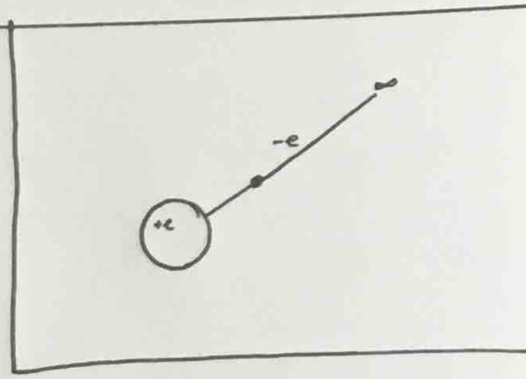
7.31 Electric Potential Energy

To form a hydrogen atom a proton is fixed at a point & an electron is brought from far away to a distance (r) between proton & electron in a hydrogen atom. How much work is done? ($r = 0.529 \times 10^{-10}$ m)



Here the electrical potential of a point charge q is given by $V = \frac{kq}{r}$

electrical potential energy $U = eV$

$$= \frac{ekq}{r}$$

$$= \frac{keq}{r}$$, where $e = q$

, the radius changes from $\infty \rightarrow 0.529 \times 10^{-10}$ m

$r_1 = \infty$, $r_2 = 0.529 \times 10^{-10}$ m

$K = 8.99 \times 10^{10} \frac{kg\, m^2}{s^2 c^2}$

$$W = |\Delta U|$$

$$= \left| \frac{Kq^2}{r_f} - \frac{Kq^2}{r_i} \right|$$

$$= \left| Kq^2 \left(\frac{1}{r_f} - \frac{1}{r_i} \right) \right| = \left| \left(8.99 \times 10^{10} \frac{kg\, m^2}{s^2 c^2}\right) \left(1.602 \times 10^{-19} c\right)^2 \left(\frac{1}{0.529 \times 10^{-10} m} - \cancel{\frac{1}{\infty}} \right) \right|$$

$$= \left(8.99 \times 10^{10} \frac{kg\, m^2}{s^2 c^2}\right) \left(1.602 \times 10^{-19} c\right)^2 \left(1.89 \times 10^{10} \frac{1}{m}\right)$$

$$\boxed{W = 4.36 \times 10^{-17} \ kg\, m/s^2}$$

7.35 Electric Potential & Potential Difference

Show that the units of V/m & N/c for electric field strength are indeed equivalent.

$$\frac{V}{m} = \frac{N}{c}$$

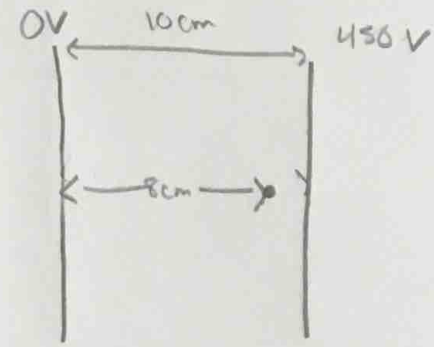
$1V = 1 J/c$, $1J = 1 N\cdot m$

$$\frac{1}{m} V = \frac{N\cdot \cancel{m}}{C} \frac{1}{\cancel{m}} \qquad N = \frac{J}{m}$$

$$\boxed{\therefore \frac{V}{m} = \frac{N}{C}}$$

7.39 Two parallel plates which are conductors are seperated by 10.0 cm, & one of them is taken to be @ 0 V.

a) what is the electric field strength between them if the potential 8.00 cm from the zero volt plate & 2.00 cm from the other is 450 V.?



Here the potential difference between 2 plates $\Delta V_{AB} = Ed$

$\therefore E = \frac{\Delta V_{AB}}{d}$

$= \frac{450 V}{.08 m} = 5625 \, V/m$

(b) what is the voltage between the plates?

$\Delta V_{AB} = Ed$

, $E = 5625 \, V/m$

$d = 10 cm$

$= 0.10 m$

$\therefore \Delta V_{AB} = 5625 \, V/m \, (0.10 m)$

$\boxed{\therefore \Delta V_{AB} = 562.5}$

7.47 If the potential due to a point charge is $5.0 \times 10^{+2}$ V @ a distance of 15.0 cm, what are the sign & magnitude of the charge?

Here the potential due to a point charge is

$$V = \frac{kQ}{r} \quad , \quad Q = \frac{Vr}{k}$$

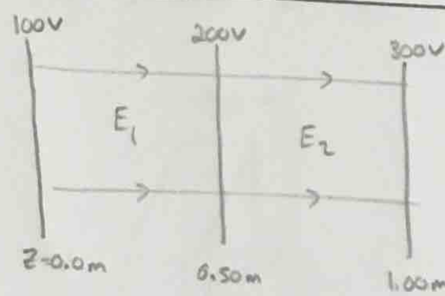
$$Q = \frac{(5.0 \times 10^2 \, V)(0.15 \, m)}{9.0 \times 10^9 \, Nm^2/C^2}$$

$$\boxed{Q = 8.33 \times 10^{-7} \, C \quad \text{positive}}$$

7.55 Determining the field from potential

Throughout a region, equipotential surfaces are given by $z = C$. The surfaces are equally spaced w/ $V = 100\ V$ for $z = 0.00m$, $V = 200\ V$ for $z = 0.50m$, $V = 300\ V$ for $z = 1.00m$. What is the electric field in this region?

Here the electric field & electric potential relationship:



$$E = \frac{\Delta V}{d}$$

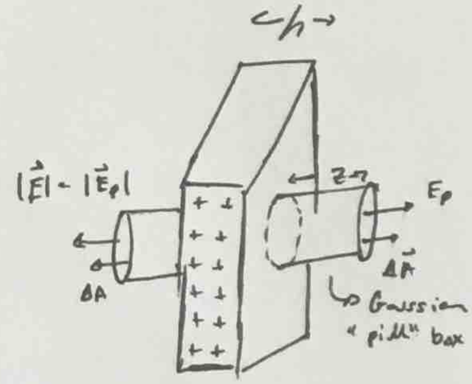
$$E_1 = \frac{300 - 200\ V}{0.50m} = \boxed{200\ \tfrac{V}{m} = E_1}$$

$$E_2 = \frac{200 - 100\ V}{0.50m} = \boxed{200\ \tfrac{V}{m} = E_2}$$

In both regions the $\boxed{\vec{E} = 200\ V/m}$

(95) Challenge Problem

Find the electric field of a large conducting plate containing a net charge q. Let A be the area of one side of the plate & h the thickness of the plate. The charge on the metal will distribute mostly on the two planar sides & very little on the edges if the plate is thin.



Gauss's Law

$$\phi = \int_s E \hat{r} \cdot \hat{n} \, dA = \frac{q_{en}}{\varepsilon_0}$$

Each side has $\frac{q}{2}$ charge on the face are ΔA

$$\phi = [E \Delta A] = \frac{q_{en}}{\varepsilon_0} \quad , \quad q_{en} = \frac{q}{2}$$

$$E \Delta A = \frac{q}{2\varepsilon_0}$$

$$\therefore E = \frac{q}{2\varepsilon_0 \Delta A} \quad , \text{ here } \sigma = \frac{q}{2\Delta A}$$

$$\boxed{\therefore E = \frac{\sigma}{\varepsilon_0} = \frac{q}{2\varepsilon_0 \Delta A}}$$