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

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

1.2.2

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

(2 × 2) (4)

1.3 1.3.1

$$From, F_{viscous} = \frac{\mu v A_{mean}}{t}$$
$$where, t = \frac{D-d}{2}$$
$$= \frac{310 - 309,5}{2} ✓$$
$$\therefore t = 0,25mm ✓$$
$$also, D_{mean} = \frac{D+d}{2}$$
$$= \frac{310 + 309,5}{2} ✓$$
$$\therefore D_{mean} = 309,75mm ✓$$
$$and, A_{mean} = \pi D_{mean} L$$
$$A_{mean} = \pi \times 309,75 \times 10^{-3} \times 200 \times 10^{-3} ✓$$
$$= 194,62167 \times 10^{-3} m^2 ✓$$
$$thus, F_{viscous} = \frac{\mu v A_{mean}}{t}$$
$$= \frac{0,196 \times 3,25 \times 194,62167 \times 10^{-3}}{0,25 \times 10^{-3}} ✓$$
$$\therefore F_{viscous} = 495,896N ✓$$

(8)

1.3.2

$$P_{viscous} = F_{viscous} \times v_{mean}$$
$$= 495,896 \times 3,25 ✓$$
$$\therefore P_{viscous} = 1,612kW ✓$$

(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 $Application\ of\ Pascal's\ principle:$

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

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

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

$= 2,66667 kN$ √

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

$F_{pedal} = \frac{2,66667}{5}$ √

$= 533,333 N$ √

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

$= 2,122 MPa$ √ (3)

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

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

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

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

$\therefore SL_{mc} = 16,6725 mm$ √

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

$SL_{pedal} = MA \times SL_{mc}$ √

$= 5 \times 16,6725$ √

$\therefore SL_{pedal} = 83,363 mm$ ✓ (4)

2.3 2.3.1

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

$$as, A_{foward} = \frac{\pi\left(D^2 - d^2\right)}{4}$$

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

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

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

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

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

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

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

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

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

(8)

2.3.2

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

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

$$\therefore P = 3,317\, MPa \checkmark$$

(2)

[20]

QUESTION 3

3.1 3.1.1

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

3.1.2

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

(2 × 2½) (5)

3.2 3.2.1

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

(5)

3.2.2

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

(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

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

$$V = Qt$$

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

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

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

$$m = \rho V$$

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

$$\therefore m = 12,215 tonnes \ \surd$$

4.1.2

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

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

$$v_i = v_o$$

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

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

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

(2 × 3) (6)

4.2 4.2.1

$$from, Q_i = Q_o ...continuity\ flow\ principle:$$
$$Q_{250} = Q_{300}$$
$$\frac{\pi d_{250}^2}{4} \times v_{250} = \frac{\pi d_{300}^2}{4} \times v_{250} \ \surd$$
$$\frac{\pi \times 250^2}{4} \times v_{250} = \frac{\pi \times 300^2}{4} \times v_{250} \ \checkmark$$
$$v_{250} = \left(\frac{300}{250}\right)^2 \times 4 \ \checkmark$$
$$v_{250} = 5,76 m/s \ \surd$$

(3)

4.2.2

$$from,$$
$$Q_{250} = Q_{300} = Q_{95} + Q_{140}$$
$$\frac{\pi d_{250}^2}{4} \times v_{250} = \frac{\pi d_{95}^2}{4} \times v_{95} + Q_{140} \ \checkmark$$
$$\frac{\pi \times 0,3^2}{4} \times 5,76 = \frac{\pi \times 0,095^2}{4} \times 3,85 + Q_{140} \ \checkmark$$
$$407,1504 \times 10^{-3} = 27,28964 \times 10^{-3} + Q_{140} \ \checkmark$$
$$Q_{140} = 407,1504 \times 10^{-3} - 27,28964 \times 10^{-3} \ \surd$$
$$\therefore Q_{140} = 379,861 l/s \ \surd$$

(4)

4.2.3

$$from, Q = Av$$
$$\frac{\pi d_{140}^2}{4} \times v_{140} = 379,861 \times 10^{-3} \ \checkmark$$
$$v_{140} = \frac{379,861 \times 10^{-3} \times 4}{\pi \times 0,14^2} \ \checkmark$$
$$v_{140} = 24,676 m/s \ \checkmark$$

(3)

4.2.4

$$\overset{o}{W}_{140} = \rho g Q_{140}$$
$$= 9810 \times 379,861 \times 10^{-3} \checkmark$$
$$= 3,726 kN/s \ \checkmark$$
$$also, \overset{o}{W}_{95} = \rho g Q_{95}$$
$$= 9810 \times 27,28964 \times 10^{-3} \checkmark$$
$$= 267,711 N/s \ \checkmark$$

(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

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

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

$$= 564mm ✓$$

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

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

$$= 0,9 \times 3,3265 ✓$$

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

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

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

$$\therefore Q = 288,043 l/s ✓$$

(8)

5.3 5.3.1

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

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

$$= 3,05578 m/s ✓$$

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

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

$$= 19,09856 m/s ✓$$

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

$$= 18,115m ✓$$

(6)

5.3.2 $$from, hs = \left(\frac{1}{C_c} - 1\right)^2 \times \frac{v_{exit}^2}{2g}$$

$$= \left(\frac{1}{0,7} - 1\right) \times \frac{19,09856^2}{19,62} \checkmark$$

$$= 7,968m \checkmark$$

(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 $$from, l/d_{sytem} = \left(\frac{l}{d}\right)_{filter} + \left(\frac{l}{d}\right)_{bends} + \left(\frac{l}{d}\right)_{valve} + \left(\frac{l}{d}\right)pipe$$

$$l/d_{sytem} = \frac{4 \checkmark}{4 \times 0,015} + 2\left(\frac{0,85}{4 \times 0,015}\right) + 60 + \frac{15}{0,03}$$

$$= 66,66667 + 28,33333 + 60 + 500$$

$$= 655 \checkmark$$

(6)

6.2.2 $$from, hf = \frac{4flv^2}{2gd}$$

$$and, Q = Av$$

$$v = \frac{4Q}{\pi d^2} \surd$$

$$= \frac{10 \times 10^{-3}}{\pi \times 0,03^2} \checkmark$$

$$= 3,53678m/s \surd$$

$$thus, hf = \frac{4fv^2}{2g} \times l/d_{sytem} \quad \checkmark$$

$$= \frac{4 \times 0,015 \times 3,53678^2}{19,62} \times 655$$

$$= 25,056m \checkmark$$

(4)

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

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

$$H_{pump}=\frac{4,25\times10^6}{960\times9,81}\surd+\frac{3,53678^2}{19,62}\surd-6\surd+25,056\surd$$

$$=470,976m\surd$$

$$from, P=\rho gQH_{pump}$$

$$=960\times9,81\times10\times10^{-3}\times470,976\checkmark$$

$$=44,355kW\surd$$

(4)

6.2.4

$$from, h_{filter}=\frac{kv^2}{2g}$$

$$where, \left(\frac{l}{g}\right)_{filter}=\frac{k}{4f}\surd$$

$$60=\frac{k}{4\times0,015}\checkmark$$

$$k=3,6\surd$$

$$now, h_{filter}=\frac{3,6\times3,53678^2}{19,62}\checkmark$$

$$\therefore h_{filter}=2,295m\checkmark$$

(4)

[20]

TOTAL: 100