

FINAL EXAM

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Discussion Section # \_\_\_\_\_

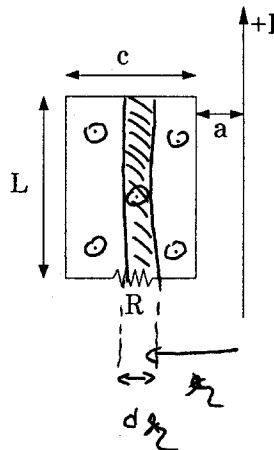
c) No credit for counter clockwise without explanation.

**SHOW ALL WORK!!!!**

**REPORT ALL NUMBERS TO THREE SIGNIFICANT FIGURES!**

**Use the conversion constants and data given on the front page.**

In the drawing shown the wire carrying current and the rectangular loop are both in the plane of the paper. The wire is long. The current in the wire is given by  $I = I_0 \cos \omega t$ . The positive direction is shown.



- 15 (a) Determine the magnetic flux through the rectangular loop in terms of the current in the wire and the geometry.  
 10 (b) Find the current in the resistor (magnitude) as a function of time.  
 5 (c) Clearly explain which direction (clockwise or counter-clockwise) the current in the rectangular loop is going at  $t = 0$ .

a)  $B = \frac{\mu_0 I}{2\pi r}$  (S)

$\phi = \int \vec{B} \cdot d\vec{A}$  (S)

at distance  $r$ ,  $B$  is constant in the infinitesimal rectangle with area  $dA = L dr$ , and  $\vec{B} \perp d\vec{A}$

$$\phi = \int_a^{c+a} B dA \cdot \cos 0 = \int_a^{c+a} \frac{\mu_0 I}{2\pi r} L dr = \frac{\mu_0 I}{2\pi} L \ln r \Big|_a^{c+a}$$

$$\phi = \frac{\mu_0}{2\pi} L \ln \frac{a+c}{a} I = \frac{\mu_0}{2\pi} L \ln \left( \frac{a+c}{a} \right) I_0 \cos \omega t$$
 (S)

b)  $\mathcal{E} = - \frac{d\phi}{dt} \Rightarrow \mathcal{E} = - \frac{\mu_0 L}{2\pi} \ln \left( \frac{a+c}{a} \right) I_0 (-\omega \sin \omega t)$

$\mathcal{E} = IR \Rightarrow I = \frac{\mu_0 L}{2\pi R} \ln \left( \frac{a+c}{a} \right) \omega I_0 \sin \omega t$

c) at  $t=0$ ,  $\sin \omega t = 0 \Rightarrow I = 0$ . So, we don't have current. However, shortly after  $t=0$ , since magnetic flux is decreasing, by Lenz's rule, the induced current tends to compensate that decrease, therefore the sense is counter clockwise. Partial credit for Lenz's rule