IES/GATE

Electrical Engineering

VOLUME-II

Electrical/Electronics Measurement
& Instrumentation
Computer Fundamentals

Contents

Electrical / Electronics Measurement and Instrumentation :-

i) Electrical :-

Measurement of
- V
- I
- P
- Pf
- energy
- R, L, C

Potentiometer

Instrument T/Fs.

ii) Electronics :-

Q-meter

CRO

Digital meter

Data Acquisition

Error Analysis

iii) Instrumentation :-

Measurement of Non Electrical quantities like Temp, pressure, flow --- etc.

Books -
1) A. K SHAWNEY
2) GOLDING
3) Copper

Gate - 6-8 marks

IAS → 40 + 40
(40 → objective, 40 → conventional)

HPT → high pressure turbine

H/W → heart well.

DM → Demeneralized

PH > 7 → Base

M water is at room temp^r. is storing in H/W. from H/W they extract the H_2O. for extraction they need a pump. Called CEP (produced a pressure : 6 kg then H_2O will flow to low pressure heter.

or running turbine at 50 RPS we eed 200 mVA Gen. (→ 2 pole rotor.) and steam parameter 150 kg, 540°c, 600 T/hr
↓
(Supper needed steam)

Thermal plant

P = 2

f = 50 Hz

N = 3000 RPM

$= \frac{3000}{60}$ RPS

= 50 RPS

Principle: Rankine cycle.

Chemical
↓ Boiler
Head
↓ Turbine
mech.
↓ Generator.
electrical.

D.

→ to remove the desolved air we are instrument → BFP (165 kg/cm²) highest pressure generating

→ 10% of the Generator power.
20 MW is used internally in turbine.

ECO – Economizer.
↓
turbo separator → Separate H_2O & Steam.
→ pres ed inside drum

High temp^r Supper heater → HTSH.

High pressure Governing valve.

V → vaccum → Extract steam and convert steam into H_2O

Boiler → 100 m. height

Cooling tower – 120 m. height.

CWP → Circulating water ~~plant~~ pump.

⇒ protect boiler from corrosion → D.M H_2O

conduction extraction pump → CEP (↑ temp of water)

Steam heater → LPH → H_2O is flowing in pipeline and they will take the steam from IPT
(intermediate)

D → protect the turbine from corrosion

ECO → ↑ temp of steam

Steam temp ↓ 200°C

Stam → HT SH → HPSV → HPT → IPT → LPT ⇒

η_o = overall efficience $\eta_B \times \eta_T \times \eta_G$ = 35-40%

η_B & η_G is more.

η_T is less bcz more energy is wasted inside condenser.

in thermal plant we convert Heat energy into elec. energy

⇒ Heat - electrical → 860kcal = 1 kWhr.

Coal used → Bituminous / lignite

↳ Calorific value C_f → C_f represent in kcal/kg.

Ex → Assume C_f of cole = 1720 k cal/kg

by burning 1 kg = $\frac{1720}{860}$ ⇒ 2kWhr electrical energy will produce
↳ if overall efficiency is 100%.

but η_o = 40%

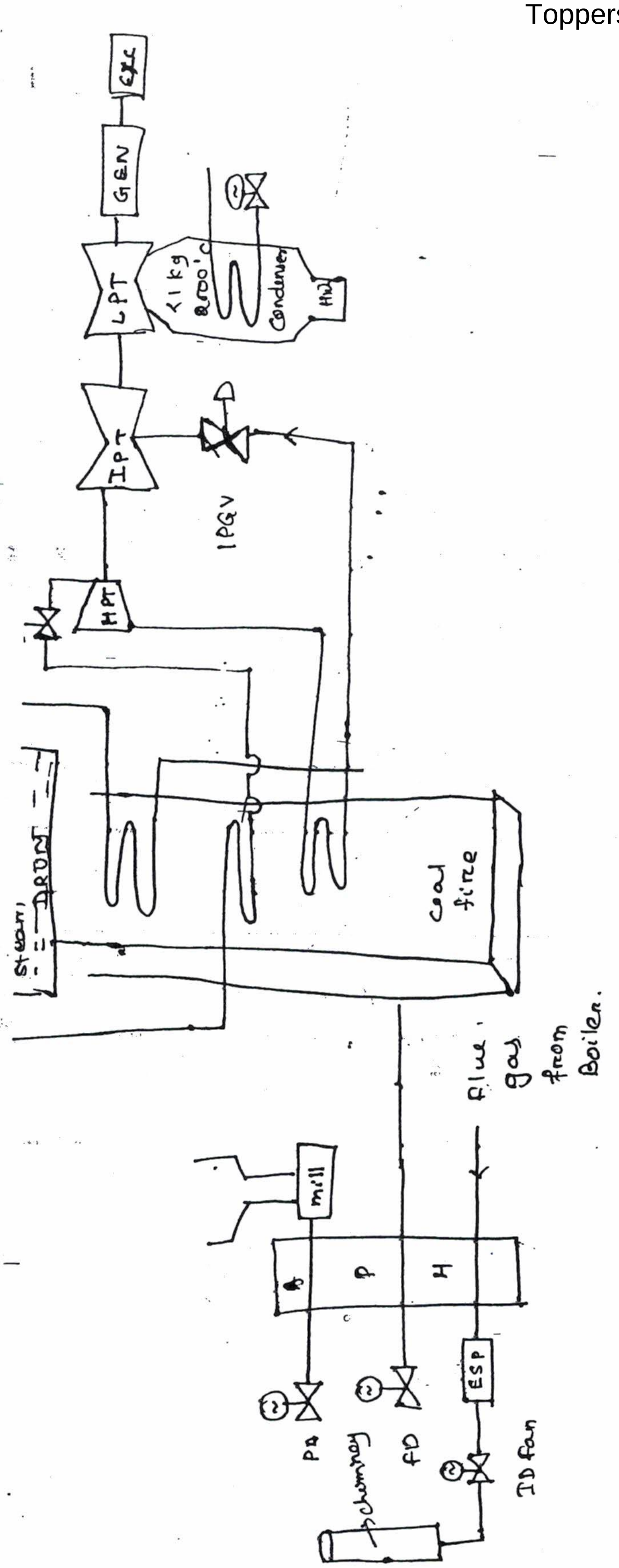
1kg = 2×0.4 = 0.8 kWhr

So for 1 kWhr → 1.25 kg coal required.

Energy/day = 200×24 MWhr = 200×10³ × 24 kWhr

Q = 200×10³×24×1.5 = 6000T/day (Tons)

Black → water cycle
Blue → steam cycle



Coal hupper → CH.
↳ coal of 20-30 mm.

↓
mill ⟶ 20-30 mm coal convert into power.

Primary air plant → sending coal power from mill into the Boiler.

Froced ~~draft~~ dumping plant → FD.
induced ~~draft~~ dumping plant → ID. (Extract flue glas from boiler)
Aire pre heater → APH

Q = quantity of coal

$$Q = \frac{P_{avg} \times T \times 860}{\eta_o \times C_f}$$

T = time. P_{avg} = MW, Q = tons
→ if C_f is in kcal/kg.

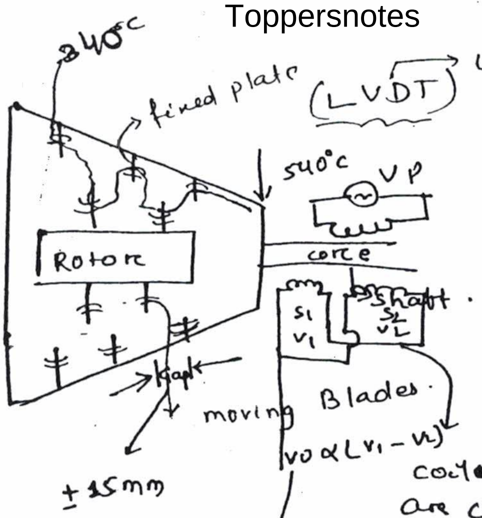
$$Q = \frac{P_{avg} \times T}{\eta_o \times C_f}$$

→ if C_f is in kwhr/kg
P_{avg} = MW, Q = Tons.

$$Q = \frac{200 \times 24 \times 80}{0.40 \times 1720} = 6000 \text{ Ton/day}$$

⇒ $P_{lf} = \frac{P_{avg}}{P_{max}}$

(LVDT) → Linear variable differential T/F



due to high tempr. rotor will expands. So there is a chance of moving plate will touching fixed plate. so damged will occur.

coils are connected in phase correction

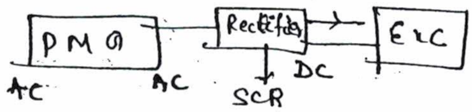
this voltage is represent in mm.

i.e. o/p voltage is used to measure the displacement

Shaft working as core. it produce flux.

Excitation

↳ it consists of Rectifier connected to permanent magnet Generator



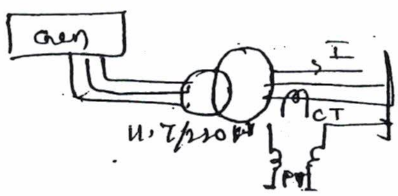
Stroboscopic effect :-

fan is running in one rotation, and image of fan in other rotation bcz in this time we see 2 freq n. i.e freq. of fan and frequence of light flickering when this freq are equal then we see fan & image move in diff. direction.

Instrument T/F

↳ CT → measure I

↳ PT → " V



Analog Meters

used to measure V
I
P
Pf
Energy

for measuring this electrical quantities we have to ~~applied~~ use Some principle i.e

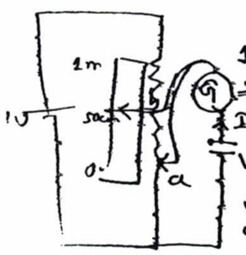
:

After measuring we ~~have~~ to read the data so we use different representation

→ indicating meter — when they have power supply they indicate quantities and when there is no power supply it comes to zero → at a perticular instant of time.

→ Recording meter — for recall the previous data → it use for graphical data.

→ Integrating meter (→ Adding) — in house we have energy meter it power supply will then it don't come zero it add the previous value aft power supply is on



1m = 100 : Galvanometer — G

=> 100cm = 1V

=> 10cm = 0.01V

V_x ↓ unknown

cm. Scale convert into voltage.

at a $V_x < V_a$ so $I_g \neq 0$

at b. $V_{50} = V_x$ → $I_g = 0$; $V_{50cm} = V_x = 50 \times 0.01$

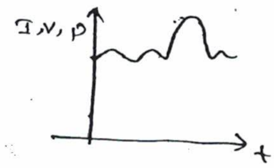
$= 5V$

Analog meter

Used to measure
- V
- I
- P
- P.f
- Energy

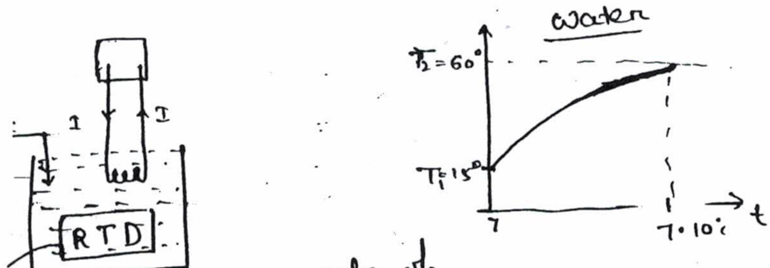
principles
i) Electromagnetic
ii) Electro induction
iii) Electrostatic
iv) Thermal

Representation
- Indicating meter
  - Voltmeter (V)
  - ammeter (A)
  - watt meter (W)
  - P.f meter
- integrating meter
  - eg:- Energy meter, Ampere hr. meter
- Recording meter
  - Galvanometer, potentiometer
- Null Detector
  - potentiometer



Order of instrument :-

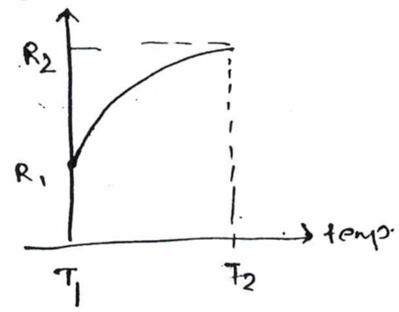
Instrument should behave simillar to the quantity to be measured



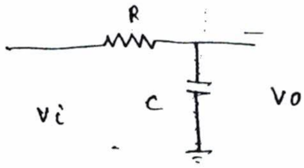
it act on the principle of change in R due to change in temp. (RTD measure the water temp)

$$R_2 = R_1[1 + \alpha(T_2 - T_1)]$$

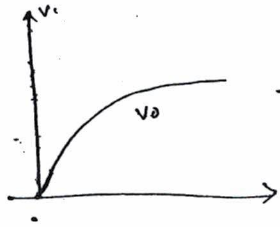
RTD (1st order)



1st order.

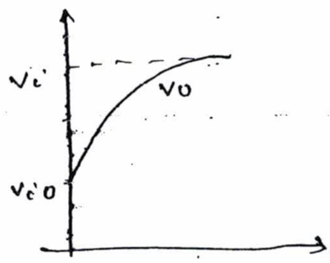


$$\frac{C(s)}{R(s)} = \frac{V_o}{V_i} = \frac{1}{(1+RCs)} = \frac{1}{1+Ts}$$



→ no charge initially within the capacitor.

if c have some initial charge then it behaviour as Same as RTD so RTD = 1st order instrument.



Thermometer → liquid RTD
↓
mercury expandation need some time
so we have wait that much time

So 1st order instrument can't able to measure instantanious value.

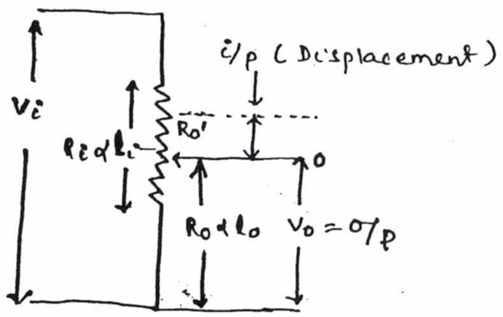
So we can't measure body temp. instantaniously

→ The instrument must behave simillar to the quantity to be measured is called order of the instrument.

Zero order

$$T(s) = \frac{C(s)}{R(s)} = K = \text{const.}$$

Potentiometer :-



→ $R = \rho l / a$

ρ & a = const. so $R \propto l$

→ $R_i \propto l_i$

→ $R_o \propto l_o$

→ R_o moves up V_o ↑

R_o " down V_o ↓

↳ voltage change immediately.

$$\frac{V_o}{V_i} \propto \frac{R_o}{R_i} \propto \frac{l_o}{l_i} = \text{const} = K$$

if the transfer function = const then the instrument is zero order.

Here V_i, l_i = const.

So $V_o \propto l_o$ → O/p will response immediately when i/p (Displacement) is change without any timedelay.

Here i/p is displacement (not voltage & Resistance)

Potentiometer – zero order

RTD → 1st order. (RTD → Resistance temp' Detector)

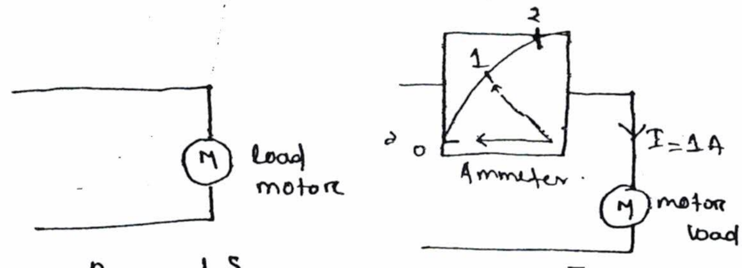
in zero order we get O/p immediately when i/p is provided without any time delay.

in 1st order we get O/p after some time delay when the i/p is applied.

Thermometer → 1st order instrument. → So we don't measure body temp' instantaneously. We need some time to measure the body temp'.

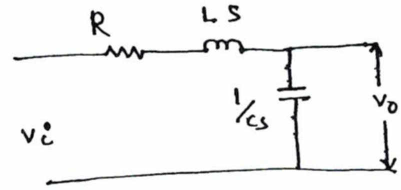
Indicating meters :- (2^{nd} order instrument)

RC → 1st order
RLC → 2nd order.



To line → combination of RLC → 2nd order.

So to measure current & voltage of To line we need same order instrument i.e 2nd order instrument.



$$\frac{V_o}{V_i} = T(s) = \frac{\frac{1}{cs}}{R+Ls+\frac{1}{cs}}$$

$$= \frac{1/Ls}{\left(s^2+\frac{R}{L}s+\frac{1}{LC}\right)}$$

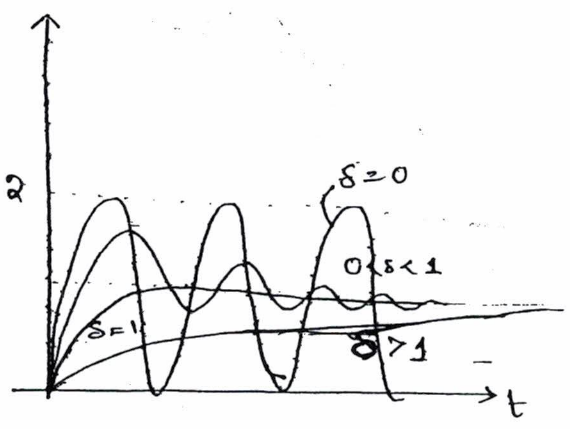
motor → 2nd order instrument.

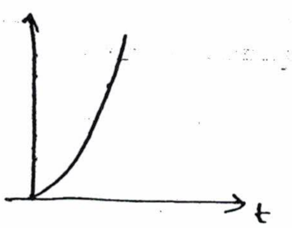
δ → damping factor.
↳ (δ = ξ)

- δ = 1 (critically damped
- 0 < δ < 1 → underdamped
- δ > 1 → overdamped
- δ = 0 → Undamped
  - ↳ it produce oscilation
- → δ < 0 → Unstable

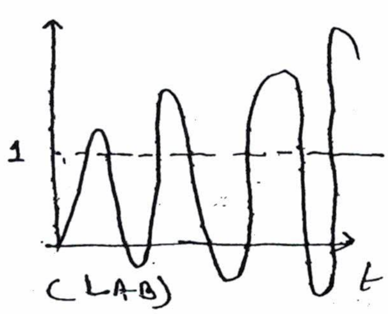
Characteristic eqn ⇒

$1 + GH = s^2 + 2\delta\omega_n s + \omega_n^2 = 0$





Or



Practical case → 0 < δ < 1 → under damped (LAB)

Time respons of indicating meter deside by damping factor.

→ Indicating meters like Ammeter, voltmeter, Wattmeter and p.f meters are of 2nd order instruments.

The practical damping factor is bet^n 0·6 to 0·8

Damping of the system determines the time response of the System.

if damping factor is nearly 1 (Critically damped value) then the oscillations of the pointer at the final steady state position are reduced.

Types of Torque in indicating meter:-

1) Damping torque → to damp out the oscillation at final steady state position.

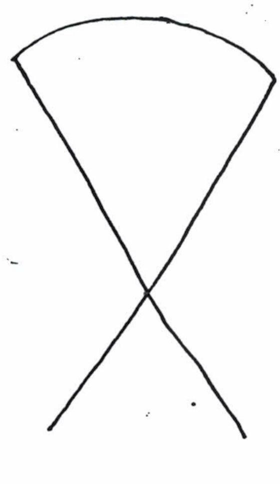
2) Deflecting torque (T_d)

3) Controlling torque (T_c)

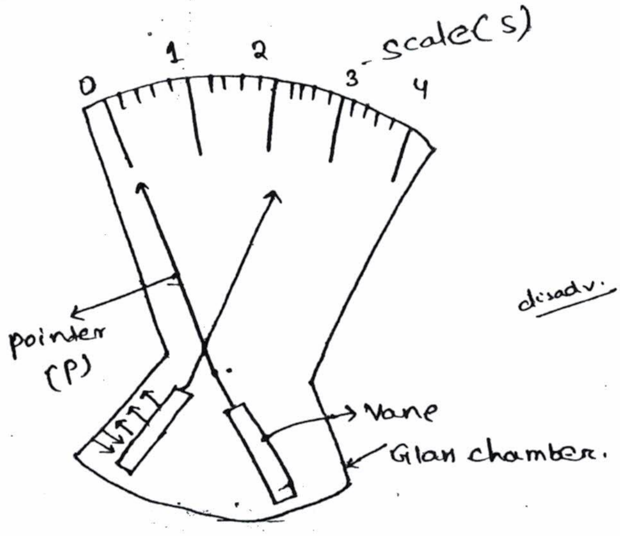
Damping torque:-

It is used to damp out (or) stop the oscillations at the final steady state position.

Air friction damping



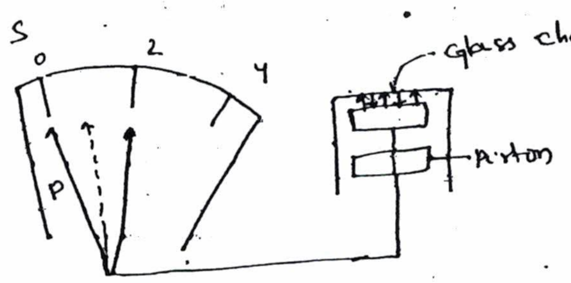
① Air friction damping :-



→ when P is at point 2 the air will compressed so it deflect the point so oscillation occur.

→ cheap & simple in construction

disadv. → since magnet are not present so no distortion in existing in magnetic field.



⇒ it is used in :-

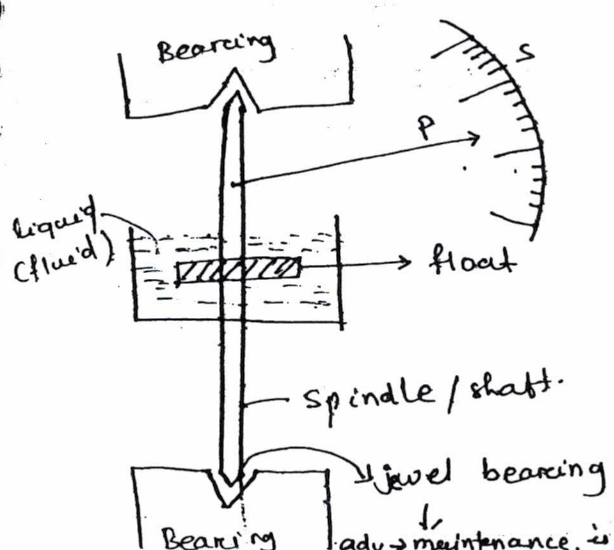
① Moving Iron (MI) meter

② Electrodynamometer (ED / EMMC)

→ It can't used in permanent type magnetic instrument

② Fluid friction damping :-

→ Viscosity of oil more so damping torque is more.



adv → maintenance is less, wear and tear is less.

→ In watches Jewel bearing is used.

→ when spindle is move in bearing the friction is produce which cause frictional loss. So to minimise frictional loss we have to use higher deflecting torque (or) weight of moving system ↓, so T_D ↑

frictional loss ↓, accuracy ①, sensitivity ② ↑ — ① more preference.

Electro static → Deflecting torque ↑ so ~~more~~ less low.
walking in air is more faster than walking in H_2O. Bcz friction is more.

Torque to weight Ratio (Tw)

$$T_w \uparrow = \frac{\text{Deflecting torque} \uparrow}{\text{weight of moving system} \downarrow}$$

if Tw ↑, frictional error ↓, accuracy & sensitivity ↑

Preference of accuracy is more than sensitivity.

Fluid friction damping is used in → Electrostatic meter.

→ spindle & point are used in less weight material like Alluminium.

→ Jewel Bearing is used to ↓ the wear and tear of the moving system.

→ The friction produced betn moving system and Bearing produces friction errors so that accuracy and sensitivity of the instruments are reduced.

The instruments which has high ~~torq~~ torque to weight ratio (Tw) has higher accuracy and sensitivity.

→ For reducing the weight of the moving system pointer and spindle are made up by aluminium.

→ The instrument which has low value of deflecting torque used the fluid friction damping to minimize errors in the instruments.

③ Eddy current & Electromagnetic damping :—
↓ used in PMMC | ↓ used in Galvanometer.

→ If a current carrying conductor wound on a metal frame or core or former placed in a magnetic field experiences force which cuts the magnetic flux so that an emf is induced in the core called eddy voltage which will produces eddy current, This current produces opposing flux which is used for damped out the oscillations. This is called eddy current damping. If it is depends on magnitude of the current passing through the coil then it is called Electromagnetic damping. These types of damping are used where the Permanent magnet is used.
These instruments has higher torque to weight ratio (Tw = more So that frictional errors are reduced/minimised.

☆ For Exam
i) Air friction → used in MI & EMMC
ii) fluid " → Electro Static (low damping co-efficient)
iii) Eddy current → PMMC. } → permanent magnet
iv) Electromagnetic → Galvanometer }

ii) Deflecting torque (Td)
By applying principles like Electromagnetic, Electrostatic, induction etc torque is produced, which is proportional to the quantity to be measured. This torque is called Deflecting torque.

ontrolling torque (T_c)

Spring → Temp independent material.

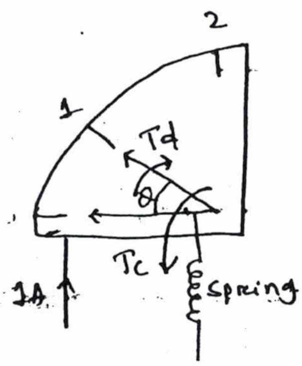
Controlling torque is used for

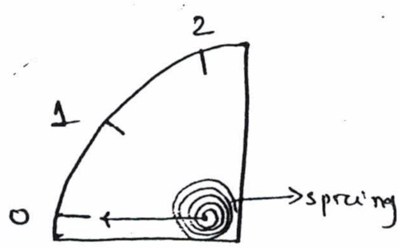
i) Balancing the pointer at steady state position at which $T_c = T_d$.

ii) In the absence of T_d bring the pointer to the zero initial position.

Spring control is more practically used which is made of phosphor Bronze, which is less affected by temp. and atmospheric condn.. and it has longer life.

pring Control





(practical condn)

$T_c \propto \theta$ → θ = Deflecting angle (rad (or) degree)

→ $T_c = K\theta$ → linear. K = Spring const. (Nm/rad or Nm/degree.)

at balanced condn → $T_c = T_d$

$$K = \frac{Ebt^3}{12l}$$

E = Young's modulus
b = Breadth of spring
t = thickness "
l = length " "