INSTRUMENTATION AND CONTROL SYSTEMS LABORATORY

LAB MANUAL

Course Code : ME104
Regulations : IARE -R16
Class : IV Year I Semester (ME)

Prepared by

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Program Outcomes	
PO1	**Engineering Knowledge:** Capability to apply knowledge of Mathematics, Science Engineering in the field of Mechanical Engineering
PO2	**Problem Analysis:** An ability to analyze complex engineering problems to arrive at relevant conclusion using knowledge of Mathematics, Science and Engineering.
PO3	**Design/ Development of solution:** Competence to design a system, component or process to meet societal needs within realistic constants.
PO4	**Conduct investigation of complex problems:** To design and conduct research oriented experiments as well as to analyze and implement data using research methodologies.
PO5	**Modern Tool usage:** An ability to formulate solve complex engineering problems using modern engineering and information technology tools.
PO6	**The Engineer society:** To utilize the engineering practices, techniques, skills to meet needs of health, safety legal, cultural and societal issues.
PO7	**Environment and Sustainability:** To understand the impact of engineering solution in the societal context and demonstrate the knowledge for sustainable development.
PO8	**Ethics:** An understanding and implementation of professional and Ethical responsibilities.
PO9	**Individual Team work:** To function as an effective individual and as a member or leader in multi-disciplinary environment and adopt in diverse teams.
PO10	**Communication:** An ability to assimilate, comprehends, communicate, give and receive instructions to present effectively with engineering community and society.
PO11	**Project Management and Finance:** An ability to provide leadership in managing complex engineering project at multi-disciplinary environment and to become a professional engineer.
PO12	**Life-Long learning:** Recognition of the need and an ability to engage in lifelong learning to keep abreast with technological changes.
Program Specific Outcomes	
PSO1	**Professional Skills:** To produce engineering professional capable of synthesizing and analyzing mechanical system including allied engineering streams.
PSO2	**Design/ Analysis:** An ability to adapt and integrate current technologies in the design and manufacturing domain to enhance the employability.
PSO3	**Successful Career and Entrepreneurship:** To build the nation by imparting technological inputsand managerial skills to become a Technocrats.

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Certificate

This is to certify that Mr. /Ms. ____

*bearingrollno*_________________________*ofB.Tech*__________________*semester*

____*branch has satisfactorily*

completed____laboratory during the academic year

__________________________________.

SignatureofHOD

Signature ofFaculty

Signature ofInternalExaminer

Signature of ExternalExaminer

INSTRUMENTATION AND CONTROL SYSTEMS LABORATORY

VII Semester: ME

Course Code	Category	Hours / Week			Credits	Maximum Marks		
		L	T	P	C	CIA	SEE	Total
AME116	Core	3	-	-	2	30	70	100
Contact Classes: Nil	**Tutorial Classes: Nil**	**Practical Classes: 36**				**Total Classes: 36**		

OBJECTIVES:

The course should enable the students to:

I. Understand basic principles of instrumentation and control systems
II. Apply calibration of measuring instruments for linear and angular displacement.
III. Understand calibration of measuring instruments for temperature
IV. Apply calibration of measuring instruments of flow and speed measurement
V. Understand the functioning of strain gauges for measuring pressure and vibration

LIST OF EXPERIMENTS

Week-1 **CALIBRATION OF CAPACTIVE TRANSDUCER**

Calibration of capacitive transducer for angular measurement.

Week-2 **CALIBRATION OF LVDT**

Study and calibration of LVDT transducer for displacement measurement.

Week-3 **STUDY OF RESISTANCE TEMPERATURE DETECTOR**

Study of resistance temperature detector for temperature measurement.

Week-4 **CALIBRATION OF THERMISTOR**

Calibration of thermister for temperature measurement.

Week-5 **CALIBRATION OF THERMOCOUPLE**

Calibration of thermocouple for temperature measurement.

Week-6 **CALIBRATION OF PRESSURE GUAGE**

Calibration of Pressure gauges.

Week-7 **CALIBRATION OF STRAIN GUAGE**

Calibration of strain gauge for temperature measurement.

Week-8 **CALIBRATION OF PHOTO SPEED PICKUP**

Study and calibration of photo speed pickups for the measurement of speed.

Week-9 **CALIBRATION OF ROTAMETER**

Study and calibration of rotameter for flow measurement.

Week-10	CALIBRATION OF VIBROMETER
Study and use of a Seismic pickup for the measurement of vibration amplitude of an engine bed at various Loads.	
WeeK-11	MEASUREMENT OF VACUUM
Calibration of Mcleod gauge for low pressure.	
Week-12	CALIBRATION OF MAGNETIC SPEED PICKUP
Study and calibration of magnetic speed pickups for the measurement of speed.	

Reference Books:

1. D.S.Kumar,―MeasurementSystems:Applications&Design‖,AnuradhaAgencies,1st Edition,2013
2. C.Nakra,K.K.Choudhary,―Instrumentation,Measurement&Analysis‖,Tata McGrawHill, 1st Edition,2013.

Web References:

1. https://nptel.ac.in/courses/112107240/

ATTAINMENT OF PROGRAM OUTCOMES AND PROGRAM SPECIFICOUTCOMES

Exp. No.	Experiment	Program Outcomes Attained	Program Specific Outcomes Attained
1	Calibration of capacitive transducer for angular displacement.	PO1, PO2, PO3	PSO1, PSO2
2	Study and calibration of LVDT transducer for displacement measurement.	PO1, PO2, PO3	PSO1, PSO2
3	Calibration of Resistance Temperature Detector (RTD) for temperature measurement.	PO1, PO2, PO3	PSO1, PSO2
4	Calibration of Thermistor for temperature measurement.	PO1, PO2, PO3	PSO1, PSO2
5	Calibration of Thermocouple for temperature measurement.	PO1, PO2, PO3	PSO1, PSO2
6	Study and calibration of Photo speed pickups for the measurement of speed	PO1, PO2, PO3	PSO1, PSO2
7	Calibration of Pressure Gauges	PO1, PO2, PO3	PSO1, PSO2
8	Calibration of Strain gauge for temperature measurement.	PO1, PO2, PO3	PSO1, PSO2
9	Study and calibration of a Rotameter for flow measurement.	PO1, PO2, PO3	PSO1, PSO2
10	Study and calibration of Magnetic speed pickups for the measurement of speed	PO1, PO2, PO3	PSO1, PSO2
11	Study and use of a Seismic pickup for the measurement of vibration amplitude of an engine bed at various loads.	PO1, PO2, PO3	PSO1, PSO2
12	Calibration of Mcleod gauge for low pressure.	PO1, PO2, PO3	PSO1, PSO2

INDEX

S.NO.	NAME OF EXPERIMENT	PAGE NO.	DATE	REMARK	SIGN
1	Calibration of capacitive transducer for angular displacement.				
2	Study and calibration of LVDT transducer for displacement measurement.				
3	Calibration of Resistance Temperature Detector (RTD) for temperature measurement.				
4	Calibration of Thermistor for temperature measurement.				
5	Calibration of Thermocouple for temperature measurement.				
6	Study and calibration of Photo speed pickups for the measurement of speed				
7	Calibration of Pressure Gauges				
8	Calibration of Strain gauge for temperature measurement.				
9	Study and calibration of a Rotameter for flow measurement.				
10	Study and calibration of Magnetic speed pickups for the measurement of speed				
11	Study and use of a Seismic pickup for the measurement of vibration amplitude of an engine bed at various loads.				
12	Calibration of Mcleod gauge for low pressure.				

EXPERIMENT -1

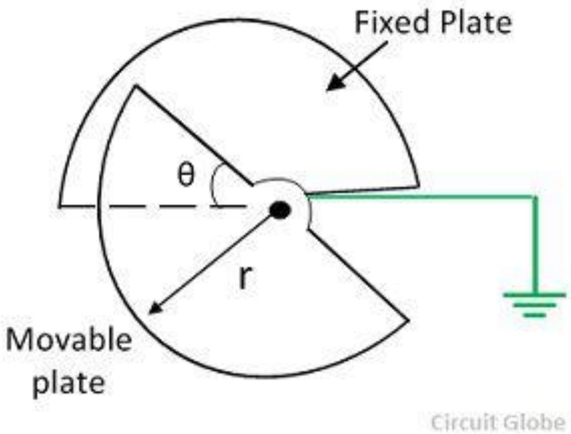
CALIBRATION OF CAPACITIVE TRANSDUCER FOR ANGULAR DISPLACEMENT

Aim:
To calibrate capacitive transducer for angular displacement.

Apparatus:
Capacitive transducer & Angular displacement indicator

Theory:
Capacitance is well known to be a function of effective area of the conductors, separation between them ,and the dielectric strength of the material in the separation. Capacitive transducers convert the physical quantity to be measured in to a change of capacitance which is processed by them ensuring circuit of the transducer. The capacitance of

A parallel plate capacitor may be changed by varying the separation between the plates, varying the effective area of the plates or varying the dielectric. The over lapping area between two stator and rotor plates of the capacitor goes on changing gas the shaft capacitor is rotated. The arrangement is used to demonstrate the measurement of angular displacement.



Principle:
The capacitive transducer works on the principle of change in capacitance due to change in overlapping area of plates can be used for angular displacement measurement. The capacitance of a parallel plate capacitor which is given by

$C = \epsilon. A/d$

where C = Capacitance of a capacitor in Farads)

$\epsilon = \epsilon_r \epsilon_o$

ϵ = Permittivity of the dielectric medium (F/m)

A= Area of plates or electrodes. (m^2)

ϵ_r = Relative permittivity (dielectric constant)

ϵ_o= Permittivity of free space ($8.54*10^{-12}$ F/m)

d = Distance between two plates (m)

The change in overlapping area of rotating parallel plates is considered for measuring angular displacement.

specification:

Sensor :	: Angular plate capacitor
Sensor Material	: Aluminum plates
Dielectric Medium	: Air
Displacement	: 0 to 90^0
Accuracy	: 5 to10%
Power	: 230V +/- 10% 50HZ

Procedure:

1. Connect the capacitive pick-up to the input socket o the front panel of the instrument tutor.
2. Allow the instrument in On position for 10 minutes for initial warm-up
3. Move the moving plate to Zero position.
4. Adjust the ZERO potentiometer so that the display reads'000'
5. Now turn the shaft of the capacitive pick-up to full clockwise position gently till the scale reading is 170^0. Adjust the meter reading to 170^0 by operating the CAL POT.
6. Turn the shaft of the capacitive pick-up full clockwise position in a gentle manner in step of 5 to 10^0 for angular sensor and note down the reading in the tabular column till 170^0
7. A known displacement is given to the parallel plate and note down the readings corresponding to input angular displacement and indicated angular displacement on the digital meter in the following observation table.
8. Plot the input and output readings on the x and y axis of a graph.
9. Repeatability can be calculated by repeating the experiment 3 to 4 times and tabulating the readings both for ascending and descending of angular displacement.

Tabular column:

Sno	Angular displacement protractor reading (R_a in Degrees)	Measured Displacement reading $(R_m)^0$ (degrees)	Error $(R_m – R_a)$ (degrees)	Correction $(R_a – R_m)$ (degrees)	Absolute %Error $[(R_m - R_a)/ R_m]*100$
1					
2	30^0	31^0	1^0	$- 1^0$	0.58 %
3					
4					
5					
6					

Specimen calculation:

Considering the second observation, the specimen calculations are as follows.
Angular displacement protractor reading, Ra= 30^0

Measured angular displacement reading using digital indicator ,$R_m = 31^0$

Error =$R_m – R_a = 31^0 - 30^0 = 1^0$

Correction = -(error) = $R_a – R_m = 30 - 31 = -1^0$

Absolute %Error = $[(R_m - R_a)/R_m]*100 = [(31- 30)/31]*100 = 3.2$ %

Graph:

Plot a graph using the true angular displacement on X axis & measured angular displacement on Yaxis . Accuracy and the linearity of the capacitance sensor can be calculated by the graphs,

Precautions:

- All connections should be neat and clean.
- Digital indicator reading has to be noted accurately.
- Readings on the Protractor is noted without parallax error.
- To check the power source, it should be 230V ±10%, 50 Hz. to avoid over voltage hazards.
- To get best performance, you have to put the instrument at dust proof and humidity free environment.
- Do not try to open the instrument or repair it.

Result:

.

Pre viva questions:

1. Name the angular displacement measuring Transducer.
2. What is the relation between d, A and permittivity of free space?
3. Why is initial adjustment is needed.?
4. What is calibration?
5. What is measurement process

Post viva Questions:

1. On what parameters the capacitance depends.
2. What is principle used in this experiment.
3. What is measurand?
4. What is the range of the instrument.
5. What is error and correction

EXPERIMENT -2

STUDY AND CALIBRATION OF LVDT TRANDUCER FOR DISPLACEMENT MEASUREMENT

Aim:

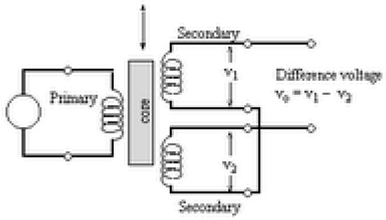
To Calibrate Linear variable differential transformer (LVDT) for the performance using micrometer.

Apparatus:

LVDT, Digital Indicator, Micrometer.

Theory:

LVDT consists of a cylindrical former where it is surrounded by a one primary winding in the center of the former and two secondary windings at the sides. The number of turns in both the secondary windings are equal, but they are opposite to each other, ie., if the left secondary windings is in the clockwise direction, the right secondary windings will be in the anti-clockwise direction, hence the net output voltages will be the difference in voltages between the two secondary coil. The two secondary coil is represented as S_1 and S_2. Esteem iron core is placed in the center of the cylindrical former which can move in to and fro motion as shown in the figure.



Principle:

LVDT works on the principle of mutual induction, and the displacement which is a non-electrical energy is converted into an electrical energy. This transducer converts linear motion to a voltage signal.

S P E C I F I C I A T I O N S

INDICATOR

DISPLAY : ½ digit seven segment red LED display of Range 200mV for full scale deflection.
OPERATING TEMPERATURE : $+10^0$ c to 55^0C
ZERO ADJUSTMENT : Front panel through Potentiometer
SENSTIVITY : 0.1 mm
SYSTEMINACCURACY : 1%
REPEATABILITY:1%
CONNECTION :Through 6 core shielded cable within connector.
FUSE : 250mA fast glow type.
POWER : 230 V +/- 10%, 50Hz

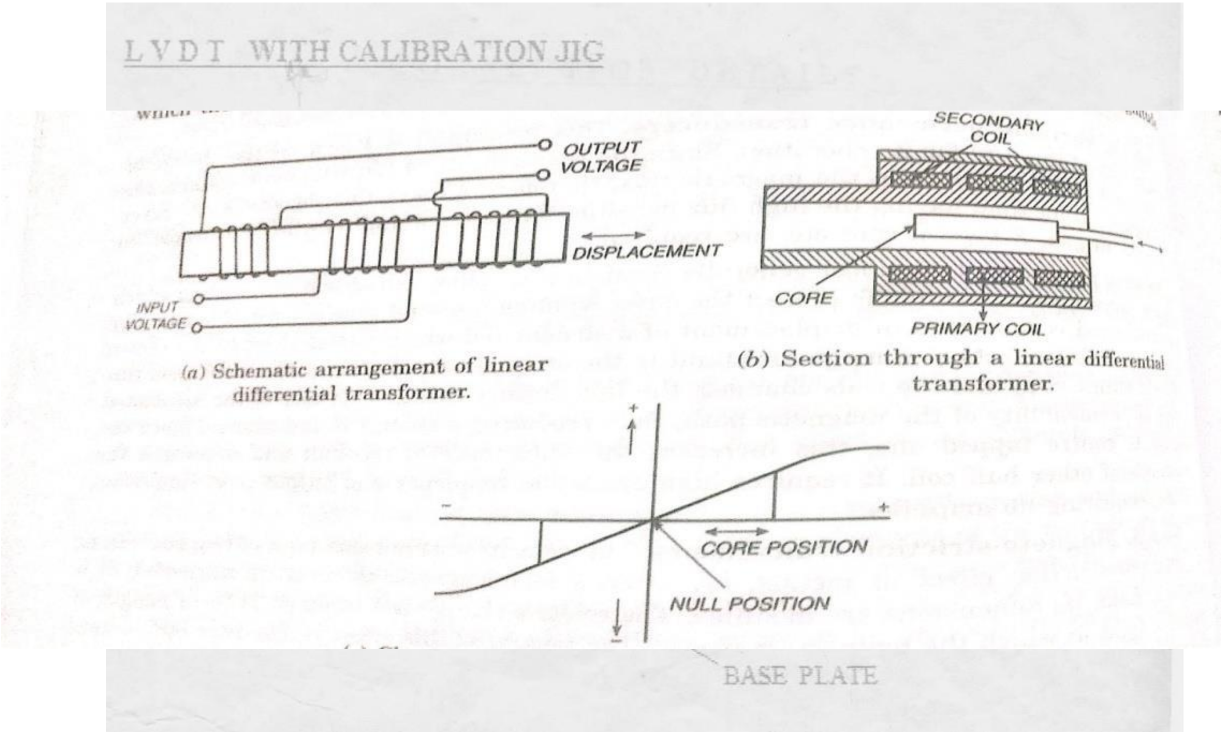


Fig: LVDT setup

Experimental procedure:

The experiment can be carried out for both +ve and –ve sides.

1. Connect the power cable to 230V, 50Hz to mains and switch on the instrument.

2. Make the display to read zero(000) by using zero knob.

3. Connect the LVDT cable pins to the instrument with proper color code.

4. Makethedisplaytoreadzerobyrotatingthemicrometer.Thisiscallednull balancing and note down the micrometer reading.

5. Give the displacement of 5mm by rotating the micrometer from the null position either clockwise or anticlockwise.

6. Then display will be read5.00mm.ifnotadjustthedisplaybyusingCalknob.Nowtheinstrumentis calibrated.

7. Again rotate the micrometer to null position and from the retake down the reading in steps of 1m,. that is on both the sides.

8. Plot the graph micrometer reading v/s display reading (Actual reading v/s Measured reading)

Observations:

Range of Micrometer. : ----------
Least count of Micrometer. : ----------
Linearity Range of LVDT. : ----------
Least count of LVDT. : ----------
Initial reading of Indicator (null position): Micro meter reading at null position.

Tabular column:

I) Display for +ve side:(Anti clock wise rotation) : Pull Position

No	Actual Reading, R_a (mm)	Measured Reading, R_m (mm)	Error = $(R_m - R_a)$ (mm)	Correction= $(R_a - R_m)$ (mm)	Absolute %Error= $[(R_m - R_a) / R_m] * 100$
1	+ 0.5	+ 0.4	- 0.10	+ 0.10	25.00 %

Parameter relations:

1. R_a=Actual Reading (Pressure gauge reading)

2. R_m=Measured Reading (Indicator reading)

3. Error (E)=R_m- R_a

4. Absolute %Error= (Error/ Actual reading)*100

Specimen calculations:

Considering the first observation, the specimen calculations are as follows.

Actual Reading, R_a = + 0.5 mm

Measured Reading, R_m = + 0.4 mm

Error = R_m -R_a = + 0.4 – 0.5 = - 0.1 mm

Correction = - Error = R_a - R_m = + 0.5 – 0.4 = + 0.1 mm

Absolute %Error = [(R_m - R_a) / R_m] * 100 = (0.4 – 0.5)*100/0.4 = 25.00 %

II) Display for –ve side: (clockwise rotation): Push Position

Tabular column

Sl.no	Actual Reading,R_a (mm)	Measured Reading, R_m (mm)	Error= (R_m - R_a) (mm)	Correction= (R_a - R_m) (mm)	Absolute %Error= |[(R_m - R_a) / R_m] * 100|
1					
2					
3					
4	- 2.0	2.1	- 0.10	+ 0.10	76 %
5					
6					
7					

Specimen calculations:

Considering the fourth observation, the specimen calculations are as follows.

Actual Reading, R_a = - 2.0 mm

Measured Reading, R_m = - 2.1 mm

Error = R_m -R_a = - 2.1 – (2.0) = - 0.1 mm

Correction= -Effor = R_a - R_m = - 2.0 – (- 2.1) = + 0.1 mm

Absolute %Error = |[(R_m - R_a) / R_m] * 100| = (-2.1 –(-2.0)*100/2.1 = 4.76 %

Graphs:

Actual reading v/s Measured reading (for both +ve & -ve displacements)

X axis micrometer reading(in mm) Y axis display reading(in mm)

Precautions:

- All connections should be neat and clean.
- Initial Zero setting may be done properly
- move the core gently.
- Micrometer should be maintained properly.
- LVDT core and micrometer are mounted on instant fixture with curve and ensure that the core and micro meter spindle lies in the same axis.
- Digital indicator reading has to be noted accurately.
- To check the power source, it should be 230V ±10%, 50 Hz. to avoid over voltage hazards.
- To get best performance, you have to put the instrument at dust proof and humidity free environment.
- Do not try to open the instrument or repair it.

Result:

Pre viva questions:

1. What is LVDT
2. What is working principle of LVDT.
3. How LVDT is Used for displacement measurement?
4. what are the advantages of LVDT?
5. How is winding of secondary coils are done ?
6. Name other displacement measuring instruments.

Post viva questions:

1. when core is at centre position, the emf produced is -----
2. What is the Range, mention the value of range for LVDT that is used.
3. Difference between Span and Range
4. Least count of LVDT
5. What is the relation error and correction?
6. Name transducers used for measurement of displacement.

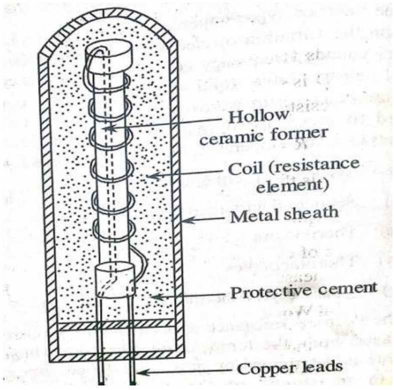
EXPERIMENT- 3

CALIBRATION OF RESISTANCE TEMPERATURE DETECTOR (RTD) FOR TEMPERATURE MEASUREMENT.

Aim:
To calibrate the given RTD (PT-100) by using Thermometer

Apparatus:
Temperature sensor (RTD), Heating coil to heat water in water bath, Digital Temperature Indicator & Thermometer.

Theory:



Resistance thermometers, also called **resistance temperature detectors (RTD)**, are temperature sensors that exploit the predictable changeinelectricalresistanceofsomematerialswithchangingtemperature. The resistance of RTD increases as the temperature increases. The RTD is linearly related over a wide temperature range. As they are almost in variably made of platinum, they are often called **platinum resistance thermometers.** There are many categories like carbon resistors, film and wire wound types are the most widely used. Platinum is widely used for sensor fabrication since it is the most stable of all the metals, is the least sensitive to contamination, and is capable of operating over a very wide range of temperature. The dynamic response of on RTD depends almost entirely on construction details. In this experiment PT-100 is considered as RTD sensor

Fig: Resistance Temperature Detector.

Principle:

The principle of operation of RTD: is that the resistance of the conductor varies with the variation in temperature

The amount of change occurred in the resistance can be given by $R = R_O(1+ \alpha 1\ T + \alpha 2\ T^2 + \alpha 3 T^3 + + \alpha_n T^n)$

Where R_O is the resistance at zero temperature

And $\alpha 1, \alpha 2, \alpha 3$ ………. α_n are constants

Considering one term only, the equation becomes $R = R_O (1+ \alpha t)$

α = temperature coefficient of resistance.

Fig: Resistance Temperature Detector setup

Experimental procedure:

1. To connect the RTD sensor (PT-100) to pin connector.
2. Switch   ‘ON’ the system the power indicator. The RED LED on the front panel will glow.
3. Immerse the transducer in the ice-bath, wait for 2-3 minutes so that the temperature equilibrium takes place and adjust the 0.00 reading on the display by adjusting Zero Pot.
4. Keep the RTD into the boiling water and adjust the display reading to 10
5. Make 0by adjusting through Span Pot 100^0 C..
6. Switch off the heater supply and allow the water and immersed RTD to cool down, and observe the bath temperature With thermometer For every 5^0 C drop in water temperature, note down the thermometer reading and the display temperature and note in observation table.
7. Calculate the Error, correction, % absolute % error and draw the graphs.
8. Keep the RTD in air in room temperature. The indicator will display room temperature.

Advantages

- High accuracy
- Low drift
- Wide operating range
- Suitable for precision applications.

Specification:

Range : 100^0C
Resolution : 0.1^0 C

Top Panel:

- Display : 3 ½ Digit LED .
- Inputs : RTD sensor (PT-100)
- Zero Pot : Provided for zero adjustment.
- Span Pot : Provided for calibration.
- ON/OFF switch : to ON/OFF the system.
- Fuse : 0.5b milliamps
- Light LED : Indicates the power supply when it is in “On” position.
- Signal Output : There are two terminals

Experimental procedure:

1. Check connection made and Switch ON the instrument by rocker switch at the front panel. The display glows to indicate the instrument is ON.

2. Allow the instrument in ON Position for 10 minutes for initial warm-up.

3. Pour around 3/4th full of water to the kettle and place RTD sensor and thermometer inside the kettle. Note down the Initial water temperature from the thermometer.

4. Select the sensor on which the experiment to be conducted through selection switch on the front panel. Adjust the initial set Potentiometer in the front panel till the display reads initial water temperature.

5. Switch on the heater, and wait till the water boils note down the reading in the thermometer and set final set potentiometer till the display reads boiling water temperature.

6. Remove the sensor from the boiling water bath and immerse it the cold water. Set the cold water temperature using initial set potentiometer.

7. Repeat the process till the display reads exact boiling water and cold water temperature. Change the water in the kettle with and reheat the water. Now the display starts showing exact temperature raise in the kettle.

8. Experiment is continued and readings are noted in steps of 10^0 C and temperature in the thermometer and the indicator readings are tabulated in tabular form.

Observation and tabular column:

Sl.no	Temp. of Water by thermometer T_a ^oC	Temp. of Water by RTD, T_m ^oC	Error = $(T_m – T_a)$ ^oC	Correction= $(T_a – T_m)$ ^oC	Absolute %Error= $[(T_m - T_a)/ T_m]*100$
1					5.63 %
2					
3					
4					
5					
6					

Specimen calculation:

Considering the first observation, the specimen calculations are as follows.

Temp. of water by Thermometer, T_a = 75 ^oC

Temp.of water by RTD, T_m = 71 ^oC

Error = $(T_m - T_a)$ = 71 – 75 = - 4 ^oC

Correction = - error = $(T_a – T_m)$ = 75 – 71 = + 4 ^oC

Absolute %Error = $|[(T_m - T_a)/T_m]*100|$ = |[(71 – 75)/ 71]*100|= 5.63 %

Graphs:

Draw the following graphs:

- T_m v/s T_a
- T_m v/s Correction
- T_m v/s Absolute % Error

Precautions:

- All connections should be neat and clean.
- Thermometer should be maintained properly.
- Digital indicator reading has to be noted accurately.
- Readings on the thermometer is noted without parallax error.
- To check the power source, it should be 230V ±10%, 50 Hz. to avoid over voltage hazards.
- To get best performance, you have to put the instrument at dust proof and humidity free environment.
- Do not try to open the instrument or repair it.

Result:

Pre viva questions:

1. What is RTD ?
2. What is principle of RTD?
3. As the temperature increases what will happen to RTD sensor resistance.
4. What are the RTD materials?
5. What is error, correction and % error?
6. Sources of errors.

Post viva questions:

1. What is calibration?
2. What is relation between temp &resistance?
3. What is positive temperature coefficient (PTC)
4. What are the advantages of RTD?
5. What is the replacement for temperature measurement, if RTD is not available?

EXPERIMENT - 4

CALIBRATIONOF THERMISTORFOR TEMERATURE MEASUREMENT

Aim:
To calibrate the given Thermistor by using Thermometer

Apparatus:
Temperature sensor (Thermistor), Heating coil to heat water in water bath , Digital temperature indicator and Thermometer

Theory:

A Thermistor is a type of resistor whose resistance varies significantly with temperature, more so than in standard resistors. Thermistors are semiconductors of certain materials that are extremely sensitive to temperature. The material is made by sintering oxides of such materials as Manganese, Nickel, Cobalt, Copper, Iron etc. Physical forms may be beads, discs, washers and rods. The temperature co-efficient of resistivity of metallic oxide semiconductors is –ve. The resistance of a thermistor decreases as the temperature increases. Moreover the temperature resistance relationships of thermistors are exponential. Most important point in favor of thermistor is their extremely high sensitivity to temperature changes. The highest temperature up to which thermistors can be used is limited up to 200^0 C.

Principle:

The temperature-resistance function for a thermistor is given by
$R = R_O e^k$

$K = \beta (1/T - 1/T_O) R_O$
R = the resistance at any temperature T in ^{0} K
R_O = the resistance at reference temp T_O *in* ^{0} *K*
E = the base of Naperian logarithms. ,
β = a constant
The constant β generally has a value between 3400 and 3900 depending on thermistor formulation.

Thermistor can be classified in to two types, depending on the sign of k. If k is positive, the resistance increases with increasing temperature ,and the device is called a positive temperature co-efficient (PTC) Thermistor .If k is negative, the resistance decreases with increasing temperature, and the device is called a negative temperature co-efficient(NTC)thermistor.Resistorsthatarenotthermistoraredesigned to have a ‘k’ as close to zero as possible, so that the resistance remains nearly constant over a wide temperature range.

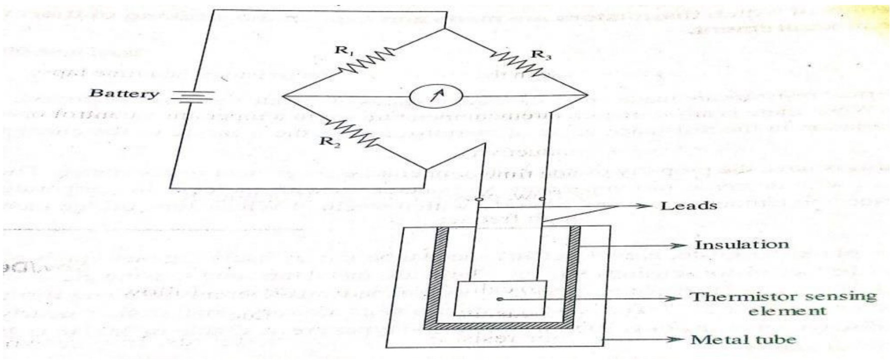


Fig. Thermistor set-up

Procedure:

1. Check connection made and Switch 'ON' the instrument by rocker switch at the front panel. The display glows to indicate the instrument is ON.

2. Allow the instrument in ON Position for 10 minutes for initial warm-up.

3. Pour around 3/4th full of water to the kettle and place sensors and thermometer inside the kettle. Note down the initial water temperature from the thermometer.

4. Select the sensor on which the experiment to be conducted through selection switch on the front panel. Adjust the Initial set Potentiometer in the front panel till the display reads initial water temperature.

5. Switch on the kept and wait till the water boils note down the reading inn the thermometer and set final set potentiometer till the display reads boiling water temperature.

6. Remove the sensor from the boiling water immerse it the cold water. Set the cold water temperature using initial set potentiometer.

7. Repeat the process till the display reads exact boiling water and cold water temperature. Change the water in the kettle with and re heat the water. Now the display starts showing exact temperature raise in the kettle.

8. Experiment can be repeated for all the three sensors. Temperature in the thermometer and the indicator readings in steps of 10^0 C can be tabulated.

Observation and tabular column:

Sl..no.	Temp. of Water by Thermometer$_a$ ^oC	Temp. of Water by Thermistor, T_m ^oC	Error = $(T_m - T_a)$ ^oC	Correction= $(T_a - T_m)$ ^oC	Absolute %Error= $[(T_m - T_a)/T_m]*100$
1					
2	75	76	1	-1	1.31 %
2					
3					
4					
5					

Specimen calculation:

Considering the second observation, the specimen calculations are as follows.

Temp. of water by Thermometer, T_a = 75 ^oC

Temp. of water by Thermistor, T_m = 76 ^oC

Error = $(T_m - T_a)$ = 76 – 75 = 1.0 ^oC

Correction = - error = $(T_a – T_m)$ = 75 – 76 = - 1 ^oC

Absolute %Error = $|[(T_m - T_a)/T_m]*100|$ = |[(76 – 75)/ 76]*100| = 1.31 %

Graphs:

Draw the following graphs:

•T_m v/s T_a

•T_m v/s Correction

•T_m v/s Absolute % Error

Precautions:

- All connections should be neat and clean.
- Thermometer should be maintained properly.
- Digital indicator reading has to be noted accurately.
- Readings on the thermometer is noted without parallax error.
- To check the power source, it should be 230V ±10%, 50 Hz. to avoid over voltage hazards.
- To get best performance, you have to put the instrument at dust proof and humidity free environment.
- Do not try to open the instrument or repair it.

Result:

Pre viva questions:

1. What is thermistor, material of thermistor
2. Principle of thermistor.
3. What is negative temperature coefficient & positive temperature coefficient.
4. What is absolute % error.
5. What are different types of errors

Post Viva Questions:

1. What are sources of error.?
2. Name different forms of thermistor.
3. Name the materials used for thermistor
4. What mean by negative temperature coefficient?
5. Name the different forms of thermistors

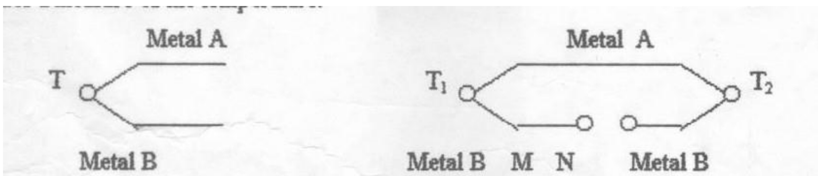
EXPERIMENT– 5

CALIBRATIONOFTHERMOCOUPLE FORTEMPERATURE MEASUREMENT

Aim:
To calibrate the given thermocouple using thermometer.

Apparatus:
Thermocouple, a heating coil to heat the water in the water bath, thermometer and a digital indicator to indicate the temperature of thermocouple.

Theory:
The common electrical method of temperature measurement uses the thermocouple, when two dissimilar metal wires are joined at both ends, an emf will exist between the two junctions, if the two junctions are at different temperatures. This phenomenon is called Seebeck effect. If the temperature of one junction is known then the temperature of the other junction may be easily calculated using the thermo electric properties of the materials. The known temperature is called reference temperature and is usually the temperature of ice. Potential(emf) is also obtained if a temperature gradient along the metal wires. This is called Thomson effect and is generally neglected in the temperature measuring process. If two materials are connected to an external circuit in such a way that current is drawn, an emf will be produced. This is called as Peltier effect. In temperature measurement, seeback emf is of prime concern since it is dependent on junction temperature.



The thermocouple material must be homogeneous. A list of common Thermocouple materials in decreasing order of emf chrome, iron and copper platinum–10%rhodium,platinum,alumelandconstantan(60%copperand 40%nickel).Each material is thermo electrically positive with respect to the below it and negatives with respect those above.

The material used in thermo couple probe is:
1. Iron–Constantan (TypeJ) (-300F to 1580F)
2. Copper–Constantan (TypeT) (-3000 F to 6000 F)
3. Chromyl–Alumel (TypeK).

Principle:
Thermocouple is a self-generating transducer and is basically a pair of dissimilar metallic conductors joined so as to produce an e.m.f , when junctions are at different temperatures. The magnitudes of e.m.f depends upon the magnitude of temperature difference and materials of conductors. Thermocouple is an electrical device consisting of two dissimilar electrical conductors forming electrical junctions at differing temperatures. A thermocouple produces a temperature-dependent voltage as a result of the thermoelectric effect, and this voltage is proportional to temperature of hot source.

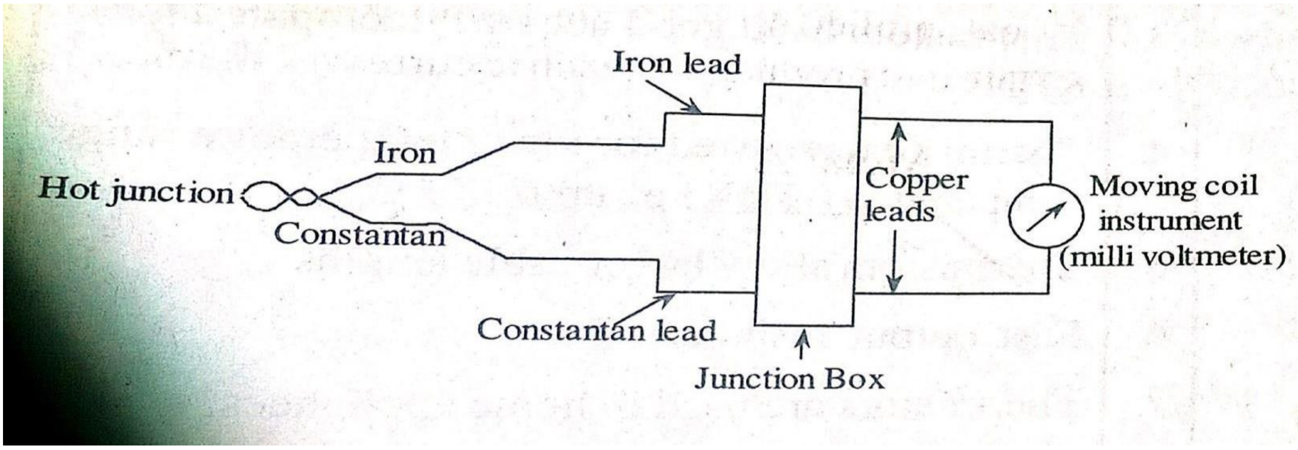


Fig: Thermocouple

Fig: Thermocouple setup

Procedure:

1. Check connection made and Switch ON the instrument by rocker switch at the front panel. The display glows to indicate the instrument is ON.
2. Allow the instrument in ‘ON’ position for 10 minutes for initial warm-up.
3. Pore around $3/4^{th}$ full of water to the heater kettle and place sensors and thermometer inside the kettle. Note down the Initial water temperature from the thermometer.
4. Select the sensor on which the experiment to be conducted through selection switch on the front panel. Adjust the Initial set Potentiometer in the front panel till the display reads initial water temperature.
5. Switch on the kept and wait till the water boils note down the reading inn the thermometer and set Final set potentiometer till the display reads boiling water temperature.
6. Remove the sensor from the boiling water immerse it I the cold water. Set the cold water temperature using initial set potentiometer.
7. Repeat the process till the display reads exact boiling water and cold water temperature. Change the water in the kettle with and re heat the water. Now the display starts showing exact temperature raise in the kettle.
8. Experiment can be repeated for all the three sensors. Temperature in the thermometer and the indicator readings in steps of 10^0 C can be tabulated.

Observation and tabular column:

Material for thermocouple wires: -------------

Sl.no	Temp. of Water by Thermometer T_a ^oC	Temp.of Water by thermocouple, T_m ^oC	Error = $(T_m – T_a)$ ^oC	Correction = $(T_a – T_m)$ ^oC	Absolute %Error = $[(T_m - T_a)/ T_m]*100$
1	73	71	- 2	+ 2	2.81 :%:
2					
3					
4					
5					
6					

Specimen calculation:

Considering the first observation, the specimen calculations are as follows.

Temp. of water by Thermometer, T_a = 73 ^oC

Temp.of water by Thermocouple, T_m = 71 ^oC

Error = $(T_m - T_a)$ = 71 – 73 = - 2 ^oC

Correction = - error = $(T_a – T_m)$ = 73 – 71 = + 2 ^oC

Absolute %Error = $[(T_m - T_a)/T_m]*100$ = [(71 – 73)/ 71]*100 = 2.81 %

Graphs:

Draw the following graphs:\

1. T_m V/s T_a
2. T_m V/s Correction
3. T_m V/s Absolute %Error

Precautions:

- All connections should be neat and clean.
- Thermometer should be maintained properly.
- Digital indicator reading has to be noted accurately.
- Readings on the thermometer is noted without parallax error.
- To check the power source, it should be 230V ±10%, 50 Hz. to avoid over voltage hazards.
- To get best performance, you have to put the instrument at dust proof and humidity free environment.
- Do not try to open the instrument or repair it.

Result:

Pre viva questions:

1. What is thermocouple?
2. What principle of thermocouple?
3. What is Peltier effect?
4. What is Thomson effect?
5. What id Law of intermediate metals

Post viva questions:

1) What is law of Intermediate metals?
2) Name the thermocouple materials.. types of thermocouples
3) What is calibration?
4) How the thermocouples are used for temperature measurement and what is the range of thermocouples?
5) What is error, correction, % error

EXPERIMENT- 6

STUDY AND CALIBRATION OF PHOTO PICKUP FOR MEASUREMENT OF SPEED

Aim:

To calibrate Photo pickup using standard Tachometer

Apparatus:

Digital RPM indicator, Photo pickup & Magnetic pickup, Variable sped motor with rotating disc, Variable speed regulator , Hand t held non-contact type digital Tachometer.

Theory:

The measurement of rotational velocity is more common. For velocity (speed) measurement the most convenient calibrator scheme uses a combination of toothed wheel, a simple magnetic proximity pickup, a photo couple sensor and an electronic indicator to measure the speed. The angular rotation is provided by some adjustable speed drive of adequate stability. The toothed wheel mounted with iron rods while passing under magnetic and photo pickup produces an electric pulse. These pulse are fed to signal conditioner unit and displays reading visually. The stability of the rotational drive is easily checked by observing the variation of display reading.

Principle:

Photo pick-up utilizes a rotating shaft to intercept a beam of light falling on a photo-electric or photoconductive cell. The shaft has an intermittent reflecting (white) and non-reflecting (black) surface. When a beam of light hits the reflecting surface on the rotating shaft, light pulses are obtained and the reflected light is focused on to the photoelectric cell. The frequency of light pulses is proportional to the shaft speed and so will be the frequency of electrical output pulses from the photo electric cell

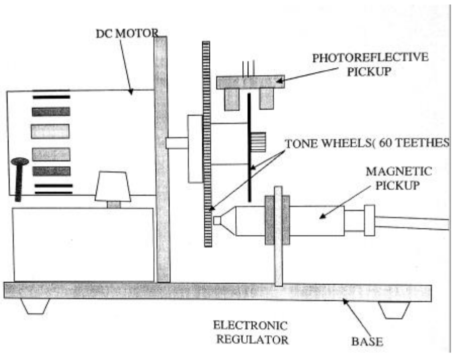


Fig: photo pickup

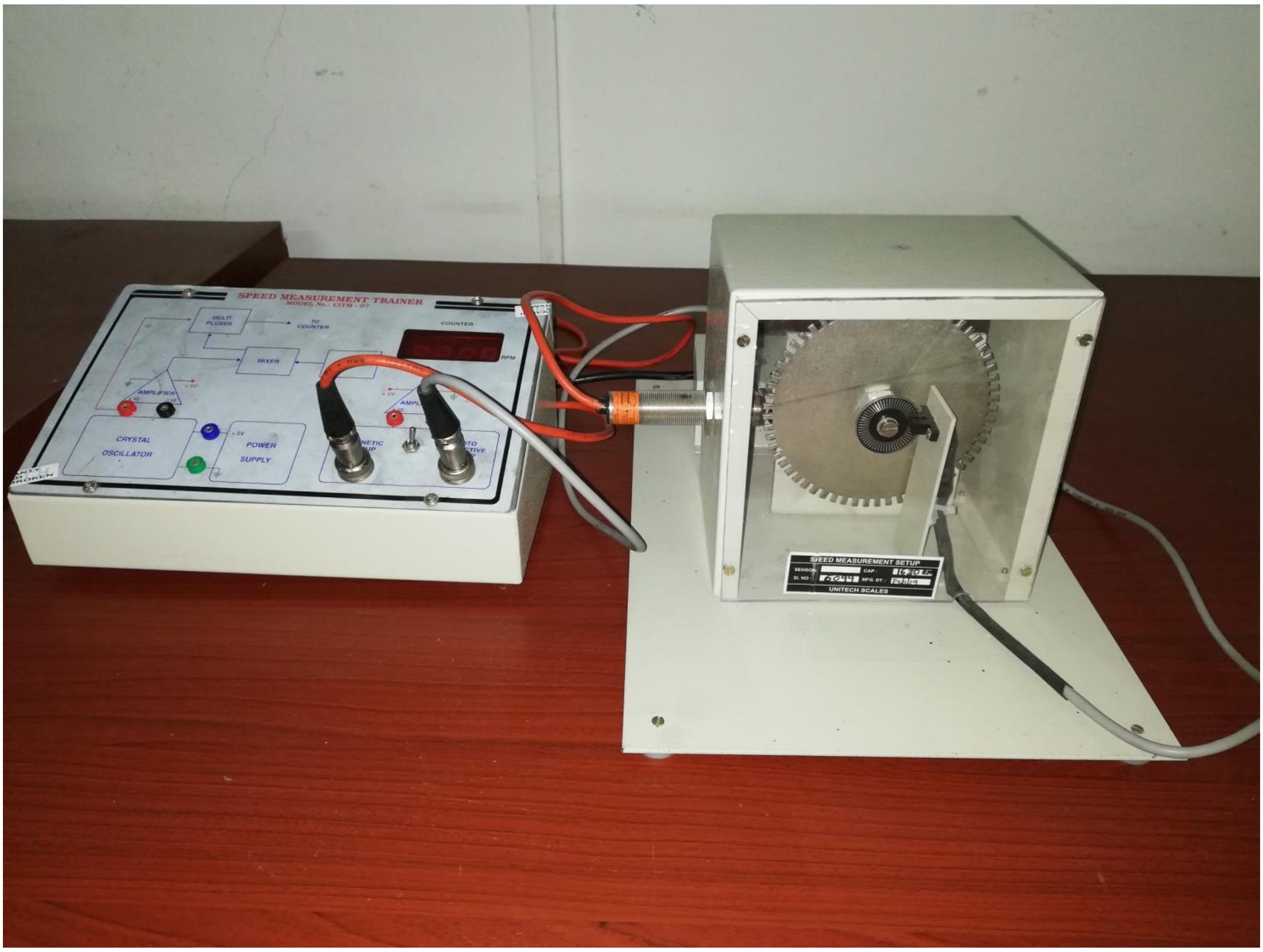


Fig: **Magnetic speed photo pickip experiment setup**

Operating procedure:

1. Check the connections of the equipment.
2. Select the mode of operation on Xenon flash lamp (Hi/lo).
3. Make a mark on the rotating wheel.
4. Now switch on the Xenon flash lamp and adjust that the light exactly projected on the rotating wheel.
5. Adjust the speed of the motor such that ONESTATIONARY mark is visible on the wheel..Note down the reading in the tabular column.
6. Now adjust the sped of the motor such that Two Stationary marks are visible and note the readings.
7. Similarly for Three and more marks and note the readings.

Tabular column:

Sl. no	Speed using Tachometer (N_a) rpm	Speed using Photo Pickup sensor (N_m) rpm	Error ($N_m – N_a$)	Correction ($N_a – N_m$)	Absolute %Error $[(N_m - N_a)/ N_m]*100$
1	52.2	52.1	- 0.1	+ 0.1	0.19 %
2					
3					
4					
5					
6					
7					

Specimen calculation:

Considering the first observation , the specimen calculations are as follows.

Speed using Tachometer, N_a=52.2 rpm

Speed using Photo-pickup sensor, N_m = 52.1 rpm

Error = $N_m – N_a$ = 52.1 – 52.2 = -0.1 rpm

Correction = - Error = $N_a – N_m$ = 52.2 – 52.1 = + 0.1rpm

Absolute %Error = | $[(N_m - N_a)/N_m]*100$| = | [(52.1 – 52.2) / 52.1]*100| = 0.19 %

Graphs:

Draw the following graphs for each of the case:

1. N_m Vs Na
2. N_m V/s Correction
3. N_m V/s Absolute %Error

Precautions:

- All connections should be neat and clean.
- Non-contact type speedometer should be maintained properly.
- Digital indicator reading has to be noted accurately.
- To check the power source, it should be 230V ±10%, 50 Hz. to avoid over voltage hazards.
- To get best performance, you have to put the instrument at dust proof and humidity free environment.
- Do not try to open the instrument or repair it.

Result:

Pre viva questions:

1. What is speed ?
2. Units for speed.
3. What are the pick-ups / sensors used in this experiment?
4. What are different speed measuring devices?
5. Principle of contact type and non-contact type speed measuring device.

Post viva questions:

1. What is principle involved in magnetic and photo pick-up sensors.
2. What is stroboscope?
3. what is the principle of photo electric transducer?
4. What are the applications of Stroboscope?
5. What are the advantages and disadvantages of Stroboscope?

EXPERIMENT-7

CALIBRATIONOFPRESSUREGAUGE

Aim:
To calibrate the given pressure cell

Apparatus:
Pressure cell, Dial type pressure indicator, Hydraulic dead weight, Pressure gauge Tester to develop the pressure, Digital pressure indicator.

Theory:
Pressure is defined as force per unit area and is measured in Newton per square meter(Pascal) or in terms of an equivalent head of some standard liquid (mm of mercury or mater of water).A typical pressure gauge will measure the difference in pressure between two pressure. Thus a pressure gauge is connected to the hydraulic line and the gauge itself stands in atmospheric pressure. The gauge reading will be the difference between the air pressure and the atmospheric pressure and is called gauge pressure. The absolute pressure(the actual pressure with in the airline)is the sum of the gauge pressure and atmospheric pressure. Pressure transducer is basically an electromechanical devices, especially manufactured and designed or wide range application in pressure measurement. The pressure transducer comprises of diaphragm and an inputs of a pressure measurement.Thestraingaugesarebondeddirectlytothesensingmembertoprovide excellent linearity, low hysteresis and repeatability. Fluid medium whose parameter has to be measure disallowed to deflect the diaphragm (sensing member), which is a singleblockmaterialandformsanintegralpartofthepressuretransducer.It is made up non-magnetic stainless steel and thus has the advantage of avoids the yielding effects and leakage problems. The slight deflection of the diaphragms due to the pressure provided an electrical output. The material most commonly used for manufacture of diaphragms are steel, phosphor bronze, nickel silver and beryllium copper. The deflection generally follows a linear variation with the diaphragm thickness.

Principle: Pressure cells are divisors that convert pressure into electrical signal through a measurement of either displacement strain or piezoelectric response. Diaphragm type pressure transducers with strain gauges as sensor is used here for measurement of pressure.

Specification of pressure gauge:

Sensor	:	strain gauges bonded on steel diaphragm for pressure measurement.
TYPE	:	Diaphragm
Range	:	10Kg/cm^2

Connectio	:	Through four cure shielded cable with the connector Attached
Excitation	:	10V DC
Accuracy	:	1%
Linearity	:	1%
Max. overload	:	150% MECHANICAL

Fig: Pressure gauge setup

.

Operating procedure:

1. Connect the pressure cell to the pressure indicator with given cable.
2. Connect the instrument to mains, i.e.230V.Power supply and switch on the instrument.
3. Adjust the zero pot of the indicator to indicate zero.
4. Close the release valve of pressure gauge tester and apply the 5/10kg dead weight on flange.
5. Slowly rotate the screw rod in clockwise direction with the help of handle until flange lift up (so that pressure is developed up to applied load). Now observe the digital reading. If it is not showing zero then make it zero by rotating ZERO knob. Now instrument is said to be calibrated.
6. Apply the load(upto10Kgs)on the flange and give pressure by rotating the screw rod.

7. Note down the readings of dial gauge and pressure indicator, simultaneously in every step.

8. Calculate the error if any and absolute% error.

Tablur column:

Sl.No	Pressure in gauge, P_c kg/ cm^2	Pressure in Digital indicator, P_g kg/ cm^2	Error $P_g – P_c$ kg/ cm^2	Correction $P_c – P_g$ kg/ cm^2	Absolute %Error $[(P_g - P_c)/ P_g] *100$
1					
2	1.00	0.98	- 0.02	+ 0.02	2.04 %
3					
4					

Specimen calculation:

Considering the second observation , the specimen calculations are as follows.

Pressure in digital gauge , P_g = 1.00 kg/ cm^2

Pressure in digital indicator, P_c = 0.98 kg/ cm^2

Error = $P_g – P_c$ = 1.00 - 0.98 = 0.02 kg/ cm^2

Absolute %Error = $[(P_g - P_c)/ P_g]$ *100 = {(1.00 – 0.98)/ 1.00 = 204%

GRAPHS:

Draw the following graphs:

- P_gv/sP_c
- P_g **V/S** Correction
- P_g **V/S** Absolute % Error

Precautions:

- All connections should be neat and clean.
- Digital Pressure Indicator reading has to be noted accurately.
- To check the power source, it should be 230V ±10%, 50 Hz. to avoid over voltage hazards.
- To get best performance, you have to put the instrument at dust proof and humidity free environment.
- Do not try to open the instrument or repair it.

Result:

Pre viva questions:

1. What is pressure transducer, name different types
2. what is calibration
3. what precision and accuracy.
4. What is measurand
5. what is error, correction, % error

Post viva questions:

1. what is mean by resolution, threshold
2. what is accuracy?
3. what is range of pressure gauge?
4. What is the span of the instrument ?
5. What is observational error?

EXPERIMENT - 8

CALIBRATION OF STRAIN GAUGE FOR MEASUREMENT OF TEMPERATURTE

Aim:
To study and calibration of Strain Gauge for Temperature measurement

Apparatus:
Temperature sensor panel (MIT-6), Multi meter set

Theory:
When a material is subjected to any external load, there will be small change in the mechanical properties of the material. The mechanical property may be, change in the thickness of the material or change in the length depending on the nature of load applied to the material. This change in mechanical properties will remain till the load is released. The change in the property is called strain in the material or the material gets strained. So the material is mechanically strained this strain is defined as. The ratio between change in the mechanical property to the original property. Suppose a beam of length L is subjected to a tensile load of P Kg the material gets elongated by a length of □1. So according to the definition strain S is given by

S= Δ1/L

Operating procedure:

1. Check connection made and Switch ON the instrument by toggle switch at the back of the box. The display glows to indicate the instrument is ON.
2. Allow the instrument in ON Position for 10 minutes for initial warm-up.
3. Adjust the ZERO Potentiometer on the panel till the display roads ‘OOP’.
4. Apply load on the sensor using the loading arrangement provided in steps of 100g up to 1Kg.
5. The instrument display exact micro strain strained by the cantilever beam.
6. Note down the readings in the tabular column. Percentage error in the readings. Hysteresis and accuracy of the instrument can be calculated by comparing with the theoretical values.

Specimen Calculation For Cantilever Beam S=(6pl) BT^{2}E

P = Load applied in Kg (1 Kg) – 0.2 kg

L = Effective length of the beam in Cms. (22 Cms) B = Width of the beam (2.8 Cms)

T = Thickness of the beam (0.25 Cm)

E = Young’s modulus ($2X10^6$) S = Micro strain

Then the micro strain for the above can be calculated as follows.

Observation and tabularcolumn:

itch posn.	mp(^{0}C)	P in mV	sistance of RTD(Ohm)	
			ing equation(2)	ltage mV/10
Posn.1	55	1320	121.175	132
Posn.2				
Posn.3				
Posn.4				
Posn.5				

Specimen calculations :

Considering first observation , the specimen calculations are as follows.

Where R_t = resistance Temperature T^{0}C

T = temperature for switch position 1 = 55^0

R_0 = resistance at 0^{0}C = 0 ohm/^{0}C

$R_{(t)}$ = 100 + T*0.385 ohm/^{0}C = 100 + 55 * 0.385 = 12.175 ohm/

Graphs:

Draw the following graphs:

- Temperature v/s Resistance
- Temperature v/s voltage

Precautions:

- All connections should be neat and clean.
- Digital multi meter indicator reading has to be noted accurately.
- To check the power source, it should be 230V ±10%, 50 Hz. to avoid over voltage hazards.
- To get best performance, you have to put the instrument at dust proof and humidity free environment.
- Do not try to open the instrument or repair it.

Result:

Pre viva questions:

1. What is stran gauge?
2. What is the Principle of RTD
3. What is positive temperature coefficient.
4. What is RTD material.
5. What is calibration.

Post viva questions:

1. What is sensitivity, Resolution.
2. Name the static characteristics
3. Name the dynamic characteristics
4. What is precision?
5. Name the other temperature measuring sensors.

EXPERIMENT- 9

STUDY AND CALIBRATION OF A ROTAMETER FOR FLOW MEASUREMENT

Aim :

To study and calibration of "Rotameter" for water flow measurement.

Apparatus :

Rotameter measuring setup, Measuring jar , Stop watch.

Principle :

The variation of flow rate through an area between annual space of the tapered tube and the float of the rotameter tube and the float generates a variable pressure drop which is related to the flow rate.

Theory :

Rotameter is a variable area meter. In the variable area meter, the drop in pressure is constant and the flow rate is a function of the area of the construction. A rotameter consists of a tapered tube with the smallest diameter at the bottom. The tube contains a freely moving float, which rests on a stop at the base of the tube. When the fluid is flowing, the float rises until its weight is balanced buy the up thrust of the fluid. Its position then indicates the rate of flow. The area for flow is the annulus formed between the float and the wall of the tube. The figure below shows schematic details of rotometer tube and float. Use top edge of the float to note rotometer reading

Procedure:

1. Connect the turbine flow sensor with indicator marked as flow sensor input.
2. Start the set up
3. Adjust 

teady is reached
4. Measure the time required for collecting 1 ltr of water in measuring jar using stop watch.
5. Drain the measuring jar
6. Repeat the experiment for different flow rates i.e. 1 to 10 LPM
7. Observe the time taken for collection of fluid with stop watch and column of fluid collected.
8. Note the observations in the observation table.

Observation table:

S.no	Rotameter reading, f_m (L.P.M)	Time required for 1 ltr water collection (Sec)	Actual Discharge, f_a (L.P.M)	Error = f_m-f_a (L.P.M)	Correction (f_a-f_m) (L.P.M)	Accuracy % = $\{(f_m-f_a)/f_m\}*100$
1	1.0	92	0.65	+ 0.35	- 0.35	3.5 %
2					-	
3					-	
4					-	
5					-	

Fig: Rotometer setup

Applications:

Used in bulk drug industries for measurement of fluid flow

Advantages:

- There is a uniform flow scale over the range of operation
- Simple in construction and is in expensive
- Easily installed.

Dis advantages:

1. The meter must be installed in a vertical position only
2. The float may not be visible when opaque fluids are used.
3. It can not be used with liquids carrying large percentage of solids in suspension.

Calculations:

1. Actual discharge = [(1*60)/ Time required for 1 ltr water] LPH
2. Error: Rotameter reading – actual reading LPH
3. Percentage Accuracy : (Error/Full flow of rotameter)* 100

Specimen calculation:

Considering the first observation , the specimen calculations are as follows.
Rotameter Reading f_m = 1.00 L.P.M

Time required for 1 ltr water collection = 92 sec

Discharge = (1 * 60)/92 = 0.65 L.P.M

Error = Rotameter reading – actual reading = 1.00 – 0.65 = 0.35 L.P.M

Percentage Accuracy = | (Error/Full flow of rotameter)*100 |= | (0.35 / 10) * 100| = 3.5 %

Graphs:

Plot the graph of Actual discharge Vs rotameter reading

Plot the graph of % accuracy Vs rotameter reading.

Precautions:

1. All connections should be neat and clean.

2. Rotameter has to be installed vertically

3. Flow has to be sent from bottom to top.

4. Stopwatch reading has to be noted accurately.

5.To check the power source, it should be 230V ±10%, 50 Hz. to avoid over voltage hazards.

6.To get best performance, you have to put the instrument at dust proof and humidity free environment.

7. Do not try to open the instrument or repair it.

Result:

Pre viva questions:

1. What is principle of Rotameter?
2. How is Rotameter is to be installed?
3. What is variable area flow meter?
4. Can it be used for flow measurement of opaque fluids. .
5. Advantages of Rotameter?

Post viva questions:

1. Disadvantages of Rotameter?
2. Applications of Rotameter.
3. Name other flow measuring instruments.
4. What is calibration?
5. What is the relation between error and correction?

EXPERIMENT - 10

STUDYANDCALIBRATIONOFMAGNETIC SPEED PICKUPS FORTHEMEASUREMENTOFSPEED

Aim:
To Calibrate Magnetic pickup using standard Tachometer

Apparatus:
Digital RPM indicator, Photo pickup & Magnetic pickup, Variable sped motor with rotating disc, Variable speed regulator , Hand t held non-contact type digital Tachometer.

Theory: The measurement of rotational velocity is more common .For velocity (speed) measurement the most convenient calibrator scheme uses a combination of toothed wheel, a simple magnetic proximity pickup, a photo couple sensor and an electronic indicator to measure the speed..The toothed wheel mounted with iron rods while passing under magnetic and photo pickup produces an electric pulse. These pulse are fed to signal conditioner unit and displays reading visually. The stability of the rotational drive is easily checked by observing the variationof display reading.

Principle: The toothed wheel mounted on the rotating shaft, while passing under magnetic setup consisting of a small permanent magnet with a coil wound on it produces change in the reluctance of the magnetic flux. As this magnetic pickup is placed near metallic toothed rotor whose speed is to be measured. The flux expands or collapses and voltage is induced in the coil.

The frequency of the pulses depends upon the number of teeth on the wheel and the speed of rotation. Since the number of teeth is known, the speed of rotation can e determined by measuring the pulse frequency.

To accomplish this task, pulse Is amplified and squared and fed into a counter of frequency measuring unit.

Let T be the no of teeth on the rotor

N; be the revolutions per second

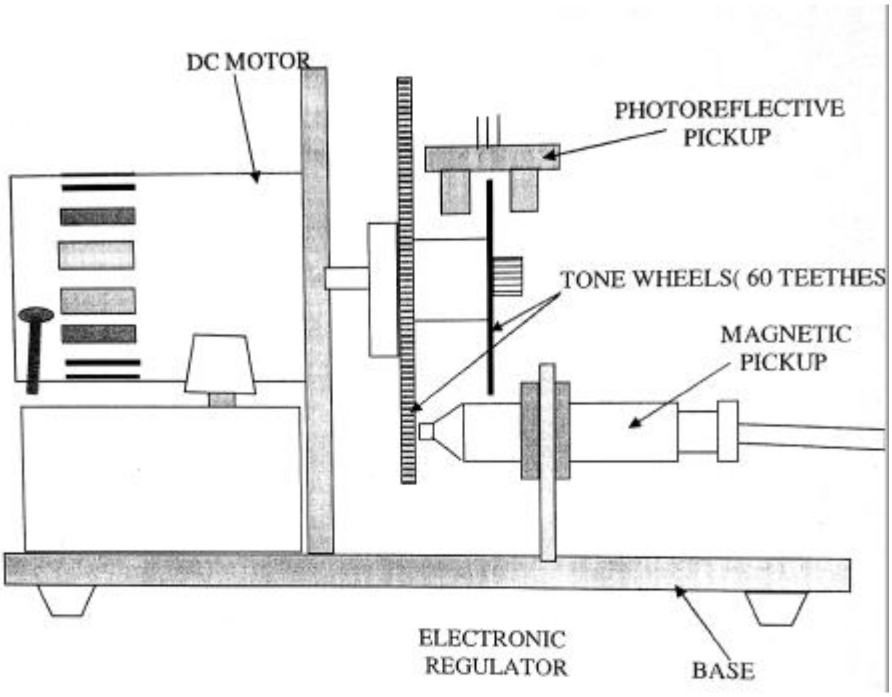
P= be the number of pulse per second.

Speed= N= pulses per second/ no. of teeth = P/T rps.

N=(P/T) *60 r.p.m

If the rotor has 60 teeth, the counter counts the pulses in one second, then the counter will directly display the speed in revolutions per minute (rpm)

Control and operation:
Speed measurement system is provided with display or signal conditioner unit and sensor unit. Sensor unit consist of magnetic and photo pickup unit with variable speed controller and a AC motor.T he pulse generated by pickup sensor is sensed by signal conditioner. Refer the front panel of the instrument, it is provided with toggle switch to select the mode of display reading by magnetic or photo pickup display reads the speed in RPM. Also provided with sensor socket for connecting magnetic and photo pickup units. Back panel of the instrument is provided with power on switch ,fuse holder and power chord for connecting AC supply.



Operating procedure:

1. Check the connections of the equipment.
2. Select the mode of operation on Xenon flash lamp(Hi/lo).
3. Make a mark on the rotating wheel.
4. Now switch on the Xenon flash lamp and adjust that the light exactly projected on the rotating wheel.
5. Adjust the speed of the motor such that ONESTATIONARY mark is visible on the wheel..Note down the reading in the tabular column.
6. Now adjust the sped of the motor such that two Stationary marks are visible and note the readings.
7. Similarly for Three and more observations note the readings.

Tabular column:

	Speed using achometer(N_a)rpm	Speed using Magnetic Pickup sensor (N_m) rpm	Error= (N_m– N_a) rpm	Correction= (N_a– N_m) rpm	Absolute %Error [(N_m - N_a)/ N_m]*100
1	73.80	74.10	+ 0.30	- 0.30	0.40 %
2					
3					
4					
5					
6					
7					

Specimen calculation:

Considering the first observation , the specimen calculations are as follows.

Speed using Tachometer, N_a= 73.80 rpm

Speed using Photo-pickup sensor , N_m = 74.10 rpm

Error = $N_m - N_a$ = 74.10 – 73.80 = -0.30 rpm

Correction = - Error = $N_a - N_m$ = 73.80 – 74.10 = + 0.30 rpm

Absolute % Error = $[(N_m - N_a)/N_m]*100$ = [(74.10 – 73.80)/74.1]*100 = 0.40 %

Graphs:

Draw the following graphs for each of the case:

- N_m Vs N_a
- N_m V/s Correction
- N_m V/s Absolute %Error

Precautions:

- All connections should be neat and clean.
- Non-contact type speedometer should be maintained properly.
- Digital indicator reading has to be noted accurately.
- To check the power source, it should be 230V ±10%, 50 Hz. to avoid over voltage hazards.
- To get best performance, you have to put the instrument at dust proof and humidity free environment.
- Do not try to open the instrument or repair it.

Pre viva questions:

1. What is speed?
2. Units for speed
3. What are the pick-ups / sensors used in this experiment?
4. What are different speed measuring devices?
5. Principle of contact type and non-contact type speed measuring device.

Post viva questions:

1. What is principle involved in magnetic and magnetic pick-up sensors.
2. What is stroboscope?
3. What is the principle of Stroboscope?
4. What are the applications of Stroboscope?
5. What are the advantages and disadvantages of Stroboscope?

EXPERIMENT - 11

STUDY AND USE OF SEISMIC PICKUP FOR MEASUREMENT OF VIBRATION AMPLITUDE OF AN ENGINE BED AT VARIOUS LOADS

Aim:
To study and measurement of Vibration amplitude of an engine bed at various loads using Seismic Pick-up

Apparatus:
Signal generator, Amplifier, Shaker, Vibration meter.

Theory:
Many methods have been developed to measure linear and angular displacements, velocities, and accelerations. Displacements and accelerations are usually measured directly, while velocities are often obtained by integrating acceleration signals. The definitions of velocity and acceleration suggest that any convenient quantity can be measured and the other can be obtained by integrating or differentiating the recorded signal. Since the integration process is an error -smoothing process, while the differentiation process is an error-amplifying process, only the integration process is widely used for practical application. Displacement measurements are most frequently made in manufacturing and process-control applications, while acceleration measurement is made in vibration, shock, or motion-measurement situations.

Piezo-electric material, an electric potential; appears across certain surfaces of a crystal. If the dimension of the crystal are changed by the application of a mechanical force. This potential is produces by the displacement of charges. This effect is reversible and is known as *piezo-electric effect*. Elements exhibiting piezo-electric quality are often referred as electro-resistive effects.

When a force F is applied to a piezo-electric crystal it develops a charge Q = d * F Coulomb

where is the charge sensitivity of the crystal in N/C. By incorporating a mass M in direct contact with the crystal, we get essential components of an accelerometer.

By applying varying acceleration to the mass-crystal assembly, the crystal experiences

a varying force which according to Newton's second law.. This force produces a varying charge given by

$Q = d \, X \, F = d \, Ma$

Where ***a*** is the acceleration

If the crystal has a capacitance C, the no load output voltage is

$Vo = Q/C = (d \, X \, F)/C = d \, (Ma/C)$

Thus the output voltage is a measure of the acceleration. The accelerometer is quit small in size and weight. The natural frequency is high of the order 100 kHz and hence can be used for any vibration and shock.

THE SETUP:

Vibration Demo is designed as a laboratory set up which can be used to demonstrate the principles of Vibration measurement. It consists of a shaker and control unit. (Refer Block Diagram Fig.1.). The shaker is of the Electro-magnetic type; The control unit consist of a signal generator, power amplifier and vibration-meter. The sinusoidal output from the signal generator is amplified by the amplifier and applied to the shaker, which generates vibrations on the spindle. The Accelerometer may be attached to the spindle through the M-5 stud. (supplied with the accelerometer). Signal output from the accelerometer is connected to the vibration meter, which gives direct read out of acceleration velocity or displacement.

SPECIFICATIONS:

01.SHAKER :

Force rating : 5 Newton (maximum)

Frequency Range : 50Hz to 1KHz.

(Max. Static load on shaker spindle : 100gm)

02. CONTROL UNIT:

POWER OSCILLATOR:-

Frequency range : 50Hz to 1000Hz.

Output Voltage : 0-10V (p-p)

Distortion :<2%.

VIBRATION METER:

Frequency Range : 10Hz to 10KHz.

Input impedance : 10,000 M ohms.

Display : 3.5 digit LCD.

Source Capacitance: 30,000 pF.

INSTALLATION:

For Test Purpose the Shaker and Control Unit may be on a laboratory table. The Accelerometer should be mounted on the shaker spindle using the M-5 stud supplied with the accelerometer. Connect the accelerometer output to the input connector on the control unit using the 1mtr long low noise cable supplied. Connect the co-axial cable attached to the socket to the amplifier output connector on the control unit, and the power cable to a 230 V, 50 Hz .

Fig: Vibration measurement setup

Operating procedure:

1. Connect the sensor to the instrument through the BNC socket provided on the Back Panel mentioned SENSOR.
2. Connect the Vibration generator to the instrument through the cable provided at the rear panel of the instrument marked EXCITER.
3. Connect the instrument to the 230V 50Hz. Supply through cable provided at the rear panel.
4. Keep the FREQ. Pot and the VOLT pot in the minimum position.
5. Switch on the instrument, the display glows to indicate the power is on. In this Position Press the Tare button to make the readings Zero.
6. Turn the VOLT pot to the max position.
7. Now turn the FREQ pot in steps of 100 Hz. And note down the readings of Acceleration, Velocity, Displacement.
8. Tabulate the readings in the tabular column. Experiment can be repeated for different voltages settable through VOLT knob provided.

Observation table:

Sl. No.	Frequency(Hz)	Indicator Reading		
		Acceleration ($m/s^{2)}$	Velocity(m/s)	Displacement(mm)
1	50	79.3	17.8	1.606
2	100			
3	200			
4	300			
5	400			
6	500			
7	600			
8	700			
9	800			
10	900			

Graphs :

Graph can be plotted for Frequency V/s Acceleration, Velocity and displacement.

Precautions:

- All connections should be neat and clean.
- Digital indicator reading has to be noted accurately.
- To check the power source, it should be 230V ±10%, 50 Hz. to avoid over voltage hazards.To get best
- performance, you have to put the instrument at dust proof and humidity free environment.
- Do not try to open the instrument or repair it

Result:

Pre viva questions:

1. What is linear motion, angular motion?
2. What is displacement, velocity, acceleration
3. What is Jerk?
4. What is vibrometer ?
5. What is accelerometer?

Post viva questions:

1. Causes of vibration.
2. Types of accelerometers
3. What is seismic accelerometer?
4. Name the transducers used for measurement of seismic instruments output.
5. Name the applications of vibrometer.

EXPERIMENT-12
CALIBRATION OF McLeod GAUGE

Aim: To calibrate the given vacuum cell.(Low Pressure Cell)

Apparatus:
Vacuum Cell, dial type Vacuum gauge, Vacuum Chamber, Vacuum pump to develop a vacuum and digital vacuum indicator.

Theory:

In everyday usage, vacuum is a volume of space that is essentially empty of matter, such that its gaseous pressure is much less than atmospheric pressure. The word comes from the Latin for "empty". A perfect vacuum would be one with no particles initially, which is impossible to achieve in practice. Physicists often discussed results that would occur in a perfect vacuum, which they simply call "vacuum" or "free space" ,and use the term partial vacuum to refer to real vacuum. The Latin term in vacuum is also used to describe an object as being in what other wise would be a vacuum.
Vacuum is useful in a variety of processes and devices. Its first wide spread use was in the incandescent light bulb to protect the filament from chemical degradation. The chemical inertness produced by a vacuum is also useful for electron beam welding, cold welding, vacuum packing and vacuum frying. Ultra-high vacuum is used in the study of atomically clean substrates, as only a very good vacuum preserves atomic-scale clean surfaces fo ra reasonably long time (on the order of minutes to days).High to ultra-high vacuum removes the obstruction of air, allowing particle beams to depositor remove materials without contamination. This is the principle behind chemical vapor deposition, physical vapor deposition, and dry etching which are essential to the fabrication of semi conductors and optical coatings, and to surface science. The reduction of convection provides the thermal insulation of thermos bottles. Deep vacuum lowers the boiling point of liquids and promotes low temperature out gassing which is used in freeze drying, adhesive preparation, distillation, metallurgy, and process purging. The electrical properties of vacuum make electron microscopes and vacuum tubes possible, including cathode ray tubes. The elimination of air friction is useful for fly wheel energy storage and ultracentrifuges.

Principle: The working principle of the McLeod gauge in vacuum is quite similar to a mercury column manometer. Though McLeod gauges usually use mercury, they may be designed to use other substances.

Fig: McLeod gauge

Digital vacuum indicator: Vacuum indicator comprises of in built power supply which provides power for strain gauge excitation, signal conditioning and amplifying circuits. Access input from the strain gauges leanearizes and amplifies the signal level. The output of the amplifier is controlled to required level and calibrated to read the vacuum in mm/in.Hg. Any stray forces on the sensor can be balanced by balancing the strain gauge bridge through potentiometer, which is provided in the front panel. Thissystemoperatesby230vAcsupply.

Panel details:
POWERON: Rocker switch which switches on the supply of the instrument, with red light indication.
ZERO: Ten turn potentiometer. The display can be adjusted to read Zero when no force is applied.

CAL:Single turn potentiometer. The output of the amplifier is adjusted by this potentiometer such that the display gives full scale for given range of sensor.

TO SENSOR: Sensor is connected to the indicator through a four core cable with 5pin socket at sensor end and respective color connections at the other end to connect the instrument.

MAINSINPUT: Power cable to be connected to the mains supply of 230V50Hz.

FUSE: 500mA cartridge fuse with holder located on the rear side of the instrument to protect the instrument from internal electrical shorting.

CAUTION: Do not remove the fuse cap with power cable plugged to the main supply

Procedure:

- Connect the vacuum cell to the vacuum indicator through given cable.
- Connect the instrument to mains i.e. 230V power supply and switch on the instrument
- Adjust the zero pot on the indicator, to indicate zero.
- Connect the vacuum pump to 230V AC mains.
- Close the out let valve of the vacuum chamber and open the inlet valve.
- Switch on the pump.
- Wait until vacuum reaches maximum level.
- Increase pressure up to 15 PSI at this position adjust span pot to get -1.5V, with this the instrument is said to be calibrated. Then slowly reduce the pressure from 15 psi step by step 1 psi note the voltage. (for 14, 13, 12, 11, 10, 9, 8, 7, 6, 5, 4, ,2, 1, PSI)observe the indicated voltage from digital multi meter for different vacuum levels and note down in observation tabular form.

Observation table:

Sl No.	Vacuum in Dial Gauge PSI (kg/cm^2)	Voltage in Multi meter(Volt)
1		
2		
3		
4		
5		
6		
7		

Graphs:

Draw the following graphs: Vacuum v/s voltage

1. What is gauge pressure
2. What principle vacuum gauge operate?

Precautions:

1. All connections should be neat and clean.
2. Digital indicator reading has to be noted accurately.
3. Readings on the millimeter is noted without parallax error.
4. To check the power source, it should be 230V ±10%, 50 Hz. to avoid over voltage hazards.
5. To get best performance, you have to put the instrument at dust proof and humidity free environment.
6. Do not try to open the instrument or repair

Result:

Measured voltage using digital millimeter for different vacuum levels .

Pre viva questions:

1. What is absolute pressure?
2. What is atmospheric pressure, Gauge pressure
3. What is the principle of McLeod gauge?
4. Relation among P_{abs} , P_{atm} and P_{gauge}
5. What is principle of McLeod gauge.

Post viva questions:

3. What is low pressure?
4. What is vacuum?
5. Applications of McLeod gauge?