



**higher education
& training**

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

FLUID MECHANICS N5

11 August 2023

This marking guideline consists of 10 pages.

QUESTION 1

1.1 The weight per unit volume of a substance (1)

1.2 A substance, of either the liquid or the gaseous phase, ✓ that tends to conform to any possible change to its shape due to a force ✓ (2)

1.3 1.3.1 $\omega = \frac{W}{V}$
 $V = \frac{50}{5087,505} \checkmark$
 $= 0,00983 \text{ m}^3 \checkmark$ (2)

1.3.2 $V = lbh$
 $h = \frac{0,00983}{0,14 \times 0,18} \checkmark$
 $\therefore h = 0,39 \text{ m} \checkmark$ (2)

1.3.3 $\rho = \frac{m}{V}$
 $W = mg \Rightarrow m = \frac{W}{g}$
 $\rho = \frac{50}{9,81 \times 0,00983} \checkmark$
 $= 518,499 \text{ kg/m}^3$
 $\text{thus, } SG = \frac{\rho_{\text{ice}}}{\rho_{\text{water}}} \checkmark$
 $\therefore \frac{518,499}{1000} \checkmark$
 $\therefore 0,519 \checkmark$ (4)

1.4 1.4.1 $F = \pi d \times \sigma \checkmark$
 $\sigma = \frac{800 \times 10^{-6}}{\pi \times 10 \times 10^{-3}} \checkmark$
 $\therefore 0,026 \text{ N/m} \checkmark$ (3)

1.4.2 $\Delta P = \frac{8\sigma}{d}$
 $\sigma = 0,026 \times 1,8 \checkmark$
 $= 0,1145 \text{ N/m} \checkmark$
 $d = \frac{8 \times 0,1145}{165} \checkmark$
 $= 7,64 \text{ mm} \checkmark$ (4)

$$\begin{aligned}
 1.4.5 \quad F &= \pi d \times \sigma \\
 &= \pi \times 7,64 \times 10^{-3} \times 0,1145 \checkmark \\
 &= 0,00275 \text{ N} \checkmark
 \end{aligned}$$

(2)
[20]**QUESTION 2**

- 2.1 A hydraulic accumulator is a device that can be used as a storage chamber✓
in which fluid energy is stored as potential energy✓ and from which it can be
released during high demand in a fluid system.✓ (3)
- 2.2 The presence of air in a hydraulic system will result in an increase of free play
and distortion to the pipes and cylinders due to expansion,✓ thereby affecting
the movement of the actuator.✓ (2)
- 2.3 2.3.1 *if no air is present and cylinder expansion is disregarded*
thus, $K_e = K_l = 3 \text{ GPa}$ ✓

$$P = \frac{4 \times 5000}{\pi \times 0,11^2} \checkmark$$

$$= 526,132 \text{ kPa} \checkmark$$

$$\epsilon = \frac{\Delta l}{l} = \frac{P}{K_e} = \frac{526,132 \times 10^3}{3 \times 10^9} \checkmark$$

$$= 175,377 \times 10^{-6} \checkmark$$

$$\therefore \Delta l = 175,377 \times 10^{-6} \times 0,3$$

$$= 52,613 \times 10^{-6} \text{ m} \checkmark$$
 (6)

2.3.2 if air is present and cylinder expansion is considered

$$K_{cyl} = \frac{E}{2,5} = \frac{205}{2,5} = 82 \text{ GPa} \checkmark$$

$$K_{air} = P\alpha = 526,132 \times 1,4 \checkmark$$

$$\hookrightarrow 736,585 \text{ KPa} \checkmark$$

$$\frac{1}{K_e} = \frac{1}{K_{cyl}} + \frac{1}{K_l} + \frac{V_{air}}{V_{total} K_{air}}$$

$$\hookrightarrow \frac{1}{44 \times 10^9} + \frac{1}{3 \times 10^9} + \frac{3}{100 \times 835,56346 \times 10^3} \checkmark$$

$$\hookrightarrow 36,25998 \times 10^{-9} \checkmark$$

$$\therefore K_e = 27,57862 \text{ MPa}$$

$$\varepsilon = \frac{\Delta l}{l} = \frac{P}{K_e} = \frac{596,83104 \times 10^3}{27,57862 \times 10^6} = 21,64108 \times 10^{-3} \checkmark$$

$$\Delta l = 21,64108 \times 10^{-3} \times 0,25 \checkmark$$

$$\hookrightarrow 5,41 \text{ mm} \checkmark$$

(9)
[20]

QUESTION 3

3.1 3.1.1 Bouyancy force = $F_b = \rho g A \times \text{draught}$

$$\hookrightarrow 950 \times 9,81 \times \frac{\pi \times 0,3^2}{4} \times 0,305 \times 1,5 \checkmark$$

$$\hookrightarrow 301,382 \text{ N} \checkmark$$

(2)

3.1.2 weight_{shaft} = $F_b + F_s \checkmark$

$$F_s = \left(500 \times 9,81 \times \frac{\pi \times 0,3^2 \times 1,5}{4} \right) - 301,382 \checkmark \checkmark$$

$$\hookrightarrow 218,689 \text{ N} \checkmark$$

(4)

3.1.3 $y = 0,25 + \frac{0,3}{2} \checkmark$

$$\hookrightarrow 400 \text{ mm} \checkmark$$

$$F_{hydro} = \rho g A y$$

$$\hookrightarrow 950 \times 9,81 \times \frac{\pi}{4} \times 0,3^2 \times 0,4 \checkmark$$

$$\hookrightarrow 263,503 \text{ N} \checkmark$$

(4)

$$\begin{aligned}
 3.1.4 \quad & h = \frac{I_g \sin^2 \theta}{A y} + y \\
 & A = \frac{\pi \times 0,3^2}{4} = 70,686 \times 10^{-3} \text{ m}^2 \checkmark \\
 & I_g = \frac{\pi \times 0,3^4}{64} = 397,608 \times 10^{-6} \text{ m}^4 \checkmark \\
 & h = \frac{397,608 \times 10^{-6} \times 1}{70,686 \times 10^{-3} \times 0,4} + 0,4 \checkmark \\
 & \therefore 414,063 \text{ mm} \quad \text{from the oil surface} \checkmark
 \end{aligned}
 \tag{4}$$

$$\begin{aligned}
 3.1.5 \quad & W_{\text{new}} = F_b = \rho_{\text{new}} g A \times \text{draught}_{\text{new}} \\
 & l_{\text{new}} = 0,25 \times 1,5 = 0,375 \text{ m} \checkmark \\
 & W_{\text{new}} = 0,2 \times 9,81 \checkmark \\
 & \therefore 1,962 \text{ N} \checkmark \\
 & \rho_{\text{new}} = \frac{m_{\text{new}}}{V_{\text{new}}} = \frac{0,2}{70,686 \times 10^{-3} \times 0,375} = 7,545 \text{ kg/m}^3 \checkmark \\
 & \text{draught}_{\text{new}} = \frac{1,962}{70,686 \times 10^{-3} \times 7,545 \times 9,81} \checkmark \\
 & \therefore 375 \text{ mm} \checkmark
 \end{aligned}
 \tag{6}$$

[20]

QUESTION 4

- 4.1 If the position of the successive molecules in a fluid can be joined up by a curve that is tangential to the direction of motion, ✓ this curve is called a stream line. ✓ However, if the stream lines are drawn through every position of all the molecules on the circumference of a small area, ✓ this forms a stream tube. ✓ (4)

$$\begin{aligned}
 4.2 \quad 4.2.1 \quad & W = \frac{W}{t} = \frac{mg}{t} = m g \\
 & m = \rho Q \\
 & \therefore \frac{1000 \times \pi \times 0,045^2 \times 11}{4} \checkmark \\
 & \therefore 17,494744 \text{ kg/s} \checkmark \\
 & W = 17,494744 \times 9,81 \checkmark \\
 & \therefore 171,623 \text{ N} \checkmark
 \end{aligned}
 \tag{3}$$

4.2.2 *from Bernoulli's equation*

$$E_1 = E_2 + \text{LOSS}$$

$$\frac{v_1^2}{2g} - \Delta Z = \frac{v_2^2}{2g} \quad \checkmark$$

$$v = \sqrt{2g \left(\frac{v_1^2}{2g} - \Delta Z \right)} \quad \checkmark$$

$$\dot{\iota} \sqrt{19,62 \left(\frac{11^2}{19,62} - 4 \right)} \quad \checkmark$$

$$\dot{\iota} 6,521 \text{ m/s} \quad \checkmark$$

(3)

4.2.3 $Q = AV \dots$ continuity of flow

$$Q = \frac{\pi \times 0,045^2 \times 11}{4} \quad \checkmark$$

$$\dot{\iota} 17,49474 \times 10^{-3} \text{ m}^3/\text{s} \quad \checkmark$$

$$\text{at } v = 6,521 \text{ m/s}$$

$$d = \sqrt{\frac{4Q}{\pi v}}$$

$$\dot{\iota} \sqrt{\frac{4 \times 17,49474 \times 10^{-3}}{\pi \times 6,521}} \quad \checkmark$$

$$\dot{\iota} 58,446 \text{ mm} \quad \checkmark$$

(3)

4.1.4 *from Bernoulli's equation*

$$E_1 = E_2 + \text{LOSS}$$

$$H = \frac{v_2^2}{2g} + Z_2 \quad \checkmark$$

$$\dot{\iota} \frac{6,521^2}{19,62} + 4 \quad \checkmark$$

$$\dot{\iota} 6,16735 \text{ m} \quad \checkmark$$

$$P = \rho g Q H$$

$$\dot{\iota} 9810 \times 17,49474 \times 10^{-3} \times 6,16735 \quad \checkmark$$

$$\dot{\iota} 1058,462 \text{ W} \quad \checkmark$$

(3)

4.1.5 from Bernolli 's equation ,the kinetic energy per unit weight

$$KE = \frac{mv^2}{2} \times \frac{1}{W} \checkmark$$

$$KE = \frac{v^2}{2g} \checkmark$$

$$\therefore \frac{11^2}{19,62} \checkmark$$

$$\therefore 6,167 \text{ Nm} \checkmark$$

(4)
[20]

QUESTION 5

5.1 5.1.1

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

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

$$\therefore 0,836 \checkmark$$

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

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

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

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

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

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

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

$$\therefore 0,748 \checkmark$$

$$C_Q = C_c \times C_v$$

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

$$\therefore 0,894 \checkmark$$

(11)

$$5.1.2 \quad h_{\text{loss}} = h(1 - C_v^2)$$

$$\hat{=} 60(1 - 0,894^2) \checkmark$$

$$\hat{=} 12,046 \text{ m} \checkmark$$

alternatively

$$h_{\text{loss}} = h - \frac{v_{\text{vena}}^2}{2g}$$

$$\hat{=} 60 - \frac{(0,894 \times 34,310348)^2}{19,62} \checkmark$$

$$\hat{=} 12,046 \text{ m} \checkmark$$

(3)

$$5.2.1 \quad h_{\text{loss}} = \frac{(v_1 - v_2)^2}{2g}$$

$$\hat{=} \frac{(6,9 - 3,5)^2}{19,62} \checkmark$$

$$\hat{=} 0,589 \text{ m} \checkmark$$

(2)

$$5.2.2 \quad \text{applying Bernoulli's theorem:}$$

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

$$\frac{\Delta P}{\rho g} = \frac{v_1^2 - v_2^2}{2g} - h_{\text{loss}}$$

$$\hat{=} \frac{6,9^2 - 3,5^2}{19,62} - 0,589 \checkmark$$

$$\hat{=} 1,213 \text{ m} \checkmark$$

$$\Delta P = 9810 \times 1,213$$

$$\hat{=} 11,902 \text{ kPa} \checkmark$$

(4)
[20]

QUESTION 6

6.1
$$W = m g = \frac{\rho V g}{t} = \rho g Q$$

$$W = \frac{9810 \times \pi \times 0,2^2 \times 4,5}{4} \checkmark$$

$\hookrightarrow 1389,856 \text{ N/s} \checkmark$ (2)

6.2
$$Q_i = Q_o$$

$$A_i v_i = A_o v_o$$

$$v_o = \frac{d_i^2 v_i}{d_o^2} \checkmark$$

$\hookrightarrow \left(\frac{0,2}{0,15} \right)^2 \times 4,5 \checkmark$

$\hookrightarrow 8 \text{ m/s} \checkmark$ (3)

6.3
$$\frac{P_i}{\rho g} + \frac{v_i^2}{2g} + Z_i = \frac{P_o}{\rho g} + \frac{v_o^2}{2g} + Z_o + h_{\text{loss}}$$

$$\frac{P_o}{\rho g} = \frac{P_i}{\rho g} + \frac{v_i^2}{2g} + Z_i - \left(\frac{v_o^2}{2g} + Z_o + h_{\text{loss}} \right) \checkmark$$

$\hookrightarrow \frac{70 \times 10^3}{9810} + \frac{4,5^2}{19,62} + 0 - \frac{8^2}{19,62} - 2,5 - 2 \checkmark$

$\hookrightarrow 9810 \times 0,405709 \checkmark$

$\therefore P_o = 3,98 \text{ kPa} \checkmark$ (4)

6.4

$$F_i = P_i A_i + mv_i$$

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

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

$$\therefore F_i = 2340,4865 \text{ N}$$

$$F_o = \left(3,98 \times 10^3 \times \frac{\pi \times 0,15^2}{4} \right) + \left(1000 \times \frac{\pi \times 0,15^2}{4} \times 8 \right)$$

$$\therefore F_o = 211,704075 \text{ N}$$

horizontal forces

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

$$\hookrightarrow 2340,4865 - 211,704075 \cos 65$$

$$\hookrightarrow 2251,01652 \text{ N}$$

vertical forces

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

$$\hookrightarrow 211,074075 \sin 65$$

$$\hookrightarrow 191,89605 \text{ N}$$

consider resul tan t force

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

$$\hookrightarrow \sqrt{2251,01652^2 + 191,89605^2}$$

$$\hookrightarrow 2348,338 \text{ N}$$

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

$$\beta = \tan^{-1} \left(\frac{191,89605}{2251,01652} \right)$$

$$\therefore \beta = 4,87^\circ$$

(11)

[20]**TOTAL: 100**