higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T640**(E)**(J24)T
AUGUST EXAMINATION

NATIONAL CERTIFICATE

FLUID MECHANICS N5

(8190205)

24 July 2014 (Y-Paper)
13:00–16:00

Nonprogrammable calculators may be used.

This question paper consists of 7 pages and 1 formula sheet.

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 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 Fluids which obey Newton's law of viscosity are known as Newtonian fluids and fluids which do not obey this law are called Non-Newtonian fluids.

Describe the two classes of fluids:

1.1.1 Newtonian fluids

1.1.2 Non-Newtonian fluids

(2 x 2) (4)

1.2 Explain what is meant by an open fluid system. Use a sketch to illustrate your explanation. (3)

1.3 The sliding parts of a lathe bed is lubricated by a 0,3 mm layer of lubricating oil which has an absolute co-efficient of viscosity of 0,2 Pa.s. The area of the lathe slide consists of two rectangular areas of 300 mm by 50 mm and the average velocity between the two surfaces is 1,2 m/s.

Determine:

1.3.1 The force needed to overcome the viscosity of the oil when moving this machine part. (4)

1.3.2 The viscous power loss to move this machine part. (2)

1.3.3 The difference in viscous power loss if the wrong oil is being used. This wrong lubricating oil has a viscosity of 0,7 Pa.s (4)

1.3.4 The kinematic viscosity of the oil in QUESTION 1.3.1 above if the relative density of that oil is 0,8. (3)

[20]

QUESTION 2

2.1 Explain, with the aid of a neat labelled drawing, the operation of a Bourdon gauge. (4)

2.2 Define the isothermal bulk modulus of a fluid and write down the applicable unit in the definition. (3)

2.3 Sketch and describe the operation of a spring type hydraulic accumulator that may be used with hydraulic systems. (3)

2.4 A brake master cylinder has a foot pedal with a mechanical advantage of 4. The 30 mm diameter cylinder has a stroke length of 40 mm and is filled with fluid with an isothermal bulk modulus of 1,8 GPa.

If a 1,2 kN force is applied to the pedal, calculate:

2.4.1 The pressure in the master cylinder

2.4.2 The play on the pedal due to the compressibility of the fluid (2 x 5) (10)

[20]

QUESTION 3

3.1 A solid cylinder of diameter 400 mm and height 1,5 m is immersed by 75% of its volume in fresh water with its height vertical.

Determine:

3.1.1 The buoyant force. (4)

3.1.2 The density of the solid cylinder material (3)

3.1.3 The force that must be applied to fully immerse the above cylinder (3)

3.2 In FIGURE 1 below a rectangular opening 900 mm wide by 600 mm high is cut in the side of a tank and closed by a bolted plate.

Determine the magnitude and the location of the hydrostatic force on the plate when the tank is filling with oil of relative density 0.9 to a depth of 1.5 m above the top of the opening.

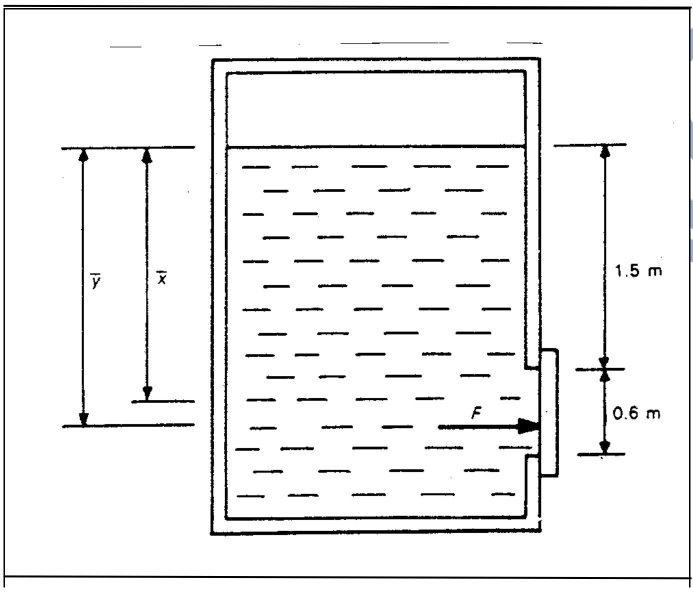

FIGURE 1

(10)
[20]

QUESTION 4

4.1 Explain what is meant by the following:

4.1.1 Turbulent flow

4.1.2 Laminar or viscous flow

(2 x 2) (4)

4.2 Write down Bernoulli's equation for energy transmission in a fluid flow system and indicate the different types of energy involved if the units are in metres. Show how energy losses are accounted for in the equation. (7)

4.3 Water flows at a velocity of 6,8 m/s though a pipe.

What form of energy does the water possess? (1)

4.4 How is this form of energy expressed in fluid mechanics? Refer to QUESTION 4.3. (1)

4.5 Calculate the velocity head in metres. Refer to QUESTION 4.3. (1)

4.6 A smooth plastic garden hose is 10 m long with inside diameter of 20 mm. It is used to drain a wading pool (shallow pool) as shown in FIGURE 2 below.

If friction losses are neglected calculate the flow rate from the pool.

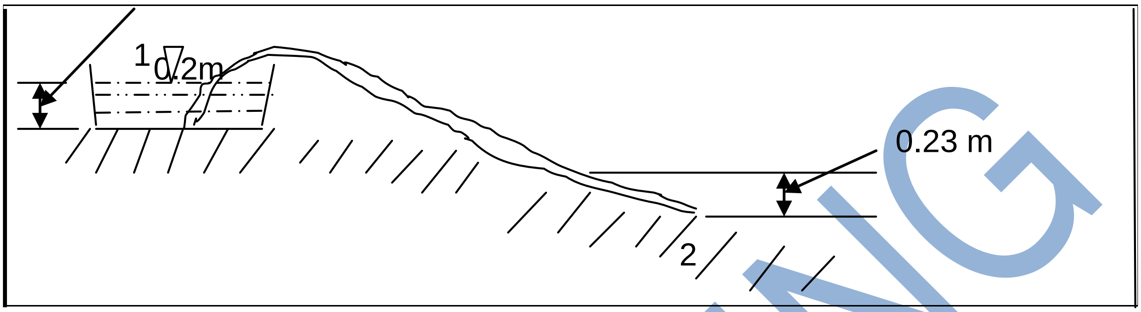

FIGURE 2

(6)
[20]

QUESTION 5

5.1 Hydraulic turbo machines, which include pumps and motors, may be classified as hydrodynamic or positive displacement machines.

Give an example of each and by virtue of pressure and flow rate, distinguish between these TWO categories. (6)

5.2 Give TWO advantages and TWO disadvantages of orifice plates as flow measuring equipment. (4)

5.3 A sharp edge orifice with a diameter of 80 mm is fitted in a 105 mm diameter pipe to measure the flow rate of oil with a relative density of 0,83. A manometer with mercury as manometric fluid, is connected over the orifice and it indicates a manometric height of 165 mm.

Calculate the actual flow rate in the pipe if the coefficient of discharge of the orifice is 0,65. (10)
[20]

QUESTION 6

An outlet pipe is fitted to a water reservoir. The pipe has two bends fitted to it each with a shock loss of 0, 75 and a valve with a length/diameter $\left(\frac{L}{D}\right)$ ratio of 60. At the outlet of the pipe a centrifugal pump is fitted with a shock loss coefficient of 5 when it is not operating. The pipe has a diameter of 30 mm, a total length of 32 m and a frictional co-efficient of 0,002. The difference in level between the free surface in the reservoir and the outlet is 25 m.

Calculate:

6.1 The total length to diameter ratio of the full system including the pump. (5)

6.2 The flow rate of the water from the reservoir into the atmosphere. (6)

6.3 The pressure needed at the outlet of the pump if the water is pumped back into the reservoir at the same flow rate as when it flowed out of the reservoir. (5)

6.4 The pressure loss over the valve during the flow conditions. (4)
[20]

TOTAL: 100

FLUID MECHANICS N5
FORMULA SHEET

$\rho = \dfrac{m}{v}$; Rel $\rho = \dfrac{\rho_{substance}}{\rho_{water}}$; *Specific* $\omega = \dfrac{\omega_{substance}}{\omega_{water}}$ or *Specific* $\omega = \rho$

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

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

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

$F_{hydrostatic} = \rho g A \bar{y}$; $\bar{h}_{rec\tan gular} = \dfrac{2}{3} d$ or $\bar{h}_{at\ angle} = \dfrac{I_g}{A\bar{y}} Sin^2\theta + \bar{y}$ where

$I_{g\ (rec\tan gular)} = \dfrac{bd^3}{12}$ or $I_{g\ (circular)} = \dfrac{\pi D^4}{64}$

$W = R = \rho g V$

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

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

$\dfrac{\mathrm{P}_{turbine}}{\overset{\circ}{W}} = Turbinehead$; $\dfrac{\mathrm{P}_{pump}}{\overset{\circ}{W}} = Pumphead$; $\eta = \dfrac{\mathrm{P}_F}{\mathrm{P}_m} x100$; $R_e = \dfrac{\rho u D}{\mu}$

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

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

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

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

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

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

$U_m = \dfrac{\pi D n}{60}$; $P = \overset{o}{m} V_{w_t} u_m$; $\eta = \dfrac{2 V_w u_m}{u_1^2} x100$