SMS-618, Particle Dynamics, Fall 2003 (E. Boss)

Assignment # 1: Answer 3 out of the 4 questions below.
Please submit electronically for easy transfer to the web site.

1. Describe properties of particles that affect their 'behavior' (e.g. activity, processes that affects them) in the environment which are dependent on:
   a. Size.
   b. Shape.
   c. Composition

2. Describe more than five methods to estimate particulate size distribution (in number of particles per volume per size bin). For each method provide:
   a. What is actually being measured?
   b. What are the assumptions relating to obtaining the PSD?
   c. If you find a good web site describing the method/instrument please provide a link.

3. Calculate and plot the rms speed due to Brownian motion and the settling speed of low Reynolds number settling sphere (Stokes law) in water as function of size, at standard pressure and temperature, and for particles with a density of 2650Kg/m^3, for particle of size varying from 10nm to 1mm (Y-axis, velocity, x-axis, diameter, on a logarithmic scale). For what size are the two comparable? How dependent is this result on particle density?

4. Optical attenuation efficiency factors (nondimensional) is the attenuation by a single particle (attenuation cross section) divided by its cross sectional area. It can be approximated for non-absorbing particles whose index of refraction is not too different from water by (van de Hulst, 1957):

$$Q_c=2-4\sin(\rho)/\rho+4[1-\cos(\rho)]/\rho^2$$

Where $\rho=2\pi D(n-1)/\lambda$, where D is the diameter of the sphere, n its index of refraction and λ the wavelength in the medium surrounding the particle.
Assume a non-absorbing quartz particle with n=1.15 and λ=0.75*0.66μm (660nm in air).
1. Plot the attenuation per particle (C_{ext}, [L]) as function of size.
2. Plot the attenuation per particle normalized by its cross-sectional area (Q_c) as function of size.
3. Plot the attenuation per particle normalized by its volume (α_v [L^{-1}]) as function of size.

Interpret these plots in terms of the contribution of different size particles to measured beam attenuation,

$$c=\int_0^\infty N(D)C_{ext}(D)dD=\frac{1}{4}\int_0^\infty N(D)Q_c(D)\pi D^2dD=\frac{1}{6}\int_0^\infty N(D)\alpha_v(D)\pi D^3dD \quad [L^{-1}]$$

Where *N(D)* is the particle size distribution in: particle number per volume per width of size bin.