Department of Mechanical Engineering
Instrumentation and Control Lab (ME-402)

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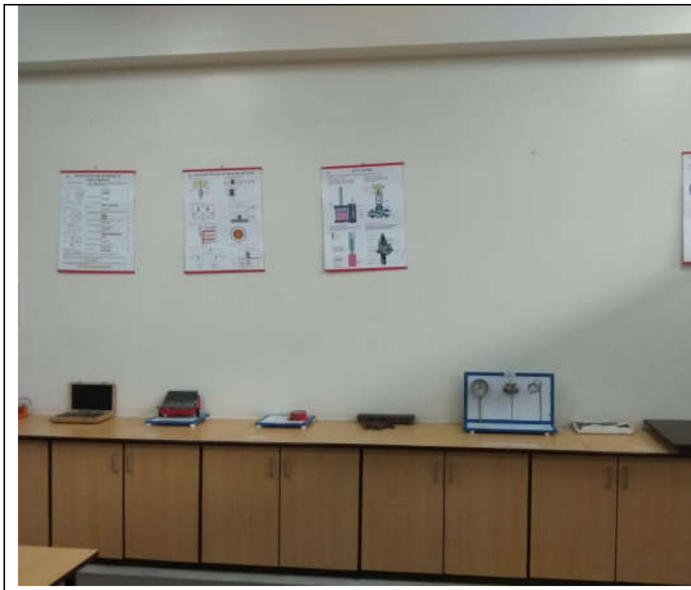
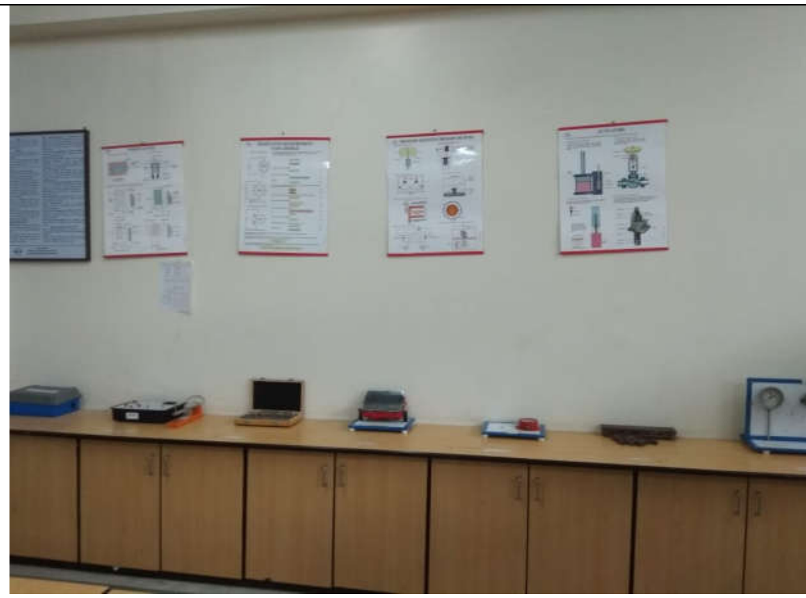
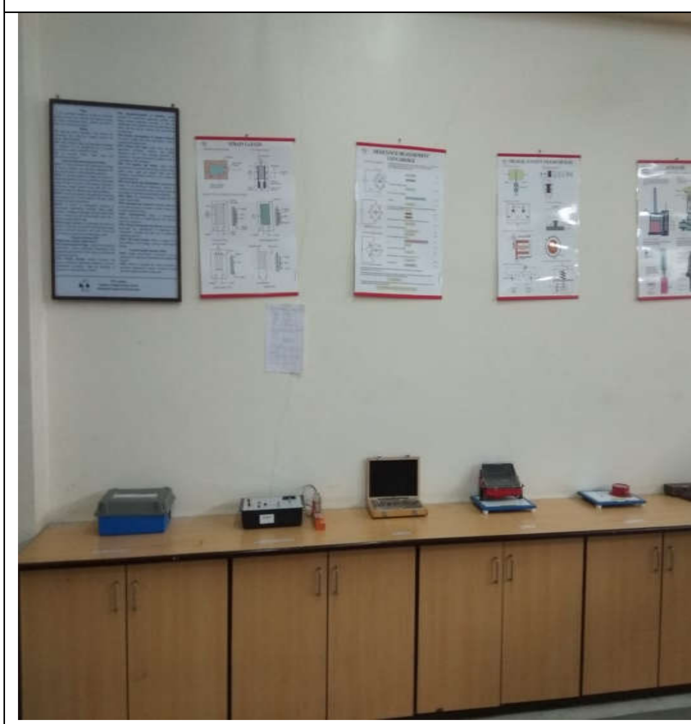
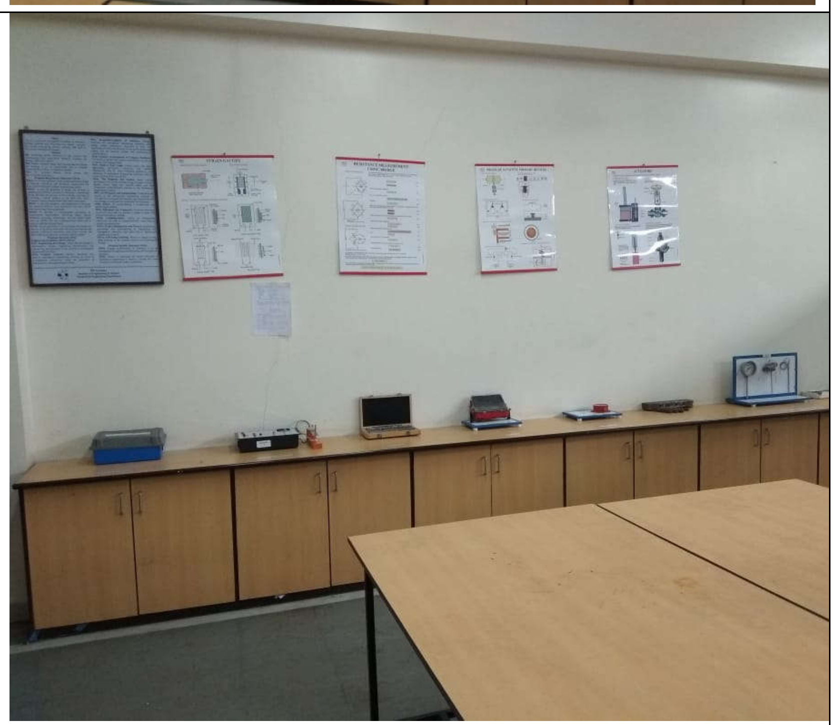








Department of Mechanical Engineering

List of Equipments With Price

Instrumentation and Control Lab

S No.	List of Equipments	Date	Price (in Rs.)
1	Thermocouple/RTD/Gas Thermometer	16/08/2015	8500
2	Pressure Gauge	16/08/2015	2500
3	Load Cell trainer kit	16/08/2015	11000
4	Milometer	16/08/2015	3500
5	Slip Gauge	16/08/2015	22000
6	Combination set	16/08/2015	5500
7	Micrometer	16/08/2015	6500
8	Sine Bar	16/08/2015	19000
9	Filler Gauge	16/08/2015	800
10	Dial gauge	16/08/2015	3000
11	Spring Calliper	16/08/2015	8800
12	Surface Plate	16/08/2015	11000
13	Wheatstone bridge	16/08/2015	10500
14	Strain Gauge Trainer Kit	5/3/2019	13320
15	LVDT Trainer Kit	5/3/2019	13320
16	Digital Infrared Thermometer	5/3/2019	4680
17	Thermohygrometer Testo 610	5/3/2019	8820
18	Digital Manometer Testo 510	5/3/2019	10800
19	Universal Hydrometer	5/3/2019	810

Department of Mechanical Engineering

List of Major Equipments with Price

Instrumentation and Control Lab

S No.	List of Equipments	Date of Purchase	Price (in Rs.)
1	Slip Gauge	16/08/2015	22000
2	Sine Bar	16/08/2015	19000
3	Strain Gauge Trainer Kit	5/3/2019	13320
4	LVDT Trainer Kit	5/3/2019	13320
5	Load Cell trainer kit	16/08/2015	11000
6	Surface Plate	16/08/2015	11000

Department of Mechanical Engineering

List of Equipments purchased in Last Five Years with Price

Instrumentation and Control Lab

S No.	List of Equipments	Date of Purchase	Price (in Rs.)
1	Strain Gauge Trainer Kit	5/3/2019	13320
2	LVDT Trainer Kit	5/3/2019	13320
3	Digital Infrared Thermometer	5/3/2019	4680
4	Thermohygrometer Testo 610	5/3/2019	8820
5	Digital Manometer Testo 510	5/3/2019	10800
6	Universal Hydrometer	5/3/2019	810

IPS Academy, Indore

Institute of Engineering & Science
Mechanical Engineering Department

LAB MANUAL
INSTRUMENTATION & CONTROL
(ME-402)

Name ……………………………………………….

Session ……………Semester …………………….

Enrollment No. ……………..

CONTENTS

Vision of the Institute

To be the fountainhead of novel ideas & innovations in science & technology & persist to be a foundation of pride for all Indians.

Mission of the Institute

M1: To provide value based broad Engineering, Technology and Science where education in students are urged to develop their professional skills.

M2: To inculcate dedication, hard work, sincerity, integrity and ethics in building up overall professional personality of our student and faculty.

M3: To inculcate a spirit of entrepreneurship and innovation in passing out students.

M4: To instigate sponsored research and provide consultancy services in technical, educational and industrial areas.

Vision of the Department

"To be a nationally recognized, excellent in education, training, research and innovation that attracts, rewards, and retains outstanding faculty, students, and staff to build a Just and Peaceful Society."

Mission of the Department

M1. Imparting quality education to the students and maintaining vital, state-of-art research facilities for faculty, staff and students

M2. Create, interpret, apply and disseminate knowledge for learning to be an entrepreneur and to compete successfully in today's competitive market

M3. To inculcate Ethical, Social values and Environment awareness

Program Educational Objectives (PEOs)

PEO1: To enrich graduates with fundamental knowledge of Physics, Chemistry and advanced Mathematics for their solid foundation in Basic Engineering science.

PEO2: To provide graduates to design the solution of engineering problems relevant to mechanical engineering design through the process of formulating, executing & evaluating a design solution as per need with socio-economic impact consideration and related constraints.

PEO3: To provide graduates with experience in learning and applying tools to solve theoretical and open ended mechanical engineering problems.

PEO4: To provide a contemporary grounding in professional responsibility including ethics, global economy, emerging technologies and job related skills such as written and oral communication skills and to work in multidisciplinary team.

PEO5: Prepare graduates to be interested, motivated, and capable of pursuing continued life-long learning through beyond curriculum education, short term courses and other training programme in interdisciplinary areas.

Program Outcomes (POs)

Engineering Graduates will be able to:

PO1: Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of Mechanical engineering problems.

PO2: Problem analysis: Identify, formulate, and analyze mechanical engineering problems to arrive at substantiated conclusions using the principles of mathematics, and engineering sciences.

PO3: Design/development of solutions: Design solutions for mechanical engineering problems and design system components, processes to meet the specifications with consideration for the public health and safety, and the cultural, societal, and environmental considerations.

PO4: Conduct investigations of complex problems: An ability to design and conduct experiments, as well as to analyze and interpret data.

PO5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to mechanical engineering problems with an understanding of the limitations.

PO6: The engineer and society: Apply critical reasoning by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the Mechanical engineering practice.

PO7: Environment and sustainability: Understand the impact of the Mechanical engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.

PO8: Ethics: An understanding of professional and ethical responsibility.

PO9: Individual and teamwork: Function effectively as an individual, and as a member or leader in teams, and in multidisciplinary settings.

PO10: Communication: Ability to communicate effectively. Be able to comprehend and write effective reports documentation.

PO11: Project management and finance: Demonstrate knowledge and understanding of engineering and management principles and apply this to Mechanical engineering problem.

PO12: Life-long learning: ability to engage in life-long learning in the broadest context of technological change.

Program Specific Outcomes (PSOs)

PSO1: Engage professionally in industries or as an entrepreneur by applying manufacturing and management practices.

PSO2: Ability to implement the learned principles of mechanical engineering to analyze, evaluate and create advanced mechanical system or processes

Course Outcomes (COs)

At the end of the course the students will be able to

Course Code with CO nos.	Statement of CO	Blooms Taxonomy Level
CO.1	Identify various functional element of measuring instrument and understand various errors and difference between static and dynamic characteristics	**BT-2**
CO.2	Solve design problems of dynamic measurements involving first and second order systems	**BT-3**
CO.3	Solve problems on temperature, pressure and flow measurement	**BT-3**
CO.4	Solve problems on strain, force, torque measurements and understand Linear Variable Differential Transducer	**BT-3**
CO.5	Describe various types of control systems	**BT-2**

Laboratory Regulations and Safety Rules

1. Never work alone in the laboratory. Students are not permitted to work in laboratory in the absence of the authority.
2. Read the instructions carefully before use of equipment.
3. If an instrument or piece of equipment fails during use, or isn't operating properly, report the issue to a technician right away. Never try to repair an equipment problem on your own.
4. Experiments must be personally monitored at all times. Do not wander around the Lab.
5. Be prepared for your work in the laboratory. Read all procedures thoroughly before entering the laboratory.
6. Put your bags outside the lab before entering in lab.

INDEX

S. No.	Name of Experiment	Date	Grade	Signature
1	To determine the Error in Measurement and their Statistical Analysis			
2	To demonstrate the use of Venturimeter & Orificemeter as flow meters			
3	To measure the velocity of flow at different points in a pipe			
4	To Study Temperature Measuring Instruments.			
5	To study the working of Bourdon Pressure Gauge			
6	To determine the stress through an Strain Gauge			
7	To determine the Weight with the help of an Load Cell			
8	To study a Linear Variable Differential Transformer (LVDT) and use it in a simple experimental set up to measure a small displacement			
9	Measurement of Brake Torque and Brake Power by Rope Brake Dynamometer			

Experiment No: 1

Aim: To determine the Error in Measurement and Their Statistical Analysis

Equipment Used:

Vernier Caliper, Micrometer Caliper & Iron bar

Objective:

To become acquainted with types of error and statistical methods for analyzing one's data and for estimating its accuracy.

Theory:

Error is known to be the difference between a calculated or observed value and the true value. All experimental uncertainties are due to the presence of two types of experimental errors: **systematic errors** and **random errors**. The difference between random errors and systematic errors can be shown by repeating the measurement of a physical quantity several times under the same conditions. Random errors are statistical fluctuations or variations in the measured data produced by the experimenter's inability to take the same measurement in exactly the same way to get exactly the same reading. Therefore, the readings will be spread about the true value.

Systematic errors, on the other hand, are reproducible in accuracies that cause the measurements to constantly be in the same direction (either too high or too low). They are mostly due to defects in the measuring devices which make them continually present throughout the entire experiment. Therefore, the readings will always be displaced far from the true value. For that reason, way Systematic errors are difficult to detect and cannot be analyzed statistically.

(a) A set of measurements taken with random errors only.
(b) Shows a set of measurements with both systematic and random errors.

• The **Accuracy** of an experiment is a measure of how close the result obtained for a given experiment is compared to the true value.

• The **Precision** of an experiment is a measure of how exactly the result is determined.

Observation Table

Sr. No.	Value in mm	Mean "x"	Deviation "d"= (x_i - X)	Mean absolute deviation **"D"= Σ | d |/N**	S.D "σ"	Variance "V"= σ^2
1						
2						
3						
4						
5						
6						
7						
8						
9						
10						

Formula Use

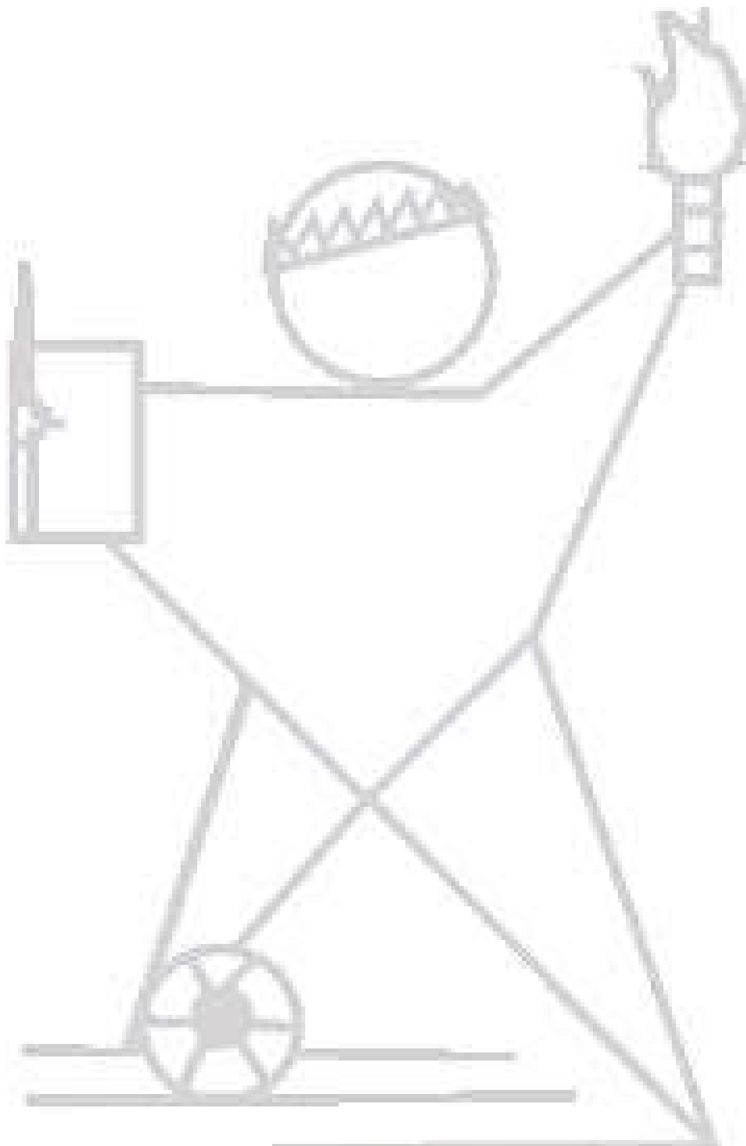
$$\overline{x} \equiv \frac{1}{N}\sum_{i=1}^{N} x_i.$$

$$\sigma = \sqrt{\frac{\sum(x-\overline{x})^2}{N}}$$

Result:

Question and Answer

Define Gross Error
Define Systematic Errors
Define Random Errors
What is Precision?



EXPERIMENT NO: 2

VENTURIMETER & ORIFICEMETER

OBJECTIVE: To demonstrate the use of Venturimeter & Orificemeter as flow meters.

AIM:To determine the Co-efficient of Discharge C_d.

INTRODUCTION: If a constriction is placed in a closed channel carrying a steam of fluid, there will be increase in velocity, and hence increase in Kinetic Energy at the constriction from an energy balance, as given by Bernoulli's Theorem, there must be a corresponding reduction in pressure. Rate of discharge from the constriction can be calculated by knowing this pressure reduction, the area available for flow at the constriction, the density of fluid, and the Co-efficient of discharge. The last named is defined as the ratio of actual flow to the theoretical flow and makes allowance for stream contraction and frictional effects.

THEORY:

VENTURIMETER:

A Venturimeter consists of:

1. An inlet section followed by a convergent cone.
2. A Cylinder Throat.
3. A gradually divergent cone.

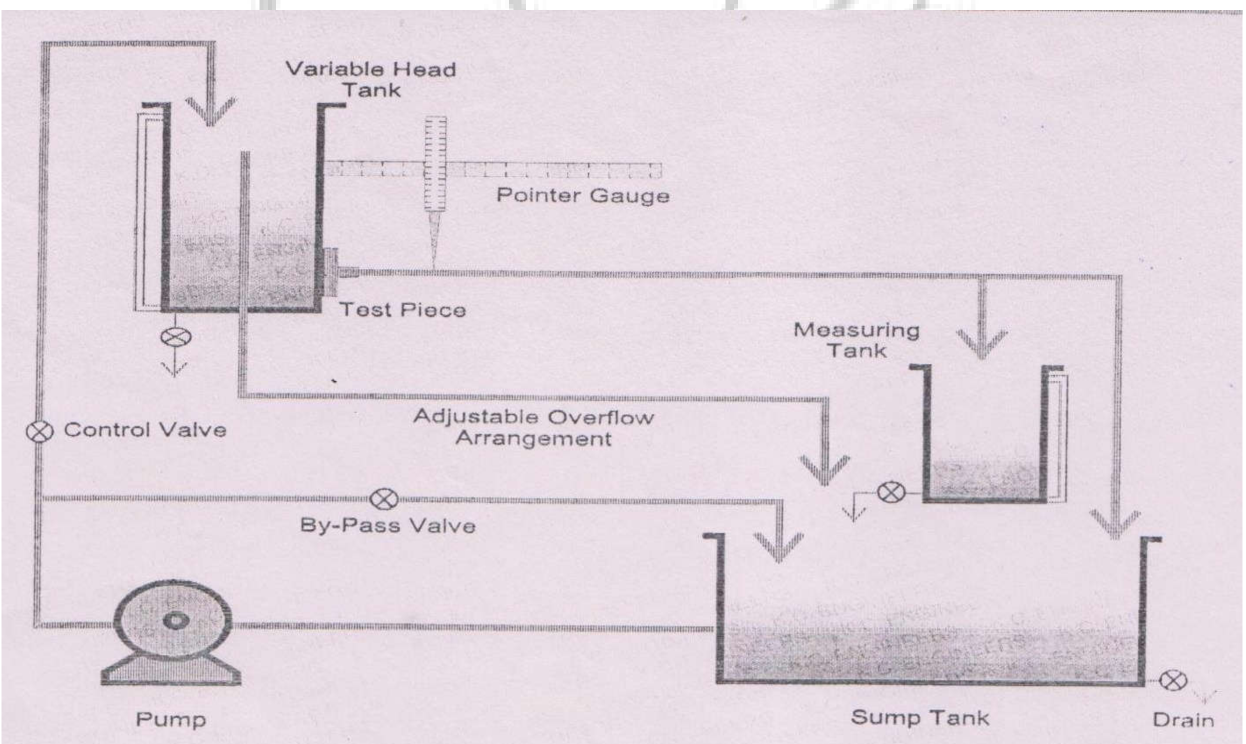
The inlet section of the Venturimeter is of the same diameter as that of the pipe, which is followed by a convergent cone. The convergent cone is a short pipe, which tapers from the original size of the pipe to that of the Throat of the Venturimeter . The Throat of the Venturimeter is a short parallel side tube having its cross-sectional area smaller than that of the pipe. The divergent cone of the Venturimeter is gradually diverging pipe with its cross-sectional area increasing from that of the Throat to the original size of the pipe. At inlet section & Throat of the Venturimeter, pressure taps are provided.

ORIFICEMETER:

An Orificemeter consists of a flat circular plate with a circular hole called Orifice which is concentric with the pipe axis.

DESCRIPTION:

The apparatus consists of a Venturimeter and an Orificemeter, fitted in pipeline. The pipeline is taken out from a common inlet. At the downstream end of the pipeline, separate control valves are provided to regulate the flow through the Venturimeter and Orificemeter to conduct experiment separately. Pressure tapings are taken out from inlet and Throat of Venturimeter , inlet and outlet of Orificemeter, and are connected to a differential manometer. Discharge is measured with the help of measuring tank & Stop Watch.



Schematic Diagram for Venturimeter & Orificemeter Apparatus

UTILITIES REQUIRED:

1. Power supply: Single Phase, 220 volts, 50Hz, 5 Amp with Earth.
2. Water Supply.
3. Drain
4. Space required : 1.6m x 0.6m

EXPERIMENTAL PROCEDURE:

Starting procedure:

1. Clean the apparatus and make all tanks free from dust.

2. Close the drain valves provided.

3. Fill sump tank ¾ with clean water and ensure that no foreign particles are there.

4. Close all Flow Control Valves given on the water line and open By-Pass Valve.

5. Check the level of mercury (Hg) in manometer tube. It should be up to half. If it is less, then fill it.

6.Close all pressure taps of manometer connected to Venturimeter & Orificemeter.

7. Ensure that On/Off switch given on the panel is at OFF position.

8. Now switch on the main power supply (220 Volts AC,50 Hz).

9. Switch on the pump.

10. Operate the flow control valve to regulate the flow of water in the desired Test Section.

11. Open the pressure taps of manometer of related test section, very slow to avoid the blow of water on manometer fluid.

12. Now open the air release valve provided on the manometer, slowly to release the air in manometer.

13. When there is no air in the manometer, close the air release valves.

14. Adjust water flown rate in desired section with the help of Control Valve.

15. Record the manometer reading.

16. Measure the flow of water discharged through desired test section, using Stop Watch and measuring tank.

17. Repeat steps 10 to 16 for different flow rates of water, operating control valve and by-pass valve.

18. When experiment is over for one desired test section, open the By-Pass Valve fully. Then close the flow control valve of running test section and open the control valve of Secondly desired test section.

19. Repeat steps 10 to 18 for selected test section and so on.

CLOSING PROCEDURE:

1. When experiment is over, close all Manometers pressure taps first.

2. Switch off Pump.

3. Switch off power supply to panel.

SPECIFICATION:

Venturimeter : Material Clear Acrylic compatible to 1’’ Dia. Pipe.

Orificemeter : Material Clear Acrylic compatible to 1’’ Dia. Pipe.

Water Circulation : FHP Pump.

Flow Measurement: Using Measuring tank with Piezometer, Capacity 25 Ltrs.

Sump Tank : Capacity 50 Ltrs.

Stop Watch : Electronic.

Control Panel Comprises of standard make On/Off Switch, Mains Indicator, etc.

Tanks will be made of Stainless Steel. The whole set-up is well designed and arranged in a good quality painted structure.

FORMULAE:

For Both Venturimeter & Orificemeter:

Theoretical Discharge (Q_t):

Q_t = □□□□√□□□ / √□□ − □□

Actual Discharge (Q_a):

Q_a = □ □ □ / □

Co-Efficient Of Discharge (C_d):

C_d = □□ / □□

H = 12.6 x h

$$H = \frac{h_1 - h_2}{100}, \text{ m} = \text{--------- m}$$

$$R = \frac{R_1 - R_2}{100}, \text{ m} = \text{---------- m}$$

$$Q_a = \frac{A \times R}{t}, \text{ m}^3/\text{sec} = \text{-------------- m}^3/\text{sec}$$

$$a_1 = \frac{\pi}{4} d_1^2, \text{m}^2 = \text{-------------} \text{ m}^2$$

$$a_2 = \frac{\pi}{4} d_2^2, \text{m}^2 = \text{-------------} \text{ m}^2$$

$$Q_t = \frac{a_1 a_2 \sqrt{2gH}}{\sqrt{a_1^2 - a_2^2}}, \text{m}^3/\text{s} = \text{----------} \text{ m}^3/\text{s}$$

$$C_d = \frac{Q_a}{Q_t} = \text{-----------}$$

NOMENCLATURE:

A	=	Area of Measuring Tank, m^2
a1	=	Area at inlet of venturi meter and orifice meter, m^2
a_2	=	Area at Throat of venturi meter and Area of orifice, m^2
C_d	=	Coefficient of discharge.
d_1	=	Diameter at inlet of venturimeter & orifice meter, m
d2	=	Diameter at throat of venturimeter & dia of orifice, m
g	=	Acceleration due to gravity, m/sec^2
H	=	Loss of head, m of water.
h_1, h_2	=	Manometer reading at both points, cm.
Qa	=	Actual discharge, m^3/sec.
Qt	=	Theoretical discharge, m^3/sec.
R	=	Rise of Water level in Measuring Tank, m.
R_1	=	Final level of water in measuring tank, cm.
R_2	=	Initial level of water in measuring tank, cm.
t	=	Time taken for Rise of water level in measuring tank, sec.
h	=	Pressure Difference in m of Hg.

OBSERVATIONS&CALCULATIONS

DATA:

A = Area of measuring tank = 0.1 m^2

S = Specific gravity of Hg = 13.6

g = Accelerations due to Gravity = 9.81 m/sec^2

For Venturimeter:

d_1 = Dia. at inlet of the Venturimeter = 0.028 m

d_2 = Dia. at throat of the Venturimeter = 0.014 m

a_1 = $\pi d_1^2/4$ cm^2 Area at inlet of Venturimeter = 6.157×10^{-4} m^2

a_2 **=** $\pi d_2^2/4$ cm^2 Area at throat of Venturimeter **= 1.539** x 10^{-4} m^2

For Orificemeter:

d_1 = Dia. at inlet of the Orificemeter = 0.028 m

d_2 = Dia. of Orifice Plate = 0.014 m

a_1 = $\pi d_1^2/4$ cm^2 Area at inlet of Orificemeter = 6.157×10^{-4} m^2

a_2 **=** $\pi d_2^2/4$ cm^2 Area of Orifice Plate = 1.539×10^{-4} m^2

OBSERVATION TABLE:

S.No.	Pressure difference, h(cm)	Rise of Water level in Measuring Tank R(cm)	Time taken for R, t (sec.)
1			
2			
3			

CALCULATION TABLE:

S.No.	H (m)	Actual discharge Q_a (m^3/s)	Theo.Discharge Q_t (m^3/s)	C

MAINTENANCE INSTRUCTIONS:

1. Do not run the pump at low voltage i.e. less than 180 Volts.

2. Never fully close the Delivery line and By-Pass line Valves simultaneously.

3. Always keep apparatus free from dust.

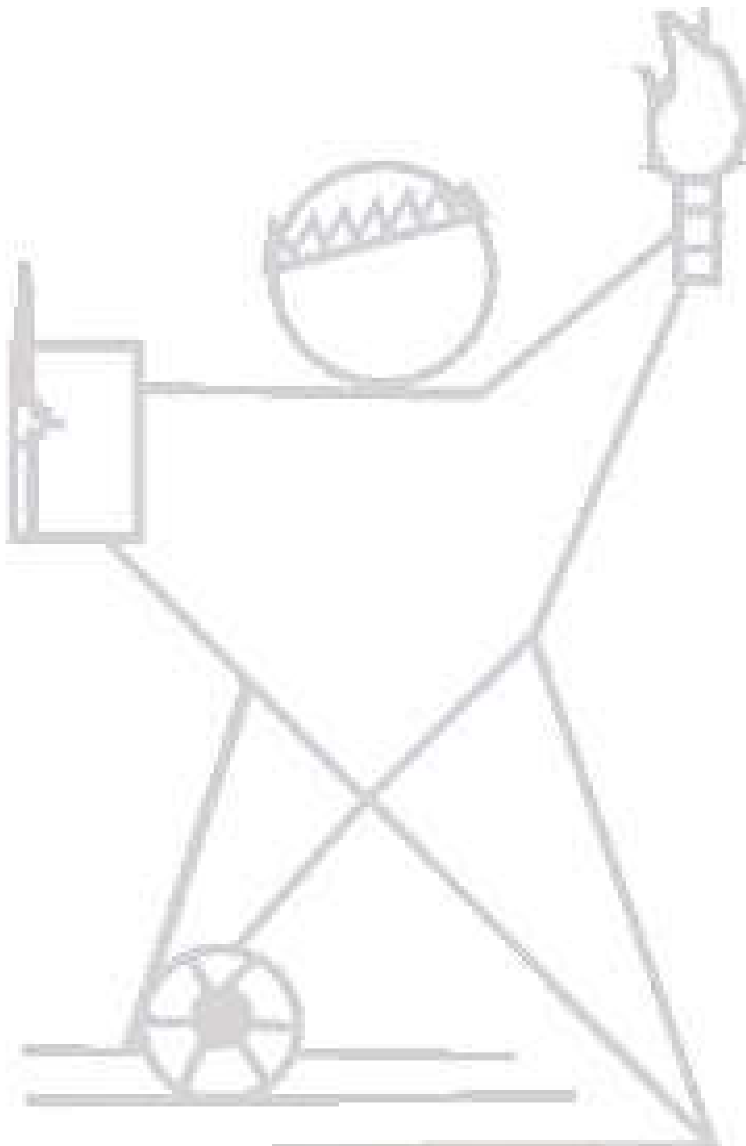
4. To prevent clogging of moving parts, Run Pump at least once in a fortnight.

5. Frequently Grease/Oil the rotating parts, once in three months.

6. Always use clean water.

7. If apparatus will not in use for more than one month, drain the apparatus

Completely, and fill pump with cutting oil.



EXPERIMENT NO: 3

PITOT TUBE APPARATUS

OBJECTIVE:

To measure the velocity of flow at different points in a pipe.

AIM:

To find the co-efficient of Pitot tube.

To find the point velocity at the centre of a tube for different flow rates.

To plot velocity profile across the cross section of pipe.

INTRODUCTION:

It is a device used for measuring the velocity of flow at any point in the pipe. It is based on the principle that the velocity of flow at a point becomes zero, there is increase in pressure due to the conversion of the kinetic energy into pressure energy. The Pitot tube consists of a capillary tube, bent at right angle.

The lower end which is bent through 90° is directed in the upstream direction. The liquid rises up in the tube due to conversion of kinetic energy into pressure energy. The velocity is determined by measuring the rise of liquid in the tube.

THEORY:

When a pitot tube is used for measuring the velocity of flow in a pipe or other closed conduit the pitot tube may be inserted in the pipe as shown in figure. Since a pitot tube measures the stagnation pressure head (or the total head) at its dipped end. The pressure head may be determined directly be connecting a suitable differential manometer between the pitot tube and pressure tapping at pipe surface. Consider two points (1) and (2) at the same level in such a way that point (2) is just at the inlet of pitot tube and point (1) is far away from the tube. At point (1) the pressure is p1 and the velocity of stream is v_1. However, at the point (2), is called stagnation point, the fluid is brought to rest and the energy has been converted to pressure energy. Therefore the pressure at (2) is p_2, the velocity v_2 is zero and since (1) and (2)are in the same horizontal plane, so z1 = z_2.

Applying Bernoulli's equation at points (1) and (2)

$$\frac{p_1}{w} + \frac{v_1^2}{2g} = \frac{p_2}{w} + \frac{v_2^2}{2g}$$

$v_2=0$

$$\frac{v_1^2}{2g} = \frac{p_2}{w} - \frac{p_1}{w}$$

$$v_1 = \sqrt{2g\left(\frac{p_2}{w} - \frac{p_1}{w}\right)}$$

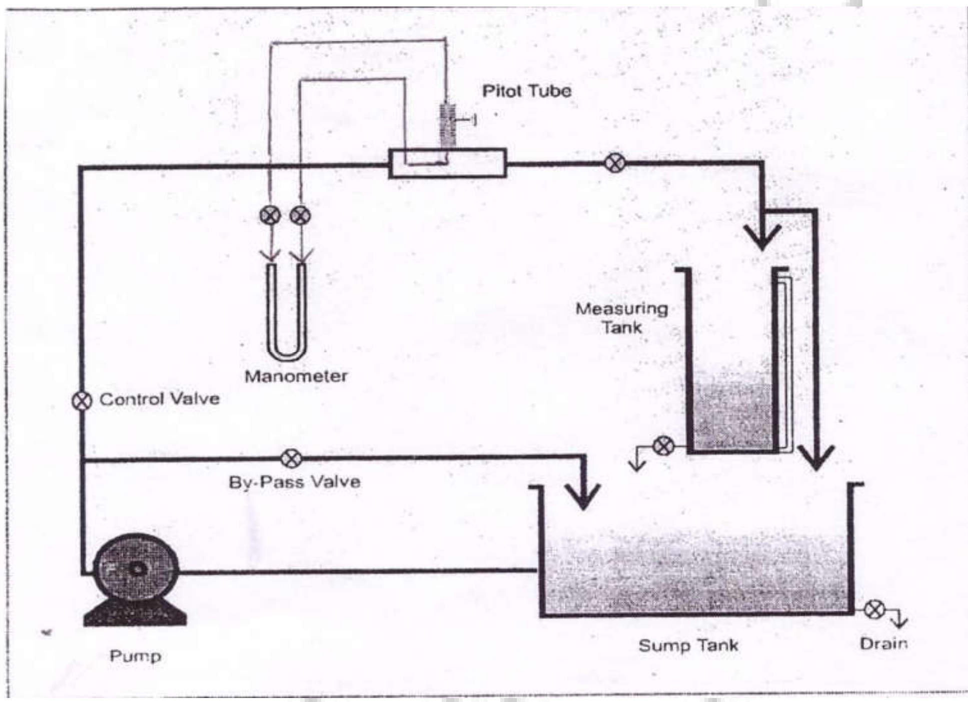
$$v_1 = \sqrt{2gh}$$

This is the theoretical velocity.

Actual velocity $(v_1)_{act} = C_v\sqrt{2}$□□

DESCRIPTION:

The apparatus consists of a Pitot tube made of copper and fixed below a pointer gauge. The pointer gauge is capable to measure the position of Pitot tube in transparent test section. The pipe has a flow control valve to regulate the flow. A U-tube manometer is provided to determine the velocity head. A pump is provided to circulate the water. Discharge is measured with the help of measuring tank and stopwatch.



Schematic Diagram for Pitot tube Set-up

UTILITIES REQUIRED:

1. Water Supply
2. Drain
3. Electricity 0.5 kW, 220V AC, Single Phase
4. Floor Area 1.5 X 0.75 m

EXPERIMENTAL PROCEDURE:

Starting Procedure:

1. Clean the tank and make the tank free from dust.

2. Close the drain valves provided.
3. Fill Sump tank ¾ with clean water and ensure there is no foreign particles there.
4. Close all flow control valves given on water line and open the By-Pass Valve.
5. Check the level of CCl_4 in all the manometer tube. It should be up to half. If it is less then fill it.
6. Close all Pressure Taps of Manometer connected to manometers.
7. Ensure that On/Off Switch is given on the panel is at OFF position.
8. Now switch on the Main Power Supply 9220V AC, 50Hz).
9. Switch on the Pump.
10. Operate the Flow Control Valve to regulate the flow of water through orifice.
11. Open the pressure taps of manometer of related section very slowly to avoid the blow of water on manometer fluid.
12. Now open the air release valve provided on the manometer slowly to release the air in manometer.
13. When there is no air the manometer close the air release valves.
14. Adjust the flow rate to desired rate with the help of control valve.
15. Set the pitot tube at the center of test section.
16. Record the manometers reading and measure the discharge with the help of measuring tank and stop watch.
17. Now move the pitot tube up and down at the same flow rate and note the manometer readings to find out the velocity at different points in pipe.
18. Calculate the co-efficient of pitot tube from actual and theoretical velocities and plot the velocities at different points inside the pipe.
19. Repeat the same procedure for different flow rates of water, operating control valve and By-Pass valve.

Closing Procedure:

1. When experiment is over, close all manometers pressure taps first, switch off pump.
2. Switch off power supply to panel.
3. Drain water from all tanks with the help of given drain valves.

SPECIFICATONS:

Pitot Tube:	Material copper of compatible size fitted with scale.
Test Section:	Material clear acrylic, compatible to 1”dia pipe.
Water Circulation:	FHP Pump
Flow Measurement:	Using measuring tank with piezometer (Capacity 40Ltrs)
Sump Tank:	Capacity 70Ltrs
Stop Watch:	Electronic

Control Panel Comprises of:

Standard make On/Off switch, Mains Indicator etc.

The whole set–up is well designed and arranged in good

Quality painted structure.

FORMULAE:

Discharge:

$$Q = \frac{A \times R}{t} \; m^3/s$$

Velocity:

$$V = \frac{Q}{a} \; (m/s)$$

Actual Velocity: $V_a = C_v\sqrt{2gH}\,(m/s)$

$$H = h\left(\frac{\rho_m}{\rho_w} - 1\right)(\text{m of water})$$

Co-efficient of Pitot tube: $C_v = \frac{V_a}{\sqrt{2gH}}$

NOMENCLATURE:

A = Area of measuring tank

a = Cross section of test section

R = Rise of water level in measuring tank

h = manometer difference

H = Pressure head in meter of water

C_v = Co-efficient of pitot tube

ρ_m = Density of manometer fluid i.e., CCl_4

ρ_w = Density of water

g = Acceleration due to gravity

V_a = Actual velocity of fluid

Q = Discharge at outlet

t = time for R

PRECAUTION & MAINTENANCE INSTRUCTIONS:

1. Do not run the pump at low voltage i.e., less than 180volts.
2. Never fully close the delivery line and By-Pass line valves simultaneously.
3. Always keep apparatus free from dust.
4. To prevent clogging of moving parts, run pump at least once in a fortnight.
5. Frequently Grease/Oil the rotating parts, once in three months.
6. Always use clean water.
7. It apparatus will not in use for more than one month, drain the apparatus completely, and fill pump with cutting oil.

TROUBLESHOOTINGS:

1. If pump gets jam, open the back cover of pump and rotate the shaft manually.
2. If pump gets heat up, switch off the main power for 15min and avoid closing the flow controlvalve and by pass valve simultaneously during operation.

OBSERVATION & CALCULATIONS:

DATA:

$A = 0.1m^2$

$a = 0.0006157m^2$

$□_m$= $1590kg/m^3$

$□_w$= $1000kg/m^3$

□ = $9.81\ m/s^2$

OBSERVATION TABLE:

S.No.	Pressure head at diff. points on up side			Pressure head at center	Pressure head at different points on down side			R(cm)	T(sec)
	8mm	6mm	4mm	0	4mm	6mm	8mm		
1.									
2.									
3.									

S.No.	C_V	v_8	v_6	v_4	v_0	v_4	v_6	v_8
1.								
2.								
3.								

CALCULATION TABLE:

Experiment No:4

Aim: To Study Temperature Measuring Instruments and to Estimate their Response times.

(a) Mercury – in glass thermometer &
(b) Thermocouple

Apparatus used: Mercury thermometer, Thermocouple setup

Theory:

(a) Mercury – in glass thermometer:

A liquid-in-glass thermometer is widely used due to its accuracy for the temperature range -200 to 600°C. Compared to other thermometers, it is simple and no other equipment beyond the human eye is required. The LIG thermometer is one of the earliest thermometers. It has been used in medicine, metrology and industry. In the LIG thermometer the thermally sensitive element is a liquid contained in a graduated glass envelope. The principle used to measure temperature is that of the apparent thermal expansion of the liquid. It is the difference between the volumetric reversible thermal expansion of the liquid and its glass container that makes it possible to measure temperature.

The liquid-in-glass thermometer comprises of

1. A bulb, a reservoir in which the working liquid can expand or contract in volume.
2. A stem, a glass tube containing a tiny capillary connected to the bulb and enlarged at the bottom into a bulb that is partially filled with a working liquid. The tube's bore is extremely small - less than 0.02 inch (0.5 millimeter) in diameter.
3. A temperature scale is fixed or engraved on the stem supporting the capillary tube to indicate the range and the value of the temperature. It is the case for the precision thermometers whereas for the low accurate thermometers such as industrial thermometer, the scale is printed on a separate card and then protected from the environment. The liquid-in-glass thermometers are usually calibrated against a standard thermometer and at the melting point of water.
4. A reference point, a calibration point, the most common being the ice point.
5. A working liquid, usually mercury or alcohol.
6. An inert gas is used for mercury intended to high temperature. The thermometer is filled with an inert gas such as argon or nitrogen above the mercury to reduce its volatilization.

The response of the thermometer depends on the bulb volume, bulb thickness, total weight and type of thermometer. The sensitivity depends on the reversible thermal expansion of the liquid compared to the glass. The greater the fluid expansion, the more sensitive the thermometer. Mercury was the liquid the most often used because of its good reaction time, repeatability, linear coefficient of expansion and large temperature range. But it is poisonous and so other working liquids are used.

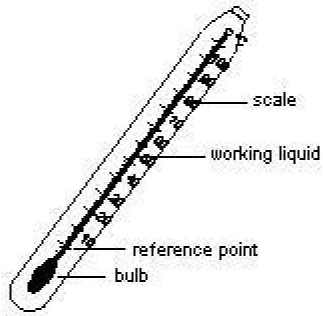


Fig: Liquid in Glass Thermometer

A **mercury-in-glass thermometer**, also known as a mercury thermometer, consisting of mercury in a glass tube. Calibrated marks on the tube allow the temperature to be read by the length of the mercury within the tube, which varies according to the heat given to it. To increase the sensitivity, there is usually a bulb of mercury at the end of the thermometer which contains most of the mercury; expansion and contraction of this volume of mercury is then amplified in the much narrower bore of the tube. The response time of the thermometer is nothing but as time constant or the time of consideration for measuring particular temperature.

(b) Thermocouple:

An electric current flows in a closed circuit of two dissimilar metals if their two junctions are at different temperatures. The thermoelectric voltage produced depends on the metals used and on the temperature relationship between the junctions. If the same temperature exists at the two junctions, the voltage produced at each junction cancel each other out and no current flows in the circuit. With different temperatures at each junction, different voltage is produced and current flows in the circuit. A thermocouple can therefore only measure temperature differences between the two junctions.

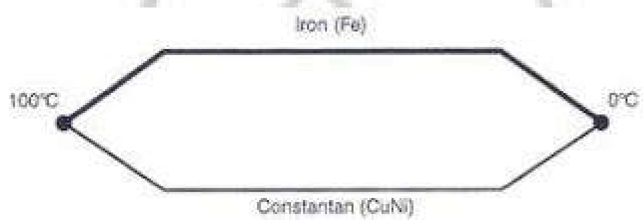


Fig: Thermocouple

Thermocouples response time is measured as a "time constant." The time constant is defined as the time required for a thermocouple's voltage to reach 63.2% of its final value in response to a sudden change in temperature. It takes five time constants for the voltage to approach 100% of the new temperature value. Thermocouples attached to a heavy mass will respond much slower than one that is left free standing because its value is governed by the temperature of the large mass. A free standing (exposed or bare wire) thermocouple's response time is a function of the wire size (or mass of the thermocouple bead) and the conducting medium. A thermocouple of a given size will react much faster if the conducting medium is water compared to still air.

Conclusion: Hence the study of various temperature measuring instruments and their response times is completed

Result:

Question and Answer

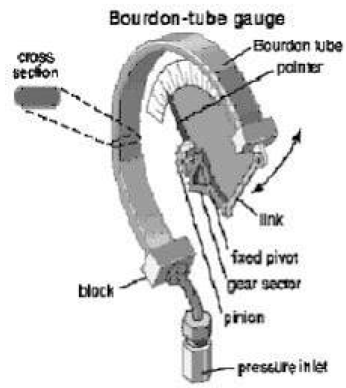
What is Peltier effect & Thomson effect ?
What is Thermocouple?
Give 5 example were Thermocouple and Mercury – in glass thermometer is used
Write Down the Material used in Thermocouple
Write down the Classification of thermocouple according to temperature range

Experiment No: 5

Aim: To study the working of Bourdon Pressure Gauge

Apparatus used: Bourdon Pressure Gauge

Working of the Bourdon Pressure Gauge: In order to understand the working of the bourdon pressure gauge, we need to consider a cross-section of the Bourdon tube, as shown in the figure.



Bourdon Tube Gauge

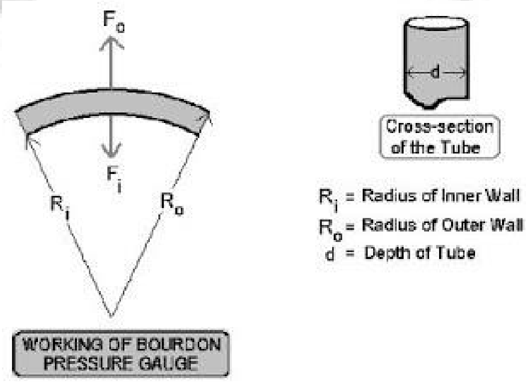


Fig: Working of Bourdon Gauge

Assume that a pressure P, which is greater than the atmospheric pressure, acts on at the pressure inlet of the gauge. According to the Pascal's Law, the pressure is transmitted equally in all directions. Therefore,
Pressure acting on the Inner Wall = Pressure acting on the Outer Wall.
Now,
Area of Outer Wall projected to the pressure = $2\pi R_o d$

Therefore,
Force on Outer wall = F_o = Pressure x Area = $2P\pi R_o d$

Similarly,
Force on Inner Wall = $F_i = 2P\pi R_i d$

Since, Ro>Ri then, Fo>Fi.

So, the force that tries to unwind the tube is greater than the force that tries to bend it further. Therefore, the tube unwinds due to the extra pressure exerted on it. This unwinding is then recorded on a scale by using a series of gears and a pointer.

Calibration is the name of the term applied to checking the accuracy or the working condition of the concerned device. So, the calibration of Bourdon Pressure Gauge refers to the checking of its accuracy or reliability in taking a reading. The apparatus used for this purpose is called the Dead-Weight Gauge Tester.

Working of the Dead-Weight Gauge Tester: The working of this gauge tester can be understood easily with the help of the following diagram.

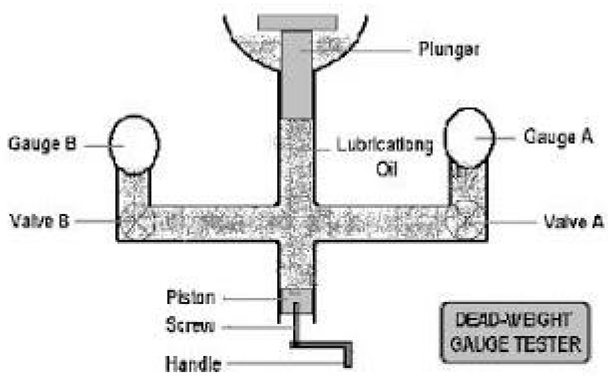


Fig: Dead-Weight Gauge Tester

In this figure gauge A and B are the ones to be calculated. We can at any stage disengage any gauge by closing the respective valve.
For the illustration purpose, we will just consider the calibration of Gauge A and assume that valve B remains closed.

Let
Weight of Plunger = W
Cross-sectional Area of the stem of Plunger = A

Therefore,
Pressure exerted on the fluid = P = W/A

Now, according to Pascal's Law, pressure is transmitted equally in all direction. Therefore pressure encountered at the inlet of Gauge A is the same as P

Now,
if Pressure registered by Gauge A = P_A = P
Within experimental limits, then the gauge is working properly. If not, then there is some problem which must be detected and accounted for.

Procedure:

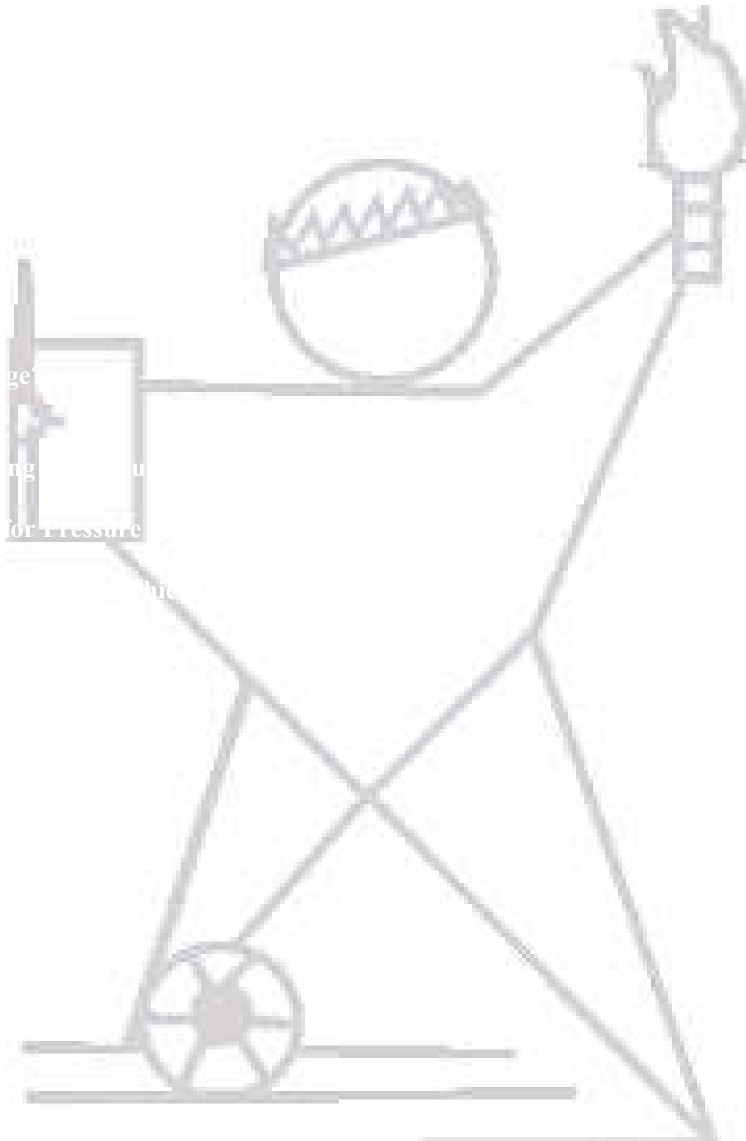
1. Fix the gauge to be tested on one end of the Dead-Weight Gauge tester and make sure that the valve is fully opened. Meanwhile close the other valve tightly so that no leakage of fluid is ensured.

2. Next, gently place the plunger in the tester ensuring that the plunger should not touch the edges of the bowl. Allow some time for the system to attain equilibrium, than take the reading from the gauge. Record both the applied

and registered pressure in a table of values. Now, remove the plunger and once again after some time record the reading on the gauge. Record it in the table.

3. Now place some weights on the plunger so that the applied pressure is varied. Then, repeat the above mentioned procedure until there are at least six readings. Record them all in the table.

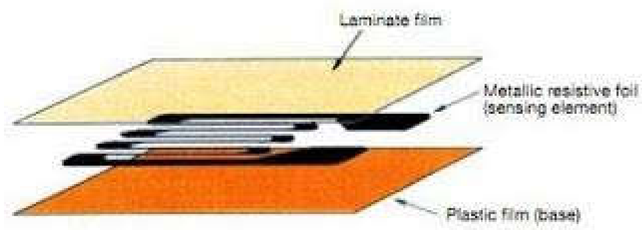
Conclusion: Hence the working of Bourdon Pressure Gauge and checking of calibration on a deadweight pressure gauge is completed.



Experiment No: 6

STRAIN GAUGE

Objective: Strain Gauge Trainer Kit with Cantilever Beam to study the performance characteristics of a Strain Gauge. It allows the students to understand the concept of Strain Gauge, its application and its associated electronic circuits.



The instrument comprises of the following parts:

(i) A bonded metal foil strain gauge is mounted on a cantilever with arrangement to fix some load on it to generate the deformation.

(ii) 3- dummy gauge DG-1, DG – 2, DG-3 are provided internally to form a 4- arm Wheatstone Bridge.

(iii) Electronic circuitry along with a 3 ½ Digit Digital Volt Meter (DVM).

SPECIFICATION:

(I) Cantilever Beam : With a bonded strain Gauge

Measuring Range : 500 µS.

Non – linearity Errors : ± 1%

Resolution : 1 µS.

(II) Electric Circuit:

Excitation Source : DC Excitation (5 Volts)

Amplifiers : Instrumentation and Inverting Summing with zero & Gain adjustment

Termination : For 2 arm strain gauge bridge.

Dummy Gauges : 3 Nos. provided

(III) DPM : 3 ½ Digit LED

Display : 0 – 2000mV F.S.

Range : 0 - 2000 µS. and 19.99 ohms,

A toggle switch is provided to select the micro strain (µS.) or resistance range.

(IV) Power Supply : The kit has number of IC Regulated Power Supplies
Which are permanently connected to all the circuits
No external DC Supply should be connected to the unit
Only 230V ± 10%, 50HZ mains supply is required to
Operate the kit.

STRAIN GAUGE:

If a metal conductor is stretched or compressed, its resistance changes

Account of the fact that both length and diameter of conductor change. Also

There is a change in the value of resistivity of the conductor when it is strained

And this property is called piezo – resistive effect.

If a conductor of elastic material is subjected or in other words positively strained, its

Longitudinal dimensions will increase while there will be a reduction in the lateral dimensions. So when a gauge is subjected to a positive strain, its length increases while its area of cross – section decrease. Since the resistance of a conductor is proportional to its length and inversely proportional to its area of a cross – section, the resistance of the gauge increases with positive strain.

The resistance of unstrained gauge is,

$$R = \frac{\square\square}{\square} \quad (1)$$

Where L is length, A is cross section area and □ is the resistivity of wire.

The gauge factor is defined as the ratio of per unit change in resistance to per unit

Change in length.

$$G_f = \frac{\Delta R/R}{\Delta\square/\square} \quad (2)$$

The gauge factor can be written as

$$G_f = 1 + 2V = \frac{\Delta\square/}{\epsilon} \quad (3)$$

The strain is usually expressed in terms of micro strains

1 micro strain = 1 μm/m

TYPES OF STRAIN GAUGES:

The following are the major types of strain Gauges.

(1) Unbounded Metal Strain Gauges.

(2) Bonded Metal Wire Strain Gauges.

(3) Bonded Metal Foil Strain Gauges.

(4) Vacuum Deposited Thin Metal Film Strain Gauges.

(5) Sputter Deposited Thin Metal Strain Gauges.

(6) Bonded Semi – conductor Strain Gauges.

(7) Diffused Metal Strain Gauges.

For a Cantilever Beam,

The strain is given by

$$€ = \frac{\sigma}{\square}$$

Where $\sigma = \frac{6FL}{\square\square 2}$

Where L = Length of Cantilever Beam (m)

t = Thickness of Cantilever Beam (m)

w = Width of Cantilever Beam (m)

E = Modulus of Elasticity (N/m^2)

F = The Applied Force (N)

For the experimental Cantilever Beam

L = $125mm \times 10^{-3}$ m

t = $2.06mm \times 10^{-3}m$

w = $22.8mm \times 10^{-3}m$

E = 210×10^{9} N/m^2

For 1 kgf Force applied on one end of cantilever

$$\sigma = \frac{6x\ 1x\ 9.80665 \times 125 \times 10^{-3}}{22.8 \square 10^{-3} \square (2.06 \square 10^{-3})2} \quad (1\ kgf = 9.80665N)$$

$$= \mathbf{76.017337 \times 10^{6}\ N/m^{2}}$$

Hence € $= \frac{\sigma}{\square} = 76.017337 \times 10^{6} / 210 \times 10^{6}$

$= 361.9873 \times 10^{-6}$ µS

So that for 1 kgf. Force, 362 µS will be developed in the present Cantilever Beam**.**

This strain we are sensing with a single Bonded Metal Foil Strain Gauge, which is bonded on a Cantilever Beam. It is observed that at 1 kgf. The change in resistance of strain gauge is 0.42 ohms. The calibration table for strain and change in resistance with applied load are given in table (10) & (2).

Note: These observations are sample observations and may vary from piece to piece.

PROCEDURE

1. Connect the Cantilever Beam leads with the trainer kit terminals i.e. Red lead with Red Terminal & Black lead with Black Terminal.

2. Keep Digital Volt Meter (DVM) switch at µS position.

3. Switch “ON” the trainer kit, the display will light up and will show some reading.

4. Adjust zero potentiometer to set 000 reading on display, without apply any load on the pan.

5. Put 1 kg. Weight on the pan of the cantilever beam and adjust Gain potentiometer to show 362 reading on display.

6. Repeat steps 3 to 5 for two or three times.

7. Now apply loads in steps of 50/100 gms. And note down the reading in the Table (3) in increasing & decreasing mode.

8. Now plot the graph between applied load and DVM reading in µS.

With a resolution of 1 µS and measure Non – Linearity, Hysteresis error etc.

RESISTANCE MEASUREMENT:

9. Keep DVM switch at Resistance position.

10. Adjust zero potentiometer to set 0.00 reading on display, without apply any load on the pan

11. Put 1 kg. weight on the pan of the cantilever beam and adjust Gain potentiometer to 0.42 reading on display.

TABLE

Sr. No.	Reading in Increasing Mode		Reading in Decreasing Mode	
	Applied Load In Kg.	DVM In µS	Applied Load In Kg.	DVM In µS
1.				
2.				
3.				
4.				
5.				

12. Repeat steps 10 to 11 for two or three times.

13. Now apply loads in steps of 50/100 g. And note down the reading in the Table (4) in increasing & decreasing mode.

14. Now plot the graph between applied load and DVM reading in ohms. With a resolution of 0.01 ohms and measure Non- linearity, Hysteresis Error etc.

TABLE

Sr. No.	Reading in Increasing Mode		Reading in Decreasing Mode	
	Applied Load In Kgs.	DVM In ohms	Applied Load In Kgs.	DVM In ohms
1.				
2.				
3.				
4.				
5.				

Calculate:

Stress=F/A=Wg/A
Strain=ΔL/L
G_f (Gauge factor) = (ΔR/R)/(ΔL/L)=

Depending upon the beam used in apparatus force stress and strain values varies accordingly with simply supported or cantilever beam terminology.

Conclusion: Hence stress =__________ & strain =_________**G_f =** _________

Question and Answer

1) Explain the working & Principle for Strain Gauge?

2) Types of Strain Gauge

3) Write down the Areas were Strain Gauge is used

4) Material Used in Strain Gauge

Experiment No: 7

LOAD CELL

(LOAD MEASUREMENT USING STRAIN GAUGE TRANSDUCER)

Load cell Trainer kit has been designed to study the performance characteristics of load cell. Strain Gauge based Load Cell Trainer for the students of instrumentation course. It allows the students to understand the concept of Load Cell, its application and its associated electronics circuits.

The instrument comprises of the following parts:

1. Load Cell made of four bonded metal strain gauges with arrangement to fix some load on it to generate the deformation.

Load Cell : Strain Gauge based

Measuring Range : 0 – 1 Kg.

Non- linearity error : ± 1%

Resolution : 0.01Kg.

2. Electronic Circuit along with a 3 ½ Digit Digital Voltmeter

Electronic Circuit

Excitation source : DC excitation (5 Volts)

Amplifiers : Instrumentation Amplifier and inverting Summing Amplifier with Gain and Zero adjustment

Termination : For 4 arm Strain Gauge Bridge

Digital Voltmeter

Display : 3 ½ Digit L.E.D. display

Range : 0 – 2000m Volts

3. The kit has numbers of IC Regulated Power Supplies which are permanently connected to all the circuit. No external D.C. supply should be connected to the training kit. Only 230 Volt, ± 10%, 50Hz main supply is required to operate the training kit.

4. Suitable Mechanism to apply the Load on a pan.

THEORY

The Load Cell is an Electro- mechanical sensor employed to measure static and dynamic forces. Load Cells can be designed to handle a wide range of operating forces with high level of reliability and hence it is one of the most popular transducer in industrial measurements.

The Load Cells derives it output from the deformation of an elastic member having high tensile strength. The basic design parameters include relative size and shape material density and modulus of elasticity, strain sensitivity, deflection and dynamic response. Through a careful choice of the material and structural configuration linear relationship between a dimensional change and measured force can be achieved. The material so chosen should posses the following properties.

(1) Linear stress strain relationship up to a fairly large elastic strain limit.

(2) Low strain Hysteresis over repeated loading

(3) Very low creep over long periods of loading

(4) Very low plastic flow due to strain

The most popular configurations of load cells are:

(1) Column – Type

(2) Proving Ring Type

(3) Cantilever Beam Type

(4) Shear – Type

In the entire configuration, deformation is sensed by the strain gauges. It is important that in All cases the strain gauges should be suitable located, so that the output strain is linearly Proportional to the input force with minimum hysteresis and creep, high repeatability and Overload capability. Some of the configurations have excellent immunity to adverse side

Eccentric loads. In all types of load cells, the stress developed due to the force is measured with four electrical strain gauges. All four strain gauges are connected to form a four arm active Wheatstone bridge.

For a Cantilever Beam.

The strain is given by

$$\epsilon = \sigma / E$$

Where $\sigma = 6FL/wt^2$

Where L = Length of cantilever beam (m)

T = Thickness of cantilever beam (m)

W = Width of cantilever beam (m)

E = Modulus of Elasticity (N/M^2)

F = The applied force (N)

For the experiment cantilever beam.

L = 215 mm. = 107 X 10^{-3} m

t = 4.5 mm. = 18 mm

w = 25 mm = 30 mm

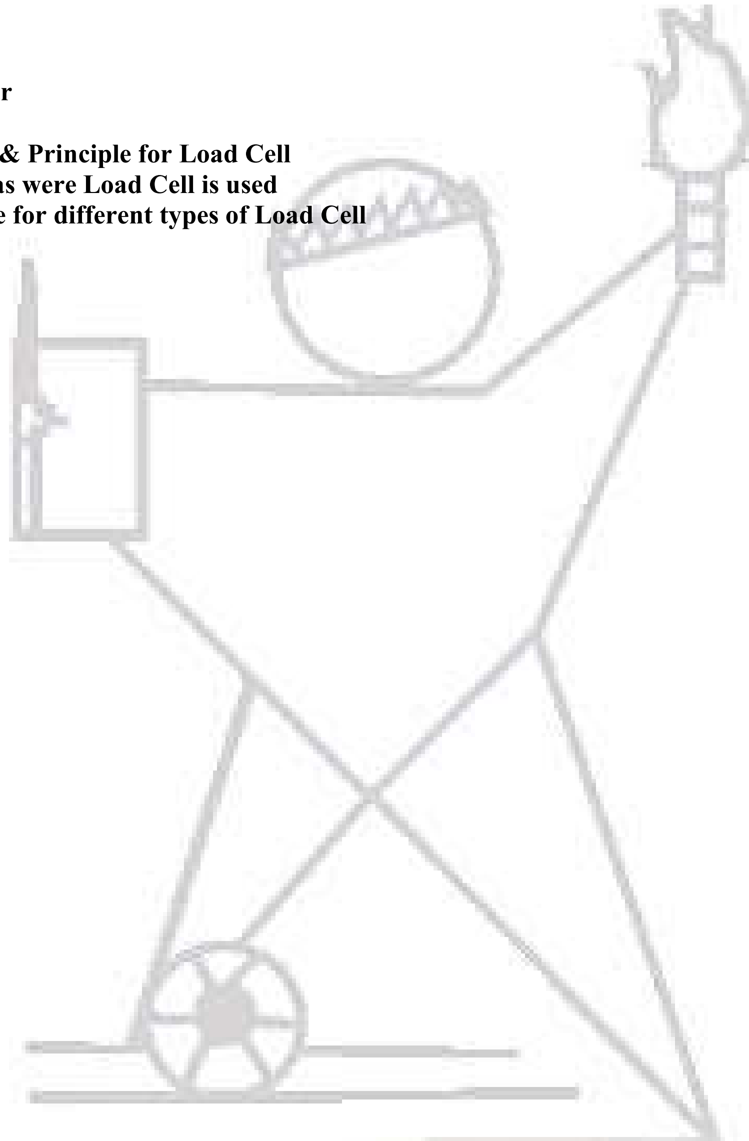
E = 2.1 X 10^{5} N/mm^{2} (steel)

PROCEDURE:

1. Connect the Cantilever Beam type Load Cell leads with the training kit terminals.
   Red Lead with Red Terminal.
   Black Lead with Black Terminal
   Green Lead with Green Terminal
   Yellow Lead with Yellow Terminal
2. Connect the 3, pin mains plug of the training kit to the mains socket (230 Volt, ±10%,50Hz)supply.
3. Switch On the training kit the display will light up and will show some reading.
4. Adjust Zero Potentiometer to set 0.00 reading on display without applying any load on the Pan.
5. Put 1Kg. weight on the pan of the cantilever beam and adjust span pot to show 1.00 reading on display.
6. Now repeat steps from 4 to 5
7. Now apply loads in steps of 50gm up to 1 Kg and note down the reading in the given table (1) in increasing & decreasing mode.
8. Now plot the graph between applied load and Digital Voltmeter readings in Kgs. With a resolution of 0.01 Kg and applied load & measure non- linearity, Hysteresis error etc.

TABLE :

S.NO.	Load Increasing Mode		Load in Decreasing Mode	
	Load (in Kg.)	DVM reading (in mV)	Load (in Kg.)	DVM reading (in mV)



Question and Answer

Explain the working & Principle for Load Cell
Write Down the Areas were Load Cell is used
Write down the name for different types of Load Cell

Experiment No: 8

Aim: To study a Linear Variable Differential Transformer (LVDT) and use it in a simple experimental set upto measure a small displacement.

Apparatus used: LVDT setup

Theory: The letters LVDT are an acronym for Linear Variable Differential Transformer, a common type of electromechanical transducer that can convert the rectilinear motion of an object to which it is coupled mechanically into a corresponding electrical signal. LVDT linear position sensors are readily available that can measure movements as small as a few millionths of an inch up to several inches, but are also capable of measuring positions up to ±20 inches (±0.5 m). The transformer's internal structure consists of a primary winding centered between a pair of identically wound secondary windings, symmetrically spaced about the primary. The coils are wound on a one-piece hollow form of thermally stable glass reinforced polymer, encapsulated against moisture, wrapped in a high permeability magnetic shield, and then secured in cylindrical stainless steel housing. This coil assembly is usually the stationary element of the position sensor. The moving element of an LVDT is a separate tubular armature of magnet i cal l y permeable material called the core, which is free to move axially within the coil's hollow bore, and mechanically coupled to the object whose position is being measured. This bore is typically large enough to provide substantial radial clearance between the core and bore, with no physical contact between it and the coil.

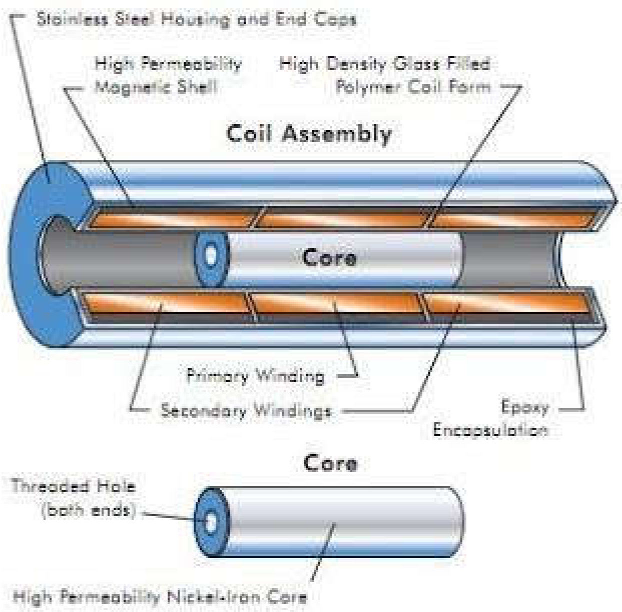


Fig: LVDT

The device consists of a primary coil, two secondary coils, and a moveable magnetic core which is connected to an external device whose position is of interest. A sinusoidal excitation is applied to the primary coil, which couples with the secondary coils through the magnetic core (ie. voltages are induced in the secondary coils). The position of the magnetic core determines the strength of coupling between the primary and each of the secondary cores, and the difference between the voltages generated across each of the secondary cores is proportional to the displacement of the core from the neutral position, or null point.

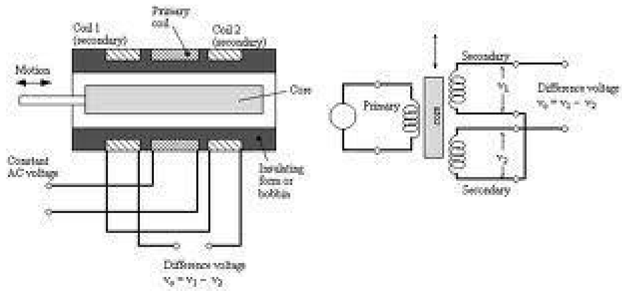


Fig: LVDT Principle

Procedure:
1. Adjust the experimental setup for probe to zero position.
2. Verify all electrical connections.
3. Give the LVDT power supply on.
4. Record the displacement and output voltage.

Observations & Calculations:

Sr. No.	Reading in clockwise movement of Caliper		Reading in Anticlockwise movement of Caliper	
	Micrometer Caliper reading in mm	DPM in MM	Micrometer Caliper reading in mm	DPM in MM
1				
2				
3				
4				
5				

Conclusion: Hence the measurement of a small displacement using LVDT is_______.

Question and Answer

Device used in pressure measurement
Give example were LVTD is use
Draw schematic block dig for LVDT
Write Down the working principle for LVDT

Experiment No: 9

Dynamometer

AIM: - To determine the braking torque and bake power of an Engine.

APPARATUS: - Working of dynamometer.

THEORY: - The dynamometer is a device used to measure the torque being exerted along a rotating shaft so as to determine the shaft power.
Dynamometers are generally classified into:

1) Absorption dynamometers (i.e. Prony brakes, hydraulic or fluid friction brakes, fan brake and eddy current dynamometers)
2) Transmission dynamometers (i.e. Torsion and belt dynamometers and strain gauge dynamometer)
3) Driving dynamometers (i.e. Electric cradled dynamometer)

ROPE BRAKE DYNAMOMETERS: - A rope brake dynamometers consists of one or more ropes wrapped around the fly wheel of an engine whose power is to be measured. The ropes are spaced evenly across the width of the rim by flywheel. The upward ends of the rope are connected together and attached to a spring balance, and the downward end is fixed. The rotation of flywheel produces frictional force and the rope tightens. Consequently a force is induced in the spring balance.

Effective radius of the brake $R = (D+ d)/2$

Brake load or net load = S in Newton Braking torque $T = S * R$ in Nm. Braking power = $2\pi N * T/60$ in N-m/s
= $2\pi N * S*R/60* 1000$ in kW
D= dia. Of drum, t = belt thickness.

S = spring balance reading in N

TABLE

Sr.No.	**RPM**	**Force (S)**	**Brake Torque**	**Shaft Power (Watt)**

Conclusion:

Questions & Answer

Q. What is Dynamometer?
Q. Explain different types of Dynamometer.
Q. Function of Rope Break Dynamometer.