Instructor: Tomoyuki Nakayama — Wednesday, May 25 2011

PHY 2005 Applied Physics 2 - Summer 2011
Solutions for Suggested Homework Problems (Chapter 21)

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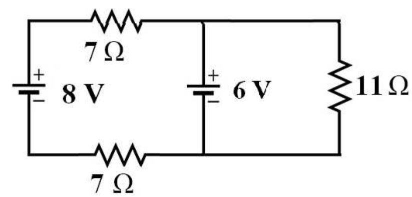
1. (a) Kirchhoff's loop rule yields $6 + 9 - 45I = 0 \Rightarrow I = 0.333$ A. (b) Again we apply the loop rule, we get $9 - 6 - 45I = 0 \Rightarrow I = 0.0667$ A. Note that the potential drops if you across a battery from its positive to negative terminal.

3. (a) I_2 is flowing into junction A, whereas I_1 and I_3 are flowing out. The junction rule gives $I_2 = I_1 + I_3$. (b) We the loop rule to obtain $+7I_2 + 12 + 5I_1 + 3I_1 - 6 = 0$ Note if you traverse a register in the opposite direction to that of the current flowing through it, the potential rises across the resistor.

7. Two resistors are connected in parallel. The equivalent resistance is $R_{eq} = (1/15 + 1/6)^{-1} = 4.29\ \Omega$. The current through the battery is $I_3 = 12/R_{eq} = 2.8$ A. The voltage across each resistor is the same as the voltage provided by the battery, we get $I_1 = 12/R_{eq} = 0.80$ A & $I_2 = 12/R_2 = 2.0$ A.

10. The current through the 6-Ω resistor is 0.8/6 = 0.133 A. Applying the loop rule to loop ABDA, we get $-6I_1 + 8I_3 + 2 = 0 \Rightarrow I_3 = (6I_1 - 2)/8 = -0.150$ A. The junction rule at point D yields $0 = I_1 + I_2 + I_3 \Rightarrow I_2 = -I_1 - I_3 = +0.0167$ A. We apply the loop rule to loop CBDC to obtain $E + 8I_3 = 0 \Rightarrow E = -8I_3 = 1.20$ V



14. The three 2-Ω resistors are connected in series. The equivalent resistance is $R = 2 + 2 + 2 = 6\ \Omega$. This equivalent resistor R is connected in parallel with the 3-Ω resistor. The equivalent resistance is $R' = (1/6 + 1/3)^{-1} = 2\ \Omega$, which is connected in series with 4-Ω and 5-Ω resistors. We combine the three resistors to obtain $R'' = 2 + 4 + 5 = 11\ \Omega$. Now we have the circuit shown on the right. The junction rule yields $I_3 = I_1 + I_2$. We apply the loop rule to the left loop and the right loop to obtain $+8 - 7I_1 - 6 - 7I_1 = 0$ & $6 - 11I_3 = 0$. Solving the three equation, we get $I_1 = 0.143$ A, $I_2 = 0.402$ A & $I_3 = 0.545$ A

19. All the bulbs are connected in parallel, thus the voltage across each bulb is the same as the provided voltage 110 V. (a) Power is given by $P = I\Delta V$. This yields $I = 60/110 = 0.545$ A. (b) The current through the right switch is the sum of the current through the 100-W bulb and 40-W bulb. I = 100/110 + 40/110 = 1.27 A. (c) The current through the fuse is equal to the sum of the current through individual bulbs. $I = \sum(P/\Delta V) = (1/\Delta V)\sum P = (60 + 100 + 100 + 40)/110 = 2.73$ A.

23. While a battery is discharging, the terminal potential difference of the battery is $\Delta V = E - rI = 1.39$ V (b) For charging, the terminal p.d. is given by $\Delta V = E + rI = 1.75$ V.

24. The loop rule yields the terminal voltage of the cell: $\Delta V - RI = 0 \Rightarrow \Delta V = RI = 0.36\ V$. The terminal voltage is smaller than the emf due to potential drop across the internal resistor. The internal resistance is $\Delta V = E - rI \Rightarrow r = (E - \Delta V)/I = 9.92\ \Omega$

26. The ampere-hour is a unit of charge. The total charge carried by a current is $Q = I\Delta t$. We solve this for the time to obtain $\Delta t = Q/I = 26.7$ h. (b) The total energy stored in a battery is $E = P\Delta t = I\Delta V\Delta t = 3.46 \times 10^6$ J. Note that you have to express the time interval Δt in seconds.

28. (a) The definition of resistance yields $I = \Delta V/R = 5.03 \times 10^{-4}$ A. (b) The voltage across the resistor is the same as the terminal voltage of the battery. We solve $\Delta V = E - rI$ for r to get $r = (E - \Delta V)I = 91.4\ \Omega$.

33. The number of silver atoms plated out by electroplating is the same as the number of electrons flowing through the circuit. Thus the mass of the plated out silver is $m = nm_{atom} = (I\Delta t/e)m_{atom}$. Solving this equation, we obtain $m_{atom} = (me/I\Delta t) = 1.75 \times 10^{-25}$ kg

36. Let I_2 be the current flowing through the switch *K.* Applying Kirchhoff's loop rule to the largest loop, we get $6 - 6\ I_2 - 4\ I_2 = 0 \Rightarrow I_2 = 0.60$ A. The loop rule applied to the loop through the two batteries yields $6 - 2\ I_1 - 6 - 3\ I_1 = 0 \Rightarrow I_1 = 0$. We apply the loop rule to the left triangular loop to obtain $+2I_1 - 6I_2 + \Delta V_C = 0 \Rightarrow \Delta V_C = 3.6$ V. The charge on the capacitor is $Q = C\Delta V_C = 7.2 \times 10^{--6}$ C.

37. Apply the loop rule to the left triangular loop, we obtain $xI_2 + R_1I_1 = 0 \Rightarrow I_1/I_2 = x/R_1$. The loop rule applied to the right triangular loop yields $R_2I_2 - R_3I_1 = 0 \Rightarrow I_1/I_2 = R_2/R_3$. Equating these two equations, we get $x/R_1 = R_2/R_3$. $\Rightarrow x = R_1(R_2/R_3)$

39. R_3 and R_4 are connected in series, they have the equivalent resistance of $R_{34} = 4 + 2 = 6$ Ω. The loop rule applied to the top loop yields $3 - 7I_1 + 3I_2 - 2 = 0$. Applying the loop rule to the bottom loop, we obtain $2 - 3I_2 + 6I_3 - 4 = 0$. The junction rule yields $I_1 + I_2 + I_3 = 0$. Solving the three equations simultaneously for I_3, we obtain $I_3 = 0.210$ A

44. Kirchhoff's loop rule yields $3 - 2I - 2I - 1I - 2 - 6I = 0 \Rightarrow I = 0.0909$ A. The power consumed in R_1 is $P = I^2R_1 = 0.0165$ W. This is the heat generated in R_1. Thus the time it takes to generate 18 J of heat is $\Delta t = W/P = 1090$ s = 18.18 min

47. The current flowing in the circuit is $I = \sqrt{(P/R)} = \pm 1.83$ A. The loop rule yields $E_1 - 1I - 3I - 4I - 2I - 28 = 0$. Plugging the values of I, we obtain $E_1 = 46.2$ V, 9.7 V