higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T710(**E**)(A6)T

NATIONAL CERTIFICATE

FLUID MECHANICS N5

(8190205)

6 April 2018 (X-Paper)
09:00–12:00

Nonprogrammable calculators may be used.

Candidates need drawing instruments.

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. 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 in this question paper.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Use the value of g = 9,81 m/s^2.
5. ALL units must at least be shown in the answers.
6. Write neatly and legibly.

QUESTION 1

1.1 Define the term *kinematic viscosity,* and give its units. (2)

1.2 If oil with a high viscosity is used for the lubrication of bearings, what impact will it have on the motion and the power? (2)

1.3 A shaft with a diameter of 120 mm rotates in a sleeve 120,2 mm in diameter at 1 100 r/min. The sleeve is 100 mm long and is lubricated by an oil with a dynamic viscosity of 0,42 Pa.s.

Calculate the following:

1.3.1 The power loss to viscous forces in the bearing (9)

1.3.2 The maximum rotational frequency of the shaft to limit the maximum power loss to 3 kW, with no changes to other variables (5)

1.3.3 The kinematic viscosity of the oil if it has a mass density of 900 kg/m^3 (2)

[20]

QUESTION 2

2.1 Define the *function* of a *hydraulic accumulator* in a fluid flowing system. (3)

2.2 Briefly explain the impact of the presence of air in a hydraulic system in relation to free play, cylinders and pipes. (2)

2.3 A cylinder 80 mm in diameter and 250 mm long is filled with a fluid with an isothermal bulk modulus of 2,5 GPa. A force of 3 000 N is applied onto a piston in the cylinder.

Calculate the play on the piston as a result of the 3 000 N force in the following cases:

2.3.1 If no air is present and the expansion of the cylinder is ignored. (6)

2.3.2 If 3% of the air is present in the cylinder and the Young's Modulus of elasticity of the cylinder material is 210 GPa. (9)

[20]

QUESTION 3

3.1 A gate in a channel is 2 m wide and 1 m deep. The gate is hinged at the top with two hinges and the lower point is kept closed with a bolt 2 m lower than the two hinges. The water surface is at the top of the gate.

3.1.1 Find the load on the bolt and the hinges. (8)

3.1.2 If the gate is in a water reservoir where its centre is 12 m below the water surface, determine the hydrostatic force under these conditions. (2)

3.2 A 50-ton ship is sailing in seawater with a density of 1 035 kg/m^3 .

Determine the following:

3.2.1 The volume of seawater displaced by the ship (3)

3.2.2 The volume of seawater which could be displaced by the ship if the ship was sailing in fresh water (2)

3.2.3 The mass of cargo that is loaded on the ship if 30% more volume of seawater was displaced than the volume in QUESTION 3.2.1 (5)

[20]

QUESTION 4

4.1 A 3 m^3 tank must be filled with oil in an estimated time of 1,25 hours.

Determine the following:

4.1.1 The rate of flow required under these conditions (2)

4.1.2 The velocity of flow in the pipe if a 30 mm diameter pipe is connected to the side of the tank (2)

4.1.3 The weight flow if the specific gravity of the oil is 0,95 (3)

4.1.4 The type of flow in the pipe system if the kinematic viscosity of the oil is 0,065 Pa.s (4)

4.2 Define the following terms which are used to describe the flow of a fluid:

4.2.1 A stream line (2)

4.2.2 A steam tube (2)

4.2.3 A path line (1)

4.2.4 Lamina flow (2)

4.2.5 Turbulent flow (2)
[20]

QUESTION 5

5.1 Give the function of each of the following in a fluid flowing system:

5.1.1 A rota-flow meter

5.1.2 A pitot tube

(2 × 1) (2)

5.2 A pitot tube is used to measure the flow rate of air with a density of 1,3 kg/m^3 in a 150 mm diameter pipe. An oil manometer is used to measure the pressure difference between the pitot tube and the static port in the side of the pipe.

If the coefficient of the tube is 0,95 and the average velocity is 75% of the central velocity, determine the manometric head for a flow rate of 50 ℓ/s. (10)

5.3 A valve and a filter must be installed into a pipeline. The valve has an L/d ratio of 8 and the filter has an L/d of 6. The velocity of flow is 3 m/s and the frictional coefficient of the pipe is 0,007.

Determine the pressure drop over the filter and valve if the density of the fluid is 920 kg/m^3. (8)
[20]

QUESTION 6

A water turbine has a wheel with vanes mounted at a mean diameter of 0,5 m and rotating at 763,944 r/min. A 45 m/s jet of water is discharged through a nozzle inclined at 25^0 to the wheel of rotation and flows over the blade at a mass rate of 25,3 kg/s. There is a blade frictional loss of 12,5% for the relative velocities over the moving vanes. The blades and nozzles are designed to ensure that no axial thrust occurs in the turbine.

6.1 Draw the complete velocity diagram for the above turbine.

Use a scale of 1 cm = 2 m/s for the construction of the velocity diagram.

Marks will be deducted for the incorrect scale. (8)

6.2 From the velocity diagram in QUESTION 6.1, determine the following:

6.2.1 The moving blade inlet and outlet angle

6.2.2 The relative velocities at the inlet and outlet of the moving blade

6.2.3 The angle and velocity of the water exiting the turbine

6.2.4 The total whirl or vortex velocity

6.2.5 The power generated by the turbine

6.2.6 The turbine overall efficiency

(6 × 2) (12)
[20]

TOTAL: 100

FORMULA SHEET

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

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

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

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

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

$$P_{gauge} = \rho gh$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

$$\text{Curved: } X - \text{Direction} \quad F_x = \rho A u^2 (1 + \cos\theta) \quad Y - \text{Direction} \quad F_y = \rho A u^2 \sin\theta$$

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