NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF INDUSTRIAL TECHNOLOGY

DEPARTMENT OF CIVIL AND WATER ENGINEERING

FLUID MECHANICS

TCW 2101

Supplementary Examination Paper

JULY 2016

This examination paper consists of 4 pages

Time Allowed: 3 hours

Total Marks: 100

Special Requirements: NONE

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INSTRUCTIONS

1. Answer any four (4) questions
2. Each question carries 25 marks
3. Use of calculators is permissible

MARK ALLOCATION

QUESTION	MARKS
1.	25
2.	25
3.	25
4.	25
5.	25
TOTAL	100

QUESTION 1

a) Explain or define the following terms with their units:
   i) Specific gravity
   ii) Specific volume
   iii) Surface tension
   iv) Compressibility
   v) Bulk modulus (10 marks)

b) Whenever a fine tube is pushed through the free surface of a liquid, the liquid rises up or falls in the tube owing to the relation between the surface tension and capillarity. Derive an expression for the mean height of the liquid surface h, when a fine tube of diameter d is immersed in a fluid of density ρ and surface tension T, and the contact angle of the liquid to the wall is θ.
(7 marks)

c) A cylinder of diameter 122 mm and length 200 mm is placed inside a concentric long pipe of diameter 125 mm, as shown in Fig. 1. An oil film is introduced in the gap between the pipe and the cylinder. What force is necessary to move the cylinder at a velocity of 1 m/s? Assume that the kinematic viscosity of oil is 30 cSt and the specific gravity is 0.9.
(8 marks)

QUESTION 2

a) The rectangular gate CD shown in Fig. 2.1 is 1.8 m wide and 2.0 m long. Assuming the material of the gate to be homogeneous and neglecting friction at the hinge C, determine the weight of the gate necessary to keep it shut until the water level rises to 2.0 m above the hinge. (10 marks)

b) A 4 m long curved gate is located in the side of a reservoir containing water as shown in Fig 2.2. Determine the magnitude of the horizontal and vertical components of the force of the water on the gate. Will this force pass through point A? Explain. (15 marks)

QUESTION 3

a) Small differences in gas pressure are commonly measured with a macrometer of the type shown in Fig. 3. This device consists of two large reservoirs each having a cross-sectional area A_r, which are filled with a liquid having a specific weight, γ_1, and connected by a U-tube of cross-sectional area, A_t, containing a liquid of specific weight, γ_2. When a differential gas pressure, $p_1 - p_2$, is applied, a differential reading, h, develops. It is desired to have this reading sufficiently large (so that it can be easily read) for small pressure differentials. Determine the relationship between h and $p_1 - p_2$ when the area ratio A_t/A_r is small, and show that the differential reading, h, can be magnified by making the difference in specific weights, $\gamma_1 - \gamma_2$ small. Assume that initially (with $p_1 = p_2$) the fluid levels in the two reservoirs are equal. (10marks)

b) An open steel tank of base 6 m square has its sides sloping outwards such that its top is 9 m square. If the tank is 3.5 m high and is filled with water, determine the total thrust and its location (i) on the base and (ii) on one of the sloping sides (15 marks)

QUESTION 4

a) Derive Bernoulli's equation of motion along a streamline (10 marks)

b) A large open tank contains a layer of oil floating on water as shown in Fig. 4. The specific gravity of the oil is 0.7. The flow is steady and inviscid. Determine:

i) the height, h, to which the water will rise

ii) the water velocity in the pipe

iii) the pressure in the horizontal pipe (15 marks)

QUESTION 5

a) Derive the Hagen-Poiseuille formula for the volume flow rate in a straight circular pipe (fully developed laminar flow). The suggested starting point is a force balance on a cylindrical element. (12 marks)

b) One end of a 150 m long, 300 mm diameter pipe is submerged in a reservoir. The other end abuts on a 90 m long, 200 mm diameter pipe at a point 30 m below the reservoir surface. Water discharges freely (K = 1.0) from the free end of the shorter pipe, which is 15 m below the junction. (This implies a 2° bend at the junction). Determine the pressure heads just above and just below the junction, if f = 0.04, and K = 0.8 for the entrance, and K = 0.24 for the contraction-bend at the junction. (13 marks)

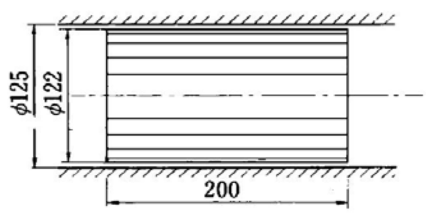

Fig. 1

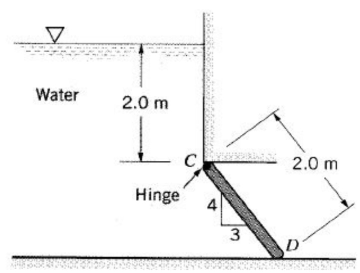

Fig. 2.1

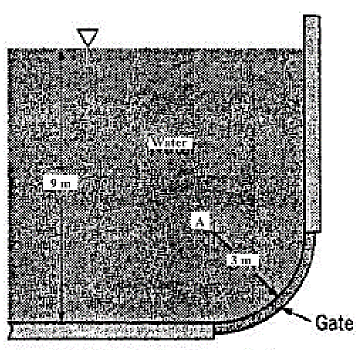

Fig. 2.2

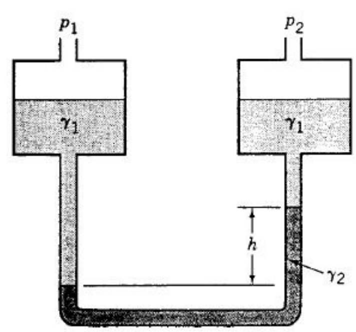

Fig. 3

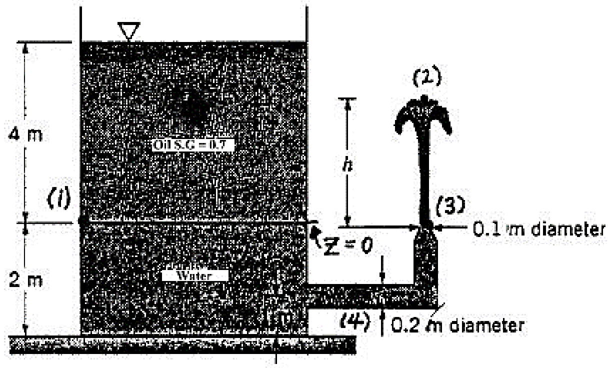

Fig. 4

<u>Useful Formulae</u>

$$y_f = y_i + v_{y_i} t - \frac{1}{2} g t^2$$

$$h_L = h_f + h_m$$

$$h_p = \bar{h} + \frac{I_G \sin^2\theta}{A\bar{h}}$$

$$y_R = \frac{I_G}{y_c A} + y_c$$

$$I_G = \frac{bd^3}{12}$$

$$I_0 = y_0^2 A + I_G$$

$$h_f = \frac{fLv^2}{2gd}$$