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 10 pages.

QUESTION 1

1.1 1.1.1 Pressure is the force exerted by a fluid✓ on any surface with which it is in contact or by one part of a fluid on the adjoining parts.✓

1.1.2 Atmospheric pressure is the pressure acting✓ or exerted on the surface of the earth due to the weight of the atmospheric pressure.✓

1.1.3 Absolute pressure is the pressure✓ which is measured above absolute zero and is the sum of the atmospheric✓ and gauge pressure.

1.1.4 Gauge pressure is the intensity of pressure measure above✓ or below atmospheric pressure and is measured by a gauge device.✓

(4 × 2) (8)

1.2 1.2.1

$$SG = \frac{\rho_{ice}}{\rho_{water}}$$

$$\rho_{ice} = SG \times \rho_{water}$$

$$= 1{,}1 \times 1\ 000 \checkmark$$

$$= 1\ \ 100\ kg/m^3 \checkmark$$

(2)

1.2.2

$$W = mg = \rho V_{ice} g$$

$$= (1\,100 \times 2) \times 9{,}81 \checkmark \checkmark$$

$$= 21{,}582\ kN \checkmark$$

(3)

1.2.3

$$W_{ice} = F_{bouyancy}$$

$$\rho_{ice} V_{ice} g = \rho_w V_{disp} g$$

$$21{,}582 \times 10^3 = 1000 \times 2 \times 2 \times h \times 9{,}81 \checkmark$$

$$V_{disp} = 4h = \frac{21{,}582 \times 10^3}{9\ 810} \checkmark$$

$$h = \frac{2{,}2}{4} \checkmark$$

$$= 0{,}55\ m \checkmark$$

(4)

1.3 Surface tension, it is the tension induced due ✓to the cohesion of forces between molecules on the surface of the fluid (liquid) which adjoins another immiscible fluid (liquid), this✓ is also the property that allows objects to float on its surface and is measured✓ in N/m. (3)

[20]

QUESTION 2

2.1 2.1.1

$$t = \frac{D - d}{2}$$
$$= \frac{95,2 - 95}{2} \checkmark$$
$$= 0,1\ mm \checkmark$$

$$\tau = \frac{\mu \times v}{t}$$
$$= \frac{0,2 \times 5}{0,1 \times 10^{-3}} \checkmark$$
$$= 10\ kPa \checkmark$$

$$F = \tau A = \tau \pi d L$$
$$= 10\ 000 \times \left(\pi \times 0,09\overset{\checkmark}{5} \times 0,12\right) \checkmark$$
$$= 358,142\ N \checkmark$$

(7)

2.1.2

$$P = Fv$$
$$= 358,142 \times 5 \checkmark$$
$$= 1790,709\ W \checkmark$$

(2)

2.1.3

$$\upsilon = \frac{\mu}{\rho}$$
$$= \frac{0,2}{850} \checkmark$$
$$= 235,294 \times 10^{-3}\ m^2/s \checkmark$$

(2)

2.2 $V = AL$

$$700 \times 10^{-6} = \frac{\pi \times D_{LP}^2 \times 0,5D_{LP}}{4} \checkmark$$

$$D_{LP} = \sqrt[3]{\frac{8 \times 700 \times 10^{-6}}{\pi}} \checkmark$$

$$= 121,124\ mm \checkmark$$

$$L = 0,5D_{LP}$$

$$= 0,5 \times 121,124 \checkmark$$

$$\therefore L = 60,625 mm \checkmark$$

$$F_{HP} = F_{LP} \checkmark$$

$$P_{HP} A_{HP} = P_{LP} A_{LP}$$

$$P_{HP} D_{HP}^2 = P_{LP} D_{LP}^2$$

$$D_{HP} = D_{LP} \sqrt{\frac{P_{LP}}{P_{HP}}} \checkmark$$

$$= 121,124 \sqrt{\frac{7}{15}} \checkmark$$

$$\therefore D_{HP} = 82,743\ mm \checkmark$$

(9)
[20]

QUESTION 3

3.1 3.1.1 *Consider oil* :

$$P_{oil-1} = \frac{\rho g h_{oil-1}}{2}$$
$$= \frac{900 \times 9{,}81 \times 2}{2}$$
$$= 8829 Pa \checkmark$$
$$F_{oil-1} = P_{oil-1} \times A_{oil-1}$$
$$= 8\,829 \times 3{,}5 \times 2 \checkmark$$
$$= 61{,}803 kN \checkmark$$
$$F_{oil2} = 900 \times 9{,}81 \times 2 \times 3{,}5 \times 3 \checkmark$$
$$= 238{,}383\ kN \checkmark$$

Consider water

$$P_w = \frac{\rho g h_w}{2}$$
$$= \frac{1\,000 \times 9{,}81 \times 3}{2}$$
$$= 14715 Pa \checkmark$$
$$F_w = P_w \times A_w$$
$$= 8\,829 \times 3{,}5 \times 2 \checkmark$$
$$= 103{,}005 kN \checkmark$$

Total hydrostatic force

$$F_{total} = F_{oil-1} + F_w + F_{oil2} \quad \checkmark$$
$$= 61{,}803 + 238{,}383 + 103{,}005 \checkmark$$
$$= 403{,}191\ kN$$

(10)

3.1.2

$$h_{oil-1} = 3 + \frac{2}{3} = 3{,}6667\ m \checkmark$$
$$h_{oil-2} = \frac{3}{2} = 1{,}5\ m \checkmark$$
$$h_w = \frac{3}{3} = 1\ m \checkmark$$

Moments taken about the turning point :

$$(F_w \times h_w) + (F_{oil-1} \times h_{oil-1}) + (F_{oil-2} \times h_{oil-2}) = F_{total}\, y_{total}$$
$$(103{,}005 \times 1) + (61{,}803 \times 3{,}6667) + (238{,}383 \times 1{,}5) = 403{,}191 y_{total} \checkmark$$
$$y_{total} = 1{,}704\ m\ (from\ bottom) \checkmark$$
$$y_{total} = 5 - 1{,}704 = 3{,}3 m\ (from\ free\ surface) \checkmark$$

(6)

3.2 The principle of Archimedes states that the upward ✓ thrust or force of buoyancy acting on a body ✓ immersed or submerged in a fluid (liquid) is equal to the weight of the fluid displaced. The greater the density of the fluid (liquid), the greater the effect of the upward thrust ✓ or force of ✓ buoyancy. (4)

[20]

QUESTION 4

4.1 4.1.1 The cross-sectional area and velocity of a stream may vary from cross-section to cross-section, however ✓ will not with respect to time: tapering ✓ pipe

4.1.2 The cross-sectional area and velocity ✓ of a stream varies with respect to time: wave in a channel ✓

4.1.3 The cross-sectional area and velocity ✓ of a stream are the same at successive sections: pipe of constant diameter running full ✓

4.1.4 The cross-sectional area and velocity ✓ of a stream are not the same at successive sections: pipe of constant diameter delivering water from ✓ reciprocating pump

(4 × 2) (8)

4.2 4.2.1

$$V = \frac{m}{\rho}$$
$$= \frac{10\ 000}{950} ✓$$
$$= 10{,}526316\ m^3 ✓$$
$$Q = \frac{V}{t}$$
$$t = \frac{10{,}526316}{12 \times 10^{-3}} ✓$$
$$= 877{,}193\,\text{sec} ✓$$
$$= 14{,}62\,\text{min} ✓$$

(5)

4.2.2

$$P = \rho g h$$
$$= 950 \times 9{,}81 \times 4 ✓$$
$$= 37{,}278\ kPa ✓$$

(3)

4.2.3 $Applying\ Bernoulli's\ theorem:$

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

$$\sin ce: P_1=P_2 ...atmospheric\ conditions$$

$$v_1 \approx 0$$

$$thus,\ Z_1=\frac{v_2^2}{2g}+Z_2 \checkmark$$

$$v_2^2=2g(Z_1-Z_2)\checkmark$$

$$=\sqrt{19,62\times 6}\checkmark$$

$$\therefore v_2=10,85\ m/s \checkmark$$

(4)
[20]

QUESTION 5

5.1 5.1.1

$$C_c=\frac{A_{vena}}{A_{ori}}=\frac{d_{vena}^2}{d_{ori}^2}$$

$$=\frac{13,382}{16}\checkmark$$

$$=0,836\checkmark$$

$$v_{ori}=\sqrt{2gh}$$

$$=\sqrt{19,62\times 60}\checkmark$$

$$34,310348\ m/s\checkmark$$

$$Q_{ori}=\frac{34,310348\times \overset{\checkmark}{\pi}\times\left(13,382\times 10^{-3}\right)^2}{4}\checkmark$$

$$=4,82566\ m^3/s \checkmark$$

$$C_Q=\frac{Q_{jet}}{Q_{ori}}$$

$$=\frac{3,61111}{4,82566}\checkmark$$

$$=0,748\checkmark$$

$$C_Q=C_c\times C_v$$

$$C_v=\frac{0,748}{0,836}\checkmark$$

$$=0,894\checkmark$$

(11)

5.1.2 $$h_{loss} = h\left(1 - C_v^2\right)$$
$$= 60\left(1 - 0{,}894^2\right) \checkmark\checkmark$$
$$= 12{,}046\ m \checkmark$$

Alternatively

$$h_{loss} = h - \frac{v_{vena}^2}{2g}$$
$$= 60 - \frac{\left(0{,}894 \times 34{,}310348\right)^2}{19{,}62} \checkmark\checkmark$$
$$= 12{,}046\ m \checkmark$$

(3)

5.2 5.2.1 $$h_{loss} = \frac{\left(v_1 - v_2\right)^2}{2g}$$
$$= \frac{\left(6{,}9 - 3{,}5\right)^2}{19{,}62} \checkmark$$
$$= 0{,}589\ m \checkmark$$

(2)

5.2.2 *Applying Bernoulli's theorem*:
$$\frac{P_1}{\rho g} + \frac{v_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{v_2^2}{2g} + Z_2 + h_{loss}$$
$$\frac{\Delta P}{\rho g} = \frac{v_1^2 - v_2^2}{2g} - h_{loss}$$
$$= \frac{6{,}9^2 - 3{,}5^2}{19{,}62} - 0{,}589 \checkmark$$
$$= 1{,}213\ m \checkmark$$
$$\Delta P = 9\ 810 \times 1{,}213 \checkmark$$
$$= 11{,}902\ kPa \checkmark$$

(4)
[20]

QUESTION 6

6.1
$$\overset{0}{W} = \overset{0}{m}g = \frac{\rho Vg}{t} = \rho gQ$$
$$\overset{0}{W} = \frac{9\,810 \times \pi \times 0{,}2^2 \times 4{,}5}{4} \checkmark$$
$$= 1389{,}856\ N/s \checkmark$$
(2)

6.2
$$Q_i = Q_o$$
$$A_i v_i = A_o v_o$$
$$v_o = \frac{d_i^2 v_i}{d_o^2} \checkmark$$
$$= \left(\frac{0{,}2}{0{,}15}\right)^2 \times 4{,}5 \checkmark$$
$$= 8\ m/s \checkmark$$
(3)

6.3
$$\frac{P_i}{\rho g} + \frac{v_i^2}{2g} + Z_i = \frac{P_o}{\rho g} + \frac{v_o^2}{2g} + Z_0 + h_{loss}$$
$$\frac{P_o}{\rho g} = \frac{P_i}{\rho g} + \frac{v_i^2}{2g} - \left(\frac{v_o^2}{2g} + h_{loss}\right) \checkmark$$
$$= \frac{70 \times 10^3}{9\,810} + \frac{4{,}5^2}{19{,}62} - \frac{8^2}{19{,}62} - 2 \checkmark$$
$$= 9\,810 \times 2{,}9057085 \checkmark$$
$$\therefore P_o = 28{,}505\ kPa$$
(4)

6.4

$$F_i = P_i A_i + \overset{0}{m} v_i$$

$$\overset{0}{m} = \rho Q = \rho A_i v_i = \rho A_o v_o$$

$$F_i = \left(70 \times 10^3 \times \frac{\pi \times 0{,}2^2}{4}\right) + \left(1\,000 \times \frac{\pi \times 0{,}2^2}{4} \times 4{,}5\right) ✓✓$$

$$\therefore F_i = 2340{,}4865N ✓$$

$$F_o = \left(28{,}507 \times 10^3 \times \frac{\pi \times 0{,}15^2}{4}\right) + \left(1\,000 \times \frac{\pi \times 0{,}15^2}{4} \times 8\right) ✓✓$$

$$\therefore F_o = 645{,}0966N ✓✓$$

Horizontal forces

$$F_h = F_i - F_o \cos\theta$$

$$= 2340{,}4865 - 645{,}0966 \cos 40$$

$$= 1846{,}31383N ✓$$

Vertical forces

$$F_v = F_i - F_o \cos\theta$$

$$= 645{,}0966 \sin 65$$

$$= 414{,}6601N ✓$$

Consider resultant force

$$F_r = \sqrt{F_v^2 + F_h^2}$$

$$= \sqrt{1846{,}31383^2 + 414{,}6601^2} ✓$$

$$= 1892{,}30488N ✓$$

$$\tan\beta = \frac{F_v}{F_h}$$

$$\beta = \tan^{-1}\left(\frac{414{,}6601}{1892{,}30488}\right)$$

$$\therefore \beta = 12{,}36^0 ✓✓$$

(11)
[20]

TOTAL: 100