MEASUREMENT OF ENGINEERING QUANTITIES

Measurement is required to asses the output, Capacity and Performance of m/c and System. It is also required to control the m/c and System, so that they keep working within required limit.

Measurement of Temperature :→

measurement of temp and Control of temp ins play very important role in furnance, processes and many engineering system.

Different m/c work with diff temp range.

Temperature Cannot be measured by direct basic standard for direct measurement change in temp is measured by the effects like change in physical state of Substance, change in dimension, change in electrical property et-c

① Liquid in glass Thermometer ④ Bimetalic Thermomet
② pressure gauge Thermometer ⑤ Thermo Couple
③ Resistance Thermometer. ⑥ Pyrometer.

Liquid-in-glass Thermometer :→

eg - clinical Theromometer

large bulb at one end, and fine capillary tube in a glass rod having a scale, a small bulb at the othe end.

Thermometric liquid which is filled in the bulb and the part of capillary. Remaining part of capillary has either vaccum or filled with inert gas

Property of Thermometric liquid :-

① The expansion of liquid should be linear
② Low freezing and high boiling point
③ Coefficient of thermal expansion should large
④ visible as fine line inside the capillary
⑤ Shouldn't be stick on the wall of capillary
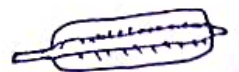
PRESSURE THERMOMETER

- A bulb may be filled with liquid, gas or vapour.
- One end of the tube connect with the bulb while another end connect with the pressure gauge
- The length of the tube may be as long as 75m.
- When the temp of the bulb change, the pressure and volume of the fluid inside it also change. The change in pressure is recorded on the pressure gage. The scale of the pressure gage can be calibrated to give temp directly
- error occure due to high length of tube.
- error can be minimise by keeping the volume of bulb is larger as compare with the tube.
- Temp range   -200°c to 500°c
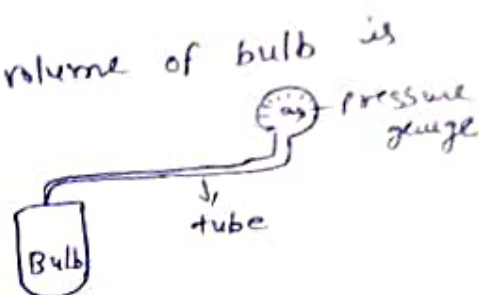
Thermocouple :→

Seeback discovered that emf exists across a junction formed by two dissimilar metals. Peltier discovered that this emf depends upon the temperature of the junction (Peltier effect). Thomson found that the emf also depends upon the temperature gradient along the conductor wires (Thomson effect) These principles are used in thermocouple for measure of temperature. The emf due to thomson effect is quite small as compare to that due to peltier effect.

Common method for making thermocouple joint

material used in thermocouple are

$$\left[Copper\ 60\%.,\ Nickel\ 40\% \right] \left[Cr\ 10\%.\ Ni\ 90\% \right] \left[Al\ 2\%.\ 90\%\ Ni\ \atop remaining\ Si,\ mn \right]$$

Copper constant thermocouple   chromel Constentan
used -200 to 350°c   -20 to 500°c

* Thermocouple are made by twisting two wire of dissimilar metal and making a junction b/w them by brazing or welding. The voltage output of thermocouple is in milivolt. Therefore suitable circuity is required for its amplification display & Recording

Pyrometer :→

Any body having temp above the absolute zero temp its gives radiation when a steel body is heated. it radiates energy in the infrared region. When the temp is increased, the colour of radiation becomes dull red. Again heating continuous the colour of body become red, bright red and finally bluish. This change in colour is due to dominance of higher frequency in spectrum at higher temp. The Pyrometer measure the temp on the basis of radiation.

① Total radiation Pyrometer ② optical Pyrometer

x[optical Pyrometer use optical mean for estimating the temperature. They use the radiation in the visible range of the spectrum of radiation from the hot body. They are non contact instrument. A Pyrometer must be calibrated for Particular application before it is put to regular use.]x.

optical Pyrometer match the colour of radiation from a hot body, with the colour of filament bulb. The current through the bulb. filament can be controlled through an electric circuit. When this current is varied, the colur of filament changes. The operaton teries to adjust the current in such a manner that the colour of filament become the same as the colour of radiation from hot body.
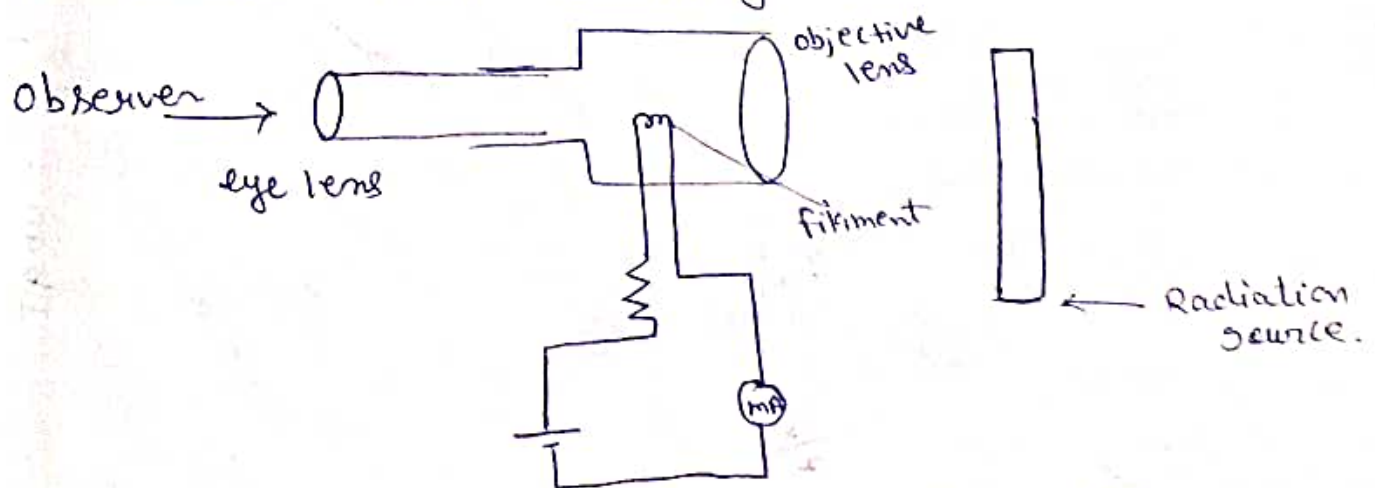

working principle of optical Pyrometer

PRESSURE MEASUREMENT

Pressure is defined as the force exerted by a fluid on a unit area. This Pressure is the Absolute Pressure. The measuring devices usually measure the difference of Pressure b/w absolute Pressure from a source and atmospheric Pressure. This Pressure is termed as Gage Pressure
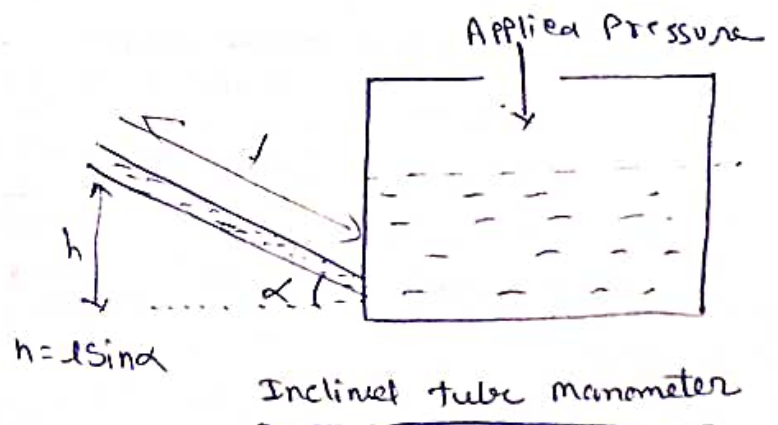
1 atm = 1.01325 bar
1 bar = 10^5 Pa

Relation b/w Absolute, gage and atm Pressure.
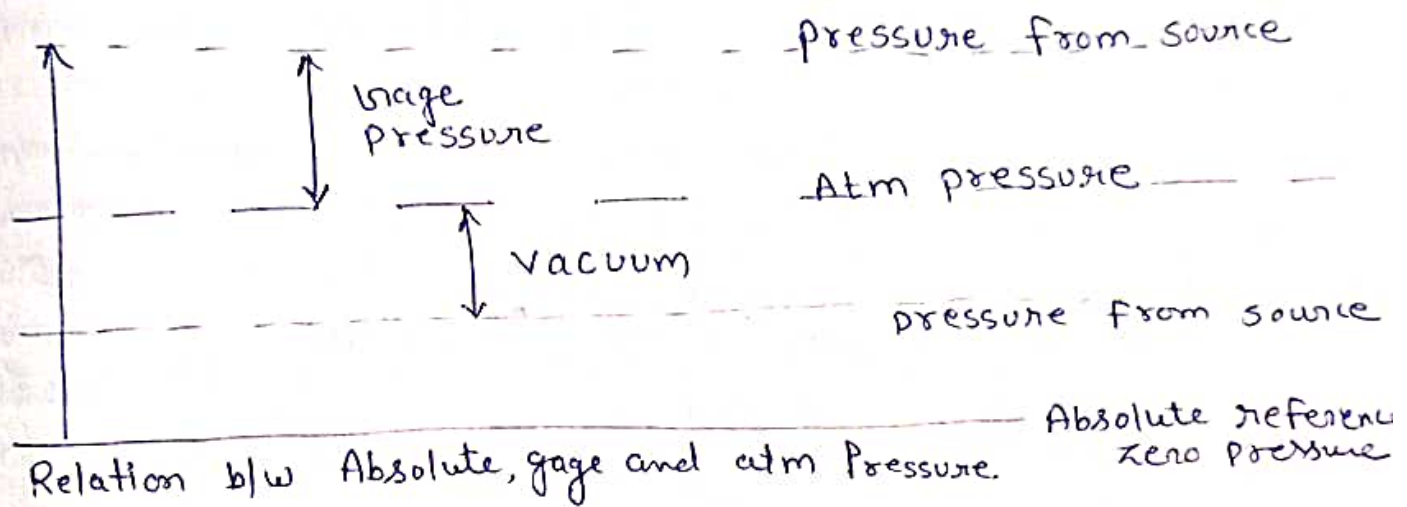
Pressure Measuring Devices: →
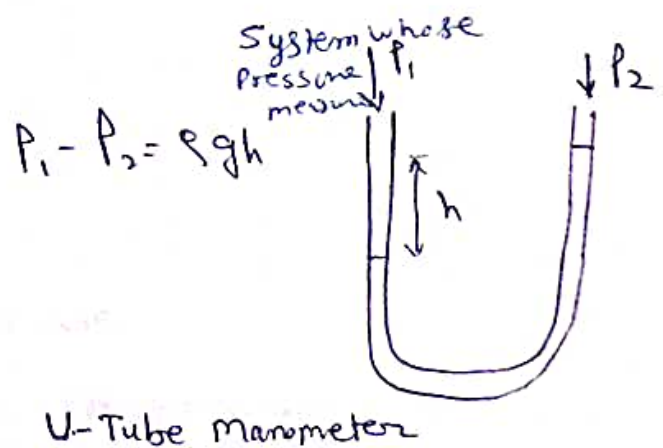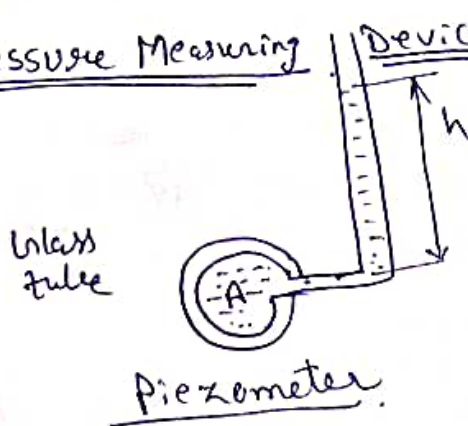
Piezometer

→ U-Tube Manometer
→ Inclined Manometer
→ Piezometer

$$P_1 - P_2 = \rho g h$$

U-Tube Manometer

$h = l \sin \alpha$

Inclined tube manometer

Bourdon Tube Pressure Inage :—→

Bourdon tube

Applied Pressure

Pointer

Arrangement of singhan tube
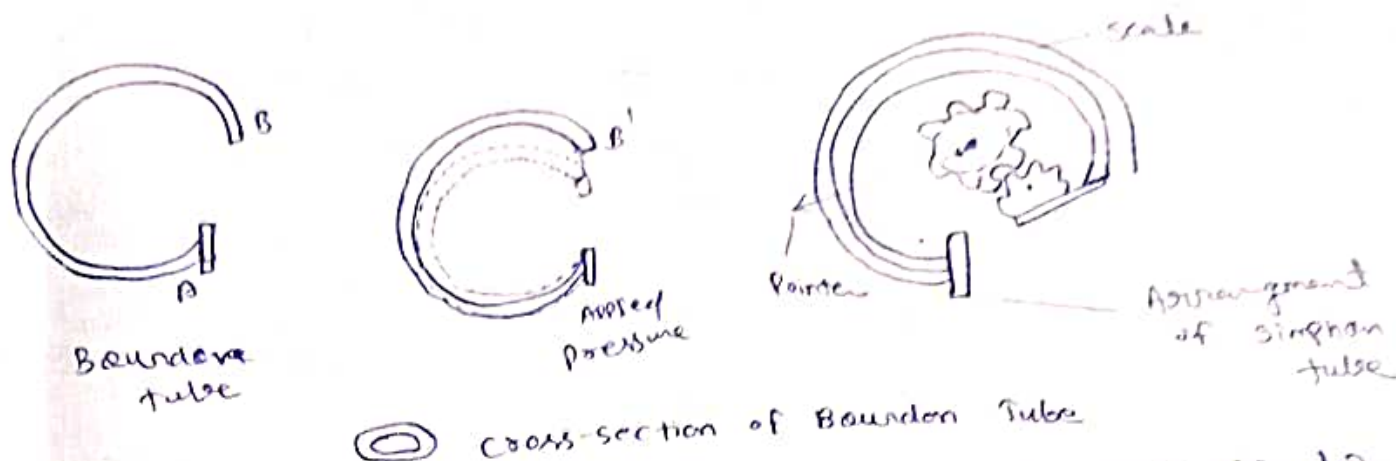
scale

○ Cross-section of Bourdon Tube

oval cross section of tube deform to become more circular
for more accuracy use more no of turns.
Calculate Press diff b/w atm press & applied Pressure
The circular scale is calibrated to read pressure directly.
The arc of bourdon tube is usually less than $360°$.

Elastic Diaphrams:-

The U-tube manometer and bourdon tube pressure gages are suitable for small pressure range, low medium sensitivity and when the variation is pressure is low. for measurement of dynamic pressure i.e Pressure very fast with time they are not suitable.

- for High Pressure difference we use elastic diaphrams.
- These diaphrams are usually circular and of thin metalic sheet
- Two basic type of Diaphrams are —
   * Flat Diaphragm. * Corrugated Diaphragm.
- Diaphragm is enclosed in a housing. The housing has threads for fitting on a suitable opening. It is fitted on the vessel or pipeline where pressure is to be measure when the pressure is applied on one side of the diaphrgm, It gets deformed. This deformation is a function of applied Pressure The deformation is measure using a suitable device for measurement of displacement.

Measurement of Velocity :→

Velocity is the rate of change of displacement. Velocity may be linear or Angular. Direct measurement of linear velocity is not easy. Linear velocity can be determine by calculating linear or angular displacement. It can also be calculated by first converting linear displacement to angular displacement and then measure the angular velocity. where is angular velocity can directly measure.

Velocity measuring Devices.

① Centrifugal Speedometers :→
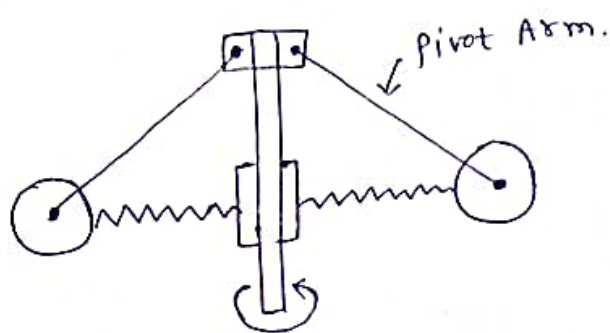
Centrifugal Speedometer

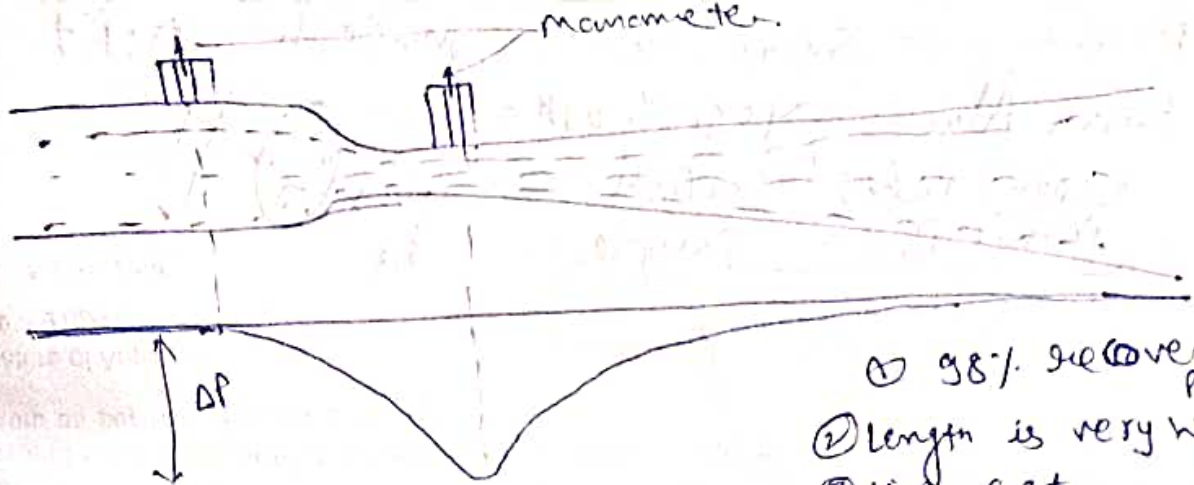### ② Tachometer :→   Ⓐ Contact Method   Ⓑ Non Contact method

Measurement of Flow

Flow rate can be define as the quantity of a substance flowing from a desired cross section in per unit time. unit is kg/sec or m³/sec.
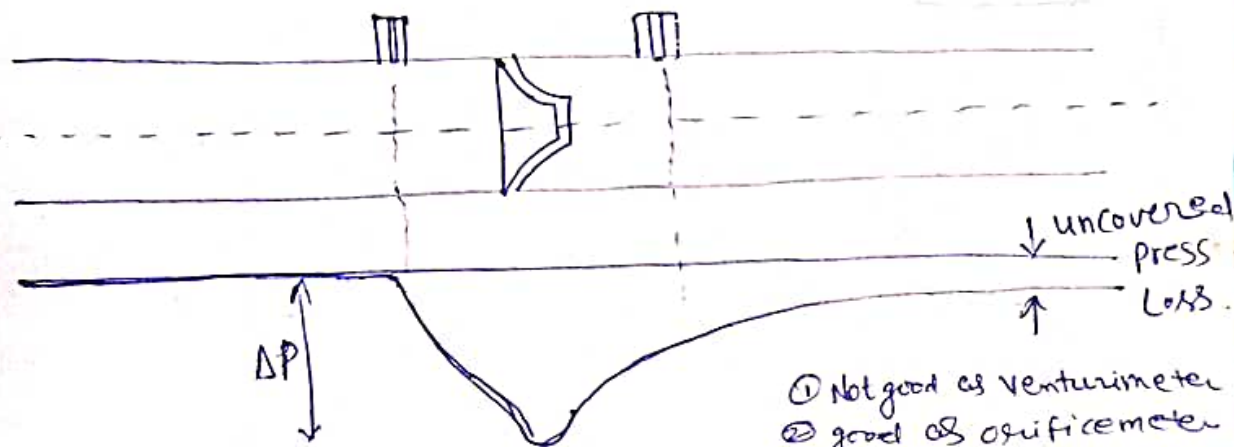
Flow measuring devices.

① Volumetric Tank ② Obstruction meter
                              venturimeter
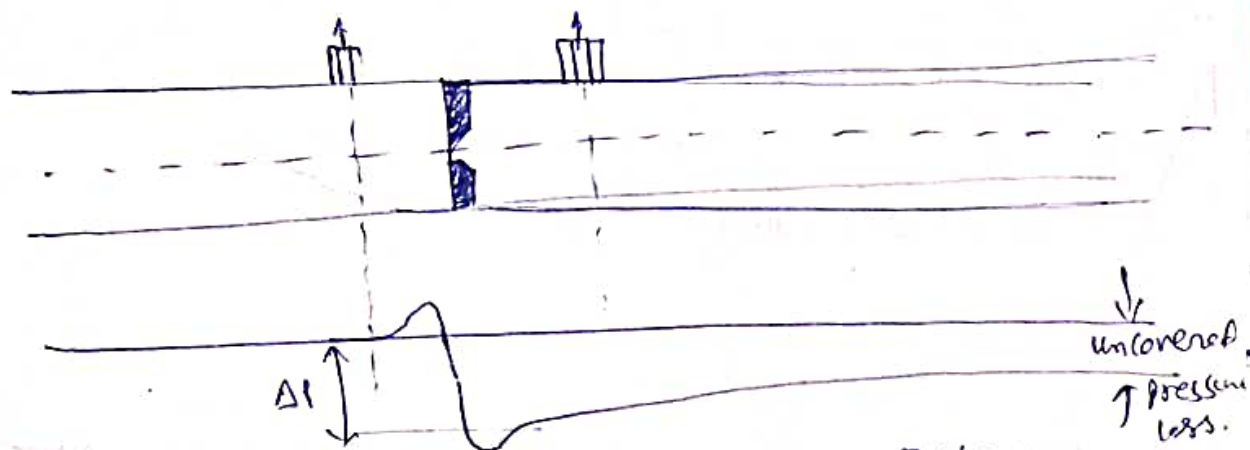   orifice meter
                              Rotameter

Manometer

ΔP

① 98% recover press
② length is very high
③ High cost

Venturimeter

↓ uncovered press
↑ Loss

ΔP

① Not good as Venturimeter
② good as orificemeter
③ Short length
④ Low cost

Nozzle meter

↓ uncovered
↑ Pressure loss

ΔP

Orifice meter

① Cheap
② Easy mfg

flow out

float

Tapered glass tube

↑ flow in
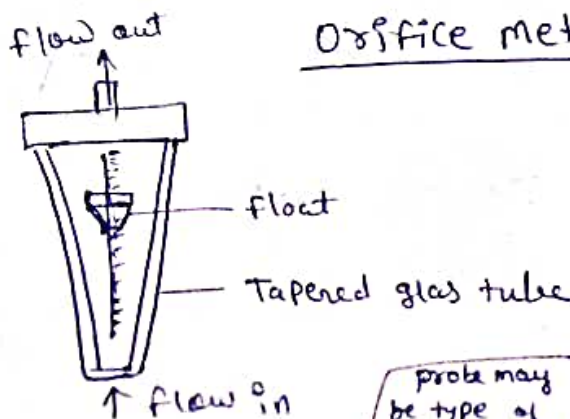
probe may be type of sensor.

⑤ Pitot Tube :— $Q = AV$ $V = \sqrt{2gh}$

↕ Pmax — Probe

measure velocity when fluid strike on wall   (Dynamic pressure)

$V = 0$

of the tube velocity of fluid become zero and sudden pressure increase fluid strike on probe and measure pressure also. Calculate pressure difference pressure sudden increase called stagnation
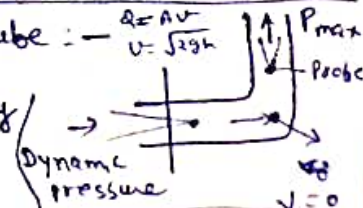
Measurement of strain : →

Measurement of strain is done for two major reasons. Firstly, strain is related to stress, and measurement of strain is done to determine stress in a machine Component. Determine of strain is also useful for determine other quantity indirectly, like temperature force, torque, Pressure and motion. The electrical Resistance strain gage is one of the most widly used Sensor for measurement of strain.
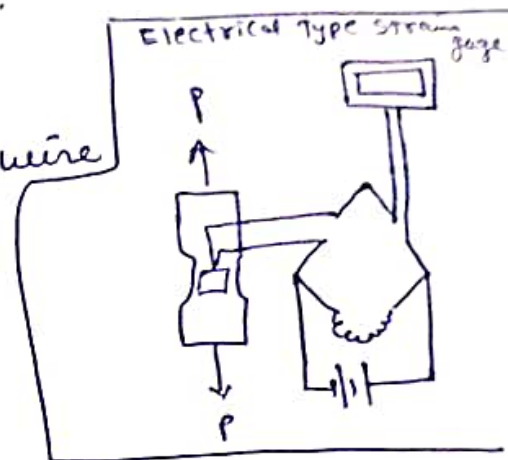
Electrical Resistance Strain gage :-

Electrical Resistance of wire

$$R = \frac{\rho L}{A}$$

ρ = electric Resistivity
L = Length
A = Area of cross section of wire
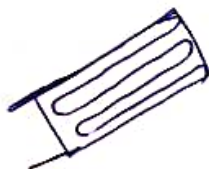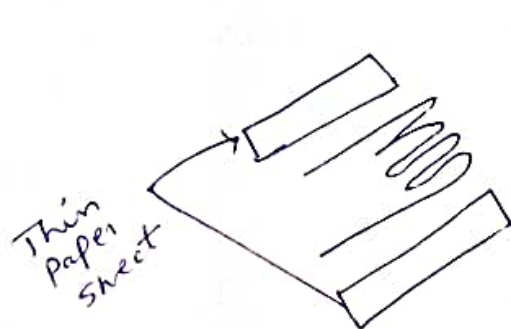
Electrical Type Strain gage

Axial Force apply on wire then length increase and dia decrease. Due to these change the electric resistance also change. This is the principle on which electrical resistance strain gages work. This property of metal, due to which their resistance changes on applying stress is Called piezo ruesistivity.

It Consist of a grid of fine wire, sandwiched b/w two thin paper sheet. The strain gage is bonded on the Surface where stress is to be measured, by means of a suitable adhesive. The Commonly used adhesive are nitro cellulose or bakelite (Phenolic)

Thin paper sheet

strain gage measure very small strain
0.000001

The Sensitivity of Strain gage is measured by its gage factor

$$G = \frac{dR/R}{dL/L} = \frac{dR/R}{\varepsilon}$$

MEASUREMENT OF Force

Force is measured using different type of elastic Transducers and strain gages. When force is applied to an elastic body it deflects. This deflection is related to the magnitude of force Thus by measuring the deflection caused by the force, its magnitude can be determined.

Spring Balance :→

$$F = K\delta$$

oA – Linear spring
AB – Non linear spring

force deflection.
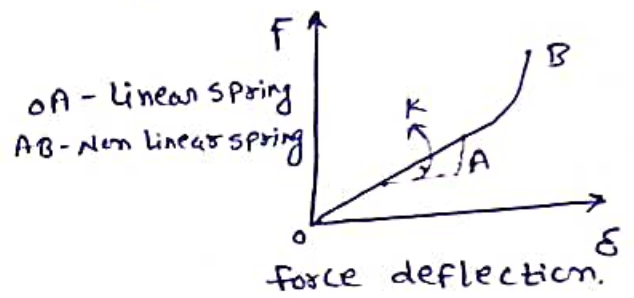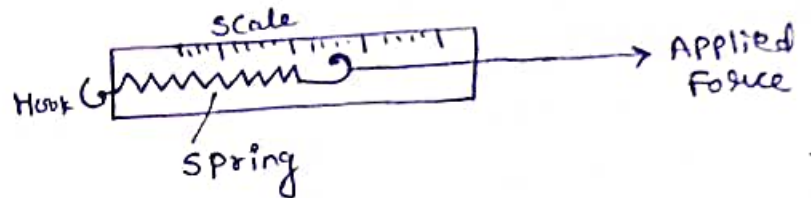
curve gives spring rate

Electric Load Cell :→

In such type of Load cell have strain gage mounted on an elastic element There is a large variety of load cell, using different geometries of elastic element, and different arrangement for mounting the strain gage. No. of strain gage mounted on elastic body
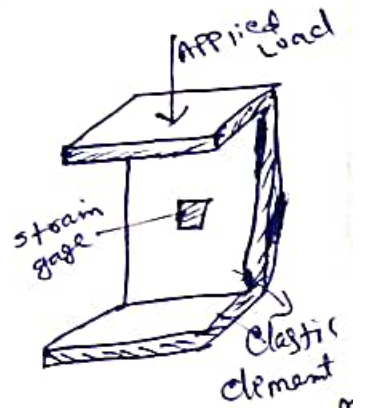
Hydraulic and Pneumatic Load Cells :→

Force can also be measured by measuring the pressure exerted by it, on a known area. This principle is used in Hydraulic & Pneumatic Load cell

Hydraulic Load cell.
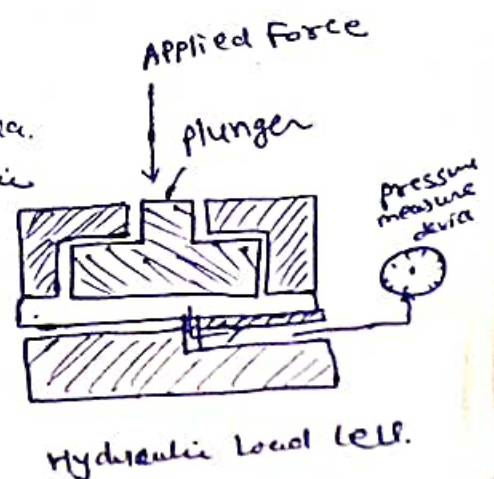
�# Measurement of Torque

Torque is the moment applied by a force. The Shaft of diff m/c like pump, engine, generator and other rotary equipment transmit power through angular motion and torque. The product of torque and angular velocity give Power (mechanical) Torque measuring devices are known as dynamometer.

Prony Brake Dynamometer:-

It is into the Category of Absorption Dynamometer. Absorbing or dissipating the power
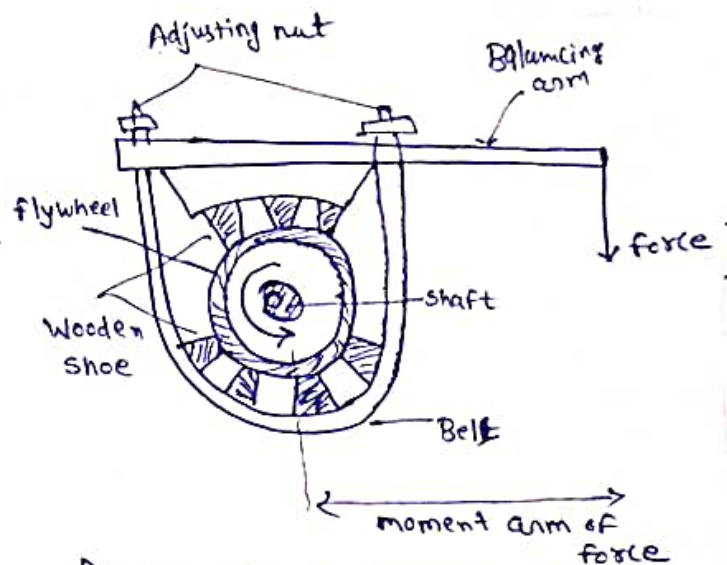
Prony Brake Dynamometer
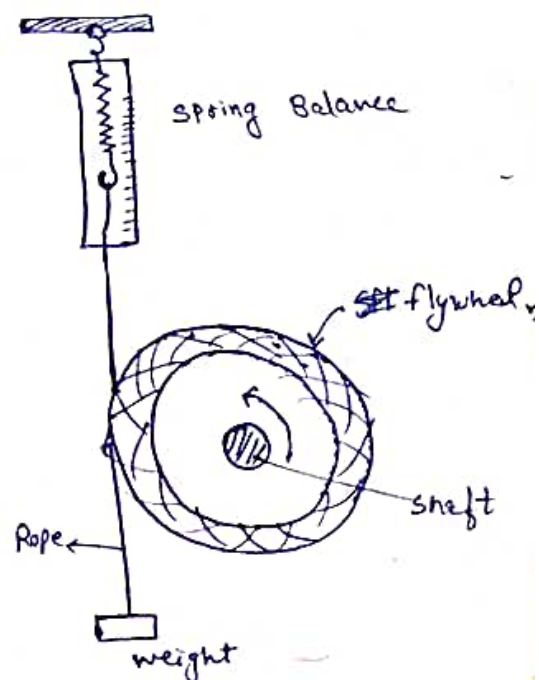
Rope Brake Dynamometer

Error and Uncertainty in Measurement

Error:→

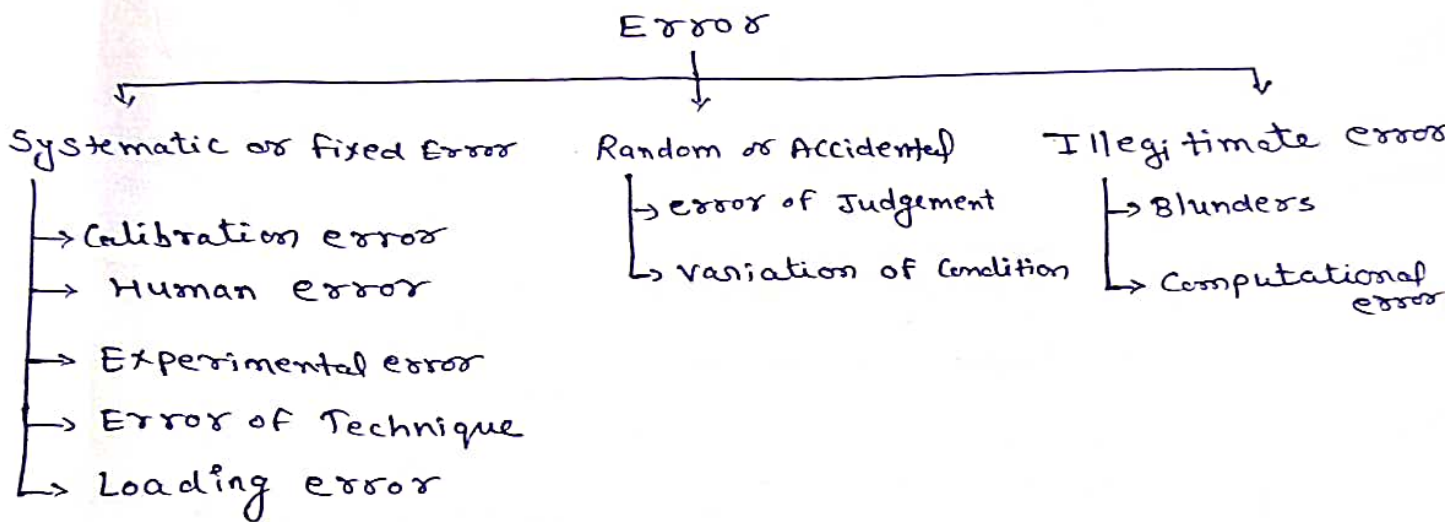The error of a measurement is defined as the difference b/w measured value and the true physical value of the quantity. The error cannot be calculated exactly unless the true value of the quantity is known. As there is some error is always present in every measurement so it is very difficult to find out true value of quantity.

Error

Systematic or Fixed Error | Random or Accidental | Illegitimate error

Systematic or Fixed Error
→ Calibration error
→ Human error
→ Experimental error
→ Error of Technique
→ Loading error

Random or Accidental
→ error of Judgement
→ variation of Condition

Illegitimate error
→ Blunders
→ Computational error

Uncertainty :→ It is the range or region in which error may vary. It is not the same as accuracy.

Eg (dia of Shaft) 99.5 mm to 100.5 mm

Systematic or fixed :- Due to improper design, fabrication or maintenance incorrect marking, defect in gear. This may happen due to improper training, incorrect technique, lack of knowledge etc.

Random or Accidential :→ consider average value (Eg) different person take different value. Temp, pressure, speed, vibration Tolerances in dimension and material are also responsible for these error. Sometime the edge of sheet having pooper edge and sometime chanfer, fillet for eliminate these error use method of symmetry

Illegitimate error !→ occure when wrong procedure follow, occure due to improper care, These error can be taken care of by identifying their source and removing it.
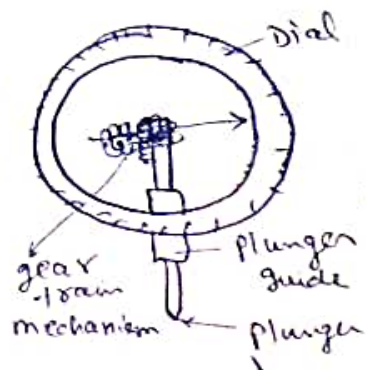
Measuring Instruments:→ There are no. of instrument available for measuring length linear dimension, (length, dia, depth) and angular dimension. During inspection and quality control, it is sometimes sufficient to know whether a mfg component is within the specified tolerance or not.
1) Vernier Calipers (2) Micrometer (3) Dial gages (4) Slip gages (5) Sine bar

Slip gages:→ It is also called precision gag block.
It is a set of very accurate rectangular block, which are used for verifying and calibrating the measuring tools, limit gages and other quality control gages. It is made of steel (alloy) plat and smooth surface high hardness and minimum wear wear and tear. having 5 grade, Grade I, Grade II, Grade O, Grade OO calibrated grade mainly use grade I M88

Size Range mm	Increment mm	No of Pieces
1.0005	—	1
1.001 to 1.009	0.001	9
1.01 to 1.49	0.01	49
0.5 to 9.5	0.5	19 total
10 to 100	10.	10 / 88 piece.

Dial gages :→ Also called Dial indicator
have a circular dial with pointer. A plunger is attached to the pointer through a gear train mechanism. The plunger moves in and out of the body of dial gage. This linear motion of plunger is convert into rotary motion by gear train mechanism. Total 100 division. Each division correspond to 0.01mm. This is the least count of the dial gage. one complete revolution of the pointer correspond to displacement of 1mm of the plunger Available in the range of   0 to 3 mm
   0 to 5 mm
                                                                    0 to 10mm

Dial, gear train mechanism, Plunger guide, Plunger

Sine Bar

Sin Bar is used to determination of angle trigonometrically. by using measured linear dimension.

It is also used for setting angle $\sin \alpha = \dfrac{H}{L}$
and tapers. Slip gages
are used to measure or set
$\alpha = \sin^{-1} \dfrac{H}{L}$
the linear dimension. Sin bar is
a steel bar with step at both end
It is made of steel and super
Finished by lapping operation.

Slip gage

Measurement of Angle using Sine Bar
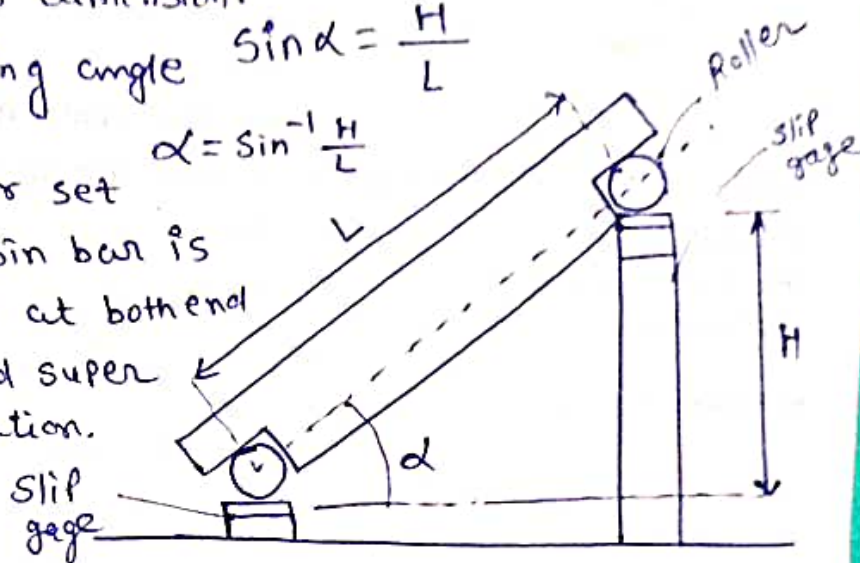
* Distance b/w two roller is known.

* Most Common size is 100mm Available upto 250mm size

* Accuracy of sine bar depends upon the correctness of roller diameter and centre distance b/w them.