

Friction`

Introduction

If we slide or try to slide a body over a surface, the motion is resisted by a Mechanical Interlocking between the body and the surface. This resistance is called friction force.

The force of friction is tangential to the surface and opposite to the direction of relative motion.

Types of Friction

(1) **Static friction** : The tangential contact force that opposes or try to oppose the relative motion between the two surfaces which are relatively at rest is static friction.

(a) If applied force is P and the body remains at rest then static friction $F = P$.

(b) If a body is at rest and no pulling force is acting on it, force of friction on it is zero.

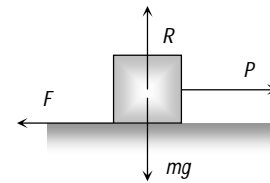


Fig. 5.1

Static friction is a self-adjusting force because it changes itself in accordance with the applied force and is always equal to net external force.

(2) **Limiting friction** : The maximum value of static friction upto which body does not move is called limiting friction.

Static friction is a self-adjusting force as it changes itself in accordance with the applied force and is always equal to net external force when the body is at rest.

If the applied force is increased, the force of static friction also increases. If the applied force exceeds a certain (maximum) value, the body starts moving.

The magnitude of limiting friction between any two bodies in contact is directly proportional to the normal reaction between them.

$$F_l \propto N \text{ OR } F_l = \mu_s N$$

Coefficient of static friction :

(a) μ_s is called coefficient of static friction and is defined as the ratio of force of limiting friction and normal reaction $\mu_s = \frac{F}{R}$

(b) Dimension : $[M^0 L^0 T^0]$

(c) Unit : It has no unit.

(d) Value of μ depends on material and nature of surfaces in contact that means whether dry or wet ; rough or smooth polished or non-polished.

(e) Value of μ does not depend upon apparent area of contact.

(3) **Kinetic or dynamic friction** : If the applied force is increased further and sets the body in motion, the friction opposing the motion is called kinetic friction.

(i) Kinetic friction depends upon the normal reaction.

$F_k \propto N$ or $F_k = \mu_k N$ where μ_k is called the coefficient of kinetic friction

(ii) Value of μ_k depends upon the nature of surface in contact.

(iii) Kinetic friction is always lesser than limiting friction $F_k < F_l \therefore$

$$\mu_k < \mu_s$$

i.e. coefficient of kinetic friction is always less than coefficient of static friction. Thus we require more force to start a motion than to maintain it against friction. This is because once the motion starts actually ; inertia of rest has been overcome. Also when motion has actually started, irregularities of one surface have little time to get locked again into the irregularities of the other surface.

(iv) Kinetic friction does not depend upon the velocity of the body.

(b) **Rolling friction** : When objects such as a wheel (disc or ring), sphere or a cylinder rolls over a surface, the force of friction that comes into play is called rolling friction.

Rolling friction is directly proportional to the normal reaction (N)

μ_r is called coefficient of rolling friction. It would have the dimensions of length and would be measured in *metre*.

Rolling friction is often quite small as compared to the sliding friction. That is why heavy loads are transported by placing them on carts with wheels.

In rolling the surfaces at contact do not rub each other.

The velocity of point of contact with respect to the surface remains zero all the times although the centre of the wheel moves forward.

Friction is a Cause of Motion

(1) While moving, a person or vehicle pushes the ground backwards (action) and the rough surface of ground reacts and exerts a forward force due to friction which causes the motion. If there had been no friction there will be slipping and no motion.

Advantages and Disadvantages of Friction

(1) Advantages of friction

- (i) Walking is possible due to friction.
- (ii) Two body sticks together due to friction.
- (iii) Brake works on the basis of friction.
- (iv) Writing is not possible without friction.
- (v) The transfer of motion from one part of a machine to other part through belts is possible by friction.

(2) Disadvantages of friction

- (i) Friction reduces the efficiency of machine.
- (ii) Friction causes wear and tear of the parts of machinery in contact. Thus their lifetime reduces.
- (iii) Frictional force result in the production of heat, which causes damage to the machinery.

Methods of Reducing Friction

We can reduce friction

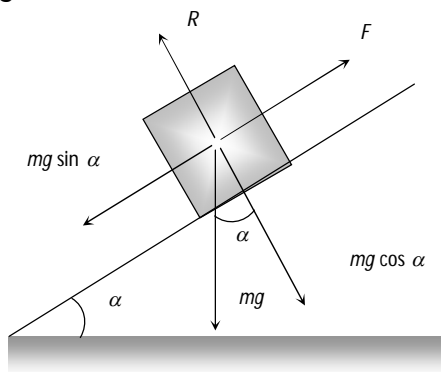
- (1) By polishing.
- (2) By lubrication.
- (3) By proper selection of material.
- (4) By streamlining the shape of the body.
- (5) By using ball bearing.

Angle of Repose

Angle of repose is defined as the angle of the inclined plane with horizontal such that a body placed on it is just begins to slide.

By definition, α is called the angle of repose.

In limiting condition $F = mg \sin \alpha$ and $R = mg \cos \alpha$



$$\text{So } \frac{F}{R} = \tan \alpha$$

$$\therefore \frac{F}{R} = \mu_s = \tan \theta = \tan \alpha \quad \left[\text{As we know } \frac{F}{R} = \mu_s = \tan \theta \right]$$

Thus the coefficient of limiting friction is equal to the tangent of angle of repose.