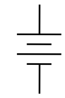
PHY132H1F Introduction to Physics II
Class 15 – **Outline:**

- Drawing Circuit Diagrams
- Ohmic and Non-ohmic materials
- Kirchhoff's Laws
- Energy and Power in Circuits
- Buying electrical power in Ontario
- Resistors connected in Series

Quick Ch. 32 reading quiz..

What does this symbol represent in a circuit diagram?



A. Wire
B. Resistor
C. Battery
D. Capacitor
E. Switch

Quick Ch. 32 reading quiz..

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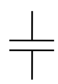

A. Wire
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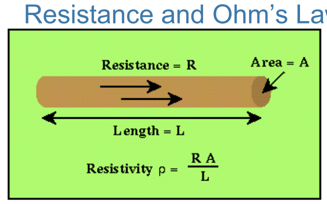
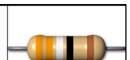
Recall from Monday… Resistance and Ohm's Law



The SI unit of resistance is the ohm.
1 ohm = 1 Ω = 1 V/A.
The current through a conductor is determined by the potential difference ΔV along its length:

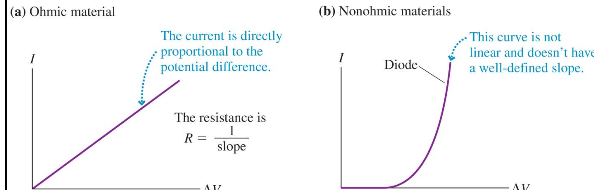
$$I = \frac{\Delta V}{R} \quad \text{(Ohm's law)}$$

Ohm's Law

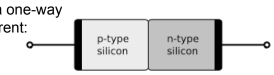


- Ohm's law is limited to those materials whose resistance *R* remains constant—or very nearly so—during use.
- The materials to which Ohm's law applies are called *ohmic*.
- The current through an ohmic material is directly proportional to the potential difference. Doubling the potential difference doubles the current.
- Metal and other conductors are ohmic devices.

FIGURE 31.22 Current-versus-potential-difference graphs for ohmic and nonohmic materials.



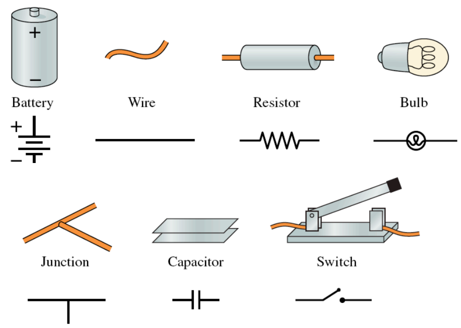
A Diode is a one-way gate for current:



LED = Light-emitting diode

- Do not create much heat – glow as electrons drop energy levels as they fall into “holes”
- High efficiency lighting

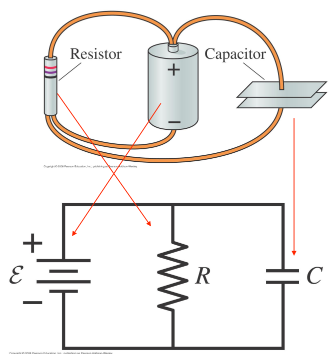
FIGURE 32.2 A library of basic symbols used for electric circuit drawings.



Circuit Diagrams

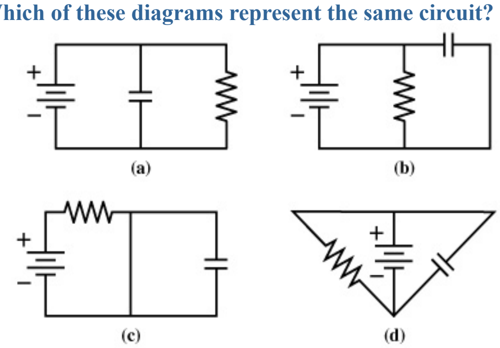
Real life:

A circuit diagram:

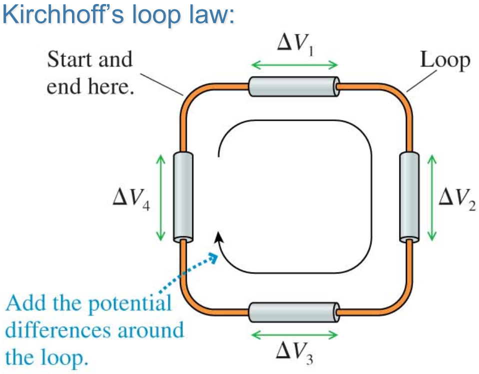


In Class Discussion Question.

Which of these diagrams represent the same circuit?



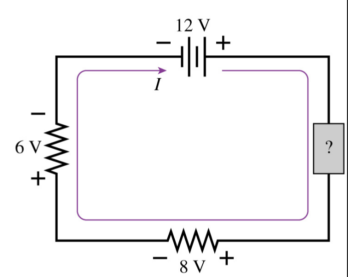
Using Kirchhoff’s loop law:



Loop law: $\Delta V_1 + \Delta V_2 + \Delta V_3 + \Delta V_4 = 0$

In Class Discussion Question.

What is ΔV across the unspecified circuit element, in the direction of I ?



A. + 2 V
B. – 2 V
C. + 14 V
D. – 14 V
E. – 26 V

Energy and Power

- Electric Potential measures the amount of energy carried by the moving charge:
- 1 Volt = 1 Joule per Coulomb
- Current measures the rate that charge flows:
- 1 Amp = 1 Coulomb per second
- The change in potential, or Voltage, times the current equals the rate that energy flows, or power.
- 1 Watt = (1 J/C) × (1 C/s) = 1 Joule per second.

$$P_R = I\Delta V_R = I^2R = \frac{(\Delta V_R)^2}{R} \quad \text{(power dissipated by a resistor)}$$

In Class Discussion Question.

A 60 W light bulb is plugged into an outlet that has an average voltage of 120 V. What is the average current drawn by the bulb?

A. 0.5 A
B. 2 A
C. 60 A
D. 120 A
E. 7200 A

Energy and Power

- Ontario Hydro Power Rates:
- on-peak rate (7-11am and 5-9pm in winter, or 11am-5pm in summer): $0.1 per kWh
- mid-peak rate (7-11am and 5-9pm in summer, or 11am-5pm in winter): $0.08 per kWh
- off-peak rate (10pm-7am all year): $0.05 per kWh
- 1 kWh = 1000 W × 1 hour = 10^3 (J/s) × 60 (m/h) × 60 (s/m)
- 1 kWh = 3.6 × 10^6 J.
- A clothes dryer uses about 2800 Watts. If you run it for 1 hour, it consumes 2.8 kWh of energy, costing you $0.28 at peak. (or $0.14 if you run it at night.)

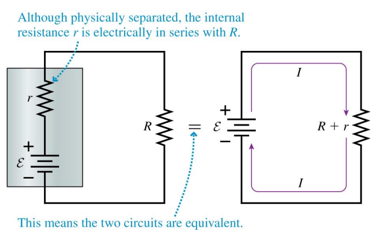
Series Resistors

- Resistors that are aligned end to end, *with no junctions between them,* are called **series resistors** or, sometimes, resistors "in series."
- The current I is the same through all resistors placed in series.
- If we have N resistors in series, their **equivalent resistance** is

$$R_{eq} = R_1 + R_2 + \cdots + R_N \quad \text{(series resistors)}$$

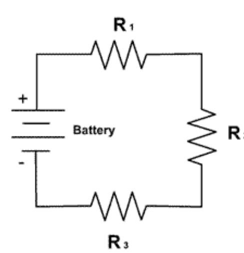
The behavior of the circuit will be unchanged if the N series resistors are replaced by the single resistor R_{eq}.

FIGURE 32.20 A single resistor connected to a real battery is in series with the battery's internal resistance, giving $R_{eq} = R + r$.



Example Series circuit

A 6 Volt battery is hooked in series to 3 resistors, with $R_1 = 10\ \Omega$, $R_2 = 100\ \Omega$, and $R_3 = 50\ \Omega$. What is the current through the circuit?



Before Next Class:

- Problem Set 6 on MasteringPhysics is due tonight by 11:59pm. It is based on Ch.31 material on capacitors.

- You will be building circuits in practicals this Friday, working on concepts from Ch. 32.

- Please finish reading Chapter 32 before next class.

- Note: U of T is closed on Monday and Tuesday, so our next class is Wed. Nov. 10

Have a great break!