ME 437/537 **Exam 1** **October, 24 2002**

1. (35 points) Consider a one-dimensional diffusion process with a space dependent diffusivity in the absence of a flow field. The governing equation is given by

$$\frac{\partial c}{\partial t} = \frac{\partial}{\partial y}(D\frac{\partial c}{\partial y})$$

   Assume that $D = \alpha y$, and an initially uniform concentration of aerosols in the neighborhood of an absorbing wall. The initial and boundary conditions are: $C(y,0) = C_0$ and $C(0,t) = 0$.

   a) Use a similarity variable $\eta = \frac{y}{\alpha t}$, reduce the governing equation and boundary conditions to the similarity form. b) Does this equation accept a similarity solution? c) Justify your solution.

2. (35 points) Consider a fully developed laminar boundary layer flow over of a dilute gas-solid mixture over a flat plate with suction. Assume that the free stream velocity is U_o, the free stream concentration is C_o, and the suction velocity at the surface of the plate is $-V_o$. a) Show that $u = U_o(1 - e^{-yV_0/\nu})$, $v = -V_o$ are the exact velocity field in the boundary layer. b) Find the fully developed concentration profile C(y) in terms of particle diffusivity and suction velocity $-V_o$. c) Evaluate the expression for particle deposition velocity and concentration boundary layer thickness.

3. (30 points) Consider a 0.03 μm particles of density of 2000 kg/ m^3 in air under normal condition.

   i. Find the terminal velocity with and without Cunningham correction.
   ii. Determine the diffusivity.
   iii. Find the intensity of Brownian excitation for a Δt of 10^{-6} s.
   iv. When the particle is falling in a shear field of 1000 s^{-1}, find the Saffman lift force.

   (Assume a kinematic viscosity of 1.5×10^{-5} m^2/s, a temperature of 300 K, and λ=0.07μm. For other needed parameters assume a typical value.)