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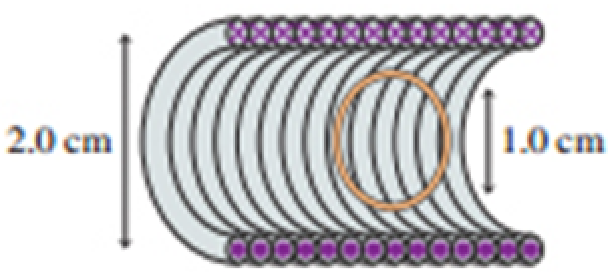
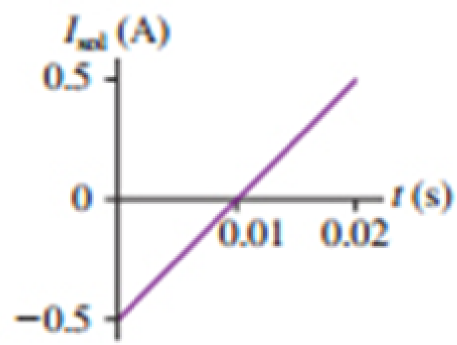
PH 213

HIP 8

The figure here shows a 1.0-cm-diameter loop with R = 0.50 Ω inside a 2.0-cm-diameter solenoid. The solenoid is 8.0 cm long, has 130 turns, and carries the current shown in the graph. A positive current is cw when seen from the left.

What is the current in the loop at t = 0.010 seconds?





An induced current is experienced by a loop of conducting material when it acquires an induced emf. An emf is induced around a closed loop if the magnetic flux through the loop changes. In our scenario we find that the change of magnetic flux is due to a change in the magnetic field which is in turn caused by the change of current over time. We can find the induced current in the ring by first finding the function I(t) and use this in our function for the Magnetic field of a solenoid, B(t). From this we would get a function for the magnetic flux, $\Phi_{mag}(t)$, through the ring. We will then take the derivative, $d\Phi_{mag}/dt$, this is our induced emf, or voltage. From this point we can find the induced current by using Ohm's Law, dividing our voltage by the resistance of the ring.

First find I(t):

I(t) = (1/.02)t → I(t)=50*t

Substitute I(t) for I in the equation for the magnetic field in a solenoid:

$B_{solenoid} = \mu_o*n*I \rightarrow B_{solenoid} = \mu_o*n*50*t$

Substitute B(t) for our equation for the magnetic flux through the conductive ring:

$\Phi_{mag} = \oint \mathbf{B} \bullet d\mathbf{A}$ → since d**A** and **B** are parallel the equation can be rewritten →

$\Phi_{mag} = \oint B * dA$ → Since this is a closed integral of the area of the circle it can be rewritten as → $\Phi_{mag} = \pi * r^2 * \mu_o * n * 50 * t$

Find voltage by taking the derivative of the magnetic flux over time:

$V = d\Phi_{mag}/dt = \pi * r^2 * \mu_o * n * 50$

Use Ohm's law to find the induced current in the ring at time t= 0.01 s:

$I = V/R$ → $I = (\pi * r^2 * \mu_o * n * 50)/R$

$r = .005$ m $\mu_o = 4\pi * 10^{-7}$ N/A^2 $n = 130/.08$ coils/length $R = 0.50\ \Omega$

$$r = .005$$

−10 10

$$u = 4 \cdot \pi \cdot 10^{-7}$$

$$u = 0.00000125663706144$$

$$n = \frac{130}{.08}$$

$$n = 1625$$

$$R = .5$$

−10 10

$$I = \frac{\left(\pi \cdot r^2 \cdot u \cdot n \cdot 50\right)}{R}$$

$$I = 0.0000160381071518$$

The induced current in the ring at t=.01s is 1.6×10^{-5} C/S.

Doing a unit check we find that the units are C/S, which is what we expect. The current is a fraction of a microampere which is within a range we would expect for the scale of the loops and the current passing through the solenoid.

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