Physics 133 Physics IIb—Thermodynamics and Waves
Test 3
November 16, 2011

Name: _____

All problems must begin with either a fundamental principle or with an equation from the equation sheet. If any question is unclear, please ask immediately. Be sure to show your work **clearly**. Partial credit may be given for work *if* it can be understood.

Problem 1: (20 pts.) Nichrome wire is often used in heating elements. Consider a long cylindrical wire of length 3.00 m and radius 0.100 mm. The resistivity of nichrome is $1.00 \times 10^{-6}\,\Omega \cdot \mathrm{m}$.

a. (5 pts.) Suppose a voltage difference of 120 V is placed across this wire. What is the electric field inside the wire? Assume that the electric field is uniform throughout the wire.

b. (5 pts.) What is the current *density*?

c. (5 pts.) What is the current?

d. (5 pts.) What is the rate at which power is dissipated by the wire?

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Name: SOLUTIONS

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Problem 1: (20 pts.) Nichrome wire is often used in heating elements. Consider a long cylindrical wire of length 3.00 m and radius 0.100 mm. The resistivity of nichrome is $1.00 \times 10^{-6}\,\Omega \cdot \text{m}$.

a. (5 pts.) Suppose a voltage difference of 120 V is placed across this wire. What is the electric field inside the wire? Assume that the electric field is uniform throughout the wire.

$E = -\frac{\partial V}{\partial x} = -\frac{\Delta V}{L} = \frac{+120\text{ V}}{3.00\text{ m}} = \boxed{40.0\text{ V/m}}$ (goes from high to low.)

b. (5 pts.) What is the current *density*?

$j = \frac{1}{\rho} E = \frac{40.0\text{ V/m}}{10^{-6}\,\Omega\cdot\text{m}} = \boxed{4.0 \times 10^{7}\text{ A/m}^2}$

c. (5 pts.) What is the current?

$I = jA = (4.0 \times 10^{7}\text{ A/m}^2)(\pi (0.100 \times 10^{-3}\text{ m})^2) = \boxed{1.26\text{ A}}$

Note: $R = \frac{\rho L}{A} = \frac{(1.00 \times 10^{-6}\,\Omega\cdot\text{m})(3.00\text{ m})}{\pi \cdot (0.100 \times 10^{-3}\text{ m})^2} = 95.5\,\Omega$

d. (5 pts.) What is the rate at which power is dissipated by the wire?

$P = IV = (1.26\text{ A})(120\text{ V}) = \boxed{151\text{ W}}$

(aside: It's not needed, but $R = \frac{\rho L}{A} = 95.5\,\Omega$.)