PHYS 1311 EOC Problems
Chapter 4, Part I

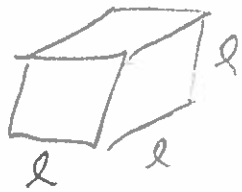
Problems P23, P27, P31, P43, and P45. 2-16-2016

Problem P23 $D_{Cu} = 2.28 \times 10^{-10}$ m, $\frac{m}{mole} = 64$ g

a) mass of one copper atom.

$$m_{Cu} = \frac{0.064\ kg}{1\ mole} \times \frac{1\ mole}{6.02 \times 10^{23}\ particles} = \boxed{1.063 \times 10^{-25}\ kg}$$

b) cubic block of copper $\ell = 0.046$ m



Volume of block, $V_b = \ell^3 = 9.7336 \times 10^{-5}\ m^3$

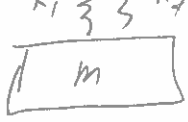
Volume of one atom (assume block) $V_a = D^3 = 1.1852 \times 10^{-29}\ m^3$

$\#\ atoms = V_b / V_a = \boxed{8.21 \times 10^{24}\ atoms}$

c) mass of the block $= \left(\frac{mass}{atom}\right)\left(N_{atoms}\right) = \left(1.063 \times 10^{-25}\ kg\right)$

$\times (8.21 \times 10^{24}\ atoms) = \boxed{0.873\ kg}$

Problem P27



$$k_{eq} = \sum_{i=1}^{N} k_i = 20{,}250\ N/m$$

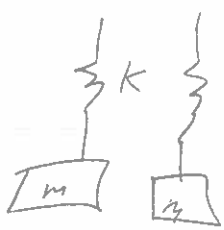
$$= Nk_1$$

$$k_1 = k_{eq}/N = 20{,}250/45 = \boxed{450\ N/m}$$

Problem P31 $D = 1.4 \times 10^{-3}$ m, $\ell_0 = 0.95$ m

$m = 36$ kg, $s = 1.83 \times 10^{-3}$ m

$\frac{m_{Cu}}{mole} = 63$ g, $\rho = 9\ g/cm^3$



chapter 4, Part I

Problem P31 (cont'd)

For the wire $\Sigma F_y = 0$

$F_s - mg = 0 \Rightarrow k_s = mg$

$k = \frac{mg}{s} = \frac{(36\ kg)(9.7\ m/s^2)}{1.83\times10^{-3}\ m} = 192{,}800\ N/m$

Wire area, $A = \pi\left(\frac{D}{2}\right)^2 = \pi\left(\frac{1.4\times10^{-3}}{2}\right)^2 = 1.539\times10^{-6}\ m^2$

Volume of wire $V = l \cdot A = (0.95\ m)(1.539\times10^{-6}\ m^2) = 1.462\times10^{-6}\ m^3$

$\rho = \frac{M}{V} \Rightarrow M = \rho V = \left(7.9\ \frac{g}{cm^3}\right)\left(\frac{100\ cm}{1\ m}\right)^3(1.462\times10^{-6}\ m^3)$

$M_{wire} = 13.16\ g$

$\#atoms = 13.16\ g \times \frac{mole}{63\ g} \times \frac{6.02\times10^{23}\ atoms}{1\ mole} = 1.257\times10^{23}\ atoms = N_{atom}$

Area of atom, $A_{atom} = (2.28\times10^{-10}\ m)^2 = 5.2\times10^{-20}\ m^2$

Number of bonds in a chain $= N_{atoms} \times \frac{A_{atom}}{A_{wire}} =$

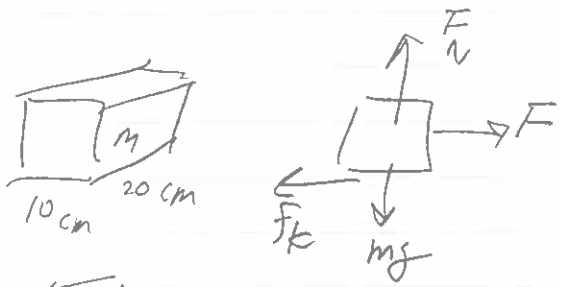
$= \frac{(1.257\times10^{23}\ atoms)(5.2\times10^{-20}\ m^2)}{(1.539\times10^{-6}\ m^2)} = 4.247\times10^{9}\ bonds$

$N_{chains} = \frac{A_{wire}}{A_{atom}} = \frac{1.539\times10^{-6}}{5.2\times10^{-20}} = 2.956\times10^{13}$

$k_{bond} = k\,\frac{N_{bonds}}{N_{chains}} = \boxed{27.7\ N/m}$

Chapter 4, Part 1

Problem P43 $m = 3\,kg$



$$\Sigma F_x = F - \mu_k F_N = 0$$

$$F = \mu_k mg = 3N$$

Since mass is the same and friction force is independent of contact surface area, $\boxed{F = 3N}$ same

Problem P45 $m = 20\,kg$ $\quad \mu_k = 0.2$

$\vec{F} = \langle 90, 0, 0 \rangle N$

$t_i = 5\,s$, $\vec{r}_i = \langle 8, 2, -1 \rangle m$, $\vec{v}_i = \langle 3, 0, 0 \rangle m/s$

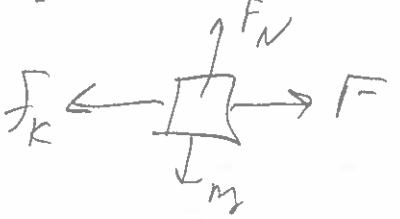
$t_f = 5.6\,s$, $\vec{r}_f = ?$, $\vec{v}_f = ?$

Use momentum principle $\vec{p}_f = \vec{p}_i + \vec{F}_{net}\Delta t$ to update velocity

$$\vec{v}_f = \vec{v}_i + \frac{\vec{F}_{net}}{m}\Delta t = \langle 3, 0, 0 \rangle + \frac{\langle 41, 0, 0 \rangle}{20}(0.6)$$

$$\Sigma F_x = F_x - f_k = F_x - \mu_k mg$$

$$= 90 - (0.2)(20)(9.8) = 41\,N$$



$$\boxed{\vec{v}_f = \langle 4.23, 0, 0 \rangle \frac{m}{s}}$$

$$\vec{r}_f = \vec{r}_i + \vec{v}_{avg}\Delta t = \langle 8, 2, -1 \rangle + \left[\frac{\langle 3, 0, 0 \rangle + \langle 4.23, 0, 0 \rangle}{2}\right](0.6)$$

$$= \boxed{\langle 10.7, 2, -1 \rangle m}$$