higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T710**(E)**(N23)T

NATIONAL CERTIFICATE

FLUID MECHANICS N5

(8190205)

23 November 2018 (X-Paper)
09:00–12:00

Nonprogrammable calculators and drawing instruments may be used.

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

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 will be marked. Clearly cross out ALL work you do NOT want to be marked.

INSTRUCTIONS AND INFORMATION

1. Answer any FIVE questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Use $g = 9{,}81\ m/s^2$.
5. Show ALL units in the answers.
6. Write neatly and legibly.

QUESTION 1

1.1 Define the term *density* and give the units in which it is measured. (2)

1.2 The pressure of an aircraft tyre is measured at a gauge pressure of 3 bar on the ground at the airport runway after landing where the barometer conditions indicated 710 mm Hg.

Calculate:

1.2.1 The atmospheric pressure at the airport (2)

1.2.2 The absolute pressure of the aircraft tyre (2)

1.2.3 What will the pressure in the tyre be at a higher altitude? (1)

1.3 A single-rod single-acting actuator has a cylinder with an external diameter of 120,5 mm, a wall thickness of 5 mm, a piston diameter of 110 mm, a hydraulic fluid with an absolute viscosity of 0,009 Pa/s and a piston 60 mm wide which is required to move at 5 m/s on its outward stroke and applies a force of 3 000 N with a 50 mm-diameter rod.

Calculate:

1.3.1 The viscous force that must be overcome on the outward stroke (5)

1.3.2 The pressure required (2)

1.3.3 The force on the return stroke (2)

1.3.4 The flow rate for this operation (2)

1.3.5 The velocity of the piston on the return stroke (2)

[20]

QUESTION 2

2.1 An 80 mm-diameter double-acting single-rod actuator is fed with a volumetric flow of 0,85 ℓ/s. It is designed to exert a maximum force of 3,5 kN. The time for the return stroke is ⅝ the time of the forward stroke.

Calculate:

2.1.1 The pressure required (3)

2.1.2 The rod diameter (5)

2.1.3 The time taken for the forward and return strokes if the stroke length is 300 mm (4)

2.2 What is the function of a barometer and the purpose of a vacuum at the top of the closed end of a tube? (2)

2.3 A pressure vessel contains oil and water to a depth of 800 mm and 1,3 m respectively. The vessel is pressurised to a pressure of 1 MPa.

The bulk modulus of the two immiscible liquids are as follows:

Oil: 2 060 MPa
Water: 2 100 MPa

Determine the downward movement of the oil and water. (6)
[20]

QUESTION 3

3.1 A sluice gate on a dam wall is in the form of a quarter circle with a diameter of 3 m. The gate is 5,5 m wide.

Calculate the resultant force and its angle of application on the gate. (10)

3.2 A piece of wood with dimensions of 2 m × 600 mm × 90 mm is floating on liquid mercury with a draught of 60 mm.

Determine:

3.2.1 The mass of the piece of wood (4)

3.2.2 The density of the wood (2)

3.2.3 The force to fully submerge the wood (4)
[20]

QUESTION 4

4.1 A jet of water with a diameter of 45 mm is discharged vertically upwards to the atmosphere. The jet exits the nozzle at a velocity of flow of 11 m/s and remains constant with a cross-sectional area until it reaches a height of 4 m.

Determine:

4.1.1 The weight flow of the water (3)

4.1.2 The velocity of the jet at the height of 4 m (3)

4.1.3 The diameter of the jet at the height of 4 m (3)

4.1.4 The power of the jet (3)

4.1.5 The flow kinetic energy of the jet at the nozzle (4)

4.2 Explain the difference between a *streamline* and a *stream tube.* (2 + 2) (4)

[20]

QUESTION 5

5.1 A confined tank is fitted with a 30 m-diameter sharp-edged orifice with a coefficient of discharge of 0,7. The liquid in the tank has a relative density of 0,8 and the surface of the liquid is 6 m above the centre of the orifice. To increase the rate of flow it was decided to pressurise the tank to a pressure of 50 kPa.

Calculate:

5.1.1 The flow rate through the orifice at the pressure (5)

5.1.2 The height of the liquid to be maintained above the centre of the orifice if the surface of the liquid is to be freed while keeping the same flow rate (4)

5.2 A basin discharges a liquid with a relative density of 1,015 into the atmosphere through a cloggy 40 mm-diameter pipe 15 m long with a pipe-friction coefficient (including clog in the pipe) of 1,1. The outlet is 5 m below the liquid surface of the liquid in the basin. A flow-control valve with an L/d ratio of 1,5 is fitted towards the discharge end of the pipe.

Calculate the flow rate that would flow from the basin if there is a shock loss at the entrance to the pipe with a loss coefficient of 0,5. (11)

[20]

QUESTION 6

In a hydraulic system, oil with a density of 900 kg/m3 is compressed inside a confined tank with an average pressure of 20,895 kPa. A pump is fed from the tank, which is connected adjacent to a pressure-regulating valve with a loss coefficient of 5 cut-in conditions. A selector valve with an L/d ratio of 400 in the selected condition follows the two components (pump and valve) and then an actuator with an average operating pressure of 800 kPa is connected to the system at 15 m below the oil surface level in the tank. A 20 m-long pipe 40 mm in diameter is used to connect all the components of the hydraulic system with two 900 bends included. Each bend has a shock-loss coefficient of 0,75. The head loss at entry to the pipe is $h_{entry} = \frac{0,5v^2}{2g}$.

Use a pipe friction of 0,002 for the system.

If a flow rate of 1,55 litres per second is required for the system, calculate:

6.1 The total length to diameter ratio of the system (5)

6.2 The total head loss of the system (4)

6.3 The pump head needed to maintain a safe working pressure at the actuator (5)

6.4 The input power required to drive the pump when there is 20% loss in the transmission of power (6)
[20]

TOTAL: 100

FORMULA SHEET

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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