AP Physics C – Current and Circuits Examples

1. A fuse or a circuit breaker is a current limiting device designed to protect circuits from overloading. (a) What is the maximum amount of charge that can pass through a 15.0 A fuse in one hour? (b) What is the minimum amount of time in which 100 C can pass through such a fuse?

2. The amount of charge on a particular metal plate decreases according to the formula $q = q_o e^{-kt}$, where $q_o = 3.0$ nC, and $k = 750\ s^{-1}$. (a) Find the maximum current from the plate. (b) Find the current at $t =$ 4.0 ms.

3. In a certain chemical solution positive ions move to the left and negative ions move to the right. If 3.0 μC moves left every second and –2.5μC moves right every second, what is the current in the solution?

4. Suppose the current in a certain solution is 7.0 mA to the right. After one minute passes, 0.21 C of positive charge collects on an electrode at the right end of the solution. How much charge collects on the electrode at the opposite end of the solution?

5. An AC power circuit has current that varies according to $I(t) = I_{max} \sin(\omega t)$. (a) Derive an expression that gives the amount of charge that "enters and exits" an AC light bulb. (b) Given an AC frequency of 60.0 Hz how many electrons "go in and out" with an rms current of 130 mA?

6. A certain resistor is rated at 18 kΩ. (a) If this resistor is connected to a 1.5 V cell, what will be the current? (b) In order to establish a current of 0.50 A in this resistor, what voltage is required?

7. A certain piece of wire carries a current of 2.5 A and has a potential at its left end 30.0 mV greater than its right end. (a) What is the resistance of the wire? (b) What would be the voltage across the wire if the current is 10.0 A? (c) If the voltage across the same wire is 20.0 mV, what will be the current?

8. Sketch the wire from part (c) above and show the direction of the electric field. Also show the direction of the current and the direction in which electrons move. If the wire is 0.50 m long, what is the strength of the electric field, assuming it is uniform?

9. A typical flashlight bulb carries a current of 0.16 A when connected to a 6.00 V battery. (a) What is the resistance of the filament in the bulb? (b) If connected to a 12 V battery what would you expect of the current? Describe the resulting amount of current with an inequality.

10. (a) Determine the resistance of 100.0 m of 12 gauge copper wire (dia. = 2.05 mm). (b) Repeat for a length of 50.0 m and 18 gauge (dia. = 1.02 mm).

11. Repeat the previous for silver wire.

12. The filament of a 60.0 W bulb is made of tungsten and has a length of 580 mm and a diameter of 0.045 mm. The resistivity of the filament increases by a factor of around 12 when the filament reaches its normal operating temperature. (a) Find the resistance at room temperature. (b) Find the resistance at operating temperature (around 2500 K).

13. A 100 W bulb must have a resistance of 144 Ω at its operating temperature and around 9.5 Ω at room temperature. (a) Assuming the filament is the same length as the previous problem, what must be its diameter? (b) Assuming the diameter is the same as the previous problem, what must be the length of the filament?

14. Within a certain flashlight a current of 0.19 A occurs when the switch is turned on. Electrons from the batteries must then travel 15.0 cm along a copper wire with diameter 0.51 mm before reaching the filament in the bulb. (a) Find the drift velocity of the electrons. (b) Find the amount of time for a single electron to go from the batteries to the filament.

15. A lamp with a 100.0 W bulb is plugged into a wall outlet with a cord that is 1.50 m long. When the switch is turned on a current of 0.83 A occurs in the wire. (a) Find the drift velocity of electrons in the wire assuming is copper and has diameter 1.63 mm. (b) How much time is required for a single electron to go from the wall to the filament in the bulb (assuming direct current). (c) Find the electric field in the wire. (d) Find the current density.

16. A 330 Ω resistor is connected to a 6.00 V battery that stores 95.0 kJ of energy. (a) Determine the current. (b) Find the power dissipated by the resistor. (c) Find the power delivered by the battery. (d) How much time can the battery provide current to the resistor before going dead? (e) What total amount of charge has passed through the circuit in this time?

17. A certain flashlight has a bulb that emits 1.20 W. The bulb runs on a 3.0 V rechargeable battery rated at 2500 mA-h. (a) Determine the current in the bulb. (b) For what amount of time can the flashlight be used before the battery needs to be recharged? (c) What total amount of charge and energy has the battery delivered in this time?

18. A typical automotive headlamp is 50.0 W. Given that it runs on a 12.0 V battery, what current does it draw? What is the resistance of the filament?

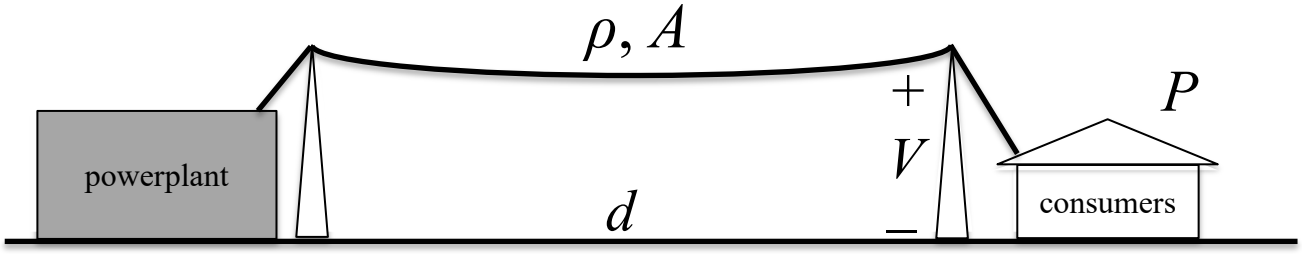
19. A typical circuit in a car is protected by a 10.0 A fuse and is powered by a 12.0 V battery. (a) What is the maximum energy that can be delivered by this circuit in a period of 5.00 minutes? (b) What must be the resistance of the circuit in order for this to occur?

20. A 12 gauge copper wire (diameter 2.05 mm) of length 20.0 m carries a current of 15 A. What is the rate at which it delivers heat to the home? Repeat for an 18 gauge wire of the same length and half the diameter.

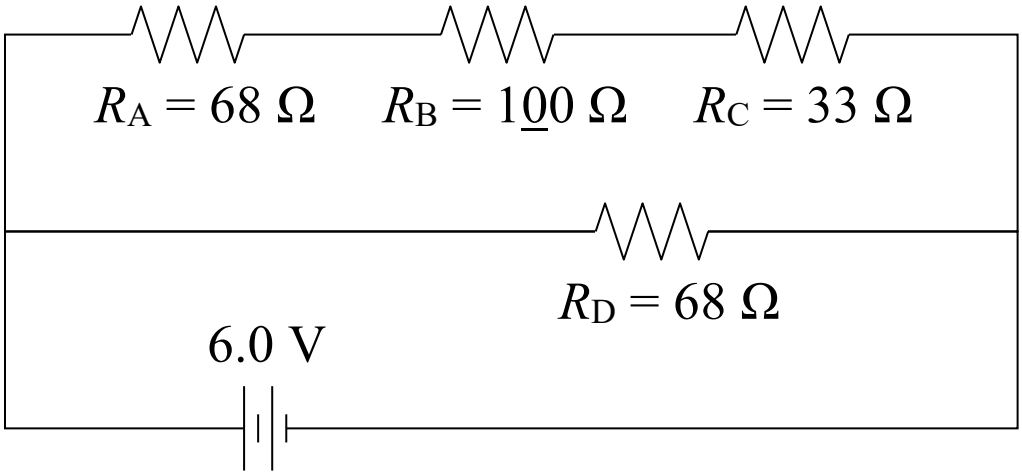
21. Determine the resistance of the filament of a 75 W bulb operating on 120 V.

22. A speaker is rated at 4.0 Ω and maximum power handling of 150 W. What is the maximum voltage and current it can handle based on these ratings?

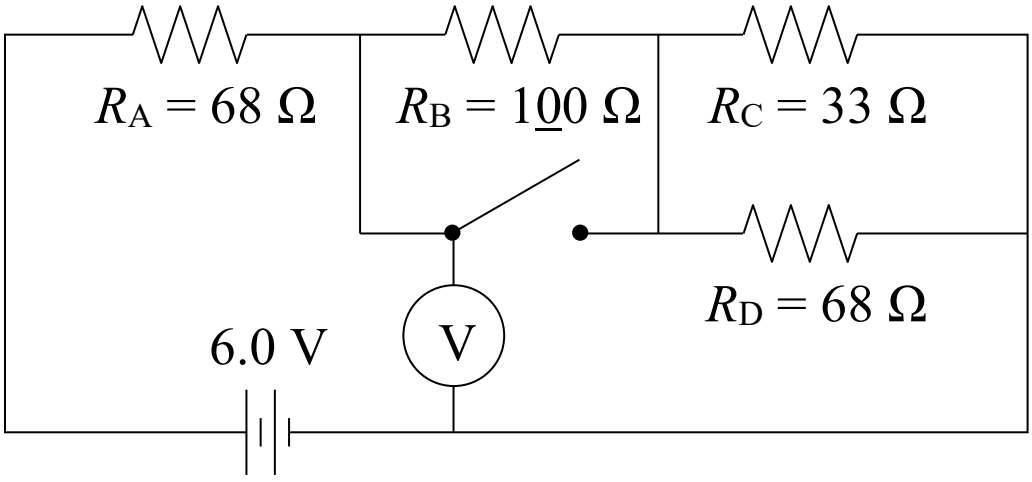
23. Electrical transmission lines waste energy by producing heat. Derive an expression for the rate at which energy is wasted in terms of the properties (ρ and A) of the wire, the distance d, and the power and voltage, P and V, at the receiving end of the transmission lines.



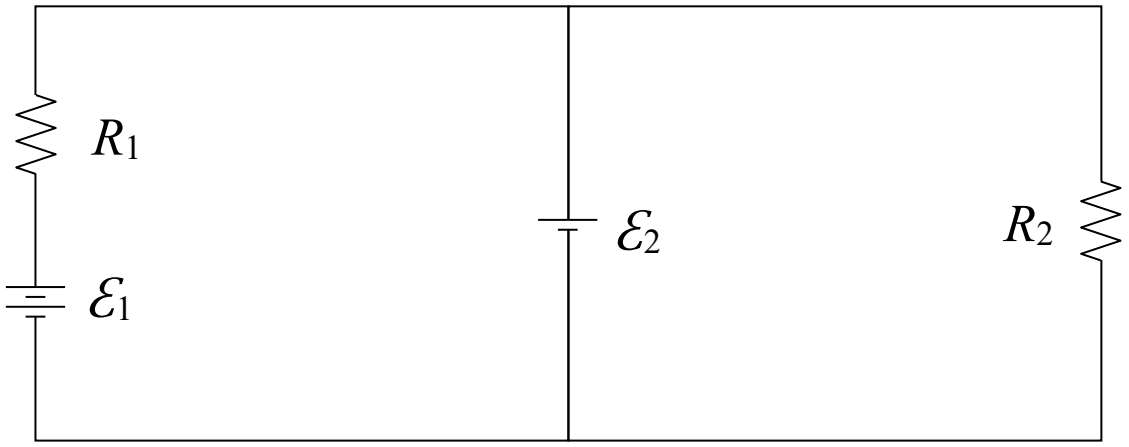
24. Solve for all currents and voltages in the following circuit:



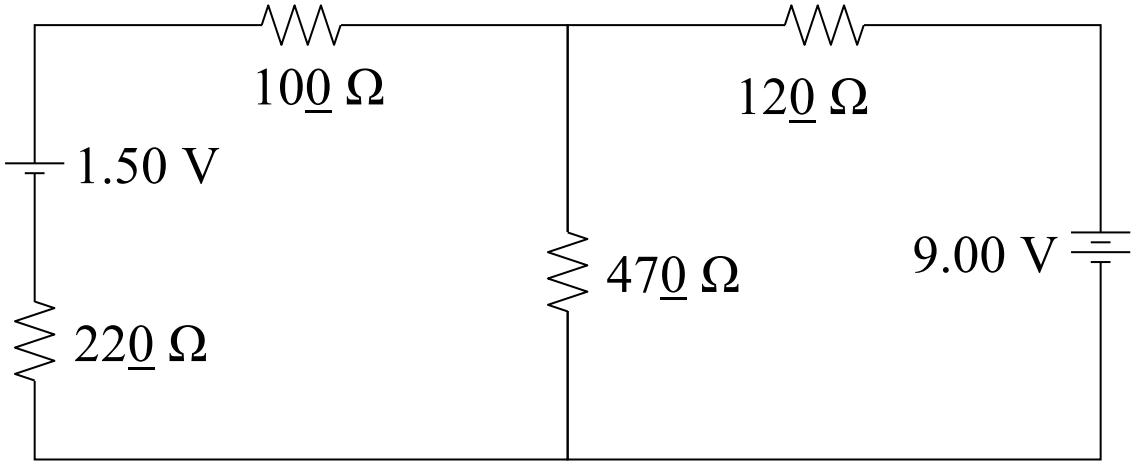
25. Find the reading of the meter with the switch open and with the switch closed:



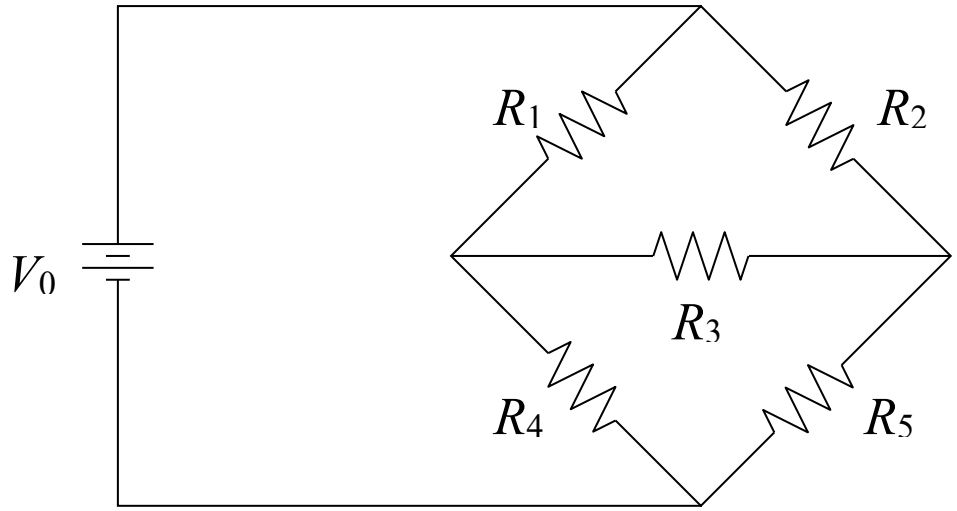
26. In the circuit below $\mathcal{E}_1 = 6.1$ V, $\mathcal{E}_2 = 1.3$ V, $R_1 = 90$ kΩ, and $R_2 = 36$ kΩ. (a) Determine current in each vertical branch. (b) Two of these three currents would be equal in amount if R_2 is changed to what value?



27. Find all currents and voltages for the circuit shown below.



28. The circuit below is known as a Wheatstone Bridge. (a) Solve for the bridge current given the following: $V_0 = 6.0$ V, $R_1 = 265\ \Omega$, $R_2 = 980\ \Omega$, $R_3 = 830\ \Omega$, $R_4 = 1200\ \Omega$, $R_5 = 434\ \Omega$. (b) What is the equivalent resistance of the five resistors? (b) What relation would exist among R_1, R_2, R_4, and R_5 if there were no current through the bridge?



29. Two D cells power are connected in series to form a battery that powers a bulb of 50.0 Ω. Each cell has emf 1.60 V and internal resistance 1.50 Ω. (a) Find the efficiency of with which energy is delivered to the bulb. (b) Repeat for a bulb of 30.0 Ω.

30. A voltaic cell with emf $\mathcal{E}$ and internal resistance r is connected to a resistor R. Determine the power output of the cell for cases: (a) $R = r/2$, (b) $R = 2r$. (c) What value of R will draw maximum power?

31. A certain galvanometer has internal resistance 77.3 Ω and reads full scale with a current of 508 μA. Find the resistor necessary to create a voltmeter that will read 5.0 V full scale. Repeat for 50 V. Make a schematic of the voltmeter.

32. A certain galvanometer has internal resistance 77.3 Ω and reads full scale with a current of 508 μA. Find the resistor necessary to create a ammeter that will read 5.0 mA full scale. Repeat for 5.0 A. Make a schematic of the ammeter.

33. A simple circuit consists of a battery with emf 6.00 V and internal resistance 2.00 Ω and a resistor of 100 Ω. An ammeter with resistance 5.00 Ω and a voltmeter with resistance 10.0 kΩ are used simultaneously to measure the current and voltage of the resistor. Find the error in the readings caused by the resistance of the meters.