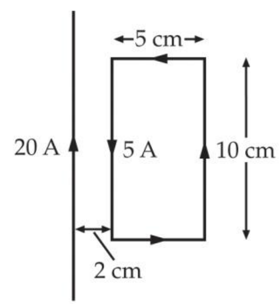
Review Problems for Physics 240 Final

Here are some review problems for chapters 29 and 30. Although there will be no problems that concentrate on material from earlier in the semester, the knowledge needed to do these problems is cumulative, and an understanding of earlier material could be required.

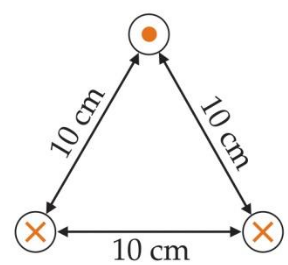
There are a large number of problems here, and some of them approach the same material in different ways. You might want to make sure you work some of each type, rather than just the ones at the beginning. The homework problems are also good review.

Answers to these problems are generally given at the end of the problem. Written solutions will be posted.

B) A long straight wire carries a current of 20 A, as shown. A rectangular coil with two sides parallel to the straight wire has sides 5 cm and 10 cm with the near side a distance 2 cm from the wire. The coil carries a current of 5 A. Find the force on the left and right hand segments of the rectangular coil due to the current in the long straight wire. (left: 0.100 mN **i**; right: -0.0286 mN **i**; the others require integration but sum to zero).



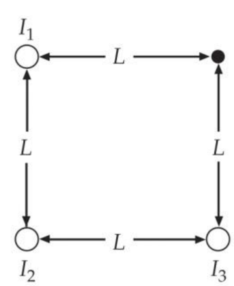
C) Three long, parallel straight wires pass through the corners of an equilateral triangle with sides 10 cm, as shown. Dots and crosses have the usual meaning. Each current is 15 A.



a) Find the magnetic field B at the upper wire due to the two lower wires. (52.0μT to the right)

b) Find the force per unit length on the upper wire (7.79×10^{-4} N/m up)

D) Three very long parallel wires are at the corners of a square, as shown. The wires each carry a current of magnitude I. Find the magnetic field B at the unoccupied corner of the square when



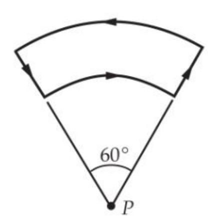
a) All the currents are into the paper

b) I_1 and I_3 are into the paper and I_2 is out, and

c) I_1 and I_2 are into the paper and I_3 is out.

The answers are too complicated to type in now!

E) The closed loop shown carries a current of 8 A in the counterclockwise direction. The radius of the outer arc is 60 cm, that of the inner arc is 40 cm. Find the magnetic field at point P. (-6.98×10^{-7}T **k**)



F) A wire of radius 0.5 cm carries a current of 100 A that is uniformly distributed over its cross-sectional area. Find the magnetic field B

a) 0.1 cm from the center of the wire (0.800 mT)

b) at the surface of the wire, (4.00 mT) and

c) at a point outside the wire 0.7 cm from the center of the wire (2.86 mT)

d) Sketch a graph of B versus the distance from the center of the wire.

e) If a thin cylindrical conductor of radius of radius r = 0.6 cm and carrying a current of 50 A in the opposite direction were placed around the wire, find B 0.7 cm from the center of the wire. (1.43 mT) Note that while this numerical answer is correct, the scanned answers have a "typo." (100A -100A should say 100A-50A) This will be fixed if time permits.

G) A solenoid 2.7-m long has a radius of 0.85 cm and 600 turns. It carries a current of 2.5 A.

a) What is the approximate magnetic field B on the axis of the solenoid? (0.698 mT).

b) What is the flux through a *single* loop.

H) A solenoid has n turns per unit length, radius R_1, and carries a current I.

a) A large circular loop of radius $R_2 > R_1$ and N turns encircles the solenoid at a point far away from the ends of the solenoid. Find the magnetic flux linkage through the loop. ($N\Phi = \pi\mu_0 N n R_1^2 I$)

b) A small circular loop of N turns and radius $R_3 < R_1$ is completely inside the solenoid, far from its ends, with its axis parallel to that of the solenoid. Find the magnetic flux linkage through this small loop ($N\Phi = \pi\mu_0 N n R_3^2 I$)

c) What is the mutual inductance (for either part (a) or part (b))?

I) A solenoid of length 25 cm and radius 0.8 cm with 400 turns is in an external magnetic field of 600 G that makes an angle of 50° with the axis of the solenoid.

a) Find the magnetic flux through a single loop of the solenoid ($\Phi = 7.75\ \mu Wb$)

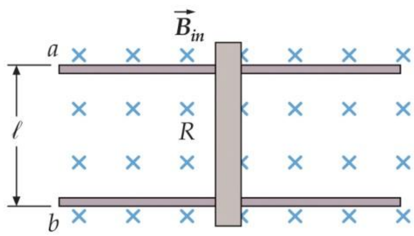
b) Find the magnitude of the emf induced in the solenoid if the external magnetic field is reduced to zero in 1.4s. ($|E| = 2.22$ mV)

J) A square loop of a conducting wire (area A) is pulled out of a region of constant, very high magnetic field B that is directed perpendicular to the plane of the wire. The wire has *non-zero* resistance. Half of the wire is in the field and half of the wire is out of the field when the wire is pulled out. A constant force *F* is exerted on the wire to pull the wire out. The wire is pulled out in time *t*.

a) All else being equal, if the force were doubled approximately how long would it take to pull the wire out? (t/2). (Note: the wire does have some resistance)

b) If the resistance is halved (all else being equal), what would the new time be? (2t)

K) The rod shown in the figure has resistance *R* and the rails are horizontal and have negligible resistance. A battery of emf *E* and negligible internal resistance is connected between points a and b so that the current in the rod is downward. The rod is placed at rest at t = 0. (We didn't do anything quite like this in class, where there was no emf source in the circuit with the moving rod, and we calculated the induced emf. In this problem, an induced current will oppose the battery current.)



a) Find the force on the rod as a function of the speed *v* and write Newton's second law for the rod when it has speed *v*.

b) Show that the rod moves at a terminal speed and find an expression for it. (V = *E*/BL) You will need to substitute $I_{battery} - I_{induced}$ for I in the eqn. for force.

c) What is the current when the rod will approach its terminal speed? (zero)

L) A solenoid has a length of 25 cm, a radius of 1 cm, 400 turns, and carries a 3-A current. Find

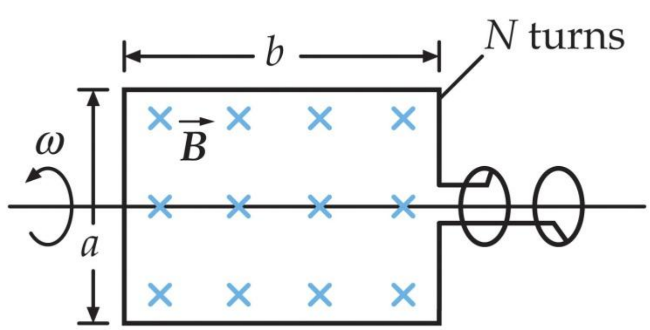
a) B on the axis of the solenoid (6.03 mT)

b) the magnetic flux linkage though the solenoid, assuming B to be uniform. (0.758 mWb)

c) the self-inductance of the solenoid (L= 0.253 mH), and

d) the induced emf in the solenoid when the current changes at 150 A/s. (*E* =38.0 mV)

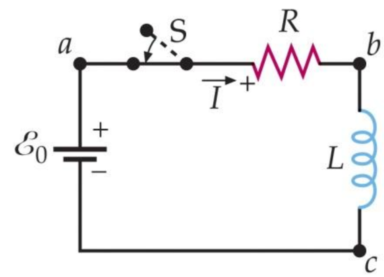
M) The figure shows an ac generator. The generator consists of a rectangular loop of dimensions *a* and *b* with *N* turns connected to slip rings. The loop rotates with an angular velocity ω in a uniform magnetic field *B*.



a) Show that the potential difference between the two slip rings is $E = NBab\omega\sin(\omega t)$

b) If *a* = 1 cm, *b* = 2 cm, *N* = 1000, and *B* = 2T, at what angular frequency ω must the coil rotate to generate an emf whose maximum value is 110V? (275/s)

N) In the circuit shown, let E_0 = 12 V, R = 3 Ω, and L = 0.6 H. The switch is closed at time t = 0. At times t = 1 s and t = 100 s, find



a) The rate at which the battery supplies power (47.7 W and 48.0 W)

b) The rate at which power is dissipated in the resistor (47.4 W and 48.0 W), and

c) The rate at which energy is being stored in the inductor (0.321W and 0.0 W).

O) An inductance *L* and resistance R are connected in series with a battery, as shown above. A long time after the switch is closed, the current is 2.5 A. when the battery is switched out of the circuit by opening the switch and simultaneously connecting the left side of the resistor to point *c*, the current drops to 1.5 A in 45 ms.

a) What is the time constant for this circuit? (0.0881 s)

b) If R = 0.4 Ω, what is *L*? (35.2 mH)

P) A solenoid of 2000 turns, area 4 cm^2, and length 30 cm carries a current of 4 A.

a) Calculate the magnetic energy stored in the solenoid from ½LI^2. (5.36×10^{-2} J)

b) Divide your answer in part (a) by the volume to find the magnetic energy per unit volume in the solenoid (447 J/m^3).

c) Find B in the solenoid. (33.5 mT)

d) Compute the magnetic energy density from $u_m = B^2/2\mu_0$ and compare your answer with your results from part (b).