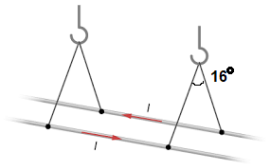
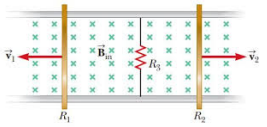
General Physics II Honors (PHYS 102H)

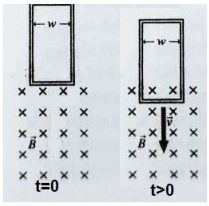
Problem set # 7 *(due April 6)*
All problems are mandatory, unless marked otherwise. Each problem is 10 points.



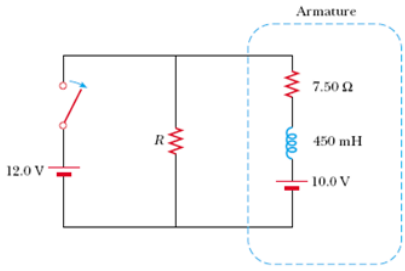
Q1 Early version of a telegraph included two long suspended wires that were repelled from each other when the current was flowing through them. For a particular configuration, the wire mass per unit length is 40 g/m, and they are supported in a horizontal plane by strings 6.0 cm long. If both wire carry the same current, the wires repel each other so that the angle θ between the supporting strings is 16^o.
(a) Explain why currents must run in the opposite directions?
(b) What is the magnitude of the current?



Q2 Two parallel rails with negligible resistance are distance d apart and are connected with the resistor R_3. Two metal rods with resistances R_1 and R_2 are pulled away from the resistor at constant speed v_1 and v_2. The whole construction is placed in a uniform magnetic field B that is perpendicular to its plane. What is the current through the resistor R_3?
Hint: since there are two loops, you need first to find the induced emf in each of them, and then use Kirchhoff's rules to find the current.



Q3 A conducting rectangular loop falls is released right above the magnetic field-filled region and starts falling down. During the time interval before the top edge of the loop reaches the field, the look approaches a constant terminal velocity. If the M is the mass of the loop, R is its resistance, w is its width, and the magnetic field is B, show that the value of the terminal velocity is
$v_t = \frac{MgR}{w^2B^2}$.
Hint: the inductance prevents any sudden changes in the current flowing through it, so you may assume that in the moment of disconnect the current through the armature is the same. However, current through a resistor may change nearly instantly.



Q4 It may be helpful to first read the textbook section about how motors work, although you don't have to know that. Briefly, motors use electricity to produce torque (rotation) of the armature. Since here is a rotating current loop involved, an emf induced in the armature that prevents the magnetic flux changes, usually called "back emf". If the motor power source is disconnected, it can produce a high voltage drop across the gap creating arcing that may damage the armature (maybe you noticed occasional spark when unplugging a power supply? similar effect). To prevent such spontaneous arc, a discharge resistor is connected parallel to the armature, as shown in the figure. If the motor runs on 12V power, and the back emf is 10V when the motor is running, what is the maximum resistance R that limits the voltage across the armature to 80 V when the 12V power supply is unplugged?

Q5 A time-varying current I (see figure) is sent through a 200-mH inductance. Make a graph of the potential difference across the inductance.