PHYS 142, EXAM 1 NAME: _____ SECTION: _____

(15) 4. (do this problem last) Consider a parallel plate capacitor with capacitance 0.1μF. Each capacitor plate is a 2cm x 2cm square. (a) If I charge the capacitor with charge Q=50μC, what is the potential difference created between the plates? (b) If the separation of the capacitor plates is 5mm, what is the electric field between the plates, and what can you say about this electric field? (draw a picture) (c) Let us now inject an electron into the capacitor from one edge of the capacitor, from the position exactly in the middle of the two plates, and let us give it an initial velocity, which is ~1/3 of the speed of light (10^8 m/s), parallel to the plates (see picture). Will the electron make it all the way through the plates? If not, how far will it travel before it hits the plate? (remember: each plate has a length of 2cm, and the electron is injected 2.5cm from one plate)

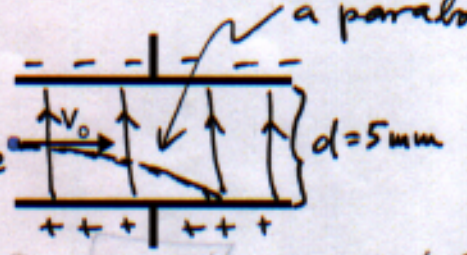
= 2.5mm

3 a) $Q = 50\mu C$, $C = 0.1\mu F$

$C \equiv \frac{Q}{\Delta V}$ (2)

$\Rightarrow \boxed{\Delta V = \frac{Q}{C}} = \frac{50\mu C}{0.1\mu F}$

$\boxed{\Delta V = 500V}$ (1)



right picture and labels (1)

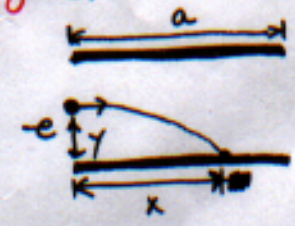
4 b) $d = 5mm$

$\Delta V = E \cdot d$ - for parallel plate capacitor (E = const.)

- the el. field will be uniform and constant, going from the positive plate to negative plate (2)

$\boxed{E = \frac{\Delta V}{d}} = \frac{500V}{5mm} = \frac{5 \times 10^2 V}{5 \times 10^{-3} m} = \boxed{10^5 \frac{V}{m}}$ (1)

8 c)



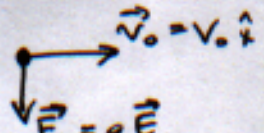
- break up the problem into x-dir and y-dir. (1) setting up correctly

(x) no force => no acceleration

$\boxed{x = v_0 t}$ v_0 = const. (2) motion in x

(y): $\vec{E} = +E\hat{j}$ => $\vec{F} = q\vec{E} = -eE\hat{j}$ => $\vec{a} = \frac{\vec{F}}{m} = \boxed{\frac{-eE}{m}\hat{j}}$ (1)

=> electron will be effectively "falling down".



$\Rightarrow \boxed{y = \frac{1}{2}|a|t^2}$ - traveling "down" (2) motion in y

=> how far will it travel in x-dir, before it "falls" a distance y = 2.5mm?

$\varepsilon_0 = 8.85 \times 10^{-12} C^2/(Nm^2)$ $e = 1.6 \times 10^{-19} C$ $m_e = 9.1 \times 10^{-31} kg$

- Will it go longer than a = 2cm?

$x = v_0 t$, $y = \frac{1}{2}|a|t^2$ $\Rightarrow t = \sqrt{\frac{2ym}{eE}}$ $\Rightarrow \boxed{x = v_0\sqrt{\frac{2ym}{eE}}}$ $\Rightarrow \boxed{x = 5.3cm}$

$\Rightarrow t^2 = \frac{2y}{|a|} = \frac{2ym}{eE}$

$x = 10^8\left(\frac{2(2.5)10^{-3}(9.1)10^{-31}}{(1.6)10^{-19}(10^5)}\right)^{1/2}$

YES! (2)