



higher education
& training

Department:
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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, $t_{upper} = t_{lower} = \frac{\text{distance between the plates}}{2}$

Consider the thin plate force acting below the upper large plate

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

$$\tau_{upper} = \frac{8,1 \times 10^{-1} \times 0,6}{24 \times 10^{-3}} \checkmark$$

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

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

$$= 40,5 \times 0,5 \checkmark$$

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

Consider the thin plate force acting above the lower large plate

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

$$= \frac{8,1 \times 10^{-1} \times 0,6}{24 \times 10^{-3}} \checkmark$$

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

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

$$= 40,5 \times 0,5 \checkmark$$

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

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

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

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

(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

$$t_{upper} = 24 - 8 = 16 \text{ mm} \checkmark$$

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

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

$$\therefore \tau = 30,375 \text{ N/m}^2 \checkmark$$

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

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

$$= 15,1875 \text{ N} \checkmark$$

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

$$t_{lower} = 24 - 16 = 8 \text{ mm} \checkmark$$

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

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

$$\therefore \tau = 60,75 \text{ N/m}^2 \checkmark$$

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

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

$$= 30,375 \text{ N} \checkmark$$

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

$$= 15,1875 + 30,375 \checkmark$$

$$= 45,563 \text{ N} \checkmark$$

(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

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

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

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

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

$$V_m = 2V_s$$

$$A_m L_m = 2A_s L_s$$

$$L_s = \frac{A_m L_m}{2A_s} = \frac{D_m^2 L_m}{2D_s^2} \checkmark$$

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

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

(5)

- 2.2.2

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

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

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

from Pascal's law

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

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

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

Taking moments for force needed on pedal :

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

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

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

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

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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 system, $V_{air} = 0$

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

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

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

$$\therefore K_e = 3,4777 \text{ GPa} \checkmark$$

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

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

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

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

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

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

$$= 139,806 \text{ m}^3 \checkmark$$

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

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

$$= 186,408 \text{ m}^3 \checkmark$$

(4)

3.2.2

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

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

$$= 772,5 \text{ kg/m}^3 \checkmark$$

Volume of substance above the surface, V_{sub}

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

$$= 47,602 \text{ m}^3 \checkmark$$

Mass of substance above the surface, m_{sub}

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

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

$$= 36772,545 \text{ kg} \checkmark$$

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

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

$$= 35,702 \text{ m}^3 \checkmark$$

(6)

3.2.3

$$m_{sub} = m_w$$

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

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

$$= \frac{772,5}{1000} \times 100\% \checkmark$$

$$= 77,25\% \checkmark$$

(3)

3.2.4

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

$$= 1030 \times 9,81 \times 1,2 \times \frac{\pi \times 1,25^2}{4} \checkmark$$

$$= 14,88 \text{ kN} \checkmark$$

(2)

3.2.5

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

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

$$= 1,246 \text{ m} \checkmark$$

(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

$$\dot{W} = \frac{\dot{m} g}{V_{sub}}$$

$$\text{since, } \dot{m} = \rho V_{sub}$$

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

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

(2)

4.2.2

$$Q_2 = A_2 v_2$$

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

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

(2)

4.2.3

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

$$Q_1 = Q_2 = Q_3 + Q_4$$

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

$$v_4 = \frac{14 \times 10^{-3}}{0,61911} \checkmark$$

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

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

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

$$= 859,075 \checkmark$$

$$\text{since, } R_e < 2000 \checkmark$$

thus, flow is laminar

(8)

$$4.2.4 \quad Q_3 = v_3 A_3$$
$$v_3 = \frac{4 \times 11 \times 10^{-3}}{\pi \times 0,062^2} \checkmark$$
$$= 3,644 \text{ m/s } \checkmark$$

Kinetic energy per unit weight (velocity head)

$$= \frac{v^2}{2g}$$
$$= \frac{3,644^2}{19,62} \checkmark$$
$$= 0,677 \text{ m} \checkmark$$

(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, $Q_a = A_a v_a$*

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

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

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

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

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

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

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

$$= 0,812 \checkmark$$

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

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

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

$$= 0,777 \checkmark$$

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

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

$$= 0,631 \checkmark$$

Alternatively

$$C_d = C_c \times C_v$$

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

$$= 0,631 \checkmark$$

(11)

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

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

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

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

$$v_2 = v_t = \sqrt{\frac{45 \times 10^3}{9810}} + 1,7 \checkmark$$

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

$$Q_a = C_d \times Q_t$$

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

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

(5)

5.3.2 *From, $P = \rho gh$*

$$h = \frac{45 \times 10^3}{9810} \checkmark$$

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

(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 Pressure difference across the pump :

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

$$= 300 - 175 \checkmark$$

$$= 125 \text{ kPa} \checkmark$$

$$\Delta P_{pump} = \rho gh$$

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

$$= 14,4797 \text{ m} \checkmark$$

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

$$\text{where, } P_{pump} = \rho gh_{pump} Q$$

$$\therefore P_{motor} = \frac{\rho gh_{pump} Q}{\eta_{mech}}$$

$$\text{Now, } P_{pump} = \rho gh_{pump} Q$$

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

$$= 781,25 \text{ W} \checkmark$$

$$\therefore P_{motor} = \frac{781,25}{0,92} \checkmark$$

$$= 849,185 \text{ W} \checkmark$$

(8)

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

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

$$= 500 + 60 + 10,4167 \checkmark$$

$$= 570,4167 \checkmark$$

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

$$= 7,07355 \text{ m/s} \checkmark$$

$$hf_{system} = \frac{4fv^2}{2g} \times l/d_{system}$$

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

$$\therefore hf_{system} = 69,825 \text{ m} \checkmark$$

(8)

[20]

TOTAL: 100