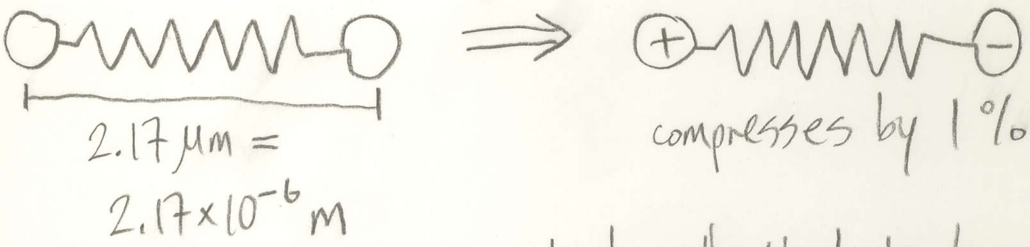
$\boxed{15-6}$



since it says it acts like a spring, start with Hooke's law

$F = -kd$ where d is the compression distance

$d = 1\%$ of length $= (0.01)(2.17\times10^{-6}\,m)$

$= 2.17\times10^{-8}\,m$

the force acting on the spring is the Coulomb force, F_c, which is equal and opposite to the spring force

$F_c = kd \qquad F_c = k_e \dfrac{q_1 q_2}{r^2} \qquad k_e = 8.99\times10^{9}\,\dfrac{Nm^2}{C^2}$

$q_1 = q_2 = 1.6\times10^{-19}\,C$

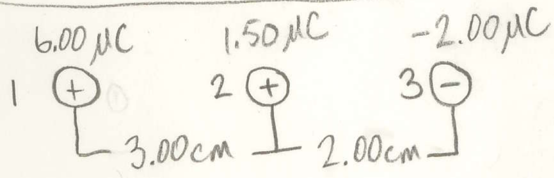
r = distance between the charges $= (0.99)(2.17\times10^{-6}\,m)$

$= 2.148\times10^{-6}\,m$

$$k_e\frac{q_1q_2}{r^2} = kd \Rightarrow k = \frac{k_e q_1 q_2}{d\,r^2} = \frac{(8.99\times10^{9})(1.6\times10^{-19})^2}{(2.17\times10^{-8})(2.148\times10^{-6})^2}$$

$$= 2.30\times10^{-9}\,\frac{N}{m}$$

$\boxed{15-10}$



use Coulomb's law and remmember to convert to C and m first force on charge 1

$$F_1 = k_e \frac{q_1 q_2}{d_{12}^2} + k_e \frac{q_1 q_3}{d_{13}^2}$$

$$= \frac{(8.99\times10^9)(6.00\times10^{-6})(1.50\times10^{-6})}{(3.00\times10^{-2})^2} + \frac{(8.99\times10^9)(6.00\times10^{-6})(-2.00\times10^{-6})}{(5.00\times10^{-2})^2}$$

$= 46.7$ N to the left

similarly

$$F_2 = \frac{(8.99\times10^9)(1.50\times10^{-6})(6.00\times10^{-6})}{(3.00\times10^{-2})^2} - \frac{(8.99\times10^9)(1.50\times10^{-6})(-2.00\times10^{-6})}{(2.00\times10^{-2})^2}$$

$= 157$ N to the right

$$F_3 = \frac{(8.99\times10^9)(-2.00\times10^{-6})(1.50\times10^{-6})}{(2.00\times10^{-2})^2} + \frac{(8.99\times10^9)(-2.00\times10^{-6})(6.00\times10^{-6})}{(5.00\times10^{-2})^2}$$

$= 111$ N to the left

$\boxed{5-20}$ $E = 300 \frac{N}{C}$

a use the field to find the force and then the acceleration

$F = Eq \quad F = ma \Rightarrow Eq = ma$ $\quad m$ = mass of electron $= 9.11\times10^{-31}$ kg

$$a = \frac{Eq}{m}$$

$$a = \frac{(300)(1.6\times10^{-19})}{(9.11\times10^{-31})}$$

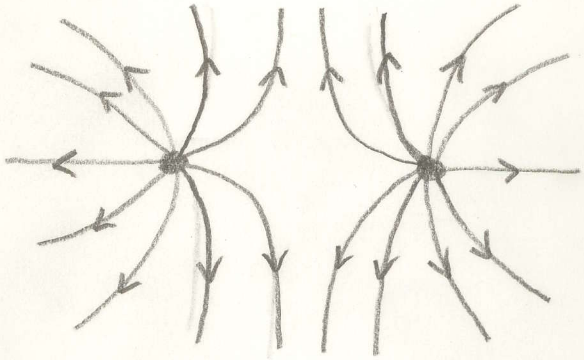
$$= 5.27\times10^{13} \frac{m}{s^2}$$

b the relevant equation is $v = v_0 + at$

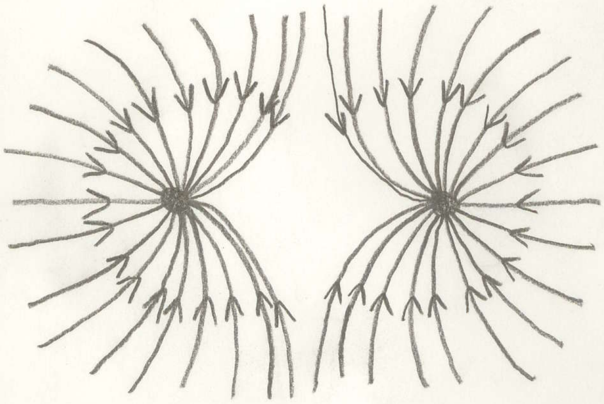
with $v_0 = 0.00$ m/s , $t = 1.00 \times 10^{-8}$ s

$$v = at = (5.27 \times 10^{13})(1.00 \times 10^{-8}) = 5.27 \times 10^{5}\ \frac{m}{s}$$

$\boxed{15-30}$ a

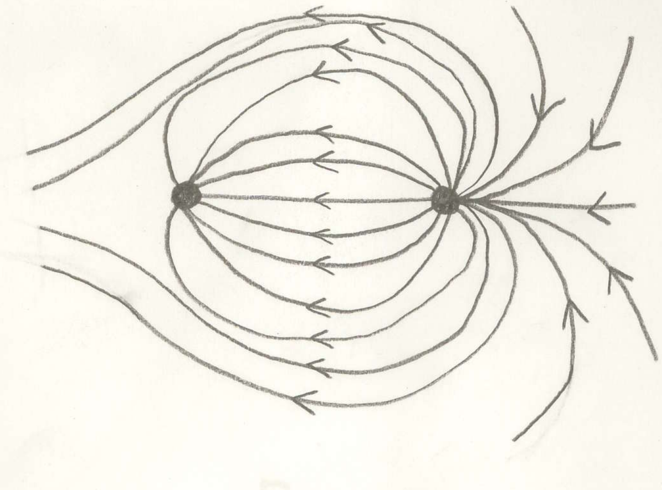


b



twice the charge hence twice the number of field lines

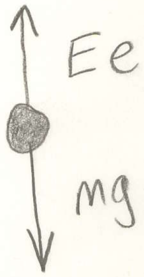
c



$\boxed{15-36}$ given $E = 3\times10^4 \frac{N}{C}$ $\quad e = 1.6\times10^{-19}\,C$

$\rho = 858 \frac{kg}{m^3}$

draw free body diagram



stationary

$F_{NET} = 0$

we can use this to solve for the mass, which can then be used, along with the density, to find the volume and finally the radius

$$Ee - mg = 0 \Rightarrow m = \frac{Ee}{g} = \frac{(3\times10^4)(1.6\times10^{-19})}{9.8}$$

$$= 4.900\times10^{-16}\ kg$$

(do not round until the end)

now solve $\rho = \frac{m}{V}$ for V

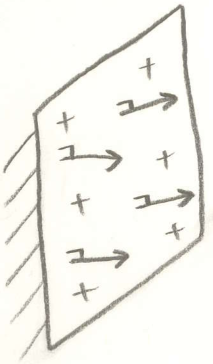
$$V = \frac{m}{\rho} = \frac{4.900\times10^{-16}}{858} = 5.709\times10^{-19}\ m^3$$

now assume the oil drops are spheres and use the formula for the volume of a sphere

$$V = \frac{4}{3}\pi r^3 \Rightarrow r = \left(\frac{3}{4\pi}V\right)^{\frac{1}{3}}$$

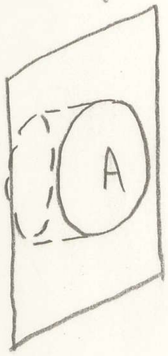
$$= \left[\frac{(3)(5.709\times10^{-19})}{(4)(3.1416)}\right]^{1/3} = 5.1\times10^{-7}\ m$$

$\boxed{15-46}$ first use the given information to draw the electric field



there is no field inside the conductor and very close to the outside surface the field is perpendicular and uniform across the surface
additionally all the charge is uniformly distributed on the surface with density σ

now choose a Gaussian surface – the best one is one that will make the calculation easiest by always being perpendicular or parallel to the field
lets use a cylinder of very small height (a coin or a Gaussian pillbox)



now calculate the flux through all the surfaces
- the inner one has 0 flux because there is no field inside
- the sides have 0 flux because the field is parallel to them (no field lines cross the sides)
- the outer one has $\Phi = EA$ because the field is constant and everywhere perpendicular

now use Gauss' law $\Phi = \frac{q}{\epsilon_0}$

q is the total charge inside the Gaussian surface and since all the charge is uniformly distributed on the surface of the metal it is

$q = (\text{charge per area})(\text{area}) = \sigma A$

combining everything gives

$$\Phi = \frac{q}{\epsilon_0} \Rightarrow E\cancel{A} = \frac{\sigma \cancel{A}}{\epsilon_0} \Rightarrow E = \frac{\sigma}{\epsilon_0}$$

force between charges

$$F = k\frac{QQ}{d^2}$$

i Q becomes $4Q$ $\quad F' = k\frac{Q4Q}{d^2} = 4k\frac{QQ}{d^2} = 4F$ $\quad$ B

ii by Newton's third law, the force are equal and opposite, hence the magnitude is the same $\quad$ B

iii d becomes $3d$ $\quad F'' = k\frac{Q4Q}{(3d)^2} = \frac{4}{9}k\frac{QQ}{d^2} = \frac{4}{9}F$ $\quad$ C

iv the forces would be the same because they depend only on the relative sign between charges $\quad$ A

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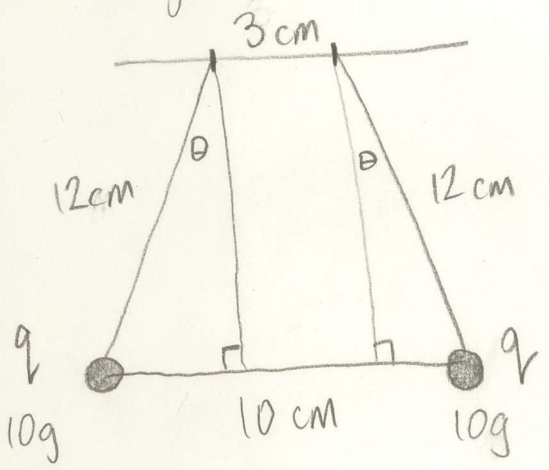
estimating charge

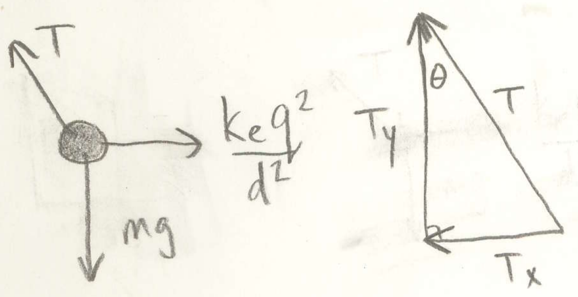
since the figure is to scale, we can find all distances by comparison to the given 3 cm



lets assume the charge is the same on both
(identical spheres prepared the same way
by trigonometry the angle is

$$\theta = \sin^{-1}\frac{3.5}{12} = 17^\circ$$

draw the free body diagram



decompose T into T_x and T_y and use Newton's second law

$$T_x = T\sin\theta$$

$$T_y = T\cos\theta$$

$$T_x = \frac{k_e q^2}{d^2} \quad T_y = mg$$

$$\frac{T_x}{T_y} = \frac{\cancel{T} \sin\theta}{\cancel{T} \cos\theta} = \tan\theta = \frac{\frac{k_e q^2}{d^2}}{mg} = \frac{k_e q^2}{mgd^2}$$

solve for q $\quad q = \pm\sqrt{\frac{mg\,d^2 \tan\theta}{k_e}}$

$$= \pm\sqrt{\frac{(0.01)(9.8)(0.1)^2(\tan 17^\circ)}{8.99 \times 10^9}}$$

$$= \pm 1.8 \times 10^{-7}\,C \simeq \pm 2 \times 10^{-7}\,C$$

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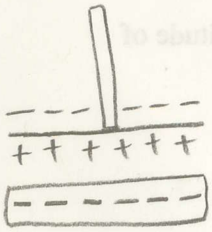
tutorial question

A bringing the metal electrode close to the charged Teflon plate polarizes it



touching the top grounds it and removes some negative charge, leaving the metal electrode with a net negative charge

the charge on the plate is not used up in the process because nothing is actually done to it — objects are brought close to it but nothing touches it

B a when the charged metal disc touches the knob, some charge is transferred to it and the rest of the electroscope; the two gold leaves are now charged to the same charge and repel each other (as in problem "estimating charge")

the sign of the charge cannot be determined by this, only that it has the same charge as the object that touched it b when the charged metal disc is held close to the knob, the electroscope polarizes (same process as in part A) and the leaves are again charged and repel

c this is same as above but while it is polarized, the knob is grounded with the finger and removes some charge leaving the electroscope charged and the leaves repel (this is the same exact process as part A with the charged metal disc acting as the charged Teflon plate and the knob as the metal disc of part A)

again the charge cannot be determined, only that it is opposite to that of the charged disk (explanation in part A)