ECE 113A
Professor Burke (15400) Section A
Homework #1 Solutions and Grading Criteria

1) If the lattice constant or unit cell length in Si is a = 5.43×10^{-8}cm:

a) Find the number of atoms/cm^3 in Si **(20 pts total)**

3 pts *Corner atoms:* *(8 corners)(1/8 atom per corner) = 1 atom*
3 pts *Face atoms:* *(6 faces)(1/2 atom per face) = 3 atoms*
3 pts *Center atoms:* *(4 centers)(1 atom per center) = 4 atoms*

3 pts *N = 1 atom + 3 atoms + 4 atoms = 8 atoms*
3 pts $V = a^3 = (5.43x10^{-8}cm)^3 = 1.60x10^{-22}cm^3$
3 pts $N/V = 8\ atoms/1.60x10^{-22}cm^3$
2 pts $= 5.00x10^{22}atoms/cm^3$

b) Find the number of atoms/m^3 in Si **(20 pts total)**

5 pts *N = 8 atoms (from part A)*
5 pts $a = 5.43x10^{-8}cm = 5.43x10^{-10}m$
3 pts $V = a^3 = (5.43x10^{-8}cm)^3 = 1.60x10^{-28}cm^3$
3 pts $N/V = 8\ atoms/1.60x10^{-28}cm^3$
4 pts $= 5.00x10^{28}atoms/m^3$

or

5 pts $1m = 10^2cm$
5 pts $1m^3 = (10^2cm)^3 = 10^6cm^3$
5 pts $N/V = (5.00x10^{22}atoms/cm^3)(10^6cm^3/1m^3)$
5 pts $= 5.00x10^{28}atoms/m^3$

2) 10^{10} electrons pass through an opening 1cmX0.5cm per second.

a) What is the current in A? **(20 pts total)**

5 pts $q = ne = (10^{10}\ electrons\ (1.6x10^{-19}C/electron)$
5 pts $= 1.6x10^{-9}C$
5 pts $I = \Delta q/\Delta t = (1.6x10^{-9}C\ ) /(1\ second) = 1.6x10^{-9}C/s$
5 pts $= 1.6x10^{-9}A$

b) What is the current density in A/cm^2? **(20 pts total)**

5 pts *A(area) = 1cm x 0.5cm*
5 pts $= 0.5cm^2$
5 pts $J = I/A = 1.6x10^{-9}A\ /\ 0.5cm^2$
5 pts $= 3.2x10^{-9}A/cm^2$

3) In a modern integrated circuit, there are 10^8 transistors. If each one occupies an area of 0.1µm x 0.1µm, how big does the chip have to be in cm^2? **(20 pts total)**

4 pts $A_{transistor} = 0.1\mu m\ x\ 0.1\mu m = 0.01\mu m^2$
4 pts $A_{chip} = \#\ transistors\ x\ A_{transitor} = (10^8\ transistors)(0.01\mu m^2/transistor) = 10^6\mu m^2$
2 pts $1\mu m = 10^{-4}cm$
3 pts $1\mu m^2 = (10^{-4}cm)^2 = 10^{-8}cm^2$
5 pts $A_{chip} = (10^6\mu m^2)(\ 10^{-8}cm^2/1\mu m^2)$
2 pts $= 10^{-2}cm^2$

or

4 pts $1\mu m = 10^{-4}cm$
4 pts $.1\mu m = 10^{-5}cm$
5 pts $A_{transistor} = 10^{-5}cm\ x\ 10^{-5}cm = 10^{-10}cm^2$
5 pts $A_{chip} = \#\ transistors\ x\ A_{transitor} = (10^8\ transistors)(\ 10^{-10}cm^2\ /transistor)$
2 pts $= 10^{-2}cm^2$