NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY
DEPARTMENT OF CIVIL AND WATER ENGINEERING
FACULTY OF INDUSTRIAL TECHNOLOGY
BACHELOR OF ENGINEERING (HONOURS) DEGREE
PART II FIRST SEMESTER EXAMINATION – APRIL 2009
FLUID MECHANICS – TCW 2101

INSTRUCTIONS

Answer any four (4) questions. All questions carry equal marks.

Time : 3 hours
Total marks :100

QUESTION 1

(a) Show that the pressure intensity at a point in a fluid is of equal magnitude in all directions. (6 marks)

(b) Define gauge pressure, absolute pressure and vapour pressure. (6 marks)

(c) Define compressibility. For an increase in pressure of a liquid from depth 475 kPa to 1012 kPa, the volume decreased by 1.15%. Determine the bulk modulus of the liquid. (4 marks)

(d) A large storage tank contains a salt solution of variable density given by $p = 1050 + kh$ in kg/m^3, where $k = 50\ kg/m^4$, at a depth h metres below the free surface. Calculate the pressure intensity at the bottom of the tank holding 5 m of the solution. (5 marks)

(e) A tank with vertical sides contains both oil and water. The oil has depth of 1.5 m and relative density. The water has a depth of 2 m. the tank is 3 m by 1.8 m in plan and is open. Calculate the total weight of the contents of the tank, the pressure on the base of the tank and show the variation of the pressure intensity with depth. (4 marks)

QUESTION 2

(a) State Archimedes' principle of floatation and explain its application to a floating body. (4 marks)

(b) Explain the 3 conditions in which a solid body can be in equilibrium (4 marks)

(c) Define metacentre and metacentric height. Show the stability of a floating body depends upon the position of the metacenter and centre of gravity. (6 marks)

(d) A steel pipe conveying gas has an internal diameter of 120 cm and an external diameter of 125 cm. It is laid across the bed of a river, completely immersed in water and is anchored at intervals of 3 m along its length. Calculate the buoyancy force in N/m run and the upward force on each anchorage. Take density of steel = 7 900 kg/$m^{3.}$ (11 marks)

QUESTION 3

(a) A dam that retains fresh water has a vertical face. Over a one metre length of the face at the centre of the valley the water has a depth of 38 m. Calculate:

(i) The resultant force on this unit length of the face;

(ii) The depth from the surface at which the resultant force acts. (4 marks)

(b) A gate at the end of a sewer measures 0.8 m by 1.2 m wide. It is hinged along its top edge and hangs at an angle of 30^{o} to the vertical, this being the angle of the banks of a trapezoidal river channel.

Calculate the hydrostatic force on the gate and the vertical distance to the centroid of the gate, G, and the centre of pressure P, when the river is 0.1 m above the top of the hinge.

If the river level is increases to 2 m above the hinge, what is the force and the distance GP now?

Has the value of GP increased or decreased, and why has it changed in this manner? (10 marks)

(c) A sector gate is constructed with a radius of 6 m and subtends an angle of 25o. The sector takes the pressure of water which is level with the upper edge. The line from the hinge to the lower edge is inclined upwards from the horizontal at 10o. Calculate the resultant force at the hinge pre metre width of the gate and also the horizontal component of this force. (11 marks)

QUESTION 4

(a) Derive the Bernoulli's equation for steady flow of a frictionless fluid of constant density, stating all the assumptions. (6 marks)

(b) A fire engine pump develops a head of 50 m. The pumps draws water from a sump through a 150 mm diameter pipe in which there is a loss of energy per unit weight due to friction $h_1 = 5u_1^2/2g$ varying with mean velocity u_1 in the pipe, and discharges it through a 75 mm nozzle, 30 m above the pump, at the end of a 100 mm diameter delivery pipe in which there is a velocity u_2 and a loss of energy per unit weight $h_2 = 12u_2^2/2g$. Calculate the velocity of the jet u_3, issuing from the nozzle and the pressure in the suction pipe at the inlet to the pump. (10 marks)

(c) Describe in words the meaning of the continuity equation. Explain what continuity of flow in pipeline entails and how this interacts with fluid and pressure. (4 marks)

(d) A pipeline of 300 mm diameter carrying water at an average velocity of 4.5 m/s branches into 2 pipes of 150 mm and 200 mm diameters. If the average velocity in the 150 mm pipe is 5/8 of the velocity in the main pipeline, determine the average velocity of flow in the 200 mm pipe and the total flow rate in the system. (5 marks)

QUESTION 5

(a) Describe what is meant by the following terms: momentum, momentum flow rate, control volume and conservation of momentum. (5 marks)

(b) A horizontal straight pipe gradually reduces in diameter from 300 mm to 150 mm. Neglecting friction, find the total longitudinal thrust on the pipe if at the end the pressure is 275 kN/m2 and the velocity is 3 m/s if the pipe is carrying water. (8 marks)

(c) A pipeline bends in the horizontal plane through an angle of 45^{o}. The diameter changes from 0.6 m before the bend to 0.4 m after it. Water enters the bend at the rate of 0.5 m^3/s with a pressure of 150 x 103 N/m2. Assuming that there is no loss of energy, calculate the force exerted on the pipe. (12 marks)