



**higher education
& training**

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

FLUID MECHANICS N5

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This marking guideline consists of 10 pages.

QUESTION 1

- 1.1 1.1.1 Pressure is the force exerted by a fluid✓ on any surface with which it is in contact or by one part of a fluid on the adjoining parts.✓
- 1.1.2 Atmospheric pressure is the pressure acting✓ or exerted on the surface of the earth due to the weight of the atmospheric pressure.✓
- 1.1.3 Absolute pressure is the pressure✓ which is measured above absolute zero and is the sum of the atmospheric✓ and gauge pressure.
- 1.1.4 Gauge pressure is the intensity of pressure measure above✓ or below atmospheric pressure and is measured by a gauge device.✓
(4 × 2) (8)
- 1.2 1.2.1
$$SG = \frac{\rho_{ice}}{\rho_{water}}$$

$$\rho_{ice} = SG \times \rho_{water}$$

$$= 1,1 \times 1\,000 \checkmark$$

$$= 1\,100 \text{ kg/m}^3 \checkmark$$
 (2)
- 1.2.2
$$W = mg = \rho V_{ice} g$$

$$= (1\,100 \times 2) \times 9,81 \checkmark$$

$$= 21,582 \text{ kN} \checkmark$$
 (3)
- 1.2.3
$$W_{ice} = F_{bouyancy}$$

$$\rho_{ice} V_{ice} g = \rho_w V_{disp} g$$

$$21,582 \times 10^3 = 1000 \times 2 \times 2 \times h \times 9,81 \checkmark$$

$$V_{disp} = 4h = \frac{21,582 \times 10^3}{9\,810} \checkmark$$

$$h = \frac{2,2}{4} \checkmark$$

$$= 0,55 \text{ m} \checkmark$$
 (4)
- 1.3 Surface tension, it is the tension induced due ✓ to the cohesion of forces between molecules on the surface of the fluid (liquid) which adjoins another immiscible fluid (liquid), this is also the property that allows objects to float on its surface and is measured ✓ in N/m. (3)
[20]

QUESTION 2

2.1 2.1.1

$$t = \frac{D - d}{2}$$

$$= \frac{95,2 - 95}{2} \checkmark$$

$$= 0,1 \text{ mm} \checkmark$$

$$\tau = \frac{\mu \times v}{t}$$

$$= \frac{0,2 \times 5}{0,1 \times 10^{-3}} \checkmark$$

$$= 10 \text{ kPa} \checkmark$$

$$F = \tau A = \tau \pi d L$$

$$= 10\,000 \times (\pi \times 0,095 \times 0,12) \checkmark$$

$$= 358,142 \text{ N} \checkmark \quad (7)$$

2.1.2

$$P = Fv$$

$$= 358,142 \times 5 \checkmark$$

$$= 1790,709 \text{ W} \checkmark \quad (2)$$

2.1.3

$$v = \frac{\mu}{\rho}$$

$$= \frac{0,2}{850} \checkmark$$

$$= 235,294 \times 10^{-3} \text{ m}^2/\text{s} \checkmark \quad (2)$$

$$2.2 \quad V = AL$$

$$700 \times 10^{-6} = \frac{\pi \times D_{LP}^2 \times 0,5D_{LP}}{4} \checkmark$$

$$D_{LP} = \sqrt[3]{\frac{8 \times 700 \times 10^{-6}}{\pi}} \checkmark$$

$$= 121,124 \text{ mm} \checkmark$$

$$L = 0,5D_{LP}$$

$$= 0,5 \times 121,124 \checkmark$$

$$\therefore L = 60,625 \text{ mm} \checkmark$$

$$F_{HP} = F_{LP} \checkmark$$

$$P_{HP} A_{HP} = P_{LP} A_{LP}$$

$$P_{HP} D_{HP}^2 = P_{LP} D_{LP}^2$$

$$D_{HP} = D_{LP} \sqrt{\frac{P_{LP}}{P_{HP}}} \checkmark$$

$$= 121,124 \sqrt{\frac{7}{15}} \checkmark$$

$$\therefore D_{HP} = 82,743 \text{ mm} \checkmark$$

(9)
[20]

QUESTION 3

3.1 3.1.1

Consider oil :

$$\begin{aligned}
 P_{oil-1} &= \frac{\rho g h_{oil-1}}{2} \\
 &= \frac{900 \times 9,81 \times 2}{2} \\
 &= 8829 Pa \checkmark \\
 F_{oil-1} &= P_{oil-1} \times A_{oil-1} \\
 &= 8829 \times 3,5 \times 2 \checkmark \\
 &= 61,803 kN \checkmark \\
 F_{oil2} &= 900 \times 9,81 \times 2 \times 3,5 \times 3 \checkmark \\
 &= 238,383 kN \checkmark
 \end{aligned}$$

Consider water

$$\begin{aligned}
 P_w &= \frac{\rho g h_w}{2} \\
 &= \frac{1000 \times 9,81 \times 3}{2} \\
 &= 14715 Pa \checkmark \\
 F_w &= P_w \times A_w \\
 &= 8829 \times 3,5 \times 2 \checkmark \\
 &= 103,005 kN \checkmark
 \end{aligned}$$

Total hydrostatic force

$$\begin{aligned}
 F_{total} &= F_{oil-1} + F_w + F_{oil2} \quad \checkmark \\
 &= 61,803 + 238,383 + 103,005 \\
 &= 403,191 kN
 \end{aligned}$$

(10)

3.1.2

$$h_{oil-1} = 3 + \frac{2}{3} = 3,6667 m \checkmark$$

$$h_{oil-2} = \frac{3}{2} = 1,5 m \checkmark$$

$$h_w = \frac{3}{3} = 1 m \checkmark$$

Moments taken about the turning point :

$$\begin{aligned}
 (F_w \times h_w) + (F_{oil-1} \times h_{oil-1}) + (F_{oil-2} \times h_{oil-2}) &= F_{total} y_{total} \\
 (103,005 \times 1) + (61,803 \times 3,6667) + (238,383 \times 1,5) &= 403,191 y_{total} \checkmark
 \end{aligned}$$

$$y_{total} = 1,704 m \text{ (from bottom)} \checkmark$$

$$y_{total} = 5 - 1,704 = 3,3 m \text{ (from free surface)}$$

(6)

- 3.2 The principle of Archimedes states that the upward thrust or force of buoyancy acting on a body immersed or submerged in a fluid (liquid) is equal to the weight of the fluid displaced. The greater the density of the fluid (liquid), the greater the effect of the upward thrust or force of buoyancy. (4)
[20]

QUESTION 4

- 4.1 4.1.1 The cross-sectional area and velocity of a stream may vary from cross-section to cross-section, however will not with respect to time: tapering pipe
- 4.1.2 The cross-sectional area and velocity of a stream varies with respect to time: wave in a channel
- 4.1.3 The cross-sectional area and velocity of a stream are the same at successive sections: pipe of constant diameter running full
- 4.1.4 The cross-sectional area and velocity of a stream are not the same at successive sections: pipe of constant diameter delivering water from reciprocating pump (4 × 2) (8)
- 4.2 4.2.1
- $$V = \frac{m}{\rho}$$
- $$= \frac{10\,000}{950}$$
- $$= 10,526316 \text{ m}^3$$
- $$Q = \frac{V}{t}$$
- $$t = \frac{10,526316}{12 \times 10^{-3}}$$
- $$= 877,193 \text{ sec}$$
- $$= 14,62 \text{ min}$$
- (5)
- 4.2.2
- $$P = \rho gh$$
- $$= 950 \times 9,81 \times 4$$
- $$= 37,278 \text{ kPa}$$
- (3)

4.2.3 Applying Bernoulli's theorem :

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + Z_2 \checkmark$$

since : $P_1 = P_2$...atmospheric conditions

$$v_1 \approx 0$$

$$\text{thus, } Z_1 = \frac{v_2^2}{2g} + Z_2 \checkmark$$

$$v_2^2 = 2g(Z_1 - Z_2) \checkmark$$

$$= \sqrt{19,62 \times 6} \checkmark$$

$$\therefore v_2 = 10,85 \text{ m/s} \checkmark$$

(4)
 [20]

QUESTION 5

5.1 5.1.1

$$C_c = \frac{A_{vena}}{A_{ori}} = \frac{d_{vena}^2}{d_{ori}^2}$$

$$= \frac{13,382}{16} \checkmark$$

$$= 0,836 \checkmark$$

$$v_{ori} = \sqrt{2gh}$$

$$= \sqrt{19,62 \times 60} \checkmark$$

$$34,310348 \text{ m/s} \checkmark$$

$$Q_{ori} = \frac{34,310348 \times \pi \times (13,382 \times 10^{-3})^2}{4} \checkmark$$

$$= 4,82566 \text{ m}^3/\text{s} \checkmark$$

$$C_Q = \frac{Q_{jet}}{Q_{ori}}$$

$$= \frac{3,61111}{4,82566} \checkmark$$

$$= 0,748 \checkmark$$

$$C_Q = C_c \times C_v$$

$$C_v = \frac{0,748}{0,836} \checkmark$$

$$= 0,894 \checkmark$$

(11)

$$\begin{aligned}
 5.1.2 \quad h_{loss} &= h(1 - C_v^2) \\
 &= 60(1 - 0,894^2) \checkmark \\
 &= 12,046 \text{ m} \checkmark
 \end{aligned}$$

Alternatively

$$\begin{aligned}
 h_{loss} &= h - \frac{v_{vena}^2}{2g} \\
 &= 60 - \frac{(0,894 \times 34,310348)^2}{19,62} \checkmark \\
 &= 12,046 \text{ m} \checkmark
 \end{aligned} \tag{3}$$

$$\begin{aligned}
 5.2 \quad 5.2.1 \quad h_{loss} &= \frac{(v_1 - v_2)^2}{2g} \\
 &= \frac{(6,9 - 3,5)^2}{19,62} \checkmark \\
 &= 0,589 \text{ m} \checkmark
 \end{aligned} \tag{2}$$

5.2.2 *Applying Bernoulli's theorem :*

$$\begin{aligned}
 \frac{P_1}{\rho g} + \frac{v_1^2}{2g} + Z_1 &= \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + Z_2 + h_{loss} \\
 \frac{\Delta P}{\rho g} &= \frac{v_1^2 - v_2^2}{2g} - h_{loss} \\
 &= \frac{6,9^2 - 3,5^2}{19,62} - 0,589 \checkmark \\
 &= 1,213 \text{ m} \checkmark \\
 \Delta P &= 9\,810 \times 1,213 \checkmark \\
 &= 11,902 \text{ kPa}
 \end{aligned} \tag{4}$$

[20]

QUESTION 6

6.1
$$\dot{W} = \dot{m} g = \frac{\rho V g}{t} = \rho g Q$$
$$\dot{W} = \frac{9\,810 \times \pi \times 0,2^2 \times 4,5}{4} \checkmark$$
$$= 1389,856 \text{ N/s } \checkmark \quad (2)$$

6.2
$$Q_i = Q_o$$
$$A_i v_i = A_o v_o$$
$$v_o = \frac{d_i^2 v_i}{d_o^2} \checkmark$$
$$= \left(\frac{0,2}{0,15} \right)^2 \times 4,5 \checkmark$$
$$= 8 \text{ m/s } \checkmark \quad (3)$$

6.3
$$\frac{P_i}{\rho g} + \frac{v_i^2}{2g} + Z_i = \frac{P_o}{\rho g} + \frac{v_o^2}{2g} + Z_o + h_{loss}$$
$$\frac{P_o}{\rho g} = \frac{P_i}{\rho g} + \frac{v_i^2}{2g} - \left(\frac{v_o^2}{2g} + h_{loss} \right) \checkmark$$
$$= \frac{70 \times 10^3}{9\,810} + \frac{4,5^2}{19,62} - \frac{8^2}{19,62} - 2 \checkmark$$
$$= 9\,810 \times 2,9057085 \checkmark$$
$$\therefore P_o = 28,505 \text{ kPa} \quad (4)$$

6.4

$$F_i = P_i A_i + m v_i^0$$

$$m = \rho Q = \rho A_i v_i = \rho A_o v_o$$

$$F_i = \left(70 \times 10^3 \times \frac{\pi \times 0,2^2}{4} \right) + \left(1000 \times \frac{\pi \times 0,2^2}{4} \times 4,5 \right)$$

$$\therefore F_i = 2340,4865 N \checkmark$$

$$F_o = \left(28,507 \times 10^3 \times \frac{\pi \times 0,15^2}{4} \right) + \left(1000 \times \frac{\pi \times 0,15^2}{4} \times 8 \right)$$

$$\therefore F_o = 645,0966 N \checkmark$$

Horizontal forces

$$F_h = F_i - F_o \cos \theta$$

$$= 2340,4865 - 645,0966 \cos 40$$

$$= 1846,31383 N \checkmark$$

Vertical forces

$$F_v = F_i - F_o \sin \theta$$

$$= 645,0966 \sin 65$$

$$= 414,6601 N \checkmark$$

Consider resultant force

$$F_r = \sqrt{F_v^2 + F_h^2}$$

$$= \sqrt{1846,31383^2 + 414,6601^2} \checkmark$$

$$= 1892,30488 N \checkmark$$

$$\tan \beta = \frac{F_v}{F_h}$$

$$\beta = \tan^{-1} \left(\frac{414,6601}{1892,30488} \right)$$

$$\therefore \beta = 12,36^\circ \checkmark$$

(11)

[20]

TOTAL: 100