higher education
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Department:
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REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

FLUID MECHANICS N6

(8190216)

5 August 2021 (X-paper)
09:00–12:00

Drawing instruments and nonprogrammable calculators may be used.

This question paper consists of 7 pages and a formula sheet of 2 pages.

209Q1G2105

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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. Sketches must be large, neat and fully labelled.
5. Round off final answers to THREE decimal places.
6. **NOTE:** Diagrams and sketches in this question paper are not drawn to scale.
7. Use g = 9,81 m/s^2
8. Write neatly and legibly.

QUESTION 1

1.1 FIGURE 1 below shows two horizontally placed pipes that are joined by their ends. Slime with a relative density of 1,1 flows from the x mm diameter pipe to the 152 mm diameter pipe. The coefficient of friction of the smaller pipe is 0,01 and that of the bigger pipe is 0,025. The flow rate in the system is 193 ℓ/s.

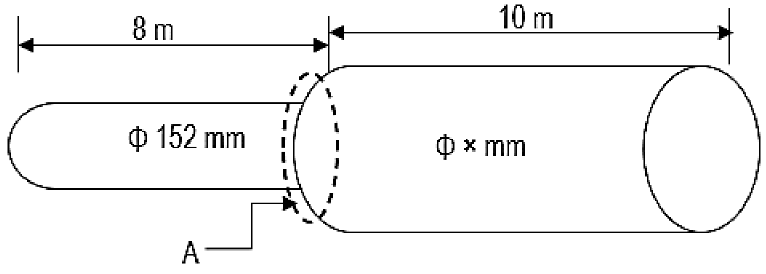

FIGURE 1

Calculate the following:

1.1.1 The density of the slime (1)

1.1.2 The hydraulic mean depth of the 8 m long pipe. (2)

1.1.3 The diameter 'x' of the biggest pipe if the total friction head in the system is 20 m (4)

1.1.4 The shock losses occurring at section A (3)

1.1.5 The pressure difference in the system, ignoring all the losses except the ones at A. (3)

1.2 The pipes in QUESTION 1.1 are disconnected and then connected in parallel to a reservoir that is discharging the total flow rate of 193 ℓ/s. The pipes have equal lengths.

Determine the discharge in each pipe. (5)

1.3 Water flows at a velocity of 2,1 m/s in a pipe that is 100 m long and has a diameter of 100 mm. The friction factor of the pipe is 0,03.

Calculate the friction head of the system using the following:

1.3.1 Darcy Weisbach's formula (2)

1.3.2 Chezy's formula (7)

[27]

QUESTION 2

2.1 Read the following scenario and complete the calculation that follows in your ANSWER BOOK.

The duct draws 10,9 m^3/s of air from an axial fan. The duct then branches in to two: A and B. Duct A is 30 m long and has a constant diameter of 800 mm. Duct B is 25 m long and has a cross sectional area of 900 × 340 mm. Both duct branches have the same pressure and coefficient of friction.

Calculate the delivery of air in each branch. (8)

2.2 FIGURE 2 below shows a semi-circular channel that is designed to overcome the overflow of storm water on the N12 highway. The hydraulic gradient of the channel is 3 m for every 4 km.

Determine the value of the depth (radius) that can satisfy the designed flow rate of 20 000 ℓ/s.

NOTE: Use Chezy's constant in the formula as 50.

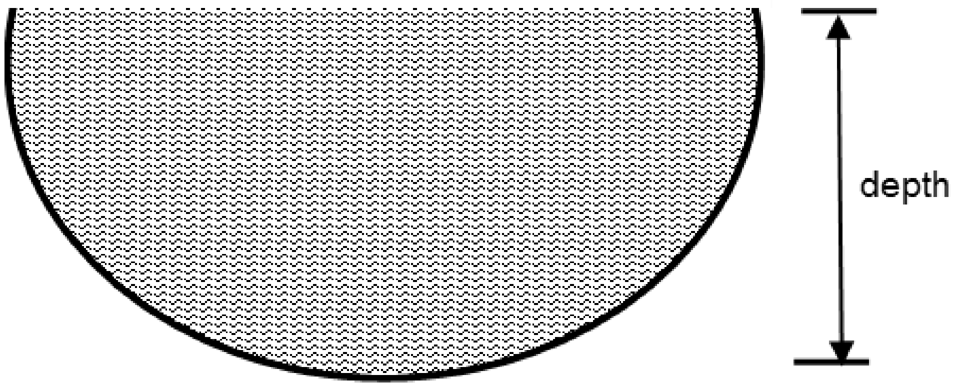

FIGURE 2 (7)

2.3 FIGURE 3 below shows a 90^0 notch that has a coefficient of discharge of 0,7. The quantity of water flowing over the notch has been observed at the head above the bottom of the notch of 899 mm.

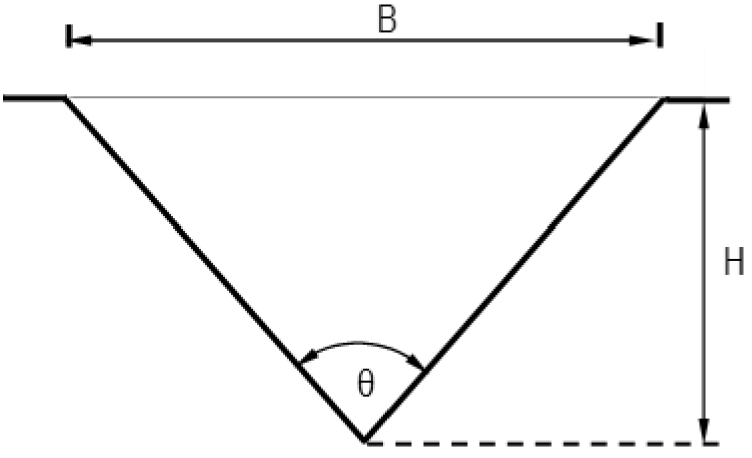

FIGURE 3

Calculate the quantity of water flowing over the notch. (3)

2.4. FIGURE 4 below shows a pipeline with an internal diameter of 300 mm that terminates in a nozzle opening with a diameter of 40 mm. Water pressure in the pipeline is 480 kPa and the coefficient of velocity is 0,97.

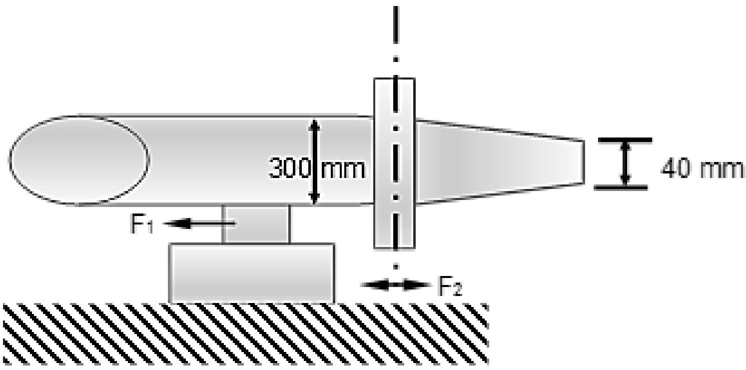

FIGURE 4

Calculate the following:

2.4.1 The discharge velocity of water (3)

2.4.2 The force F_1 reacting on the pipe support (2)

2.4.3 The force on the bolts F_2 that hold the flanges (2)
[25]

QUESTION 3

3.1 A double-acting reciprocating pump is used to raise water to a height of 42 m through a delivery pipe that is 80 m long and has a diameter of 90 mm. The pump speed is 75 r/min, the stroke length is 350 mm, and the piston diameter is 130 mm. An air vessel is fitted in the delivery pipe 4 m from the cylinder, measured along the pipe. The friction coefficient in the pipe is 0,007 and the atmospheric pressure is 10,4 m of water. Assume simple harmonic motion.

Calculate the following:

3.1.1 The absolute pressure in the cylinder at the middle of each delivery stroke. (7)

3.1.2 The absolute pressure in the cylinder at the end of each delivery stroke. (4)

3.2 A three-throw pump displays the following data:

Stroke	= 400 mm
Bore	= 150 mm
Crank speed	= 50 r/min
Head	= 900 m
Slip	= 5%
Efficiency	= 92%

Determine the following:

3.2.1 The actual delivery. (4)

3.2.2 The power required. (2)

3.3 A centrifugal pump delivers water at 150 ℓ/s at an operating speed of 1 440 r/min and against a total head of 400 m.

Determine the following:

3.3.1 The diameter of the suction and delivery branches if the radial flow velocity of water at the suction outlet is 2 m/s and at the delivery outlet 3 m/s. (4)

3.3.2 The number of stages (rounded to a whole number) required for a head of 150 m per stage. (3)

3.3.3 The power input to the pump if the efficiency if 80%. (3)

[27]

QUESTION 4

4.1 The flow rate through a Francis turbine is 0,34 m^3/s and the effective head is 23 m. The pressure at inlet is 166 kPa and the diameter is 300 mm. The pressure at tail water end is -40 kPa and the vertical height between two points is 2 m.

Determine the following:

4.1.1 The diameter at the tail water end (7)

4.1.2 The power supplied to the turbine (2)

4.2 The available head at the inlet of a nozzle which supplies a Pelton wheel with water is 400 m. The coefficient of velocity for the nozzle is 0,97. The diameter of the wheel 1,6 m and the diameter of the nozzle is 200 mm. The deflection angle is 166^0.The relative velocity decreases by 15 % as the water flows over the bucket surface.

Calculate the following:

4.2.1 The theoretical speed in r/min running at the maximum efficiency (6)

4.2.2 The hydraulic efficiency (2)

4.2.3 The power required (4)

[21]

TOTAL: 100

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FLUID MECHANICS N6 FOMULA SHEET

Any applicable formula may also be used.

$$Z_1 + \frac{P_{r1}}{\rho g} + \frac{V_1^2}{2g} = Z_2 + \frac{P_{r2}}{\rho g} + \frac{V_2^2}{2g} + h_L$$

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

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

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

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

$$Q = A.C\sqrt{mi}$$

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

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

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

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

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

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

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

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

$$\frac{Q_1}{Q_2} = \frac{N_1}{N_2}$$

$$\frac{P_{r1}}{P_{r2}} = \left(\frac{N_1}{N_2}\right)^2$$

$$\frac{kW_1}{kW_2} = \left(\frac{N_1}{N_2}\right)^3$$

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

$$\frac{P_{r1}}{P_{r2}} = \left(\frac{D_1}{D_2}\right)^2$$

$$\frac{kW_1}{kW_2} = \left(\frac{D_1}{D_2}\right)^5$$

$$\frac{P_{r1}}{P_{r2}} = \frac{\rho_1}{\rho_2}$$

$$\frac{kW_1}{kW_2} = \frac{1}{\rho}$$

$$\frac{H_1}{H_2} = \left(\frac{Q_1}{Q_2}\right)^2$$

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

$$\frac{H_1}{H_2} = \frac{L_1}{L_2}$$

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

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

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

$$P = \rho \times g \times Q \times w.g.$$

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

$$\eta = \frac{u}{gh}\,(v - u)\,[1 + n\cos(180° - y)] \times 100$$

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