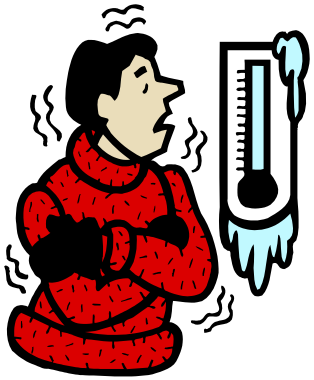
TEMPERATURE MEASUREMENT



Outline….

- Introduction
- Temperature
- Heat
- Scale
- Glass-Thermometer
- Bi-metallic Thermometer
- RTD
- Thermocouple
- Thermistor
- IC Sensor
- How to choose

INTRODUCTION

- ✓ The accurate measurement of temperature is vital across abroad spectrum of human activities,
  - ❖ Including industrial processes (e.g. making steel) Manufacturing;
  - ❖ Health and safety.
- ✓ In fact, in almost every sector, temperature is one of the key parameters to be measured.
- ✓ Different people will have different perceptions of what is hot and what is cold.

❑ Temperature ?

- ➢ scalar quantity
- ➢ Degree of hotness or coldness
- ➢ Molecular K.E. ↑ = Temperature ↑

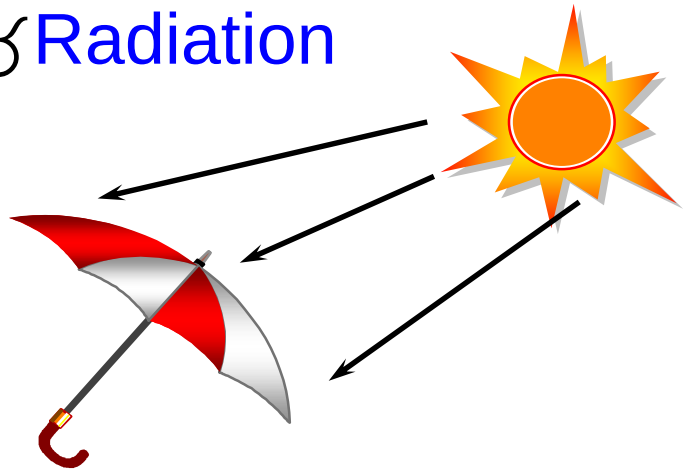
❑ Heat ?

- ➢ Form of energy.
- ➢ Measured in calories or BTU'S[British Thermal Units].

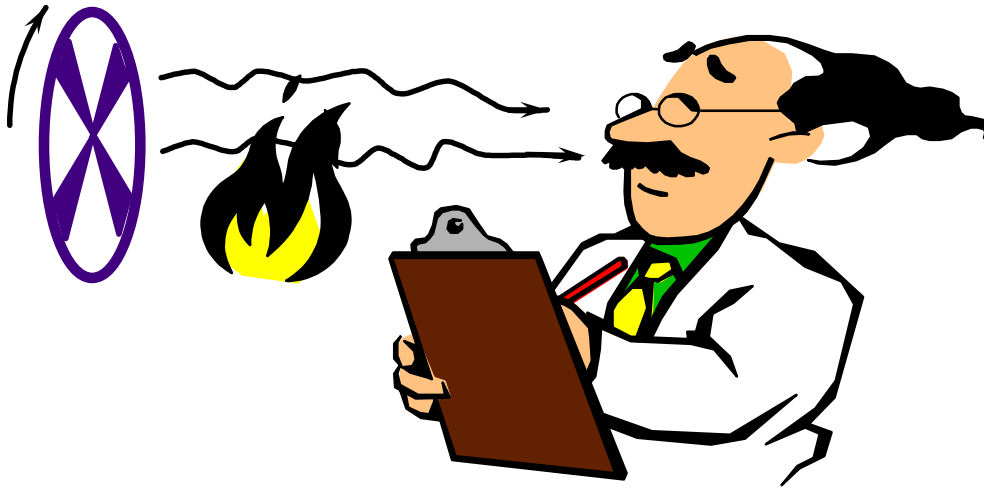
How is heat transferred?

- Conduction
  - Metal coffee cup

- Radiation

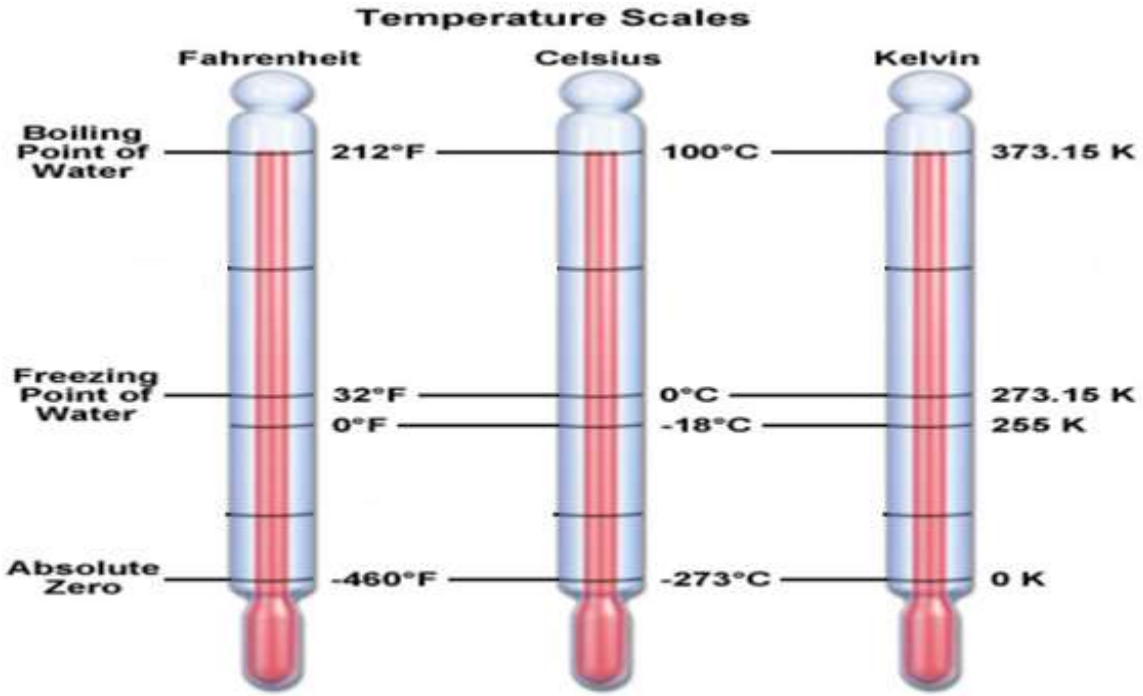


- Convection



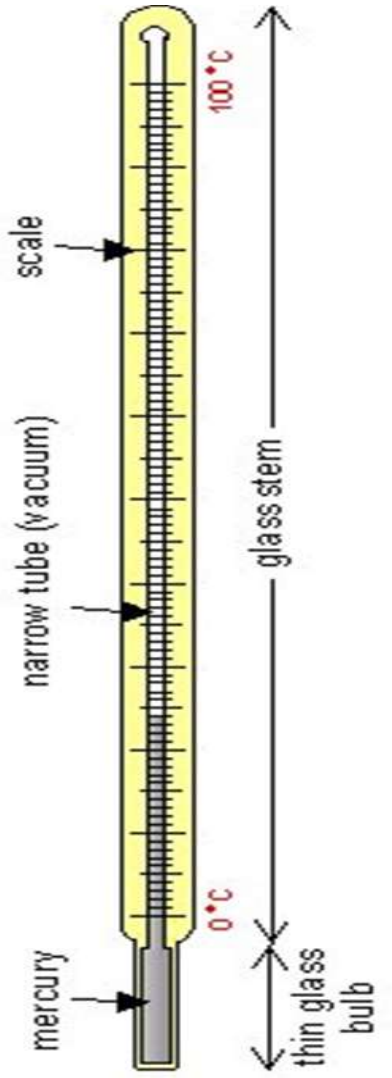
Scale

- Temperature - measure of the thermal energy.
- Measured in degrees [°]using scales.
  1. Fahrenheit.[°F]
  2. Celsius or centigrade. [°C]
  3. Kelvin .[°K]



1.Liquid – in – Glass Thermometer

- The volume of mercury changes slightly with temperature.
- The space above the mercury may be filled with nitrogen or it may be at less than atmospheric pressure, a partial vacuum

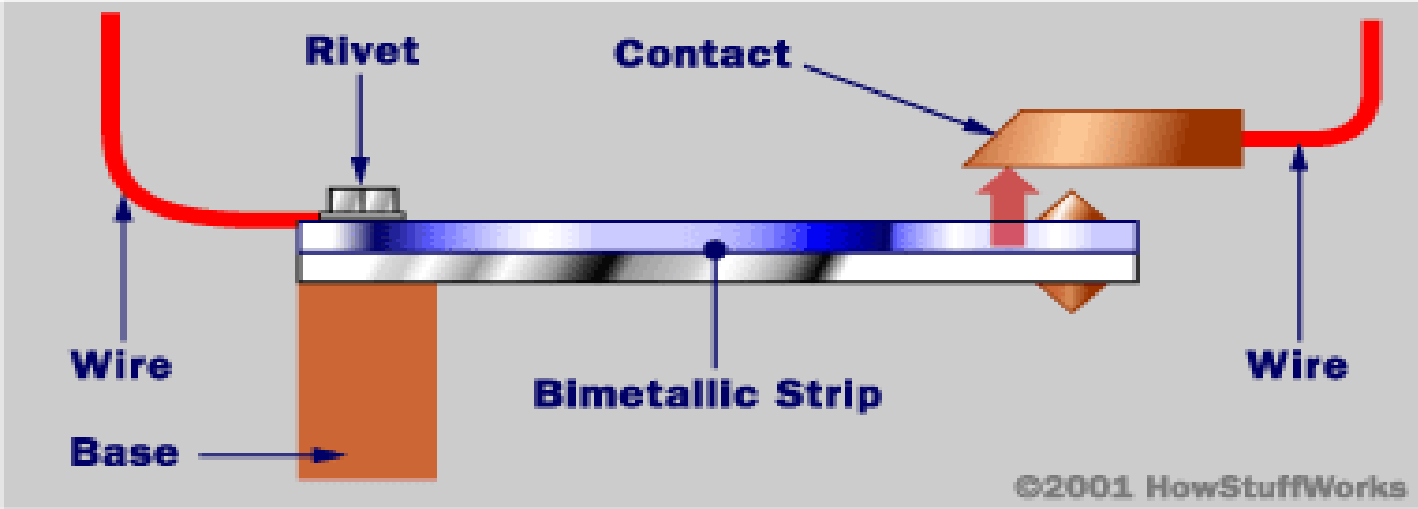


- **Thermal expansion:**

$$V = V_0(1 + \gamma T)$$

2.Bimetallic Thermometer

✓ Temperature Indicators (TI) or Temperature Gauges (TG)

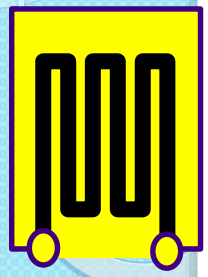


Principles :

- Expansion/Contraction - change in temperature.
- Different metals -- different co-efficient of temperatures.

The rate of volumetric change depends on this co-efficient of temperature.

3.Resistance Temperature Detector (RTD)



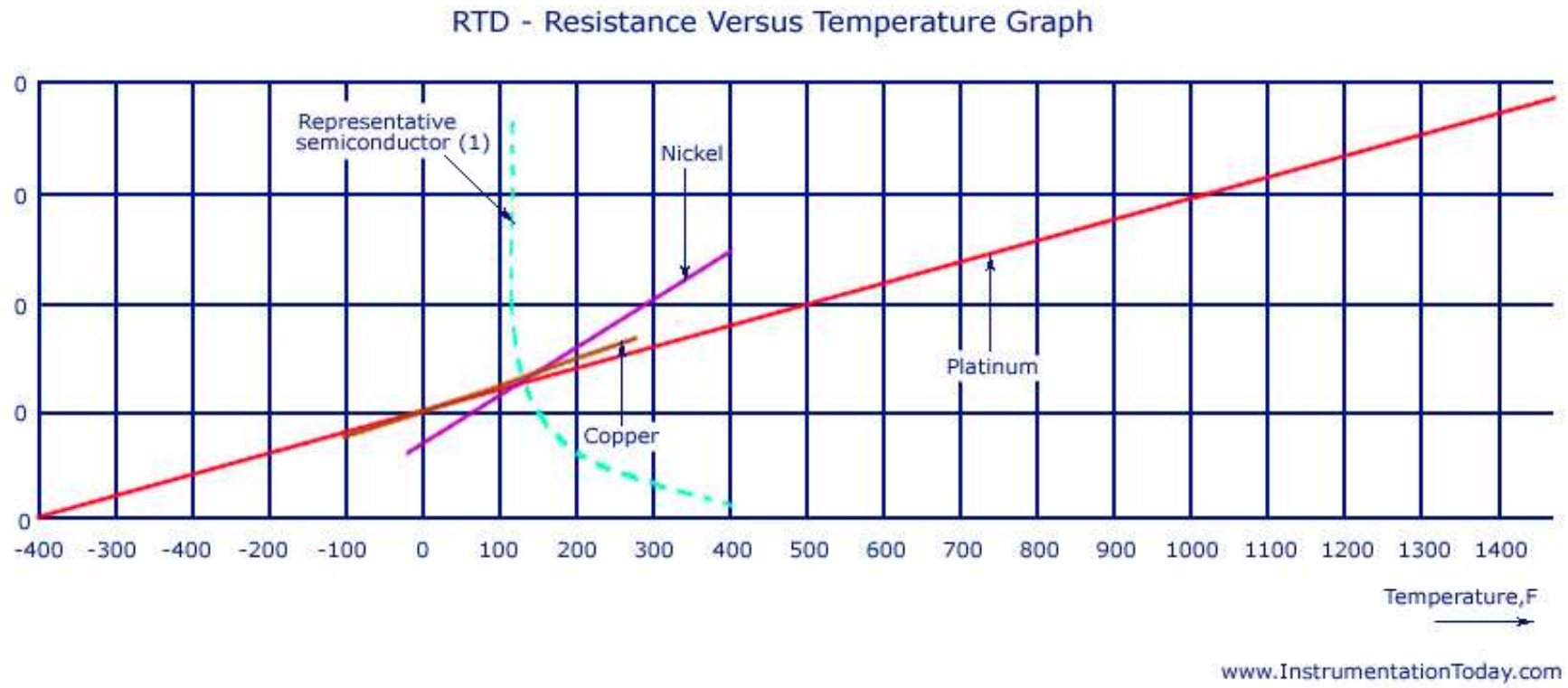
- Resistance thermometer
- PRINCIPLE :

  TEMPATURE ⇅ = RESISTANCE ⇅
- Positive temperature coefficient
- $R = R_0(1 + AT + BT^2)$ $T > 0$ C

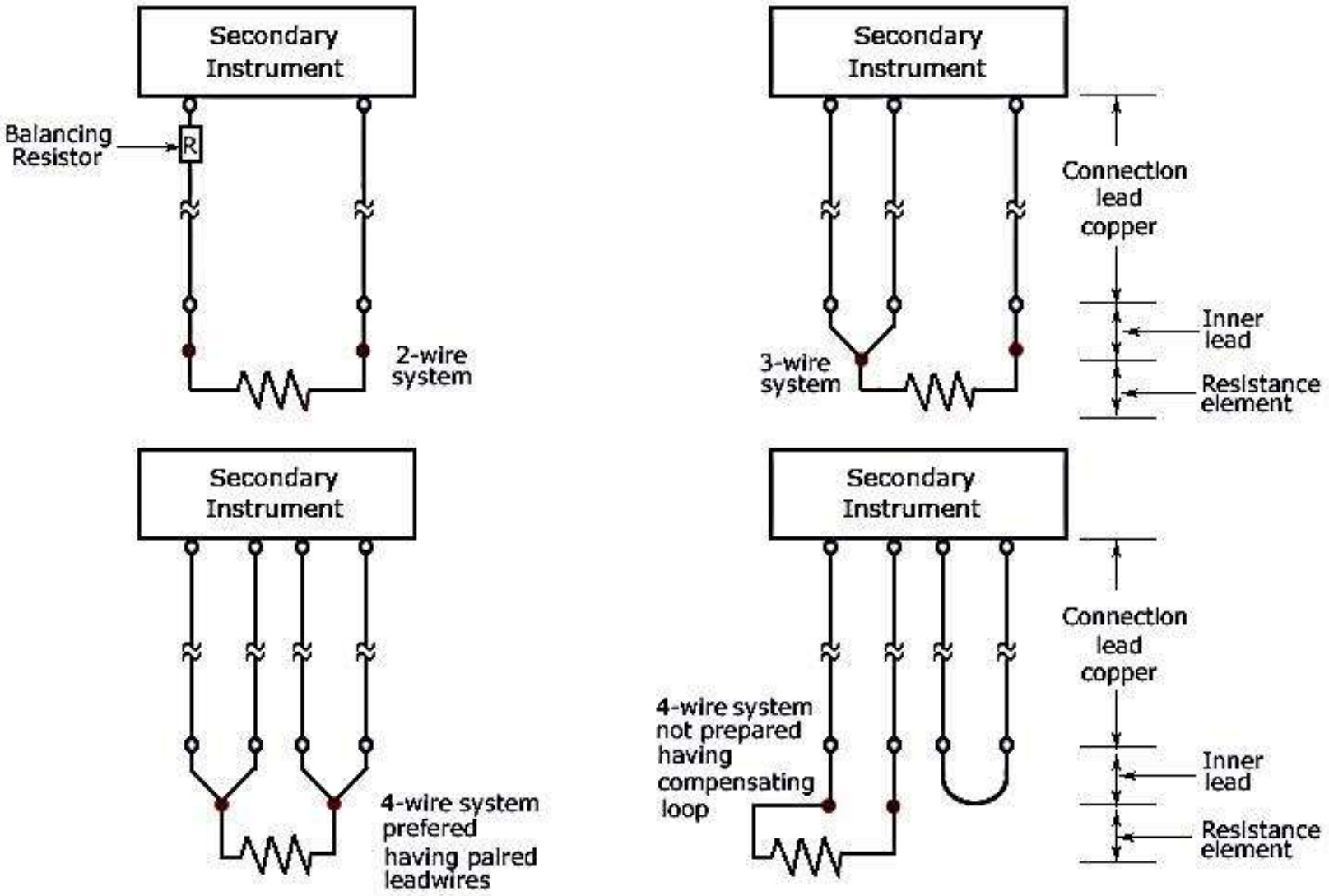
RTD Types

- classified according to the different sensing elements used -

Platinum
Nickel
Copper

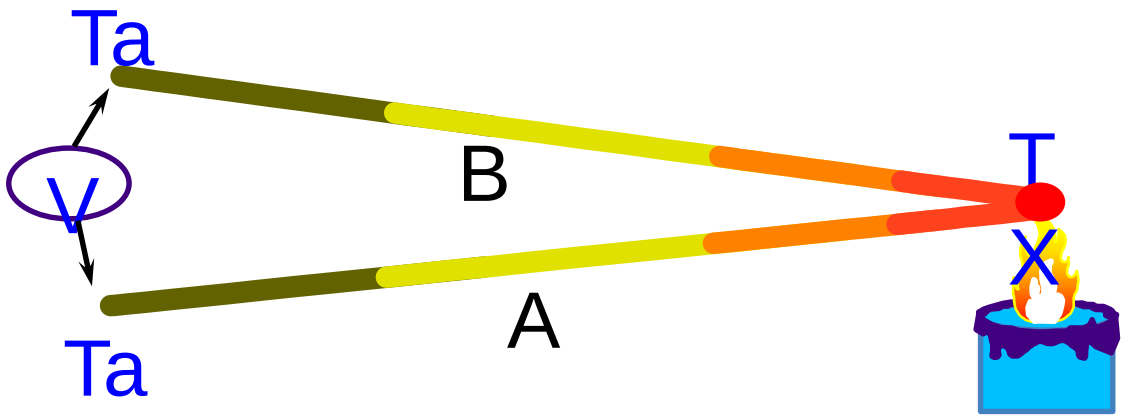


Resistance Temperature Detector (RTD) - 2-Wire,3-Wire,4-Wire Systems



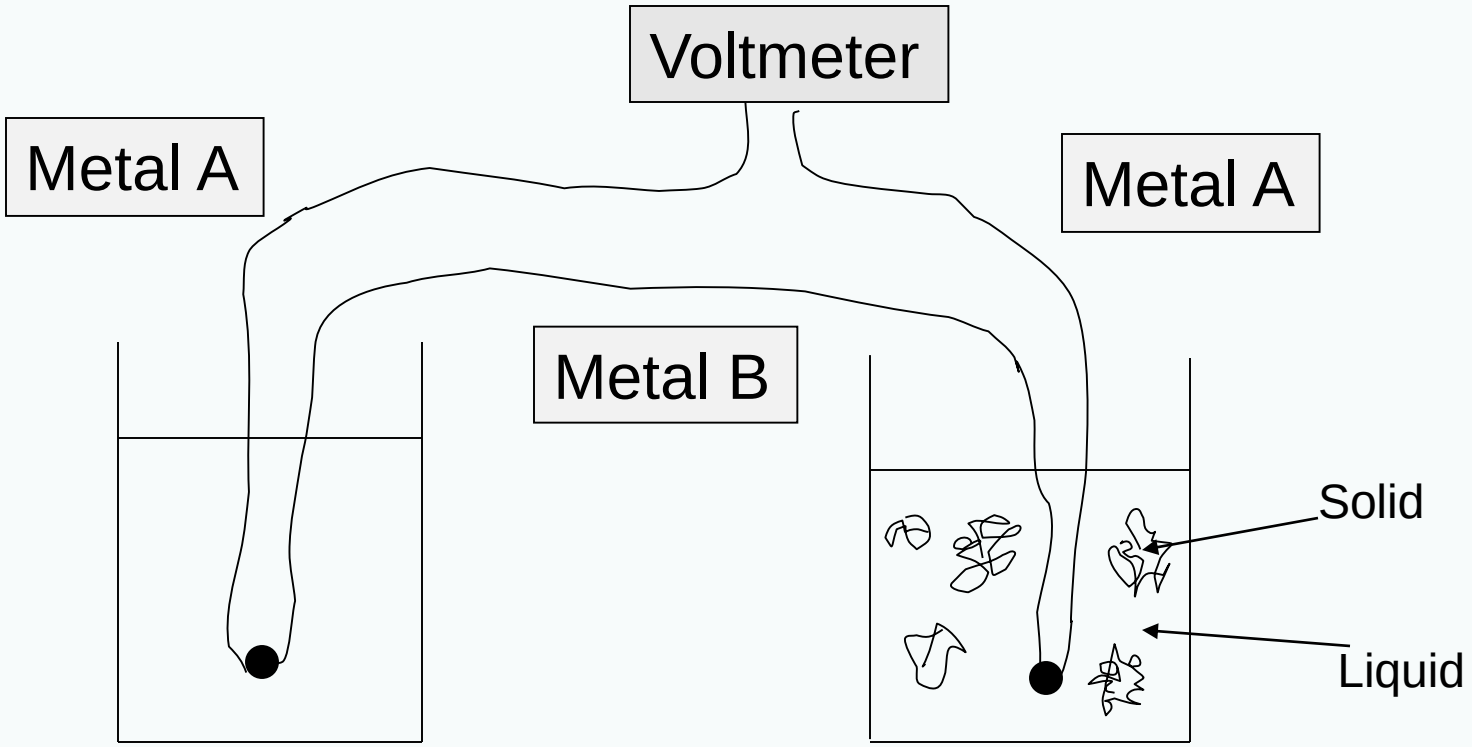
For each arrangement,the secondary Instrument measures the resistance of the wires drawn with a heavy line

4.Thermocouples



- SEEBECK EFFECT

Typical Thermocouple Configuration



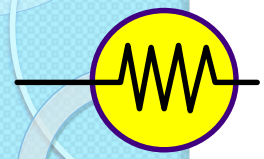
Unknown temperature

Reference temperature (slush bath)

Thermocouple Types

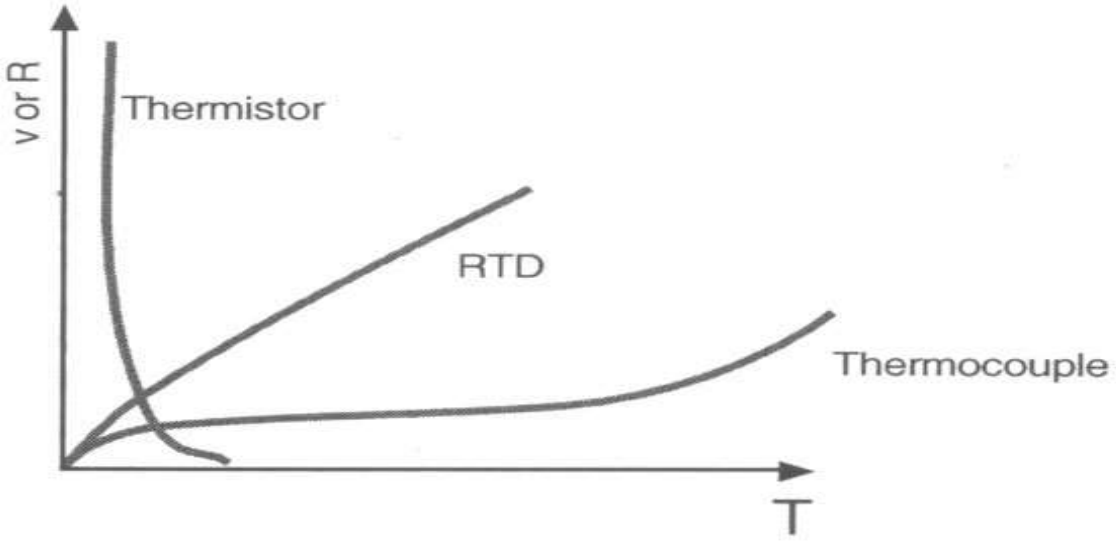
Type	Metals	See beck Coif: uV/C
J	Fe-Con	50
K	Ni-Cr	40
T	Cu-Con	38
S	Pt./Rh-Pt.	10
E	Ni/Cr-Con	59
N	Ni/Cr/Si-Ni/Si	39

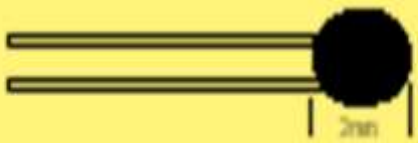
5.Thermistors



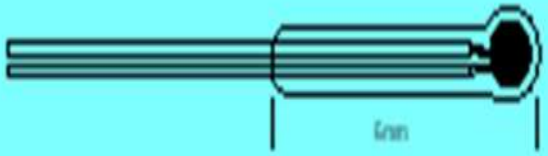
- Thermally sensitive resistors
- Highly sensitive and very reproducible resistance vs. temperature.
- Limited range
- Typically used over a small temperature range (due to non-linear characteristics)
- Thermistors do not do well at high temperatures and show instability with time
- Manufactured from oxides of nickel, magnesium, iron, cobalt,manganese,titatinum and other metals.
- NTC Thermistor
- **Steinhart – Equation** : $1/T = a + b \ln(R) + \ln^3(R)$

Thermistor Non-Linearity



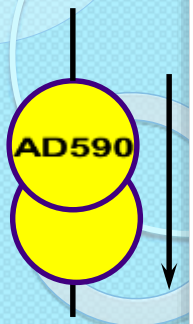


a. Epoxy Coated Thermistor Bead.

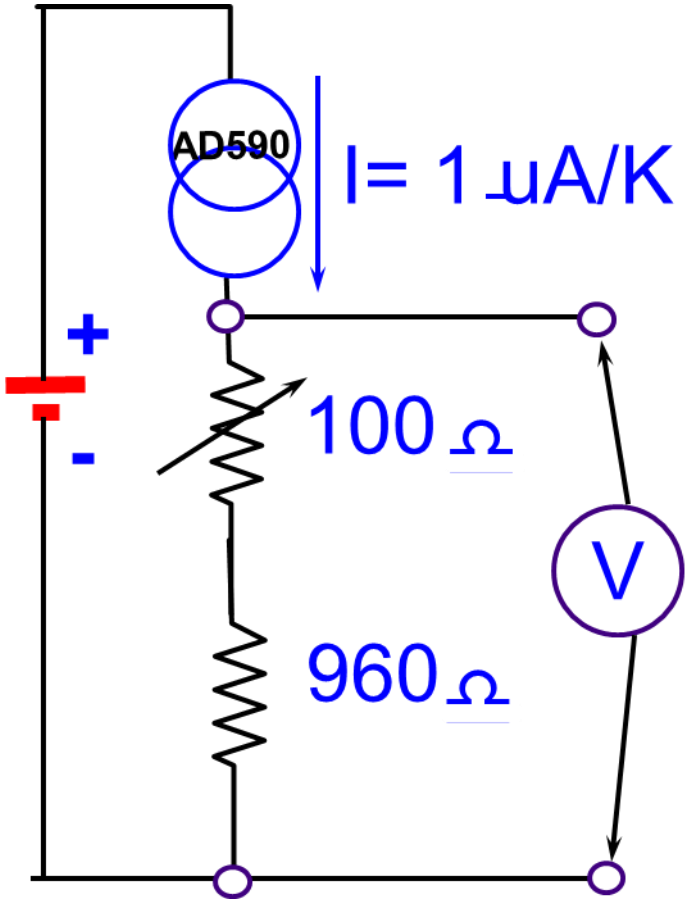


b. Glass Coated Thermistor Bead.

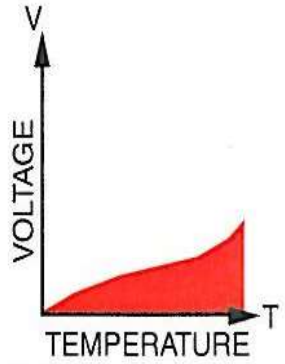
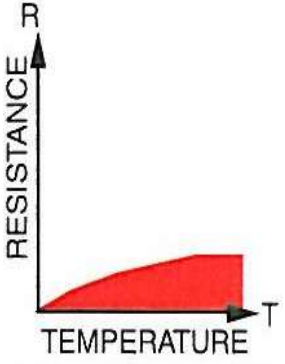
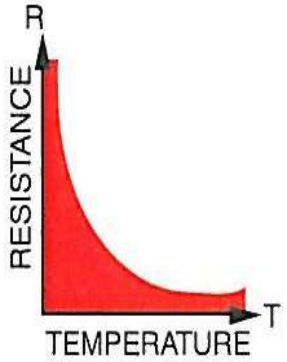
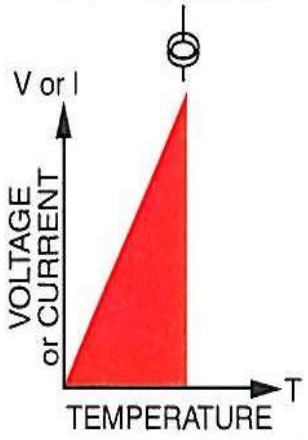
6. I.C. Sensor



- V&I signal output
- Output ↑ = Temp.↑
- Very linear
- Accurate @ room ambient
- Limited range
- Cheap



Practical Temperature Measurements*

	Thermocouple	RTD	Thermistor	I. C. Sensor
				
Advantages	☐ Self-powered ☐ Simple ☐ Rugged ☐ Inexpensive ☐ Wide variety ☐ Wide temperature range	☐ Most stable ☐ Most accurate ☐ More linear than thermocouple	☐ High output ☐ Fast ☐ Two-wire ohms measurement	☐ Most linear ☐ Highest output ☐ Inexpensive
Disadvantages	☐ Non-linear ☐ Low voltage ☐ Reference required ☐ Least stable ☐ Least sensitive	☐ Expensive ☐ Current source required ☐ Small Δ R ☐ Low absolute resistance ☐ Self-heating	☐ Non-linear ☐ Limited temperature range ☐ Fragile ☐ Current source required ☐ Self-heating	☐ T<200°C ☐ Power supply required ☐ Slow ☐ Self-heating ☐ Limited configurations

More temperature measurement possibilities

- ✓Thyorister
- ✓Thermowell
- ✓Infrared Thermometer
- ✓pyrometer

How to Choose a Temperature Control Device or System ?

Things to take into account

- Standards
- Cost
- Accuracy
- Stability over time (esp. for high temperatures)
- Sensitivity
- Size
- Contact/non-contact
- Temperature range
- Fluid

Examples

Measurement	*Sensor*
☿Photochemical process control:	☿RTD (most accurate)
☿Flower petal:	☿Thermistor (lowest thermal mass)
☿Molten glass:	☿Optical pyrometer (hi temp, no contact)
☿Induction furnace:	☿RTD (if <800C); or T/C (Beware magnetic I noise)
☿100 degree Heat aging oven:	☿Any of the 4 sensors

- Reference :

- http://www.omega.com/temperature/z/zsection.asp
- http://www.instrumentationtoday/temperature/asp
- http://www.instrumentationtools/temperaturesensors/.jsp

THANK YOU