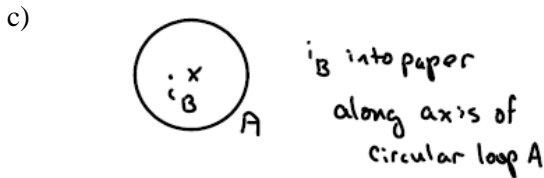
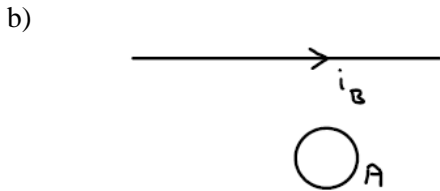
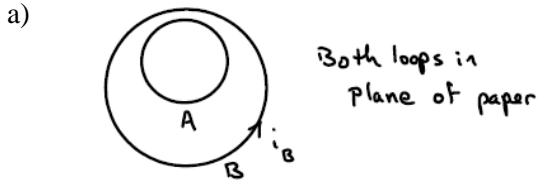


Exam 2 (October 16, 2010)

Please read the problems carefully and answer them in the space provided. Write on the back of the page, if necessary. Show all your work. Partial credit will be given.

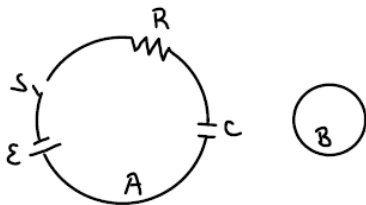
Problem 1 (9 pts, briefly indicate reasoning):

In the three cases shown below the current i_B is increasing with time. Indicate the direction of the induced current in the loop labeled A in each case. If there is no current induced in loop A, indicate that by writing "no current" beside loop A for that case.



Problem 2 (9 pts, show your work):

The sketch below shows an EMF arranged in series with a resistor, R, and a capacitor, C. Qualitatively describe the current in loop B (which is in the same plane as loop A) as a function of time after switch S is closed in loop A. A graphical description is acceptable.



Problem 3 (18 pts, use care, no partial credit for each part, no need to show work):

A charged particle moving at a constant speed enters a region of constant magnetic field as shown in the sketch below.



A number of changes to this initial situation are described in parts a-f below. Relative to this initial situation, select from choices i-v below that describe how each change will affect the magnetic force on the particle shortly after it enters the magnetic field. Place the best choice (i, ii, iii, iv or v) next to the part where the change is described.

- i) This change will alter only the direction of the force on the particle.
- ii) This change will only increase the magnitude of the magnetic force on the particle.
- iii) This change will only decrease the magnitude of the magnetic force on the particle.
- iv) This change will alter both the magnitude and direction of the magnetic force on the particle.
- v) This change will not affect the magnetic force on the particle.

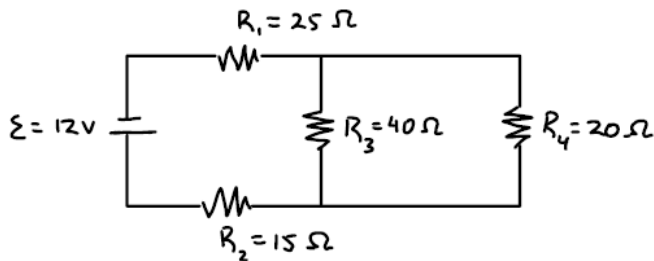
Each change below refers to the initial situation described above:

- a) _____ The +q particle is replaced by a +2q particle.
- b) _____ The +q particle is replaced by a -q particle.
- c) _____ The +q particle is replaced by a neutral particle.
- d) _____ The particle enters the region moving at a slower initial velocity.
- e) _____ The magnetic field is one-third its original strength.
- f) _____ The direction of the magnetic field is parallel to the particle's initial velocity.

1)	/9
2)	/9
3)	/18
4)	/10
5)	/10
6)	/10
7)	/17
8)	/17
<hr/>	
tot	/100

Problem 4 (10 pts, show your work):

Consider the circuit below. Determine the current in R_3 .



Problem 5 (10 pts, show your work):

A cubical volume with sides of length 1 m contains 1 coulomb of electric charge, evenly distributed. What will be the charge density in the volume as observed by a scientist in a spaceship traveling past the volume at $0.95c$. Assume the direction of travel for the spaceship is perpendicular to one of the faces of the cube of charge.

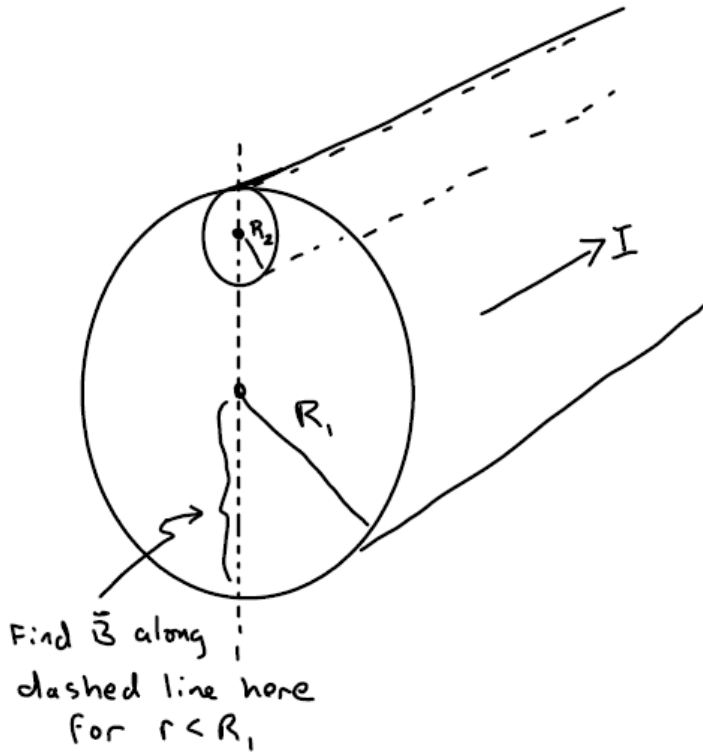
Problem 6 (10 pts, show your work):

- (a) What is the energy per unit length stored in an infinite solenoid of radius R_1 , n turns per unit length and carrying a current I ?

- (b) What is the energy per unit length if the same solenoid is filled with a paramagnetic material of permeability μ ?

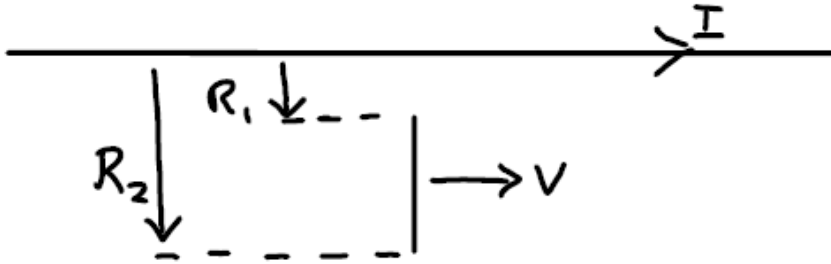
Problem 7 (17 pts, show your work):

Consider the infinite cylindrical conductor of radius R_1 sketched below. This conductor has a cylindrical hole of radius $R_2 < R_1/2$ along its length. The hole is adjacent to the surface as shown. The conductor carries a current I with a uniform current density. Determine the magnetic field at a point along the line joining the center of the conductor and the center of the hole, on the side for $r < R_1$ on the side opposite the hole.



Problem 8 (17 pts, show your work):

An infinite straight wire carries current I . A thin, straight length of conductor moves in the direction along the wire at speed v as shown in the sketch. The moving conductor is perpendicular to the wire and oriented along a radial line from the current-carrying wire. Determine the potential difference between the two ends of the moving conductor.



EXAM 2 Formulas

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

$$\vec{F} = k \frac{q_1 q_2}{r_{12}^2} \hat{r}_{12} = \frac{1}{4\pi\epsilon_0} \frac{q_1 q_2}{r_{12}^2} \hat{r}_{12}$$

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

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

$$\vec{E} = \int_{\text{vol}} k \frac{dQ}{r^2} \hat{r}$$

$V = \text{work/charge}$

$$V_{\text{POINT charge}} = \frac{kQ}{r}$$

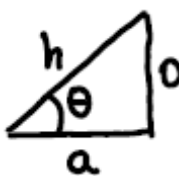
$$V = \int_{\text{vol}} \frac{k dQ}{r}$$

$$E_s = -dV/ds$$

$$|e| = 1.6 \times 10^{-19} \text{ coulombs}$$

$$k = 8.99 \times 10^9 \frac{\text{N m}^2}{\text{C}^2}$$

$$\epsilon_0 = 8.85 \times 10^{-12} \text{ C}^2/\text{Nm}^2$$



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

$$\tan \theta = o/a$$

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

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

$$x' = \gamma(x - vt)$$

$$y' = y$$

$$z' = z$$

$$t' = \gamma(t - \frac{vx}{c^2})$$

$$\gamma = \frac{1}{\sqrt{1 - (\frac{v}{c})^2}}$$

$$U'_x = \frac{U_x - V}{1 - \frac{V}{c^2} U_x}$$

$$U'_{y,z} = \frac{U_{y,z}}{\gamma(1 - U_x \frac{v}{c^2})}$$

$$E = \gamma mc^2$$

$$P = m\eta = m \frac{dx}{dt} = m\gamma v$$

$$U_{\text{capacitor}} = \frac{1}{2} CV^2$$

$$Q = CV$$

$$E_{\text{plate}} = \sigma / \epsilon_0$$

$$U_E = \frac{\epsilon_0}{2} E^2$$

$$P = iV = i^2 R = \frac{V^2}{R}$$

$$V = iR$$

$$\mathbf{F} = \oint \vec{v} \times \vec{B}$$

$$|\vec{\mu}| = |niA|$$

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

$$\oint \vec{B} \cdot d\vec{l} = \mu_0 I_{\text{encl}}$$

$$B_{\text{solenoid}} = \mu_0 ni$$

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

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

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

$$E = E_0 / \kappa$$

$$\mathcal{E} = -d\Phi_M / dt$$

$$\Phi_M = \oint \vec{B} \cdot d\vec{a}$$

$$\mathcal{E} = -L di / dt$$

$$\Phi = Li$$

$$U_B = \frac{B^2}{2\mu_0} \quad \mu = \mu_0(1 + \chi)$$

$$\vec{B}_{\text{matter}} = \mu \vec{B}_{\text{free}}$$

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

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

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

$$\int \frac{x dx}{(x^2 + a^2)^{3/2}} = \frac{1}{\sqrt{x^2 + a^2}}$$