1. **Multiple Correct.** Which two arrangements of resistors shown above have the same resistance between the terminals? Select two answers:

- (A) I
- (B) II
- (C) III
- (D) IV

![Diagram](image)
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The resistances are as follows: I: $2 \, \Omega$, II: $4 \, \Omega$, III: $1 \, \Omega$, IV: $2 \, \Omega$
2. In the circuit shown below, what is the value of the potential difference between points X and Y if the 6-volt battery has no internal resistance? 
(A) 2 V  (B) 3 V  (C) 4 V  (D) 6V
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(A) 2 V       (B) 3 V        (C) 4 V      (D) 6V

The total resistance of the 3 Ω and 6 Ω in parallel is 2 Ω making the total circuit resistance 6 Ω and the total current \( \frac{E}{R} = 1 \) A. This 1 A will divide in the ratio of 2:1 through the 3 Ω and 6 Ω respectively so the 3 Ω resistor receives \( \frac{2}{3} \) A, making the potential difference \( IR = \left(\frac{2}{3} \text{ A}\right)(3 \Omega) = 2 \text{ V} \).
• Adding resistors in parallel decreases the total circuit resistance, this increasing the total current in the circuit.
3. A lamp, a voltmeter $V$, an ammeter $A$, and a battery with zero internal resistance are connected as shown above. Connecting another lamp in parallel with the first lamp as shown by the dashed lines would
(A) increase the ammeter reading
(B) decrease the ammeter reading
(C) increase the voltmeter reading
(D) decrease the voltmeter reading
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(B) decrease the ammeter reading 
(C) increase the voltmeter reading 
(D) decrease the voltmeter reading 

Adding resistors in parallel decreases the total circuit resistance, this increasing the total current in the circuit.
4. The five resistors shown below have the lengths and cross-sectional areas indicated and are made of material with the same resistivity. Which has the greatest resistance?

(A) \( l \) (A) \( 2l \) (A) \( \frac{l}{2A} \) (A) \( \frac{2l}{2A} \)
4. The five resistors shown below have the lengths and cross-sectional areas indicated and are made of material with the same resistivity. Which has the greatest resistance?

(A) \[ \ell \quad \text{A} \]  (B) \[ 2\ell \quad \text{A} \]  (C) \[ \ell \quad 2A \]  (D) \[ 2\ell \quad 2A \]

B is the answer;
Equation to use \( R = \rho L/A \).
Greatest resistance is the longest, narrowest resistor.
5. The circuit shown below is made up of a variable resistor and a battery with negligible internal resistance. A graph of the power $P$ dissipated in the resistor as a function of the current $I$ supplied by the battery is given above right. What is the emf of the battery?

(A) 0.025 V      (B) 2.5 V      (C) 6.25 V      (D) 40 V
5. The circuit shown below is made up of a variable resistor and a battery with negligible internal resistance. A graph of the power $P$ dissipated in the resistor as a function of the current $I$ supplied by the battery is given above right. What is the emf of the battery?

(A) 0.025 V  (B) 2.5 V  (C) 6.25 V  (D) 40 V

$P = IE$

where 'i is amps, 'e is volts, 'p is watts
$W = Pt = I^2Rt$

- Work  = Power x time
- $= I^2Rt$
6. An immersion heater of resistance R converts electrical energy into thermal energy that is transferred to the liquid in which the heater is immersed. If the current in the heater is I, the thermal energy transferred to the liquid in time t is

   (A) IRt     (B) I^2Rt     (C) IRt^2     (D) IR/t
6. An immersion heater of resistance $R$ converts electrical energy into thermal energy that is transferred to the liquid in which the heater is immersed. If the current in the heater is $I$, the thermal energy transferred to the liquid in time $t$ is

(A) $IRt$  (B) $I^2Rt$  (C) $IRt^2$  (D) $IR/t$

$$W = Pt = I^2Rt$$
7. The total equivalent resistance between points X and Y in the circuit shown below is

(A) 3 \, \Omega \quad (B) 4 \, \Omega \quad (C) 5 \, \Omega \quad (D) 6 \, \Omega
7. The total equivalent resistance between points X and Y in the circuit shown below is

(A) 3 Ω   (B) 4 Ω   (C) 5 Ω   (D) 6 Ω

The resistance of the two 2 Ω resistors in parallel is 1 Ω. Added to the 2 Ω resistor in series with the pair gives 3 Ω.
8. The four resistors shown below have the lengths and cross-sectional areas indicated and are made of material with the same resistivity. Which resistor has the least resistance?

(A)      (C)

(B)      (D)
8. The four resistors shown below have the lengths and cross-sectional areas indicated and are made of material with the same resistivity. Which resistor has the least resistance?

\[ R = \frac{\rho L}{A} \]

Least resistance is the widest, shortest resistor.
9. The below circuit diagram shows a battery with an internal resistance of 4.0 ohms connected to a 16–ohm and a 20–ohm resistor in series. The current in the 20–ohm resistor is 0.3 amperes.

What power is dissipated by the 4–ohm internal resistance of the battery?
(A) 0.36 W  (B) 1.2 W  (C) 3.2 W  (D) 3.6 W
• The second rule we can apply to a circuit is
• The Loop Rule: The sum of all the potential differences around a closed loop equals zero.
• \( \Sigma \Delta V = 0 \) for a complete loop.
• In a circuit there are charges moving through these potential differences, so another way to say the rule is that when a charge goes around a complete loop, returning to its starting point, its potential energy must be the same. Positive charges gain energy when they go through batteries from the - terminal to the + terminal, and give up that energy to resistors as they pass through them.
• Use the loop rule to determine the current through the battery in a circuit consisting a 16-volt battery connected to a set of three resistors, a 2 \( \Omega \) resistor in series with a 2 \( \Omega \) resistor and a 3 \( \Omega \) resistor in parallel.
• Our closed loop will consist of the battery and the two 2 \( \Omega \) resistors. It doesn't matter where we start, as long as we come back to the same spot. Let's go clockwise around the loop starting at the bottom left corner.
• \( +16 \text{ V} - (2 \Omega) I - (2 \Omega) \frac{3I}{5} = 0 \)
• \( +16 \text{ V} = (10 \Omega) \frac{I}{5} + (6 \Omega) \frac{I}{5} \)
• \( +16 \text{ V} = (16 \Omega) \frac{I}{5} \)
• This gives \( I = 5 \text{ A.} \)
9. The below circuit diagram shows a battery with an internal resistance of 4.0 ohms connected to a 16–ohm and a 20–ohm resistor in series. The current in the 20–ohm resistor is 0.3 amperes.

The loop rule involves the potential and energy supplied by the battery and its use around a circuit loop.

What power is dissipated by the 4–ohm internal resistance of the battery?
(A) 0.36 W (B) 1.2 W (C) 3.2 W (D) 3.6 W