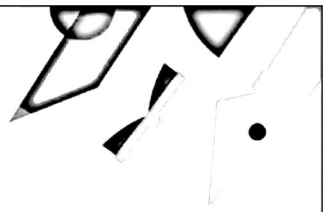


Measurements - Part I

Comprehensive Course on Electrical and Electronic Measurements - Part I

Aditya Kanwal · Lesson 1 · Dec 10, 2021

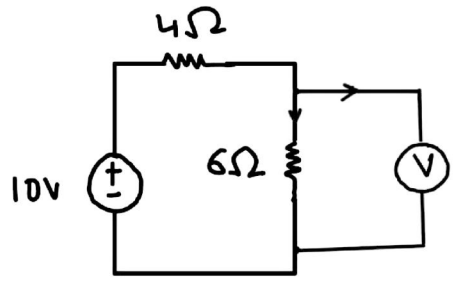
Measurement:-

It is a process of comparison between a standard and an unknown resulting in knowing the magnitude of the unknown in terms of the standard. and Instrument is a device that facilitates this comparison.

The two essential characteristics of an electrical measuring instrument:-

i) Its operational power consumption should be minimal.

ii) The instrument should not change the ambient conditions of the circuit in which it is introduced.



$R_v = \infty$

if $R_v = 6\Omega$

Analog instruments

Quantity to be measured.
- Current
- Voltage
- Power
- pf
- Energy
- freq.

Principle
- Magnetic effect.
- Thermal effect.
- Electrostatic effect.
- Electromagnetic effect.
- Hall effect.

Representation
- Indicating
  eg Ammeter, Voltmeter.
- Integrating
  eg Energy meter.
- Recording.
- Null detectors
  Potentiometer.

- Magnetic effect:- When a current carrying conductor is placed in a magnetic field then a force acts on the conductor which makes the conductor to move.
- Thermal effect:- The current to be measured is passed through a small element which heats up. The temp. rise is converted into an emf by a thermocouple attached to the element.
- Electrostatic effect:- When two plates are charged, there is a force between the plates. This force moves one of the plates

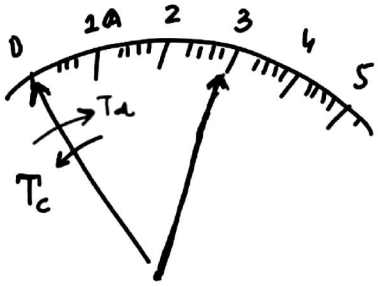
- Electromagnetic effect.
- Hall effect:- If a metal or a semiconductor carrying a current I is placed in a transverse magnetic field B then an emf is produced between the edges of the conductor which is perpendicular to both B & I.

  This principle is used in the designing of the pointing vector Wattmeter and Hall effect transducer.

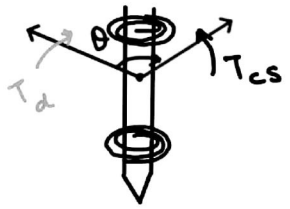
Types of Torques:-

1) Deflecting torque:- The utility of the deflecting torque is to deflect the pointer away from the zero position. It is produced by the parameter under measurement due to one of those effects of electric current which converts electrical into mechanical energy. The magnitude of the deflecting torque produced is proportional to the parameter under measurement.

2) Controlling Torque:-



1) Spring Control mechanism:-



$E \rightarrow$ Young's modulus.

$$T_{cs} = \frac{E b t^3}{12 l} \theta$$

$$\boxed{T_{cs} = K \theta}$$

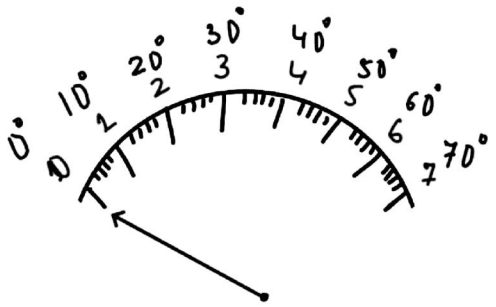
$$T_{cs} \propto \theta$$

At steady state position,

$$T_c = T_d \quad (\text{let } T_d = k_d I)$$

$$K\theta = k_d I \Rightarrow \theta = k_a I$$

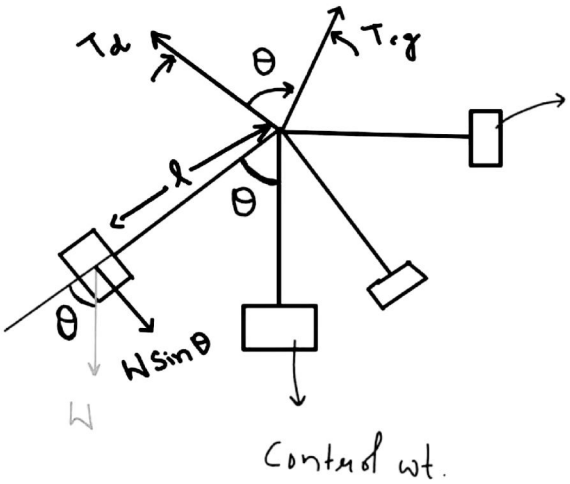
$$\boxed{\theta \propto I}$$



$K_1 = 10$

- Linear Scale.
- Uniform Scale.

2) Gravity Control mechanism:-



Control Wt. > balance wt.

$T_{cg} = (W \sin\theta)(l)$

$T_{cg} = K \sin\theta$

$T_{cg} \propto \sin\theta$

At equilibrium position,

$$T_{cg} = T_d$$

$$K \sin\theta = K_d I$$

- $$\sin\theta = K_2 I$$

$$\theta = \sin^{-1}(K_2 I)$$

- I_{max} produces a deflection of 90°.

- $\frac{I_{max}}{2} = ?$

$$\sin 90^\circ = K_2 I_{max}$$

$$K_2 = \frac{1}{I_{max}}$$

When $I = \frac{I_{max}}{2}$

$$\theta = \sin^{-1}\left(\frac{1}{I_{max}} \cdot \frac{I_{max}}{2}\right)$$

$$\boxed{\theta = 30^\circ}$$

Continuous monitoring → Gravity control.

Periodic usage → Spring control.

Disadvantages of Gravity Control mechanism:-

i) This type of control is used in vertically mounted instrument.

ii) In this case instrument must be perfectly levelled.

Advantages of Gravity control mechanism:-

i) It is cheap.

ii) The control is independent of temp. variations.

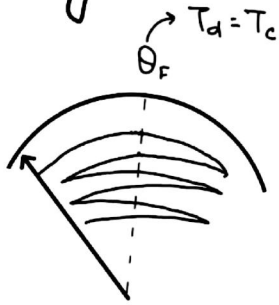
iii) It does not deteriorate with time.

↳ The essential qualities of a spring which is used in spring control mechanism:-

i) It should undergo minimal mechanical fatigue.

ii) It should be made up of non-magnetic material.

* The most commonly used material for fabricating the spring is Phosphor Bronze.

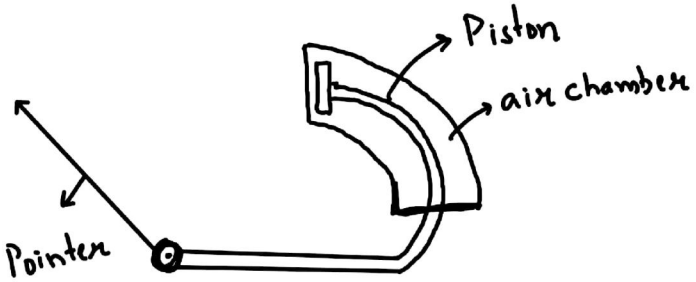


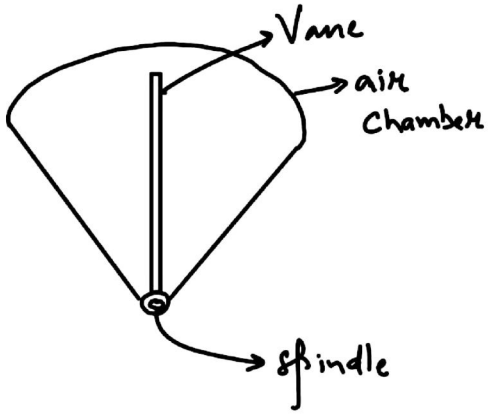
3) Damping Torque:-

The utility of the damping torque is to damp the oscillations.

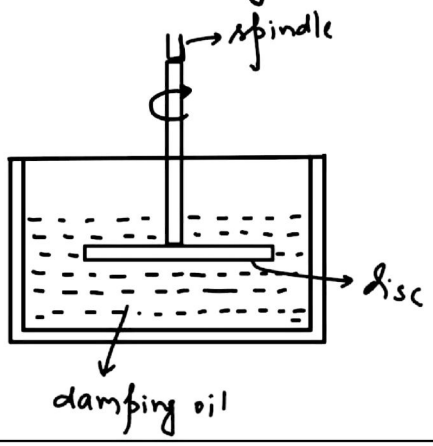
The damping torque is produced by damping mechanisms and the most commonly used damping mechanisms are:-

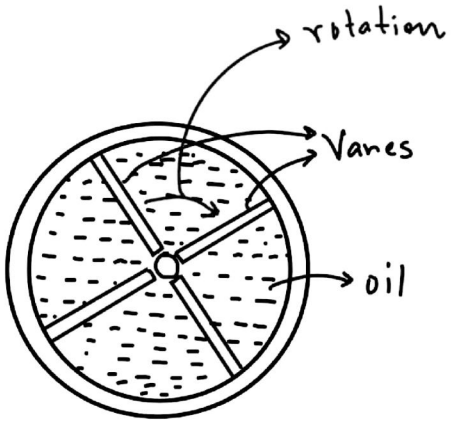
i) Air friction damping mechanism. (It is used when the operating field that is producing the deflecting torque is very weak.





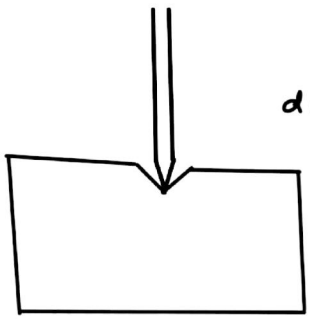
ii) Fluid friction damping mechanism:- (It is used in electrostatic instrument i.e used for measurement of high voltage).





iii) Eddy Current damping mechanism (It is used when the operating field i.e producing the deflecting torque is large).

iv) Electromagnetic damping mechanism(It is used in galvanometers).



eddy current damping mechanism is the most efficient form of damping.