Friction

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It is an opposing force that comes into pla
when one body actually moves or tries to
move over the surface of another body.

Static friction

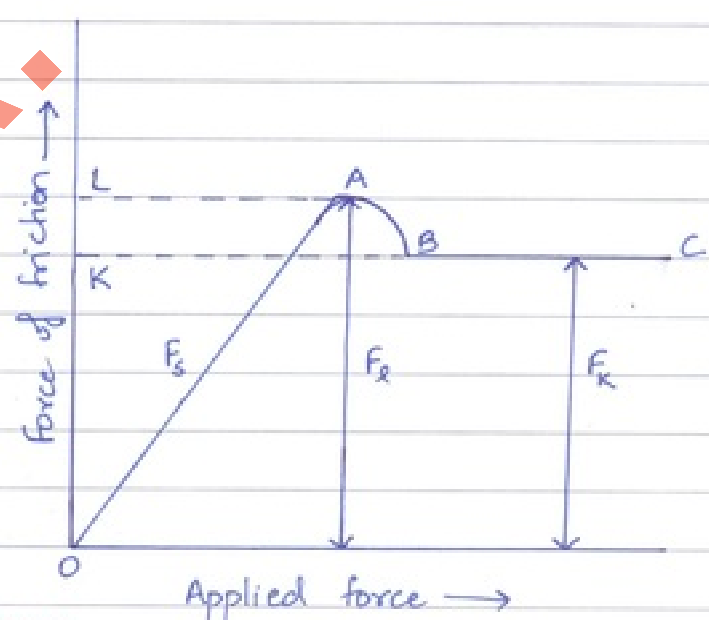
The opposing force that comes into play when one body tends to move over the surface of another, but the actual motion has yet not started is called static friction.

Limiting friction

It is the max. opposing force that comes into play, when one body is just at the verge of moving over the surface of the other body.

Kinetic friction

It is the opposing force that comes into play when one body actually moves over the surface of another body.



curve OA – static friction (F_s)
at A – limiting static friction (F_l)
beyond A – friction reduces slightly
curve BC – kinetic friction (F_k)

Sliding friction

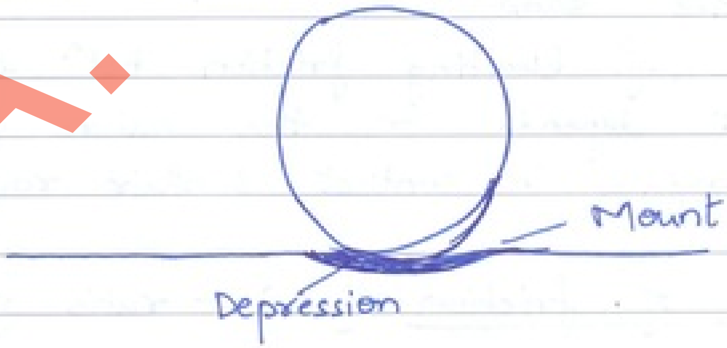
The opposing force that comes into play when one body is actually sliding over the surface of the other body.

Rolling friction

The opposing force that comes into play when one body is actually rolling over the surface of the other body.

Cause of rolling friction

- When a body rolls on a level track, the area of contact is very small.
- So, pressure (Wt./area) is very large.
- This causes a depression in the surface below & a bump in front.



- In turn, the surface of the rolling body in contact gets slightly compressed.
- So, a rolling wheel
(a) constantly pulls out of depression & goes uphill on the mount.

(b) simultaneously detaches itself from the road (which is opposed by the forces of adhesion betⁿ the surfaces in contact.

- This causes rolling friction.

Laws of limiting friction

1. The magnitude of the force of limiting friction betⁿ any 2 bodies in contact is directly proportional to the normal reaction betⁿ them.

$$F \propto R$$

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

μ - coefficient of friction

2. The direction of the force of limiting friction is always opposite to the direction in which the body is moving.
3. The force of limiting friction is independent of the apparent area of contact, so long as normal reaction betⁿ the 2 bodies in contact remains the same.
4. The force of limiting friction betⁿ any 2 bodies in contact depends on the nature of material of the surfaces in contact & their roughness.

Coefficient of friction (μ) - ratio of F & R

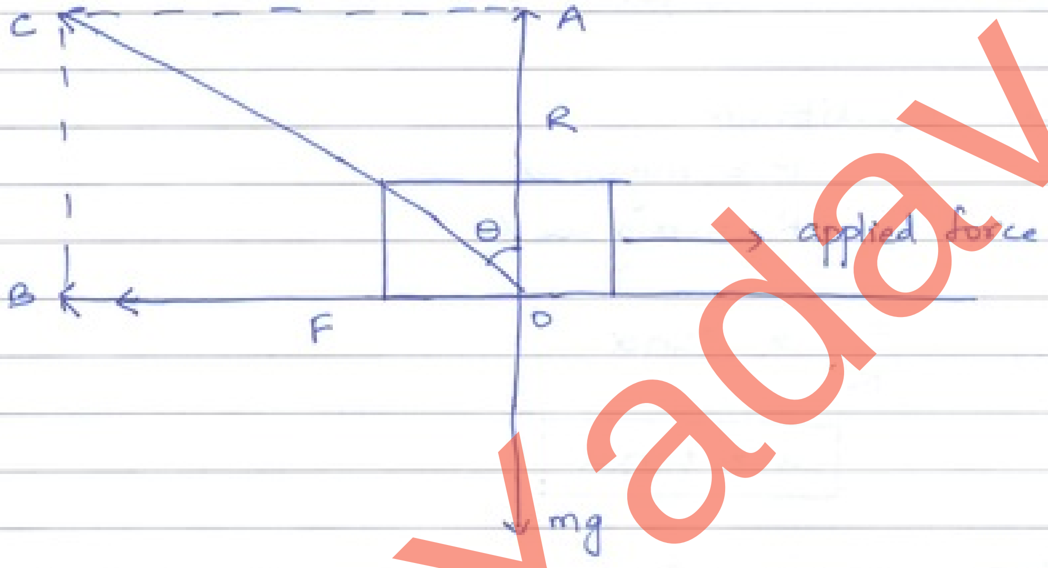
$$\mu = \frac{F}{R}$$

μ depends upon :

(a) nature of the surfaces in contact.
(b) [illegible] " " " " "

Angle of friction (θ)

It is defined as the angle which the resultant of the force of limiting friction (F) and normal reaction (R) makes with the direction of R.



In ΔAOC, $\tan\theta = \frac{AC}{AO}$

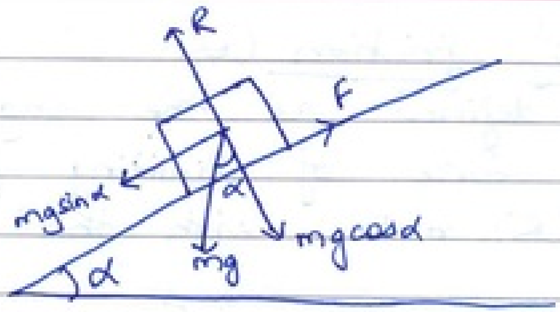
$$\tan\theta = \frac{F}{R}$$

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

$\therefore$ $\boxed{\mu = \tan\theta}$

Angle of repose (α)

It is defined as the minimum angle of inclination of a plane with the horizontal, such that a body placed on the plane just begins to slide down.



In equilibrium

$$F = mg \sin\alpha$$
$$R = mg \cos\alpha$$

so, $\frac{F}{R} = \tan\alpha$

$$\boxed{\mu = \tan\alpha}$$

But $\mu = \tan\theta$

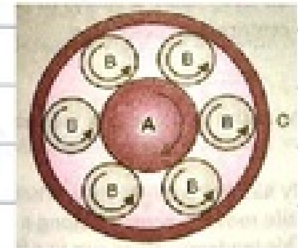
$\therefore$ $\boxed{\theta = \alpha}$

* Read "friction is a necessary evil" & "methods of changing friction" on your own

Ball- bearings

The ball-bearing arrangment consists of :

(i) A & C - co-axial cylinders
(ii) B - hard steel balls betⁿ A & C
(iii) A - fitted on the axle
C - " " " wheel



- When the wheel rotates, it rolls the balls on the axle
- In this way sliding friction is converted to rolling friction which is less.