Lab: AP Review Sheets

Chapter 9: Current and Resistance

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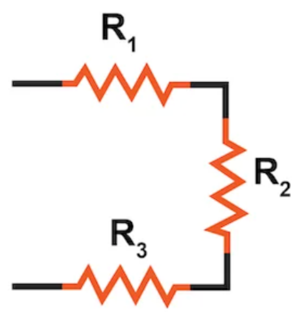
Background: The current and resistance unit in AP Physics goes over the relationships of current, resistance, electric potential, and power as they pertain to electrical circuits.

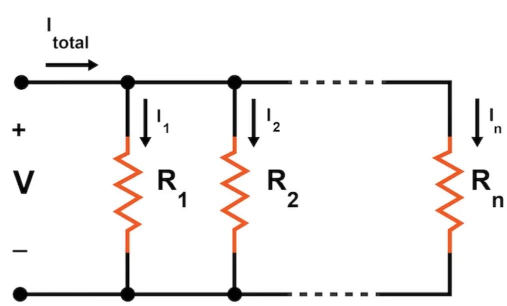
Key Points

1. *Current* is defined as the number of charges passing through a specific area in a given time (the flow rate).
2. In a circuit, the *electromotive force* ε creates the electric field that motivates charge to move through the wires.
3. Resistors limit the current in a circuit and convert electrical energy into other forms of energy (heat, light, etc.)
4. Unless otherwise stated, always assume conventional current (the direction positive charges would flow) for circuits.
5. Resistors in parallel share the same voltage, but the current running through each differs.
6. Resistors in series share the same current but the voltage across each differs.

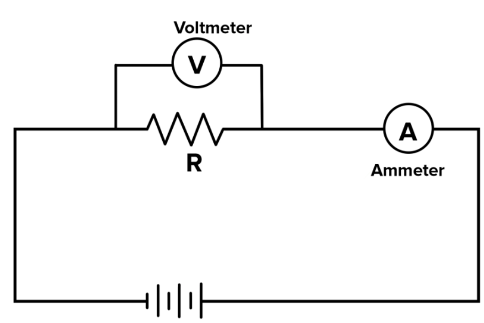
Resistors in Series



Resistors in Parallel



Ammeters and Voltmeters



Equations

$$I = \frac{\Delta V}{R}$$

$$I = \frac{dQ}{dt}$$

$$R_s = \sum_i R_i$$

$$\frac{1}{R_p} = \sum_i \frac{1}{R_i}$$

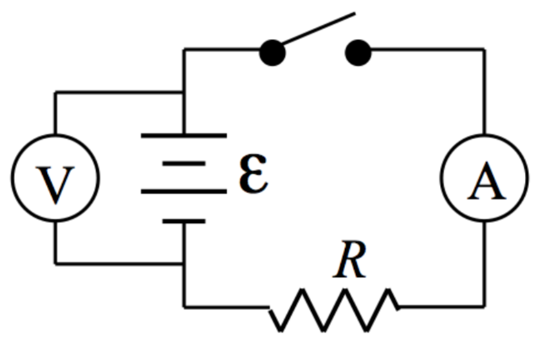
$$P = I\Delta V$$

$$P = I^2 R$$

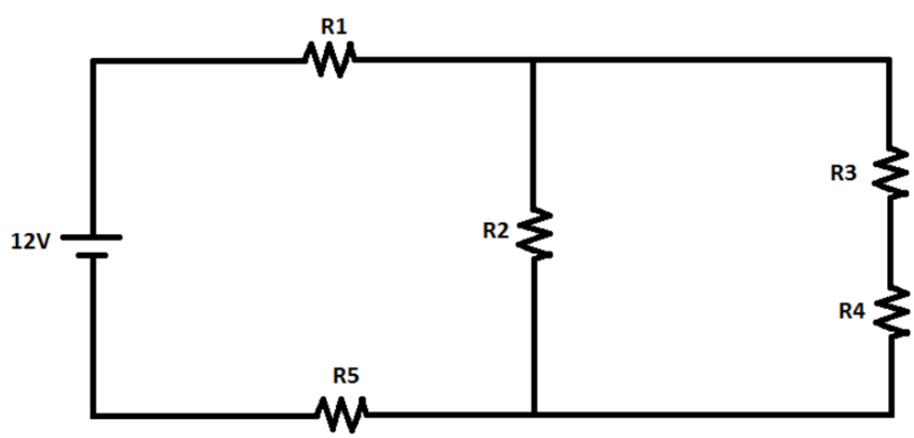
$$V_{terminal} = \mathcal{E} - Ir$$

Problem Set

1. [Easy] The charge flow in a wire varies with time as $q = 3t^2 + 4t + 9$. Come up with an expression for the current through the wire as a function of time, then evaluate it at 2.00 seconds.



2. [Medium] As shown in the circuit above, a battery Ɛ is connected to a load resistor R, with a voltmeter V and ammeter A connected as shown. Before the switch is closed, the voltmeter indicates a potential of 10 Volts across the batter. After the switch is closed, the voltmeter indicates a potential of 9.2 Volts, and the ammeter indicates a current of 0.80 Amps. What is the internal resistance in the battery?



3. [Hard] As shown above, five resistors are connected to an 12V battery. R1 = 5Ω, R2 = 3Ω, R3 = 4Ω, R4 = 1Ω, and R5 = 2Ω. What is the equivalent resistance, of the five resistors? When connected, how much current is drawn from the battery? How much power is drawn?

Solutions:

1. Knowns: $q = 3t^2 + 4t + 9$

   We can solve this problem by using the relationship $I = \frac{dQ}{dt}$

   I(t) = $\frac{dQ}{dt} = \frac{d}{dx}(3t^2 + 4t + 9)$

   I(t) = $6t + 4$

   Now we can use the derived equation to find the current at t = 2.00 seconds:

   I(2.00) = $6(2.00) + 4$

   I = 16 Amps

2. Knowns:

   $\varepsilon = 10$ V

   $V_{term} = 9.2\ V$

   $I = 0.80\ A$

   r = ?

   In order to find the internal resistance of the battery, we can use $V_{terminal} = \mathcal{E} - Ir$.

   $$V_{term} = \varepsilon - Ir$$

   $$Ir = \varepsilon - V_{term}$$

   $$r = \frac{\varepsilon - V_{term}}{I}$$

   $$r = \frac{10\ V - 9.2\ V}{0.80\ A}$$

   $$\boxed{r = 1\,\Omega}$$

4. Knowns: R1 = 5Ω, R2 = 3Ω, R3 = 4Ω, R4 = 1Ω, and R5 = 2Ω

   To find the equivalent resistance, break the resistors up into parts:

   First, condense R3 and R4, which are in series.

   $$R_s = \sum_i R_i$$

   $$R34 = R3 + R4$$

   $$R34 = 4\Omega + 1\Omega$$

   R34 = 5Ω

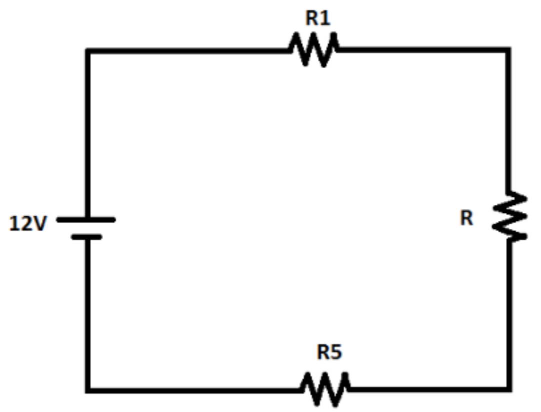
   Now, we can condense R34 and R5, which are in parallel.

$$\frac{1}{R_p} = \sum_i \frac{1}{R_i} = \frac{1}{R34} + \frac{1}{R2}$$

$$\frac{1}{R} = \frac{1}{5} + \frac{1}{3} = \frac{8}{15}$$

$$R = \frac{15}{8}\Omega$$

Now the circuit should look like this:



Since everything is in series we can add all the resistances together to get R_{eq}

$$R_{eq} = R1 + R + R5$$

$$R_{eq} = 5\Omega + \frac{15}{8}\Omega + 2\Omega$$

$$R_{eq} = \boxed{\frac{71}{8}\Omega}$$

Now we can calculate how much current is drawn from the 12 V battery using $I = \frac{\Delta V}{R}$

$$I = \frac{\Delta V}{R}$$

$$I = \frac{12\ V}{\frac{71}{8}\Omega} = \boxed{1.35\text{ A}}$$

And finally we can calculate the power with $P = I\Delta V$

$$P = I\Delta V$$

$$P = (1.35\ A)(12\ V)$$

$$\boxed{P = 16.2\ W}$$