higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

FLUID MECHANICS N5

18 November 2020

This marking guideline consists of 12 pages.

NOTE: ✓ = ONE mark
√ =½ mark

QUESTION 1

1.1 1.1.1

$$W = \frac{2\sigma\pi r^2}{r}$$
$$= 2\sigma\pi r \ ✓$$
$$= 2 \times 0,085 \times \pi \times 3 \times 10^{-3} \ ✓$$
$$\therefore W = 1,602 \times 10^{-3}\, N \ ✓$$ (3)

1.1.2

$$\Delta P = \frac{W}{A}$$
$$= \frac{1,602 \times 10^{-3}}{\pi \times 0,003^2} \ ✓$$
$$= 56,667\, Pa \ ✓$$ (2)

1.2 1.2.1

$$From, F_{viscous} = \frac{\mu v A}{t}$$
$$= \frac{0,11 \times 0,65 \times 1,5}{0,3 \times 10^{-3}} \ ✓$$
$$\therefore F_{viscous} = 357,5N \ ✓$$ (2)

1.2.2

$$From, WD = Fv$$
$$= 357,5 \times 0,65 \ ✓$$
$$\therefore WD = 232,375J/s \ or \ 232,375W \ ✓$$ (2)

1.2.3

$$From, \nu = \frac{\mu}{\rho}$$
$$since, \rho_{rel} = \frac{\rho_{substance}}{\rho_{water}}$$
$$\rho_{substance} = \rho_{rel} \times \rho_{water} \ √$$
$$= 0,95 \times 1000 \ √$$
$$\therefore \rho_{substance} = 950kg/m^3 \ ✓$$
$$thus, \nu = \frac{0,11}{950} \ ✓$$
$$\therefore \nu = 115,79 \times 10^{-6} m^2/s \ ✓$$ (4)

1.2.4

$$From, F = \frac{\mu v A}{t}$$

$$where, WD = Fv$$

$$90 = F \times 0,78 \checkmark$$

$$\therefore F = 115,38462N \checkmark$$

$$F = \frac{\mu v A}{t} \checkmark$$

$$\therefore A = \frac{115,38462 \times 0,2 \times 10^{-3}}{0,07} \checkmark$$

$$\therefore A = 329,67034 \times 10^{-3} m^2 \checkmark$$

$$thus, A = w \times l$$

$$w = \frac{329,67034 \times 10^{-3}}{0,6} \checkmark$$

$$\therefore w = 549,451mm \checkmark$$

(7)

[20]

QUESTION 2

2.1 Property of matter of either of liquid or gaseous phase,✓ which measures the ability to resist any form of compression (compressibility) when a force is applied to it✓ (2)

2.2 2.2.1

$$Applying\ Pascal's\ principle:$$

$$where, P_{ram} = P_{plunger}$$

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

$$now, F_{ram} = 6 \times 10^6 \times \frac{\pi \times 0,06^2}{4} \checkmark$$

$$\therefore F_{ram} = 16,965kN \checkmark$$

(2)

2.2.2

$$from, F_{plunger} = PA_{plunger}$$

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

$$\therefore F_{plunger} = 1,88496kN \sqrt{}$$

$$also, MA = \frac{F_{plunger}}{F_{lever}}$$

$$F_{lever} = \frac{1,88496 \times 10^3}{8} \checkmark$$

$$= 235,62N \sqrt{}$$

(3)

2.2.3

$$from, SV_{plunger} = SV_{ram}$$

$$n \times A_{plunger} \times SL_{plunger} = A_{ram} \times SL_{ram} \quad \surd$$

$$n = \left(\frac{60}{20}\right)^2 \times \frac{120}{35} \quad \checkmark$$

$$\therefore n = 30,857 \quad \surd$$

$$thus, a\ total\ of\ 31\ strokes\ is\ required\ to\ lift\ the\ ram\ 120mm \quad \checkmark$$

(3)

2.2.4

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

with no air in the system and modulus of elasticity

$$thus, \frac{1}{K_e} = \frac{1}{K_l} \quad \surd$$

$$K_e = K_l = 1,9GPa \quad \checkmark$$

$$as, K_e = \frac{\Delta P \times V}{\Delta V_{play}} \quad \surd$$

$$\Delta L_{play} = \frac{\Delta P \times L}{K_e} \quad \surd$$

$$= \frac{6 \times 10^6 \times 120}{1,9 \times 10^9} \quad \checkmark$$

$$\therefore \Delta L_{play} = 378,947mm \quad \surd$$

(4)

2.2.5 $$from, \frac{1}{K_e} = \frac{1}{K_l} + \frac{1}{K_{cyl}} + \frac{V_{air}}{V_{total} K_{air}}$$

$$with V_{air} = 1,55ml$$

$$also, K_{air} = P\gamma$$

$$= 6 \times 10^6 \times 1,4 \quad \surd$$

$$\therefore K_{air} = 8,4MPa \quad \surd$$

$$and, V_{total} = AL$$

$$= \frac{\pi \times 0,06^2}{4} \times 0,12 \quad \surd$$

$$\therefore V_{total} = 339.29201 \times 10^{-6} m^3 \quad \surd$$

$$thus, \frac{1}{K_e} = \frac{1}{1,9 \times 10^9} + \frac{1,55 \times 10^{-6}}{339,29201 \times 10^{-6} \times 8,4 \times 10^6} \quad \checkmark$$

$$\frac{1}{K_e} = 526,31579 \times 10^{-12} + 543,84956 \times 10^{-12} \quad \surd$$

$$\frac{1}{K_e} = 1,07017 \times 10^{-6} \quad \surd$$

$$\therefore K_e = 934,435MPa \quad \surd$$

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

$$= \frac{6 \times 10^6 \times 120}{934,435 \times 10^6} \quad \checkmark$$

$$\therefore \Delta L_{play} = 770,519mm \quad \surd$$

(6)

[20]

QUESTION 3

3.1 3.1.1 Upward thrust or force of fluid reacting (opposing direction) against any object which exerts a force (weight) along the surface of equal magnitude

3.1.2 Distance measured from liquid surface to base or lowest point of an object below floating or submerged below the surface of the liquid displaced by the object

(2 × 1) (2)

3.2 3.2.1

$$\sin ce, \bar{y} = 3 + \frac{0,9}{2} \quad ✓$$
$$= 3,45m \quad ✓$$
$$and, A = \frac{\pi \times 0,9^2}{4} \quad \surd$$
$$= 636,17251 \times 10^{-3} m^2 \quad \surd$$
$$F_{hydrostatic} = \rho g \bar{y} A$$
$$= 1020 \times 9,81 \times 3,45 \times 636,17251 \times 10^{-3} \quad ✓$$
$$= 21,962kN \quad ✓$$

(5)

3.2.2

$$from, \bar{h} = \frac{I_G \sin^2 \theta}{A \bar{y}} + \bar{y}$$
$$as, I_G = \frac{\pi \times 0,9^4}{64} \quad \surd$$
$$= 32,20623 \times 10^{-3} m^4 \quad \surd$$
$$hus, \bar{h} = \frac{32,20623 \times 10^{-3} \times \sin^2 90}{636,17251 \times 10^{-3} \times 3,45} + 3,45 \quad ✓ \quad \surd$$
$$= 14,67391 \times 10^{-3} + 3,45 \quad ✓$$
$$\therefore \bar{h} = 3,465m \quad \surd$$

(4)

3.3 3.3.1

Application of Archimedes law for partially or fully submerged objects

$$where, F_{ball} = F_{bouyancy} \quad \surd$$
$$mg = \rho g V_{\substack{water \\ displaced}} \quad \surd$$
$$= 1000 \times 6,25 \times 4 \times 1,2 \quad \surd$$
$$\therefore m = 30 tonnes \quad \surd$$

(2)

3.3.2

Application of Archimedes law for partially or fully submerged objects

$$where, F_{ball} = F_{bouyancy} \quad \surd$$
$$mg = \rho g V_{\substack{water \\ displaced}} \quad \surd$$
$$m = \rho V_{\substack{water \\ displaced}} \quad \surd$$
$$30 \times 10^3 = 1020 \times 6,25 \times 4 \times draught \quad ✓$$
$$\therefore draught = 1,177m \quad \surd$$

(3)

3.3.3 *Application of Archimedes law for partially or fully submerged objects:*

$$where, F_{pantoon} + F_{water} = F_{bouyancy} \quad \surd$$

$$m_{pantoon} g + m_{water} g = \rho g V_{\substack{water\\displaced}} \quad \surd$$

$$m_{pantoon} + m_{water} = \rho V_{\substack{water\\displaced}} \quad \surd$$

$$30 \times \underset{\surd}{10^3} + m_{water} = 1000 \times 6,25 \times 4 \times 1,66 \quad \surd$$

$$m_{water} = 41,5 \times 10^3 - 30 \times 10^3 \checkmark$$

$$\therefore m_{water} = 11500\ l \quad \surd$$

(4)

[20]

QUESTION 4

4.1 4.1.1 Line traced or followed by a given or known particle.✓ Generated by injecting a die into the fluid in order to follow the movement of the particle along a path✓

4.1.2 Line taken or followed by a fluid particle in instantaneous motion.✓ The particle will lie tangential to the streamline at some particular point or position.✓

(2 × 2) (4)

4.2 4.2.1

$$from, \overset{o}{W} = \overset{o}{m} g$$

$$as, \overset{o}{m} = \rho Q$$

$$now, \overset{o}{W} = \rho g Q \quad \surd$$

$$= 9810 \times \frac{\pi \times 0,065^2}{4} \times 8 \quad \surd$$

$$\therefore \overset{o}{W} = 260,421 N/s \quad \checkmark$$

(2)

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

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

$from, Q_{inlet}=Q_{outlet}$ ...*continuity of flow principle:*

$$thus, v_o=\frac{d_i^2}{d_o^2}\times v_i \quad \surd$$

$$=\frac{60^2}{45^2}\times 8 \quad \surd$$

$$\therefore v_o=14,22222 m/s \quad \surd$$

$$thus, \frac{P_i}{\rho g}+\overset{\surd}{\frac{8^2}{19,62}}+\overset{\surd}{0}=\overset{\surd}{\frac{50\times10^3}{9810}}+\overset{\surd}{\frac{14,22222^2}{19,62}}+\overset{\surd}{5,5}+\overset{\surd}{3}$$

$$\frac{P_i}{\rho g}=\frac{50\times10^3}{9810}+\frac{14,22222^2}{19,62}+5,5+3-\frac{8^2}{19,62} \quad \surd$$

$$P_i=9810\times 20,64432 \quad \surd$$

$$\therefore P_i=202,521 kPa \quad \surd$$

(6)

4.2.3 *Energy head at entry:*

$$E_i=\frac{P_i}{\rho g}+\frac{v_i^2}{2g}+Z_i$$

$$=\overset{\surd}{20,64432}+\overset{\surd}{\frac{8^2}{19,62}}+0 \quad \surd$$

$$\therefore E_i=23,9063 m \quad \surd$$

$$P_i=\rho g Q E_i$$

$$=9810\times\frac{\pi}{4}\times0,06^2\times8\times23,9063 \quad \surd$$

$$\therefore P_i=5,305 kW \quad \surd$$

(3)

4.2.4 *Energy head at exit:*

$$E_o=\frac{P_o}{\rho g}+\frac{v_o^2}{2g}+Z_o$$

$$=\overset{\surd}{\frac{50\times10^3}{9810}}+\overset{\surd}{\frac{14,22222^2}{19,62}}+\overset{\surd}{5,5}$$

$$\therefore E_o=20,90627 m \quad \surd$$

$$P_i=\rho g Q E_i$$

$$=9810\times\frac{\pi}{4}\times0,045^2\times14,22222\times20,90627 \quad \surd$$

$$\therefore P_i=4,639 kW \quad \surd$$

(3)

4.2.5 $\eta_o = \frac{P_o}{P_i} \times 100\%$

$= \frac{4,639}{5,305} \times 100\%$ ✓

$= 87,446\%$ ✓

(2)

[20]

QUESTION 5

5.1 Advantages:

- Relatively cheaper
- They are compact, which makes them easier to fit them between two measuring position, i.e. pipe flanges

Disadvantages:

- They are less accurate in providing data during flow measuring operation

(2 + 1) (3)

5.2 5.2.1 *Application of Bernoulli's energy equation between the inlet and outlet*:

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

$as, P_i = P_o$ √

$also, h_{loss} = 0$

$now, \frac{v_o^2}{2g} = \frac{v_i^2}{2g} + Z_i - Z_o$ √

$\frac{v_o^2}{2g} = \frac{2,55^2}{19,62} + 5$ ✓

$\therefore v_o = \sqrt{19,62\left(\frac{2,55^2}{19,62} + 5\right)}$ ✓

$= 10,228 m/s$ √

(4)

5.2.2 $from, Q_{inlet} = Q_{outlet}$ ...*continuity of flow principle*:

$thus, v_o \times d_o^2 = d_i^2 \times v_i$ √

$d_o = \sqrt{\frac{30^2 \times 2,55}{10,228}}$ ✓

$\therefore d_o = 14,98 mm$ √

(2)

5.2.3 *KE per unit weight;*

$$\frac{KE}{W} = \frac{mv_o^2}{2W} \surd$$
$$= \frac{v_o^2}{2g} \surd$$
$$= \frac{10,228^2}{19,62} \checkmark$$
$$= 5,332m \checkmark$$

(3)

5.3 *Application of Bernoulli's energy equation between the inlet and throat:*

$$\frac{P_i}{\rho g} + \frac{v_i^2}{2g} + Z_i = \frac{P_t}{\rho g} + \frac{v_t^2}{2g} + Z_t + h_{loss}$$
$$as, Z_i = Z_t ...horizontal$$
$$also, h_{loss} ...are\ ignored$$
$$thus, \frac{P_i - P_t}{\rho g} = \frac{v_t^2 - v_i^2}{2g} \checkmark$$
$$from, Q_{inlet} = Q_{outlet} ...continuity\ of\ flow\ principle:$$
$$thus, v_t \times d_t^2 = d_i^2 \times v_i \surd$$
$$v_i = \frac{d_t^2}{d_i^2} v_t \surd$$
$$now, \frac{P_i - P_t}{\rho g} = \frac{v_t^2 - \left(\frac{d_t^2}{d_i^2} v_t\right)^2}{2g}$$
$$\frac{25 \times 10^3}{9,81 \times 900} = \frac{v_t^2 - \left(\frac{40^2}{65^2} v_t\right)^2}{19,62} \checkmark$$
$$55,55556 = 0,85659 v_t^2 \surd$$
$$\therefore v_t = \sqrt{\frac{55,55556}{0,85659}} \checkmark$$
$$= 8,05337 m/s \surd$$
$$Q_t = A_t v_t$$
$$= \frac{\pi \times 0,04^2}{4} \times 8,05337 \checkmark$$
$$= 10,12017\ l/s \surd$$
$$Q_{actual} = 0,87 \times 0,12017 \checkmark$$
$$= 8,805\ l/s \surd$$

(8)
[20]

QUESTION 6

6.1 6.1.1 False
6.1.2 False
6.1.3 True

(3 × 1) (3)

6.2 6.2.1

$$from, \sum\left(\frac{l}{d}\right)_{system} = \left(\frac{l}{d}\right)_{valve} + \left(\frac{l}{d}\right)_{filter} + \left(\frac{l}{d}\right)_{pipe} + \left(\frac{l}{d}\right)_{bend} \surd$$

$$= 50 + \frac{3,5}{4\times 0,0015} \surd + \frac{15}{15,5\times 10^{-3}} \surd + 2\left(\frac{0,8}{4\times 0,0015}\right) \checkmark$$

$$= 50 + 583,33333 + 967,74194 + 266,66667$$

$$= 1867,742 \surd$$

(5)

6.2.2

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

$$thus, hf = \frac{4\times 0,0015\times 4,15^2}{19,62}\times 1867,742 \checkmark$$

$$\therefore hf = 9,837m \checkmark$$

(2)

6.3 6.3.1

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

$$\frac{P_i}{\rho g} + \frac{v_i^2}{2g} + Z_i = \frac{P_t}{\rho g} + \frac{v_t^2}{2g} + Z_t + h_{loss}$$

$$as, v_i = v_o ...constant\ pipe\ diameter$$

$$where, \frac{Z_i - Z_t}{L} = \sin\theta$$

$$Z_i - Z_t = 580\times\frac{1}{110} \checkmark$$

$$= 5,273m \checkmark$$

$$\frac{400\times 10^3}{9810} + 5,273 \surd = \frac{4\times 0,0012\times 580v_{pipe}^2}{19,62\times 0,03} \surd + \frac{6,25v_{pipe}^2}{19,62} \surd$$

$$v_{pipe}^2 = \frac{46,04772}{\left(\frac{4\times 0,0012\times 580}{19,62\times 0,03} + \frac{6,25}{19,62}\right)} \checkmark \surd$$

$$= \sqrt{9,12121} \surd$$

$$\therefore v_{pipe} = 3,02m/s \surd$$

(6)

6.3.2

$$P_{loss} = \rho g Q h_{loss}$$

$$where, h_{loss} = \frac{kv_{pipe}^2}{2g} + \frac{4flv_{pipe}^2}{2gd}$$

$$= \frac{4 \times 0,0012 \times 580 \times 3,02^2}{19,62 \times 0,03} \checkmark + \frac{6,25 \times 3,02^2}{19,62} \checkmark$$

$$\therefore h_{loss} = 46,04361 m \quad \surd$$

$$= 9810 \times \frac{\pi \times 0,03^2}{4} \times 3,02 \times 46,04361 \quad \checkmark$$

$$= 964,225 W \quad \surd$$

(4)

[20]

TOTAL: 100