higher education & training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

FLUID MECHANICS N6

1 AUGUST 2018

This marking guideline consists of 6 pages.

QUESTION 1

1.1
- *Hydraulic mean depth* is the cross-sectional area of a structure divided by its wetted perimeter.
- *Hydraulic gradient* is the distance between two or more different water levels (h_f) OR the ratio of the frictional head of a structure to its length. (2)

1.2
$V_1A_1 = V_2A_2$
$4 \times (90)^2$✓ $= V_2 \times (150)^2$ ✓
$V_2 = 1,44$ m/s✓

OR

$Q_1 = V_1A_1$
$= 4 \times \frac{\pi}{4}(0,09)^2$
$= 0,0254$ m^3/s✓
Since $Q_1 = Q_2$
$V_2 = \frac{0,0254\ x\ 4}{\pi\ x\ (0,15)^2}$ ✓
$= 1,44$ m/s✓ (3)

1.3
$A = 5 \times 1,5 = 7,5$ m^2✓
$P = 2(1,5) + 5 = 8$ m✓
$m = \frac{7,5}{8} = 0,938$ m✓ (3)

1.4
$h_L = \frac{(v_1 - v_2)^2}{2g}$
$v_1 = \frac{0,0667 \times 4}{\pi \times (0,4)^2}$ ✓ $= 0,531$ m/s✓
$v_2 = \frac{0,0667 \times 4}{\pi \times (0,9)^2}$✓ $= 0,105$ m/s✓
$h_L = \frac{(0,531 - 0,105)^2}{2 \times 9,81}$✓
$= 0,009$ m✓ (6)

1.5 1.5.1

Entry $= \frac{0,5\ v_1^2}{2g}$
$= \frac{0,5 \times v_1^2}{2 \times 9,81}$ ✓
$= 0,0255v_1^2$ ✓

Pipe $= \frac{4flv_1^2}{2gd}$
$= \frac{4 \times 0,002 \times 650\ x\ v_1^2}{2 \times 9,81\ x \times 0,15}$✓
$= 1,767v_1^2$✓

Exit $= \frac{(v_1 - v_2)^2}{2g}$
$= \frac{(v_1 - 0)^2}{2 \times 9,81}$✓
$= 0,0509v_1^2$✓

$h_L = 0,0255v_1^2 + 1,767v_1^2 + 0,0509v_1^2$
$= 1,843v_1^2$ ✓

OR

$h_L = \frac{0,5\ v_1^2}{2g} + \frac{4flv_1^2}{2gd} + \frac{(v_1 - v_B)^2}{2g}$
$= \frac{0,5\ v_1^2}{2 \times 9,81}$ ✓ $+ \frac{4 \times 0,002 \times 650\ x\ v_1^2}{2\ x\ 9,81 \times 0,15}$✓ $+ \frac{(v_1 - 0)^2}{2 \times 9,81}$ ✓
$= 0,0255v_1^2$✓ $+ 1,7167v_1^2$✓ $+ 0,05097v_1^2$✓
$= 1,843v_1^2$✓ (7)

1.5.2
$25 = 1,843v_1^2$ ✓
$V_1 = 3,683$ m/s ✓ (2)

1.5.3 $Q = VA$
$= 3{,}683 \times \frac{\pi}{4}(0{,}15)^2$ ✓
$= 0{,}0651\ m^3/s$ ✓ (2)
[25]

QUESTION 2

2.1 2.1.1 $\frac{b}{2} + d = \sqrt{2}\,d$✓
$b = 0{,}828d$……(1)✓

$A = d(b + d)$
$= bd + d^2$ ✓
$= 1{,}828\,d^2$ ✓
$P = 2(\sqrt{2}\,d) + b$
$= 2{,}828d + 0{,}828d$✓
$= 3{,}657\,d$✓

$m = \frac{1{,}828\,d^2}{3{,}657\,d}$ ✓
$= 0{,}5\,d$ ✓

$Q = AC\sqrt{mi}$
$8 = 1{,}828\,d^2 \times 50\sqrt{0{,}5d \times 0{,}0001176}$✓
$d = 2{,}647$ m✓ (10)

2.1.2 $b = 2{,}6471(0{,}828)$✓
$= 2{,}194$ m✓ (2)

2.2 $Q = Cd\frac{8}{15}\sqrt{2g}\tan\frac{\theta}{2}H^{2,5}$✓
$= 0{,}7 \times \frac{8}{15}\sqrt{2 \times 9{,}81}\tan\frac{90}{2}0{,}8^{2,5}$✓
$= 0{,}947\ m^3/s$✓
$= 946{,}610$ l/s✓ (4)

2.3 $\frac{V_A}{C_v} = \sqrt{2gh}$✓

But $V_A = \sqrt{\frac{gx^2}{2y}}$

$\sqrt{\frac{9{,}81 \times (1{,}8)^2}{2(2{,}5 - h)}}$✓ $= 0{,}86\sqrt{2\,x\,9{,}81 \times h}$✓

$31{,}7844 = 14{,}511h(5 - 2h)$✓

$h^2 - 2{,}5h + 1{,}095 = 0$✓

$h = \frac{-(-2{,}5) \pm \sqrt{(-2{,}5)^2 - 4(1)(1{,}095)}}{2(1)}$ ✓✓

$h = 1{,}934$✓ or $0{,}566$✓ (9)
[25]

QUESTION 3

3.1 $P = \rho gh$

$h = \frac{6,5 \times 10^6}{10^3 \times 9,81}$ ✓

$= 662,589$ m✓

$h_f = \frac{1}{4} \times 662,589$ ✓

$= 165,647$ m✓

$h_f = \frac{flQ^2}{3d^5}$

$Q = \sqrt{\frac{165,647 \times 3 \times 0,25^5}{0,006 \times 3500}}$ ✓

$= 0,152$ m^3/s✓

$= 152,017$ l/s✓ (7)

3.2 3.2.1 $Ha_s = \frac{l}{g} \times \frac{D^2}{d^2} \times \omega^2 R$

$= \frac{7}{9,81} \times \frac{(0,1)^2}{(0,06)^2} \times \left(\frac{2\pi x\ 35}{60}\right)^2 \times \frac{0,45}{2}$ ✓

$= 5,991$ m✓ (2)

3.2.2 $Ha_d = \frac{l}{g} \times \frac{D^2}{d^2} \times \omega^2 R$

$= \frac{35}{9,81} \times \frac{(0,1)^2}{(0,06)^2} \times \left(\frac{2\pi x\ 35}{60}\right)^2 \times \frac{0,45}{2}$ ✓

$= 29,955$ m✓ (2)

3.2.3 $Hf_s = \frac{4fl}{2gd}\left[\left(\frac{D^2}{d^2}\right)\ \omega\ R\right]^2$

$= \frac{4 \times 0,01 \times 7}{2 \times 9,81 \times 0,06}\left[\left(\frac{0,1^2}{0,06^2}\right) \times \left(\frac{2\pi \times 35}{60}\right) \times \frac{0,45}{2}\right]^2$ ✓

$= 1,248$ m✓ (2)

3.2.4 $Hf_d = \frac{4fl}{2gd}\left[\left(\frac{D^2}{d^2}\right)\ \omega\ R\right]^2$

$= \frac{4 \times 0,01 \times 35}{2 \times 9,81 \times 0,06}\left[\left(\frac{0,1^2}{0,06^2}\right) \times \left(\frac{2\pi x\ 35}{60}\right) \times \frac{0,45}{2}\right]^2$ ✓

$= 6,241$ m✓ (2)

3.2.5 (a) Pressure head (at beginning) $= H_{at} + h_d + H_{ad}$

$= 9,6 + 31 + 29,955$ ✓

$= 70,555$ m✓

(b) Pressure head (at middle) $= H_{at} + h_d + H_{fd}$

$= 9,6 + 31 + 6,241$ ✓

$= 46,841$ m✓

(c) Pressure head (at end) = H_{at} + h_d – H_{ad}
= 9,6 + 31 – 29,955✓
= 10,645 m✓

(3 × 2) (6)

3.3 $P_r = \frac{k\,S\,V^2}{a}$

S = π d L
= π × d × 50✓ = 157,079 d✓

a = $\frac{\pi}{4}$ d²✓ = 0,785 d²✓

V = $\frac{Q}{a}$ = $\frac{8}{0{,}785\,d^2}$ ✓ = $\frac{10{,}186}{d^2}$ ✓

$V^2 = \frac{103{,}753}{d^4}$

$200 = \frac{0{,}00445 \times 157{,}079\,d \times \frac{103{,}753}{d^4}}{0{,}785\,d^2}$✓

d^5 = 0,462✓

D = 0,857 m = 856,785 mm✓ (9)

[30]

QUESTION 4

4.1 4.1.1 $V_i = 0{,}17\sqrt{2 \times 9{,}81\,x \times 15}$ ✓
= 2,916 m/s✓ (2)

4.1.2 $\eta = \frac{E}{H} \times 100$

E = $\frac{88 \times 15}{100}$✓ = 13,2 m✓ (2)

4.1.3 $E = \frac{U_i^2}{g}$

$U_i = \sqrt{13{,}2 \times 9{,}81}$✓
= 11,379 m✓ (2)

4.1.4 Tan $\theta_i = \frac{V_i}{U_i} = \frac{2{,}916}{11{,}379}$✓
θ_i = 14,375°✓ (2)

4.1.5 U_o = ½ U_i
= ½ (11,379)✓ = 5,689 m/s✓

Tan $\beta_o = \frac{V_o}{U_o}$ since $V_i = V_o$

Tan $\beta_o = \frac{2{,}916}{5{,}689}$✓

β_o = 27,138°✓ (4)

4.1.6 $U_i = \frac{\pi DN}{60}$

$D = \frac{11,379 \times 60}{\pi \times 350}$✓

$= 0,621 = 620,947$ mm✓

$d = \frac{0,621}{2} = 0,310 = 310,474$ mm✓ (3)

4.2 4.2.1 For maximum efficiency:

$U = 0,5\ V$

$= 0,5 \times 67 = 33,5$ m/s✓

$\eta = \frac{U}{gh}\ (V - U)\ (1 + \cos\ (180° - y) \times 100\%$

$= \frac{33,5}{9,81 \times 250}\ (67 - 33,5)\ [1 + \cos\ (180° - 160°)] \times 100\%$✓

$= 88,759\%$✓ (3)

4.2.2 $N = \frac{U \times 60}{\pi \times D}$

$= \frac{33,5 \times 60}{\pi \times 0,8}$✓

$= 799,754$ r/min✓ (2)

[20]

TOTAL: 100