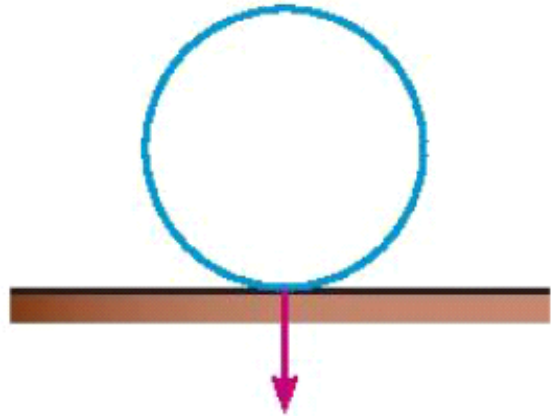
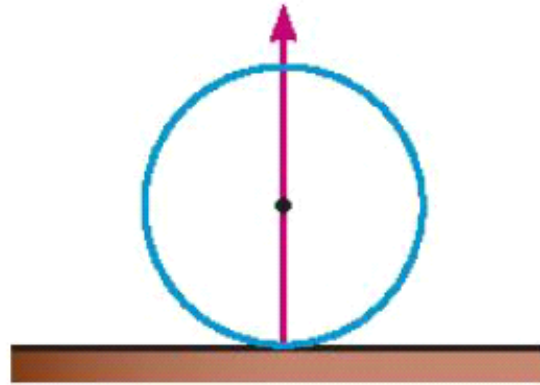


## Reaction:

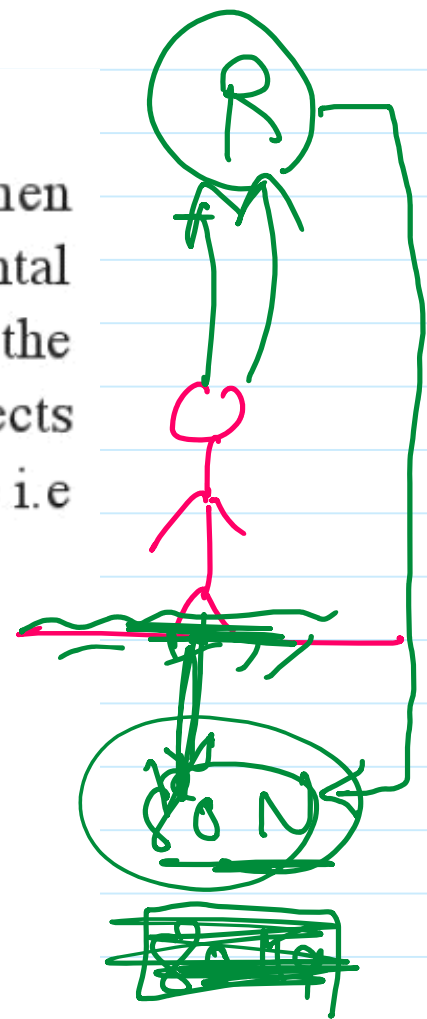
We have previously learned that there is a type of force generated when two bodies touch and it is called reaction. If you place a ball horizontal table, then the ball affects on the table by a force pressure (p) equal the ball weight in this case and the Newton's third law then the table affects the ball by force reaction (r) and equal the pressure ball on the table i.e  $r = p$ .



The pressure affecting the table  
Figure (1)

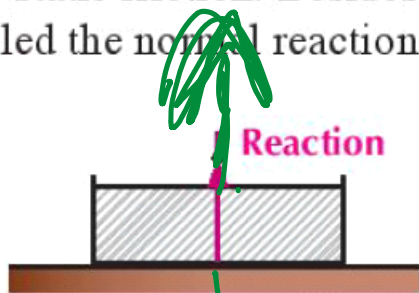


The reaction affecting the ball  
Figure (2)

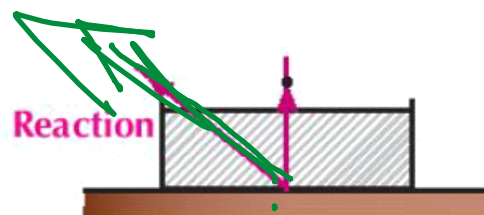


## Smooth and Rough Surfaces

Scientists relate the friction forces among bodies to the presence of microscopic cavities and projections in the surfaces of the bodies whatever their smoothness is. The overlapping of such projections and cavities of the two surfaces in contact produces what is called the friction force. As a result, we can find resistance as we try to move one of the two surfaces against the other, The coefficient of the friction a good scale to measure the roughness degree of the surfaces. If the value of the coefficient of the friction increases, the roughness increases and vice versa. If the coefficient of the friction equals zero, the friction forces are not existed totally. The reaction between the two bodies in contact depends upon the nature of the two bodies and upon the other forces acting on the body in case of the smooth surfaces the reaction is normal to the common tangent plane to the surfaces of the two bodies in contact. On the contrary, when the two bodies are rough, the reaction would have a component in the direction of the tangent surface which is called the static friction. Besides the reaction has a normal component on the tangent surface which is called the normal reaction.



Reaction in case of smooth surfaces  
figure (3)



Reaction in case of rough surfaces  
figure (4)

$$F_s = \mu_s N$$

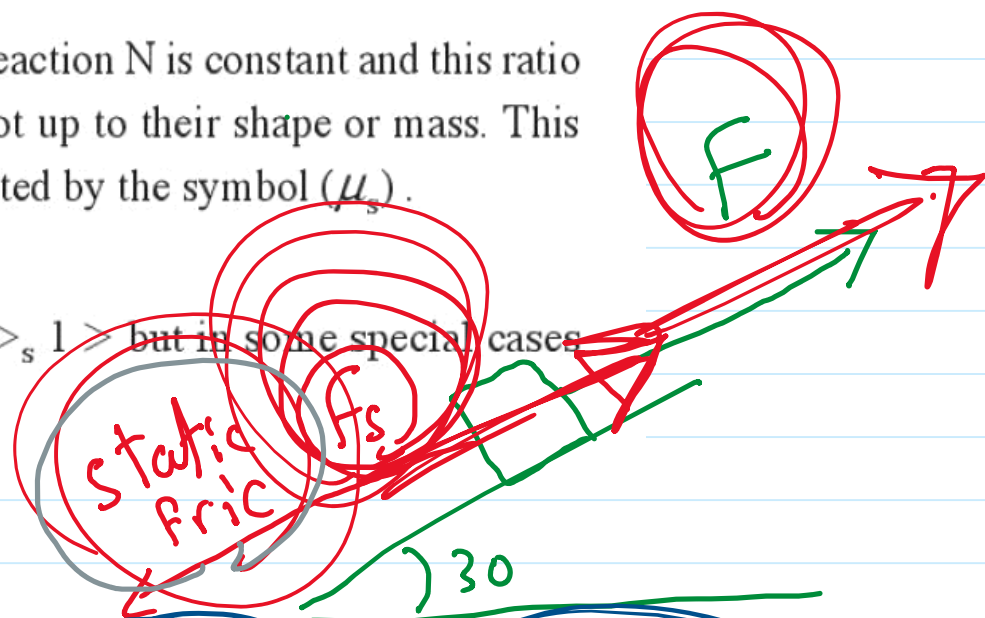
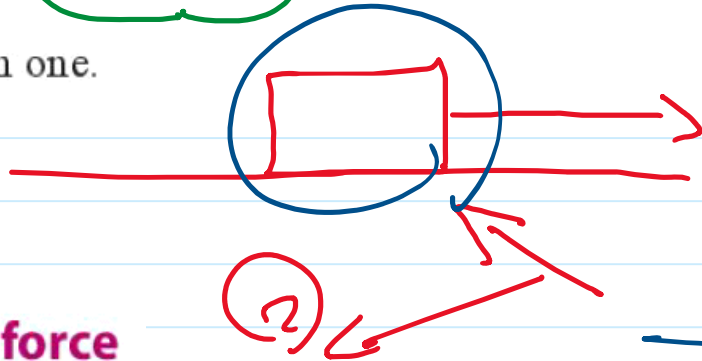
static fric.

## The properties of the static friction force:

- (1) The static friction force ( $F$ ) acts in opposing the slide it is in the opposite direction to the direction which the body tends to slide
- (2) The static friction force ( $F$ ) is only equal to the tangential force which tends to move the body so that it can't be more than such a force and remain equal to the force as long as the body balanced.
- (3) The static friction force ( $F$ ) increases, whenever the tangential force which cause the motion increases until you arrive up to a certain limit which it doesnot exceed it . At such a limit, the body is about to slide in this case, the friction is called the limiting static friction and it is denoted by the symbol ( $F_s$ ).
- (4) The ratio between the limiting static friction and the normal reaction  $N$  is constant and this ratio depends up on the nature of the two bodies in contact but not up to their shape or mass. This ratio is called the coefficient of the static friction and is denoted by the symbol ( $\mu_s$ ).

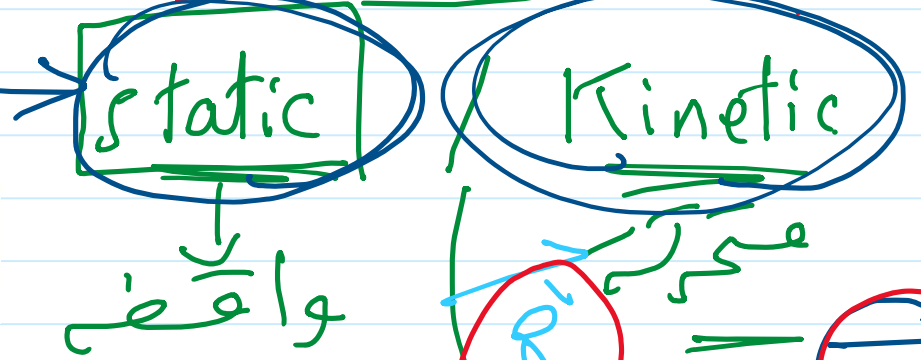
i.e.  $\mu_s = \frac{F_s}{N}$  where  $F_s$  the limiting static friction

**it is noticed** that the static friction coefficient often have  $0 < \mu_s < 1$  but in some special cases it may be more than one.



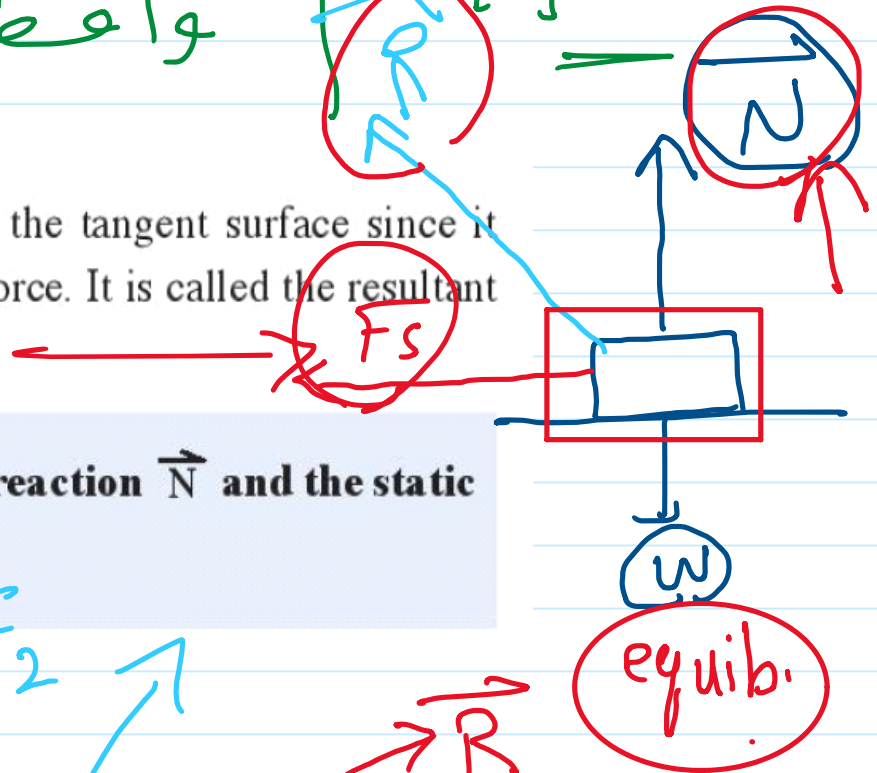
## Kinetic Friction force

i.e.:  $\mu_k = \frac{F_k}{N}$  where  $F_k$  is the kinetic friction force

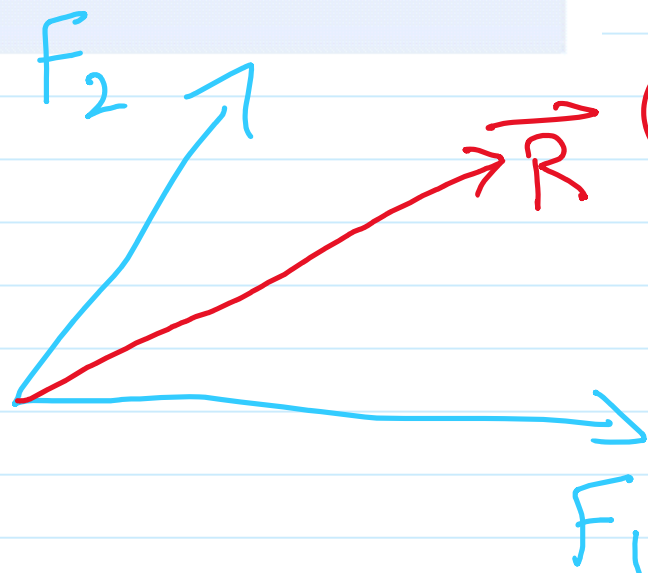


## Resultant Reaction (R')

in case of the rough surfaces the resultant reaction is inclined on the tangent surface since it expresses the resultant of the normal reaction and the static friction force. It is called the resultant reaction.



**Definition** The resultant reaction ( $\vec{R}'$ ) is the resultant of the normal reaction  $\vec{N}$  and the static friction force  $\vec{F}$



equib.

# Equilibrium of a body on a horizontal rough plane\_3

Monday, October 27, 2025 5:16 PM

$$R' = \sqrt{N^2 + F^2}$$

## Angle of Friction

Notes that the measure of the angle included between the normal reaction and the resultant reaction increases as the magnitude of the friction force increases [suppose that the normal reaction is constant] and this value is limiting  $\lambda$  when the friction becomes limiting and this angle in this case called the angle of friction

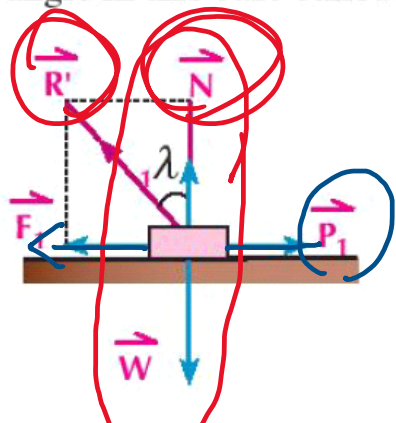


figure (6)

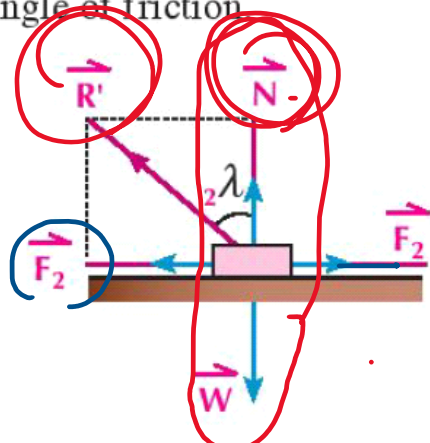


figure (7)

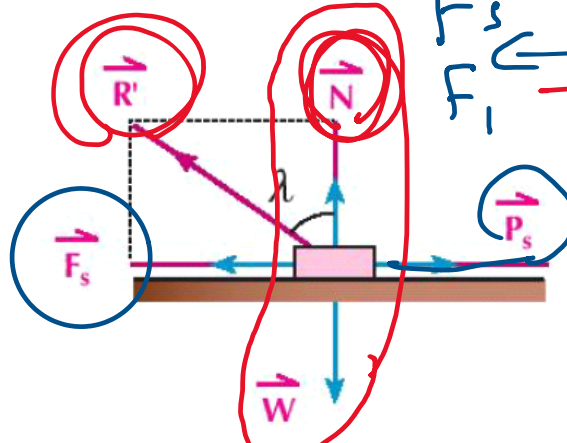
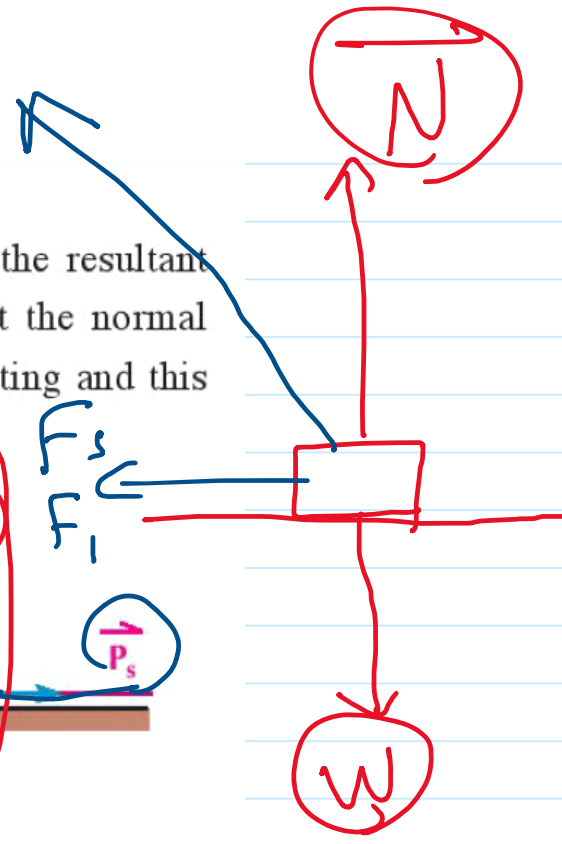


figure (8)



In fig (1) and fig (2) we find: the vector resultant  $\vec{R}'$  is the resultant of the normal reaction  $\vec{N}$  and the friction force  $\vec{F}$ , its magnitude is given by  $R' = \sqrt{N^2 + F^2}$

and in fig (3) when the friction force is limiting we have :

$$\therefore R' = \sqrt{N^2 + F_s^2} \quad \because F_s = \mu_s N \quad \therefore R' = \sqrt{N^2 + N^2 \mu_s^2} \quad \therefore R' = N \sqrt{1 + \mu_s^2}$$

## The relation between coefficient of friction and angle of friction :

in case the friction is limiting as in shown fig (8) :

we find :  $\tan \lambda = \frac{F_s}{N}$  where  $\frac{F_s}{N} = \mu_s$

i.e.  $\mu_s = \tan \lambda$

## Equilibrium of a body on a rough horizontal plane

If a body of weight ( $w$ ) is in equilibrium on a horizontal rough plane and acted upon by a force  $p$  inclined by an angle of measure  $\theta$  with the horizontal fig (9) the body is equilibrium under the action of :

- 1) The weight  $\vec{w}$  which is directed vertically downward
- 2) The resultant reaction  $\vec{R}'$  and its magnitude is  $R'$
- 3) The given force  $\vec{P}$  with magnitude  $P$  as in fig (9)

by resolve  $\vec{P}$  into two components in the horizontal and vertical, direction then their magnitudes are  $P \cos \theta$ ,  $P \sin \theta$ .

and by resolve  $\vec{R}'$  into two perpendicular components which are the normal reaction  $\vec{N}$  and its magnitude  $N$ , and the friction force  $\vec{F}$  and its magnitude  $F$  as shown in fig (10).

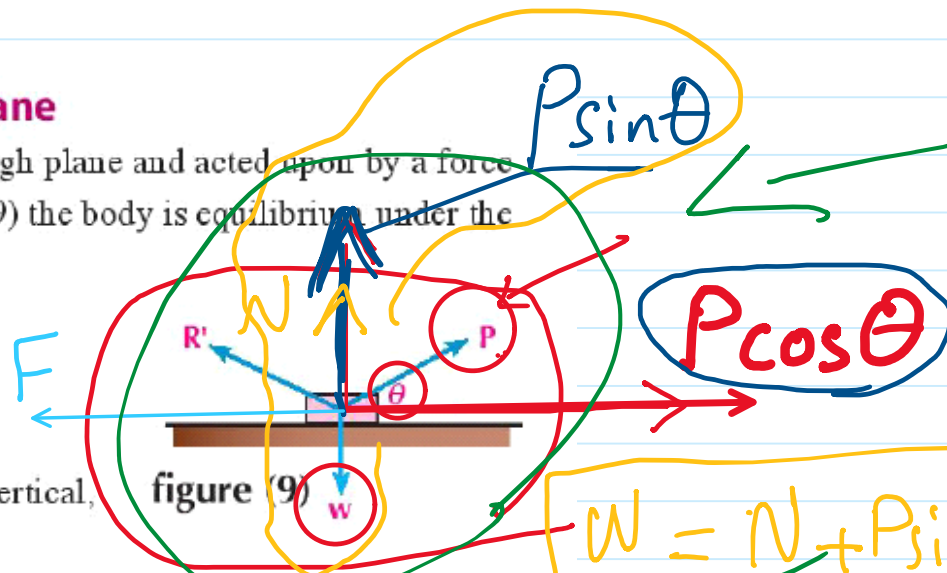


figure (9)

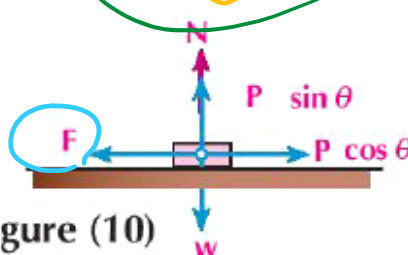


figure (10)

$P \sin \theta$

$P \cos \theta$

$w = N + P \sin \theta$

$F = P \cos \theta$

The equations for equilibrium are :  $F = P \cos \theta$  ,  $N + P \sin \theta = w$

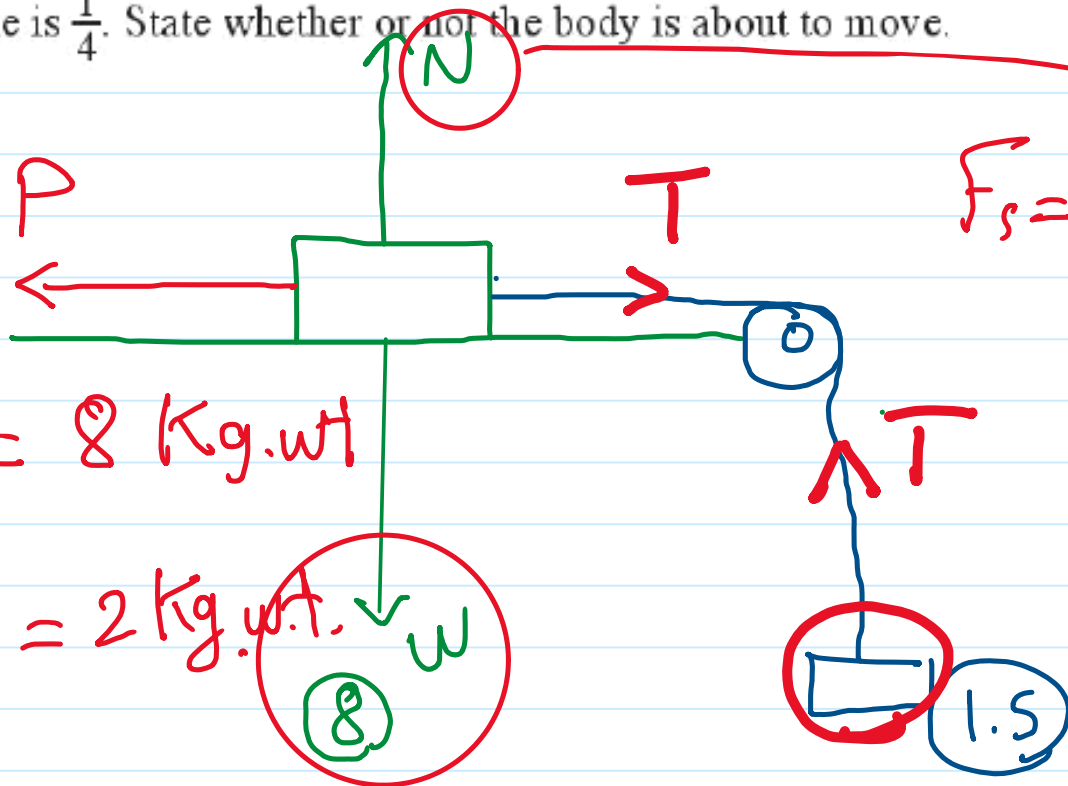
# Equilibrium of a body on a horizontal rough plane\_4

Monday, October 27, 2025 5:16 PM

- 2) A body of weight 8 kg. wt is placed on a horizontal table, and is connected by a string passing over a smooth pulley at the edge, to a weight of magnitude 1.5 kg. wt which is hanging freely and the body is in equilibrium, find the friction force. If the coefficient of friction between the body and the table is  $\frac{1}{4}$ . State whether or not the body is about to move.

$$\mu_s = \frac{1}{4}$$

$$F_s = ?$$



$$F_s = \mu_s \cdot N$$

$$\therefore N = W = 8 \text{ Kg. wt}$$

$$\therefore F_s = \frac{1}{4} \cdot 8 = 2 \text{ Kg. wt.}$$

- 3) A body of weight 12 kg. wt is placed on a horizontal rough plane, two forces act on the body of magnitudes 4, 4 kg. wt and include an angle of measure  $60^\circ$  where the two horizontal forces are on the same horizontal plane. If the body is about to move find the coefficient of friction between the body and the plane also find angle of friction.

$$R = \sqrt{4^2 + 4^2}$$

$$= 4\sqrt{2}$$

