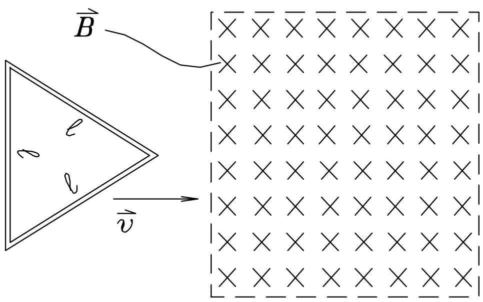
THE UNIVERSITY OF BRITISH COLUMBIA

Science 1 Physics Assignment # 17:

Faraday, Inductance and AC Circuits

Mon. 5 Mar. 2001 — finish by Mon. 12 Mar.

1. **Triangular Loop**: A wire loop in the shape of an equilateral triangle (length of a side $\ell = 0.25$ m) travelling at a constant speed $v = 4.0$ m/s moves, pointy-end first, into a region where a uniform magnetic field $B = 0.50$ T points into the paper, as shown.

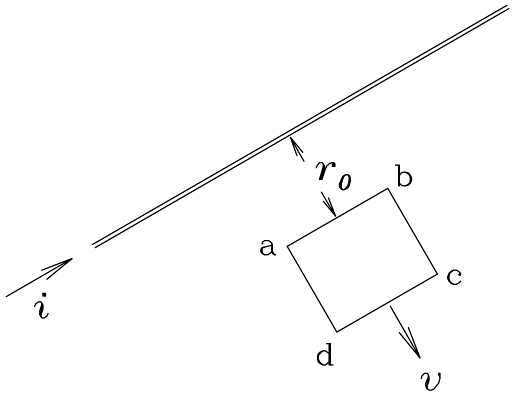


(*a*) Does current flow clockwise or counterclockwise (or not at all) around the triangular loop as it enters the field?

(*b*) What is the maximum induced $\mathcal{EMF}$ around the loop as it enters the field?

(*c*) Sketch the induced $\mathcal{EMF}$ around the loop as a function of time, from the time it begins to enter the field until it is entirely in the field.

2. **Moving Loop in Non-Uniform Field**: A long, straight, stationary wire carries a constant current of $i = 150$ A. Nearby **abcd**, a square loop 12 cm on a side, is moving *away* from the stationary wire (in a direction perpendicular to the wire) at a speed of $v = 6$ m/s. The long wire and the sides of the loop are all in a common plane; the near (**ab**) and far (**cd**) sides of the loop are parallel to the long wire and the other two sides (**bc** and **da**) are perpendicular to it. The near side (**ab**) is initially $r_\circ = 15$ cm away from the long wire. Calculate the $\mathcal{EMF}$ around the square loop at this instant, assuming that the resistance of the loop is large enough that any actual current flowing around it produces a negligible magnetic flux. Also indicate the *direction* of the small current in side **cd**.



3. **Solenoid as an *RL* Circuit:** A long wire with net resistance $R = 150\ \Omega$ is wound onto a nonmagnetic spindle to make a solenoid whose cross-sectional area is $A = 0.015\ \text{m}^2$ and whose effective length is $\ell = 0.40$ m. (Treat the coil as an ideal, long solenoid.) Using a battery with a 1 MΩ internal resistance, a magnetic field of $B_\circ = 0.5$ T has been built up inside the solenoid. At $t = 0$ the battery is shorted out and then disconnected so that the current begins to be dissipated by the coil's resistance R. We find that after 3.0 ms the field in the coil has fallen to 0.1 T.

(a) How many joules of energy are stored in the coil at $t = 0$?

(b) How long does it take for the stored energy to fall to half its initial value?

(c) What is the total number of turns in the coil?

4. ***LC* Circuit Time-Dependence:** In an LC circuit with $C = 90\ \mu\text{F}$ the current is given as a function of time by $i = 3.4\cos(1800t + 1.25)$, where t is in seconds and i is in amperes.

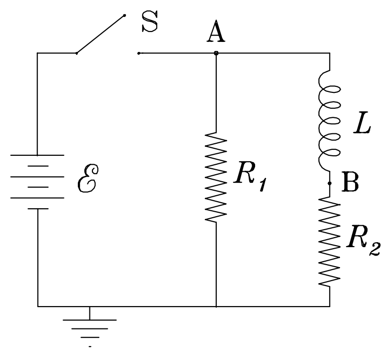
(a) How soon after $t = 0$ will the current reach its maximum value?

(b) Calculate the inductance.

(c) Find the total energy in the circuit.

5. **Build Your Own Circuit:** You are given a 12 mH inductor and two capacitors of 7.0 and 3.0 μF capacitance. List the *resonant frequencies* that can be produced by connecting these circuit elements in various combinations.

6. ***LRR* Circuit Time-Dependence:** In the circuit shown, the $\mathcal{E} = 12$ V battery has negligible internal resistance, the inductance of the coil is $L = 0.12$ H and the resistances are $R_1 = 120\ \Omega$ and $R_2 = 70\ \Omega$. The switch **S** is closed for several seconds, then opened. Make a quantitatively labelled graph with an abscissa of *time* (in milliseconds) showing the *potential* of point **A** with respect to ground, just before and then for 10 ms after the opening of the switch. Show also the variation of the potential at point **B** over the same time period.

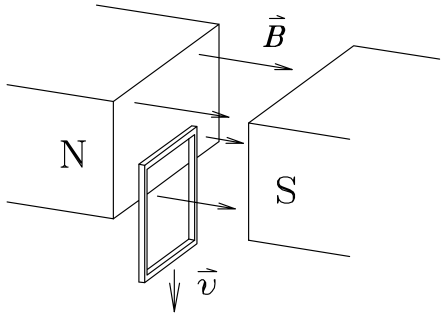


... *and* Tipler (4$^{\text{th}}$ Edition)

Ch. **30**: problems **27**, **28**, **35** and **74**

Ch. **31**: problems **61**, **71** and **86**

Challenge Problem:



Dropping Frame: A square metallic frame is located, as shown, between the poles of an electromagnet, with its face perpendicular to $\vec{\boldsymbol{B}}$. The upper side is in a region of effectively uniform field with magnitude $B = 1.5$ T, while the lower side is outside the gap, where the field is essentially zero. If the frame is released and falls under its own weight, *determine the downward terminal velocity*. Assume the frame is made of aluminum (density 2.7 g/cm^3 and resistivity 2.8×10^{-6} Ω-cm). This problem requires careful thought. It is interesting that the terminal speed can be found with so little information about the metallic frame.