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JEE

(Main)

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

2022


COMPUTER BASED TEST (CBT)
Memory Based Questions & Solutions

Date: 26 June, 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 : MATHS

1. The function $f(x) = \frac{x-1}{x+1}$, $R = \{-1, 0, -1\}$ and $f^{n+1}(x) = f(f^n(x))$, then the value of $f^6(6) + f^7(7)$ equals to

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

Sol. $f(f(x)) = f\left(\frac{x-1}{x+1}\right) = \frac{\frac{x-1}{x+1}-1}{\frac{x-1}{x+1}+1} = \frac{-2}{2x} = -\frac{1}{x}$

$f(f(f(x))) = f\left(f\left(-\frac{1}{x}\right)\right) = x$

$f^6(6) = \frac{1}{6}, f\left(-\frac{1}{x}\right) = f^7(x)$

$\frac{-\frac{1}{x}-1}{-\frac{1}{x}+1} = \frac{-1-x}{-1+x}$

$f^7(x) = \frac{x+1}{1-x}$

$f^7(7) = -\frac{4}{3}$

$f^6(6) + f^7(7) = -\frac{1}{6} - \frac{4}{3} = \frac{-1-8}{6} = -\frac{3}{2}$

2. If the line $\frac{x}{a} + \frac{y}{b} = 2$ is tangent to the curve $\left(\frac{x}{a}\right)^n + \left(\frac{y}{b}\right)^n = 2$ at point (a,b), then find the value of n

- (1) ϕ (2) singleton set (3) even (4) $n \in \mathbb{N}$

Ans. (04.00)

Sol. Slope of tangent

$n\left(\frac{x}{a}\right)^{n-1} \left(\frac{1}{a}\right) + n\left(\frac{y}{b}\right)^{n-1} \left(\frac{1}{b}\right) \frac{dy}{dx} = 0$

$\left(\frac{dy}{dx}\right)_{(a,b)} = -\frac{b}{a}$

equation of tangent $y - b = -\frac{b}{a}(x - a)$

$ay - ab = -bx + ab$

$bx + ay = 2ab$

\Rightarrow for all $n \in \mathbb{N}$

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3. If $F(x) = \max(|x+1|, |x+2|, |x+3|, \dots, |x+5|)$, then find the value of $\int_{-6}^0 f(x) dx$.

Ans. 21.00

Sol. $\int_{-6}^{-3} |x+1| dx + \int_{-3}^0 |x+5| dx$

$= -\int_{-6}^{-3} (x+1) dx + \int_{-3}^0 (x+5) dx$

$= -\left(\frac{x^2}{2} + x\right)_{-6}^{-3} + \left(\frac{x^2}{2} + 5x\right)_{-3}^0$

$= -\left(\frac{9}{2} - 3 - 18 + 6\right) - \left(\frac{9}{2} - 15\right)$

$= -\left(\frac{9-30}{2}\right) - \left(\frac{9-30}{2}\right)$

$= 21$

4. Evaluate $\lim_{x \rightarrow \frac{1}{\sqrt{2}}} \frac{(\sin(\cos^{-1}x) - x)}{(1 - \tan(\cos^{-1}x))}$

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

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

(3) -1

(4) 1

Ans. (1)

Sol.
$$\lim_{x \rightarrow \frac{1}{\sqrt{2}}} \frac{\sin(\cos^{-1}x) - x}{1 - \tan(\cos^{-1}x)}$$

$$= \lim_{x \rightarrow \frac{1}{\sqrt{2}}} \frac{\sin(\sin^{-1}\sqrt{1-x^2}) - x}{1 - \tan\left(\tan^{-1}\frac{\sqrt{1-x^2}}{x}\right)}$$

$$= \lim_{x \rightarrow \frac{1}{\sqrt{2}}} \frac{\sqrt{1-x^2} - x}{1 - \frac{\sqrt{1-x^2}}{x}}$$

$$= \lim_{x \rightarrow \frac{1}{\sqrt{2}}} (-x) = -\frac{1}{\sqrt{2}}$$

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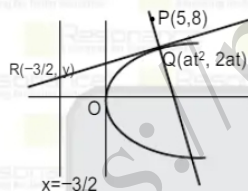
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5. A normal is drawn from P(5, 8) to the parabola $y^2 = 6x$ meeting it at Q. Tangent at Q to $y^2 = 6x$ meet at point R on the directrix, then ordinate of point R is

- (1) $\frac{3}{2}$ (2) $\frac{9}{2}$ (3) $\frac{9}{4}$ (4) $\frac{6}{2}$

Ans. (3)

Sol.



Equation of normal to parabola

$$y = -tx + 2at + at^3$$

$$y = -tx + 3t + \frac{3}{2}t^3 \therefore a = \frac{3}{2}$$

$$8 = -5t + 3t + \frac{3}{2}t^3$$

$$\Rightarrow \frac{3}{2}t^3 - 2t - 8 = 0$$

$$\Rightarrow 3t^3 - 4t - 16 = 0$$

$$\Rightarrow (t-2)(3t^2 + 6t + 8) = 0$$

$$\text{So, } t = 2$$

As, $t = 2$, we get Q(6,6)

Equation of tangent to parabola $y^2 = 6x$

$$yt = x + at^2$$

$$2y = x + \frac{3}{2} \times 4$$

$$2y = x + 6 \dots\dots\dots(1)$$

$$\text{put } x = \frac{-3}{2} \text{ in equation (1)}$$

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

$$y = \frac{9}{4}$$

Ans. (2)

Sol. $|24A|^2 = |3adj2A|^2$

$\Rightarrow 24^6 |A|^2 = 3^6 |2A|^4$

$\Rightarrow 8^6 |A|^2 = 2^{12} |A|^4$

$\Rightarrow |A|^2 = 2^6$

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7. Let common tangent to $x^2 + y^2 = \frac{9}{4}$ and $y^2 = 4x$ meet x-axis at point Q. If an ellipse with length of major axis equal to 6 and minor axis is of length 'OQ' is drawn, then the value of $\frac{l}{e^2}$ is

(Where l is length of latus rectum and 'e' is eccentricity of the ellipse and O is origin)

(1) 2

(2) 5

(3) 7

(4) 8

Ans. (1)

Sol. $y = mx \pm \frac{3}{2} \sqrt{1+m^2}$ (i)

$y = mx + \frac{1}{m}$ (ii)

comparing (i) and (ii)

$\frac{3}{2} \sqrt{1+m^2} = \frac{1}{m}$

$\Rightarrow 9(m^2 + m^4) = 4$

Put, $m^2 = t$

$9t^2 + 9t - 4 = 0$

$(3t)^2 + 3 \cdot (3t) - 4 = 0$

$(3t + 4)(3t - 1) = 0$

$m^2 = -\frac{4}{3}, \frac{1}{3}$

Let $m = \frac{1}{\sqrt{3}}$

$y = \frac{1}{\sqrt{3}}x + \sqrt{3}$ if $y = 0 \Rightarrow x = -3 \Rightarrow OQ = 3$

Now $2a = 6$ and $2b = 3$ $b^2 = a^2(1 - e^2)$

$\frac{l}{e^2} = \frac{2b^2}{a} = \frac{2ab^2}{a^2 - b^2}$

$= \frac{6 \times \frac{9}{4}}{9 - \frac{9}{4}} = \frac{\frac{6 \times 9}{4}}{1 - \frac{1}{4}} = \frac{6}{3} = 2$

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8. In how many ways a team of 3 boys and 3 girls can be formed from 10 boys and 5 girls, if two particular boys B_1 and B_2 are not in team together :

- (1) 1115 (2) 1120 (3) 1280 (4) 1220

Ans. (2)

Sol. Total no. of way to select 3 boys and 3girls = ${}^{10}C_3 \cdot {}^5C_3 = 1200$
 When particular boys B_1 and B_2 both are in team = ${}^8C_1 \cdot {}^5C_3 = 80$
 So required number of ways = $1200 - 80 = 1120$

9. If $(2021)^{2023}$ is divided by 7, then remainder is equal to

Ans. (05.00)

Sol. $(288 \times 7 + 5)^{2023}$
 $= 7^\lambda + 5^{2023}$
 $= 7^\lambda + (7 - 2)^{2023}$
 $= 7^\lambda + 7^\mu - 2^{2023}$
 $= 7^\lambda + 7^\mu - 2 \cdot 8^{674}$
 $= 7^\lambda + 7^\mu - 2(7 + 1)^{674}$
 $= 7^\lambda + 7^\mu - 2(7 + 1)$
 $= 7m - 2 = 7(m - 1) + 7 - 2 = 7(m - 1) + 5$
 where λ, μ, l, m are integers

10. A biased coin is tossed 5 times and probability of getting exactly 4 heads is equal to probability of getting exactly 5 heads, then the probability of getting at most 2 heads, is

- (1) $\frac{27}{648}$ (2) $\frac{25}{648}$ (3) $\frac{23}{648}$ (4) $\frac{24}{648}$

Ans. (3)

Sol. ${}^5C_4 \cdot p^4 \cdot q = {}^5C_5 \cdot p^5$
 $5q = p$, & $p + q = 1$
 So $5q = 1 - q$
 $\Rightarrow q = \frac{1}{6}$, $p = \frac{5}{6}$
 $P(\text{at most two heads}) = P(x=0) + P(x=1) + P(x=2)$
 ${}^5C_0 \cdot q^5 + {}^5C_1 \cdot p \cdot q^4 + {}^5C_2 \cdot p^2 \cdot q^3$
 $q^5 + 5pq^4 + 10p^2 \cdot q^3$
 $= q^3 (q^2 + 5qp + 10p^2)$
 $= \frac{1}{6^3} \left(\frac{1}{6^2} + 5 \cdot \frac{5}{6^2} + 10 \cdot \frac{25}{6^2} \right)$
 $= \frac{276}{6^5} = \frac{46}{6^4} = \frac{23}{3 \cdot 6^3} = \frac{23}{648}$

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11. Triangle ABC is an equilateral triangle with vertex A(3, 7) & B, C lie on line $x + y = 5$. Area of ΔABC is

- (1) $\frac{25}{2\sqrt{3}}$ (2) $\frac{25}{\sqrt{6}}$ (3) 25 (4) $\frac{25}{\sqrt{2}}$

Ans. (1)

Sol.



$$h = \frac{|3+7-5|}{\sqrt{2}} = \frac{5}{\sqrt{2}}$$

$$\ell \sin 60^\circ = h$$

$$\ell = \frac{2h}{\sqrt{3}}$$

$$\text{Area of } \triangle ABC = \frac{\sqrt{3}}{4} \ell^2 = \frac{\sqrt{3}}{4} \times \frac{4h^2}{3}$$

$$= \frac{1}{\sqrt{3}} \times \left(\frac{5}{\sqrt{2}}\right)^2 = \frac{25}{2\sqrt{3}}$$

12. If $A = \sum_{j=1}^{10} \sum_{i=1}^{10} \min(i, j)$, $B = \sum_{i=1}^{10} \sum_{j=1}^{10} \max(i, j)$, then $A + B$ is equal to
 (1) 1000 (2) 1100 (3) 1200 (4) 1190

Ans. (2)

Sol. (1,1), (1,2) (1,10)
 (2,1), (2,2) (2,10)
 (3,1), (3,2) (3,10)

.....
 (10,1), (10,2) (10,10)
 $A + B = 2 \cdot (9 \times 1 + 8 \times 2 + 7 \times 3 + \dots + 2 \times 8 + 1 \times 9)$
 $+ 2 (2 \times 1 + 3 \times 2 + 4 \times 3 + \dots + 9 \times 8 + 10 \times 9)$
 $+ 2 (1 + 2 + 3 + \dots + 10)$
 $= 2 \cdot (11 \times 9 + 11 \times 8 + 11 \times 7 + \dots + 11 \times 1) + 2 \times \frac{10 \times 11}{2}$
 $= 2 \times 11 \times \frac{9 \times 10}{2} + 10 \times 11 = 10 \times 11 \times 10 = 1100$

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13. If five observations a,b,5,8,10 has mean and variance as 6 and 6.8 respectively, then the value of (mean deviation about mean) \times 25 is

Ans. (60.00)

Sol. $a + b + 23 = 30 \Rightarrow a + b = 7$ (1)

$$6.8 = \frac{1}{5} \times (a^2 + b^2 + 25 + 64 + 100) - 36$$

$$34 = a^2 + b^2 + 189 - 180$$

$$a^2 + b^2 = 25$$
(2)

from equation (1) & (2)

$$a = 4, b = 3 \text{ or } a = 3, b = 4$$

$$\text{M.D.} = \frac{\sum |x_i - 6|}{5} = \frac{12}{5}$$

So answer is 60

14. Sum of the cube of the roots of the equation $x^4 - 3x^3 - 2x^2 + 3x + 1 = 0$ is equal to :

Ans. (36)

Sol. $x^4 - 3x^3 - 2x^2 + 3x + 1 = 0$

$\therefore x \neq 0$ so divided by x^2

$$\Rightarrow x^2 - 3x - 2 + \frac{3}{x} + \frac{1}{x^2} = 0$$

$$\Rightarrow x^2 + \frac{1}{x^2} - 3 \left(x - \frac{1}{x}\right) - 2 = 0$$

$$\Rightarrow \left(x - \frac{1}{x}\right)^2 - 3 \left(x - \frac{1}{x}\right) = 0$$

$$\Rightarrow x - \frac{1}{x} = 3 \text{ or } x - \frac{1}{x} = 0$$

$$\Rightarrow x^2 - 3x - 1 = 0 \text{ (Let roots of } x^2 - 3x - 1 = 0 \text{ are } \alpha \text{ \& } \beta \text{)}$$

$$\text{and } x^2 - 1 = 0 \text{ (Let roots of } x^2 - 1 = 0 \text{ are } \gamma \text{ \& } \delta \text{)}$$

$$\alpha + \beta = 3$$

$$x = \pm 1$$

$$\alpha\beta = -1$$

$$\text{Let } \gamma = 1, \delta = -1$$

$$\alpha^3 + \beta^3 = (\alpha + \beta)^3 - 3\alpha\beta(\alpha + \beta) = 36$$

$$\text{So required sum} = \alpha^3 + \beta^3 + \gamma^3 + \delta^3 = 36 + 1 - 1 = 36$$

15. If $\vec{a} \cdot \vec{b} = 1$, $\vec{b} \cdot \vec{c} = 2$, $\vec{c} \cdot \vec{a} = 3$ then the value of $[\vec{a} \times (\vec{b} \times \vec{c}), \vec{b} \times (\vec{a} \times \vec{c}), \vec{c} \times (\vec{a} \times \vec{b})]$ is

Ans. (00.00)

$$\text{Sol. } [(\vec{a} \cdot \vec{c})\vec{b} - (\vec{a} \cdot \vec{b})\vec{c} \quad (\vec{b} \cdot \vec{c})\vec{a} - (\vec{b} \cdot \vec{a})\vec{c} \quad (\vec{c} \cdot \vec{b})\vec{a} - (\vec{c} \cdot \vec{a})\vec{b}]$$

$$= [3\vec{b} - \vec{c} \quad 2\vec{a} - \vec{c} \quad 2\vec{a} - 3\vec{b}]$$

$$= \begin{vmatrix} 0 & 3 & -1 \\ 2 & 0 & -1 \\ 2 & -3 & 0 \end{vmatrix} [\vec{a} \ \vec{b} \ \vec{c}]$$

$$= \begin{vmatrix} 0 & 1 & -1 \\ 6 & 1 & 0 \\ 1 & -1 & 0 \end{vmatrix} [\vec{a} \ \vec{b} \ \vec{c}] = 6 \cdot (0) \cdot [\vec{a} \ \vec{b} \ \vec{c}] = 0$$

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16. Area bounded between the curves $y = |x^2 - 9|$ and $y = 3$ is equal to :

(1) $8(4\sqrt{3} - 2\sqrt{6} - 9)$

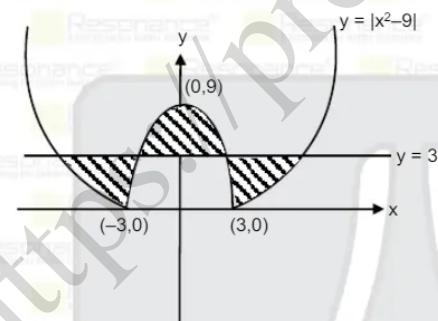
(2) $8(2\sqrt{6} - 4\sqrt{3} - 9)$

(3) $8(4\sqrt{3} + 2\sqrt{6} - 9)$

(4) $4(4\sqrt{3} + 2\sqrt{6} - 9)$

Ans. (3)

Sol.



$$\text{Area} = 2 \left(\int_0^3 (\sqrt{y+9} - \sqrt{9-y}) dy + \int_3^9 \sqrt{9-y} dy \right)$$

$$= 2 \left(\int_0^3 \sqrt{y+9} dy + \int_0^9 \sqrt{9-y} dy - 2 \int_0^3 \sqrt{9-y} dy \right) = \frac{4}{3} \left[(y+9)^{3/2} + 2(9-y)^{3/2} \right]_0^3 - \frac{4}{3} \left[(9-y)^{3/2} \right]_0^3$$

$$= \frac{4}{3} \left[12^{3/2} + 2 \cdot 6^{3/2} - 2 \cdot 9^{3/2} \right] = \frac{4}{3} [12 \times 2\sqrt{3} + 2 \cdot 6\sqrt{6} - 2 \cdot 27] = \frac{4}{3} [24\sqrt{3} + 12\sqrt{6} - 54]$$

$$= 4[8\sqrt{3} + 4\sqrt{6} - 18] = 8[4\sqrt{3} + 2\sqrt{6} - 9]$$

17. If $f(x) = 2\cos^{-1}x + 4 \cot^{-1}x - 3x^2 - 2x + 10$, the range of $f(x)$ is $[a, b]$, then the value of $4a - b$ is

(1) $11 - \pi$

(2) $11 + \pi$

(3) 11

(4) π

Ans. (1)

Sol. $f(x) = 2\cos^{-1}x + 4 \cot^{-1}x - 3x^2 - 2x + 10$

$$f'(x) < 0$$

so the function $f(x)$ is decreasing

the domain of function is $[-1, 1]$

$$f(-1) = 2\pi + 3\pi - 3 + 2 + 10$$

$$f(1) = \pi - 3 - 2 + 10 = 5 + \pi = a$$

$$4a - b = 4\pi + 20 - 9 - 5\pi = 11 - \pi$$

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