DPP – 5 (Electrostatics)

Video Solution on Website:- https://physicsaholics.com/home/courseDetails/93

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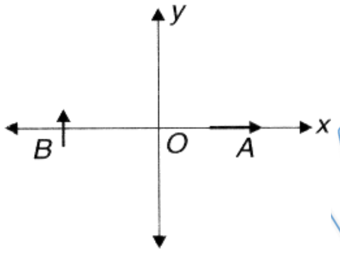
Q 1. Two dipoles of dipole moments p each are placed on points A (a, 0) and B (-a, 0) as shown in figure. How much work is done in rotating both the dipoles with 90° angle in clockwise direction?



(a) PE (b) - $\frac{KP}{r^4}$ (c)Zero (d) - $\frac{KP}{r^4}$

Q 2. Two small electric dipoles each of dipole moment p (along x axis) are situated at (0, 0, 0) and (r, 0, 0). The electric potential at a point $\left(\frac{r}{2}, \frac{\sqrt{3}r}{2}, 0\right)$ is:

(a) $\frac{P}{4\pi\epsilon_0 r^2}$ (b) 0 (c) $\frac{P}{2\pi\epsilon_0 r^2}$ (d) $\frac{P}{8\pi\epsilon_0 r^2}$

Q 3. A thin ring of radius R metres is placed in x-y plane such that its centre lies on origin. The half ring in region x< 0 carries uniform linear charge density +l C/m and the remaining half ring in region x> 0 carries uniform linear charge density–l C/m.

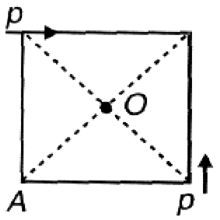
(a) Then the direction of electric field at point P whose coordinates are (0m, +$\frac{R}{2}$m) is along positive x-direction

(b) Then the electric potential (in volts) at point P whose coordinates are (0m, +$\frac{R}{2}$m) is 0

(c) Then the dipole moment of the ring in C–m is $(4R^2\text{l})\hat{\imath}$

(d) Then the dipole moment of the ring in C–m is $(2R^2\text{l})\hat{\imath}$

Q 4. Two short dipoles of dipole moment p are placed at two corners of square as shown in figure. What is the ratio of magnitude of electric field at two points O & A?

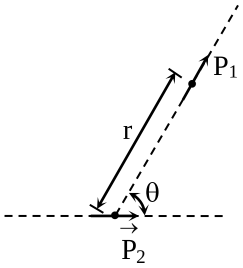


(a) 2 (b) $2\sqrt{2}$ (c) 1 (d) $\sqrt{2}$

Q 5. An electric dipole is made up of two particles having charges +1μC, mass 1 kg and other with charge -1 μc and mass 1 kg separated by distance 1 m. It is in equilibrium in a uniform electric field of 20 × 10^3V/m. If the dipole is deflected through angle 2°, time taken by it come again in equilibrium is

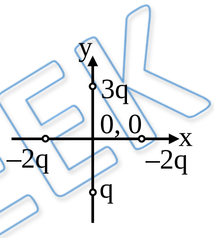
(a) 2.5 πs (b) 2.5 s (c) 5 πs (d) 4 π

Q 6. Two short electric dipoles are placed as shown. The energy of electric interaction between these dipoles will be –



(a) $\frac{2kp_1p_2Cos\,\theta}{r^3}$ (b) - $\frac{2kp_1p_2Cos\,\theta}{r^3}$ (c) - $\frac{2kp_1p_2Sin\,\theta}{r^3}$ (d) - $\frac{4kp_1p_2Cos\,\theta}{r^3}$

Q 7. 4 charges are placed each at a distance ‘a’ from origin. The dipole moment of configuration is-

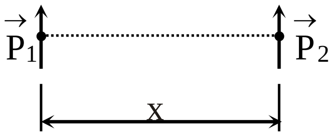


(a) 2qa
(b) $2\sqrt{2}$ qa
(c) $2\sqrt{5}$ qa
(d) None of these

Q 8. The magnitude of electric field intensity at point B (2, 0, 0) due to a dipole of dipole moment, $\vec{p} = \hat{\imath} + \sqrt{3}\,\hat{\jmath}$ kept at origin is (assume that the point B is at large distance from the dipole)

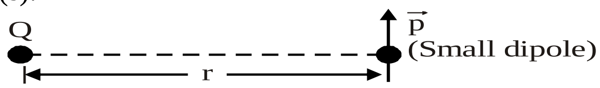
(a) $\frac{\sqrt{13}}{8}k$ (b) $\frac{\sqrt{13}}{4}k$ (c) $\frac{\sqrt{7}}{8}k$ (d) $\frac{\sqrt{7}}{4}k$

Q 9. Figure shows two short dipole moments parallel to each other and placed at a distance x apart is, then –



(a) they will repel each other
(b) they will attract each other
(c) force of interaction is of magnitude of $\frac{3P_1P_2}{4\pi\varepsilon_0x^4}$
(d) force of interaction is of magnitude of $\frac{6P_1P_2}{4\pi\varepsilon_0x^4}$

Q 10. For the situation shown in the figure below (assume r >> length of dipole) mark out the correct statement(s).



(a) Force acting on the dipole is zero.

(b) Force acting on the dipole is approximately $\frac{pQ}{4\pi\varepsilon_0 r^3}$ and is acting upward

(c) Torque acting on the dipole is $\frac{pQ}{4\pi\varepsilon_0 r^2}$ in clockwise direction.

(d) Torque acting on the dipole is $\frac{pQ}{4\pi\varepsilon_0 r^2}$ in anti-clockwise direction

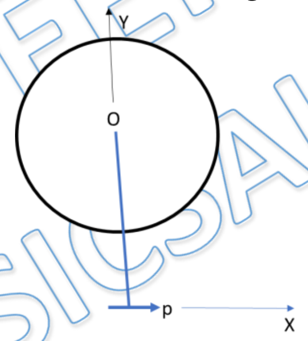
Q 11. Two point charges +4q and –q are placed on x axis at separation l_0 . Number of points on x axis where a dipole will experience zero force is (do not count x = $\pm\infty$)

(a) 2 (b) 1 (c) 3 (d) 4

Q 12. A short dipole of dipole moment p is placed on the axis of uniformly charged ring of radius R and charge Q . Distance of dipole from centre of ring is r = $\frac{R}{\sqrt{2}}$ and it is placed along axis. Force on dipole is

(a) $\frac{2KpQ}{R^3}$ (b) $\frac{KpQ}{3\sqrt{3}R^3}$ (c) $\frac{2\sqrt{2}KpQ}{R^3}$ (d) Zero

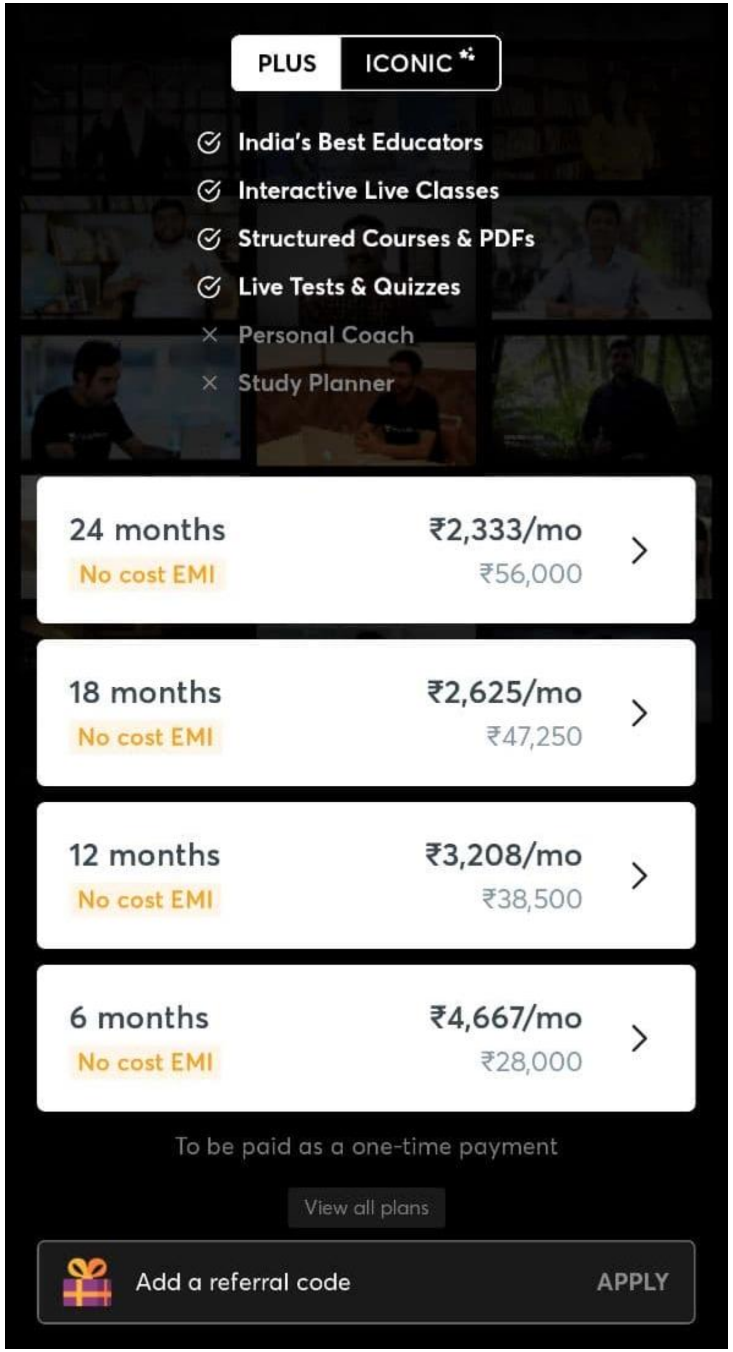
Q 13. In given figure circle is in xy plane and dipole is along x axis . O is centre of circle and R is radius of circle. If there are 4 points on circle where electric field is perpendicular to dipole moment, possible values of distance of O from origin is/are



(a) R (b) 2R (c) 1.5 R (d) 3R

Answer Key

Q.1 c	**Q.2 b**	**Q.3 a, b, c**	**Q.4 b**	**Q.5 a**
Q.6 b	**Q.7 a**	**Q.8 c**	**Q.9 a, c**	**Q.10 b, c**
Q.11 a	**Q.12 d**	**Q.13 a, c**		



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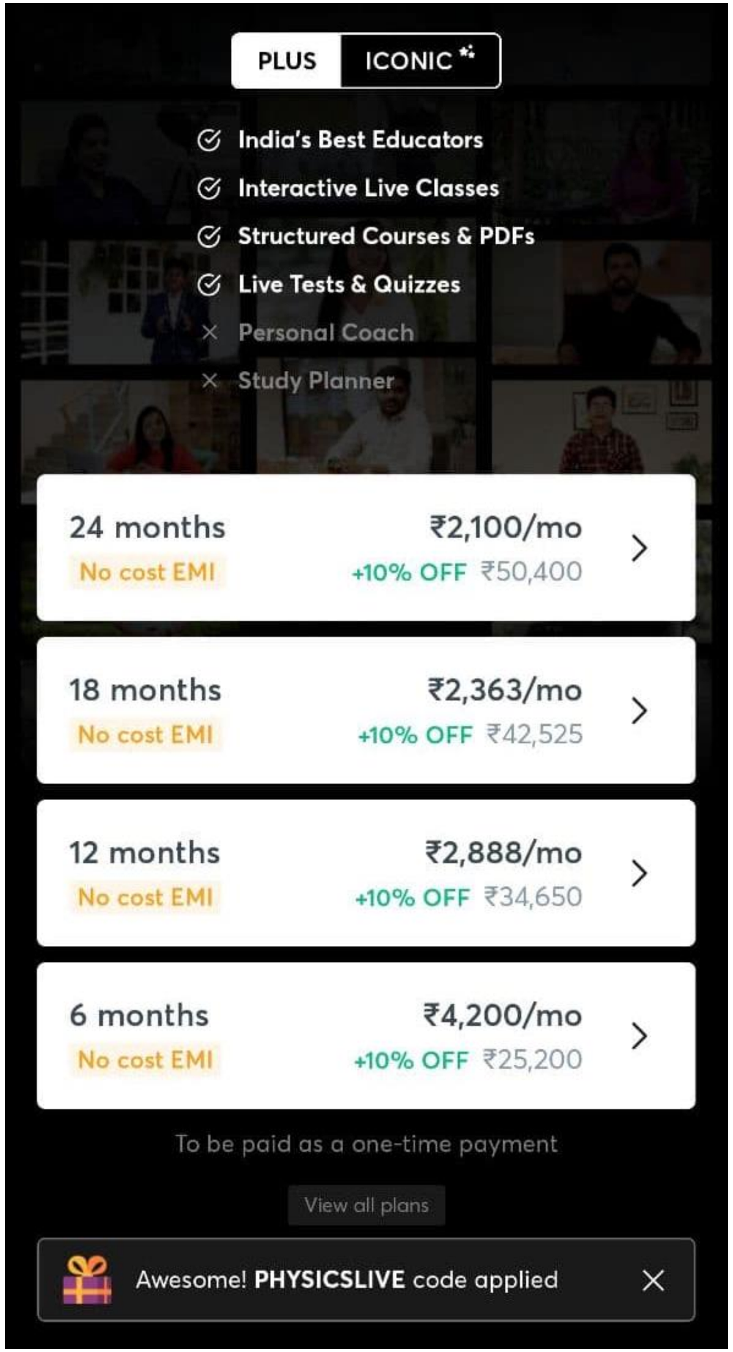

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Written Solution

DPP- 5 : Electric Dipole

By Physicsaholics Team

Q1) Two dipoles of dipole moments p each are placed on points A (a, 0) and B (-a, 0) as shown in figure. How much work is done in rotating both the dipoles with 90° angle in clockwise direction?

(a) PE

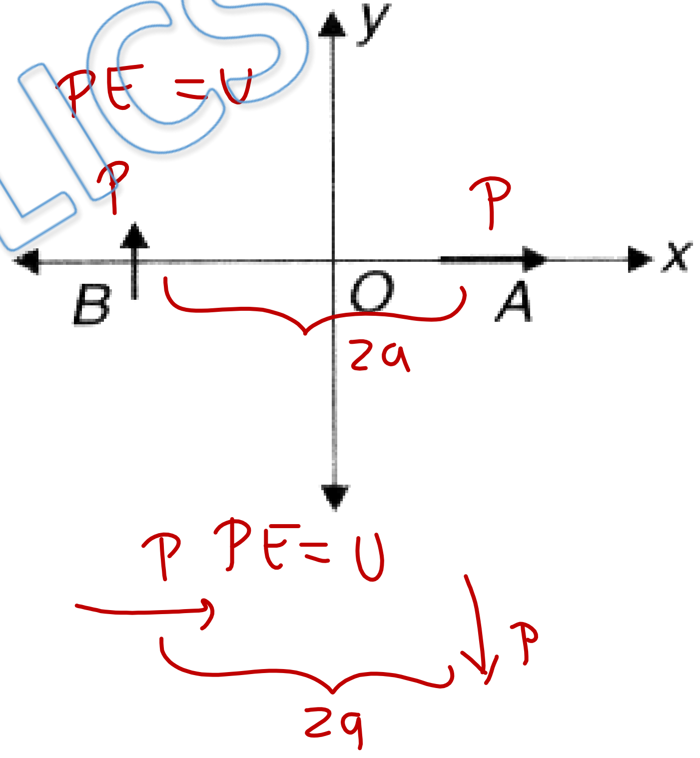
(b) $-\frac{KP}{r^4}$

[✓ (c) Zero]

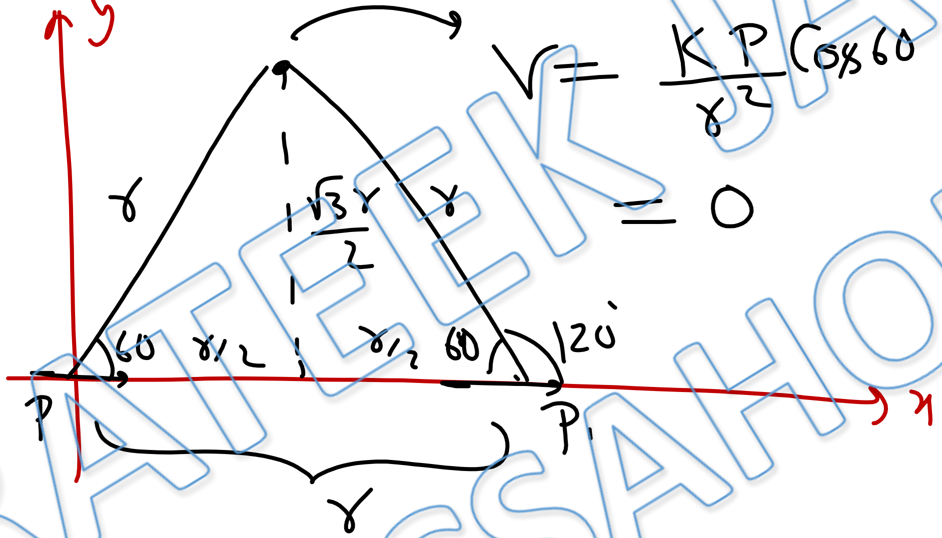
(d) $-\frac{KP}{r^4}$

$$W = U_f - U_i$$

$$= 0$$



Q2) Two small electric dipoles each of dipole moment p (along x axis)are situated at (0, 0, 0) and (r, 0, 0). The electric potential at a point $\left(\frac{r}{2}, \frac{\sqrt{3}r}{2}, 0\right)$ is :



$$V = \frac{KP\cos 60}{r^2} + \frac{KP\cos 120^\circ}{r^2}$$

$$= 0$$

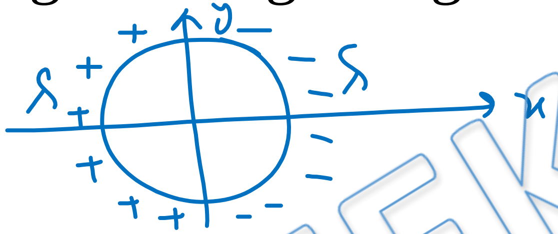
(a) $\frac{P}{4\pi\epsilon_0 r^2}$

[✓ (b) 0]

(c) $\frac{P}{2\pi\epsilon_0 r^2}$

(d) $\frac{P}{8\pi\epsilon_0 r^2}$

Q3) A thin ring of radius R metres is placed in x-y plane such that its centre lies on origin. The half ring in region x< 0 carries uniform linear charge density +λ C/m and the remaining half ring in region x> 0 carries uniform linear charge density– λ C/m.



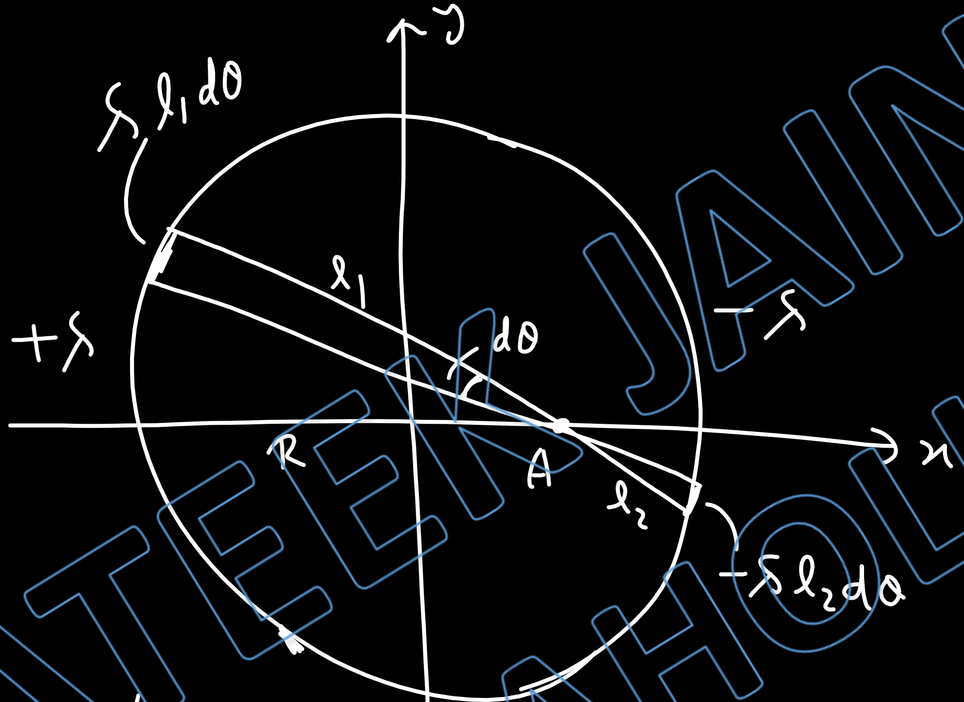
(a) Then the direction of electric field at point P whose coordinates are (0m, $+\frac{R}{2}$m) is along positive x-direction

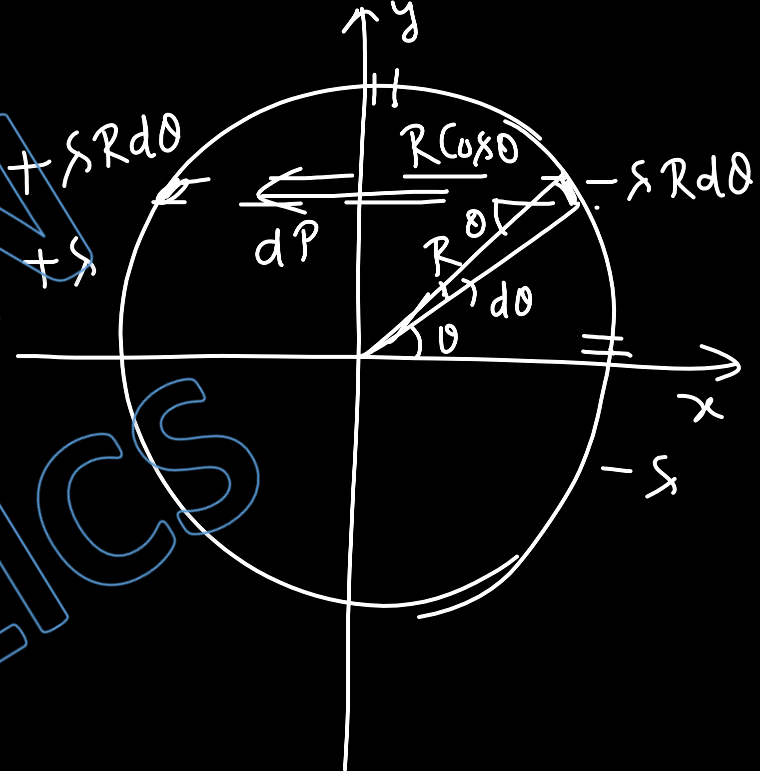
(b) Then the electric potential (in volts) at point P whose coordinates are (0m, $+\frac{R}{2}$m) is 0

(c) Then the dipole moment of the ring in C–m is (-4R^2λ)$\hat{\imath}$

(d) Then the dipole moment of the ring in C–m is (2R^2λ)$\hat{\imath}$

Ans. a,b,c ✓ ✓





$$V_A = \sum \frac{K\lambda \cancel{l_1} d\theta}{\cancel{l_1}} + \frac{K(-\lambda \cancel{l_2} d\theta)}{\cancel{l_2}}$$

$$= 0$$

$$dP = (\lambda R d\theta)\, 2R\cos\theta$$

$$\int dP = 2\lambda R^2 \int_{-\pi/2}^{\pi/2} \cos\theta\, d\theta$$

$$P = 2\lambda R^2 \left[+\sin\theta\right]_{-\pi/2}^{\pi/2}$$

$$= 4\lambda R^2 \text{ along } -x \text{ axis}$$

Q4) Two short dipoles of dipole moment p are placed at two corners of square as shown in figure. What is the ratio of magnitude of electric field at two points O & A?

$E_A = \frac{KP}{l^3}\sqrt{2}$

(a) 2

✓ (b) $2\sqrt{2}$

(c) 1

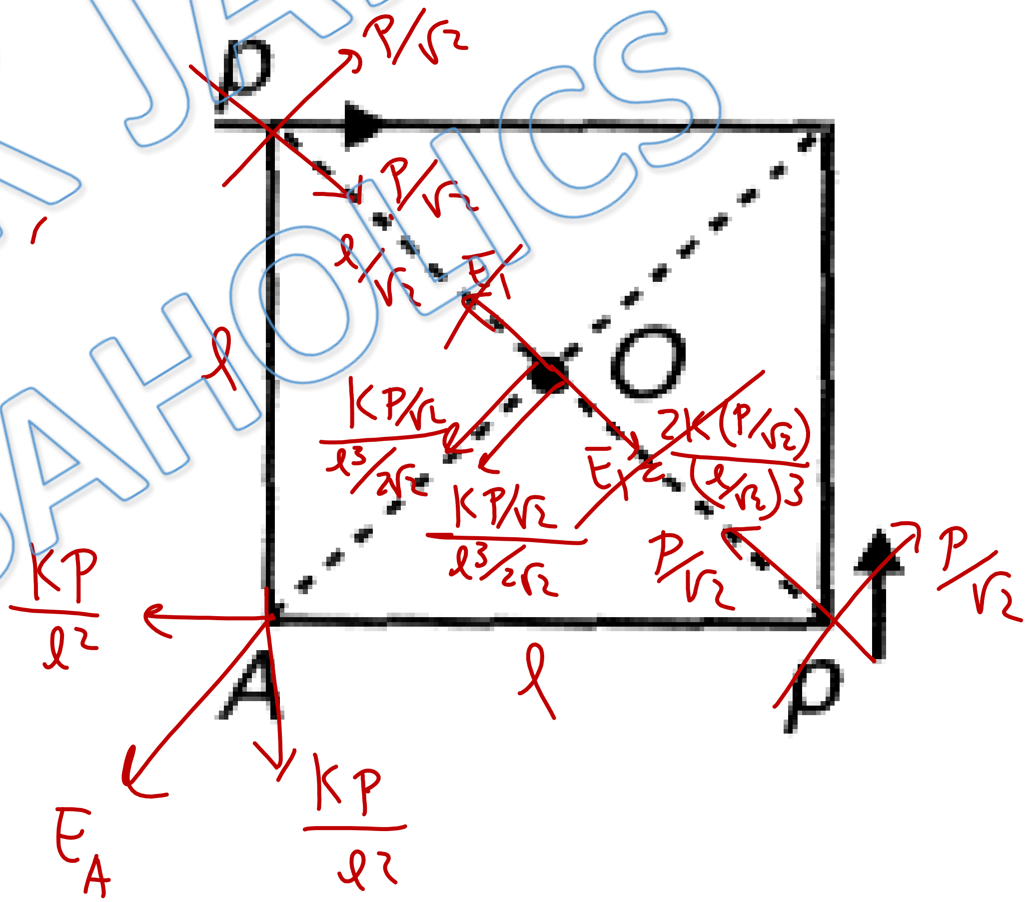
(d) $\sqrt{2}$

$E_0 = 2\frac{KP \times 2\cancel{\sqrt{2}}}{l^3 \cancel{\sqrt{2}}}$

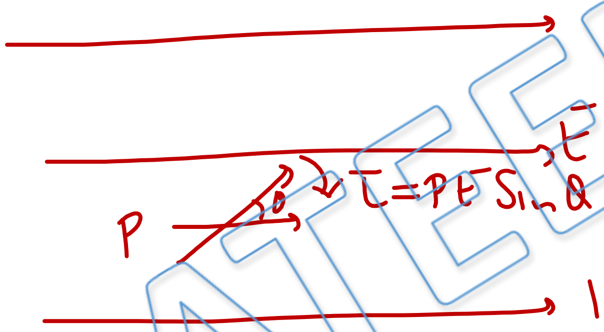
$= \frac{4KP}{l^3}$

$\frac{E_0}{E_A} = \frac{4}{\sqrt{2}}$

$= 2\sqrt{2}$



Q5) An electric dipole is made up of two particles having charges +1μC, mass 1 kg and other with charge -1 μc and mass 1 kg separated by distance 1 m. It is in equilibrium in a uniform electric field of 20×10^3V/m. If the dipole is deflected through angle 2°, time taken by it come again in equilibrium is



$I = 1\times\frac{1}{4} + 1\times\frac{1}{4} = \frac{1}{2}$

$Ans = \frac{T}{4} = \frac{\pi}{2}\sqrt{\frac{I}{PE}}$

$= \frac{\pi}{2}\sqrt{\frac{.5}{10^{-6}\times 20\times 10^3}}$

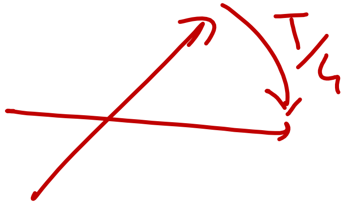
$= \frac{\pi}{2}\sqrt{\frac{50\cancel{0}}{2\cancel{0}}} = \frac{5\pi}{2}$

(a) 2.5 πs ✓ (b) 2.5 s (c) 5 πs (d) 4 π

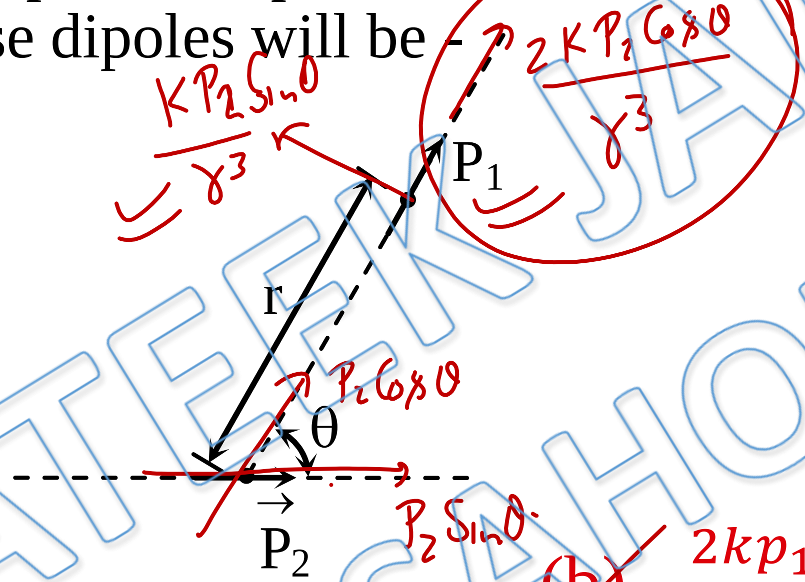
$I\alpha = PE\,\mathrm{Sin}\,\theta$

$\alpha = \frac{PE}{I}\theta$

$T = 2\pi\sqrt{\frac{I}{PE}}$



Q6) Two short electric dipoles are placed as shown. The energy of electric interaction between these dipoles will be -



$$U = \underbrace{-PE\,Cos\theta}_{} \xrightarrow{} \text{formula} = -\vec{P}\cdot\vec{E}$$

$$= -\frac{2KP_1P_2}{r^3}\,Cos\theta$$

(a) $\frac{2kp_1p_2Cos\,\theta}{r^3}$

(b) ✓ $-\frac{2kp_1p_2Cos\,\theta}{r^3}$

(c) $-\frac{2kp_1p_2Sin\,\theta}{r^3}$

(d) $-\frac{4kp_1p_2Cos\,\theta}{r^3}$

Q7) 4 charges are placed each at a distance 'a' from origin. The dipole moment of configuration is-

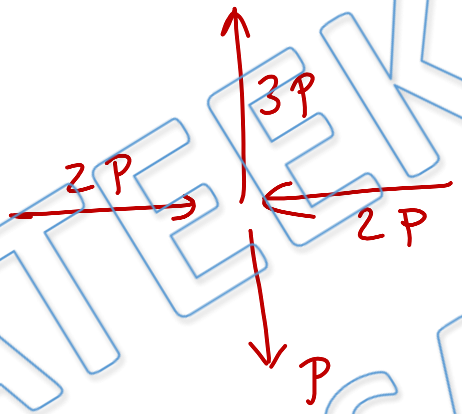
$P = qa$

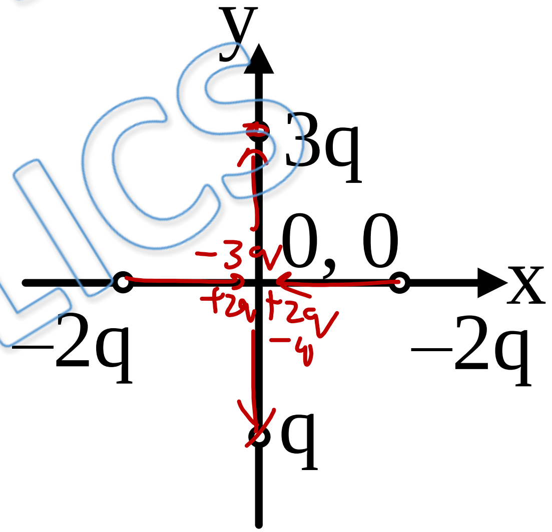
(a) 2qa

(b) $2\sqrt{2}$ qa

(c) $2\sqrt{5}$ qa

(d) None of these

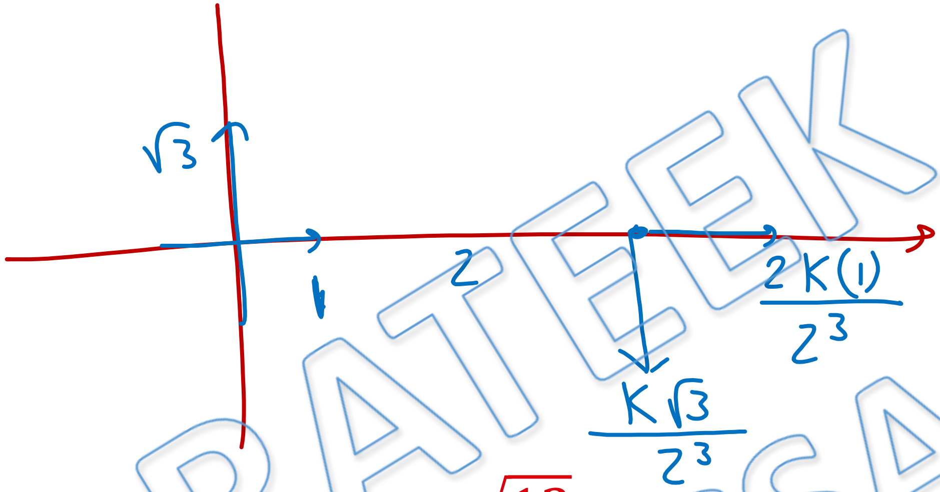




$P_{net} = 2P$

$= 2qa$

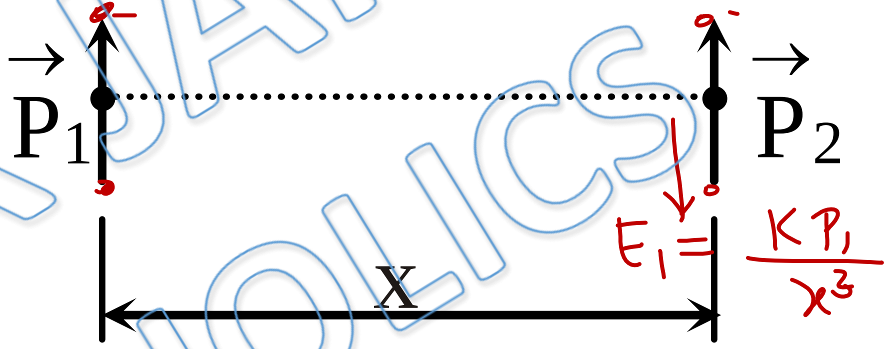
Q8) The magnitude of electric field intensity at point B (2, 0, 0) due to a dipole of dipole moment, $\vec{p} = \hat{\imath} + \sqrt{3}\,\hat{\jmath}$ kept at origin is (assume that the point B is at large distance from the dipole)



$$E = \frac{K}{2^3}\sqrt{4+3}$$
$$= \frac{\sqrt{7}\,K}{8}$$

(a) $\frac{\sqrt{13}}{8}k$ (b) $\frac{\sqrt{13}}{4}k$ [✓ (c) $\frac{\sqrt{7}}{8}k$] (d) $\frac{\sqrt{7}}{4}k$

Q9) Figure shows two short dipole moments parallel to each other and placed at a distance x apart is, then –



$E_1 = \frac{KP_1}{x^3}$

[✓ (a) they will repel each other]

(b) they will attract each other

[✓ (c) force of interaction is of magnitude of $\frac{3P_1P_2}{4\pi\varepsilon_0 x^4}$]

(d) force of interaction is of magnitude of $\frac{6P_1P_2}{4\pi\varepsilon_0 x^4}$

$$U = +\frac{KP_1P_2}{x^3}$$

$$F = -\frac{dU}{dx}$$

$$= -\left(\frac{-3KP_1P_2}{x^4}\right)$$

$$F = \frac{3KP_1P_2}{x^4}$$

Q10) For the situation shown in the figure below (assume r >> length of dipole) mark out the correct statement(s).

$F = \frac{KPQ}{r^3}$ ↓

$E = \frac{KP}{r^3}$

$\rightarrow E$ (due to Q)

$= \frac{KQ}{r^2}$

$\tau = PE = \frac{KPQ}{r^2}$ ⊗

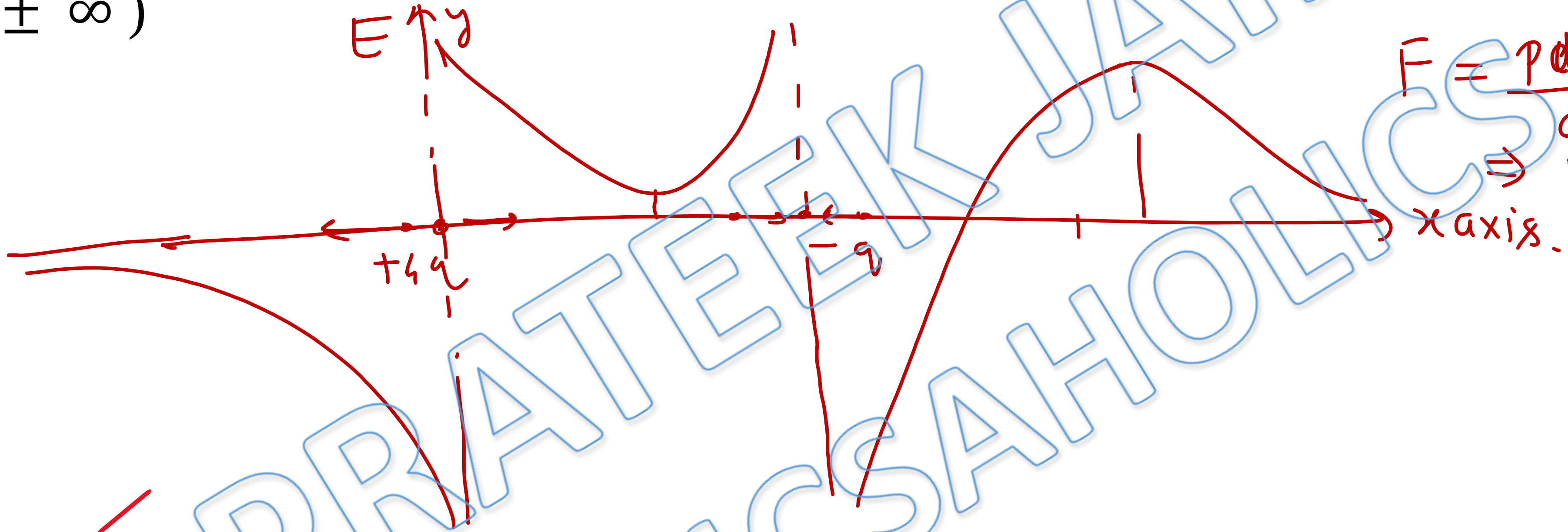
(a) Force acting on the dipole is zero.

(b) Force acting on the dipole is approximately $\frac{pQ}{4\pi\varepsilon_0 r^3}$ and is acting upward

(c) Torque acting on the dipole is $\frac{pQ}{4\pi\varepsilon_0 r^2}$ in clockwise direction.

(d) Torque acting on the dipole is $\frac{pQ}{4\pi\varepsilon_0 r^2}$ in anti-clockwise direction

Q11) Two point charges +4q and –q are placed on x axis at separation l_0 . Number of points on x axis where a dipole will experience zero force is (do not count x = ± ∞)



$F = p\frac{dE}{dx} = 0$

⇒ F = 0 at maxima & minima of E–x graph

(a) 2 ✓

(b) 1

(c) 3

(d) 4

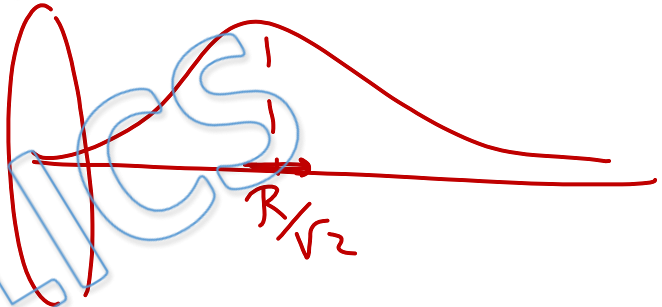
Q12) A short dipole of dipole moment p is placed on the axis of uniformly charged ring of radius R and charge Q . Distance of dipole from centre of ring is r = $\frac{R}{\sqrt{2}}$ and it is placed along axis. Force on dipole is

(a) $\frac{2KpQ}{R^3}$

(b) $\frac{KpQ}{3\sqrt{3}R^3}$

(c) $\frac{2\sqrt{2}KpQ}{R^3}$

(d) Zero



at $x = R/\sqrt{2}$

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

$\Rightarrow F = 0$

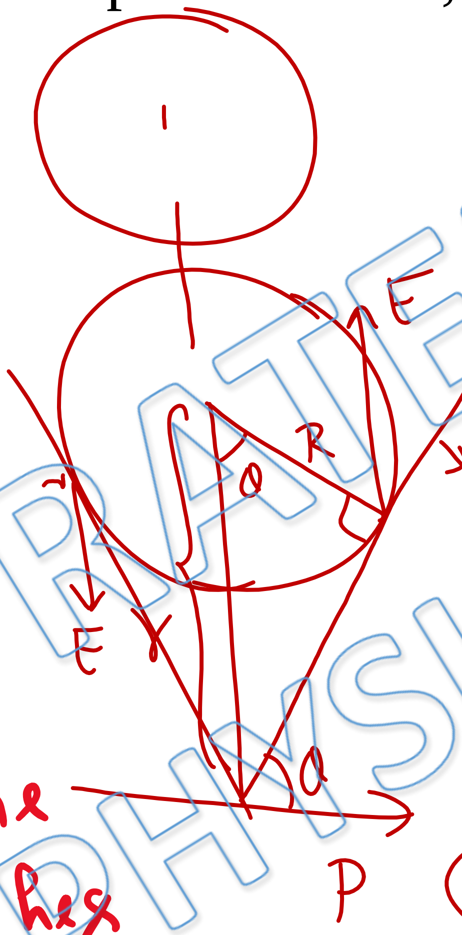
Q13) In given figure circle is in xy plane and dipole is along x axis . O is centre of circle and R is radius of circle. If there are 4 points on circle where electric field is perpendicular to dipole moment, possible values of distance of O from origin is/are

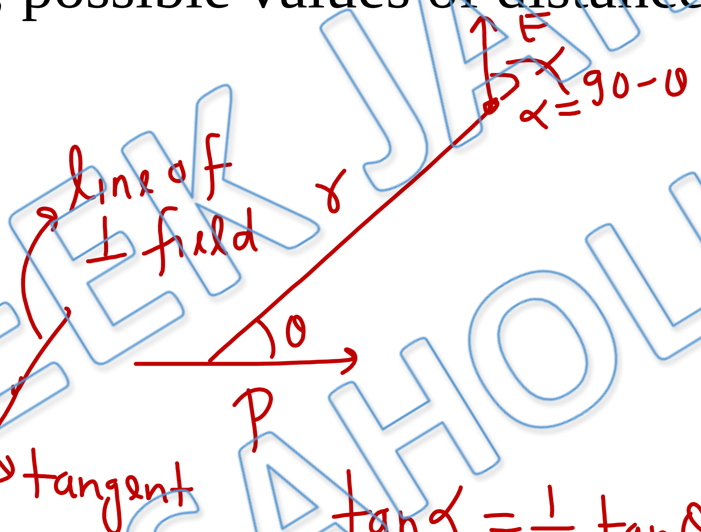
[✓ (a) R]

(b) 2R

[✓ (c) 1.5 R]

(d) 3R





$$\cos\theta = \frac{R}{r}$$

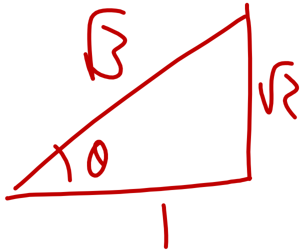
$$\frac{1}{\sqrt{3}} = \frac{R}{r}$$

$$\boxed{r = R\sqrt{3}}$$

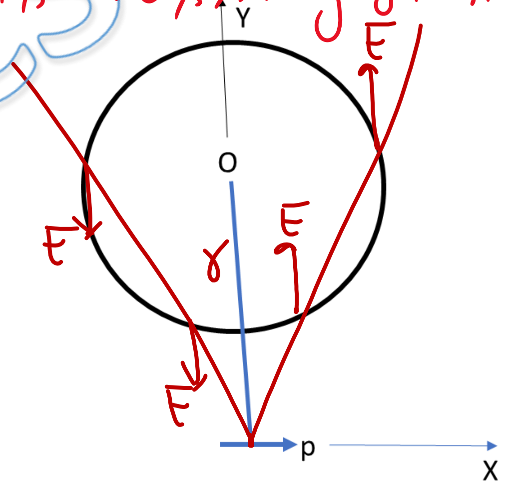
$$\tan\alpha = \frac{1}{2}\tan\theta.$$

$$\cot\theta = \frac{1}{2}\tan\theta$$

$$\tan\theta = \sqrt{2}$$



Here line of ⊥ field is crossing given circle.



$$r < R\sqrt{3}$$

$$r < 1.7R.$$

* at $r = R\sqrt{3}$, line of ⊥ field touches given circle.

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