higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T600**(E)**(N22)T

NOVEMBER EXAMINATION

NATIONAL CERTIFICATE

FLUID MECHANICS N6

(8190216)

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

NON-PROGRAMMABLE CALCULATORS MAY BE USED.

This question paper consists of 6 pages and 1 formula sheet of 2 pages.

DEPARTMENT OF HIGHER EDUCATION AND TRAINING
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE
FLUID MECHANICS N6
TIME: 3 HOURS
MARKS: 100

INSTRUCTIONS AND INFORMATION

1. Answer ALL the questions.
2. Read ALL the questions carefully.
3. Number the answers according to the numbering system used in this question paper.
4. Use $g = 9{,}81 \text{ m/s}^2$
5. ALL units must be shown in the answers at least.
6. Write neatly and legibly.

QUESTION 1

1.1 A 300 mm pipeline is used to transport kerosene with a relative density of 0,82 from the processing units to the storage tanks at a refinery. Just before the tank the pipeline divides into two smaller pipelines; one is 150 mm and the other is 225 mm in diameter. The velocity in the 150 mm pipe is 0,5 m/s and the velocity in the 225 mm pipe is 0,8 m/s.

Calculate the following for the 300 mm pipeline:

1.1.1 Flow rate in ℓ/s (7)

1.1.2 Velocity in m/s (2)

1.2 In a town a new reservoir has to be built to serve an industrial area that is under development 7 km away from the main reservoir and will be connected by means of a 500 mm diameter siphon. The difference in water level between the two reservoirs which are both open to atmosphere will be 98 m. The vertex of the pipeline is 5 m above the surface level of the upper reservoir. Neglect all but frictional losses and assume the barometric height to be 8,5 m of water. Assume that the siphon runs full and that f = 0,0058.

Calculate the flow rate of the water into the lower reservoir in ℓ/s. (6)

1.3 Distinguish clearly between *laminar flow* and *turbulent flow*. (4)

[19]

QUESTION 2

2.1 Water has to be channelled from a river to provide water at an artificial lake in a game reserve 10 kilometres away from the river. The maximum flow will be controlled by sluice gates at 20 m^3/s and a velocity of 5 m/s.

NOTE: For a rectangular section the best hydraulic section has to be a width that is twice the depth.

2.1.1 Calculate what the width and depth should be for the best hydraulic section. (6)

2.1.2 A steel weir is erected in this channel over its full width.

Calculate the head of water at the weir. (3)

2.2 The delivery over a rectangular notch must be 0,14 m^3/s when the water level is 23 cm above the crest.

Calculate what the width of the notch must be if the coefficient of discharge is 0,6. (3)

2.3 Name THREE factors that will influence the value of the constant C in the Chezi formula: $C = \frac{87}{1 + \frac{k}{\sqrt{m}}}$ (3)

[15]

QUESTION 3

A 45 mm diameter sharp-edged orifice was made on the vertical side of a tank which then discharges into a container used to cool off heat-treated metals. If the coolant discharges under a head of 4,5 m, then Cc = 0,62 and Cv = 0,98.

Calculate the following:

3.1 Diameter of the jet (6)

3.2 Velocity of the jet (2)

3.3 Discharge in ℓ/s (2)

[10]

QUESTION 4

4.1 A single-acting reciprocating pump is used to pump water from a condenser to a tank. The piston has a diameter of 420 mm and a stroke length of 250 mm. Water is lifted through a height of 18,2 m when the pump is running at 75 r/min. The pipe diameter is 180 mm and the actual quantity delivered is 40 ℓ/s.

Calculate the following:

4.1.1 Percentage slip in the pump (6)

4.1.2 Coefficient of discharge (2)

4.1.3 Theoretical power to drive the pump (2)

4.2 At a dam a centrifugal pump is used to pump water into a reservoir at a rate of 3 m^3/min through a vertical pipeline at a static head of 22 m. The power consumption to achieve this is 26,4 kW. The delivery pipe is 30 m in length and has a diameter of 125 mm.

Due to lack of maintenance a leak develops at a flange joint halfway up the delivery pipe and the discharge at the leak is 1,32 m^3/min. This results in a drop in delivery from 3 m^3/min to 1,32 m^3/min. The efficiency of the pump remains constant and the friction factor *f* for the delivery pipe is 0,01.

NOTE: Ignore all other losses

Calculate the following:

4.2.1 Power output before the leak started (5)

4.2.2 Efficiency of the pump before the leak started (2)

4.2.3 Required power up to the leak (5)

4.2.4 Required power from the leak up to the discharge (5)

4.2.5 Total power required to drive the pump under the new conditions (2)
[29]

QUESTION 5

A ventilation system is equipped with a fan running at 400 r/min while delivering air at a rate of 7,3 m^3/s against a static head of 39 mm water gauge. The power required to drive the fan is 5,9 kW..

Calculate the following if the fan speed increases to 600 r/min:

5.1 Volume of air that can be delivered

5.2 Static head of air that can be delivered

5.3 Power required to drive the fan at the higher speed

(3 × 2) **[6]**

QUESTION 6

6.1 A generator at a hydroelectric plant is operated by an overhung Pelton wheel. The effective head is 350 m at the base of the nozzle which allows a flow of 360 m^3/min. The buckets deflect the jet with a nozzle coefficient of 0,96 through an angle of 155° and the mean bucket speed is 37 m/s. The jet ratio is 12 and the speed ratio 0,45.

Calculate the following:

6.1.1 Velocity of water jet (2)

6.1.2 Diameter of jet (5)

6.1.3 Power of Pelton wheel in MW (2)

6.1.4 Efficiency of Pelton wheel (2)

6.2 The effective turbine pressure head for an axial flow hydraulic turbine is 92 m and the volumetric flow is 21 m^3/s. The radius of the guide vanes is 1,6 m and the height is 1 m. The inlet velocity is 41,8 m/s, the exit flow which is axial is 18,6 m/s and the guide vanes are at an angle of 11°.

Calculate the following:

6.2.1 Diameters at inlet and outlet (6)

6.2.2 Input power supplied to turbine (2)

6.3 Cavitation on water turbine runners can cause serious problems.

Name TWO of the results cavitation can have on water turbine runners. (2)
[21]

TOTAL: 100

FLUID MECHANICS N6

FORMULA SHEET

Any applicable formula may also be used.

$$Z_1 + \frac{Pr_1}{\rho g} + \frac{V_1^2}{2g} = Z_2 + \frac{Pr_2}{\rho g} + \frac{V_2^2}{2g} + h_L$$

$$hf = \frac{4fLV^2}{2gd}$$

$$hf = \frac{4fL}{2gd} \times \left[\frac{D^2}{d^2} \times \omega \times r\right]^2$$

$$hf = \frac{4fL}{2gd} \times \left[\frac{D^2}{d^2} \times \frac{\omega r}{\pi}\right]^2$$

$$hs = \frac{kV^2}{2g}$$

$$hs = \frac{(V_1 - V_2)^2}{2g}$$

$$hs = \frac{V^2}{2g} \times \left[\frac{1}{C_c} - 1\right]^2$$

$$Q = AC\sqrt{mi}$$

$$Q = 1{,}84(L - 0{,}1\,n.H)H^{1,5}$$

$$Q = \frac{2}{3}Cd\sqrt{2g} \times L \times H^{1,5}$$

$$Q = \frac{8}{15}Cd\sqrt{2g} \times \tan\frac{\theta}{2} \times H^{2,5}$$

$$Q = \frac{2}{3}Cd\sqrt{2g}\;H^{1,5}\left(L + \frac{4}{5}\tan\frac{\theta}{2} \times H\right)$$

$$Q = \frac{ALSEN}{60}$$

$$Ha = \frac{L}{g} \times \frac{D^2}{d^2} \times \omega^2 \times r \times \cos\theta$$

$$\frac{Q_1}{Q_2} = \frac{N_1}{N_2} \qquad \frac{Q_1}{Q_2} = \left(\frac{D_1}{D_2}\right)^3$$

$$\frac{P_{r1}}{P_{r2}} = \left(\frac{N_1}{N_2}\right)^2 \qquad \frac{P_{r1}}{P_{r2}} = \left(\frac{D_1}{D_2}\right)^2 \qquad \frac{P_{r1}}{P_{r2}} = \frac{\rho_1}{\rho_2}$$

$$\frac{kW_1}{kW_2} = \left(\frac{N_1}{N_2}\right)^3 \qquad \frac{kW_1}{kW_2} = \left(\frac{D_1}{D_2}\right)^5 \qquad \frac{kW_1}{kW_2} = \frac{1}{\rho}$$

$$\frac{H_1}{H_2} = \left(\frac{Q_1}{Q_2}\right)^2 \qquad \frac{H_1}{H_2} = \left(\frac{N_1}{N_2}\right)^2 ; \ \frac{w.g._1}{w.g._2} = \left(\frac{N_1}{N_2}\right)^2 \qquad \frac{H_1}{H_2} = \frac{L_1}{L_2}$$

$$\frac{W_1}{W_2} = \left(\frac{D_1}{D_2}\right)^2$$

$$\frac{N_1^2 D_1^2}{gh_1} = \frac{N_2^2 D_2^2}{gh_2}$$

$$\Pr = \frac{kSV^2}{a}$$

$$P = \rho \times g \times Q \times w.g. \qquad P = \rho \times Q \times u(v-u)[1 + n\cos(180° - y)]$$

$$\eta = \frac{u}{gh}(v-u)[1 + n\cos(108° - y)] \times 100$$