For the charge configuration:

The dashed line represents the desired plane seen "edge-on". The plane itself is $\perp$ to the paper. There are no electric field lines crossing the plane. Thus $E = 0$ in the flux equation and thus there is no flux. The flux represents the number of field lines going through an area and in this example, no field lines pass through the plane.

If the flux over a surface is zero, it could represent a situation such as the one above where $E = 0$ but not always. For enclosing two charges, one positive and one negative, there is electric
#2 cont'd

Field on the Gaussian surface. Recall though that the flux is a sum of the perpendicular component of electric field times small pieces of area. Some pieces of the Gaussian surface will have electric field lines leaving while others will have electric field lines coming. They add to cancel each other out over the area.

The shape of the Gaussian surface will make no difference. (That's where the $\mathbf{A}$ and $\cos \phi$ come in)

#3 pg 551 #18

a) The charges determining the electric flux are the ones enclosed in the Gaussian surface.
For charge \( q_3 \), the field lines entering the Gaussian surface add to cancel with the ones leaving, giving 0 flux.

b) At point \( P \), all charges contribute to the electric field.

\[ m = 3.5 \times 10^{-9} \text{ kg} \]

\[ E = 8480 \frac{N}{C} \]

a) The net charge on the water drop must be positive. The charge creating the electric field is keeping the water from falling, leading to a repulsive force.

b) Drawing a force diagram:

\[ \vec{F}_E \]

\[ \vec{F}_g \]

\[ mg \]

For one water droplet to be suspended, the forces must equal each other:

\[ F_E = gE = mg \]
(4) Cont'd

where \( q \) is the charge of the droplet.

so \[ g = \frac{ma}{E} = \frac{(3.5 \times 10^{-9} \text{ kg})(9.8 \text{ m/s}^2)}{8.480 \frac{N}{C}} \quad (N = \text{kg m/s}^2) \]

\[ = 4.04 \times 10^{-12} \text{ C} \]

The charge of the proton is \( 1.6 \times 10^{-19} \text{ C} \).

So the number of protons on the water droplet is:

\[ \frac{4.04 \times 10^{-12}}{1.6 \times 10^{-19}} = 2.53 \times 10^7 \text{ protons} \]

(5) pg 553 #38

repeat from hw wk 1

See page 9 in this solution set.

(6) pg 580 Q1

The work done by the electric force is the difference in electric potential energy:

\[ W_{AB} = E_{PA} - E_{PB} \]

But \( V = E_{PE} \) so \( W_{AB} = -q(V_B - V_A) \)

In each situation presented, the potential at A is greater than the potential at B so.
cont'd the electron will travel from A to B. So, \( W_{AB} = -q(V_B - V_A) \)

For case 1, \( V_B - V_A = -50 \text{ V} \)

Case 2, \( V_B - V_A = -50 \text{ V} \)

Case 3, \( V_B - V_A = -50 \text{ V} \)

The value of work done by the electrostatic force is taken same for all cases and positive.

What if \( A = +10 \text{ V} \) and \( B = +60 \text{ V} \)? Then, still working with a positive charge, the proton would want to travel from B to A. The potential difference \( \Delta V = V_B - V_A = 50 \text{ V} \)

So \( W_{AB} = -50q \) instead of \( +50q \).

Because work is negative, something is doing work against the electric field instead of being done by the electric field.
Note: In this question the center of mass is moving different than in Hw #1, where the center of mass was stationary.

The force between the two charges in both cases is the same

\[ F = \frac{kq_1q_2}{r^2} \]

but \[ F = ma \]

and since \( F \) is the same and the mass is different for each case, the acceleration will be different. The acceleration for the electron will be larger so it will be going faster when it collides with the proton when the proton collides with the fixed electron.

Bringing one charge in at a time to calculate the difference in potential energy:

1st, the proton: the potential at a distance \( r \) from the proton is \( V = \frac{kq}{r} \). Then, the electron is brought in from infinity.
The electric potential energy is then
\[ E_{PE} = -eV. \]

The difference in \( E_{PE} \) is:
\[ E_{PE_{\text{final}}} - E_{PE_{\text{initial}}} = -e \left( \frac{k_e}{r_{\text{final}}} - \frac{k_e}{r_{\text{initial}}} \right) \]

where \( r_{\text{final}} = 5.29 \times 10^{-11} \text{ m} \) and \( r_{\text{initial}} = \infty \)

So \( \Delta E_{PE} = -\frac{e^2 k}{5.29 \times 10^{-11} \text{ m}} - \frac{e^2}{\infty} \)
\[ = -\left( 1.6 \times 10^{-19} \frac{\text{C}}{} \right)^2 \left( 9.99 \times 10^9 \frac{\text{N \cdot m}^2}{\text{C}^2} \right) \]
\[ = -4.35 \times 10^{-18} \text{ N \cdot m} \]
\[ = -4.35 \times 10^{-18} \text{ J} \]

\( (\text{N} \cdot \text{m} = \frac{\text{kg \cdot m \cdot m}}{\text{s}^2} = \frac{\text{kg \cdot m}^2}{\text{s}^2} = \text{J}) \)

In electron volts, \( 1 \text{ eV} = 1.6 \times 10^{-19} \text{ J} \)
So, \( \left( -4.35 \times 10^{-18} \text{ J} \right) \left( \frac{1 \text{ eV}}{1.6 \times 10^{-19} \text{ J}} \right) = \boxed{27.19 \text{ eV}} \)

Why does it take \( \frac{1}{2} \) that energy to ionize the atom? -27.19 eV is only the potential energy of the system. The electron is
moving around the proton so it has a kinetic energy. Thus, the total energy of the system needs to be considered.

\[ F = ma \Rightarrow \frac{ke^2}{r^2} = \frac{m v^2}{r} \]

So \( m v^2 = \frac{ke^2}{r} \).

And \( KE = \frac{1}{2}mv^2 = \frac{1}{2} \frac{ke^2}{r} \),

which is half the potential energy

\[ E_P = -\frac{1}{2}EPE \]

(negative because \( W = -q \Delta V \) and force is directly related to work)

Therefore \( E_{total} = E_{PE} + KE \)

\[ = E_{PE} - \frac{1}{2}E_{PE} \]

\[ = \frac{1}{2}E_{PE} = -13.6 \text{ eV} \]
9. \( q = CV \) so the voltage required of a 6.0 mF capacitor to store 7.2 \times 10^{-5} \text{C} of charge is:

\[
V = \frac{7.2 \times 10^{-5} \text{C}}{6.0 \times 10^{-6} \text{F}} = 12 \text{ V}
\]

The energy stored in this capacitor is:

\[
E = \frac{1}{2} CV^2 = \frac{1}{2} (6.0 \times 10^{-6} \text{F})(12 \text{V})^2 = 4.32 \times 10^{-4} \text{ J}
\]

10. \( p. 553 \# 41 \)

a) \( E = \frac{1}{2} CV^2 = \frac{1}{2} (750 \times 10^{-6} \text{F})(330 \text{V})^2 = 40.84 \text{ J} \)

b) Power = \frac{\text{Energy}}{\text{time}} = \frac{40.84 \text{ J}}{5.0 \times 10^{-3} \text{s}} = 8167.5 \text{ W}

5. \( p. 553 \# 38 \) - do same problem using energy conservation. In energy conservation, the potential + kinetic energy before must equal the potential + kinetic energy after. In this case, the potential is electric. So,

\[
E_{\text{P}i} + \frac{1}{2} mv_i^2 = E_{\text{P}f} + \frac{1}{2} mv_f^2
\]
But \( V_i = 0 \) and since we are finding the velocity when the electron just reaches the other plate, \( E \text{PE}_f = 0 \).

So,

\[
\text{EPE}_i = \frac{1}{2}mv_f^2
\]

For a capacitor, \( E \text{PE} = qE \text{d} \) (\( E \) is uniform)

\[
= \frac{eE d}{\varepsilon_0} \quad \text{when} \quad e = -1.6 \times 10^{-19}
\]

So,

\[
\frac{eE d}{\varepsilon_0} = \frac{1}{2}mv_f^2
\]

giving for \( v_f \),

\[
v_f^2 = \frac{2eE d}{me_0}
\]

So, \( v_f = \boxed{1 \times 10^7 \frac{m}{s}} \)
Correction to hwvk problem #1 on hwvk set #1:

A proton and an electron are both a distance d from the origin.

\[ \text{\( \Theta \)} \hspace{1cm} \text{\( \Theta \)} \]
\[ \text{\( d \)} \hspace{1cm} \text{\( d \)} \]

There is an equal attractive force between them when let go, which one will reach the origin first? Because \( F = ma \), and the force is equal between them, the acceleration for the proton will be lower than for the electron because of their mass difference. \( m_e \sim 10^{-31} \text{ kg} \), \( m_p \sim 10^{-27} \text{ kg} \) — therefore, the electron speeds up quicker and will reach the origin first. Actually, in this problem the center of mass remains stationary, so the proton hardly moves at all.