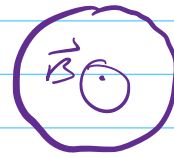


29.47

•• **CALC** A very long, straight solenoid with a cross-sectional area of 2.00 cm^2 is wound with 90.0 turns of wire per centimeter. Starting at $t = 0$, the current in the solenoid is increasing according to $i(t) = (0.160 \text{ A/s}^2)t^2$. A secondary winding of 5 turns encircles the solenoid at its center, such that the secondary winding has the same cross-sectional area as the solenoid. What is the magnitude of the emf induced in the secondary winding at the instant that the current in the solenoid is 3.20 A ?



End View



$$B \text{ due to solenoid} = \mu_0 n i$$

$$\Phi = \text{flux through coil} = \underset{5}{N} \underset{\mu_0 n i}{B} \underset{2.00 \text{ cm}^2}{A}$$

$$A = 2.00 \text{ cm}^2 \times \left(\frac{1 \text{ m}}{100 \text{ cm}} \right)^2 = 2 \times 10^{-4} \text{ m}^2$$

$$\mathcal{E} = - \frac{d\Phi}{dt} = - \frac{d}{dt} (N A \mu_0 n i)$$

$$\mathcal{E} = N A \mu_0 n \left(\frac{di}{dt} \right)$$

$$i = 0.160 \frac{\text{A}}{\text{s}^2} \cdot t^2$$

$$\frac{di}{dt} = 0.320 \frac{\text{A}}{\text{s}^2} \cdot t \quad \text{at what time?}$$

$$\text{Given } 3.20 \text{ A} = 0.160 \frac{\text{A}}{\text{s}^2} t^2$$

$$t = \sqrt{\frac{3.20}{0.160}} \text{ s} = \sqrt{20} \text{ s}$$

Plugging in ...

$$\mathcal{E} = -NA\mu_0 n \left(\frac{di}{dt} \right)$$

$$\mathcal{E} = - (5) (2 \times 10^{-4} \text{ m}^2) (4\pi \times 10^{-7} \text{ Tm/A}) \cdot$$

$$\left(\frac{90 \text{ turns}}{\text{cm}} \times \frac{100 \text{ cm}}{\text{m}} \right) \times \left(0.320 \frac{\text{A}}{\text{s}^2} \right) \sqrt{20 \Omega}$$

$$|\mathcal{E}| = 1.62 \times 10^{-5} \text{ V} = 16.2 \mu \text{ V}$$