Physics 11
Circuits Unit Test Solutions

	a.	b.	c.	d.
1.			X	
2.	X			
3.		X		
4.		X		
5.	X			
6.				X
7.	X			
8.		X		
9.		X		
10.				X
11.			X	
12.		X		
13.			X	
14.			X	
15.			X	
16.		X		
17.		X		
18.		X		
19.	X			
20.		X		

1. **Problem**
   Which device can be used to measure the current in a circuit?

   a. voltmeter
   b. ohmmeter
   c. ammeter
   d. currentometer

   Solution
   Current can be measured by an ammeter.

2. **Problem**
   Car batteries are rated in "amp-hours". This is a measure of their

   a. electric charge
   b. current
   c. energy density
   d. energy capacity

   Solution
   The amp-hour comes from multiplying current and time and is therefore a unit of electric charge.

3. **Problem**
   A battery is rated at $12\,\mathrm{V}$ and $1100\,\mathrm{mAh}$. How much energy does the battery store at full charge?

   a. $88.4\,\mathrm{kJ}$
   b. $48\,\mathrm{kJ}$
   c. $41\,\mathrm{kJ}$
   d. $27.9\,\mathrm{kJ}$

   Solution
   Convert to SI units and multiply the voltage by the charge:

   $$E = QV = (1100\,\mathrm{mAh} \times 3.6\,\mathrm{C/mAh})(12\,\mathrm{V}) = 48\,\mathrm{kJ}$$

4. **Problem**
   What voltage is applied across a $4\,\Omega$ resistor if the current is $7.8\,\mathrm{A}$?

   a. $40\,\mathrm{V}$
   b. $31\,\mathrm{V}$
   c. $2\,\mathrm{V}$
   d. $6.6\,\mathrm{V}$

   Solution
   Use Ohm's law:

   $$V = IR = (7.8\,\mathrm{A})(4\,\Omega) = 31\,\mathrm{V}$$

5. **Problem**
   A lamp draws a current of $8\,\mathrm{A}$ when it is connected to a $7.5\,\mathrm{V}$ source. What is the resistance of the lamp?

   a. $0.94\,\Omega$
   b. $16\,\Omega$
   c. $1.1\,\Omega$
   d. $60\,\Omega$

   Solution
   Use Ohm's law:

$$R = \frac{V}{I} = \frac{7.5\,\mathrm{V}}{8\,\mathrm{A}} = 0.94\,\Omega$$

6. **Problem**
   A lamp with a resistance of $6.8\,\Omega$ is placed across a potential difference of $8.5\,\mathrm{V}$. What is the current through the lamp?

   a. $0.65\,\mathrm{A}$
   b. $0.8\,\mathrm{A}$
   c. $0.96\,\mathrm{A}$
   d. $1.2\,\mathrm{A}$

   Solution
   Use Ohm's law:

$$I = \frac{V}{R} = \frac{8.5\,\mathrm{V}}{6.8\,\Omega} = 1.2\,\mathrm{A}$$

7. **Problem**
   A voltage source of $8\,\mathrm{V}$ delivers a current of $5.3\,\mathrm{A}$ to an electric motor that is connected across its terminals. What power is consumed by the motor?

   a. $42\,\mathrm{W}$
   b. $37\,\mathrm{W}$
   c. $29\,\mathrm{W}$
   d. $7\,\mathrm{W}$

   Solution
   Use the formula for the power in a circuit:

$$P = IV = (5.3\,\mathrm{A})(8\,\mathrm{V}) = 42\,\mathrm{W}$$

8. **Problem**
   A space heater with a resistance of $9.3\,\Omega$ operates at a voltage of $117\,\mathrm{V}$. How much energy does the space heater use in 9.1 hours?

   a. $6.7\,\mathrm{kWh}$
   b. $13\,\mathrm{kWh}$
   c. $8.2\,\mathrm{kWh}$
   d. $9.6\,\mathrm{kWh}$

   Solution
   Find the power of the device using $P = IV = V^2/R$ and multiply by the time. Remember to convert all units.

$$E = Pt = \frac{V^2}{R}t = \frac{(117\,\mathrm{V})^2}{9.3\,\Omega}(9.1\,\mathrm{h}) = 13000\,\mathrm{Wh} = 13\,\mathrm{kWh}$$

9. **Problem**
   As more resistors are added in **series** to a constant voltage source, the power supplied by the source

   a. increases.
   b. decreases.
   c. remains the same.
   d. not enough information.

   Solution
   The total resistance increases, causing the total current to decrease. Since the voltage is constant and $P = IV$, the power decreases.

10. **Problem**
    Three resistors are connected in **series**. Their resistances are $68\,\Omega$, $60\,\Omega$, and $38\,\Omega$. What is the equivalent resistance of the resistors?

    a. $17\,\Omega$
    b. $140\,\Omega$
    c. $320\,\Omega$
    d. $170\,\Omega$

    Solution
    The equivalent resistance of resistors in series is the sum of the resistances.

$$R = R_1 + R_2 + R_3 = 166\,\Omega$$

11. **Problem**
    When different resistors are connected in series, it is true that

    a. the potential difference across each is the same.
    b. the power dissipated in each is the same.
    c. the same current flows in each one.
    d. the total resistance is equal to the greatest resistance of any individual resistor.

    Solution
    The current is the same in resistors in series.

12. **Problem**
You have a $5\,\Omega$ light bulb and a $10\,\Omega$ light bulb. You make a circuit that places them in series across a battery. Which light bulb is brighter?

    a. The $5\,\Omega$ bulb is brighter.
    b. The $10\,\Omega$ bulb is brighter.
    c. Both bulbs glow at the same brightness.
    d. It depends on the voltage.

    Solution
    The current through both bulbs is the same since they are placed in series. However, the voltage drop is greater for the greater resistance. Since $P = IV$, and V is greater for the greater resistance, the $10\,\Omega$ light bulb is brighter.

13. **Problem**
A total of 993 resistors, all with resistance $765\,\Omega$, are connected in **parallel**. What is the equivalent resistance of the resistors?

    a. $0.5\,\Omega$
    b. $0.59\,\Omega$
    c. $0.77\,\Omega$
    d. $0.41\,\Omega$

    Solution
    The equivalent resistance of resistors in parallel when they all have the same resistance R_i is

$$R = \left(\frac{1}{R_i} + \frac{1}{R_i} + \frac{1}{R_i} + ...\right)^{-1} = \frac{R_i}{993} = 0.77\,\Omega$$

14. **Problem**
A total of 945 Christmas light bulbs, all with resistance $817\,\Omega$, are connected in **series**. What is the equivalent resistance of the lights?

    a. $850\,\mathrm{k}\Omega$
    b. $1100\,\mathrm{k}\Omega$
    c. $770\,\mathrm{k}\Omega$
    d. $960\,\mathrm{k}\Omega$

    Solution
    The equivalent resistance of resistors in series when they all have the same resistance R_i is

$$R = R_i + R_i + R_i + ... + R_i = 945R_i = 770\,\mathrm{k}\Omega$$

15. **Problem**
    Two resistors are connected in **parallel**. Their resistances are $465\,\Omega$ and $414\,\Omega$. A battery applies $1.6\,\mathrm{V}$ to the combination. What is the current through the $465\,\Omega$ resistor?

    a. $3.8\,\mathrm{mA}$
    b. $2.2\,\mathrm{mA}$
    c. $3.4\,\mathrm{mA}$
    d. $5.5\,\mathrm{mA}$

    Solution
    The full voltage of the battery is applied to both resistors. The current through the first resistor is

    $$I = \frac{V}{R} = \frac{1.6\,\mathrm{V}}{465\,\Omega} = 3.4\,\mathrm{mA}$$

16. **Problem**
    Two resistors are connected in **series**. Their resistances are $5\,\Omega$ and $8\,\Omega$. A difference in potential of $31\,\mathrm{V}$ is applied to the combination. What is the current through the $8\,\Omega$ resistor?

    a. $1.5\,\mathrm{A}$
    b. $2.4\,\mathrm{A}$
    c. $2.1\,\mathrm{A}$
    d. $3.2\,\mathrm{A}$

    Solution
    The equivalent resistance of resistors in series is the sum of the resistances.

    $$R = R_1 + R_2 + R_3 = 13\,\Omega$$

    The current is the same through all components in series and its value is

    $$I = \frac{V}{R} = \frac{31\,\mathrm{V}}{13\,\Omega} = 2.4\,\mathrm{A}$$

17. **Problem**
    Two resistors are connected in **parallel**. Their resistances are $15\,\Omega$ and $35\,\Omega$. A battery applies $95\,\mathrm{V}$ to the combination. What is the current drawn from the battery?

    a. $7.7\,\mathrm{A}$
    b. $9\,\mathrm{A}$
    c. $14\,\mathrm{A}$
    d. $11\,\mathrm{A}$

    Solution
    The equivalent resistance of resistors in parallel is

    $$R = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)^{-1} = 10.5\,\Omega$$

    The current drawn from the battery is

$$I = \frac{V}{R} = \frac{95\,\text{V}}{10.5\,\Omega} = 9\,\text{A}$$

18. **Problem**
Three resistors are connected in **parallel**. Their resistances are $28\,\Omega$, $89\,\Omega$, and $33\,\Omega$. What is the equivalent resistance of the resistors?

    a. $17\,\Omega$
    b. $13\,\Omega$
    c. $22\,\Omega$
    d. $9.3\,\Omega$

    Solution
    The equivalent resistance of resistors in parallel is

$$R = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}\right)^{-1} = 13\,\Omega$$

19. **Problem**
A $600\,\text{mA}$ current flows into a parallel combination of a $95\,\Omega$ and a $67\,\Omega$ resistor. What current flows through the $95\,\Omega$ resistor?

    a. $250\,\text{mA}$
    b. $170\,\text{mA}$
    c. $370\,\text{mA}$
    d. $340\,\text{mA}$

    Solution
    The total current is equal to the sum of the current through each resistor

$$I = I_1 + I_2$$

The voltage across each resistor is the same and $V = IR$ so

$$I_1 R_1 = I_2 R_2$$

Combining the two equations and solving for I_1 gives

$$I_1 = \left(\frac{R_2}{R_1 + R_2}\right) I = 250\,\text{mA}$$

20. **Problem**
When a battery with an emf of $9.7\,\mathrm{V}$ supplies a $1.7\,\mathrm{A}$ current, its terminal voltage is $5.9\,\mathrm{V}$. What is the internal resistance of the battery?

    a. $4.2\,\Omega$
    b. $2.2\,\Omega$
    c. $3.9\,\Omega$
    d. $1.5\,\Omega$

    Solution
    The terminal resistance is related to the emf by $V_{terminal} = \mathcal{E} - Ir$. Therefore,

$$r = \frac{\mathcal{E} - V_{terminal}}{I} = 2.2\,\Omega$$