18.1  \( e = -1.6 \times 10^{-19} \) C, \( e^-\) charge of an electron.

\( e^- = \) an electron

So how many \( e^-\) in \(-2.4 \mu C\)?

Well \(-2.4 \mu C\) = \(-2.4 \times 10^{-6} \) C

\[
\begin{align*}
-2.4 \times 10^{-6} \text{ C} & = 1.5 \times 10^{13} e^- \\
-1.6 \times 10^{-19} \text{ C} & = 1.5 \times 10^{13} e^- \\
\end{align*}
\]

18.2 Same as above reasoning wise.

We want a change of \(5 \mu C\). How many \( e^-\) in \(5 \mu C\)? Just divide by \( e^-\)

\[
3.1 \times 10^{13} e^-
\]

18.3 Now we multiply instead of divide. Note \( q = \) amount of charge

\[
q = (6.0 \times 10^{15})(-1.6 \times 10^{-19} \text{ C}) = -9.6 \times 10^{-4} \text{ C} = -9.6 e^-
\]

18.4 O.K. we're shuffling electrons around here, so if I got more negative, I'm giving \( e^-\) and if I got more positive I'm losing electrons.

Electrons have mass. The one that got more negative got \( e^-\) added and its mass went up.

\[
\begin{align*}
\text{So } & \frac{q}{e^-} = 9.6 \times 10^{-13} e^- \\
& 1.6 \times 10^{-19} \text{ C} \\
\text{Mass } & 9.11 \times 10^{-31} \text{ kg} \\
\text{so } & (1.9 \times 10^{13})(9.11 \times 10^{-31}) = 1.7 \times 10^{-17} \text{ kg}
\end{align*}
\]

Is how much mass rest A gained.

18.5

<table>
<thead>
<tr>
<th>A</th>
<th>B</th>
<th>C</th>
<th>Total q</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>5</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>2</td>
<td>1</td>
<td>0</td>
<td>4</td>
</tr>
<tr>
<td>3</td>
<td>0</td>
<td>5</td>
<td>0.5</td>
</tr>
</tbody>
</table>
18.18 \[ F = k \frac{q_1 q_2}{r^2}, \text{ remember equal and opposite forces} \]

\[
= 26 \, \text{N}
\]

18.19

\[ \text{So break into x and y directions} \]

\[
F_{xy} = F_x + F_{xy}
\]

\[
F_x = k \frac{q_1 q_x}{r_x^2}
\]

\[
F_y = k \frac{q_1 q_y}{r_y^2} 
\]

\[
\text{2.} \quad \text{mag} \, F_{tot} = \left( F_x^2 + F_y^2 \right)^{1/2}
\]

Remember your directions when dealing with vectors.

Define: positive \( x \) as east or west, positive \( y \) as north or east.

18.16

\[ F = k \frac{q_1 q_2}{r^2} \]

Ok. Our charge \( q_1 \) is pushed away from the -q at the bottom and we have a square. But the negative charges at A and C put it in equilibrium.

\[ \text{So,} \quad F_{bc} = F_{dc} = 0 \]

\[ \therefore \, (?) \, B \, \text{and} \, (?) \, C \, \text{must be positive.} \]
\[ \sqrt{(F_{\text{R}})^2 + (F_{\text{E}})^2} = F_{\text{G}} \] Note: These are magnitudes here.

The rest is algebra:

\[ \frac{k^2}{d^4} \left[ (r_e + a)^2 + (r_e - a)^2 \right] = \frac{k^2}{4} \frac{q^4}{d^4} \]

\[ (4.7)^2 q^2 + (3.7)^2 q^2 = \frac{q^4}{4} \]

\[ 2q^2 (4.7)^2 = \frac{q^4}{4} \]

\[ (c \tau)^2 = q^2 / 8 \]

\[ \Rightarrow q = 2.5 \text{ cm} \]

18.25

\[ F = qE \text{ by definition} \]

\[ (7 \times 10^{-6} \text{ cm} \times 260000 \text{ N/cm}) = 1.8 \text{ N} \]

18.28

At A:

\[ |E| = |E_1| + |E_2| \quad \text{or} \quad \vec{E} = \vec{E}_1 + \vec{E}_2 \]

At B:

\[ |E| = |E_1| + |E_2| \quad \text{or} \quad \vec{E} = \vec{E}_1 + \vec{E}_2 \]

18.29

\[ 3 \text{ m} \cdot \text{c} \quad \Rightarrow \quad \frac{Kq_+}{(3 + x)^2} = \frac{Kq_+}{x^2} \]

\[ E_{q_+} \quad \Rightarrow \quad \text{Use quadratic form to solve for } x. \]
18.35
\[ E = -E_3 + E_4 = \frac{-kq_3}{r_3^2} + \frac{kq_4}{r_4^2} \]

\text{Mind directions}

18.35
\[ E \uparrow \uparrow \bar{v} = qE \rightarrow A \text{. To go up, the droplet must be } \uparrow \uparrow \]
\[ \downarrow \bar{v} \quad m \bar{g} \quad \rightarrow \quad m \bar{g} = qE \rightarrow q = \frac{E}{mg} \]

18.44
\[ E = \frac{q}{\varepsilon_0} \text{ for a plate in a capacitor. This comes from Gauss's law.} \]

a) So \( \phi = E \cdot A \)

b) \( A = \pi r^2 \)
\[ q = \varepsilon A = \varepsilon \pi r^2 \]

18.66
The proton covers a distance \( d \)
\[ \downarrow \quad \rightarrow \quad \text{Work} = F \cdot d = qEd = \Delta KE \quad \rightarrow \]
\[ qEd + \frac{1}{2}mv_0^2 = \frac{1}{2}mv_f^2 \]
\[ v_f = \left[ 2 \frac{qEd}{m} \left( qEd + \frac{1}{2}mv_0^2 \right) \right]^{\frac{1}{2}} \]