*Department Of Civil Engineering*
*Politeknik Merlimau, Melaka*

# DCC40172

# STRUCTURE, HIDRAULICS AND WATER QUALITY LABORATORY

## Quick Guide Book For Hydraulics Laboratory Practical Handling

CURATED BY
HJ. ZAMALI BIN OMAR
HAZILAH BINTI MOHAMAD

# DCC 40172

## Structure, Hydraulics and Water Quality Laboratory

**Writer**

HJ. ZAMALI BIN OMAR
HAZILAH BINTI MOHAMAD

**Published in 2021**



Perpustakaan Negara Malaysia

e ISBN 978-967-2762-08-9

**Published by:**
Politeknik Merlimau, Melaka
KB1031 Pej Pos Merlimau,
77300 Merlimau Melaka

**ACKNOWLEDGEMENT**

I would like to express my special thanks to the Head of Civil Engineering Department, Mr. Ab Razak bin Ahmat who gave me the golden opportunity to do this eBook (DCC 40172 Structure, Hydraulics and Water Quality Laboratory). Secondly, I would also like to thank my Head Programme of Civil Engineering, Ts. Mohd Khairolnizam bin Yunos and friends who helped me a lot in finalizing this eBook within the limited time frame.

## PREFACE

Laboratory Procedure eBook is the result of a new alternative for the course of DCC 40172 Structure, Hydraulics and Water Quality Laboratory for student of semester four. It is written for the use of student references to undergo practical which is in line with today's technological advances and educational demands that are global in nature. This eBook fits the current learning style of mobility where learning can take place anywhere and at any time is not limited to a particular location. This eBook is based on the syllabus developed by the JPPKK and is suitable for the courses offered. It is hoped that this eBook will be able to contribute in achieving the course learning outcomes of this course.

## TABLE OF CONTENT

| No. | Content | Page |
|---|---|---|

# LABORATORY RULES

## 1. Attendance

i. Students are required to be in the lab prior to commencing the course records set for arrival at the lab and read the instructions

ii. Students who arrive late are required to seek permission from the lecturer concerned whether can conduct experiments or not, and if 15 minutes late without reasonable excuse, will not be recorded arrival

iii. Students are allowed to leave the laboratory only after the completion of experiments, cleaning equipment and laboratory equipment as well as restructure the permission of the lecturer concerned

iv. Students who are absent on the day of the experimental tests should be replaced at another time by submitting a letter off to the lecturer concerned

## 2. Discipline In The Laboratory

i. Students must dress modestly according to rules set by the polytechnics, are not allowed to wear sandals and do not allow eating, drinking and smoking while conducting experiments

ii. Any damage to equipment in the lab should be reported immediately to the lecturer concerned

iii. Students are not allowed to touch the equipment that is not related to the experiment or to take out the goods belonging to the laboratory

iv. Students need to obtain permission to use the equipment in the laboratory

# 3. Laboratory Report

i. Every student should read and understand the theory laboratory instruction relating to testing prior to entry into the laboratory

ii. Report shall be submitted within 7 days of experiments undertaken

iii. Written report should follow the format given

iv. Delay in sending the report will lead to cuts of 20% marks for each day of delay, except for certain reasons and approved by the lecturer

v. Students who do not conduct experiments will not be accepted for the title of lab report experiment

DCC40172 - Structure, hydraulics & Water Quality Laboratory

**CIVIL ENGINEERING DEPARTMENT**
*Diploma of Civil Engineering Programme (DKA)*

# A Guide for : Practical Work 1

## FLUID CHARACTERISTICS

PW1

# Objective

To determine density and specific gravity.

# Theory/General

Density is mass per unit volume. The unit of density is ($kg/m^3$) and the formula is:

$$\rho = \frac{m}{V}$$

where: m = mass (kg)
and
V = volume ($m^3$)

Fluid density depends on the temperature and pressure. Density declined with the rise in temperature. The density of water is 1000 $kg/m^3$.

**Specific gravity is density of liquid times the gravity acceleration divided by the density of water times the gravity acceleration. No unit for specific gravity and the formula is:**

$$Gs = \frac{\rho \text{ liquid } (g)}{\rho \text{ water}(g)}$$

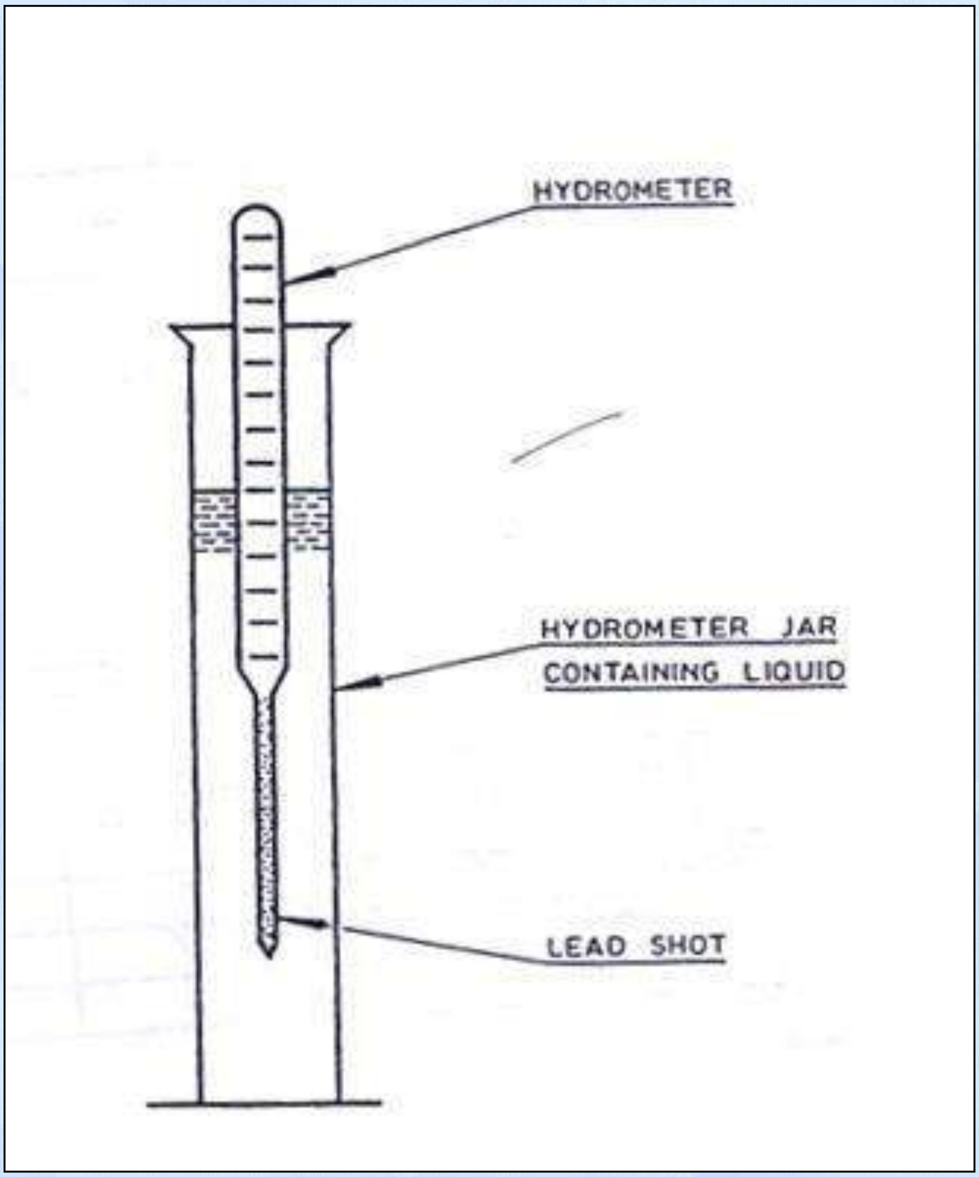
**where: g = gravity = 9.81 m/s$^2$**

**and**

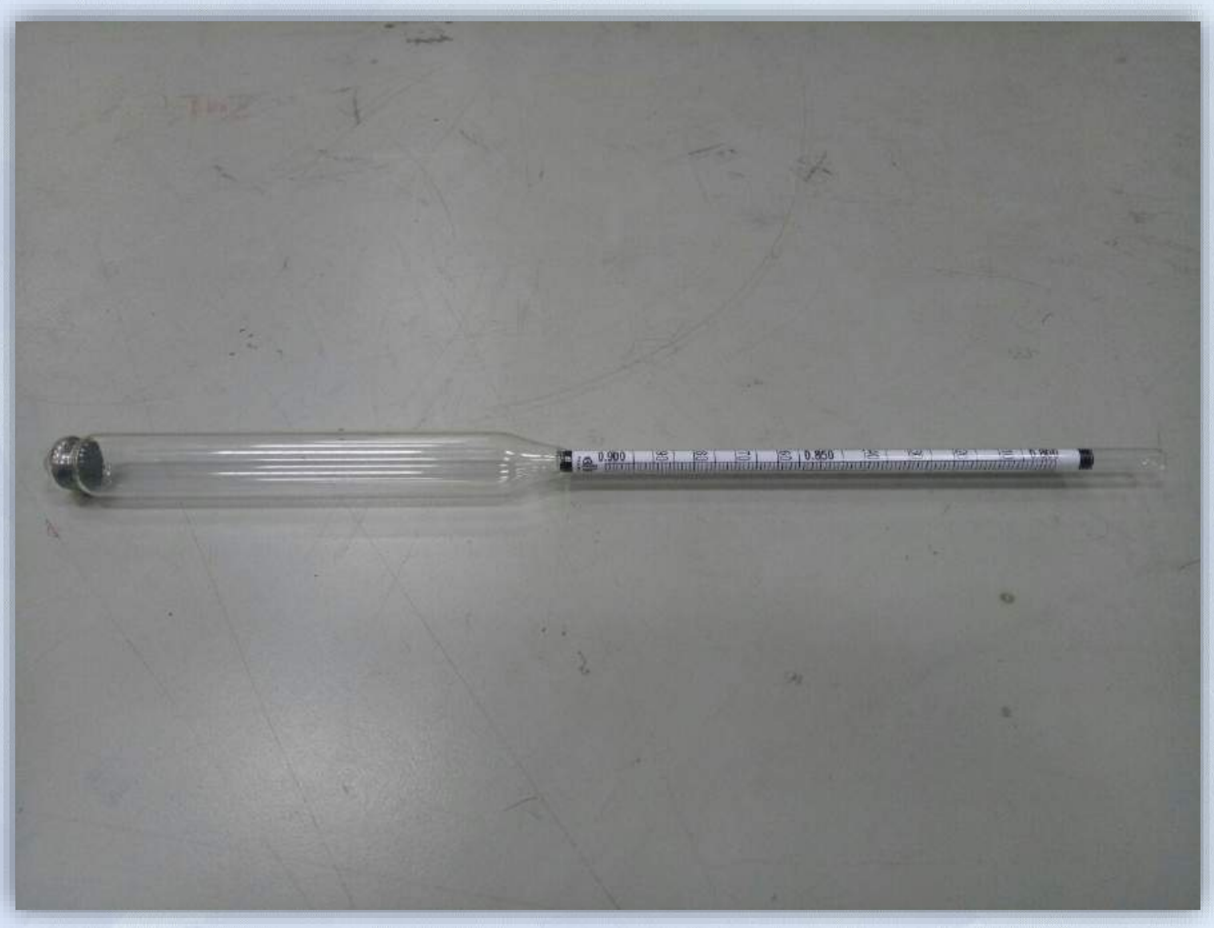
**ρ water = water density = 1000 kg/m$^3$**

# Apparatus

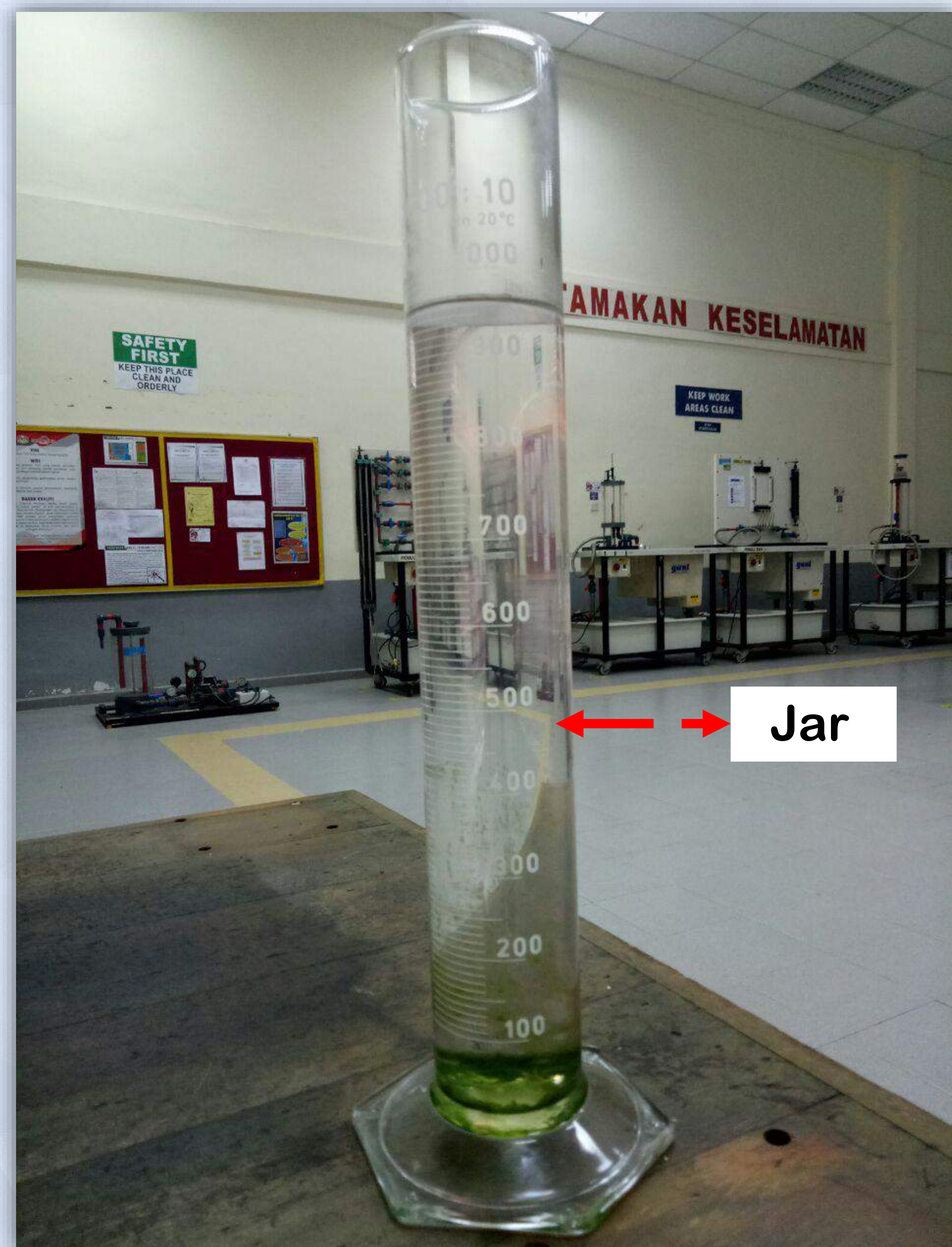
i. Universal Hydrometer
ii. 3 off Hydrometer



# Equipment's for PW1



1. Universal Hydrometer

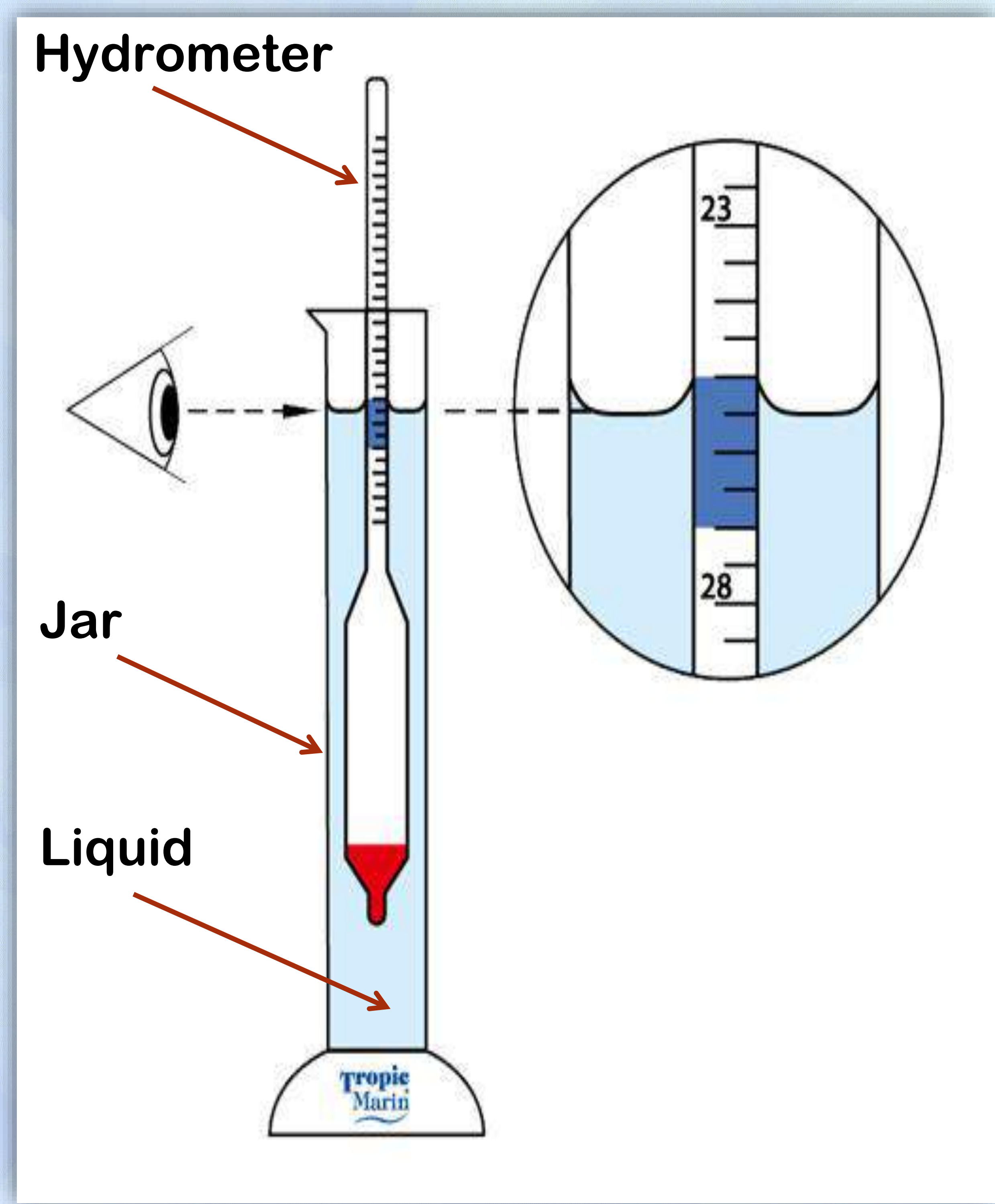

Jar
SAFETY FIRST
KEEP THIS PLACE CLEAN AND ORDERLY
AMAKAN KESELAMATAN
KEEP WORK AREAS CLEAN
700
600
500
400
300
200
100

**2. Water**


UTAMAKAN KESELAMATAN
SAFETY FIRST
KEEP THIS PLACE CLEAN AND ORDERLY
KEEP WORK AREAS CLEAN

# 3. Castor Oil


# 4. Engine Oil




## 5. Accurate Reading Scale Method

# Instruction

1. Fill one hydrometer jar with sufficient water to float the hydrometer and check that the scale marking corresponding to depth of immersion reads 1.00

2. Fill two hydrometers with the liquids to be tested with sufficient of the liquids to float the hydrometer and note for each liquid the scale reading.

   (The specific gravity is read directly from scale)

# Result

a)

| Liquid | Scale Reading : Specific Gravity, Gs |
|---|---|
| Water | |
| Engine Oil | |
| Castor Oil | |

b)

| Liquid | Density, P | |
|---|---|---|
| | Kg/m$^3$ | g/ml |
| Water | | |
| Engine Oil | | |
| Castor Oil | | |

* Show all the calculations

# Discussions

The discussion should answer the following question:

i. Determine the specific gravity.
ii. Determine the density of liquid in unit $kg/m^3$ & g/ml.
iii. Prove the specific gravity is equal to relative density.
iv. What can you have concluded from the result?

## *Link Simulation Video*

- Now.. you can start your Practical Work

- Please Refer to YouTube link to run your PW1
  1. https://www.youtube.com/watch?v=t9XAiRbL7t4
  2. https://www.youtube.com/watch?v=-zGxQItcrEw

- Have a Good Day and Enjoy your Practical Work

Thank You

DCC40172 - Structure, hydraulics & Water Quality Laboratory

**CIVIL ENGINEERING DEPARTMENT**

*Diploma of Civil Engineering Programme (DKA)*

# A Guide for : Practical Work 2

## BERNOULLI'S THEOREM

PW2

# Objectives

i. To investigate the validity of Bernoulli's Theorem
ii. To investigate pressure measurements along ventury tube

# Theory/General

The measured values are to be compared to Bernoulli's equation. Bernoulli's equation for constant head h:

$$\frac{P_1}{\rho g} + \frac{{v_1}^2}{2g} = \frac{P_2}{\rho g} + \frac{{v_2}^2}{2g} = const.$$

Allowance for friction losses and conversion of the pressures $p_1$ and $p_2$ into static pressure heads $h_1$ and $h_2$ yields:

$$h_1 + \frac{v_1^2}{2g} = h_2 + \frac{v_2^2}{2g} + h_v$$

Where:

$p_1$ = Pressure at cross-section $A_1$
$h_1$ = Pressure head at cross-section $A_1$
$v_1$ = Flow velocity at cross-section $A_1$
$p_2$ = Pressure at cross-section $A_2$
$h_2$ = Pressure head at cross-section $A_2$
$v_2$ = Flow velocity at cross-section $A_2$
$\rho$ = Density of medium = constant for incompressible fluids such as water
$h_v$ = Pressure loss head

The ventury tube used has 6 measurement points. The table below shows the standardised reference velocity $\bar{v}$. This parameter is derived from the geometry of the ventury tube.

$$\bar{v} = \frac{A_1}{A_i}$$

| Point, i | $d_i$ (mm) |
|---|---|
| 1 | 28.4 |
| 2 | 22.5 |
| 3 | 14.0 |
| 4 | 17.2 |
| 5 | 24.2 |
| 6 | 28.4 |

Multiplying the reference velocity values with a starting value, the student can calculate the theoretical velocity values $v_{calc}$ at the 6 measuring points of the ventury tube.

At constant flow rate, the starting value for calculating the theoretical velocity is found as:

$$v = \frac{Q}{A_1}$$

The results for the calculated velocity, $v_{calc}$ can be found in the table.

Calculation of dynamic pressure head:

$$h_{dyn} = h_{tot} - 80mm - h_{stat}$$

80 mm must be subtracted, as there is a zero-point difference of 80 mm between the pressure gauges.

The velocity, $v_{meas}$ was calculated from the dynamic pressure;

$$v_{meas.} = \sqrt{2.g.h_{dyn}}$$

# Apparatus

1. Assembly board
2. Single water pressure gauge
3. Discharge pipe
4. Outlet ball cock
5. Ventury tube with 6 measurement points
6. Compression gland
7. Probe for measuring overall pressure (can be moved axially)
8. Hose connection, water supply
9. Ball cock at water inlet
10. 6-fold water pressure gauge (pressure distribution in venture tube)

# Apparatus

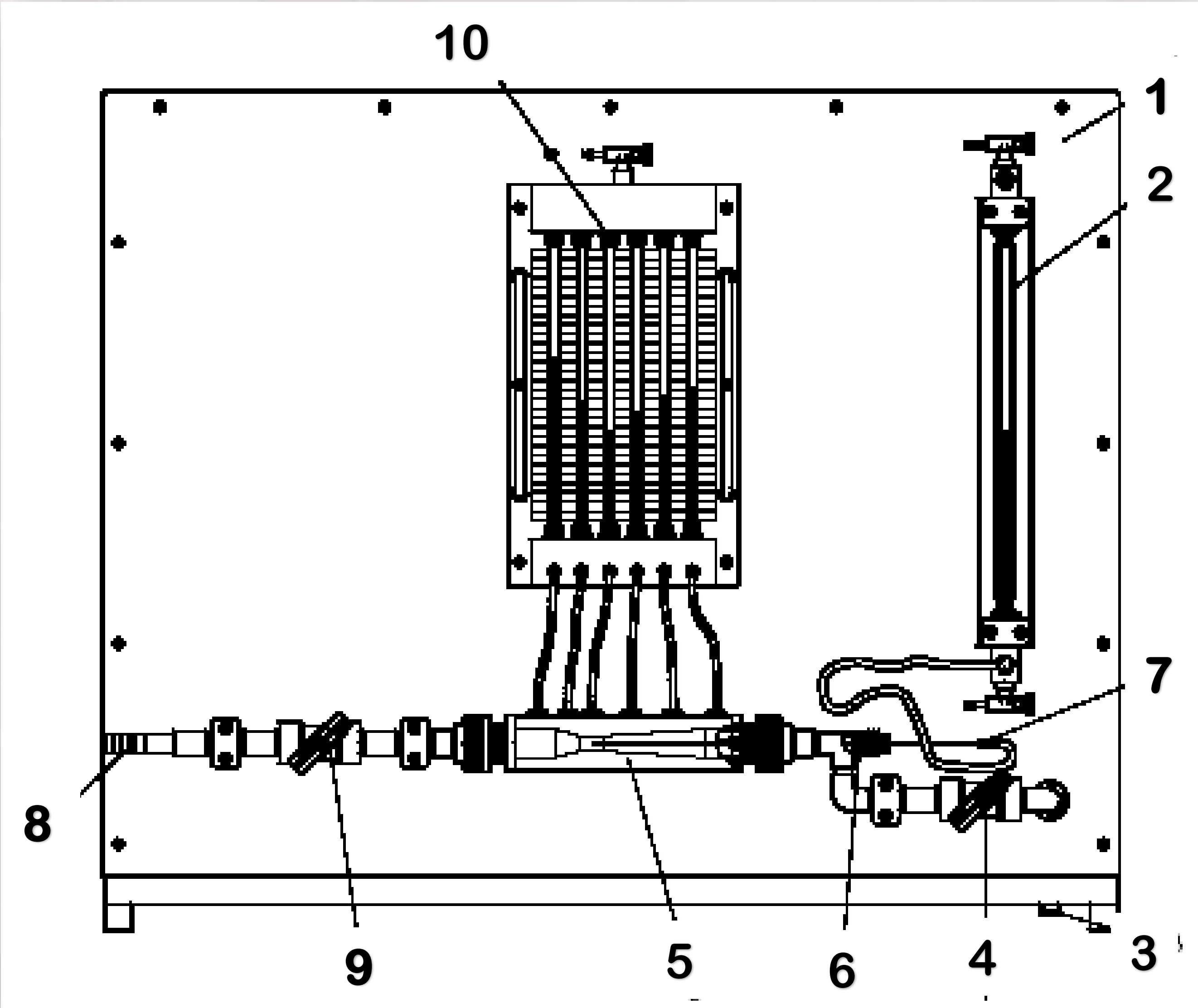
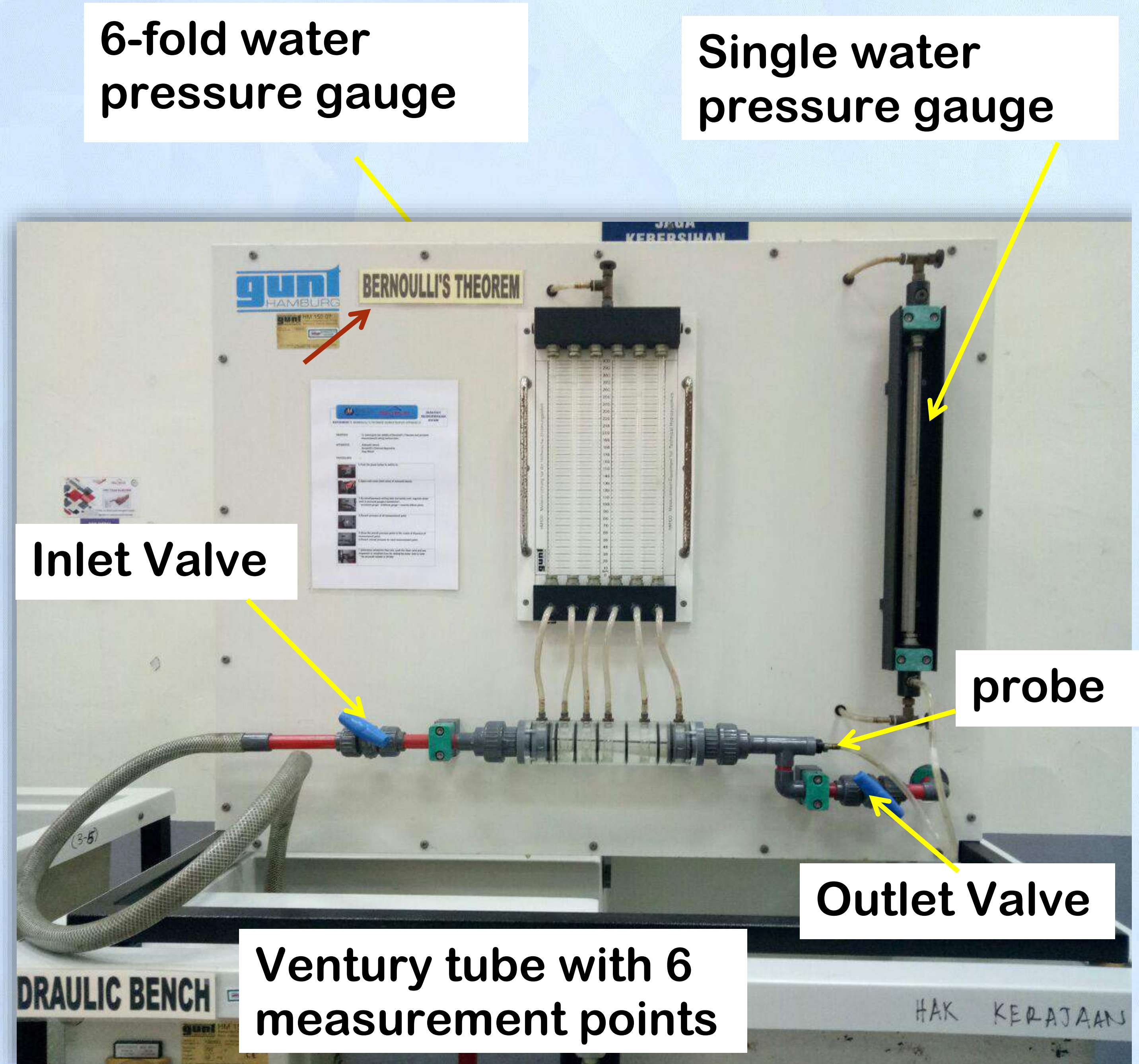



Figure 1: Bernoulli's Theorem

# Equipment's for PW2


1. Hydraulics Bench




## 2. Bernoulli's Theorem Apparatus

1. Switch on the Hydraulic Bench

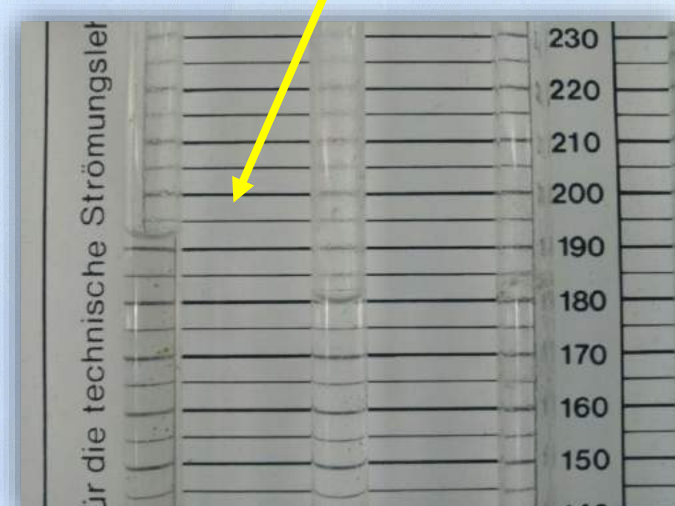
2. Open Main cock/ Inlet valve

3. Setting inlet and outlet valve to regulate water in pressure gauge

## 3. Operation

4. Move the probe to the centre of diameter for each measurement point

$h_{static}$ $h_{total}$




5. Record the water level for each measurement point

1. Push the valve to stop the water drain to tank


2. Water rise in glass tube column. Get ready for time record

3. Stop Watch for record time (second) for water rise in glass water column. Minimum is 10 liter

# 5. Volumetric Flow Reading

# Instruction

1. Switch On the Apparatus and open discharge of hydraulic bench (inlet valve).
2. Set cap nut of probe compression gland such that slight resistance is felt on moving probe.
3. Open inlet and outlet ball cock.
4. Close drain valve at bottom of single water pressure gauge.
5. Switch on pump and slowly open main cock of hydraulic bench.
6. By simultaneously setting inlet and outlet cock, regulate water level in pressure gauges such that neither upper nor lower range limit is overshot or undershot.
7. Record pressures at all measurement points. Then move overall pressure probe to corresponding measurement level and note down overall pressure.
8. Determine volumetric flow rate. To do so, use stopwatch to establish time, t required for raising the level in the volumetric tank of the hydraulic bench from 10 to 20 liters.
9. Repeat above procedure.

# Result

| i | 1 | 2 | 3 | 4 | 5 | 6 | V ($m^3$) | t (s) | $Q_{calc}$ ($m^3/s$) |
|---|---|---|---|---|---|---|---|---|---|
| $h_{static}$ (m) | | | | | | | | | |
| $h_{total}$ (m) | | | | | | | | | |
| $h_{dynamic}$ (m) | | | | | | | | | |
| Diameter, d (m) | | | | | | | | | |
| Area, A ($m^2$) | | | | | | | | | |
| Velocity $V_{meas.}$ (m/s) | | | | | | | | | |
| Velocity $V_{calc.}$ (m/s) | | | | | | | | | |

$Q = A v$

$Q_{calc} = V / t$

$A = \pi d^2/4$

$V_{calc} = Q_{calc} / A$

$V_{meas} = \sqrt{2gh_{dynamic}}$

$h_{dynamic} = h_{total} - 0.08m - h_{static}$

**Where:**

Q = flowrate, v = velocity, t = time,
A = cross sectional area, d = diameter
g = gravity, h = pressure head

# Discussion

The discussion should answer the following question:

i. Determine the dynamic pressure head, $h_{dyn}$.

ii. Determine theoretical velocity head and measured velocity head at each tapping position. Illustrate the measured and theoretical velocity with plotting the graph of Flow Velocity, V against measurement point, i.

iii. Plot the graph of pressure head, $h_{static}$, $h_{total}$ & $h_{dyn}$ against measuring point, i. What can you conclude from the graph?

## *Link Simulation Video*

- Now.. you can start your Practical Work
- Please Refer to YouTube link to run your PW2 https://www.youtube.com/watch?v=9Gd1CJI159c
- Have a Good Day and Enjoy your Practical Work

DCC40172 - Structure, hydraulics & Water Quality Laboratory

**CIVIL ENGINEERING DEPARTMENT**

*Diploma of Civil Engineering Programme (DKA)*

# A Guide for : Practical Work 3

## REYNOLDS NUMBER

PW3

# Objective

i. To observe the characteristics of the flow of a fluid in a pipe, this may be laminar, transitional or turbulent flow by measuring the Reynolds number and the behavior of the flow.

ii. To calculate and identify Reynolds number (Re) for the laminar, transitional and turbulent flow.

# Theory/General

Osborne Reynolds in 1883 conducted a number of experiments to determine the Laws of Resistance in pipes to classify types of flow. Reynolds number 'Re' is the ratio of inertia force to the viscous force where viscous force is shear stress multiplied area and inertia force is mass multiplied acceleration. Reynolds determined that the transition from laminar to turbulent flow occurs at a definite value of the dimensionally property, called Reynolds number.

$$Re = \frac{\rho v d}{\mu}$$

or

$$Re = \frac{v d}{\nu}$$

**Where:**

v = flow velocity (m/s)
ρ = density ($kg/m^3$)
d = inside diameter of pipe section (m)
μ = dynamic viscosity of the fluid (kg/ms)
ν = kinematics viscosity ($m^2/s$)

Reynolds carried out experiments to decide limiting value of Reynold's number to a quantitatively decide whether the flow is laminar or turbulent. The limits are as given below:

- Laminar when Re < 2300
- Transition when 2300 < Re < 4000
- Turbulent when Re > 4000

The motion is laminar or turbulent according to the value of Re is less than or greater than a certain value. If experiments are made with decreasing rate of flow, the value of Re depends on degree of care which is taken to eliminate the disturbances in the supply or along the pipe.

On the others hand, if experiments are made with decreasing flow, transition from turbulent to laminar flow takes place at a value of Re which is very much depends on initial disturbances.

The valve of Re is about 2000 for flow through circular pipe and below this the flow is laminar in nature. The velocity at which the flow in the pipe changes from one type of motion to the other is known as critical velocity.

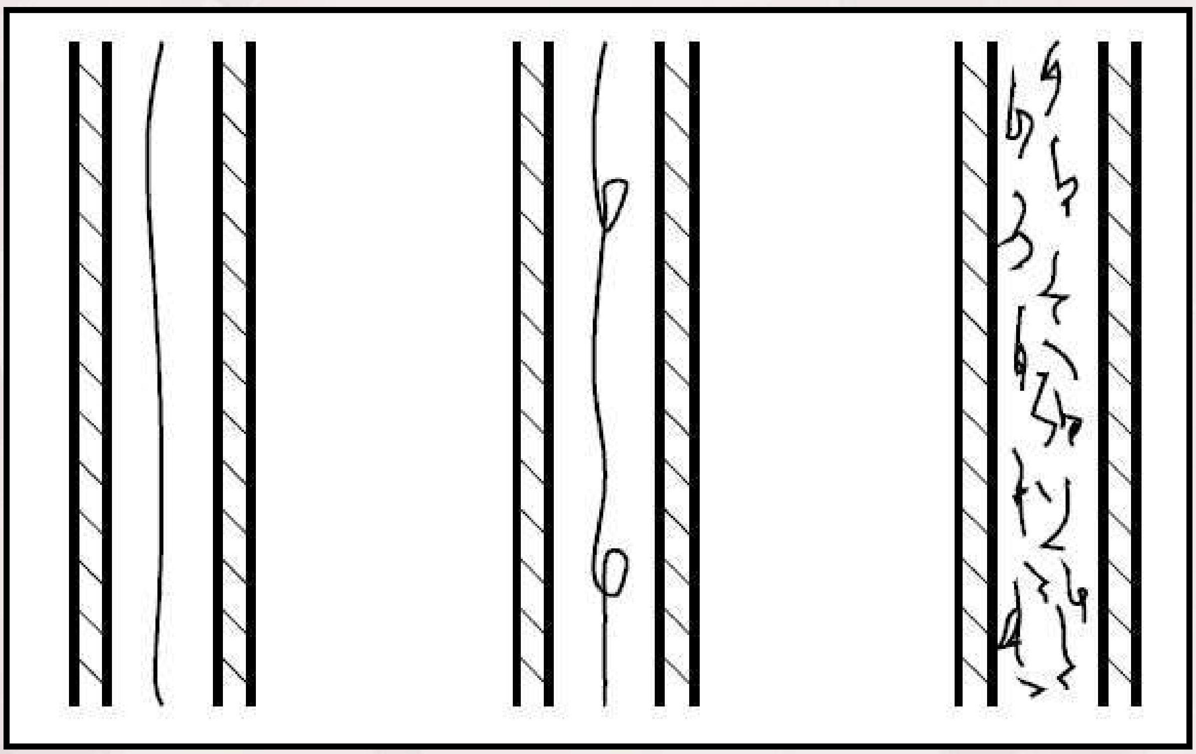
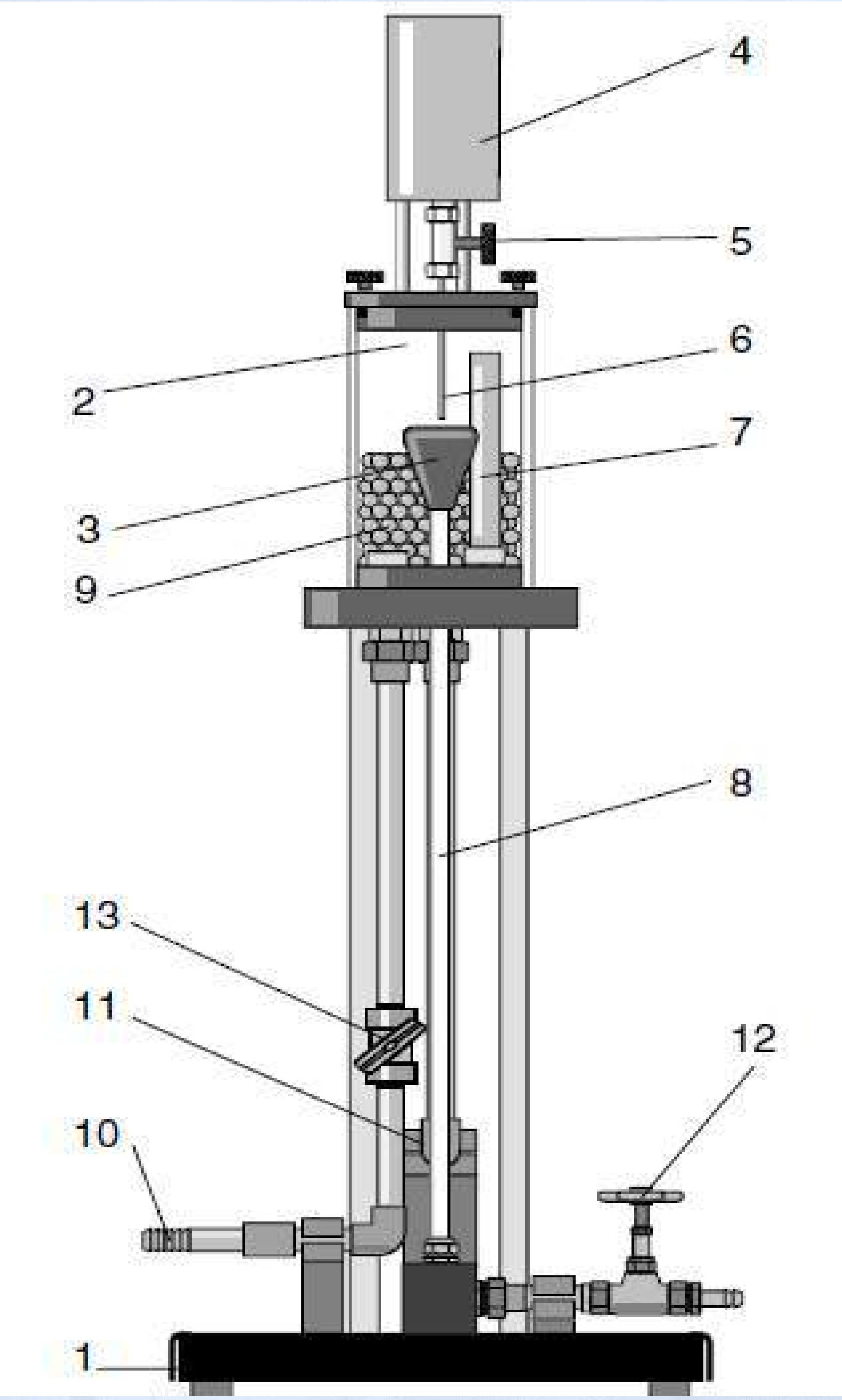


**Figure 2**: Three flow regimes: (a) laminar, (b) transitional & (c) turbulent

# Apparatus

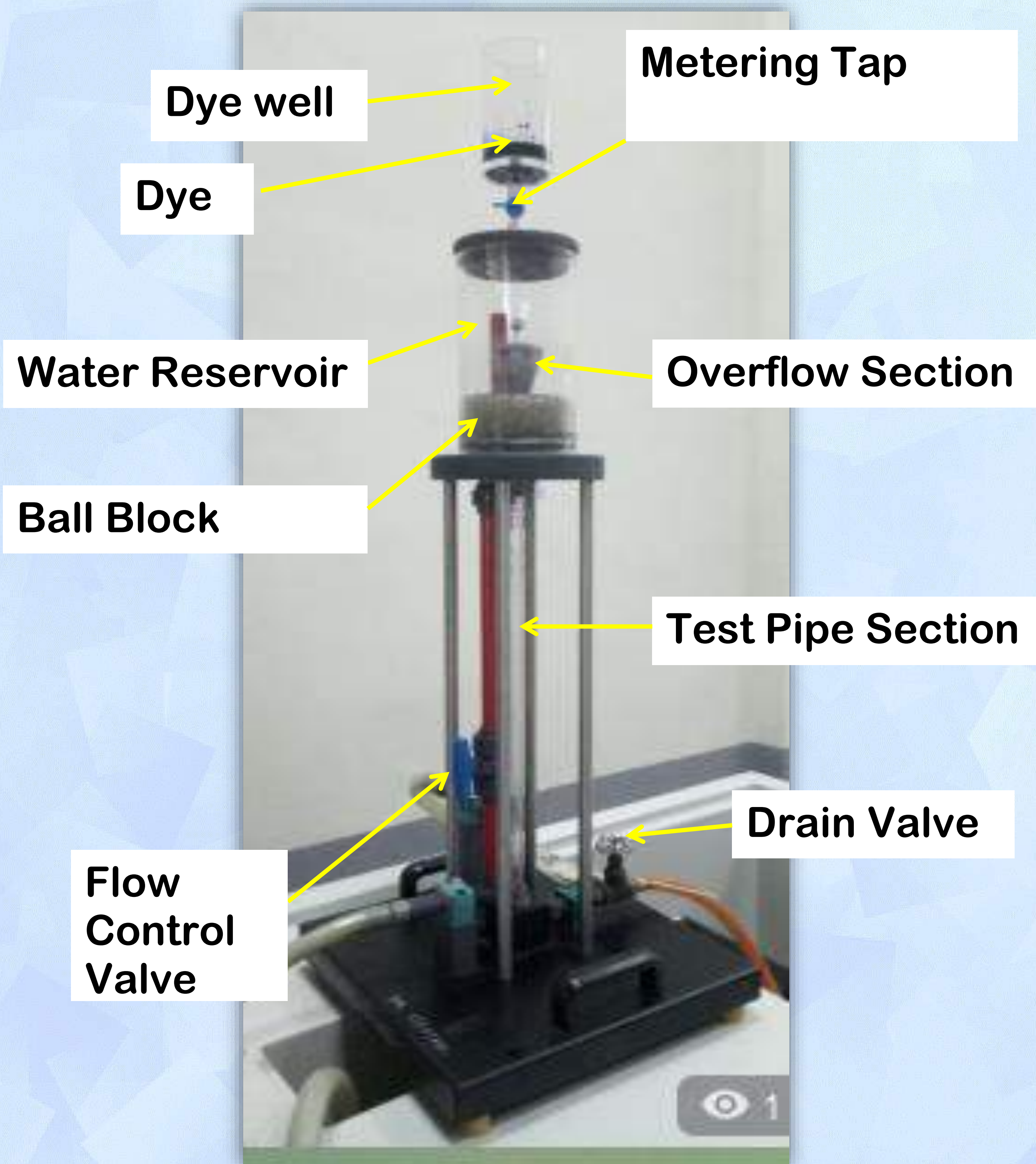



1. Base Plate
2. Water Reservoir
3. Overflow Section
4. Aluminium Well
5. Metering Tap
6. Brass Inflow Tip
7. Flow-Optimised Inflow
8. Test Pipe Section
9. Ball Block
10. Waste Water Discharge
11. Connections for Water Supply
12. Drain Cock
13. Control valve

Figure 1: Osborne Reynolds Demonstration Apparatus

# Equipment's for PW3


## 1. Hydraulics Bench




2. Osborne Reynolds Apparatus


1. Switch on the Hydraulic Bench

2. Open Control Valve

3. Open Dye Metering Tap

# 3. Operation

4. Control Drain Valve for Laminar, Transition or Turbulent

5. Observation the characteristics of the flow

## 3. Operation

Jar

1. Control The Drain Valve

2. Water rise in measuring cylinder. Get ready for time record


3. Stop Watch for record time (second) for water rise in measuring cylinder. Minimum is 1 liter


# 4. Volumetric Flow Reading

# Instruction

1. Firstly, the apparatus is set up and note down diameter of pipe and also room temperature. Fill the Ink well with dye, the metering tap (dye flow control valve) and drain cock must be closed.
2. Switch on the pump, carefully open the control valve above the pump and adjust the tap to produce a constant water level in the reservoir. After a time the test pipe section is completely filled.
3. Open the drain cock slightly to produce a low rate of flow into the test pipe section.
4. Open the metering tap and the dye is allowed to flow from the nozzle at the entrance of the channel until a colored stream is visible along the test pipe section. The velocity of water flow should be increased if the dye accumulates around the nozzle.
5. Adjust the water flow until a laminar flow pattern which is a straight thin line or streamline of dye is able to be seen along the whole test pipe section.
6. Record the time in seconds for the 1 liters volume of colored waste water that flows down at the outlet pipe. The volume flow rate is calculated from the volume and a known time.
7. Repeat step 5-6 with increasing rate of flow by opening the drain cock and the flow pattern of the fluid is observed as the flow changes from laminar to transition and turbulent. Take five to six readings till the dye stream in the test pipe section breaks up and gets diffused in water.
8. Clean all the apparatus after the experiment is done.

# Result

Inside diameter of pipe section, d = 0.010 m
Cross sectional area of the pipe, A =_____$m^2$
Density of water, ρ = ______ $kg/m^3$
Kinematics viscosity of water at room temperature, ν = ______$m^2/s$
Average room temperature, θ = _____°C

| Run No | Volume, V ($m^3$) | Time, t (s) | Flow rate, Q ($m^3/s$) | Velocity, v (m/s) | Reynolds Number (Re) | Type of Flow |
|---|---|---|---|---|---|---|
| 1 | | | | | | |
| 2 | | | | | | |
| 3 | | | | | | |
| 4 | | | | | | |
| 5 | | | | | | |
| 6 | | | | | | |

**where:**

**A – Cross sectional Area = ($\pi d^2 / 4$) @ $m^2$**

**Q – Flow rate = V / t @ $m^3/s$**

**V – Velocity = Q / A @ m/s**

# Discussion

The discussion should answer the following question:

i. What is Reynold's number?
ii. State some practical examples of laminar and turbulent flow?
iii. State the difference between laminar flow and turbulent flow?
iv. What is the behavior of path lines?
    i) Laminar flow
    ii) Transitional flow
    iii) Turbulent flow
v. What are the application of Reynolds's No. other than type of flow?

## *Link Simulation Video*

- Now.. you can start your Practical Work

- Please Refer to YouTube link to run your PW3
- https://www.youtube.com/watch?v=qveJ4RC4tJE
- Have a Good Day and Enjoy your Practical Work

Thank You

DCC40172 - Structure, hydraulics & Water Quality Laboratory

**CIVIL ENGINEERING DEPARTMENT**

*Diploma of Civil Engineering Programme (DKA)*

# A Guide for : Practical Work 4

## HYDROSTATIC FORCE

PW4

# Objective

i. To investigate the hydrostatic pressure of water
ii. To determine the position center of pressure
iii. To calculate the Hydrostatic forces
iv. To check the balance of moments between the areas

# Theory/General

The hydrostatic pressure of liquids is the "gravitational pressure" *phyd*.
It rises due to the intrinsic weight as the depth t increases, and is calculated from:

$$phyd = \rho . g . t \quad - \quad (1)$$

*where:* $\rho$ - Density of water

g - gravity ($g=9,81\ m/s^2$)

t - Distance from liquid surface

**To calculate forces acting on masonry dams or ships' hulls, for example, from the hydrostatic pressure, two steps are required:**

**- Reduce the pressure load on an active surface down to a resultant force Fp, which is applied at a point of application of force, the "centre of pressure", vertical to the active surface.**

**- Determine the position of this centre of pressure by determining a planar centre of force on the active surface.**
**It is first demonstrated how the centre of pressure can be determined. The resultant force *Fp* is then calculated.**

**Determining the "resultant force"**

The hydrostatic pressure acting on the active Surface can be represented as resultant force Fp, of which the line of application leads through the centre of pressure D. The size of this resultant force corresponds to the hydrostatic pressure at the planar centre of force C of the active surface:

$$pc = \rho.g.tc$$

where:

pc - Hydrostatic pressure at the planar centre of force of the active surface

tc - Vertical distance of the planar centre of force from the surface of the liquid

That is to say, the force due to weight G of the water volume always exerts the same moment of momentum as the force Fp at the centre of pressure D. The derivation of leads via determination of the centre of force of a ring segment and its volume.

# Apparatus

1) Hydrostatic bench
2) Loading
3) Jar

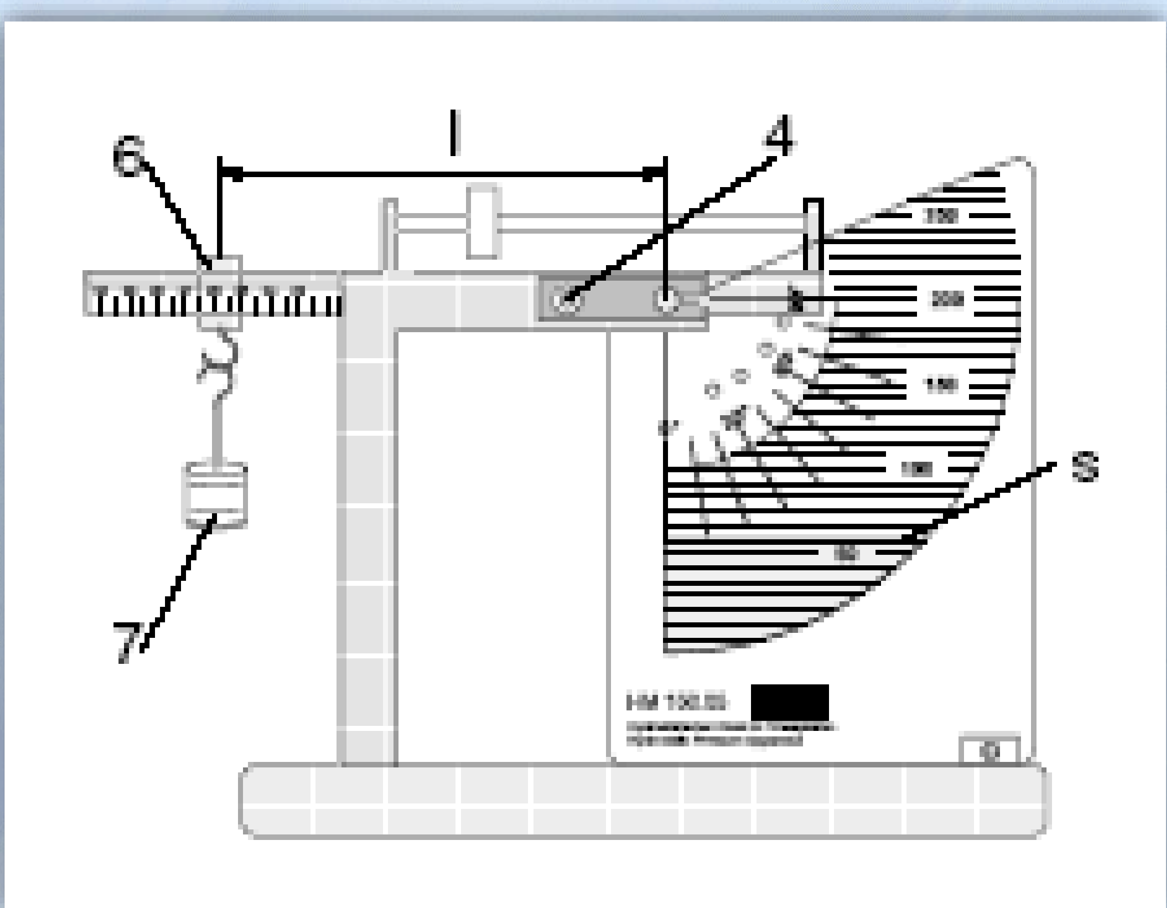
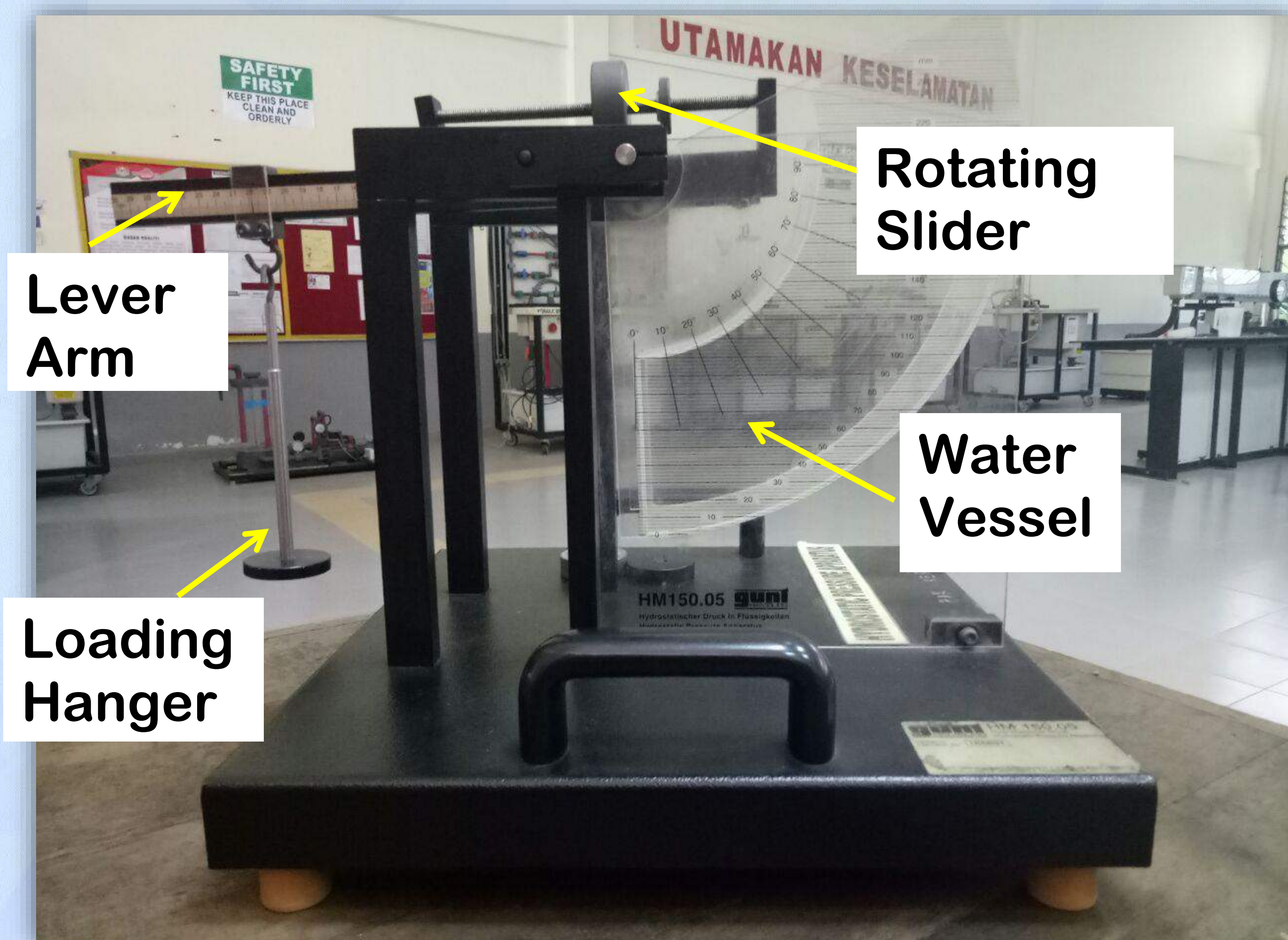
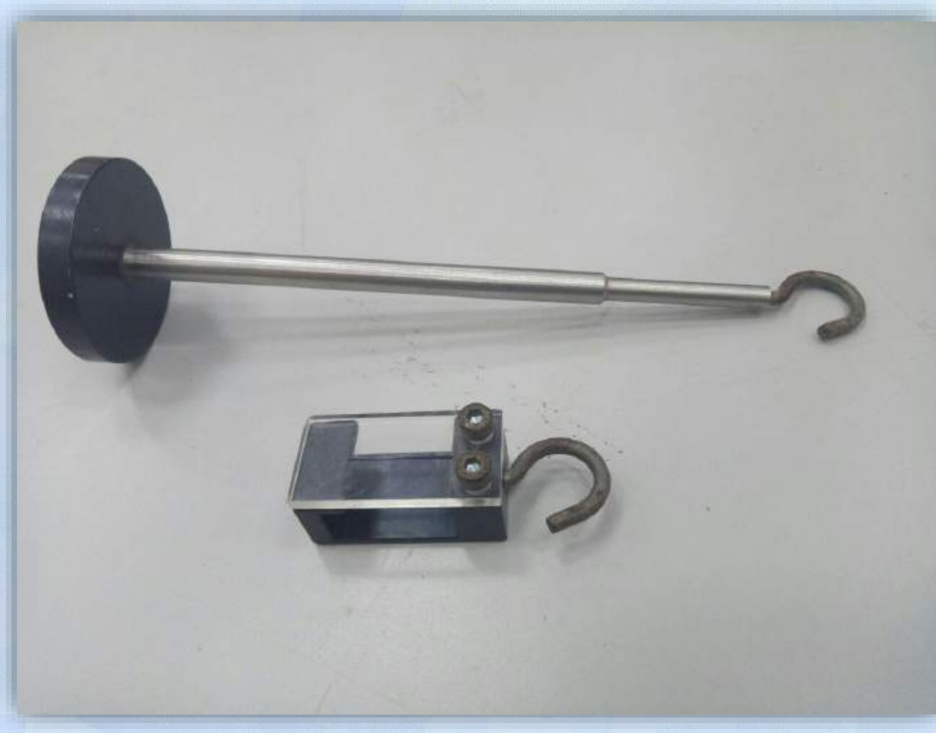



**Figure 1: Unit Description**

# Equipment's for PW4




## 1. Hydrostatic Force Apparatus



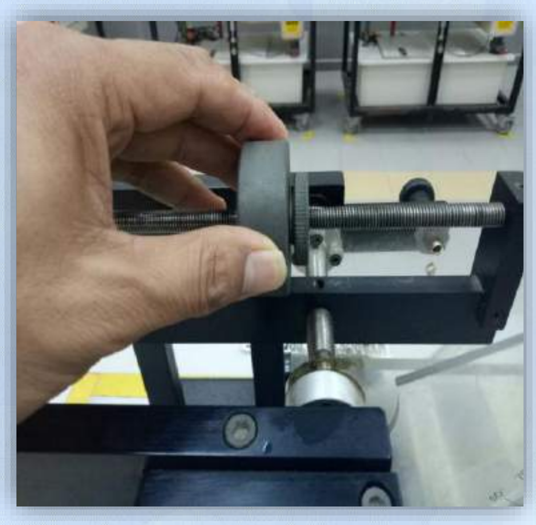
2. Hanger

3. Appended weight/Loading


4. Big Wash Bottle

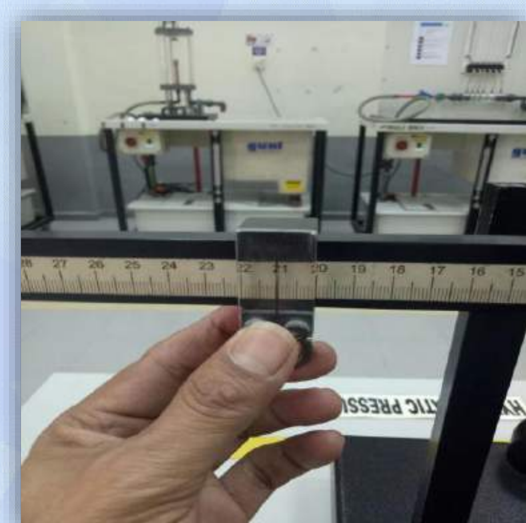

5. Jar

# Operation



1. Set up the water vessel to an angle $0^0$. Counterbalance the unit with a rotating slider

2. The stop pin precisely in the middle of the hole.



3. Place the Hanger to the Lever Arm and set Lever arm on the Scale


4. Hang the appended weight/loading


5. Pour water to the vessel until the unit is balance (stop pin at the middle)


6. Record the water level (S)

# Instruction

1. Set up the water vessel to an angle $0^0$. Counterbalance the unit with a rotating slider. The stop pin precisely in the middle of the hole.

2. Place the Hanger to the Lever Arm and set Lever arm on the Scale (ex; 130mm or etc.)

3. Pour water to the vessel until the unit is balance (stop pin at the middle)

4. Read off water level (S) and record in the lab sheet.

5. Increase the appended weight and set lever arm. Repeated the measurement.

# Result

| Appended Weight FG ( N ) | Lever Arm L (m) | Water Level S (m) | Calculated Level Arm Id (m) | Resultant Force Fp (N) | Appended Weight Moment (Nm) | Water Moment (NM) | Balance Of Moment (Nm) |
|---|---|---|---|---|---|---|---|
| 1.243 | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| 2.243 | | | | | | | |
| | | | | | | | |
| | | | | | | | |
| | | | | | | | |

# Discussion

The discussion should answer the following question:

i. Plot Appended Weight Moment (Nm) vs Water Moment (Nm)

## *Link Simulation Video*

- Now.. you can start your Practical Work
- Please Refer to YouTube link to run your PW4
- https://www.youtube.com/watch?v=K1g0WNMdg7A&t=24s
- Have a Good Day and Enjoy your Practical Work

Thank You

DCC40172 - Structure, hydraulics & Water Quality Laboratory

**CIVIL ENGINEERING DEPARTMENT**

*Diploma of Civil Engineering Programme (DKA)*

# A Guide for : Practical Work 5

## IMPACT OF JET

PW5

# Objective

To investigate the forces impacting against stationary deflectors

# Theory/General

The theoretical jet force is calculated from the principle of linear momentum
The density ($\rho$) of the water is 1000 kg/m$^3$

Force = Fluid Mass x Variable of Velocity

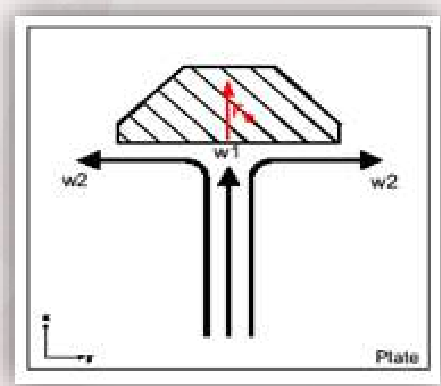
$$= (\rho . A . v) \times (\Delta v)$$

$$= (\rho Q) \times (v_1 - v_2)$$

**Where:** $\rho$ = Density of fluids
$A$ = Area of nozzle
$V_1$ = first velocity
$V_2$ = Second velocity

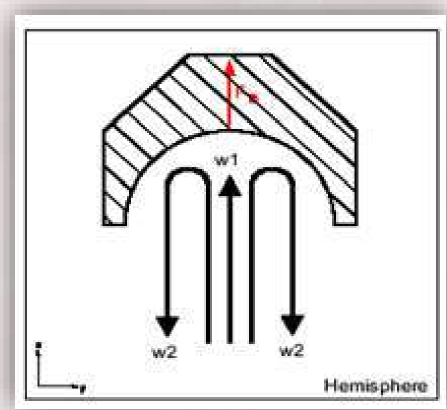
# Deflectors Stationary

## i. For Plate



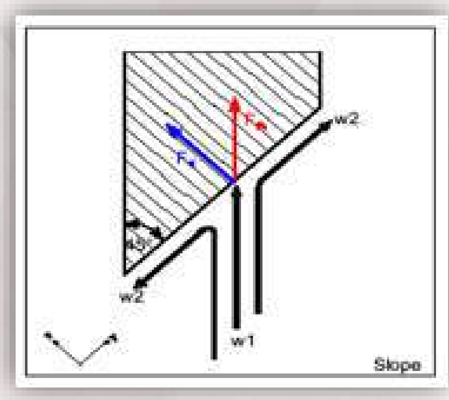

Fth = ρ Q x ( $v_1$ - $v_2$ )
if $v_2 = 0$ then
Fth = ρ Q . $v_1$

## ii. For Hemisphere




Fth = ρ Q x ( $v_1$ - $v_2$ )
if $v_2 = - v_1$ then
Fth = ρ Q . $2v_1$

## iii. For Slope

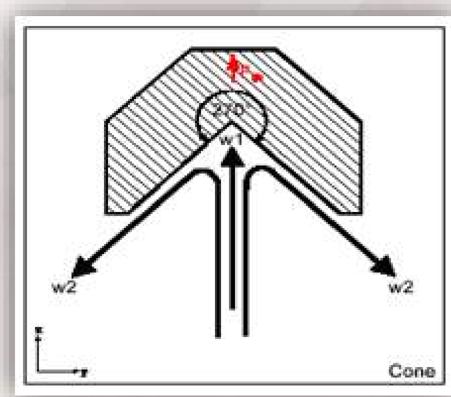



$$Fx = \rho\, Q \times (\, v_1 \cos\alpha\,)$$

$$Fth = F_x \cos\alpha \qquad \text{with } \alpha = 45^0$$

$$Fth = \rho\, Q \,.\, v_1 \,.\, \cos^2\alpha$$

## iv. For Cone




$$Fth = \rho\, Q \times (\, v_1 - v_{2x}\,)$$

$$\text{if } v_2 = -\, v_1 \cos\alpha \qquad \text{with } \alpha = 45^0$$

$$v_{2x} = v_2 \cos\alpha$$

$$Fth = \rho\, Q \,.\, v_1 (\, 1 + \cos^2\alpha\,)$$

# Apparatus

1) Hydrostatic bench
2) Impact of jet apparatus
   i. Loading
   ii. Deflectors
   iii. Stop Watch

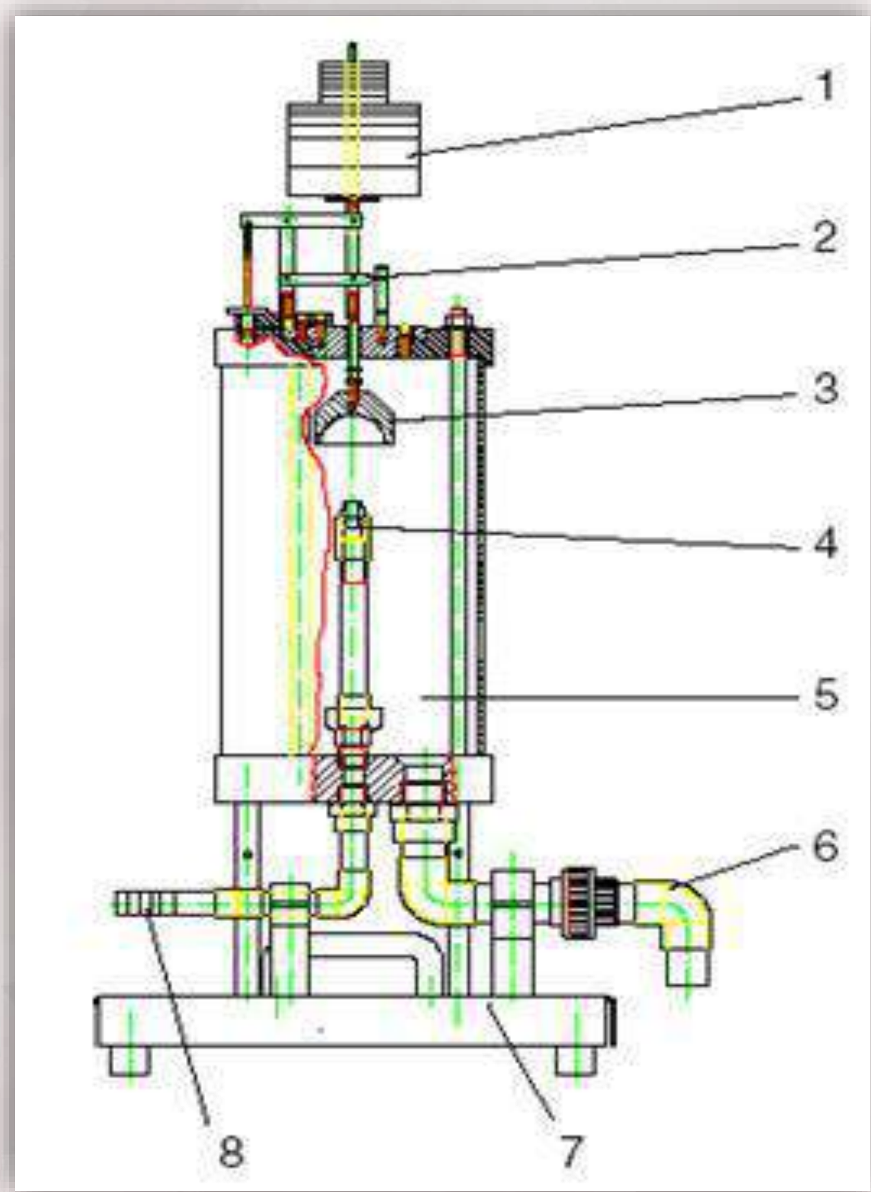



Figure 1: Unit Description

# Components Impact of jet apparatus

The unit essentially consists of:

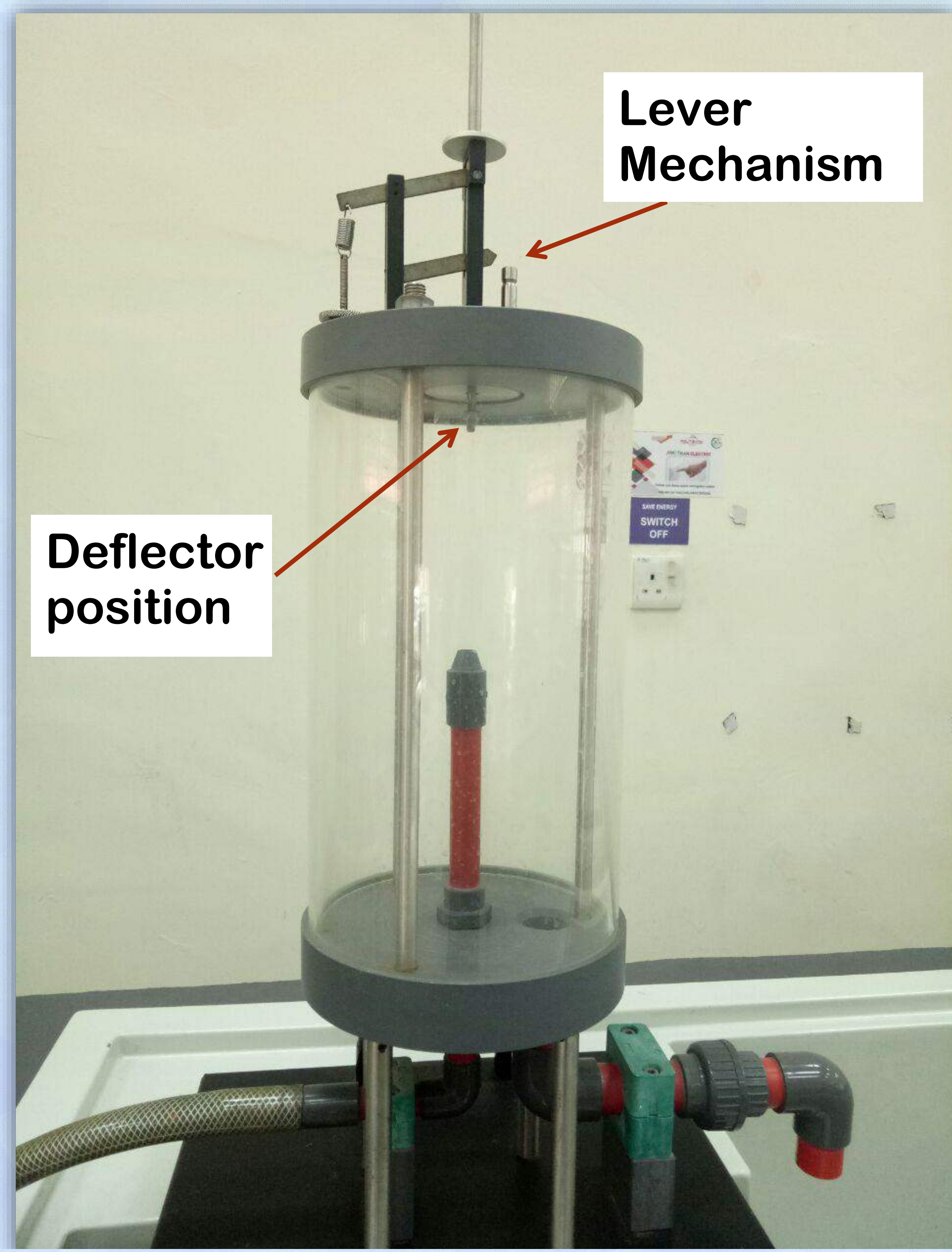
1 – Loading Weights
2 – Lever Mechanism
3 – Deflector
4 – Nozzle
5 – Perspex Vessel
6 – Drain Connection
7 – Base Plate
8 - Inlet Connection

Four (4) Types of 'Deflectors Stationery' can be fitted at position – 3

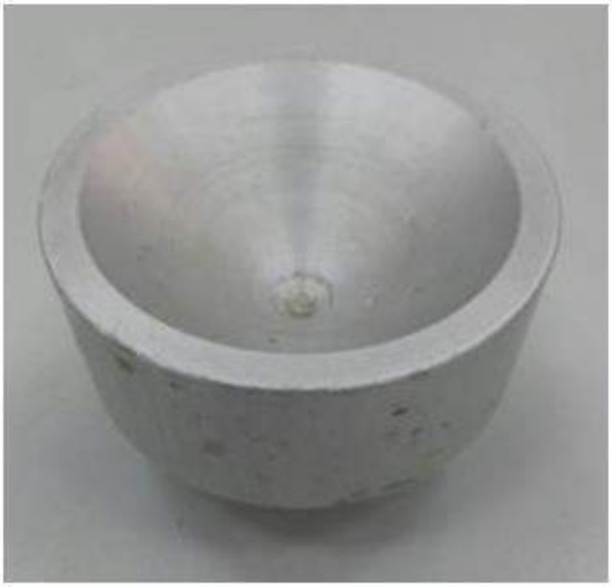
i. Plate
ii. Hemisphere
iii. Slope
iv. Cone

# Equipment’s for PW5


## 1. Hydraulics Bench

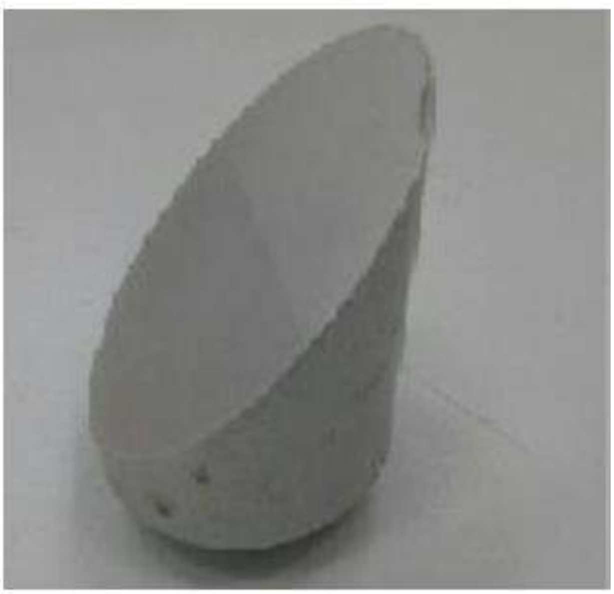



2. Impact Of Jet Apparatus



1. Cone

2. Plate



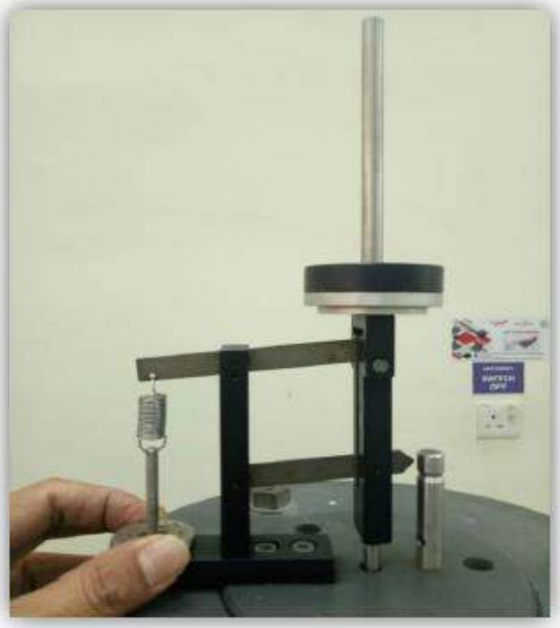
3. Slope

4. Hemisphere

3. Deflectors Stationary


# 4. Loading

1. Assemble the Deflector



2. Adjust Screw to pointer & Apply desired Loading


3. Switch on the pump

4. Control Flow Valve

# 5. Operation

1. Push the valve to stop the water drain to tank


2. Water rise in glass tube column. Get ready for time record

3. Stop Watch for record time (second) for water rise in glass water column. Minimum is 10 liter

# 6. Volumetric Flow Reading

# Instruction

1. Assemble deflector (Plate, Hemisphere, Slope or Cone). remove cover together with lever mechanism. Fit appropriate deflector. Screw cover back onto vessel.
5. Use adjusting screw to set pointer to zero. When doing so, do not place any loading weights on measurement system.
6. Apply desired loading weight 0.2N, 0.3N, 0.5N or combinations thereof.
7. Close main **HM150** cock.
8. Switch on **HM150** pump.
9. Carefully open main cock until pointer is on zero again.
10 Determine volumetric flow. This involves recording time t required to fill up the volumetric tank of the **HM150** from 10 to 20 liters.
12. Add loading weights and record time (second) for 10 liters to 20 liters
13. Switch off pump, open drain.

# Result

**Measured Values for**

i. **Plate**
ii. **Hemisphere**
iii. **Slope**
iv. **Cone**

| Force, F ( N ) | Measuring time ( s ) | Flow rate ($m^3/s$) |
|---|---|---|
| 0.5 | | |
| 0.8 | | |
| 1.1 | | |
| 1.3 | | |
| 1.5 | | |
| Measured volume : 10 liter | | |

**(Different table for each Deflectors)

**Note:** Nozzle diameter = 10mm
Velocity = v = Q/A

# Discussion

The discussion should answer the following question:

1. Comparison of the four bodies with completing the table below

| Loading ( N ) | Calculated Forces , $F_{th}$ ( N ) | | | |
|---|---|---|---|---|
| | Plate | Hemisphere | Slope | Cone |
| 0.5 | | | | |
| 0.8 | | | | |
| 1.1 | | | | |
| 1.3 | | | | |
| 1.5 | | | | |

2. Plot the bar chart of forces (Calculated and Measured) versus deflectors.

## *Link Simulation Video*

- Now.. you can start your Practical Work
- Please Refer to YouTube link to run your PW5
  https://www.youtube.com/watch?v=tXLI-IeAynI
- Have a Good Day and Enjoy your Practical Work

**CIVIL ENGINEERING DEPARTMENT**

*Diploma of Civil Engineering Programme (DKA)*

# DCC40172 - Structure, hydraulics & Water Quality Laboratory

# A Guide for : Practical Work 6

## OPEN CHANNEL

PW6

# Objective

Observe and investigate:

i. Outflow processes over an under water weir
ii. Subcritical and supercritical flow
iii. Energy level of flows in open flumes

# Theory/General

## Specific Energy and Alternate Depths Of Flow

The specific energy, E at a particular section is defined as the energy head referred to the channel bed as datum Thus:

$$E = y + \frac{v^2}{2g} \quad \text{.............} \ (1.1)$$

If the channel is of uniform depth and relatively wide, the flow near the center of the channel will be unaffected by the side boundaries of the channel and the flow q per unit width b can be expressed as q = Q/b. The average velocity V = Q/A = qb/by = q/y and equation 1.1 can be expressed as:

$$E = y + \frac{1}{2g}\left[\frac{q^2}{y^2}\right] \text{.................} (1.2)$$

where:
q = Discharge per flume width
Q = Discharge over flume
b = Flume width
E = Specific energy
y = water depth

A relation for critical depth in a wide rectangular channel can be found differentiating E of eq. (1.2) with respect to y to find the value of y for which E is a minimum. Thus

$$\frac{dE}{dy} = 1 - \frac{q^2}{gy^3} = 0$$

From which $q^2 = gy^3$

Substituting q = V y gives

$V_c^2 = g.y_c$ and $V_c = \sqrt{g.y_c}$ .......(1.3)

Where the subscript c indicates critical flow conditions (minimum specific energy for a given q). Equation (1.3) applicable to wide open channels may also be expressed as:

$$y_c = \frac{V_c^2}{g} = \left[\frac{q^2}{y^2}\right]^{1/3} \quad .........(1.4)$$

From eq. (1.4) $\frac{Vc^2}{2g} = 0.5\, y_c$

$$E_c = E_{min} = y_c + \frac{V_c^2}{2g} = 1.5\, y_c \quad .........(1.5)$$

And $y_c = \frac{2E_c}{3} = \frac{2E_{min}}{3}$ ......(1.6)

If the base of channel is horizontal and assume as datum, total of specific energy. Thus

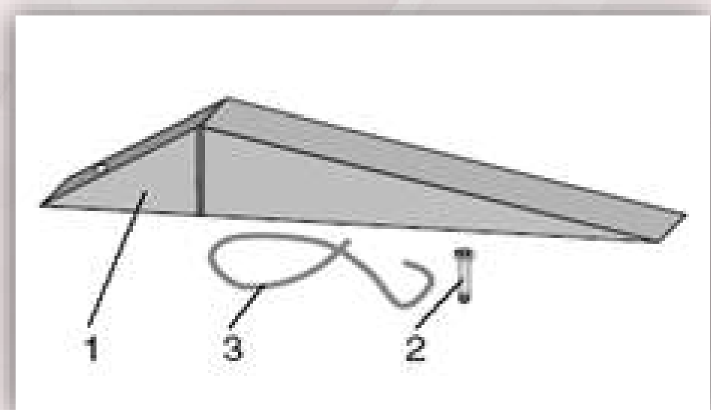
$$H = E + S$$

$$H = y + \frac{q^2}{2gy^2} + S \qquad \text{............(1.7)}$$

Where: S = height of crump weir

# Apparatus

i. Hydrostatic bench
ii. Loading
iii. Jar




The crump weir comprises the following components:
- weir body (1) with edge inclination ratios 2 : 3 and 2 : 9 respectively
- Hexagon socket screw M6 (2)
- Plastic sealing tube (3)

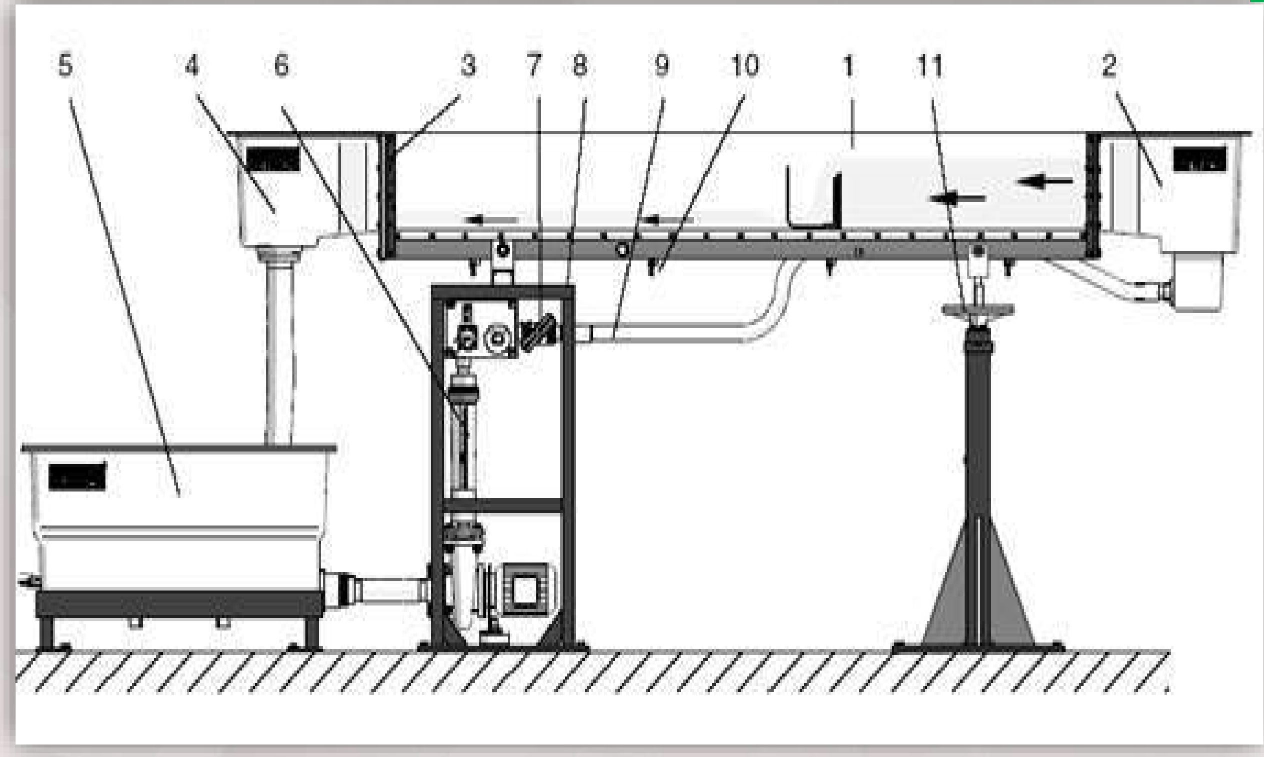
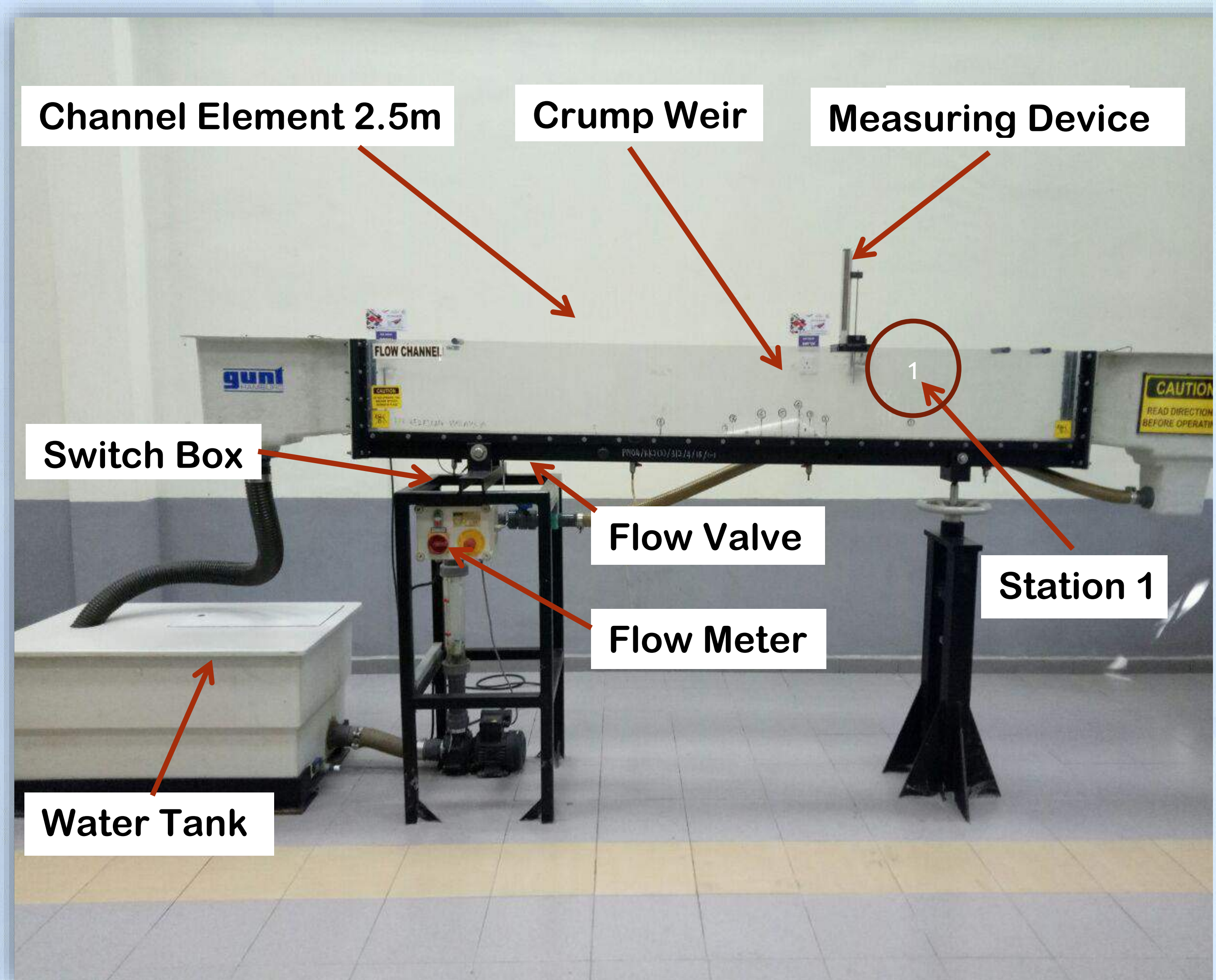



**Figure 1: Unit Description**

**Designation of components, water circuit diagram:**

1. Channel element 2.5m
2. Flow channel element
3. Groove for overflow weir
4. Outflow segment
5. Tank with outflow valve
6. Flowmeter
7. Shut-off valve
8. Bearing pedestal with fixed bearing
   Centrifugal pump and switch box
9. Pressure line
10. Outflow valve with measuring glands
11. Inclination adjustment devise

# Equipment's for PW6




## 1. Multipurpose Teaching Flume Channel


1. Switch On

2. Control Valve to
Set The Flowrate

3. Flowrate Reading

## 2. Operation

4. Measure The length of Station 1 to the other station (2, 3, 4, 5, 6, 7, 8 & 9)

5. Measure the height of crump weir from base of channel at every station

6. Measure the height of water from base of channel at every station

## 2. Operation

# Instruction

1. Make sure the apparatus is in good conditions.
2. Position the crump weir at multi – purpose teaching flume.
3. Marked the station at the channel in 8 point (depend on distance given)
4. Set the measuring device to base channel and zero reading (datum).
5. Take the height of water at every station from the base of channel (S).
6. Switch on the pump and lets the water flow over the crump and adjust the cock to get the stable flow (2-3 minute)
7. When the water flow was stable, started to measure the height of water (started from point 1 to point 9).
8. Record the volumetric flow rate in the channel (A variable-area flow meter is flanged onto the delivery side of the pump to measure the flow).

# Result

| Station Number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|---|---|
| Distance From Station 1 (m) | | | | | | | | | |
| Height of crump from base of channel, S (m) | | | | | | | | | |
| Height of the water flow, y (from crump weir) (m) | | | | | | | | | |
| Height of the water flow (from base of channel) (m) | | | | | | | | | |
| Velocity, V (from experiment) (m/s) | | | | | | | | | |
| Static Energy, Es (from experiment) (m) | | | | | | | | | |
| Kinetic Energy, Ek (from experiment) (m) | | | | | | | | | |
| Specific energy, E (from experiment) (m) | | | | | | | | | |
| Total of specific energy, H (from experiment)(m) | | | | | | | | | |

# Discussions

The discussion should answer the following question:

i. Plot the graph of specific energy (water depth Vs Specific energy)
ii. Plot the graph of total specific energy against station point

## *Link Simulation Video*

- Now.. you can start your Practical Work

- Please Refer to YouTube link to run your PW6

- Have a Good Day and Enjoy your Practical Work

Thank You

# REFERENCES

## Main references supporting the course


i. APHA, AWWA, WPCF (2012). Standard Methods for the Examination of Water and Wastewater (22nd Edition), Washington, American Public Health Association.

ii. Jabatan Alam Sekitar (2002), Akta Kualiti Alam Sekeliling (1974) (Akta127) & Peraturan-Peraturan dan Perintah-Perintah (2002), Kuala Lumpur: International Law Books Services.

iii. R.C. Hibbeler (2014), Mechanics of Materials (9 th Edition), Pearson Education Inc. Ferdinand P. Beer.

iv. Robert L.M. (2005), Applied Fluid Mechanics (6th Edition), USA, Pearson.

## Additional references supporting the course


i. Clayton T.C (2005), Engineering Fluid Mechanics (8 th Edition), US, Wiley.

ii. Dr. R.K. Bansal (2010), A Textbook of Strength of Materials (Revised 4 th Edition), New Delhi, Laxmi Publications (P) LTD.

iii. Ferdinand P. Beer (2012), Mechanics of Materials (6th Edition), New York, McGraw-Hill International Edition.

iv. Hibbeler R.C. (2012), Structural Analysis (8 th Edition), New Jersey, Prentice Hall.

v. Sukumar Pati (2013), A Textbook on Fluid Mechanics and Hydraulics Machines, New Delhi, McGraw-Hill Edition Private Limited.

vi. Tchobanoglous G. (1985), Water Quality; Characteristics, Modelling, Modification, Addison-Wesley, Reading, MA.

vii. Wagner. (2012), Environmental Sciences: Active Learning Laboratories and Applied Problem Sets (2nd Edition), New Jersey, John Wiley & Sons.

**HAJI ZAMALI BIN OMAR** is from Machang, Kelantan. Obtained his secondary school education at Sekolah Menengah Vokasional, Kuala Krai, Kelantan, then continued his studies of Sijil Awam Pembinaan and Diploma Kejuruteraan Awam at Politeknik Kota Bharu, Kelantan. After that, he continued his studies for a Bachelor of Science in Civil Engineering and a Master of Technical Education at Universiti Teknologi Malaysia. He has teaching experienced in the field of civil engineering for almost of 23 years at Politeknik Kuching, Sarawak and Politeknik Merlimau, Melaka.

**HAZILAH BINTI MOHAMAD** is from Melaka. Obtained her secondary school education at Sekolah Menengah Seri Tanjung, Melaka then continued her studies of Diploma Kejuruteraan Awam at Politeknik Port Dickson, Negeri Sembilan Darul Khusus. After that, she continued her studies for a Bachelor of Civil Engineering and a Master of Technical and Vocational Education at Kolej Universiti Teknologi Tun Hussein Onn, Batu Pahat Johor Darul Takzim. She has teaching experienced in the field of civil engineering for almost of 17 years at Politeknik Merlimau, Melaka.

e ISBN 978-967-2762-08-9
9 7 8 9 6 7 2 7 6 2 0 8 9