higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

FLUID MECHANICS N5

(8190205)

18 November 2020 (X-paper)
09:00–12:00

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

141Q1E2018

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 questions.
2. Read all the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Work neatly and legibly.

QUESTION 1

1.1 The surface tension coefficient of a fluid is 0,085 N/m and the diameter of a droplet of the fluid is 6 mm.

Calculate each of the following:

1.1.1 Surface tension force of droplet (3)

1.1.2 Pressure difference over skin of droplet (2)

1.2 A flat plate with a contact surface area of 1,5 m^2 is moved over a smooth surface with a velocity of 0,65 m/s. The smooth surface is lubricated with a layer of oil with an absolute coefficient of viscosity of 0,11 Pa/s. The oil film is 0,3 mm thick.

Calculate each of the following:

1.2.1 Force required to overcome viscous forces when flat plate is moved (2)

1.2.2 Work done per second (2)

1.2.3 Kinematic viscosity of oil if relative density of oil is 0,95 (4)

1.2.4 Width, if the flat plate in QUESTION 1.2 is replaced with a 600 mm long rectangular plate moving at a velocity of 0,78 m/s. The absolute coefficient of viscosity and the oil film thickness changed to 0,07 Pa/s and 0,2 mm respectively. The work done per second to overcome friction is 90 W. (7)

[20]

AND/OR

QUESTION 2

2.1 Define the *bulk modulus* of a fluid in a system. (2)

2.2 A hydraulic press has a plunger with a diameter of 20 mm and a hand lever with a mechanical advantage of 8 operating the plunger. The hydraulic press is designed to withstand a working pressure of 6 MPa. Take the isothermal bulk modulus of the liquid as 1,8 GPa.

Calculate each of the following:

2.2.1 Maximum force a hydraulic ram of 60 mm would be able to exert on a load (2)

2.2.2 Effort required at the lever to operate the hydraulic press (3)

2.2.3 Total number of strokes necessary for the lever to operate the plunger to move the ram a distance of 120 mm if the effective stroke length of the plunger is 35 mm (3)

2.2.4 Play on the ram due to compressibility of the fluid if the nonreturn valve is fitted at the fluid entrance of the ram and the volume that must be considered is only due to the 120 mm movement (4)

2.2.5 Alteration of play if there is 155 mℓ of air trapped inside the ram (6)
[20]

AND/OR

QUESTION 3

3.1 Explain the expressions below regarding objects partially or fully submerged in a liquid.

3.1.1 Buoyancy force of liquid

3.1.2 Draught of partially or fully submerged object in liquid
(2 × 1) (2)

3.2 The top of a round glass on the vertical side of a seawater fish tank is fitted 3 m below the surface of the water. The density of the seawater is 1020 kg/m^3.

Calculate each of the following:

3.2.1 Hydrostatic force the window must withstand if its diameter is 0,9 m (5)

3.2.2 Centre of pressure position the hydrostatic force are acting from the seawater surface (4)

3.3 A rectangular pontoon which is 6,25 m long and 4 m wide has a draught of 1,2 m in fresh water.

Calculate each of the following:

3.3.1 Mass in tonnes of the pontoon in fresh water (2)

3.3.2 Draught of the pontoon in the seawater (density of seawater is 1020 kg/m^3). (3)

3.3.3 Quantity in litres of fresh water required to submerge the pontoon if the total draught of the pontoon is 1,66 m (4)
[20]

AND/OR

QUESTION 4

4.1 Define each of the following terms in relation to patterns of the fluid within a system:

4.1.1 Path line

4.1.2 Stream line

(2 × 2) (4)

4.2 A water pipeline has a diameter of 60 mm at the entrance and 45 mm at the exit. At the entry, the velocity of water flow is 8 m/s and the exit pressure must not exceed 50 kPa. There is a system head loss of 3 m and the exit is 5,5 m above pipeline entry section.

Calculate each of the following:

4.2.1 Weight flow in N/s (2)

4.2.2 Pressure at entrance (6)

4.2.3 Water power at entrance (3)

4.2.4 Water power at exit (3)

4.2.5 Overall hydraulic efficiency (2)

[20]

AND/OR

QUESTION 5

5.1 Give TWO advantages and ONE disadvantage of an orifice plate meter compared to a venturi meter used for measuring and data collection in a fluid flowing system. (2 + 1) (3)

5.2 The water overflow from a tank on a stand is discharged at a velocity of 2,55 m/s in a circular jet with a 30 mm diameter dropping 5 m to the ground.

Determine each of the following:

5.2.1 Velocity with which water falls to the ground (4)

5.2.2 Diameter of jet at ground level if it remains circular (2)

5.2.3 Kinetic energy per unit weight of jet just before reaching ground level (3)

5.3 A venturi meter is installed in a 65 mm diameter pipe to measure the flow rate of oil with a mass density of 900 kg/m^3. The difference between the readings of the two pressure gauges fitted at the entrance and the throat of the meter is 25 kPa.

Determine the true flow rate through the meter if the throat diameter of the venturi meter is 40 mm and the meter has a coefficient of 0,87. (8)

[20]

AND/OR

QUESTION 6

6.1 Indicate whether the following statements are TURE or FALSE by writing only 'True' or 'False' next to the question number (6.1.1–6.1.2) in the ANSWER BOOK.

6.1.1 If the area increases, the velocity increases.

6.1.2 Turbulent flow means the fluid is flowing slowly and steadily through a pipeline system.

6.1.3 In a sudden enlargement in pipe cross-section systems the flow pressure rises and the flow velocity decreases. (3 × 1) (3)

6.2 A hydraulic motor system is connected with a 15,5 mm diameter pipe including two bends with a loss coefficient (k) of 0,8 each, a control valve with an L/d ratio of 50 and filter with a loss coefficient (k) of 3,5. The system has a total pipe length of 15 m with a friction coefficient (f) of 0,0015 and the flow velocity is kept to 4,15 m/s.

Calculate each of the following:

6.2.1 Total length to diameter ratio of the system (5)

6.2.2 Total head friction loss of the system (2)

6.3 A 30 mm diameter pipe has a rise ratio of 1 in 110 over a length of 580 m. The difference in pressure from the inlet to the outlet is 400 kPa. A filter with a shock loss of 6,5 $v^2/2g$ is fitted in the pipe. Use a pipe friction coefficient of 0,0012 for the water pipeline system.

Use a pipe friction coefficient of 0,0012 for the water pipeline system and calculate each of the following:

6.3.1 Downward flow velocity in the pipe system. Use Bernoulli's energy equation. (6)

6.3.2 Power to overcome friction (4)

[20]

TOTAL: 100

FLUID MECHANICS N5

FORMULA SHEET

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

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

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

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

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

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

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

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

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

$$W = mg$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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