ZIMBABWE

MINISTRY OF HIGHER AND TERTIARY EDUCATION, INNOVATION, SCIENCE AND TECHNOLOGY DEVELOPMENT

HIGHER EDUCATION EXAMINATIONS COUNCIL (HEXCO)

HIGHER NATIONAL DIPLOMA

IN

MECHANICAL ENGINEERING

MODULE: Thermofluids **PAPER NO: 713/24/M06**

DURATION: 3 Hours

JUNE 2026 EXAMINATION

REQUIREMENTS

1. Answer booklet
2. Formula booklet
3. Steam tables
4. Non – programmable scientific calculator

INSTRUCTIONS TO CANDIDATE

1. This paper consists of eight (8) questions.
2. Answer any five (5) questions.
3. Each question carries 20 marks.
4. Do not write your name inside or outside the answer booklet.
5. Do not write anything on the question paper.

This paper consists of 5 printed pages.

QUESTION 1

A cold store wall 6m long and 3m high is constructed of 120mm thick brick with an inside layer of 80mm thick cork insulation. The thermal conductivity of the brick is 1.15W/mk while that of cork is 0.043W/mk. The inner and outer wall surface temperatures are -4°C and 21°C respectively.

Calculate:

a) the amount of heat flow through the wall in 24h. (15 marks)

b) the interface temperature between the cork and the brick. (5 marks)

QUESTION 2

A single stage impulse turbine has a mean blade diameter of 600mm and a blade velocity of 120m/s. The nozzle angle is 18° and the enthalpy drop across the nozzles is 465kJ/kg. Determine:

a) the turbine rotational speed (6 marks)

b) the blade inlet angle (13 marks)

c) the axial component of the steam at the blade inlet (1 mark)

QUESTION 3

A steam turbine operating on the Rankine cycle receives steam from the boiler at $3.5MN/m^2$ and 350°C and exhaust to the condenser at $10kN/m^2$. The condensate is then returned to the boiler by the feed pump. Neglecting all losses, calculate:

a) the energy supplied in the boiler per kg of steam generated. (7 marks)

b) the dryness fraction of the steam entering the condenser. (7 marks)

c) the Rankine efficiency (6 marks)

QUESTION 4

a) Define and give one (1) example of the following terms:

i) Newtonian fluid (2 marks)
ii) Bingham fluid (2 marks)
iii) Pseudoplastic fluid (2 marks)
iv) Dilatant fluid (2 marks)

b) A liquid at 20°C has a relative density of 0.80 and a kinematic viscosity of 2.3 centistoke. Determine its:

i) Unit weight (4 marks)
ii) Dynamic viscosity (3 marks)

c) The space between two parallel plates kept 3mm apart is filled with an oil of dynamic viscosity of 0.2 Pa-s. Calculate the shear stress on the lower fixed plate if the upper one is moved with a velocity of 1.50m/s. (5 marks)

QUESTION 5

Figure Q5 shows a plate with a cross sectional area of $4cm^2$ moves at a constant velocity of 0.1m/s. A Newtonian fluid with a specific gravity of 0.92 and a Kinematic viscosity of $4 \times 10^{-4} m^2/s$, is filled between the plate and the fixed surface at a constant thickness of 5cm. Due to the 'no-splip' condition, the velocity of the fluid V, at any thickness of the fluid, y, can be determined by the velocity profile given by: $V = \frac{1}{3}y - 40y^3$

Determine:

a) Dynamic viscosity. (2 marks)

b) Magnitude and direction of shear stress developed on the plate. (5 marks)

c) Shear stress at the fixed surface. (3 marks)

d) Magnitude of force required to move the plate. (2 marks)

e) Percentage reduction or increment of the force required to move the plate, if the Newtonian fluid is replaced with water. (8 marks)

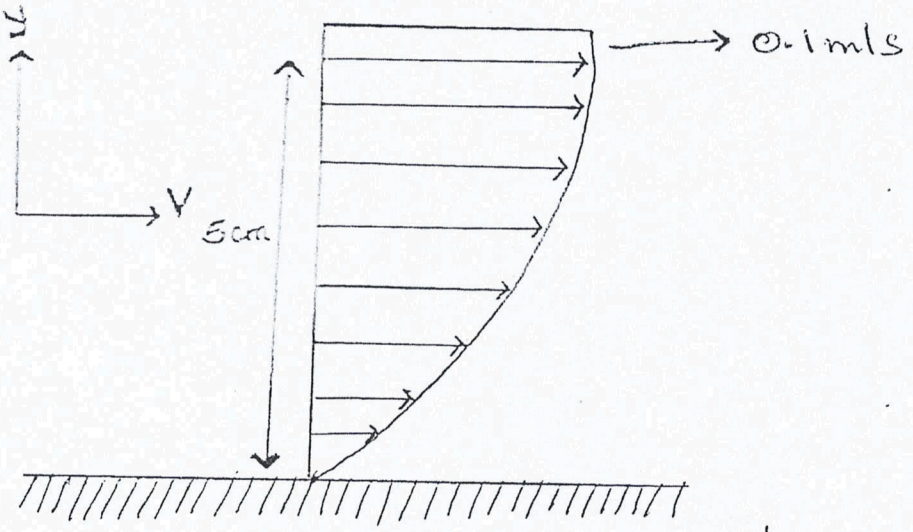

Fig Q5 Velocity profile

QUESTION 6

a) Explain Buckingham pi theorem. (2 marks)

b) Define the following terms:

i) Geometric similarity (2 marks)
ii) Kinematic similarity (2 marks)
iii) Dynamic similarity (2 marks)

c) Find an expression for the drag force on smooth sphere of diameter D moving a uniform velocity V in a fluid of density ρ and dynamic viscosity μ. (12 marks)

QUESTION 7

a) Differentiate between laminar and turbulent flow. (8 marks)

b) For linear distribution of velocity in the boundary layer on a flat plate is given by:

$$\frac{u}{u\infty} = \frac{y}{\delta}$$

Find the ratio of displacement thickness to momentum thickness. (12 marks)

QUESTION 8

A three (3) stage centrifugal pump has an impeller 40cm in diameter and 2cm width. The blade angle at outlet is 45° and the area occupied by thickness of the vanes may be assumed to be 8% of the outlet area. If pump delivered 3.6m^3/min when running at 920rpm. Calculate:

a) Manometric head (H_m) (11 marks)

b) Power of pump (input) (5 marks)

c) Specific speed.

Assume mechanical and manometric efficiency as 88% and 77% respectively. (4 marks)

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