Notes

PHYSICS 11

OHM'S LAW

$$R = \frac{V}{I} \quad \text{or} \quad V = IR \quad \text{or} \quad I = \frac{V}{R}$$

where R is resistance measured in Ohms [Ω]
V is voltage measured in Volts [V]
and I is electric current measured in Amperes [A]

RESISTANCE

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

where ρ is resistivity of the material measured in Ohm meter [Ω · m]
A is the cross-sectional area of the conductor measured in meter squared [m^2]
and L is the length of the conductor measured in meters [m]

ELECTRIC POWER

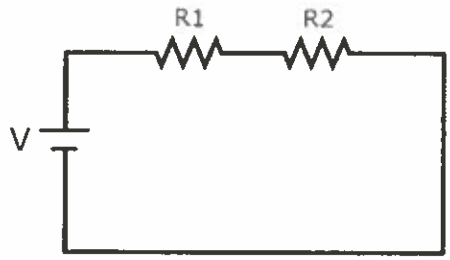
$$P = IV = I^2 R$$

where P is power measured in Watts [W]
I is electric current measured in Amperes [A]
V is voltage measured in Volts [V]
and R is resistance measured in Ohms [Ω]

RESISTORS CONNECTED IN SERIES

- Equivalent (total) resistance in a circuit with resistors in series is the sum of all individual resistances.
- Same current goes through every resistor.

$$R_{eq} = R_1 + R_2 + R_3 + \cdots + R_n$$



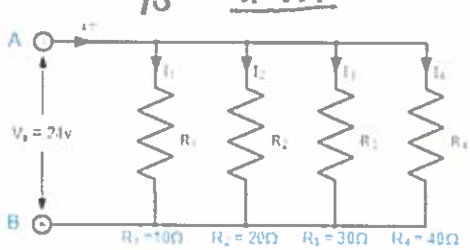
RESISTORS CONNECTED IN PARALLEL

- Equivalent (total) resistance in a circuit with resistors in parallel is calculated by finding the sum of reciprocal values of all resistors followed by reciprocating that sum.

$$\frac{1}{R_{eq}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots + \frac{1}{R_n}$$

$$R_{eq} = \frac{1}{\frac{1}{R_{eq}}}$$

- Same voltage is applied across each resistor.



- $\frac{1}{R_{eq}} = \frac{1}{10} + \frac{1}{20} + \frac{1}{30} + \frac{1}{40}$

  $\frac{1}{R_{eq}} = \frac{12+6+4+3}{120} = \frac{25}{120}$

  $\rightarrow R_{eq} = \frac{120}{25} = 4.8\ \Omega$

- $V_1 = V_2 = V_3 = V_4 = V_{battery} = 24\ V$

- $I_{TOT} = \frac{V_B}{R_{eq}} = \frac{24}{4.8} = 5.0\ A$

- $I_{TOT} = I_1 + I_2 + I_3 + I_4$

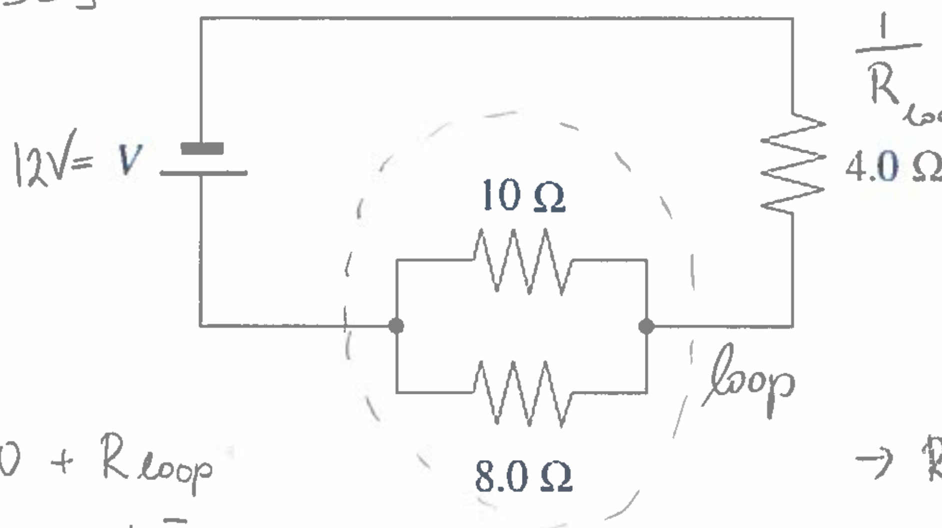
- $I_1 = \frac{V_1}{R_1} \rightarrow \frac{24}{10} = 2.4A$
- $I_2 = \frac{24}{20} = 1.2A$
- $I_3 = \frac{24}{30} = 0.8A$
- $I_4 = \frac{24}{40} = 0.6A$

RESISTORS CONNECTED IN SERIES AND IN PARALLEL

- Most circuits have resistors wired in series as well as in parallel

Example : Find the equivalent resistance in the circuit below. If the battery provides 12.0 V of voltage, what is the current through the 10Ω resistor?

• $R_{eq} = ?\ [\Omega]$



• R_{loop} :

$$\frac{1}{R_{loop}} = \frac{1}{10} + \frac{1}{8.0} = \frac{4+5}{40} = \frac{9}{40}$$

$$\rightarrow R_{loop} = \frac{40}{9} = 4.\overline{4}\ \Omega$$

• $R_{eq} = 4.0 + R_{loop}$

$R_{eq} = 4.0 + 4.\overline{4}$

$= 8.\overline{4}\ \Omega$

∴ The equivalent resistance is 8.4 Ω.

• $I_{10} = ?\ [A]$

$I_{TOT} = I_4 = \frac{V_B}{R_{eq}} = \frac{12}{8.\overline{4}} = 1.4211\ A$

➔ $I_{TOT} = I_{10} + I_8$ AND $V_{10} = V_8 = V_B - V_4 = 12 - (4.0)(1.4211) = 6.3156\,V$

$I_{10} = \frac{V_{10}}{10}$

$= \frac{6.3156}{10}$

$= 0.6316\ A$

∴ The current through the 10Ω resistor is 6.3×10^{-1} A.

$* \frac{1}{R_{loop}} = \frac{1}{8.0} + \frac{1}{R}$

$\frac{1}{R_{loop}} = \frac{1}{8.0} + \frac{1}{13.\bar{3}}$

$R_{loop} = 5.0\ \Omega$

$R = \frac{V_R}{I_R} = \frac{10}{0.75} = 13.\bar{3}\ \Omega$

$I_R = I_{tot} - I_8$

$= 2.0 - 1.25$

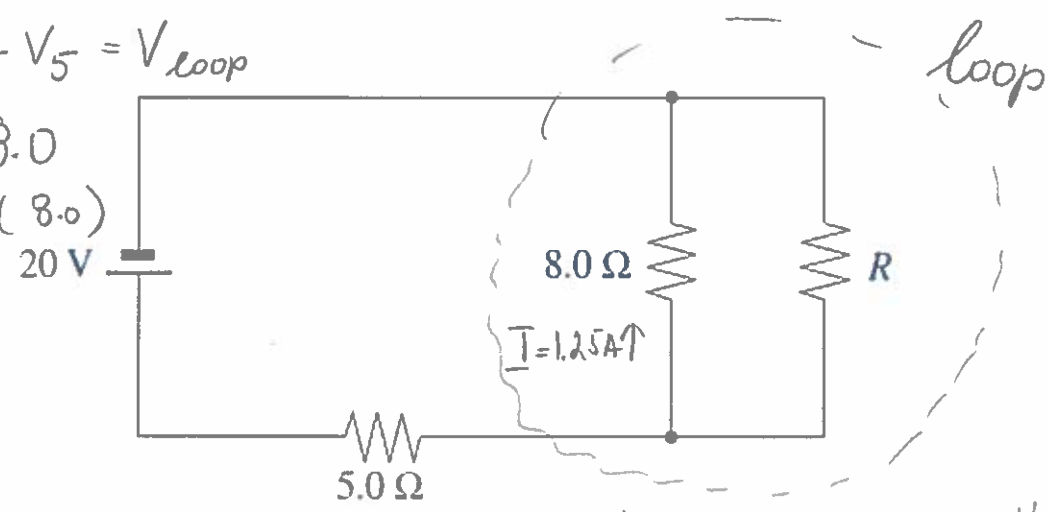
$= 0.75\ A$

KIRCHHOFF'S RULES

1. Junction rule: The sum of the magnitudes of the currents directed into a junction equals the sum of magnitudes of the currents directed out of the junction.

2. Loop rule: Around any closed-circuit loop, the sum of potential drops equals the sum of potential rises.

Example: Find the equivalent resistance in the circuit given that the current through the 8.0 Ω is 1.25 A.



- $V_8 = V_R = V_B - V_5 = V_{loop}$
  $= I_8 \times 8.0$
  $= (1.25)(8.0)$
  $= 10\ V$
- $V_R = 10V$
- $V_5 = V_B - V_{loop}$
  $= 20 - 10$
  $= 10\ V$
- $I_{TOT} = I_5 \rightarrow I_5 = \frac{V_B}{R_{eq}}$ OR $I_{tot} = \frac{V_B - V_{loop}}{5.0}$
  $= \frac{20 - 10}{5.0}$
  $= 2.0\ A$
- $R_{eq} = 5.0 + R_{loop}^{*}$ OR $R_{eq} = \frac{V_B}{I_{TOT}} = \frac{20}{2.0} = 10\ \Omega$
  $= 5.0 + 5.0$
  $= 10\ \Omega$

$\therefore R_{eq} = 1.0 \times 10^1\ \Omega$