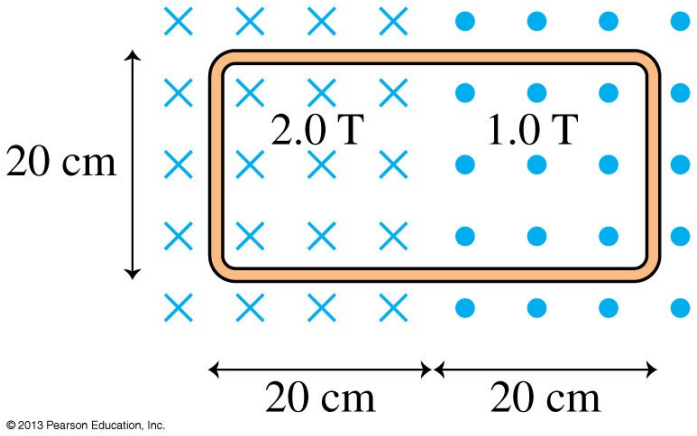
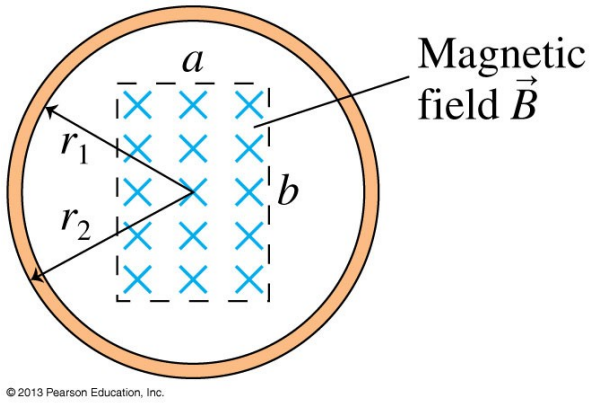
Electromagnetism and Light Course
HW06 –

Answer the following questions and e-mail to "mpsonnenfeld@gmail.com" (Please note this is not my usual e-mail address but is a special one for collecting homework). Some of these are amenable to a word processor, but you will probably need to scan in sketches. I put this out in "doc" format so you can use the homework itself as a template. (* problems are harder)

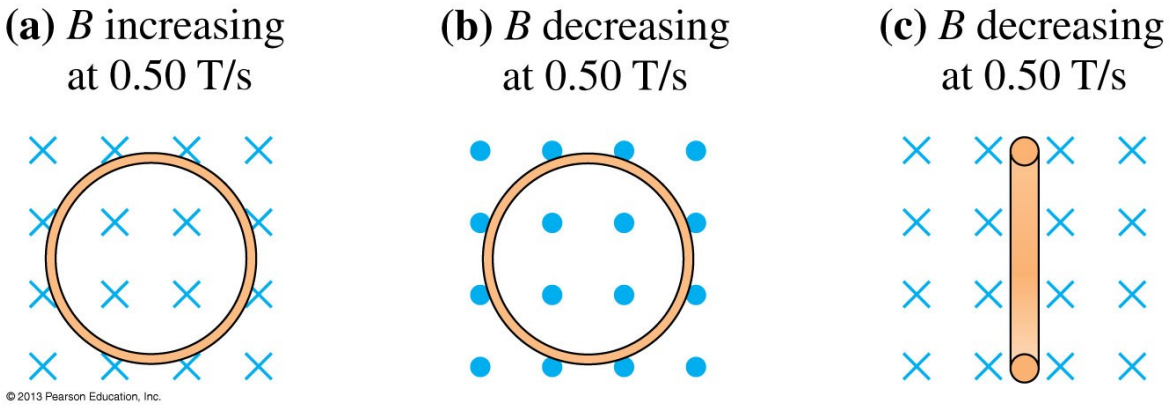
1) What is the magnetic flux through the loop shown (at left) below?





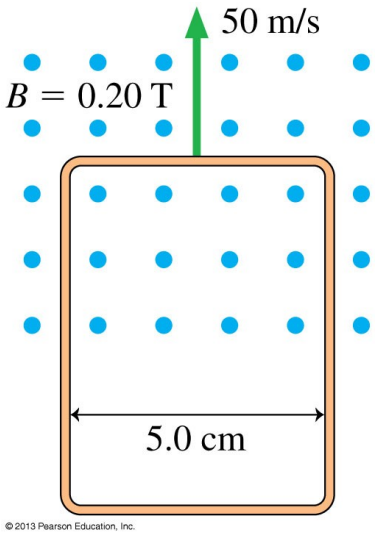
2) What is the magnetic flux through the loop shown (at right) above? (Your answer will be a formula, not a number)

3) Below are three sketches of a 10-cm-diameter loop in three different magnetic fields. The loop's resistance is 0.20 Ohms. What is the induced current in each case?



4) A 1000-turn coil of wire 1.0 cm in diameter is in a magnetic field that changes from -0.10 T to +0.10 T in 10 millisec. The axis of the coil is parallel to the field. What is the voltage induced in the coil?

5) The loop below is being pushed into the magnetic field at constant speed as shown. The loop resistance is 0.1 Ohm. What is the magnitude of the current induced in the loop?



6) A 5.0-cm-diameter coil has 20 turns and a resistance of 0.50 Ohms. A magnetic field perpendicular to the coil is $B(t)=4t-2t^2$, where B is in Tesla and time is in seconds. What is the current induced in the loop at 0, 1 and 2 seconds? Some of your answers will be negative. What do you think is the physical interpretation of a negative current?

7) A 100-turn, 2.0-cm-diameter coil is at rest in a horizontal plane.
a) At t=0, a uniform magnetic field of magnitude 0.5 Tesla and direction 60 degrees from vertical exists in the region of the coil. What is the magnetic flux through the coil at this time?
b) At t=0.6 s, this uniform magnetic field has the same direction but has increased in strength to 1.50 Tesla. What is the magnetic flux through the coil now?
c) What is the voltage (EMF) induced in the coil between 0 and 0.6 seconds?

8) A 100-turn, 8.0-cm-diameter coil has a resistance of 0.1 Ohms. At what rate must a vertical B-field decrease to induce a two Ampere current in this coil?

9) THERE IS NO PROBLEM #9

9) An electric generator works by rotating N coils of wire in a constant magnetic field. The Area (A) of the coil is constant and so is the field (B). Nonetheless the flux varies because of the rotation of the coil. The formula for variation of flux in an electrical generator is:

$\Phi(t)=N\,A\,B\cos(\omega t)$ To figure out the voltage (EMF) from an electric generator, you need to use

Faraday's law $\varepsilon=V(t)=\frac{d\Phi}{dt}$

a) Based on the expression for Flux, calculate the derivative to arrive at a general expression for V(t).
b) Given a generator with 100 coils rotating 60 times per second with square coils that are 10 cm on a side in a 0.5 Tesla magnetic field, come up with a formula for the EMF as a function of time.
c) What is the maximum EMF?

10) All generators require magnets, but you can make a weak generator using the Earth's magnetic field as your magnet. At temperate latitudes, the Earth's field is about 0.055 milliTesla and is tilted 60

degrees down from horizontal. Make a coil of 1000 turns and 2 meters diameter and lay it on the ground.
a) What is the flux through the coil
b) Flip the coil over, what is the change in flux
c) Assume you rotated the coil about 10 times a second. What average EMF would you generate across the coil? (This is comparable to a couple of batteries!)

11) A radio receiver can be thought of as a generator. The varying magnetic field of an incoming radio wave can induce an electric field in a loop antenna which is then amplified and converted back into music. A loop antenna, such as was used on older televisions to pick up UHF, is 25 cm in diameter. The plane of the loop is perpendicular to the oscillating magnetic field at 150 MHz. The magnetic field through the loop is $B(t) = (20\,nT)\sin\omega t$.

a) What is the maximum voltage induced in the antenna?

12) A transformer for a laptop computer converts a 120-V input to a 24 V output.
a) If the primary coil (the one that goes to the 120 V supply) has 50 turns, how many turns does the secondary have?
b) If the laptop uses 1.8 Amps at 24 V, and the transformer does not itself consume power, how much current is drawn from the 120 V outlet?

13) Electricity is distributed from electrical substations to neighborhoods at 15,000 Volts. Neighborhood transformers, seen on utility poles, step this voltage down to 120 V that is delivered to your house.

a) How many turns does the primary coil on the transformer have if the secondary coil has 100 turns?
b) No energy is lost in an ideal transformer, so the output power P_out from the secondary equals the input P_in to the primary. Suppose a neighborhood transformer delivers 250 A at 120 V. What is the current in the 15,000 V line from the substation.