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

JEE (Main) 2020

COMPUTER BASED TEST (CBT)

Memory Based Questions & Solutions

Date: 03 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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1. \[ \int_0^1 \frac{x^2}{(1-x^2)^{3/2}} \, dx = \frac{k}{6} \text{, then } k = \]

   (1) \( 3\sqrt{2} + \pi \)  
   (2) \( 2\sqrt{3} - \pi \)  
   (3) \( 2\sqrt{2} + \pi \)  
   (4) \( 3\sqrt{2} - \pi \)

**Ans.** (2)

**Sol.**

\[ k = \int_0^1 \frac{x^2}{(1-x^2)^{3/2}} \, dx \]

\[ x = \sin \theta \; ; \; dx = \cos \theta \, d\theta \]

\[ \Rightarrow k = \frac{\int_{0}^{\pi/2} \frac{\sin^2 \theta}{(1-\sin^2 \theta)^{3/2}} \cos \theta \, d\theta}{6} \Rightarrow k = \frac{\int_{0}^{\pi/2} \sin^2 \theta \cos^2 \theta \, d\theta}{6} \]

\[ \Rightarrow k = \frac{1}{6} \left( \frac{\int_{0}^{\pi/2} \sin^2 \theta \, d\theta}{2} \right) \Rightarrow k = \frac{1}{6} \left( \frac{\pi}{2} - \frac{\pi}{3} \right) \Rightarrow k = \frac{\pi}{12} \]

\[ \Rightarrow k = \frac{\pi}{12} = \frac{2\sqrt{3} - \pi}{6} \]

2. Let \( \frac{x^2}{25} + \frac{y^2}{16} = 1 \) and \( \frac{x^2}{25} - \frac{y^2}{16} = 1 \) are ellipse and hyperbola respectively such that \( e_1, e_2 = 1 \) where \( e_1, e_2 \) are eccentricities. If distance between foci of ellipse is \( \alpha \) and that of hyperbola is \( \beta \) then \((\alpha, \beta) = \)

   (1) \( (4, 5) \)  
   (2) \( (8, 10) \)  
   (3) \( (10, 7) \)  
   (4) \( (4, 10) \)

**Ans.** (2)

**Sol.**

\[ e_1 = \sqrt{1 - \frac{b^2}{25}} ; \quad e_2 = \sqrt{1 + \frac{b^2}{16}} \]

\( e_1 \cdot e_2 = 1 \)
\[ \Rightarrow \left( \frac{a}{b} \right)^2 = 1 \Rightarrow \left( \frac{b^2}{16} + \frac{b^2}{16} - 1 \right) = 1 \Rightarrow \frac{2b^2}{16} - 1 = 1 \Rightarrow b^2 = 9 \]
\[ \Rightarrow e_1 = \sqrt{1 - \frac{9}{25}} = \frac{4}{5} \]
\[ \Rightarrow e_2 = \sqrt{1 - \frac{9}{16}} = \frac{5}{4} \]
\[ \alpha = 2(5\sqrt{4}) = 8 \]
\[ \beta = 2(4\sqrt{4}) = 10 \]
\[ (\alpha, \beta) = (8, 10) \]

3. Two equal circles of radius \(2\sqrt{5} \) passes through the entries LR of \( y^2 = 4x \) then find the dist. between centres of circles

(1) 4
(2) 8
(3) 2
(4) 6
Ans. (2)

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Sol.

\[ y = \sqrt{x} \]
\[ C_2 = 2C_1 \]
\[ S = 2\sqrt{20} - 4 = 8 \]

4. If \( f(x) = \int \frac{\sqrt{x}}{\sqrt{1+x}} \) dx = \( A\sqrt{x} + B\sqrt{x} + C \) then \( A(x) \) and \( B(x) \) will be

(1) 1 + x, \( \sqrt{x} \)
(2) 1 - x, -\( \sqrt{x} \)
(3) 1 + x, -\( \sqrt{x} \)
(4) 1 - x, \( \sqrt{x} \)
Ans. (3)

Sol. \( f(x) = \int \frac{\sqrt{x}}{\sqrt{1+x}} \) dx

\[ f(x) = \int \frac{\sqrt{x}}{\sqrt{1+x}} \sqrt{x} = x \sqrt{1} - \frac{1}{2} \sqrt{1} \times \frac{1}{2} x + C \]
\[ = x \tan^{-1} \sqrt{x} - \frac{1}{2} \sqrt{1} \times \frac{1}{2} x + C \]
\[ = x \tan^{-1} \sqrt{x} - \frac{1}{2} \sqrt{1} \times \frac{1}{2} x + C \]
\[ = x + 1 \tan^{-1} \sqrt{x} + C \]
\[ \Rightarrow (A(x)) + B(x) = \sqrt{x} \]

5. The coefficient of term independent of \( x \) in the expansion of \( \left( \frac{3x^2}{2} - \frac{1}{3x} \right)^9 \) is \( \lambda \), then \( 18\lambda \), is

(1) 9
(2) 7
(3) 6
(4) 4
Ans. (2)

Sol. \( T_{r+1} = \binom{9}{r} \left( \frac{3x^2}{2} \right)^{9-r} \left( -\frac{1}{3x} \right)^r \]

For the term independent of \( x \) put \( r = 6 \)

\[ \Rightarrow T_7 = \binom{9}{6} \left( \frac{3}{2} \right)^3 \left( -\frac{1}{3} \right)^6 \]
\[ C_0 \binom{9}{6} = \frac{9 	imes 8 	imes 7}{3 	imes 2 	imes 1} \binom{1}{6} = \frac{7}{18} \]

6. If \( |z_1 - 1| = \text{Re}(z_1) \), \( |z_2 - 1| = \text{Re}(z_2) \) and \( \arg(z_1 + z_2) = \frac{\pi}{3} \), then \( \text{Im}(z_1 + z_2) = \)

(1) \( \frac{1}{\sqrt{3}} \)
(2) \( \frac{2}{\sqrt{3}} \)
(3) \( \frac{3}{\sqrt{3}} \)
(4) \( \sqrt{3} \)

Ans. (4)
Sol. 

\[ |z| - 1 = \text{Re}(z) \]  
Let \( z = x + iy \) and \( z = x + iy \)

\[ (x - 1)^2 + y^2 = x^2 \]  
\[ y^2 - 2x + 1 = 0 \]  
\[ |x| - 1 = \text{Re}(z) \]  
\[ x^2 - 1 + y^2 = x^2 \]  
\[ y^2 - 2x + 1 = 0 \]  
\[ \frac{y^2 - 2x + 1}{2} = 0 \]  
\( y^2 - 2x + 1 = 0 \)  
\( y^2 - 2(x - x_0) = 0 \)  
\( (y_1 - y_2)(y_1 + y_2) = 2(x_1 - x_2) \)  
\( y_1 + y_2 = 2 \frac{x_1 - x_2}{y_1 - y_2} \)  
\( \gamma \)  
\( \tan^{-1} \frac{y_1 - y_2}{x_1 - x_2} = \frac{\pi}{3} \)  
\( \frac{y_1 - y_2}{x_1 - x_2} = \frac{\pi}{3} \)  
\( \frac{x_1 - x_2}{x_1 - x_2} = \sqrt{3} \)  
\( \frac{x_1 - x_2}{x_1 - x_2} = \frac{2}{\sqrt{3}} \)  
\( \implies \text{Im}(z) = \text{Im}(z) = \frac{2}{\sqrt{3}} \)

7. The probability of 5 digit numbers that are made up of exactly two distinct digits is

\[ \begin{align*} 
(1) & \quad \frac{135}{10^7} \\
(2) & \quad \frac{125}{10^7} \\
(3) & \quad \frac{144}{10^7} \\
(4) & \quad \frac{127}{10^7} 
\end{align*} \]

Ans. (3)

Sol.  
\text{total} = 9(10^4)  
\text{fav. way} = C_2^2 (2^5 - 2) + 3 C_1 (2^4 - 1) = 36(30) + 9(15) = 1080 + 135

\[ \text{Prob} = \frac{36 \times 30 + 9 \times 15}{9 \times 10^4} = \frac{4 \times 30 + 15}{10^4} \]

8. Let \((\lambda^2 + 1)x^2 - 4x + 2 = 0 \) be a quadratic equation then set of values of \( \lambda \) if exactly one root of quadratic equation lies in \((0, 1)\) is

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

Ans. (4)

Sol.  
\( f(0) f(1) \leq 0 \)  
\( \Rightarrow 2(\lambda^2 + 1 - 4\lambda + 2) \leq 0 \)  
\( \Rightarrow 2(\lambda^2 - 4\lambda + 3) \leq 0 \)  
\( \lambda \in [1, 3] \)  
\( \text{But at } \lambda = 1, \text{ both roots are 1 so } \lambda \neq 1 \)

9. The orthocentre of \( \triangle ABC \) where vertices are \( A(-1, 7) \), \( B(-7, 1) \), \( C(5, -5) \) is

\[ \begin{align*} 
(1) & \quad (-3, 3) \\
(2) & \quad (3, -3) \\
(3) & \quad (3, 3) \\
(4) & \quad (-3, -3) 
\end{align*} \]

Ans. (1)
Sol.

\[ m_{BC} = \frac{6}{12} = \frac{1}{2} \]

\[ \therefore \text{Equation of AD is} \ y = -2(x + 1) \]
\[ y = 2x + 9 \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (1) \]

\[ m_{DE} = \frac{1}{-6} = \frac{1}{2} \quad \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots \ldots (2) \]

\[ \therefore \text{Equation of BE is} \]
\[ y - 1 = \frac{1}{2}(x + 7) \]

by (1) and (2)
\[ 2x + 9 + \frac{1}{2}x + \frac{9}{2} = 0 \]
\[ \Rightarrow 4x + 18 = x + 9 \]
\[ \Rightarrow 3x = 9 \Rightarrow x = 3 \]
\[ \therefore y = 3 \]

10. \(m, A, M, \) and \(3 \text{ GM are inserted between 3 and 243} \) such \(2^{nd} \text{ GM = 4}^{th} \text{ AM then} m = \)

Ans. 39

Sol.

\[ A_1, A_2, A_3, \ldots \ldots , A_n, 243 \]
\[ d = \frac{243 - 3}{n - 1} = \frac{240}{n - 1} \]
\[ 3, G_1, G_2, G_3, 243 \]
\[ r = \frac{243}{3^{1-1}} = (31)^{1/3} = 3 \]
\[ G_2 = A_4 \]
\[ \Rightarrow 3(3)^2 = 3 + 4 \times \frac{240}{m+1} \]
\[ \Rightarrow 27 = 3 + \frac{960}{m+1} = m + 1 = 40 \]
\[ m = 39 \]

11. A normal is drawn to parabola \(y^2 = 4x\) at \((1,2)\) and tangent is drawn to \(y = e^x\) at \((c, e^c)\). If tangent and normal intersect at \(x - \) axis then find \(C\).

Ans. 04.00

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Sol.

For \((1,2)\) of \(y^2 = 4x \Rightarrow t = 1, a = 1\)

normal \(\Rightarrow bx + y = 2at + at^3\)
\(\Rightarrow x + y = 3 \) intersect \(x-\) axis at \((3,0)\)

\(y = e^x \Rightarrow \frac{dy}{dx} = e^x\)

\(\text{tangent} \Rightarrow y = \phi (x-c) \)
\(\text{at} (3,0) \Rightarrow 0 = \phi (3-c) \Rightarrow c = 4 \)

12. If relation \(R_1 = \{(a, b) : a, b \in R, a^2 + b^2 \in Q\} \)
and \(R_2 = \{(a, b) : a, b \in R, a^2 + b^2 \in Q\} \)

Then

(1) \(R_1\) is transitive, \(R_1\) is not transitive
(2) \(R_1\) is not transitive, \(R_1\) is not transitive
(3) \(R_1\) is transitive, \(R_1\) is transitive
(4) \(R_1\) is not transitive, \(R_2\) is transitive

**Sol.**

For \(R_1\):

Let \(a = 1 + \sqrt{2}, b = 1 - \sqrt{2}, c = 8^{1\text{/}4}\)

- \(aRb \iff a^2 + b^2 = (1 + \sqrt{2})^2 + (1 - \sqrt{2})^2 = 6 \in Q\)
- \(aRc \iff b^2 + c^2 = (1 - \sqrt{2})^2 + (8^{1\text{/}4})^2 = 3 \in Q\)
- \(aRc \iff a^2 + c^2 = (1 + \sqrt{2})^2 + (8^{1\text{/}4})^2 = 3 + 4\sqrt{2} \notin Q\)

\[\therefore \quad R_1 \text{ is not transitive.}\]

For \(R_2\):

Let \(a = 1 + \sqrt{2}, b = \sqrt{2}, c = 1 - \sqrt{2}\)

- \(aRb \iff a^2 + b^2 = (1 + \sqrt{2})^2 + (\sqrt{2})^2 = 5 + 2\sqrt{2} \in Q\)
- \(bRb \iff b^2 + c^2 = (\sqrt{2})^2 + (1 - \sqrt{2})^2 = 6 - 2\sqrt{2} \in Q\)
- \(aRc \iff a^2 + c^2 = (1 + \sqrt{2})^2 + (1 - \sqrt{2})^2 = 6 \in Q\)

\[\therefore \quad R_2 \text{ is not transitive.}\]

13. If the sum of first \(n\) terms of series \(20 + 19\frac{3}{5} + 19\frac{1}{5} + 18\frac{4}{5} \ldots\) is 488 and \(n\)th term is negative then find \(n\).

\[
\begin{align*}
\text{Anns.} & \quad (1) \quad 4 \quad 6 \\
\text{Sol.} & \quad 488 = n \left( \frac{100}{5} + (n-1) \left( 2 \frac{2}{5} \right) \right) \\
& \quad 488 = \frac{n}{2} (101 - n) \quad \Rightarrow \quad n^2 - 101n + 2440 = 0 \\
& \quad \Rightarrow \quad n = 61 \text{ or } 40
\end{align*}
\]

- For \(n = 40\) \(\Rightarrow T_n > 0\)
- For \(n = 61\) \(\Rightarrow T_n > 0\)

\[
\begin{align*}
T_n = \frac{100}{5} + (61 - 1) \left( -2 \frac{2}{5} \right) &= -4
\end{align*}
\]

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14. Surface area of a cube is increasing at a rate of 3.6 cm\(^2\)/s. Find the rate at which its volume increases when lengths of side \(a\) is 10 cm.

\[
\begin{align*}
\text{Anns.} & \quad (1) \quad 9 \\
\text{Sol.} & \quad S = 6a^2 \Rightarrow \frac{ds}{dt} = 12a \frac{da}{dt} = 3.6 \Rightarrow 12(10) \frac{da}{dt} = 3.6 \Rightarrow \frac{da}{dt} = 0.03 \\
V = a^3 \Rightarrow \frac{dv}{dt} = 3a^2 \frac{da}{dt} = 3(10)^2 \left( \frac{3}{100} \right) = 9
\end{align*}
\]

15. Which of the following point lies on plane containing lines \(\vec{r} = \hat{i} - \lambda(2\hat{j} + \hat{k})\) and \(\vec{r} = -\hat{j} - \mu(\hat{i} - 2\hat{j} + \hat{k})\)

\[
\begin{align*}
\text{Anns.} & \quad (2) \quad (1, -3, 6) \\
\text{Sol.} & \quad \text{Normal of plane} = \begin{vmatrix} 1 & 1 & 1 \\ -1 & 2 & 1 \end{vmatrix} \\
& \quad \vec{n} = 3\hat{i} - 2\hat{j} - \hat{k} \\
& \quad \text{D.R. of plane} = 3, -2, -1 \\
& \quad \Rightarrow \quad 3(x - 1) - 2(y - 0) - 1(z - 0) = 0 \\
& \quad \Rightarrow \quad 3x - 2y - z - 3 = 0
\end{align*}
\]

\[
\begin{align*}
\text{Sol.} & \quad \left( \frac{a^2 + 2x^2}{3} \right)^{\frac{1}{3}} - \left( 3x^2 \right)^{\frac{1}{3}} = \\
& \quad \left( \frac{2x^2}{3} \right)^{\frac{1}{3}} \\
\text{Anns.} & \quad (4) \quad \left( \frac{1}{3} \right)^{\frac{1}{3}} \\
& \quad \frac{1}{2} \left( a^3 + 2x^3 \right) - \frac{3}{2} \left( 3x^3 \right)^{\frac{1}{3}} = \frac{1}{3} \left( 3x^3 \right)^{\frac{1}{3}} = 6x
\end{align*}
\]
17. If \( x \, dy + y \, dx = 2 \, y \, dx + x^2 \, dy \) and \( y(2) = e \) then \( y(4) = ? \)

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

**Ans. (4)\)**

**Sol.**

\( x \, dy + y \, dx = 2 \, y \, dx + x^2 \, dy \)

\[
\Rightarrow (x^2 - x^2) \, dy = (2 - x) \, y \, dx
\]

\[
\Rightarrow \int \frac{dy}{y} = \int \frac{2 - x}{x(x - 1)} \, dx
\]

\[
\Rightarrow \ln y = \ln x + 2 + \ln |x - 1| + C
\]

\[
\Rightarrow y(2) = e
\]

\[
\Rightarrow 1 = -\ln 2 + 1 + 0 + C
\]

\[
\Rightarrow C = \ln 2
\]

\[
\Rightarrow \ln y = \ln |x| + 2 + \ln |x - 1| + \ln 2
\]

at \( x = 4 \)

\[
\Rightarrow \ln y(4) = -\ln 4 + \frac{1}{2} + \ln 3 + \ln 2
\]

\[
\Rightarrow \ln y(4) = -\ln \left( \frac{3}{2} \right) + \frac{1}{2} = \ln \left( \frac{3}{2} e^{\frac{1}{2}} \right)
\]

\[
\Rightarrow y(4) = \frac{3}{2} e^{\frac{1}{2}}
\]

18. Find the number of 3 digit numbers if sum of their digits is 10

**Ans. 55.00**

**Sol.** Let \( xyz \) be the three digit number

\( x + y + z = 10, \ x \leq 1, \ y \geq 0, \ z \geq 0 \)

\( x - 1 = t \Rightarrow x = 1 + t \quad x - 1 \geq 0 \quad t \geq 0 \)

\( t + y + z = 10 - 1 \)

\( t + y + z = 9, \quad 0 \leq t, z \leq 9 \)

coefficient of \( x^3 \) is \( (1 + x + x^2 + \ldots + x^n) \)

\[
= \left( \frac{1 - x^{10}}{1 - x} \right) = (1 - x)^{-3}
\]

coefficient \( x^3 \) is \( 3 + 9 - 1 = 11C_3 = 11C_2 = \frac{11 \times 10}{2} = 55 \)
19. \[
\frac{a}{\cos \theta} = \frac{b}{\cos \left(\theta + \frac{2\pi}{3}\right)} = \frac{c}{\cos \left(\theta + \frac{4\pi}{3}\right)}
\]
then find angle between vectors \(a\hat{i} + b\hat{j} + c\hat{k}\) and \(b\hat{i} + c\hat{j} + a\hat{k}\)

If \(\theta = \frac{2\pi}{9}\) and \(a^2 + b^2 + c^2 = 1\), is

\[
\begin{align*}
(1) & \quad \frac{\pi}{3} \\
(2) & \quad \frac{\pi}{6} \\
(3) & \quad \frac{2\pi}{3} \\
(4) & \quad \frac{5\pi}{6}
\end{align*}
\]

Ans. (3)

Sol. \[
\frac{a}{\cos \theta} = \frac{b}{\cos \left(\theta + \frac{2\pi}{3}\right)} = \frac{c}{\cos \left(\theta + \frac{4\pi}{3}\right)} = \frac{a + b + c}{0}
\]

\[a + b + c = 0 \quad \Rightarrow \quad a^2 + b^2 + c^2 + 2(ab + bc + ca) = 0 \quad \Rightarrow \quad ab + bc + ca = -\frac{1}{2}\]

Now let angle between given vectors is \(\phi\)

\[\cos \phi = \frac{(a\hat{i} + b\hat{j} + c\hat{k})(b\hat{i} + c\hat{j} + a\hat{k})}{a^2 + b^2 + c^2}\]

\[\cos \phi = \frac{ab + bc + ca}{1} = -\frac{1}{2}\]

\[\phi = \frac{2\pi}{3}\]

20. \(\text{If } (p \land q) \rightarrow (\neg q \lor r) \text{ has truth value false then the truth values of } p, q, r \text{ respectively are}
\]

\[
(1) \quad T, T, T \\
(2) \quad T, F, T \\
(3) \quad F, F, T \\
(4) \quad T, T, T
\]

Ans. (1)

Sol. \((p \land q)\) should be TRUE and \((\neg q \lor r)\) should be FALSE.
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