Remember: \( B = \mu_0 n I \) inside a long solenoid

\[
\varepsilon_{\text{induced}} = -\frac{d\Phi_B}{dt} = -L \frac{dI}{dt} ; \quad \Phi_B = B \cdot A = BA \cos \theta ; \quad L = \frac{N\Phi_B}{I}
\]

\( \mu_0 = 4\pi \times 10^{-7} \text{ Wb}/\text{A} \cdot \text{m} = 1.26 \times 10^{-6} \text{ N/A}^2; \)

Area of circle = \( \pi R^2 \); Circumference of circle = \( 2\pi R \);

\( \sin 30^\circ = \cos 60^\circ = 1/2 ; \quad \sin 60^\circ = \cos 30^\circ = \sqrt{3}/2 ; \quad \sin 45^\circ = \cos 45^\circ = \sqrt{2}/2 \)

Correct answers have correct electrical units and 2 significant figures.

You are given an air-filled solenoid with \( N \) turns, radius \( R \) and length \( Z \) where the current \( I(t) \) changes as a function of time, \( \frac{dI}{dt} \neq 0 \).

A. At the instant when the current is \( I \), what is the direction of the field \( B \) in the center of the solenoid in the figure? Circle one of the following: into the page, out of the page, to the left, to the right, no field.

B. At the instant when the current is \( I \), what is the magnitude of the field \( B \) in the center of the solenoid?

\[
B = \mu_0 n I = \mu_0 \left( \frac{N}{Z} \right) I
\]

C. What is the magnetic flux \( \Phi_B \) through a single turn of the solenoid?

\[
\Phi_B = B \cdot A = \mu_0 \left( \frac{N}{Z} \right) I \pi R^2
\]

D. What is the self-inductance \( L \) of the entire solenoid?

\[
L = \frac{\Phi_B}{\frac{dI}{dt}} = \frac{\mu_0 \left( \frac{N}{Z} \right) I \pi R^2}{\frac{dI}{dt}} = \frac{\mu_0 N^2 \pi R^2}{Z}
\]

E. If \( R = 0.020 \text{ m}, Z = 0.50 \text{ m}, N = 500 \) and \( \frac{dI}{dt} = 10 \text{ A/s} \), what is the numerical value of the self-inductance \( L \) of the entire solenoid?

\[
L = \left(1.26 \times 10^{-6} \frac{\text{N}}{\text{A}^2} \right) \left(500 \right)^2 \pi \left(0.020 \text{ m} \right)^2 / 0.50 \text{ m}
\]

\[
= 7.9 \times 10^{-4} \text{ H}
\]