higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

FLUID MECHANICS N5

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This marking guideline consists of 11 pages.

QUESTION 1

1.1
- Newtonian fluids are those real fluids which obey the relation in the law.
- Non-Newtonian fluids are those real fluids that do not obey this law. (2)

1.2 1.2.1 *As the thin plate is in the middle between the two large plates, 't' will be the same for both conditions*

$$where, t_{upper} = t_{lower} = \frac{distance\ between\ the\ plates}{2}$$

Consider the thin plate force acting below the upper large plate

$$from, \tau = \frac{\mu v}{t}$$

$$\tau_{upper} = \frac{8{,}1\times10^{-1}\times0{,}6}{\frac{24\times10^{-3}}{2}} \checkmark$$

$$\therefore \tau = 40{,}5 N/m^2 \checkmark$$

$$F_{upper} = \tau A$$

$$= 40{,}5\times0{,}5 \checkmark$$

$$= 20{,}25 N \checkmark$$

Consider the thin plate force acting above the lower large plate

$$\tau_{lower} = \frac{\mu v}{t}$$

$$= \frac{8{,}1\times10^{-1}\times0{,}6}{\frac{24\times10^{-3}}{2}} \checkmark$$

$$\therefore \tau = 40{,}5 N/m^2 \checkmark$$

$$F_{lower} = \tau A$$

$$= 40{,}5\times0{,}5 \checkmark$$

$$= 20{,}25 N \checkmark$$

$$F_{total} = F_{upper} + F_{lower}$$

$$= 20{,}25 + 20{,}25 \checkmark$$

$$= 40{,}5 N \checkmark$$

(10)

1.2.2 *Consider new distance for the thin plate between the two large plates*

Consider the *distance* of *the thin plate and the upper large plate*

$t_{upper} = 24 - 8 = 16\ mm$ ✓

$from, \tau = \dfrac{\mu v}{t}$

$\tau_{upper} = \dfrac{8{,}1 \times 10^{-1} \times 0{,}6}{16 \times 10^{-3}}$

$\therefore \tau = 30{,}375 N/m^2$ ✓

$F_{upper} = \tau A$

$= 30{,}375 \times 0{,}5$

$= 15{,}1875 N$ ✓

Consider the *distance* of *the thin plate and the lower large plate*

$t_{lower} = 24 - 16 = 8\ mm$ ✓

$\tau_{lower} = \dfrac{\mu v}{t}$

$= \dfrac{8{,}1 \times 10^{-1} \times 0{,}6}{8 \times 10^{-3}}$

$\therefore \tau = 60{,}75 N/m^2$ ✓

$F_{lower} = \tau A$

$= 60{,}75 \times 0{,}5$

$= 30{,}375 N$ ✓

$F_{total} = F_{upper} + F_{lower}$

$= 15{,}1875 + 30{,}375$ ✓

$= 45{,}563 N$ ✓

(8)

[20]

QUESTION 2

2.1
- The hydraulic head is the pressure exerted by a body of liquid at a height, which is a specific measurement of liquid pressure above a reference position.
- It is measured as liquid surface elevation in units of length. (2)

2.2 2.2.1

Consider the distance moved by the master cylinder thus, the distance ratio

$$MA = \frac{L_{pedal}}{L_{lever}} = \frac{x}{L_{brake}}$$

$$\frac{105{,}5}{350} = \frac{x}{70} \checkmark$$

$$\therefore x = L_{master} = 21{,}1\ mm \checkmark$$

$$V_m = V_s ...according\ to\ Pascal's\ law$$

$$V_m = 2V_s$$

$$A_m L_m = 2A_s L_s$$

$$L_s = \frac{A_m L_m}{2A_s} = \frac{D^2{}_m L_m}{2D^2{}_s} \checkmark$$

$$= \frac{40^2 \times 21{,}1}{2 \times 60^2} \checkmark$$

$$= 4{,}689\ mm \checkmark$$

(5)

2.2.2

$$P_s = \frac{F}{A_s}$$

$$= \frac{4 \times 125 \times 10^3}{\pi \times 0{,}06^2} \checkmark$$

$$= 44{,}2097 MPa \checkmark$$

from Pascal's law

$$P_{master} = P_{slave} = 44{,}2097 MPa$$

$$F_m = 44{,}2097 \times 10^6 \times \frac{\pi \times 0{,}04^2}{4} \checkmark$$

$$\therefore F_m = 55{,}556 kN \checkmark$$

Taking moments for force needed on pedal :

$$F_{pedal} \times L_{pedal} = F_m \times L_{brake}$$

$$F_{pedal} \times 350 = 55{,}556 \times 70 \checkmark$$

$$\therefore F_{pedal} = \frac{55{,}556 \times 70}{350} \checkmark$$

$$= 11{,}111 kN \checkmark$$

(7)

2.2.3

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

$$for\ no\ air\ in\ the\ sytsem, V_{air} = 0$$

$$now, \frac{1}{K_e} = \frac{1}{K_{fluid}} + \frac{1}{K_{cyl}}$$

$$also, K_{cyl} = \frac{13}{2,5} = 5,2GPa\ \checkmark$$

$$K_e = \frac{1}{10,5 \times 10^9} + \frac{1}{5,2 \times 10^9}\checkmark$$

$$\therefore K_e = 3,4777GPa\ \checkmark$$

$$\Delta V = A \times \Delta L_{master} = \frac{200 \times 10^{-6} \times 44,2097 \times 10^6}{3,4777 \times 10^9}\checkmark$$

$$\therefore \Delta L_{master} = \frac{4 \times 2,54246 \times 10^{-6}}{\pi \times 0,04^2}\ \checkmark$$

$$\therefore \Delta L_{master} = 2,023\ mm\checkmark$$

(6)

[20]

QUESTION 3

3.1
- The mass or weight of the body
- The density of the fluid subject to the load of the body (2)

3.2 3.2.1

$$m_{sub} = m_{sea-displaced}$$

$$\therefore \rho_{sea} = \frac{m_{sea}}{V_{sea}}$$

$$= \frac{144000}{1030}\checkmark$$

$$= 139,806m^3\checkmark$$

$$However, V_{sea} = 80\% \times V_{sub}$$

$$\therefore V_{sub} = \frac{139,806}{0,75}\checkmark$$

$$= 186,408m^3\checkmark$$

(4)

3.2.2

$$\rho_{sub} = \frac{m_{sub}}{V_{sub}}$$

$$= \frac{144\ 000}{186{,}408}$$

$$= 772{,}5\ kg/m^3\ ✓$$

$$Volume\ of\ subs\tan ce\ above\ the\ surface, V_{sub}$$

$$V_{sub} = 186{,}408 - 138{,}806\ ✓$$

$$= 47{,}602\ m^3 ✓$$

$$Mass\ of\ subs\tan ce\ above\ the\ surface, m_{sub}$$

$$m_{sub} = \rho_{sub} \times V_{sub}$$

$$= 772{,}5 \times 47{,}602$$

$$= 36772{,}545\ kg ✓$$

$$m_{sub}\ is\ the\ same\ as\ the\ mass\ of\ seawater\ required (m_{sea})$$

$$V_{sea} = \frac{36772{,}5}{1030} ✓$$

$$= 35{,}702\ m^3 ✓$$

(6)

3.2.3

$$m_{sub} = m_w$$

$$\rho_{sub} V_{sub} = \rho_w V_w$$

$$\therefore \frac{V_w}{V_{sub}} = \frac{\rho_{sub}}{\rho_w} \times 100\%\ ✓$$

$$= \frac{772{,}5}{1\ 000} \times 100\% ✓$$

$$= 77{,}25\%\ ✓$$

(3)

3.2.4

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

$$= 1\ 030 \times 9{,}81 \times 1{,}2 \times \frac{\pi \times 1{,}25^2}{4} ✓$$

$$= 14{,}88 kN\ ✓$$

(2)

3.2.5

$$\bar{h} = \bar{y} + \frac{I_G \sin^2\theta}{\bar{y} A}$$

$$= 1{,}2 + \frac{\overset{✓}{\frac{\pi \times 0{,}625^4}{4}} \sin^2 70}{1{,}2 \times \frac{\pi \times 1{,}25^4}{4}}\ ✓$$

$$= 1{,}246\ m\ ✓$$

(3)
[20]

QUESTION 4

4.1 Lamina region, the cross-sectional area and velocity of a stream under this condition may not vary from section to section,✓ however it does not change with time and its movement does not affect other adjacent flow line in the flow region.✓
Whilst turbulent flow, the cross-sectional area and velocity of a stream under this condition will vary with time✓ and is accompanied by indiscriminate eddy current in flow region.✓ (4)

4.2 4.2.1

$$\overset{O}{W} = \frac{\overset{o}{m}\, g}{V_{sub}}$$

$$\sin ce, \overset{o}{m} = \rho V_{sub}$$

$$now, \overset{O}{W} = 950 \times 9{,}81 \times 25 \times 10^{-3} \checkmark$$

$$= 232{,}988\ N/s \checkmark$$

(2)

4.2.2

$$Q_2 = A_2 v_2$$

$$v = \frac{4 \times 25 \times 10^{-3}}{\pi \times 0{,}07^2} \checkmark$$

$$= 6{,}496\ m/s \checkmark$$

(2)

4.2.3

$$For\ the\ continuity\ of\ flow\ in\ a\ system, Q_{in}(total) = Q_{out}(total)$$

$$Q_1 = Q_2 = Q_3 + Q_4$$

$$25 \times 10^{-3} = 11 \times 10^{-3} + \left(v_4 \times \frac{\pi \times 0{,}048^2}{4} \right) \quad \checkmark \checkmark$$

$$v_4 = \frac{14 \times 10^{-3}}{03{,}61911} \quad \checkmark$$

$$= 8{,}293\ m/s \checkmark$$

$$R_e = \frac{\rho v d}{\mu}$$

$$= \frac{950 \times 7{,}545 \times 0{,}048}{0{,}44} \checkmark$$

$$= 859{,}075 \checkmark$$

$$\sin ce, R_e \langle\ 2\ 000 \checkmark$$

$$thus, flow\ is\ la\min a \checkmark$$

(8)

4.2.4 $Q_3 = v_3 A_3$

$$v_3 = \frac{4 \times 11 \times 10^{-3}}{\pi \times 0{,}062^2} \checkmark$$

$$= 3{,}644\ m/s \checkmark$$

$$Kinetic\ energy\ per\ unit\ weight\ (velocity\ head)$$

$$= \frac{v^2}{2g}$$

$$= \frac{3{,}644^2}{19{,}62} \checkmark$$

$$= 0{,}677\ m \checkmark$$

(4)
[20]

QUESTION 5

5.1
- The coefficient of velocity, is the ratio of the actual jet of fluid at the vena contractor
- to the theoretical velocity at the orifice. (2)

5.2 $From, Q_a = A_a v_a$

$$v_a = \frac{4 \times \frac{0{,}405}{60}}{\pi \times 0{,}01675^2} \checkmark$$

$$= 30{,}6362\ m/s \checkmark$$

$$v_t = \sqrt{2gh}$$

$$= \sqrt{19{,}62 \times 65} \checkmark$$

$$= 37{,}7113\ m/s \checkmark$$

$$C_v = \frac{v_t}{v_a}$$

$$= \frac{30{,}3662}{37{,}7113} \checkmark$$

$$= 0{,}812 \checkmark$$

$$C_c = \frac{A_a}{A_t}$$

$$= \frac{\frac{\pi D_a^2}{4}}{\frac{\pi D_t^2}{4}} = \frac{D_a^2}{D_t^2} \checkmark$$

$$= \frac{16{,}75^2}{19^2} \checkmark$$

$$= 0{,}777 \checkmark$$

$$C_d = \frac{Q_a}{Q_t}$$

$$= \frac{4 \times 0{,}00675}{37{,}7113 \times \pi \times 0{,}019^2} \checkmark$$

$$= 0{,}631 \checkmark$$

Alternatively

$$C_d = C_c \times C_v$$

$$= 0{,}777 \times 0{,}812 \checkmark$$

$$= 0{,}631 \checkmark$$

(11)

5.3 5.3.1 *Applying Bernoulii's equation between two energy points:*

$$E_1 - H_{loss} = E_2$$

$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + Z_2$$

$$\frac{P_1}{\rho g} + Z_1 = \frac{v_2^2}{2g} \checkmark$$

$$v_2 = v_t = \sqrt{\frac{45 \times 10^3}{9\,810} + 1{,}7} \checkmark$$

$$= 11{,}1065\ m/s \checkmark$$

$$Q_a = C_d \times Q_t$$

$$= 0{,}67 \times 11{,}1065 \times \frac{\pi \times 0{,}035^2}{4} \checkmark$$

$$= 7{,}16\ l/s \checkmark$$

(5)

5.3.2 $From, P = \rho g h$

$$h = \frac{45 \times 10^3}{9\,810} \checkmark$$

$$= 4{,}587\ m \checkmark$$

(2)

[20]

QUESTION 6

6.1

- Friction head loss is when a fluid flowing through a pipeline, experiences frictional resistance due to pipe friction
- which is the energy lost in overcoming the frictional resistance.
- Shock losses occurring in a pipeline system are accompanied by vibration (turbulence) and noise
- due to sudden changes in flow or pressure, by sudden changes (increase or decrease) in pipe diameters, pipe bends and entrance or exit in pipes from reservoirs. (4)

6.2 $\text{Pr}\,essure\ \ difference\, across\, the\ pump:$

$\Delta P_{pump} = P_o - P_i$

$= 300 - 175$ ✓

$= 125\ kPa$ ✓

$\Delta P_{pump} = \rho g h$

$h_{pump} = \dfrac{125 \times 10^3}{880 \times 9{,}81}$ ✓

$= 14{,}4797\ m$ ✓

$From: \eta_{mech} = \dfrac{P_{pump}}{P_{motor}} \times 100\%$

$where, P_{pump} = \rho g h_{pump} Q$

$\therefore P_{motor} = \dfrac{\rho g h_{pump} Q}{\eta_{mech}}$

$Now, P_{pump} = \rho g h_{pump} Q$

$= 880 \times 9{,}81 \times 14{,}4797 \times 6{,}25 \times 10^{-3}$ ✓

$= 781{,}25\ W$ ✓

$\therefore P_{motor} = \dfrac{781{,}25}{0{,}92}$ ✓

$= 849{,}185\ W$ ✓ (8)

6.3 $Consider\ the\ total\ 'l/d'\ ratio\ \ for\ the\ system$

$l/d_{system} = \left(\overset{\checkmark}{\dfrac{30}{0{,}06}}\right)_{pipe} + \left(\overset{\checkmark}{\dfrac{2{,}88}{4 \times 0{,}012}}\right)_{valve} + \left(\overset{\checkmark}{\dfrac{0{,}5}{4 \times 0{,}12}}\right)$

$= 500 + 60 + 10{,}4167$ ✓

$= 570{,}4167$ ✓

$v_{pipe} = \dfrac{4 \times 20 \times 10^{-3}}{\pi \times 0{,}06^2}$

$= 7{,}07355\ m/s$ ✓

$hf_{sytem} = \dfrac{4 f v^2}{2g} \times l/d_{system}$

$= \dfrac{4 \times 0{,}012 \times 7{,}07355^2}{19{,}62} \times 570{,}4167$ ✓

$\therefore hf_{sytem} = 69{,}825\ m$ ✓

(8)
[20]
TOTAL: 100