Electrostatics

Question1

An electron and a positron enter a uniform electric field E perpendicular to it with equal speeds at the same time. The distance of separation between them in the direction of the field after a time ' t ' is

($\frac{e}{m}$ is specific charge of electron)

TG EAPCET 2025 (Online) 2nd May Evening Shift

Options:

A.

$\frac{2Eet^2}{m}$

B.

$\frac{Eet^2}{m}$

C.

$\frac{Eet^2}{2m}$

D.

zero

Answer: B

Solution:

Acceleration of electron in electric field is

$a_e = \frac{F_e}{m} = -\frac{eE}{m}$

Acceleration of positron in electric field.

$a_p = \frac{F_p}{m} = \frac{eE}{m}$

Displacement of electron in electric field

$y_e = 0 \times t + \frac{1}{2} a_e t^2 = -\frac{1}{2} \frac{eE}{m} t^2$

Displacement of positron in electric field

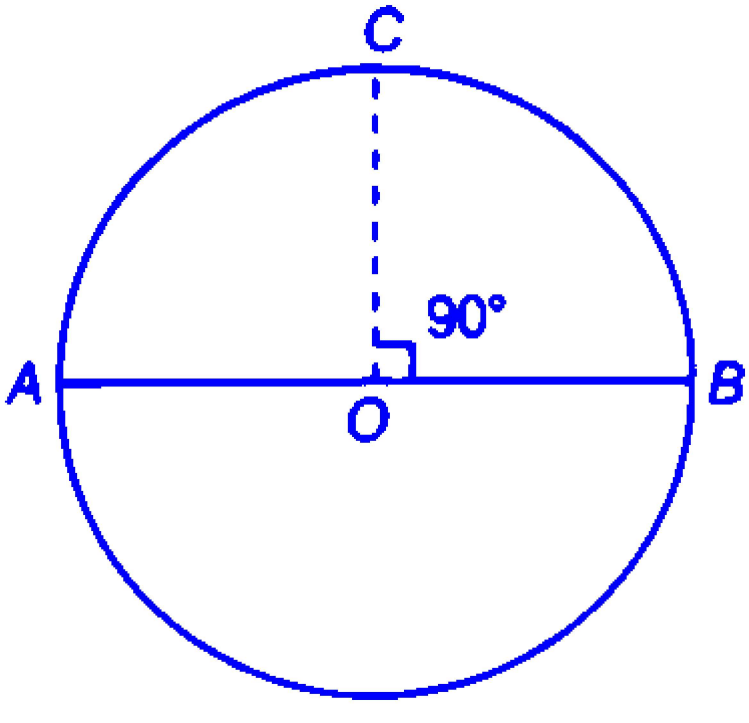
$y_p = \frac{1}{2} a_p t^2 = \frac{1}{2} \frac{eE}{m} t^2$

The distance of separation between electron and positron

$$
\begin{aligned}
&= |y_p - y_e| \\
&= \left| \frac{\frac{1}{2} eEt^2}{m} - \left(-\frac{1}{2} \frac{eEt^2}{m} \right) \right| \\
&= \left| \frac{eEt^2}{m} \right| = \frac{eEt^2}{m}
\end{aligned}
$$

Question2

A charge q is placed at the centre ' O ' of a circle of radius R and two other charges q and q are placed at the ends of the diameter AB of the circle. The work done to move the charge at point B along the circumference of the circle to a point C as shown in the figure is



TG EAPCET 2025 (Online) 2nd May Evening Shift

Options:

A.

$\frac{1}{4\pi\varepsilon_0} \cdot \frac{q^2}{R}(\sqrt{2})$

B.

zero

C.

$\frac{1}{4\pi\varepsilon_0} \cdot \frac{q^2}{R}\left(\frac{\sqrt{2}-1}{2}\right)$

D.

$\frac{1}{4\pi\varepsilon_0} \cdot \frac{q^2}{R}\left(\frac{1}{\sqrt{2}}\right)$

Answer: C

Solution:

The potential at points B and C due to the charges at O and A

Potential at B

$V_B = \frac{q}{4\pi\varepsilon_0 R} + \frac{q}{4\pi\varepsilon_0 2R}$

Potential at C

$V_c = \frac{q}{4\pi\varepsilon_0 R} + \frac{q}{4\pi\varepsilon_0\sqrt{2}R}$

Work done

$$
\begin{aligned}
W &= q\,(V_C - V_B) \\
&= q\left[\begin{array}{l}\left(\frac{q}{4\pi\varepsilon_0 R} + \frac{q}{4\pi\varepsilon_0\sqrt{2}R}\right) \\ -\left(\frac{q}{4\pi\varepsilon_0 R} - \frac{q}{4\pi\varepsilon_0 2R}\right)\end{array}\right] \\
&= \frac{q^2}{4\pi\varepsilon_0 R}\left[\frac{1}{\sqrt{2}} - \frac{1}{2}\right] \\
&= \frac{q^2}{4\pi\varepsilon_0 R}\left[\frac{\sqrt{2}-1}{2}\right]
\end{aligned}
$$

Question3

For any fixed distance, the electromagnetic force between two protons is 10^n times of the gravitational force between them. Then, $n =$

TG EAPCET 2025 (Online) 2nd May Morning Shift

Options:

A.

26

B.

13

C.

39

D.

36

Answer: D

Solution:

The electromagnetic force between two protons is much stronger than the gravitational force between them.

Let F_e be the electromagnetic force, and F_g be the gravitational force.

According to the problem: $F_e = 10^n F_g$

We write the formulas for both forces:

Electromagnetic force: $F_e = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2}$

Gravitational force: $F_g = \frac{Gm^2}{r^2}$

Replace F_e and F_g in the equation: $\frac{1}{4\pi\varepsilon_0}\frac{e^2}{r^2} = 10^n\frac{Gm^2}{r^2}$

Since r^2 is on both sides, it cancels out:

$\frac{1}{4\pi\varepsilon_0}e^2 = 10^n Gm^2$

Solve for 10^n:

$10^n = \frac{1}{4\pi\varepsilon_0}\frac{e^2}{Gm^2}$

Now, use the constants:

$\frac{1}{4\pi\varepsilon_0} = 9 \times 10^9$

Charge of proton, $e = 1.6 \times 10^{-19}$

Gravitational constant, $G = 6.67 \times 10^{-11}$

Mass of proton, $m = 1.67 \times 10^{-27}$

Plug in the values:

$10^n = \frac{9\times10^9\times(1.6\times10^{-19})^2}{6.67\times10^{-11}\times(1.67\times10^{-27})^2}$

Calculate the numerator: $9 \times 10^9 \times (1.6 \times 10^{-19})^2 = 9 \times 10^9 \times 2.56 \times 10^{-38} = 2.304 \times 10^{-28}$

Calculate the denominator: $6.67 \times 10^{-11} \times (1.67 \times 10^{-27})^2 = 6.67 \times 10^{-11} \times 2.79 \times 10^{-54} = 1.86 \times 10^{-64}$

Divide the values: $\frac{2.304\times10^{-28}}{1.86\times10^{-64}} = 1.23 \times 10^{36}$

This means $10^n = 1.23 \times 10^{36}$, so $n = 36$.

Question4

A thin spherical shell of radius R and surface charge density σ is placed in a cube of side $5R$ with their centers coinciding. The electric flux through one face of the cube is (ε_0 = Permittivity of free space)

TG EAPCET 2025 (Online) 2nd May Morning Shift

Options:

A.

$\frac{2\pi R^2\sigma}{3\varepsilon_0}$

B.

$\frac{\pi R^2\sigma}{3\varepsilon_0}$

C.

$\frac{\sigma}{6\varepsilon_0}$

D.

$\frac{\sigma}{4\pi\varepsilon_0 R^2}$

Answer: A

Solution:

Total charge on spherical shell.

$Q = \sigma A = \sigma\left(4\pi R^2\right) = 4\pi R^2\sigma$

According to Gauss's law total electric flux through a closed surface.

$\phi = \frac{Q}{\varepsilon_0} = \frac{4\pi R^2\sigma}{\varepsilon_0}$

$\therefore$ Flux through one face

$\phi_1 = \frac{\phi}{6} = \frac{4\pi R^2\sigma}{6\varepsilon_0} = \frac{2\pi R^2\sigma}{3\varepsilon_0}$

Question5

The electric flux due to an electric field $\mathbf{E} = (8\hat{\mathbf{i}} + 13\hat{\mathbf{j}})\mathrm{NC}^{-1}$ through an area 3 m^2 lying in the XZ-plane is

TG EAPCET 2024 (Online) 11th May Morning Shift

Options:

A. 39 Wb

B. 24 Wb

C. 63 Wb

D. 15 Wb

Answer: A

Solution:

Given,

$\mathbf{E} = (8\hat{\mathbf{i}} + 13\hat{\mathbf{j}})\text{N/C}$

$A = 3\ \text{m}^2$

$\phi = ?$

$\therefore$ Area is lying in the XZ-plane, so vector component of area,

$\mathbf{A} = 3\hat{\mathbf{j}}$

Now, $\phi = \mathbf{E} \cdot \mathbf{A}$

$\phi = (8\hat{\mathbf{i}} + 13\hat{\mathbf{j}}) \cdot (3\hat{\mathbf{j}})$

$\phi = (0 + 39)\text{Wb}$

$\phi = 39\ \text{Wb}$

Question6

A proton and an α-particle are both accelerated from rest in a uniform electric field. The ratio of work done by the electric field on the proton and the α-particle in a given time is

TG EAPCET 2024 (Online) 10th May Evening Shift

Options:

A. 1 : 1

B. 1 : 2

C. 1 : 4

D. 4 : 1

Answer: A

Solution:

The work done by an electric field on a charged particle is determined by the equation $W = F \cdot s$, where F is the force exerted by the electric field and s is the displacement of the particle.

The force F can be expressed as $F = qE$, where q is the charge of the particle and E is the electric field strength. The displacement s can be determined using the kinematic equation $s = \frac{1}{2}at^2$, where a is the acceleration and t is the time.

Substituting these into the work formula gives:

$W = E \cdot q \cdot \frac{1}{2}at^2$

Since both the proton and the alpha particle are in the same electric field and experienced for the same time:

$W \propto q \cdot a$

Let's denote:

W_1 as the work on the proton,

W_2 as the work on the alpha particle.

Hence,

$\frac{W_1}{W_2} = \frac{q_1 \cdot a_1}{q_2 \cdot a_2}$

For the proton:

$q_1 = 1\,\text{C}$,

The acceleration $a_1 = \frac{E \cdot q_1}{m}$ (where m is the mass of the proton).

For the alpha particle:

$q_2 = 2\,\text{C}$,

The acceleration $a_2 = \frac{E \cdot (2q)}{4m} = \frac{E}{2}$.

Substituting these into the work ratio equation yields:

$\frac{W_1}{W_2} = \frac{1 \cdot \frac{E}{E}}{2 \cdot \frac{E}{2E}}$

Simplifying,

$\frac{W_1}{W_2} = \frac{1}{2} \times 2 = 1 : 1$

Thus, the ratio of the work done by the electric field on the proton compared to the alpha particle is $1 : 1$.

Question7

Two point charges $-10\mu\text{C}$ and $-5\mu\text{C}$ are situated on X-axis at $x = 0$ and $x = \sqrt{2}\ \text{m}$. The point along the X-axis, where the electric field becomes zero is

TG EAPCET 2024 (Online) 10th May Morning Shift

Options:

A. $x = (\sqrt{2} - 1)m$

B. $x = 2(\sqrt{2} - 1)\text{m}$

C. $x = 2(\sqrt{2} + 1)\text{m}$

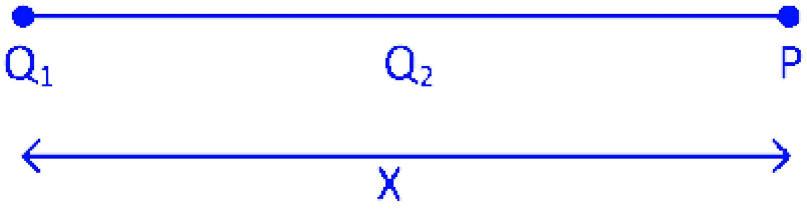
D. $x = (\sqrt{2} + 1)m$

Answer: C

Solution:

$Q_1 = -10\mu\text{C}, Q_2 = +5\mu\text{C}$

$x = 0, x = \sqrt{2}\,\text{m}$



Net electric field is zero at point P

$E = \frac{k[Q_1]}{x^2} + \frac{k[Q_2]}{(x-\sqrt{2})^2} = 0$

$\frac{(-10\mu\text{C})k}{x^2} + \frac{k(5\mu\text{C}}{(x-\sqrt{2})^2} = 0$

$\frac{+2}{x^2} = \frac{1}{(x-\sqrt{2})^2}$

Square root both side

$$\frac{\sqrt{2}}{x} = \frac{1}{(x - \sqrt{2})}$$

$\sqrt{2}(x - \sqrt{2}) = x$

$x(\sqrt{2} - 1) = 2$

$$x = \frac{2}{\sqrt{2} - 1}$$

Rationalize the denominator

$x = \frac{2}{\sqrt{2}-1} \times \frac{\sqrt{2}+1}{\sqrt{2}+1}$

$x = 2(\sqrt{2} + 1)\text{m}$

Question8

Two point charges of magnitudes $-8\mu C$ and $+32\mu C$ are separated by a distance of 15 cm in air. The position of the point from $-8\mu C$ charge at which the resultant electric field becomes zero is

TG EAPCET 2024 (Online) 9th May Evening Shift

Options:

A. 15 cm

B. 30 cm

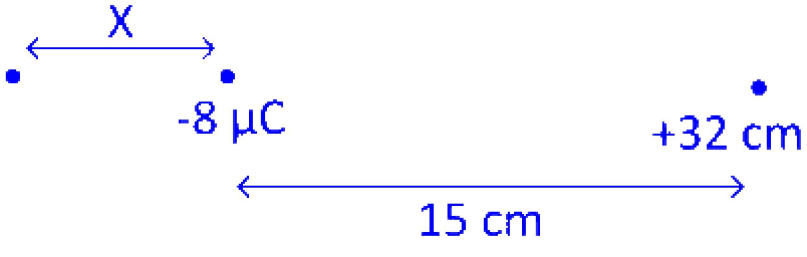
C. 7.5 cm

D. 5 cm

Answer: A

Solution:

From the diagram,



$\frac{K(8)}{x^2} = \frac{K(32)}{(15+x)^2}$ (direction of

attraction/repulsion is considered)

$$\Rightarrow \quad \frac{1}{x^2} = \frac{4}{(15+x)^2}$$

$$\Rightarrow \quad \frac{1}{x} = \frac{2}{15+x}$$

$$\Rightarrow \quad 15 + x = 2x$$

$$\Rightarrow \quad x = 15 \text{ cm}$$

From $-8\mu C$ charge

Question9

Two positive point charges are separated by a distance of 4 m in air. If the sum of the two charges is $36\mu C$ and the electrostatic force between them is 0.18 N , then the bigger charge is

TG EAPCET 2024 (Online) 9th May Morning Shift

Options:

A. $30\mu C$

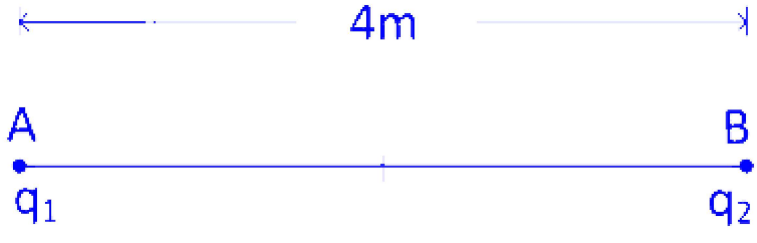
B. $18\mu C$

C. $20\mu C$

D. $16\mu C$

Answer: C

Solution:



Given, Distance of separation, $r = 4$ m

$r^2 = 16$ m

Sum of two charges

$q_1 + q_2 = 36\mu C$

$= 36 \times 10^{-6} C$

$F = 0.18$ N

Coulomb's law,

$F = K\frac{q_1 q_2}{r^2}$

Here, $q_2 = 36 \times 10^{-6} - q_1$

Thus, $0.18 = 8.98 \times 10^9 \times \frac{q_1(36\times10^{-6}-q_1)}{16}$

Solving quadratic equation,

$$q_1 = \frac{36\times10^{-6}+}{\sqrt{(36\times10^{-6})^2-4\times\frac{0.18\times16}{8.98\times10^9}}}$$

$$q_1 = \frac{36\times10^{-6}+}{\sqrt{(36\times10^{-6})^2-4\times\frac{2.88}{8.98\times10^9}}}$$

$$q_1 = 1.98\times10^{-5}\text{C}$$

$$q_1 \approx 20.8\times10^{-6}\text{C}$$

$$q_1 = 20\mu\text{C}$$

Question10

The electric field and electric potential at a point due to a point charge are 500NC^{-1} and 30 V respectively, then the magnitude of the charge is

TS EAMCET 2023 (Online) 12th May Evening Shift

Options:

A. $1.3\times10^{-9}\text{C}$

B. $3\times10^{-12}\text{C}$

C. $2\times10^{-10}\text{C}$

D. $1.6\times10^{-20}\text{C}$

Answer: C

Solution:

To determine the magnitude of the charge, we have the following given information:

Electric field $E = 500\,\text{N/C}$

Electric potential $V = 30\,\text{V}$

First, we use the formula for the potential gradient, which relates the electric field and potential through the distance x from the point charge:

$E = \frac{V}{x}$

Solving for x:

$x = \frac{30}{500} = 0.06\,\text{m}$

Now, we employ the formula for the electric potential due to a point charge:

$V = \frac{1}{4\pi\varepsilon_0}\frac{q}{x}$

Substitute the known values to solve for the magnitude of the charge q:

$30 = \frac{9\times10^9}{0.06} \times q$

Rearranging gives:

$q = \frac{30\times0.06}{9\times10^9} = 2 \times 10^{-10}\,\text{C}$

Thus, the magnitude of the charge is:

$2 \times 10^{-10}\,\text{C}$

Question11

A clock dial has point charges $-q, -2q, -3q, \ldots\ldots\ldots, -12q$ at the positions of the corresponding numbers on the dial respectively. The time at which the hour's hand points the direction of the net electric field at the centre of the dial is(Assume clock hands do not influence the net electric field)

TS EAMCET 2023 (Online) 12th May Morning Shift

Options:

A. 8 : 30

B. 9 : 30

C. 10 : 30

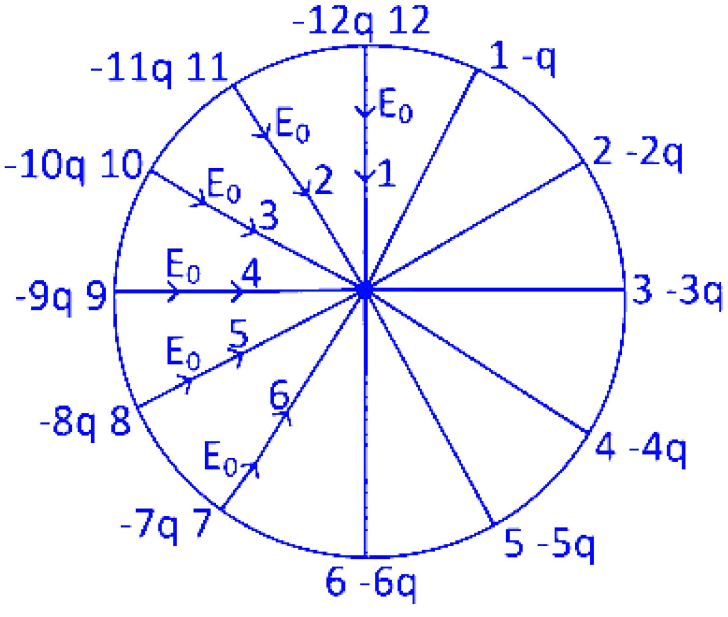
D. 12 : 30

Answer: B

Solution:

Given,

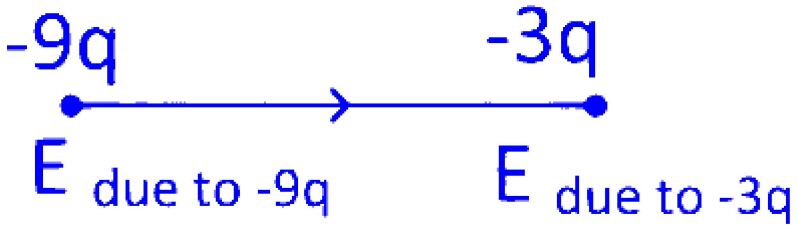
' 'The charges corresponding to number's of a clock $-q, -2q \ldots 12q$.



Electric field is given by

$E = kq/r^2 \Rightarrow E \propto q$

Let's take a pair of charges ($-9q$ and $-3q$)



The value of E due to $-9q > -3q$

and net magnitude $= -6q = E_0$

Same goes for all pairs with magnitude of $(-6q)$.

The angle between each field,

$\theta = \frac{360^\circ}{12} = 30^\circ$

From the property of vector addition, if two equal vector is separated by 120°, then resultant vector is same as initial vector.

For making 120°, take vector 1 to vector 5 Resultant of vector 1 and $5 = E_0 =$ Vector 3 direction.

Resultant of vector 2 and $6 = E_0 =$ Vector 4 direction

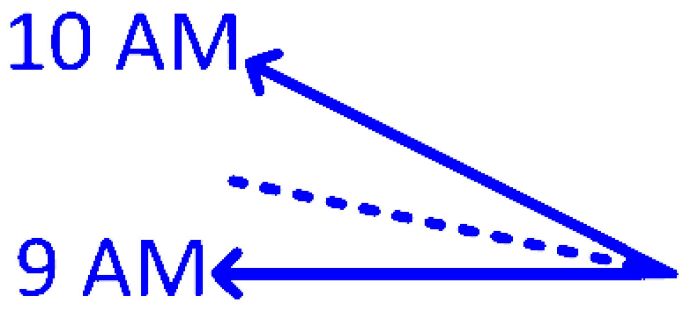
Now, vector (1 and 5) and (2 and 6) are eliminated

Now, vector $3 = E_0 + E_0 = 2E_0$

Vector $4 = E_0 + E_0 = 2E_0$

Vector 3 denotes 10 AM

Vector 4 denotes 9 AM



So, the resultant vector of 9 AM and 10 AM is in midway direction.

i.e., 9 : 30.

Question12

The electric potential at a place is varying as $V = \frac{1}{2}\left(y^2 - 4x\right)\mathrm{V}$. Then, the electric field at $x = 1\ \mathrm{m}$ and $y = 1\ \mathrm{m}$ is

TS EAMCET 2023 (Online) 12th May Morning Shift

Options:

A. $(2\hat{i} + \hat{\mathrm{j}})\mathrm{Vm}^{-1}$

B. $(-2\hat{\mathbf{i}} + \hat{\mathrm{j}})\mathrm{Vm}^{-1}$

C. $(2\hat{\mathbf{i}} - \hat{\mathbf{j}})\mathrm{Vm}^{-1}$

D. $(-2\hat{\mathbf{i}} + 2\hat{\mathbf{j}})V\ \mathrm{m}^{-1}$

Answer: C

Solution:

The electric field $\vec{E}$ is related to the electric potential V by the following relation:

$\vec{E} = -\nabla V = -\left(\frac{\partial V}{\partial x}\hat{i} + \frac{\partial V}{\partial y}\hat{j} + \frac{\partial V}{\partial z}\hat{k}\right)$

Given the potential $V = \frac{1}{2}(y^2 - 4x)$, we need to find the partial derivatives with respect to x and y.

Partial derivative with respect to x:

$\frac{\partial V}{\partial x} = \frac{\partial}{\partial x}\left[\frac{1}{2}(y^2 - 4x)\right] = \frac{1}{2}(-4) = -2$

Partial derivative with respect to y:

$\frac{\partial V}{\partial y} = \frac{\partial}{\partial y}\left[\frac{1}{2}(y^2 - 4x)\right] = \frac{1}{2}(2y) = y$

Now, let's plug these into the formula for the electric field:

$\vec{E} = -\left(\frac{\partial V}{\partial x}\hat{i} + \frac{\partial V}{\partial y}\hat{j}\right) = -(-2\hat{i} + y\hat{j}) = 2\hat{i} - y\hat{j}$

We need to find the electric field at the point $x = 1\,\text{m}$ and $y = 1\,\text{m}$. So, we substitute $y = 1$ into the equation:

$\vec{E} = 2\hat{i} - (1)\hat{j} = (2\hat{i} - \hat{j})\,\text{V/m}$

So, the correct answer is:

Option C: $(2\hat{i} - \hat{j})\,\text{V/m}$
