higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

FLUID MECHANICS N5

24 November 2022

This marking guideline consists of 8 pages.

QUESTION 1

1.1
1.1.1 True
1.1.2 False
1.1.3 True
1.1.4 True
1.1.5 False
1.1.6 False

(6 × 1) (6)

1.2
1.2.1 It is the ratio of the density of any fluid substance✓ to the density of water.✓

1.2.2 It is the property of a fluid, that will allow any object of low mass or weight✓ to float along its surface due to a force that tends to pull adjacent parts of the fluid surface together.✓

(2 × 2) (4)

1.3
1.3.1

$$v = \frac{\pi DN}{60}$$
$$= \frac{\pi \times 0,05 \times 3000}{60} \checkmark$$
$$= 7,854 m/s \checkmark$$

(2)

1.3.2

$$A = \pi D_{mean} L$$
$$= \pi \times \left(\frac{(50,2 + 50) \times 10^{-3}}{2} \right) \times 0,1 \checkmark$$
$$= 15,739 \times 10^{-3} m^2 \checkmark$$

(2)

1.3.3

$$F = \frac{\mu A v}{t}$$
$$as, t = \frac{D - d}{2}$$
$$= \frac{(50,2 - 50) \times 10^{-6}}{2} \checkmark$$
$$= 100 \times 10^{-9} mm \checkmark$$
$$thus, F = \frac{0,355 \times 15,739 \times 10^{-3} \times 7,854}{100 \times 10^{-9}} \checkmark$$
$$= 438830,076 N \checkmark$$

(4)

1.3.4

$$P = Fv$$
$$= 438830,076 \times 7,854 \checkmark$$
$$= 3446571,417 W \checkmark$$

(2)
[20]

QUESTION 2

2.1
- Hydraulic press
- Mechanical press
- Pneumatic press (3)

2.2 It is a mechanical device or tool that is used for converting fluid pressure energy✓ into mechanical energy by generating motion.✓ (2)

2.3 2.3.1

$$P = \frac{F}{A}$$
$$= \frac{4 \times 8000}{\pi \times 0{,}12^2} \checkmark$$
$$= 707{,}355 kPa \checkmark$$
(2)

2.3.2

$$\frac{1}{K_e} = \frac{1}{K_l} + \frac{1}{K_{cyl}} + \frac{V_{air}}{V_{total} K_{air}}$$
$$\frac{1}{K_e} = \frac{1}{1{,}95 \times 10^9} + \frac{1}{\left(\frac{12{,}5 \times 10^9}{2{,}5}\right)} + 0 \checkmark$$
$$\frac{1}{K_e} = 712{,}821 \times 10^{-12} \checkmark$$
$$K_e = 1{,}403 GPa \checkmark$$
(3)

2.3.3

$$K_e = P \times \frac{V}{\Delta V} = P \times \frac{L}{\Delta L}$$
$$1{,}403 \times 10^6 = 707{,}355 \times 10^3 \times \frac{0{,}6}{\Delta L_{free-play}} \checkmark$$
$$\Delta L_{free-play} = \frac{707{,}355 \times 10^3 \times 0{,}6}{1{,}403 \times 10^9} \checkmark$$
$$= 302{,}504 \times 10^{-3} mm \checkmark$$
(3)

2.4 2.4.1

$$K_{air} = \gamma \times P$$
$$= 1{,}4 \times 707{,}355 \checkmark$$
$$= 990{,}297 kPa \checkmark$$
(2)

2.4.2

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

$$\frac{1}{K_e} = 712{,}821 \times 10^{-12} + \frac{3{,}5}{100 \times 990{,}297 \times 10^3} \checkmark$$

$$K_e = \frac{1}{36{,}056 \times 10^{-9}} \checkmark$$

$$= 27{,}735 MPa \checkmark$$

(3)

2.4.3

$$K_e = P \times \frac{L_{free-play}}{\Delta L_{free-play}}$$

$$\Delta L = \frac{707{,}355 \times 10^3 \times 0{,}6}{27{,}735 \times 10^6} \checkmark$$

$$= 15{,}302 mm \checkmark$$

(2)

[20]

QUESTION 3

3.1 3.1.1 It is a fluid resultant force✓ generated by the pressure intensity of the fluid acting on the plane of a submerged surface.✓

3.1.2 It is the upward force or thrust generated by the fluid.✓ The force is equal and in opposite direction to the weight exerted by a body or object positioned along the surface of the fluid.✓

3.1.3 It is the measured depth of an object from the free surface of a fluid✓ to which an object is immersed below the free surface.✓

(3 × 2) (6)

3.2 3.2.1

$$V_{displaced} = 36\% \times \frac{\pi D^3}{6} \checkmark$$

$$= \frac{\pi \times 0{,}2^3}{6} \times 0{,}36 \checkmark$$

$$= 1{,}508 \times 10^{-3} m^3 \checkmark$$

(3)

3.2.2

$$F_{balloon} = B$$

$$m_{ballon} = \rho V_{dispaced} \checkmark$$

$$= 1025 \times 1{,}508 \times 10^{-3}$$

$$= 1{,}546 kg \checkmark$$

(2)

3.2.3

$$\rho_{bolloon} = \frac{m_{ballon}}{V_{balloon}}$$

$$= \frac{6 \times 1{,}546}{\pi \times 0{,}2^3} \checkmark$$

$$= 369{,}08 kg/m^3 \checkmark$$

(2)

3.2.4

$$F_{balloon} = B$$

$$m_{balloon} = \rho V_{dispaced}$$

$$1{,}546 = 13600 \times \frac{\pi \times 0{,}2^3}{6} \times \%balloon_{submerged} \checkmark$$

$$\%balloon_{submerged} = \frac{6 \times 1{,}546}{13600 \times \pi \times 0{,}2^3} \times 100\% \checkmark$$

$$= 2{,}714\% \checkmark$$

(3)

3.2.5

$$F_{balloon} + F_{required} = B$$

$$m_{balloon} + m_{required} = \rho V_{dispaced} \checkmark$$

$$1{,}546 + m_{required} = 1025 \times \frac{\pi \times 0{,}2^3}{6} \checkmark$$

$$m_{required} = 4{,}294 - 1{,}546 \checkmark$$

$$= 2{,}748 kg \checkmark$$

(4)
[20]

QUESTION 4

4.1 4.1.1 It is the imaginary boundary✓ that is defined by streamlines drawn in order to enclose a tubular region of fluid.✓

4.1.2 It is the volume of a fluid✓ flowing past a particular point within a system at a given unit of time.✓

4.1.3 It is the energy stored by an object✓ (e.g. a fluid) due to its position above a reference point.✓

(3 × 2) (6)

4.2 4.2.1

$$Q_{system} = Av_{main}$$

$$= \frac{\pi \times 0{,}225^2}{4} \times 2{,}285 \checkmark$$

$$= 90{,}853 l/s \checkmark$$

(2)

4.2.2

$$\overset{0}{m} = \rho Q_{system}$$

$$= 920 \times 90{,}853 \times 10^{-3} \times 60 \checkmark\checkmark$$

$$= 5{,}015 tonnes/\min \checkmark$$

(3)

4.2.3
$$Q_{\phi105} = Av_{\phi105}$$
$$= \frac{\pi \times 0{,}105^2}{4} \times \frac{5{,}235}{1{,}5} \checkmark$$
$$= 30{,}22 l/s \checkmark$$
(2)

4.2.4
$$Q_{\phi225} = Q_{\phi25} + Q_{\phi55} + 2Q \text{...continuity of flow principle} \checkmark$$
$$90{,}853 \times 10^{-3} = \left(\frac{\pi \times 0{,}07^2 \times 5{,}235}{4}\right) + 30{,}22 + 2Q_{indentical} \checkmark$$
$$90{,}853 \times 10^{-3} = 20{,}147 \times 10^{-3} + 30{,}22 \times 10^{-3} + 2Q_{indentical} \checkmark$$
$$Q_{indentical} = \frac{90{,}853 \times 10^{-3} - (20{,}147 \times 10^{-3} + 30{,}22 \times 10^{-3})}{2} \checkmark$$
$$= 20{,}243 l/s \checkmark$$
(5)

4.2.5
$$Q_{identical} = Av_{identical}$$
$$d^2_{identical} = \sqrt{\frac{20{,}243 \times 10^{-3} \times 4}{\pi \times 4{,}756}} \checkmark$$
$$d_{identical} = 73{,}616 mm \checkmark$$
(2)
[20]

QUESTION 5

5.1
- 5.1.1 False
- 5.1.2 False
- 5.1.3 True
- 5.1.4 False
- 5.1.5 True

(5 × 1) (5)

5.2

5.2.1
$$\text{from}, \frac{\Delta P}{\rho g} = \Delta H = h_{mech}\left(\frac{\rho_{mercury}}{\rho_{subs\tan ce}} - 1\right) \checkmark$$
$$\Delta H = 0{,}15\left(\frac{13600}{832} - 1\right) \checkmark$$
$$= 2{,}302 m \checkmark$$
(3)

5.2.2
$$v_t = \sqrt{2g\Delta H}$$
$$= \sqrt{19{,}62 \times 2{,}302} \checkmark$$
$$= 6{,}721 m/s \checkmark$$
(2)

5.2.3
$$v_{\max} = C_v v_t$$
$$= 0{,}96 \times 6{,}721 \checkmark$$
$$= 6{,}452 m/s \checkmark$$
(2)

5.2.4 $v_{mean} = Kv_{max}$

$= 0,86 \times 6,452$ ✓

$= 5,549 m/s$ ✓ (2)

5.2.5 $Q_{mean} = Av_{mean}$

$= \frac{\pi \times 0,5^2}{4} \times 5,549 \times 60$ ✓✓

$= 65,373 m^3/\min$ ✓ (3)

5.2.6 $Q_{actual} = Q_{mean} \times C_q \times time\ shift$

$= 65,373 \times 0,92 \times 60 \times 6$ ✓✓

$= 21651,538 m^3$ *for the 6hr duration* ✓ (3)

[20]

QUESTION 6

6.1 The total energy in the system at any two points is assumed to be the same throughout,✓ provided that no energy is neither added to nor removed from the system.✓ (2)

6.2
- Lamina (viscous) flow
- Transition flow
- Turbulent flow
- Steady flow
- Unsteady flow
- Compressible flow
- Incompressible flow (Any 2 × 1) (2)

6.3 6.3.1 $\sum l/d_{system} = l/d_{valve} + l/d_{filter} + l/d_{elbow} + l/d_{pipe}$

$= \frac{0,66 \surd}{4 \times 0,0025} + \frac{3,2 \surd}{4 \times 0,0025} + \frac{0,675 \surd}{4 \times 0,0025} + \frac{35 \surd}{0,065}$

$= 66 + 320 + 67,5 + 538,462$ √√√√

$= 991,962$ ✓ (5)

6.3.2 *Using Bernoulli's energy equation:*

$E_i + \sum h_{loss} = E_o$

$\frac{P_i}{\rho g} + \frac{v_i^2}{2g} + Z_i + \sum hf_{system} = \frac{P_o}{\rho g} + \frac{v_o^2}{2g} + Z_o$ ✓

$\sum hf_{system} = Z_o - Z_i + \frac{P_o}{\rho g} - \frac{P_i}{\rho g} + \frac{v_o^2}{2g} - \frac{v_i^2}{2g}$ ✓

$\sum hf_{system} = Z_o - Z_i + 0 + 0$ ✓

$= 8,5 m$ ✓ (4)

6.3.3

$$\sum hf_{system} = \frac{4fv^2}{2g} \times \left(\sum l/d\right)_{system}$$

$$8{,}5 = \frac{4 \times 0{,}0025 \times 991{,}962}{19{,}62} \times v_{pipe}^2 \ \checkmark$$

$$v_{pipe} = \sqrt{\frac{8{,}5 \times 19{,}62}{4 \times 0{,}0025 \times 991{,}962}} \ \checkmark$$

$$v_{pipe} = 4{,}1 m/s \ \checkmark$$

(3)

6.3.4

$$Q = Av_{pipe}$$

$$= \frac{\pi}{4} \times 0{,}065^2 \times 4{,}1 \ \checkmark$$

$$= 13{,}605 \times 3600 \times 24 \quad \checkmark\checkmark$$

$$= 1175472 l \ for\ a\ 24\ hour\ routine\ maintenance \ \checkmark$$

(4)
[20]

TOTAL: 100