NATIONAL UNIVERSITY OF SCIENCE AND TECHNOLOGY

FACULTY OF ENGINEERING

DEPARTMENT OF INDUSTRIAL AND MANUFACTURING ENGINEERING

BENG HONORS DEGREE IN INDUSTRIAL AND MANUFACTURING ENGINEERING

FLUID MECHANICS

EIE2202

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This examination paper consists of **5** printed pages

Time Allowed: **3 hours**

Total Marks: **100**

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INSTRUCTIONS AND INFORMATION TO CANDIDATE

1. Answer any FIVE **(5)** Questions.
2. Each Question carries a total of 20 Marks.
3. Start the answer to each full question on a fresh page.
4. Ensure neatness and legibility of work.

QUESTION 1

a) Briefly outline 4 types of non-Newtonian fluids giving examples for each. [8]

b) State the differences between laminar and turbulent flow using neat sketches and relevant examples. [6]

c) Blood flows in a blood vessel of radius 2 mm. Blood has a viscosity of $2.1\text{x}10^{3}$ Pa.s (at body temperature) and a density 1060 kgm^{-3}.

i. Calculate the greatest speed of blood flow if the flow is to remain laminar. [3]

ii. What is the corresponding flow rate? [3]

QUESTION 2

a) Using well labelled diagrams describe the principle of operation of a Venturi meter stating its advantages and disadvantages in fluid flow measurement. [6]

b) In a domestic hot water heating system, water circulates throughout the house. If the water is pumped at a speed of 0.50m/s through a 4cm diameter pipe in the basement under a pressure of 3atm, what will be the flow speed and pressure in 2.6cm diameter pipe on the second floor 5.0m above? [4]

c) A pipe carrying water has a 30cm x15cm Venturi meter which is positioned inclined at 30° to the horizontal. The flow is upwards. The converging cone is 45cm in length and the C_d of the meter is 0.98. A differential U tube manometer with mercury as indicating fluid is connected to the inlet and to the throat and shows a differential column height of 30cm as shown in Figure 2.

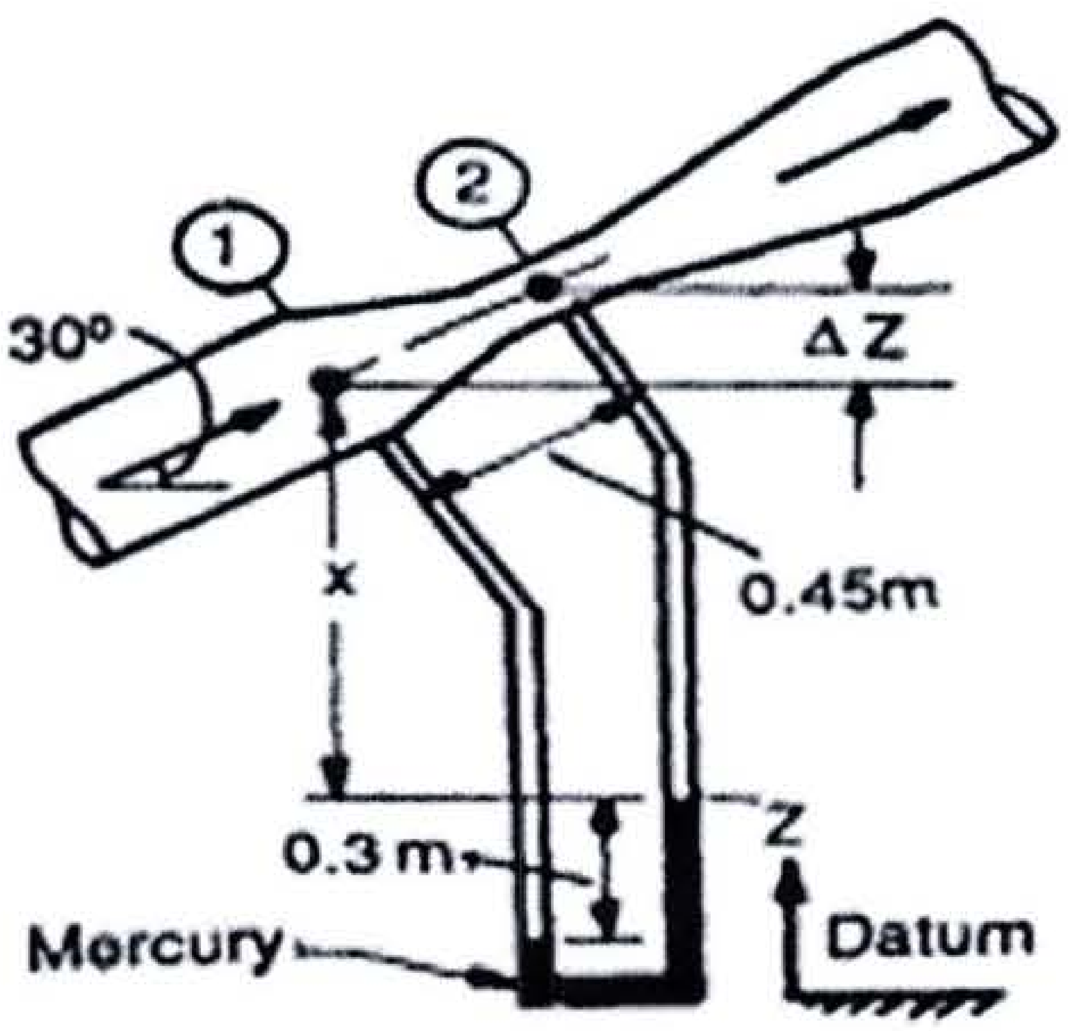

Figure 2

i. Calculate the discharge in the pipe [4]

ii. If the pressure in the inlet section is 50kPa determine the pressure at the throat. [4]

iii. Find the head loss in the converging section of the venturi meter. [2]

QUESTION 3

a) The water is flowing through a tapering pipe having diameters 300 mm and 150 mm at section 1 and 2 respectively. The discharge through the pipe is 40 litres/sec. The section 1 is 10 m above datum and section 2 is 6 m above datum. Find the intensity of pressure at section 2 if that at section 1 is 400 kN/m^2. [6]

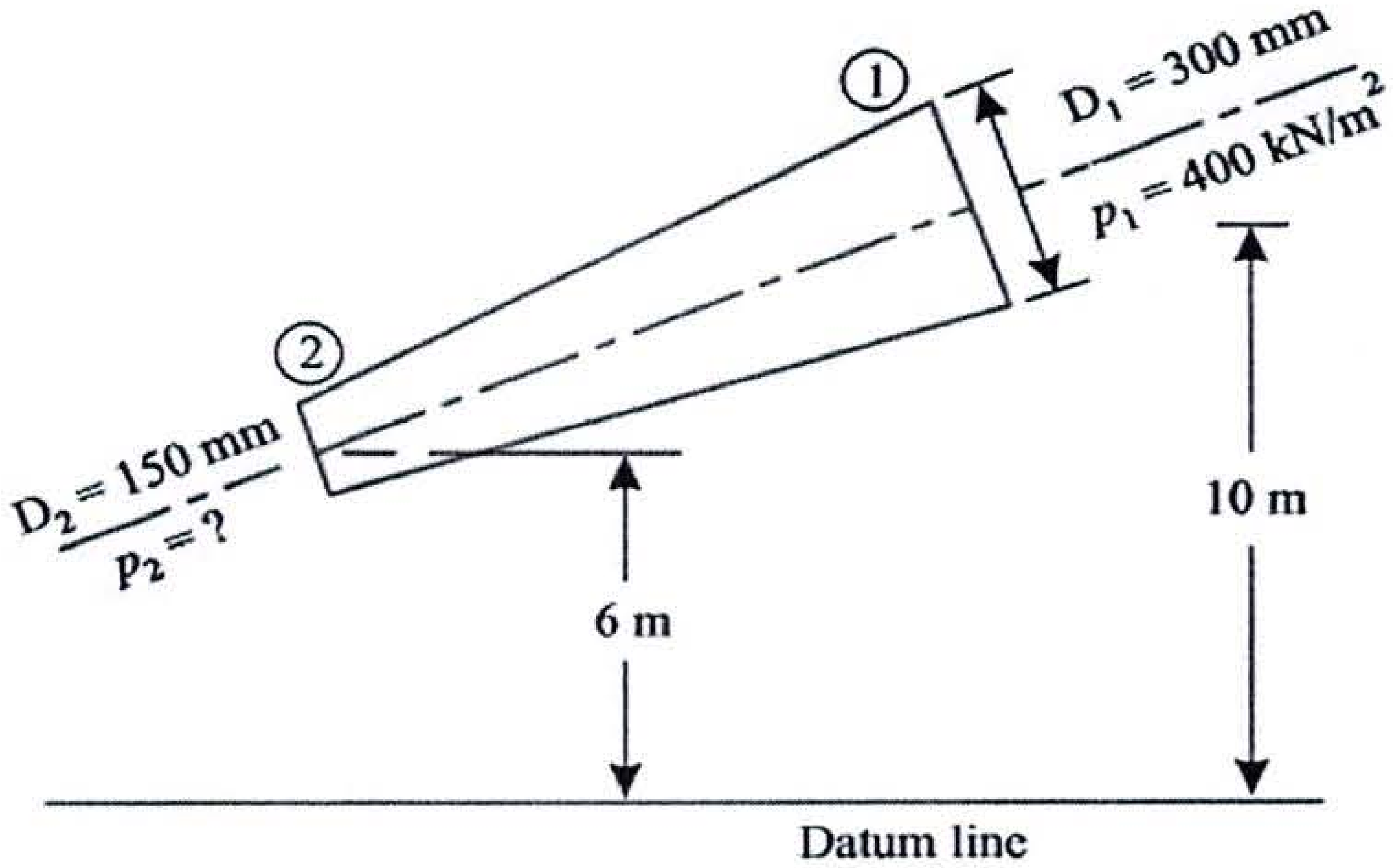

Figure 3

b) The space between two square flat parallel plate is filled with oil. Each side of the plate is 60 cm. The thickness of the oil film is 12.5 mm. The upper plate, which moves at 2.5 m/s are requires a force of 98.1 N to maintain the speed. If the specific gravity (S) of the oil is 0.95 determine;

i. the dynamic viscosity of the oil. [3]

ii. the kinematic viscosity of the oil. [3]

c) A 50° reducing bend is connected in a pipeline, the diameters at the inlet and outlet of the bend being 700mm and 350mm respectively.

i. Find the force exerted by the water on the bend if the intensity of pressure at the inlet to bend is 9.2N/cm^2 and rate of flow of water is 500l/s. [5]

ii. Also find the angle made by the resultant force with horizontal direction. [3]

QUESTION 4

a) Derive from first principles Bernoulli's equation for frictionless, incompressible flow through a pipe. Explain the terms involved and all the assumptions taken. [10]

b) State any 6 minor losses associated with flow in pipes. [3]

c) A 150mm diameter pipe reduces in diameter abruptly to 100mm diameter. If the pipe carries water at 30lts/sec, taking the coefficient of contraction as 0.6. Calculate the pressure loss across the contraction. [7]

QUESTION 5

a) Outline the 3 constants that govern the performance of an orifice. [6]

b) Water of head 9m is flowing through an orifice of 60 mm diameter. The coefficients of discharge and velocity are 0.6 and 0.9 respectively.

i. Calculate the actual discharge through the orifice. [3]

ii. Determine the actual velocity at vena contraction. [2]

c) The water in a large lake is to be used to generate electricity by the installation of a hydraulic turbine–generator at a location where the depth of the water is 50 m as shown in Figure 5. Water is to be supplied at a rate of 5000 kg/s. If the electric power generated is measured to be 1862 kW and the generator efficiency is 95 percent. Determine;

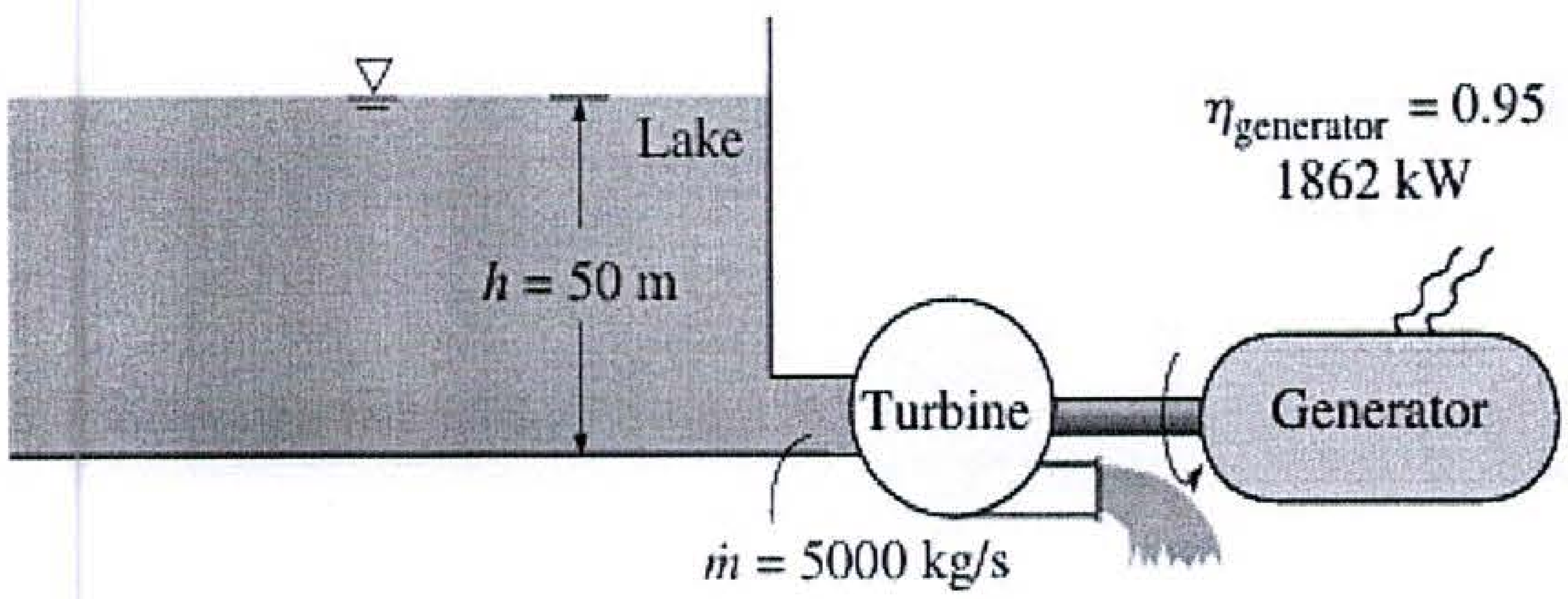

Figure 5

i. the overall efficiency of the turbine–generator, [3]

ii. the mechanical efficiency of the turbine, and [3]

iii. the shaft power supplied by the turbine to the generator. [3]

QUESTION 6

a) Use well labelled sketches to define the following terms in relation to boundary layer theory.

i. Laminar boundary layer. [3]

ii. Displacement thickness σ*. [3]

The velocity distribution in the boundary layer is given by $\frac{u}{U} = \frac{3}{2}\frac{y}{\delta} - \frac{1}{2}\left(\frac{y}{\delta}\right)^3$,

where u is the velocity y from the plate and $u=U$ at , $y=\delta$,δ being boundary layer thickness. Find

i. The boundary layer thickness. [4]

ii. Shear stress. [4]

iii. Drag force . [4]

iv. Coefficient of drag in terms of Reynolds number. [2]

QUESTION 7

a) Oil of specific gravity 0.9 and kinematic viscosity 0.00033 $m^2\ s^{-1}$ is pumped over a distance of 1.5 km through a 75 mm diameter tube at a rate of 25 x 10^3 kg h^{-1}. Determine whether the flow is laminar and calculate the pumping power required, assuming 70 per cent mechanical efficiency. [10]

b) Discuss how rotodynamic pumps are classified giving examples and applications in all cases. [10]

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