higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

T720**(E)**(A6)T

NATIONAL CERTIFICATE

FLUID MECHANICS N6

(8190216)

6 April 2018 (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.

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. Show all the necessary steps for every calculation. All units must be shown in the final answers.
5. Round off your final answers to THREE decimal places.
6. Use $g = 9{,}81$ m/s^2
7. The sketches in this question paper are NOT drawn to scale.
8. Write neatly and legibly.

QUESTION 1

1.1 Differentiate between *uniform flow* and *steady flow.* (2)

1.2 Study the diagram in FIGURE 1 below.

It shows the water flow from the Rhino Dam through main pipe ① to Mr Oosthuizen's farm, through pipes ②, ③, ④ and ⑤, to irrigate his plantation as indicated below.

This new clean piping system is manufactured from a mild steel.

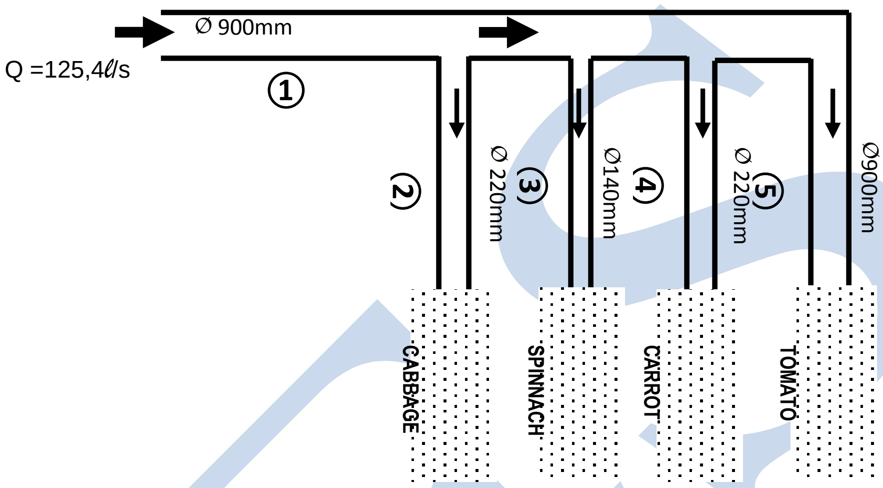

FIGURE 1

1.2.1 Will the friction head at ② differ or be the same at ③? Give a reason for your answer. (2)

1.2.2 Will the quantity of flow at ① differ or be the same at ③? Give a reason for your answer. (2)

1.2.3 Will the velocity at ① differ or be the same at ④? Give a reason for your answer. (2)

Hence, determine the following:

1.2.4 The velocity of water in the main pipe (from the dam) (2)

1.2.5 The velocity of water in the pipe which supplies the carrot plantation (2)

1.2.6 The friction head in an 11 m long pipe ④, if its friction factor is $0{,}005\left(1 + \frac{1}{40d}\right)$ (3)

1.3 A 500 mm diameter pipe line is 1,45 km long and delivers 1,249 m^3/s of water. The coefficient of friction in the system is 0,007.

Calculate the following:

1.3.1 The Chezy constant (C) (2)

1.3.2 The head loss due to friction using the Chezy formula (6)

1.4 Two reservoirs are connected by means of a 70 m long pipe. The first 30 m has a diameter of 154 mm and is reduced to 84 mm for the remaining length. The difference in water levels between the reservoirs is constant at 11 m.

Consider the pipe friction and neglect all other losses.

Use the friction factor 0,008 and calculate the rate of flow at the 84 mm section.

HINT: Consider Bernoulli's equation between TWO reservoirs. (8)

[31]

QUESTION 2

2.1 What is an *orifice*? (1)

2.2 Each side of a V-shaped open channel is inclined at 60^0 from the vertical.

If the rate of flow is 347 m^3/min and its maximum depth is 1,2 m, calculate the gradient of the channel (in ratio form) using the Chezy formula.

Assume the Chezy constant C as $\frac{87}{1+\frac{k}{\sqrt{m}}}$ where k is the constant for the dirty surfaces and equals 0,276. (12)

2.3 The maximum flow of water expected in a channel is 145 ℓ/s.

If the coefficient of discharge of a 90° notch is 0,6, what should be the minimum height (in mm) of a suitable notch? (4)

2.4 A sharp-edged orifice of 60 mm diameter has a coefficient of velocity of 0,89 and a contraction coefficient of 0,56. It discharges into a tank where the water surface is 2,1 m below the centre of the orifice. The jet of water strikes the surface of the water in the tank at a horizontal distance of 5,3 m from the orifice.

Calculate the head of water above. (6)

2.5 What is a *notch*? (2)

[25]

QUESTION 3

3.1 TWO similar plunger pumps are capable of delivering 22 500 ℓ of water per hour and are arranged for pumping in parallel through a common pipe delivery pipe. The static head is 320 m. When ONE pump operates, the total head is 335 m.

Assume a pump efficiency of 86% and calculate the following:

3.1.1 The required power when ONE pump operates (4)

3.1.2 The required power for EACH pump when both pumps are operating simultaneously (6)

3.2 Study the velocity diagram for the impeller outlet of a centrifugal pump in FIGURE 2 below and answer the questions.

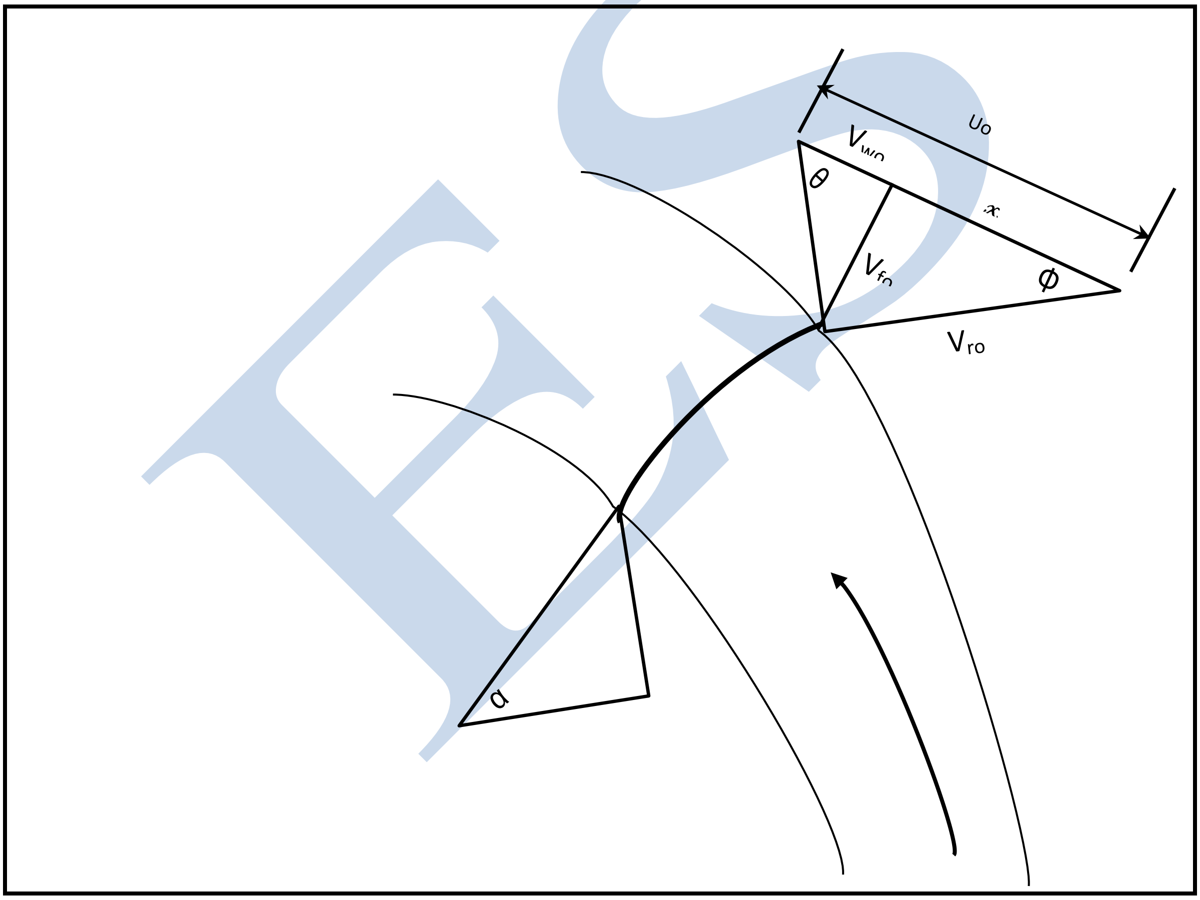

FIGURE 2

The single-stage centrifugal pump operating at a speed of 1 100 r/min delivers 1,25 m^3 of water per minute. The impeller diameter is 365 mm and the breadth of the vanes at the outlet is 14 mm. The pressure generated from the inlet to the outlet flange is 285 kPa. The pump's manometric efficiency is 65%.

Neglect all the losses and calculate the following:

3.2.1 The manometric head generated (H_m)

3.2.2 The theoretical head generated (H_T)

3.2.3 The peripheral velocity of the impeller at the outlet (U_o)

3.2.4 The area of the impeller outlet

3.2.5 The radial (flow) velocity of the water leaving the impeller (V_{fo})

3.2.6 The tangential (whirl) velocity of the water leaving the impeller (V_{wo})
(6 × 2) (12)

3.3 A fan running at 500 r/min delivers 550 m^3/min of air. Its dynamic pressure is 48,4 mm water gauge with an efficiency of 78%. The density of air = 1 kg/m^3.

3.3.1 Calculate the input power on the fan. (2)

3.3.2 Calculate the power required on the fan if its speed is decreased to 350 r/min. (2)

3.3.3 From your answer in QUESTION 3.3.2, what conclusion can you draw about the relationship/behaviour between the rotational speed and power? (1)

[27]

QUESTION 4

4.1 Water is supplied to an axial flow turbine under a total head of 45 m. The mean diameter of the runner is 2,3 m and it is rotating at 145 r/min. Water leaves the guide vanes at 30° to the direction of the runner rotation and at mean radius the angle of the runner blade outlet is 27°.

If 10% of the total head is lost in the casing and the guide vanes and the relative velocity is reduced by 8% due to friction in the runner, determine the following:

4.1.1 The absolute velocity of water at the inlet (2)

4.1.2 The tangential velocity of the runner (2)

4.1.3 The hydraulic efficiency if the whirl velocities at the inlet and the outlet are 20 m/s and 5 m/s respectively (4)

4.2 A Pelton wheel is driven by three similar jets. The runner has a diameter of 1,8 m, is fixed in a horizontal position and runs at 350 r/min. The head from the reservoir level to the nozzle is 340 m and the efficiency of power transmission through the pipeline and the nozzle is 85%. The relative velocity decreases by 9% as the water transverses the bucket surface which deflects the jet at an angle of 162°. The coefficient of velocity for the jets is 0,98 and the discharge is 7 660 m^3/h.

Calculate the following:

4.2.1 The spouting velocity of the jet driving the runner (2)

4.2.2 The diameter of a jet (2)

4.2.3 The diameter of the supply pipe if the friction factor is 0,007 and the length of the pipe is 1,5 km (2)

4.2.4 The hydraulic efficiency (3)
[17]

TOTAL: 100

FLUID MECHANICS N6

FORMULA SHEET

Any applicable formula may also be used.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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