P3323 Solenoid October 26, 2016

A long solenoid of radius a, carrying n turns per unit length, is looped by a wire with resistance R.



1. If a current in the solenoid is increasing at a constant rate $(\frac{dI}{dt} = k)$, what current flows in the loop, and which way (left or right) does it pass through the resistor? [Solution: The flux through the loop due to the field in the solenoid is

$$\Phi = \mu_0 n I \pi a^2$$

and

$$\mathcal{E} = -\frac{d\Phi}{dt} = -\mu_0 nk\pi a^2$$

 $I = \frac{\mathcal{E}}{R} = \frac{\mu_0 k n \pi a^2}{R}$. It passes from left to right through the resistor, opposite the direction of the current in the solenoid.]

2. If the current I in the solenoid is constant but the solenoid is pulled out of the loop (toward the left, to a place far from the loop), what total charge passes through the resistor?

[Solution:

$$I = \frac{dQ}{dt} = -\frac{d\Phi}{dt}\frac{1}{R} \to \Delta Q = -\frac{\Delta\Phi}{R} = \frac{\mu_0 n I \pi a^2}{R}$$