Programme: B. Sc in Chemical Engineering

Session: 2009 – 10

Level: II

Module Leader: Dr N. Meyyappan

16 January 2010

Duration: THREE Hours

FLUID MECHANICS
(ENME 202)

CANDIDATES SHOULD ATTEMPT ANY FIVE FULL QUESTIONS

PLEASE READ THE QUESTIONS CAREFULLY

MATERIALS TO BE SUPPLIED/ ALLOWED:

Question paper (Supplied)

Blank Examination Script (Supplied)

Non-programmable calculator (Allowed)

Students for whom English is not their first language are permitted to use a Standard English/Foreign Language dictionary, e.g. English/Arabic, Arabic/English, during their examination. Please ensure that the dictionary does not contain any notes or other materials. Electronic dictionaries are not permissible.
Q1(a) List types of pressure measuring devices and briefly discuss their use. [05]

(b) With a aid of a neat sketch explain Boundary Layer Separation and Wake Formation. [08]

(c) Calculate the pressure drop for a inverted differential manometer which shows a manometric reading of 300mm. The manometric liquid used is an oil having a specific gravity of 1.8 and it is connected between two points of a pipe containing water and the same when air is flowing at 20°C Also write your comments. [07]

Q2(a) Using a differential momentum balance derive the equation of motion. [10]

(b) The pressures at two sections of a horizontal pipe are 0.4 kgf/cm² and 0.8 kgf/cm² and the diameters are 8 cm, and 16 cm respectively. Determine the direction of flow if water flows at a rate of 7.5 kg/sec. State your assumptions. [10]

Q3(a) Explain Equivalent Diameter and Hydraulic Radius. [05]

(b) Show that \( \frac{\bar{v}}{u_{\text{max}}} = 0.5 \) for a fluid flow under laminar flow conditions. [08]

(c) A fluid having a viscosity of 1.1 poise and a density of 850 kg/m³, is flowing through a straight, circular pipe having an inside diameter of 4 cm. A pitot tube is installed on the pipeline with its impact tube located at the center of the pipe cross section. At a certain flow rate, the pitot tube indicates a reading of 4 cm of mercury. Calculate the mass flow rate of the fluid. [07]

Q4(a) List the possible uses of packed towers in the Process Industries. Discuss the various types of packing available and indicate their individual advantages. Define Sphericity and Porosity for a packed bed. [10]

(b) An oil having a viscosity of 1.32 cp, and a density of 0.75 gm/cm³, is flowing through a pipe having an inside diameter of 5 cm and 1m in length. The pressure drop across the pipe line is 10 kN/m². Determine the volumetric flow rate of the fluid. Confirm your use of the Hagen Poiseullie equation is justified by calculating the Reynolds Number. [10]
Q5(a) Estimate the power required for pumping water from a reservoir to a height of 100 m, through a pipe of 8 cm I.D. at an average velocity of 2.5 m/s. If the pipeline along with the fittings is equivalent to 20 m long and the overall efficiency is 60%, Friction factor \( f = 0.046 \, \text{Re}^{-0.2} \). [05]

(b) Discuss any one application of Fluidization in detail. [05]

(c) The pressure drop required for fluidizing a coal bed with a liquid petroleum fraction of viscosity 0.025 Ns/m\(^2\) is \( 2 \times 10^5 \, \text{N/m}^2 \). What is the pressure drop required for fluidizing the same bed with an oil (same density as the petroleum fraction) of viscosity 0.02 Ns/m\(^2\). [10]

Q6(a) Describe about Fans and Blowers. [05]

(b) Explain about the characteristics of a centrifugal pump. [10]

(c) Write short notes related to the equipment necessary to pump gaseous systems. [05]

Q7(a) Describe about the types of fluidization in detail

(b) 1.16 m\(^3\)/h water at 320 K is pumped through a 20 mm I.D. pipe through a length of 100 m in a horizontal direction and up through a vertical height of 10 m. What power must be supplied to the pump if it is 70% efficient? Take the value of Fanning friction factor as 0.002. Water viscosity is 0.75 cp, and density = 1 gm/cm\(^3\). [10]

END OF THE QUESTION PAPER
FORMULAE SHEET

Pressure drop, \( \Delta p = h (\rho_m - \rho) \cdot g \)

\[
\frac{\Delta p}{L} = \frac{2f \rho \cdot V^2}{D}
\]

Power required = Volumetric Flow rate x Pressure Developed / \( \eta \)

Frictional loss per unit mass of the fluid:

\[
h_f = \frac{2fL \cdot V^2}{D}
\]

Hagen Poiseuille's Equation

\[
\Delta P = \frac{32 \cdot L \cdot \bar{V} \cdot \mu}{D^2}
\]

Modified Reynolds Number

\[
N_{Re_{PM}} = \frac{D \cdot \rho \cdot V_0}{\mu (1 - \varepsilon)}
\]

Reynolds Number, \( N_{Re} = \frac{DV\rho}{\mu} \)