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JEE (Main)

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

2021

COMPUTER BASED TEST (CBT)
Memory Based Questions & Solutions

Date: 20 July, 2021 (SHIFT-1) | TIME : (9.00 a.m. to 12.00 p.m)

Duration: 3 Hours | Max. Marks: 300

SUBJECT: MATHEMATICS

Resonance Eduventures Ltd.

Reg. Office & Corp. Office : CG Tower, A-46 & 52, IPIA, Near City Mall, Jhalawar Road, Kota (Raj.) - 324005

Ph. No.: +91-744-2777777, 2777700 | **FAX No. :** +91-022-39167222

To Know more : sms **RESO** at **56677** | **Website :** www.resonance.ac.in | **E-mail :** contact@resonance.ac.in | **CIN :** U80302RJ2007PLC024029

Toll Free : 1800 258 5555 7340010333 facebook.com/ResonanceEdu twitter.com/ResonanceEdu www.youtube.com/resowatch blog.resonance.ac.in

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Total Selections in JEE (Advanced) 2020	Eligible for JEE (Advanced) Through JEE (Main) 2020	NEET 2020
4505	14755	2646
Classroom: 3441 | Distance: 1064	Classroom: 11047 | Distance: 3708	Classroom: 1833 | Distance: 813

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PART : MATHEMATICS

1 All possible words with or without meaning were formed using all the letters of the word 'EXAMINATION'. The probability that 'M' appears at fourth position is :

(1) $\frac{2}{11}$ (2) $\frac{1}{11}$ (3) $\frac{4}{11}$ (4) $\frac{8}{11}$

Ans. (2)

Sol. EXAMINATION

$E \to 1$

$X \to 1$

$A \to 2$

$M \to 1$

$O \to 1$

$T \to 1$

$N \to 2$

$I \to 2$

$$n(S) = \frac{11!}{2!\,2!2!}$$

$$n(E) = \frac{10!}{2!\,2!2!}$$

$$P(E) = \frac{n(E)}{n(s)} = \frac{1}{11}$$

2 If a cricket team consist of 15 players have 6 batsmen , 7 Ballers and 2 wicket keepers then the number of ways in which cricket team formed with atleast 4 batsmen, 5 ballers and 1 wicket keeper

(1) 567 (2) 525 (3) 462 (4) 777

Ans. **(4)**

Sol. **Case-I :** Team consist 5 Batsman , 5 Bowlers and 1 wicket keeper then number of ways.

$= {}^6C_5 \times {}^7C_5 \times {}^2C_1 = 6 \times 21 \times 2 = 252$

Case - II 4 Batsmen, 6 blowers and 1 wicket keeper

$= {}^6C_4 \times {}^7C_6 \times {}^2C_1 = 15 \times 7 \times 2 = 210$

Case-III 4 Batsmen, 5 bowler and 2 wicket keepers

${}^6C_4 \times {}^7C_5 \times {}^2C_2 = 15 \times 21 \times 1 = 315$

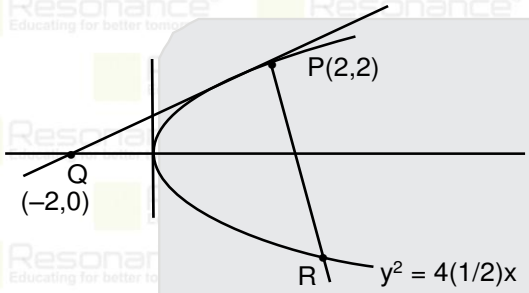
Total 252 + 210 + 315 = 777

3 Tangent drawn at a point P(2,2) to parabola $y^2 = 2x$ cuts x-axis at point Q and normal drawn at point P(2,2) to parabola cut parabola again at point R then area of ΔPQR is

(1) 25 (2) $\frac{25}{2}$ (3) $\frac{15}{2}$ (4) 50

Ans. **(2)**

Sol.



Equation of tangent at P(2,2) is T = 0

$2y = x + 2$

$y^2 = 4$ So, Q (–2,0)

$2at_1 = 1 \Rightarrow t_1 = 2$

$$t_2 = -t_1 - \frac{2}{t_1} = -2 - \frac{2}{2} = -3$$

$$\therefore R\left(\frac{1}{2}(-3)^2, 2\left(\frac{1}{2}\right)(-3)\right) = \left(\frac{9}{2}, -3\right)$$

$$\text{Area of } \Delta PQR = \frac{1}{2}\begin{vmatrix} 2 & 2 & 1 \\ -2 & 0 & 1 \\ \frac{9}{2} & -3 & 1 \end{vmatrix}$$

$$= \frac{1}{2}[2(0+3) - 2(-2 - 9/2) + 1(6 - 0)] = \frac{1}{2}[6 + 4 + 9 + 6] = \frac{25}{2} \text{ sq. unit.}$$

4. Coefficient of x^{256} in the expansion of $(1 - x)^{101}(x^2 + x + 1)^{100}$ is

(1) ${}^{100}C_{86}$ (2) ${}^{100}C_{85}$ (3) ${}^{100}C_{84}$ (4) ${}^{100}C_{83}$

Ans. **(2)**

Sol. $\Rightarrow (1 - x)^{101}(x^2 + x + 1)^{100}$

$\Rightarrow (1 - x)^{100}(x^2 + x + 1)^{100}(1 - x)$

$\Rightarrow (1 - x^3)^{100}(1 - x)$

$\Rightarrow (1 - x)\,({}^{100}C_0 - {}^{100}C_1x^3 + {}^{100}C_2x^6 + \ldots + {}^{100}C_{84}x^{252} - {}^{100}C_{85}x^{255} + {}^{100}C_{86}x^{256} + \ldots)$

$\Rightarrow {}^{100}C_{85}x^{256}$

so, the coefficient of x^{256} is ${}^{100}C_{85}$

5. The value of $\lim_{x\to 0}\left(2-\cos x\sqrt{\cos 2x}\right)^{\frac{x^2+2}{x}}$ is

Ans. 1

Sol. $\lim_{x\to 0}\left(2-\cos\sqrt{\cos 2x}\right)^{\frac{x^2+2}{x}}$ $\quad (1^\infty \text{ form})$

$$= e^{\lim_{x\to 0}\frac{\left(1-\cos x\sqrt{\cos 2x}\right)}{x}\left(x^2+2\right)}$$

$$= e^{\lim_{x\to 0}\left\{\frac{1-\cos^2 x(\cos 2x)}{x}\right\}(x^2+2)}$$

$$= e^{\lim_{x\to 0}\left\{\frac{1-\cos^2 x(\cos 2x)}{x}\right\}\left(\frac{x^2+2}{1+\cos x\sqrt{\cos 2x}}\right)}$$

$$= e^{\lim_{x\to 0}\left\{\frac{1-\cos^2\left(2\cos^2 x-1\right)}{x}\right\}\left(\frac{x^2+2}{1+\cos x\sqrt{\cos 2x}}\right)}$$

$$= e^{\lim_{x\to 0}\frac{\left(1-2\cos^4 x+\cos^2 x\right)}{x}\frac{x^2+2}{1+\cos x\sqrt{\cos 2x}}}$$

$$= e^{\lim_{x\to 0}\frac{-\left(2\cos^4 x-\cos^2 x-1\right)}{x}\frac{x^2+2}{1+\cos x\sqrt{\cos 2x}}}$$

$$= e^{\lim_{x\to 0}\frac{(2\cos^2 x+1)(\cos^2 x-1)}{x}\frac{x^2+2}{1+\cos x\sqrt{\cos 2x}}}$$

$$= e^{\lim_{x\to 0}\frac{+(2\cos^2 x+1)\sin^2 x}{x}\frac{x^2+2}{1+\cos x\sqrt{\cos 2x}}}$$

$$= e^{\lim_{x\to 0}(2\cos^2 x+1)\frac{\sin x}{x}.\sin x\frac{x^2+2}{1+\cos x\sqrt{\cos 2x}}}$$

$= e^0 = 1$

6. If the focal chord $y = mx + c$ of parabola $y^2 = -64x$ is also the tangent to the circle $(x+10)^2 + y^2 = 4$ then absolute value of $4\sqrt{2}\,(m + c)$ is

Ans. **34**

Sol. Focus of parabola is (–16, 0)

So, $-16m+c= 0 \Rightarrow c = 16m$ ……(i)w

Now slope form of tangent to the circle

$(x+10)^2 + y^2 = 4$ is given by

$y = m(x+10) \pm 2\sqrt{1+m^2}$

So, $c = 10m \pm 2\sqrt{1+m^2}$ ……. (ii)

By (i) and (ii)

$16m = 10m \pm 2\sqrt{1+m^2}$

$\Rightarrow 9m^2 = 1 + m^2 \Rightarrow m = \pm\frac{1}{2\sqrt{2}}$

$\Rightarrow c = 16m = \pm\frac{8}{\sqrt{2}}$

$\therefore \quad 4\sqrt{2}(m+c) = \pm 34$

7. The mean of 6 numbers is 6.5 and its variance is 10.25 if 4 numbers are 2, 4, 5 and 7, then find the other two :

(1) 10 ,11 (2) 11, 12 (3) 9, 12 (4) 9, 11

Ans. **(1)**

Sol. Let two number x and y according to question

$18 + x + y = 39$

$x + y = 21$ .....(1)

$10.25 = \frac{\sum x_i^2}{n} - (\bar{x})^2$

$10.25 = \frac{x^2+y^2+4+16+25+49}{6} - (6.5)^2$

$10.25 = \frac{x^2+y^2+94}{6} - (6.5)^2$

$\Rightarrow x^2 + y^2 = 221$ .....(2)

solving (1) and (2)

So, x = 10 or y = 11

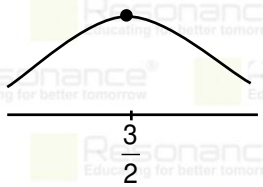
8. A continuous & differentiable function f(x) is increasing in $\left(-\infty, \frac{3}{2}\right)$ and decreasing in $\left(\frac{3}{2}, \infty\right)$ then $x = \frac{3}{2}$ is:

(1) point of local maxima (2) point of local minima

(3) point of Inflection (4) None of these

Ans. (1)

Sol. Roughly graph of f(x) can be drawn as



Thus $x = \frac{3}{2}$ is a point of local maxima

9. If the roots of the quadratic equation $x^2 + 3^{\frac{1}{4}}x + 3^{\frac{1}{2}} = 0$ are α and β then the value of $\alpha^{96}(\alpha^{12}-1) + \beta^{96}(\beta^{12}-1)$

(1) 50.3^{24} (2) 51.3^{24} (3) 52.3^{24} (4) 104.3^{24}

Ans. (3)

Sol. $x^2 + \sqrt{3} = -3^{\frac{1}{4}}x$

$\Rightarrow x^4 + 2\sqrt{3}x^2 + 3 = \sqrt{3}x^2$

$\Rightarrow x^4 + \sqrt{3}x^2 + 3 = 0$

$\Rightarrow x^8 + 6x^4 + 9 = 3x^4$

$\Rightarrow x^8 + 3x^4 + 9 = 0$

$\Rightarrow \alpha^8 = -9 - 3\alpha^4$

$\Rightarrow \alpha^{12} = -9\alpha^4 - 3\alpha^8 = -9\alpha^4 - 3(-9-3\alpha^4) = 27$

Similarly $\beta^{12} = 27$

$\Rightarrow \alpha^{96}(\alpha^{12}-1) + \beta^{96}(\beta^{12}-1) = (27)^8 .26 + (27)^8 .26 = 52.(27)^8 = 52.3^{24}$

10. In a ΔABC, If AB = 5, $\angle B = \cos^{-1}(3/5)$ and radius of circumcircle of triangle is 5 then the area of ΔABC is :

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

Ans. (1)

Sol. $\cos B = \frac{3}{5} \Rightarrow \sin B = \frac{4}{5}$, R = 5

$\Rightarrow \frac{b}{2R} = \frac{4}{5} \Rightarrow b = 8$, c = 5

$\cos B = \frac{a^2 + c^2 - b^2}{2ac} = \frac{3}{5} \Rightarrow \frac{a^2 + 25 - 64}{2a(5)} = \frac{3}{5}$

$a^2 - 39 = 6a \Rightarrow a^2 - 6a - 39 = 0$

$\Rightarrow a = \frac{6 + 8\sqrt{3}}{2} \Rightarrow a = 3 + 4\sqrt{3}$

$\Delta = \frac{abc}{4R} = \frac{(3+4\sqrt{3})(8)(5)}{4(5)} = 6 + 8\sqrt{3}$

11. The number of integral terms is the expansion of $\left(4^{\frac{1}{4}} + 5^{\frac{1}{6}}\right)^{120}$ is :

(1)11 (2)21 (3)20 (4)30

Ans. (2)

Sol. General term of $\left(2^{\frac{1}{2}}+5^{\frac{1}{6}}\right)^{120}$ is

given by $T_{r+1} = {}^{120}C_r \left(2^{\frac{1}{2}}\right)^{120-r}\left(5^{\frac{1}{6}}\right)^{r}$

For integral term, r should be a multiple of 6

i.e $r \in \{0,6,12,18, \ldots\ldots, 120\}$

$\therefore$ 21 integral terms are there in the expansion $\left(2^{\frac{1}{2}}+5^{\frac{1}{6}}\right)^{20}$

12. If the shortest distance between the lines $\vec{r}_1 = \alpha\hat{i}+2\hat{j}+2\hat{k}+\lambda(\hat{i}-2\hat{j}+2\hat{k}), \lambda \in R, \alpha > 0$ and $\vec{r}_2 = -4\hat{i}-\hat{k}+\mu(3\hat{i}-2\hat{j}-2\hat{k}), \mu \in R$ is 9, then the value of α is

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

Ans. **(3)**

Sol. Shortest distance $= \left|\dfrac{(a_2-a_1).(b_1\times b_2)}{|b_1\times b_2|}\right|$

$\Rightarrow 9 = \left|\dfrac{|((\alpha+4)\hat{i}+2\hat{j}+3\hat{k}).(8\hat{i}+8\hat{j}+4\hat{k})|}{\sqrt{64+64+16}}\right|$

$\Rightarrow \left|\dfrac{8(\alpha+4)+16+12}{12}\right| = 9$

$\therefore \alpha = 6$

13. If $\vec{a},\vec{b},\vec{c}$ are mutually $\perp$ unit vectors equally inclined to $\vec{a}+\vec{b}+\vec{c}$ at an angle θ, find $36\cos^2 2\theta$.

Ans. **4**

Sol. $|\vec{a}+\vec{b}+\vec{c}|^2 = (\vec{a}+\vec{b}+\vec{c}).(\vec{a}+\vec{b}+\vec{c}) = |\vec{a}|^2+|\vec{b}|^2+|\vec{c}|^2 = 3$

$\Rightarrow |\vec{a}+\vec{b}+\vec{c}| = \sqrt{3}$

Now $\vec{a}.(\vec{a}+\vec{b}+\vec{c}) = |\vec{a}||\vec{a}+\vec{b}+\vec{c}|\cos\theta$

$\Rightarrow \cos\theta = \dfrac{1}{\sqrt{3}} \Rightarrow \cos 2\theta = 2\cos^2\theta - 1$

$\Rightarrow \cos 2\theta = -\dfrac{1}{3} \Rightarrow \cos^2 2\theta = \dfrac{1}{9} \Rightarrow 36\cos^2 2\theta = 4$

14. If z and ω are complex n-umber such that |zω| = 1, arg(z) – arg(ω) = $\frac{3\pi}{2}$. Find the arg$\left(\frac{1-2\bar{z}\omega}{1+3\bar{z}\omega}\right)$.

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

Ans. **(4)**

Sol. Let $z = re^{i\theta}$ & $\omega = \frac{1}{r}e^{i\left(\theta-\frac{3\pi}{2}\right)}$

then $\frac{1-2\bar{z}\omega}{1+3\bar{z}\omega} = \frac{1-2re^{-i\theta}.\frac{1}{r}e^{i\left(\theta-\frac{3\pi}{2}\right)}}{1+3re^{-i\theta}.\frac{1}{r}e^{i\left(\theta-\frac{3\pi}{2}\right)}}$

$= \frac{1-2e^{-i\frac{3\pi}{2}}}{1+3e^{-i\frac{3\pi}{2}}} = \frac{1-2i}{1+3i}$

$= -\frac{1}{2}-\frac{1}{2}i$

The arg$\left(-\frac{1}{2}-\frac{1}{2}i\right) = -\frac{3\pi}{4}$

15. If $f(x) = \begin{cases} \sin x - e^x ; & x \le 0 \\ a+[-x] ; & 0 < x < 1 \\ 2x-b ; & x \ge 1 \end{cases}$ is continuous and differentiable function then find the value of a + b.

(where [•] is GIF)

Ans. **(03.00)**

Sol. Since f(x) is continuous at x = 0

So $\lim_{x\to 0^-} f(x) = \lim_{x\to 0^+} f(x) = f(0)$

$-1 = a - 1 = -1 \Rightarrow a = 0$

Since f(x) is continuous at x = 1

So $\lim_{x\to 1^-} f(x) = \lim_{x\to 1^+} f(x) = f(1)$

$a - 1 = 2 - b = 2 - b$

$\Rightarrow a = 0$, so $0 - 1 = 2 - b$

$\Rightarrow -3 = -b$

$\Rightarrow b = 3$

So the value of a + b = 3

16. If $A = [a_{ij}]_{3\times3}$ where $a_{ij} = \begin{cases} 1 & i = j \\ -x & |i-j| = 1 \\ 2x+1 & \text{otherwise} \end{cases}$ and f(x) = det (A), then the sum of local maximum and local minimum value of f(x) is:

(1) $\frac{20}{27}$ (2) $\frac{-20}{27}$ (3) $\frac{88}{27}$ (4) $\frac{-88}{27}$

Ans. **(4)**

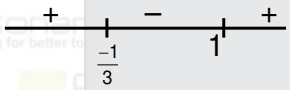
Sol. $|A| = \begin{vmatrix} 1 & -x & 2x+1 \\ -x & 1 & -x \\ 2x+1 & -x & 1 \end{vmatrix} = 1 + x^2(2x+1) + x^2(2x+1) - (2x+1)^2 - x^2 - x^2$

$\Rightarrow f(x) = 4x^3 - 4x^2 - 4x$

$\Rightarrow f'(x) = 12x^2 - 8x - 4$

$= 4(3x^2 - 2x - 1)$

$= 4(x-1)(3x+1)$



$\Rightarrow$ f(x) is maximum at $x = \frac{-1}{3}$ and minimum at x = 1

$\therefore$ maximum value = $\frac{20}{27}$ and minimum value = –4

$\therefore$ sum = $\frac{20}{27} - 4 = -\frac{88}{27}$

17. The coefficient of $a^3 b^4 c^5$ in $(ab + bc + ac)^6$ is:

(1) 60 (2) 45 (3)40 (4) 90

Ans. (1)

Sol. $(ab + bc + ac)^6 = \sum_{p+q+r=6} \frac{6!}{p!q!r!}(ab)^p(bc)^q(ca)^r$

$= \sum_{p+q+r=6} \frac{6!}{p!q!r!} a^{p+r} b^{p+q} c^{q+r}$

For $a^3b^4c^5$, we need

p + r = 3

p + q = 4

q + r = 5

Solving we get, p = 1, q=3, r=2

$\therefore$ coefficient of $a^3 b^4 c^5$ in $(ab + bc + ac)^6$ is $\frac{6!}{1!.2!.3!} = 60$

18. If an invertible function f(x) is defined as f(x) = 3x – 2 , g(x) is also an invertible function such that $f^{-1}(g^{-1}(x)) = x - 2$ then g(x) is

(1) $\frac{x-8}{3}$ (2) $\frac{x+8}{3}$ (3) $\frac{x-3}{8}$ (4) $\frac{x+3}{8}$

Ans. (2)

Sol. $f^{-1}(g^{-1}(x)) = x - 2$

$f(x-2) = g^{-1}(x)$

$3(x-2) - 2 = g^{-1}(x)$

$3x - 8 = g^{-1}(x)$

$g^{-1}(x) = 3x - 8$

or $x = 3g(x) - 8$

$g(x) = \frac{x+8}{3}$

19. $\int_{-1}^{1} \ell n\left(\sqrt{1-x}+\sqrt{1+x}\right)dx = ?$

(1) $\pi + \ell n2$ (2) $2\ell n2$ (3) $\frac{\pi}{2} - 1 + \ell n2$ (4) $\ell n2 - \frac{\pi}{2} - 1$

Ans. **(4)**

Sol. $f(x) = \ell n\left(\sqrt{1-x}+\sqrt{1+x}\right)$ $x \in [-1, 1]$ is an even function

$\Rightarrow I = 2\int_{0}^{1} \ell n\left(\sqrt{1-x}+\sqrt{1+x}\right)dx$

Put $x = \cos 2\theta \Rightarrow dx = -2\sin 2\theta\, d\theta$

$\therefore \cos 2\theta = 2\cos^2\theta - 1 = 1 - 2\sin^2\theta$

$\Rightarrow I = -4\int_{\frac{\pi}{4}}^{0}\left[\ell n\left\{(\sin\theta+\cos\theta)\sqrt{2}\right\}\right]\sin 2\theta\, d\theta$

$= 4\int_{0}^{\frac{\pi}{4}}\left[\ell n\left\{(\sin\theta+\cos\theta)\sqrt{2}\right\}\right]\sin 2\theta\, d\theta$

$= 4\int_{0}^{\frac{\pi}{4}} \ell n(\sin\theta+\cos\theta)\sin 2\theta\, d\theta + 4\,\ell n\sqrt{2}\int_{0}^{\frac{\pi}{4}}\sin 2\theta\, d\theta$

$= 4\left[\left|-\ell n(\sin\theta+\cos\theta)\frac{\cos 2\theta}{2}\right|_{0}^{\frac{\pi}{4}} + \int_{0}^{\frac{\pi}{4}} -\frac{\cos\theta-\sin\theta}{\sin\theta+\cos\theta}.\frac{\cos 2\theta}{2}d\theta\right] + 4\ell n\sqrt{2}\left(-\frac{\cos 2\theta}{2}\right)\Big|_{0}^{\frac{\pi}{4}}$

$= 4\left[0 - \frac{1}{2}\int_{0}^{\frac{\pi}{4}}(\cos\theta-\sin\theta)^2 d\theta\right] + 4\ell n\sqrt{2}\left(0+\frac{1}{2}\right)$

$$= 4\left[0 - \frac{1}{2}\int_0^{\frac{\pi}{4}}(1-\sin 2\theta)d\theta\right] + 2\ell n\sqrt{2}$$

$$= -2\left[\theta + \frac{\cos 2\theta}{2}\right]_0^{\frac{\pi}{4}} + \ell n2$$

$$= -2\left[\frac{\pi}{4} - \frac{1}{2}\right] + \ell n2 = -\frac{\pi}{2} - 1 + \ell n2$$

20. The probability of selecting integers $a \in [-5,30]$, such that $x^2 + 2(a+4)x - 5a + 64 > 0$ for all $x \in R$ is :

(1) $\frac{7}{9}$ (2) $\frac{4}{9}$ (3) $\frac{2}{9}$ (4) $\frac{1}{3}$

Ans. (3)

Sol. $x^2 + 2(a+4)x - (5a - 64) > 0$

$D < 0$

$\therefore 4(a+4)^2 + 4(5a - 64) < 0$

$\Rightarrow (a+4)^2 + (5a - 64) < 0$

$\Rightarrow a^2 + 13a - 48 < 0$

$$a = \frac{-13 \pm \sqrt{169+192}}{2} = -16, 3$$

So, $a \in (-16, 3)$

So, $a = -5, -4, -3, -2, -1, 0, 1, 2$

$\therefore$ Required Probability $= \frac{8}{36} = \frac{2}{9}$

21. If $\int_0^a e^{x-[x]}dx = 10e - 9$, then the value of 'a' is (where [•] is GIF)

(1) $9+\ell n2$ (2) $10+\ell n2$ (3) 10 (4) 9

Ans. (2)

Sol. Let $a = 10 + K$, $0 \le K < 1$

$$\int_0^a e^{\{x\}}dx = 10e - 9$$

$$\int_0^{10} e^{\{x\}}dx + \int_{10}^{10+K} e^{\{x\}}dx = 10e - 10 + 1 \Rightarrow \int_{10}^{10+K} e^{\{x\}}dx = 1 \Rightarrow \int_0^K e^{\{x\}}dx = 1$$

$e^K - 1 = 1$

$K = \ell n2$

so, $a = 10 + \ell n2$

22. If $\vec{A}.\vec{B} = \left|\vec{A} \times \vec{B}\right|$, then $\left|\vec{A} - \vec{B}\right|$ is

(1) $\sqrt{A^2 + B^2 + \sqrt{2}AB}$ (2) $\sqrt{A^2 + B^2 - \sqrt{2AB}}$ (3) $\sqrt{A^2 + B^2 + \sqrt{2AB}}$ (4) $\sqrt{A^2 + B^2 - \sqrt{2}AB}$

Ans. (4)

Sol. $\vec{A}.\vec{B} = \left|\vec{A} \times \vec{B}\right| \Rightarrow \cos\theta = \sin\theta \Rightarrow \tan\theta = 1$

$\theta = \frac{\pi}{4}$

$|\vec{A} - \vec{B}|^2 = A^2 + B^2 - 2\vec{A}.\vec{B}$

$= A^2 + B^2 - 2AB\cos\left(\frac{\pi}{4}\right)$

$= A^2 + B^2 - \sqrt{2}AB$

$\Rightarrow |\vec{A} - \vec{B}| = \sqrt{A^2 + B^2 - \sqrt{2}AB}$