



JEE (Main)

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

2022

COMPUTER BASED TEST (CBT) Memory Based Questions & Solutions

Date: 26 June, 2022 (SHIFT-2) | TIME : (3.00 a.m. to 6.00 p.m)

Duration: 3 Hours | Max. Marks: 300

SUBJECT: MATHEMATICS

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PART : MATHEMATICS

1. The value of $\lim_{x \rightarrow 0} \frac{\cos(\sin x) - \cos x}{x^4}$ is

- (1) $\frac{1}{2}$
- (2) $\frac{1}{6}$
- (3) $\frac{1}{12}$
- (4) $\frac{1}{3}$

Ans. (2)

Sol. $\lim_{x \rightarrow 0} \frac{x^4}{-2 \sin\left(\frac{\sin x + x}{2}\right) \sin\left(\frac{\sin x - x}{2}\right)}$

$\Rightarrow \lim_{x \rightarrow 0} \frac{x^4}{\left(\frac{\sin x}{x} + 1\right) (\sin x - x)}$

$\Rightarrow -\frac{1}{2} \lim_{x \rightarrow 0} \frac{x^4}{x^3 \left[\left(x - \frac{x^3}{3!} + \frac{x^5}{5!} \dots \right) - x \right]}$

$\Rightarrow -\frac{1}{2} (1+1) \lim_{x \rightarrow 0} \frac{x^4}{x^3} = \frac{1}{6}$

2. The value of $16(\sin 20^\circ)(\sin 40^\circ)(\sin 80^\circ)$ is
 (1) $2\sqrt{3}$ (2) $2\sqrt{5}$ (3) $-2\sqrt{5}$ (4) $-2\sqrt{3}$

Ans. (1)

Sol. $\therefore \sin x \cdot \sin(60^\circ - x) \cdot \sin(60^\circ + x) = \frac{\sin 3x}{4}$
 $\Rightarrow 16(\sin 20^\circ)(\sin 40^\circ)(\sin 80^\circ)$
 $= 16(\sin 20^\circ)(\sin(60^\circ - 20^\circ))(\sin 60^\circ + 20^\circ)$
 $= 16 \times \frac{\sin 60^\circ}{4}$
 $= 4 \times \frac{\sqrt{3}}{2}$
 $= 2\sqrt{3}$

3. Let $y(x)$ represents the solution of differential equation $x \frac{dy}{dx} + 2y = xe^x$ and $z(x) = x^2 y(x) - e^x$, and $y(1) = 0$, then the maximum value of $z(x)$ is

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

Ans. (1)

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

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$\frac{dy}{dx} + \frac{2}{x} \cdot y = e^x$

I.F. = $e^{\int \frac{2}{x} dx} = x^2$

final solution is $y \cdot x^2 = \int x^2 \cdot e^x dx$

$yx^2 = x^2 e^x - 2xe^x + 2e^x + k$

given $y(1) = 0$

$x = 1, y = 0$ given

$0 = e - 2e + 2e + k \Rightarrow k = -e$

$y \cdot x^2 - e^x = x^2 e^x - 2xe^x + e^x - e$

$z(x) = (x - 1)^2 e^x - e$

$z'(x) = 2(x - 1)e^x + (x - 1)^2 e^x = 0$

for maximum or minimum $z'(x) = 0$

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

$(x - 1)(x + 1)e^x = 0$

$z(x)_{\max} = 4e^{-1} - e = \frac{4}{e} - e$

4. If $z^2 + z + 1 = 0, (z \in \mathbb{C})$ then the value of $\left| \sum_{n=1}^{15} \left(z^n + \frac{(-1)^n}{z^n} \right)^2 \right|$ is equal to

Ans. (2)

Sol. $z = w, w^2 = \frac{1}{z}$

$\left(z^n + \frac{(-1)^n}{z^n} \right)^2 = z^{2n} + \frac{1}{z^{2n}} + (-1)^n \cdot 2$

$$\text{exp.} = \left| \sum_{n=1}^{15} \left(z^n + \frac{(-1)^n}{z^n} \right)^2 \right| = \left| \sum_{n=1}^{15} z^{2n} + 2 \sum_{n=1}^{15} (-1)^n + \sum_{n=1}^{15} \frac{1}{z^{2n}} \right|$$

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

5. Let $p, q \in \mathbb{R}$ such that $p + q = 3$ and $p^4 + q^4 = 369$ then the value of $\left(\frac{1}{p} + \frac{1}{q}\right)^{-2}$ is
- (1) 5 (2) $\frac{1}{4}$ (3) 4 (4) $\frac{1}{5}$

Ans. (3)

Sol. $p^4 + q^4 = (p^2 + q^2)^2 - 2p^2q^2$

$$\Rightarrow 369 = (p+q)^2 - 2pq)^2 - 2(pq)^2$$

$$\Rightarrow 369 = (9 - 2x)^2 - 2x^2 \quad (\text{where } x = pq)$$

$$\Rightarrow 369 = 81 - 36x + 4x^2 - 2x^2$$

$$\Rightarrow 2x^2 - 36x - 288 = 0$$

$$\Rightarrow x^2 - 18x - 144 = 0$$

$$\Rightarrow (x - 24)(x + 6) = 0$$

$$\Rightarrow x = 24, -6$$

$$\left(\frac{1}{p} + \frac{1}{q}\right)^{-2} = \left(\frac{p+q}{pq}\right)^{-2} = \left(\frac{pq}{p+q}\right)^2 = \left(\frac{-6}{3}\right)^2 = 4$$

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6. If the common tangent of $\frac{x^2}{16} + \frac{y^2}{9} = 1$ and $x^2 + y^2 = 12$ is $y = mx + c$ then the value of $12m^2$ is
- (1) 12 (2) 10 (3) 9 (4) 6

Ans. (3)

Sol. Slope of the common tangent is m

Then Equation of tangent to Ellipse is $y = mx \pm \sqrt{16m^2 + 9}$

Equation of tangent to Circle is $y = mx \pm 2\sqrt{3}\sqrt{1+m^2}$

Since both tangents are identical

$$\Rightarrow 16m^2 + 9 = 12 + 12m^2$$

$$\Rightarrow 4m^2 = 3$$

$$\Rightarrow 12m^2 = 9$$

7. If $\int \frac{1}{x\sqrt{1-x}} dx = g(x) + C$, then the value of $g\left(\frac{1}{2}\right)$ is
- (1) $\frac{\pi}{3} + \ln(2 + \sqrt{3})$ (2) $\frac{\pi}{6} + \ln(2 + \sqrt{3})$ (3) $\frac{\pi}{3} - \ln(2 + \sqrt{3})$ (4) $\frac{\pi}{6} - \ln(2 + \sqrt{3})$

Ans. (3)

Sol. $\int \frac{1}{x\sqrt{1-x}} dx$ Put $x = \frac{1}{t}$

$$dx = -\frac{1}{t^2} dt$$

$$= \int \frac{-t}{t^2} \sqrt{\frac{t-1}{t+1}} dt$$

$$= -\int \frac{\sqrt{t-1}}{t\sqrt{t+1}} dt$$

$$= -\int \frac{t-1}{t\sqrt{t^2-1}} dt$$

$$= \int \frac{1}{t\sqrt{t^2-1}} dt - \int \frac{dt}{t^2-1}$$

$$\sec^{-1}t - \ln\left(t + \sqrt{t^2-1}\right) + C$$

$$\sec^{-1}\frac{1}{x} - \ln\left(\frac{1}{x} + \sqrt{\frac{1}{x^2}-1}\right) + C$$





$$g\left(\frac{1}{2}\right) = \sec^{-1}(2) - \ln\left(2 + \sqrt{2^2-1}\right)$$

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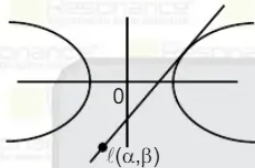
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8. The locus of point of intersection of any tangent to the hyperbola $\frac{x^2}{16} - \frac{y^2}{4} = 1$ and a line perpendicular to the tangent and passing through (0,0) is $(x^2+y^2)^2 = \alpha x^2 + \beta y^2$, then value of $(\alpha+\beta)$ is

Ans. (12.00)

Sol. $\frac{x^2}{16} - \frac{y^2}{4} = 1$



tangent $y = mx \pm \sqrt{16m^2 - 4}$

Given $y = \frac{-x}{m}$

$\Rightarrow m = \frac{-x}{y}$

then $y = \frac{-x^2}{y} + \frac{\sqrt{16x^2 - 4y^2}}{y}$

$y^2 + x^2 = \sqrt{16x^2 - 4y^2}$

$(y^2 + x^2)^2 = 16x^2 - 4y^2$

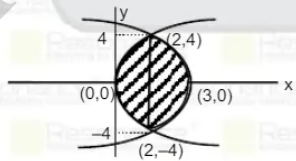
$\alpha = 16, \beta = -4$

the value of $\alpha + \beta = 12$

9. Area bounded between the curve $y^2 = 8x$ and $y^2 = 16(3-x)$ is :
 (1) 32 (2) 42 (3) 48 (4) 16

Ans. (4)

Sol. $y^2 = 8x$ & $y^2 = 16(3-x)$
 Point of intersection $8x = 16(3-x)$
 $x = 6-2x$
 $\Rightarrow x = 2 \therefore y = \pm 4$







$A = 2 \left(\int_0^2 2\sqrt{2}\sqrt{x} \, dx + \int_2^3 4\sqrt{3-x} \, dx \right)$

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$$= 4\sqrt{2} \left[\frac{x^{\frac{3}{2}}}{\frac{3}{2}} \right]_0^2 + 8 \left[-\frac{(3-x)^{\frac{3}{2}}}{\frac{3}{2}} \right]_2^3$$

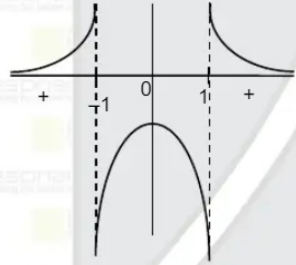
$$= \frac{8\sqrt{2}}{3} \cdot 2\sqrt{2} - \frac{16}{3} (0-1)$$

$$= \frac{32}{3} + \frac{16}{3} = \frac{48}{3} = 16$$

10. If $f(x) = x-1 : \mathbb{R} \rightarrow \mathbb{R}$ and $g(x) = \frac{x^2}{x^2-1} : \mathbb{R} - \{-1,1\} \rightarrow \mathbb{R}$ then $f(g(x))$ is
- (1) one-one and onto function (2) many-one and into function
 (3) one-one and into function (4) many-one and onto function
- Ans. (2)

Sol. $f(g(x)) = f\left(\frac{x^2}{x^2-1}\right) \quad x \neq \pm 1$

$$= \frac{x^2}{x^2-1} - 1 = \frac{1}{x^2-1} \quad x \neq \pm 1$$



11. If ${}^{40}C_0 + {}^{41}C_1 + {}^{42}C_2 + \dots + {}^{60}C_{20} = \frac{m}{n} ({}^{60}C_{20})$ where m & n are co-prime then the value of $m+n$ is
- (1) 105 (2) 102 (3) 107 (4) 109
- Ans. (2)

Sol. ${}^{40}C_0 + {}^{41}C_1 + {}^{42}C_2 + \dots + {}^{60}C_{20}$

$$= {}^{40}C_{40} + {}^{41}C_{40} + {}^{42}C_{40} + \dots + {}^{60}C_{40}$$

$$= {}^{41}C_{41} + {}^{41}C_{40} + {}^{42}C_{40} + \dots$$

$$= {}^{42}C_{41} + {}^{42}C_{40} + \dots$$

$$\vdots$$

$$= {}^{60}C_{41} + {}^{60}C_{40} = {}^{61}C_{41} = \frac{61}{41} \times {}^{60}C_{40}$$

$$= \left(\frac{61}{41}\right) {}^{60}C_{20}$$

So, $m = 61, n = 41$
 $m+n = 102$

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12. The equation of normal to the hyperbola $\frac{x^2}{\alpha} + \frac{y^2}{9} = 1$ at point $(8, 3\sqrt{3})$
- (1) $4x + \sqrt{3}y = 41$ (2) $4x - \sqrt{3}y = 41$ (3) $\sqrt{3}x + 4y = 41$ (4) $\sqrt{3}x - 4y = 41$
- Ans. (1)

Sol. $\because (8, 3\sqrt{3})$ lies on Hyperbola $\frac{x^2}{\alpha} + \frac{y^2}{9} = 1$

$$\Rightarrow \frac{64}{\alpha} + \frac{27}{9} = 1 \Rightarrow \alpha = -32$$

Equation of hyperbola is $-\frac{x^2}{32} + \frac{y^2}{9} = 1$

Differentiating w.r.t. x $\Rightarrow -\frac{2x}{32} + \frac{2y}{9} \frac{dy}{dx} = 0$

$\Rightarrow \frac{dy}{dx} = \frac{9x}{32y}$

Slope of normal at $(8, 3\sqrt{3}) \Rightarrow -\frac{32(3\sqrt{3})}{9(8)} = -\frac{4\sqrt{3}}{3}$

Equation of normal $\Rightarrow y - 3\sqrt{3} = -\frac{4}{\sqrt{3}}(x - 8)$

$\Rightarrow \sqrt{3}y - 9 = -4x + 32$

$\Rightarrow 4x + \sqrt{3}y = 41$

13. The value of $\cos^{-1}\left(\frac{3}{10}\cos\left(\tan^{-1}\left(\frac{4}{3}\right)\right) + \frac{2}{5}\sin\left(\tan^{-1}\left(\frac{4}{3}\right)\right)\right)$ is-

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

Ans. (4)

Sol. $\cos^{-1}\left(\frac{3}{10}\cos\left(\tan^{-1}\left(\frac{4}{3}\right)\right) + \frac{2}{5}\sin\left(\tan^{-1}\left(\frac{4}{3}\right)\right)\right)$

$\cos^{-1}\left(\frac{3}{10}\cos\left(\cos^{-1}\left(\frac{3}{5}\right)\right) + \frac{2}{5}\sin\left(\sin^{-1}\left(\frac{4}{5}\right)\right)\right)$

$\cos^{-1}\left(\frac{3}{10} \times \frac{3}{5} + \frac{2}{5} \times \frac{4}{5}\right) = \cos^{-1}\left(\frac{9}{50} + \frac{8}{25}\right)$

$\cos^{-1}\frac{1}{2} = \frac{\pi}{3}$

14. There are 50 observation $x_1, x_2, x_3, \dots, x_{49}, a$. The mean and standard deviation of these observation are 15 and 2 respectively. Now if 'a' is replaced by b, then mean of these 50 observations so obtained is 16 then the variance of new 50 observations is (it is given that $a + b = 70$)

Ans. (46)

Sol. Given $\frac{x_1 + x_2 + \dots + x_{49} + a}{50} = 15$

$= \sum x_i + a = 750$

$\therefore \sum x_i = 750 - a$

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$\sigma^2 = \frac{\sum x^2}{n} - \left(\frac{\sum x}{n}\right)^2$

$\Rightarrow 4 = \frac{\sum x_i^2 + a^2}{50} - 225$

$\Rightarrow \sum x_i^2 + a^2 = 11450$

New sum $\sum x_i + b = 750 - a + b$

\therefore New mean $\frac{750 - a + b}{50} = 16$

$-a + b = 800 - 750 = 50$

$a + b = 70$

$\therefore 2b = 120 \Rightarrow b = 60$ & $a = 10$

\therefore New $\sum x^2 = 11450 - a^2 + b^2 = 14950$

\therefore new $\sigma^2 = \frac{\sum x^2}{n} - (16)^2 = \frac{14950}{50} - 256$

$= 46$

15. If the compound statement $(r \vee \sim p) \rightarrow (p \wedge q) \vee r$ is tautology then r is equivalent to

- (1) $\sim p$ (2) p (3) q (4) $\sim q$

Ans. (1)

Sol. $(r \vee \sim p) \rightarrow (p \wedge q) \vee r$

$\Rightarrow \sim(r \vee \sim p) \vee (p \wedge q) \vee r$

$\Rightarrow (\sim r \wedge p) \vee (p \wedge q) \vee r$

$\Rightarrow ((\sim r \wedge p) \vee r) \vee (p \wedge q)$

$\Rightarrow (p \vee r) \vee (p \wedge q)$

$(p \vee r) \vee (p \wedge q)$
 $\Rightarrow (p \vee r) \vee (p \wedge q)$
 $\Rightarrow r \vee (p \vee (p \wedge q))$
 $\Rightarrow r \vee p$
 will be a tautology if $r = \sim p$.

16. If the probability that 6 digits number formed using digits 8 and 1. Which is divisible by 21 is P then the value of 96 P is

Ans. (33)

Sol. No. of numbers formed by 8 and 1 of 6 digits which is divisible by 3 as well as 7 will contain three 8 and three 1 like given below .

8 8 8 1 1 1

1 8 1 8 1 8

and any number of 6 digits using same number will be divisible by 3 and 7 so two cases will arise like

1 1 1 1 1 1 & 8 8 8 8 8 8

$$R. Prop = P = \frac{\binom{6}{3} 3^3}{2^6} = \frac{11}{32}$$

$$96 P = 96 \times \frac{11}{32} = 33$$

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