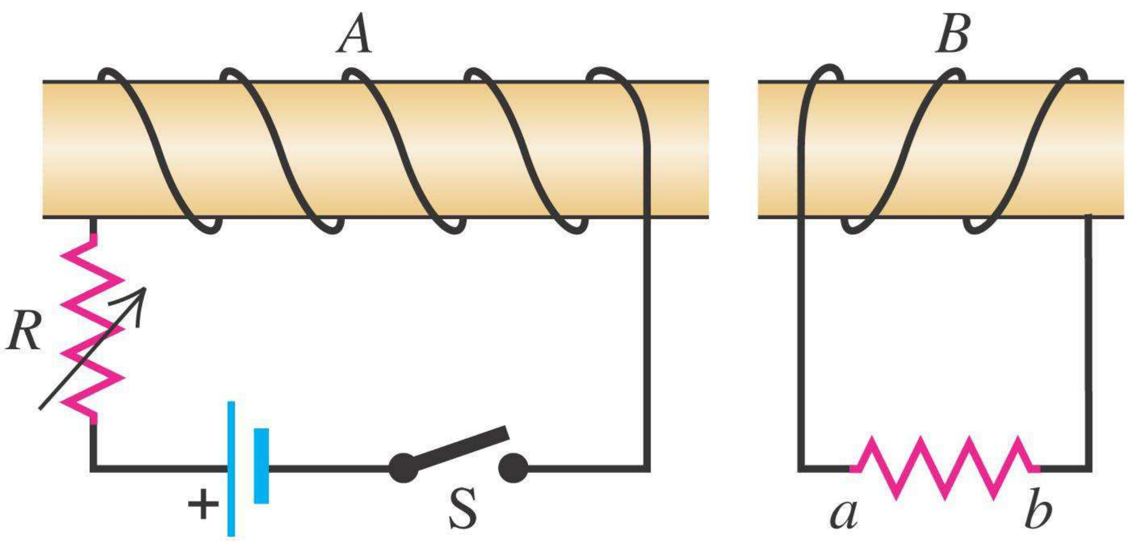
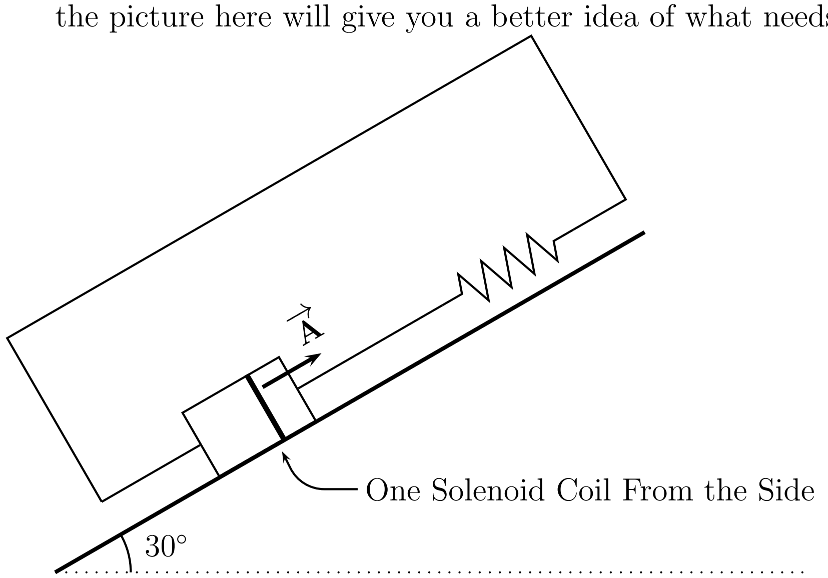
PHYS 161
Summer 2012
Homework Assignment #7
Due Monday, July 23

#1. Using Lenzs law, determine the direction of the current in the resistor *ab* of Fig E29.17 when (a) Switch S is opened after been closed for several minutes; (b) Coil B is brought closer to coil A with the switched closed; (c) The resistance R is decreased while the switch remains closed. For full credit, you must give a detailed explanation of the direction of the original magnetic field, whether the flux is increasing or decreasing, the direction of the induced magnetic field, and finally, the direction of the induced current.

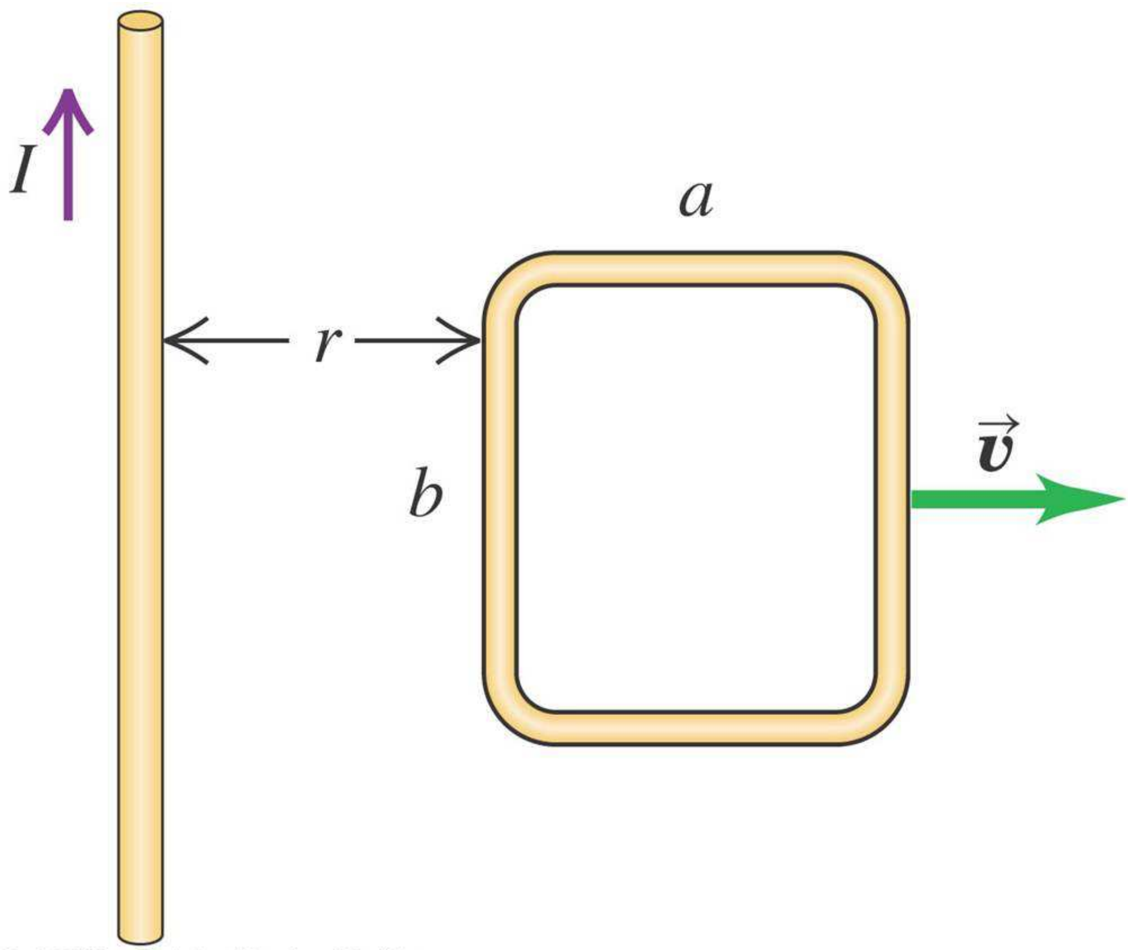


#2. **A changing magnetic field.** You are testing a new data-acquisition system. This system allows you to record a graph of the current in a circuit as a function of time. As part of the test, you are using a circuit made up of a 4.00-cm radius, 1500-turn, 1000-Ω solenoid connected in series to a 600-Ω resistor. You place the coil on a table that is tilted 30.0° from the horizontal and that lies between the poles of an electromagnet. The electromagnet generates a vertically upward magnetic field that is zero for $t < 0$, equal to $(0.25\,T) \times (1 - \cos \pi t)$ for $0 \leq t \leq 3.00\,s$, and equal to $0.5\,T$ for $t > 3.00\,s$. (a) Draw the graph that should be produced by your data-acquisition system. (This is a full-featured system, so the graph will include labels and numerical values on its axes.) (b) If you were looking down the table at the solenoid, would the current be clockwise or counterclockwise?

Note: It's kind of unclear what the original textbook problem intended here, so I want you to find the induced current plot and direction for the case where the solenoid coils are sitting on the table such that their area vectors are parallel to the table surface as shown below. Hopefully, the picture here will give you a better idea of what needs to be done.



#3. In Fig. P29.53 the loop is being pulled to the right at constant speed v. A constant current I flows in the long wire, in the direction shown. (a) Calculate the magnitude of the net emf induced in the loop. Do this in two ways: (i) by using Faradays law of induction and (ii) by looking at the emf induced in each segment due to its motion. (b) Find the direction of the current induced in the loop. Do this two ways: (i) using Lenzs law and (ii) using the magnetic force on the charges in the loop. (c) Check your answer for the emf in part (a) in the following special cases to see whether it is physically reasonable. (i) the loop is stationary; (ii) the loop is very thin so $a \to 0$;(iii) the loop gets very far from the wire.



#4. **Displacement Current in a Wire.** A long, straight, copper wire with a circular cross-sectional are of $1.5\,mm^2$ carries a current of $3\,A$. The resistivity of the material is $2.0 \times 10^{-8}\,\Omega \cdot m$. (a) What is the uniform electric field in the material? (b) If the current is changing at the rate of $6.6 \times 10^7\,A/s$, at what rate is the electric field in the material changing? (c) What is the displacement current density in the material in part (b)? (Hint: Since κ is very close to 1, use $\epsilon = \epsilon_o$.) (d) If the current is changing as in part (b), what is the magnitude of the magnetic field $6.0\,cm$ from the center of the wire? Note that both conduction current and the displacement current should be included in the calculation of B. Is the contribution from the displacement current significant?

#5. One solenoid is centered inside another. The outer one has a length of $75\,cm$ and contains 6750 coils, while the coaxial inner solenoid is $12.0\,cm$ long and $1.4\,cm$ in diameter and contains 1200 coils. The current in outer solenoid is changing at $49.2\,A/s$. (a) What is the mutual inductance of these solenoids? (b) Find the emf induced in the inner solenoid.

#6. **Solar Magnetic Energy.** Magnetic fields within a sunspot can be as strong as $0.4\,T$. Sunspots can be as large as $25,000\,km$ in radius. The material in a sunspot has a density of about $3 \times 10^{-4}\,kg/m^3$. Assume μ for a sunspot material is μ_0. If 100% of the magnetic-field energy stored in the sunspot could be used to eject the sunspots material away from the suns surface, at what speed would the material be ejected? Compare to the suns escape speed which is about $6 \times 10^5\,m/s$. (Hint: Calculate the kinetic energy the magnetic field could supply to $1\,m^3$ of sunspot material.)