

**PHYS 122: Homework Assignment #06**

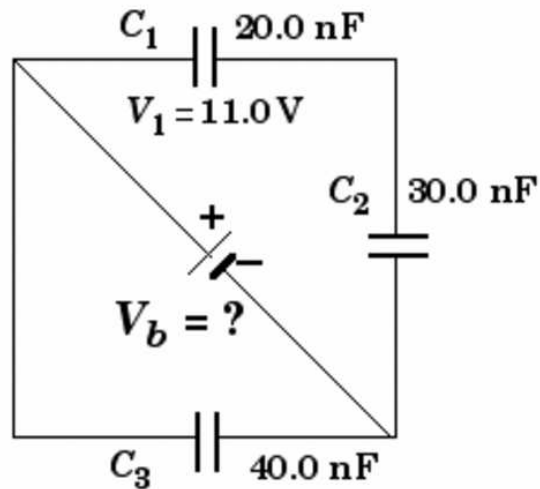
**February 23, 2009**

**This homework due in Box outside of Rock 207:  
5:00 PM Sharp, Monday, March 2, 2009**

**Announcements:**

- The **Second Hour Exam** is scheduled for Friday, March 6th, 9:30 AM in Strosacker. You may bring up to **two** pages (front and back) of hand-written notes and an inexpensive calculator (that you will almost certainly not need).

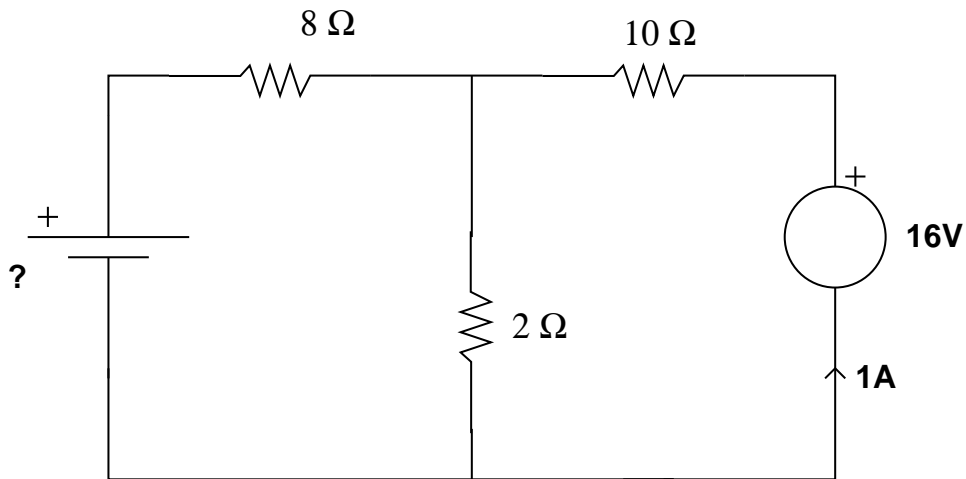
**Problem 1:**



Three capacitors are connected to a battery of unknown voltage as shown in the circuit diagram above. The voltage drop across capacitor  $C_1$  is  $V_1 = 11.0$  volts.

- a) What is the steady-state current through the battery?
- b) What is the effective capacitance of the three capacitors?
- c) What is the voltage of the battery?
- d) Which capacitor has the largest charge on it and what is the value of that charge?
- e) How much work was done by the battery to charge up all three capacitors?

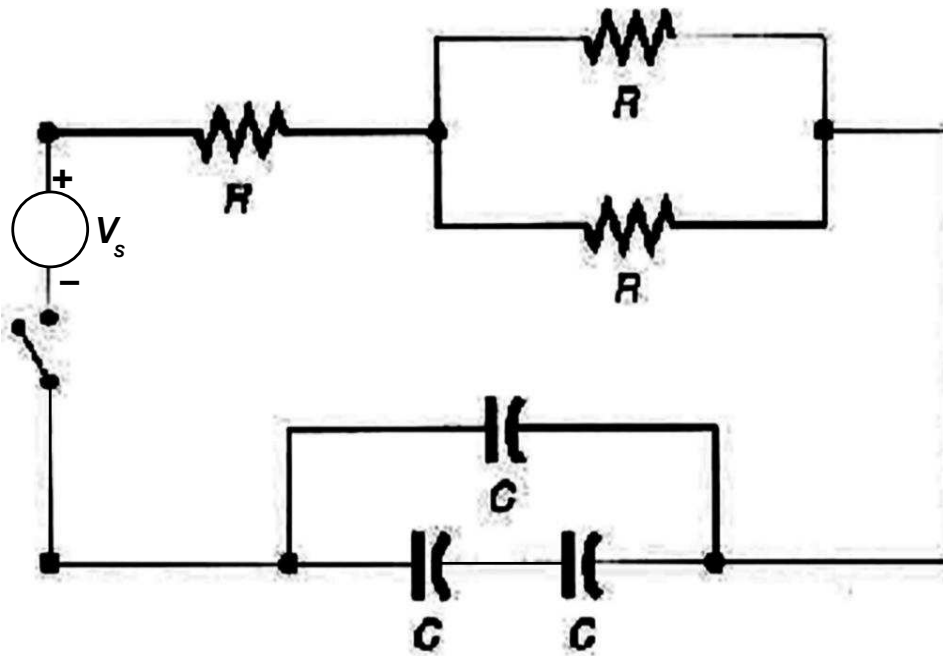
**Problem 2: Again from a previous exam:**



A circuit is put together as shown and includes an “ideal” battery. However the battery has an unknown voltage.

Suppose in this configuration you are able to measure that that current through the voltage source on the right is 1 Amp. Can you determine the unknown battery voltage? Explain your work.

**Problem 3:**

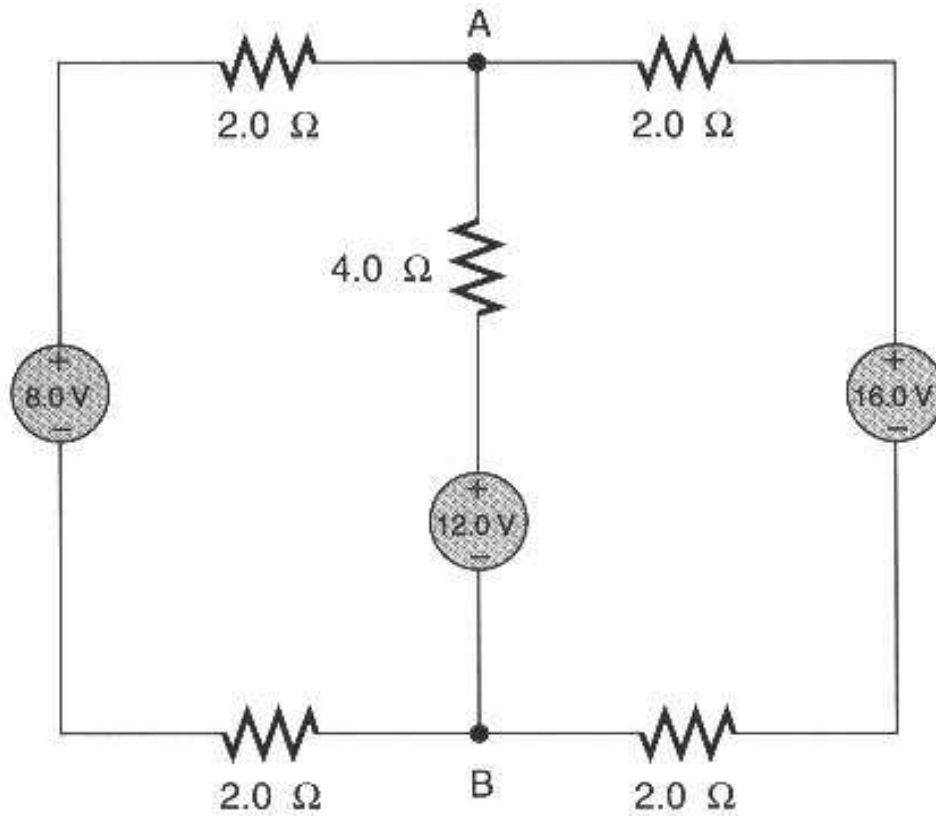


**Part (a)** Immediately after the switch is closed, what is the current through the voltage source?

**Part (b)** Some long time after the switch is closed, what is the current through the voltage source?

**Part (c)** What is the “time constant” associated with this circuit?

**Problem 4:**



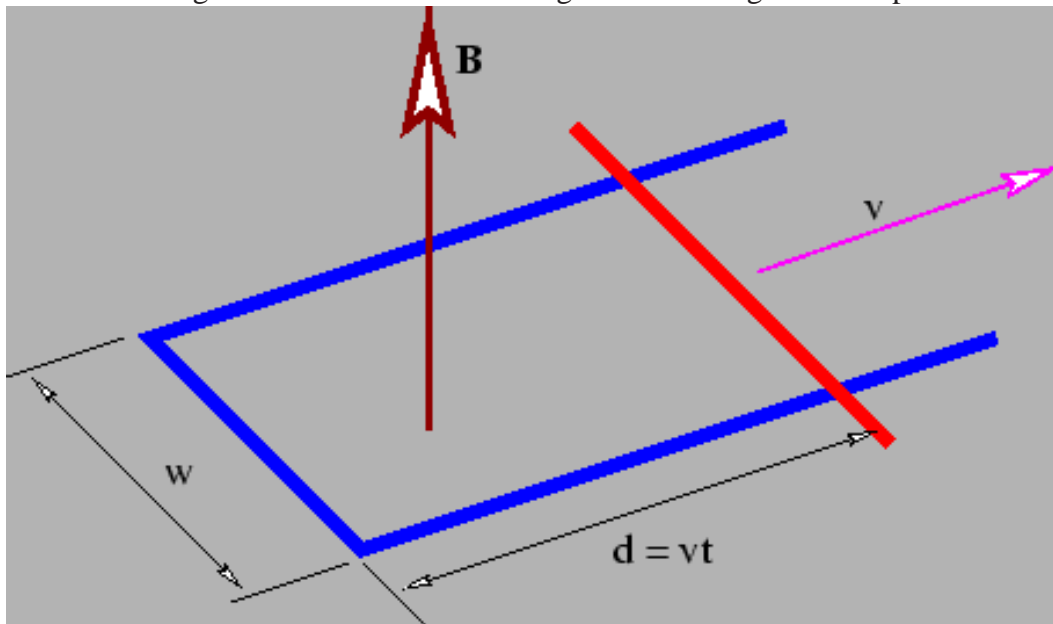
**Part (a)** Calculate the current through each of the three voltage sources.

**Part (b)** What is the voltage measured at point A relative to point B?

**Problem 5: Faraday's Law Review:**

Here's a problem to get more practice with Faraday's Law. We still have a spatially uniform field, but now the area is changing with time, not the field strength.

Imagine a stationary U-shaped conductor with a moving conducting bar in contact with the U as shown in the figure below. A uniform magnetic field exists normal to the plane of the U and has a uniform constant magnitude  $B$ . The bar is moving outward along the U at speed  $v$  as shown.



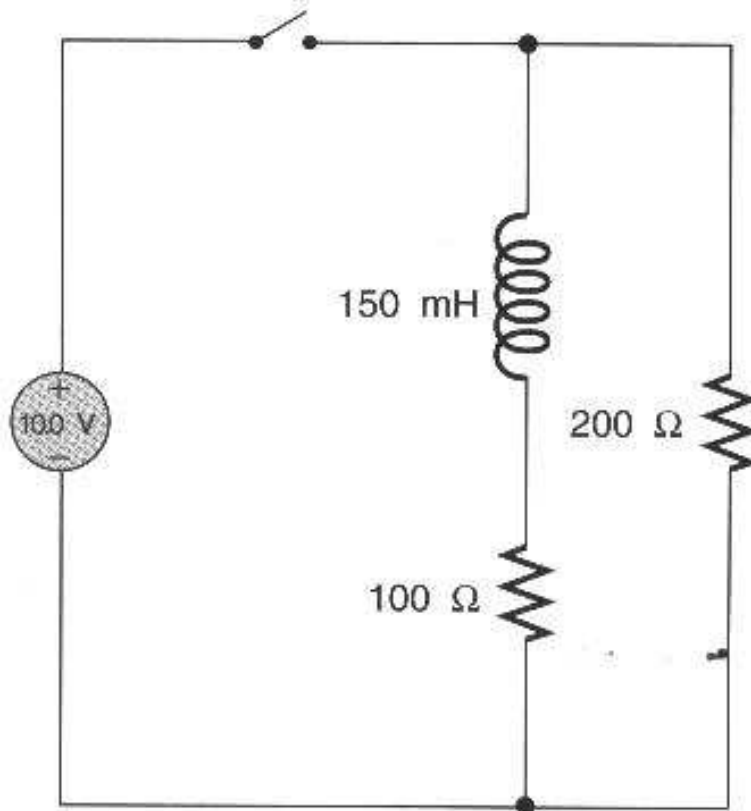
**Part (a):** Given that the bar moves with constant speed, what is the induced voltage around the loop?

**Part (b):** Assume that the u-shaped bar has negligible resistance, but that the bar itself has a finite resistance  $R$ . It is observed that in order to keep the bar moving at constant speed, an external contact force must be applied to the bar – it must be pushed. In terms of the parameters given what is the direction and magnitude of this force required to keep the bar moving with constant velocity?

**Part (c):** Note that pushing the bar with a constant force implies work being done to the system. Where does the energy associated with this work go? Does it stay in the system? If not, how does it get out?

**Problem 6:** Time-dependent behavior

Suppose you are given the following circuit:



**Part (a)** Immediately after the switch is closed, what is the voltage across the inductor?

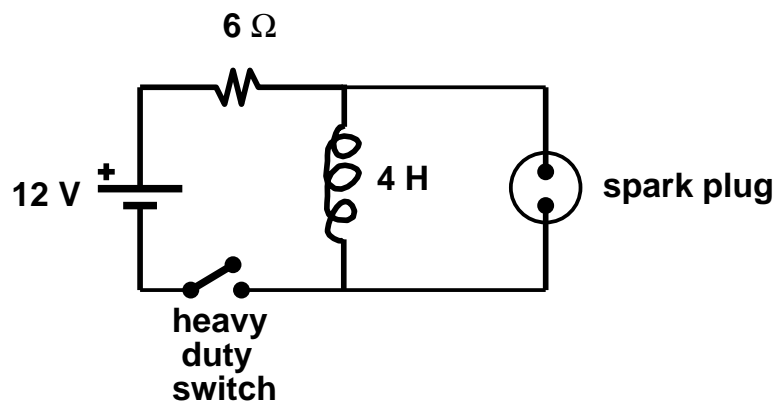
**Part (b)** Some long time after the switch is closed, what is the voltage across the inductor?

**Part (c)** Immediately after the switch is closed, what is the current through the voltage source?

**Part (d)** Some long time after the switch is closed, what is the current through the voltage source?

**Problem 7.** Spark Plugs (from an old exam):

A spark plug is a device that ignites vaporized fuel inside a combustion engine by generating a small white-hot spark of electric current. The spark results when the electric field in the gap of the spark plug exceeds the breakdown field for air. For a typical spark plug, the spark occurs when the voltage across the gap exceeds several thousand volts. If the voltage is less than this, no current will flow through the spark plug. The circuit here shows conceptually how a real spark plug works:

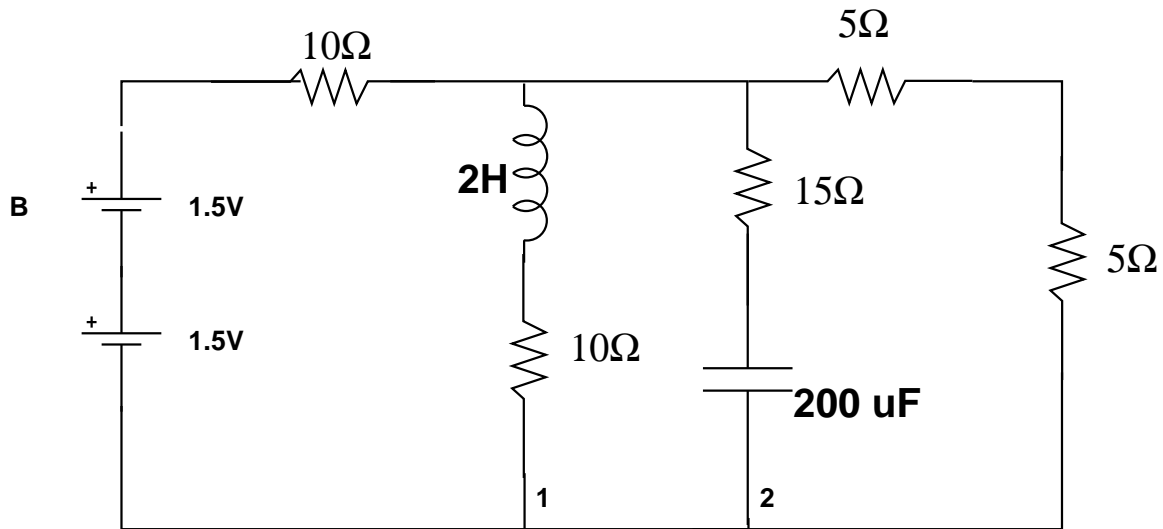


At time  $t = 0$  the switch is closed as shown. At time  $t_s$  which is *a long time later* the switch is thrown open. This has the impact of suddenly changing the current through the inductor  $L$  at time  $t_s$ . In fact, throwing the switch changes the current from its equilibrium value to zero Amps within 1 microsecond.

**a)** At the time *just before* the switch is thrown open at  $t_s$ , what is the current through the inductor? What is the voltage across the spark plug?

**b)** How much voltage will be briefly applied across the spark plug as a result of throwing open the switch?

**Problem 8: Circuit With Everything (old exam problem)**



A circuit is assembled as above and then some time is allowed to pass so that the whole circuit comes to a steady state. All questions below refer to the circuit in the steady state:

**Part (a):** Approximately how much time is required to ensure that the circuit will be in a steady state? Explain your answer.

**Part (b):** In the steady state, what is the voltage drop across the inductor? Explain your answer.

**Part (c):** In the steady state, what is the current through the battery labeled “B”? Explain your answer.

**Part (d):** (Harder) In the steady state, what is the voltage drop across the capacitor? Hint: it is *not* zero. Explain your answer.