AVIT
AARUPADAI VEEDU INSTITUTE OF TECHNOLOGY
VINAYAKA MISSION'S RESEARCH FOUNDATION
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DEPARTMENT OF BIOMEDICAL ENGINEERING

BIO TRANSDUCERS LAB MANUAL

EX.NO:	CHARACTERISTICS OF THERMOCOUPLE
DATE:	

AIM

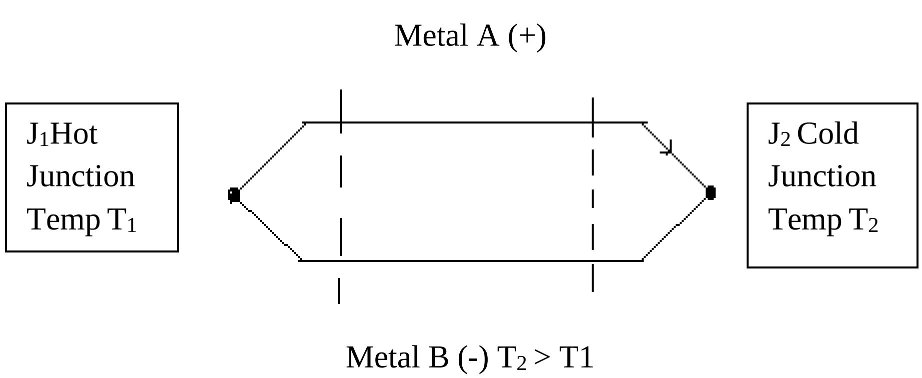
To study the temperature characteristics of J-types of thermocouple (Iron-Constantan)

APPARATUS REQUIRED

SI.NO	ITEMS	QUANTITY
1	J-type Temp measurement trainer	**1**
2	Thermometer	**1**
3	Multimeter	**1**
4	Heating bath	**1**
5	Connecting wires	Required

THEORY

Thermocouple is one of the simplest and most commonly used methods of measuring process & temperature. A pairs of two dissimilar metals that are in physical contact with each form a thermocouple. The operation is based on seeback effect which states that when heat applied to junction (hot junction) of two dissimilar metals, an emf is generated which can be measured at other junction (cold junction). It has two junctions' namely hot and cold junctions. The two dissimilar metals form an electric circuit, and a current as a result of the generated as shown in figure.



The emf produced is function of the difference in temperature of hot and cold junctions and is given by:

$$E = \alpha \Delta \theta$$

Where $\Delta \theta$ = difference between temperature of hot and cold junctions.

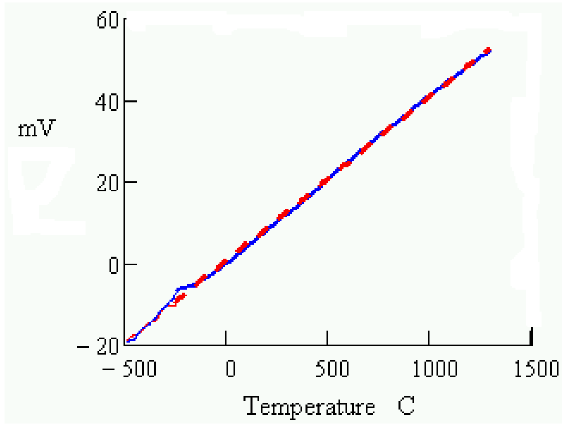
There are four types of sensors based on the following physical properties, which are temperature dependent.

1. Expansion of a substance with temperature, which produces a change in length, volume or pressure.
2. Changes in contact potential between dissimilar metal with temperature; thermocouple.
3. Changes in radiated energy with temperature; optical and radiation pyrometers.
4. Changes in electrical resistance with temperature, used in resistance thermometer and thermistors.

PROCEDURE

1. Connect the two terminals of thermocouple to the T/C input and ground point.
2. Connect the voltmeter or multimeter in millivolts range.
3. Measure the displayed voltage in the multimeter for room temperature.
4. Now insert the thermocouple in to the water bath and start heating it gradually.
5. Using a thermometer, measure the temperature and the corresponding thermocouple output voltage.
6. Repeat the step 5 for different temperature of water bath.
7. Tabulate the readings and plot the graph of temperature Vs thermocouple output.
8. This gives the temperature characteristics of the J-Type Thermocouple

MODEL GRAPH



TABULAR COLUMN

S.No	Temperature (•C)	Thermocouple voltage (mv)
1		
2		
3		
4		
5		
6		

RESULT

Thus the temperature characteristics of J- type thermocouple have been studied

APPLICATIONS

1. The law makes it possible to use extension wires o a metal different from the metal used for thermocouples. For examples, the extension wires used for platinum/ platinum rhodium thermocouple may be made of copper which is an inexpensive material.
2. The law enables a measuring instrument to be introduced into the circuit without affecting the emf generated by the thermocouple. This is subject to the condition that the meter has infinite impedance and therefore there are no loading effects.
3. Another important consequence of this law is that the wires forming the junction can be soldered or brazed together without altering the performance of the junction.
4. The thermal emf of any two homogeneous metals with respect to another is the algebraic sum of their individual emfs with respect to a third homogeneous metal.

VIVA QUESTIONS

1. What is temperature transducer?
2. Mention four types of sensor based on physical properties.
3. What is thermocouple?
4. Give an example of changes in radiated energy with temperature.
5. State seebeck effect.
6. What type of material wire used in thermocouple?
7. State thermo-electric laws.
8. Give some application of thermocouple.
9. Give an example of changes in electrical resistance with temperature.
10. Give an example of changes in contact potential between dissimilar metal with temperature.
11. State law of intermediate metals.
12. Give the advantages of thermocouple.
13. What is j-type thermocouple?
14. What is compensating leads?
15. Give the disadvantages of thermocouple.

EX.NO:	CHARACTERISTICS OF THERMISTOR
DATE:	

AIM

To study the temperature versus resistance characteristics of the thermistor

APPARATUS REQUIRED

SI.NO	ITEMS	QUANTITY
1	Thermistor	1
2	Temperature measuring module	1
3	Heating bath	1
4	Thermometer (0-100)	1
5	Multimeter	1
6	Connecting wires	Required

THEORY

Thermistor is a contraction of a term ‘thermal resistor’. They are generally composed of semiconductor material. Most of the thermistor has a negative temperature coefficient .i.e. the resistance decreases with increase of temperature. The negative temperature coefficient of resistance can be as large as several percent per degree Celsius. This allows the thermistor circuit to detect very small change in temperature which could not be observed with a RTD or a thermocouple. The high sensitivity to the temperature changes makes it extremely useful for precision temperature measurement control compensation. Thermistors are widely used in applications which involve measurement in the range of -60ċ to 150 ċ. The resistance of thermistor range from 0.5Ω to 0.75Ω. Thermistor is a highly sensitive device.

There are four types of sensors based on the following physical properties, which are temperature dependent.

1. Expansion of a substance with temperature, which produces a change in length, volume or pressure.
2. Changes in contact potential between dissimilar metal with temperature; thermocouple.

3. Changes in radiated energy with temperature; optical and radiation pyrometers.
4. Changes in electrical resistance with temperature, used in resistance thermometer and thermistor.

PROCEDURE

1. Ensure that the power to the unit is switched off.

2. Patch the three wires of the thermistor to the plus, minus and ground terminals placed in the thermistor input block.

3. Place an ohmmeter or a multimeter in resistance mode across the points T1 and T2.

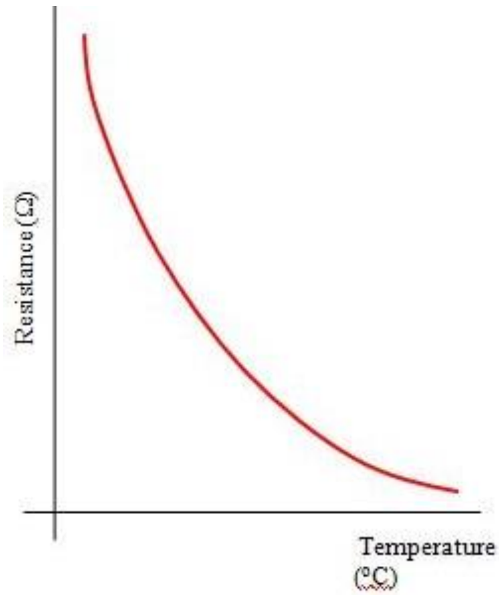
4. Insert the thermistor in to the water bath and note the resistance offered at room temperature.

5. Heat the water and note the values of temperature and resistance

6. Repeat the step 5 for different values of temperature and tabulate the readings.

7. Plot a temperature Vs resistance graph.

MODEL GRAPH



TABULAR COLUMN

Temperature in C	Resistance in ohm
1	
2	
3	
4	
5	
6	
7	

RESULT

Thus the Temperature Vs resistance characteristics of Thermistor has been studied

APPLICATIONS

1. Measurement of power of high frequencies

2. Measurement of thermal conductivity

3. Measurement of level, flow and pressure of liquids.

4. Measurement of composition of gases.

5. Vacuum Measurement.

VIVA QUESTION

1. What is temperature transducer?
2. Mention four types of sensor based on physical properties.
3. What is thermistor?
4. Draw the resistance temperature
5. What is positive temperature coefficient?
6. Give the measurement range of thermistor.
7. What type of metal used in thermistor?
8. Mention the commercial forms of thermistor.
9. Draw the voltage current characteristics of thermistor.
10. List the characteristics of thermistor.
11. What is negative temperature coefficient?
12. Draw the current time characteristics of thermistor.
13. Give the advantages of thermistor.
14. Mention the application of thermistor.
15. Give the advantages of thermistor over the thermocouple.

EX.NO:	**CHARACTERISTICS OF LVDT**
DATE:	

AIM:

To study the displacement versus output characteristics of LVDT

APPARATUS REQUIRED:

SI.NO	Items	Quantity
1	LVDT setup	1
2	Indicating instrument	1
3	Multimeter	1
4	Connecting wires	Required

THEORY:

LVDT works on the principle of variation in mutual inductance. Inductance of a coil can be describes in the terms of no of turns, permeability of material and the geometric factor.

$$L=\mu o \mu n^2 G$$

L = inductance of coil
μo = permeability of air
μ = relative permeability
n = no of turns
G = geometric factor of coil

It is a most common mutual inductance element. This is considering to versatile transducer element for electro mechanical measuring system with regards to resolution, hysteresis, dynamic response, temp characteristics, linearity and life.

It consists of primary winding and two identical secondary winding connect in series opposition manner and ferromagnetic movable core. At o/p terminal the difference of secondary voltage will be obtained A.C carrier excitation of frequency 60 to 2000 HZ and magnitude 3 to 15 volts applied to the primary motion of non-contacting magnetic core is inductance of each other. When the core is inductance of each secondary to primary which determine the voltage induced if the core is moved towards left the flux linkage of s1 increases while s2 decreases this will be in phase with primary input voltage

PROCEDURE:

1. Connect the LVDT with displaying instrument
2. Switch on the power supply
3. Calibrate the instrument to zero to indicate zero through zero connection
4. Using micrometer displacement given to LVDT corresponding display and LVDT o/p is measured

TABULAR COLUMN:

S.No	Displacement with right In mm			Displacement with left in mm		
	Micrometer Reading	Indicator Reading	o/p vge in mv	Micrometer Reading	Indicator Reading	o/p vge in mv

RESULT:

Thus the displacement versus output characteristics of LVDT has been studied.

VIVA QUESTIONS:

1. What is the principle of LVDT?
2. What is the residual voltage?
3. What are causes for residual voltage?
4. What is reason for connecting secondary of LVDT in series opposition?
5. What are materials used for core of the LVDT?
6. What are the advantages with differential o/p of LVDT?
7. What is the range of primary excitation voltage of LVDT?
8. What is the range of frequency which is applied to primary of LVDT?
9. What are advantages of LVDT?
10. What are disadvantages of LVDT?
11. What are the applications of LVDT?
12. What are the different types of transducers used for displacement measurement?
13. What is the difference between variable resistance & variable inductance displacement transducer?
14. Explain about LVDT basic construction and connection of secondary winding.
15. List few advantages of the LVDT type of displacement sensors.
16. Define the term residual voltage.
17. Define the characteristics of LVDT.
18. What is input voltage applied for the LVDT?
19. How can you measure the angular displacement?
20. Explain about synchros & resolvers.

EX.NO:	CHARACTERISTICS OF HALL EFFECT TRANSDUCER
DATE:	

AIM:

To measure the flux density using hall effect transducer

APPARATUS REQUIRED:

SI.NO	Items	Quantity
1	Electromagnet and its power supply	**1**
2	hall effect element	**1**
3	gauss meter	**1**
4	gauss probe	**1**

THEORY:

When a hall element is subjected to a magnetic field in one duration an electric current in another direction which is in the direction of magnetic flux then an electric potential is generated in a third direction which is mutually to other direction the magnitude of voltage generated depends on the magnetic field strength

Kh= et/BI

Where,

e = hall voltage generation

I = current in A

B = flux density in wb/m^2

t = thickness of hall element in m

Kh = hall co-efficient in Vm/A wb m^2

PROCEDURE:

1. Connect the width wise contact of hall probe to the terminals marked ‘Voltage’ and length wise contact to the terminals marked ‘current’
2. Switch on the Hall Effect setup and adjust the current.
3. Switch over the display to the voltage side there may be some voltage reading even outside of magnetic field.
4. Now place the probe in the magnetic field and switch on the electromagnet power supply and adjust the current to any desired value.
5. Measure the hall voltage for both the direction of current and magnetic field.
6. Measure the hall voltage as function of current keeping magnetic field constant.
7. Measure the hall voltage as function of magnetic field keeping a suitable value of current as constant.
8. Plot a graph.

TABULAR COLUMN:

1. Keeping current constant

S.No	Hall current (mA)	Emt current (mA)	Hall voltage (mV)	Gauss value

2. Keeping gauss constant

S.No	Hall current (mA)	Emt current (mA)	Flux density In gauss	Hall voltage (mV)

RESULT:

Thus the flux density is measured using Hall Effect transducer.

EX.NO:	CHARACTERISTICS OF STRAIN GAUGE
DATE:	

AIM:

To study stress and strain using strain gauge mounted on a cantilever beam

APPARATUS REQUIRED:

SI.NO	ITEMS	QUANTITY
1.	Strain gauge kit	1
2.	Load (1 kg each)	10
3.	Cantilever beam weights	1
4.	Multimeter	1

FORMULA:

$$S = (6PL)/BT^2E$$

Where,

P=Load applied in Kg (1Kg)
L=Effective length of the beam in cms (22cms)
B=Width of the beam (2.8 cms)
T=Thickness of the beam (0.25 cms)
E=Youngs modulus (2x 10^6)
S=Microstrain

$$\% \text{ Error} = \frac{[(\text{Actual reading}-\text{Indicated reading})]\times 100}{\text{Max.weight in gms}}$$

THEORY:

Strain gauge works on the principle of piezo resistive effect. If a metal conductor is stretched or compressed its resistance changes on account of the fact that both length and diameter of conductor changes. Also there is an additional change in value of resistivity of conductor. When it is strained and this property is called piezo resistive effect.

A resistance wire made up of copper nickel, chrome nickel or nickel iron alloy. The resistance wire is cemented with grid (case) made up of thin sheet of paper, thin sheet of Bakelite of sheet of Teflon. The spreading of wire will give uniform disturbance of stress over the grid.

The strain gauge made of circular wire. The wire having dimensions length=L; area=A; diameter=D. Before being strained the material of wire have a resistivity 'ρ' therefore resistance of unstrained strain gauge. Let the stress

$$R = \rho L/A$$

Thus when the wire is strained there are changes in dimensions. Strain gauges are sensitive resistance which is based on principle that resistance of a conductor increases with the increase in length and decreases with increase in area. Strain gauges are of three types: -

1. Foil type
2. Wire type
3. Semi conductor type

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 min for initial warm-up.

3. Select the FULL or HALF bridge configuration from the selector switch on the panel.

4. Adjust the ZERO potentiometer on the panel till the display reads "000".

5. Apply 1Kg load on the cantilever beam and adjust the CAL potentiometer till the display reads 377 micro strains. Remove the weights the display should come to ZERO in case of any variation adjust the ZERO pot again and repeat the procedure again. Now the instrument is calibrated to read micro-strain.

6. Apply load on the sensor using the loading arrangement provided in steps of 100g up to 1 Kg.

TABULATION:

S.No:	Weight in gms	Actual reading **S= (6PL)/BT²E** In microstrain	Indicated reading	Error in %
1				
2				
3				
4				
5				
6				
7				
8				
9				
10				

RESULT:

Thus the characteristics of strain gauge was studied

VIVA QUESTION:

1. What is a strain gauge?
2. Define transducer.
3. Classify the transducers.
4. What is active transducer?
5. What is passive transducer?
6. What is the principle of resistive transducer?
7. Define the term strain.
8. What is the importance of strain measurement?
9. What is the working principle of strain gauge?
10. Define the term gauge factor of a strain gauge.
11. Give the mathematical expression for gauge factor of strain gauge.
12. What is meant by Poisson's ratio?
13. What are the different types of strain gauges?
14. What do you meant by bounded strain gauge?
15. What are the limitations of unbounded strain gauge?
16. Explain the principle of foil type strain gauge.
17. What are the desirable characteristics of grid material?
18. What are the different materials used for strain gauge?
19. What are the different circuits used in strain measurement?
20. What is a role of dummy gauge in bridge circuit?

EX.NO:	CHARACTERISTICS OF POTENTIOMETER TRANSDUCER
DATE:	

AIM:

To study the displacement Vs output voltage characteristics of potentiometric transducer.

APPARATUS REQUIRED:

SI.NO	ITEMS	QUANTITY
1	Potentiometer 360 ohm/1.5A	**2**
2	Rps (0-30v)	**2**
3	Multimeter	**1**
4	Connecting wires	Required

THEORY:

Potentiometer is a passive type transducer. Since, it requires external power source for its operation. The simplest transducer for converting linear or angular displacement in to change of resistance in resistive element provided with a movable contactor the change in the resistance is brought out by only a change in the length or portion of resistance from one end point of contact. This is a passive transducer. Since, it is excited by a DC or AC supply.

PROCEDURE:

1 UNI-DIRECTIONAL:

1. Connections are made as per the circuit -1.

2. Connect the multimeter across the o/p.
3. The movable contact should be kept at minimum resistance position.

4. Movable contactor is moved by minimum 7 steps.

5. Each step corresponding o/p & distance of moving contactor is measured.

PROCEDURE:

2 BI- DIRECTIONAL:

1. Connections are made as per the circuit -2.

2. Connect the multimeter across the load resistor.

3. Movable contactor should keep at center position.

4. Using Rps Dc i/p is applied potentiometer (+ ve & -ve voltage).

5. Movable contactor in steps minimum 5 to 10 from center point.

6. Draw the graph.

TABULAR COLUMN:

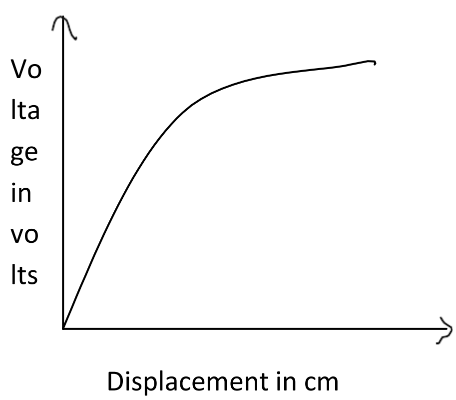
BI- DIRECTIONAL:

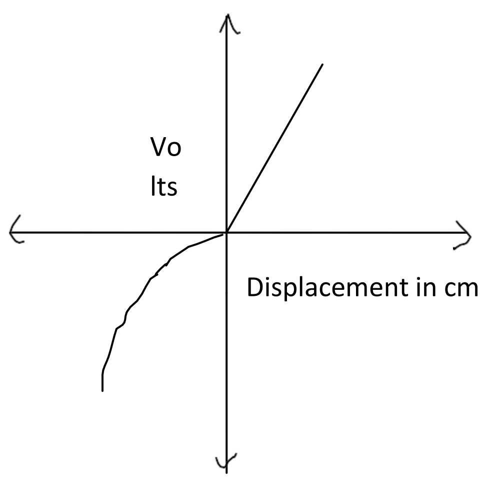
	Displacement	Voltage
Right side Left side		

UNI-DIRECTIONAL:

Displacement	voltage

MODEL GRAPH:





RESULT:

Thus the displacement versus output characteristics of potentiometric transducer was studied and graph was drawn.

APPLICATION:

- Mechanical potentiometer and trimmer replacements
- LCD backlight, contrast, and brightness controls
- Digital volume control
- Portable device-level adjustments
- Electronic front panel-level controls
- Programmable power supply

VIVA QUESTIONS:

1. What is a potentiometer?
2. What is its principle?
3. How can you increase the accuracy of the potentiometer?
4. A potentiometer is a better instrument than a voltmeter for measuring emf of a cell. why?
5. What is meant by potential gradient?
6. What is the internal resistance of a primary cell due to?
7. What is the function of the rheostat in the primary circuit?
8. Aim of the Potentiometer Experiment.
9. Apparatus of the Potentiometer Experiment.
10. Procedure to compare the emfs of two cells.

EX.NO:	CHARACTERISTICS OF LDR
DATE:	

AIM:
To study the response of optical sensors, by varying the distance from the light source, follow the processor given in sequence.

APPARATUS REQUIRED:

SI.NO	ITEMS	QUANTITY
1	LDR Trainer	1
2	Multimeter	1
3	Measurement scale	1
4	60 Watts bulb	1

THEORY:

A photo resistor or light dependent resistor or cadmium sulfide (CdS) cell is a resistor hose resistance decreases with increasing incident light intensity. It can also be referred to as a photoconductor. A photo resistor is made of a high resistance semiconductor. If light falling on the device is of high enough frequency, photons absorbed by the semiconductor give bound electrons enough energy to jump into the conduction band. The resulting free electron (and its hole partner) conduct electricity, thereby lowering resistance.

Cadmium sulfide (CdS) cells rely on the material's ability to vary its resistance according to the amount of light striking the cell. The large amount of light that strikes the cell the lower the resistance. Although not accurate, even a simple CdS cell can have a wide range of resistance from less than 100 Ω in bright light to in excess of 10 MΩ in darkness. Many commercially available CdS cells have peak sensitivity in the region of 500nm - 600nm (green light). The cells are also capable of reacting to a broad range of frequencies, including infrared (IR), visible light, and ultraviolet (UV). They are often found on street lights as automatic on/off switches.

CIRCUIT DIAGRAM:

PROCEDURE:

1. Initially, position the pointer at 0 on the scale when the bulb is at maximum distance away from sensors.
2. Switch ON the power supply to the instrument.
3. Measure the DC voltage output of LDR using a multimeter or a CRO across TP1 and TP2.
4. Gradually move the bulb towards the sensor in steps of 5 mm and note the corresponding voltages.
5. Repeat the above procedure for the other two sensors, photodiodes and photo transistors.
6. Tabulate the readings and plot the graph of distance versus sensor output voltage.

VIVA QUESTIONS:

1. What are the materials used for fabricating LDR?
2. What is the relationship between resistance of the LDR and the light intensity?
3. What will happen if LDR and resistor R2 are interchanged?
4. What are the applications of LDR?

EX.NO:	CHARACTERISTICS OF RTD
DATE:	

AIM:
To measure the temperature using RTD – pt 100

APPARATUS REQUIRED:

SI.NO	ITEMS	QUANTITY
1	RTD	1
2	Memory Thermometer	1
3	Water Bath	1
4	Stop watch	1
5	Multimeter	1

THEORY:

A **Resistance Thermometer** or **Resistance Temperature Detector** is a device which used to determine the temperature by measuring the resistance of pure electrical wire. This wire is referred to as a temperature sensor. If we want to measure temperature with high accuracy, RTD is the only one solution in industries. It has good linear characteristics over a wide range of temperature.

The variation of resistance of the metal with the variation of the temperature is given as,

$$R_t = R_0[1 + (t - t_0) + \beta(t - t_0)^2 + \cdots\cdots]$$

Where, R_t and R_0 are the resistance values at t°C and t_0°C temperatures. α and β are the constants depends on the metals.

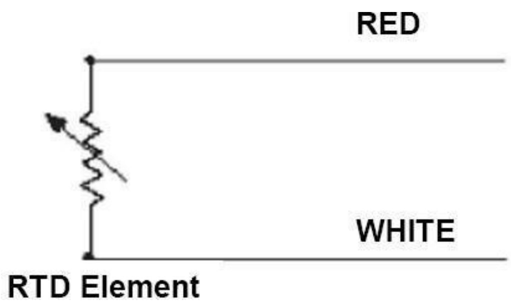
This expression is for huge range of temperature. For small range of temperature, the expression can be,

$$R_t = R_0[1 + (t - t_0)]$$

In **RTD** devices; Copper, Nickel and Platinum are widely used metals. These three metals are having different resistance variations with respective to the temperature variations. That is called resistance-temperature characteristics. Platinum has the temperature range of 650°C, and then the Copper and Nickel have 120°C and 300°C respectively. The figure-1 shows the resistance-temperature characteristics curve of the three different metals. For Platinum, its resistance changes by approximately 0.4 ohms per degree Celsius of temperature.

The purity of the platinum is checked by measuring R_{100} / R_0. Because, whatever the materials actually we are using for making the RTD that should be pure. If it will not pure, it will deviate from the conventional resistance-temperature graph. So, α and β values will change depending upon the metals.

CIRCUIT DIAGRAM:



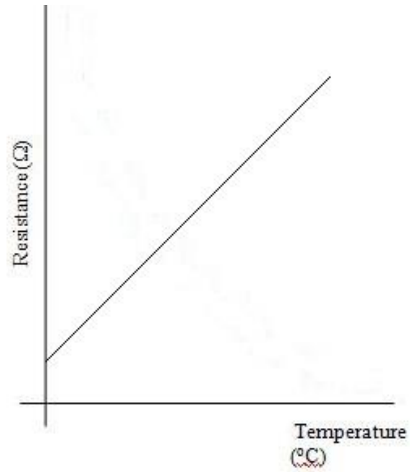
PROCEDURE:

1. Connect the wires of RTD to the T1 and T2 terminals of the RTD input block and switch ON the unit.
2. Place the RTD and thermometer into the holes provide in the water bath.
3. Keep the switch SW1 in right direction.
4. Place the multimeter in the resistance mode across T3 and T4 terminals.
5. Switch ON the water bath and notes the temperature in thermometer and corresponding resistance value in multimeter.
6. Plot the graph of resistance Vs temperature

TABULAR FORM:

SI.NO	TEMPERATURE (°C)	RESISTANCE (Ω)
1	0°C	100
2		
3		
4		
5		
6		
7		
8		
9		
10	100°C	150

MODEL GRAPH:



Resistance Vs Temperature

APPLICATIONS:

1. Air conditioning and refrigeration servicing
2. Food Processing
3. Stoves and grills
4. Textile production
5. Plastics processing
6. Petrochemical processing
7. Micro electronics
8. Air, gas and liquid temperature measurement
9. Exhaust gas temperature measurement

VIVA QUESTIONS:

1. Name different types of transducers for the measurement of temperature?
2. What is principle of RTD?
3. The temperature range that can be measured by using RTD is
4. What are materials used for RTD?
5. State the reasons for selecting platinum as RTD material?
6. What are the properties of material that can be used for RTD?
7. What is meant by positive temperature coefficient of resistance of RTD?
8. What is equation for converting Fahrenheit into Celsius?
9. One RTD is named as PT-100. What it means?
10. What are the methods to calibrate RTD?
11. Why temperature is important parameter in process Industries.
12. Why RTD is less sensitive than thermistor.

13. What are advantages of RTD?
14. What are the applications of RTD?
15. Why RTD needs lead wire compensation?
16. What is meant by 2 wire configuration?
17. How do use RTD for measuring average temperature
18. What meant by 3 wire compensation?
19. What are the advantages with 3 wire compensation?
20. What meant by positive temperature coefficient of temperature?