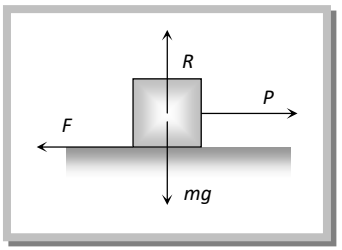
Types of Friction.

(1) **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.



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

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

(iii) Static friction is a self-adjusting force because it changes itself in accordance with the applied force.

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

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

$$F_l \propto R \text{ Or } F_l = \mu_s R$$

(ii) Direction of the force of limiting friction is always opposite to the direction in which one body is at the verge of moving over the other

(iii) Coefficient of static friction: (a) μ_s is called coefficient of static friction and 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_s lies in between 0 and 1

(e) 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.

(f) 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.

$F_k \propto R$ or $F_k = \mu_k R$ 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) Types of kinetic friction

(a) **Sliding friction**: The opposing force that comes into play when one body is actually sliding over the surface of the other body is called sliding friction. *e.g.* A flat block is moving over a horizontal table.

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

❑ Rolling friction is directly proportional to the normal reaction (*R*) and inversely proportional to the radius (*r*) of the rolling cylinder or wheel.

$$F_{rolling} = \mu_r \frac{R}{r}$$

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

a. 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.
b. In rolling the surfaces at contact do not rub each other.
c. The velocity of point of contact with respect to the surface remains zero all the times although the center of the wheel moves forward.