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JEE
(Main)

2021

COMPUTER BASED TEST (CRT)

Memory Based Questions & Solutions

Date: 27 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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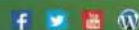
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1. Area bounded by the curve $y = x^2$ and the line $y-x-2=0$ is

(1) $\frac{7}{2}$

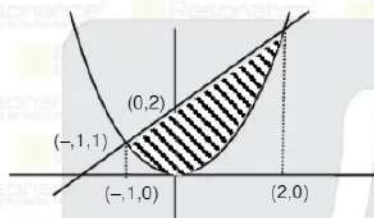
(2) $\frac{9}{2}$

(3) $\frac{11}{2}$

(4) $\frac{13}{2}$

Ans. (2)

Sol.



$$x^2 - x - 2 = 0$$

$$(x-2)(x+1) = 0$$

$$\text{Required area} = \frac{1}{2} (3) (5) - \int_{-1}^2 x^2 dx$$

$$= \frac{15}{2} - \frac{1}{3}(8+1)$$

$$= \frac{15}{2} - 3 = \frac{9}{2} \text{ sq. unit}$$

2. If $A_{3 \times 3} = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix}$ and $M = A + A^2 + A^3 + \dots + A^{20}$, then the sum of all the elements of M is :

Sol. $A^2 = \begin{bmatrix} 1 & 1 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 1 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 2 & 3 \\ 0 & 1 & 2 \\ 0 & 0 & 1 \end{bmatrix}$

$$A^3 = \begin{bmatrix} 1 & 2 & 3 \\ 0 & 1 & 2 \\ 0 & 0 & 1 \end{bmatrix} \begin{bmatrix} 1 & 1 & 1 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} 1 & 3 & 6 \\ 0 & 1 & 3 \\ 0 & 0 & 1 \end{bmatrix}$$

$$T_n = 1 + 2 + \dots + n = \frac{n(n+1)}{2} = \frac{20 \times 21}{2} = 210$$

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$$S_r = \frac{1}{2} \left(\frac{n(n+1)(2n+1)}{6} + \frac{n(n+1)}{2} \right)$$

$$= \frac{n(n+1)}{4} \left(\frac{2n+1}{3} + 1 \right)$$

$$= \frac{n(n+1)(n+2)}{6} = \frac{20 \times 21 \times 22}{6} = 1540$$

$$T_{20} = 1 + 2 + \dots + 20 = \frac{20 \times 21}{2} = 210$$

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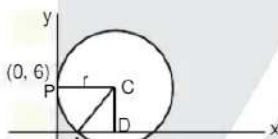
$$M = \begin{bmatrix} 20 & 210 & 1540 \\ 0 & 20 & 210 \\ 0 & 0 & 20 \end{bmatrix}$$

$$\text{Sum of elements of } M = 3(20) + 420 + 1540 = 2020$$

3. A circle touches y-axis at (0, 6) and has x-intercept equal to $6\sqrt{5}$ then radius of the circle is :

Ans. 9

Sol.



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$$AD = 3\sqrt{5}$$

$$CA^2 = CD^2 + AD^2$$

$$= 36 + 45$$

$$CA^2 = 81$$

$$CA = 9$$

$$\Rightarrow r = 9$$

4. Three vectors $\vec{a}$, $\vec{b}$, $\vec{c}$ with magnitude $\sqrt{2}$, 1 and 2 respectively follows the relation $\vec{a} = \vec{b} \times (\vec{b} \times \vec{c})$.

The acute angle between the vectors $\vec{b}$ & $\vec{c}$ is θ . Then the value of $(1 + \tan \theta)$ is :

Ans. 2

Sol. $\vec{a} = \vec{b} \times (\vec{b} \times \vec{c})$

$$\vec{a} = (\vec{b} \cdot \vec{c})\vec{b} - (\vec{b} \cdot \vec{b})\vec{c}$$

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PAGE # 2

$$\vec{a} \cdot \vec{b} = 2 \cos \theta = 2 \cos \theta$$

$$\Rightarrow \vec{a} \cdot \vec{b} = 0$$

$$\vec{a} \cdot \vec{a} = 2 \cos \theta (\vec{b} \cdot \vec{a}) - \vec{c} \cdot \vec{a}$$

$$\vec{c} \cdot \vec{a} = -2$$

$$\vec{a} \cdot \vec{c} = 2 \cos \theta (\vec{b} \cdot \vec{c}) - 4$$

$$-2 + 4 = 2 \cos \theta \times 2 \cos \theta$$

$$\cos^2 \theta = \frac{1}{2}$$

$$\cos \theta = \frac{1}{\sqrt{2}}$$

$$\theta = 45^\circ$$

$$\text{So, } (1 + \tan \theta) = 2$$

5. Two square matrices A & B are such that $A^2 + B^2$ is invertible and $A^2 + B^2 + A^2B^2 = B^2A^2$. Then the value of $|A^3 - B^3|$ is :

Ans. 0

$$\text{Sol. } (A^2 - B^2)(A^2 + B^2) = A^4 - B^4 + A^2B^2 - B^2A^2 = 0$$

$$\text{Since } |A^2 + B^2| \neq 0 \Rightarrow |A^2 - B^2| = 0$$

6. Evaluate $\lim_{x \rightarrow 0} \frac{x}{\sqrt[3]{1-\sin x} - \sqrt[3]{1+\sin x}}$

$$(1) 0$$

$$(2) -4$$

$$(3) 8$$

$$(4) 2$$

Ans. (2)

Sol. Rationalize denominator three times

$$\lim_{x \rightarrow 0} \frac{x \left((1-\sin x)^{1/3} + (1+\sin x)^{1/3} \right) \left((1-\sin x)^{2/3} + (1+\sin x)^{2/3} + (1-\sin x)^{1/3} + (1+\sin x)^{1/3} \right)}{(1-\sin x - 1 + \sin x)}$$

$$= -4$$

7. If two given APs are $\tan \frac{\pi}{9}, x, \tan \frac{7\pi}{18}$ and $\tan \frac{\pi}{9}, y, \tan \frac{5\pi}{18}$. Then the value of $|x-2y|$ is :

Ans. 0

$$\text{Sol. } \left| \frac{1}{2} \left(\tan \frac{\pi}{9} + \tan \frac{7\pi}{18} \right) - \tan \frac{\pi}{9} - \tan \frac{5\pi}{18} \right|$$

$$\therefore 2x = \tan \frac{\pi}{9} + \tan \frac{7\pi}{18} \text{ and } 2y = \tan \frac{\pi}{9} + \tan \frac{5\pi}{18}$$

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$$\left| \frac{1}{2} \left(\cot \frac{\pi}{9} - \tan \frac{\pi}{9} \right) - \tan \frac{5\pi}{18} \right|$$

$$\left| \frac{1}{2} \times 2 \cot \frac{2\pi}{9} - \tan \frac{5\pi}{18} \right|$$

$$|\cot 40^\circ - \tan 50^\circ| = 0$$

roots, then the minimum number of roots of the equation $g'(x) g(x) = 0$ is :

(1) 12

(2) 3

(3) 5

(4) 7

Ans. (4)

Sol. $f'(x) = g(x)$

$$g'(x) = f''(x)$$

$$f(x) = \int_a^x g(t) dt$$

$$g(x) = f'(x)$$

$$g'(x) = f''(x)$$

$$g(x) \cdot g'(x) = f'(x) f''(x)$$

Graph of $f(x)$ can be drawn as

If $f(x) = 0$ has atleast 5 real roots

$f'(x) = 0$ has atleast 4 real root

$f''(x) = 0$ has atleast 3 real root

$f'(x) f''(x) = 0$ has atleast 7 real root

$g(x) g'(x) = 0$ has atleast 7 real root

9. If $(x + x^3) dy = (y + yx^2 + x^3) dx$ and $y(1) = 0$, then $y(2)$ is :

(1) $\ln\left(\frac{17}{2}\right)$

(2) 0

(3) $\ln\left(\frac{5}{2}\right)$

(4) $\ln\left(\frac{2}{5}\right)$

Ans. (3)

Sol. $\frac{dy}{dx} = \frac{y + yx^2 + x^3}{x + x^3}$

$$dx \quad x \quad x^2 + 1$$

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$$I.F = e^{-\int \frac{1}{x} dx} = \frac{1}{x}$$

$$y\left(\frac{1}{x}\right) = \int \frac{x^2}{x^2+1} \left(\frac{1}{x}\right) dx$$

$$\Rightarrow \frac{y}{x} = \frac{1}{2} \ln(1+x^2) + \ln c$$

$$\Rightarrow y = \frac{x}{2} (\ln(1+x^2) + \ln c)$$

$$\text{Now } y(1) = 0$$

$$\Rightarrow 0 = \frac{1}{2}(\ln 2 + \ln c)$$

$$\ln 2c = 0$$

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$$\text{Now } y(2) = \frac{2}{2} \left(\ln 5 + \ln \frac{1}{2} \right)$$

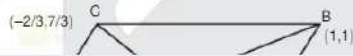
$$y(2) = \ln \frac{5}{2}$$

10. If two sides of a parallelogram are $4x + 5y = 0$ and $7x + 2y = 0$. If one of the diagonals is $11x + 7y = 9$ then the other diagonal passes through the point :

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

Ans. (2)

Sol. AC : $11x + 7y = 9$



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$$OA : 4x + 5y = 0$$

$$OC : 7x + 2y = 0$$

$$\Rightarrow A \left(\frac{5}{3}, -\frac{4}{3} \right) \text{ and } C \left(-\frac{2}{3}, \frac{7}{3} \right) \Rightarrow M = \left(\frac{1}{2}, \frac{1}{2} \right)$$

$$\text{equation of OB} \Rightarrow y = x$$

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11. The point P(a, b) undergoes following transformation to a new co-ordinate P' $\left(-\frac{1}{\sqrt{2}}, \frac{7}{\sqrt{2}} \right)$

(i) Reflection about $y = x$

(ii) Translation through 2 units in the positive direction of x-axis

(iii) Rotation through an angle $\frac{\pi}{4}$ in anti clockwise sense about the origin

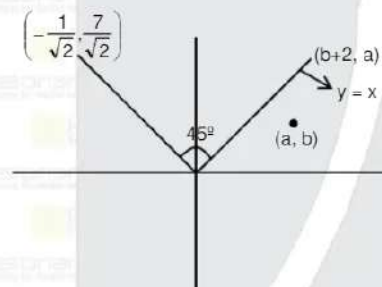
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then the value of $2a + 5b$ is :

- (1) 1 (2) 3 (3) 4 (4) 9

Ans. (4)

Sol.



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$$-\frac{1}{\sqrt{2}} + \frac{7}{\sqrt{2}} = t(b+2) + ai \left\{ \cos \frac{\pi}{4} + i \sin \frac{\pi}{4} \right\}$$

$$\sqrt{2} \cdot \sqrt{2} = 4 \Rightarrow 2 = 4 \Rightarrow 4 = 4$$

$$\frac{-1}{\sqrt{2}} + \frac{7}{\sqrt{2}} = \left(\frac{b+2}{\sqrt{2}} - \frac{a}{\sqrt{2}} \right) + \left(\frac{b+2}{\sqrt{2}} + \frac{a}{\sqrt{2}} \right)$$

$$b - a + 2 = -1 \quad \dots\dots (i)$$

$$b + 2 + a = 7 \quad \dots\dots (ii)$$

Using equation (i) & (ii)

$$a = 4, b = 1$$

$$\Rightarrow 2a + b = 9$$

12. If $\alpha^{1/5}$ and $\beta^{1/5}$ are roots of the equation $8x^2 + bx + c = 0$ where $\alpha = \max(2^{6\sin 3x} + 8\cos 3x)$ and $\beta = \min(2^{6\sin 3x} + 8\cos 3x)$. Then the value of $|b-c|$ is :

Ans. (4) (A)

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$$\beta = \min(2^{6\sin 3x} + 8\cos 3x) = 2^{-10}$$

$$\alpha^{1/5} = 2^2 \text{ and } \beta^{1/5} = 2^{-2}$$

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$$\Rightarrow 8x^2 + bx + c = 0 \begin{cases} \alpha^{1/5} \\ \beta^{1/5} \end{cases}$$

$$\Rightarrow \alpha^{1/5} + \beta^{1/5} = 4 + \frac{1}{4} = \frac{17}{4} = \frac{-b}{8}$$

$$b = -34$$

$$= \alpha^{1/5} + \beta^{1/5} = 1 = \frac{c}{8} \Rightarrow c = 8$$

$$|b-c| = 42$$

13. For an ellipse E, centre lies at the point (3, -4), one of the foci is at (4, -4) & one of vertices is at (5, -4). If the equation of tangent on the ellipse E is $mx - y - 4(m > 0)$. The value of $5m^2$ is :

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Ans. (1)

Sol. Equation of the ellipse is $\frac{(x-3)^2}{a^2} + \frac{(y+4)^2}{b^2} = 1$

$$\frac{4}{a^2} = 1 \Rightarrow a^2 = 4$$

$$a - ae = 1$$

$$2 - 2e = 1 \Rightarrow e = \frac{1}{2}$$

$$b^2 = a^2 - a^2 e^2 = 4 - 4 \left(\frac{1}{4} \right) = 3$$

$$\Rightarrow \frac{(x-3)^2}{4} + \frac{(y+4)^2}{3} = 1$$

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Given tangent is $y = mx - 4$

$$3m = \pm \sqrt{4m^2 + 3} \Rightarrow 9m^2 = 4m^2 + 3$$

$$5m^2 = 3$$

14. The number of solutions of the equation $e^{4x} - e^{3x} - 4e^{2x} - e^x + 1 = 0$ is :

Ans. (2)

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

$$e^{2x} - e^x - 4 - \frac{1}{e^x} + \frac{1}{e^{2x}} = 0$$

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$$\Rightarrow \left(e^x + \frac{1}{e^x}\right)^2 - 2 - \left(e^x + \frac{1}{e^x}\right) - 4 = 0$$

$$\Rightarrow \left(e^x + \frac{1}{e^x}\right)^2 - \left(e^x + \frac{1}{e^x}\right) - 6 = 0$$

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$$\Rightarrow t^2 - t - 6 = 0$$

$$t = 3, t = -2 \text{ (not possible)}$$

$$\Rightarrow e^x + \frac{1}{e^x} = 3$$

$$e^{2x} - 3e^x + 1 = 0$$

$$\text{Put } e^x = p$$

$$\Rightarrow p^2 - 3p + 1 = 0$$

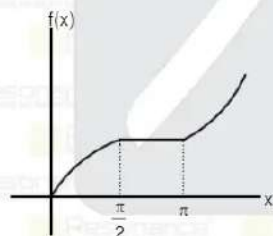
$$\Rightarrow \text{number of solutions} = 2$$

15. If $f(x) = \begin{cases} \max(\sin t) & ; 0 \leq t \leq x, x \in [0, \pi] \\ 2 + \cos x & ; x > \pi \end{cases}$ then the number of points where of $f(x)$ is not continuous or non-differentiable.

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Ans. (1)

Sol.



Critical point $\frac{\pi}{2}$ & π

$$\text{At } x = \frac{\pi}{2}$$

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$$\text{at } x = \pi$$

$$f(x) \text{ is again continuous and differentiable at } x = \pi \Rightarrow \text{LHD} = \text{RHD} = 0$$

$$\text{So, number of dis-continuous and non differentiable point} = 0$$

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16. If $f(x) = \frac{1 - \sin x + \cos x}{1 + \sin x + \cos x}$, $x \neq \pi$ then the value of $f(\pi)$ so that $f(x)$ is continuous.

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

Ans. (3)

Sol. Since $f(x)$ is continuous at $x = \pi$

$$\Rightarrow f(\pi) = \lim_{x \rightarrow \pi} \frac{1 - \sin x + \cos x}{1 + \sin x + \cos x}$$

$$= \lim_{x \rightarrow \pi} \frac{2 \cos^2 \frac{x}{2} - 2 \sin \frac{x}{2} \cos \frac{x}{2}}{2 \cos^2 \frac{x}{2} + 2 \sin \frac{x}{2} \cos \frac{x}{2}}$$

$$= \lim_{x \rightarrow \pi} \frac{\cos \frac{x}{2} - \sin \frac{x}{2}}{\cos \frac{x}{2} + \sin \frac{x}{2}}$$

$$\text{So } f(\pi) = -1$$

17. Let $\left(3^{\frac{1}{6} \log_3 (25^{x-1} + 7)} + 3^{\frac{1}{6} \log_3 (5^{x-1} + 1)} \right)^{10}$ is expanded in the increasing power of $3^{\frac{1}{6} \log_3 (5^{x-1} + 1)}$. If 9th terms of the expansion is 180 then the value of x is :

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

Ans. (2)

Sol. 9th terms of the expansion $\left((25^{x-1} + 7)^{\frac{1}{6}} + (5^{x-1} + 1)^{\frac{1}{6}} \right)^{10}$ is

$${}^{10}C_8 \left((25^{x-1} + 7)^{\frac{2}{6}} \times (5^{x-1} + 1)^{\frac{8}{6}} \right) = 180$$

$$\Rightarrow \frac{10 \times 9}{2} \left((25^{x-1} + 7)^{\frac{1}{3}} \times (5^{x-1} + 1) \right) = 180$$

After solving x :

$$x = 1$$

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PAGE # 9