NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY
BACHELOR OF ENGINEERING (HONS) DEGREE
Part Three Examination June 2010

TCE3005 Fluid-Solid Systems

Duration of Examination 3Hours

Instructions to Candidates

1. Answer any FOUR questions.
2. Show all your steps clearly in your calculation.
3. Start the answers for each question on a new page.

---

1. a) State any five important characteristics of a particle. [5]

   b) What do you understand by the following terms? [5]
   i) free-falling diameter
   ii) skin friction drag
   iii) surface-volume diameter
   iv) minimum fluidization velocity
   v) projection sphericity

   c) With the aid of a diagram, explain the effects of decreasing the gas superficial velocity on the pressure drop per unit length of pipeline for a vertical pneumatic transport system of initial solids feed-rate G. [10]

   d) State and explain five factors taken into consideration in the selection of a dust collector. [5]

2. a) What is hindered settling? [3]

   b) Describe the four transport states that may occur in horizontal pipelines when pneumatically conveying solids. [12]

   c) Show that in the range $0.1 < \mathrm{Re}_t < 750$, a particle at its terminal velocity satisfies the relationship below: [10]

$$C_D \mathrm{Re}_t^{\,2} = \frac{4\rho_f \left(\rho_p - \rho_f\right) g d_p^{\,3}}{3\mu^2}$$

3. a) Briefly describe the operation of the following equipment:

   i) An impactor
   ii) A coulter-counter particle sizer
   iii) A cyclone [12]

   b) Two particles A and B of diameters d_A and d_B are falling freely under gravity in a liquid of density ρ_f. Show that if Newton's law applies, the particles' terminal velocities are equal if:

$$\frac{d_A}{d_B} = \frac{\rho_A - \rho_f}{\rho_B = \rho_f} \quad [5]$$

   c) It is desired to separate a mixture of quartz and galena of a size range from 0.015mm to 0.065mm into two pure fractions by the use of a hindered settling process. What is the minimum apparent density of the fluid that will give this separation? [8]

4. a) State four particulate solids that can be transported by pneumatic conveying. [4]

   b) A bed consists of uniform spherical particles of diameter 3mm and density 4200kg/m^3. What will be the minimum fluidizing velocity in a liquid of viscosity 3mNs/m^2 and density 1100kg/m^3 if $Re_{mf} = 25.7\left[\sqrt{1 + 5.53 * 10^{-5} Ga} - 1\right]$ when $\varepsilon_{mf} = 0.4$. [11]

   c) Derive from first principles, the terminal falling velocity of a particle of density ρ_p in a fluid of density ρ_f and viscosity μ. Assume the particle motion is under gravity in the Stokes region. [10]

5. a) Describe the fluidization behavior of the four classes of particulates according to Geldart's classification citing examples of real materials that fall within those classes. [8]

   b) State and explain five methods employed in filter cleaning. [5]

   c) Using diagrams, briefly explain the mechanisms of particle capture in gas cleaning. [12]

END OF EXAM