Jawaharlal Nehru Engineering College

Automatic Control System

Laboratory Manual

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Mechanical Engineering Department

For

Final year students

List of Experiments

1] Study of control system components.

2] An Experiment on speed control of stepper motor.

3] An Experiment level control system.

4] An experiment on ON-OFF temperature control.

5] An Experiment on various models of control I, P, P+I, P+D & P+I+D.

Study of control system

Aim: Study of controller of CNC machine,

Apparatus: CNC Machine.

Theory:

Principle:

Numerical control system:

Numerical control can be defined as a form of programmable automation in which the process is controlled by numbers form program, letters and symbol. In NC, the numbers form a program of instructions, designed for a particular work part. When the job changes, the program of the instructions also changed. This capability to change the program for each new job is what gives NC flexibility.

An operational NC system consist of following basic components,
1] Program of instruction.
2] Controller unit also called as machine control unit.
3] Machine tool or other controlled process.
The process of introduction or instructions is detailed step by step set of directions which tell the machine tool what to do. It is coded in the numerical or symbolic form on some type of input medium that can be interpreted by the controller unit input media used are punched cards, magnetic tapes and even 35mm motion picture film. The programmer's job is to provide a set of detailed instruction by which the sequence of processing step is to be performed. For a machine operation, the processing step involves the relative movement between the cutting tool & w/p.

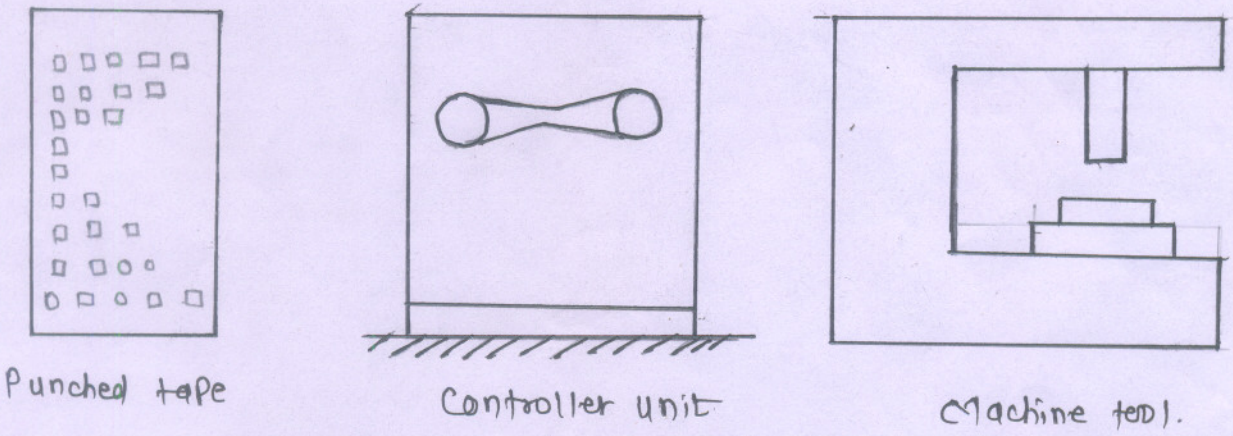


Fig: Basic Component of NC system.

Controller Unit:

The controller unit consist of electronic and hardware that read and interpret the program of instruction & convert into mechanical action of machine tool. The typical element of the machine tool or conventional NC controller unit include the tape reader, a data buffer, signal output channels to the machine tool and sequence control to co-ordinate the overall operation of forgoing elements.

The tape reader is an electromechanical device for winding and reading the punched tape containing the program of instructions. The data contained on the tape are read into the data buffer. The purpose of this device is to stack the input instructions in the logical block of information.

The signal output channel are connected to the servomotor and other controls in the machine tool through these channels, the instructions are set to the machine tool from the controller unit to make certain that the instructions have been properly executed by the machine , feedback data are sent back to the controller via feedback channels. The most important function of this return loop is to assure that the table and the work part have been properly located with respect to the tool.

Sequence control co-ordinates the activities of the other elements of controller unit such as the tape reader is actuated to read data into the buffer form the tape, signals are sent to and fro the machine tool and so on.

The control panel is another part of machine tool; it consists of dial and switches by which the machine operator runs the NC system. It may also contain data display to provide information to the operators.

Machine tool or other controlled process:

The machine tool consists of a work table and spindle as well as the motors and controls necessary to drive them. It also includes the cutting tool, work fixtures and other auxiliary equipments needed in machining operation.

Computer numeric control system:

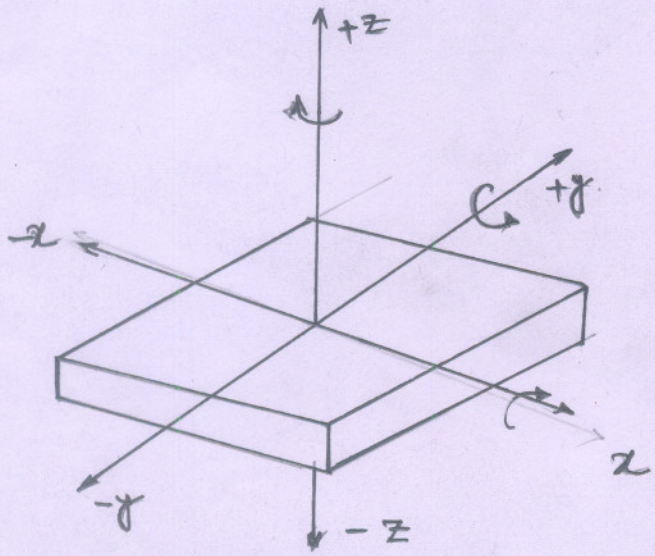
Computer numerical control is an NC system that utilizes a dedicated, stepped program. We have to program the computer for some or all the basic numerical control function. The external appearance of CNC machine is similar to that of commercial NC machines. CNC offers additional flexibility compatibility.

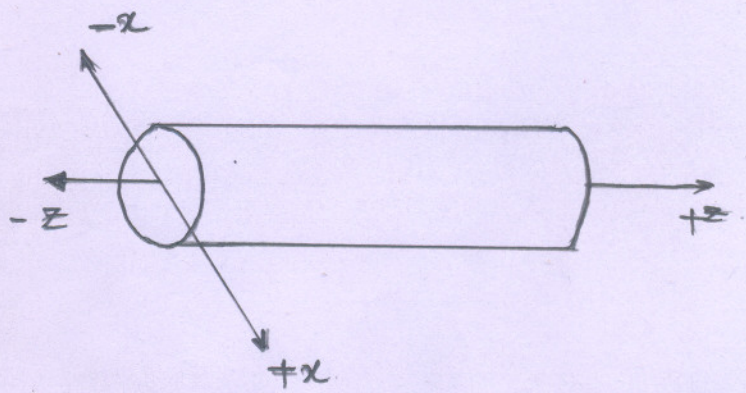
NC Coordinate system:

In order for part programmers to plan the sequence of positions and movements of the tools relative to the output of the work piece, it is necessary to establish a standard axis system by which relative positions can be specified.

The axis x & y are defined in the plan of table. The Z axis is perpendicular to the plane and movement in Z direction is controlled by vertical motion of the spindle. The positive and negative directions of motions of the tool relative to table along three axes are as shown in figure.

Three rotational axis are defined in NC, the a, b &c axis. These axes specify angles a X, Y&Z axis respectively. Using right hand rule with thumb pointing the positive linear axis direction (x, y&z) the fingers of hand were curled to point in the rotational directions



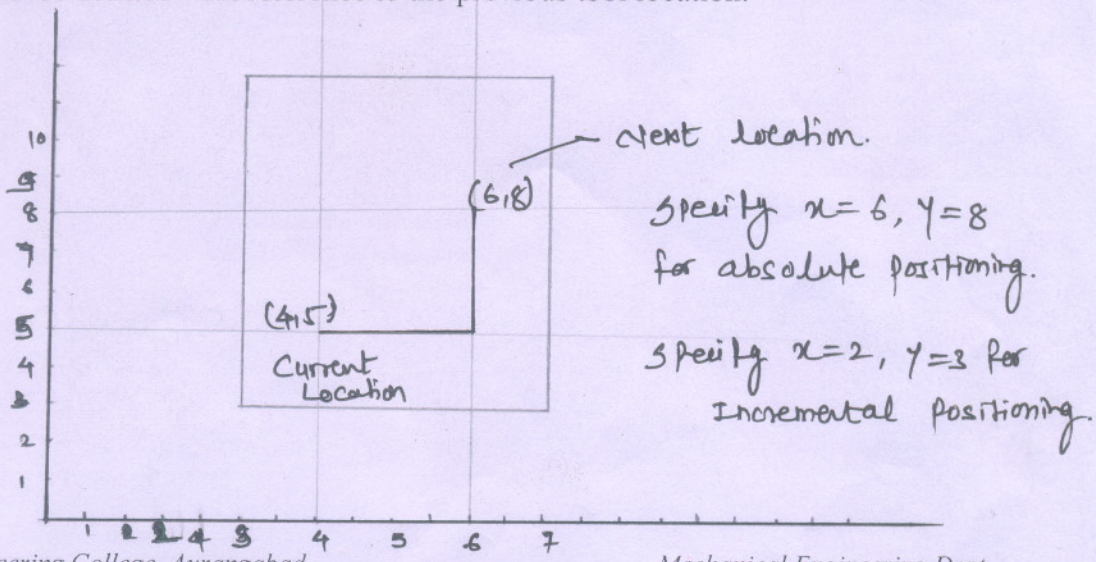


Fixed zero & floating zero:

The programmer most determines position of tool relative to the origin of co-ordinate system.
N machines have either of two methods for specifying the zero point.
The first possibility is for the machine to have a fixed zero. In this case, the origin is always located at the same position on the machine table. All tools location is specified by positive X & Y coordinate. The second & more common feature on modern machines allow the machine operator to set the zero point at any position on the machine table. The part programmer is one who decides where zero point should be located.

Absolute positioning & incremental positioning:

Absolute positioning means that tool locations are always defined in relation to the zero point. If a hole is to be drilled at a spot that is 8cm above X axis, 6cm to the right of y axis to coordinate location of the hole would be specified as X=6& Y=8. Incremental positioning means that the next tool location must be defined with reference to the previous tool location.



Trends & development in NC:

Without question, the most important general trends in NC involve the expanding use of computers. The standard medium used to contain the part program, in NC has been in wide punched tape. With greater use of computers in today's numerically controlled processes, there is a movement among machine builders and controls people to replace the punch tape and reader with the medium that is more compatible with modern computer systems.

In many respect, development in computerized geometric modeling have outpaced and outdated APT geometric concepts. One of the important developments in DNC was introduction of FM's in which machine material handling equipments are controlled by computers. Also in terms of control technology and programming industrial robots share much in common with numerical control machines, Design and development of robots is the next major area of work.

Experiment on speed control of stepper motor

Aim: Study of stepper motor control.

Apparatus: 1] Stepper motor control kit.
2] UJT oscillator.
3] Translator & stepper motor.
4] Connecting wire & Power supply.

Theory:

Principle:

Stepper motor is an electro mechanical device, which actuates a train of step angular or linear moment in response to train of input pulse one to one basis .One step actuation of each pulse input.

Types of stepper motors: 1] Variable reluctant types.
2] Permanent magnet stepper motor.

The operation of stepping motor can be understood from the simple model shown in above fig-1, which has 90 per step. In this motor the rotor is a permanent magnet which driven by particular set of electromagnets. In this position the system shown is in equilibrium electromagnets. The switch is in solid state device such as transistor, SCR etc.The switch sequence will direct the switches a sequence of positions as the pulses are received. The next pulse in fig-1 will change S2 from c to d resulting in poles of that electromagnet reversing fields.

Now, because the pole north/ south orientation is different, the rotor is repelled & attracted so that it moves to the new position of equilibrium as shown in fig-2 with the next pulse s is changed to B counting the same kind of pole reversal & rotation of PM S2. To switch C again and PM rotor again steps to new equilibrium position as shown in fig-D, the next pulse will send the system back to original position . This sequence is then repeated.

Operation of stepper motor:

Fig. a

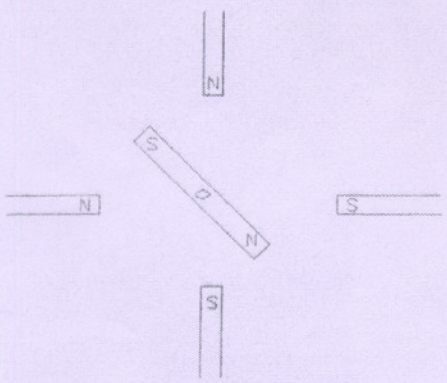


fig. b

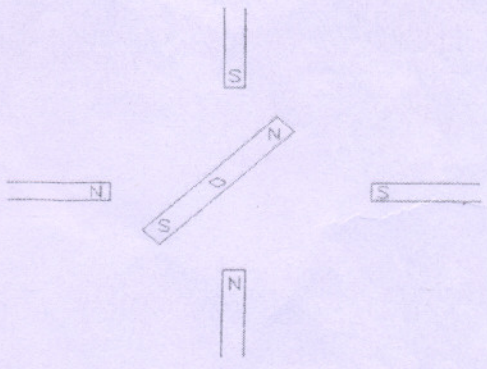


fig c

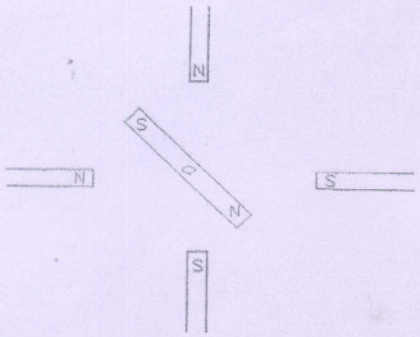
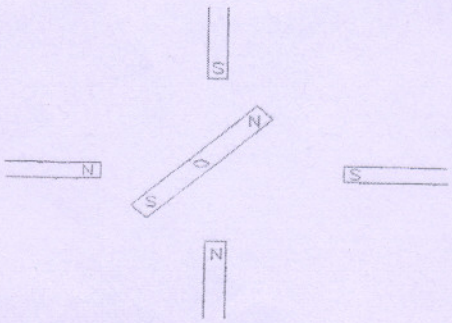


fig d



90°/step.

Steps/revolution (s) = m Nr
Where m= Phase
Nr= No. of rotor teeth.
Angle/step=360/m
N=360/s

Specification:

1] Step Angle = 1.8 Degree
2] Operating Voltage = 12 Volt (D.C)
3] Current Rating = 1.2 Amp
4] Torque = 3 Kg.cm

ANTICLOCK WISE CLOCKWISE			CLOCKWISE		
1	A	C	1	A	C
2	B	C	2	B	C
3	B	D	3	B	D
4	A	D	4	A	D

Properties:

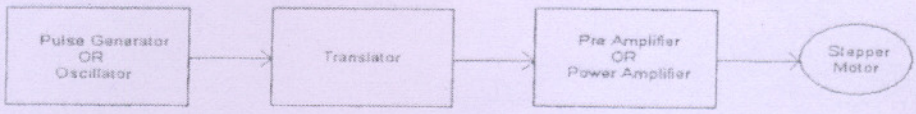
1] When driven with digital pulses it moves one & only one step per pulse.
2] Self-starting, no external means is required.
3] It starts /stops & reverses instantaneously.
4] It is bi-directional motor and can rotate in either directional.

Operation of Stepper motor:

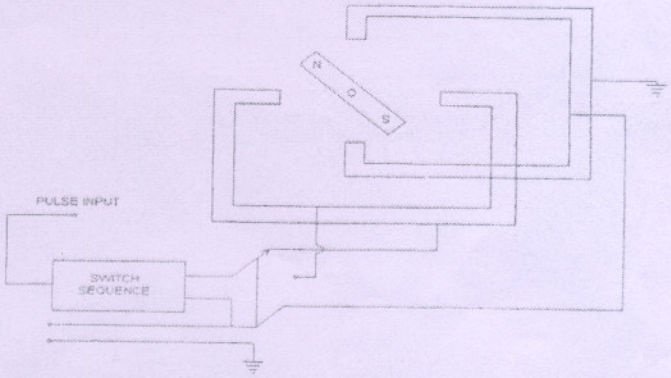
Permanent magnet stepper motor

Driving circuit for stepper motor: -

(Open Loop Control)



Elementary diagram of stepper motor: -



Applications of stepper motor:

1] Pulse converter on production lines.
2] Remote indicator.
3] Numerically controlled machine tool drive.
4] Line spacing controls for point out machine.
5] Punch tape drives.
6] In optical & medical equipments.
7] Focus control of camera & filmstrip projector.
8] Automatic servo operated AC voltage regulator.
9] AC drives, it can be used, strip chart recorder & curve tracer.
10] For recording instruments.

Conclusion:

In this way we studied the operation of stepper in open loop mode. It is observed that as frequency is changed the speed of motor is also changed and direction of motor can be changed by changing the pulses to bifilar windings.

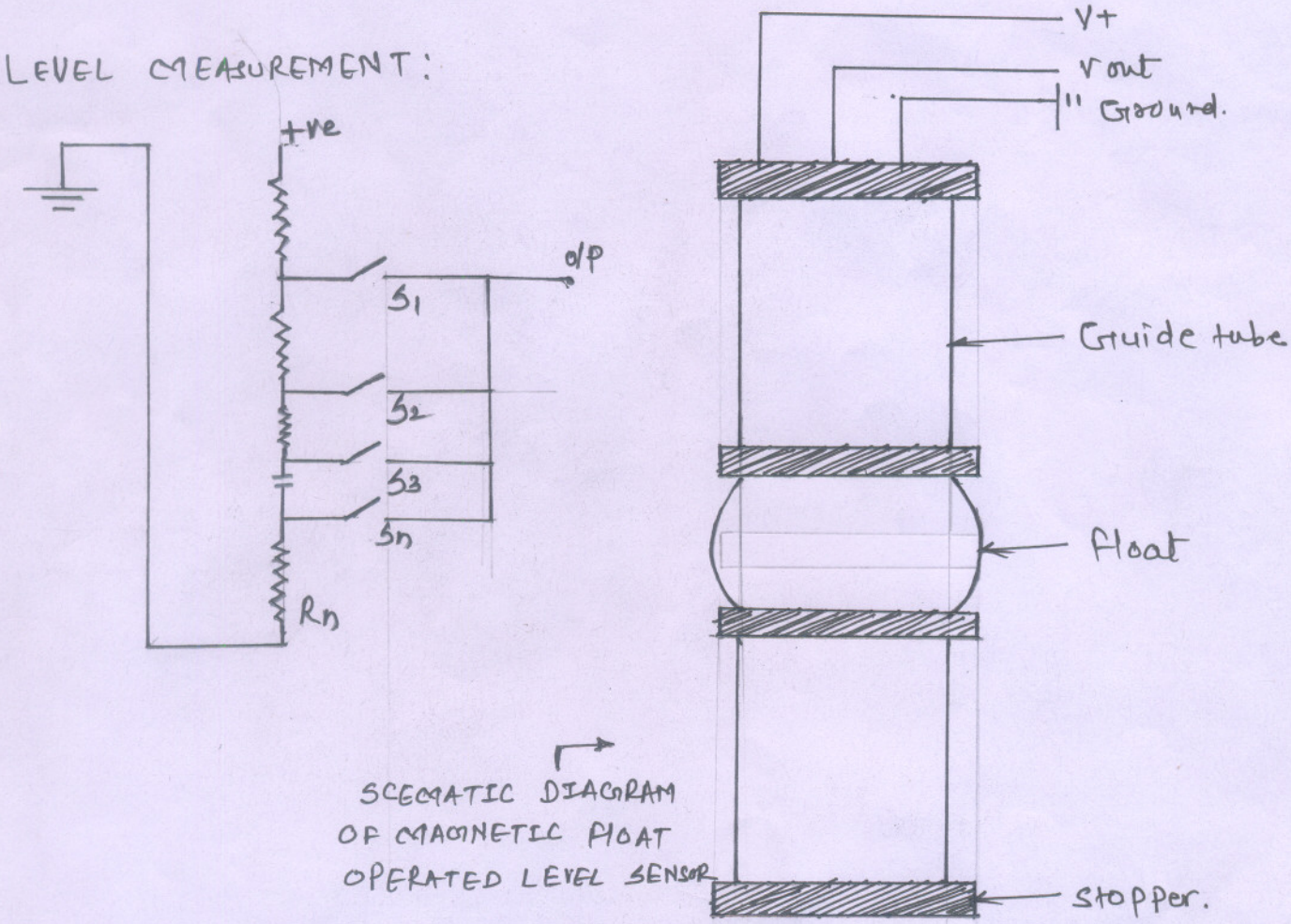
Experiment on a level control system

Aim: Study of level measurement using mechatronics & electrical method. (*Water Level measurement*)

Apparatus: 1] Experimental set up (reed switch, float, display unit & motor)
2] Level measurement system (Controller unit)
3] Water supply & Power supply.

Theory:

Level measurement using float is one of the most common method. However float is to be coupled to a suitable displacement sensor (for ex potentiometer) for converting mechanical position of the float in electrical form.
Using magnetic type float noncontact type coupling can be done. Here the transducer consists of a float guide tube assembly in nonmagnetic material to achieve undisturbed flux. A chain of closely spaced glass encapsulated reed switches & resistor is placed inside the glass tube as shown in the figure.
During rise & fall of the liquid level, the float moves & actuates a reed switch in the chain, through a magnet system within it & develops a proportional voltage. The operation is similar to a sliding resistance potentiometer.



SCEMATIC DIAGRAM OF MAGNETIC FLOAT OPERATED LEVEL SENSOR

Experimental set up:

1] Magnetic float operated Level Sensors is provided for level measurement.

2] Display unit is provided which accepts signal from float to be connected to the unit at % pin Connector.
When float is in down most position then output is zero.
As the float moves up it directly reads the level in the tank.

Calibration: Add water in tank up to 20 cm height as read on side glass capillary & adjust GAIN ADJUST potmeter to read display 20.

3] 35 cm height steel water tank mounted on stand is provided with the system .side glass capillary mounted near scale is provided to read the water level in the tank directly.

Specification:

Range 0-30 cm
Accuracy= 10 mm
Total resistance 6000 Ω

Procedure:

Place the magnetic float operated sensor in a water tank.
Connect the sensor o/p to the display unit.
Make power on to the display unit.
Go on slowly adding water in the tank.
Note the water level in the tank from the side glass capillary & as it read on display unit.
(At 20 cm height if required adjust pot to match the reading)
Repeat the process by discharging the tank in proper steps & noting down both the readings.

Observation Table:

Sr. No.	Glass capillary Reading	Display reading

Graph: Plot graph of display reading against glass capillary reading.

Conclusion: Display reading & glass capillary reading are near about same

Experiment on-off temperature controllers

Aim: Study of different ON-OFF Temperature controllers. (*Temperature measurement*)

Apparatus: 1] Thermocouple.
2] Thermostat, (Range: 0-90 degree centigrade) (Case study)
3] Electronic Temperature controller. (Case studies of Circuit dig)

Theory:

To study the temperature measurement by using the thermo couple and case study of different types of temperature controllers and their principle of measuring the temperature.

Experimental set up:

- Thermocouple: i) Copper- Constantan, ii) Iron – Constantan.
- Electric Heater.
- Water Container.
- Multimeter.
- Thermometer.
- Temp Measurement trainer.

Theory:

Devices that measure temperature on the basis of thermoelectric principle is called Thermocouples.

Thermoelectric Effect:

Different metals have different electrical & thermal transport properties. When a temperature differential is maintained across a given metal, the vibration of atom & motion of electrons is affected so that a difference in potential exists across material.
This potential difference is related to the fact that electrons in the hotter end of the material have more thermal energy than those in the cooler end & thus tend to drift toward the cooler end. This drift varies for different metals at the same temperature because of their difference in thermal conductivities. If the circuit is closed by connecting the ends through another conductor, a current is found to flow in the closed loop.

Seeback Effect:

The current flows in the closed circuit made up of two different metals if the junctions of the two metals are kept at different temperatures. In each lead, the concentration of valance electrons is proportional to the temperature, and at the point of contact, the electron differ through the boundary layer between the leads, resulting in one lead becoming positive and the other becoming negative. Thus EMF generated is proportional to the temperature difference in predictable manner. This phenomenon is called as seeback effect.

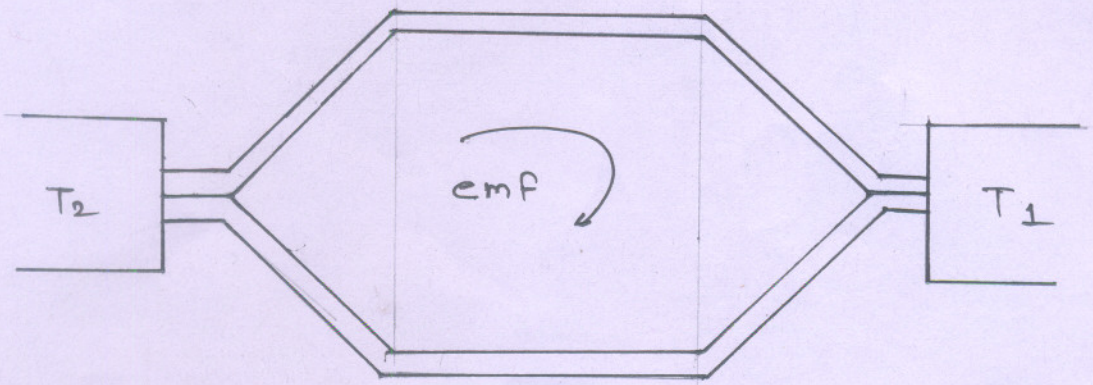


fig: SEEBACK EFFECT

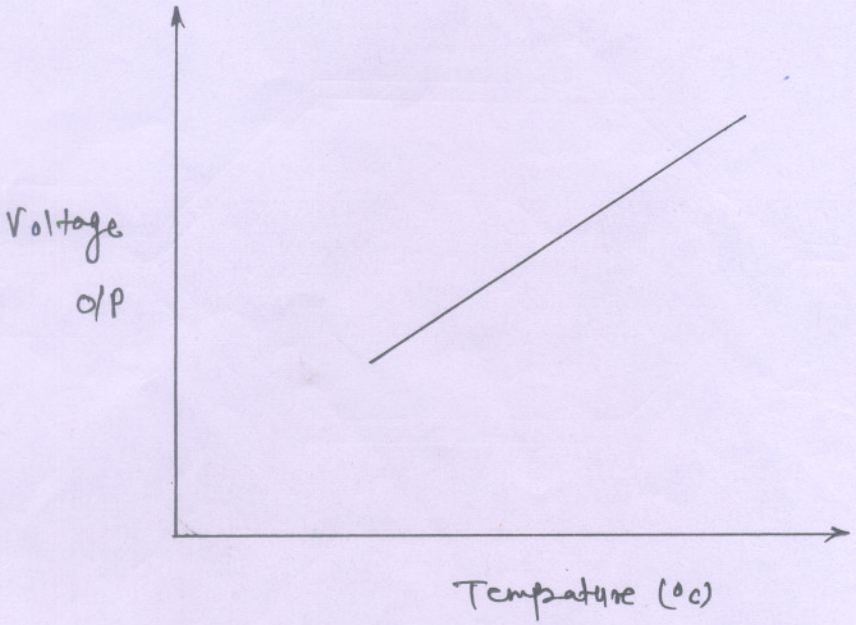
Procedure:

1] Connect the thermocouple supplied to you, at the input terminals. If copper constantan thermocouple is used copper wire must be connected to positive terminal and constantan wire must be connected to negative terminal.
2] Deep the junction in water container.
3] Hold the thermometer in water container.
4] Switch ON the electric heater.
5] Note down the temperature on the thermometer, temperature of the measuring instrument and note down the voltage output at the end terminal of both metal wires using multimeter.
6] Plot the Temperature vs. Output characteristic.

Observation Table:

Sr. No.	Thermometer reading (Degree Centigrade)	Instrument reading (Degree Centigrade)	Output Voltage

Graph:



Result:

Precaution:

While connecting the wire the thermocouple to the input terminals, observe the polarity.