

MEASURING INSTRUMENTS

MEASURING INSTRUMENTS

“The device used for comparing the unknown quantity with the unit of measurement or standard quantity is called a Measuring Instrument.”

OR

“An instrument may be defined as a machine or system which is designed to maintain functional relationship between prescribed properties of physical variables & could include means of communication to human observer.”

CLASSIFICATION OF INSTRUMENTS

Electrical instruments may be divided into two categories, that are;

1. Absolute instruments,
2. Secondary instruments.
 - Absolute instruments gives the quantity to be measured in term of instrument constant & its deflection.
 - In Secondary instruments the deflection gives the magnitude of electrical quantity to be measured directly. These instruments are required to be calibrated by comparing with another standard instrument before putting into use.

CLASSIFICATION OF INSTRUMENTS



CLASSIFICATION OF INSTRUMENTS

Electrical measuring instruments may also be classified according to the kind of quantity, kind of current, principle of operation of moving system.

CLASSIFICATION OF SECONDARY INSTRUMENTS

- * Secondary instruments can be classified into three types;
 - i. Indicating instruments;
 - ii. Recording instruments;
 - iii. Integrating instruments.

CLASSIFICATION OF SECONDARY INSTRUMENTS

- Indicating Instruments:

It indicates the magnitude of an electrical quantity at the time when it is being measured. The indications are given by a pointer moving over a graduated dial.



CLASSIFICATION OF SECONDARY INSTRUMENTS

- Recording Instruments:

The instruments which keep a continuous record of the variations of the magnitude of an electrical quantity to be observed over a defined period of time.



CLASSIFICATION OF SECONDARY INSTRUMENTS

- Integrating Instruments:

The instruments which measure the total amount of either quantity of electricity or electrical energy supplied over a period of time. For example energy meters.



ESSENTIALS OF INDICATING INSTRUMENTS

A defined above, indicating instruments are those which indicate the value of quantity that is being measured at the time at which it is measured. Such instruments consist essentially of a pointer which moves over a calibrated scale & which is attached to a moving system pivoted in bearing. The moving system is subjected to the following three torques:

1. A deflecting (or operating) torque;
2. A controlling (or restoring) torque;
3. A damping torque.

DEFLECTING TORQUE

- The deflecting torque is produced by making one of the magnetic, heating, chemical, electrostatic and electromagnetic induction effect of current or voltage and cause the moving system of the instrument to move from its zero position.
- The method of producing this torque depends upon the type of instrument.

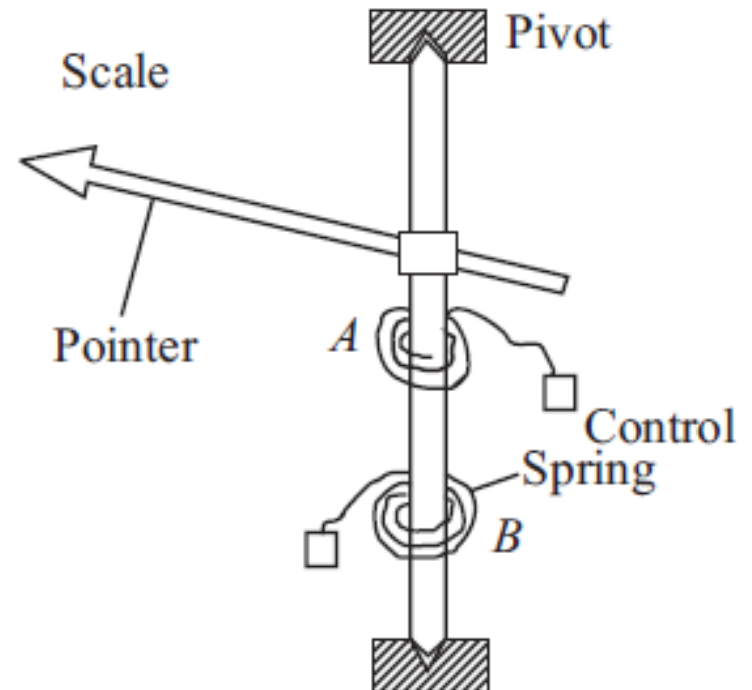
CONTROLLING TORQUE

- The magnitude of the moving system would be somewhat indefinite under the influence of deflecting torque, unless the controlling torque existed to oppose the deflecting torque.
- It increases with increase in deflection of moving system.
- Under the influence of controlling torque the pointer will return to its zero position on removing the source producing the deflecting torque.
- Without controlling torque the pointer will swing at its maximum position & will not return to zero after removing the source.

- Controlling torque is produced either by spring or gravity control.

Spring Control:

* When the pointer is deflected one spring unwinds itself while the other is twisted. This twist in the spring produces restoring (controlling) torque, which is proportional to the angle of deflection of the moving systems.



Spring Control

$$T_c \propto \theta$$

$$T_c = K_s \theta$$

$$T_d \propto I$$

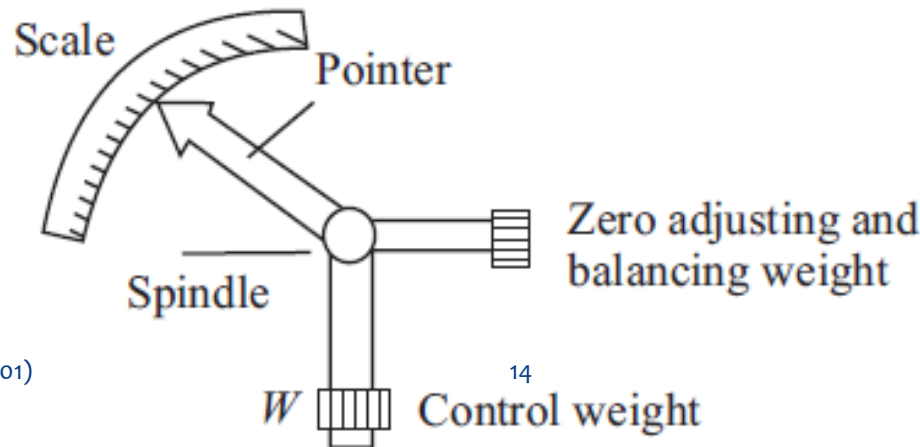
$$T_d = K_s I$$

$$T_c = T_d$$

$$\theta = I$$

Gravity Control

- * In gravity controlled instruments, a small adjustable weight is attached to the spindle of the moving system such that the deflecting torque produced by the instrument has to act against the action of gravity.
- * Thus a controlling torque is obtained. This weight is called the *control weight*. Another adjustable weight is also attached to the moving system for zero adjustment and balancing purpose. This weight is called *Balance weight*.



DAMPING TORQUE

- * We have already seen that the moving system of the instrument will tend to move under the action of the deflecting torque.
- * But on account of the control torque, it will try to occupy a position of rest when the two torques are equal and opposite.
- * However, due to inertia of the moving system, the pointer will not come to rest immediately but oscillate about its final deflected position as shown in figure and takes appreciable time to come to steady state.
- * To overcome this difficulty a damping torque is to be developed by using a damping device attached to the moving system.

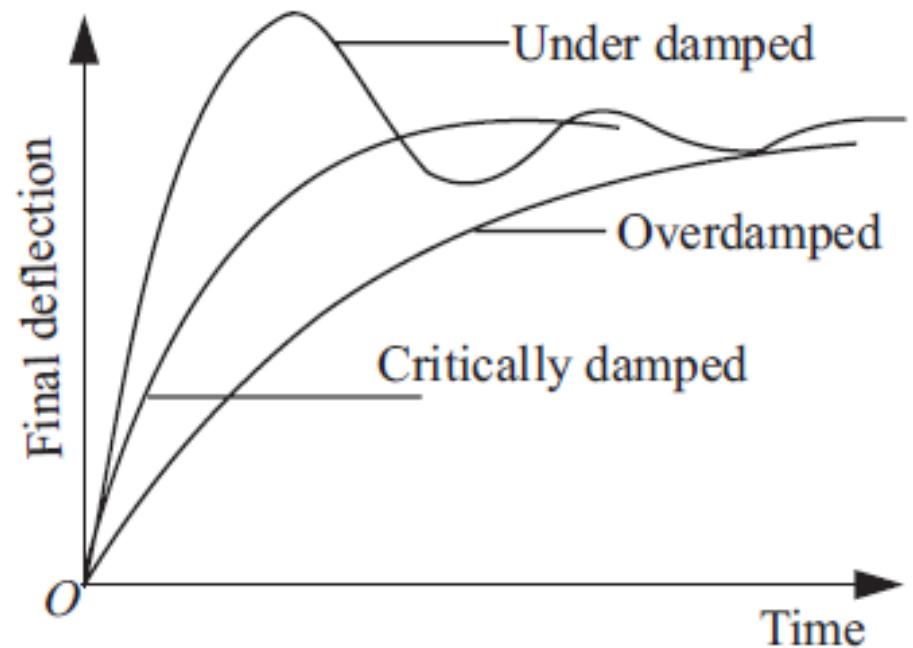
DAMPING TORQUE

- * The damping torque is proportional to the speed of rotation of the moving system, that is

$$T_v = k_v \frac{d\theta}{dt}$$

where k_v = damping torque constant

$\frac{d\theta}{dt}$ = speed of rotation of the moving system



- * Depending upon the degree of damping introduced in the moving system, the instrument may have any one of the

DAMPING TORQUE

1. **Under damped condition:**

The response is oscillatory

2. **Over damped condition:**

The response is sluggish and it rises very slowly from its zero position to final position.

3. **Critically damped condition:**

When the response settles quickly without any oscillation, the system is said to be critically damped.

The damping torque is produced by the following methods:

1. Air Friction Damping

2. Fluid Friction Damping

3. Eddy Current Damping

4. Electromagnetic

TYPES OF AMMETERS & VOLTMETERS

- 1) **Moving Iron Type Meters (AC & DC);**
 - a) **Attraction type,**
 - b) **Repulsion type.**

- 2) **Moving Coil Type Meters (AC & DC);**
 - a) **Permanent Magnet type,**
 - b) **Electrodynamic or Dynamometer.**

- 3) **Hot Wire Type (AC & DC);**

- 4) **Induction Type (AC & DC);**
 - a) **Split phase,**
 - b) **Shaded Pole type.**

- 5) **Electrostatic Type for Voltmeters Only;**