Skill 39: Resistance in a wire

158. Resistance is the difficulty an electron experiences traveling through a material.

The variable for resistance is ___R___ and the unit of measurement is ___Ω___.

159. An object's resistance depends on several factors.

Resistivity (ρ)

Listed on the Reference Table resistance.

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

Length (L)

Long wires have a ___large___ resistance

Temperature

High temp has a ___large___ resistance

Cross-sectional Area (A)

Large X-section is ___Small___ resistance
Area $= \pi r^2$

low resistance is Short, Fat, Cold, "Gold" metallic

160. What is the resistance of a piece of copper wire with a length of 1 meter and a cross sectional area of 0.01 m^2?

$R = ?$
$L = 1m$
$A = .01m^2$
$\rho = 1.72 \times 10^{-8}\ \Omega m$

$R = \frac{\rho L}{A} = \frac{(1.72 \times 10^{-8}\ \Omega m)(1m)}{.01m^2} = 1.72 \times 10^{-6}\ \Omega$

161. What is the composition of a wire with a resistance of 31.8 Ohms if it is 5 x 10^7 meters long and has a cross-sectional area of 0.025 m^2?

$R = 31.8\Omega$
$L = 5 \times 10^7 m$
$A = .025m^2$
$\rho = ?$

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

$\rho = \frac{RA}{L} = \frac{(31.8\Omega)(.025m^2)}{5 \times 10^7 m} = .795$

$= \frac{.795\ \Omega m^2}{5 \times 10^7\ m} = .159 \times 10^{-7}\ \Omega m$

$1.59 \times 10^{-8}\ \Omega m$

162. A 14 gauge aluminum wire has a radius of 8.0×10^{-4} meter.

a. Calculate the cross sectional area of the wire.

$A = \pi r^2$

$= \pi (8 \times 10^{-4} m)^2$

$= 3.14 (64 \times 10^{-8} m^2) = 200.96 \times 10^{-8} m^2 = 2 \times 10^{-6} m^2$

b. Calculate the resistance of the wire if it is 30.0 meters long.

$R = \frac{\rho L}{A} = \frac{(2.82 \times 10^{-8} \Omega m)\, 30 m}{2 \times 10^{-6} m^2} = .423 \Omega$

163. A 500 meter long wire with a cross-sectional area of 4×10^{-6} meter^2 has a resistance of 3.05 ohm. Calculate the resistivity of the wire then use the chart to determine the wire's composition.

$L = 500 m$

$A = 4 \times 10^{-6} m^2$

$R = 3.05 \Omega$

$\rho = ?$

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

$\rho = \frac{(3.05 \Omega)(4 \times 10^{-6} m^2)}{500 m} = 2.4 \times 10^{-8} \Omega m$

164. A 100 meter long wire has a resistance of 10 ohms. What would the resistance of each piece of this wire be if it were cut into four, equal length sections?

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

R and L are directly related

If L is divided by 4

R is divided by 4

$\therefore$ $L \div 4$ means $R \div 4$ $\frac{10 \Omega}{4} = 2.5 \Omega$

165. A 0.02 meter long carbon resistor with a cross sectional area of 2×10^{-6} meter^2 has a resistance of 300 ohms.

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

a. What would its resistance be if its length were doubled? $L \times 2$ $R \times 2$

R & L direct $300 \Omega \times 2 = 600 \Omega$

b. What would its resistance be if its cross-sectional area were tripled?

R & A inverse $A \times 3$ $R \div 3$ $\frac{300 \Omega}{3} = 100 \Omega$

$R = \frac{\rho L}{\pi r^2}$

c. What would its resistance be if its radius were doubled? (Careful!)

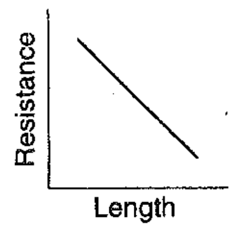
R & r is inverse^2 $r \times 2$ $R \div 4$ $\frac{300 \Omega}{4} = 75 \Omega$

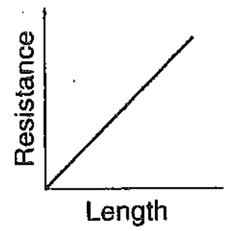
166. A manufacturer recommends that the longer the extension cord used with an electric drill, the thicker (heavier gauge) the extension cord should be. This recommendation is made because the resistance of a wire varies

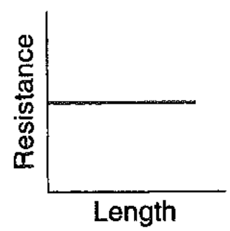
A) directly with length and inversely with cross-sectional area
B) inversely with length and directly with cross-sectional area
C) directly with both length and cross-sectional area
D) inversely with both length and cross-sectional area

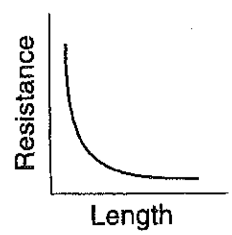
$R = \frac{\rho L}{A}$

167. A copper wire is part of a complete circuit through which current flows. Which graph best represents the relationship between the wire's length and its resistance?

A)


B)


C)


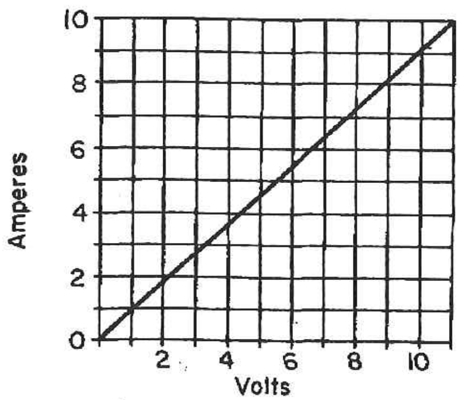
D)


168. If the length of a copper wire is reduced by half, then the resistance of the wire will be

A) halved B) doubled
C) quartered D) quadrupled

$R = \frac{\rho L}{A}$ Direct $L \div 2$ means $R \div 2$

169. Base your answer to the following question on the accompanying graph which shows the data collected for a copper wire at a constant temperature.



If the length of the copper wire being tested is decreased, its total resistance will

A) decrease B) increase
C) remain the same

Graph has nothing to do with question
$R = \frac{\rho L}{A}$

170. Which change decreases the resistance of a piece of copper wire?

A) increasing the wire's length ↑ direct
B) increasing the wire's resistivity ↑ direct
C) decreasing the wire's temperature ↓ direct
D) decreasing the wire's diameter ↑ inverse

171. The resistance of a copper wire is measured to be 4 ohms at 20°C. If the wire is heated to 30°C, the resistance of the wire will be

A) zero ohms B) less than 4 ohms
C) more than 4 ohms D) 4 ohms

172. To reduce the resistance of a metal conductor one should

A) cool the conductor to a low temperature
B) ~~heat the conductor to a high temperature~~
C) ~~coat the conductor with an insulator~~
D) ~~wire the conductor in series with another resistor~~

Short, fat, cold, gold

173. The electrical resistance of a metallic conductor is inversely proportional to its

A) temperature direct not in equation $R = \frac{\rho L}{A}$
B) length direct
C) cross-sectional area
D) resistivity direct

174. If the diameter of a wire were decreased, its electrical resistance would

A) decrease B) increase
C) remain the same

diameter is direct to radius
radius is inv² to
$R = \frac{\rho L}{A} = \frac{\rho L}{\pi r^2}$
Resistance ↑

175. If a wire of cross-sectional area equal to A has a resistance of R, then another wire of the same material with a cross-sectional area equal to 2A will have a resistance of

A) R B) 2R C) $R/2$ D) $R/4$

A | 2A
R |

$R = \frac{\rho L}{A}$
inverse
A×2 = R÷2

Skill 39: Resistance in a wire

176. A copper wire has a resistance of 200 ohms. A second copper wire with twice the cross-sectional area and the same length would have a resistance of

A) 50Ω B) 100Ω
C) 200Ω D) 400Ω

copper R=200Ω A | copper R=? 2A
$R=\frac{\rho L}{A}$
A×2 = R÷2 so $\frac{200\,\Omega}{2}$

177. At 20°C, four conducting wires made of different materials have the same length and the same diameter. Which wire has the *least* resistance?

A) aluminum 2.82×10^{-8} B) gold $2.44\times10^{-8}\,\Omega m$
C) nichrome D) tungsten $5.6\times10^{-8}\,\Omega m$

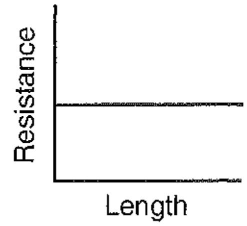
they have different ρ
lowest ρ = lowest R

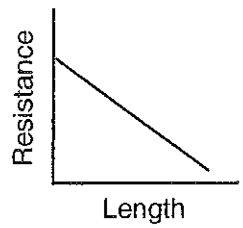
178. What is the resistance at 20.°C of a 2.0-meter length of tungsten wire with a cross-sectional area of 7.9×10^{-7} meter^2?

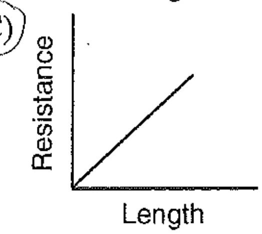
A) $5.7\times10^{-1}\,\Omega$ B) $1.4\times10^{-1}\,\Omega$
C) $7.1\times10^{-2}\,\Omega$ D) $4.0\times10^{-2}\,\Omega$

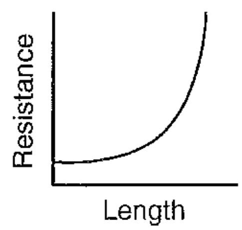
$R=\frac{\rho L}{A}=\frac{(5.6\times10^{-8}\,\Omega m)(2m)}{(7.9\times10^{-7}\,m^2)}$
$=1.4\times10^{-1}\,\Omega$

179. Which graph best represents the relationship between resistance and length of a copper wire of uniform cross-sectional area at constant temperature?

A)


B)


C)


D)


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

180. A 12.0-meter length of copper wire has a resistance of 1.50 ohms. How long must an aluminum wire with the same cross-sectional area be to have the same resistance?

A) 7.32 m B) 8.00 m
C) 12.0 m D) 19.7 m

$R_{copper} = R_{Aluminum}$
$\frac{\rho_c L}{A}=\frac{\rho_A L}{A}$
$\rho L = \rho L$
$(1.72\times10^{-8}\,\Omega m)(12m)=(2.82\times10^{-8}\,\Omega m)(L)$
$L=7.32m$

OR

copper: L=12m, R=1.5Ω, $\rho=1.72\times10^{-8}\,\Omega m$ | Aluminum: L=?, R=1.5Ω, $\rho=2.82\times10^{-8}\,\Omega m$

$R=\frac{\rho L}{A} \Rightarrow L=\frac{RA}{\rho}$ (Inverse)
Solve for L