higher education
& training

Department:
Higher Education and Training
REPUBLIC OF SOUTH AFRICA

MARKING GUIDELINE

NATIONAL CERTIFICATE

AUGUST EXAMINATION

FLUID MECHANICS N5

24 August 2014

This marking guideline consists of 16 pages.

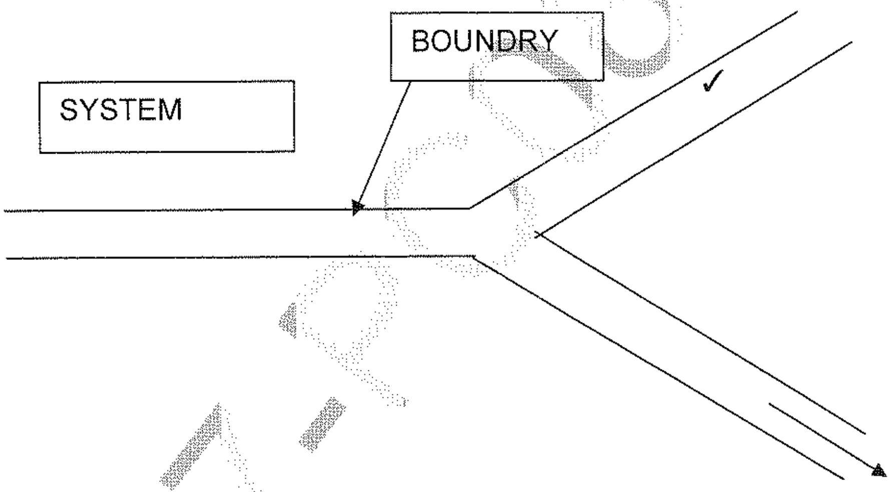
DHET

QUESTION 1

1.1 1.1.1 In Newtonian fluids the co-efficient of viscosity is not dependent on the velocity gradient. ✓✓ (2)

1.1.2 In non-Newtonian fluids the co-efficient of viscosity is dependent on the velocity gradient. ✓✓ (2)

1.2 An open fluid system is a system that does not have a constant mass of fluid in the system, the fluid mass flows through the system and a controlled volume of fluid is considered. Examples are pipelines, venturis, etc. ✓✓



(3)

1.3 $C = 0{,}3mm$ $\mu_1 = 0{,}2$ Pa.s

$= 0{,}3 \times 10^{-3}m$ $\mu_2 = 0{,}7$ Pa.s

$\dot{x} = 1{,}2 m/s$ Relative density = 0,8

$A = 2 \times 300mm \times 50mm$

$= 2 \times 0{,}3m \times 0{,}05m$

$= 0{,}03m^2$ ✓

1.3.1 FIND VISCOUS FORCE

$$F = \frac{\mu \; x \; A \; x \; \dot{X}}{C} \checkmark$$

$$= \frac{0.2 kg/ms \; x \; 0{,}03 m^2 \; x 1{,}2 m/\sec}{0{,}3 \, x 10^{-3} \; m} \checkmark$$

$$= \checkmark 24N$$ (4)

1.3.2 FIND POWER LOSS

$$Power \; Loss = F \; x \; \dot{x} \checkmark$$

$$= 24N \; x \; 1{,}2 m/s$$

$$= 28{,}8W \checkmark$$ (2)

1.3.3 FIND DIFFERENCE IN POWER LOSS

$$P = \frac{\mu \; A \left(\dot{x} \right)^2}{C} \checkmark$$

$$= \frac{0{,}7 kg/ms \; x \; 0{,}03 m^2 \; x \; (1{,}2 m/s)^2}{0{,}3 \; x \; 10^{-3} \; m} \checkmark$$

$$= 100{,}8W \checkmark$$

$$\Delta P = 100{,}8W - 28{,}8W$$
$$= 72W \checkmark$$ (4)

1.3.4 FIND THE KINEMATIC VISCOSITY

$$\rho_{OIL} = \rho_{Relative} \; x \; \rho_{water}$$

$$= 0{,}8 \times 1000$$

$$= 800 \text{ kg/m}^3 \quad ✓$$

$$\upsilon = \frac{\mu}{\rho} \quad ✓$$

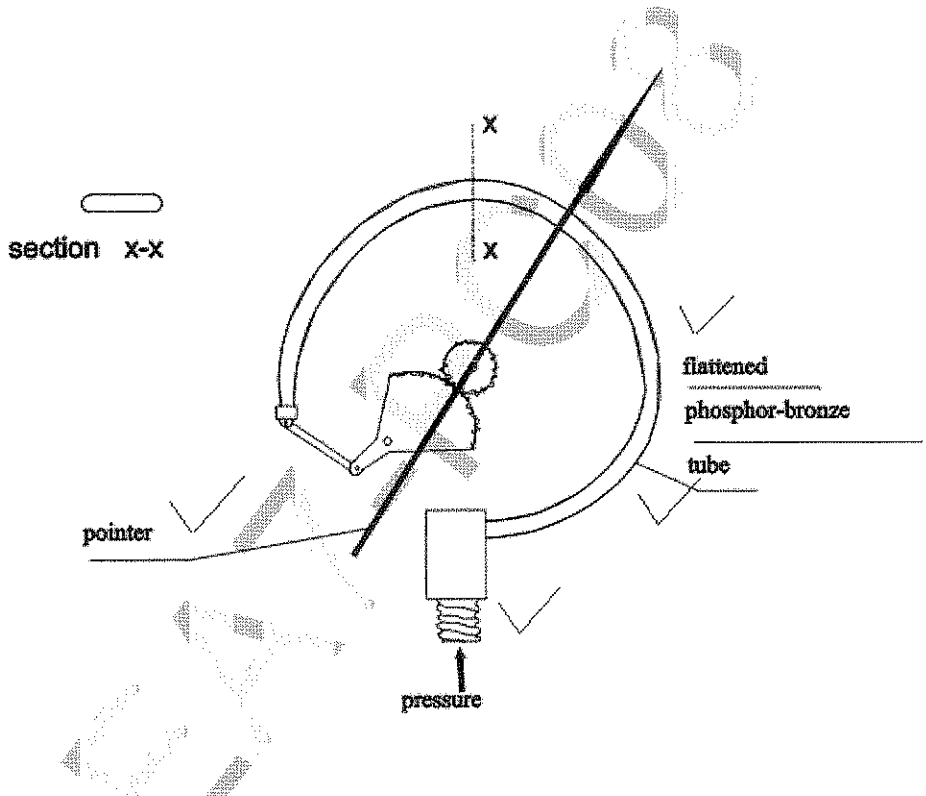
$$= \frac{0{,}2 kg/ms}{800 kg/m^3}$$

$$= 2{,}5 \times 10^{-4} \text{m}^2\text{/s} \quad ✓$$

(3)
[20]

QUESTION 2

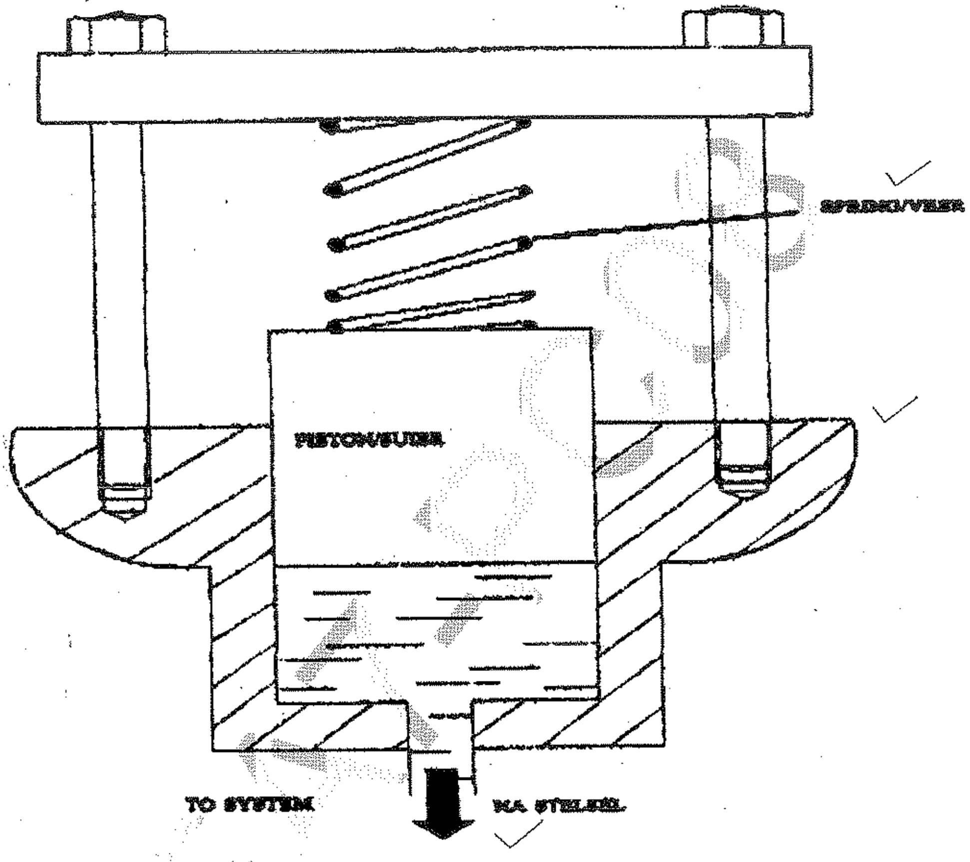
2.1 The fluid pressure is applied to the inside of the flattened phosphor-bronze tube and it tend to straighten out. This movement of the loose end of the tube is communicated ✓
through the gearing system to the pointer. The magnified movement of the pointer then indicate the pressure applied on the scale which is marked off in either Pa, kPa, MPa, PSI, m_{water}, etc. ✓



(4)

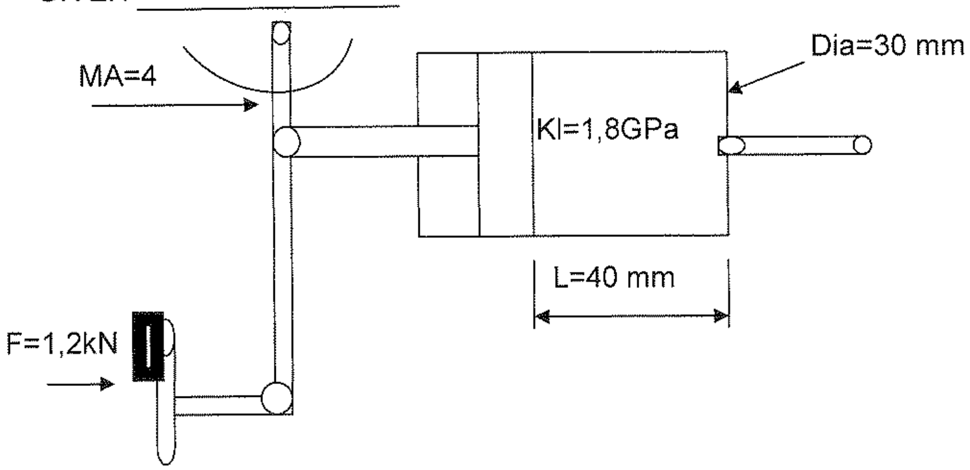
2.2 The isothermal bulk modulus of a fluid is an indication of the compressibility of a fluid. ✓ It is the relationship between the change in pressure and volumetric strain of a fluid. Units: Pa. ✓ The co-efficient of compressibility (β) of a fluid is the reciprocal of the isothermal bulk modulus ✓ .Units: ℓ/Pa (3)

2.3 Pressure is dependent on the compression of the spring with minimum energy stored at the installed length. ✓



(3)

2.4 GIVEN



2.4.1 FIND PRESSURE

$$A = \frac{\pi \times d^2}{4}$$
$$= \frac{\pi \times 0{,}03m^2}{4}$$
$$= 7{,}0686 \times 10^{-4} m^2$$
$$F_{Piston} = F_{Pedal} \times MA \checkmark$$
$$= 1{,}2kN \times 4$$
$$= 4{,}8kN \checkmark$$

$$\therefore P = \frac{F}{A} \checkmark$$
$$= \frac{4{,}8 \times 10^3 N}{7{,}0686 \times 10^{-4} m^2} \checkmark$$
$$= 6{,}7906 \times 10^6 Pa$$
$$= 6{,}7906 MPa \checkmark$$

(5)

2.4.2 Find play on Pedal

$$\frac{\Delta\forall}{\forall} = \frac{P}{K_\ell}$$
$$\therefore \Delta_{\ell_{Pedal}} = \frac{P\ell}{K\ell} \checkmark$$
$$= \frac{6{,}7906 \times 10^6 Pa \times 0{,}04m}{1{,}8 \times 10^9 Pa} \checkmark$$
$$= 1{,}509 \times 10^{-4} m \checkmark$$

$$\therefore \Delta_{\ell_{Pedal}} = \Delta_{\ell_{Piston}} \times MA \checkmark$$
$$= 1{,}509 \times 10^{-4} \times 4$$
$$= 0{,}0006036m$$
$$= 0{,}6036mm \checkmark$$

(5)
[20]

QUESTION 3

3.1 3.2 GIVEN:-

Diameter = 0,4 m

Height = 1,5 m

%immersed = 75%

3.1.1

$$Volume\ of\ cylinder = \frac{\pi d^2}{4} x\ h$$ ✓

$$= \frac{\pi\ x\,(0{,}4\ m)^2}{4} x\,1{,}5\ m$$ ✓

$$= 0{,}1885\ m^3$$ ✓

$$Floating\ force = \rho g \forall_{under} = 1000\ kg/m^3\ x\,9{,}81\ m/s^2\ x\,\frac{75}{100}\ x\,0{,}1885\ m^3$$

$$= 1386{,}86\ N$$

$$= \underline{1{,}39\ kN}$$ ✓

(4)

3.1.2

$$Floating\ Force = Weight\ of\ cylinder \quad \therefore \rho = \frac{m}{v} = \frac{W}{gv}$$ ✓

$$= \frac{1386{,}86\ N}{9{,}81\ m/s^2\ x\,0{,}1885\ m^3}$$

$$= \underline{749{,}99\ kg/m^3}$$ ✓

(3)

3.1.3

$$Floating\ Force = \rho g \forall_{rest\ of\ cylinder}$$ ✓

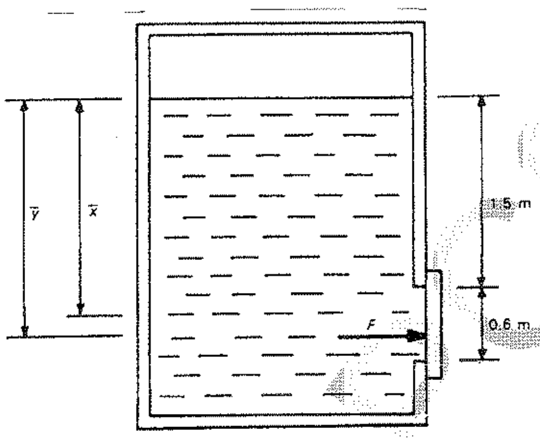
$$= 1000\ kg/m^3\ x\,9{,}81\ m/s^2\ x\,\frac{25}{100}\ x\,0{,}1885\ m^3$$ ✓

$$= 462{,}963\ N$$

$$= \underline{4{,}623\ kN}$$ ✓

(3)

3.2 Given : Relative Density = 0,9



$$\bar{x} = 1{,}5 + 0{,}3 \checkmark$$
$$= 1{,}8m$$

A = 0,6 x 0,9 = 0,54 m^2

Density = 0,9 x 1000 ✓
= 900kg/m^3

$$F = \rho \; x \; g \; x \; A \; x \; \bar{y} \checkmark$$
$$= 900 \; x \; 9{,}81 \; x \; 0{,}54 \; x \; 1{,}8$$
$$= 8{,}58kN \checkmark$$

✓ ✓

$$I_{GG} = \frac{bd^3}{12} \checkmark \checkmark$$
$$= \frac{0{,}9 \; x \; (0{,}6)^3}{12} \checkmark$$
$$= 0{,}0162m^4 \checkmark$$

(10)
[20]

QUESTION 4

4.1 4.1.1 Turbulant flow in which the particles of a fluid move in a disorderly manner occupying different relative positions in successive cross-sections. ✓

4.1.2 This is a smooth type of flow which occurs at low ✓ velocities and is called laminar flow due to the laminar (layer) approach to this fluid flow. ✓

(2 x 2) (4)

4.2 $\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + Z_2 + losses$ ✓

$\frac{P_1}{\rho g_1}$ = Pressure Head At Beginning 1 to end ✓

$\frac{V_1^2}{2g_1}$ = Velocity Head or Kinetic head at beginning 1 and end 2 ✓

Z_1 = Potential head at beginning 1 and end 2 ✓

$Losses = k\frac{V^2}{2g}$ where k depends on the friction factor of the pipe ✓ (7)

4.3 Velocity Head ✓ (1)

4.4 $H = \frac{V_1^2}{2g_1}$ ✓ (1)

4.5
$$H = \frac{V_1^2}{2g_1}$$
$$= \frac{(6{,}8m)^2}{2 \times 9{,}81}$$
$$= 2{,}36m$$ ✓

(1)

4.6

$$\frac{P_1}{\rho g}+\frac{V_1^2}{2g}+Z_1=\frac{P_2}{\rho g}+\frac{V_2^2}{2g}+Z_2+losses$$

$$where P_1 = P_2 = 0 \ \ and \ \ Z_1 = 0{,}2m \ \ and \ \ Z_2 = -0{,}23m$$

$$V_1 = 0$$

$$V_2=\sqrt{2g(Z_1-Z_2)}$$

$$=\sqrt{[(2\times 9{,}81m/s^2)(0{,}2m-(-0{,}23m))]}$$

$$=2{,}90m/s$$

$$Q=A\times V$$

$$=\frac{\pi\times(0{,}02m)^2}{4}\times 2{,}90m/s$$

$$=9{,}11\times 10^{-4}m^3/s$$

(6)
[20]

QUESTION 5

5.1

HYDRODYNAMIC	POSITIVE DISPLACEMENT
Propeller ✓ centrifugal	Screw type ✓ Gear type✓ Vane type ✓ Piston type✓ *Any 2 answers*
Hydrodynamic machine are high ✓ in flow rates, lower in pressure.	Definite displacement per revolution ✓ Higher pressure head ✓ Lower flow rates.✓ More efficient at lower flow rates Use for control systems.✓ *Any 2 answers*

(6)

5.2 **Advantages of Orifice plate**:

Easy to manufacture. ✓

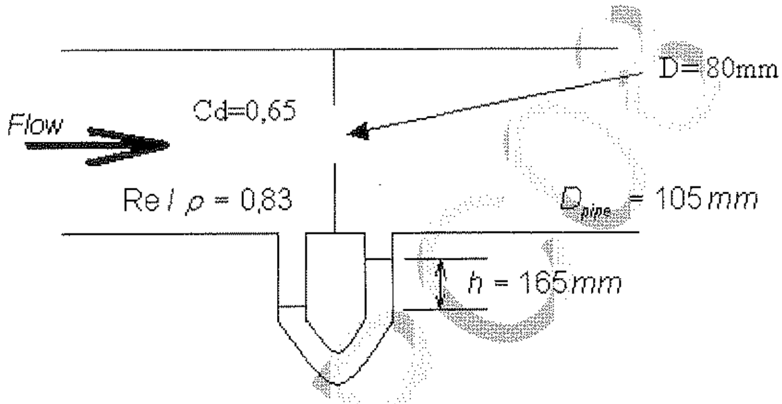
Easy to install ✓

Disadvantages of Orifice plate:

High friction losses. ✓

Dirt in system could build up against orifice plate. ✓ (4)

5.3 GIVEN:



Find the flow rate ✓

$\rho_{oil} = (\rho_w \ x \ \text{Relative density})$

$= 1000 \ x \ 0{,}830$

$= 830 kg/m^3$ ✓

$A_{pipe} = \frac{\pi d_1^2}{4} = \frac{\pi \ x \ 0{,}105^2}{4} = 0{,}00866$

$A_{orifice} = \frac{\pi d_o^2}{4} = \frac{\pi \ x \ 0{,}08^2}{4} = 0{,}00503$

$A_1 \ x \ u_1 = A_2 \ x \ u_2$ ✓

$\therefore \ u_2 = \frac{A_1 \ x \ u_1}{A_2}$

$= \frac{8{,}66 \ x \ 10^{-3} \ x \ u_1}{5{,}0265 \ x \ 10^{-3}}$ ✓

$u_2 = 1{,}7229 u_1$ ---------[1]

$P_1 - P_2 = gh(\rho_m - \rho_w)$ ✓

$= 9{,}81 \ x \ 0{,}165 \ (13600 - 1000)$

$= 20394{,}99 \ Pa$

$= 20{,}395 \ kPa$ ✓

$$\frac{P_1}{\rho g} + \frac{u_1^2}{2g} + Z_1 = \frac{P_2}{\rho g} + \frac{u_2^2}{2g} + Z_2 + h_\ell$$

$$\frac{P_1 - P_2}{\rho g} = \frac{u_2^2 - u_1^2}{2g}$$

$$\therefore \frac{20{,}395 \times 10^3}{830} = \frac{(1{,}7229\, u_1)^2 - u_1^2}{2} \checkmark$$

$$\therefore \frac{20{,}395 \times 10^3 \times 2}{830} = 1{,}9684\, u_1^2$$

$$u_1 = \sqrt{\frac{49{,}145}{1{,}9684}}$$

$$= 4{,}9967\ m/s \checkmark$$

$$Q = Cd\ A_1\ u_1$$

$$= 0{,}65 \times 8{,}659 \times 10^{-3} \times 4{,}9967$$

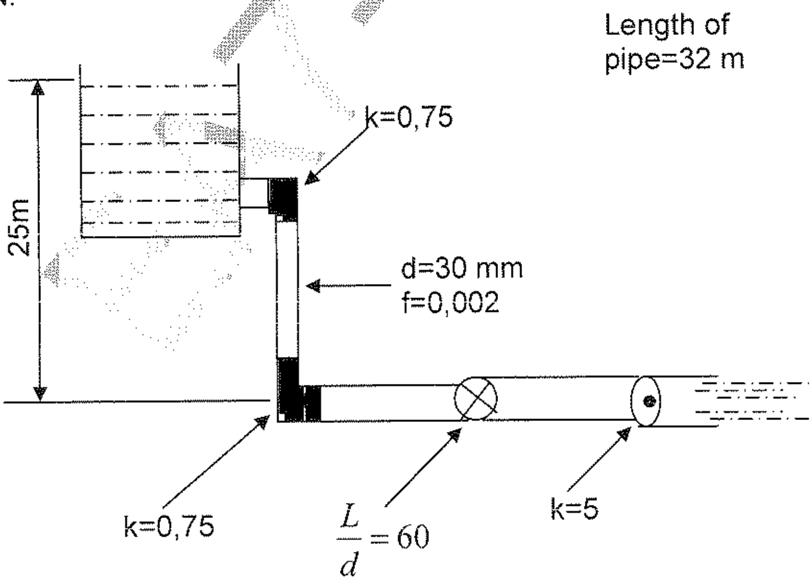
$$= 0{,}02812\ m^3/s$$

$$= 28{,}12\ \ell/s \checkmark$$

(10)
[20]

QUESTION 6

6.1 GIVEN:-



$$Area\ of\ pipe = \frac{\pi \times 0{,}030^2}{4} = 0{,}000707 m^2$$

6.1.1 FIND TOTAL LENGTH TO DIAMETER RATIO

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

$$\therefore \frac{L}{d} = \frac{k}{4f} \checkmark$$

Bends

$$\frac{L}{d} = \frac{0{,}75}{4 \times 0{,}002} = 93{,}75 \checkmark$$

Pipe

$$\frac{L}{d} = \frac{32}{0{,}03} = 1066{,}67 \checkmark$$

Pump

$$\frac{L}{d} = \frac{5}{4 \times 0{,}002} = 625 \checkmark$$

$$\left(\frac{L}{d}\right)_t = \left(\frac{L}{d}\right)_{bends} + \left(\frac{L}{d}\right)_{Pipe} + \left(\frac{L}{d}\right)_{valve} + \left(\frac{L}{d}\right)_{pump}$$

$$= (2 \times 93{,}75) + (1066{,}67) + 60 + 625$$

$$= 1939{,}166 \checkmark$$

(5)

6.1.2 $$\frac{P_1}{\rho g}+\frac{V_1^2}{2g}+Z_1=\frac{P_2}{\rho g}+\frac{V_2^2}{2g}+Z_2+h_\ell \checkmark$$

$$But\ h_\ell=4f\left(\frac{L}{d}\right)_t\frac{V_2^2}{2g}$$

$$\therefore\frac{P_1}{\rho g}+\frac{V_1^2}{2g}+Z_1=\frac{P_2}{\rho g}+\frac{V_2^2}{2g}+Z_2+4f\left(\frac{L}{d}\right)_t\frac{V_2^2}{2g} \checkmark$$

$$25m=\frac{V_2^2}{2g}+(4\times 0{,}002\times 1939{,}166)\frac{V_2^2}{2g} \checkmark$$

$$25m=\frac{V_2^2}{2g}+15{,}51\frac{V_2^2}{2g}$$

$$25m=16{,}51\frac{V_2^2}{2g}$$

$$25m=0{,}841V_2^2$$

$$V_2=\sqrt{\frac{25}{0{,}841}}$$

$$=5{,}45m/s \checkmark$$

$$\therefore Q=AV \checkmark$$

$$=\frac{\pi\times 0{,}030^2}{4}m^2\times 5{,}45m/s \checkmark$$

$$=0{,}00385m^3/s$$

$$=3{,}85\ell/s \checkmark$$

(6)

6.1.3 $$\left(\frac{L}{d}\right)=\left(\frac{L}{d}\right)_{bends}+\left(\frac{L}{d}\right)_{Pipe}+\left(\frac{L}{d}\right)_{valve}$$

$$=(2\times 93{,}75)+1066{,}67+60$$

$$=1314{,}17 \checkmark$$

$$h_\ell=4f\left(\frac{L}{d}\right)\frac{V_2^2}{2g}$$

$$=4\times 0{,}002\times 1314{,}17\times\frac{(5{,}45)^2}{2\times 9{,}81}\ \therefore\frac{P_1}{\rho g}+\frac{V_1^2}{2g}+Z_1=\frac{P_2}{\rho g}+\frac{V_2^2}{2g}+Z_2+4f\left(\frac{L}{d}\right)_t\frac{V_2^2}{2g}$$

$$=15{,}916m \checkmark$$

✓

$$\therefore \frac{P_1}{\rho g}+\frac{V_1^2}{2g}+Z_1=\frac{P_2}{\rho g}+\frac{V_2^2}{2g}+Z_2+h_\ell$$

$$\therefore \frac{P_1}{1000kg/m^3\times 9,81m/s^2}+\frac{(5,45m/s)^2}{2\times 9,81m/s^2}=25m+15,916m \checkmark$$

$$P_1=9810kg/m^2s^2(40,916m-1,514m)$$

$$P_1=386533,62Pa$$

$$=386,533kPa \checkmark$$

(5)

6.1.4

$$h=4f\left(\frac{L}{d}\right)\frac{V_2^2}{2g} \checkmark$$

$$=4\times 0,002\times 60\times\frac{(5,45m/s)^2}{2\times 9,81m/s^2}$$

$$= 0,7267m \checkmark$$

$$\Delta P=\rho gh \checkmark$$

$$=1000kg/m^3\times 9,81m/s^2\times 0,7267m$$

$$= 7128,6Pa$$

$$=7,128kPa \checkmark$$

(4)
[20]

TOTAL: 100