

Answers to selected problems from Essential Physics, Chapter 18

1. In a circuit, removing a parallel resistor increases the equivalent resistance of the circuit, and reduces the total current in the circuit. By analogy, closing one trail on the ski hill reduces the rate at which skiers make it down the hill. The speed of the lift should be reduced, so the rate at which skiers are carried up the hill is equal to the rate at which they go down the hill.
3. (a) Graph (a) corresponds to the resistors being in series. Graphs (b) and (c) are for the individual resistors. Graph (d) corresponds to the resistors being in parallel. (b) The resistors have resistances of $2\ \Omega$ and $3\ \Omega$.
5. (a) A gets dimmer (b) B gets dimmer (it turns off) (c) C gets brighter
(d) D gets brighter.
7. (a) $D > A = C > B$ (b) $D > A > B = C$ (c) $C = D > A = B$ (d) $B = C = D > A$
9. (a) The current decreases through A. (b) The current increases through B.
(c) The current decreases through C. (d) The current decreases through the battery.
(e) $R_C = 6\ \Omega$
11. (a) $3.0\ \text{V}$ (b) $1.0\ \text{A}$ (c) $0.50\ \text{A}$ (d) The capacitor, which was being charged with a current of $1.0\ \text{A}$ at the instant the switch is closed, is being charged with a current of only $0.50\ \text{A}$ immediately after the switch is closed. The rest of the current is diverted to resistor B. The capacitor is still charging, it is simply charging more slowly.
(e) After a long time, the capacitor has a potential difference of $4.0\ \text{V}$ across it, and the resistors each have a current of $(2/3)$ of an amp passing through them.
15. (a) Current multiplied by time is charge, so the milliamp-hour is a unit of charge.
(b) $4\frac{2}{3}$ hours
17. (a) The resistance has increased, because of the increased length and the decreased cross-sectional area. (b) $16R$
19. This requires about $1980\ \text{m}$ of copper wire, and just $1.52\ \text{m}$ of carbon wire.
21. (a) $288\ \Omega$ (b) $144\ \Omega$ (c) $96\ \Omega$ (d) $150\ \text{W}$
25. (a) $N = 4$ (b) $R = 6\ \Omega$
29. (a) $4R$ (b) $1/3$ (c) $I_{2R} > I_{3R} > I_R = I_{5R}$ (d) $\Delta V_{2R} = \Delta V_{3R} > \Delta V_{5R} > \Delta V_R$

31. (a) 96Ω (b) If we let R represent the resistance of one bulb, the equivalent resistance of the circuit is $(6/7)R$, and by the power equation $P = (V)^2/R$ we find that the power is $(7/6)$ times that of what it is from a single bulb getting the full potential difference. Thus, the total power output is larger than that from a single bulb that has 120 V across it. (c) Bulbs A and B each have a power of $(50/3)$ W; bulb C has a power of $(200/3)$ W; bulbs D and E each have a power of 37.5 W. The total power is 175 W.

33. (a) $5R$ (b) $I_A = 6I_D$ $I_B = 3I_D$ $I_C = 2I_D$ $I_E = I_D$
(c) $\Delta V_A > \Delta V_B = \Delta V_C > \Delta V_E > \Delta V_D$

37. 28.3 V

39. (a) 1 A down through the battery. (b) 14 V (c) 8Ω (d) -3 V

41. $I_1 = +\frac{5}{13}$ A $I_2 = +\frac{14}{13}$ A $I_3 = -\frac{9}{13}$ A

43. (a) $I_1 + I_2 + I_3 = 0$ (b) This junction equation makes it look like all three currents are directed into a junction, and none are directed away (or vice versa, depending on which junction you look at). In reality, there must be at least one current directed into the junction and at least one directed away, which tells us that either one or two of the currents have the wrong sign, and therefore are shown going the wrong way on the diagram.

45. (a) 6.8 V. (b) A is 9.2 V higher than B

47. (a) 0.556 A (b) 5.44 V (c) 0.510 A (d) 4.51 V

49. (a) 100 kW h (b) 100 kW h

(c) Total energy used = 500 kW h; energy cost = \$100; total cost = \$102.50

(d) Total energy used = 100 kW h; energy cost = \$20; total cost = \$24

51. 19.6 V

53. (a) R_1 has the largest current through it. Because R_2 is at least 4Ω , the total resistance of the branch of the circuit with resistors 2 and 3 is at least 10Ω , greater than the resistance of the branch containing R_1 . Thus, more current will go through R_1 .

(b) The current through R_1 is 1 A no matter what R_2 is. In this circuit, the potential difference across R_1 is always 9 V, so R_1 always has the same current.

55. There are two cases to consider. The $5\ \Omega$ resistor can be placed in parallel with the $4\ \Omega$ resistor, or it can be placed in series with the $6\ \Omega$ resistor. After analyzing both cases, it can be shown that to maximize the current through $3\ \Omega$ resistor, the $5\ \Omega$ resistor should be placed in parallel with the $4\ \Omega$ resistor. This increases the current through the $3\ \Omega$ resistor by $0.84\ \text{A}$, from $2.00\ \text{A}$ to $2.84\ \text{A}$.

57. $I_A = 0.5\ \text{A}$, $I_B = 0.22\ \text{A}$, $I_C = I_D = 0.11\ \text{A}$, $I_E = 0.33\ \text{A}$.

59. (a) The $5\ \Omega$ resistor has the largest current. All the current that passes through the battery also passes through the $5\ \Omega$ resistor, while all the other resistors only get a fraction of the total current. (b) These two resistors have equal currents – both parallel branches of the circuit have $10\ \Omega$ of resistance, so the current divides equally between them. (c) The $10\ \Omega$ resistor has a larger potential difference than the $8\ \Omega$ resistor. Both parallel branches have the same potential difference across them. The $10\ \Omega$ resistor has that potential difference across it, while the $8\ \Omega$ resistor has to share that potential difference with the pair of $4\ \Omega$ resistors. Another way to answer this part is simply to apply Ohm's law to the two resistors – they have the same current, so the one with the largest resistance also has the largest potential difference across it.

61. (a) $+16\ \text{V} - I_2(56\ \Omega) - I_1(68\ \Omega) - I_1(47\ \Omega) = 0$

(b) $-I_1(47\ \Omega) + 16\ \text{V} - I_2(56\ \Omega) - I_1(68\ \Omega) = 0$. The terms are in a different order, but the equation is equivalent.

(c) $+I_1(47\ \Omega) + I_1(68\ \Omega) + I_2(56\ \Omega) - 16\ \text{V} = 0$ The terms are in a different order, and every sign is flipped, but the equation is still equivalent to the two above.

63. (a) $3.7\ \text{V}$ (b) $t = 11.4\ \text{s}$ (c) $t = \infty$