PHYS 122 **EXAM II** **November 7, 2008**
Prof. S. M. Bhagat

Name: Solution.
(Sign in ink, print in pencil)

Notes

FOUR(4)

1) There are [redacted] problems in this exam. Please make sure that your copy has all of them.

2) Please show your work indicating clearly what formula you used and what the symbols mean. Just writing the answer will not get you full credit. In stating vectors give both magnitude and direction.

3) Write your answers on the sheets provided.

4) Do not forget to write the units.

5) Do not hesitate to ask for clarification at any time during the exam. You may buy a formula at the cost of one point.

Take Care! God Bless You!

$$k_e = 9\times10^{9}\frac{N\cdot m^2}{C^2}, \mu_0 = 4\pi x10^{-7}\frac{T-m}{A}$$

$$\varepsilon_0 = 9\times10^{-12}\, F/m$$

Mass of proton	$m_p = 1.6\times10^{-27}\,kg$
Mass of electron	$m_e = 9\times10^{-31}\,kg$
Elementary Charge	$e = 1.6\times10^{-19}\,C$

Problem 1a

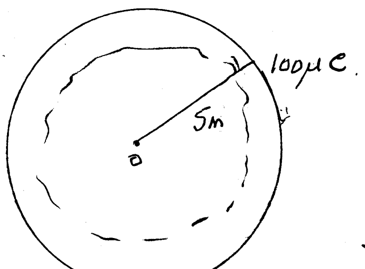
Write down Gauss's Law for an $\underset{\rightarrow}{E}$-field. (5)

Total flux of $\underset{\rightarrow}{E}$ through a closed surface is determined solely by the enclosed charges

$$\sum_c \underset{\rightarrow}{E} \cdot \underset{\rightarrow}{\Delta A} = \frac{1}{\varepsilon_0} \sum Q_i$$

Problem 1b

A hollow sphere of radius $5m$ is located with its center at $r = 0$ and carries a charge of $100\ \mu C$. Using the equation of Problem 1a calculate the $\underset{\rightarrow}{E}$-fields at $r = 4m$ and $r = 5m$ (that is just outside the surface of the sphere). (20)



spherical symmetry about $r=0$
$\underset{\rightarrow}{E}$ is a function of r and along $\hat{r}$
use sphere of radius r with center at $r=0$
to calculate $\sum_c \underset{\rightarrow}{E} \cdot \underset{\rightarrow}{\Delta A}$.

$\underline{r = 4m}$ $\quad E(4)\, 4\pi (4)^2 = 0$ No charge enclosed.

$$\underset{\rightarrow}{E}(4) = 0.$$

$r = 5m$ $\quad E(5)\, 4\pi (5)^2 = \frac{10^{-4}}{9 \times 10^{-12}}$

$$\underset{\rightarrow}{E}(5) = \frac{10^{-4}}{4 \times \pi \times 25 \times 9 \times 10^{-12}} N/c\ \hat{r}$$

$$= 3.5 \times 10^{4} N/c\ \hat{r}$$

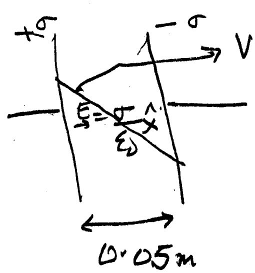
Problem 2a

What is potential energy? (DO NOT WRITE mgh) (5)

Work stored in a system when it is assembled in the presence of a conservative force.

Problem2b

A capacitor consists of two plates each of area $2m^2$ separated by $5cm$. i) If you put charges of $\pm 20\mu C$ on the plates what is the potential difference between them? Why? ii) If you put a conductor of thickness $2.5cm$ between the plates what is the potential difference between the plates? Why? (20)



charge density

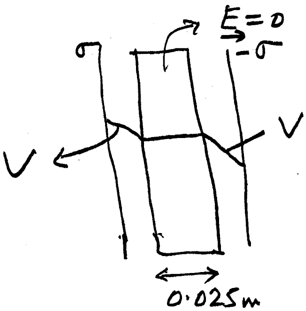
$$\sigma = \frac{20 \times 10^{-6}}{2} = 10^{-5} C/m^2$$

$\vec{E}$ field is $\frac{\sigma}{\varepsilon_0}\hat{x}$

$$\Delta V = -\vec{E} \cdot \Delta\vec{x} = -\frac{\sigma}{\varepsilon_0} \times d \text{ volts}$$

$$= -\frac{10^{-5} \times 0.05}{9 \times 10^{-12}} \text{ volts}$$

$$= -5.5 \times 10^{4} \text{ volts.}$$



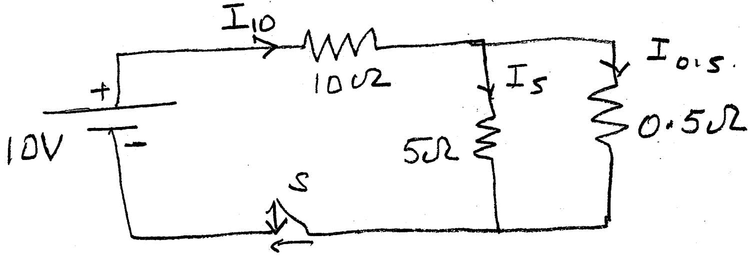
$$\Delta V = -\vec{E} \cdot \Delta\vec{x}$$

$$= -\frac{\sigma}{\varepsilon_0} \times \frac{d}{2}$$

$$= 2.7 \times 10^{4} \text{ Volts.}$$

Problem 3a

In the circuit shown which resistor will have i) the largest current and ii) the smallest current when the switch is closed? (10)



JN. RULE

$I_5 + I_{0.5} = I_{10}$ I_{10} is largest.

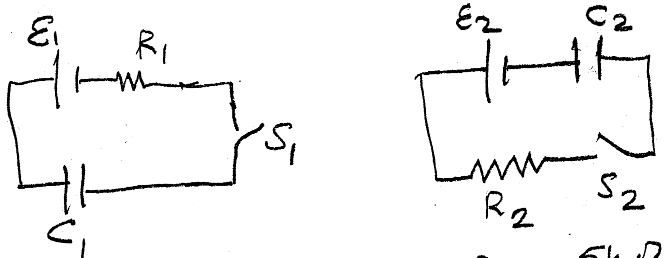
Loop Rule $V_5 = V_{0.5}$

$I_5 = \frac{V_5}{5}$ → smallest current

Problem 3b

Two circuits are shown. Both switches are closed at the same time, which capacitor voltage will reach 1 volt first if i) $\varepsilon_1 = \varepsilon_2 = 2.5V$ and ii) $\varepsilon_1 = 2.5, \varepsilon_2 = 3V$? Why?

(15)



$R_1 = 10\,k\Omega$
$C_1 = 20\,\mu F$

$R_2 = 5\,k\Omega$
$C_2 = 40\,\mu F$

$$V_c = \mathcal{E}\left[1 - e^{-t/RC}\right]$$

$R_1 C_1 = 10^4 \times 2 \times 10^{-5} = 0.2\,sec$

$R_2 C_2 = 5 \times 10^3 \times 4 \times 10^{-5} = 0.2\,sec$

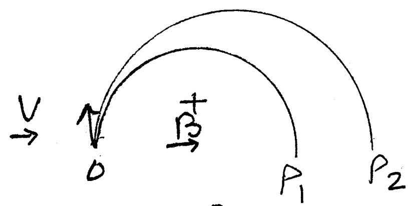
Case (i) $\mathcal{E}_1 = \mathcal{E}_2$ so both arrive together

Case (ii) $\mathcal{E}_2$ is larger so $[1 - e^{-t/RC}]$ can be smaller which needs smaller t

Hence ② arrives first.

Problem 4a

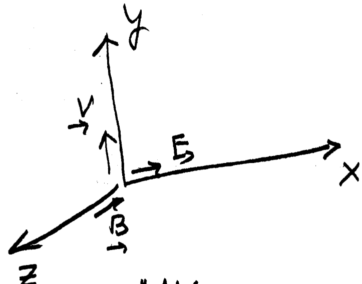
Shown are the paths of two particles in a mass spectrometer. Both have the same initial velocity $\underline{v} = v\hat{y}$. For the $\underline{B} = -B\hat{z}$. What is the sign of the charge on the particles? In case i) both particles have same charge but different masses M_1 and M_2. Where will the larger mass land, at P_1 or P_2. Why? ii) In case the masses are equal but $q_1 \neq q_2$, where will the larger charge land? Why? (4, 4, 4)



$\vec{B} = -B\hat{z}$

$\vec{F} = q\,[\vec{v} \times \vec{B}]$

To get $\vec{F} \parallel +\hat{x}$ at O you need $q\vec{v} \parallel -\hat{y}$ so q must be -ive.



Radius of orbit $R = \frac{MV}{qB}$

(i) So if $q_1 = q_2$ & $M_1 \neq M_2$ larger mass at P_2 b/c $R \propto M$.

(ii) If $M_1 = M_2$ and $q_1 \neq q_2$ $\quad R \propto \frac{1}{q}$

larger q at P_1

Problem 4b

A wire carrying a current of 10 amps is located on the y-axis. Calculate the $\underrightarrow{B}$ fields at

$x = 2m,\ z = -2m$

$x = -2m,\ z = 2m$

(4,3,3,3)