

## Homework set #1 ECE112

### For more depth on conductors and semiconductors:

<http://matse1.mse.uiuc.edu/~tw/sc/prin.html>

<http://matse1.mse.uiuc.edu/~tw/sc/ware.html>

### Short Answers:

1. Name the 4 categories of materials based on their ability to conduct electricity.
2. Label each as C-conductor, SC semiconductor, or I- insulator:  
Copper wire\_\_\_\_\_ Glass rod \_\_\_\_\_ Silicon with Boron atoms added \_\_\_\_\_
3. In a metallic conductor, are the electrons in the outermost orbital shell easy or hard to remove?
4. A battery rated at 10AH contains how many electrons?
5. What 3 things (conceptual, not physical) do you need to describe an electrical current?
6. What 3 things (conceptual, not physical) do you need to describe a voltage level?
7. How is conventional electrical current related to electron current?
8. Electrons flowing through an conductor is called what?
9. What condition is necessary to make a superconductor act as a perfect conductor?
10. What are the two fundamental characteristics of electric charge?
11. What force causes electrons to move.
12. What characteristic of a circuit node is maintained anywhere (physically) on the node?
13. What particle is the charge carrier in metallic conductors?
14. Name four types of energy that can be used to push electrons.

### Long Answers:

Note: In the following questions, the assumption is that the appliance or device operates until the last coulomb is used.

1. A camcorder battery is rated at 6V with 1 Ah (AmpHour) capacity.
  - a) How many coulombs of charge are stored in the battery when fully charged?
  - b) The camcorder consumes 500mA of current from the battery. How long will it run assuming a fully charged battery?
2. You have a flashlight which gets accidentally turned on inside your backpack. When on, the flashlight draws 500mA from its 3 AH cells. When you pull the flashlight out to use it, the light goes out in 30 minutes. How long was the light on inside your backpack?
3. For a joke, your wise-cracking buddy shorts out your spare pacemaker battery by placing a paper clip across the battery terminals for 10 minutes. While shorted, 150mA of

current flows through the paper clip. The battery manufacturer claims that their batteries can deliver 1mA for 200 hours. The pacemaker draws 50uA while operating.

- a) How much (in percentage) of the initial charge is left in the battery after the prank?
- b) Once the spare pacemaker is installed, approximately how many days do you have before the ambulance arrives for you?

4. Your laptop computer runs for 45 minutes before its batteries are exhausted. While running, the computer draws 350mA.

- a) What is the AmpHour rating for the battery?
- b) When fully charged, how many coulombs of charge are inside the battery?

5. While watching the double feature with his gal at the drive-in theater, Sam leaves the radio in his '57 Chevy on. The radio consumes 1A of current\*. To save enough money for the movie, Sam decided not to replace his old battery which has only 20,000 coulombs of charge left. Starting the car engine will require 6000 coulombs of charge. The double feature lasts 4 hours.

- a) Will Sam be able to start the car after the movie?
- b) If not, when should he have left? (answer in hours and minutes)

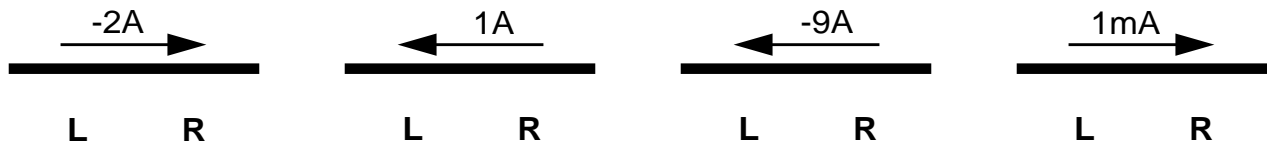
6. A robot has a 3V battery that has a capacity of 2850mAh. When the robot moves forward, its motor appears as a resistive load of 12 ohms. The forward speed of the robot is 0.5ft/sec. How many inches will the robot travel before it stops?

7. An LED (light emitting diode) consumes 20mA when connected through a resistor to a 9V, 100mAh battery. How long will the LED remain illuminated?

8. A 12V battery illuminates a light bulb for 20minutes. What is the mAh rating of the battery if the light bulb consumes 100mA when on?

9. A 5 volt camcorder battery now holds 20% fewer electrons than it did two years ago. Today, with a fully charged battery, a user can get 30 minutes of operation before the battery is dead. What was the original AH rating of the battery? The camcorder consumes 1A when operating.

10. For each of the following conductors shown below, circle "L" or "R" to indicate if the current flows to the left or the right.



11. Which of the following batteries can push more electrons through a conductor in a given time?

- a) 12V, 500mAh
- b) 1.2V, 1000mAh
- c) 9V,  $3.12 \times 10^{17}$  electrons
- d) 6V, 1Ah

12. Which of the following batteries has the most stored charge?

a) 12V, 500mAh

b) 1.2V, 1200uAh

c) 6V,  $3.12 \times 10^{17}$  electrons

d) 6V, 0.01MAh

13. If 1Ampere of current is flowing in a wire, how many electrons will flow past a point in the wire in one minute?

\*Historical note:

These old classic cars had a 6 volt electrical system. The entertainment system i.e., AM radio, was tube-based (hollow-state as opposed to solid-state). To generate the high voltage (~100V) for the tubes, a mechanical “vibrator” was used. This device used mechanical vibration to operate what was essentially a small AC generator. These vibrators consumed lots of current. The AC voltage was converted to DC for the receiver tubes using a “OZ4” rectifier tube. If a '56 or '57 Chevy radio did not work, replacement of the vibrator or the OZ4 tube would usually fix it. Because of this, auto part stores of the day usually carried both the vibrators and OZ4 tubes.

Although it had mechanical parts, and tubes in sockets, and primitive assembly techniques, these radios were remarkably reliable.