# Introduction to Physical Science

Resistance and Electric Power

Presented by Robert Wagner

## Resistance

- The electrical resistance of a cylindrical object is proportional to its length and inversely proportional to the area.
- The resistance also depends on the resistivity of the substance, ρ. What the substance is composed of
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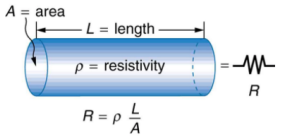
  - Resistivity has units of

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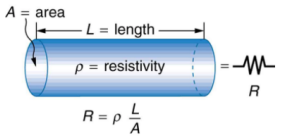
## Conductors, Semiconductors, & Insulators

- Conductor - small resistivity
- Semiconductor - intermediate resistivity
- Insulators - large resistivity
- See Table 20.1 in the OpenStax College Physics textbook

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## Example

$L = 4.00x10^{-2}\,m\,;\; R = 0.350\,\Omega\,;\; \rho = 5.6x10^{-8}\,\Omega \cdot m$

- A car headlight filament is made of tungsten and has a resistance of 0.350Ω. If the filament is a cylinder 4.00 cm long, what is its radius?
  - Draw a sketch (if applicable)
  - Identify known values
  - Identify equation
  - Enter values in the equation and solve

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

$$A = \frac{(5.6x10^{-8}\,\Omega \cdot m)(4.00x10^{-2}\,m)}{0.350\,\Omega}$$

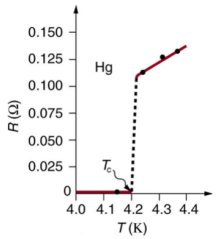
$$A = 6.40x10^{-9}\,m^2$$

$$A = \pi r^2\,;\; r = \sqrt{\frac{A}{\pi}}$$

$$r = \sqrt{\frac{6.40x10^{-9}\,m^2}{\pi}} = 4.5x10^{-5}\,m = 0.045\,mm$$

## Temperature Variation of Resistance

- The resistivity of a material depends on the temperature
- Superconductors
  - Resistance drops to zero at very low temperatures

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## Power in Electric Circuits

- Power is the rate of energy use or conversion
  - Light bulbs - power quoted on Watts (60 Watt bulb)
- Power can be written in a number of ways
  -
  -
  -

## Example

- An automobile headlight has a current of 2.50 A when a voltage of 12.0 V is applied to it. It has a cold resistance of 0.350 Ω. What is the power dissipated when it is hot and cold? What is the current drawn when cold?
  - Draw a sketch (if applicable)
  - Identify known values
  - Identify equation
  - Enter values in the equation and solve

$$I = 2.50\,A\,;\; V = 12.0\,V\,;\; R = 0.350\,\Omega$$

$$P = IV = (2.50\,A)(12.0\,V) = 30.0\,W$$

$$P = \frac{V^2}{R} = \frac{(12.0\,V)^2}{0.350\,\Omega} = 411W$$

$$P = I^2R\,;\; I = \sqrt{\frac{P}{R}}$$

$$I = \sqrt{\frac{411\,W}{0.350\,\Omega}} = 34.3\,A$$

## Cost of Electricity

- Energy cost is related to the power consumed
  -
- The unit for energy on an electric bill is the kilowatt hour ( )
  -
- Reducing energy costs can be done in two ways
  - Reducing the time used
  - Improving the efficiency
    - CFL vs. Incandescent bulb

## Example

- If the cost of electricity is 12 cents per kWh, what is the cost of using a 60W incandescent bulb for 1000 hours. If we replace it with a CFL at 1/4 the wattage, what would be the cost for 1000 hours?
  - Draw a sketch (if applicable)
  - Identify known values
  - Identify equation
  - Enter values in the equation and solve

$c = 12\ cents/kWh\ ;\ P = 60\ W\ ;\ t = 1000\ hr$

$E = Pt = (60.0\ W)(1000.\ hr) = 60000\ W \cdot h$

$E = 60.0\ kW \cdot h$

$Cost = (Energy)(rate)$

$Cost = (60.0\ kW \cdot h)(\$0.12/\ kWh)$

$Cost = \$7.20$

$Cost(CFL) = \frac{Cost}{4} = \$1.80$

## Summary

- The electrical resistance of an object depends on its length, area and composition
- Conductors, semiconductors and insulators all have different levels of resistance
- Power is the rate of energy use. Energy use is often measured in