \frac{1}{4}$$

9. A is 2×2 matrix such that $\det(A) = -1$, $\det((A + I)(\text{adj}A + I)) = 4$. The sum of diagonal elements of matrix A is

- (1) $\sqrt{2}$ (2) 1 (3) 2 (4) $-\sqrt{2}$

Ans. (3)

Sol. $|(A + I)(\text{adj}A + I)| = |A \text{adj}A + A + \text{adj}A + I|$

$$\Rightarrow ||A| \cdot I + A + \text{adj}A + I|$$

$$= |-1 + A + \text{adj}A + I| = |A + \text{adj}A|$$

$$\text{Let } A = \begin{bmatrix} a & b \\ c & d \end{bmatrix} \quad |A| = ad - bc = -1$$

$$A + \text{adj}A = \begin{bmatrix} a & b \\ c & d \end{bmatrix} + \begin{bmatrix} d & -b \\ -c & a \end{bmatrix} = \begin{bmatrix} d & -b \\ -c & a \end{bmatrix} = (a+d)I$$

$$|A + \text{adj}A| = |(a+d)I| = (a+d)^2 \quad |I| = (a+d)^2$$

$$\Rightarrow (a+d)^2 = 4 \Rightarrow a+d = \pm 2$$

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10. If $f(x) = \begin{cases} \frac{\ln(1-x+x^2) + \ln(1+x+x^2)}{\sec x - \cos x} & x \neq 0 \\ k & x = 0 \end{cases}$ is continuous at $x = 0$ then k is equal to

- (1) 2 (2) 1 (3) -1 (4) 0

Ans. (2)

Sol. $f(0) = \lim_{x \rightarrow 0} \frac{\ln(1-x+x^2) + \ln(1+x+x^2)}{\sec x - \cos x}$

$$\Rightarrow k = \lim_{x \rightarrow 0} \frac{\ln(1+x^2+x^4)}{\sin^2 x} \times \cos x$$

$$\Rightarrow k = \lim_{x \rightarrow 0} \frac{\ln(1+x^2+x^4)}{x^2+x^4} \times \frac{(x^2+x^4)}{\sin^2 x} \times \cos x$$

$$\Rightarrow k = 1$$

11. If $g(x) = \begin{cases} x+a & x \leq 0 \\ |x-4| & x > 0 \end{cases}$ and $f(x) = \begin{cases} x+1 & x < 0 \\ (x-4)^2 + b & x \geq 0 \end{cases}$ and g and f are continuous functions then the

value of $(g \circ f)(2) + (f \circ g)(-2)$ is equal to

- (1) 18 (2) -18 (3) 10 (4) -11

Ans. (2)

Sol. $g(0) = g(0^+)$

$$a = 4$$

$$f(0) = f(0^-)$$

$$16 + b = 1$$

$$b = -15$$

$$\text{Now } g(x) = \begin{cases} x+4 & x \leq 0 \\ |x-4| & x > 0 \end{cases}$$

$$f(x) = \begin{cases} x+1 & x < 0 \\ (x-4)^2 - 15 & x \geq 0 \end{cases}$$

$$\text{Now } (g \circ f)(2) + (f \circ g)(-2) = g(-11) + f(2)$$

$$= -7 + 4 - 15$$

$$= -3 - 15 = -18$$

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12. Number of all 5 digit natural numbers such that the product of all digits is 36.

- (1) 90 (2) 180 (3) 150 (4) 120

Ans. (3)

Sol. $abcde = 36$ $a, b, c, d, e > 0$

$$\text{C-I } a, b, c, d, e \in \{1, 2, 2, 3, 3\}$$

$$\text{Total ways} = \frac{5!}{2! \cdot 2!} = 30$$

$$\text{C-II } a, b, c, d, e \in \{1, 1, 4, 3, 3\}$$

$$\text{Total ways} = \frac{5!}{2!} = 60$$

$$\text{Total ways} = \frac{5!}{2!2!} = 30$$

$$\text{C-III } a, b, c, d, e \in \{1, 1, 6, 2, 3\}$$

$$\text{Number of ways} = \frac{5!}{2!} = 60$$

$$\text{C-IV } a, b, c, d, e \in \{1, 1, 2, 2, 9\}$$

$$\text{Total ways} = \frac{5!}{2!2!} = 30$$

$$\text{Total number of integers} = 30 + 30 + 60 + 30 = 150$$

13. If $a = \lim_{n \rightarrow \infty} \sum_{r=1}^n \frac{2n}{r^2 + n^2}$ and a function $f(x) = \sqrt{\frac{1 - \cos x}{1 + \cos x}}$ then which of the following statement is correct

(1) $F\left(\frac{a}{2}\right) = 2F\left(\frac{a}{2}\right)$

(2) $F\left(\frac{a}{2}\right) + \sqrt{2}F\left(\frac{a}{2}\right) = 0$

(3) $F\left(\frac{a}{2}\right) = \sqrt{2}F\left(\frac{a}{2}\right)$

(4) $F\left(\frac{a}{2}\right) \cdot F\left(\frac{a}{2}\right) = \sqrt{2}$

Ans. (3)

Sol. $a = \lim_{n \rightarrow \infty} \frac{1}{n} \sum_{r=1}^n \frac{2}{\frac{r^2}{n^2} + 1}$

$$= \int_0^1 \frac{2}{1+x^2} dx$$

$$a = 2[\tan^{-1}(x)]_0^1$$

$$\Rightarrow a = \frac{\pi}{2}$$

now after doing rationalisation we get $F(x) = \operatorname{cosec} x - \cot x$

$$F'(x) = -\operatorname{cosec} x \cot x + \operatorname{cosec}^2 x$$

$$F'(x) = -\operatorname{cosec} x \cot x + \operatorname{cosec}^2 x$$

$$F'(x) = \operatorname{cosec} x (\operatorname{cosec} x - \cot x)$$

$$F'(x) = \operatorname{cosec} x \cdot F(x)$$

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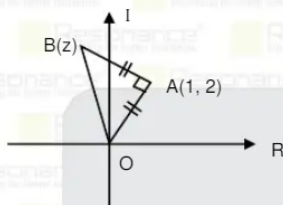
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14. In complex plane, three points O, A, B are such that O is origin, $A(1, 2)$ and $\operatorname{Re}(B) < 0$. If $\triangle OAB$ is right angle isosceles with OB as hypotenuse then the point B is

(1) $(-3, 4)$ (2) $(-1, 3)$ (3) $(-2, 3)$ (4) $(-1, 4)$

Ans. (2)

Sol. By rotation theorem



$$\frac{z - (1 + 2i)}{0 - (1 + 2i)} = \frac{|\overline{AB}|}{|\overline{OA}|} e^{-i\frac{\pi}{2}}$$

$$\therefore |\overline{AB}| = |\overline{OA}|$$

$$\frac{z - (1 + 2i)}{0 - (1 + 2i)} = -i$$

$$\Rightarrow z = -1 + 3i \text{ so point B is } (-1, 3)$$



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