GOVERNMENT POLYTECHNIC, GAJAPATI

DEPARTMENT OF MECHANICAL ENGG

STUDY MATERIAL

THEORY OF MACHINE (TH-1)

4TH SEMESTER

MECHANICAL ENGG.

BY

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CONTENTS:

Course outcomes

At the end of the course students will be able to:

C221.1	Able to identify and explain different types of mechanism.
C221.2	Able to explain friction in screw,bearing,clutches,brakes and dynamometer.
C221.3	Able to explain and analyse power transmission in belt,gear drive.
C221.4	Able to explain vibration of machine parts,working of governers and analyse static and dynamic balancing.

Simple Mechanism :-

*) **Rigid Body :-**

A rigid Body is an idealization of a body that does not deform or change shape.

Ex:- Cast iron, Diamond, wood ... etc.

*) **Resistant Body :-**

A resistant body is a body which is not a rigid body but also like a rigid body whiles its functioning in the machine.

Ex:- Cast iron, wood ... etc.

*) **Link / Element / Kinematic link :-**

Each part of machine which is having relative motion with other parts is known as Link.

Different types of link :-

=> **Rigid Link :-**

The link which is not deform during relative motion with other part is known as Rigid Link.

Ex:- Connecting Rod ... etc.

⇒ **Flexible Link :-**

The link which is deform during relative motion with other parts is known as Flexible Link.

Ex:- Spring, belt ... etc.

⇒ **Fluid Link :-**

The link which acts in fluid medium due to its fluid pressure, is known as Fluid Link.

Ex:- Hydralic pressure, ... etc.

* **Motion :-**

Change with time of the position of a body is known as Motion.

Constrained Motion :-

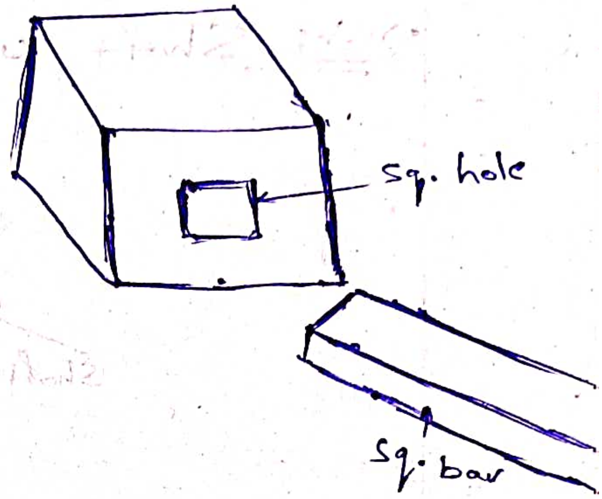
The motion that occurs when the body is allowed to move in one direction, but constrained in all the other direction is know as Constrained Motion.

Different types of Constrained Motion:

⇒ **Completely Constrained Motion :-**

When the motion of the pair is limited to one direction, irrespective of the direction applied force is known as Completely Constrained Motion.

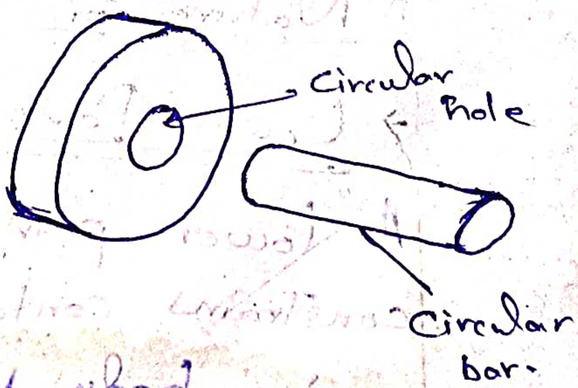
Ex:- A square Shaft moving in square hole ... etc.



Incompletely Constrained Motion:-

The motion between the pair can take place ~~between~~ in more than one direction, is known as Incompletely Constrained Motion.

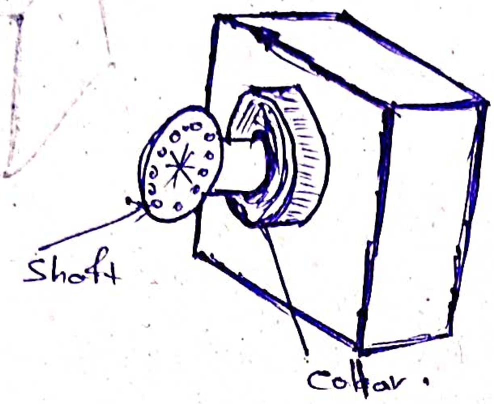
Ex:- A circular shaft moving in Circular hole ... etc.



=) **Successfully Constrained Motion:-**

If the motion of a pair is along one direction only under the influence of external forces, then this motion is known as Successfully Constrained Motion.

=) Ex:- Shaft with Collar, ... etc.



Pair/ Kinematic Pair:-

Two Links joined to each other which have relative motion with other parts of machine is known as Pair.

Types of Pairs:-

=) Kinematic Pairs are classified according to

i) **Nature of contact:-**

→ **Lower Pair:-**

A lower pair is an ideal joint that constrains contact between a surface in the moving body to a corresspoinding in the fixed body.

Ex:- Nut and Screw.....etc.

Higher Pair:-

When a pair has a point or line contact between the links, it is known as a higher Pair.

Ex:- Cam and follower pair, tooth gears...etc.

ii) **Based on the nature of Mechanical Constraint:-**

-> **Closed Pair:-**

A pair in which element of pairs are held together mechanically due to their geometry, is known as Closed pair.

Ex:- Screw and nut, ball and socket joint...etc

-> **Unclosed Pair:-**

When two links of a pair are in contact either due to force of gravity or some Spring action, is termed as Unclosed Pair.

Ex:- Cam and follower pair...etc.

iii) Nature of relative motion between links :-

→ Turning Pair :-

It consists of two components connected in such a way that one is constrained to relove about fixed axis of another element.

Ex:- Ball and roller bearing .... etc.

→ Sliding Pair :-

When two links are so connected that one is constrained to have sliding motio relative to another, is known as Sliding Pair.

Ex:- Square rod in Square hole --etc

→ Rolling Pair :-

It consists of two elements connected in such a way that one is constrained to roll in another element which is fixed.

Ex:- Ball and roller bearings ---- etc.

→ **Screw Pair:-**

This consists of two elements connected in such a way that one component turns about the other component through thread.

Ex:- Nut and bolt...etc.

→ **Spherical Pair:-**

It consists of two elements joined in such a way that one element in the form of a sphere turns about the other fixed element.

Ex:- Ball and socket joint...etc.

* Kinematic chain:-

When the kinematic pairs are coupled in such a way that the last link is joined to the first Link to transmit definite motion ~~or successfully~~, it is called Kinematic Chain.

→ **Condition to form kinematic Chain:-**

⇒ If there are four links, any motion to any point or link results in a particular motion relative to any other point or link.

⇒ Thus, this arrangement satisfies the requirements of a kinematic chain.

⇒ four-link chain, has four kinematic links.

⇒ Each link has two turning pairs.

⇒ In kinematic chain the relationship is as follows.

$$L = 2P - 4$$

where, L = number of links

P = number of pairs.

⇒ Another relation between the number of links (L) and the number of joints (j) which constitute a kinematic chain given by the expression,

$$j = \frac{3}{2}L - 2$$

→ <u>Locked Chain</u> :-

If the links are connected in such a way that no motion is possible, is known as Locked chain.

⇒ Condition for this, $L = 2P - 3$

→ <u>Constrained Chain</u> :-

A constrained chain is an assembly of rigid bodies connected by joints to provide constrained motion that is the mathematical model for a mechanical system.

→ Unconstrained Chain :-

For a particular position of a link of the chain, the positions of each of the other links of the chain cannot be predicted, then it is called Uncontrained Chain.

⇒ Conditions for this, $L = 2P - 5$

→ Four bar chain :-

In the study of mechanisms, a four bar linkage, also called four-bar, is the simplest closed-chain movable linkage. It consists of four bodies, called bars or links, connected in a loop by four joints.

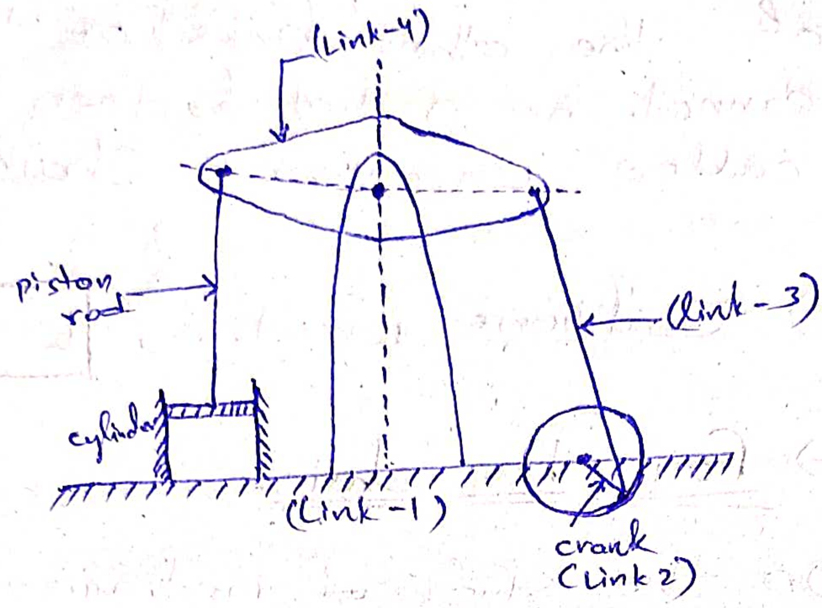
→ Inversion of four bar chain :-

i) Beam Engine.
ii) Coupling rod of Locomotive.
iii) Watt's indicator mechanism.

→ Single slider crank chain :-

A single slider crank chain is a modification of the basic four bar chain..

⇒ It consists of a one sliding pair and three turning pairs.



→ **Inversion of single slider crank chain**

i) Bull Engine.

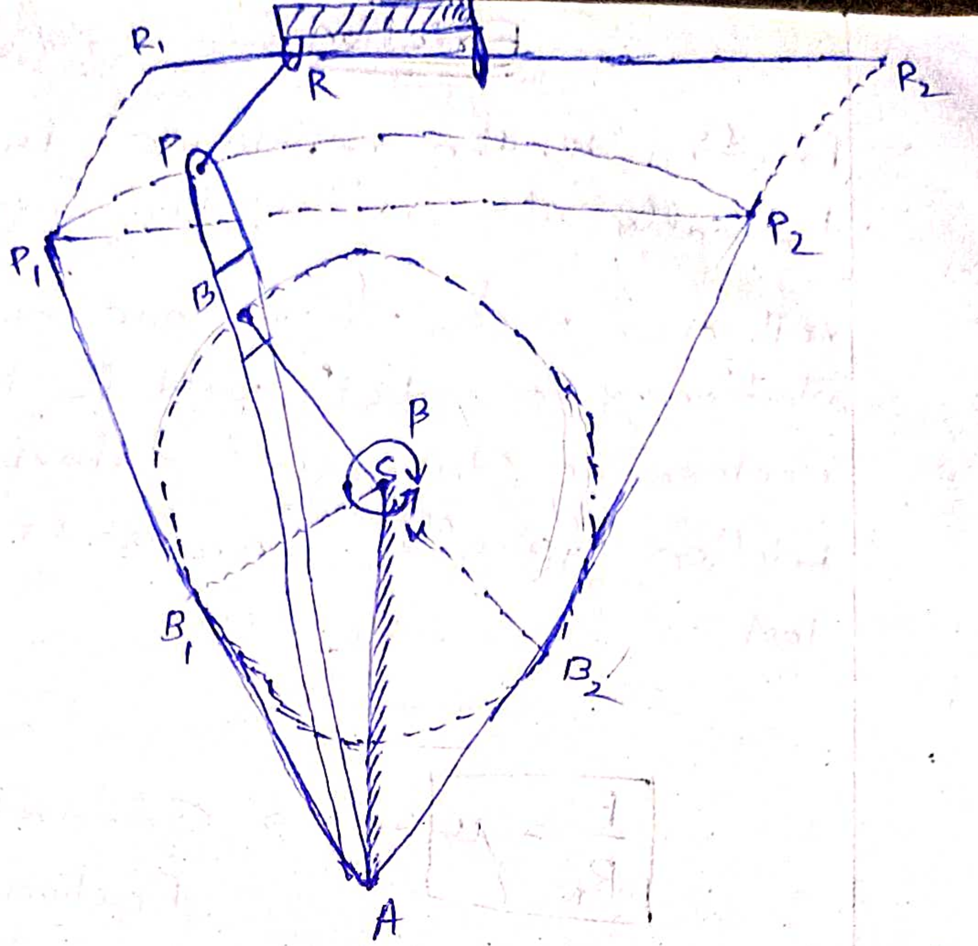
ii) Quick return Mechanism.

iii) Rotary engine.

Crank and slotted bar quick return Mechanism :-

The crank and slotted quick return mechanism converts rotary motion into linear motion.

⇒ It is extensively used in shapping and cutting machines and is particularly useful in cutting flat surfaces out of metal stock.



$$\Rightarrow \frac{\text{Time of cutting stroke}}{\text{Time of return stroke}} = \frac{\beta}{\alpha} = \frac{360-\alpha}{\alpha}$$

→ Cam and follower motion :-

A cam is a mechanical member used for transmitting a desired motion to a follower by direct contact.

⇒ Cams transforms rotary motion into reciprocating motion.

Friction

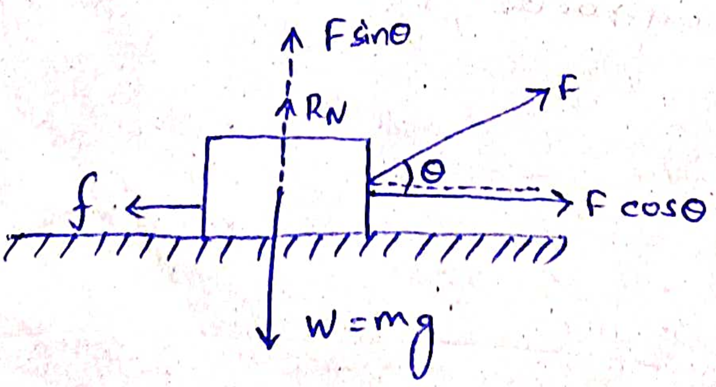
Friction is the resistance to movement, typically this is as two surface slide or roll over each other; one could be stationary or both could be in motion. In a engineering / tribological context the level of friction typically represents the energy lost.

$$\boxed{\frac{F}{R_N} = \mu} \longrightarrow \text{Co-efficient of Friction.}$$

→ **Limiting friction:-**

It is defined as the friction created when two static surfaces come into contact with each other.

⇒ The limiting frictional force is independent of the area of contact and is proportional to the reasonable reaction between the contacting surface.



Resolve the forces :-

$$\Sigma H = 0$$

$$f = F\cos\theta$$

$$\Sigma V = 0$$

$$W = f\sin\theta + R_N$$

→ **Friction in screw jack :-**

Lead:- One complete rotation of screw in axial movement is known as Screw Jack.

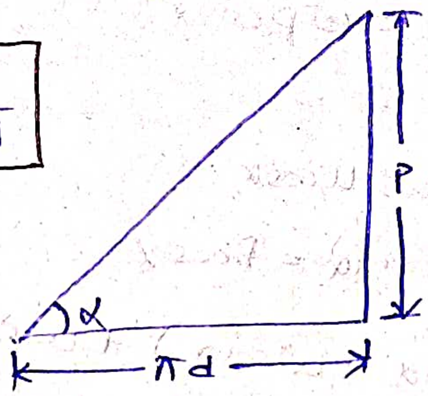
$L = P$; Single slot

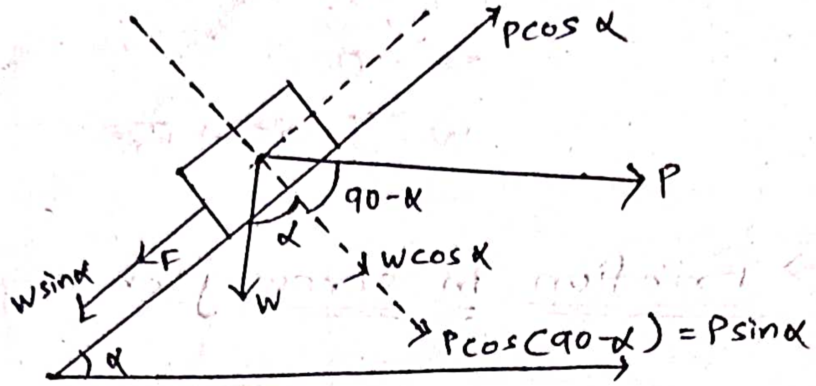
$L = 2P$; Double slot

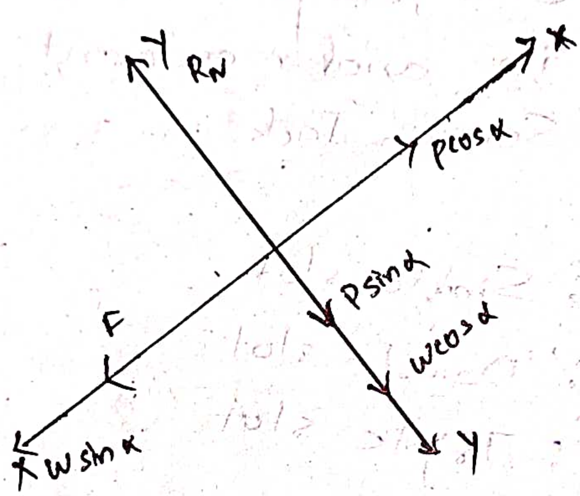
$L = 3P$; Triple slot

α = helix angle.

$$\boxed{\tan\alpha = \frac{P}{\pi d}}$$







$\Sigma x = 0$

$F + w\sin\alpha = p\cos\alpha$

$\Sigma y = 0$

$\Rightarrow R_N = P\sin\alpha + W\cos\alpha$

$\Rightarrow \mu R_N + W\sin\alpha = P\cos\alpha$

$\Rightarrow \mu(P\sin\alpha + W\cos\alpha) + W\sin\alpha = P\cos\alpha$

$\Rightarrow \mu p\sin\alpha + \mu w\cos\alpha + w\sin\alpha = P\cos\alpha$

$\Rightarrow \mu p\sin\alpha - p\cos\alpha = -(\mu w\cos\alpha + w\sin\alpha)$

$\Rightarrow p\cos\alpha - \mu p\sin\alpha = \mu w\cos\alpha + w\sin\alpha$

$\Rightarrow p(\cos\alpha - \mu\sin\alpha) = w(\mu\cos\alpha + \sin\alpha)$

$$\therefore P = w\left[\frac{\mu\cos\alpha + \sin\alpha}{\cos\alpha - \mu\sin\alpha}\right]$$ → (divided by $\cos\alpha$)

$$P = W\left[\frac{\mu + \tan\alpha}{1 - \mu\tan\alpha}\right]$$

$$P = W\left[\frac{\tan\phi + \tan\alpha}{1 - \tan\phi \cdot \tan\alpha}\right]$$

$$\text{Effort} = P = W\tan(\alpha + \phi)$$

→ **Torque to raise the load :-**

$$T = P \times \frac{d}{2}$$

$$T = W\tan(\alpha + \phi) \cdot d/2$$

$$d_I = d_o - \frac{\text{Pitch}}{2}$$

$$\text{Speed } N = \frac{\text{Speed of nut}}{\text{Pitch of screw}}$$

$$N = \frac{V}{\text{pitch}}$$

Efficiency of screw jack :-

$$\eta = \frac{\text{Ideal effort}}{\text{Actual effort}}$$

$$\eta = \frac{\tan\alpha}{\tan(\alpha + \phi)}$$

$$\eta_{max} = \frac{1 - \sin\phi}{1 + \sin\phi}$$

Overhouling :-

After removing the effort, if the screw will begin to turn and ~~descend~~ goes down, it is called Overhauling.

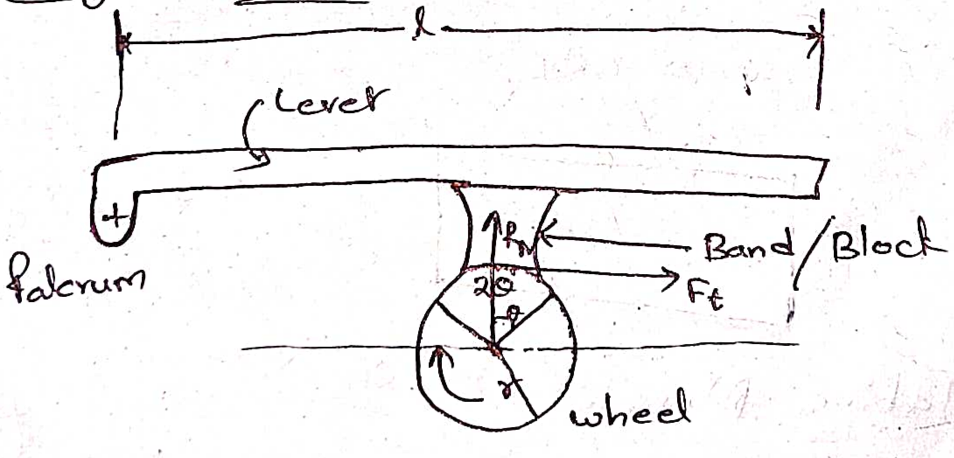
→ Seat of Pressure :-

i) Considering Uniform Pressure.

ii) Considering Uniform Wear.

sl no.	Types of Bearing	Torque Considering Uniform Pressure	Torque Considering Uniform Wear
1	Flat pilot Bearing	$T = \frac{2}{3}\mu W R$	$T = \frac{1}{2}\mu W R$
2	Conical Pilot Bearing	$T = \frac{2}{3}\mu W R \operatorname{cosec}\alpha$	$T = \frac{1}{2}\mu W R \operatorname{cosec}\alpha$
3	Flat collar Bearing	$T = \frac{2}{3}\mu w\left(\frac{r_1^3 - r_2^3}{r_1^2 - r_2^2}\right)$	$T = \frac{1}{2}\mu w(r_1 + r_2)$
4	Single plate Clutch	$T = \frac{2}{3}\mu w\left(\frac{r_1^3 - r_2^3}{r_1^2 - r_2^2}\right)$	$T = \frac{1}{2}\mu w(r_1 + r_2)$

→ **Single Block or Shoe brake:-**



rotation → clockwise

P = force applied at the end of lever.

R_N = Normal Force

r = radius of the wheel.

2θ = angle of contact surface of the block.

μ = co-efficient of friction.

F_t = tanjenotial braking force at the contact surface of the block and wheel.

$$F/R_N = \mu$$

$$F_t = \mu R_N$$

$$T_B = F_t \times r$$

$$= \mu R_N \times r$$

$$\boxed{T_B = \mu R_N . r}$$

Taking Moment at "O"

"↻" (−) "↺" (+)

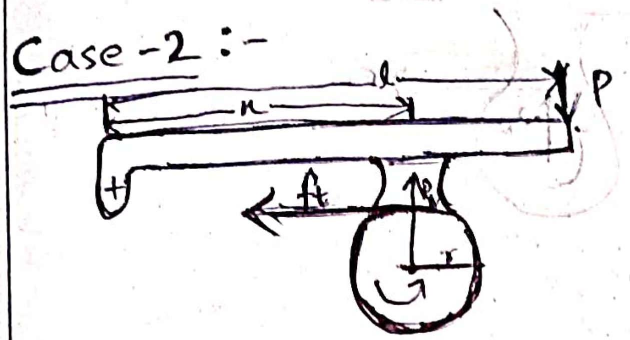
$$-P \times l + R_N \times x = 0$$

$$R_N x = Pl$$

$$\boxed{R_N = \frac{Pl}{x}}$$

$$T_B = \mu \times \frac{Pl}{x} \times r$$

Case-2 :-



anti-clockwise

Taking moment at "O"

"↩" (-) "↪" (+)

$$\Rightarrow -P \times l + R_N \times x = 0$$

$$\Rightarrow R_N x = Pl$$

$$R_N = \frac{Pl}{x} \quad \text{--------} \quad (1)$$

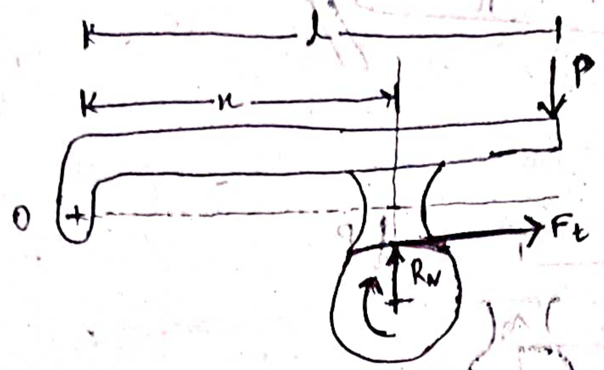
$$\therefore \frac{f_t}{R_N} = \mu$$

$$f_t = \mu R_N$$

$$T_B = f_t \times r$$

$$T_B = \mu R_N \times r$$

Case-3 :-



$$\therefore \frac{f_t}{R_N} = \mu$$

$$\boxed{f_t = \mu R_N}$$

$$T_B = f_t \times r$$

$$\boxed{T_B = \mu R_N \times r}$$

Taking moment at "O"

"↺" (−) "↻" (+)

$$\Rightarrow -P \times l + R_N \times x + f_t \times a = 0$$

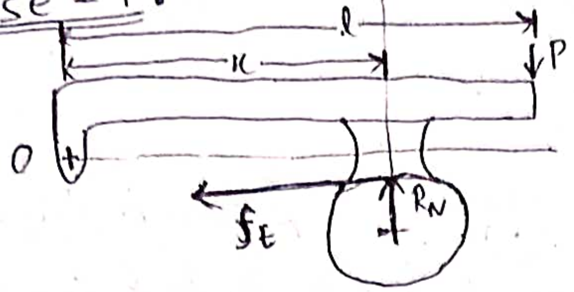
$$\Rightarrow R_N x = Pl - f_t \times a$$

$$\Rightarrow \boxed{R_N = \frac{Pl - f_t a}{x}}$$

$$\therefore T_B = \mu R_N r$$

$$\boxed{T_B = \mu \left(\frac{Pl - f_t a}{x}\right) r}$$

Case - 4 :-



$\therefore \frac{f_t}{R_N} = \mu$

$$\boxed{f_t = \mu R_N}$$

$T_B = f_t \times r$

$$\boxed{T_B = \mu R_N \times r}$$

• Taking moment at "O",

"↺" (−) "↻" (+)

$-P \times l + R_N \times x - f_t \times a = 0$

$\Rightarrow R_N x = Pl + f_t a$

$$\Rightarrow \boxed{R_N = \frac{Pl + f_t a}{x}}$$

$\therefore T_B = \mu R_N r$

$$\boxed{T_B = \mu \left(\frac{Pl + f_t a}{x} \right) r}$$

~~Dynameter~~:-

Dynamometer:-

A dynamometer is a device for measuring force, moment of force (torque) or power.

Classification:-

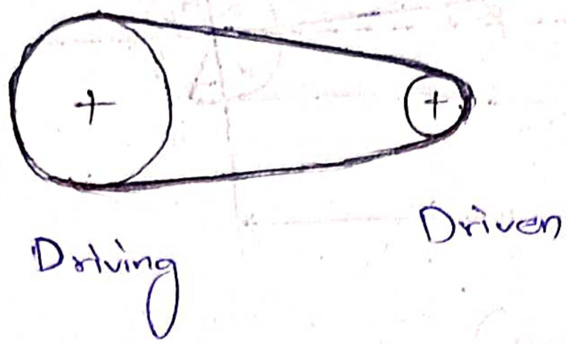
The dynamometer classified by two types:-
i) Absorption type
ii) Transmission type.

i) Absorption type
- Proney Brake Dynamometer.
- Rope-Brake Dynamometer.

ii) Transmission type
- Epicyclic train transmission Dynamometer
- Belt transmission Dynamometer.
- Torsion type Dynamometer.

Power Transmission :-

Belt Drive :-



Classification of Belt drive :-

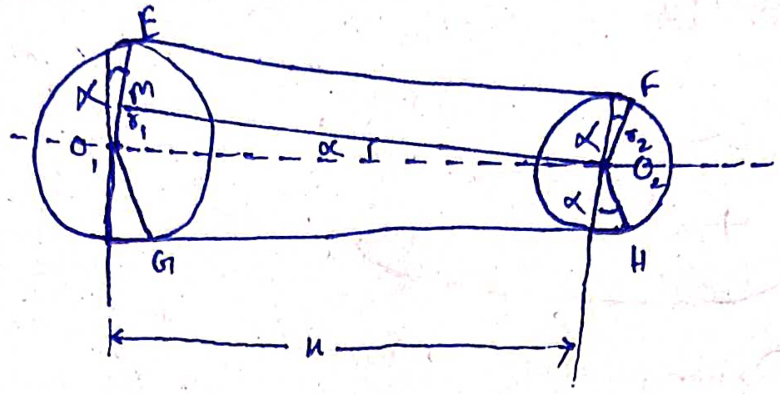
Belt Drive
- Light Drive ($v < 10$ m/sec)
- Medium Drive (10 - 22 m/sec)
- Heavy Drive ($v > 22$ m/sec)

Flat Belt Drive :-

→ Open belt drive. 

→ Closed / crossed belt drive 

Length of open belt drive :-



$(\overline{EF} = \overline{GH})$

$\widehat{GJE} = \widehat{GJ} + \widehat{JE}$

$= 2\widehat{JE}$

$= 2\left\{r_1\left(\frac{\pi}{2}+\alpha\right)\right\}$

$\widehat{FKH} = \widehat{FK} + \widehat{KH}$

$= 2\widehat{FK}$

$= 2\left\{r_2\left(\frac{\pi}{2}-\alpha\right)\right\}$

$\overline{EF}$,

In O_1O_2M, right-angle tringle,

$MO_2 = \sqrt{(O_1O_2)^2 - (O_1M)^2}$

$= \sqrt{x_2^2 - (R_1-R_2)^2}$

~~Bio~~ Binomial expression,

$x\left[1 - \frac{1}{2}\left(\frac{r_1 - r_2}{x}\right)^2 + \dots\right]$

We will take 1st two terms,

$$MO_2 = x\left[1 - \frac{1}{2}\left(\frac{r_1 - r_2}{x}\right)^2\right]$$

$$L_{open} = \pi(r_1 + r_2) + 2x + \frac{(r_1 - r_2)^2}{x}$$

or $$\frac{\pi}{2}(d_1 + d_2) + 2x + \frac{(d_1 - d_2)^2}{4x}$$ //

Let,

σ = Maximum Safe stress in N/mm^2

b = width of the belt in mm.

t = thickness of the belt.

$A = b \times t$

~~$\sigma = \frac{T}{A}$~~

$$\boxed{\sigma = \frac{T}{A}}$$

$$\boxed{T = \sigma \times A}$$

$$\boxed{T = \sigma b t}$$

↙ Maximum tension

Derive the condition for maximum power transmission in belt :-

Let, T_1 = tight side tension in N

T_2 = slack side tension in N

v = Velocity of belt in m/sec

We know, $P = (T_1 - T_2)v$

again, $\frac{T_1}{T_2} = e^{\mu\theta}$

$$T_2 = \frac{T_1}{e^{\mu\theta}}$$

Put in value of P

$$P = \left(T_1 - \frac{T_1}{e^{\mu\theta}}\right) v$$

$$= T_1 \left(1 - \frac{1}{e^{\mu\theta}}\right) v$$

$$P = T_1 \, c v$$

$$1 - \frac{1}{e^{\mu\theta}} = c$$

$$P = (T - T_c) v \cdot c$$

$$T_1 = T - T_c$$

$$= (T - m v^2) v \cdot c$$

$$= (T v - m v^3) c$$

For maximum condition for power transmission.

$$\frac{dp}{dv} = 0$$

$$\Rightarrow \frac{d}{dv}\left[(T v - m v^3) c \right] = 0$$

$$\Rightarrow c \frac{d}{dv} (T v - m v^3) = 0$$

$$\Rightarrow \frac{d}{dv}(T v) - \frac{d}{dv}(m v^3) = 0$$

$$\Rightarrow T \cdot \frac{d}{dv} v - m \frac{d}{dv} v^3 = 0$$

$$\Rightarrow T \cdot 1 - m 3 v^2 = 0 \quad \text{——— (i)}$$

$$\Rightarrow T = 3 m v^2$$

$$\Rightarrow v = \frac{T}{3M}$$

$$\Rightarrow \boxed{v = \sqrt{\frac{T}{3M}}}$$

From eq^n — (i)

$$T - 3 m v^2 = 0$$

$$T - 3 T_c = 0$$

$$\boxed{T = 3 T_c}$$

$$\boxed{T_c = T/3}$$

Gear drive :-

Gear drives are packaged units used for a wide range of power - transmission applications. They are used to transmit power to a driven piece of machinery and to change the power transmission.

Gear train :-

A gear train is a machine elements of a mechanical system formed by mounting gears on a frame so ~~that~~ the teeth of the gear engage.

Types of Gear train :-

i) Spur Gear
ii) Helical Gear.
iii) Spiral Gear
iv) Worm Gear
v) Helical Gear

i) Spur Gear :-

Teeth are cut parellel to the axis of the shaft.

ii) Helical Gear :-

The teeth of these gears are cut at an angle to the axis of the shaft

iii) Bevel gear :-

It have the shape of truncated cone.

The intersecting angle can be less then 90° OR equal to 90° on greater then 90°.

iv) Spiral gear

It used to connect non-coplaner and non-intersecting shafts. They are employed for transmitting small powers.

*) The teeth of spiral gear is curved

v) Worm gear:-

The axis of the gears don't intersect and are perpendicular to each other.

Advantages:-

=> More compact.
=> Reliable in service.
=> Higher efficiency.
=> Wide transmitted power range.
=> Light loads on the shafts and bearings.

Disadvantages:-

=> Not suitable for the shafts which are at ~~range~~ longer distance.
=> Required perfect alignment of shaft.
=> Requires more attention to lubricant
=> Unable to absorb shock in service.

Governor:-

Device that automatically maintains the rotary speed of an engine or other prime mover within reasonably close limits regardless of the load. is known as Governor.

A typical governor regulates an engines speed by varying the rate at which fuel is furnished to it.

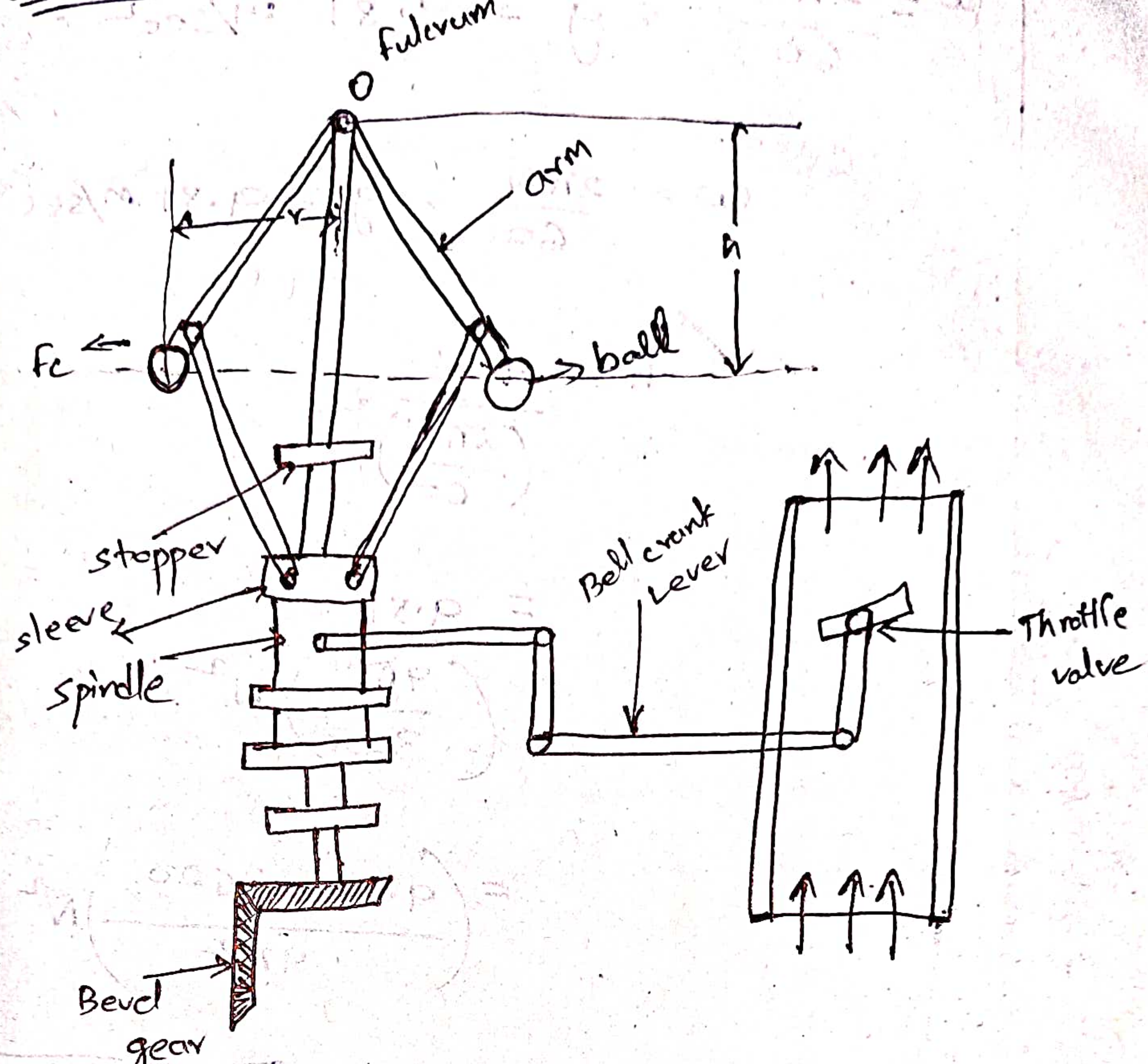
Flywheel :-

It stores the energy in form of inertia.

Flowchart of Governor :-

- Governor
  - Centrifugal
    - Pendulum type (watt gover.)
    - Loaded type
      - Dead weight
        - Porter gov.
        - Prowell gov.
      - Spring loaded type
        - Hartnell
        - Hartung
        - Wilson Hartnel
        - Pickering gov.
  - Inertia

Governor:-



Taking moment at "O"

"↶" "↷"

(−) (+)

$$-F_c \times h + W \times r = 0$$

$$F_c \times h = W r$$

$$F_c \times h = m g r$$

$$h = \frac{m g r}{F_c}$$

$$F_c = m r \omega^2$$

$$h = \frac{m g r}{m r \omega^2} \Rightarrow h = \frac{g}{\omega^2}$$

$\omega = \frac{2\pi N}{60}$, $g = 9.81\ m/sec^2$

$\omega = \frac{2\pi N}{60}$, $g = 9.81\ m/sec^2$

$$h = \frac{9.81}{\left(\frac{2\pi N}{60}\right)^2}$$

$$= \frac{9.81}{\left(\frac{4\pi^2}{3600}\right) N^2}$$

$$= \left(\frac{9.81 \times 3600}{4\pi^2}\right) N^2$$

$$\boxed{h = \frac{895}{N^2}} \quad \text{OR} \quad \boxed{N = \sqrt{\frac{895}{h}}}$$

Porter Governior:-

Porter Governor is dead weight loaded type of gravity controlled centrifugal governor. It is similar to watt governor with slight modification.

*) It refers to a type of engine that is used to maintain the mean speed of an engine by controlling fuel flow with respect to the load on the engine.

Proell Governor:-

The proell Governor has two or more flyweights that are connected to the drive shaft.

The proell Governor is a mechanical device used for controlling the speed of engines and turbine.

Hartnell Governor:-

It consists of a frame/casing, in which a precompressed helical spring is housed.

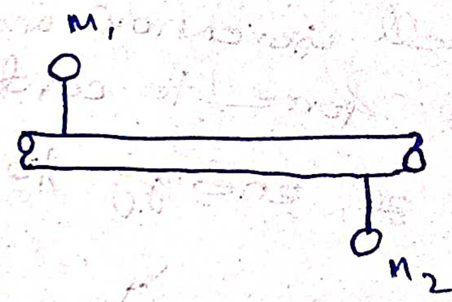
The Hartnell Governor works by using centrifugal force to control the flow of fuel or energy to the engine.

Balancing of Machine :-

Balancing is the complex procedure of working to enhance the mass spread of a body, so as to rotate in its bearings without the unbalanced centrifugal forces acting on it.

static balancing of rotating masses :-

Static balance occurs when the centre of gravity of an object is on the axis of rotation.



Balancing of several masses rotating in the same plane :-

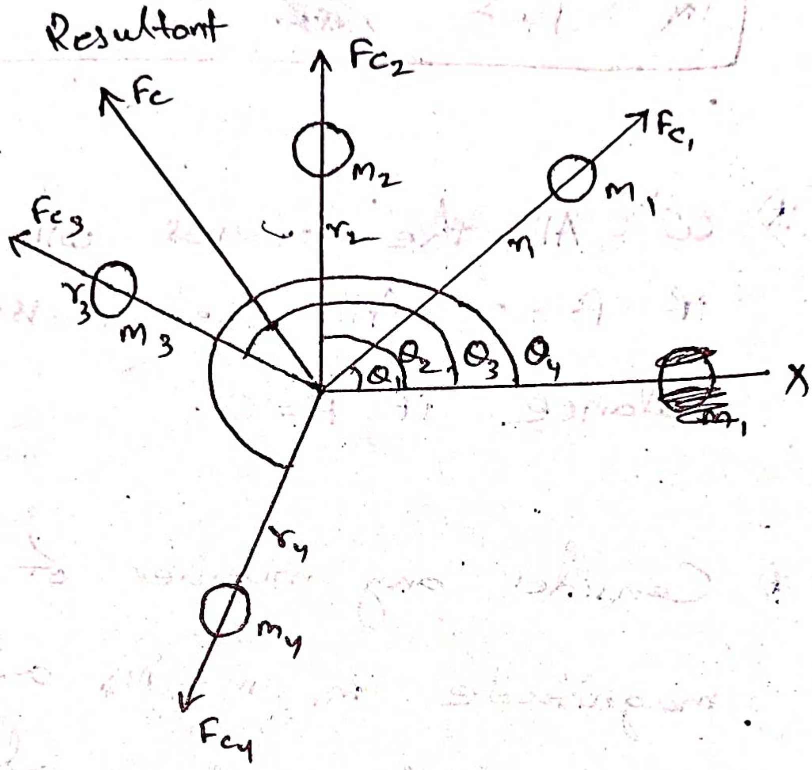
Balancing of several masses in the same plane, If a system of masses of masses are rotating in the same lane then, if the vector sum of centrifugal forces are zero then the rotor is statically balanced.

*) Considering a disturbing mass m lying in a plane A to be balanced by two rotating masses m_1 and m_2 lying in two ...

*) ω^2 - All the masses will be in balance if F = 0. All the masses will be in balance if F = 0.

*) Consider any number of masses of magnitude m_1, m_2, m_3 and m_4 at a distance of r_1, r_2, r_3 and r_4 from the axis of the rotating shaft.

*) Let $\theta_1, \theta_2, \theta_3$ and θ_4 be the angles of these masses with the horizontal line ox, as shown in fig.



$$\Sigma H = m_1 r_1 \cos\theta_1 + m_2 r_2 \cos\theta_2 + \cdots$$

$$\Sigma V = m_1 r_1 \sin\theta_1 + m_2 r_2 \sin\theta_2 + \cdots$$

$$F_c = \sqrt{(\Sigma H)^2 + (\Sigma V)^2}$$

$$\tan\theta = \frac{\Sigma V}{\Sigma H}$$

$$F_c = m \cdot r$$

m = Balancing mass.

ad r = Radius of rotation

Balancing several rotating masses in different planes :-

When several masses rotate in different planes, the centrifugal forces, in addition to being out of balance, also from couples. A system of rotating masses is in dynamic balance when there does not exist any resultant centrifugal force as well as resultant couple.

$$m_L r_L = \text{vector } eO$$

$$m_L = \frac{\text{vector } eO}{r_L}$$

Principle of balancing of reciprocating parts :-

Balancing of Reciprocating and rotating masses is done by adding another mass that could generate the same force as of disturbing force which is the centrifugal force.

$$F_c = mr\omega^2$$

Vibration in Machine :-

Mechanical vibration is defined as the measurement of a periodic process of oscillations with respect to an equillibrium point.

or

It also known as, the unbalance forces of machine components.

Basic Terminology of Vibration :-

Cycle :-

*) It is the motion completed during one time period.

Time period :-

*) It is the time interval after which the motion is repeated itself.

Frequency :-

*) Frequency is an important parameter used in science and engg. to specify the rate of oscillatory and vibratory phenomena.

④ Amplitudes:-

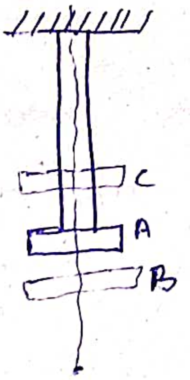
The maximum displacement moved by a point on a vibrating body or wave measured from its equilibrium position, is known as Amplitude.

It is equal to one-half the length of the vibration path.

Types of vibration:-

- Free vibration
  - Longitudinal vib.
  - Transverse vib.
  - Torsional vib.
- Forced vibration
- Damped vibration

i) Longitudinal Vibration:-

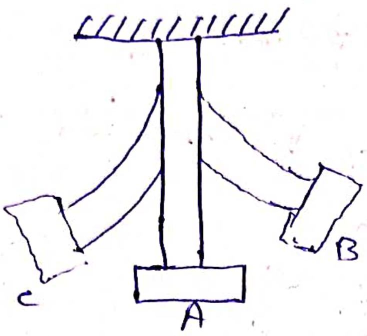


~~→ Longitudinal wav~~

⇒ when the particles of the shaft or disc travel parallel to the shaft's axis.

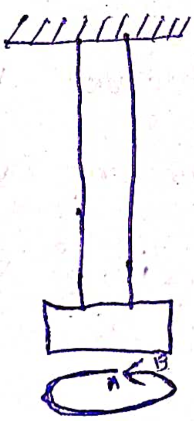
Transverse vibration:-

A vibration in which the element moves to and fro in a direction perpendicular to the direction of the advance of the wave, is known as Transverse Vibration.



Torsional Vibration:-

Torsional vibration is angular vibration of an object - commonly a shaft along its axis of rotation.



Forced Vibration:-

Forced vibration occurs when motion is sustained or driven by an applied periodic force in either damped or undamped systems.

Damped vibration:-

Damped vibrations are periodic vibrations of a body with diminishing amplitude in the presence of a resistance force.

Causes of Vibration:-

=) Unbalanced mechanism.

=) Bent Shaft.

=) Gears in the machine.

=) Bearings.

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