EECS170A Fall 2004 first Midterm Exam
11/19/2004
Sec.B: Peter Burke 3:30 to 4:50 pm

Name: Solutions
ID no.:

PROBLEM ONE: (20 points)

A) (10 points) What is the relationship between the resistance R and resistivity ρ of a wire of diameter d and length L?

$$R = \frac{L}{A}\rho = \frac{L}{\left(\frac{d}{2}\right)^2 \pi}\rho$$

B) (10 points) Calculate the resistance of a copper wire that is 100 feet long and 3 mm in diameter. Express your answer in units of Ω. Get your answer right to within 10%. Assume the resistivity of copper is 10 μΩ-cm.

$$R = \frac{100\ \text{feet}}{\left(\frac{3\text{mm}}{2}\right)^2 \pi}\ 10\ \mu\Omega\text{-cm}$$

Convert to MKSA

$$= \frac{100 \times 12 \times 2.54 \times 10^{-2}\ \text{m}}{\left(\frac{3\ 10^{-3}\ \text{m}}{2}\right)^2 \pi}\ 10\ 10^{-6}\ 10^{-2}\ \Omega\text{-m}$$

$$= 10^{2-2+1-6-2+6}\ \frac{12 \cdot 2.54 \cdot 4}{9\ \pi}\ \Omega$$

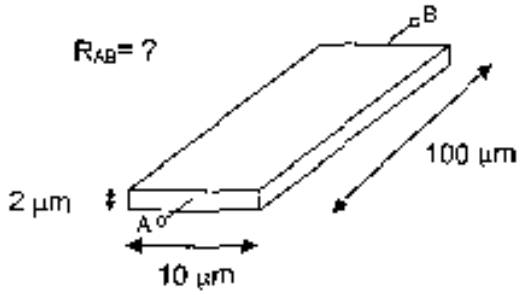
$$= 10^{-1} \times 4.31\ \Omega = 0.43\ \Omega$$

EECS170A Fall 2004 **first Midterm Exam** Name: Solutions

11/19/2004 ID no.:

Sec.B: Peter Burke 3:30 to 4:50 pm

PROBLEM TWO: (40 points)



A new semiconductor is discovered. Scientists find that the mobility of electrons is approximately 20,000 $cm^2/V\text{-}s$, and that the effective mass of electrons is equal to the free electron mass.

A) (20 points)
The material is doped n-type so that $n=10^{18}\ cm^{-3}$.
Find the resistivity ρ of the semiconductor to within 10% in units of μΩ-cm.

$$\rho = \frac{1}{q\mu n} = \frac{1}{1.6\times10^{-19}\,C \quad 20{,}000\ cm^2/V\text{-}s \quad 10^{18}\ cm^{-3}}$$

$$= \frac{1}{1.6\times10^{-19}\,C \quad 2\cdot10^{4}\ 10^{-4}\ m^2/V\text{-}s \quad 10^{18}\ 10^{6}\ m^{-3}}$$

$$= \frac{1}{1.6} \frac{1}{2} 10^{+19-4-18}\ \Omega\text{-}m = 0.31\ 10^{-5}\ \Omega\text{-}m = 3.1\ 10^{-6}\ \Omega\text{-}m$$

$= 3.1\ \mu\Omega\text{-}m$

$= 3.1\times10^{2}\ \mu\Omega\text{-}cm$

B) (20 points)
For this hypothetical semiconductor, what is the average time between scattering events τ?

$$\mu = \frac{q\tau}{m} \Rightarrow \tau = \frac{m\mu}{q} = \frac{9.11\ 10^{-31}\ kg \quad 2\cdot10^{4}\ 10^{-4}\ m^2/V\text{-}s}{1.6\times10^{-19}\,C}$$

$$= 11.39\ ps$$

PROBLEM THREE (40 points):

The two figures below represent two different Si wafers at 300 K.

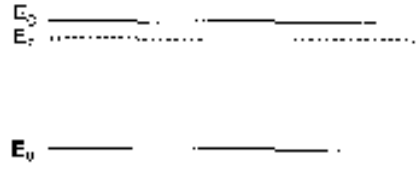


Figure 1

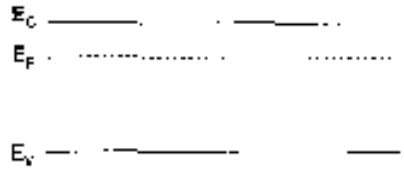


Figure 2

A) (10 points) For figure 1, which is larger: n or p?

n

B) (10 points) For figure 2, which is larger: n or p?

n

C) (10 points) Is n for figure 1 larger than n for figure 2?

Yes

D) (10 points) Is p for figure 1 larger than p for figure 2?

No.