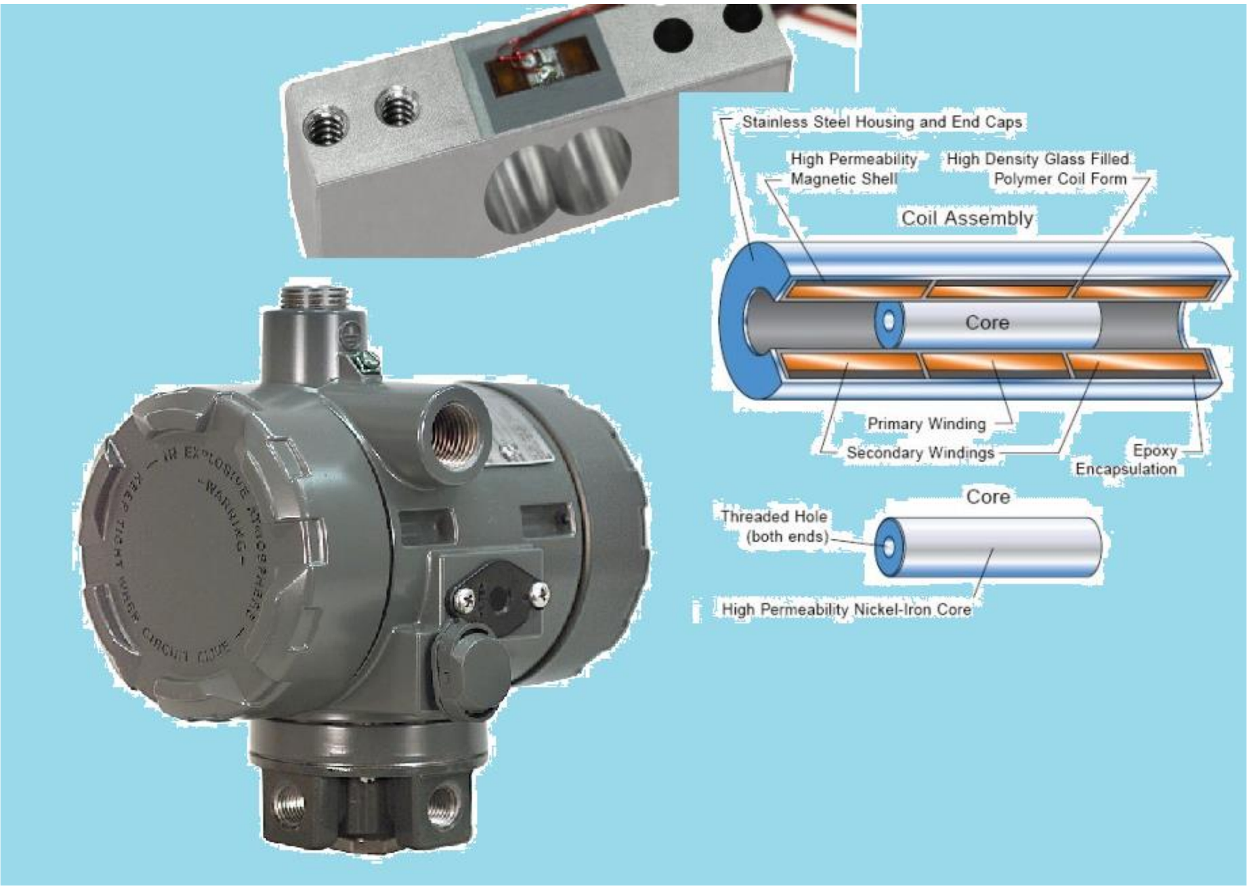
INSTRUMENTATION LAB I



Section A		
Experiment No	**Title of the Experiments**	**Objective of the experiments**
1	LVDT	1. To draw the characteristics Of a LVDT 2. To determine the sensitivity of the system
2	Torque Transducer	1. Study of the torque transducer. 2. To use torque transducer having strain gauges as sensors & to determine its I/O characteristics.
3	Load Cell	1. T study the Colum type Load Cell 2. To calculate the sensitivity of load cell
4	Orifice	1. To study the flow of air through an orifice and hence determine the flow rate with the help of U-Tube manometer. 2. To plot the flow versus pressure difference characteristics for different flow rates**.**
5	Rotational Potentiometer	1. To study the input output characteristics of rotational Potentiometer
6	Thermocouple	1. To determine the sensitivity and time constant of a thermocouple [iron constantan or copper constantan] for step input. 2. To compare its response with that for ramp input.
7	I/P-P/I Converter	To determine- A. Linearity of I/P converter B. Hysteresis of I/P converter C. Accuracy of I/P converter D. Linearity of P/I converter E. Linearity of P/I converter F. Hysteresis of P/I converter G. Accuracy of p/i converter.
8	PV cell	1 To draw the characteristic curve of a PV cell

Text books:

1. Principle of industrial Instrumentation; D Patranabis
2. Introduction to instrumentation engineering; AK Sahwany

Experiment No	Title of experiments	Remarks
1	LVDT	
2	Torque Transducer	
3	Load Cell	
4	Orifice	
5	Rotational Potentiometer	
6	Thermocouple	
7	I/P-P/I Converter	
8	PV cell	
1	LVDT	
2	Torque Transducer	
3	Load Cell	
4	Orifice	
5	Rotational Potentiometer	

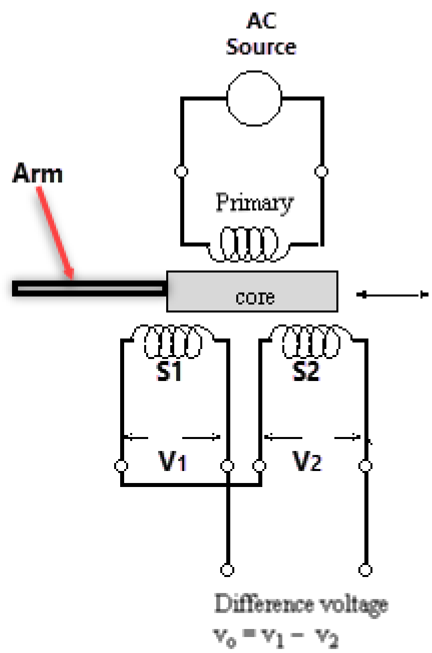
OFFICE USE		
Checked and found…………………………………………. Grade/Marks…………………………………………………... Signature…………………………………………………….		

EXPERIMENT NO 1: LVDT

<u>AIM OF THE EXPERIMENT</u>: To draw the static characteristic of LVDT

<u>OBJECTIVE</u>: To study the input-output characteristics of LVDT and to determine sensitivity.

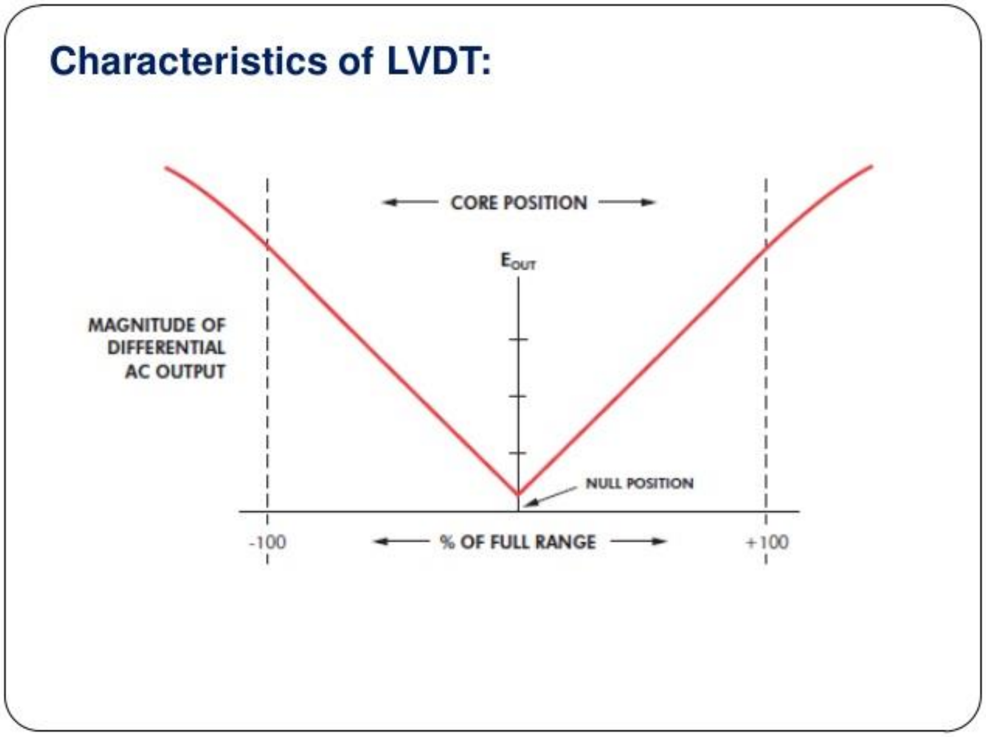
<u>CIRCUIT & ITS COMPONENTS DIAGRAM:</u>



THEORY:

The linear variable differential transformer is basically a mutual-inductance type transducer with variable coupling between the primary and the two secondary coils. It is equivalent to E pick off in its operation except that the reluctance of the magnetic path is mostly due to the air path. It consists of a primary coil, uniformly wound over a certain length of the primary coil and away from the centre. The iron core is free to move inside the coils in either direction from t e null position. When to primary coil is excited by ac supply, the induced emfs of the secondaries are equal to each other, with the core lying in the null position. The secondaries are connected in series but in phase opposition so that the resultant output voltage is zero. Displacement of the core in either direction from null position results in output voltage is zero. Displacement of the core in the either direction from the null position results in output voltages results in proportional to displacement but of opposite polarity. The output voltage, as read by an ac rms voltmeter and it is observed that there is a residual voltage at the null position due to stray capacitance., and the characteristics is linear over a limited range.

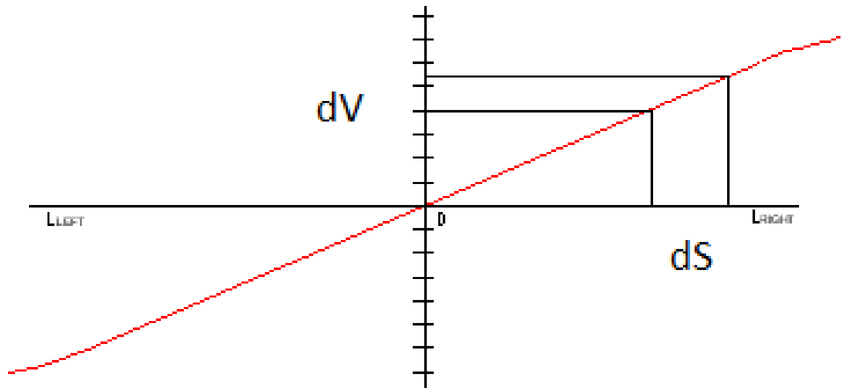
The range of displacement for which the transducer is linear within certain limits is determined by the dimensions of the transducer. The movable core is slightly more than three times the length of the primary winding and lies symmetrically with respect to the primary in its null position.



OBSERVATIONS:

SL. NO.	Displacement	Output voltage

THE CHARACTERISTIC CURVE:



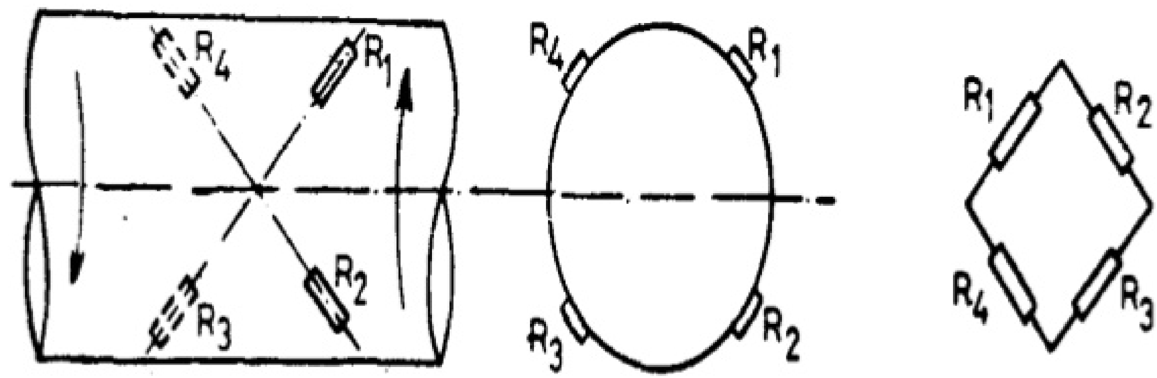
RESULT AND DISCUSSION:

Sensitivity Is given by:

dS/dV

Experiment No 2: Torque transducer

Theory:



<u>THEORY:</u>

Torque measurement involves, fundamentally, measurement of force and the length of the arm perpendicular to the force and extending from it to the axis of rotation. The torque applied to bodies held rigidly or free may be measured directly by measuring the force transducers. However, in practice, torque measurement is often undertaken to estimate the shaft power of machines serving as sources and sinks. Dynamometers are known to be the torque-measuring systems for such machines, based on the measurement of force. Another common requirement of torque measurement is in respect of measuring the shaft power conveyed by a source machine to sink machine under dynamic conditions.

Alternatively, the torque is obtained from measurements of the surface shear strain, by locating strain gauges precisely at $45^0$to the shaft axis as the merits of this method are independence from ambient temperature variations and insensitivity to bending or axial strains.

<u>Observation table:</u>

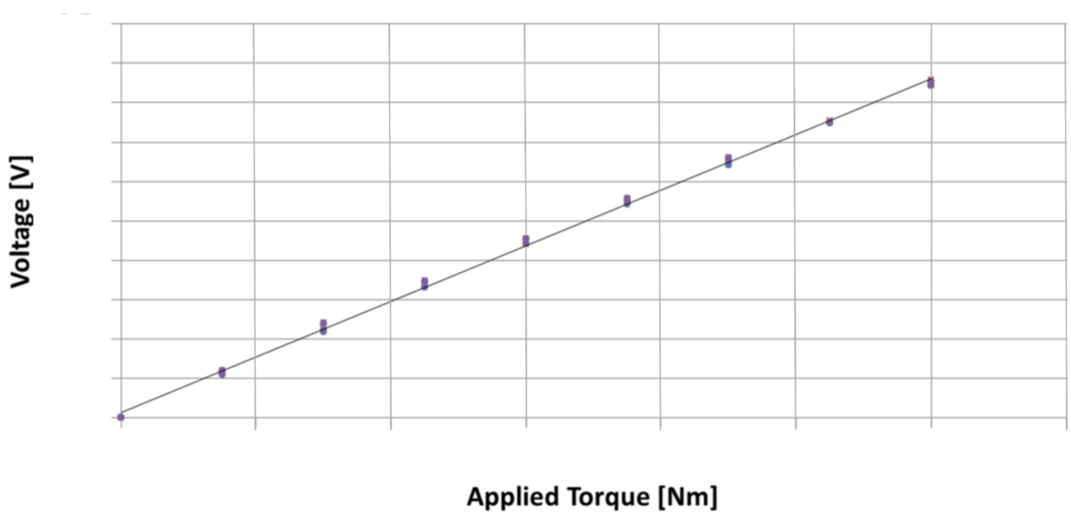
Case 1. Length = 18.5cm

Weight(gm)	Torque delivered τ =mg (N/m)	Output voltage

Case 2. Length = 20.5 cm

Weight(gm)	**Torque delivered** **τ =mg(N/m)**	**Output voltage**

Characteristics of torque transducer



Experiment No 3: Load Cell

Theory:

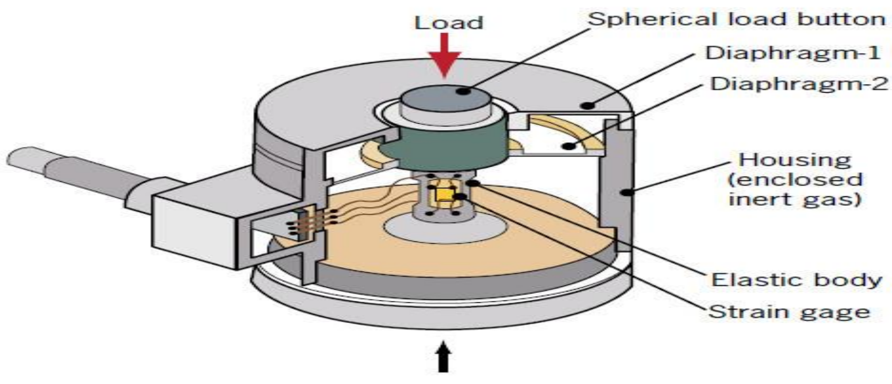


FIG:- Column type load cell

THEORY: -

A load cell is a transducer that is used to create an electrical signal whose magnitude is directly proportional to the force being applied .Load cells are primarily intended for measurement of weight of bodies such as slowly moving vehicles. They are as well design for various applications where concentrated forces can be conveyed to the load cell through mechanical linkage those cell meant for weighing are provided with platforms onto which vehicle are admitted at slow speed or are provided with support for hanging the body to be weighted.

A column type load cell primarily consist of either slender rod, robust column of rectangular or circular cross-section, or even square cylinder. Those column of regular configuration enable them measurement of deformation with reasonable accuracy, through ultimately they are calibrated against standard weight. IT is essential to recognize the importance of transmitting the force uniformly over the entire cross-section area of this load cell; it is also essential to reorganization there is no other force working on the column apart from one under measurement, acting along the axis of the column. Due to stress F/a, the surface of the column undergoes compression strain (ε_a) along its axis and tensile strain (ε_t) along its circumference. Those strains are measured conveniently by the resistance type strain gauges, by locating them suitably on the outside surface.

OBSERVATION TABLE: -

Sl. No.	Load increasing (kg)	Output voltage(mv)	Load decreasing (kg)	Output voltage (mv)

CALCULATION:-

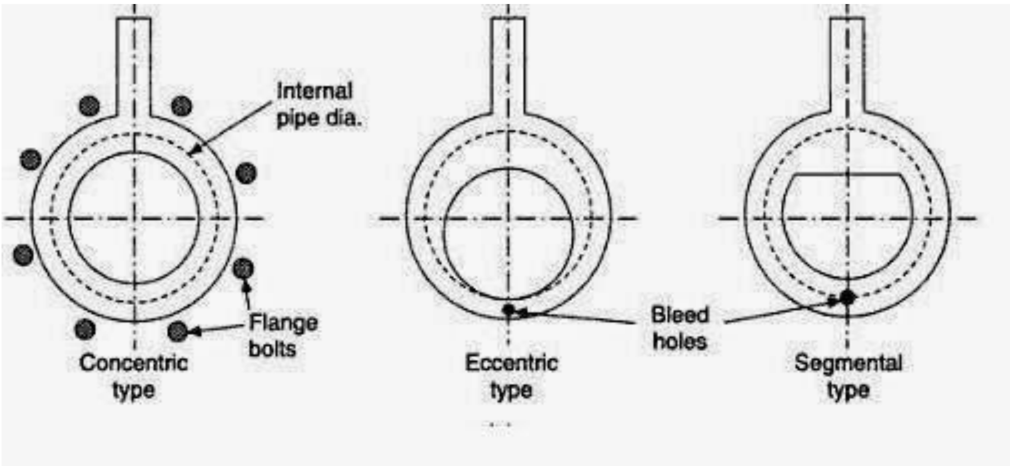
Strain are given by $\varepsilon_a = \frac{F}{AE} = \varepsilon_1 = \varepsilon_3$

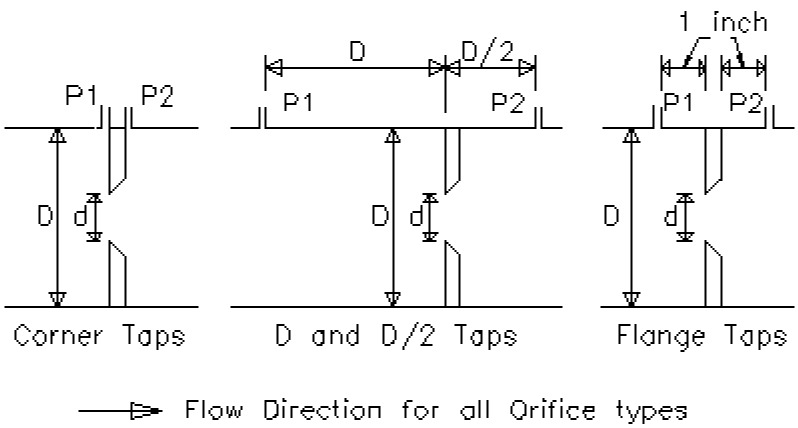
$\varepsilon_t = \frac{-\mu F}{AE} = \varepsilon_2 = \varepsilon_4$

EXPERIMENT NO 4: ORIFICE

Theory:

<u>CIRCUIT DIAGRAM AND COMPONENTS:</u>





<u>THEORY:</u>

Of the four types of commercially available restriction type flow measuring elements, orifice is the most common. It is the cheapest and takes the form of thin plate square edges and is mounted in between the flanges. The other venture, flow nozzle and Dahl Tube.

The orifice may be concentric, segmental or even eccentric type .While the concentric one is the more common, the segmental or the eccentric types are used for the fluids containing solids and these are to be mounted in such a way that the bottom of the orifice is flush with the bottom inside the pipe. The disadvantage with this types are the standard flow coefficient tables are not available for them.

An orifice plate is a thin plate with a hole in it, which is usually placed in a pipe. When a fluid (whether liquid or gaseous) passes through the orifice, its pressure builds up slightly upstream of the orifice but as the fluid is forced to converge to pass through the hole, the velocity increases and the fluid pressure decreases. A little downstream of the orifice the flow reaches its point of maximum convergence, the *vena contracta* where the velocity reaches its maximum and the pressure reaches its minimum. Beyond that, the flow expands, the velocity falls and the pressure increases. By measuring the difference in fluid pressure across tappings upstream and downstream of the plate, the flow rate can be obtained from Bernoulli's equation using coefficients established from extensive research.

In general, the mass flow rate measured in kg/s across an orifice can be described as:

$$q_m = \frac{C_d}{\sqrt{1-\beta^4}} \, \epsilon \, \frac{\pi}{4} \, d^2 \, \sqrt{2 \, \rho_1 \Delta p}$$

where:

= coefficient of discharge, dimensionless, typically between 0.6 and 0.85, depending on the orifice geometry and tapings

= diameter ratio of orifice diameter to pipe diameter, dimensionless

= expansibility factor, 1 for incompressible gases and most liquids, and decreasing with pressure ratio across the orifice, dimensionless

= internal orifice diameter under operating conditions, m

= fluid density in plane of upstream tapping, kg/m^3

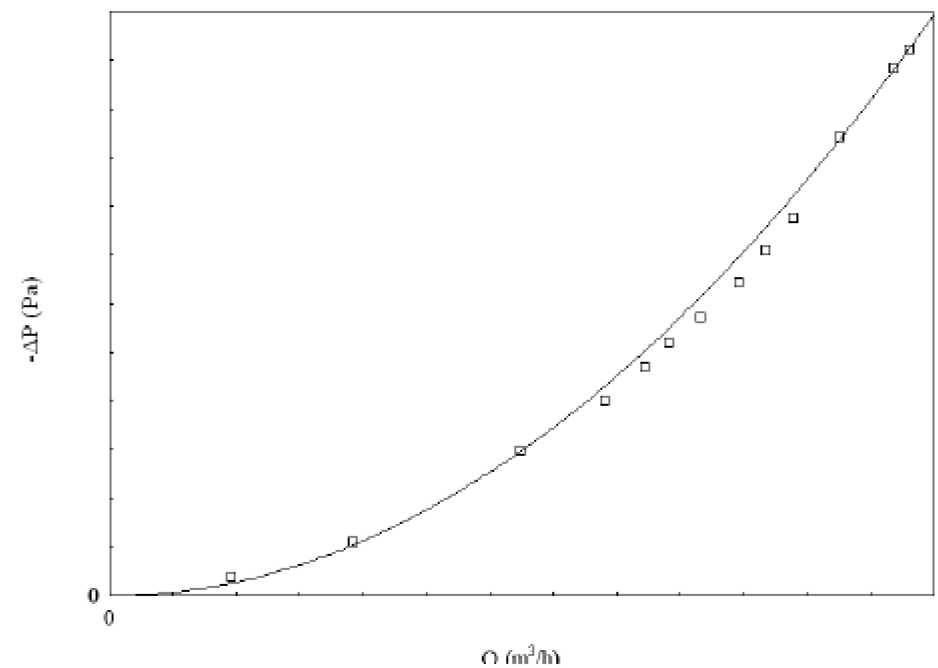
= differential pressure measured across the orifice, Pa

The overall pressure loss in the pipe due to an orifice plate is lower than the measured pressure, typically by a factor of $(1-\beta^{1.9})$.

OBSERVATION TABLE:

Pressure	h 1(cm)	h 2 (cm)	$\Delta h = h1 - h2$	$= k(\Delta h)\frac{1}{2}$

Characteristics curve of orifice



Experiment No 5: Rotational potentiometer

Theory:

The simplest transducer for converting linear or angular displacements into a change of resistance is the resistive element provided with a movable contactor. The change in resistance is bought out by a only change in length of the resistor from one end point of contact .When measuring a relative motion between a moving body and a fixed body, the moving body is mechanically coupled to the contactor and the relative displacement is measured. Although the variable resistor of this kind can be treated as the primary transducer for mechanical displacements, its main application in instrumentation is to function as a secondary electrical transducer converting the output displacement signal of the primary mechanically transducer such as the Bourdon tube and cantilever elements into corresponding resistance changes.

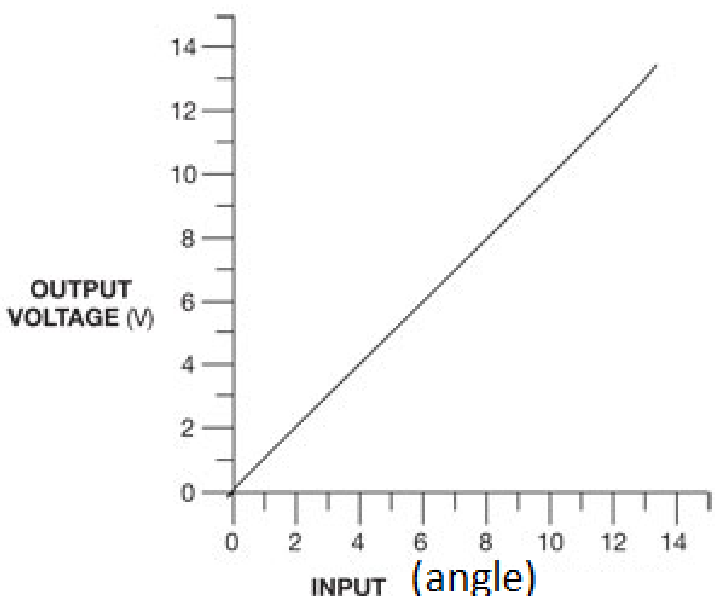
Other important factors for consideration regarding the resistance potentiometers are linearity, resolution, loading error and noise level in output voltages, Resistance values range from 1 ohm to 1M ohm, depending on whether they are of wire-wound type or film or conducting plastic type. Theoretically, stretched wire or a film type potentiometer posses infinite resolution, whereas the wire-wound type has its resolution limited by its number of turns. The latter has the additional advantage of its range of angular displacement extended to 50 or 60 revolutions, is known as helical potentiometers. Linearity between resistance and displacement generally depends on the uniformity of the wire diameter and the uniformity of the winding. Considering the fact that the output signals are voltages, it is essential to take into account the effect of electrical loading due to the voltmeter coming in parallel with the tapped portion of the potentiometer. Hence under no-load conditions

$x = R / R = V / E$

OBSERVATION TABLE:

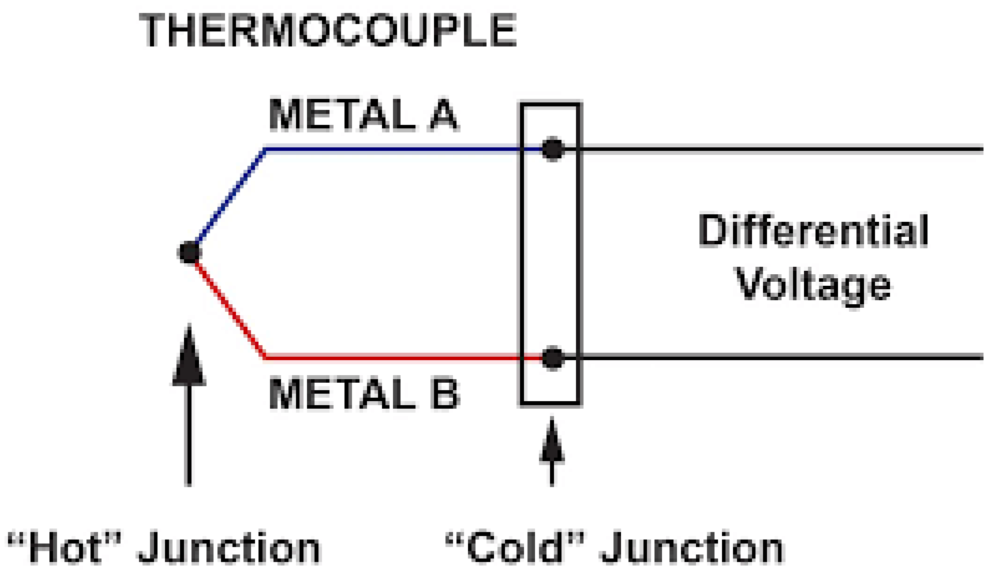
Sl. No.	Angular displacement in degrees	Output voltage(mv)

CHARACTERISTIC CURVE:



EXPERIMENT NO 6: THERMOCOUPLE

Theory:



A thermocouple is a thermoelectric device that converts thermal energy into electrical energy. The thermocouple is used as a primary transducer for measurement of temperature, converting temperature changes directly into emf. Three phenomena which govern the behaviour of a thermocouple are the Seeback effect, Thompson effect and Petlier effect.

If two wires f different metals A and B are joined together to form two junctions are at the two junctions are at different temperatures, an electric current will flow round the circuit, this is Seeback effect. Seeback arranges 35 metals in order of their thermoelectric properties. The current flows across the hot junction from the former to the later metal of the following series-

Bi-Ni-Co-Pd-Pt-

U-Cu-Mn-Ti-Hg-Pb-

Sn –Cr-Mo-Ph-Ir-Au-Ag-

Zn-W-Cd-Fe-As-Sb-Te-

If metal A is of copper and metal B of iron, then the current flows from copper to iron at the hot junction and from iron to copper at cold junction. If copper wire is cut, an emf will appear across the open circuit. The Seeback emf depends on the difference in the temperatures of the two junctions.

The reverse phenomenon is the Petlier effect. An external source of emf is connected and a current is force through the junctions. It is observed that heat is absorbed when the current flows across the iron copper junction from copper to iron and liberated if the flow of current is reversed. The amount of heat liberated or absorbed is proportional to the quantity of electricity that crosses the junction. And the amount of heat liberated or absorbed when one ampere passes for a second is called the Petlier co-efficient.

Another reversible heat-flow effect, called the Thompson effect involves the contribution of emf on Seeback effect in the wire of same metal, if a temperature difference existed within that particular conductor. When a current flows through a copper conductor having a thermal gradient (and hence a heat flow)along its length, heat is liberated at any point where the current is in the same direction as the heat flow while heat is absorbed at any point where these are opposite.

OBSERVATION TABLE:

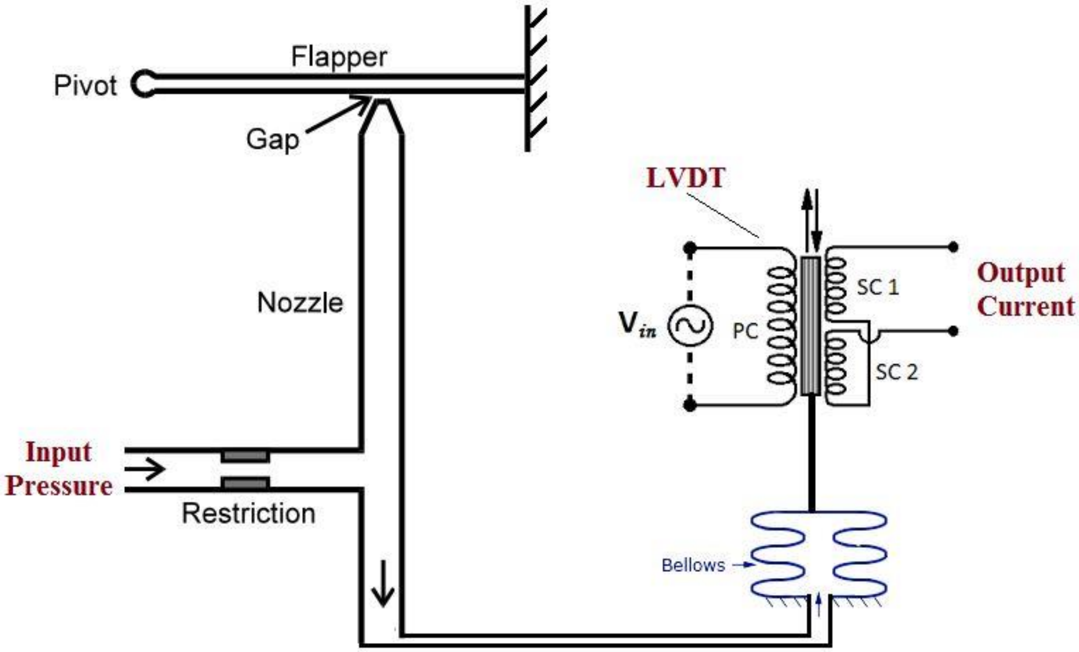
Sl. No.	**Time(sec)**	**Temperature (°C)**	**Output voltage(mv)**

RESULT AND DISCUSSION:

Experiment No 7: I-P/P-I converter

P/I converter

P/I converter or Pneumatic pressure-to-Current is a transducer. It converts pressure input to a current in mili ampere range. P/I converter is a common instrument in automation system. Like a temperature senor or level sensor it transmit data to other source like PLC, instrument to control systems only here the input is pressure.



OBSERVATION TABLE:

For pressure Increasing

Sl. No.	Pressure	Current

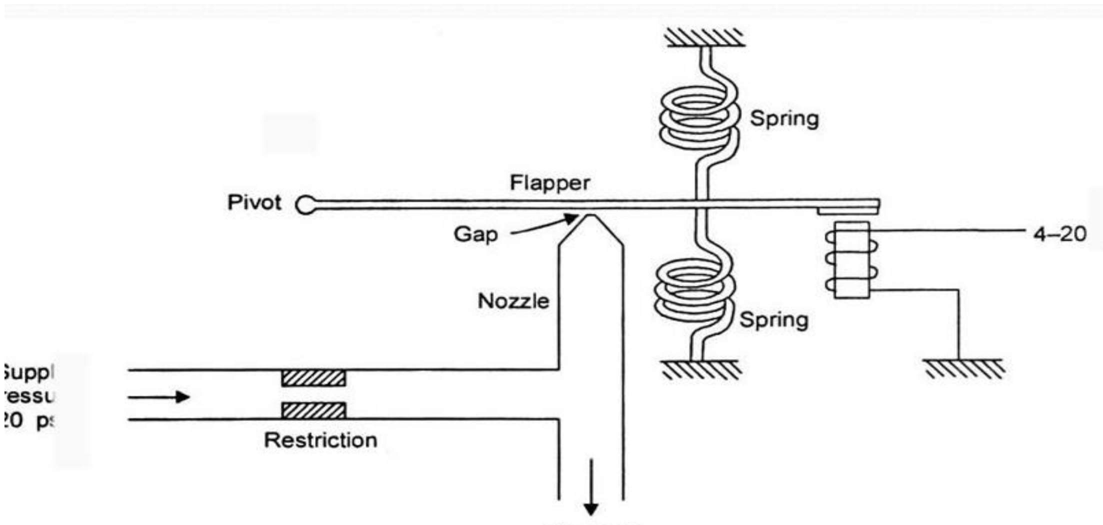
For pressure decreasing

Sl. No.	Pressure	Current

I/P converter:

THEORY:

A "current to pressure" converter (I/P) converts an analog signal (4 to 20 mA) to a proportional linear pneumatic output (3 to 15 psig). Its purpose is to translate the analog output from a control system into a precise, repeatable pressure value to control pneumatic actuators/operators, pneumatic valves, dampers, vanes, etc. Pneumatic assisted control valves often require a converter to change an electrical signal into a pneumatic one, thereby delivering an adjustable downstream flow rate translates a current input signal, usually between 4-20mA, into a pneumatic output, usually between 3-15pisg, which in turn proportionally controls the opening or closing of a valve. Operating according to the 'force balance principle', the operating principle of a current to pressure transducer consists of a coil suspended in a magnetic field on a flexible mount. A flapper valve is positioned at the lower end of the coil and operates against a precision nozzle to create backpressure.



Experiment No. 7 (a): Linearity of I/P converter

Procedure

- Start up the set up as mentioned in commissioning part above.
- Put digital calibrator in source mode.
- Give current input in the step of 4 mA from 4 to 20 mA by slowly rotating the knob of digital calibrator.
- Note down corresponding pressure on output pressure gauge in psig.
- Tabulate above readings in the observation table given below.

Observations

Sl. No.	INPUT (current)	Measured OUTPUT (pressure)	Expected OUTPUT (Pressure)

Calculations

Linearity: Linearity of I/P converter is 5% maximum of output span between 3 to15 psig (as stated by manufacturer). Therefore 5/100 * (15-3) = 0.6 psig. This is the maximum deviation in the output.

Plot graph of Input current (mA) on X axis and output pressure (psig) on Y-axis. Draw a straight line that best fits all the points. The graph shows the straight line. Observe the maximum deviation in output and compare with specified by manufacturer.

Conclusions

We may observe some deviation in actual linearity of I/P converter from manufacturer's specification, as it depends upon accuracy of pressure gauges used, accuracy of digital calibrator and visual error in recording the readings.

Experiment No 7 (B) : Hysteresis of I/P converter

Procedure

- Start up the set up as mentioned in commissioning part above.
- Put digital calibrator in source mode.
- Give current input in the step 4 mA from 4 to 20 mA by slowly rotating the adjust knob on digital calibrator.
- Note down corresponding output pressure on output pressure gauge in psig.
- Now note the output pressure in psig by applying input current in decreasing mode from 20 mA to 4 mA.
- Tabulate above readings in the observation table given below.

Observations

Sl. No.	Input current (mA)	Output Pressure (psig) (X)	Sr. No.	Input current (mA)	Output Pressure (psig) (Y)	Hysteresis psig (Y)-(X)

Calculations

1. ***Hystersis:*** Hystersis of I/P converter is 0.5 psig typical (as stated bmanufacturer).
2. Calculate hysteresis by using formula:

Hystersis =Output at decreasing Input – Output at increasing input.

3. Plot the graph showing hysteresis as input (increasing and decreasing) on X axis and corresponding output on Y-axis.

Conclusions

We may observe some deviation in hysteresis of I/P converter as it depends upon accuracy of pressure gauges used accuracy of digital calibrator and visual error in recording the readings.

Experiment No. 7 (c): Accuracy of I/P converter

Procedure

- Start up the set up as mentioned in commissioning part above.
- Now put digital calibrator in source mode.
- Give current input in the step of 4 mA from 4 to 20 mA by slowly rotating the knob of digital calibrator.
- Note down corresponding pressure on output pressure gauge in psig.

Observations

Sl. No.	Input current(mA)	Standard Output Pressure (psig) (X)	Actual Output Pressure (psig) (Y)	Deviation (psig) (X)-(Y)
1	4	3		
2	8	6		
3	12	9		
4	16	12		
5	20	15		

Calculations

Accuracy: Accuracy can be calculated with reference to above definitions intheory part.

Experiment No. 7 (D): Repeatability of I/P converter

Procedure

- Start up the set up as mentioned in commissioning part above.
- Now put digital calibrator on source mode.
- Give current input in the step 4 mA from 4 to 20 mA by slowly rotating the adjust knob on digital calibrator.
- Note down corresponding output pressure on output pressure gauge in psig.
- Now repeat the above steps for more trials.
- Tabulate above readings in the observation table given below.

Observations

Sl. No.	Input current (mA)	Output Pressure (psig) (X)	Sl. No.	Input current (mA)	Output Pressure (psig) (X)	Deviation in output psig (X)-(Y)
	Trial 1				**Trial 2**	
1	4		1	4		
2	8		2	8		
3	12		3	12		
4	16		4	16		
5	20		5	20		

Sl. No.	Input current (mA)	Output Pressure (psig) (X)	Sl. No.	Input current (mA)	Output Pressure (psig) (X)	Deviation in output psig (X)-(Y)
	Trial 3				**Trial 4**	
1	4		1	4		
2	8		2	8		
4	16		4	16		
5	20		5	20		

Calculations

Repeatability: Note down the values of output for same input in repeated trials.

Repeatability can be found out in % of each reading

EXPERIMENT NO. 7 (E): LINEARITY OF P/I CONVERTER

Procedure

- Start up the set up as mentioned in commissioning part above.
- Now put digital calibrator on measure mode.
- Give pressure input in the step of 3 psig from 3 to 15 psig by slowly rotating the air regulator.
- Note down corresponding current output on digital calibrator in mA.
- Tabulate above readings in the observation table given below.

Observations

Sl. No.	Input Pressure (psig)	Standard Output current(mA)	Actual Output current (mA)
1	3	4	
2	6	8	
3	9	12	
4	12	16	
5	15	20	

Calculations

Linearity: Plot graph of Input pressure (psig) on X-axis and output current (mA) on Y-axis. Draw a straight line that best fits all the points. The graph shows the straight line. Observe the maximum deviation in output.

EXPERIMENT NO. 7 (F): HYSTERESIS OF P/I CONVERTER.

Procedure

- Start up the set up as mentioned in commissioning part above.
- Now put digital calibrator on measure mode.
- Give pressure input in the step of 3 psig from 3 to 15 psig by slowly rotating the air regulator.
- Note down corresponding current output on digital calibrator in mA.

- Now note the output current in mA by applying input pressure in decreasing mode from 15 psig to 3 psig.
- Tabulate above readings in the observation table given below.

Observations

Sl. No	Input Pressure (psig)	Output current (mA) (X)	Sl. No.	Input Pressure (psig)	Output current(mA) (Y)	Hysteresis mA (Y)-(X)
Increasing input current			**Decreasing input current**			
1	3		1	3		
2	6		2	6		
3	9		3	9		
4	12		4	12		
5	15		5	15		

Calculations

Hystersis:

Calculate hysteresis by using formula:

Hystersis =Output at decreasing Input – Output at increasing input.

Plot the graph showing hysteresis as input (increasing and decreasing) on X axis and corresponding output on Y-axis.

EXPERIMENT NO. 7 (G) : ACCURACY OF P/I CONVERTER.

Procedure

- Start up the set up as mentioned in commissioning part above.
- Now put digital calibrator measure mode.
- Give pressure input in the step of 3 psig from 3 to 15 psig by slowly rotating the air regulator.
- Note down corresponding current output on digital calibrator in mA.
- Tabulate above readings in the observation table given below.

Observations

Sl. No.	Input Pressure (psig)	Standard Output current (mA) (X)	Actual Output Current (mA) (Y)	Deviation (mA) (Y) – (X)
1	3	4		
2	6	8		
3	9	12		
4	12	16		
5	15	20		

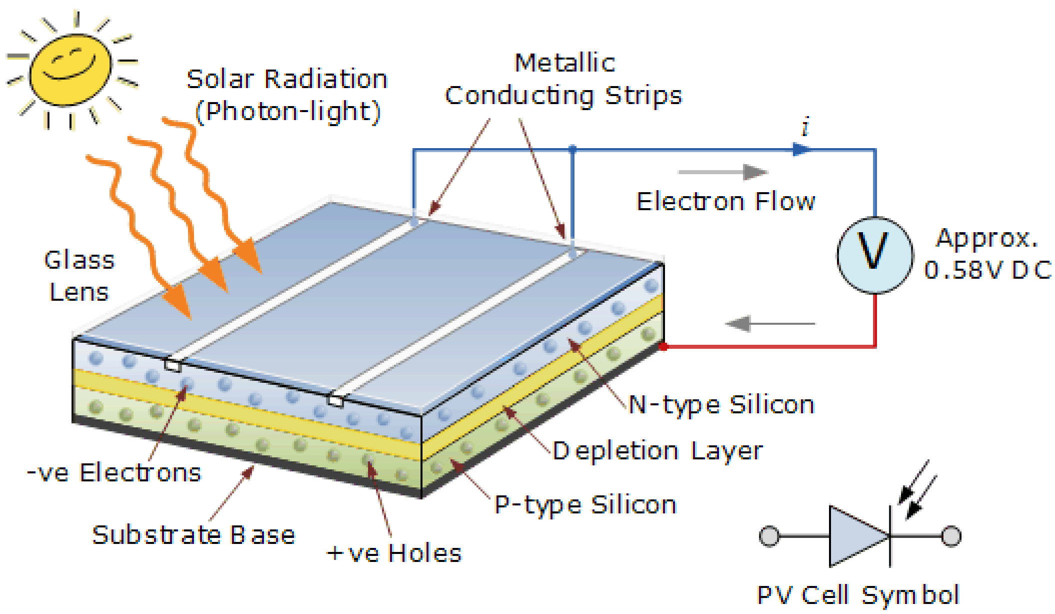
Calculations

Accuracy: Accuracy can be calculated with reference to above definitions intheory part.

EXPERIMENT NO 8: PV CELL

<u>AIM OF THE EXPERIMENT</u>: To draw the static characteristic of PV cell

<u>THEORY:</u>



A photovoltaic cell (PV cell) is a specialized semiconductor diode that converts visible light into direct current (DC). Some PV cells can also convert infrared (IR) or ultraviolet (UV) radiation into DC electricity. Photovoltaic cells are an integral part of solar-electric energy systems, which are becoming increasingly important as alternative sources of utility power.

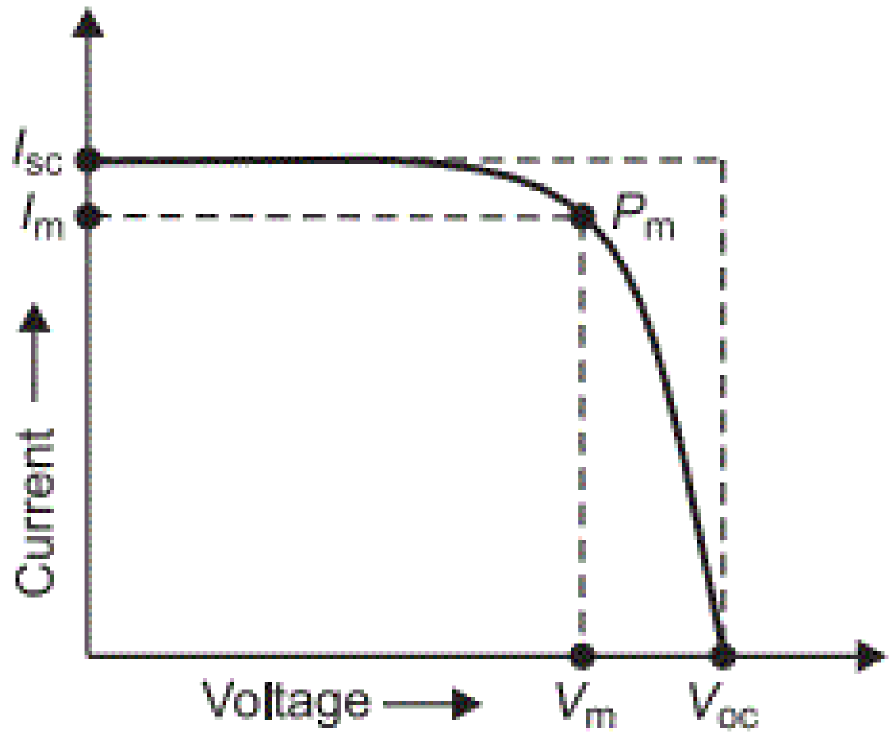
There are two basic types of semiconductor material, called positive (or P type) and negative (or N type). In a PV cell, flat pieces of these materials are placed together, and the physical boundary between them is called the P-N junction. The device is constructed in such a way that the junction can be exposed to visible light, IR, or UV. When such radiation strikes the P-N junction, a voltage difference is produced between the P type and N type materials. Electrodes connected to the semiconductor layers allow current to be drawn from the device.

Large sets of PV cells can be connected together to form solar modules, arrays, or panels. The use of PV cells and batteries for the generation of usable electrical energy is known as photovoltaics. One of the major advantages of photovoltaics is the fact that it is non-polluting, requiring only real estate (and a reasonably sunny climate) in order to function. Another advantage is the fact that solar energy is unlimited. Once a photovoltaic system has been installed, it can provide energy at essentially no cost for years, and with minimal maintenance.

OBSERVATIONS:

SL NO.	**Light intensity**	**Output voltage**

THE CHARACTERISTIC CURVE:



RESULT AND DISCUSSION: