PHYSICS 100B
EXAM I
Spring

NAME KEY

Problem	Value	Score
I	30	
II	30	
III	20	
IV	20	
TOTAL	100	

change IV 0.71 → 9.71

1. Giving or receiving aid in any examination is cause for dismissal from the university.
2. Perform the necessary calculation in the spaces provided. If additional space is required, use the backs of the questions sheets.
3. **All work must be shown in order to receive FULL credit.** Work must be legible and comprehensible, and answers should be clearly indicated.

USEFUL EQUATIONS AND CONSTANTS

$k = 9.0 \times 10^9\ Nm^2/C^2$ $q_e = -1.6 \times 10^{-19}C$ $m_e = 9.1 \times 10^{-31}kg$
$m_p = 1.7 \times 10^{-27}kg$ $1\ eV = 1.60 \times 10^{-19}J$ $q_p = +1.6 \times 10^{-19}C$

$|\vec{F}_{12}| = k\frac{q_1 q_2}{r^2}$ $\vec{E} = \frac{\vec{F}}{q}$ $|\vec{E}| = \frac{kq}{r^2}$ $\vec{E_{net}} = \vec{E}_1 + \vec{E}_2 + \vec{E}_3 + ...$

$V_{ba} = V_b - V_a = W_{ba}/q$, where W_{ba} is the work done by the electric force to move the charge from b to a

$W_{ab} = qEd$ $V_a = \frac{PE_a}{q}$ $V_{ba} = \frac{W_{ba}}{q}$ $E = \frac{V_{ab}}{d}$ $V = \frac{kq}{r}$ (point charge)

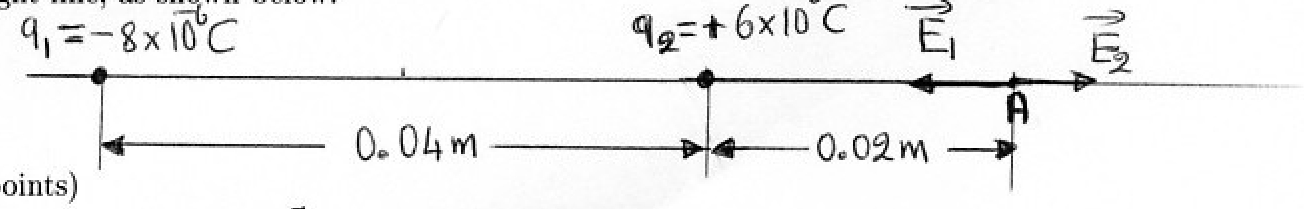
$KE = \frac{mv^2}{2}$ $C = \frac{Q}{V}$ $C = \frac{1}{4\pi k}\frac{A}{d}$ $W = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$

$\kappa = \frac{C}{C_0}$ $\quad$ $I = \frac{Q}{t}$ $\quad$ $I = \frac{V}{R}$ $\quad$ $R = \frac{V}{I}$ $\quad$ $R = \varrho\frac{L}{A}$

$W = Pt = IVt$ $\quad$ $P = IV = I^2R = \frac{V^2}{R}$

Problem **I.** (30 points)

Two point charges $q_1 = -8.0 \text{ X } 10^{-6}$C and $q_2 = +6.0 \text{ X } 10^{-6}$ are placed 0.04 m apart on a straight line, as shown below.



a) (8 points)

Calculate the electric field $\vec{E}_1$ at point A due to charge q_1. Point A is 0.02 m away from charge q_2, as shown above. Specify the magnitude and the direction of the electric field.

$$|\vec{E}_1| = k\frac{q_1}{r_1^2} = k\frac{q_1}{(r+d)^2} = \left(9\times10^9\ \frac{N\,m^2}{C^2}\right)\frac{8\times10^{-6}C}{(0.06m)^2}$$

$$|\vec{E}_1| = 2\times10^7\ N/C \qquad \vec{E}_1 \leftarrow$$

b) (8 points)

Calculate the electric field $\vec{E}_2$ at point A due to charge q_2. Specify the magnitude and the direction of the electric field.

$$|\vec{E}_2| = k\frac{q_2}{d^2} = \left(9\times10^9\ \frac{N\,m^2}{C^2}\right)\frac{6\times10^{-6}\,C}{(0.02)^2 m^2} = 1.35\times10^8\ \frac{N}{C} \qquad \vec{E}_2 \rightarrow$$

c) (6 points)

Calculate the **net** electric field $\vec{E}$ at point A. Specify both the magnitude and direction.

$$E_{net} = -|\vec{E}_1| + |\vec{E}_2| = -2\times10^7\ \frac{N}{C} + 13.5\times10^7\ \frac{N}{C}$$

$$= +11.5\times10^7\ N/C = 1.15\times10^8\ \frac{N}{C}$$

$\rightarrow E_{net}$

d) (8 points)

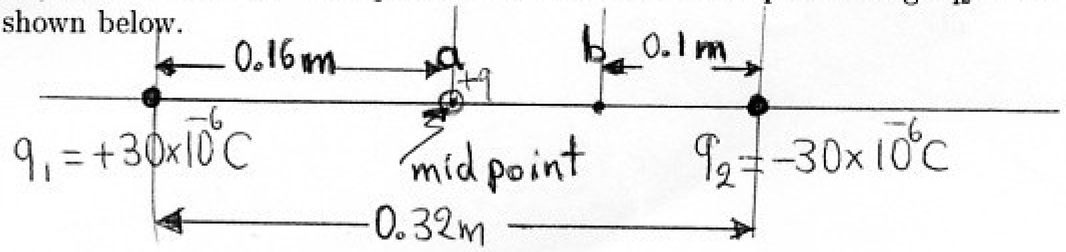
If an electron ($q_e = -1.6 \text{ X } 10^{-19}$C) is placed at point A, calculate the magnitude and direction of the **net** force acting on the electron.

$$\vec{F} = q\vec{E} \qquad F = -(1.6\times10^{-19}C)\ 1.15\times10^8\ \frac{N}{C} =$$

$$= -1.84\times10^{-11}\ N$$

$\leftarrow \vec{F}$

Problem **II.** (30 points)
A point charge q_1 = +30 X 10^{-6}C is placed 32 cm from a second point charge q_2 = -30 X 10^{-6}C, as shown below.



a) (8 points)
Calculate the **net** electric potential V_a at point a, which is midway the two point charges.

$$V_a = k\frac{q_1}{(d/2)} + k\frac{q_2}{(d/2)} = \frac{k}{(d/2)}(q_1+q_2) = 0V \text{ since } q_2 = -q_1$$

b) (8 points)
Calculate the **net** electric potential V_b at point b, which is 10 cm **closer** to charge q_2, as shown above.

$$V_b = k\frac{q_1}{r_1} + k\frac{q_2}{r_2} = 9\times10^9\frac{Nm^2}{C^2}\left[\frac{30\times10^{-6}C}{(0.22m)} - \frac{30\times10^{-6}C}{(0.10m)}\right]$$
$$= \left(9\times10^9\frac{Nm^2}{C^2}\right)(30\times10^{-6}C)\left[\frac{1}{0.22m} - \frac{1}{0.10m}\right] = \underline{-1.47\times10^6\ V}$$

c) (9 points)
Calculate the work done by the electric field to move the charge q_3 = +1 X 10^{-6}C from point a to point b.

$$W_{ab} = q_3(V_a - V_b) = (1\times10^{-6}C)[0V - (-1.47\times10^6V)] =$$
$$= \underline{1.47\ J}$$

d) (5 points)
Calculate the **change** in kinetic energy of the charge q_3 as it moves from point a to point b.

$$\Delta(KE) = KE_b - KE_a = W_{ab} = \underline{1.47\ J}$$

Problem **III.** (20 points)

An electric field of 8.50 X 10^5 V/m is desired between two parallel plates each of area 35.0 cm^2 and separated by 2.45 mm of air.

a) (7 points)

Calculate the potential difference between the plates.

$$E = \frac{V}{d} \Rightarrow V = E \cdot d = \left(8.50 \times 10^{5} \frac{V}{m}\right)\left(2.45 \times 10^{-3} m\right) =$$

$$= \underline{\underline{2.082 \times 10^{3} V}}$$

b) (7 points)

What is the charge on each plate?

$$C = \frac{1}{4\pi k} \frac{A}{d} = Q/V$$

$$\Rightarrow Q = \frac{V A}{4\pi k d} = \frac{\left(2.082 \times 10^{3} V\right)\left(35 \times 10^{-4} m^2\right)}{4\pi \left(9 \times 10^{9} \frac{Nm^2}{C^2}\right)\left(2.45 \times 10^{-3} m\right)} = \underline{\underline{2.63 \times 10^{-8} C}}$$

While the battery is still connected to the capacitor, a sheet of plastic is inserted between the plates. The dielectric constant of plastic is 4.

c) (6 points)

What is the charge on each plate in the presence of the dielectric?

$$K = \frac{C}{C_0} = \frac{Q'/V}{Q/V} = \frac{Q'}{Q}$$

$$\Rightarrow Q' = kQ = 4 \times \left(2.63 \times 10^{-8} C\right) = \underline{\underline{1.05 \times 10^{-7} C}}$$