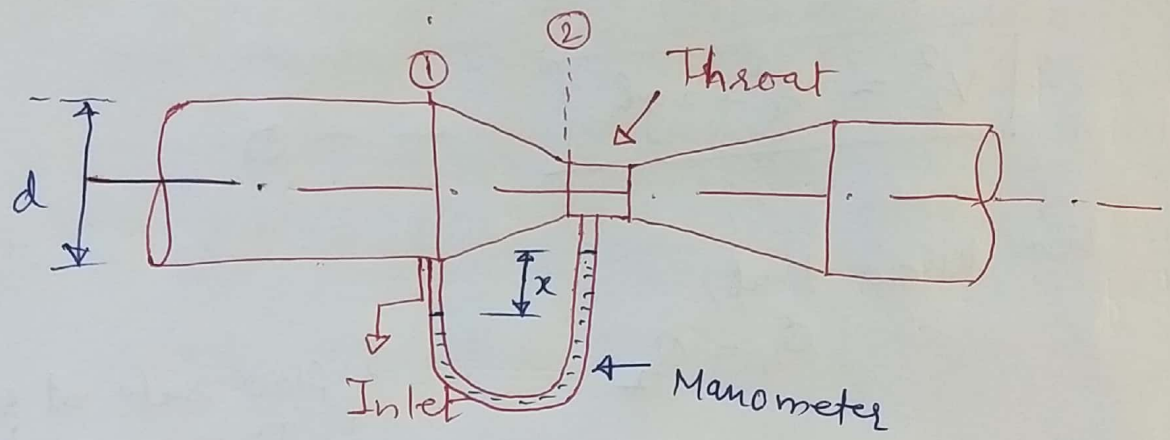
# * Venturi meter :-

> It is a device used to measure the flow rate of the fluid flowing through a pipe.

> It can not be used in open channel.

> It consists of three parts as shown in figure.

ⓐ Converging part
ⓑ Throat
ⓒ Diverging part




> Manometer is used to measure pressure difference between section ① & ②.

> Divergent angle must be very small to avoid energy loss. (5° to 9°). and ~~throu~~ throat diameter should be between $d/3$ to $d/2$.

> Consider two sections ① & ②

> Let, $P_1$, $V_1$, $a_1$ are the pressure, velocity and area at section ①.

And $P_2$, $V_2$, $a_2$ are the corresponding values at section ②

On applying Bernoulli's ~~eqn~~ equation,

$$\frac{P_1}{\rho g} + \frac{V_1^2}{2g} + \cancel{Z_1} = \frac{P_2}{\rho g} + \frac{V_2^2}{2g} + \cancel{Z_2}$$

If pipe is horizontal
$Z_1 = Z_2$

$$\therefore \frac{P_1 - P_2}{\rho g} = \frac{V_2^2 - V_1^2}{2g}$$

$$\therefore h = \frac{V_2^2 - V_1^2}{2g}$$

$\left\{ \because \frac{P_1 - P_2}{\rho g} = h \right.$

$$\therefore \boxed{V_2^2 = V_1^2 + 2gh} \quad \text{--- (1)}$$

We know that,

$$Q_1 = Q_2$$

{ flow rate at section (1) is equal to flow rate at section (2)

$$a_1 V_1 = a_2 V_2$$

$$V_1 = \frac{a_2 V_2}{a_1}$$ -- put it in eqn (1)

$$\therefore V_2^2 = \frac{a_2^2 V_2^2}{a_1^2} + 2gh$$

$$\therefore V_2^2 \left(1 - \frac{a_2^2}{a_1^2}\right) = 2gh$$

$$\therefore V_2^2 = \frac{a_1^2 \times 2gh}{a_1^2 - a_2^2}$$

$$\therefore V_2 = a_1 \sqrt{\frac{2gh}{a_1^2 - a_2^2}} \quad \text{--- (11)}$$

$\therefore$ Flow rate $Q = a_2 V_2$ or $a_1 V_1$

$$\therefore \boxed{Q_{th} = \frac{a_2 \times a_1 \sqrt{2gh}}{\sqrt{a_1^2 - a_2^2}}}$$

Above eqn gives the theoretical value of flow rate.

~~for~~ Actual flow rate $\boxed{Q_a = C_d \times Q_{th}}$

Where $C_d$ = Coefficient of discharge.

—x—

## * Strain measurement :-

### Strain gauge :-

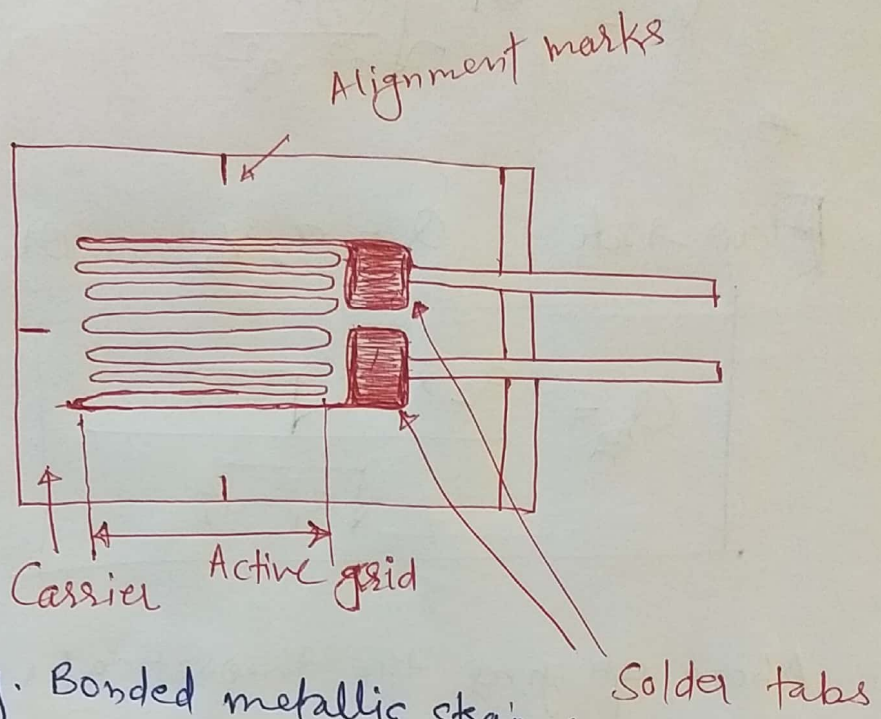



Fig. Bonded metallic strain gauge

> Most common device for strain measurement is strain gauge.

> Its electrical resistance varies in proportion to the amount of strain produced in the device.

> It consists of a very fine wire arranged in a grid pattern. It maximizes the amount of wire.

> The grid is bonded to a thin backing called as carrier which is attached directly to the ~~carrier~~. specimen whose strain is to be measured.

> Strain experienced by the specimen is directly transferred to the strain gauge.

> Its electrical resistance changes ~~in~~ proportionally to the strain produced.

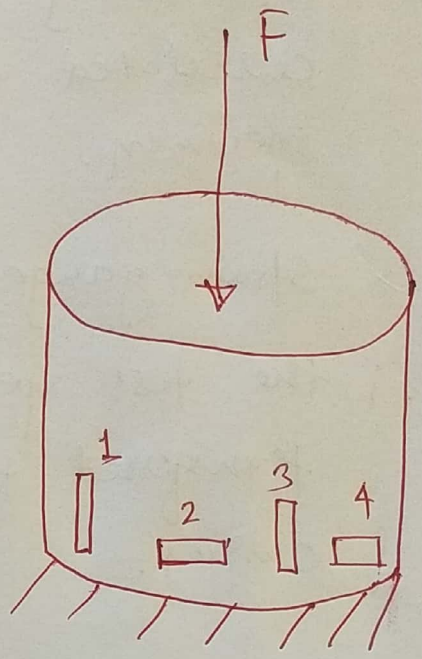
This change in electrical resistance is ~~correlated~~ correlated with the strain produced in the specimen.

> Strain gauge should be properly mounted on the test specimen so that strain is accurately transferred from specimen to grid through carrier.

———— x ————

## * Force measurement :-

### * Load Cell :-




Load cell with four strain gauges.

- Force can be measured easily from a load cell.
- In this device, an elastic member such as ~~ste~~ ~~stra~~ stainless steel is used in cylindrical ~~form~~ shape.
- Four strain gauges are mounted on it.
- Two strain gauges measure the longitudinal strain while two other measure transverse strain as shown in figure.
- The strain gauges measuring the similar strain are placed in opposite arms.
- Adjacent arms measure opposite strains (One tensile & other compressive).
- When force is applied on elastic member, longitudinal strain developed in the load cell would be compression in nature and is given by,

$$\boxed{\varepsilon_1 = -\frac{F}{AE}}$$

Where,
F ⇒ applied force
A ⇒ Cross section area
E = Young's modulus

This strain develops in strain gauge ① & ③.

while tensile strain produced in strain gauges ② & ④ would be,

$$\boxed{\varepsilon_2 = -\frac{\nu F}{AE}}$$

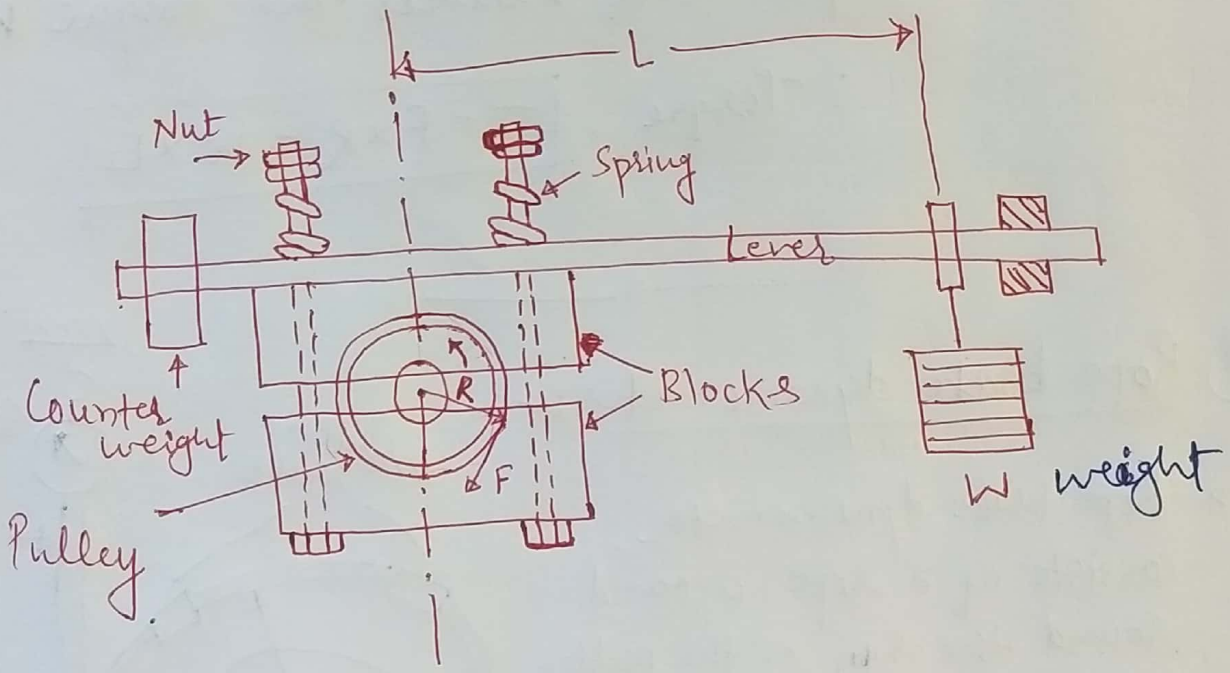
$\nu \Rightarrow$ Poisson's ratio.

—— x ——

## * Torque measurement :—

> A torque is a vector product of force & radial distance that measures the ~~test~~ tendency of a force to rotate an object about ~~its~~ an axis.

### ① Prony Brake Dynamometer :—




> It consists of two wooden blocks placed around a pulley fixed to the shaft whose power or torque is to be measured.

> A helical spring is provided between nut and upper block to adjust the pressure on the pulley to control its speed.

> The upper block has long lever attached to it and carries a weight W at its outer end.

> Prony brake develops mechanical friction on the periphery of a rotating pulley by means of ~~brake~~ blocks that are squeezed against the wheel by tightening the bolts until the friction torque F·R balances the torque W·L

∴ Torque, $\boxed{T = F \times R = W \times L}$

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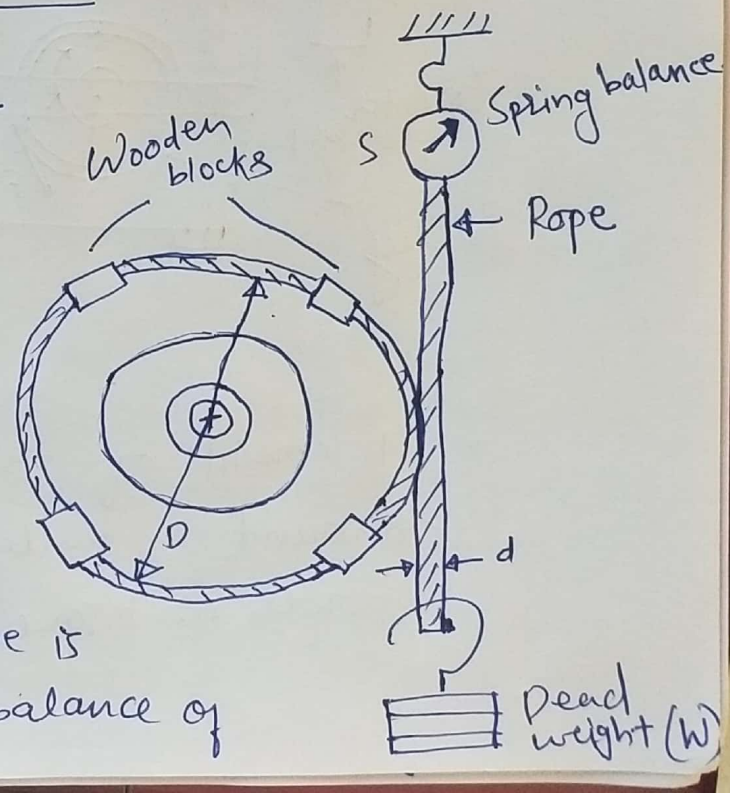
## ② Rope brake dynamometer:-




> Rope brake dynamometer consists of a rope wound round the rim of the pulley fixed to the shaft of the engine whose torque is to be measured.

> The upper end of the rope is attached with a spring balance of

Stiffness S. ~~and for~~

> Lower end of the rope is attached with a load W as shown in figure.

> If the diameter of pulley is D and rope diameter is d then the torque can be measured as -

$$\boxed{T = (W - S) \times \frac{D+d}{2}}$$

———x———

# Introduction to robotics :-

> Robot is any automatically operated machine that replaces human effort.

Robotics is the engineering discipline which deals with the design, construction and operation of robots.

## * Anatomy of Robots :-

There are several classes of robots. ~~for assembly, painting, welding etc.~~
Application of robot is in industry for assembly, painting, welding etc.

Industrial robots consist of manipulators which are controlled by a microprocessor.

Subsystem of robots —

1. Actuators
2. Transmission system.
3. Power supplies and power storage system.
4. Sensors
5. Microprocessors and controllers.
6. Algorithms and softwares.

① Actuators :-

> Actuators are prime movers for providing force and motion.

> Advanced actuators are based on smart materials.

② Transmission system :-

> The transmission system used in robots to transmit power and motion consists of chains, belts, cables, pulleys, gears etc.

③ Power supplies :-

> Hydraulic and pneumatic power packs consists of ~~two~~ pumps or compressors to generate high pressure fluid flow.

> Electric motors, electronic devices consisting of transistors used as switches to rapidly switch on and off the supply in controlled manner.

④ Sensors and other electronics :-

> The sensors for feedback in robots consists of tachometers and ~~encoders~~ ~~an~~ potentiometer to sense motor motions.
It also consists of force sensor, acceleration sensors, ~~spec~~ optical systems, special cameras etc.

## ⑤ Electronics :-

> It consists of electronic circuits, motor controllers, analog to digital converters and digital to analog converters and so on to handle sensors and vision systems.

## ⑥ Softwares :-

> Softwares used consists of several levels.

Motor control software consists of algorithms which help the servo to move smoothly.

> At next level there is a software to plan the trajectory of the end effector.

The output of sensor is also to be interpreted and decisions made.

> At the highest level there is software which accepts commands from the user of the robot and translate it into appropriate actions.