University Physics II

Homework Set 5

1. During lightning strikes from a cloud to the ground, currents as high as 25,000 A can occur and last for about 40 μs. How much charge is transferred from the cloud to the earth during such a strike?
2. In the Bohr model of the hydrogen atom, an electron in the lowest energy state moves at a speed of 2.19×10^6 *m/s* in a circular path of radius 5.29×10^{-11} *m*. What is the effective current associated with this orbiting electron?
3. A proton beam in an accelerator carries a current of 125 μA. If the beam aimed at a target, how many protons strike the target in a period of 23.0 *s*?
4. A silver wire 2.6 *mm* in diameter transfers a charge of 420 C in 80 *min*. Silver contains 5.8×10^{28} free electrons per cubic meter.
    a. What is the current in the wire (*in m*A)?
    b. What is the magnitude of the drift velocity of the electrons in the wire?
5. The quantity of charge *q* (in coulombs) that has passed through a surface area 2.00 cm^2 varies with time according to the equation $q(t) = 4t^3 + 5t + 6$, where *t* is in seconds. What is the instantaneous current through the surface at $t = 1.00$ *s*?
6. The current in a wire varies with time according to the relationship $I(t) = 55\text{ A} - (0.65\text{ A}/s^2)t^2$.
    a. How many coulombs of charge pass through a cross-section of the wire between $t = 0$ and $t = 8.0$ *s*?
    b. What constant current would transport the same charge in the same time interval?
7. An electric current in a conductor varies with time according to the expression $I(t) = 100 \sin(120\pi t)$, where *I* is in amperes and *t* is in seconds. What is the total charge passing through a given point in the conductor from $t = 0$ to $t = 1/240$ *s*?
8. Nerve cells transmit electric signals through their long tubular axons. These signals propagate due to a sudden rush of Na^+ ions, each with charge $+e$, into the axon. Measurements have revealed that typically about 5.6×10^{11} Na^+ ions enter each meter of the axon during the time of 10 *ms*. What is the current during this inflow of charge in a meter of axon in μA?
9. A lightbulb has a resistance of 240 Ω when operating with a potential difference of 120 V across it. What is the current in the lightbulb?
10. An electric heater carries a current of 13.5 A when operating at a voltage of 120 V. What is the resistance of the heater?
11. In household wiring, copper wire 2.05 *mm* in diameter is often used. Find the resistance of a 24.0 *m* length of this wire.
12. The power rating of a light bulb (such as a 100-W bulb) is the power it dissipates when connected across a 120 V potential difference. What is the resistance of:
    a. A 100-W bulb
    b. A 60-W bulb
    c. How much current does each bulb draw in normal use?

13. Electric eels generate electric pulses along their skin that can be used to stun an enemy when they come into contact with it. Tests have shown that these pulses can be up to 500 V and produce currents of 80 *m*A (*or even larger*). A typical pulse lasts for 10 *ms*.
    a. How much power is created?
    b. How much energy is delivered to the unfortunate enemy with a single pulse, assuming a steady current?

14. A heart defibrillator is used to restart the heart if it has stopped beating. This is done by passing a large current of 12 A through the body at 25 V for a very short time, usually about 3.0 *ms*.
    a. What power does the defibrillator deliver to the body?
    b. How much energy is transferred?

15. A certain waffle iron is rated at 1.00 *k*W when connected to a 120 V source.
    a. What current does the waffle iron carry?
    b. What is its resistance?

16. The potential difference across a resting neuron in the human body is about 75.0 *m*V and carries a current of about 0.200 *m*A. How much power does the neuron release in μW?

17. A resistor with a 4 band color marking is shown at right.
    a. What is the indicated value of the resistor?
    b. What are the range of values the resistor could actually be?

18. **According to the U.S National Electrical Code, copper wire used for interior wiring of houses, hotels, office buildings, and industrial plants is permitted to carry no more than a specified maximum amount of current. The table below shows values with varnished cambric insulation. The "wire gauge" is a standard used to describe the diameter of wires.

    Note: The larger the diameter of the wire, the smaller the wire gauge.

Wire gauge	Diameter (cm)	I_{max} (A)
14	0.163	18
12	0.205	25
10	0.259	30
8	0.326	40
6	0.412	60
5	0.462	65
4	0.519	85

    a. A total of 4200 W of power is supplied through the wires of a house to the household electrical appliances. If the potential difference across the group of appliances is 120 V, determine the gauge of the thinnest permissible wire that can be used in the house.

    b. Suppose the wire used in this house is of the gauge found in part (*a*) and has a total length of 42.0 m. How much power is dissipated by the wires if the current is that found in part (*a*)?

        Hint: The resistivity (ρ) of copper is 1.72×10^{-8} Ω *m* and $R = \rho L/A$

    c. The house is built in a community where the consumer cost of electrical energy is $0.11 per kilowatt-hour (kWh). If the house were built with wire of the next larger diameter than that found in part (*a*), what would be the savings in electricity costs in one year? Assume that the appliances are kept on for an average of 12 hours a day.