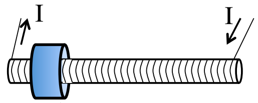
Problem 31.9

$n_{solenoid} = 1000$ turns/meter
$r_{solenoid} = .03$ m

What is the induced current in the secondary coil of the solenoid? We need an expression for the flux through the coil when it is sitting at the end. The change of that flux will create the induced EMF that drives current in the coil. That EMF is:



$B_{middle} = (\mu_o n_{sol} I)$
$B_{end} = B_{middle}/2 = (\mu_o n_{sol} I)/2$
$r_{ring} = .05$ m
$R_{ring} = 3x10^{-4}\ \Omega$
$\frac{dI}{dt} = 270$ A/s

$$\varepsilon_{induced} = -N_{ring}\frac{d\Phi_B}{dt}$$

B_{end}

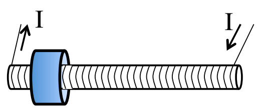
$$= -N_{ring}\left[\frac{d\left(\left(\frac{1}{2}B_{middle}\right)A_{coil}\cos 0^\circ\right)}{dt}\right]$$

$$= -(1)\left[\frac{d\left[.5(\mu_o n I)(\pi r^2_{coil})\right]}{dt}\right]$$

$$= -\left[.5\mu_o n\frac{dI}{dt}\pi r^2_{coil}\right]$$

$n = 1000$ turns/meter
$r_{coil} = .03$ m

a.) With the induced EMF, Ohm's Law suggests that:



$$i_{ring} = \frac{\varepsilon}{R}$$

$$= \frac{-N\frac{d\Phi_B}{dt}}{R}$$

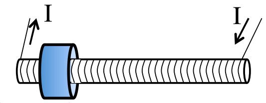
$$= \frac{-\left[\frac{1}{2}\mu_o n\frac{dI}{dt}\pi r^2_{coil}\right]}{R}$$

$$= -\frac{\frac{1}{2}(4\pi x10^{-7}\ T\bullet m/A)(1000\ turns/m)\left[\pi(.03\ m)^2\right](270\ A/s)}{(3x10^{-4}\ \Omega)}$$

$$= 1.6 \text{ amps}$$

$n = 1000$ turns/meter
$r_{coil} = .03$ m

b.) The induced current will generate a magnetic field down the axis of the ring. That magnetic field from Biot Savart is:



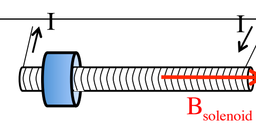
$B_{middle} = (\mu_o n_{sol} I)$
$B_{end} = B_{middle}/2$
$r_{ring} = .05$ m
$R_{ring} = 3x10^{-4}\ \Omega$
$\frac{dI}{dt} = 270$ A/s

$$B_{ring} = \frac{\mu_o i}{2r_{ring}}$$

$$= \frac{(4\pi x10^{-7}\ T\bullet m/A)(1.6\ A)}{2(.05\ m)^2}$$

$$= 4.02x10^{-4}\ T$$

c.) the Lenz's Law approach:



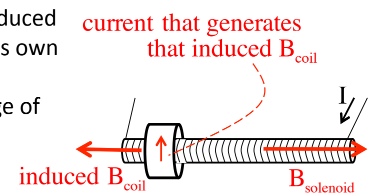
i.) Identify the direction of the external B-fld.

In this case, using the curled-fingers rule on the solenoid, the external fld is to the right.

ii.) Determine whether the magnetic flux is increasing or decreasing.

In this case, the current is increasing so as far as the ring is concerned, it is experiencing an external B-fld that is increasing.

iii.) If the induced EMF is increasing, the induced current in the coil will generate a B-fld of its own that will be OPPOSITE the direction of the external field (that is, it will *fight* the change of flux that is causing the situation).



In this case, using the curve-fingers rule on the coil to determine in what direction the coil's current flow would have to be to create that induced B-fld, we find it would have to be as shown in the sketch.