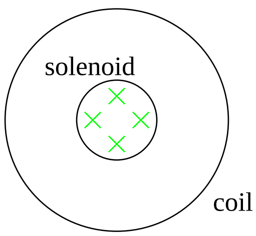
The essence of induced electric field

Strategy: Work backwards to find what we'll need:

We want the current in the coil.
To find that we'll need the emf in the coil.
To find that we'll need the change in magnetic flux through the coil.
To find that we'll need the change in magnetic field of the solenoid.
To find that we'll need the initial magnetic field of the solenoid.



Execute strategy: The initial magnetic field of the solenoid is (SI units... convert n from 220 turns/cm to 22000 turns/m)

$$B = \mu_0 i n = (4\pi \times 10^{-7})(1.5)(22000) = 0.041 \text{ T}. \tag{1}$$

The magnetic field drops steadily from this value to zero in 25 milliseconds, so

$$\frac{dB}{dt} = \frac{0.041 \text{ T}}{0.025 \text{ s}} = 1.7 \text{ T/s}. \tag{2}$$

Now the magnetic flux through one loop of the coil (*not* the solenoid) is

$$\begin{aligned} \Phi_B &= [B \text{ inside solenoid}][\text{area of solenoid}] + [B \text{ outside solenoid}][\text{area of annulus}] \\ &= [B \text{ inside solenoid}][\pi(0.016 \text{ m})^2] + [0][\text{area of annulus}]. \end{aligned}$$

(Note that the given diameter of the coil, 3.2 cm, is irrelevant data.) Thus

$$\text{emf in one turn of the coil} = \frac{d\Phi_B}{dt} = \frac{dB}{dt}\pi(0.016 \text{ m})^2 \tag{3}$$

and

$$\text{emf in coil} = [\text{number of turns}][\text{emf in one turn}] = 120\frac{dB}{dt}\pi(0.016 \text{ m})^2 = 0.16 \text{ V}. \tag{4}$$

Finally

$$\text{current in coil} = \frac{\text{emf in coil}}{\text{resistance of coil}} = \frac{0.16 \text{ V}}{5.3 \ \Omega} = 30 \text{ mA}. \tag{5}$$

Debrief/Contemplate: How can the $\vec{B}$, confined to the interior of the solenoid, affect the current in the coil? It's not the $\vec{B}$ that pushes the charge carriers in the coil, nor even the changing $\vec{B}$. It's the $\vec{E}$ produced by the changing $\vec{B}$ that pushes the charge carriers. The $\vec{E}$ produced by changing $\vec{B}$ exists far from the changing $\vec{B}$ just as the $\vec{E}$ produced by charge exists far from the charge.

Grading: two points for each of the five numbered equations.