higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T710**(E)**(A8)T

NATIONAL CERTIFICATE

FLUID MECHANICS N5

(8190205)

8 April 2019 (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 especially in the answers.
6. Write neatly and legibly.

QUESTION 1

1.1 Define a *real fluid* and define the *specific weight* of this substance with its unit. (3)

1.2 Calculate the specific gravity of grease used for lubricating a clearance space between a square plate (0,95 m × 0,95 m) and an inclined surface plane. The angle of inclination for the surface plane is 35° with the horizontal. The mass of the square plate is 31 kg and it slides down the surface plane with a uniform velocity of 0,5 m/s. The kinematic viscosity of the grease is 849,308 × 10^{-6} m^2/sand clearance space between the square. The inclined plane is 2 mm.

HINT: Consider the weight-gravitational components acting on the inclined surface plane. (10)

1.3 Oil is used to lubricate a solid shaft rotating inside a 95 mm long sleeve. The solid shaft and sleeve diameters are 400 mm and 401,5 mm respectively.

Determine the speed at which the solid shaft must rotate in r/min to overcome a viscous force of 181 N. (7)

[20]

QUESTION 2

2.1 Define *dynamic viscosity* (*absolute viscosity)*. (2)

2.2. Define each of the following terms used in fluid-flowing systems:

2.2.1 Continuity of flow

2.2.2 Mass flow rate

(2 × 2) (4)

2.3 An oil drop of 2 mm in diameter falls freely from a height into a water reservoir. The oil droplet has a surface-tension coefficient of 0,07 N/m.

Determine:

2.3.1 The surface tension of the oil drop

2.3.2 The pressure difference on the surface of the oil drop

(2 × 2) (4)

2.4 A piezometer is used to measure the pressure in a pipeline which delivers different types of fluid.

To keep a constant pressure of 150 kPa, at which pressure head should the following fluids in the pipe be when:

2.4.1 The pipe carries water

2.4.2 The pipe carries oil with a specific gravity of 0,83

(2 × 2) (4)

2.5 A cylinder with an internal diameter of 80 mm and a stroke length of 350 mm has a double-acting actuator with a 20 mm diameter single rod sliding inside the actuator. Fluid is drawn into the cylinder at a rate of 200 millilitres per second at a pressure of 500 kPa during the sliding motion.

Calculate:

2.5.1 The difference in the force between the outward and inward strokes (4)

2.5.2 The time to complete the outward (forward) stroke (2)

[20]

QUESTION 3

3.1 Explain Archimedes' principle as applied to floating bodies and state the role density plays in this principle. (5)

3.2 A hollow steel pipe, with a diameter of 1,2 m and 3 m long and with both ends closed off with the same metal and thickness as the pipe, floats in water with 30% of its volume above the water.

$$\text{HINT: V} = \pi \times \text{D} \times \text{L} \times t + 2\frac{\pi \times D^2}{4}t$$

$$\text{V} = \pi \times \text{D} \times \left(L - 2t\right)t + \left(2\frac{\pi \times D^2}{4}t\right)$$

Determine:

3.2.1 The weight of the pipe (3)

3.2.2 The thickness of the metal needed to have the pipe floating just below the water surface (the density of steel is 7 850 kg/m^3) (8)

3.2.3 The hydrostatic force on one of the circular sides if the pipe floats horizontally below the water (4)

[20]

QUESTION 4

4.1 Briefly explain the difference between a *lamina* and a *turbulent* flow region in a fluid field in relation to the viscosity of a fluid. Give an example of a fluid for each flow region to support the answer. (2 + 2) (4)

4.2 A fuel with a relative density of 0,82 is pumped into a jumbo jet. The velocity of flow inside a 100 mm diameter refuel pipe is 0,1 m/s.

Determine whether the fuel velocity of flow inside the pipe is lamina or turbulent if its kinematic viscosity is 24,39 – 10^{-6} Pa.s. (5)

4.3 200 000 litres of fuel is to be loaded to the jumbo jet in QUESTION 4.2 through a refuel pipe for a long-distance flight. The refuel pipe is 100 mm in diameter and the fuel is pumped into ventilated tanks at a pressure of 100 kPa at ground level. These tanks have an average height of 3 m above the ground level and the rate at which the fuel level rises inside these tanks could be neglected. There is a head loss of 5 m in the refuel system.

Calculate:

4.3.1 The rate of flow at which the aircraft is filled up (7)

4.3.2 The time it would take to refuel the aircraft in minutes (3)

4.3.3 The rate at which the mass of the aircraft drops during the flight if all the engines consume a total of 225 litres of fuel per minute (1)

[20]

QUESTION 5

5.1 What is the function of a venturi flowmeter in a pipe fluid-flow system? (3)

5.2 A ski-boat with a maximum speed of 50 km/h must be fitted with a pitot tube and a speedometer. The speedometer is mounted 1 m above the pitot tube which is at the rear of the boat. The pitot tube has a tube coefficient of unity and the pipe from the pitot tube to the speedometer is full of water.

Calculate the pressure at the speedometer. (6)

5.3 A prototype assembly of a hydraulic system consists of the components listed in the table below:

Part name	Quantity	Friction coefficient (k)	Length (m)	Diameter (m)
90° bend pipe	2	0,75	-	-
Filter	1	3	-	-
Valve	1	0,64	-	-
Connecting pipe	1	-	10	25

Assuming the rate of flow through the hydraulic system is 1,2 litres per second, and the pipe friction coefficient is 0,002, calculate:

5.3.1 The length-to-diameter ratio of the prototype system (7)

5.3.2 The system head loss (4)
[20]

QUESTION 6

A reducer bend is installed in a hydraulic pipe system having a bend angle of 55° upwards to the horizontal. On the inlet section of the bend, there is an internal diameter of 150 mm in which water is flowing at a velocity of 2 m/s at a pressure of 300 kPa. An outlet section of the bend is 100 mm in diameter and positioned at a height of 3 m above the inlet section. The hydraulic system experiences a total head loss of 2 m through the bend.

Calculate the following:

6.1 The weight flow through the bend (3)

6.2 The velocity of flow at the outlet (2)

6.3 The pressure at the outlet (4)

6.4 The power loss in the bend (2)

6.5 The reaction force at the inlet and outlet (4)

6.6 The magnitude and direction of the resultant force (5)
[20]

TOTAL: 100

FORMULA SHEET

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

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

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

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

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

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

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

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

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

$$W = mg$$

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

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

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

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

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

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

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

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

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

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

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

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

$$Q \text{ or } \overset{\circ}{V} = A_1u_1 = A_2u_2; \quad \overset{\circ}{m} = \rho\overset{\circ}{V}; \quad \overset{\circ}{W} = g\overset{\circ}{m} = \rho gAu; \quad P = H\overset{\circ}{W} = \rho gQH$$

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

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

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

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

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

$$F_{inlet} = \overset{\circ}{m}u_1 + P_1A_1 \quad and \quad F_{exit} = \overset{\circ}{m}u_2 + P_2A_2$$

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

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

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