Physicsaholics

DPP – 4 (Electrostatics)

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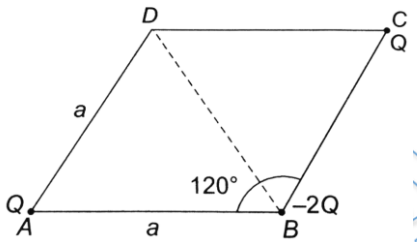
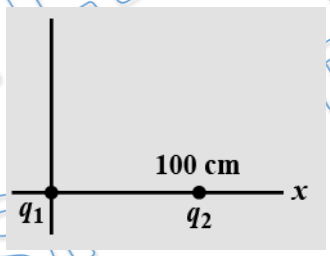
Q 1. A charge +Q at A produces electric field E and electric potential V at D. If we now put charges -2Q and +Q at B and C vertices of a parallelogram ABCD, then the magnitude of electric field and potential at D will be:



(a) E and zero (b) zero and V (c) $\sqrt{2}E$ and $\frac{V}{\sqrt{2}}$ (d) $\frac{E}{\sqrt{2}}$ and $\frac{V}{\sqrt{2}}$

Q 2. A point charge $q_1 = +2\mu C$ is placed at the origin of co-ordinates. A second charge, $q_2 = -3\mu C$, is placed on the x-axis at x = 100cm. At what point (or points) on the x-axis will the absolute potential be zero?



(a) $x = 40cm$ and $x = -200cm$
(b) $x = 40cm$ only
(c) $x = -200cm$ only
(d) $x = 80cm$ only

Q 3. Two charges $q_1 = 5 \times 10^{-8}C$ and $q_2 = -3 \times 10^{-8}C$ are located 16 cm apart. At what point(s) on the line joining the two charges is the electric potential zero? Take the potential at infinity to be zero:
(a) 10cm from charge q_1 (b) 10cm from charge q_2
(c) 6cm from charge q_1 (d) None of these

Q 4. In a regular polygon of n sides each corner is at a distance r from the centre. Identical charges are placed at (n-1) corners. At the centre, the intensity is E and the potential is V. The ratio V/E has magnitude:
(a) nr (b) $r(n-1)$ (c) r (d) $-\frac{r}{n}$

Q 5. Electric potential is given by $V = 6x - 8xy^2$. Then electric force acting on 2C point charge placed at the origin will be:
(a) 2N (b) 6N (c) 8N (d) 12N

Q 6. Electric potential 'v' in space as a function of co-ordinates is given by, $v = \frac{1}{x} + \frac{1}{y} + \frac{1}{z}$. Then the electric field intensity at (1,1,1) is given by:

(a) $-(\hat{\imath} + \hat{\jmath} + \hat{k})$ (b) $\hat{\imath} + \hat{\jmath} + \hat{k}$

(c) Zero (d) $\frac{1}{\sqrt{3}}(\hat{\imath} + \hat{\jmath} + \hat{k})$

Q 7. Two equipotential surfaces of 40V and 50V potential are separated by 2 cm. If the electric field present between them is uniform, then its strength is:

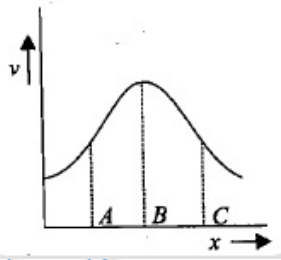
(a) $200\ V/m$ (b) $1000\ V/m$

(c) $400\ V/m$ (d) $500\ V/m$

Q 8. Electric field in a region is given by $E = \left(\frac{M}{x^3}\right)\hat{\imath}$, then the correct expression for the potential in the region is (assume potential at infinity is zero)

(a) $\frac{M}{2x^2}$ (b) Mx^2 (c) $\frac{M}{3x^4}$ (d) None of these

Q 9. Variation of electrostatic potential along x−direction is shown in the figure. The correct statement about electric field is:



(a) x-component at point B is maximum

(b) x-component at point A is towards positive x-axis

(c) x-component at point C is towards negative x-axis

(d) x-component at point C is towards positive x-axis

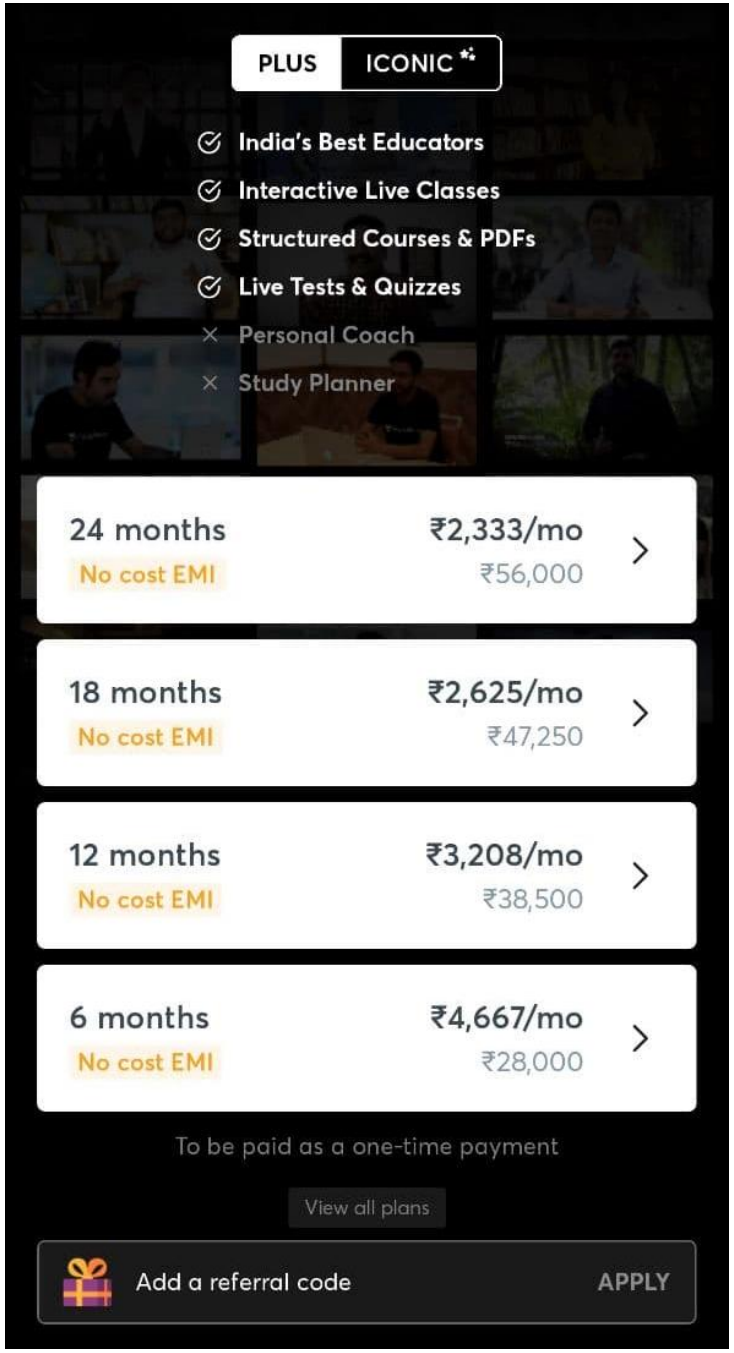
Q 10. In a certain $0.1\ m^3$ free space, electric potential is found to be 5 V throughout. What is the electric field in this region?

(a) 5 N/C (b) -5 N/C

(c) zero (d) Cannot be determined

Answer Key

Q.1 a	**Q.2 a**	**Q.3 a**	**Q.4 b**	**Q.5 d**
Q.6 b	**Q.7 d**	**Q.8 a**	**Q.9 d**	**Q.10 c**



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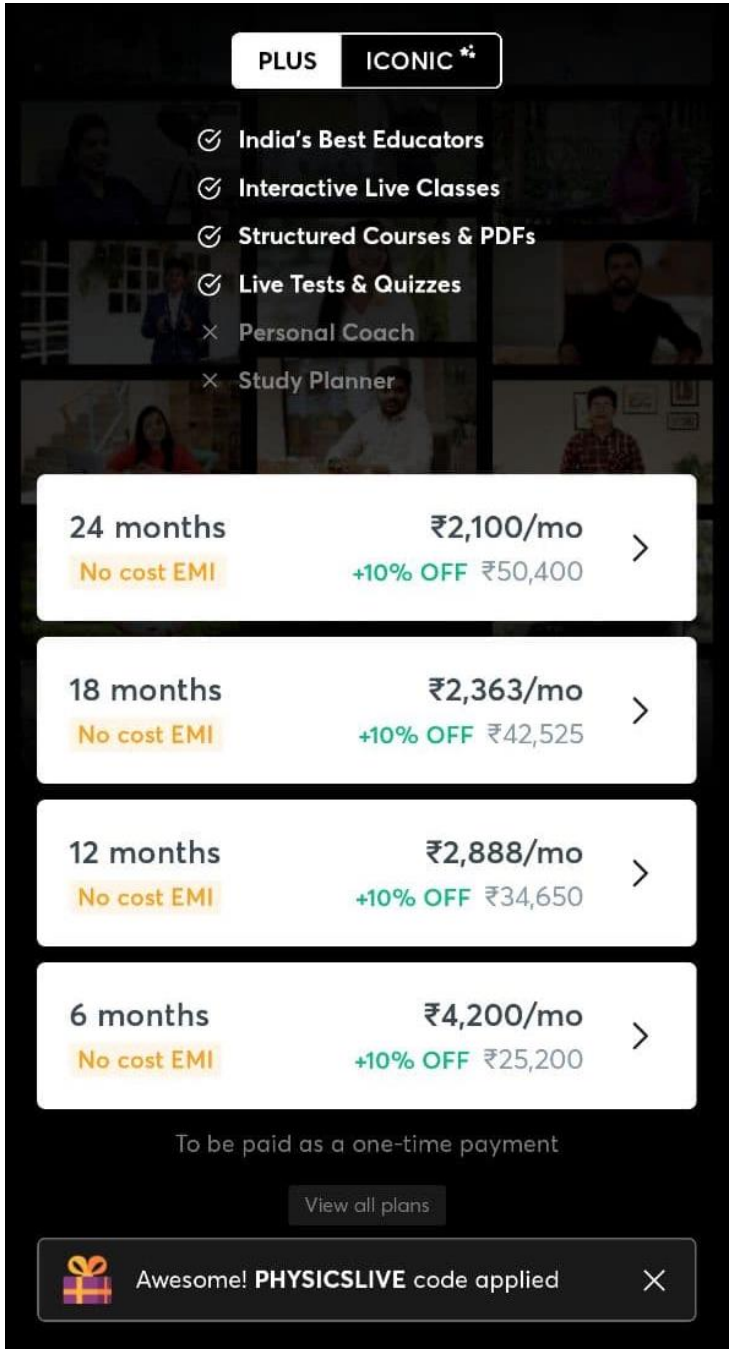
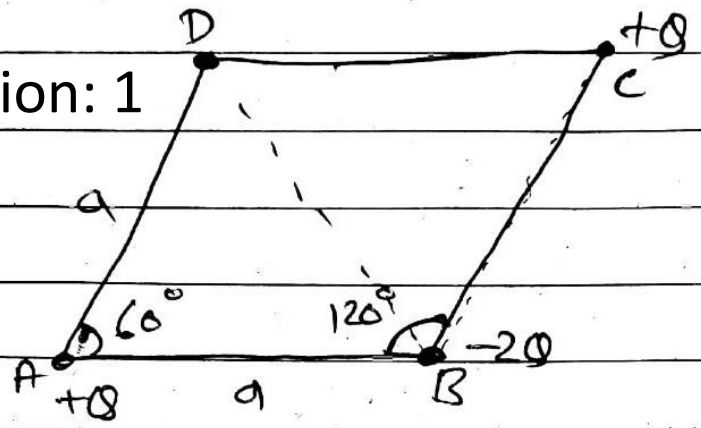


Written Solution

DPP-4 Electric Potential (Relation between E and V)

By Physicsaholics Team

Solution: 1



$\angle DAB + \angle ABC = 180^\circ$

$\therefore \angle ABC = 120^\circ$

$\therefore \angle DAB = 60^\circ$

$AB = AD = a$ (given)

$\therefore \Delta ABD$ is equilateral triangle

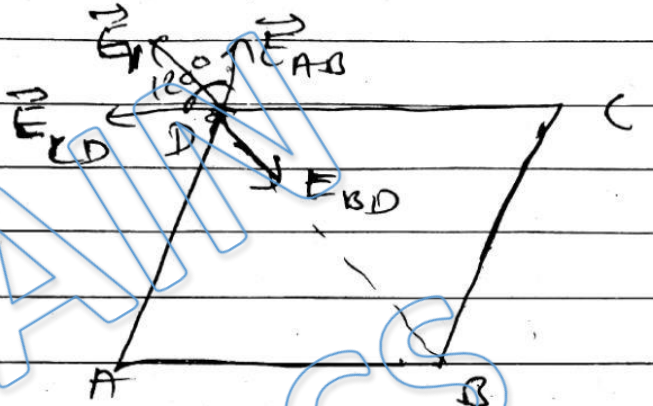
$\therefore \boxed{DB = a}$

(given) $E = \frac{kQ}{a^2}$, $V = \frac{kQ}{a}$

Now when $-2Q$, & Q charges are placed then

$V_D = \frac{kQ}{a} + \frac{k(-2Q)}{a} + \frac{k(Q)}{a} = 0$

Now $\vec{E_D} = \vec{E_{AD}} + \vec{E_{CD}} + \vec{E_{BD}}$



E_1 is resultant of $\vec{E_{AD}} + \vec{E_{CD}}$

$|E_1| = |\vec{E_{AD}}| = |\vec{E_{CD}}|$

$\because$ Angle $= 120^\circ$ between them

& $|E_{AD}| = |E_{CD}| = \frac{kQ}{a^2}$

$\therefore E_D = E_{BD} + E_1$

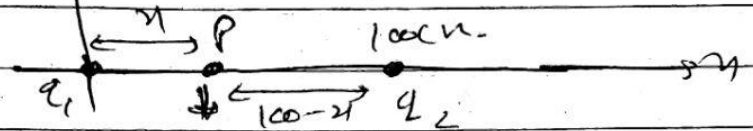
$E_D = \frac{kQ}{a^2} + \frac{k(-2Q)}{a^2} = -\frac{kQ}{a^2}$

$|E_D| = E$

$\therefore \boxed{E_D = E, \; V_D = 0 \text{ (zero)}}$

Ans. a

Solution: 2



Let at point P at distance x from origin (q_1) Potential is zero

$$\therefore \quad V_P = \frac{kq_1}{x} + \frac{kq_2}{(100-x)} = 0$$

$$\frac{k(2\mu C)}{x} + \frac{k(-3\mu C)}{(100-x)} = 0$$

$$\frac{2}{x} - \frac{3}{100-x} = 0$$

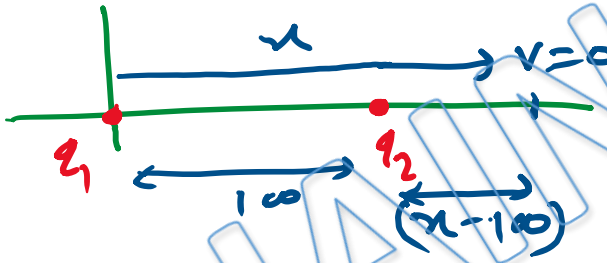
$$\frac{2}{x} = \frac{3}{100-x}$$

$$200 - 2x = 3x$$

$$5x = 200$$

$$\boxed{x = 40 \text{ cm.}}$$

And if; point is outside of q_1 & q_2



$$V = \frac{kq_1}{x} + \frac{kq_2}{(x-100)} = 0$$

$$\frac{k(2\mu C)}{x} + \frac{k(-3\mu C)}{x-100} = 0$$

$$\frac{2}{x} - \frac{3}{x-100} = 0$$

$$\frac{2}{x} = \frac{3}{x-100}$$

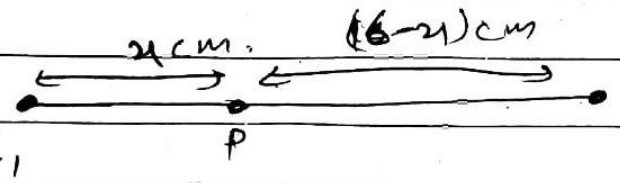
$$2x - 200 = 3x$$

$$\boxed{x = -200 \text{ cm}}$$

So; $\boxed{x = 40\text{cm}, -200\text{cm}}$ Ans

Ans. a

Solution: 3



$(5 \times 10^{-8} C)$ $(-3 \times 10^{-8} C)$

Let at (P) $V_P = 0$

$$V_P = \frac{kq_1}{x} + \frac{kq_2}{16-x} = 0$$

$$\frac{k(5 \times 10^{-8})}{x} + \frac{k(-3 \times 10^{-8})}{(16-x)} = 0$$

$$\frac{5}{x} - \frac{3}{16-x} = 0$$

$$\frac{5}{x} = \frac{3}{16-x}$$

$$80 - 5x = 3x$$

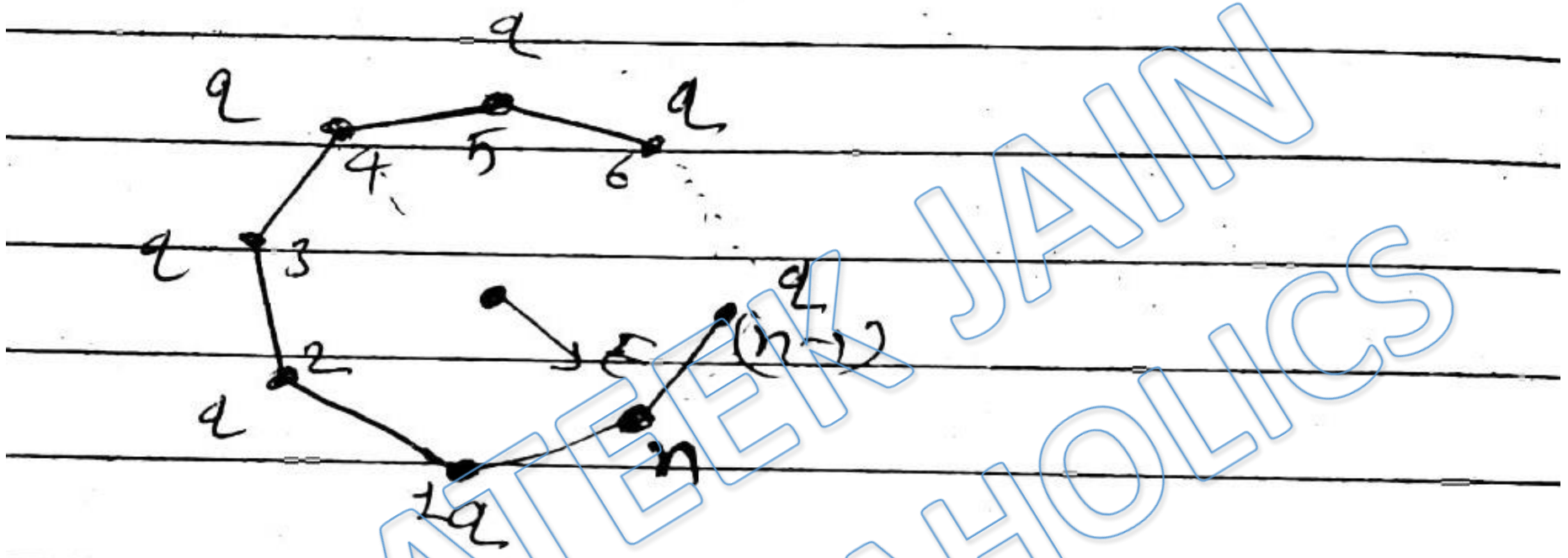
$$8x = 80$$

$$\boxed{x = 10 cm}$$

$\therefore x = 10 cm$ from charge $5 \times 10^{-8} C$.

Ans. a

Solution: 4



$$E = \frac{kq}{r^2} \quad , V = (n-1)\frac{kq}{r}$$

$$\frac{q}{V} \Big/ \frac{V}{E} = \frac{(n-1)\frac{kq}{r}}{\frac{kq}{r^2}} = (n-1)r$$

Ans. b

Solution: 5

$$V = 6x - 8xy^2$$

$$\Rightarrow \frac{\partial V}{\partial x} = 6 - 8y^2 \quad \& \quad \frac{\partial V}{\partial y} = -16xy$$

$$\vec{E} = -(6 - 8y^2)\hat{i} - (-16xy)\hat{j}$$

at $(0,0)$

$$\vec{E} = -6\hat{i} + 0\hat{j}$$

$$\vec{F} = q\vec{E} = -12\hat{i}$$

Ans (d)

Solution: 6

$$V = \frac{1}{x} + \frac{1}{y} + \frac{1}{z}$$

$$E_x = -\frac{\partial V}{\partial x} = -\left(-\frac{1}{x^2}\right) = \frac{1}{x^2}$$

$$E_y = -\frac{\partial V}{\partial y} = -\left(-\frac{1}{y^2}\right) = \frac{1}{y^2}$$

$$E_z = -\frac{\partial V}{\partial z} = -\left(-\frac{1}{z^2}\right) = \frac{1}{z^2}$$

$$\vec{E} = E_x \hat{i} + E_y \hat{j} + E_z \hat{k}$$

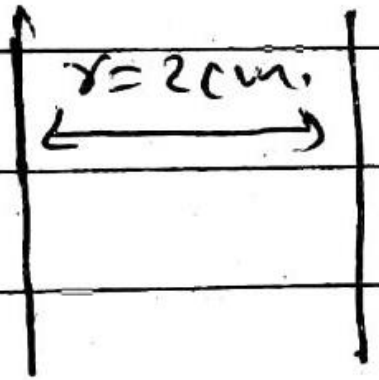
$$\vec{E} = +\frac{1}{x^2}\hat{i} + \frac{1}{y^2}\hat{j} + \frac{1}{z^2}\hat{k}$$

at $(1, 1, 1)$

$$\boxed{\vec{E} = +\hat{i} + \hat{j} + \hat{k}}$$

Ans. b

Solution: 7



$V_1 = 40\,V \qquad V_2 = 50\,V$

$\Delta V = 10\,V.$

$r = 2\,cm.$

$$E = \frac{\Delta V}{r} = \frac{10}{2} = 5\,V/cm.$$

$$\boxed{E = 500\,V/m}$$

Ans. d

Solution: 8

$$E = \frac{M}{x^3}\hat{i}$$

$$E = -\frac{dV}{dx}$$

$$-dV = E \cdot dx$$

$$-\int_{V_x}^{V_\infty} dV = \int_{x}^{\infty} E \cdot dx$$

$$-(V)_{V_x}^{V_\infty} = \int_{x}^{\infty} \frac{M}{x^3} dx = \left[\frac{-M}{2x^2}\right]_{x}^{\infty}$$

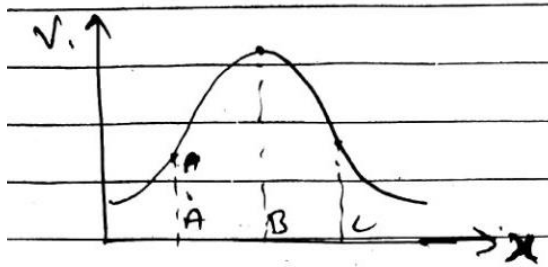
$$-[V_\infty - V_x] = \left[\frac{-M}{2x^2}\right]_{x}^{\infty}$$

$$-[0 - V_x] = \left[\frac{-M}{2(\infty)^2}\right] - \left[\frac{-M}{2x^2}\right]$$

$$\boxed{V_x = \frac{M}{2x^2}}$$

Ans. a

Solution: 9



$E = -\frac{dV}{dx}$

at Point 'B'

$\frac{dV}{dx}$ = Slope of curve = 0

$\therefore E = 0$

at Point 'A'

$\frac{dV}{dx}$ = +ve

$\therefore E = -\frac{dV}{dx}$ = -ve

$\therefore \vec{E}$ is towards -ve x-axis.

③ at Point 'C'

$\frac{dV}{dx}$ = -ve

$E = -\frac{dV}{dx}$ = +ve

$\therefore \vec{E}$ is towards +ve x-axis.

Ans. d

Solution: 10

$$E = -\frac{dV}{dx}$$

$$V = 5V$$

$$\frac{dV}{dx} = 0$$

$$\therefore E = \frac{-dV}{dx} = 0$$

$$\therefore \boxed{E = 0}$$

Ans. c

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