Physics 1C

MIDTERM 1 - April 25, 2016

The exam lasts 50 minutes. You may consult both sides of a single $3'' \times 5''$ notecard, otherwise the exam is closed book and closed notes. A graphing calculator is allowed.

Show all your work in order to receive credit for your answer! Include any supporting diagrams and calculations, be sure to give the magnitude and direction of vectors, and clearly indicate your final answers.

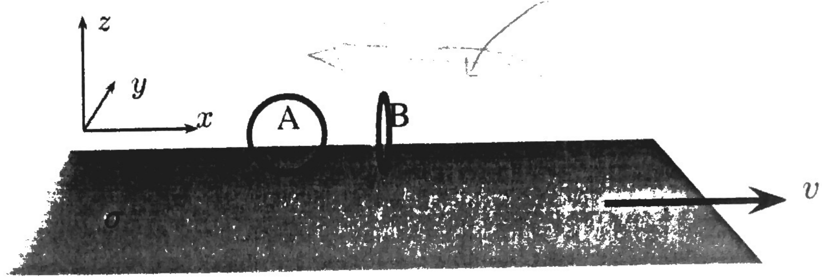
Do not begin the exam until everyone is instructed to do so. Your signature below indicates your adherence to the University's policies of academic integrity.

Name: ______________________

Signature: ______________________

Student ID #: ______________________

Question Number	Maximum Points	Points Earned
1	30	25
2	30	3
2	30	5
Total:	90	33



25

1. A very long and wide sheet of uniform surface charge σ lies in the xy-plane and moves with velocity v in the x-direction.

   The two conducting rings in the figure have the same resistance R and area S. Ring A lies in the xz-plane, and ring B lies in the yz-plane. Ignore the self-inductance of the rings.

   Assume for now that the velocity v is constant.

   (a.) (10) Find the magnetic field produced by the sheet (magnitude and direction).

$\sigma = \frac{Q}{A}$

$dq = \sigma \cdot l v dt$

$I = \frac{dq}{dt} = \sigma l v$

$v dt$

$\oint B \cdot ds = \mu_0 I_{encl}$

$Bl + Bl = \mu_0 \sigma l v$

$$\boxed{B = \frac{\mu_0 \sigma v}{2} \ (-\hat{x})}$$

$\hat{z}$

8

(b.) (10) Find the induced currents in the rings, including the directions.

$I_{induced} =$

A

Φ_B through A = 0

so $I_{induced} = 0$.

B

~~Induced in $-\hat{y}$ direction.~~

$\mathcal{E} = -\frac{d\Phi_B}{dt}$

$= \frac{d}{dt} -\frac{\mu_0 \sigma}{2}$

$= 0$

no induced current

10

The sheet now accelerates with acceleration a.

(c.) (10) Find the induced currents in the rings, including the directions.

A

$I_{induced} = 0$

b/c plane of ring A to $\vec{B}$

5

B

$\mathcal{E} = -\frac{d\Phi_B}{dt}$

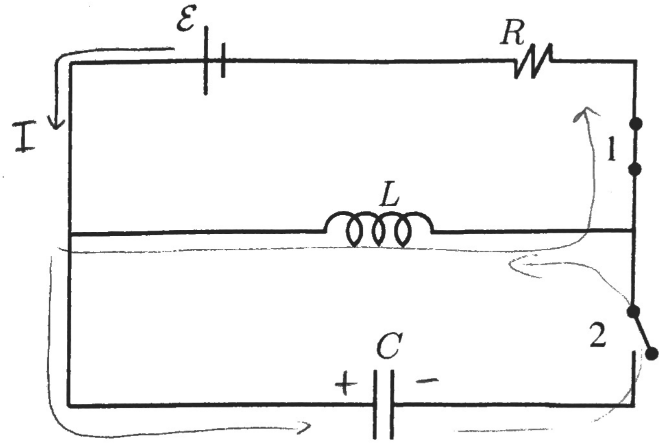
$= \frac{\mu_0 \sigma}{2} \frac{dv}{dt} \times S$

2

$\mathcal{E} = IR$

$I = \frac{\mu_0 \sigma}{2I} \frac{dv}{dt} \times S$ in $-\hat{y}$ direction

×



3

2. In the circuit shown in the figure switch 1 has been closed for a long time. At time $t = 0$ switch 1 is opened as switch 2 is closed simultaneously.

(a.) (10) What is the maximum charge that will appear on the capacitor?

$\mathcal{E} - L\cancel{\frac{dI}{dt}}^{\to 0} - IR = 0$ when ① closed.

$\mathcal{E} = IR$

$I_{max} = \mathcal{E}/R$ ✓ 3 $I(t) = \mathcal{E}/R\,(1-e^{-tR/L})$

① open ② closed

$-\frac{Q}{C} - \frac{LdI}{dt} = 0$

at $t=0$, $Q=0$

so $\varphi = 90$.

$\frac{LdI}{dt} = \frac{Q}{C}$

$Q(t) = Q_{max}\cos(\omega t + \varphi)$

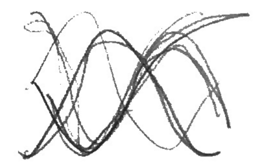
$\omega = \sqrt{1/LC}$

$Q(t) = Q_{max}\cos(\omega t + 90)$

$Q_{max} = ?$

(b.) (10) How much time will pass after $t = 0$ until the energy stored in the capacitor will be increasing at its greatest rate?

$Q(t) = Q_{max} \cos(\omega t + \frac{\pi}{2})$



$dq = -Q_{max} \cdot \omega \sin(\omega t + \frac{\pi}{2})$

$= Q_{max} \cdot \omega \cos(\omega t)$

at $\boxed{t = \frac{3\pi}{2}}$ x

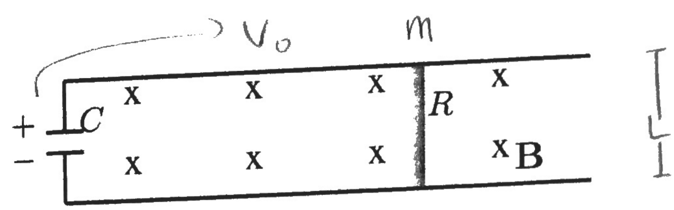
(c) (10) What is the greatest rate at which energy flows into the capacitor?

$$E = \frac{1}{2}LI^2 + \frac{1}{2}\frac{Q^2}{C}$$

$$\frac{1}{2}LI^2 = \frac{1}{2}\frac{Q^2}{C}$$

$$\Delta U = \int_0^t \frac{1}{2}\frac{Q(t)^2}{C}\,dt$$

$$\Delta U = \int_0^t P\,dt =$$



3. A capacitor is charged to a voltage V_0, and at time $t = 0$ the capacitor is connected to a pair of horizontal conducting rails on which a conducting bar can slide without friction. The rails have zero resistance, and the bar has mass m, length L, and resistance R. A uniform magnetic field B is directed into the page. Ignoring the magnetic field created by the rails, find:

$\dot{B}$ and $\vec{A}$ in same direction

(a.) (5) the initial current in the bar at $t = 0$;

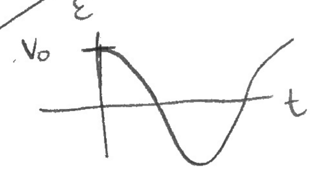
$V_0 - IR - vB\ell = 0$; at $t=0$, $v=0$ so

$V_0 = IR$

$\boxed{I_0 = \frac{V_0}{R}}$

(b.) (15) the current in the bar at any time $t > 0$;

$\mathcal{E}(t) = V_0 \cos(\omega t)$



so

$V_0 \cos(\omega t) - IR - vB\ell = 0$

$I \ell B$.

take $\frac{d}{dt}$

$-V_0 \omega \sin(\omega t) - R\frac{dI}{dt} - B\ell\frac{dv}{dt} = 0$

-15

(c.) (10) the maximum velocity of the bar.

at V_{max} , $I=0$

$V_0 - vBl = 0$

$V_0 = V_{max} Bl$ - 10

$$\boxed{V_{max} = \frac{V_0}{Bl}}$$