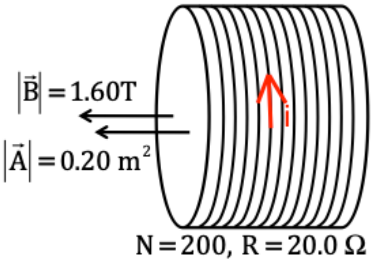
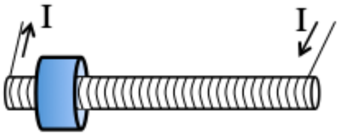
31-Series Problem (Faraday's Law)



31.6) A 1.60 T magnetic field is generated by an electromagnet over a $20.0\ cm^2$ cross-sectional area. A 200-turn coil is placed around the electromagnet. If the net resistance of the coil is $20.0\ \Omega$, determine the induced current in the coil as the current in the electromagnet is reduced in a smooth fashion to zero over 20.0 ms.

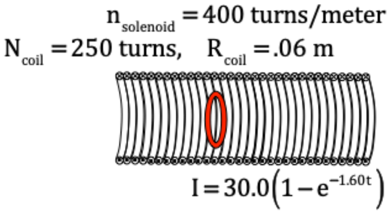


31.9) A long, 1000 turn-per-meter, air-core solenoid has a radius of $r_2 = 3.00\ cm$. Around one end of the solenoid is an aluminum ring of radius $r_1 = 5.00\ cm$. The resistance of the ring is $R = 3.00 x 10^{-4}\ \Omega$. A good assumption for solenoids is that their axial magnetic field evaluated at the end of the solenoid is one-half that of the field calculated in the mid-region of the solenoid (that is the region for which you have a formula). With that in mind, and assuming the solenoid produces no appreciable B-fld outside itself, if the solenoid's current is increased at a rate of 270 A/s:

a.) Determine the induced current in the aluminum ring.

b.) Determine the *magnitude* of the B-fld generated by the induced current in the ring as it exists down the axis of the ring.

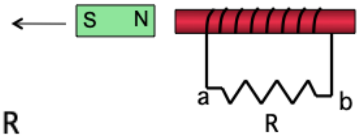
c.) Determine the *direction* of the B-fld generated by the induced current in the ring as it exists down the axis of the ring.



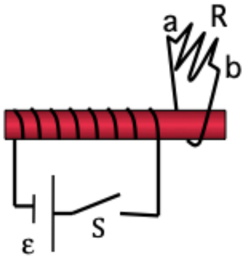
31.14) A long, 400 turn-per-meter solenoid (see cross-section to right) has an $I = 30.0\left(1 - e^{-1.60t}\right)$ amp current passing through it. A 250-turn coil of radius R = 6.00 cm sits coaxially inside the solenoid. Derive an expression for the induced current in the coil due to the changing current in the solenoid.

31.20) This is an exercise in the use of Lenz's Law. Use it to determine the direction of induced current flow (*a-to-b* or *b-to-a* across each resistor shown) if:

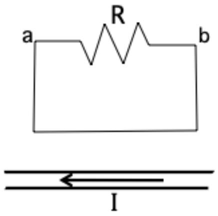
a.) the bar magnet shown in the figure is moved *to the left*.



b.) just after the switch S is closed in the circuit.



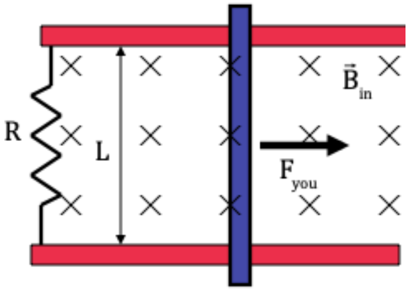
c.) the current I is *decreased rapidly to zero*.



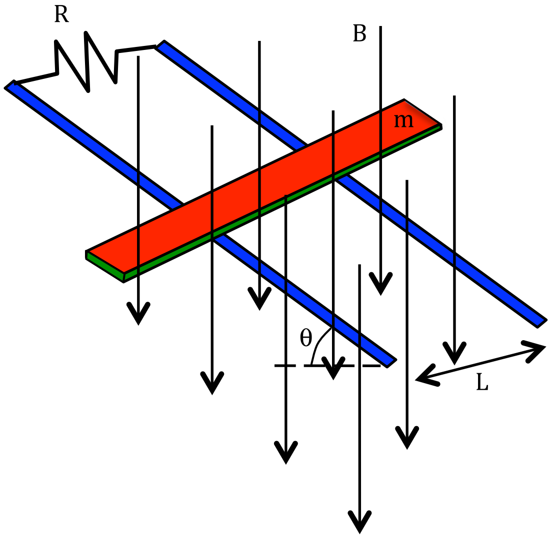
31.23) The sketch to the right shows a magnetic field of magnitude 2.50 T oriented into the page permeating the space in which there exists a pair of frictionless rails upon which slides a metal bar. The resistance in the system is $R = 6.00\ \Omega$. Assume the distance between the rails is L = 1.20 m.

a.) You apply a force to the bar to the right. How large would the force have to be to motivate the bar to move with a constant speed of 2.00 m/s?

b.) At what rate is energy dissipated in the resistor in this system?



31.25) The physical set-up in *Problem 23* is tilted (the B-fld is still oriented into the page) so that the rails are at a 25° angle with the horizontal. The resistance in the system is reduced to $R = 1.00\ \Omega$, but the length between the rails is still 1.20 m. If the mass of the bar is m = 0.200 kg, and if the B-fld is re-set to a constant 0.500 T, what will the bar's constant speed be as it slides down the ramp? (If you are thinking *free body diagram*, I'd suggest you approach this from the side.)

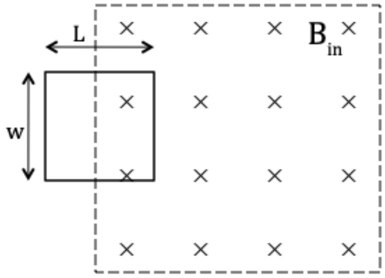


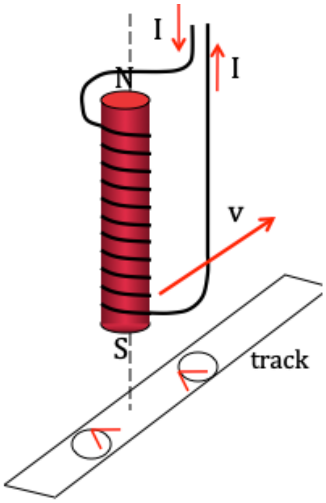
31.30) An *N-turn* rectangular coil with length *L* and width *w* moves with constant velocity *v* into a uniform B-fld. Determine the magnitude and direction of the magnetic force on the coil:

a.) as it enters the field;

b.) as it moves fully within in the field;

c.) as it leaves the field.





31.44) Eddy current brakes are used to stop trains. This rather clever device is predicated on the fact that a conductor moving into (or out of) an external magnetic field will experience a changing magnetic flux in the conductor, which will induce a current in the conductor. That current will interact with the external B-fld producing a force on the conductor that *fights* whatever the conductor is doing (i.e., if it's moving *into* the field, the force will fight the entering; if it's moving *out of* the field, the force will fight the leaving . . . the force always *fights the change*). In trains, an electromagnetic is mounted on the train's chassis. To stop the train, a current is passed through the electromagnet producing a B-fld down its axis. That B-fld interacts with the steel tracks producing eddy currents in the track . . . which produce a force on the track . . . and from Newton's Third Law, a force back on the train. The question at hand here is, "Given the direction of the B-fld set up by the electromagnet, and the direction of the train's motion (see sketch for both), which of the two eddy current directions shown on the track is the correct one?" (Hint: To more easily see what is really going on, think of the coil as being stationary and the track as moving out of the page toward you.)