higher education & training
Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T590**(E)**(N30)T
NOVEMBER EXAMINATION

NATIONAL CERTIFICATE

FLUID MECHANICS N5

(8190205)

30 November 2016 (X-Paper)
09:00–12:00

Nonprogrammable calculators and drawing instruments may be used.

This question paper consists of 7 pages and 1 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 of 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 of the six 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 $g = 9{,}81 \text{ m/s}^2$.
5. ALL units must at least be shown in the answers.
6. Write neatly and legibly.

QUESTION 1

1.1 Define the following properties of a fluid:

1.1.1 Mass density

1.1.2 Relative density

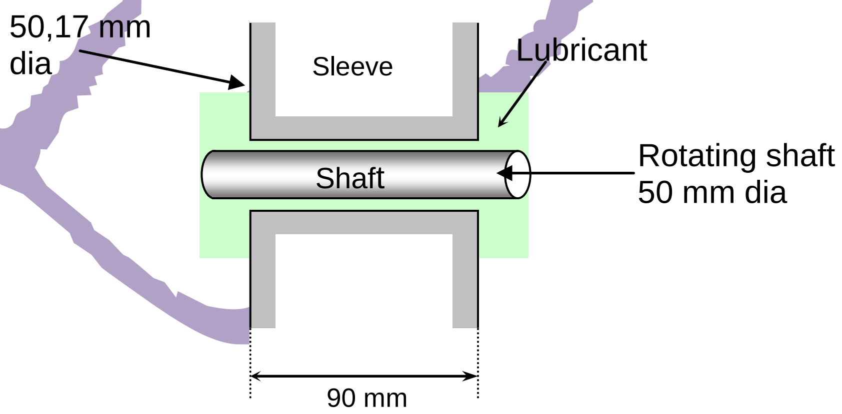
1.1.3 Specific volume

(3 × 2) (6)

1.2 What is the weight of the ethanol that exactly fills a 200 mℓ container? The density of the ethanol is 0,789 g/mℓ. (3)

1.3 What volume of silver metal will weigh exactly 2 500 gram if the density of the silver is 10,5 g/cm^3 ? (2)

1.4 Find the torque and power absorbed to rotate a shaft of diameter 50 mm, at 1 200 r/min concentrically within a sleeve 50,17 mm in diameter and 90 mm long, flooded with oil for which the coefficient of viscosity is 0,08 N-s/m^3.



(9)
[20]

QUESTION 2

A 15 mm diameter piston fits into a cylinder which has a stroke volume of 15 000 mm^3**.** The cylinder is used to supply fluid via a 5 mm diameter pipe which is 8 m in length to a vertical cylinder 75 mm in diameter. This cylinder contains a piston which is required to exert a vertical force of 8 kN. Assume that both the pistons are approximately on the same level. The bulk modulus of the fluid is 2,5 GPa.

Calculate the following:

2.1 The force and stroke required at the 15 mm diameter piston. (2)

2.2 The number of strokes required by the smaller piston in order to move the larger piston 250 mm. (2)

2.3 The change in volume of the fluid in the system due to compressibility if the amount of the fluid trapped in the cylinders is equal to twice the amount in the pipe. Assume that no air is present in the system. (10)

2.4 The change in volume in the system if 6% air is present in the fluid in terms of volume. $\left(\text{Take } \alpha_{AIR} = 1{,}4\right)$ (6)

[20]

QUESTION 3

3.1 Explain the FOUR basic laws as applicable to hydrostatic forces. (4)

3.2 Define the term *centre of buoyancy.* (3)

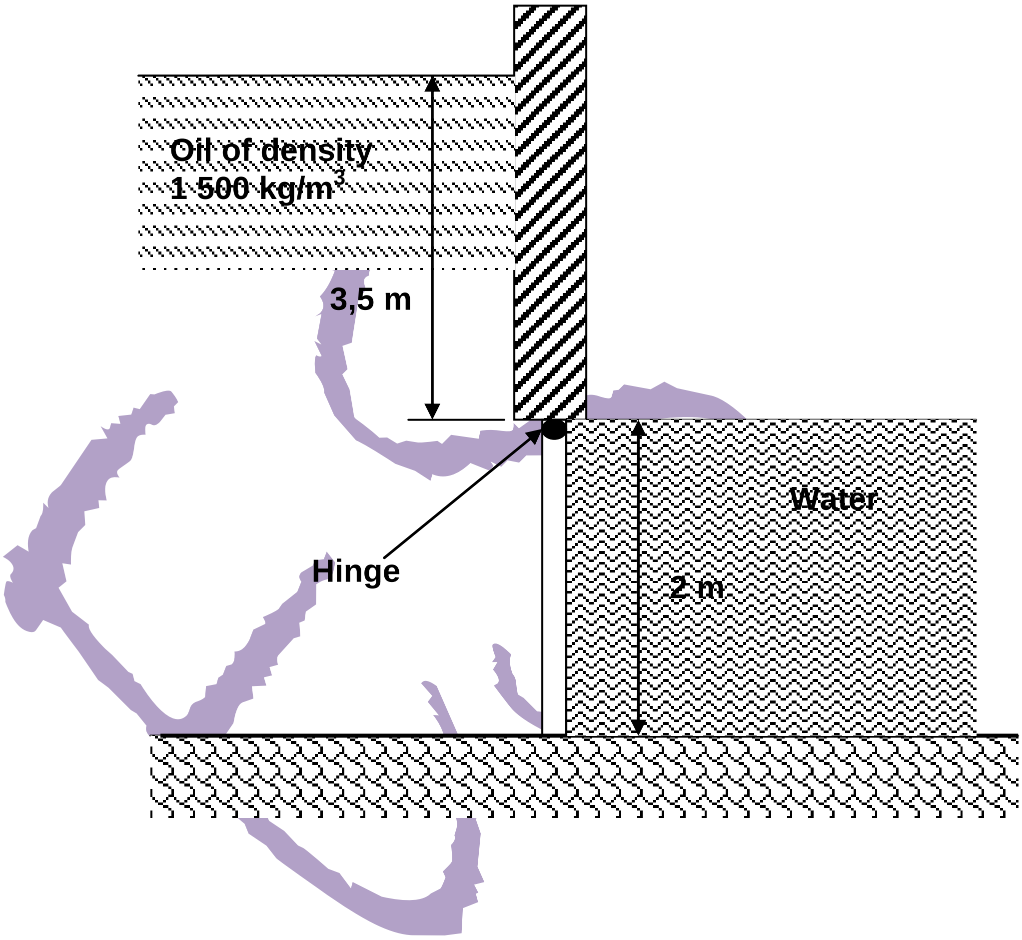
3.3 A solid sphere of diameter 500 mm floats immersed by 30% of its volume in fresh water. Determine the buoyant force.

$$\text{Given : Volume} = \frac{\pi \times d^3}{6}$$

(3)

3.4 In the FIGURE below a vertical sluice gate 4 m wide and 2 m deep is hinged at the top. Oil with a density of 1 500 kg/m^3 reacts on the upstream side of the gate to a height of 3,5 metres above the top edge of the gate. Water reacts on the downstream side of the gate up to the top edge of the gate.

Calculate the resultant hydrostatic force acting on the gate.



(10)
[20]

QUESTION 4

4.1 Write down Bernoulli's equation with the energy units in metres. State the different forms of energy present in the equation. (6)

4.2 What is meant by *continuity of flow* and under what conditions does it occur? (2)

4.3 Oil is transported under high pressure through a pipe of diameter 25 mm and 20 m long at 0,001 m^3/s. The pressure at the pipe entrance is 1,4 MPa and $f = \dfrac{h_f}{4\dfrac{L}{d} x \dfrac{U^2}{2g}} = 0{,}012$. The oil has a density of 780 kg/m^3 and an absolute coefficient of viscosity of 5×10^{-4} Pa.s. The pipe is horizontal.

Determine the following:

4.3.1 The Reynolds number (3)

4.3.2 The pressure of the oil at the pipe exit (4)

4.3.3 The efficiency of power transmission (2)

4.3.4 The available power at the pipe outlet (3)

[20]

QUESTION 5

5.1 A venturi meter has an inlet with a diameter of 150 mm and a throat of 75 mm diameter.

What will be the manometric reading, in metres, between the inlet and the throat of the venturi meter if the water is passing through the meter at a rate of 40 ℓ/s? (6)

5.2 At a steel manufacturing plant it was found that there was a need for 13 620 m^3 of water per day. The water is to be discharged by two circular orifices under a constant head of 0,75 m measured to the centre of the orifice.

Take

$C_c = 0{,}62$

$C_v = 0{,}97$ and

12 hours = one day

Calculate the diameter that will be required to give a discharge of 13 620 m^3 per day. (14)

[20]

QUESTION 6

6.1 A hydraulic pump increases the pressure in a system from 500 kPa to 3 MPa at a flow rate of 0,002 m^3/s. The fluid density is 820 kg/m^3. The shock loss over the pump is 0,8 m. Assume the inlet and outlet of the pump are at the same level and have the same diameter.

Determine the mechanical power to drive the pump with a mechanical efficiency of 80%. (6)

6.2 A turbine is supplied with water at a rate of 24 m^3/min. The pressure at the inlet is 190 kPa and the diameter is 0,5 m. The pressure at the tail water end is 24 kPa and 1 m in diameter. The vertical height between these two points is 1,8 m.

Apply Bernoulli's equation and calculate the following:

6.2.1 The effective turbine pressure head (9)

6.2.2 The input power supplied to the turbine (3)

6.2.3 The mechanical power of the turbine if the mechanical efficiency is 83% (2)

[20]

TOTAL : 100

FLUID MECHANICS N5

FORMULA SHEET

$$V = \frac{\pi DN}{60};\ \omega = \frac{2\pi N}{60};\ A = \pi D\ell;\ t = \frac{D-d}{2};\ F = \frac{\mu AV}{t};\ T = F \times r$$

$$\text{Power Absorbed} = T \times \omega;\quad \text{Power Absorbed} = \frac{\mu V^2 \pi D\ell}{t}$$

$$\text{Viscous force on Shaft} = \frac{\mu V\pi D\ell}{t};\ \text{P} = \frac{\mu AV^2}{t}$$

$$\rho = \frac{m}{v};\quad \text{Rel } \rho = \frac{\rho_{substance}}{\rho_{water}};\quad Specific\ \omega = \frac{\omega_{substance}}{\omega_{water}}\quad or\ Specific\ \omega = \rho g$$

$$P = \frac{F}{A};\quad P_{absolute} = P_{gauge} + P_{atmospheric};\quad P = \rho g h$$

$$F_{Surface\ tension} = \sigma 2\pi R;\quad P_i - P_o = \frac{2\sigma}{R};\quad F_{viscous} = \frac{\mu A \chi}{C_r}\ and\ \upsilon = \frac{\mu}{\rho}$$

$$K_e = \frac{P}{\varepsilon_v}\ where\ \varepsilon_v = \frac{\Delta V}{V};\quad \frac{1}{K_e} = \frac{1}{K_\ell} + \frac{1}{K_c} + \frac{V_g}{V_t}\left(\frac{1}{K_g}\right)\ where\ K_g = \alpha P\ and\ K_c = \frac{E}{2{,}5}$$

$$F_{hydrostatic} = \rho g A\bar{y};\ \bar{h}_{rectangular} = \frac{2}{3}d\ \ or\ \ \bar{h}_{at\ angle} = \frac{I_g}{A\bar{y}} Sin^2\theta + \bar{y}\quad where$$

$$I_{g\ (rectangular)} = \frac{bd^3}{12}\ \ or\ \ I_{g\ (circular)} = \frac{\pi D^4}{64}$$

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

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

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

$$\frac{\text{P}_{turbine}}{\overset{\circ}{W}} = Turbine\ head;\ \frac{\text{P}_{pump}}{\overset{\circ}{W}} = Pump\ head;\ \eta = \frac{\text{P}_F}{\text{P}_m} x100;\quad R_e = \frac{\rho u D}{\mu}$$

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

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

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

$F_{inlet} = \dot{m}\, u_1 + P_1 A_1$ and $F_{exit} = \dot{m}\, u_2 + P_2 A_2$

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

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

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