



**higher education
& training**

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

FLUID MECHANICS N6

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This marking guideline consists of 6 pages.

QUESTION 1

1.1 1.1.1 $\rho = 1,1 \times 1000 \sqrt{}$
 $= 1\,100 \text{ kg/m}^3 \sqrt{}$ (1)

1.1.2 $m = \frac{D}{4}$
 $= \frac{0,152}{4} \sqrt{}$
 $= 0,038 \text{ m} \sqrt{}$ (2)

1.1.3 The diameter 'x' of the biggest pipe if the total friction head in the

$$h_{f_T} = \left(\frac{f l Q^2}{3 d^5} \right)_1 + \left(\frac{f l Q^2}{3 d^5} \right)_2 \sqrt{}$$

$$20 = \frac{0,01 \times 8 \times 0,193^2}{3 \times 0,152^5} + \frac{0,025 \times 10 \times 0,193^2}{3 x^5} \sqrt{}$$

$$x = 209,142 \text{ mm} \sqrt{}$$

OR

$$V_1 = \frac{0,193 \times 4}{\pi \times 0,152^2} = 10,636 \text{ m/s} \sqrt{}$$

$$V_2 = \frac{0,193 \times 4}{\pi x^2} = \frac{0,246}{x^2} \sqrt{}$$

$$h_{f_T} = \left(\frac{4 f l v^2}{3 g d} \right)_1 + \left(\frac{4 f l v^2}{2 g d} \right)_2$$

$$20 = \frac{4 \times 0,01 \times 8 \times 10,636^2}{2 \times 9,81 \times 0,152} + \frac{0,01 \times 10 \times (0,246/x^2)^2}{2 \times 9,81 \times x} \sqrt{}$$

$$x = 208,232 \text{ mm} \sqrt{}$$

(4)

1.1.4. $V_2 = \frac{0,193 \times 4}{\pi \times 0,209142^2}$

$$= 5,618 \text{ m/s} \sqrt{}$$

OR $V_2 = \frac{0,193 \times 4}{\pi \times 0,208232^2}$

$$= 5,667 \text{ m/s} \sqrt{}$$

$$h_l = \frac{(v_1 - v_2)^2}{2g}$$

$$h_l = \frac{(10,636 - 5,618)^2}{2 \times 9,81} \sqrt{}$$

$$h_l = \frac{(10,636 - 5,667)^2}{2 \times 9,81} \sqrt{}$$

OR

$$= 1,283 \text{ m} \sqrt{}$$

$$= 1,258 \text{ m} \sqrt{}$$

(3)

1.1.5. $\frac{Pr_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{Pr_2}{\rho g} + \frac{v_2^2}{2g} + z_2 + \frac{(v_1 - v_2)^2}{2g} \checkmark$
 $\frac{Pr_1}{1100 \times 9,81} + \frac{10,636^2}{2 \times 9,81} = \frac{Pr_2}{1100 \times 9,81} + \frac{5,618^2}{2 \times 9,81} + 1,283 \checkmark$
 $Pr_1 - Pr_2 = -31,015 \text{ kPa} \checkmark$
 alternatively
 $Pr_2 - Pr_1 = 31,015 \text{ kPa} \checkmark$
 Alternatively
 $\frac{Pr_1}{\rho g} + \frac{v_1^2}{2g} + z_1 = \frac{Pr_2}{\rho g} + \frac{v_2^2}{2g} + z_2 + \frac{(v_1 - v_2)^2}{2g} \checkmark$
 $\frac{Pr_1}{1100 \times 9,81} + \frac{10,636^2}{2 \times 9,81} = \frac{Pr_2}{1100 \times 9,81} + \frac{5,667^2}{2 \times 9,81} + 1,258 \checkmark$
 $Pr_1 - Pr_2 = -30,979 \text{ kPa} \checkmark$
 alternatively
 $Pr_2 - Pr_1 = 30,979 \text{ kPa} \checkmark$ (3)

1.2 $\left(\frac{f l Q^2}{3 d^5} \right)_1 = \left(\frac{f l Q^2}{3 d^5} \right)_2$
 $\left(\frac{0,01 \times Q^2}{(0,152)^5} \right)_1 = \left(\frac{0,025 Q^2}{(0,209142)^5} \right)_2 \checkmark$
 $Q_2 = 1,405 Q_1 \dots\dots\dots(1) \text{ alternatively } Q_1 = 0,712 Q_2 \dots\dots\dots(1) \checkmark$
 $0,193 = 1,405 Q_1 + Q_1 \text{ alternatively } 0,193 = 0,712 Q_2 + Q_2 \checkmark$
 $Q_1 = 0,0803 \text{ m}^3/\text{s} \checkmark$
 $Q_2 = 0,113 \text{ m}^3/\text{s} \checkmark$ (5)

1.3 1.3.1 $h_f = \frac{4 f l v^2}{2 g d}$
 $= \frac{4 \times 0,03 \times 100 \times 2,1^2}{2 \times 9,81 \times 0,1} \checkmark$
 $= 26,972 \text{ m} \checkmark$ (2)

1.3.2 $C = \sqrt{\frac{2g}{f}}$ $m = \frac{d}{4}$ $A = \frac{\pi}{4} d^2$ (7)
 $= \sqrt{\frac{2 \times 9,81}{0,03}} \checkmark$ $= \frac{0,1}{4} \checkmark$ $= \frac{\pi}{4} (0,2)^2 \checkmark$
 $= 25,573 \checkmark$ $= 0,025 \text{ m}$ $= 7,854 \times 10^{-3} \checkmark$
 $2,1 = 25,573 \sqrt{0,025 \times i} \checkmark$
 $i = 0,2697$
 $\frac{h_f}{L} \checkmark = 0,2697$

$$h_f = 26,972 \text{ m} \checkmark$$

[27]**QUESTION 2**

2.1

$$a_A = \frac{\pi \times (0,8)^2}{4} = 0,503 \text{ m}^2 \checkmark$$

$$S_A = \pi \times 0,8 \times 30 = 75,398 \text{ m}^2 \checkmark$$

$$a_B = 0,9 \times 0,34 = 0,306 \text{ m}^2 \checkmark$$

$$S_B = [2(0,9) + 2(0,34)] \times 25 = 62 \text{ m}^2 \checkmark$$

$$\left(\frac{kS v^2}{a} \right)_A = \left(\frac{kS v^2}{a} \right)_B$$

$$\left(\frac{75,398 \times v^2}{0,503} \right)_A = \left(\frac{62 \times v^2}{0,306} \right)_B \checkmark$$

$$V_A = 1,162 V_B \dots \dots \dots (1) \checkmark$$

$$10,9 = (1,162 V_B \times 0,6362) + V_B \times 0,306 \checkmark$$

$$V_B = 12,244 \text{ m/s} \checkmark$$

$$V_A = 14,231 \text{ m/s} \checkmark$$

$$Q_A = 14,231 \times 0,503 = 7,153 \text{ m}^3/\text{s} \checkmark$$

$$Q_B = 12,244 \times 0,306 = 3,747 \text{ m}^3/\text{s} \checkmark$$

(8)

2.2.

$$A = \frac{1}{2} \pi R^2 = 1,571 R^2$$

alternatively

$$A = \frac{1}{2} \left(\frac{\pi \times D^2}{4} \right) = 0,393 D^2 \checkmark$$

$$P = \frac{1}{2} (2\pi R) = 3,142 R$$

alternatively

$$P = \frac{1}{2} (2\pi D) = 3,142 D \checkmark$$

$$m = \frac{1,571 R^2}{3,142 R} = 0,5R$$

alternatively

$$m = \frac{0,393 D^2}{3,142 D} = 0,25D \checkmark$$

$$\epsilon = \frac{3}{4000} = 7,5 \times 10^{-4} \checkmark$$

$$Q = AC\sqrt{mi}$$

$$20 = 1,571 R^2 \times 50 \sqrt{0,5 R \times 7,5 \times 10^{-4}}$$

$$\text{OR } 20 = (0,393 D^2 \times 50) \sqrt{0,25 D \times 7,5 \times 10^{-4}} \checkmark$$

$$R = 2,803 \text{ m}$$

$$\text{OR } D = 5,605 \text{ m} \quad R = \frac{5,605}{2} = 2,803 \text{ m} \checkmark$$

(7)

2.3

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

$$= 0,7 \times \frac{8}{15} \times \sqrt{2 \times 9,81} \tan \frac{90}{2} \times 0,899^{2,5} \checkmark$$

$$= 1,267 \text{ m}^3/\text{s} \checkmark$$

(3)

2.4 2.4.1
$$h = \frac{P}{\rho g}$$

$$= \frac{480}{9,81} \sqrt{}$$

$$= 48,93 \text{ m} \sqrt{}$$

$$V = C_v \sqrt{2gh}$$

$$= 0,97 \sqrt{2 \times 9,81 \times 48,93} \checkmark$$

$$= 30,054 \text{ m/s} \checkmark \quad (3)$$

2.4.2
$$F = PA$$

$$= 480 \times 10^3 \times \frac{\pi}{4} (0,04)^2 \checkmark$$

$$= 603,186 \text{ N} \checkmark \quad (2)$$

2.4.3 Force on the bolt = (Pressure x Area of pipe) – (Force exerted by nozzle)

$$= 450 \times 10^3 \times \frac{\pi}{4} (0,3)^2 - 603,186 \checkmark$$

$$= 33,326 \text{ kN} \checkmark \quad (2)$$

[25]

QUESTION 3

3.1 3.1.1
$$Q = va = \text{ALSEN}/60$$

$$v = \left(\frac{0,13}{0,09} \right)^2 \times 0,35 \times 1 \times 2 \times \frac{75}{60} \checkmark$$

$$= 1,826 \text{ m/s} \checkmark$$

$$h_f = \frac{4flv^2}{2gd}$$

$$= \frac{4 \times 0,007 \times (80-4) \times 1,826^2}{2 \times 9,81 \times 0,09} \checkmark$$

$$= 4,0165 \text{ m} \checkmark$$

$$H_{\text{pre}} = H_{\text{at}} + h_d + h_{fd} \checkmark$$

$$= 10,4 + 42 + 4,0165 \checkmark$$

$$= 56,417 \text{ m} \checkmark \quad (7)$$

3.1.2
$$h_a = \frac{4}{9,81} \times \left(\frac{0,13}{0,09} \right)^2 \times \left(\frac{2\pi \times 75}{60} \right)^2 \times \frac{0,35}{2} \checkmark$$

$$= 9,184 \text{ m} \checkmark$$

$$H_{\text{pre}} = H_{\text{at}} + h_d - h_a$$

$$= 10,4 + 42 - 9,184 \checkmark$$

$$= 43,216 \text{ m} \checkmark \quad (4)$$

3.2 3.2.1
$$Q_{th} = \text{ALSEN}/60$$

$$= \frac{\pi}{4} 0,15^2 \times 0,4 \times 3 \times 1 \times \frac{50}{60} \checkmark$$

$$= 0,01767 \text{ m}^3/\text{s} \checkmark$$

$$\% \text{ slip} = \frac{Q_{th} - Q_A}{Q_{th}} \times 100$$

(4)

$$5 = \frac{0,01767 - Q_A}{0,01767} \times 100 \checkmark$$

$$Q_A = 0,0168 \text{ m}^3/\text{s} \checkmark$$

3.2.2

$$P = \frac{\rho g Q H}{\eta}$$

$$= \frac{10^3 \times 9,81 \times 0,0168 \times 900}{0,92} \checkmark$$

$$= 161,109 \text{ kW} \checkmark$$

(2)

3.3

3.3.1

$$Q = a \times V_{f0}$$

$$0,15 = \frac{\pi}{4} \times d^2 \times 2 \checkmark$$

$$d = 309,019 \text{ mm} \checkmark$$

$$Q = a \times V_{f0}$$

$$0,15 = \frac{\pi}{4} \times d^2 \times 3 \checkmark$$

$$d = 252,313 \text{ mm} \checkmark$$

(4)

3.3.2

$$N = \frac{\text{total head}}{\text{head/stage}} \checkmark$$

$$= \frac{400}{150} \checkmark$$

$$= 2,667 \text{ say 3 stages} \checkmark$$

(3)

3.3.3

$$P = \frac{\rho g Q H_{\text{total}}}{\eta} \checkmark$$

$$= \frac{10^3 \times 9,81 \times 0,15 \times 400}{0,8} \checkmark$$

$$= 735,75 \text{ kW} \checkmark$$

(3)

[27]

QUESTION 4

4.1

4.1.1

$$V_1 = \frac{0,34 \times 4}{\pi \times 0,3^2} = 4,81 \text{ m/s} \checkmark$$

$$V_2 = \frac{0,34 \times 4}{\pi \times D_2^2} \checkmark = \frac{0,433}{D_2^2} \text{ m/s} \checkmark$$

$$\frac{Pr_1}{\rho g} + \frac{v_1^2}{2g} + z_A - H_e = \frac{Pr_2}{\rho g} + \frac{v_2^2}{2g} + z_2$$

$$\frac{166}{9,81} + \frac{4,81^2}{2 \times 9,81} + 2 - 23 \checkmark = \frac{-60}{9,81} + \frac{9,552 \times 10^{-3}}{D_2^4} + 0 \checkmark$$

$$D_2^4 = 2,9592 \times 10^{-3}$$

$$D = 233,431 \text{ mm} \checkmark$$

(7)

$$\begin{aligned}
 4.1.2 \quad \text{Power} &= \rho g Q H_e \\
 &= 10^3 \times 9,81 \times 0,34 \times 23 \checkmark \\
 &= 76,714 \text{ kW} \checkmark
 \end{aligned}
 \tag{2}$$

$$\begin{aligned}
 4.2 \quad 4.2.1 \quad V_i &= C_v \sqrt{2gh} \\
 &= 0,97 \sqrt{2 \times 9,81 \times 400} \checkmark \\
 &= 85,931 \text{ m/s} \checkmark \\
 &\text{For maximum efficiency} \\
 U_i &= 0,5 V_i \\
 &= (0,5 \times 85,931) \checkmark \\
 &= 42,966 \text{ m/s} \checkmark \\
 N &= \frac{60 U_i}{\pi D} \\
 &= \frac{60 \times 42,966}{\pi \times 1,6} \checkmark \\
 &= 512,864 \text{ r/min} \checkmark
 \end{aligned}
 \tag{6}$$

$$\begin{aligned}
 4.2.2 \quad \eta &= \frac{U}{g h} (V - U)(1 + n \cos \theta) \times 100\% \\
 &= \frac{42,966}{9,81 \times 400} (85,931 - 42,966)(1 + 0,85 \cos 14^\circ) \times 100\% \checkmark \\
 &= 85,845 \% \checkmark
 \end{aligned}
 \tag{2}$$

$$\begin{aligned}
 4.2.3 \quad Q &= VA \\
 &= 85,931 \times \frac{\pi}{4} (0,2)^2 \checkmark \\
 &= 2,6996 \text{ m}^3/\text{s} \checkmark \\
 P_{out} &= \rho Q U (V - U)(1 + n \cos \theta) \\
 &= 10^3 \times 2,6996 \times 42,966 (85,931 - 42,966)(1 + 0,85 \cos 14^\circ) \checkmark \\
 &= 9,094 \text{ MW} \checkmark
 \end{aligned}
 \tag{4}$$

[21]

TOTAL: 100