higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

FLUID MECHANICS N6

(8190216)

22 November 2022 (X-paper)
09:00–12:00

Nonprogrammable calculators may be used.

This question paper consists of 7 pages and a formula sheet of 3 pages.

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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. 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.

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QUESTION 1

1.1 A pipeline, 720 m long, connects the new and existing reservoirs which have a difference in level of 8 m. The pipeline rises to a height of 3 m above the upper reservoir at a distance of 260 m from the entrance, before falling to the new lower reservoir. The pipe is 1,2 m in diameter with a coefficient of 0,01. Shock loses must be ignored.

Determine the following :

1.1.1. The discharge. (3)

1.1.2. The pressure at the highest point of the pipeline. The atmospheric pressure can be taken as 101,3 kPa. (3)

1.2 Use the following information to calculate the pressure difference in a horizontally placed pipeline:

Large diameter section is 300 mm
Small diameter section is 100 mm
Quantity is 180 cubic metres of water per hour
Flow is from the smaller to the bigger section
Ignore ALL losses. (6)

1.3 Two water tanks are connected by three pipes with diameters of d, 2d and 3d. These are laid in parallel when connected. The three pipes have the same length and coefficient of friction, f.

If the smallest of the three pipes discharges 88 ℓ/s, calculate the discharge through each of the other TWO pipes in litres per second. (6)

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1.4 FIGURE 1 below shows a diagram of a pipe AC, 2,5 km long and 900 mm in diameter carrying non flowing water. Stand pipes are connected to the main pipe. Study the diagram and answer the questions that follow.

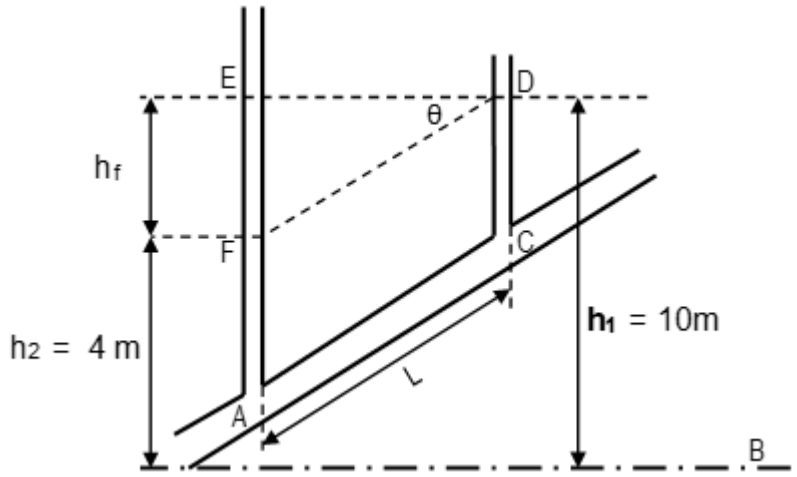

FIGURE 1

1.4.1 The friction head (1)

1.4.2 The hydraulic gradient (2)

1.4.3 Hydraulic mean depth of the pipe (2)

1.4.4 The friction factor, if a new and clean pipe is used (2)

1.4.5 Hence, calculate the velocity of water if it starts flowing upwards (2)

[27]

QUESTION 2

2.1 V notches are used to determine the flow in the streams and small rivers by placing a wooden measuring ruler in the centre of the V-notch and measuring the height of the water flow over the notch. In this case a V-notch must be designed for a maximum flow of 860 litres per second.

The 90 degree V-notch has a coefficient of discharge of 0,98. Calculate a suitable height (in mm) for this V-notch to be able to handle the above maximum flow. (4)

2.2 A jet of water issues from an orifice in a vertical wall. The orifice has a diameter of 60 mm and discharges 2 m below the surface. The discharge jet strikes the ground 4,2 m horizontally from the opening. The coefficient of velocity is 0,98.

Calculate :

2.2.1 The time taken for the jet to strike the surface level (4)

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2.2.2. The head of water above the orifice (2)

2.2.3. The theoretical discharge in ℓ/s (3)

2.3. Ventilation is considered critical in mining and employees need a dust-free working environment. At a Colliery mine plant, 25 m^3/s of air is pumped into the section which splits into two branches at the same point. The branches have the following dimensions:

BRANCH NO.	**LENGTH IN (m)**	**WIDTH IN (mm)**	**HEIGHT IN (mm)**
A	110	800	950
BRANCH NO.	**LENGTH IN (m)**	**DIAMETER (mm)**	-
B	75	800	

Calculate the quantity of air delivered by each branch. Assume equal values for k and that each branch discharges into areas having the same pressure. (8)

[21]

QUESTION 3

3.1 A single stage centrifugal pump operating at 1 500 r/min delivers 300 m^3 of water per hour against a total head of 10 m at an efficiency of 85%. The impeller has an outer diameter of 210 mm while the width of the flow passages at outlet is 60 mm.

Use N = $\frac{60\sqrt{2ghs}}{\pi D_o}$

Calculate the following:

3.1.1 The peripheral velocity of the impeller at outlet (2)

3.1.2 The radial (flow) velocity of the water leaving the impeller (3)

3.1.3 The tangential (whirl) velocity of the water leaving the impeller (2)

3.1.4 The outlet angle of the impeller vane (3)

3.1.5 The output power of the motor driving the power if the efficiency (mechanical) is 82%. (2)

3.1.6 The speed at which flow will commence when the pump is started against a static head of 7 m. (2)

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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:

3.2.1 The actual delivery (4)

3.2.2 The power required. (2)

3.3. Define the following terms:

3.3.1. Water hammer

3.3.2. Cavitation

3.3.3. Piston pump

(3 × 1) (3)
[23]

QUESTION 4

4.1 The pipeline supplying a triple-jet Pelton wheel with water is 3 km in length. The water height of the reservoir above the wheel surface is 500 m. The turbine develops 7 000 kW at 500 r/min. The pipeline losses are 15% of the gross head, while the friction factor for the pipes is 0,005. Assume the coefficient of velocity of the jets as 0,97, the bucket speed as 0,45 of the jet speed and the efficiency of the turbine as 92%.

Calculate the following:

4.1.1. The velocity of water entering the buckets (3)

4.1.2. The mean diameter of the wheel (3)

4.1.3. The diameter of a jet (7)

4.1.4 The diameter of the supply pipe if f = 0,007 and the length of the supply pipe is 1,5 km. (3)

4.2 Reaction turbines can be classified with respect to the direction of the water flow.

Name FOUR types of the reaction turbines. (4)

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4.3 A vertical shaft Francis turbine is supplied with water at a rate of 22,5 m^3/min. The pressure at the inlet is 196 kPa and the diameter is 0,7 m. The pressure at the tail-water end is -28 kPa and 1,3 m in diameter. The vertical height between these two points is 2,5 m



Calculate

4.3.1 The effective turbine pressure head. (7)

4.3.2 The input power supplied to the turbine. (2)
[29]

TOTAL: 100



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FLUID MECHANICS N6

FORMULA SHEET

Any applicable formula may also be used.

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

$$hf = \frac{4fLV^2}{2gd} \qquad hs = \frac{kV^2}{2g}$$

$$hs = \frac{(V_1 - V_2)^2}{2g} \qquad hs = \frac{V^2}{2g} \times \left(\frac{1}{C_c} - 1\right)^2$$

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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