higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

FLUID MECHANICS N5

(8190205)

5 August 2021 (X-paper)
09:00–12:00

Nonprogrammable calculators may be used.

This question paper consists of 7 pages and a formula sheet of 2 pages.

207Q1G2105

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
FLUID MECHANICS N5
TIME: 3 HOURS
MARKS: 100

NOTE: If you answer more than the required number of questions, only the required number of questions will be marked. All that work you do not want to be marked, must be clearly crossed out.

INSTRUCTIONS AND INFORMATION

1. Answer any FIVE of the SIX questions.
2. Read all the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Start each question on a new page.
5. Use only a black or blue pen.
6. Write neatly and legibly.

QUESTION 1

1.1 What is the purpose of a bearing lubrication process in a mechanism? (2)

1.2 Give any TWO advantages of a bearing lubrication process in a mechanism. (2)

1.3 Define the absolute coefficient of viscosity of a fluid and relate the kinematic viscosity in relation to this value (include units). (3)

1.4 A shaft with a diameter of 150 mm rotates inside a bearing with a diameter of 150,3 mm which is 170 mm long at a rotational frequency of 1 200 r/min. The oil lubricating this bearing has an absolute coefficient of viscosity of 0,02 Pa.s with a density of 830 kg/m^3.

Calculate the following:

1.4.1 The power loss due to viscous forces in kW (8)

1.4.2 The kinetic viscosity of the oil in m^2/s (2)

1.4.3 The power loss due to viscous forces if the shaft is not rotating, but moves axially through the bearing with a velocity of 5 m/s in kW (3)

[20]

QUESTION 2

2.1 A hydraulic motor vehicle hoist has a cylinder of 680 mm diameter and a plunger diameter of 42,5 mm.

Determine each of the following below:

2.1.1 The force that is required on the plunger to raise a vehicle with a mass of 2 250 kg (3)

2.1.2 The number of strokes that will be necessary to lift the vehicle by 3,4 m if the plunger has a stroke of 425 mm (3)

2.1.3 The work done in hoisting the vehicle to a height of 3,4 m (2)

2.1.4 Neglecting losses and assuming that the hoist moves at a steady rate, what power would be required to drive the plunger if the vehicle hoist is lifted 3,4 m in 51 seconds? (2)

2.2 A cylinder with a diameter of 60 mm is filled with hydraulic fluid with an isothermal bulk modulus of 2,035 GPa. The length of the cylinder filled with the fluid is 170 mm and the effective Young's modulus of elasticity for the cylinder material is 8,8 GPa when a force of 3,4 kN is applied to the piston rod.

Determine the following:

2.2.1 The cylinder stroke volume in m^3 (2)

2.2.2 The pressure exerted due to the force applied to the piston (2)

2.2.3 The bulk modulus of air in MPa if $\gamma = 1{,}4$ (1)

2.2.4 The effective bulk modulus in MPa, if there is 3,44% air present in the system (3)

2.2.5 The play on the piston due the presence of air in the cylinder (2)

[20]

QUESTION 3

3.1 A cylindrical tank with a diameter of 1,45 m and length of 3,75 m is mounted on its side with its length horizontal. If the tank is full of oil with a relative density of 0,963, determine each of the following below:

3.1.1 The hydrostatic pressure applied on the circular of the tank in kPa (3)

3.1.2 The hydrostatic force exerted on the circular of the tank in kN (2)

3.1.3 The centre of mass (gravity) in m^4 (2)

3.1.4 The position of this hydrostatic from the top surface oil in mm (3)

3.2 An iron marble of 5 cm in diameter is dropped from a height into a small container full of glycerine with a density 1 260 kg/m^3. The marble displaces the glycerine with 7,5% of its volume above the free surface of the glycerine.

Calculate the following:

3.2.1 The weight of the iron marble exerted on the glycerine (4)

3.2.2 The density of the iron marble (2)

3.2.3 The total weight required to fully submerge the iron marble in kg (4)
[20]

QUESTION 4

4.1 Define each of the following terms which are used to describe the flow of fluid:

4.1.1 A stream line

4.1.2 A stream tube

4.1.3 A path line

4.1.4 Turbulent flow

4.1.5 Laminar flow

(5 × 2) (10)

4.2 A quantity of 93,45 ℓ liquid flows through a hole out of a container in 22 seconds.

Determine the following:

4.2.1 The rate of flow of liquid through the 45 mm hole in m^3/s (1)

4.2.2 The velocity of flow through the hole (2)

4.3 A municipal water main with an internal diameter of 425 mm has a connection leading from the main, gradually tapering to a pipe 6,8 m below with an internal diameter of 212,5 mm. Water in the small pipe is at a pressure of 1 351,5 kPa and flowing at 10 540 ℓ/min when no one else in the neighbourhood is drawing water.

Determine the following:

4.3.1 The velocity of flow in the 425 mm diameter pipe (2)

4.3.2 The velocity of flow in the 212,5 mm diameter pipe (2)

4.3.3 Neglect all possible losses and apply Bernoulli's equation to calculate the pressure in the municipal main. (3)
[20]

QUESTION 5

5.1 Briefly define an *orifice*. (2)

5.2 An orifice with a diameter of 14,5 mm at the bottom of a tank can discharge an average of 4,774 ℓ of water per second into the atmosphere at a head of 59,4 m.

Determine the following:

5.2.1 The theoretical velocity of flow through the orifice (2)

5.2.2 The actual velocity of flow through the orifice if the jet diameter just after the vena contracta is 13,4 mm (2)

5.2.3 The coefficient of contraction (2)

5.2.4 The coefficient velocity (2)

5.2.5 The coefficient of discharge (2)

5.2.6 The head loss through the orifice (3)

5.3 An orifice plate meter is fitted to a pipe with a diameter of 340 mm carrying oil with relative density of 0,88. The pressure gauge indicates an average pressure of 6,8 kPa as the oil flows through the pipe and orifice diameter respectively. The meter has a coefficient of 0,715 and an orifice diameter of 213,5 mm.

Calculate actual flow through the system in ℓ/s. (5)

[20]

QUESTION 6

A horizontally-placed reducing bend with an inlet diameter of 220 mm and an outlet diameter of 100 mm bends 52° upwards. The outlet is 1,35 m above the inlet. Oil with a density of 820 kg/m^2 flows through the bend at an average velocity of 2,356 m/s and at a pressure of 86,856 kPa at the inlet.

Determine the following:

6.1 The weight flow along the bend in N/s (2)

6.2 The velocity of flow at the inlet bend (2)

6.3 The mass flow rate of oil through the bend in kg/s (2)

6.4 The pressure at the outlet if the friction head through the bend is 1,063 m (4)

6.5 The momentum force at the inlet to the bend in Newton (1)

6.6	The force due to the fluid pressure at the inlet to the bend in Newton	(1)
6.7	The momentum force at the outlet to the bend in Newton	(1)
6.8	The force due to the fluid pressure at the outlet to the bend in Newton	(1)
6.9	The magnitude of the resultant force through the bend in kN	(4)
6.10	The direction of the resultant force through the bend	(2)
		[20]

TOTAL: 100

FLUID MECHANICS N5: FORMULA SHEET

$$\rho = \frac{m}{v}$$

$$SG = Rel = \frac{\rho_{\text{substance}}}{\rho_{water}}$$

$$Specific\omega = \frac{weight}{volume} = \rho g$$

$$P = \frac{F}{A}$$

$$P_{absolute} = P_{gauge} + P_{atmospheric}$$

$$P_{gauge} = \rho g h$$

$$F_{Surface\ tension} = \sigma 2\pi R$$

$$\Delta P = P_i - P_o = \frac{2\sigma}{R} = \frac{4\sigma}{D}$$

$$F_{viscous} = \frac{\mu A v}{t} \text{ and } \upsilon = \frac{\mu}{\rho}$$

$$W = mg$$

$$W_{\substack{perpendicular-inclined \\ plane}} = mg\cos\theta$$

$$W_{\substack{parallel-inclined \\ plane}} = mg\sin\theta$$

$$K_e = \frac{P}{\varepsilon_v}$$

$$\varepsilon_v = \frac{\Delta V}{V}$$

$$\frac{1}{K_e} = \frac{1}{K_\ell} + \frac{1}{K_c} + \frac{V_g}{V_t}\left(\frac{1}{K_g}\right)$$

$$K_g = \delta P \text{ and } K_c = \frac{E}{2{,}5}$$

$$F_{hydrostatic} = \rho g A\bar{y}$$

$$\bar{h} = \frac{I_g Sin^2\theta}{A\bar{y}} + \bar{y}$$

$$I_{g(\text{rectangular})} = \frac{bd^3}{12}$$

$$I_{g(\text{circular})} = \frac{\pi D^4}{64}$$

$$W = R = \rho g V$$

$$V_{\substack{hollow-pipe \\ with\ closed\ ends}} = \pi DLt + 2\frac{\pi}{4}D^2 t$$

$$\overset{\circ}{Q}\ or\ \overset{\circ}{V} = A_1 u_1 = A_2 u_2; \quad \overset{\circ}{m} = \rho \overset{\circ}{V}; \quad \overset{\circ}{W} = g\ \overset{\circ}{m} = \rho g A u; \quad P = H\overset{\circ}{W} = \rho g Q H$$

$$\frac{P_1}{\rho g} + \frac{u_1^2}{2g} + Z_1 + \frac{P_{pump}}{\overset{\circ}{W}} = H_{total} = \frac{P_2}{\rho g} + \frac{u_2^2}{2g} + Z_2 + \frac{P_{motor}}{\overset{\circ}{W}} + \frac{P_{turbine}}{\overset{\circ}{W}} + h_{loss}\ (J/N,\ m)$$

$$\frac{P_{turbine}}{\overset{\circ}{W}} = Turbine\ head; \quad \frac{P_{pump}}{\overset{\circ}{W}} = Pump\ head; \quad \eta = \frac{P_F}{P_m} \times 100; \quad R_e = \frac{\rho v D}{\mu}$$

$\underline{h_{loss}\ (J/N)\ or\ m:}$

$$h_s = k\frac{u^2}{2g}; \quad h_s = \left(\frac{1}{C_c} - 1\right)^2 \frac{u^2}{2g}; \quad h_a = h(1 - C^2{}_v); \quad h_f = 4f\left(\frac{L_e}{d}\right)_T \frac{u^2}{2g}$$

$$\frac{l}{d} = \frac{k}{4f}$$

$$h_s = \frac{(u_1 - u_2)^2}{2g}$$

$$F_{inlet} = \overset{\circ}{m}u_1 + P_1 A_1 \quad and \quad F_{exit} = \overset{\circ}{m}u_2 + P_2 A_2$$

$$Flat\ plate: \quad Stationary\ F = \rho A u^2 \quad Moving\ F = \rho A(u - u_m)^2 \quad Angle\ F = \rho A u^2 Cos\theta$$

$$Curved: \ X - Direction \quad F_x = \rho A u^2 (1 + Cos\theta) \quad Y - Direction \quad F_y = \rho A u^2 Sin\theta$$

$$U_m = \frac{\pi D n}{60}; \quad P = \overset{\circ}{m} V_{w_t} u_m; \quad \eta = \frac{2V_w u_m}{u_1^2}\ x\ 100$$

