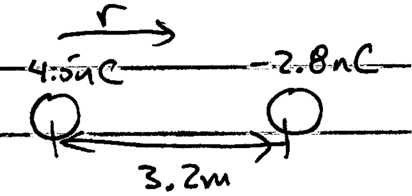
Chap 15

Physics 1B Solutions

Easy



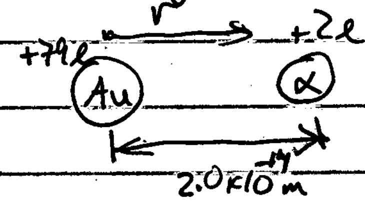
1.) Choose the 4.5nC charge as $r=0$.

$q_1 = 4.5\times10^{-9}C$, $q_2 = -2.8nC$, $r_{12} = 3.2m$

To find the electrostatic force use:

$$F_{elec} = k_e \frac{|q_1||q_2|}{r_{12}^2} = (8.99\times10^9 \tfrac{Nm^2}{C^2}) \frac{|4.5\times10^{-9}C||-2.8\times10^{-9}C|}{(3.2m)^2} = \boxed{1.1\times10^{-8}N}$$

Also the direction will be $\boxed{\text{attractive}}$. The force on the 4.5nC charge would be directly toward the -2.8nC Charge since they have opposite signs of charge.



3.) Choose the gold nucleus as $r=0$.

$q_1 = +79e$, $q_2 = +2e$, $r_{12} = 2.0\times10^{-14}m$

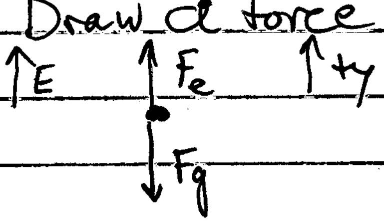
To find the electrostatic force use:

$$F_{elec} = k_e \frac{|q_1||q_2|}{r_{12}^2} = (8.99\times10^9 \tfrac{Nm^2}{C^2}) \frac{|+79e||+2e|}{(2.0\times10^{-14}m)^2} = \frac{(8.99\times10^9 \frac{Nm^2}{C^2})}{4.0\times10^{-28}m^2} 158e^2$$

$$\Rightarrow F_{elec} = (2.2\times10^{37}\tfrac{N}{C^2})(158)(1.602\times10^{-19}C)^2 = \boxed{91N}$$

Also, the direction will be $\boxed{\text{repulsive}}$. The force on the α-particle would be directly away from the Au nucleus since they have the same charge sign (+).

17.) Choose up as positive. Draw a force diagram for the situation.



Since the mass is "floating" the net force on it must be zero.

$$\Rightarrow \Sigma F = F_e - F_g = 0 \Rightarrow F_e = F_g \Rightarrow qE = mg$$

$$\Rightarrow m = \frac{qE}{g} = \frac{(24\times10^{-6}C)(610\,N/C)}{9.8\,N/kg} = \boxed{1.5\times10^{-3}kg} \text{ or } 1.5g$$

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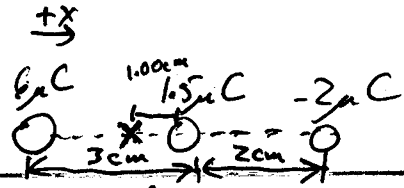


18.) Choose $x=0$ at the $6\mu C$ charge and let the positive x-direction

(a) move ~~to~~ the right.

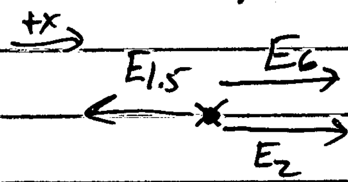
Calculate the electric field separately for each charge:

$E_6 = k_e \frac{|q_6|}{r_6^2} = (8.99\times10^9 \frac{Nm^2}{C^2}) \frac{|6\times10^{-6}C|}{(0.02m)^2} = 1.35\times10^8 N/C$ (in the +x direction) away from the 6μC charge

$E_{1.5} = k_e \frac{|q_{1.5}|}{r_{1.5}^2} = (8.99\times10^9 \frac{Nm^2}{C^2}) \frac{|1.5\times10^{-6}C|}{(0.01m)^2} = 1.35\times10^8 N/C$ (in the -x direction) away from the 1.5μC charge

$E_2 = k_e \frac{|q_2|}{r_2^2} = (8.99\times10^9 \frac{Nm^2}{C^2}) \frac{|-2.0\times10^{-6}C|}{(0.03m)^2} = 2.00\times10^7 N/C$ (in the +x direction) toward the -2μC charge

So, the point will have



Sum the electric fields to get: $E_{tot} = E_6 - E_{1.5} + E_2$

$\Rightarrow E_{tot} = 1.35\times10^8 N/C - 1.35\times10^8 N/C + 2.00\times10^7 N/C = \boxed{2.00\times10^7 N/C}$

The direction will be $\boxed{\text{to the right}}$ (the +x direction).

(b) To calculate the force on a $-2\mu C$ charge use:

$\vec{F} = q\vec{E} = (-2.00\times10^{-6}C)(2.00\times10^7 N/C) = -40 N$

This means that the magnitude of the force is $\boxed{40.0 N}$ and it will point opposite the direction of the electric field. This means the force will point $\boxed{\text{to the left}}$.

20.) The lone force on ~~o~~ the electron appears to be the

(a) electric force. Choose the direction of motion as +x:

$\Rightarrow \Sigma F = ma = F_{elec.} = |q|E \Rightarrow ma = |q|E \Rightarrow a = \frac{|q|E}{m} = \frac{|-e|E}{m}$

$\Rightarrow a = \frac{(1.602\times10^{-19}C)\, 300 N/C}{9.11\times10^{-31} kg} = \boxed{5.27\times10^{+13} m/s^2}$

(b) We know: $a = 5.27\times10^{+13} m/s^2$, $V_o = 0$, $t = 1.00\times10^{-8}s$, $\Delta x = ?$, $V \leftarrow$ finding

Use: $V = V_o + at = at = (5.27\times10^{+13} m/s^2)(1.00\times10^{-8}s) = \boxed{5.27\times10^{+5} m/s}$

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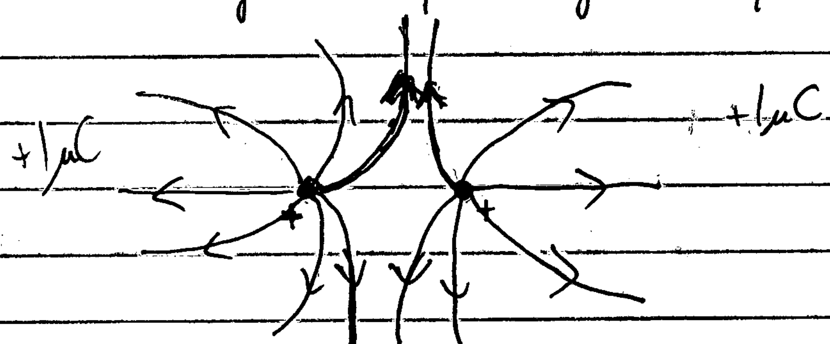
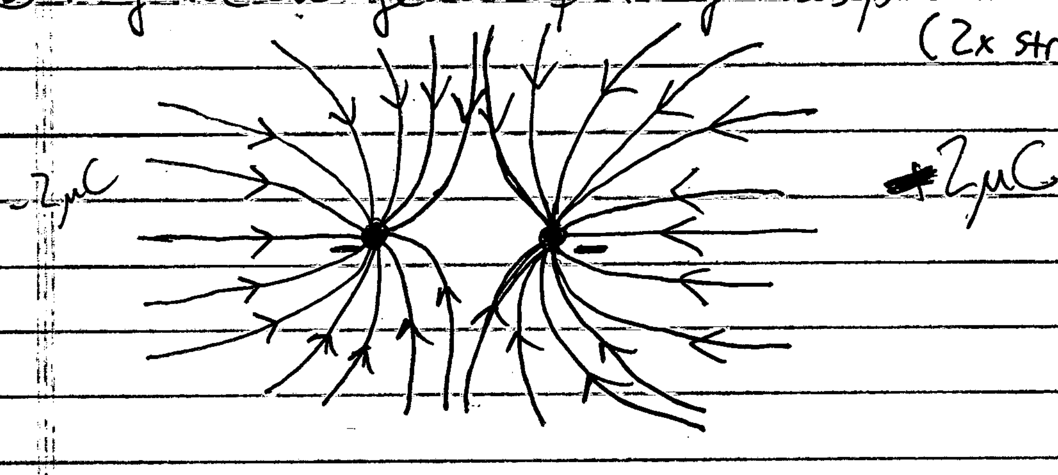
28.) The amount of lines entering or leaving a charge is proportional
(a) to the magnitude of the charge.
18 field lines leave q_2. 6 field lines enter q_1.
This means that q_2 is three times stronger than q_1.
In addition, one has field lines entering and the other has field lines leaving this means they are oppositely charged
$\Rightarrow q_1/q_2 = -1/3$

(b.) q_1 must be negatively charged as field lines are terminating on it. $\boxed{(q_1 < 0)}$
q_2 must be positively charged as field lines are starting from it. $\boxed{(q_2 > 0)}$

30.) Positive charges of equal magnitudes placed close together
(a.)


(b.) Negative charges of equal magnitudes placed close together
(2x stronger than before)


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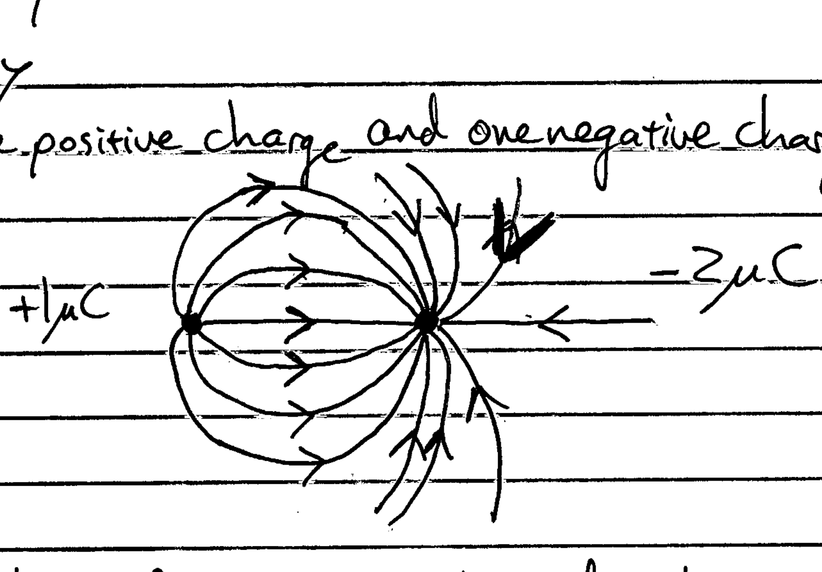
30.) One positive charge and one negative charge (~~+~~ charge 2x greater). Placed Close together.

(c.)



37.) ~~At~~ the surface you will have the electric field pointing outward

(a.) at a magnitude of 3.0×10^4 N/C.

$\Rightarrow \vec{F} = q\vec{E} = (1.602\times10^{-19}C)(3.0\times10^4 N/C) = \boxed{4.8\times10^{-15} N}$ pointing away from the generator

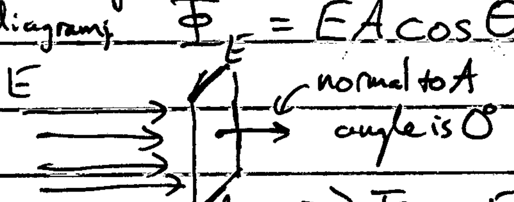
(b.) Using Newton's 2nd Law: $\Sigma\vec{F} = m\vec{a} \Rightarrow \vec{a} = \frac{\Sigma\vec{F}}{m}$

$\Rightarrow \vec{a} = \frac{(4.8\times10^{-15}N)}{(1.67\times10^{-27}kg)} = \boxed{2.9\times10^{12} m/s^2}$ pointing away from the generator

outward

38.) Using the definition of electric flux:

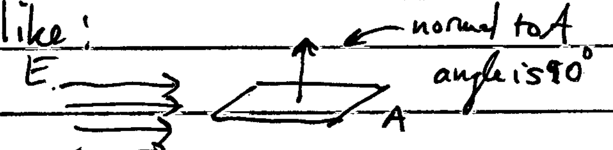
(a.) diagram: $\Phi_E = EA\cos\theta$ where θ is the angle between the electric field E and the area A.



$\Rightarrow \Phi_E = EA\cos\theta = EA\cos 0 = EA$

$\Rightarrow \Phi_E = (6.2\times10^5 N/C)(3.2m^2) = \boxed{2.0\times10^6 \frac{Nm^2}{C}}$

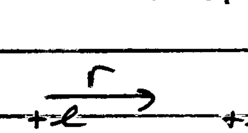
(b.) Now, the diagram will look like:



$\Rightarrow \Phi_E = EA\cos\theta = EA\cos 90° = \boxed{0}$

There is no flux through the surface.

47.) Choose left proton as r = 0.



$q_1 = +e,\ q_2 = +e,\ r_{12} = 2\times10^{-15}$ m Use Coulomb's Law:

$F_{elec} = k_e\frac{|q_1||q_2|}{r_{12}^2} = (8.99\times10^9\frac{Nm^2}{C^2})\frac{(1.602\times10^{-19}C)^2}{(2.0\times10^{-15}m)^2} = \boxed{57.7 N}$

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[35] We treat spherical charge distributions like a point charge if we are outside. Thus we want the E field of an unknown charge to equal the breakdown field at a distance equal to the sphere's radius

$$E_{breakdown} = \frac{kq}{R^2} \qquad E_{break} = 3.0 \times 10^6 \, N/C$$
$$R = 2.0 \, m$$

solve for $q \rightarrow q = \frac{R^2 E}{k} = \boxed{1.3 \, mC}$

Medium

[23] $E = 640 \, N/C$ $\qquad m_p = 1.67 \times 10^{-27} \, kg$
$V_f = 1.20 \times 10^6 \, m/s$ $\qquad q_p = +1.6 \times 10^{-19} \, C$

(a) accel of proton $= \frac{F}{m} = \frac{q_p E}{m}$ (neglect gravity)

$\boxed{a = 6.13 \times 10^{10} \, m/s^2}$

(b) How long does it take? $V = at \Rightarrow t = V/a = \frac{1.20 \times 10^6 \, m/s}{6.13 \times 10^{10} \, m/s}$

$\boxed{t = 1.96 \times 10^{-5} \, s}$

(c) How far has it moved: $d = \underbrace{d_0}_{0} + \underbrace{V_0 t}_{0} + \frac{1}{2} a t^2 = \boxed{11.8 \, m = d}$

(d) Kinetic Energy $= \frac{1}{2} m v^2 = \boxed{1.20 \times 10^{-15} \, J = KE}$

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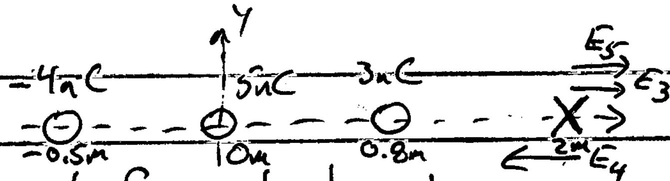
49.) Coordinate system already chosen:



Calculate the electric field separately for each charge:

$E_4 = k_e \frac{|q_4|}{r_4^2} = (8.99\times10^9 \frac{Nm^2}{C^2}) \frac{|-4\times10^{-9}C|}{(-2.5m)^2} = 5.75\ N/C$ (in the $-x$ direction)

$E_5 = k_e \frac{|q_5|}{r_5^2} = (8.99\times10^9 \frac{Nm^2}{C^2}) \frac{|5\times10^{-9}C|}{(-2.0m)^2} = 11.2\ N/C$ (in the $+x$ direction)

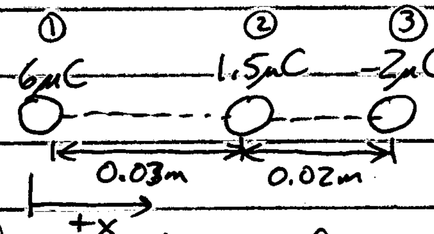
$E_3 = k_e \frac{|q_3|}{r_3^2} = (8.99\times10^9 \frac{Nm^2}{C^2}) \frac{|-3\times10^{-9}C|}{(1.2m)^2} = 18.7\ N/C$ (in the $+x$ direction)

Sum the electric fields to get: $E_{Tot.} = -E_4 + E_5 + E_3$

$\Rightarrow E_{Tot.} = -5.75\ N/C + 11.2\ N/C + 18.7\ N/C = \boxed{24\ N/C \text{ in the } +x \text{ direction}}$

Medium

10.) Choose the $6\mu C$ as $x=0$ and the right as the $+x$ direction.



Since there are three charges, there are also six forces:

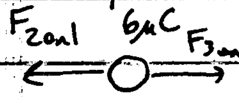
$F_{1on2}, F_{1on3}, F_{2on1}, F_{2on3}, F_{3on1}, F_{3on2}$ but only 3 are unique in magnitude

$F_{1on2} = F_{2on1} = k_e \frac{|q_1||q_2|}{r_{12}^2} = (8.99\times10^9 \frac{Nm^2}{C^2}) \frac{|6\times10^{-6}C||1.5\mu C|}{(0.03m)^2} = 89.9N$

$F_{1on3} = F_{3on1} = k_e \frac{|q_1||q_3|}{r_{13}^2} = (8.99\times10^9 \frac{Nm^2}{C^2}) \frac{|6\times10^{-6}C||-2\times10^{-6}C|}{(0.05m)^2} = 43.2N$

$F_{2on3} = F_{3on2} = k_e \frac{|q_2||q_3|}{r_{23}^2} = (8.99\times10^9 \frac{Nm^2}{C^2}) \frac{|1.5\times10^{-6}C||-2\times10^{-6}C|}{(0.02m)^2} = 67.4N$

Now, let us find out the direction for the forces on charge ①



F_{2on1} will repel, while F_{3on1} will attract.

F_{2on1} is in the $-x$ direction, F_{3on1} is in the $+x$ direction.

$\Rightarrow$ Forces on $6\mu C \Rightarrow \sum F_{on1} = F_{2on1} + F_{3on1} = -89.9N + 43.2N = -46.7N$

The net force is $\boxed{46.7N \text{ to the left on the } 6\mu C \text{ charge.}}$

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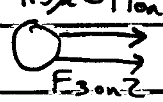
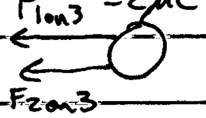
Medium

10.) Next, let's find out the direction for the forces on charge ②
(cont.)



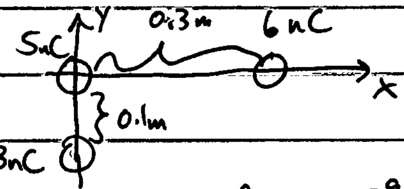
F_{1on2} will repel, while F_{3on2} will attract.
F_{1on2} is in the $+x$ direction, F_{3on2} is also in the $+x$ direction.
$\Rightarrow$ Forces on $1.5\mu C \Rightarrow \Sigma F_{on2} = F_{1on2} + F_{3on2} = 89.9N + 67.4N = 157N$
The net force is $\boxed{157N \text{ to the right on the } 1.5\mu C \text{ charge.}}$

Finally, let's find out the direction for the forces on charge ③



F_{1on3} will attract, and F_{2on3} will attract
F_{1on3} is in the $-x$ direction, F_{2on3} is also in the $-x$ direction.
$\Rightarrow$ Forces on $-2\mu C \Rightarrow \Sigma F_{on3} = F_{1on3} + F_{2on3} = -43.2N - 67.4N = -111N$
The net force is $\boxed{111\,N \text{ to the left on the } -2.0\mu C \text{ charge.}}$

11.) Coordinate system already chosen;
Calculate each force separately:

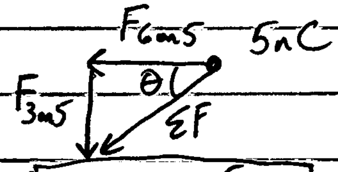


First, calculate F_{6on5} then F_{3on5}

$$\Rightarrow F_{6on5} = k_e \frac{|q_6||q_5|}{r_{65}^2} = \left(8.99\times10^9 \frac{Nm^2}{C^2}\right) \frac{(6\times10^{-9}C)(5\times10^{-9}C)}{(0.3m)^2} = 3.00\times10^{-6}N$$

$$\Rightarrow F_{3on5} = k_e \frac{|q_3||q_5|}{r_{35}^2} = \left(8.99\times10^9 \frac{Nm^2}{C^2}\right) \frac{|-3\times10^{-9}C||5\times10^{-9}C|}{(0.1m)^2} = 1.35\times10^{-5}N$$

The direction of F_{6on5} will be repulsive; it will point in the $-x$ direction.
The direction of F_{3on5} will be attractive; it will point in the $-y$ direction.
The forces on the 5nC will be:



$\Rightarrow \Sigma \vec{F}_{on5} = \vec{F}_{6on5} + \vec{F}_{3on5}$
Magnitude $\Rightarrow \Sigma F = \sqrt{F_{6on5}^2 + F_{3on5}^2}$
$\Rightarrow \Sigma F = \sqrt{(3.00\times10^{-6}N)^2 + (1.35\times10^{-5}N)^2} = \boxed{1.38\times10^{-5}N}$

Direction $\Rightarrow \tan\theta = \frac{F_{3on5}}{F_{6on5}} = \frac{1.35\times10^{-5}N}{3.00\times10^{-6}N} = 4.5 \Rightarrow \theta = \tan^{-1}(4.5) = \boxed{77.5^\circ}$
The net force on the 5nC charge is $\boxed{1.38\times10^{-5}N \text{ directed } 77.5^\circ \text{ below } -x \text{ axis.}}$

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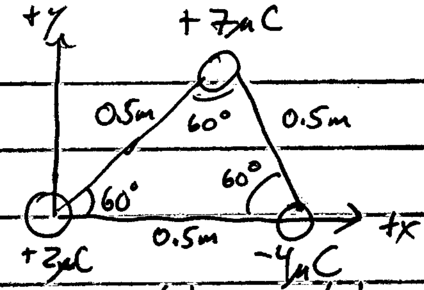
Medium



13.) Coordinate system already chosen;

Calculate each force separately:

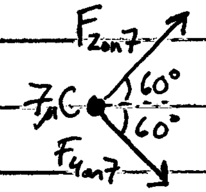
First, calculate F_{2on7}, then F_{4on7}

$\Rightarrow F_{2on7} = k_e \frac{|q_2||q_7|}{r_{27}^2} = (8.99\times10^9 \frac{Nm^2}{C^2}) \frac{|2\times10^{-6}C||7\times10^{-6}C|}{(0.5m)^2} = 0.503N$

$\Rightarrow F_{4on7} = k_e \frac{|q_4||q_7|}{r_{47}^2} = (8.99\times10^9 \frac{Nm^2}{C^2}) \frac{|-4\times10^{-6}C||7\times10^{-6}C|}{(0.5m)^2} = 1.01N$

The direction of F_{2on7} will be repulsive; the direction of F_{4on7} will be attractive

The forces on $7\mu C$ will be:



$\Rightarrow$ break into components and add

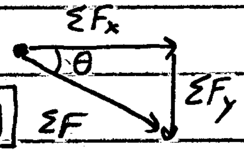
$\Sigma F_x = (F_{2on7})\cos60^\circ + (F_{4on7})\cos60^\circ$

$\Rightarrow \Sigma F_x = (F_{2on7} + F_{4on7})\cos60^\circ = (0.503N + 1.01N)(\frac{1}{2}) = 0.756N$

$\Sigma F_y = (F_{2on7})\sin60^\circ - (F_{4on7})\sin60^\circ = (F_{2on7} - F_{4on7})\sin60^\circ$

$\Rightarrow \Sigma F_y = (0.503N - 1.01N)(0.866) = -0.436N$

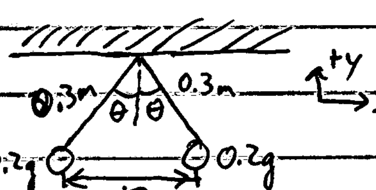
To find resultant, use Pythagorean Theorem:



$\Rightarrow \Sigma F = \sqrt{\Sigma F_x^2 + \Sigma F_y^2} = \sqrt{(0.756N)^2 + (-0.436N)^2} = \boxed{0.872N}$

Direction $\Rightarrow \tan\theta = \frac{\Sigma F_y}{\Sigma F_x} = \frac{0.436N}{0.756N} = 0.577 \Rightarrow \theta = \tan^{-1}(0.577) = \boxed{30.0^\circ}$

The net force on the $7\mu C$ charge is $\boxed{0.872N \text{ directed } 30.0^\circ \text{ below } +x \text{ axis.}}$



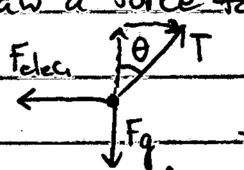
← balls are at rest

$\Rightarrow \Sigma F = 0$

$q_1 = q_2 = q$

15.) Choose up as +y direction and to the right as +x direction.

Draw a force diagram for the left sphere:



Break Tension into components: $T_x = T\sin\theta$, $T_y = T\cos\theta$

$\Rightarrow \Sigma F_y = T_y - F_g = 0 \Rightarrow T_y = F_g \Rightarrow T\cos\theta = mg \Rightarrow T = \frac{mg}{\cos\theta}$

Now in the x-direction: $\Sigma F_x = T_x - F_{elec} = 0 \Rightarrow F_{elec} = T_x = T\sin\theta$

$\Rightarrow k_e \frac{q_1 q_2}{r^2} = T\sin\theta = (\frac{mg}{\cos\theta})\sin\theta = mg\tan\theta$

$\Rightarrow k_e \frac{q^2}{r^2} = mg\tan\theta \Rightarrow q^2 = \frac{mgr^2\tan\theta}{k_e} \Rightarrow q = \sqrt{\frac{mgr^2\tan\theta}{k_e}}$

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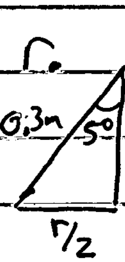
Medium

15.) We know the value for every variable except r.
(cont) Look back at the triangle to get that value.



$\sin 5^\circ = \frac{r/2}{0.3m}$

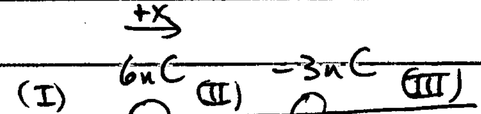
$\Rightarrow r = 2(0.3m)\sin 5^\circ$

$\Rightarrow r = 0.0523m$

$$\Rightarrow q = \sqrt{\frac{(0.20\times10^{-3}kg)(9.8\,N/kg)(0.0523m)^2\tan 5^\circ}{8.99\times10^{9}\,Nm^2/C^2}}$$

$$\Rightarrow q = 7.2\times10^{-9}C = \boxed{7.2nC}$$

16.) Make a diagram of the situation.

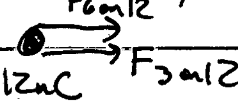


Choose the right as the +x direction. A +12nC charge needs to be placed somewhere on the x-axis where it will feel no net electrostatic force.

It can be placed in one of three regions (I), (II), or (III).

If it is placed in (II) it will be repelled by 6nC and attracted by -3nC

This can never lead to a zero electrostatic force. Can't place in (II).

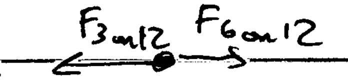


If it is placed in (I) it will be repelled by 6nC and attracted by -3nC

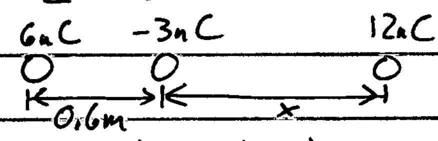
Then F_{6on12} will always be greater than F_{3on12} since it has a greater charge and it will have a smaller r in $F = k_e\frac{|q_1||q_2|}{r^2}$

The only place it can go is in region (III) where it is closer to the smaller charge.

$\Sigma F_{on12} = 0 = F_{6on12} - F_{3on12} \Rightarrow F_{6on12} = F_{3on12}$



$$\Rightarrow k_e\frac{|q_6||q_{12}|}{r_{6\,12}^2} = k_e\frac{|q_3||q_{12}|}{r_{3\,12}^2}$$



where $r_{6\,12} = x + 0.6m$ and $r_{3\,12} = x$; cancelling out k_e & $|q_{12}|$ gives:

$$\frac{|q_6|}{(x+0.6m)^2} = \frac{|q_3|}{x^2} \Rightarrow \frac{6nC}{(x+0.6m)^2} = \frac{3nC}{x^2} \Rightarrow \frac{2}{(x+0.6m)^2} = \frac{1}{x^2}$$

$$\Rightarrow 2x^2 = (x+0.6m)^2 \Rightarrow 2x^2 = x^2 + (1.2m)x + 0.36m^2$$

$$\Rightarrow x^2 - (1.2m)x - (0.36m^2) = 0$$

Use quadratic formula

$$\Rightarrow x = \frac{1.2m \pm \sqrt{(-1.2m)^2 - 4(1)(-0.36m^2)}}{2(1)}$$

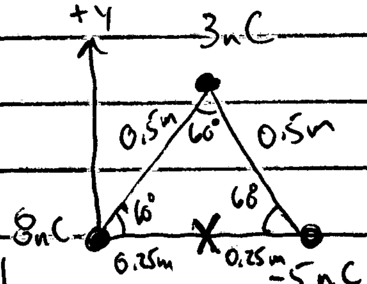
$$\Rightarrow x = 0.6m \pm 0.849m \Rightarrow x = 1.45m \text{ or } x = -0.25m$$

As it turns out 12nC is $\boxed{\text{1.45m past -3nC}}$

Chap 15

Medium

24.) Coordinate system is already chosen.
Calculate each electric field vector separately.



$E_8 = k_e \frac{|q_8|}{r_8^2} = \left(8.99 \times 10^9 \frac{Nm^2}{C^2}\right) \frac{|8 \times 10^{-9} C|}{(0.25m)^2}$

$\Rightarrow E_8 = 1150\ N/C$ (points in the +x direction).

$E_5 = k_e \frac{|q_5|}{r_5^2} = \left(8.99 \times 10^9 \frac{Nm^2}{C^2}\right) \frac{|-5 \times 10^{-9} C|}{(0.25m)^2} = 719\ N/C$ (points in the +x direction)

$E_3 = k_e \frac{|q_3|}{r_3^2}$ here r_3 is $0.5m$ $30°$ r_3 $\Rightarrow \cos 30° = \frac{r_3}{0.5m} \Rightarrow r_3 = (0.5m)\cos 30° = 0.433m$

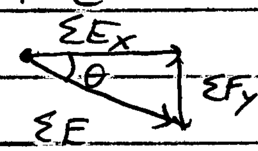
$\Rightarrow E_3 = \left(8.99 \times 10^9 \frac{Nm^2}{C^2}\right) \frac{|3 \times 10^{-9} C|}{(0.433m)^2} = 144\ N/C$ (points in the -y direction)

Sum E-field vectors in like directions: $\Sigma E_x = 1150\ N/C + 719\ N/C = 1870\ N/C$

$\Sigma E_y = -144\ N/C$

For magnitude:

$\Sigma E = \sqrt{\Sigma E_x^2 + \Sigma E_y^2} = \sqrt{(1870\ N/C)^2 + (-144\ N/C)^2}$

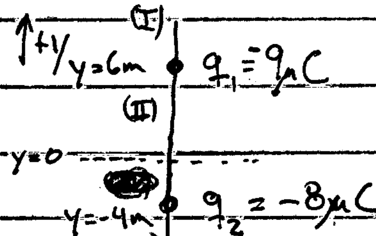


$\Rightarrow \Sigma E = \boxed{1880\ N/C}$

For direction: $\tan\theta = \frac{\Sigma E_y}{\Sigma E_x} = \frac{144\ N/C}{1870\ N/C} = 0.077 \Rightarrow \theta = \tan^{-1}(0.077) = 4.40°$ below x axis

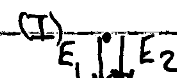
The net electric field is $\boxed{1880\ N/C \text{ directed } 4.40° \text{ below x-axis.}}$

26.) Coordinate system already chosen for us:

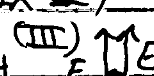


The electric field could be zero in either region (I), (II), or (III).

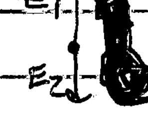
Both charges are negative.



If E=0 in region (I), then E_1 would have to oppose E_2, but they are in the same direction. So point can't be in region (I)



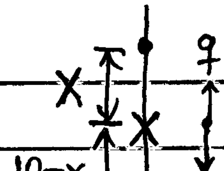
If E=0 in region (III), then E_1 would have to oppose E_2, but they are in the same direction. So point can't be in region (III).



This leaves region (II) as the only place where E_1 and E_2 can be equal in magnitude and opposite.

Chap 15

Medium



↑+y q_1 at $y = +6m$

q_2 at $y = -4m$

26.) The distance between the point

(cont.) and either charge is: $r_1 = x$, $r_2 = 10m - x$

$\Rightarrow E_1 = k_e \frac{|q_1|}{r_1^2}$ & $E_2 = k_e \frac{|q_2|}{r_2^2}$ → in the +y-direction

-y dir.

$\Rightarrow \Sigma E = -E_1 + E_2 = 0 \Rightarrow E_1 = E_2 \Rightarrow k_e \frac{|q_1|}{r_1^2} = k_e \frac{|q_2|}{r_2^2} \Rightarrow \frac{|q_1|}{r_1^2} = \frac{|q_2|}{r_2^2}$

$\Rightarrow \frac{|-9\mu C|}{x^2} = \frac{|-8\mu C|}{(10m - x)^2} \Rightarrow \frac{9/8}{x^2} = \frac{1}{(10m - x)^2} \Rightarrow \frac{9}{8}(10m - x)^2 = x^2$

$\Rightarrow (100m^2 - (20m)x + x^2) = \frac{8}{9}x^2 \Rightarrow \frac{1}{9}x^2 - (20m)x + 100m^2 = 0$

$\Rightarrow x^2 - (180m)x + 900m^2 = 0$

Use the quadratic formula: $x = \frac{180m \pm \sqrt{(-180m)^2 - 4(1)(900m^2)}}{2(1)}$

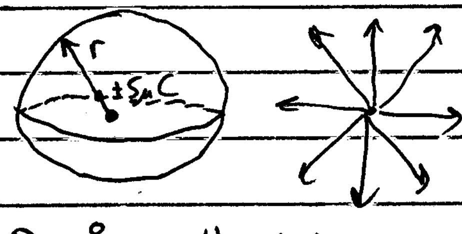
$\Rightarrow x = 90m \pm 84.85m \Rightarrow x = 175m$ ← this would put $E = 0$ in region (II), not correct

or $x = 5.15m$ which is correct

Thus, $E = 0$ at 5.15m below the $-9\mu C$ charge. Since q_1 is at $y = +6m$

$\Rightarrow E = 0$ at $y = 6m - 5.15m = \boxed{0.85m}$.

42.) Make the charge $r = 0$. At any point on the sphere the electric field lines will be perpendicular to the surface and parallel to the normal. $\Rightarrow \theta = 0°$ at all points.



The surface area of the sphere will be: $A = 4\pi r^2$

The electric field given by the charge will be: $E = k_e \frac{|q|}{r^2}$

The electric flux will then be:

$\Phi_E = EA\cos\theta = (k_e \frac{|q|}{r^2})(4\pi r^2)\cos 0° = 4\pi k_e |q|$

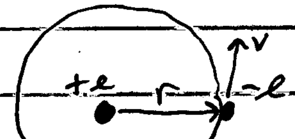
$\Rightarrow \Phi_E = 4\pi(8.99 \times 10^9 \frac{Nm^2}{C^2})(5 \times 10^{-6} C) = \boxed{5.65 \times 10^5 \frac{Nm^2}{C}}$

Note: we didn't need to know r here. The same amount of flux would exit a sphere of any size.

Chap 15

Medium

48.) Choose the proton to be at $r=0$



ⓐ with the electron "orbiting" it.

$q_{proton} = +e$, $q_{electron} = -e$, $r_{ep} = 0.53\times10^{-10}$ m

Using Coulomb's Law: $F_{elec} = k_e \frac{|q_1||q_2|}{r^2} = k_e \frac{|+e||-e|}{r^2} = k_e \frac{e^2}{r^2}$

$\Rightarrow F_{elec} = (8.99\times10^{9}\,\frac{Nm^2}{C^2})\frac{(1.602\times10^{-19}C)^2}{(0.53\times10^{-10}m)^2} = \boxed{8.2\times10^{-8}N}$ The forces are attractive

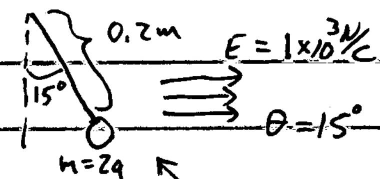
ⓑ The only force acting on the electron is the electrostatic force,

$\Rightarrow \Sigma F = F_{elec} = m_e a_c = m_e \frac{v^2}{r}$ where $a_c = \frac{v^2}{r}$ centripetal acceleration

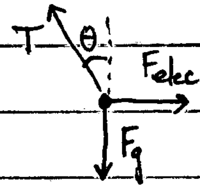
$\Rightarrow v^2 = \frac{(F_{elec})r}{m_e} \Rightarrow v = \sqrt{\frac{(F_{elec})(r)}{m_e}} = \sqrt{\frac{(8.2\times10^{-8}N)(0.53\times10^{-10}m)}{(9.11\times10^{-31}kg)}} = \boxed{2.2\times10^{6}\,m/s}$

50.) Coordinate system already chosen: +y ↑ → +x

Draw a force diagram for the plastic ball:



at rest, $\Sigma F=0$



(Note: F_{elec} could have pointed in +x or −x but since it must oppose tension, it has to be +x)

Break tension into components: $T_x = T\sin\theta$, $T_y = T\cos\theta$

$\Rightarrow \Sigma F_y = T_y - F_g = 0 \Rightarrow T_y = F_g \Rightarrow T\cos\theta = mg \Rightarrow T = \frac{mg}{\cos\theta}$

Now in the x-direction: $\Sigma F_x = -T_x + F_{elec} = 0 \Rightarrow F_{elec} = T_x = T\sin\theta$

$\Rightarrow F_{elec} = (\frac{mg}{\cos\theta})\sin\theta \Rightarrow qE = mg\tan\theta \Rightarrow q = \frac{mg\tan\theta}{E}$

$\Rightarrow q = \frac{(2.0\times10^{-3}kg)(9.8\,N/kg)\tan 15^\circ}{(1.0\times10^{3}\,N/C)} = 5.25\times10^{-6}C = \boxed{5.25\mu C}$

Note: we couldn't use Coulomb's Law here because we don't know if E is caused by a point charge or not.

Physics 1B Solutions

Medium

52 $m = 1.00\,g = .001\,kg$ w/ (+) charge
$h = 5\,m$
$E = 1.00 \times 10^4\,N/C$
$V_f = 21.0\,m/s$

(a) If the field points down, the field will cause an additional force to gravity & V_f will be larger than if only gravity were acting. If $\vec{E}$ points upward, V_f will be lower. Thus, we need to find v_f if only gravity were acting.

$$KE = PE \rightarrow \frac{1}{2}mV_f^2 = mgh \rightarrow V_f = \sqrt{2gh}$$

(grav) $V_f = 9.9\,m/s$ → Thus E points down b/c the true final velocity is greater than this

$\boxed{\text{E points down}}$

(b) Find charge on bead: The formula on left tells us we need a_E; we know $a_E = a_{TOT} - \text{gravity}$ and

$$F = qE = ma_E \qquad a_{TOT} = \frac{V^2}{2d} = 44.1\,m/s^2$$

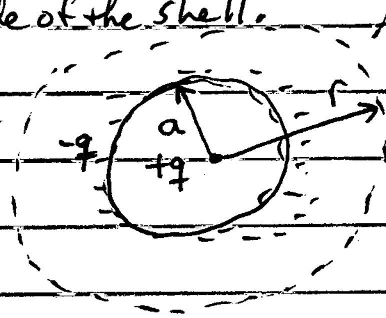
$$q = \frac{ma_E}{E} \qquad \text{So } a_E = 34.3\,m/s^2$$

$$\boxed{q = +3.43\,\mu C}$$

Chap 15

Hard

43) We want to know the electric field outside of the shell.



(a) Choose $r = 0$ as the $+q$ charge.

Use Gauss's Law, a spherical surface of radius r $(r > a)$.

via Gauss's Law: $\Phi_E = \frac{Q_{inside}}{\varepsilon_0}$

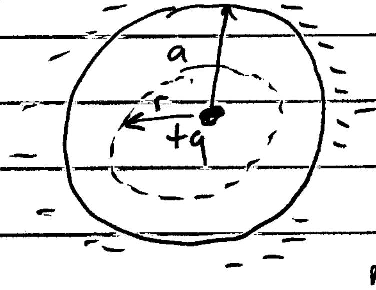
but here $Q_{inside} = +q + (-q) = 0 \Rightarrow \Phi_E = 0$ for the sphere

By definition of flux:

$\Rightarrow \Phi_E = EA\cos\theta = E(4\pi r^2)\cos 0° = E(4\pi r^2)$

So, $0 = E(4\pi r^2) \Rightarrow \boxed{E = 0}$ ← there is no electric field outside sphere $(r > a)$.

(b) Now, we are inside the negatively charged shell.

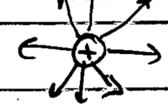


Choose $r = 0$ as the $+q$ charge.

Use Gauss's Law, a spherical surface of radius r $(r < a)$.

via Gauss's Law: $\Phi_E = \frac{Q_{inside}}{\varepsilon_0}$

here $Q_{inside} = +q \Rightarrow \Phi_E = \frac{+q}{\varepsilon_0}$



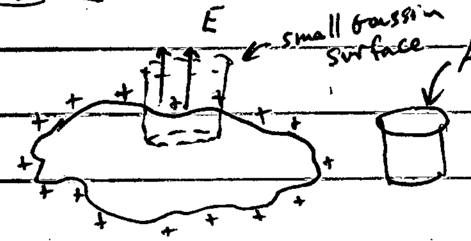
By definition of flux:

$\Rightarrow \Phi_E = EA\cos\theta = E(4\pi r^2)\cos 0° = E(4\pi r^2)$

So, $\frac{+q}{\varepsilon_0} = E(4\pi r^2) \Rightarrow E = \frac{1}{4\pi\varepsilon_0}\frac{+q}{r^2} = k_e\frac{+q}{r^2}$ ← inside negative field. where $k_e = \frac{1}{4\pi\varepsilon_0}$

The direction will be outward, radially.

$\Rightarrow \boxed{E = k_e\frac{+q}{r^2} \text{ directed radially outward}}$



46.) For the conductor we know some facts:

1.) The electric field is zero inside the conductor.

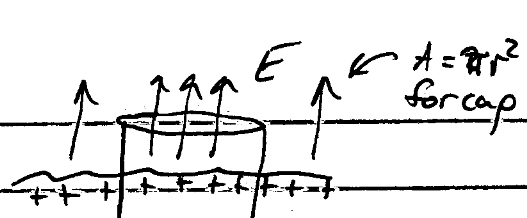
2.) All charge resides at the surface.

3.) The electric field is perpendicular to the conductor's surface.

Choose a very small cylindrical Gaussian surface one end in conductor.

Chap 15

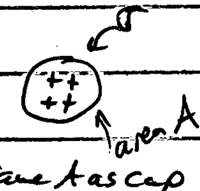
Hard



46.) (cont.) There will be no electric field in any part of the surface that is inside the conductor. Plus, since the electric field is perpendicular to the surface, it will only flow through the "cap" (circular region) of the Gaussian surface.

$\Rightarrow \Phi = EA\cos\theta = EA\cos 0^\circ = EA$ ⇐ where A is area of the circular cap,

The charge enclosed by the Gaussian surface will be:



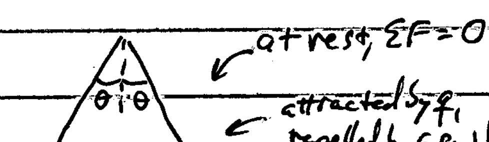
$\sigma A = Q_{inside}$ since σ is charge density

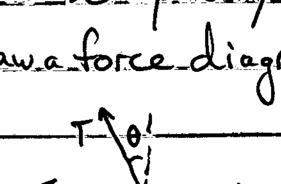
Via Gauss's Law

$\Rightarrow \Phi_E = \frac{Q_{inside}}{\varepsilon_0} \Rightarrow EA = \frac{\sigma A}{\varepsilon_0} \Rightarrow \boxed{E = \frac{\sigma}{\varepsilon_0}}$

57.) Choose up as +y and to the right as +x: +y +x

Draw a force diagram for the positive sphere.





Break tension into components: $T_x = T\sin\theta$, $T_y = T\cos\theta$

Sum like components:

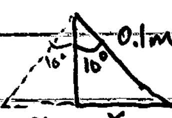
$\Rightarrow \Sigma F_y = T_y - F_g = 0 \Rightarrow T_y = F_g \Rightarrow T\cos\theta = mg \Rightarrow T = \frac{mg}{\cos\theta}$

Now in the x-direction: $\Sigma F_x = F_{elec} - F_{1on2} - T\sin\theta = 0$

$\Rightarrow F_{E on 2} = F_{1 on 2} + T\sin\theta = k_e \frac{|q_1||q_2|}{r_{12}^2} + \frac{mg}{\cos\theta}\sin\theta$

$\Rightarrow q_2(E) = k_e \frac{|q_1||q_2|}{r_{12}^2} + mg\tan\theta \Rightarrow E = k_e \frac{|q_1|}{r_{12}^2} + \frac{mg}{q_2}\tan\theta$

To find r_{12} look at triangle!



$\sin 10^\circ = \frac{x}{0.1m} \Rightarrow x = 0.1m \cdot \sin 10^\circ$

$\Rightarrow x = 0.0174 m$

$\Rightarrow r_{12} = 2x = 0.0347 m$

$\Rightarrow E = (8.99\times10^9 \frac{Nm^2}{C^2})\frac{(5\times10^{-8}C)}{(0.0347m)^2} + \frac{(2\times10^{-3}kg)(9.8 N/kg)}{(5\times10^{-8}C)}\tan 10^\circ = 3.73\times10^5 N/C + 6.9\times10^4 N/C$

$\Rightarrow E = \boxed{4.4\times10^5 N/C}$

Physics 1B Solutions

Hard

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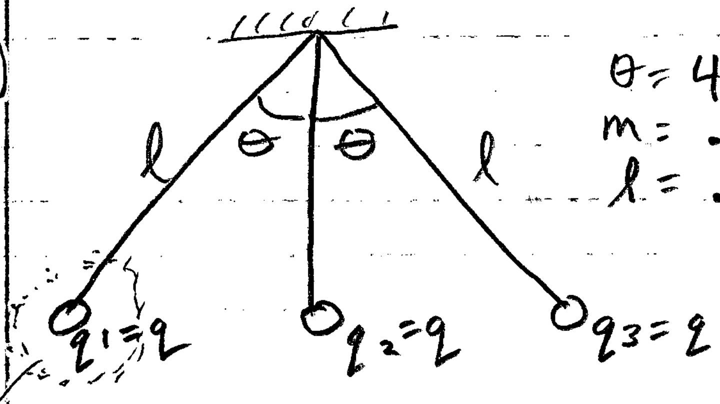
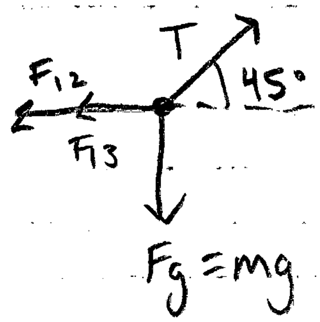


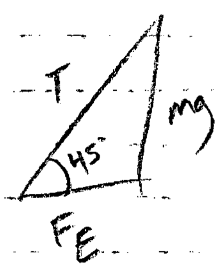
$\theta = 45°$
$m = .1$ kg
$l = .3$ m

Find q on each (all have $+q$)

Notes: ① By sym. we can examine only one side
② we must balance the forces on each charge

Examine left charge:





Need distances for Coulomb force equation:

$R_{12} = l\cos\theta = (.3\,m)\cos 45$

$R_{12} = .212\,m$

$R_{13} = 2R_{12} = .424\,m$

From diagram: $\tan 45° = \frac{mg}{F_E} = 1 \rightarrow mg = F_E = F_{12} + F_{13}$

$F_{13} = \frac{kq^2}{R_{13}^2}$; $F_{12} = \frac{kq^2}{R_{12}^2}$; $F_E = kq^2\left(\frac{1}{R_{13}^2} + \frac{1}{R_{12}^2}\right)$

$F_E = kq^2\,(27.8\,m^{-2})$

$F_E = mg \rightarrow kq^2(27.8\,m^{-2}) = mg \rightarrow q = \sqrt{\frac{mg}{k(27.8\,m^{-2})}}$

$\boxed{q = 1.98\,\mu C}$