AL-BAHA UNIVERSITY
FACULTY OF ENGINEERING
CIVIL ENGINEEING DEPARTMENT

FLUID MECHANICS AND HYDRAULICS LABORATORY MANUAL

CIVIL ENGINEERING DEPARTMENT
2024

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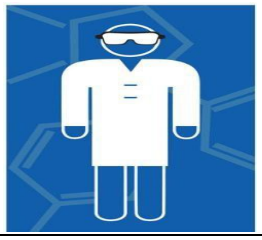
General Safety Guidelines:

Rule	Guideline/Prohibition	Rationale
1	No Eating, Drinking, or Chewing Gum	To maintain a sterile and safe environment. 
2	No Smoking in the Laboratory Area	To safeguard the laboratory and its occupants. 
3	Dress Appropriately	Appropriate attire for personal safety and experiment integrity. 
4	Conduct Yourself Responsibly	Maintain a focused and serious atmosphere. 
5	Hazard Symbols Awareness	Identify potential dangers in the laboratory. 
6	Equipment Shutdown	Conserve energy and prevent equipment damage. 
7	Equipment Cleaning	Promote equipment longevity and prevent cross-contamination. 
8	Maintain Cleanliness	Ensure a safe, efficient, and well-maintained laboratory. 

SAFETY FIRST

(General Administration of Safety and Risks)

الإدارة العامة للسلامة والمخاطر

Phone: 0177257700 - 15424

Email: safety@bu.edu.sa

(Important Phone Number)

ارقام مهمة

الجهة	رقم التلفون	الجهة	رقم التلفون
الشرطة Police	999	طوارئ الكهرباء Electricity Emergency	933
الدفاع المدني Fire Department	998	طوارئ المياه Water Emergency	939
الاسعاف Red Crescent	997	استشارة طبية Medical advice	937
امن الطرق Roads Security	996	الدوريات الأمنية Emergency Number	911
المرور Traffic	993	مكافحة الفساد Corruption (Nazaha)	980

Fluid Mechanics and Hydraulics Laboratory

- **Introduction**

Fluid mechanics, the branch of science that deals with the study of fluids (liquids and gases) in a state of rest or motion, is an important subject of Civil Engineering. Its various branches are fluid statics, fluid kinematics and fluid dynamics.

The Hydraulics Course is one of the main courses at the Civil Engineering Department of Al-Baha University. The course is concerned with the practical applications of fluids, primarily water, in motion. The objective of the course is to enable students to design the components of closed and open conduits water systems such as transmission lines, pumping station, and open channels; and to select suitable hydraulic machines such as pumps and turbines based on the hydraulic design. Besides the theoretical part of the courses, the students are qualified to perform selected lab experiments. the laboratory exercises outlined here are designed to assist the student in the investigation of fluid properties, application of flow measurement techniques, application of conservation laws for pipe and open channel flow.

- **Objectives**

1. Investigate Fluid Properties: Students will delve into the heart of fluids by exploring properties like viscosity, density, and surface tension through hands-on experiments. This provides crucial insights into how fluids behave in different scenarios.
2. Master Flow Measurement Techniques: Learning is not just theoretical; students will gain practical mastery in measuring flow rates using diverse techniques like weirs, flumes, and flow meters. This equips them for real-world applications involving water management and design.
3. Apply Conservation Laws in Practice: Conservation principles, like continuity and momentum, underpin fluid mechanics. The lab provides a platform to translate these theories into tangible experiences. Students will witness firsthand how these laws govern fluid behavior in various setups.
4. Explore Pipe and Open Channel Flow: Analyzing water movement in both confined pipes and open channels is fundamental to hydraulic engineering. Through experiments, students gain a firsthand understanding of factors like head loss, friction, and channel characteristics, enabling them to design and analyze such systems effectively.

- **Report Writing**

Use the report template provided in Appendix (A) as a guide.

- **Lab. Instruments**

The lab allows the students to perform the experiments outlined in the course specification. The equipment used is listed in the Table and figures below.

Condition	Quantity	اسم الصنف		م
		باللغة الإنجليزية	باللغة العربية	
Excellent	1	Properties of fluids and hydrostatics bench	طاولة معملية لقياس خواص الموائع	1
Excellent	3	Basic hydraulic bench	طاولات معملية هيدروليكية أساسية	2
Excellent	1	Bernoulli's principle demonstrator	جهاز فنشوري(للتحقق من معادلة برنولي)	3
Excellent	1	Losses in bends and fittings	جهاز احتكاك السوائل(لقياس الفاقد الثانوية في الأنابيب)	4
Excellent	1	Flow visualization apparatus	جهاز نظر للسيلان (للتحقق من أنواع السريان)	5
Excellent	1	Orifice and jet velocity apparatus	جهاز التدفق عبر الفوهات(يركب على الطاولة في بند1)	6
Excellent	1	Impact of jet apparatus	جهاز اثر قوى الدفع على الأسطح المختلفة	7
Excellent	1	Flow channel	جهاز السريان عبر القنوات المفتوحة	8
Excellent	1	Potential flow	جهاز تدفق الجهد	9
Excellent	1	Drainage and seepage tank	حوض دراسة الصرف والتسرب	10
Excellent	1	Advanced hydrology system	وحدة متقدمة للدراسات الهيدرولوجية	11
Excellent	1	Rainfall hydrograph unit	وحدة دراسات سقوط الأمطار	12
Excellent	5	Experimental benches 180*90*80 cm with electrical	طاولة مختبر مقاس 180*90*80سم	13
Excellent	20	Student chair	كرسي طالب	14
Excellent	3	Cabinet for storing devices	خزانة لحفظ الأجهزة مقاس 120*80*60سم(مرتبطة بالطاولة في بند	15

Properties of fluids and hydrostatics bench (GUNT-HM 115)

Basic hydraulic bench (GUNT-HM 150)

Bernoulli’s principle demonstrator (GUNT-HM 150.07)

Losses in bends and fittings (GUNT-HM 150.29)

Flow visualization apparatus (GUNT-HM 150.10)

Orifice and jet velocity apparatus (GUNT-HM 150.09)

Impact of jet apparatus (GUNT-HM 150.08)

Flow channel (GUNT-HM 150.21)

Potential flow (GUNT-HM 152)

Drainage and Seepage Tank (GUNT-HM 169)

Advance Hydrology System (GUNT-HM 145)

Rainfall Hydrograph Unit (GUNT-HM 141)

- **Experiment Name, Tools, and Equipment: MORE DETAILS IN APPENDIX (B)**

Item No.	Experiment(s) Name	Tools & Equipment
1	Determination of Discharge	Base module for experiments in fluid mechanics
2	Pressure distribution along an effective area in a liquid at rest: • lateral force of the hydrostatic pressure • determination of the center of pressure and center of area • determination of the resulting compressive force	Properties of Fluids, Hydrostatic pressure in liquids and Hydraulic Bench
3	• How differently shaped weirs affect the flow. • Determining the discharge coefficient • Comparison of measuring weirs • Free over fall at the sharp-crested weir	Control Structures: Plate weirs
4	Energy conversion in divergent/convergent pipe flow: • recording the pressure curve in a Venturi nozzle • recording the velocity curve in a Venturi nozzle	Bernoulli's principle
5	• study of the jet forces • study of the outlet jet (diameter, velocity) letermine pressure losses and contraction coefficient for different outlet contours	Measurement of jet forces
6	• influence of flow rate, flow velocity and different deflection angles • recording the trajectory of the water jet at different outlet velocities • determination of the contraction coefficient for different contours and diameters • • streamlines in flow around drag bodies and flow through changes in cross-section	Orifice &jet velocity apparatus
7	• visualization of streamlines for flow incident to a weir • visualization of streamlines when flowing around various drag bodies	Visualization of streamlines
8	• pressure losses in pipes, piping elements and fittings how the flow velocity affects the pressure loss determining resistance coefficients	Losses in a pipe system
9	isualization of streamlines in an open channel around different shapes of bodies	Visualization of streamlines in an open channel
10	• investigate pressure losses at segment bend and bends • investigate pressure loss at contraction and enlargement • pressure loss at a ball valve and determination of a simple valve characteristic	Energy losses in piping elements
11	effect of rainfall of varying duration on the discharge • storage capacity of a soil • investigating steady processes • seepage flow • effects of wells on the groundwater level over time	Advanced hydrological investigations
12	Hele-Shaw cell with screening in the bottom glass panel for optimal observation of the streamlines • two-dimensional, in viscid potential flows • influence of sources and sinks on the streamlines • various models: drag bodies and changes in cross-section	Potential flow
13	Simulation of rainfall and determination of the rainfall hydrograph	Rainfall hydrograph unit

Appendixes

A.Writing lab Report Template

Albaha University

Faculty of Engineering

Civil Engineering Department

Course # (……..)

Course Title: ……

Semester: (……)

Instructor: ……

Group ….

Experiment No. …….

Title of Experiment: ……

Names	ID.s
1.	

Date of Experiment: ……

Time of Experiment……

Table of contents

Team meeting (Optional)

Introduction

Experimental design

Data

Calculations

Figures & Graphs

Results & Discussion

References

(Optional)

Meeting Minutes

Meeting#... of Report#...

Time: …….

Date: …….

Venue: ……

Attendants:

1) ……
2) ……
3) ……
4) ……

Agenda

Writing tasks that are taken before and during the meeting.

Discussion Taken

Writing down all objectives you will discuss in the meeting.

Actions Person Responsible

Writing the distribution of tasks between team members.

Introduction:

Usually, the Introduction is one paragraph that **explains the objectives or purpose of the lab**. In one sentence, state the hypothesis. Sometimes an introduction may contain background information, briefly **summarize how the experiment was performed**, state the findings of the experiment, and list the conclusions of the investigation. Even if you don't write a whole introduction, you need to state the purpose of the experiment, or why you did it. This would be where you state your hypothesis.

Experimental design

a) Materials

List everything needed to complete your experiment.

b) Equipment:

List everything needed to complete your experiment.

c) Methods

Describe the steps you took during your investigation. This is your procedure. Be sufficiently detailed that anyone could read this section and duplicate your experiment. Write it as if you were giving directions for someone else to do the lab. It may be helpful to provide a Figure to diagram your experimental setup.

Data:

Numerical data obtained from your procedure usually is presented as a table. Data encompasses what you recorded when you conducted the experiment. It's just the facts, not any interpretation of what they mean.

Calculations:

The Analysis section contains **any calculations you made based on those numbers**. This is where you interpret the data and determine whether a hypothesis was accepted.

Figures & Graphs

Graphs and figures must both be labeled with a descriptive title. Label the axes on a graph, being sure to include units of measurement.

Results & Discussion

Describe in words what the data means. Sometimes the Results section is combined with the Discussion (Results & Discussion).

Reference:

If your research was based on someone else's work or if you cited facts that require documentation, then you should list these references.

B. Experiments described as per Al-Baha University Curriculum for Fluid Mechanics and Hydraulics Laboratory.

1. **Experiment Title: Determination of Density, Specific Weight, Specific Volume, Relative Density and Specific Gravity of Solids:**

- **Objective:** Determination of Density, Specific Weight, Specific Volume, Relative Density and Specific Gravity of Aluminum, Brass and Poly Oxy methylene
- **Equipment:** Solid cylinders of Aluminum, Brass and Poly Oxy methylene, balance & Ruler.
- **Procedure:** find the following:
  a. Weight in Newton using the balance.
  b. Dimensions of the material sample using the ruler.
  c. From the weight find the mass of the material.
  d. From the dimensions find the volume of the sample.
- **Calculations and Results:**
  a. Find the density of the material: ρ = Mass/Volume
  b. Find the specific Weight of the material: γ = Weight/Volume
  c. Find the specific volume = $1/\rho$
  d. Find the relative density of the material: r.d. = ρ/ρ_{water}
  e. Find the specific gravity of the material: S.G = γ / γ_{water}

2. **Experiment Title: Determination of Density, Specific Weight, and Relative Density of Liquids using Pressure:**

- **Objective:** Determination of Density, Specific Weight, and Relative Density of Tap water using Pressure
- **Equipment:** Water tank, Submersible Pump, Pipework and valves, transparent graduated cylinder, pressure sensor and screen.
- **Procedure:**
  a. Put the electric power "ON".
  b. Operate the water pump.
  c. Pump water to the transparent cylinder to a certain height (say 40 cm).
  d. Read and record the pressure reading (in mbar) on the screen.
  e. Open the valve gradually to enable water to drain from the cylinder such that water level goes down by 5 cm.
  f. Read and record the new pressure (in mbar) reading on the screen.
  g. Repeat the previous step until the water height is 5cm.
- **Calculations and Results:**
  a. Change the pressure (P) readings from mbar to Pascal (N/m^2)
  b. Change the water heights from centimeters to meters (H)
  c. Find the specific Weight of the material: γ = Pressure /Height
  d. Find the Density of Fluid $\rho = \gamma/g$
  e. Find the specific volume = $1/\rho$
  f. Find the relative density of the material: r.d. = ρ/ρ_{water}
  g. Find the specific gravity of the material: S.G = γ / γ_{water}

3. **Experiment Title: Surface Tension, Head& Pressure, and Pressure using Different Shapes of Tubes**:

- **Objective:** observe the Surface Tension, Head& Pressure, and Pressure using Different Shapes of Tubes
- **Equipment:** Different diameters of vertical glass tubes connected via a horizontal tube, Different shapes of vertical glass tubes connected via a horizontal tube, set of four shapes of glass tubes
- **Procedure**:

i. Using Different diameters of vertical glass tubes connected via a horizontal tube:
   a. Pour water in the largest diameter tube.
   b. Notice the water level in smaller diameter tubes.

ii. Different shapes of vertical glass tubes connected via a vertical tube:
   c. Pour water in each tube to predetermined level.
   d. Notice the water level in the other different shapes tubes.

iii. set of four shapes of glass tubes:
   e. Pour water in each tube to predetermined level.
   f. Read the value on of pressure on the pressure meter.

- **Calculations and Results**:

a. Surface Tension Experiment: Water height should be inversely proportional to the diameter.
b. Head and Pressure Experiment: water level should be the same in all different diameters pipes.
c. Pressure using different shapes of tubes Experiment: Pressure should be the same for each water height irrespective of the shape of tube.

4. **Experiment Title: Determination of Discharge (Q):**

- **Objective:** Determination of Discharge
- **Equipment:** Lower Water tank, Submersible Pump, Pipework, and valves graduated upper water tank, Stopwatch.
- **Procedure**:
  a. Put the electric power "ON".
  b. Operate the water pump.
  c. Close the valve connecting the upper and lower water tanks and operate the stopwatch simultaneously.
  d. Read and record the cumulative volume and Time.
- **Calculations and Results**:
  a. Find Δt and ΔV.
  b. For each time step Δt and ΔV find the discharge = ΔV/ Δt.
  c. Find the average discharge for all steps.

5. **Experiment Title: Flow over Sharp Crested Weir:**

- **Objective:** Determination of the coefficient of discharge for the Sharp Crested Weir
- **Equipment:** Sharp crested weir on rectangular channel, Lower Water tank, Submersible Pump, Pipework, and valves, graduated upper water tank, Stopwatch.
- **Procedure**:
  a. Put the electric power "ON".
  b. Operate the water pump.
  c. Find the discharge as per experiment (4).
  d. Measure and record the width of channel.
  e. Measure and record the water depth before the weir.
  f. Measure and record the height of the weir.

- **Calculations and Results**:
  d. Estimate the total head above the weir.
  e. Equate the discharge found in step "C" above to the flow over the weir.
  f. Using the equation of the weir find the discharge coefficient (C_d).

6. **Experiment Title: Demonstration of Bernoulli Principle:**

- **Objective:** Demonstration of Bernoulli Principle
- **Equipment:** Venturi-meter, Lower Water tank, Submersible Pump, Pipework, and valves, six piezometers fixed in the venturi-meter, pitot tube, Total head piezometer.
- **Procedure**:
    a. Put the electric power "ON".
    b. Operate the water pump.
    c. Find the discharge as per experiment (4).
    d. Move the pitot tube sensor to first piezometer.
    e. Read the water level on the first piezometer.
    f. Read the water level on the total head piezometer.
    g. Repeat the steps c, d, and e for the remaining five piezometers.
    h. Record the cross-sectional area of the venturi at each piezometer.
- **Calculations and Results**:
    i. Find the pressure head at each piezometer: P= γh.
    j. Find the velocity head at each piezometer= Total head –pressure head.
    k. Find the velocity of water at each piezometer.
    l. Find the velocity of water at each piezometer using the continuity equation= Q/A
    m. Compare the velocities found in steps K and I
    n. Draw the profile of the total head.
    o. Draw the profile of the pressure head.
    p. Draw the profile of the velocity head.

7. **Experiment Title: Head losses in Valves and Fittings:**

- **Objective**: Find the head losses and loss coefficient in valves and fittings.
- **Equipment:** Venturi-meter, Lower Water tank, Submersible Pump, Pipework, and valves, six piezometers fixed in the venturi-meter, pitot tube, Total head piezometer.
- **Procedure**:
    a. Put the electric power "ON".
    b. Operate the water pump.
    c. Find the discharge as per experiment (4).
    d. Read the water level on the piezometers before and after the fittings or valve.
    e. Record the cross-sectional area of at each fitting or valve.

- **Calculations and Results**:
    a. Find the velocity of flow at each fitting or valve.
    b. Find the head loss at each fitting or valves= head before–head after.
    c. Find the head loss coefficient.

8. Experiment Title: Flow over Sharp Crested Weirs and Hydraulic Jump:

- **Objective**: Find the Characteristics of a Hydraulic Jump**.**
- **Equipment:** Sharp crested weir on rectangular channel, Lower Water tank, Submersible Pump, Pipework, and valves, graduated upper water tank, Stopwatch.
- **Procedure**:
    a. Put the electric power "ON".
    b. Operate the water pump.
    c. Find the discharge as per experiment (4)
    d. Adjust the flow and channel to form a hydraulic jump.
    e. Measure the water depth before the weir, after the weir and after the jump.
- **Calculations and Results**:
    a. Find the velocity of flow before the weir, after the weir and after the jump.
    b. Find Froude number before the weir, after the weir and after the jump.
    c. Determine the type of jump, head loss in jump and efficiency of the jump.

9. Experiment Title: Flow over Broad Crested Weirs and Hydraulic Jump:

- **Objective**: Find the Characteristics of a Hydraulic Jump
- **Equipment:** Broad crested weir on rectangular channel, Lower Water tank, Submersible Pump, Pipework and valves, graduated upper water tank, Stop watch.
- **Procedure**:
    a. Put the electric power "ON".
    b. Operate the water pump.
    c. Find the discharge as per experiment (4).
    d. Adjust the flow and channel to form a hydraulic jump.
    e. Measure the water depth before the weir, after the weir and after the jump.
- **Calculations and Results**:
    a. Find the velocity of flow before the weir, after the weir and after the jump.
    b. Find Froude number before the weir, after the weir and after the jump.
    c. Determine the type of jump, head loss in jump and efficiency of the jump.

10. Experiment Title: Manning's and Chazy's Normal Flow Equations:

- **Objective**: Find the Manning's and Chazy's **Coefficients** for Normal Flow
- **Equipment:** rectangular channel, Lower Water tank, Submersible Pump, Pipework and valves, graduated upper water tank, Stopwatch.
- **Procedure**:
    a. Put the electric power "ON".
    b. Operate the water pump.
    c. Find the discharge as per experiment (4)
    d. Measure the width of channel.
    e. Measure the average water depth in the channel.
- **Calculations and Results**:
    a. Find the Channel Parameters i.e. hydraulic radius, wetted perimeter, and slope of water level.
    b. Find Manning's "n".
    c. Find Chazy's **Coefficients**.