Instructor: Tomoyuki Nakayama Wednesday, May 18 2011

PHY 2005 Applied Physics 2 - Summer 2011
Solutions for Suggested Homework Problems (Chapter 20

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2. The definition of capacitance ($C = Q/\Delta V$) yields $Q = C\Delta V = 2.64 \times 10^{-6}$ C.

6. The capacitance of a parallel plate capacitor is given by $C = \varepsilon_0 A/d$. We solve it for the area of the plate to obtain $A = Cd/\varepsilon_0 = 102$ m^2

8. We approximate a spherical capacitor with a parallel-plate capacitor of plate area $A = 4\pi r^2 = 0.126$ m^2. The capacitance is $C = \varepsilon_0 A/d = 2.22 \times 10^{-9}$ F.

11. (a) If capacitors are connected in series, the reciprocal of the equivalent capacitance is the sum of the reciprocals of the individual capacitances. Therefore, we get $1/C_{eq} = 1/2 + 1/7 + 1/14 = 10/14 \Rightarrow C_{eq} = 1.4$ μF. (b) If capacitors are connected in parallel, the equivalent capacitance is the sum of the individual capacitances. We have $C_{eq} = 2+7+14 = 23$ μF.

13. (a) When multiple capacitors are connected in parallel across a battery, the potential drop across each capacitor is the same as the potential difference provided by the battery. We obtain $Q_1 = C_1\Delta V = 24$ C, $Q_2 = C_2\Delta V = 72$ C and $Q_3 = C_3\Delta V = 144$ C (b) The equivalent capacitance is $1/C_{eq} = 1/2 + 1/6 + 1/12 = 3/4 \Rightarrow C_{eq} = 1.33$ μF. Since the capacitors are connected in series, the charge stored in each capacitor is the same as that stored in the equivalent capacitor. $Q_1 = Q_2 = Q_3 = C_{eq}\Delta V = 16$ C

14. Electric field between a parallel plate capacitor is constant and is given by $E = \Delta V/d$. (a) $E = 1.14 \times 10^4$ V/m (b) $E = 8.00 \times 10^3$ V/m

16. We use the same equation used in the previous problem to get $\Delta V = Ed = 9 \times 10^3$ V.

20. The electric field between the two plates is $E = \Delta V/d = 300$ V/m. The field exerts Coulomb force of magnitude $F = eE$ on the electron. The force is directed toward the negative plate. Newton's 2nd law yields the acceleration of the electron: $ma = eE \Rightarrow a = eE/m = 5.27 \times 10^{13}$ m/s^2. The time interval for the electron to pass the region between the two plates of length L is $t = L/v = 8.75 \times 10^{-9}$ s. During this time interval, the electron is deflected a distance $h = (1/2)at^2 = 2.02 \times 10^{-3}$ m

23. Electric current is defined as the amount of charge that passes through a cross section of a wire in one second. Therefore, the amount of charge flowing through the bulb in one second is $Q = 0.5$ C. Each electron has a charge of magnitude e. The number of electrons is $Q/e = 3.13 \times 10^{18}$.

31. (a) If resistors are connected in series, the equivalent resistance is the sum of the resistances of the individual resistors. $R_{eq} = 2 + 6 + 12 = 20$ Ω. (b) If resisters are connected in parallel, the reciprocal of the equivalent resistance is equal to the sum of the reciprocals of the individual resistances. $1/R_{eq} = 1/2 + 1/6 + 1/12 = 3/4 \Rightarrow R_{eq} = 1.33$ Ω.

35. $R_1 = 5$ Ω and $R_2 = 4$ Ω are connected in parallel. The equivalent resistance of these two resistors is $R_{12} = (1/R_1 + 1/R_2)^{-1} = 2.22$ Ω. R_{12} and $R_3 = 3$ Ω are connected in series. Thus the equivalent resistance of all the three resistors is $R_{eq} = R_{12} + R_3 = 5.22$ Ω.

37. Let $R_1 = 3$ Ω, $R_2 = 10$ Ω, $R_3 = 6$Ω, $R_4 = 2$ Ω and $R_5 = 5$ Ω. R_4 and R_5 are connected in series. The equivalent resistance is $R_{45} = R_4 + R_5 = 7$ Ω. R_{45} is connected in parallel with R_3. We obtain $R_{345} = (1/R_3 + 1/R_{45})^{-1} = 3.23$ Ω. R_1 and R_{345} are connected in series. $R_{1345} = R_1 + R_{345} = 6.23$ Ω. Finally, R_{1345} and R_2 are connected in parallel. Thus the equivalent resistance between a and b is $R_{eq} = (1/R_2 + 1/R_{1345})^{-1} = 3.84$ Ω.

41. Since R_{1345} and R_2 are connected in parallel, the potential drops across them are the same;

they are also the same as the potential difference provided by the battery. The current through the 10-Ω resistor (= R_2) is $I_2 = \Delta V/ R_2$ = 2 A. To find out the current though the 2-Ω (= R_4) resistor, we first calculate the current through $R_{1345.}$ I_{1345}. = $\Delta V/ R_{1345}$ = 3.21 A This current flows through resistor R_{345}. Thus the voltage across R_{345} is $\Delta V_{345} = I_{1345}R_{345}$ = 10.4 V. This voltage is the same as that across $R_{45.}$ Therefore, the current flows in resistor R_{45} is $I_{45} = \Delta V/ R_{1345}$ = 1.49 A. Since R_4 and R_5 are connected in series, the current though the 2-Ω resistor is the same as that through $R_{45.}$ The current through the 2-Ω resistor is 1.49 A

48. The relation between joule and horsepower is given by 1hp = 746 W. Therefore, 1/3 hp = 1/3 hp × 746 W/ 1 hp = 249 W. Solving the equation of the power consumption in a circuit ($P = I\Delta V$) for the current to obtain $I = P/\Delta V$ = 1.91 A.

49. (a) We assume all the energy consumed by the heater is used to heat coffee water. Since 1 cal corresponds to 4.186 J, the energy consumed by the heater in 1 minute (= 60 s) is ΔE = 10 000 cal = 10 000 cal × 4.186 J/1 cal = 41 860 J. The definition of power yields $P = \Delta E/\Delta t$ = 697 W. (b) The power consumption equation gives $I = P/\Delta V$ = 5.80 A. (c) We use the definition of resistance to obtain $R = \Delta V/I$ = 20.7 Ω.

51. The resistance of a wire is related to the resistivity of its material as $R = \rho L/A$. Solving this equation for resistivity, we get $\rho = \pi(D/2)^2 R/L$ = 1.12× 10^{-6} Ω·m, where D is the diameter of the wire in meter and R/L is the resistance of the wire per unit meter.

55. The capacitance of the parallel-plate capacitor is $C = Q/\Delta V$ = 7.5 × 10^{-10} F. When a dielectric is inserted in a parallel-plate capacitor, its capacitance is given by $C = \kappa\varepsilon_0 A/d$. We solve this equation for the separation distance to obtain $d = \kappa\varepsilon_0 A/d = \kappa\varepsilon_0/C = 8.50$ × 10^{-5} m