NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING

DEPARTMENT OF CIVIL AND WATER ENGINEERING

FLUID MECHANICS

ECW 2101

Main Examination Paper

DECEMBER 2024

This examination paper consists of 4 pages

Time Allowed: 3 hours

Total Marks: 100

Special Requirements: NONE

Examiner's Name: ELLEN NDUNA

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. Describe what is meant by i. surface tension, ii. capillarity, iii. vapor pressure, iv. the equal level equal pressure, v. absolute pressure (10 marks)

b. What is the pressure in kN/m^2 absolute and gauge at a point 3 m below the free surface of a liquid having a mass density of 1.53×10^3 kg/m^3 if the atmospheric pressure is equivalent to 750 mm of mercury? Take the specific gravity of mercury as 13.6 and the density of water as 1000 kg/m^3. (5 marks)

c. An inclined manometer is required to measure an air measure an air pressure difference of about 3 mm of water with an accuracy of ±3%. The inclined arm is 8 mm diameter and the enlarged end is 24 mm diameter. Density of manometer fluid is 740 kg/m^3. Find the angle which the inclined arm must make with the horizontal to achieve the required accuracy assuming acceptable readability of 0.5 mm. (10 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. Explain what is meant by i. buoyancy, ii. metacentre and iii. metacentric height of a vessel (5 marks)

b. A rectangular pontoon has a width B of 6 m, a length of l of 12 m and a draught D of 1.5 m in water. Calculate the weight of the pontoon and the load that can be supported by the pontoon in water if the maximum draught permissible is 2 m. (10 marks)

c. A pontoon 15 m long, 7 m wide and 3 m high weighs 700 kN unloaded and carries a load of 1600kN. The load is symmetrically on the pontoon so that its centre of gravity is on the longitudinal centre line at a height of 0.5 m above the deck (3.5 m above the base). The centre of gravity of the pontoon can be assumed to be on the longitudinal centerline at a height of 1.5 m above the base. The pontoon floats in saline water of density 1025 kg/m^3. Calculate the metacentric height of the pontoon. (10 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)

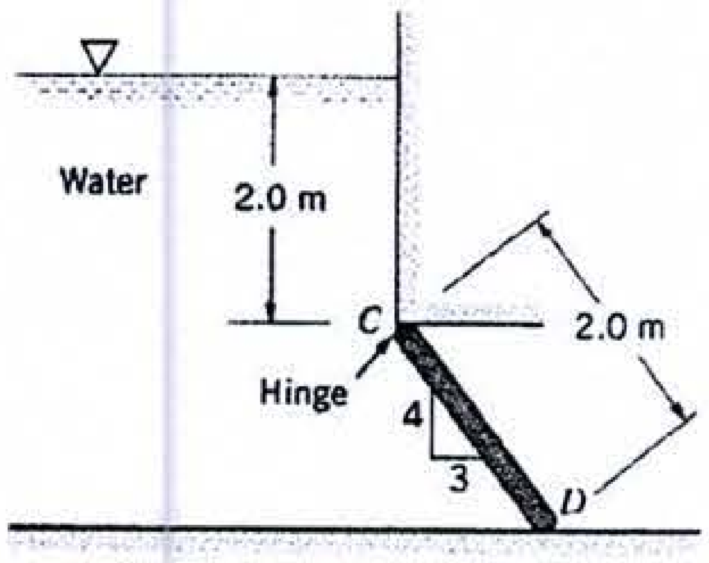
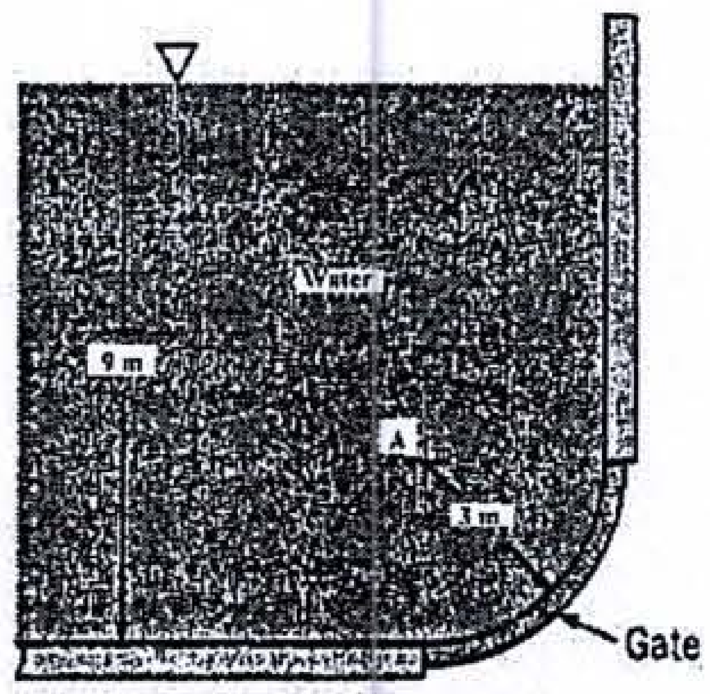


Fig 2.1



■ FIGURE P2.70

Fig. 2.2

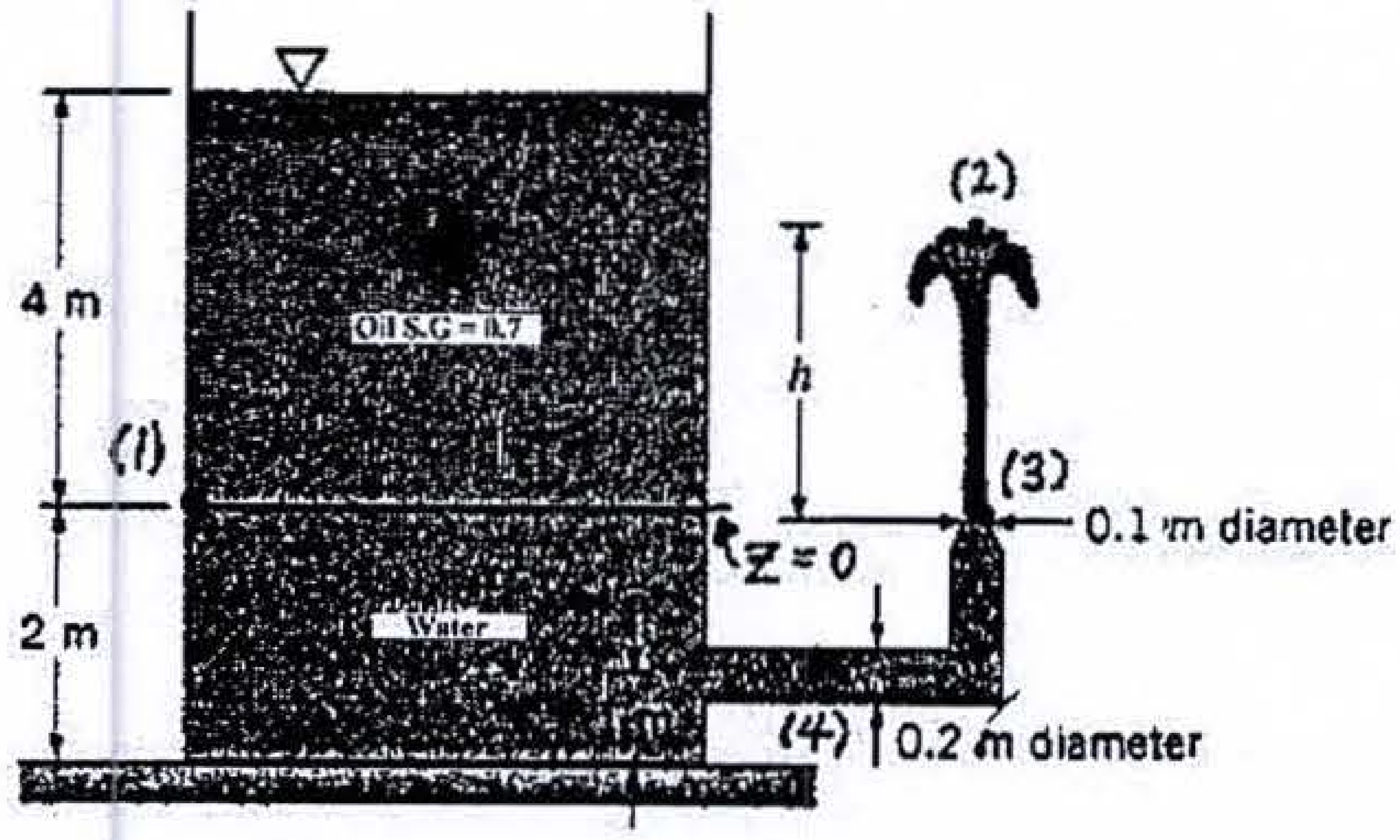


Fig. 4

Useful Formulae

$$h_L = h_f + h_m$$

$$h_o = \bar{h} + \frac{I_g \sin^2\theta}{A\bar{h}}$$

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

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

$$I_o = {y_c}^2 A + I_c$$

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