higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

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

NATIONAL CERTIFICATE

FLUID MECHANICS N5

(8190205)

6 August 2019 (X-Paper)
09:00–12:00

Nonprogrammable calculators may be used.

This question paper consists of 5 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 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 questions.
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 be shown in the answers.
6. Write neatly and legibly.

QUESTION 1

1.1 According to Newton's law of viscosity, the shear stress on the fluid layer of an element is directly proportional to the rate of the shear strain.

Examine this law and briefly explain the behaviour of a Newtonian and a non-Newtonian fluid in relation to Newton's law of viscosity. (2)

1.2 Two large plates are 24 mm apart and the space between the two surfaces is filled with glycerine.

Calculate the force required to pull a very thin plate with a surface area of 0,5 m^2 between the two large surfaces at a speed of 0,6 m/s, if the coefficient of viscosity of glycerine is 0,81 Pa.s and if:

1.2.1 The thin plate is in the middle of the surfaces of the two plates (10)

1.2.2 The thin plate is 8 mm from the surface of one of the plates. (8)

[20]

QUESTION 2

2.1 Briefly explain the hydraulic head of a liquid and how it is expressed. (2)

2.2 The brake system of a motor car consists of a master cylinder with a diameter of 40 mm and two slave cylinders. The brake-pedal lever has a total length of 350 mm from the pivot to the foot piece and the piston rod of the master cylinder is attached to the brake-pedal lever at a distance of 70 mm from the pivot point.

The force needed at each of the two slave cylinders of the two brake callipers is 125 kN with a 60 mm diameter slave cylinder piston. The fluid in the system has an isothermal bulk modulus of 10,5 GPa and the average Young's modulus for the system is 13 GPa. (Assume $K_{cylinder} = E/2{,}5$). The total volume of the fluid in the system is $200\ ml$.

Calculate the following:

2.2.1 The distance that each slave piston in the brake callipers would move when the pedal is depressed over a distance of 105,5 mm (Assume that ALL the slave pistons move this distance.) (5)

2.2.2 The force needed on the pedal to have 125 kN exerted by each slave piston at the callipers (7)

2.2.3 The play on the master cylinder piston if the brakes are fully applied and there is no air in the system (6)

[20]

QUESTION 3

3.1 What are the TWO factors that determine how deep a body will sink into a fluid while it is floating on the surface of the fluid? (2)

3.2 A 144 metric ton prototype submarine floats in seawater (1 030 kg/m^3) with 75% of its volume below the surface of the water. There is a 1,25 m diameter observation window on the side of the submarine and its centre is 1,2 m below the surface of the seawater if the submarine is in its floating attitude. The surface of the flat window is inclined at 70^0 to the surface of the water when the submarine is floating in a level attitude (laterally and longitudinally).

Calculate the following:

3.2.1 The total volume that the submarine would displace if totally submerged (4)

3.2.2 The volume of seawater that would enter the ballast tanks of the submarine in order to allow it to dive until it floats just below the surface of the seawater (6)

3.2.3 The volume of fresh water that the submarine would displace expressed as a percentage of the total volume of the submarine (3)

3.2.4 The hydrostatic force that is exerted on the observation window (2)

3.2.5 The centre of pressure of the hydrostatic force on the window (3)

[20]

QUESTION 4

4.1 Define *laminar* and *turbulent flow* of fluid in a pipeline. (2 × 2) (4)

4.2 A pipe narrows from a diameter of 120 mm to a diameter of 70 mm and then forks into two legs at constant diameters of 62 mm and 48 mm respectively. Oil with a density of 950 kg/m^3 flows at a rate of $25\,l/s$ through a single pipe and a flow rate of $11\ l/s$ is measured at the 62 mm leg of the forked pipe.

Calculate the following:

4.2.1 The weight flow rate in N/s through the tapering pipe (2)

4.2.2 The flow velocity at the 70 mm diameter section of the tapering pipe (2)

4.2.3 The flow velocity in the 48 mm diameter leg of the forged pipes and the nature of flow in this section of the branch if $\mu = 0{,}44 Pa.s$ (8)

4.2.4 The flow kinetic energy in the 62 mm branch of the forked pipes (4)

[20]

QUESTION 5

5.1 Define the *coefficient of velocity* for a fluid system. (2)

5.2 Water is discharged at 0,405 m^3/m through a 19 mm orifice under a head of 65 m and the diameter of the water jet is 16,75 mm.

Determine the values of the THREE coefficients. (11)

5.3 An orifice with a diameter of 35 mm and a coefficient discharge of 0,67 is fitted at the bottom of a closed tank with water in the tank to a head of 1,7 m. The volume above the water surface is pressurised to a pressure of 45 kPa.

Calculate the following:

5.3.1 The actual flow through the orifice (5)

5.3.2 The head of water that must be added to take the place of the 45 kPa pressure (2)

[20]

QUESTION 6

6.1 Explain what is meant by friction head loss and shock losses in a fluid flowing system. (4)

6.2 A fluid with a density of 880 kg/m^3 is displaced at a rate of $6{,}2\ l/s$ by a pump. The pressure is raised from 175 kPa at the inlet of the pump to 300 kPa at the outlet. The inlet and outlet dimeters of the pump are equal and there is no height difference between the inlet and outlet of the pump. The head loss through the pump and the efficiency of the pump is 92%.

Calculate the mechanical power required to drive the pump. (8)

6.3 A large pressure tank full of oil (relative density of 0,8), at the base of the tank is connected to a pipe of 60 mm and 30 m in length to discharge the oil. A valve with a loss head coefficient (k) of 2,88 is fitted to the pipe near the outlet. The discharge through the pipeline is $20\ l/s$. Assume the frictional coefficient of the pipe to be 0,012. Take the shock loss at the entrance to the pipe as 0,5 times the kinetic head.

Calculate the total head loss of the system using the length-diameter ratio method. (8)

[20]

TOTAL: 100

FLUID MECHANICS N5

FORMULA SHEET

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

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

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

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

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

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

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

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

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

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

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

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

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

$$F_{hydrostatic} = \rho gA\bar{y}$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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