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 $3.00\,\mathrm{m}$ and radius $0.100\,\mathrm{mm}$. The resistivity of nichrome is $1.00 \times 10^{-6}\,\Omega \cdot \mathrm{m}$.

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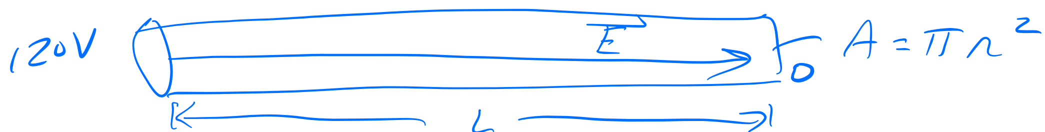
a. (5 pts.) Suppose a voltage difference of 120 V is placed across this wire. What is the electric field inside the wire? Assume that the electric field is uniform throughout the wire.



$E = \frac{\Delta V}{L} = \frac{120\,V}{3.00\,m} = 40.0\ V/m$, from high V to low V.

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

$j = \frac{1}{\rho} E = \frac{40.0\ V/m}{1\times10^{-6}\ \Omega\cdot m} = 40.0\times10^{6}\ A/m^2$

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

$I = j\cdot(\text{area}) = (40\times10^{6}\ A/m^2)\left(\pi\cdot(1\times10^{-4}\,m)^2\right) = 1.26\ A$

OR $R = \frac{\rho L}{A} = \frac{(1\times10^{-6}\ \Omega\cdot m)(3.00\,m)}{\pi\,(1.0\times10^{-4}\,m)^2} = 95.5\ \Omega$, so $I = \frac{\Delta V}{R} = \frac{120\,V}{95.5\ \Omega}$

$I = 1.26\,A$

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

$P = I(\Delta V) = (1.26\,A)(110\,V) = 151\,W$

OR I^2R or $\frac{(\Delta V)^2}{R}$ all give 151 W.

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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.

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

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

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

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

$I = j A = (4.0 \times 10^7\,A/m^2)(\pi\,(0.10 \times 10^{-3}\,m)^2) = \boxed{1.26\,A}$

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

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

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

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