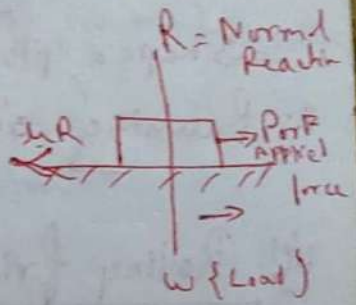
# Friction

## * Friction/Frictional force:-

When a body slides over another body, a tangential force is exerted at the surface of contact by the stationary body on the moving body. This resisting force is called the force of friction/Frictional force.

∴ Force of friction, $F = \mu R$

where $\mu$ = coefficient of friction.




## * Types of friction:-

Generally, the friction is of two types:-

1) Static friction 2) Dynamic friction.

### 1) Static friction:-

It is the friction experienced by a body, when it is at rest or we can say in other words, it is the friction, when the body before tends to move.

Limiting friction:- It is the maximum value of force of static friction which comes into play when a body just begins to slide over the surface of another body.

2) Dynamic Friction:- It is the friction experienced by a body when it is in motion, it is also called Kinetic friction.

The dynamic friction is of the following two types.

ii): Sliding friction.
iii): Rolling friction.

ii): Sliding friction:-
It is the friction experienced by a body when it slides over the surface of another body.
Ex:- Sliding parts in working machine such as shaper, planner.
* Rubbing oil on child body.

iii): Rolling friction:- It is the friction experienced by a body when it rolls over the surface of another body.
Ex:- Skating
Moving on foot
moving wheels on road and on railway tracks.

Note:- i) Dynamic friction is always less than the static friction.
ii): Rolling friction is always less than the sliding friction.

* Law of Friction:-

Law of Static friction:-

i): Frictional force always acts tangential on the surface of contact in a direction opposite to the applied force due to which the body tends to move.

*: The magnitude of the frictional force is exactly equal to the applied force. So it is a self adjusting force.

*: The frictional force depends upon the nature of the surface in contact.

*: The frictional force is independent of the area of contact b/w two surface. But it depends upon the normal reaction to the contact surface(R).

$F = \mu R$. $\mu$ is a constant.

$F < R$.

*: The magnitude of the max static friction(limiting friction) bear a constant ratio to the normal reaction b/w the two surface. $F = \mu R$.

$\frac{F}{R}$ = constant = $\mu$ {Coefficient of static friction}

## Law of Dynamic or Kinetic Friction:-

*: The force of friction always acts in a direction opposite to that in which the body is moving.

*: The dynamic friction bears a constant ratio to the normal reaction b/w the two surface of contact $\{\mu = \frac{F}{R}\}$. which is known as coefficient of dynamic friction.

*: The frictional force remains constant for moderate (controlled) speeds. But it decreases slightly with the increase of speed.

*: The magnitude of the force of dynamic friction is a little less than the force of static friction.

*: The force of dynamic friction comes into play during the motion of the body and as soon as the body stops, the force of dynamic friction disappears.

*: The force of dynamic friction is independent of shape, size, area of contact and Velocity etc of the body as long as normal reaction remains the same.

Coefficient of Friction:-

It is the ratio of limiting friction (F) to the normal reaction (R) b/w the two surface of contact. It is generally denoted by $\mu$, which is called coefficient of friction.

$\mu$ = Limiting friction ($F$)
Normal Reaction ($R$)

$$\mu = \frac{F}{R}$$

Note:-

*: $\mu$ has no unit because $\mu$ is a ratio.

*: Value of $\mu$ remains b/w 0 to 1. A max value of $\mu$ may be 1

*: Value of $\mu$ remains constant for a material.

*: Value of $\mu$ depends upon the materials of making surface. It may be changed if we change the materials of the surfaces of contact.

*: $\mu = 0$ for smooth planes always.

*: Angle of Frictim :- It is the angle b/w the resultant & normal reactim

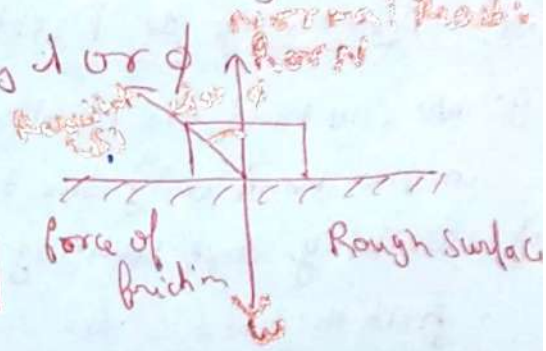
or

The angle which the resultant (S) makes with normal reaction (R or N) when the motim is impending.

Angle of frictim is denoted by $\lambda$ or $\phi$

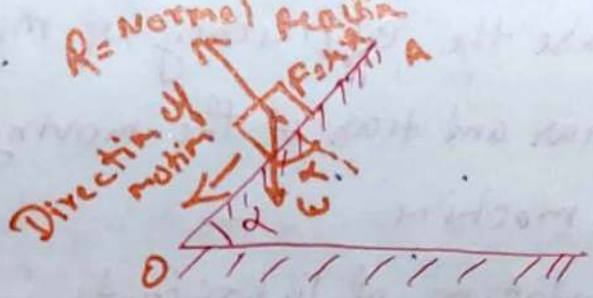
$$\tan\phi \text{ or } \tan\lambda = \frac{\mu R}{R}$$

$$\boxed{\tan\lambda = \mu} \text{ or } \boxed{\tan\phi = \mu}$$




*: Angle of Repose or Critical angle :-

Angle of repose is the max angle of inclinatim of the plane at which a body remains in equilibrium under the action of frictim only. It is generally denoted by $\alpha$ or $\theta$




$F = \mu R = W\sin\alpha$ --(I)

$R = W\cos\alpha$ --(II)

Dividing (I) and (II)

we get $\tan\alpha = \mu$ {But in term of angle of frictim the coefficient of frictim is $\mu = \tan\phi$ or $\tan\lambda$

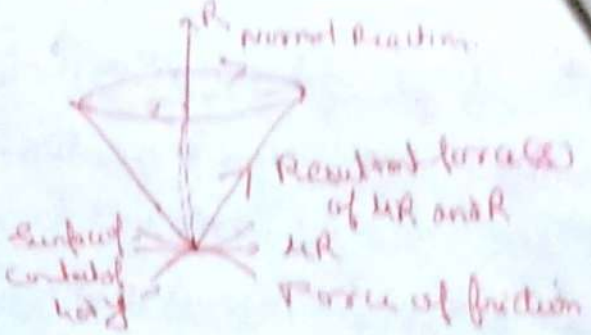
then $\tan\phi = \mu = \tan\alpha$

$\boxed{\phi = \mu}$ i.e. $\boxed{\mu = \alpha}$

∴ Angle of repose = Angle of frictim.

## Cone of Friction:-

Taking K as axis and O as Vertex of a cone, if the line OA is revolved around the axis the cone so formed is called cone of friction.




## Advantage of Friction: [Importance of friction in Engineering]

i: We can hold the chalks, pencils, pen and screw drivers etc. in our hand only due to friction.

ii: Walking and skating on the road and ground is possible due to friction.

iii: Friction - clutches, brakes, gear drives & rope drives system works on the basis of friction.

iv: Running of motor cars, train and bicycles etc is possible due to friction only.

## Disadvantage of Friction:

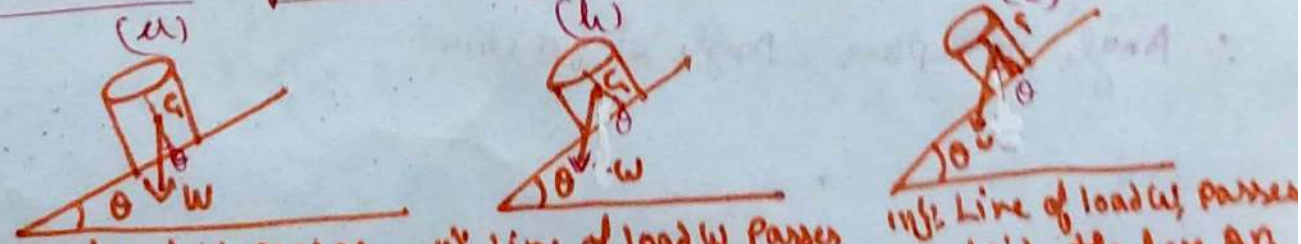
i: It decreare the efficiency of machine.

ii: It cause wear and tear of the moving parts (like bearing and axles) of machine.

iii: Implementation of lubricants in machine can increare the overall cost.

iv: It causes loss of energy in the machines and due to friction some energy convert into heat energy due to which efficiency of machines falls down.

## * Conditions of Toppling over and Slipping:-




i: Line of load W, passes inside the base AB

ii: Line of load W passes through end A of the base AB

iii: Line of load W passes outside the base AB

If we put a block (body) on the inclined plane of inclination $\theta$ with horizontal the following are the condition of toppling over.

In case (a) the body will not be at the point of toppling over condition.

In case (b) the body will be at the point of toppling over condition.

In case (c) the body will topple

Slipping Condition:

$\phi$ = the angle of friction in $\lambda$ of the plane.

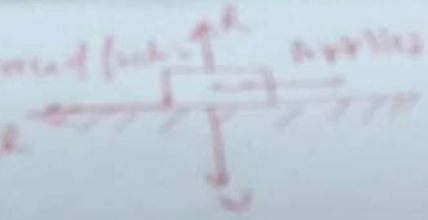
i) If $\theta = \lambda$, the body is just at the point of sliding

ii) If $\lambda > \theta$, the body will topple before slipping.

iii) If $\lambda < \theta$, the body will slip before toppling.

To Find the coefficient of friction ($\mu$) on horizontal plane.

$$\mu = \frac{P}{W} = \frac{F}{R}$$




To find the coefficient of friction ($\mu$) on an inclined plane when the body is at the point of sliding upwards.

For balanced condition

$R = W\cos\theta$

$P = W\sin\theta + \mu R$

$P = W\sin\theta + \mu W\cos\theta$

$$\mu = \frac{P - W\sin\theta}{W\cos\theta}$$