

1. An electric heater is constructed by applying a potential difference of 110 V across a wire with a resistance of 5.0 Ω . What is the power rating of the heater?

- a. 2.0 kW
- b. 2.4 kW
- c. 1.7 kW
- d. 1.5 kW
- e. 60 kW

$$I = \frac{110\text{V}}{5.0\Omega} = 22 \text{ A}$$

$$P = I^2 R = (22)^2 (5\Omega) = 2420 \text{ W} = 2.4 \text{ kW}$$

2. A 4.0- Ω resistor has a current of 3.0 A in it for 5.0 min. How many electrons pass through the resistor during this time interval?

- a. 7.5×10^{21}
- b. 5.6×10^{21}
- c. 6.6×10^{21}
- d. 8.4×10^{21}
- e. 2.1×10^{21}

$$I = \frac{\Delta Q}{\Delta t};$$

$$\Delta Q = I \cdot \Delta t = 3 \cdot 5 \cdot 60 = 900 \text{ C}$$

$$\Delta Q = q \cdot N$$

$$N = I \cdot \Delta t / q = 900 \text{ C} / 1.6 \cdot 10^{-19} \text{ C} = 5.6 \cdot 10^{21}$$

3. A wire (length = 2.0 m, diameter = 1.0 mm) has a resistance of 0.45 Ω . What is the resistivity of the material used to make the wire?

- a. $5.6 \times 10^{-7} \Omega \cdot \text{m}$
- b. $1.2 \times 10^{-7} \Omega \cdot \text{m}$
- c. $1.8 \times 10^{-7} \Omega \cdot \text{m}$
- d. $2.3 \times 10^{-7} \Omega \cdot \text{m}$
- e. $7.1 \times 10^{-7} \Omega \cdot \text{m}$

$$R = \rho \frac{L}{A}$$

$$\rho = R \frac{A}{L} = 0.45\Omega \frac{\pi \cdot (0.001)^2}{2\text{m}} = 1.8 \cdot 10^{-7} \Omega \text{ m}$$

4. A small bulb is rated at 7.5 W when operated at 125 V. Its resistance (in ohms) is

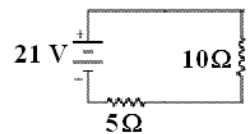
- a. 0.45.
- b. 7.5.
- c. 17.
- d. 940.
- e. **2100.**

$$P = V^2 / R$$

$$R = V^2 / P = 125^2 / 7.5 = 2083 \Omega$$

5. What is the current in the 10-Ω resistor?

- a. 0.60 A
- b. 3.0 A
- c. **1.4 A**
- d. 2.4 A
- e. 0.30 A

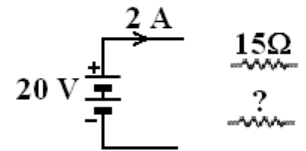


$$I = V / R$$

$$I = 21[V] / (10[\Omega] + 5[\Omega]) = 21[V] / 15[\Omega] = 1.4[A]$$

6. A resistor of unknown resistance and a 15-Ω resistor are connected across a 20-V battery in such a way that a 2.0 A current is observed in the battery. What is the value of the unknown resistance?

- a. 75 Ω
- b. 12 Ω
- c. 7.5 Ω
- d. **30 Ω**
- e. 5.0 Ω



The equivalent resistance is $20V/2A=10\Omega$. If one of the known resistors is 15Ω , then there is only one way to connect the two resistors: in parallel. (note if you connect them in series, then the equivalent resistance should be more than 15Ω).

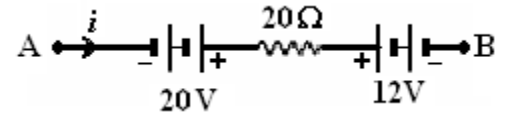
Thus we are looking for the unknown resistance:

$$\frac{1}{10\Omega} = \frac{1}{15\Omega} + \frac{1}{R}$$

$$R = 15 \cdot 10 / (15 - 10) = 30\Omega$$

7 What is the potential difference $V_B - V_A$ when the $I = 1.5 \text{ A}$ in the circuit segment below?

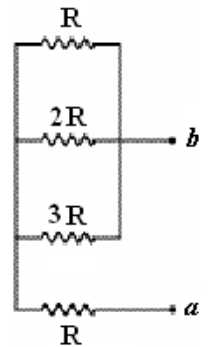
- a. +22 V
- b. -22 V
- c. -38 V
- d. +38 V
- e. +2.0 V



Without the EMFs, the potential difference is -30V . Two EMFs add a positive ($20\text{V}-12\text{V}=+8\text{V}$) shift. Finally, the potential difference $V_B - V_A = -30\text{V}+8\text{V}=-22\text{V}$.

8. What is the equivalent resistance between points a and b when $R = 13 \Omega$?

- a. 29Ω
- b. 23Ω
- c. 26Ω
- d. 20Ω
- e. 4.6Ω



We have 3 resistors in parallel:

$$\frac{1}{R_{eq1}} = \frac{1}{R} + \frac{1}{2R} + \frac{1}{3R} = \frac{6+3+2}{6R}$$

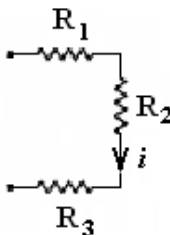
$$R_{eq1} = (6/11)R$$

This equivalent resistor is connected in series with R (the bottom one).

The total resistance: $(6/11)R+R=(17/11)R$. Plug 13Ω instead of R and obtain: 20Ω

9. If $R_1 = 10 \Omega$, $R_2 = 15 \Omega$, $R_3 = 20 \Omega$, and $I = 0.50 \text{ A}$, at what rate is heat being generated in these resistors?

- a. 29 W
- b. 16 W
- c. 22 W
- d. 11 W
- e. 1.1 W

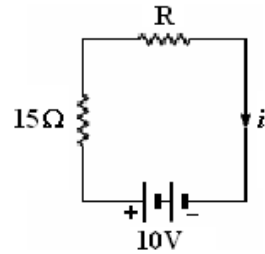


The equivalent resistance for three resistors in series is: $10 \Omega+15 \Omega+20 \Omega=45\Omega$.

Power $P=I^2R=0.5^2 \cdot 45=22.5\text{W}$

10. A 10-V battery is connected to a 15-Ω resistor and an unknown resistor R , as shown. The current in the circuit is 0.40 A. How much heat is produced in the 15-Ω resistor in 2.0 min?

- a. 0.40 kJ
- b. 0.19 kJ
- c. 0.29 kJ
- d. 0.72 kJ
- e. 0.80 kJ



$\text{Heat} = P \cdot t = I^2 \cdot R \cdot t = 0.4^2 \cdot 15 \cdot 2 \cdot 60 = 288 \text{ J} = 0.29 \text{ kJ}$

11. If body P, with a positive charge, is placed in contact with body Q (initially uncharged), what will be the nature of the charge left on Q?
- a. must be equal in magnitude to that on P
 - b. must be negative
 - c. must be positive
 - d. must be greater in magnitude than that on P
 - e. must be negative and less in magnitude than that on P

Only positive charge can be left on Q that originates from positive charge on P.
The total charge will be redistributed between Q and P according to their capacitances.

12. Two point charges are 4 cm apart. They are moved to a new separation of 2 cm. By what factor does the resulting mutual force between them change?
- a. 1/2
 - b. 2
 - c. 1/4
 - d. 4
 - e. 1

The force between two charges: $F = \kappa \frac{q_1 \cdot q_2}{r_{12}^2}$. If distance decreases by a factor of 2, then the force increases by a factor of 4.

13. Two equal charges, each Q , are separated by some distance. What third charge would need to be placed half way between the two charges so that the net force on each charge would be zero?
- a. $-Q$
 - b. $-Q/2$
 - c. $-Q/4$
 - d. $-Q/8$
 - e. $-Q/16$

The middle charge q will be in equilibrium for any value of the charge. But for two charges at the right and left sides, the forces need to be balanced. So, the middle charge should have an opposite sign. For example, for the charge on the left:

$$F = \kappa \frac{q \cdot Q}{(R/2)^2} + \kappa \frac{Q \cdot Q}{R^2} = 0$$

$$-\frac{4q \cdot Q}{R^2} = \frac{Q \cdot Q}{R^2};$$

$$-4q = Q; \quad q = -Q/4$$

14. A 9.0-V battery is connected between two parallel metal plates 4.0 mm apart. What is the magnitude of the electric field between the plates?

- a. $2.3 \times 10^3 \text{ N/C}$
- b. 9.0 N/C
- c. 2.3 N/C
- d. $0.75 \times 10^{-6} \text{ N/C}$
- e. $0.56 \times 10^{-9} \text{ N/C}$

$$E = \frac{\Delta V}{d} = \frac{9}{0.004} = 2.25 \times 10^3 \text{ N/C}$$

- _____ 15. A uniform electric field, with a magnitude of 600 N/C, is directed parallel to the positive x -axis. If the potential at $x = 3.0 \text{ m}$ is 1 000 V, what is the change in potential energy of a proton as it moves from $x = 3.0 \text{ m}$ to $x = 1.0 \text{ m}$? ($q_p = 1.6 \times 10^{-19} \text{ C}$)

- a. $8.0 \times 10^{-17} \text{ J}$
- b. $1.9 \times 10^{-16} \text{ J}$
- c. $0.80 \times 10^{-21} \text{ J}$
- d. 500 J
- e. $2.2 \times 10^{-15} \text{ J}$

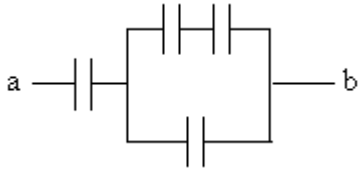
$$|\Delta U| = q \cdot E_x \cdot \Delta x = 600 (1.6 \times 10^{-19}) (3-1) = 1.92 \times 10^{-16} \text{ J}$$

- _____ 16. An electron in a cathode ray tube is accelerated through a potential difference of 5.0 kV. What kinetic energy does the electron gain in the process? ($e = 1.6 \times 10^{-19} \text{ C}$)

- a. $1.6 \times 10^{-16} \text{ J}$
- b. $8.0 \times 10^{-16} \text{ J}$
- c. $1.6 \times 10^{-22} \text{ J}$
- d. $8.0 \times 10^{22} \text{ J}$
- e. $1.6 \times 10^{16} \text{ J}$

$$|\Delta U| = q \cdot \Delta V = \frac{1}{2} mv^2 = K = 1.6 \times 10^{-19} \text{ C} \cdot 5000 \text{ V} = 8 \times 10^{-16} \text{ J}$$

___ 17. What is the equivalent capacitance between points a and b? All capacitors are $1.0 \mu\text{F}$.



- a. $4.0 \mu\text{F}$
- b. $1.7 \mu\text{F}$
- c. $0.60 \mu\text{F}$
- d. $0.25 \mu\text{F}$
- e. $0.50 \mu\text{F}$

$$C_{series} = \left(\frac{1}{C_1} + \frac{1}{C} \right)^{-1} = \left(\frac{1}{C_2+C} + \frac{1}{C} \right)^{-1} = \left(\frac{1}{\left(\frac{1}{C} + \frac{1}{C} \right)^{-1} + C} + \frac{1}{C} \right)^{-1} = 0.6 \mu\text{F}$$

Where $C=1 \mu\text{F}$

___ 18. A metallic conductor has a resistivity of $18 \times 10^{-6} \Omega \cdot \text{m}$. What is the resistance of a piece that is 30 m long and has a uniform cross sectional area of $3.0 \times 10^{-6} \text{ m}^2$?

- a. 0.056Ω
- b. 180Ω
- c. 160Ω
- d. 90Ω
- e. 60Ω

$$R = \rho \frac{L}{A}$$

$$\frac{30 * 18 \times 10^{-6}}{3.0 \times 10^{-6}} = 6(30) = 180 \Omega$$

___ 19. A 60-W light bulb is in a socket supplied with 120 V. What is the current in the bulb?

- a. 0.50 A
- b. 2.0 A
- c. 60 A
- d. $7\,200 \text{ A}$
- e. $10\,000 \text{ A}$

$$P=V*I$$

$$I=P/V=60W/120V=0.5A$$

20. A resistor is connected to a battery with negligible internal resistance. If you replace the resistor with one that has twice the resistance, by what factor does the power dissipated in the circuit change?
- 0.50
 - 0.25
 - 4.0
 - 2.0
 - 1.0

We assume that the voltage remains the same.

Power $P = V^2/R$ If resistance increased by 2, then the power decreases by 2.

21. The heating coil of a hot water heater has a resistance of 20Ω and operates at 210 V. How long a time is required to raise the temperature of 200 kg of water from 15°C to 80°C ? (The specific heat for water = $10^3 \text{ cal/kg}\cdot^\circ\text{C}$ and $1.0 \text{ cal} = 4.186 \text{ J}$.)
- 1.7 h
 - 3.8 h
 - 5.1 h
 - 6.9 h
 - 8.8 h

$$I = \frac{\Delta V}{R} = \frac{210}{20} = 10.5 \text{ A}$$

$$P = I^2 R = 10.5^2 (20) = 2,205 \text{ W}; Q_{\text{heater}} = P \cdot t;$$

$$Q_{\text{water}} = m \cdot c \cdot \Delta T = 200 \text{ kg} \cdot 4186 \text{ J/kg} \cdot (80-15) \text{ K} = 54,418,000 \text{ J}$$

$$t = \frac{Q}{P} = \frac{54,418,000}{2,205} = 24,679 \text{ s} \times \frac{1}{3,600} = 6.85 \text{ hours}$$

22. An $8.00\text{-}\Omega$ resistor is dissipating 100 watts. What are the current through it, and the difference of potential across it?
- 12.5 A, 28.3 V
 - 3.54 A, 12.5 V
 - 3.54 A, 28.3 V
 - 28.3 A, 3.54 V
 - 12.5 A, 3.54 V

$$P = I^2 R$$

$$100 = I^2 (8)$$

$$\sqrt{12.5} = I$$

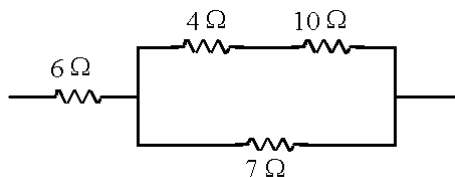
$$I = 3.54 \text{ A}$$

$$P = VI$$

$$100 = V(3.54)$$

$$V = 28.3 \text{ V}$$

23. Resistors of values 6.0Ω , 4.0Ω , 10.0Ω and 7.0Ω are combined as shown. What is the equivalent resistance for this combination?



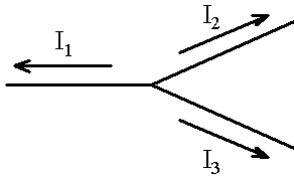
- a. 2.3Ω
- b. 3.0Ω
- c. 10.7Ω
- d. 27Ω
- e. 30Ω

The equivalent resistance for three resistors on the right is:
$$\frac{1}{R_{eq1}} = \frac{1}{7\Omega} + \frac{1}{4\Omega + 10\Omega} = \frac{3}{14\Omega}$$

$$R_{eq1} = 14 / 3\Omega = 4.66\Omega$$

Finally, we combine it with the single one on the left: $6 \Omega + 4.66 \Omega = 10.66 \approx 10.7 \Omega$

____ 24. What is Kirchhoff's 1st equation for this junction?



- a. $I_1 = I_2 + I_3$
- b. $I_2 = I_1 + I_3$
- c. $I_3 = I_1 + I_2$
- d. $I_1 + I_2 + I_3 = 0$
- e. $I_2 = I_3$

$I_1 + I_2 + I_3 = 0$ Kirchhoff's equation for this junction
One of the currents should be negative with respect to the shown direction.

Answer Section

1B 2B 3C 4E 5C 6D 7B 8D 9D 10C

- | | |
|------------|---|
| 11. ANS: C | TOP: Insulators and Conductors |
| 12. ANS: D | TOP: Coulomb's Law |
| 13. ANS: C | TOP: Coulomb's Law |
| 14. ANS: A | TOP: Potential Difference and Electric Potential |
| 15. ANS: B | TOP: Potential Difference and Electric Potential |
| 16. ANS: B | TOP: Potential Difference and Electric Potential |
| 17. ANS: C | TOP: The Parallel-Plate Capacitor, Combinations of Capacitors |
| 18. ANS: B | TOP: Resistivity |
| 19. ANS: A | TOP: Electrical Energy and Power |
| 20. ANS: A | TOP: Electrical Energy and Power |
| 21. ANS: D | TOP: Electrical Energy and Power |
| 22. ANS: C | TOP: Electrical Energy and Power |
| 23. ANS: C | TOP: Sources of emf, Resistors in Series, Resistors in Parallel |
| 24. ANS: D | TOP: Kirchhoff's Rules and Complex DC Circuits |