# Exam 2 (March 23, 2010)

*Please read the problems carefully and answer them in the space provided. Write on
the back of the page, if necessary. Show your work where indicated.*

Problem 1 (8 pts):

In each of the four sketches
to the right, the specified
electric charge (note the
sign of each charge is
given) is moving in the
direction of the velocity
vector in a region of
uniform magnetic field. In
each case clearly indicate
the direction of the force on
the charge due to the
magnetic field. If there is
no force write "no net
force" next to the particular
sketch.
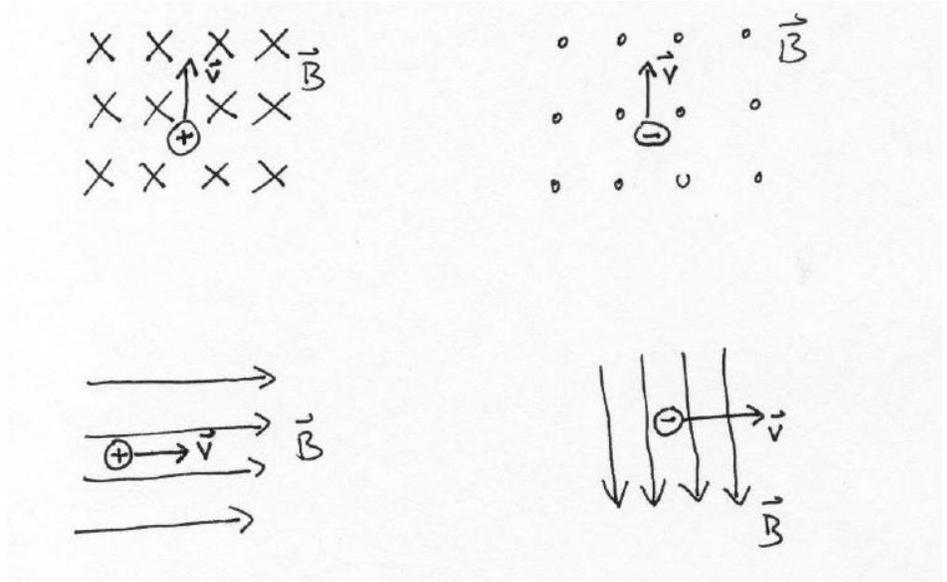
Problem 2 (6 pts):

In each of the three sketches below a positively charged particle moves in a uniform magnetic
field in the direction specified by the velocity vector. Also shown is a vector representing the
force on the moving charge due to the magnetic field through which it moves. Indicate the
direction of the magnetic field in each case.
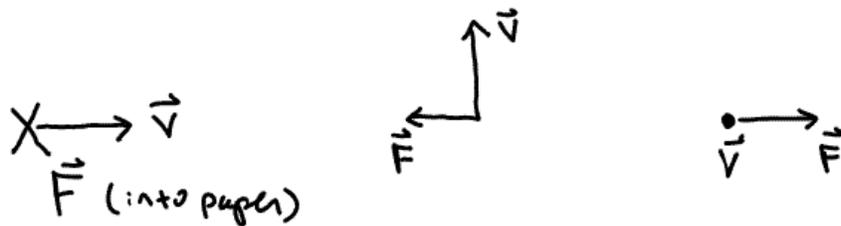
Problem 3 (6 pts):

Six separate situations are sketched below. In each case, electric charges(shown as small black circles) are arranged equal distances from a point where the potential is specified. The charges in each situation have the same magnitude but the signs of the charges are not specified.

Label the charges in each situation as "+" or "-".

In which of the six situations is the electric field zero at the point where the potential is specified? *(There might be more than one situation that satisfies this criterion.)*

In which of the six situations is the magnitude of the electric field greatest (relative to the other situations) at the point where the potential specified?   *(There might be more than one situation with that maximum electric field magnitude.)*

A   B   C

$V=0$ $V=4V_o$ $V=2V_o$

D   E   F

$V=-4V_o$ $V=-2V_o$ $V=2V_o$
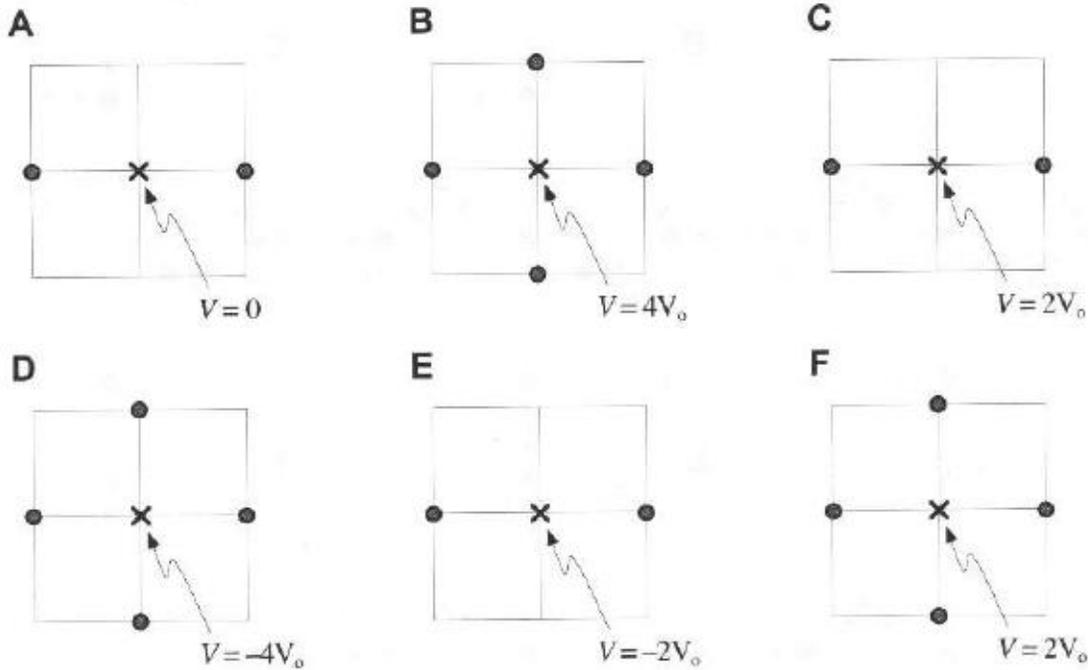
|	
1)	/8
2)	/6
3)	/6
4)	/8
5)	/10
6)	/10
7)	/10
8)	/11
9)	/11
10)	/10
11)	/10
tot	/100

Problem 4 (8 pts):

A battery is connected to a series combination of a switch, a resistor, and an initially uncharged capacitor. The switch is closed at t=0. Which of the following statements is true? Give a brief explanation to justify your answer.

   a) As the charge on the capacitor increases, the current increases.
   b) As the charge on the capacitor increases, the voltage drop across the resistor increases.
   c) As the charge on the capacitor increases, the current remains constant.
   d) As the charge on the capacitor increases, the voltage drop across the capacitor decreases.
   e) As the charge on the capacitor increases, the voltage drop across the resistor decreases.
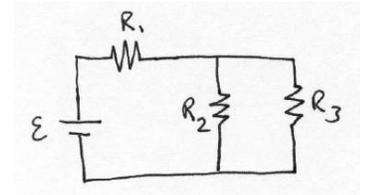
Problem 5 (10 pts):

Referring to the figure to the right, determine the current through the circuit (with the direction of positive current flow defined by the direction of I in the figure. Show your work.

a) +0.83 A
b) -0.50 A
c) +0.5 A
d) +0.55 A
e) -0.92 A
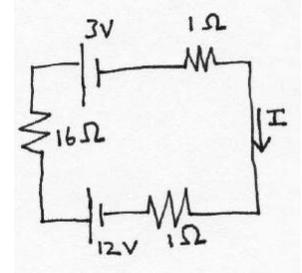
Problem 6 (10 pts):

Find the ratio of the power dissipated in resistor 1 to that in resistor 2 to that in resistor 3, $P_1:P_2:P_3$, for the circuit sketched to the right. Assume $R_1=R_2=R_3$. Show your work.

Problem 7 (10 pts):

Consider two parallel plate capacitors that are identical in every way except that one (capacitor A) has air between the plates while the other (capacitor B) has a dielectric material between the plates which has a dielectric constant of 2.

(a) If each capacitor is fully charged by a battery with a potential difference of V, how does the energy stored in capacitor A compare to that in capacitor B?

(b) Suppose the fully charged capacitors in part (a) are discharged separately through the same resistor. When capacitor A is discharging through the resistor, it is observed that it takes 20 seconds for the charge on the capacitor to drop by half. How long will it take for the charge on capacitor B to drop by half when it is discharging through the resistor?

Problem 8 (11 pts):

Two resistors, 3.0 Ω and 5.0 Ω, are connected in series. The current through the 5.0 Ω resistor is 0.75 A. What is the potential difference across the series combination?

Problem 9 (11 pts):

Three capacitors are connected as shown in the sketch to the right. Their capacitances are C_1=4.0 μF, C_2=6.0 μF, and C_3=3.0 μF. If the voltage across the combination, V_{AB}, is 400V, what is the charge on each capacitor?
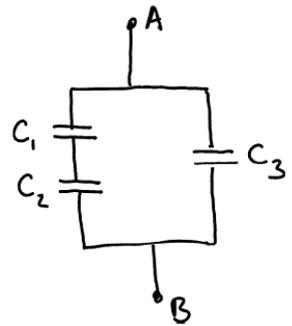
Problem 10 (10 pts):

An infinitely long, straight wire carrying a current I_1 is partially surrounded by a loop as shown in the sketch to the right. The loop has a length L and radius R, and it carries a current I_2. The axis of the loop coincides with the wire. Calculate the force exerted on the loop. (*If it is not obvious from the sketch, each of the semicircular parts of the loop are in a plane that is perpendicular to the long, straight wire and the linear parts of the loop are parallel to and on opposite sides of the long straight wire.*)
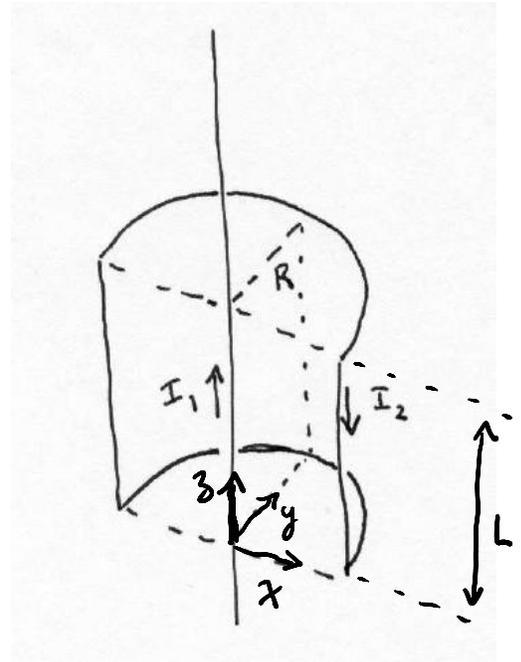
Problem 11 (10 pts):

Liquid dielectrics having polar molecules (such as water) always have dielectric constants that decrease with increasing temperature. Why?

Exam 2 Formulas

$$\vec{F} = q\vec{E}$$

$$\vec{F} = \frac{kq_1q_2}{r_{12}^2}\hat{r}_{12} = \frac{1}{4\pi\epsilon_0}\frac{q_1q_2}{r_{12}^2}\hat{r}_{12}$$

$$\phi_E = \oint \vec{E}\cdot d\vec{A}$$

$$\oint \vec{E}\cdot d\vec{A} = \frac{Q_{enclosed}}{\epsilon_0}$$

$$\vec{E} = \int_{vol} \frac{kdQ}{r^2}\hat{r}$$

$$V = work/charge$$

$$V_{\substack{point \\ charge}} = \frac{kQ}{r}$$

$$V = \int_{vol} \frac{kdQ}{r}$$

$$E_s = -dV/ds$$

$$V = IR$$

$$Q = CV$$

$$U = \tfrac{1}{2}CV^2$$

$$P = IV = I^2R = \frac{V^2}{R}$$

$$|e| = 1.6\times10^{-19}\ coulombs$$

$$k = 8.99\times10^9\ \frac{Nm^2}{C^2}$$

$$\epsilon_0 = 8.85\times10^{-12}\ C^2/Nm^2$$

$$\mu_0 = 4\pi\times10^{-7}\ \frac{Tm}{A}$$

$$E = E_0/\kappa$$

$$C = \kappa C_0$$

$$Q(t) = C\mathcal{E}(1-e^{-t/RC})$$

$$Q(t) = Q_0 e^{-t/RC}$$

$$\left.\begin{array}{l} R_{eq} = \Sigma r_i \\ 1/C_{eq} = \Sigma 1/c_i \end{array}\right\} \begin{array}{l} \text{For series} \\ \text{geometry} \end{array}$$

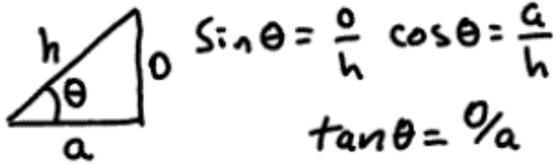$$\vec{F} = q\vec{V}\times\vec{B} = \ell\vec{i}\times\vec{B}$$

$$\vec{\mu} = nIA$$

$$\vec{\tau} = \vec{\mu}\times\vec{B}$$

$$B_{solenoid} = \mu_0 nI$$

$$\vec{B} = \frac{\mu_0}{4\pi}\int \frac{i\,d\vec{l}\times\hat{r}}{r^2}$$

$$\int_{curve} \vec{B}\cdot d\vec{l} = \mu_0 I_{encl}$$

$$\sin\theta = \frac{o}{h} \quad \cos\theta = \frac{a}{h}$$

$$\tan\theta = \frac{o}{a}$$

Sphere: $A = 4\pi r^2 \quad V = \frac{4}{3}\pi r^3$

cylinder: $A = 2\pi r L + 2\pi r^2$

$$V = \pi r^2 L$$

$$a_c = \frac{mv^2}{r}$$

$$S = r\theta$$

$$KE = \frac{1}{2}mv^2$$

$$PE_{spring} = \frac{1}{2}kx^2$$

$$\int u^n du = \frac{u^{n+1}}{n+1}$$

$$\int \frac{du}{u} = \ln|u|$$

$$\int e^u du = e^u$$

$$\int \frac{x\,dx}{(x^2+a^2)^{1/2}} = \sqrt{x^2+a^2}$$

$$V = V_0 + at$$

$$x = x_0 + V_0 t + \frac{1}{2}at^2$$

$$V^2 = V_0^2 + 2a(x-x_0)$$

$$x = x_0 + \frac{1}{2}(V+V_0)t$$