higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

FLUID MECHANICS N5

(8190205)

9 April 2020 (X-paper)
09:00–12:00

Drawing instruments and nonprogrammable calculators may be used.

This question paper consists of 7 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

NOTE: 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.

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 section on a new page.
5. Use only a black or a blue pen.
6. Write neatly and legibly.

QUESTION 1

1.1 Define the following terms:

1.1.1 Fluid

1.1.2 Vapour pressure of water

(2 × 2) (4)

1.2 A bearing in a petrol engine is lubricated with an oil which has an absolute coefficient of viscosity of 0,7 Pa/s. The shaft diameter is 46 mm with a bearing diameter of 46,3 mm and a length of 50 mm. The shaft rotates at 3 500 r/min.

Calculate:

1.2.1 The power used to overcome the fluid resistance (9)

1.2.2 The change in power used to overcome fluid resistance, when the coefficient of viscosity has been reduced to a value of 0,1 Pa/s while the shaft rotates at the same speed (5)

1.2.3 The kinematic viscosity under the new condition mentioned in QUESTION 1.2.2 (2)

[20]

QUESTION 2

2.1 2.1.1 What is the function of a hydraulic accumulator in a hydraulic system? (1)

2.1.2 Give THREE examples of a hydraulic accumulator. (3)

2.2 The diameter of a piston of a double-acting single-rod actuating cylinder is 75 mm and the diameter of the rod is 30 mm as shown in FIGURE 1. The actuator is fitted to a system where the pressure in maintained at 20 kPa.

Determine the difference in the force applied on the sides of the piston.

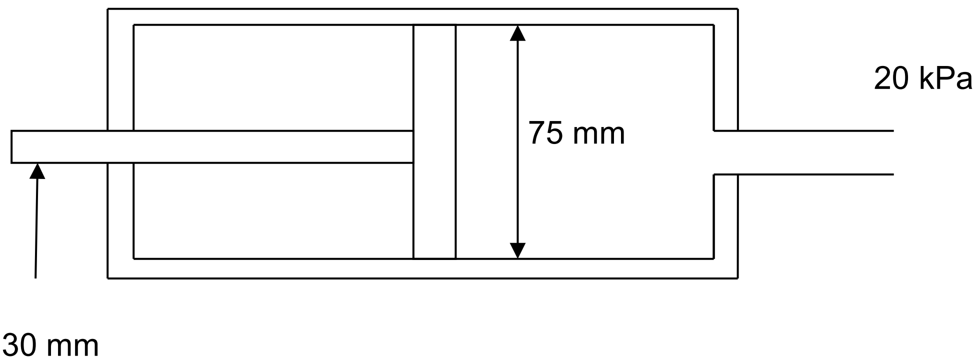

FIGURE 1 (6)

2.3 A vertically placed cylindrical tank of 2,5 m in length and 700 mm in diameter, contains two immiscible fluids, water and oil, up to a head of 2,35 m. The depth of the water and oil in the tank are 1 500 mm and 850 mm respectively. The tank is pressurised to a pressure of 1 MPa resulting in a longitudinal and circumferential strain. The bulk moduli of the water and oil are 2 100 MPa and 2 060 MPa respectively.

Calculate the total drop in height of both fluids due to the pressure of 1 MPa, but ignore the impact of the circumferential strain (hydrostatic pressure) from the given information. (10)

[20]

QUESTION 3

3.1 A half-section of a ship as shown in FIGURE 2, the side is vertical to a depth of 1 m below the waterline and then curves to the centre line in the form of a parabolic arc, the axis of the parabola being a horizontal line of 1 m below the waterline.

Determine the magnitude and direction of the resultant hydrostatic force per metre length along the half-section. Take the density of the water as 1 025 kg/m^3.

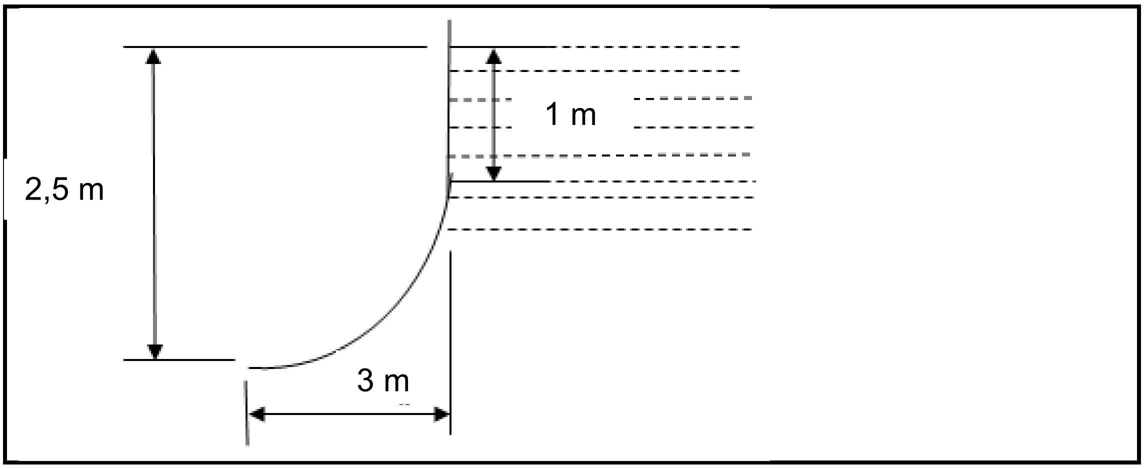

FIGURE 2 (10)

3.2 The piston of the ball valve as shown in FIGURE 3, has an effective diameter of 13 mm. The valve only closes when a quarter of the volume of the ball is submerged in water.

Calculate the pressure in kPa of the main supply. Also make use of the information provided in the sketch.

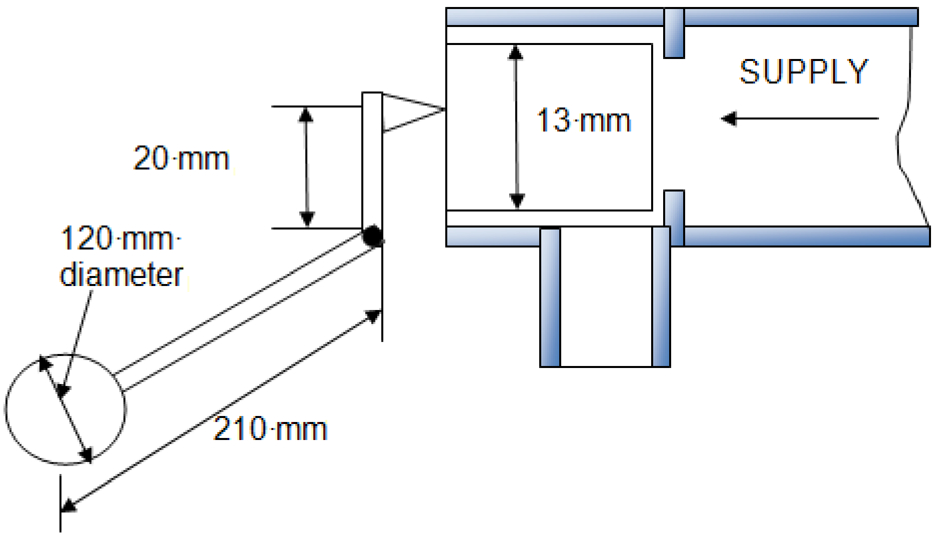

FIGURE 3 (10)

[20]

QUESTION 4

4.1 Oil with a density of 900 kg/m^3 flows through a pipeline which contracts from 70 mm diameter to 40 mm diameter. The velocity of the oil flow is 4,25 m/s at the exit of the reducer.

Calculate:

4.1.1 The volumetric flow of the oil along the pipeline (2)

4.1.2 The mass flow of the oil along the pipeline (2)

4.1.3 The entrance velocity of the oil flow (2)

4.1.4 The diameter of the two-discharge pipe, if the pipeline forks (branches) into two pipes, with $\frac{3}{5}$ of the total flow discharging through one leg and the remaining into the other leg. Assume a limiting condition for the velocity of the oil flow of 3,25 m/s per leg. (6)

4.2 A pipe gradually expands from a 120 mm diameter at entrance and connects into a 180 mm diameter pipe of which the centre is 3,5 m above the entrance. The direction of flow for the water is upwards at a rate of 20 ℓ/s.

Calculate:

4.2.1 The velocities at the entrance and exit of the pipe (3)

4.2.2 The exit pressure if the pressure at the entrance is 0,6 MPa. Ignore all possible losses. (5)

[20]

QUESTION 5

5.1 Briefly explain the use of a pitot tube and the use of an orifice flow meter in a fluid flowing system. (2)

5.2 A pitot tube is placed with its opening in the centre of a 65 mm diameter pipe and its static port is placed on the side of the pipe at 90° to the flow direction of the oil. It is used to measure the velocity of the oil flowing in the pipe. The relative density is 0,86 and the height of the mercury in the U-tube, which is attached to these points, is 30 mm.

Calculate the flow rate in the pipe if the average velocity is 0,82 times the central velocity and the coefficient of discharge is unity. (7)

5.3 A sharp edge orifice of 50 mm in diameter on the vertical side of the tank, discharges water under a head of 42,5 m. If the coefficient of contraction is 0,65 and the coefficient of velocity is 0,98.

Calculate:

5.3.1 The diameter of the jet at the vena contracta (3)

5.3.2 The velocity of the jet at the vena contracta (4)

5.3.3 The actual discharge through the orifice in litres per second (2)

5.3.4 The head loss due to the fluid resistance at exit from the orifice (2)

[20]

QUESTION 6

A water turbine has a wheel with the vanes mounted at a mean diameter of 0,4 m and rotating at 716,19 r/min. A stream of water at an angle of 20° leaves the nozzle at 40 m/s and flows over the vanes at a rate of 20 kg/s. There is a loss of 10% relative velocity when the water passes over the vanes and the vanes and nozzle are arranged in such a way that no axial thrust occurs. Use a scale of 10 mm = 2 m/s

Determine:

6.1 The inlet blade tip angle by drawing an inlet vector diagram (7)

6.2 The velocity at which the water leaves the turbine by drawing the outlet vector diagram (6)

6.3 The theoretical power output of the turbine according to the diagrams obtained in QUESTIONS 6.1 and 6.2. (4)

6.4 The diagram efficiency of the turbine (3)
[20]

TOTAL: 100

FLUID MECHANICS N5

FORMULA SHEET

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

<u>$h_{loss} \; (J/N) \; or \; m:$</u>

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

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

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

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

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

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