Charge is quantized

Friday, 29 January, 2021 19:53

How many electrons would have to be removed from a coin to leave it with a charge of $1 \times 10^{-7}\ C$?

The Hydrogen Atom

Friday, 29 January, 2021 19:45

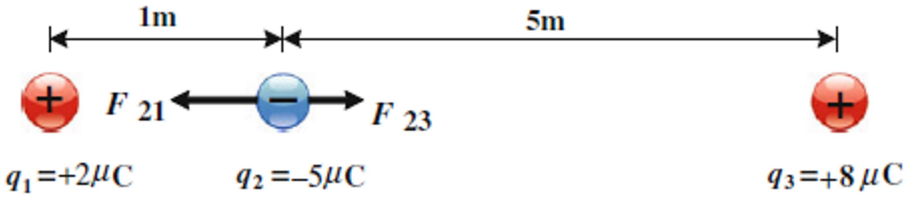
The electron and proton of a hydrogen atom are separated by a distance of approximately $5.3 \times 10^{-11}\, m$. Find the magnitudes of the electric force and the gravitational force between the two particles.

$m_p = 1.67 \times 10^{-27}\, kg$
$m_e = 9.11 \times 10^{-31}\, kg$
$e = 1.6 \times 10^{-19}\, C$
$k_e = 9 \times 10^{9}\ N.m^2/C^2$
$G = 6.67 \times 10^{-11}\ N.m^2/kg^2$

Find the Resultant Force 1

Friday, 29 January, 2021 19:47

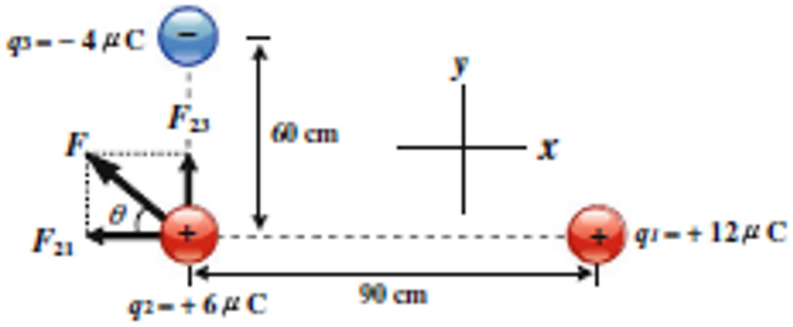
Consider the three point charges: $q_1 = +2\,\mu C$, $q_2 = -5\,\mu C$ and $q_3 = +8\,\mu C$ that are shown. Find the resultant force exerted on the charge q_2.



Find the Resultant Force 2

Friday, 29 January, 2021 19:48

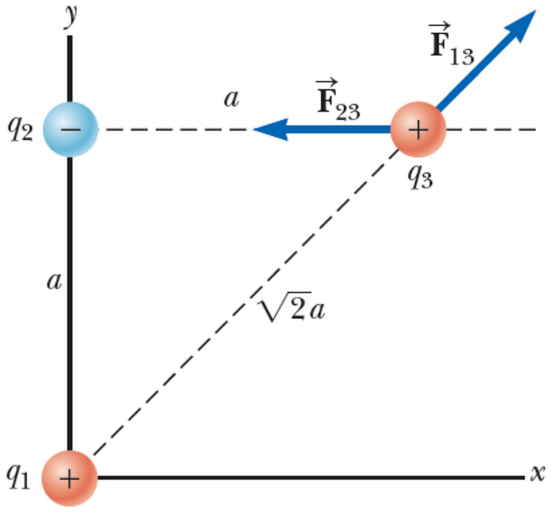
Consider three charges: $q_1 = +12\,\mu C$, $q_2 = +6\,\mu C$ and $q_3 = -4\,\mu C$ are setup as shown. Find the resultant force exerted on the charge q_2.



Find the Resultant Force 3

Friday, 29 January, 2021 19:49

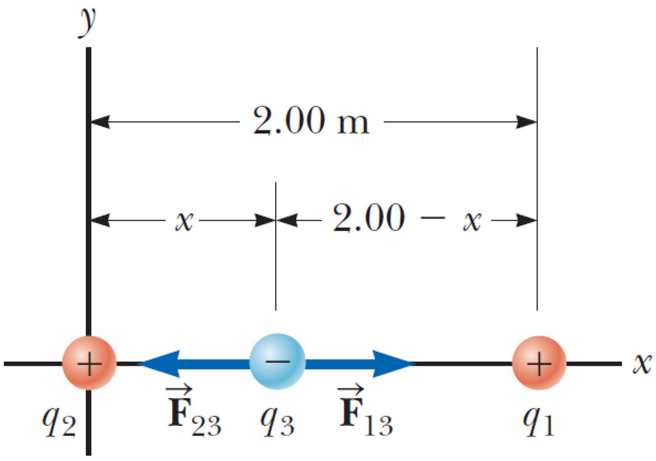
Consider three point charges located at the corners of a right triangle as shown, where $q_1 = q_3 = 5\,\mu C$, $q_2 = -2\,\mu C$ and $a = 0.1\,m$. Find the resultant force exerted on q_3 .



Where Is the Net Force Zero? 1

Friday, 29 January, 2021 19:49

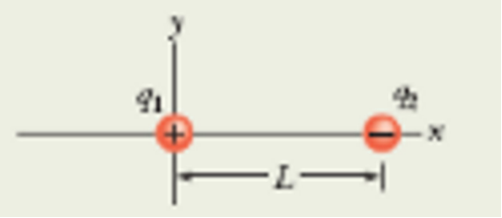
Three point charges lie along the x axis as shown. The positive charge $q_1 = 15\,\mu C$ is at $x = 2\,m$, the positive charge $q_2 = 6\,\mu C$ is at the origin, and the net force acting on q_3 is zero. What is the x coordinate of q_3 ?



Where Is the Net Force Zero? 2

Friday, 29 January, 2021 19:50

The figure (a) shows two particles fixed in place: a particle of charge $q_1 = +8q$ at the origin and a particle of charge $q_2 = -2q$ at $x = L$. At what point can a proton be placed so that it is in equilibrium?

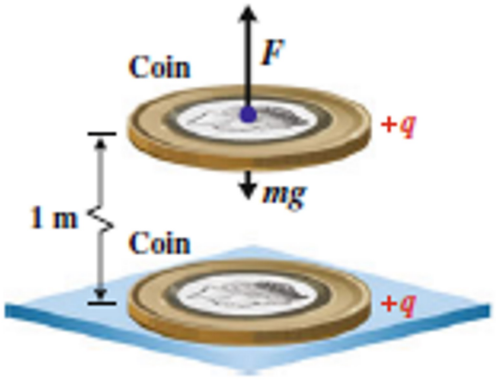


Equilibrium

Friday, 29 January, 2021 19:50

Two identical copper coins of mass $m = 2.5\ g$ contain about $N = 2 \times 10^{22}\ atoms$ each. A number of electrons n are removed from each coin to acquire a net positive charge q. Assume that when we place one of the coins on a table and the second above the first, the second coin stays at rest in air at a distance of $1m$.

- Find the value of q that keeps the two coins in that configuration.
- Find the number of removed electrons n from each coin.



Distance is changed

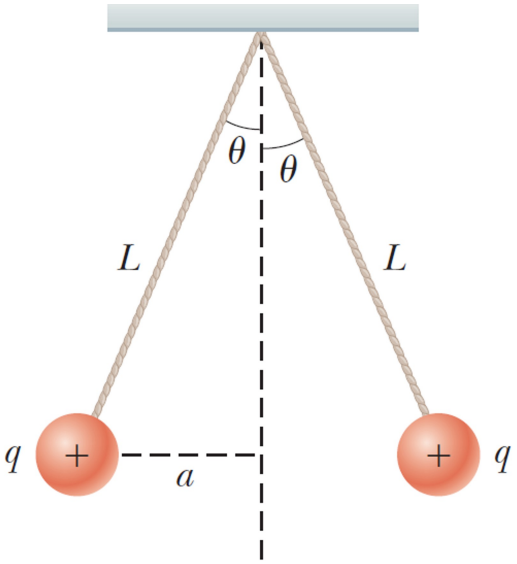
Friday, 29 January, 2021 19:50

A charged particle A exerts a force of $2.62\ \mu N$ to the right on charged particle B when the particles are $13.7\ mm$ apart. Particle B moves straight away from A to make the distance between them $17.7\ mm$. What vector force does it then exert on A?

Find the Charge on the Spheres

Friday, 29 January, 2021 19:50

Two identical small charged spheres, each having a mass of $3 \times 10^{-2}\ kg$ hang in equilibrium as shown. The length (L) of each string is 0.150 m, and the angle $\theta = 5^{\circ}$. Find the magnitude of the charge on each sphere.



A Suspended Water Droplet

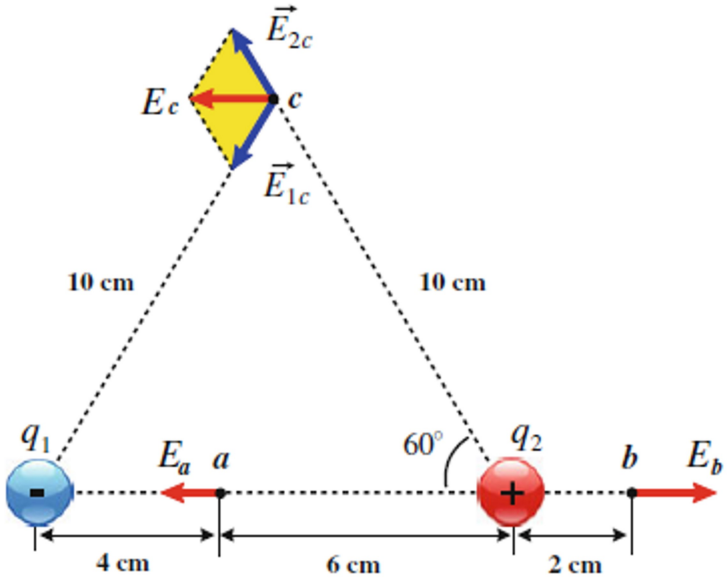
Friday, 29 January, 2021 19:54

A water droplet of mass $3 \times 10^{-12}\ kg$ is located in the air near the ground during a stormy day. An atmospheric electric field of magnitude $6 \times 10^{3}\ N/C$ points vertically downward in the vicinity of the water droplet. The droplet remains suspended at rest in the air. What is the electric charge on the droplet?

Find the Resultant E - 1

Friday, 29 January, 2021 19:55

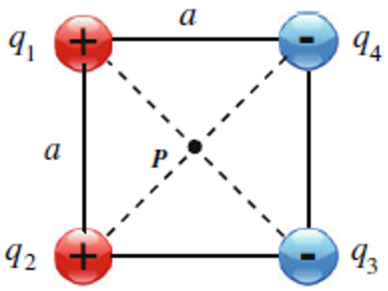
Consider two point charges $q_1 = -24\,nC$ and $q_2 = +24\,nC$ that are $10\,cm$ apart, forming an electric dipole. Calculate the electric field due to the two charges at points a, b and c.



Find the Resultant E - 2

Friday, 29 January, 2021 19:55

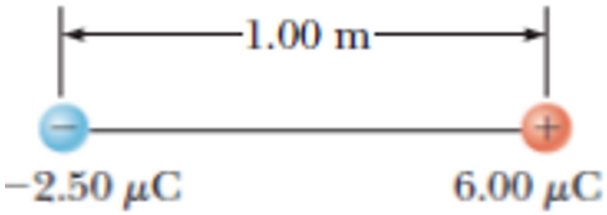
Four point charges $q_1 = q_2 = Q$ and $q_3 = q_4 = -Q$, where $Q = \sqrt{2}\,\mu C$, are placed at the four corners of a square of side $a = 0.4\,m$. Find the electric field at the center P of the square.



Where Is the Net E Zero?

Friday, 29 January, 2021 19:56

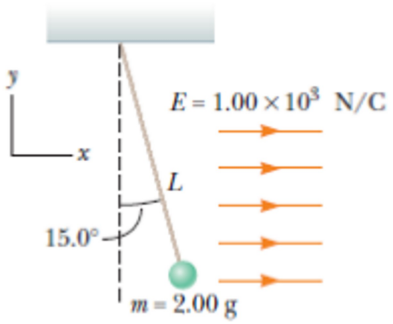
In the figure, determine the point at which the electric field is zero.



Equilibrium

Friday, 29 January, 2021 19:56

A small, $2\ g$ plastic ball is suspended by a $2\ cm$ long string in a uniform electric field. If the ball is in equilibrium when the string makes a 15° angle with the vertical, what is the net charge on the ball?

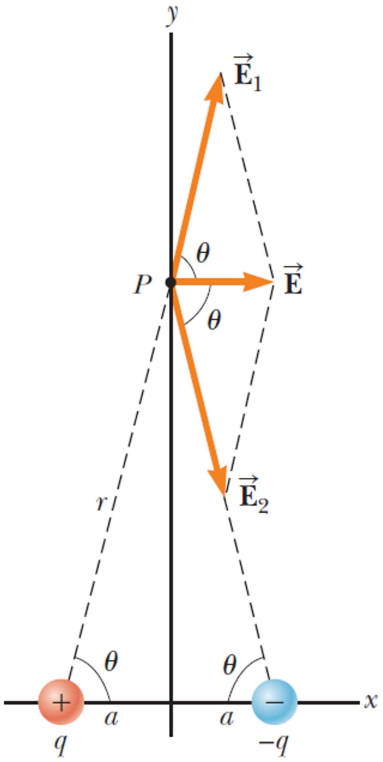


E Along the Perpendicular Bisector of a Dipole Axis

Friday, 29 January, 2021 19:57

Charges $+q$ and $-q$ are located on the x axis, at distance (a) from the origin as shown.

- Find the components of the net electric field at the point P, which is at position $(0, y)$.
- Find the electric field due to the electric dipole when point P is a distance $(y \gg a)$ from the origin.



Answers:

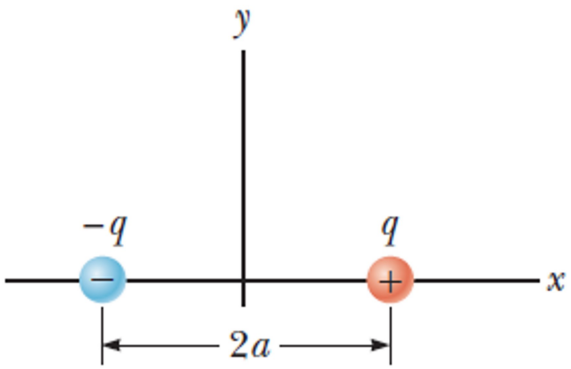
$$E = k_e \frac{2aq}{(a^2 + y^2)^{3/2}}$$

$$E \cong k_e \frac{2aq}{y^3}$$

E Along the Dipole Axis

Friday, 29 January, 2021 19:57

Consider the electric dipole shown.



- Find the electric field at a point P, which is at position $(0, x)$.
- Find the electric field when point P is a distance $(x \gg a)$ from the origin.

Answers:

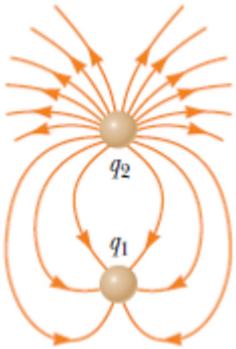
$$E = k_e \frac{4axq}{(x^2 - a^2)^2}$$

$$E \cong k_e \frac{4aq}{x^3}$$

E Lines

Friday, 29 January, 2021 19:58

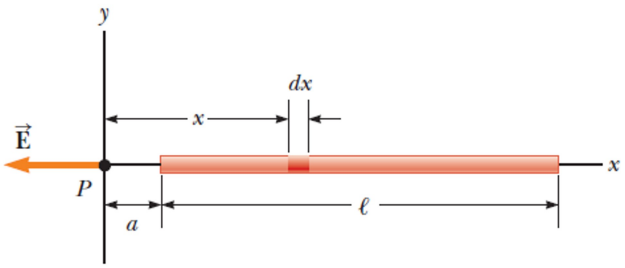
The figure shows the electric field lines for two charged particles separated by a small distance. Determine the ratio q_1/q_2.



Charged rod 1

Friday, 29 January, 2021 19:59

A rod $14\ cm$ long is uniformly charged and has a total charge of $-22\ \mu C$. Determine the magnitude of the electric field along the axis of the rod at a point $36\ cm$ from its center.



Answer:

$$E = k_e \lambda \int_a^{L+a} \frac{dx}{x^2}$$

$$E = \frac{k_e \lambda L}{a(L+a)} = \frac{k_e Q}{a(L+a)}$$

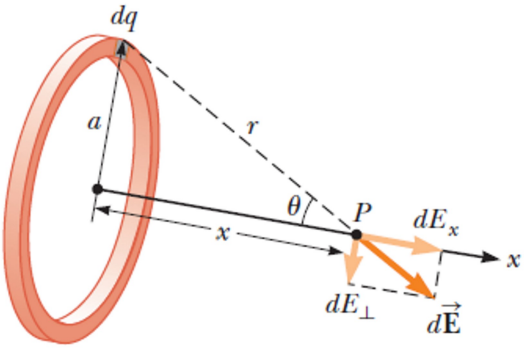
When $a \gg L$:

$$E \cong \frac{k_e Q}{a^2}$$

Charged ring

Friday, 29 January, 2021 19:59

A uniformly charged ring of radius $10\ cm$ has a total charge of $75\ \mu C$. Find the electric field on the axis of the ring at (a) $1\ cm$, (b) $5\ cm$, (c) $30\ cm$ and (d) $100\ cm$ from the center of the ring.



Answer:

By symmetry:

$$E_y = 0$$

$$E_x = \frac{k_e\ Q\ x}{a\ (a^2 + x^2)^{3/2}}$$

When $x \gg a$:

$$E_x \cong \frac{k_e Q}{x^2}$$

When $x = 0$:

$$E_x = 0$$

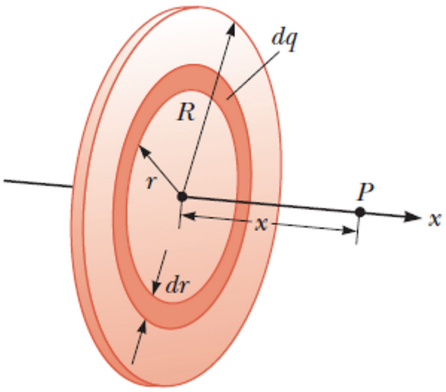
When $x \ll a$:

$$E_x \cong \frac{k_e Q}{a^3} x$$

Charged disk

Friday, 29 January, 2021 20:00

A uniformly charged disk of radius 35.0 cm carries charge with a density of $7.9 \times 10^{-3}\ C/m^2$. Calculate the electric field on the axis of the disk at (a) $5\ cm$, (b) $10\ cm$, (c) $50\ cm$ and (d) $200\ cm$ from the center of the disk.



Answer:

By symmetry:

$$E_y = 0$$

$$E_x = 2k_e\pi\sigma x \int_0^R \frac{r\,dr}{(r^2 + x^2)^{3/2}}$$

$$E_x = 2k_e\pi\sigma \left[1 - \frac{x}{(x^2 + R^2)^{1/2}}\right]$$

When $x \gg R$:

$$E_x \cong \frac{k_e Q}{x^2}$$

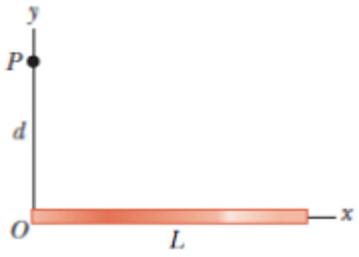
When $x \ll R$:

$$E_x \cong 2k_e\pi\sigma \cong \frac{\sigma}{2\epsilon_\circ}$$

Charged rod 2

Friday, 29 January, 2021 20:00

A uniformly charged rod of length L and total charge Q lies along the x axis as shown. Find the magnitudes of the components of the electric field at the point P on the y axis a distance d from the origin.



Answer:

$$E_x = k_e\lambda \int_0^L \frac{x\,dx}{(d^2+x^2)^{3/2}} = k_e\lambda\left[\frac{1}{d} - \frac{1}{(d^2+L^2)^{1/2}}\right]$$

$$E_y = k_e\lambda d \int_0^L \frac{dx}{(d^2+x^2)^{3/2}} = \frac{k_e\lambda L}{d}\frac{1}{(d^2+L^2)^{1/2}}$$

When $d \gg L$:

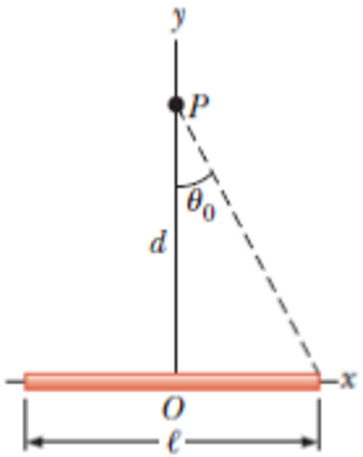
$E_x = 0$

$E_y \cong \frac{k_e Q}{d^2}$

Charged rod 3

Friday, 29 January, 2021 20:01

A thin rod of length L and uniform charge per unit length λ lies along the x axis as shown. Find the electric field at P, a distance d from the rod along its perpendicular bisector.



Answer:

By symmetry: $E_x = 0$

$$E_y = 2k_e\lambda d \int_0^{L/2} \frac{dx}{(d^2 + x^2)^{3/2}}$$

$$E_y = \frac{2k_e\lambda}{d} sin$$

For an infinite length: $\theta_o = 90^\circ$

When $d \gg L$:

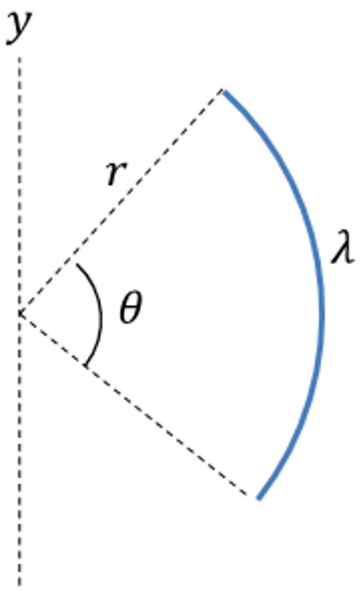
$$E_y = \frac{2k_e\lambda}{d}$$

$\theta_\circ$

Charged Circular arc

Friday, 29 January, 2021 20:01

A charge is uniformly distributed over a circular arc of radius r, with linear charge density λ. Find the magnitude of the electric field at the center of the circular arc.



Answer:

By symmetry: $E_y = 0$

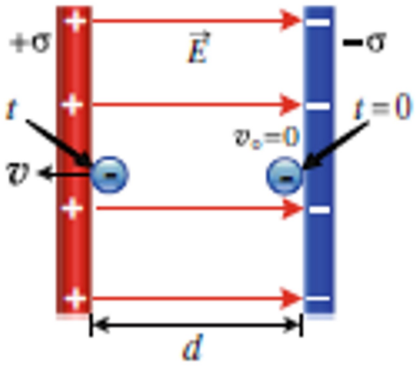
$$E_x = \frac{2k_e\lambda}{r}\int_0^{\theta/2} cos\theta\, d\theta$$

$$E_x = \frac{2k_e\lambda}{r} sin\frac{\theta}{2}$$

Along the Electric Field -1

Friday, 29 January, 2021 20:02

The figure shows two oppositely charged parallel plates that are separated by a distance $d = 1.5\ cm$. Each plate has a charge per unit area of magnitude $\sigma = 4\ \mu C/m^2$. An electron is released from rest at $t = 0$ from the negative plate.



- Calculate the electric field between the two plates.
- Find the resultant force exerted on the electron?
- Find the acceleration of the electron.
- How long does it take the electron to strike the positive plate?
- What is the speed and kinetic energy of the electron just before striking the positive plate?

Along the Electric Field - 2

Friday, 29 January, 2021 20:02

A proton is projected in the positive x direction into a region of a uniform electric field $\vec{E} = -6 \times 10^5\ N/C\,, \hat{\imath}$ at $t = 0$. The proton travels $7\ cm$ as it comes to rest. Determine:

- the acceleration of the proton,
- its initial speed, and
- the time interval over which the proton comes to rest.

Perpendicular to the Electric Field

Friday, 29 January, 2021 20:03

An electron enters the region of a uniform electric field as shown, with $v_i = 3 \times 10^6\ m/s$ and $E = 200\ N/C$. The horizontal length of the plates is $\ell = 0.1\ m$.

- Find the acceleration of the electron while it is in the electric field.
- Assuming the electron enters the field at time $t = 0$, find the time at which it leaves the field.
- Assuming the vertical position of the electron as it enters the field is $y_i = 0$, what is its vertical position when it leaves the field?