higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

FLUID MECHANICS N6

(8190216)

1 December 2023 (X-paper)
09:00–12:00

Nonprogrammable calculators may be used.

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

201Q1G2301

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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. Unless otherwise stated, round off your final answers to THREE decimal places.
5. Diagrams and sketches in this question paper are not drawn to scale.
6. Use g = 9,81 m/s^2.
7. Write neatly and legibly.

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QUESTION 1

1.1 Main pipe A forks into pipes B and C (as shown in FIGURE 1 below), collects water from a centrifugal pump and deposits it into a valley. Pipe B has a diameter and friction factor of 400 mm and 0,01, respectively. The main pipe is 100 m long, 600 mm in diameter and has the same coefficient of friction as pipe B. The friction head in pipe A is 6 m. Both pipe B and pipe C have the same length of 80 m and run parallel to each other.

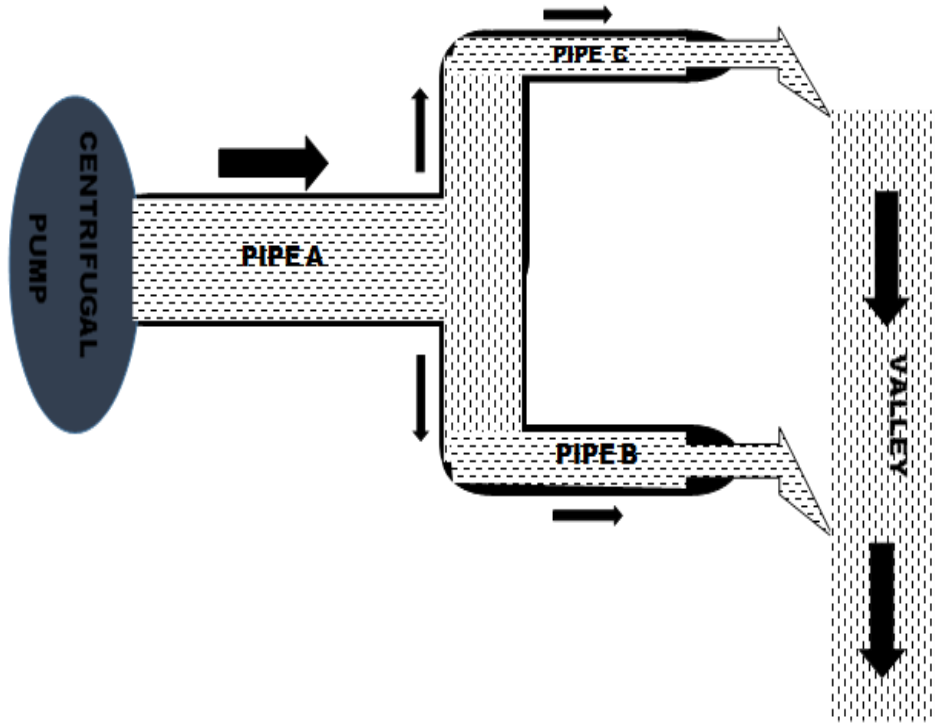

FIGURE 1

Calculate the following:

1.1.1 The velocity of flow through pipe A (2)

1.1.2 The delivery in pipe A (2)

1.1.3 The quantity of flow in pipe C if water flows at 3,5 m/s in pipe B (3)

1.1.4 The friction head in pipe B (2)

1.1.5 The coefficient of friction of pipe C, if it is a clean, new pipe and its diameter is one-third of that of the main pipe. Round off your answer to FIVE decimal places.

$HINT$: $(a)\ \ f = 0{,}01\left(1 + \frac{1}{40d}\right)$ $(b)\ \ f = 0{,}005\left(1 + \frac{1}{40d}\right)$ $(c)\ \ f = 0{,}007$ (2)

1.2 Define the *wetted perimeter* of a pipe. (1)

1.3 FIGURE 2 below shows a 1 125-m long pipe that conveys slime with a relative density of 0,8 from a tank at a rate of 1 240 m^3 every hour. Study it and answer the questions that follow.

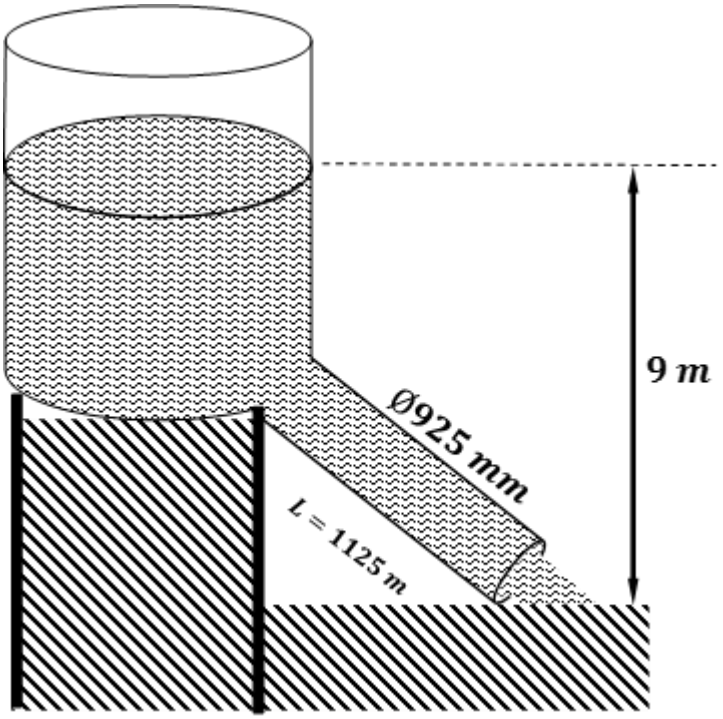

FIGURE 2

1.3.1 Define the term *relative density*. (1)

1.3.2 Calculate the following:

1.3.2.1 The density of the running fluid (1)

1.3.2.2 The friction factor of the pipe using Darcy's formula (2)

1.3.2.3 The hydraulic gradient of the pipe using Chezy's formula (5)

1.3.2.4 The losses at the exit point of the tank (4)

[25]

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QUESTION 2

2.1 A trapezoidal channel with sides of smooth stones slopping at 29º is shown in FIGURE 3 below. Its hydraulic mean depth is 2,3 m.

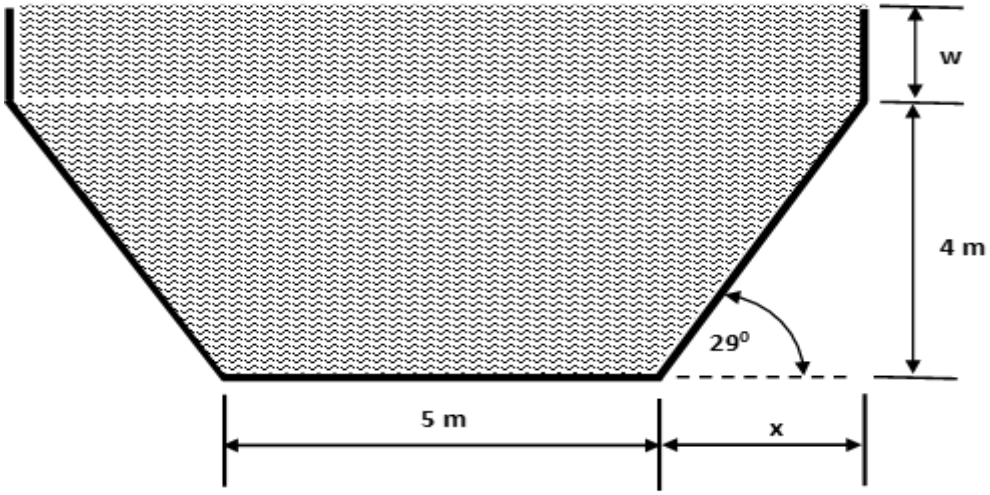

FIGURE 3

Calculate:

2.1.1 The dimension “x” (2)

2.1.2 The dimension “w” (6)

2.1.3 The discharge if the channel has a hydraulic gradient of 4 m/km. Use Chezy's constant as 65. (2)

2.2 FIGURE 4 below shows a square channel with a hydraulic gradient of $1{,}235 \times 10^{-3}$ and Chezy's constant of 50. It discharges a water quantity of 20 m^3 every second.

Determine the dimensions of this channel.

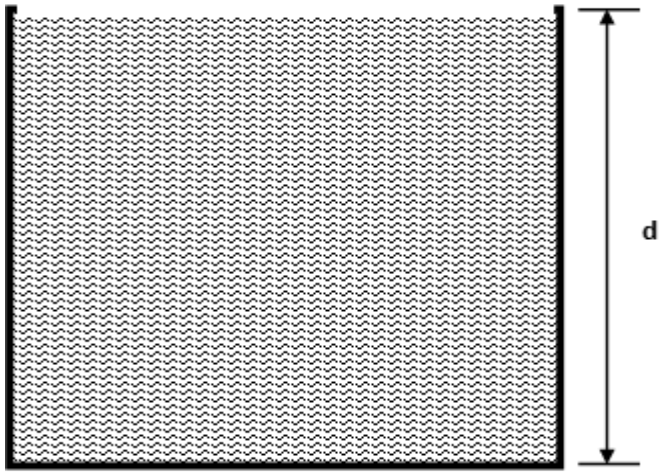

FIGURE 4 (4)

2.3 Define a *notch.* (1)

2.4 A 90º V-notch delivers water with a quantity of 1,5 m^3/s. The head above the bottom of the notch is 900 mm.

Determine the discharge coefficient. (3)

2.5 The coefficient of velocity, contraction and discharge of a jet are 0,83, 0,81 and 0,67, respectively. The diameter of the nozzle is 40 mm and the nozzle discharges water at a rate of 0,2 m^3 every minute from a reservoir. Determine:

2.5.1 The constant head (5)

2.5.2 The loss of head due to fluid resistance (2)

2.5.3 The horizontal distance travelled by the jet if the reservoir is 4 m high (3)

[28]

QUESTION 3

3.1 A double-acting three-throw reciprocating pump has a stroke of 300 mm, a plunger diameter of 200 mm and a crank rotational speed of 40 r/min. It is sucking and delivering water through 100-mm diameter pipes. The centre of the pump is 6 m above the water level, while the delivery head is 7 m. Take the barometric reading as 12 m.

3.1.1 If the pressure head at the beginning of the suction stroke is 3,5 m, determine the length of the suction pipe. (4)

3.1.2 If the friction head at the middle of the suction stroke is 5 m, determine the coefficient of friction of the suction pipe. (2)

3.1.3 If the friction factor of the delivery pipe is 0,02 and it is 9 m long, determine its pressure head:

3.1.3.1 At the beginning of the delivery stroke (3)

3.1.3.2 At the middle of the delivery stroke (3)

3.1.3.3 At the end of the delivery stroke (1)

3.1.4 Determine the discharge. (2)

3.1.5 Calculate the power required to drive the pump. Ignore the velocity of the head. (4)

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3.2 The outlet angle of the impeller guide vanes of a centrifugal pump is 29º. The diameter of the impeller and its rotational speed are 400 mm and 1 500 r/min, respectively. Water is sucked through a 200-mm diameter pipe. The difference between the peripheral and the whirl outlet velocities is 3,5 m/s.

Determine:

3.2.1 The width of the vanes at the outlet (4)

3.2.2 The total head if the manometric efficiency of the pump is 75% (4)

3.2.3 The torque exerted on the impeller shaft (2)

[29]

QUESTION 4

4.1 The rate of flow through the vertical shaft of a Francis turbine is 0,3 m^3/s. The input power supplied to the turbine is 42 kW. The pressure at the inlet and the tail water end is 150 kPa and -35 kPa, respectively. The vertical height between the two points is 2 m, while the diameter at the inlet is 310 mm.

Determine the diameter at the tail water end (in mm). (7)

4.2 In an impulse turbine, the governor is used to regulate its speed. Is this statement TRUE or FALSE? (1)

4.3 A Pelton wheel with a diameter of 1,5 m is driven by a certain number of similar jets rotating at 345 r/min at a total head of 350 m. Each jet has a diameter of 73 mm. It develops power of 5 000 kW while operating. The relative velocity is reduced by 8,5% as the water transverses the bucket surfaces, which deflects at an angle of 160º. The efficiency of the power transmission through the pipeline and the nozzles is 89%. Take the velocity coefficient as 0,9.

Calculate:

4.3.1 The number of jets driving the Pelton wheel (8)

4.3.2 The length of the 400-mm diameter supplying pipeline if its coefficient of friction is 0,006 (2)

[18]

TOTAL: 100

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FLUID MECHANICS N6

FORMULA SHEET

Any applicable formula may also be used.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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