higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

NATIONAL CERTIFICATE

FLUID MECHANICS N6

(8190216)

9 April 2020 (X-paper)
09:00–12:00

This question paper consists of 6 pages and a formula sheet of 2 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. Start each section on a new page.
5. Use only a black or blue pen.
6. Use $g = 9,81\ m/s^2$.
7. Round off final answers to TWO decimals.
8. Write neatly and legibly.

QUESTION 1

Choose a term from COLUMN B that matches a description in COLUMN A. Write only the letter (A–R) next to the question number (1.1–1.17) in the ANSWER BOOK.

COLUMN A		COLUMN B	
1.1	Vertical height from the sump to the centre of the pump	A	Bernoulli's theorem
1.2	Prevent a pump from leaking	B	siphon
1.3	Ratio between water contained in air and water required for saturation	C	hydraulic mean depth
1.4	Any substance that can take the shape of a container	D	hydraulic gradient
1.5	Where a pump gives a value of the discharge and head under a certain test	E	buckets
1.6	Consists of an inlet leg, crest and outlet leg	F	atmospheric head
1.7	Small opening on the side of a tank	G	plunger pump
1.8	Cross-sectional area of a pipe varies throughout its length	H	stuffing boxes
1.9	Power difference due to friction between the time when an air vessel is installed and when no air vessel is installed	I	vena contracta
1.10	Mass per unit volume	J	density of a fluid
1.11	$i = \sin\theta$	K	governor
1.12	Constant sum of the pressure, kinetic and potential energy of a fluid	L	steady flow
1.13	Ratio of area and perimeter	M	orifice
1.14	Piston length longer than the stroke	N	power saved
1.15	Region of the jet that starts widening immediately after the orifice	O	operating point
1.16	Speed regulator of an impulse turbine	P	relative humidity
1.17	Used to deflect water when entering the Pelton wheel	Q	fluid
		R	deflecting angle

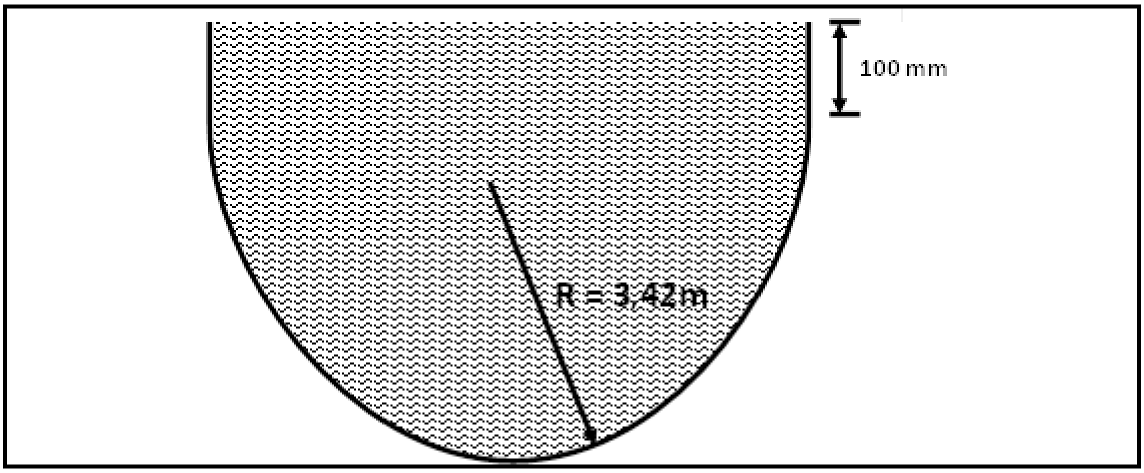
(17 × 1) **[17]**

QUESTION 2

2.1 A concrete pipe 350 mm in diameter and 3 km long discharges 4,35 m^3/min water. The coefficient of friction for the pipe is 0,02.

Calculate the total head loss due to friction using Chézy's formula. (9)

2.2 The diagram of a channel below shows a semicircle region at the bottom and a rectangular region at the top joined together and filled with water. Its gradient and Chézy's constant are 1 in 7 800 and 75 respectively.



Determine:

2.2.1 The cross-sectional area of the channel

2.2.2 The wetted perimeter of the channel

2.2.3 The hydraulic mean depth

2.2.4 The delivery of water by the channel in ℓ/s

(4 × 2) (8)

2.3 A circular orifice with an area of 600 mm^2 issues water from the side of the tank. The jet strikes the surface of the water 3 m from the side of the container which is 1,5 m above the surface. The coefficient of contraction is 0,75 and the coefficient of velocity is 0,9.

Calculate:

2.3.1 The discharge of the jet in m^3/s (6)

2.3.2 The horizontal reaction of the jet (2)

2.3.3 The loss of the head due to fluid reaction (4)

2.4 A fan delivers 7 m^3/s of air into a 52 m long duct of a certain cross-sectional area. If the coefficient of friction of the duct is 0,003 and the pressure required to overcome friction is 200 Pa.

Determine:

2.4.1 The cross-sectional area of the duct 'a' in terms of the diameter 'd' (1)

2.4.2 The air velocity 'v' in terms of the diameter 'd' (2)

2.4.3 The rubbing surface area 'S' in terms of the diameter 'd' (2)

2.4.4 The diameter 'd' in mm (3)
[37]

QUESTION 3

3.1 A three-throw plunger pump has a plunger diameter of 200 mm and a stroke of 600 mm delivers water at a head of 700 m. The speed of the crankshaft is 55 r/min with an efficiency of 82%.

Determine:

3.1.1 The quantity of water delivered in ℓ/s (3)

3.1.2 The output power of the motor (3)

3.2 List FIVE faults that can occur in a reciprocating pump during two operations. (5)

3.3 A single-acting plunger pump rotating at 50 r/min has a plunger with a diameter of 255 mm and a stroke of 455 mm. The water level is 5 m below the centre of the pump. The suction pipe has a diameter of 180 mm and is 8 m long.

Calculate:

3.3.1 The acceleration head when there is a large air vessel fitted 1,6 m from the cylinder (3)

3.3.2 The friction head when there is a large air vessel fitted 1,6 m from the cylinder (4)

3.3.3 The acceleration head when there is no air vessel fitted (3)

3.3.4 The friction head when there is no air vessel fitted (4)
[25]

QUESTION 4

4.1 A vertical-shaft Francis turbine is supplied with water at a rate of 25 m^3/min. The pressure at the inlet is 150 kPa. The pressure at the tail-water end is -10 kPa and 1,2 m in diameter. The vertical height between these two points is 2 m and the effective turbine pressure head is 24 m.

Apply Bernoulli's equation and calculate:

4.1.1 The diameter at the inlet in mm (8)

4.1.2 Input power supplied to the turbine in kW (3)

4.2 The head available at the entrance to the nozzle supplying a Pelton wheel is 350 m and the diameter of the wheel is 1,8 m. The nozzle diameter is 150 mm and the coefficient of velocity is 0,97. The relative velocity decreases by 10% as the water transverses the bucket surfaces which are so shaped that if they were stationary they deflect the jet through an angle of 160° (k = 0,5).

Calculate:

4.2.1 The velocity of water entering the buckets (2)

4.2.2 The power developed by the Pelton wheel in megawatt (6)

4.2.3 The efficiency of the runner (2)
[21]

TOTAL: 100

FORMULA SHEET

Any applicable formula may also be used.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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