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.

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QUESTION 1

1.1 Kinematic viscosity is the ratio between the dynamic viscosity✓ and the density of a fluid and is measured in m^2/s.✓ (2)

1.2 The high viscosity will cause the oil to have a large shear resistance to motion,✓ resulting in high power loss.✓ (2)

1.3 1.3.1 *radial clearence*

$$t = \frac{D-d}{2}$$
$$= \frac{120,2-120}{2}$$
$$= 0,1mm\checkmark$$

tan *gential velocity*

$$v = \frac{\pi dN}{60}$$
$$= \frac{\pi \times 0,12 \times 1100}{60}\checkmark$$
$$= 6,9115m/s\checkmark$$

shear stress

$$\tau = \frac{\mu v}{t} = \frac{0,42 \times 6,9115}{0,1}\checkmark$$
$$= 29,028kPa\checkmark$$

shear force

$$F = \tau A$$
$$= 29,028 \times \pi \times 0,12 \times 0,1\checkmark$$
$$= 1094,342N\checkmark$$
$$P = Fv$$
$$= 1094,342 \times 6,9115\checkmark$$
$$= 7,564kW\checkmark$$

(9)

1.3.2 *rotaional frequency*

$$F = \frac{\mu v}{t} \times A$$
$$= \frac{0,42 \times v}{100 \times 10^{-6}} \times \pi \times 0,12 \times 0,1\checkmark$$
$$\therefore F = 158,33627v\checkmark\P$$

$$P = Fv$$
$$3000 = 158{,}33627v \times v \checkmark$$
$$\therefore v = 4{,}353 m/s \checkmark$$
$$v = \pi dn$$
$$n = \frac{4{,}353}{\pi \times 0{,}12}$$
$$= 11{,}546 r/s \checkmark \quad (5)$$

1.3.3
$$\upsilon = \frac{\mu}{\rho}$$
$$= \frac{0{,}42}{900} \checkmark$$
$$= 466{,}667 \times 10^{-6} m^2/s \checkmark \quad (2)$$

[20]

QUESTION 2

2.1 2.1.1
$$P = \frac{F}{A}$$
$$A = \frac{\pi \times 0{,}08^2}{4} \surd$$
$$= 5{,}02665 \times 10^{-3} m^2 \surd$$
$$\therefore P = \frac{3{,}5 \times 1000}{5{,}02665 \times 10^{-3}} \checkmark$$
$$= 696{,}303 kPa \checkmark \quad (3)$$

2.1.2
$$Q_{foward} = Q_{return} \surd$$
$$\frac{\pi D^2 \times SL_f}{4t_f} = \frac{\pi\left(D^2 - d^2\right) \times SL_r}{4t_r}$$
$$\text{since}: t_r = \frac{5}{8} t_f \surd$$
$$now:$$
$$D^2 = \frac{8\left(D^2 - d^2\right)}{5} \surd$$
$$d = \sqrt{D^2 - \frac{5D^2}{8}} \surd$$
$$= \sqrt{0{,}08^2 - \frac{5 \times 0{,}08^2}{8}} \checkmark$$
$$\therefore d = 48{,}99 mm \checkmark \quad (5)$$

2.1.3

$$t_r = \frac{V}{Q} = \frac{A \times SL}{Q}$$
$$= \frac{\pi\left(0{,}08^2 - 0{,}04899^2\right) \times 0{,}3}{4 \times 0{,}85 \times 10^{-3}} \checkmark$$
$$= 1{,}109 \sec s \checkmark$$
$$t_r = \frac{V}{Q} = \frac{A \times SL}{Q}$$
$$= \frac{\pi \times 0{,}08^2 \times 0{,}3}{4 \times 0{,}85 \times 10^{-3}} \checkmark$$
$$= 1{,}774 \sec s \checkmark$$

(4)

2.2 A barometer is used to measure atmospheric pressure.✓ The vacuum at the top surface of the fluid creates a lift towards the closed end of the tube.✓

(2)

2.3

consider oil

$$\Delta P = K \frac{\Delta V}{V}$$
$$V = A \times h$$
$$\Delta V = A \times \Delta h$$
$$\Delta h_o = \frac{h \times \Delta P}{K} \sqrt{¶}$$
$$= \frac{0{,}8 \times 1}{2060} \sqrt{¶}$$
$$= 388{,}3495 \times 10^{-6} mm \checkmark$$

consider water

$$\Delta P = K \frac{\Delta V}{V}$$
$$V = A \times h$$
$$\Delta V = A \times \Delta h$$
$$\Delta h_w = \frac{h \times \Delta P}{K} \sqrt{¶}$$
$$= \frac{1{,}3 \times 1}{2100} \sqrt{¶}$$
$$= 619{,}04762 \times 10^{-6} mm \checkmark$$

downwardmovement

$$\Delta h_{total} = 619{,}04762 \times 10^{-6} + 388{,}3495 \times 10^{-6} \checkmark$$
$$= 1{,}007 mm \checkmark ¶$$

(6)

[20]

QUESTION 3

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

3.2 3.2.1

consider oil :

$$P_{oil-1} = \frac{\rho g h_{oil-1}}{2}$$
$$= \frac{900 \times 9{,}81 \times 2}{2}$$
$$= 8829Pa \checkmark ¶$$

$$F_{oil-1} = P_{oil-1} \times A_{oil-1}$$
$$= 8829 \times 3{,}5 \times 2 \checkmark ¶$$
$$= 61{,}803kN \checkmark ¶$$
$$F_{oil2} = 900 \times 9{,}81 \times 2 \times 3{,}5 \times 3 \checkmark$$
$$= 238{,}383kN \checkmark ¶$$

consider water

$$P_w = \frac{\rho g h_w}{2}$$
$$= \frac{1000 \times 9{,}81 \times 3}{2}$$
$$= 14715Pa \checkmark ¶$$

$$F_w = P_w \times A_w$$
$$= 8829 \times 3{,}5 \times 2 \checkmark ¶$$
$$= 103{,}005kN \checkmark ¶$$

Total hydrostatic force

$$F_{total} = F_{oil-1} + F_w + F_{oil2}$$
$$= 61{,}803 + 238{,}383 + 103{,}005 \checkmark$$
$$= 403{,}191kN$$ (10)

3.2.2

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

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

$$h_w = \frac{3}{3} = 1m \checkmark ¶$$

$$moments\ taken\ about\ the\ turning\ point:$$
$$(F_w \times h_w) + (F_{oil-1} \times h_{oil-1}) + (F_{oil-2} \times h_{oil-2}) = F_{total} y_{total}$$
$$(103{,}005 \times 1) + (61{,}803 \times 3{,}6667) + (238{,}383 \times 1{,}5) = 403{,}191 y_{total} \checkmark$$
$$y_{total} = 1{,}704 m (from\ bottom) \checkmark$$
$$y_{total} = 5 - 1{,}704 = 3{,}3 m (from\ free\ surface) \checkmark$$ (6)

QUESTION 4

4.1 If the position of the successive molecules in a fluid can be joined up by a curve that is tangential to the direction of motion,✓ this curved is called a streamline.✓ However, if the streamlines are drawn through every position of all the molecules on the circumference of a small area,✓ this forms a stream tube.✓ (4)

4.2 4.2.1
$$\overset{0}{W} = \frac{W}{t} = \frac{mg}{t} = \overset{0}{m} g$$
$$\overset{0}{m} = \rho Q$$
$$= \frac{1000 \times \pi \times 0{,}045^2 \times 11}{4} \surd$$
$$= 17{,}494744 kg/s \surd$$
$$\overset{0}{W} = 17{,}494744 \times 9{,}81 \checkmark$$
$$= 171{,}623 N$$ (5)

4.2.2 *from Bernoulli's equation*

$$E_1 = E_2 + LOSS$$

$$\frac{v_1^2}{2g} - \Delta Z = \frac{v_2^2}{2g}\surd$$

$$v = \sqrt{2g\left(\frac{v_1^2}{2g} - \Delta Z\right)}\surd$$

$$= \sqrt{19{,}62\left(\frac{11^2}{19{,}62} - 4\right)}\checkmark$$

$$= 6{,}521 m/s\checkmark$$ (3)

4.2.3 $Q = AV$ *...continuity of flow*

$$Q = \frac{\pi \times 0{,}045^2 \times 11}{4}\surd$$

$$= 17{,}49474 \times 10^{-3} m^3/s\surd$$

at $v = 6{,}521 m/s$

$$d = \sqrt{\frac{4Q}{\pi v}}$$

$$= \sqrt{\frac{4 \times 17{,}49474 \times 10^{-3}}{\pi \times 6{,}521}}\checkmark$$

$$= 58{,}446 mm\checkmark$$ (4)

(4)
[20]

QUESTION 5

5.1 5.1.1 *from Bernolli's equation, the kinetic energy per unit weight*

$$E_{inlet} = E_{exit}$$

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

$$\frac{50 \times 10^3}{800 \times 9{,}81} \checkmark + 0 + 0 - 0 = 0 + \frac{v_2^2}{2g} \checkmark - 6$$

$$v = \sqrt{19{,}62(6{,}37105 + 6)} \surd$$

$$= 15{,}57947 m/s \surd$$

$$Q_t = Av$$

$$= \frac{\pi \times 0{,}03^2 \times 15{,}57947}{4} \surd$$

$$= 11{,}015 \times 10^{-3} m^3/s \surd$$

$$Q_a = 11{,}015 \times 10^{-3} \times 0{,}7 \surd$$

$$= 7{,}711 m^3/s \surd$$

(5)

5.1.2 *from Bernoulli's equation*

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

$$0 + 0 + 0 + -0 = 0 + \frac{v_2^2}{2g} \checkmark$$

$$\Delta Z = \frac{v^2}{2g} \checkmark$$

$$= \frac{15{,}57947^2}{19{,}62} \checkmark$$

$$\therefore \Delta Z = 12{,}371 m \checkmark$$

(4)

5.2

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

$$L/d=\frac{k}{4f}$$

$$k=1{,}5\times 4\times 1{,}1\ \checkmark$$

$$=6{,}6\checkmark$$

$$LOSS=\frac{4flv^2}{2gd}+\frac{0{,}5v^2}{2g}+\frac{kv^2}{2g}\checkmark$$

$$=\frac{4\times 1{,}1\times 15v^2}{19{,}62\times 0{,}04}+\frac{0{,}5v^2}{19{,}62}+\frac{6v^2}{19{,}62}\checkmark$$

$$=84{,}42915v^2\checkmark$$

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

$$0+0+0-84{,}42915v^2=0+0{,}050968v^2-5\ \checkmark\ \checkmark$$

$$v=\frac{5}{(84{,}42915+0{,}050968)}\checkmark$$

$$=0{,}0592m/s\checkmark$$

$$Q=AV$$

$$=\frac{\pi\times 0{,}04^2\times 0{,}0592}{4}\checkmark$$

$$=74{,}442\times 10^{-6}m^3/s\checkmark$$

(11)

[20]

QUESTION 6

6.1 Refer to the attached velocity diagram.
Up to 4 marks will be deducted for incorrect use of scale. (8)

6.2 6.2.1 Moving blade inlet and outlet angle:

$\alpha=36^0\checkmark$

$\phi=42^0\checkmark$

6.2.2 Relative velocities at inlet and outlet of moving blade:

$v_{ri}=32m/s\checkmark$

$v_{ro}=28m/s\checkmark$

6.2.3 Angle and velocity of water exiting turbine:

$\beta=73{,}5^0\checkmark$

$v_{exit}=19m/s\checkmark$

6.2.4 Total vortex velocity:

$$\Delta v_w = v_{wi} + v_{wo}$$
$$= 5{,}6 + 40.8 \checkmark$$
$$= 46{,}4 m/s \checkmark$$

6.2.5 Power generated by turbine:

$$P = \overset{0}{m}\Delta v_w u$$
$$= 25{,}3 \times 46{,}4 \times 20 \checkmark$$
$$= 23{,}478 kW \checkmark$$

6.2.6 Turbine overall efficiency:

$$\eta = \frac{2\Delta v_w u}{v_i^2} \times 100\%$$
$$= \frac{2 \times 46{,}4 \times 20}{45^2} \times 100\% \checkmark$$
$$= 91{,}654\% \checkmark$$

(6 × 2) (12)
[20]

TOTAL: 100

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