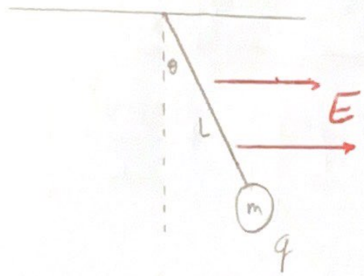
Exam 1 review

1.



$E = 1.00 \times 10^{3} \frac{N}{C}$

$L = 0.20\ m$

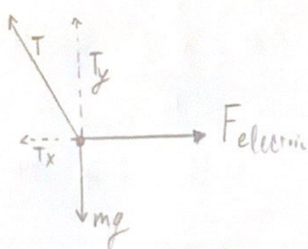
$m = 0.010\ kg$

$\theta = 15°$

$q = ?$

$\star\ F_e = q \cdot E$

Force diagram of ball



$y:\ T \cdot \cos 15° - mg = 0$

$T = \frac{mg}{\cos 15°}$

$X:\ -T \sin 15° + F_{electric} = 0$

$F_{electric} = T \sin 15°$

$F_e = mg \cdot \frac{\sin 15°}{\cos 15°} = mg \cdot \tan 15°$

$q \cdot E = mg \cdot \tan 15°$

$$q = \frac{mg \cdot \tan 15°}{E}$$

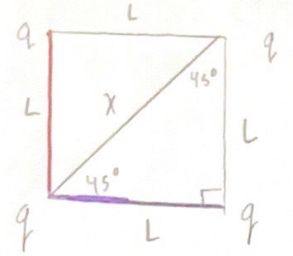
$q = 2.63 \times 10^{-5}\ C \approx 26.8\ \mu C$

Answer

2.

$$X = \sqrt{L^2 + L^2}$$

$$X = L \cdot \sqrt{2}$$



↑ Force acting on this charge

$$F_y: \frac{k \cdot q \cdot q}{L^2} + \frac{k \cdot q \cdot q}{(\sqrt{2}L)^2} \cdot \sin 45^\circ$$

$$F_{net}\,y = k \cdot q^2 \left[\frac{1}{L^2} + \frac{\sin 45^\circ}{2L^2} \right]$$

$$F_{net}\,y = \frac{k \cdot q^2}{L^2} \cdot 1.35$$

$$F_x: \frac{k \cdot q^2}{L^2} + \frac{k q^2}{L^2} \cdot \cos 45^\circ$$

$* \cos 45^\circ = \sin 45^\circ$

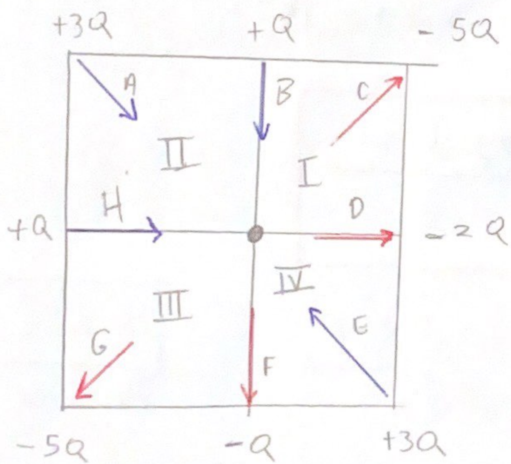
$$F_{net}\,x = \frac{k q^2}{L^2} \cdot 1.35$$

$$F_{net} = \sqrt{F_y^2 + F_x^2}$$

$$= \sqrt{\frac{2 \cdot k^2 \cdot q^4}{L^4} \cdot 1.83}$$

$$\boxed{F_{net} = \frac{1.91\, k q^2}{L^2}}$$ Answer

3.



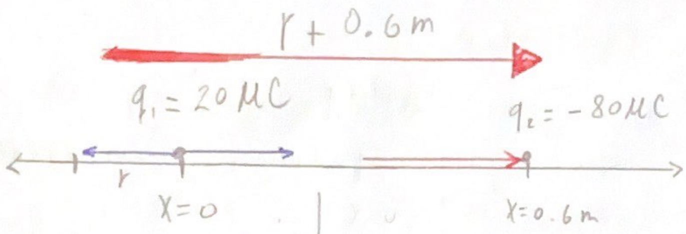
Electric fields point away from positive charges and point towards negative charges.

- A & E cancel out
- C & G cancel out
- B & F point down
- H & D point to the right

Therefore, resulting E field points ↘

Answer **IV quadrant**

4.



E will not cancel out between the two charges

* E fields point away from + charges & point towards − charges

* The point @ which E=0 will be @ X<0.

* E will cancel out @ a point closer to the smaller charge → |q|

$$E=0 = -\frac{k \cdot q_2}{(r+0.6m)^2} + \frac{k q_1}{r^2}$$

$$\frac{k q_2}{(r+0.6m)^2} = \frac{k q_1}{r^2}$$

$$\frac{r}{r+0.6m} = \sqrt{\frac{k q_1}{k q_2}}$$

$$\frac{r}{r+0.6m} = \sqrt{\frac{20}{80}} = \frac{1}{2}$$

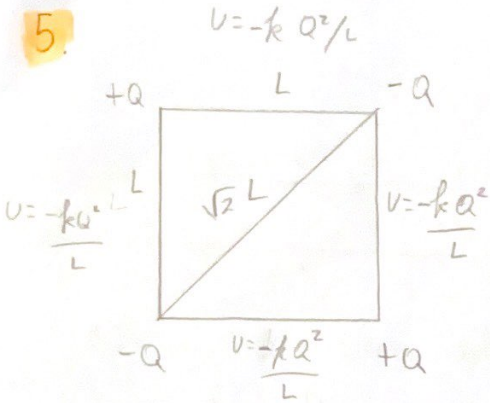
$$r = 0.5r + 0.6 \cdot (0.5)$$

$$0.5r = 0.3$$

$$r = 0.6 \, m$$

So, $\boxed{X_{E=0} = -0.6 \, m}$ Answer

5.



- There are 6 potential energies to be calculated
- We can just add them up, no need to split potential energies into components!

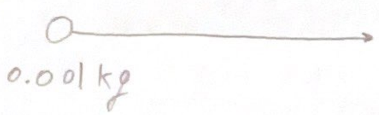
$L = 0.25\ m$ $\qquad Q = 3.0\times10^{-6}\,C$

$$P.E.\ \text{or}\ U = 4\cdot\left[\frac{-k\cdot Q^2}{L}\right] + \frac{kQ^2}{\sqrt{2}\cdot L} + \frac{kQ^2}{\sqrt{2}L}$$

$$= -2.59\,\frac{kQ^2}{L}$$

answer **U = -0.84 J**

6.



$\Delta x = 20m$
$t = 2\ s$

$q = 0.002\ C$

$V_0 = 0\ \frac{m}{s}$

What is E?

$F = qE = ma$

- solve a, then solve E

$v_i = 0$

$\Delta x = \cancel{v_i t} + \frac{a}{2}\cdot t^2$

$\frac{2\cdot\Delta x}{t^2} = a$

$a = \frac{20m\cdot 2}{4s^2}$

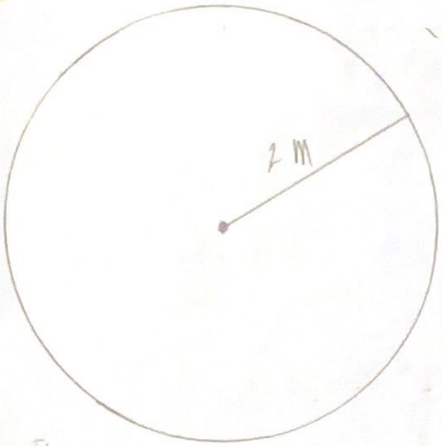
$a = \frac{10m}{s^2}$

$m\cdot a = F = qE$

$E = \frac{ma}{q}$

$E = \frac{5\,N}{C}$ Answer

7.



There was no reason to draw this

E pointing away $= \frac{899\,N}{C} = \frac{kq}{r^2}$

$$\frac{r^2 \cdot E}{k} = q$$

$$\frac{4m^2 \cdot \frac{899N}{C}}{8.99 \times 10^9 \frac{C^2 N}{m^2}} = 4 \times 10^{-7} C = \boxed{0.4 \mu C}$$

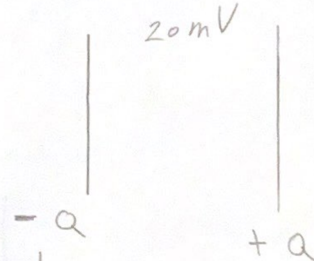
answers

8. $C = 2.0\,pF = 2 \times 10^{-12} F$

$V = 20mV = 0.020V$

$Q = VC$

$\therefore Q = 4 \times 10^{-14} C$



- Q ↓ has excess electrons

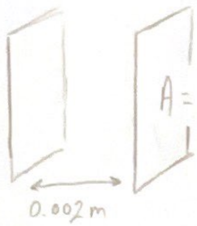
+ Q ↘ is missing electrons

$$\# electrons = (+Q - Q) \cdot \frac{1e^-}{1.6 \times 10^{-19} C}$$

$$= \frac{\Delta Q \cdot 1e^-}{q_{e^-}} = 2(4 \times 10^{-14} C) \cdot \frac{1e^-}{1.6 \times 10^{-19} C}$$

$$= 500000 = \boxed{0.5 \times 10^6 \text{ electrons}}$$

9.



$A = 7.5cm^2 \cdot \frac{1m}{100cm} \cdot \frac{1m}{100cm} = 0.00075m^2 = A$

$V = 0.0012V$

What is Q?

$C = k \cdot \varepsilon_0 \cdot \frac{A}{d}$

$k_1 = 1$ because there is no material inserted between plates

$Q = VC$

$Q = \frac{V \cdot k \cdot \varepsilon_0 \cdot A}{d}$

$Q = \frac{0.0012V \cdot 8.85 \times 10^{-12} \frac{C^2}{Nm^2} \cdot 0.00075m^2}{0.002m}$

$Q = 3.98 \times 10^{-15}$ C

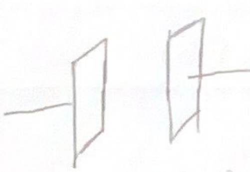
4 in units of 10^{-15} C

answer

10. $C = 12 \times 10^{-6}$ F

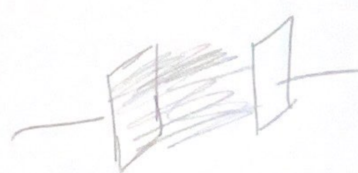
Emf = 3V

$k = 4$ gets inserted



· no material inserted

$U_c = \frac{1}{2} C V^2$



material added

$C' = k \cdot C$
$= 4C$

$U_c' = \frac{1}{2} \cdot 4C \cdot V^2$

$U_c' = 2CV^2$

$\Delta U_c = U_c' - U_c$

$= 2CV^2 - \frac{1}{2}CV^2$

$= \frac{3}{2}CV^2$

$= \frac{3}{2}\cdot(12\times10^{-6}\,F)\cdot(3\,V)^2$

$\boxed{\Delta U_c = 1.62\times10^{-4}\,J}$ answer

11. $V = 200\,V$

after 130 km, battery needs $2\times10^{8}\,J$

what is the charge @ the positive terminal?

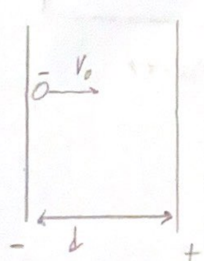
$U_c = 2\times10^{8}\,J = q\cdot V$

* They gave you 130 Km for <u>no reason</u>

$q = \frac{U_c}{V}$

$\boxed{q = 10^{6}\,C}$ answer

12.



$d = 0.005\,m$

$V_0 = 0\,\frac{m}{s}$

$V = 5\,V$

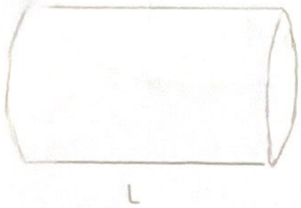
$V_{final} = ?$

$\frac{1}{2}m_e V_f^2 = P.E. = q_e\cdot Voltage$

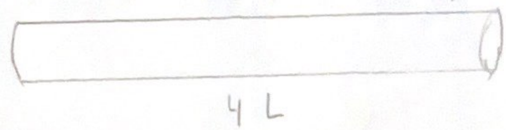
$V_f = \sqrt{\frac{2q_e\cdot Voltage}{m_e}}$

$\boxed{V_f = 1.3\times10^{6}\,\frac{m}{s}}$ answer

13.



Same Volume though



Resistance $= R = \rho \cdot \frac{L}{A}$

$$R' = \rho \frac{4L}{A'}$$

$V = L \cdot A$

$V = 4L \cdot A'$ · Because volume is the same the new area (A') must $= \frac{A}{4}$

$$V = 4L\left(\frac{A}{4}\right)$$

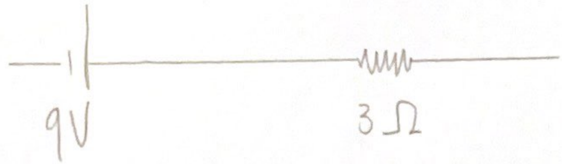
So, $R' = \rho \cdot \frac{4L}{\frac{A}{4}}$

$$R' = \rho \cdot 16 \cdot \frac{L}{A}$$

$$\boxed{R' = 16\,R}$$

Answer

14.



how much Charge goes through in 3 hours?

$V = IR$

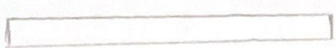
$I = \frac{V}{R} \equiv Amps \equiv \frac{C}{s}$ → $I = \frac{3C}{s}$

$q = I \cdot t$

$q = \frac{3C}{s} \cdot 3 \text{ hours} \cdot \frac{3600 \text{ seconds}}{1 \text{ hour}}$

$q = 32400 \, C$ Answer

15.



$\rho = 1.7 \times 10^{-8} \, \Omega \cdot m$

$I = 200$ Amps

Power loss of $\frac{2.0W}{m}$

radius = ?

* "Power loss" is in units of $\frac{W}{m}$

So it must be power over length $\left(\frac{P}{L}\right)$

$\frac{P}{L} = \frac{2.0W}{m}$

$P = I^2 \cdot R$

$R = \rho \cdot \frac{L}{A} = \rho \cdot \frac{L}{\pi r^2}$

$\frac{P}{L} = \frac{2.0W}{m}$

$\frac{P}{L} = \frac{I^2 \cdot R}{L}$

$\frac{P}{L} = \frac{I^2 \cdot \rho \cdot \cancel{L}}{\cancel{L} \cdot \pi r^2}$

* $\frac{L}{P} = \frac{1}{2} \frac{m}{W}$

$r = \sqrt{\frac{I^2 \cdot \rho_{resistivity}}{\pi} \cdot \frac{L}{P}}$

$r = 1.04 \, cm$ answer

16.

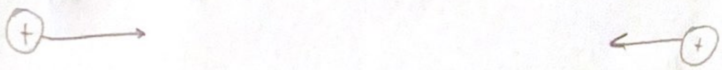
A	B	C	
2Q	3Q		
Q	3Q	Q	C touches A
Q	2Q	2Q	C touches B

Force between A & B originally $= \frac{6kQ^2}{r^2}$

F between A & B @ the end $= F' = \frac{2kQ^2}{r^2}$

$$\boxed{F' = \frac{F}{3}}$$ Answer

17.



$K.E._i = 1.2\ MeV \cdot \frac{1.6\times10^{-13} J}{1\ MeV} = 1.92\times10^{-13} J$ → * per each proton

↳ There are 2 protons

$2K.E._i = U = \frac{kq_1 \cdot q_2}{r}$

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

$r = \frac{kq^2}{2K.E._i}$ $\boxed{r = 0.6 \times 10^{-15}\ m}$ answer

18.

$U_c = \frac{1}{2} C V^2 = \frac{Q^2}{C}$ based on $Q = VC$

Because the battery is disconnected, Q will remain the same
↳ charge

$U_c = \frac{Q^2}{C}$ $C = k \cdot \varepsilon_0 \cdot \frac{A}{d}$

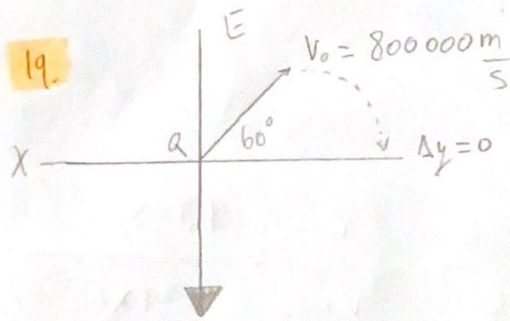
$C' = k \cdot \varepsilon_0 \frac{A}{d/5} = 5k \cdot \varepsilon_0 \cdot \frac{A}{d} = 5C$

$U_c' = \frac{Q^2}{5C} = \frac{U_c}{5}$

How much work is done by the person?

Work done $= U_{final} - U_{initial} = \frac{U_c}{5} - U_c = \boxed{-\frac{4U}{5}}$ Answer

19.



How much time for proton to return to X-axis?

$V_{0,y} = V_0 \cdot \sin 60°$

$a = \frac{q \cdot E}{m}$ pointing down $= -4.79 \times 10^{11} = a$

$q = 1.6 \times 10^{-19} C$

$\Delta y = 0 = V_{0,y} \cdot t + \frac{a}{2} t^2$

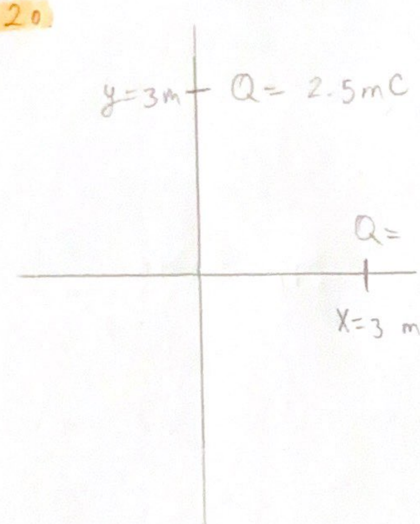
$m = 1.67 \times 10^{-27} kg$

$-V_{0,y} = \frac{a}{2} \cdot t \rightarrow t = \frac{-2V_{0,y}}{a}$

$E = 5000 \frac{V}{m}$

$\boxed{t = 2.89 \times 10^{-6} s}$ Answer

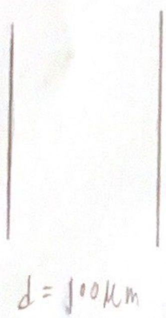
20.



what is the direction of the potential @ the origin?

Potential doesn't have a direction.
When adding potentials, there's no need to split them into components

21



C = 3nF
V = 8.0V

$C = k \cdot \varepsilon_0 \cdot \frac{A}{d}$

$A = \frac{d \cdot C}{k \cdot \varepsilon_0}$

$A = 0.0339\ m^2$

$V = A \cdot d$

$V = 3.39 \times 10^{-6}\ m^3$
(V = Volume)

$P.E. = \frac{1}{2} CV^2$ for capacitors

$= 9.6 \times 10^{-8} J$

$\text{Energy density} = \frac{P.E.}{\text{Volume}} = \frac{9.6 \times 10^{-8} J}{3.39 \times 10^{-6} m^3}$

$= 0.028 \frac{J}{m^3}$

Answer $= 28\ mJ/m^3$