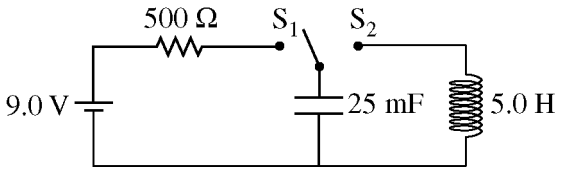


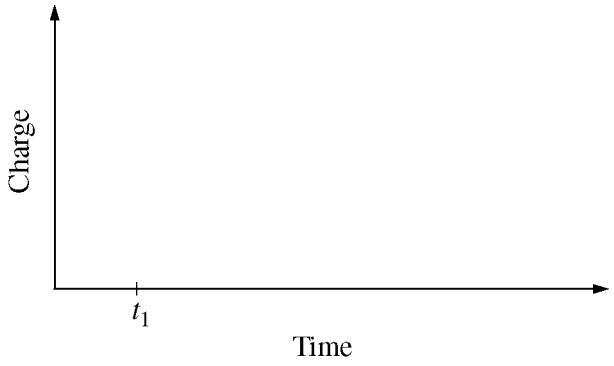
E&M. 2.

The circuit represented above contains a 9.0 V battery, a 25 mF capacitor, a 5.0 H inductor, a 500 Ω resistor, and a switch with two positions, S_1 and S_2. Initially the capacitor is uncharged and the switch is open.

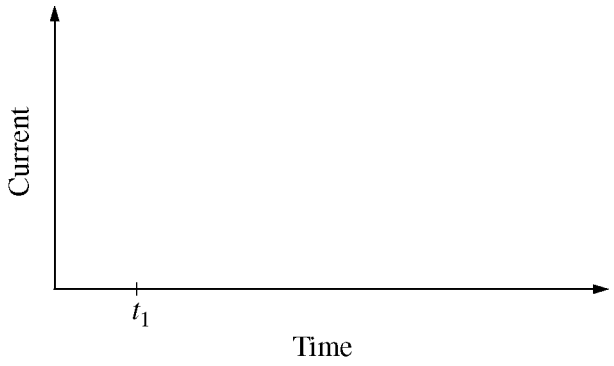
(a) In experiment 1 the switch is closed to position S_1 at time t_1 and left there for a long time.

i. Calculate the value of the charge on the bottom plate of the capacitor a long time after the switch is closed.

ii. On the axes below, sketch a graph of the magnitude of the charge on the bottom plate of the capacitor as a function of time. On the axes, explicitly label any intercepts, asymptotes, maxima, or minima with numerical values or algebraic expressions, as appropriate.



iii. On the axes below, sketch a graph of the current through the resistor as a function of time. On the axes, explicitly label any intercepts, asymptotes, maxima, or minima with numerical values or algebraic expressions, as appropriate.

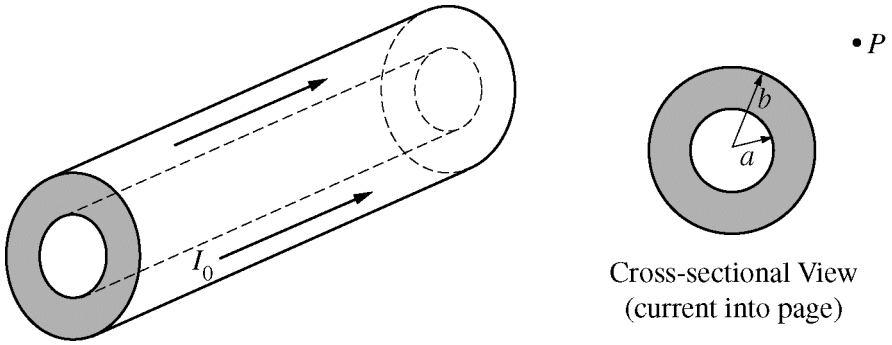


(b) In experiment 2 the capacitor is again uncharged when the switch is closed to position S_1 at time t_1. The switch is then moved to position S_2 at time t_2 when the magnitude of the charge on the capacitor plate is 105 mC, allowing electromagnetic oscillations in the LC circuit.

i. Calculate the energy stored in the capacitor at time t_2.

ii. Calculate the maximum current that will be present during the oscillations.

iii. Calculate the time rate of change of the current when the charge on the capacitor plate is 50 mC.



E&M. 3.

A section of a long conducting cylinder with inner radius a and outer radius b carries a current I_0 that has a uniform current density, as shown in the figure above.

(a) Using Ampère's law, derive an expression for the magnitude of the magnetic field in the following regions as a function of the distance r from the central axis.

i. $r < a$

ii. $a < r < b$

iii. $r = 2b$

(b) On the cross-sectional view in the diagram above, indicate the direction of the field at point P, which is at a distance $r = 2b$ from the axis of the cylinder.

(c) An electron is at rest at point P. Describe any electromagnetic forces acting on the electron. Justify your answer.

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Question 2

15 points total **Distribution of points**

(a)

i. 2 points

For correctly calculating the magnitude of the charge on the bottom plate of the capacitor and including correct units — 1 point

$V = Q/C$

$Q = CV$

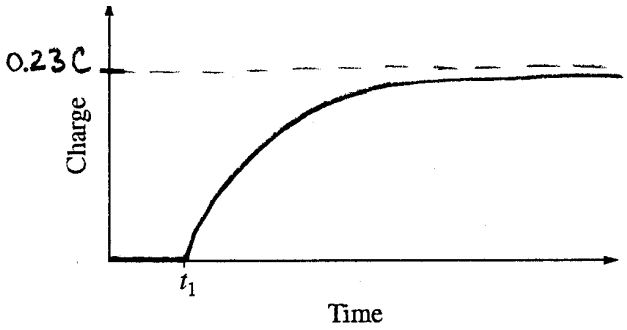
$Q = \left(25 \times 10^{-3}\ \text{F}\right)(9.0\ \text{V})$

$Q = 0.23\ \text{C}$

For correctly identifying the charge on the bottom plate as negative. — 1 point

With the polarity of the battery terminal attached to the bottom plate shown in the figure, the charge is negative.

ii. 3 points



For correctly indicating and labeling the asymptote, with either the value determined in part (a) or an equivalent algebraic expression — 1 point

For explicitly showing $Q = 0$ for $t < t_1$ — 1 point

For correctly sketching the curve, starting at $t = t_1$ and asymptotically approaching the maximum charge — 1 point