PHYS 4310, Quiz 2

1. Momentum, $\vec{p}$, is a vector. Reconcile that notion with the de Broglie relationship which equates momentum to h/λ.

$$\bar{p} = \hbar \bar{k} = h/\lambda \, \hat{k}$$

h/λ is the magnitude of p. The direction of propagation defines the direction of $\bar{k}$ $\left(\hat{k} = \frac{\bar{k}}{|\bar{k}|}\right)$, which is not explicitly captured in the numerical relation $p = h/\lambda$.

2. In 1773, Benjamin Franklin investigated how oil could "calm" water near a pond in London. He found that a few cm^3 of oil (use 3 cm^3) could cover an area of 2000 m^2. Assuming that the oil on the surface of the water is one molecule thick, estimate the size of an oil molecule. As a historical aside, Franklin never did this calculation and thus never obtained an estimate for the linear dimension of a single molecule. However, similar methods were employed nearly a century later by Lord Kelvin and other scientists to obtain molecule size estimates (French and Taylor, 1978).

$$V = 3\ cm^3$$
$$= 3\ cm^3 \times \left(\frac{10^{-2}\ m}{1\ cm}\right)^3$$
$$= 3\times 10^{-6}\ m^3$$

$$V = A \cdot d = 3\times 10^{-6}\ m^3$$
$$A = 2\times 10^{3}\ m^2$$
$$d = \frac{3}{2}\, 10^{-9}\ m = 1.5\ nm$$

This estimate is quite low (especially for long chain oil molecules), but not unreasonable.