(University of Choice)

MASINDE MULIRO UNIVERSITY OF SCIENCE AND TECHNOLOGY (MMUST)

MAIN CAMPUS

UNIVERSITY MAIN EXAMINATIONS 2023/2024 ACADEMIC YEAR

SECOND AND THIRD YEAR FIRST SEMESTER EXAMINATIONS

FOR THE DEGREE OF BACHELOR OF SCIENCE IN CIVIL AND STRUCTURAL ENGINEERING AND BACHELOR OF TECHNOLOGY EDUCATION IN CIVIL & BUILDING TECHNOLOGY

COURSE CODE: CSE 251/TEB 351

COURSE TITLE: FLUID MECHANICS I

DATE: 7TH DECEMBER 2023 **TIME:** 3 P.M – 5 P.M

Instructions to candidates

- This paper consists of **FIVE** questions.
- Answer question **ONE** and **ANY** other **THREE** questions
- Candidates are **NOT** allowed to write **ANYTHING** on the question paper
- All symbols have their usual meaning unless otherwise stated
- Take density of water as 1000 kg/m^3 and specific gravity of mercury as 13.6
- Time allowed is **TWO (2)** hours

MMUST observes ZERO tolerance to examination cheating

Question ONE {Compulsory (25 marks)}

a) What are the three conditions in which a solid body can be in equilibrium? (3 marks)

b) The surface tension of water in contact with air at 20° is 0.0715 N/m. If the pressure inside a droplet of water is to be 200 N/m^2 greater than the outside pressure, determine the diameter of the water droplet. (3 marks)

c) Determine:
   i) the specific weight ii) mass density iii) specific volume iv) specific gravity of 1 litre of a liquid which weighs 7N. (4 marks)

d) Define the following terms used in connection with the flow of a liquid. (4 marks)
   i) Uniform flow ii) steady flow ii) Unsteady flow iv) discharge

e) A block of wood 4m long×2m wide ×1m deep is floating horizontally in water {Figure Q1(e)}. If the density of wood is 700 kg/m^3, determine the volume of water displaced and the position of center of buoyancy. (5 marks)

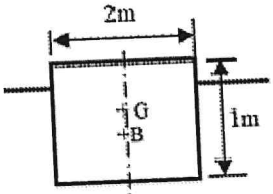

Figure Q1(e)

f) A force P of 850N is applied to the smaller cylinder of a hydraulic jack {Figure Q1(f)}. The area a of the smaller piston is 15cm^2 and the area A of the larger piston is 150cm^2. What load W can be lifted on the larger piston if:
   i. The pistons are in the same level (2 marks)
   ii. The larger piston is 0.75m below the smaller. (4 marks)

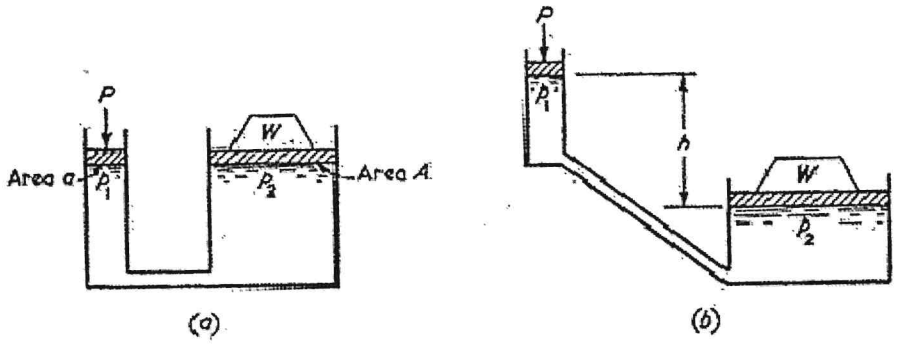

Figure Q1(f)

Question TWO (15 marks)

a) A vessel has a displacement of 2500 tons of fresh water. A mass of 20 tons moved 9m across the deck causes the lower end of pendulum 3m long to move 23m horizontally. Calculate the transverse metacentric height. (4 marks)

b) The diameters of a pipe at entrance and exit sections are 100mm and 150mm respectively. If the velocity of water at the pipe entrance is 5m/s, determine:
   i. The discharge at the entrance. (2 marks)
   ii. The velocity at the exit. (2 marks)

c) A U-tube manometer {Figure Q2(c)} measures the pressure difference of water between two points A and B. the U-tube contains mercury. Calculate the pressure difference given that a = 1.5m, b = 0.75 and h = 0.5m. (7 marks)

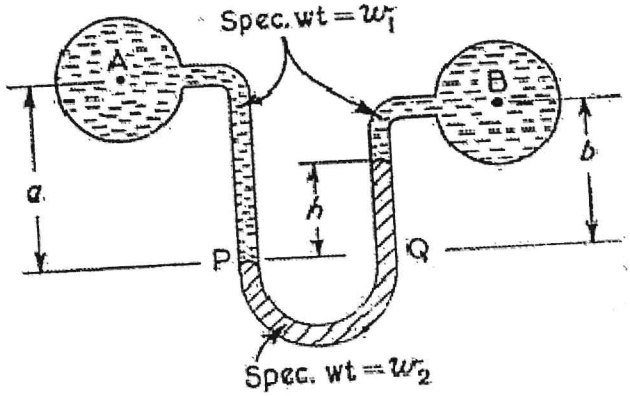

Figure Q2(c)

Question THREE (15 marks)

a) Determine the bulk modulus of elasticity of a liquid which is compressed in a cylinder from a volume of 0.0126m^3 at a pressure of 75N/cm^2 to a volume of 0.0125m^3 at a pressure of 150 N/cm^2. (3 marks)

b) A circular lamina 125cm in diameter is immersed in water so that the distance of its perimeter measured vertically below the water surface varies between 60cm and 150cm {Figure Q3(b)}. Find:
   i. The total force due to the water acting on one side of the lamina. (2 marks)
   ii. The vertical distance of the centre of pressure below the water surface. (4 marks)

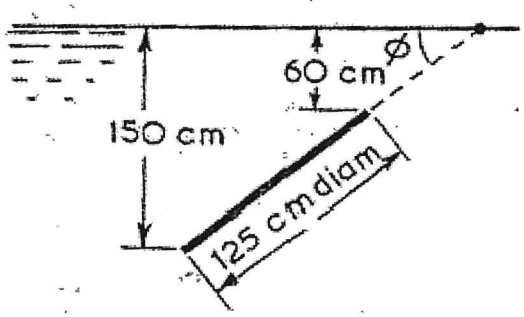

Figure Q3(b)

c) Find an expression for power P, developed by a pump when P depends upon head H, the discharge Q and specific weight w of the fluid. (6 marks)

Question FOUR (15 marks)

a) The discharge through a weir is 1.5 m^3/s. Find the discharge through the model of the weir if the horizontal dimension of the model is 1:50 the horizontal dimension of the prototype and vertical dimension of the model is 1:10 the vertical dimension of the prototype. (5 marks)

b) The gates of a lock which is 7.5m wide make an angle of 120° with each other in plan. Each gate is supported on two hinges which are situated 0.75m and 6.25m above the bottom of the lock. The depths of water on the two sides of the gate are 9m and 3m respectively {Figure Q4(b)}. Find the magnitude of forces on each hinge. (10 marks)

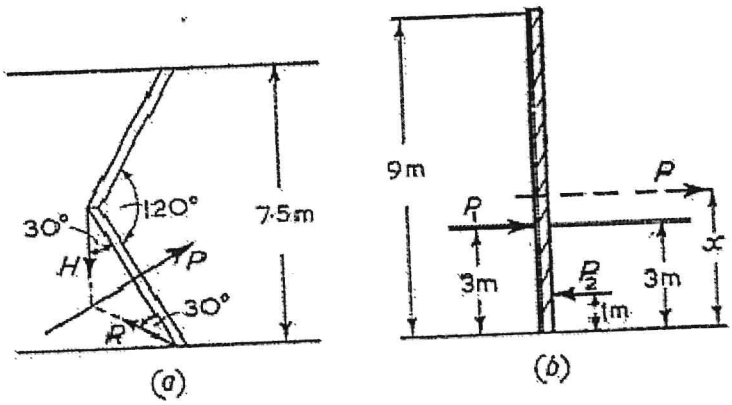

Figure Q4(b)

Question FIVE (15 marks)

a) The velocity distribution over a plate is given by: $u = \frac{2}{3}y - y^2$ in which u is the velocity in m/s at a distance y metres above the plate. Determine the shear stress at y=0 and y=0.15m. Take dynamic viscosity of the fluid μ as 0.863 Ns/m^2. (6 marks)

b) The following cases represent the two velocity components. Determine the third velocity component if the flow satisfies the continuity equation: (9 marks)

$$u = x^2 + y^2 + z^2;\ v = xy^2 - yz^2 + xy$$