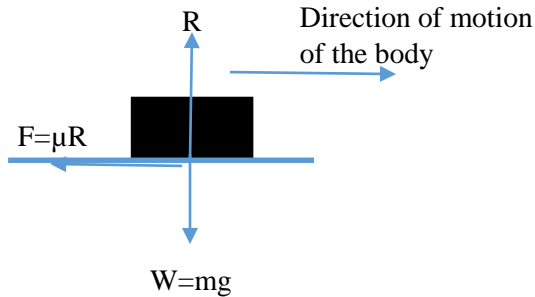


FRICTION

Friction is the force which opposes the relative motion between two surfaces in contact.



Properties (laws) of friction

1. Friction opposes motion of two surfaces in contact
2. Friction depends on the nature of area of surface in contact
3. Limiting friction is directly proportional to normal reaction.
4. Friction is independent of relative velocity of two surfaces in contact if normal reaction is constant.

Coefficient of friction (μ)

Coefficient of friction is the ratio of friction force between two surfaces in contact to the normal reaction.

Friction = coefficient of friction \times normal reaction

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

Coefficient of friction has no units since it is a ratio of forces.

Types of friction

There are three types of friction

1. Static friction
2. Dynamic/kinetic friction
3. Limiting friction

STATIC FRICTION

Static friction is a type of friction between two surfaces in contact which are at rest i.e. not moving.

DYNAMIC/KINETIC OR SLIDING FRICTION

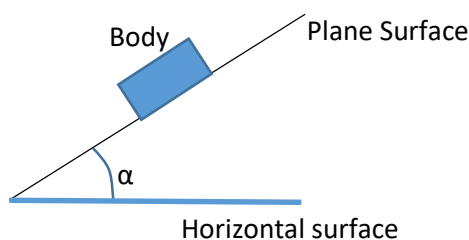
Dynamic friction is a type of friction between two surfaces in contact which are in motion.

LIMITING FRICTION

Limiting friction is the maximum friction between two surfaces in contact before motion occurs.

EXPERIMENT TO DETERMINE COEFFICIENT OF STATIC FRICTION

The experiment is set up as shown below.

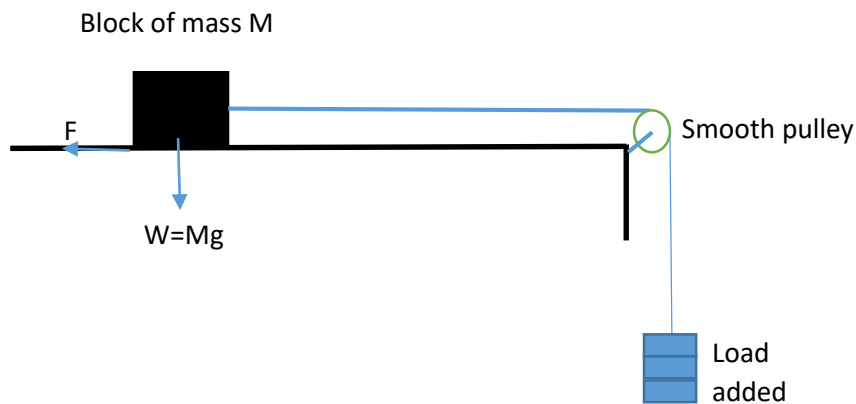


- A body is placed on a plane surface.
- The plane surface is then lifted slowly until the body just starts moving down the plane with constant velocity.
- The angle α between the plane surface and the horizontal is measured using a protractor and recorded.
- The coefficient of static friction is then calculated using the formula: $\mu = \tan \alpha$.
- The experiment may be repeated and the average value is calculated.

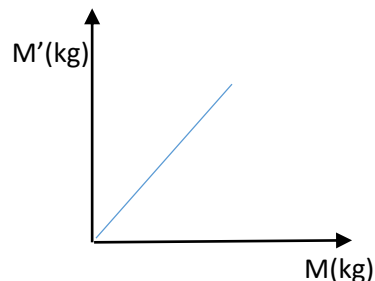
ANOTHER METHOD

EXPERIMENT TO DETERMINE COEFFICIENT OF STATIC FRICTION

The experiment is set up as shown below.



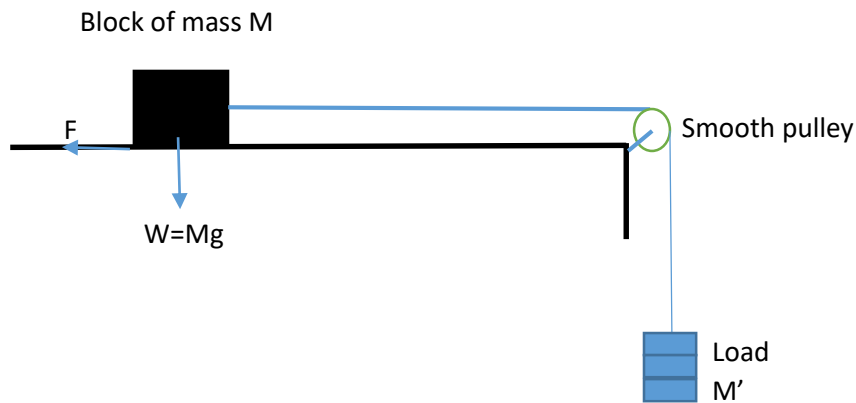
- A block of known mass M is placed on a horizontal table.
- An inextensible string carrying a mass hanger is passed over a smooth pulley at the edge of the table and connected to the block.
- Masses are placed on the mass hanger one at a time until the block starts moving with uniform velocity.
- Total masses M' added together with the mass hanger are recorded.
- The experiment is repeated using different blocks.
- Results obtained are entered in a table and used to plot a graph of M' is plotted against M as shown below.



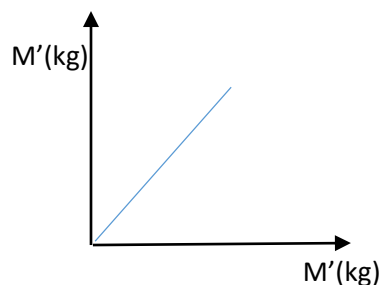
A straight line graph is obtained and its slope is calculated and it is equal to coefficient of static friction.

EXPERIMENT TO DETERMINE COEFFICIENT OF KINETIC FRICTION

The experiment is set up as shown below.



- A block of known mass M is placed on a horizontal table.
- An inextensible string carrying a mass hanger is passed over a smooth pulley at the edge of the table and connected to the block.
- Masses are placed on the mass hanger one at a time.
- The block is given a slight push to see if can start moving with uniform velocity.
- Total masses M' added together with the mass hanger at the point where the block continues to move with uniform velocity are recorded.
- The experiment is repeated using different blocks.
- Results obtained are entered in a table and used to plot a graph of M' is plotted against M as shown below.



A straight line graph is obtained and its slope is calculated and it is equal to coefficient of static friction.

Note

Friction F = Weight of total mass added together with hanger = $M'g$

Normal reaction R = Weight of block used = Mg

$$\text{Coefficient of friction } \mu = \frac{F}{R} = \frac{M'g}{Mg} = \frac{M'}{M} = \text{Slope of the graph of } M' \text{ plotted against } M$$

APPLICATIONS OF FRICTION

Some reasonable amount between moving parts is necessary. It helps in

1. Writing

2. Moving
3. Stopping moving objects
4. Driving nails through wood

UNDESIRABLE EFFECTS OF FRICTION

Friction causes

1. Unnecessary heat and noise
2. Wear and tear of moving parts of machines
3. Wastes energy
4. Reduces efficiency of machines
5. Machines to break down

How to minimize friction in moving parts of machines

1. Use lubricants such as oil and grease.
2. Use rollers
3. Make surfaces smooth