Marwari College Darbhanga

Subject - Science (Physics)
class - I.Sc. first year (XIth)
Topic - Friction
Lecture Series - 5

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Friction

Frictional force is the opposing force that is created bet^{n} two surfaces that try to move in the same direction or that try to move in opposite directions.

The main purpose of a frictional force is to create resistance to the motion of one surface over the other surface.

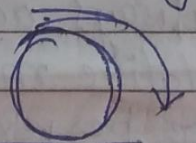
OR

Friction is the property due to which a force is set up at the surface of contact of two bodies preventing any relative motion bet^{n} them.

- Solid friction / external friction
  - (1) Sliding friction
    - (a) Static friction
    - Kinetic / dynamic
  - (2) Rolling friction

(1) Sliding friction → Whenever a body slides or tends to slide over the surface of another body, the friction that is called sliding friction.

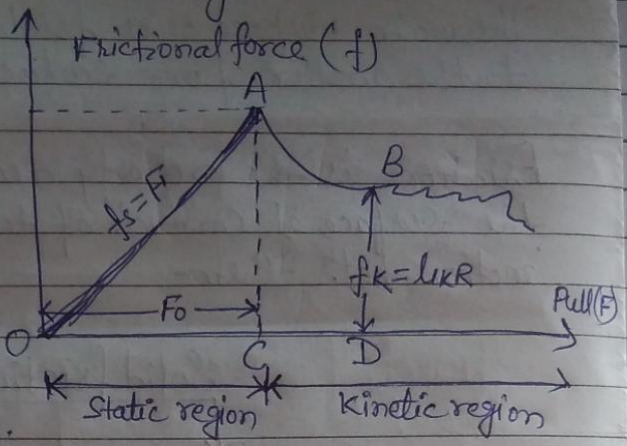
(2) Rolling friction → When a body rolls on a surface, then the force resisting the motion is called rolling friction



(a) Static friction → It is that opposing force which comes (स्थैतिक घर्षण) into play when a body tends to slide over the surface of another body.

OR

(b) Kinetic / dynamic friction → It is that opposing force which comes into play when a body is actually sliding over the surface of another body.



AC = max^{m} Static friction force.
= limiting friction.

f_s = Static friction
f_k = Kinetic friction
f_{ms} = max^{m} force of static friction.

* The force of friction is thus self-adjusting in nature.
i.e, $f_s \leq f_{ms}$

* The kinetic friction (f_k) is thus less than the maximum force of static friction (f_{ms}).
i.e, $f_k < f_{ms}$

Laws of Friction

(a) Static friction

(i) The force of friction always acts in a direction opposite to the direction of relative motion.
i.e, friction is of perverse nature (विकृत प्रकृति).

(ii) The maximum force of static friction (f_{ms}) is directly proportional to the normal reaction (R) bet^{n} the two surfaces in contact.
i.e, $f_{ms} \propto R$

(iii) The force of limiting friction depends upon the nature and the state of polish of the two surface in contact and it acts tangential to the interface bet^{n} the two surfaces.

(iv) The force of limiting friction is independent of the extent of the areas of the surfaces in contact so long as the normal reaction remains the same.

Coefficient of Static friction

$f_{ms} \propto R$ or $f_{ms} = \mu_s R$

$\left[\mu_s = \frac{f_{ms}}{R}\right]$ = Coefficient of static friction.
= Proportionality constant.

* Coefficient of static friction for any pair of surfaces in contact is equal to the ratio of the limiting friction and the normal reaction.

(B) Kinetic friction

The laws of kinetic friction are exactly the same as those for static friction. Accordingly, the force of kinetic friction is also directly proportional to the normal reaction.

i.e, $f_k \propto R$ or $f_k = \mu_k R$

where μ_k = Coefficient of kinetic friction.

or, $\mu_k = \frac{f_k}{R} = \frac{\text{Kinetic friction}}{\text{Normal reaction}}$

* Typical values of Average Coefficients of friction

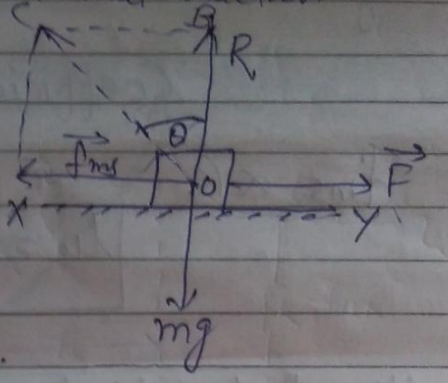
Surface	Coefficient of Static friction (μ_s)	Coefficient of kinetic friction (μ_k)
(1) Wood on wood (dry)	0.25 – 0.5	0.2
(2) Steel on steel (clean surface)	0.74	0.57
(3) Steel on steel (greased)	0.09	0.05
(4) Wood on leather (dry)	0.5	0.4
(5) Rubber on concrete (dry)	1.0	0.8
(6) Rubber on Concrete (wet)	0.7	0.6
(7) glass on glass	0.9 – 1.0	0.4

(*) friction depends on Clearness of the surface, temperature and humidity.

Angle of Friction →

The angle of friction is thus the angle which the resultant of the maximum force of static friction and the normal reaction makes with the normal reaction.

Let us consider a body being moved over a surface xy by applying a pull $\vec{F}$ (force).



mg = weight, R = normal Reaction.

f_{ms} ⟹ max^{m} force of static friction.

θ = Angle of friction.

$$\therefore \tan\theta = \frac{BC}{OB} = \frac{OA}{OB} = \frac{f_{ms}}{R}$$

But, $\mu_s = \frac{f_{ms}}{R} \Rightarrow \mu_s = \tan\theta$

* The coefficient of static friction is thus equal to the tangent of the angle of friction.

Angle of Repose / Angle of Sliding

Angle of repose is thus the angle which an inclined plane makes with the horizontal when a body placed over it just starts sliding down.