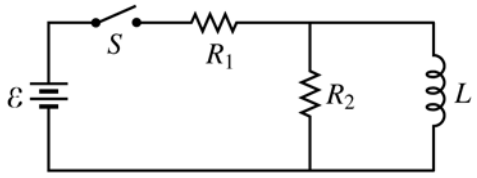


E&M. 2.

In the circuit shown above, resistors 1 and 2 of resistance R_1 and R_2, respectively, and an inductor of inductance L are connected to a battery of emf $\mathcal{E}$ and a switch S. The switch is closed at time $t = 0$. Express all algebraic answers in terms of the given quantities and fundamental constants.

(a) Determine the current through resistor 1 immediately after the switch is closed.

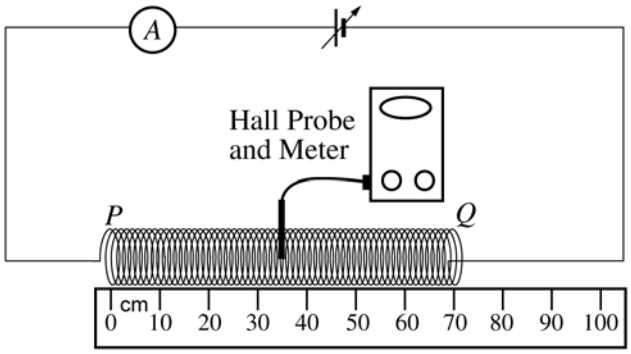
(b) Determine the magnitude of the initial rate of change of current, dI/dt, in the inductor.

(c) Determine the current through the battery a long time after the switch has been closed.

(d) On the axes below, sketch a graph of the current through the battery as a function of time.

Some time after steady state has been reached, the switch is opened.

(e) Determine the voltage across resistor 2 just after the switch has been opened.



E&M. 3.

A student performs an experiment to measure the magnetic field along the axis of the long, 100-turn solenoid PQ shown above. She connects ends P and Q of the solenoid to a variable power supply and an ammeter as shown. End P of the solenoid is taped at the 0 cm mark of a meterstick. The solenoid can be stretched so that the position of end Q can be varied. The student then positions a Hall probe* in the center of the solenoid to measure the magnetic field along its axis. She measures the field for a fixed current of 3.0 A and various positions of the end Q. The data she obtains are shown below.

Trial	Position of End Q (cm)	Measured Magnetic Field (T) (directed from P to Q)	n (turns/m)
1	40	9.70×10^{-4}	
2	50	7.70×10^{-4}	
3	60	6.80×10^{-4}	
4	80	4.90×10^{-4}	
5	100	4.00×10^{-4}	

(a) Complete the last column of the table above by calculating the number of turns per meter.

*A Hall Probe is a device used to measure the magnetic field at a point.

Question 2 (continued)

Distribution of points

(c) 2 points

After a long time the current is constant, so $V_L = 0$.

$V_L = V_{R_2} = 0$, so a constant current goes through resistor 1 and the inductor.

$V_{\text{batt}} = V_{R_1}$

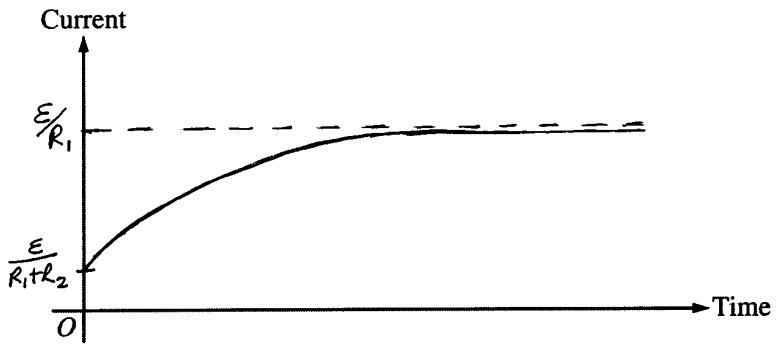
For the correct substitution of both voltage and resistance, using Ohm's law for V_{R_1} — 1 point

$\mathcal{E} = I_{\text{batt}} R_1$

For the correct answer — 1 point

$I_{\text{batt}} = \mathcal{E}/R_1$

(d) 4 points



For a graph that rises asymptotically — 1 point

This point must be earned in order to obtain any of the following points.

For starting the line above zero — 1 point

For starting the line at the lower limit determined in (a) — 1 point

For approaching the upper limit determined in part (c) — 1 point

(e) 3 points

The current calculated in part (c) that was going through the inductor now goes through only resistor 2.

For correct application of the loop theorem — 1 point

$I_{R_2} = I_L$, where I_L equals I_{batt} determined in (c)

For correct substitution of both currents, using Ohm's law for I_{R_2} with a resistance R_2 — 1 point

$V_{R_2}/R_2 = \mathcal{E}/R_1$

For a correct final answer — 1 point

$V_{R_2} = \mathcal{E}R_2/R_1$