higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

FLUID MECHANICS N5

(8190205)

15 April 2021 (X-paper)
09:00–12:00

Nonprogrammable calculators may be used.

This question paper consists of 6 pages and a formula sheet of 2 pages.

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DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

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

INSTRUCTIONS AND INFORMATION

1. Answer any FIVE of the SIX questions.
2. If you answer more than the required FIVE questions, only the first five questions will be marked. All work you do not want to be marked must be clearly crossed out.
3. Read all the questions carefully.
4. Number the answers according to the numbering system used in this question paper.
5. Only use a black or blue pen.
6. Write neatly and legibly.

QUESTION 1

1.1 Define the terms concerning fluids and write down the unit of measurement for each one:

1.1.1 Specific weight

1.1.2 Relative density

1.1.3 Surface tension

(3 × 2) (6)

1.2 A 300 ℓ drum is filled with oil with a relative density of 0,96.

Determine:

1.2.1 The specific weight of the oil

1.2.2 The weight of the oil

(2 × 2) (4)

1.3 A piston moves (slides) inside a cylinder at an average velocity of 3,25 m/s. The cylinder has an inside diameter of 310 mm and the piston diameter is 309,5 mm with a length of 200 mm. The piston is lubricated with oil with a coefficient of viscosity of 0,196 Pa.s.

Determine:

1.3.1 The force to overcome viscous resistance inside the cylinder (8)

1.3.2 The power loss due to viscous resistance inside the cylinder (2)

[20]

QUESTION 2

2.1 Define *Pascal's law* and state its application and units. (3)

2.2 A hydraulic brake system is used as a test rig and the following specifications of the device were collected from the experiment:

Master cylinder piston diameter = 40 mm
Slave cylinder piston diameter = 60 mm
Mechanical advantage (MA) = 5
Force induced (slave cylinder) = 6 000 N
Slave cylinder piston movement = 7,41 mm per stroke

Calculate:

2.2.1 The pressure exerted by the pedal on the master cylinder during the test (3)

2.2.2 The distance the pedal should move in order to move the slave cylinder for 7,41 mm per stroke (4)

2.3 A single-rod double-acting hydraulic actuator has a stroke length of 400 mm with a diameter of 210 mm. The rod diameter is 60 mm and it is fed with a flow rate of $0{,}56\ l/s$. A force of 6 000 N is applied to the actuator during its operation.

Calculate:

2.3.1 Time taken for the forward and return strokes (8)

2.3.2 The pressure induced on the piston on the side where the rod is (2)

[20]

QUESTION 3

3.1 A drum which is 6 m long and which has an internal diameter of 3,6 m is filled with oil with a relative density of 0,84. The total mass of the empty drum is 90 kg.

3.1.1 Calculate the force exerted by the drum (filled with oil) on the surface of seawater.

3.1.2 Take the density of the seawater as 1 025 kg/m^3 and calculate the draught of the drum.

(2 × 2½) (5)

3.2 A solid steel pipe which is 3,8 m long and which has a diameter of 1,55 m, is floating in freshwater with 45% of its volume below the surface of the water.

Determine:

3.2.1 The mass of the solid pipe (5)

3.2.2 The mass of the load that enables the pipe to float just below the water surface.

NOTE: The density of steel is 8 000 kg/m^3. (6)

3.2.3 The hydrostatic force on one of the circular sides if the solid pipe when it floats horizontally 2,25 m below the surface of the water (4)

[20]

QUESTION 4

4.1 A lorry transporting petrol is loaded to its maximum capacity with petrol at 3 litres per minute (relative density of 0,87) in an average time of 18 minutes during loading operations. There is an average pressure of 34 kPa in the feed pipe from the lorry at a valve at ground level when the valve is closed.

Calculate:

4.1.1 The maximum load that the lorry can take during the 18 minutes that it is loaded to its capacity

4.1.2 The petrol free surface during the time of loading the lorry to its capacity

(2 × 3) (6)

4.2 The inlet of a pipe has a diameter of 300 mm and it tapers to a diameter of 250 mm. The pipe then branches from the 250 mm section into two different pipes of 140 mm and 95 mm respectively. Oil with a density of 850 kg/m^3 enters the pipe at a velocity of 4 m/s. The velocity in the pipe with a diameter of
95 mm is 3,85 m/s.

Calculate:

4.2.1 The velocity of flow in the section of the pipe that has a diameter of 250 mm (3)

4.2.2 The flow rate in the pipe with a diameter of 140 mm (4)

4.2.3 The velocity of flow in the pipe with a diameter of 140 mm (3)

4.2.4 The weight flow in each of the two pipes of the fork (4)

[20]

QUESTION 5

5.1 Define:

5.1.1 Laminar flow or viscous flow

5.1.2 Unsteady flow

(2 × 2) (4)

5.2 Oil with a density of 900 kg/m^3 is flowing in a pipeline system with a diameter of 350 mm. A pitot tube is used as a flow velocity measuring tool. The pressure difference between the pitot tube orifice and the static orifice energy point is indicated in a mercury manometer as a head of 40 mm of mercury rise. The legs to the mercury manometer are filled with water. The average velocity of the flow in the system is 0,9 times the central velocity of flow.

Calculate the rate of flow in the oil pipeline in ℓ/s (8)

NOTE: Assume the coefficient of the tube as unity.

5.3 A pipe with a 50 mm diameter has a sudden reduction in diameter to 20 mm. The flow rate in the system is $6\ l/s$.

Calculate:

5.3.1 The change in velocity head (6)

5.3.2 The head loss due to the sudden reduction in diameter if C_c = 0,7 (2)

[20]

QUESTION 6

6.1 Briefly explain the function of a pump in a hydraulic system. (2)

6.2 A hydraulic reservoir pressurised to 12,5 kPa contains a fluid with a density of 960 kg/m^3. The reservoir feeds a hydraulic pump with a flow rate of 10 l/s through a filter with a shock loss constant (k) of 4.

After the pump, there are two bends, each with a shock loss constant (k) of 0,85 and a selector valve with a length to diameter ratio of 60. The actuator requires a pressure of 4,25 MPa to operate. The actuator is located 6 m lower than the fluid level in the reservoir. A 30 mm diameter pipe of 15 m connects the components. The pipe has a friction coefficient of 0,015.

Calculate:

6.2.1 The total length to diameter ratio of the system (ignore entrance loss to the pipe.) (6)

6.2.2 The total head loss throughout the system (4)

6.2.3 The fluid power the pump requires to operate the actuator (4)

6.2.4 The head loss across the filter fitting (4)

[20]

TOTAL: 100

FLUID MECHANICS N5

FORMULA SHEET

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

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

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

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

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

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

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

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

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

$$W = mg$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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