higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

FLUID MECHANICS N5

6 APRIL 2018

This marking guideline consists of 10 pages.

QUESTION 1

1.1 Kinematic viscosity is the ratio between the dynamic viscosity ✓ and the density of 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 a high power loss. ✓ (2)

1.3.1 *radial clearence*

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

tan *gential velocity*

$$v = \frac{\pi dN}{60}$$
$$= \frac{\pi \times 0{,}12 \times 1\,100}{60} ✓$$
$$= 6{,}9115\ m/s ✓$$

shear stress

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

shear force

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

(9)

1.3.2 *rotaional frequency*

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

$P = Fv$

$3\,000 = 158{,}33627v \times v$ ✓

$\therefore v = 4{,}353\ m/s$ ✓

$v = \pi dn$

$n = \dfrac{4{,}353}{\pi \times 0{,}12}$

$= 11{,}546\ r/s$ ✓ (5)

1.3.3 $\upsilon = \dfrac{\mu}{\rho}$

$= \dfrac{0{,}42}{900}$ ✓

$= 466{,}667 \times 10^{-6}\ m^2/s$ ✓ (2)

[20]

QUESTION 2

2.1 A hydraulic accumulator is a device which can be used as a storage ✓ chamber in which fluid energy is stored as ✓ potential energy and from which it can be released during high demand in a fluid system.✓ (3)

2.2 The presence of air in a hydraulic will result in the increase of free ✓ play and distortion to the pipes and cylinders due to expansion, thus affecting the movement of the actuator.✓ (2)

2.3.1 *if no air is present and cylinder expansion is disregarded*

$thus, K_e = K_l = 3GPa$ ✓

$P = \dfrac{4 \times 3\,000}{\pi \times 0{,}08^2}$ ✓ ✓

$= 596{,}83104\ kPa$ ✓

$\varepsilon = \dfrac{\Delta l}{l} = \dfrac{P}{K_e} = \dfrac{596{,}83104 \times 10^3}{3 \times 10^9}$ ✓

$= 198{,}94368 \times 10^{-6}$ ✓

$\therefore \Delta l = 198{,}94368 \times 10^{-6} \times 0{,}25$

$= 49{,}736 \times 10^{-6}\ m$ (6)

2.3.2 $\text{if air is present and cylinder expansion is considered}$

$$K_{cyl} = \frac{E}{2,5} = \frac{110\ GPa}{2,5} = 44\ GPa \checkmark$$

$$K_{air} = P\alpha = 596,83104 \times 1,4 \checkmark$$

$$= 835,56346\ KPa \checkmark$$

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

$$= \frac{1}{44 \times 10^9} + \frac{1}{3 \times 10^9} \checkmark + \frac{3}{100 \times 835,56346 \times 10^3} \checkmark$$

$$= 36,25998 \times 10^{-9} \checkmark$$

$$\therefore K_e = 27,57862\ MPa \checkmark$$

$$\varepsilon = \frac{\Delta l}{l} = \frac{P}{K_e} \checkmark = \frac{596,83104 \times 10^3}{27,57862 \times 10^6} \checkmark = 21,64108 \times 10^{-3}$$

$$\Delta l = 21,64108 \times 10^{-3} \times 0,25$$

$$= 5,41\ mm$$

(9)
[20]

QUESTION 3

3.1 3.1.1 hydrostatic force

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

$$\bar{y} = \frac{2,3}{2} = 1,15\ m \checkmark$$

$$A = 2,3 \times 3,5$$

$$= 8,05\ m \checkmark$$

$$F_{hydro} = 9810 \times 8,05 \times 1,15$$

$$= 90,81608\ kN \checkmark$$

force on bolts

$$\sum M_{bolt} = 0$$

$$\sum M_{bolt}(CW) = \sum M_{bolt}(ACW)$$

$$F_{bolt} \times h_{bolt} = F_{hydro} \times h_{hydro} \checkmark$$

$$F_{bolt} = \frac{90,81608 \times 0,66667}{1} \checkmark$$

$$= 60,544\ kN \checkmark$$

$$\sum M_{hinge} = 0$$
$$\sum M_{hinge}(CW) = \sum M_{hinge}(ACW)$$
$$F_{hinge} \times h_{hinge} = F_{hydro} \times h_{hydro} \checkmark$$
$$F_{bolt} = \frac{90{,}81608 \times 0{,}3333}{1} \checkmark$$
$$= 30{,}272\ kN \checkmark$$
(8)

3.1.2 $F_{hydro} = 9\ 810 \times 12 \times 8{,}05 \checkmark$
$$= 947{,}646\ kN \checkmark$$
(2)

3.2 3.2.1 *volume of seawater displaced*
$$F_{bouyancy} = F_{ship}$$
$$\rho g V_{displaced} = m_{ship} g \checkmark$$
$$V_{displaced} = \frac{50\ 000}{1035} \checkmark$$
$$= 48{,}309\ m^3 \checkmark$$
(3)

3.2.2 *volume of fresh water displaced*
$$F_{bouyancy} = F_{ship}$$
$$\rho g V_{displaced} = m_{ship} g$$
$$V_{displaced} = \frac{50\ 000}{1\ 000} \checkmark$$
$$= 50\ m^3 \checkmark$$
(2)

3.2.3 *volume of seawater displaced*
$$V_{displaced} = (48{,}309 \overset{\checkmark}{\times} 30\%) + 48{,}309 = 62{,}8017\ m^3 \checkmark$$
$$F_{bouyancy} = F_{ship}$$
$$\rho g V_{displaced} = m_{ship} g \checkmark$$
$$= 1\ 035 \times 62{,}8017 \checkmark$$
$$\therefore m = 64{,}1876\ tons \checkmark$$
(5)
[20]

QUESTION 4

4.1.1

$$Q = \frac{V}{t}$$
$$= \frac{3}{4\,500} \checkmark$$
$$= 666{,}667\ m^3/s \checkmark \quad (2)$$

4.1.2

$$Q = Av$$
$$v = \frac{4Q}{\pi d^2}$$
$$= \frac{4 \times 666{,}667 \times 10^{-6}}{\pi \times (0{,}03)^2} \checkmark$$
$$= 0{,}943\ m/s \checkmark \quad (2)$$

4.1.3

$$\overset{0}{W} = \frac{mg}{t} = \overset{0}{m}\,g = \rho Q g$$
$$= (1\,000 \underset{\checkmark}{\times} 0{,}95) \times 9{,}81 \times 666{,}667 \times 106 \checkmark$$
$$= 6{,}213\ N/s \checkmark \quad (3)$$

4.1.4

$$R_e = \frac{\rho v d}{\mu}$$
$$= \frac{950 \times 0{,}943 \times 0{,}03}{0{,}065} \checkmark$$
$$= 413{,}469 \checkmark$$
$$R_e \angle 2\,100 \checkmark$$
$$\Rightarrow flow\, is\, la\min a \checkmark \quad (4)$$

4.2 4.2.1 A stream line: at any given instant of time the position of successive molecules can be coupled up✓ by a curve which is tangential to the direction of the motion at that instant✓. (2)

4.2.2 A steam tube: it is an imaginary boundary✓ defined by stream lines drawn to enclose a tubular region of a fluid. No fluid flows across the boundary of such a tube✓. (2)

4.2.3 A path line: this is the path followed by a molecule. (1)

4.2.4 Lamina flow: this is the flow when each particle✓ flows smoothly alongside its neighbours without interfering with the adjacent paths; in this case the stream lines do not intersect at any given unit of time✓. (2)

4.2.5 Turbulent flow: this is when flow is accompanied by an indiscriminate eddy current✓; in this case the stream lines intersect at random✓. (2)

[20]

QUESTION 5

5.1 5.1.1 The rota-flow meter is used to measure the flow of a fluid. (1)

5.1.2 The pitot tube is used to measure the velocity of a fluid. (1)

5.2 *mean velocity*

$$v_{mean} = \frac{4Q}{\pi d^2}$$

$$= \frac{4 \times 50 \times 10^{-3}}{\pi \times 0{,}15^2} \checkmark$$

$$= 4{,}42097 m/s \checkmark$$

$\max imum\ velocity$

$$v_{mean} = 0{,}75 v_{\max} \checkmark$$

$$\therefore v_{\max} = \frac{4{,}42097}{0{,}75} \checkmark$$

$$= 5{,}89463 m/s \checkmark$$

head of air

from:

$$v_{\max} = \sqrt{2gh_a}$$

$$h_a = \frac{5{,}89463^2}{19{,}62} \checkmark$$

$$\therefore h_a = 1{,}77098 m \checkmark$$

manometric head of water

$$h_a = h_w \left[\frac{\rho_w}{\rho_a} - 1 \right]$$

$$h_w = \frac{h_a}{\left[\frac{\rho_w}{\rho_a} - 1 \right]} \checkmark$$

$$h_w = \frac{1{,}77098}{\left[\frac{1\,000}{1{,}3} - 1 \right]} \checkmark$$

$$= 2{,}305\ m$$

(10)

5.3 *head loss for fittings*

$$from: h_l = \frac{kv^2}{2g}$$

$$and: h_f = \frac{4flv^2}{2gd}$$

$$\sin ce: \frac{l}{d} = \frac{k}{4f}$$

$$thus: h_{valve} = \frac{4fv^2}{2g} \times \frac{l}{d}$$

$$= \frac{4 \times 0{,}007 \times 3^2}{19{,}62} \times 8 \quad \checkmark$$

$$= 102{,}752\ mm \quad \checkmark$$

$$h_{filter} = \frac{4fv^2}{2g} \times \frac{l}{d}$$

$$= \frac{4 \times 0{,}007 \times 3^2}{19{,}62} \times 6 \quad \checkmark$$

$$= 77{,}064\ mm \quad \checkmark$$

$$P_{valve} = \rho g h_{valve}$$

$$= 920 \times 9{,}81 \times 102{,}752 \times 10^{-3} \quad \checkmark$$

$$= 927{,}36 Pa \quad \checkmark$$

$$P_{valve} = \rho g h_{valve}$$

$$= 920 \times 9{,}81 \times 77{,}064 \times 10^{-3} \quad \checkmark$$

$$= 695{,}518 Pa \quad \checkmark$$

(8)
[20]

QUESTION 6

6.1 **Refer to the attached velocity diagram.**
Up to 4 marks will be deducted for incorrect usage of scale.

VELOCITY
DIAGRAM.pdf

(8)

6.2 6.2.1 The moving blade inlet and outlet angle

$\alpha = 36^0$ ✓

$\phi = 42^0$ ✓

6.2.2 The relative velocities at the inlet and outlet of the moving blade

$v_{ri} = 32m/s$ ✓

$v_{ro} = 28m/s$ ✓

6.2.3 The angle and velocity of the water exiting the turbine

$\beta = 73{,}5^0$ ✓

$v_{exit} = 19m/s$ ✓

6.2.4 The total whirl or vortex velocity

$\Delta v_w = v_{wi} + v_{wo}$

$= 5{,}6 + 40.8$ ✓

$= 46{,}4\ m/s$ ✓

6.2.5 the power generated by the turbine

$P = \overset{0}{m}\Delta v_w u$

$= 25{,}3 \times 46{,}4 \times 20$ ✓

$= 23{,}478\ kW$ ✓

6.2.6 The turbine overall efficiency

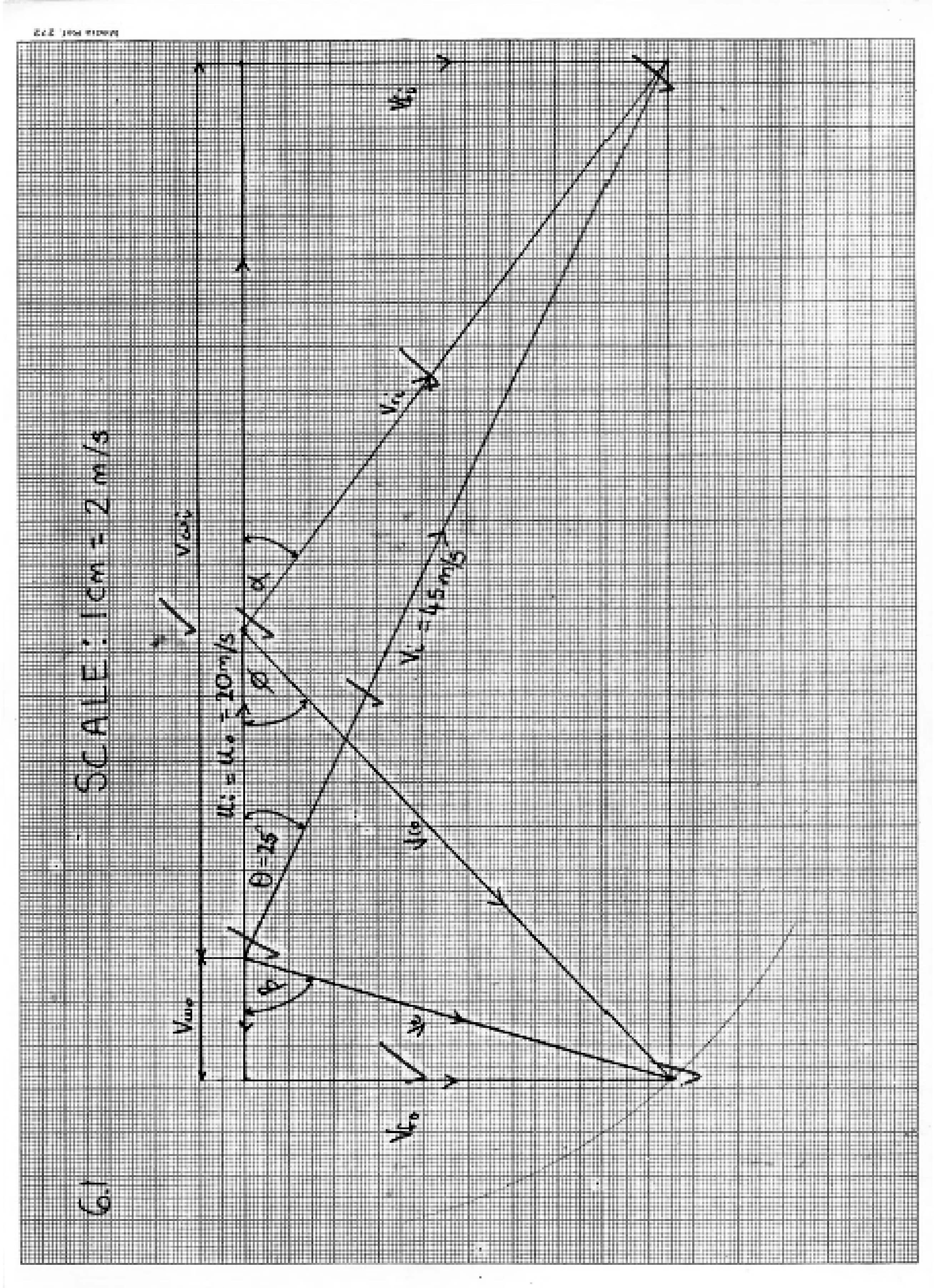
$$\eta = \frac{2\Delta v_w u}{v_i^2} \times 100\%$$

$$= \frac{2 \times 46{,}4 \times 20}{45^2} \times 100\% \checkmark$$

$= 91{,}654\%$ ✓

(6 × 2) (12)
[20]

TOTAL: 100


6.1
SCALE: 1cm = 2 m/s
$u_i = u_o = 20$ m/s
$V_i = 45$ m/s
$\theta = 25°$