



higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

FLUID MECHANICS N5

15 April 2021

This marking guideline consists of 11 pages.

NOTE: Students must answer any FIVE of the SIX questions.

QUESTION 1

1.1 1.1.1 This is a property that a fluid possesses due to the ratio of the weight per unit volume of the fluid✓ measured in N/m^3 .✓

1.1.2 This is a property a fluid possesses due to the ratio of the density of any substance (fluid) to that of the water✓ and it is dimensionless.✓

1.1.3 This the property possessed by a fluid along the surface membrane to react against any form thrust which is exerted up the surface per unit length✓ and is measured in N/m .✓

(3 × 2) (6)

1.2 1.2.1 *from*, $\omega_{oil} = \rho_{oil} g$
 $= \rho_{relative} \times \rho_{water} \times g \checkmark$
 $= 1000 \times 0,96 \times 9,81 \checkmark$
 $\therefore \omega_{oil} = 9417,6 N / m^3 \checkmark$

1.2.2 *also*, $\omega_{oil} = \frac{W_{oil}}{V_{oil}}$
 $= \omega_{oil} \times V_{oil} \checkmark$
 $= 9417,6 \times 300 \times 10^{-3} \checkmark$
 $W_{oil} = 2825,28 N \checkmark$

(2 × 2) (4)

1.3 1.3.1

$$\text{From, } F_{\text{viscous}} = \frac{\mu v A_{\text{mean}}}{t}$$

$$\text{where, } t = \frac{D-d}{2}$$

$$= \frac{310-309,5}{2} \checkmark$$

$$\therefore t = 0,25\text{mm} \checkmark$$

$$\text{also, } D_{\text{mean}} = \frac{D+d}{2}$$

$$= \frac{310+309,5}{2} \checkmark$$

$$\therefore D_{\text{mean}} = 309,75\text{mm} \checkmark$$

$$\text{and, } A_{\text{mean}} = \pi D_{\text{mean}} L$$

$$A_{\text{mean}} = \pi \times 309,75 \times 10^{-3} \times 200 \times 10^{-3} \checkmark$$

$$= 194,62167 \times 10^{-3} \text{m}^2 \checkmark$$

$$\text{thus, } F_{\text{viscous}} = \frac{\mu v A_{\text{mean}}}{t}$$

$$= \frac{0,196 \times 3,25 \times 194,62167 \times 10^{-3}}{0,25 \times 10^{-3}} \checkmark$$

$$\therefore F_{\text{viscous}} = 495,896\text{N} \checkmark$$

(8)

1.3.2

$$P_{\text{viscous}} = F_{\text{viscous}} \times v_{\text{mean}}$$

$$= 495,896 \times 3,25 \checkmark$$

$$\therefore P_{\text{viscous}} = 1,612\text{kW} \checkmark$$

(2)

[20]**QUESTION 2**

2.1 According to Pascal's law, the pressure exerted in a closed system is equally distributed in all directions✓, provided no fluid changes (fluid added or removed from the system) occur within the system.✓ Its unit of measurement is pascal (Pa).✓

(3)

2.2 2.2.1 *Application of Pascal's principle:*

where, $P_{mc} = P_{sc}$

$$F_{mc} = \left(\frac{d_{mc}}{d_{sc}} \right)^2 \times F_{sc}$$

$$= \left(\frac{40^2}{60^2} \right) \times 6000 \checkmark$$

$$= 2,66667 \text{ kN} \checkmark$$

$$\text{as, } MA = \frac{F_{mc}}{F_{pedal}}$$

$$F_{pedal} = \frac{2,66667}{5} \checkmark$$

$$= 533,333 \text{ N} \checkmark$$

$$P_{mc} = \frac{2,66667 \times 1000 \times 4}{\pi \times 0,04^2} \checkmark$$

$$= 2,122 \text{ MPa} \checkmark$$

(3)

2.2.2 *from, $SV_{mc} = SV_{sc}$*

$$d_{mc}^2 \times SL_{mc} = d_{sc}^2 \times SL_{sc} \checkmark$$

$$= \frac{d_{sc}^2}{d_{mc}^2} \times SL_{sc} \checkmark$$

$$SL_{mc} = \frac{60^2}{40^2} \times 7,41 \checkmark$$

$$\therefore SL_{mc} = 16,6725 \text{ mm} \checkmark$$

$$MA = \frac{SL_{pedal}}{SL_{mc}}$$

$$SL_{pedal} = MA \times SL_{mc} \checkmark$$

$$= 5 \times 16,6725 \checkmark$$

$$\therefore SL_{pedal} = 83,363 \text{ mm} \checkmark$$

(4)

2.3 2.3.1

$$\text{from, } Q = \frac{\text{volume}}{\text{time}} = \frac{A \times L}{\text{time}}$$

$$\text{as, } A_{\text{forward}} = \frac{\pi(D^2 - d^2)}{4}$$

$$= \frac{\pi}{4}(0,21^2 - 0,06^2) \checkmark$$

$$A_{\text{forward}} = 31,80863 \times 10^{-3} \text{ m}^3 \checkmark$$

$$\text{also, } A_{\text{return}} = \frac{\pi D^2}{4}$$

$$= \frac{\pi \times 0,21^2}{4} \checkmark$$

$$A_{\text{return}} = 34,63606 \times 10^{-3} \text{ m}^3 \checkmark$$

$$\text{now, } t_{\text{forward}} = \frac{31,80863 \times 10^{-3} \times 0,5}{0,56 \times 10^{-3}} \checkmark$$

$$\therefore t_{\text{forward}} = 28,401 \text{ s } \checkmark$$

$$\text{and, } t_{\text{return}} = \frac{34,63606 \times 10^{-3} \times 0,5}{0,56 \times 10^{-3}} \checkmark$$

$$\therefore t_{\text{return}} = 30,925 \text{ s } \checkmark$$

(8)

2.3.2

$$\text{from, } P = \frac{F}{A}$$

$$= \frac{6000}{1,80863 \times 10^{-3}} \checkmark$$

$$\therefore P = 3,317 \text{ MPa } \checkmark$$

(2)
[20]

QUESTION 3

3.1 3.1.1 $W_{object} + F_{oil} = F_{total}$
 as, $F_{total} = F_{total}$...Archimede's law
 $F_{total} = mg + \rho Vg \checkmark$
 $= (90 \times 9,81) + \left(840 \times 9,81 \times \frac{\pi}{4} \times 3,6^2 \times 6 \right)$
 $\therefore F_{total} = F_{bouyancy} = 504145,233N \checkmark$

3.1.2 Now, $F_{total} = F_{bouyancy} \checkmark$
 $504145,233 = 1025 \times 9,81 \times \frac{\pi}{4} \times 3,6^2 h \checkmark$
 $504145,233 = 102349,9785h \checkmark$
 $h = \frac{504145,233}{102349,9785} \checkmark$
 $\therefore h = 4,946m \text{ below the surface} \checkmark$

(2 × 2½) (5)

3.2 3.2.1 $W_{object} = F_{bouyancy} \checkmark$
 $m_{object}g = \rho g V_{displaced} \checkmark$
 $= 9810 \times \frac{\pi \times 1,55^2}{4} \times 3,8 \times 0,45 \checkmark$
 $9,81m_{object} = 31653,256 \checkmark$
 $m_{object} = \frac{31653,256}{9,81} \checkmark$
 $\therefore m_{object} = 3,227tonnes \checkmark$

(5)

3.2.2 Application of Archimedes principle:
 where, $W_{object} + W_{load} = F_{bouyancy}$
 $m_{object}g + m_{load}g = \rho g V_p \checkmark$
 $9,81(3,227 \times 10^3 + m_{load}) = 9810 \times \frac{\pi \times 1,55^2}{4} \times 3,8 \checkmark$
 $3,227 \times 10^3 + m_{load} = 7170,29253 \checkmark$
 $m_{load} = 7170,29253 - 3,227 \times 10^3 \checkmark$
 $\therefore m_{load} = 3943,293kg \checkmark$

(6)

3.2.3

$$F = \rho g \bar{y} A$$

$$\bar{y} = 2,55 + \frac{1,55}{2} \checkmark$$

$$\therefore \bar{y} = 3,325m \checkmark$$

$$F = 9810 \times 3,325 \times \frac{\pi}{4} \times 1,55^2 \checkmark$$

$$\therefore F = 615,48kN \checkmark$$

(4)
 [20]

QUESTION 4

4.1 4.1.1

$$\text{from, } Q = \frac{\text{volume}}{\text{time}}$$

$$V = Qt$$

$$= 13 \times 10^{-3} \times 18 \times 60 \checkmark$$

$$\therefore V = 14,04m^3 \checkmark$$

$$\text{also, } \rho = \frac{\text{mass}}{\text{volume}}$$

$$m = \rho V$$

$$= 870 \times 14,04 \checkmark$$

$$\therefore m = 12,215\text{tonnes} \checkmark$$

4.1.2 *Application of Bernoulli's energy equation between the inlet and outlet :*

$$\frac{P_i}{\rho g} + \frac{v_i^2}{2g} + Z_i = \frac{P_o}{\rho g} + \frac{v_o^2}{2g} + Z_o + h_{\text{loss}} \dots \text{ignoring all possible losses} \checkmark$$

$$v_i = v_o$$

$$\text{thus, } Z_i - Z_o = \frac{P_o}{\rho g} \checkmark$$

$$Z_i - Z_o = \frac{34 \times 10^3}{870 \times 9,81} \checkmark$$

$$\therefore Z_i - Z_o = 3,984m \checkmark$$

(2 × 3) (6)

4.2 4.2.1 *from, $Q_i = Q_o$...continuity flow principle:*

$$Q_{250} = Q_{300}$$

$$\frac{\pi d_{250}^2}{4} \times v_{250} = \frac{\pi d_{300}^2}{4} \times v_{250} \checkmark$$

$$\frac{\pi \times 250^2}{4} \times v_{250} = \frac{\pi \times 300^2}{4} \times v_{250} \checkmark$$

$$v_{250} = \left(\frac{300}{250}\right)^2 \times 4 \checkmark$$

$$v_{250} = 5,76 \text{ m / s } \checkmark \tag{3}$$

4.2.2 *from,*

$$Q_{250} = Q_{300} = Q_{95} + Q_{140}$$

$$\frac{\pi d_{250}^2}{4} \times v_{250} = \frac{\pi d_{95}^2}{4} \times v_{95} + Q_{140} \checkmark$$

$$\frac{\pi \times 0,3^2}{4} \times 5,76 = \frac{\pi \times 0,095^2}{4} \times 3,85 + Q_{140} \checkmark$$

$$407,1504 \times 10^{-3} = 27,28964 \times 10^{-3} + Q_{140} \checkmark$$

$$Q_{140} = 407,1504 \times 10^{-3} - 27,28964 \times 10^{-3} \checkmark$$

$$\therefore Q_{140} = 379,861 \text{ l / s } \checkmark \tag{4}$$

4.2.3 *from, $Q = Av$*

$$\frac{\pi d_{140}^2}{4} \times v_{140} = 379,861 \times 10^{-3} \checkmark$$

$$v_{140} = \frac{379,861 \times 10^{-3} \times 4}{\pi \times 0,14^2} \checkmark$$

$$v_{140} = 24,676 \text{ m / s } \checkmark \tag{3}$$

4.2.4 $\overset{\circ}{W}_{140} = \rho g Q_{140}$

$$= 9810 \times 379,861 \times 10^{-3} \checkmark$$

$$= 3,726 \text{ kN / s } \checkmark$$

also, $\overset{\circ}{W}_{95} = \rho g Q_{95}$

$$= 9810 \times 27,28964 \times 10^{-3} \checkmark$$

$$= 267,711 \text{ N / s } \checkmark \tag{4}$$

[20]

QUESTION 5

5.1 5.1.1 In laminar flow each particle of a fluid flows smoothly along or adjacent to one another ✓ without interfering with one another along the path or with turbulence. ✓

5.1.2 Flow is said to be unsteady when the conditions in relation to time are unsteady. The fluid flows along a path with unparallel layers ✓ or with turbulence or conditions constantly changing with relation to time. ✓

(2 × 2) (4)

5.2

$$h_l = h_m \left(\frac{\rho_m}{\rho_s} - 1 \right)$$

$$= 40 \left(\frac{13600}{900} - 1 \right) \checkmark$$

$$= 564 \text{ mm } \checkmark$$

$$v_{ave} = C_v \sqrt{2gh_l}$$

$$v_{max} = \sqrt{19,62 \times 0,564} = 3,3265 \text{ m/s } \checkmark$$

$$= 0,9 \times 3,3265 \checkmark$$

$$\therefore v_{max} = 2,99386 \text{ m/s } \checkmark$$

$$Q = v_{max} \times A$$

$$= \frac{\pi \times 0,35^2 \times 2,99386}{4} \checkmark$$

$$\therefore Q = 288,043 \text{ l/s } \checkmark$$

(8)

5.3 5.3.1

$$v_1 = \frac{Q}{A_1}$$

$$= \frac{4 \times 6 \times 10^{-3}}{\pi \times 0,05^2} \checkmark$$

$$= 3,05578 \text{ m/s } \checkmark$$

$$v_2 = \frac{Q}{A_2}$$

$$= \frac{4 \times 6 \times 10^{-3}}{\pi \times 0,02^2} \checkmark$$

$$= 19,09856 \text{ m/s } \checkmark$$

$$h_v = \frac{19,09856^2 - 3,05578^2}{19,62} \checkmark$$

$$= 18,115 \text{ m } \checkmark$$

(6)

5.3.2

$$\begin{aligned} \text{from, } h_s &= \left(\frac{1}{C_c} - 1 \right)^2 \times \frac{v_{\text{exit}}^2}{2g} \\ &= \left(\frac{1}{0,7} - 1 \right)^2 \times \frac{19,09856^2}{19,62} \checkmark \\ &= 7,968m \checkmark \end{aligned}$$

(2)
 [20]

QUESTION 6

6.1 The function of a pump in a hydraulic system is to convert mechanical energy to hydraulic energy, ✓ by means of generating a lift (by means of vacuum or negative pressure) to the fluid on its suction side in order to deliver it. ✓ (2)

6.2 6.2.1

$$\begin{aligned} \text{from, } l/d_{\text{system}} &= \left(\frac{l}{d} \right)_{\text{filter}} + \left(\frac{l}{d} \right)_{\text{bends}} + \left(\frac{l}{d} \right)_{\text{valve}} + \left(\frac{l}{d} \right)_{\text{pipe}} \\ l/d_{\text{system}} &= \frac{4 \checkmark}{4 \times 0,015} + 2 \left(\frac{0,85}{4 \times 0,015} \right) + 60 + \frac{15 \checkmark}{0,03} \\ &= 66,66667 + 28,33333 + 60 + 500 \\ &= 655 \checkmark \end{aligned} \quad (6)$$

6.2.2

$$\begin{aligned} \text{from, } h_f &= \frac{4fv^2}{2gd} \\ \text{and, } Q &= Av \\ v &= \frac{4Q}{\pi d^2} \checkmark \\ &= \frac{10 \times 10^{-3}}{\pi \times 0,03^2} \checkmark \\ &= 3,53678m/s \checkmark \\ \text{thus, } h_f &= \frac{4fv^2}{2g} \times l/d_{\text{system}} \checkmark \\ &= \frac{4 \times 0,015 \times 3,53678^2}{19,62} \times 655 \\ &= 25,056m \checkmark \end{aligned} \quad (4)$$

6.2.3 *Application of Bernoulli's energy equation between the inlet and outlet :*

$$\frac{P_i}{\rho g} + \frac{v_i^2}{2g} + Z_i + H_{pump} = \frac{P_o}{\rho g} + \frac{v_o^2}{2g} + Z_o + h_{loss}$$
$$H_{pump} = \frac{4,25 \times 10^6}{960 \times 9,81} + \frac{3,53678^2}{19,62} - 6 + 25,056$$
$$= 470,976m \checkmark$$

from, $P = \rho g Q H_{pump}$

$$= 960 \times 9,81 \times 10 \times 10^{-3} \times 470,976 \checkmark$$
$$= 44,355kW \checkmark$$

(4)

6.2.4

$$\text{from, } h_{filter} = \frac{kv^2}{2g}$$
$$\text{where, } \left(\frac{l}{g}\right)_{filter} = \frac{k}{4f} \checkmark$$
$$60 = \frac{k}{4 \times 0,015} \checkmark$$
$$k = 3,6 \checkmark$$
$$\text{now, } h_{filter} = \frac{3,6 \times 3,53678^2}{19,62} \checkmark$$
$$\therefore h_{filter} = 2,295m \checkmark$$

(4)
[20]

TOTAL: 100