

Problem 3.4

~~Comparing cylindrical and spherical capacitors.~~

- (a) ~~Compare the capacitance of a capacitor of 2 concentric spheres with $R_1 = 6$ cm and $R_2 = 9$ cm, with that of a cylindrical capacitor having the same radii and axial length of 15 cm. Why are the capacitance values nearly equal?~~
- (b) ~~Show that, when R_1 and R_2 are nearly equal ($R_2 = R_1 + \delta; \delta \ll R_1$) the formulas for the spherical and cylindrical capacitors may be approximated by the formula for the parallel plate capacitor, $C = \epsilon_0 A/d$ (eq. 24-2). Hint: make use of Taylor's expansion in terms of δ/R_1 .~~

Problem 3.5

~~The Van de Graaff~~

~~The spherical dome of a Van de Graaff electrostatic generator has a radius of R m. A rubberized belt 50 cm wide travels at a velocity of 30 m/sec. The belt is given a surface charge density which produces a field of approximately 10^6 V/m on each side of the belt. (see Figure 23-37 on page 612).~~

- (a) ~~What is the current carried by the belt?~~
- (b) ~~What is the maximum charge that the spherical dome can hold, and how long will it take to reach this value?~~
- (c) ~~What is the maximum electrostatic potential of the spherical dome?~~
- (d) ~~What are your answers under (b) and (c) for $R = 0.15$ and $R = 0.5$ m?~~

Problem 3.6

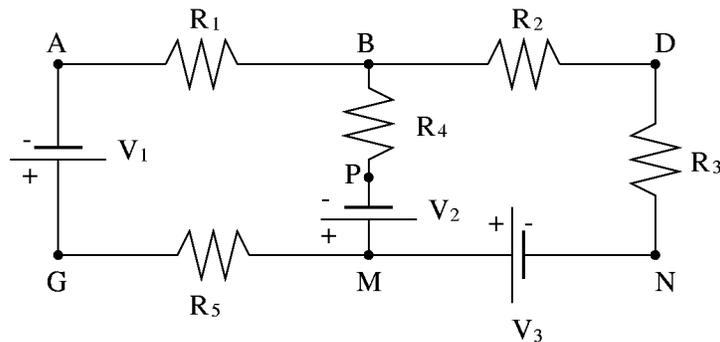
~~Resistor Circuit.~~

~~Giancoli 26-25~~

Problem 3.7

~~Resistor Network.~~

~~A circuit consists of 5 resistors and 3 batteries (see diagram); the connecting wires have all a negligible resistance. The values for $R_1, R_2, R_3, R_4,$ and R_5 are $10 \Omega, 30 \Omega, 50 \Omega, 70 \Omega,$ and $100 \Omega,$ respectively. The batteries have a negligible internal resistance; their voltages $V_1, V_2,$ and $V_3,$ are $12 \text{ V}, 24 \text{ V},$ and $36 \text{ V},$ respectively (for their polarities, see the diagram).~~



- (a) Calculate the current (magnitude and direction) of the currents through each of the 5 resistors.
- (b) What is the potential difference (observe signs!) between the points A&P, P&N, and G&D.

Problem 3.8

~~Wire resistance.~~

~~Giancoli 25-52.~~

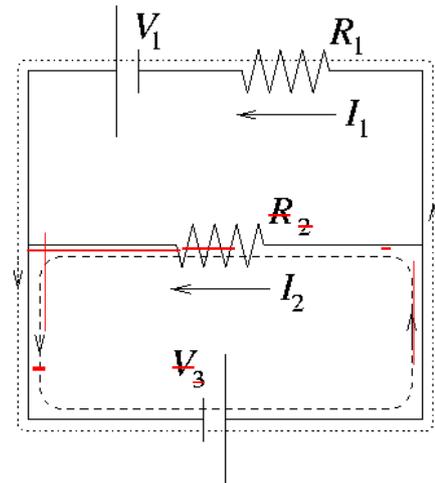
Problem 3.6

Resistor circuit. (Giancoli 26-25.)

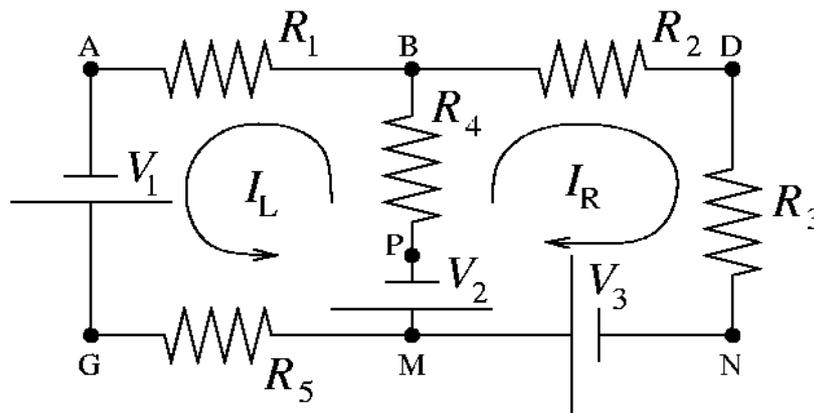
Let I_1 and I_2 be the currents in resistors R_1 and R_2 respectively, with the sense of positive current flow as shown in the diagram at right. Kirchhoff's loop rule applied to a loop around the outside of the circuit (dotted path in diagram) gives us the relation $V_1 + V_3 = I_1 R_1$. Taking a second loop around just the lower half of the circuit (dashed path in diagram) gives $V_3 = I_2 R_2$. Solving for the currents and plugging in given voltages and resistances, we have

$$\begin{aligned} I_1 &= (V_1 + V_3)/R_1 = 0.68 \text{ A} , \\ I_2 &= V_3/R_2 = 0.4 \text{ A} . \end{aligned}$$

Both I_1 and I_2 are positive, so the current through each resistor is directed "to the left".

**Problem 3.7**

Resistor network.



$$(R_1, R_2, R_3, R_4, R_5) = (10, 30, 50, 70, 100)\Omega$$

$$(V_1, V_2, V_3) = (12, 24, 36)\text{V}$$

(a) We'll designate the currents in the left and right parts of the circuit by I_L and I_R , and take them to be in the sense shown in the diagram above. The current through R_4 and V_2 is then $I_L + I_R$ upward, by conservation of charge (Kirchhoff's junction rule). If we move around the left circuit, Kirchhoff's loop rule says that the sum of the EMFs and voltage drops must be zero. This gives

$$+V_1 - I_L R_5 - V_2 - (I_L + I_R)R_4 - I_L R_1 = 0 .$$

The sign of V_1 is positive here because we are moving from the negative terminal to the positive terminal of that battery. In the case of V_2 , we are moving from the positive to the negative terminal, giving us a negative sign. Moving in a loop around the right-hand part of the circuit gives

$$+V_3 - V_2 - (I_L + I_R)R_4 - I_R R_2 - I_R R_3 = 0 \ .$$

If we rearrange these two equations, we get

$$\begin{aligned} (R_1 + R_4 + R_5)I_L + (R_4)I_R &= V_1 - V_2 \ , \\ (R_4)I_L + (R_2 + R_3 + R_4)I_R &= V_3 - V_2 \ . \end{aligned}$$

To save ourselves an algebraic headache, we can insert the given numerical values for the resistances and battery voltages (in SI units) at this point:

$$\begin{aligned} 180I_L + 70I_R &= -12 \ , \\ 70I_L + 150I_R &= 12 \ . \end{aligned}$$

The solution of this system gives

$$I_L = -119 \text{ mA} \ , \ I_R = 136 \text{ mA} \ , \ I_L + I_R = 16.3 \text{ mA} \ .$$

Having obtained a negative value for I_L , we realize that the current in the left-hand side of the circuit in fact flows in a *clockwise* sense. To summarize the current picture:

- 119 mA flows clockwise through R_1 and R_5 ,
- 136 mA flows clockwise through R_2 and R_3 , and
- 16.3 mA flows upwards through R_4 .

(b)

$$V_A - V_P = -(16.3 \times 10^{-3})(70) + (119 \times 10^{-3})(10) = 0.049 \text{ V} \ .$$

Note that the potential drops as we go through the $70 \ \Omega$ resistor (R_4), because we go through with the current, but rises as we go through the $10 \ \Omega$ resistor (R_1), because we go through against the current.

$$V_P - V_N = +36 \text{ V} - 24 \text{ V} = 12 \text{ V} \ .$$

$$V_G - V_D = +(136 \times 10^{-3})(30) + (119 \times 10^{-3})(10) + 12 \text{ V} = 17.3 \text{ V} \ .$$
