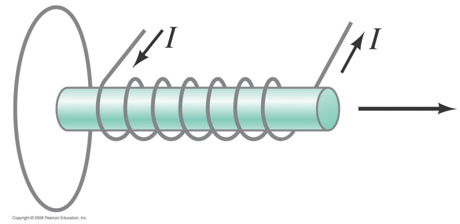
PH2223 Test 4 Practice Problems

Version 2 : 28 April 2023

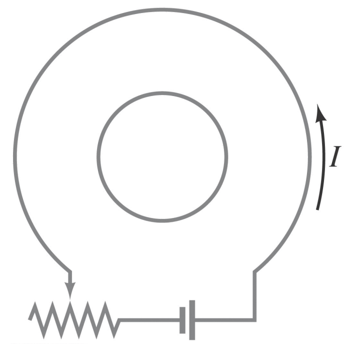
Chapter 29 : Electromagnetic Induction and Faraday's Law

You'll likely be using Lenz's Law to determine induced current directions in some problems, so here are a few problems that focus just on that part of the process.

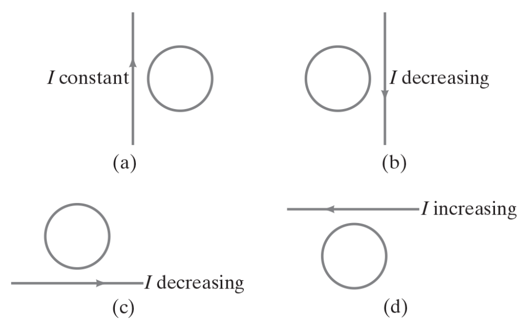
- **HW 29.07** : If the solenoid in the figure is being pulled away from the loop as shown in the figure, in what direction is the induced current in the loop on the left? Explain.



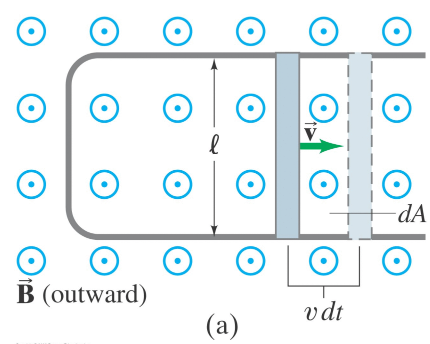
- **HW 29.08** : (a) If the resistance of the resistor in the figure is slowly increased, what is the direction of the current induced in the small circular loop inside the larger loop? (b) What would it be if the small loop were placed <u>outside</u> the larger one, to the left? Explain.



- **HW 29.11** : What is the direction of the induced current in the circuit loop due to the current shown in each part of this figure. Explain why.



- **HW 29.25** : The rod in the figure is moving to the right with a speed of 1.6 m/s on rails 30 cm apart. Suppose the rod has a resistance of 2.5 Ω. The magnetic field here is 0.35 T and the resistance of the **U**-shaped conductor is 24 Ω at the instant shown in the figure. Calculate (a) the induced emf, (b) the current flowing (including its direction), (c) the external force needed to keep the rod's velocity constant at that instant.



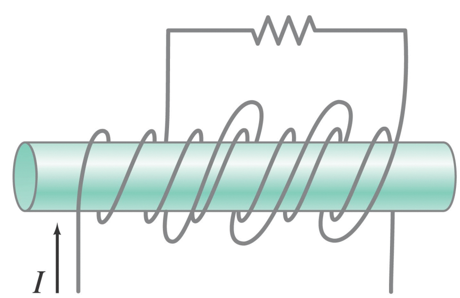
- **HW 29.35** : A 280-loop circular armature coil with a diameter of 10 cm rotates at 120 rev/s in a uniform magnetic field of strength 0.45 T.
  - (a) What is the rms voltage output of this generator?
  - (b) What would you do to the rotation frequency to double the rms voltage output?

- A long straight wire is carrying 1000 A of (DC) current. I wrap 100 turns of wire around a square frame that is 10 cm on each side. How fast do I need to rotate this gadget to generate a voltage with $V_{rms} = 1.5\ volts$ if I'm standing 2 m away from this wire? How does the rotation axis of the gadget have to be aligned relative to the wire to maximize this effect? (Draw a sketch showing this, including the rotation axis needed.)

- **HW 29-45** : A transformer has 330 primary turns and 1120 secondary turns. The input voltage is 120 V and the output current is 15 A. What are the output voltage and input current?

- Some laptops, TV's and other devices come with a 'power brick' that is essentially just a transformer. Looking at the labelling on a random laptop power brick, it's designed to plug into a 120 V (rms) wall socket, and produces 9 V (rms) on the side that connects to the device. If the device is drawing $P_{avg} = 100\ W$ while charging, (a) how much (rms) current is going from the wall into the power brick, (b) how much (rms) current is being delivered to the laptop, (c) what is the N_P/N_S ratio for this transformer?

- **HW 29.50** : A coil with 160 turns, a radius of 5 cm, and a resistance of 12 Ω surrounds a solenoid with 230 $turns/cm$ and a radius of 4.5 cm. The current in the solenoid changes at a constant rate from 0 to 2 A in 0.1 sec. Calculate the magnitude and direction of the induced current through the resistor in the outer coil.



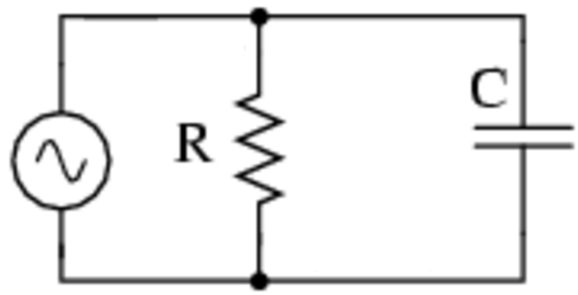
- **HW 29.71** : An overloaded motor may burn out due to high currents. Suppose you have a blender with an internal resistance of 3 Ω. (a) At $V_{rms} = 120\ V$, what is the initial current through the blender? (b) Once the electric motor armature has spun up to the normal operating speed of the blender, it draws $I_{rms} = 2\ A$. What is the back-emf of the motor? (c) How much power does this device draw when its motor is fully spun up? (d) How much power would it draw if the motor locks up?

Chapter 30 : Inductance, AC Circuits

- **HW 30.39** : What is the inductance L of the primary of a transformer whose input is 110 v at 60 Hz and the current drawn is 3.1 A? (Assume no current in the secondary.)

  (Since the other side of the transformer isn't connected to anything, we basically have a solenoid with 110 *volts* producing a current of 3.1 A.)

- **HW 30.41** : A capacitor is placed in parallel with some device to filter out stray high frequencies but to allow ordinary 60 Hz AC to pass through with little loss. If $R = 490\ \Omega$ and $C = 0.35\mu F$, what percentage of the current will pass through C rather than R if (a) $f = 60\ Hz$, and (b) $f = 60,000\ Hz$?



  At the given frequencies, what is the impedance of the resistor? The capacitor? The elements are in parallel, so will have the same V_{rms} across each of them and $V_{rms} = I_{rms}Z$ for each. We don't know V_{rms} here, but it's the same for each, so we can at least relate the different I_{rms} values through each element for each of the two different frequencies.

- **HW 30.80** : (a) What is the rms current in a series RC circuit if $R = 3800\ \Omega$ and $C = 0.80\mu F$, and the rms applied voltage is 120 V at 60 Hz? (b) What is the phase angle between voltage and current? (c) What is the power dissipated by the circuit? (d) What are the voltmeter readings across R and C individually?

  (We did a full R-L-C version of this scenario in class and if one of the elements is missing, we just drop that term from the impedance (Z) calculation.)

- **HW 30.50** : (a) What is the rms current in a series LR circuit when a 60 Hz, 120 V (rms) AC voltage is applied, where $R = 965\ \Omega$ and $L = 255mH$? (b) What is the phase angle between voltage and current? (c) How much power is dissipated by the circuit? (d) What are the rms voltage readings across R and L individually?

  (We did a full R-L-C version of this scenario in class and if one of the elements is missing, we just drop that term from the impedance (Z) calculation.)

- **HW 30.53** : A 75 watt lightbulb is designed to operate with an applied ac voltage of 120 *volts* (rms). The bulb is placed in series with an inductor L and this series combination is connected to a 60 Hz 240 *volt* (rms) power supply. For the bulb to operate properly, determine the required L. (ADDED: go through the same process assuming we use a CAPACITOR in series with the bulb instead of an INDUCTOR.)

  (When operating normally, what will the rms current flowing through the bulb? What is its resistance? When we add the inductor in series and expose them to the higher voltage, we still need the bulb to experience the same rms current as before. What impedance is needed to allow this? What L is needed so that the Z of the circuit is what we need it to be?)

- **HW 30.68 (modified)** : (More of a thought-experiment, testing your understanding of what how inductors and capacitors behave.)

  (a) How much current will flow through the three resistors the instant just after the switch is closed?

  (b) How much current will flow through the three resistors after a long time has passed?