



higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

FLUID MECHANICS N5

7 April 2025

This marking guideline consists of 7 pages.

QUESTION 1

1.1 It is defined as the ratio of weight per unit volume of a substance ✓ (1)

1.2 1.2.1 $\varpi = \rho g = \frac{m}{v} \times g \checkmark = \frac{w}{v} = \frac{10,08}{0,084} \checkmark = 120 \text{ N/m}^3 \checkmark$ (3)

1.2.2 $\rho_{rel} = SG = \frac{\rho_{soap}}{\rho_w} = \frac{\varpi}{g\rho_w} = \frac{120}{9,81 \times 1000} \checkmark = 0,012 \checkmark$ (2)

1.2.3 $\varpi = \rho g$
 $\rho = \frac{\varpi}{g} = \frac{120}{9,81} \checkmark = 12,232 \text{ kg/m}^3 \checkmark$ (2)
[8]

QUESTION 2

2.1 Atmospheric pressure is the pressure exerted by the weight of the surrounding air on the surface of the earth. ✓ (1)

2.2 2.2.1 $P_{atm} = \rho g h_{bar} = 13600 \times 9,81 \times 0,71 \checkmark = 94,725 \text{ kPa} \checkmark$ (2)

2.2.2 $P_{abs} = P_{atm} + P_g = 94,725 - 15 \checkmark = 1000 \times 9,81 \times h_s \checkmark$
 $h_s = 8,126 \text{ m} \checkmark$ (3)
[6]

QUESTION 3

3.1 In any closed system, the pressure applied within the system is equally distributed or transmitted in all directions provided no losses occur. ✓ (1)

3.2 3.2.1 $P = \frac{F}{A} = \frac{4 \times 5200}{\pi \times 0,2^2} = 165,521 \text{ kPa} \checkmark$ (1)

3.2.2 $\frac{1}{K_e} = \frac{1}{K_{liquid}} + \frac{1}{K_{cylinder}} + \frac{v_{air}}{v_{cylinder} K_{air}}$
 $\frac{1}{K_e} = \frac{1}{1,95 \times 10^9} + \frac{2,5}{10 \times 10^9} + 0 \checkmark$
 $K_e = 1,311 \text{ GPa} \checkmark$ (2)

$$3.2.3 \quad K_e = P \times \frac{v}{\Delta v}$$

$$1,311 \times 10^9 = 165,621 \times 10^3 \times \frac{A \times 900 \times 1000}{A \times \text{Free Play}} \checkmark$$

$$\text{Free play} = 0,114 \text{ mm} \checkmark \quad (2)$$

$$3.2.4 \quad K_{air} = \gamma_{air} P = 1,4 \times 165,621 = 231,869 \text{ kPa} \checkmark \quad (1)$$

$$3.2.5 \quad \frac{1}{K_e} = \frac{1}{K_{liquid}} + \frac{1}{K_{cylinder}} + \frac{v_{air}}{v_{cylinder} K_{air}}$$

$$\frac{1}{K_e} = \frac{1}{1,95 \times 10^9} + \frac{1}{2,5 \times 10^9} + \frac{3,2}{100 \times 231,869 \times 10^3} \checkmark$$

$$\frac{1}{K_e} = 1,388 \times 10^{-7} \checkmark$$

$$K_e = 7,206 \text{ MPa} \checkmark \quad (3)$$

$$3.2.6 \quad \text{The free play on the piston rod in mm}$$

$$K_e = P \times \frac{v}{\Delta v} = \checkmark$$

$$7,206 \times 10^6 = 165,621 \times 10^3 \times \frac{A \times 900 \times 1000}{A \times \text{Free Play}}$$

$$\text{Free play} = 20,685 \text{ mm} \checkmark \quad (2)$$

[12]

QUESTION 4

4.1 A point/position $\checkmark$ at which the total/resultant pressure $\checkmark$ is considered to act. (2)

$$4.2 \quad 4.2.1 \quad P_{ave} = \frac{P_{top} + P_{base}}{2}$$

$$P_{ave} = \frac{0 + (1005 \times 9,81 \times 3)}{2} \checkmark = 14,789 \text{ kPa} \checkmark \quad (3)$$

$$4.2.2 \quad P_{ave} = P_{ave} A$$

$$A = \frac{\pi \times 1,5^2}{4} \checkmark = 1,767 \text{ m}^2 \checkmark$$

$$F_{ave} = 14,789 \times 1,767 \checkmark = 26,134 \text{ kN} \checkmark \quad (4)$$

[9]

QUESTION 5

- | | | | |
|-----|-------|--|-------------|
| 5.1 | 5.1.1 | <p>The tendency/ability of an object to float in a fluid</p> <p>OR</p> <p>An upthrust on a body submerged in a fluid</p> <p>OR</p> <p>An upward force that acts on an object due to the fluid the object is immersed in.</p> <p>OR</p> <p>A reaction force to an object's weight when it is immersed in a fluid.</p> | |
| | 5.1.2 | An object, partially or fully immersed in a fluid experiences an upward force that equals the weight of the fluid displaced by the object. | (2 × 1) (2) |
| 5.2 | 5.2.1 | $W_{buoy} = F_{buoyancy}$
$m_{buoy}g = \rho g \times \% \times V_{displaced} \checkmark$
$m_{buoy} = 1023 \times \frac{\pi}{4} \times 0,4^2 \times 1,1 \times 0,7 \checkmark$
$m_{buoy} = 98,987 \text{ kg} \checkmark$ | (3) |
| | 5.2.2 | $W_{buoy} + W_{dead} = F_{buoyancy} \checkmark$
$m_{buoy}g + m_{dead}g = \rho g \times \% V_{displaced} \checkmark$
$m_{dead} = \left(1023 \times \frac{\pi}{4} \times 0,4^2 \times 1,1 \times 0,8\right) - 98,987 \checkmark = 14,141 \text{ kg} \checkmark$ | (4) [9] |

QUESTION 6

- | | | | | |
|-----|-------|--|---------|-----|
| 6.1 | 6.1.1 | A smooth✓ flow of a fluid✓ | | |
| | 6.1.2 | A disorderly✓ flow of a fluid✓ | (2 × 2) | (4) |
| 6.2 | 6.2.1 | $Q = Av$
$v = \frac{4 \times \left(\frac{44,8 \times 10^{-3}}{60} \right) \checkmark}{\pi \times 0,05^2} \checkmark$ $v = 0,38 \text{ m/s} \checkmark$ | | (3) |
| | 6.2.2 | $R_e = \frac{\rho v d}{\nu} = \frac{(1000 \times 0,9) \checkmark \times 0,38 \times 0,05}{0,012} \checkmark$ $= 1425 \checkmark$ | | (3) |
| | 6.2.3 | $Sinc, R_e < 2500 \checkmark$
Therefore, the flow through the nozzle is said to be Lamina✓ | | (2) |
- [12]**

QUESTION 7

- 7.1 7.1.1 To measure the velocity of a fluid.
- 7.1.2 An instrument/device that is used to measure the pressure and density of a fluid flowing through a system. (2 × 1) (2)
- 7.2 7.2.1 $Q_1 = Q_2$
- $$d_1^2 v_1^2 = d_2^2 v_2^2 \checkmark$$
- $$v_1 = \left(\frac{120}{150}\right)^2 \times v_2 \checkmark$$
- $$v_1 = 0,64 v_2 \checkmark$$
- Since, $\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + Z_2$
- $$\frac{P_1}{\rho g} - \frac{P_2}{\rho g} + Z_1 - Z_2 = \frac{v_2^2}{2g} - \frac{v_1^2}{2g} \checkmark$$
- $$\frac{50 \times 10^3}{9810} + 0 = \frac{v_2^2 - (0,64 v_2)^2}{19,62}$$
- $$v_2 = 13,015 \text{ m/s} \checkmark \quad (5)$$
- 7.2.2 $C_d = \frac{Q_a}{Q_t} \checkmark$
- $$Q_a = \frac{\pi}{4} \times 0,12^2 \times 13,015 \times 1000 \times 0,98 \checkmark = 144,252 \text{ l/s} \checkmark \quad (3)$$
- [10]**

QUESTION 8

- 8.1 If there are no losses or additions, the sum of energy✓ in a system is conserved✓ (2)
- 8.2 8.2.1 $P = \rho g \Delta H$
- $$\Delta H = \frac{450 \times 10^3}{9810} = 45,872 \text{ m} \checkmark$$
- $$\sin \theta = i = \frac{h}{L}$$
- $$h = \frac{1}{100} \times 700 = 7 \text{ m} \checkmark$$
- $$\sum H_{f_{losses}} = 45,872 - 7 = 38,872 \text{ m} \checkmark$$

$$\begin{aligned}
 8.2.2 \quad \sum H_{losses} &= h_{f_{pipe}} + h_{f_{filter}} \\
 \sum H_{losses} &= \frac{4flv^2}{2gd} + \frac{6v^2}{2g} \\
 38,872 &= \frac{4 \times 0,0013 \times 700v^2}{19,62 \times 0,04} + \frac{6v^2}{19,62} \checkmark \\
 38,872 &= 4,638v^2 + 0,306v^2 \checkmark \\
 v &= 2,804 \text{ m/s} \checkmark
 \end{aligned}
 \tag{3}$$

$$\begin{aligned}
 8.2.3 \quad &\text{The head loss due to friction in the system in metres} \\
 h_{f_{pipe}} &= \frac{4flv^2}{2gd} \checkmark \\
 h_{f_{pipe}} &= \frac{4 \times 0,0013 \times 700 \times 2,804^2}{19,62 \times 0,04} = 36,466 \text{ m} \checkmark
 \end{aligned}
 \tag{2}$$

[10]

QUESTION 9

- 9.1 9.1.1 The ratio of the actual velocity to the theoretical velocity.
 9.1.2 The ratio of the actual discharge to the theoretical discharge. (2 × 1) (2)

$$\begin{aligned}
 9.2 \quad 9.2.1 \quad C_d &= \frac{Q_a}{Q_t} \\
 Q_t &= \frac{14}{0,63} \checkmark = 22,222 \text{ l/s} \checkmark \\
 9.2.2 \quad Q_t &= Av_t \\
 22,222 \times 10^{-3} &= \frac{\pi \times 0,04^2}{4} \times v_t \checkmark \\
 v_t &= 17,683 \text{ m/s} \checkmark \\
 9.2.3 \quad v_t &= \sqrt{2gH} \\
 17,683 &= \sqrt{19,62H} \checkmark \\
 H &= 15,939 \text{ m} \checkmark
 \end{aligned}
 \tag{3 \times 2} \tag{6}$$

[8]

QUESTION 10

- 10.1 The volume✓ flow rate of a fluid between any two points is constant✓. (2)
- 10.2 10.2.1 $F = \rho A v \times \Delta v$
 $F = 1000 \times \frac{\pi \times 0,07^2 \times 20}{4} \times (20 - 0)✓ = 1539,38 \text{ N}✓$
- 10.2.2 $T = F \times R$
 $T = 1539,38 \times 1,25✓ = 1,847 \text{ kNm}✓$
- 10.2.3 $P = F v$
 $P = 1539,38 \times 20✓ = 30,788 \text{ kW}✓$
- (3 × 2) (6)
[8]

QUESTION 11

- 11.1 11.1.1 The kinetic energy per unit metre.
- 11.1.2 The difference in pressures between inlet and outlet points of a pump.
 (2 × 2) (2)
- 11.2 11.2.1 $C_d = 1 - \% \text{ slip}$
 $C_d = 1 - 0,035 = 0,965✓$ (1)
- 11.2.2 $C_d = \frac{Q_a}{Q_t}$
 $Q_t = \frac{0,5}{0,965}✓ = 0,518 \text{ m}^3✓$ (2)
- 11.2.3 $Q_t = \frac{LANK}{60}$
 $N = \frac{60Q_t}{LAK}✓$
 $N = \frac{60 \times 0,518}{0,31 \times \left(\frac{\pi \times 0,15^2}{4}\right) \times (3 \times 1)}✓$
 $N = 1891,149 \text{ r/min}✓$ (3)
[8]

TOTAL: 100