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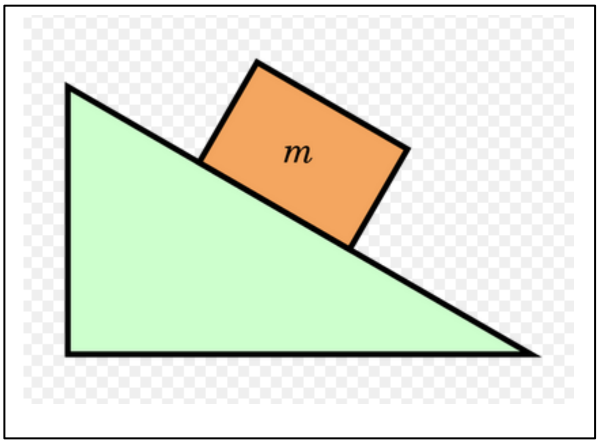
Coefficient of Friction



Key words

- Physics, Math
- Newton's 2nd law
- Friction
- Forces

The science behind

Introducing Newton's 2nd law of motion

Newton's second law refers to the motion of bodies. Provides the link between strength, mass and acceleration. Strength and acceleration are vector quantities. But when it comes to force it refers to the cumulative force (resultant force) as the sum of those forces acting on the body.

$$\vec{F} = m\vec{a} = \sum_i \vec{F_i}$$

Let us consider how the object moves along a given plane and what forces act on it.

When an object is moving down a slope it is moved under the action of the

the force of gravity

$$\vec{G} = m\vec{g}$$

Between the object and the surface occurs friction force that depends on the roughness of the surface and the roughness of the object.

The resistance that one surface or object encounters when moving over another is called **Friction.**

The force of friction is calculated with the equation:

$\overrightarrow{F_f} = \mu\overrightarrow{F_n}$ (Consequence of Newton's third law)

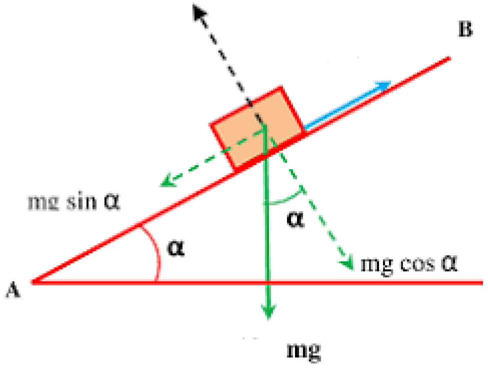
where : **μ** is friction coeficient and depends on the roughness of the surface of the slope a

F_n is a force that acts normally on the surface.

The friction force has an opposite direction from the direction of the moving object.

- **Vectors** are geometrical entities that have magnitude and direction. A vector can be represented by a line with an arrow pointing towards its direction and its length represents the magnitude of the vector. Therefore, vectors are represented by arrows, they have initial points and terminal points.
- **Force is a vector** quantity; its units are newtons, N.Thats why all mathematical operations for vectors they apply. Vector quantities have both magnitude and an associated direction. This makes them different from scalar quantities, which just have magnitude.

Calculate the coefficient of friction μ



$$\vec{F} = m\vec{a} = \sum_i \vec{F_i}$$

$$\vec{G} = m\vec{g}$$

$$\vec{G_x} = m\vec{g_x} = m\vec{g}\sin\alpha = \vec{G}\ \sin\alpha$$

$$\vec{G_y} = m\vec{g_y} = m\vec{g}\cos\alpha = \vec{G}\ \cos\alpha$$

To solve this, we will start from Newton's Second Law which in our example is:

$$\vec{F} = m\vec{a} = 0 = \sum_i \vec{F_i} = \vec{F_n} + \vec{F_f} + \vec{G}$$

We consider the movement in two dimensions (according to the given data):

- **Normal component** (normal to the ground, no movement, no acceleration)

According to Newton's Third Law it follows (from the Drawing):

$$\vec{F_n} = \vec{G_y} = m\vec{g_y} = m\vec{g}\cos\alpha = \vec{G}\ \cos\alpha$$

$$\boldsymbol{\vec{G} = \frac{\vec{F_n}}{\cos\alpha}}$$

- **Parallel component** (parallel to the ground, no movement no acceleration, that is the moment before the movement starts)

$$0 = \sum_i \vec{F_i} = \vec{F_f} + \vec{G_x}$$

$$F_f = -G_x = -mg\sin\alpha = -G\ \sin\alpha = -\frac{F_n}{\cos\alpha}\sin\alpha = -\tan\alpha\ \ F_n$$

$$\boldsymbol{F_f = -\mu_s F_n}$$

where $\boldsymbol{\mu_s = \tan\alpha}$ is a **static coefficient of friction** and is determined at the moment when the body begins to move along the plane

There are two main types of friction.

- Static Friction
- Kinetic Friction

Static Friction	**Kinetic Friction**
Static friction is the friction present between two or more objects that are not moving with respect to each other	Kinetic friction is the friction present between two or more objects that are in motion with respect to each other.
The magnitude of static friction is greater due to the greater value of its coefficient	The magnitude of the kinetic friction is comparatively lesser due to the low value of its coefficient
The equation representing static friction is given by $F_s = \mu_s F_n$ where, • F_s is the force of static friction • μ_s is the coefficient of static friction • F_n is the normal force	The equation representing kinetic friction is given by $F_k = \mu_k F_n$ where, • F_k – force of kinetic friction • μ_k - coefficient of kinetic friction • F_n –normal force

Kinetic friction is of two types; sliding and rolling. Rolling friction is less than sliding friction. This is the reason why rolling a body is always easier than sliding a body.

Rolling friction is the resistive force that slows down the motion of a rolling ball or wheel. It is also called ***rolling resistance***.

Sliding friction is defined as the resistance that is created between any two objects when they are sliding against each other.

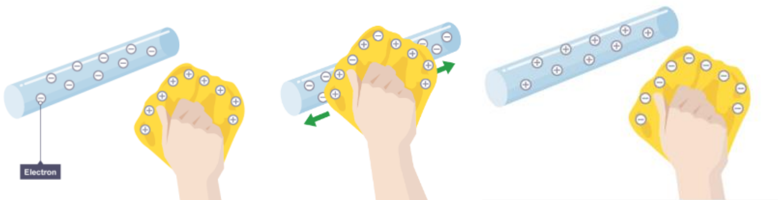
Static friction have greater value than the kinetic friction because static friction acts when the body is at rest. And there is much more inter molecular attraction between the object and the surface for a long time which is required to be overcome first.

Every day life

Practical example

While driving vehicles and riding bicycles, friction occurs between the wheels of the vehicle and the surface over which the vehicle is traversing. The coefficient of friction determines the "stickiness" between two objects. If the friction is zero, the vehicle would fail to move forward. It is only because of friction that we are able to stop our vehicle.

Static electricity When insulating materials rub against each other, they may become electrically charged. Electrons, which are negatively charged, may be 'rubbed off' one material and on to the other. The material that gains electrons becomes negatively charged. The material that loses electrons is left with a positive charge.



Balloon Party Trick The balloon party trick involves the deposition of charges on the outer surface of the balloon by rubbing it against a person's hair. After developing a considerable amount of charge on its surface, the balloon easily sticks to any surface containing the opposite charge or no charge. This interaction between the two bodies is nothing but electrostatic interaction.

Charged Comb After we finish combing our hair, we unintentionally deposit a significant amount of charge on the teeth of the comb. When this charged comb is subjected to some lighter particles such as bits of paper, it causes the paper particles to get attracted to the comb. This process is a clear demonstration of electrostatic force existing between the comb and the paper particles.

Doorknob When a person randomly touches a metallic doorknob, he/she is prone to feel a short-term electric shock. This is due to the existence of electrostatic force between the doorknob and the person's hand. Since the door nob is made up of metal, it is capable of transferring the electrons to every object that comes in contact with it.

Some examples of the force of gravity include:

- The force that holds the gases in the sun.
- The force that causes a ball you throw in the air to come down again.
- The force that causes a car to coast downhill even when you aren't stepping on the gas.
- The force that causes a glass you drop to fall to the floor.
- The force that keeps the Earth and all of the planets in line in the proper position in their orbits around the sun.
- The force that propels a toddler down a slide.
- The force that causes the moon to revolve around the Earth.
- The force that keeps Jupiter's moons located around the planet.
- The force from the moon that causes the tides of the ocean.
- The force that causes your drink to rest at the bottom of your glass instead of hovering near the top of your glass.
- The force that causes an apple to fall downward from an apple tree.
- The force that keeps you walking on Earth instead of floating away into space.
- The force that causes a pen that rolls off of your desk to fall onto the floor.
- The force that causes a piece of paper that is blowing in the wind to eventually come back down to Earth.
- The force that causes a balloon that is out of helium to come back down to the ground.
- The force that causes a jump rope to come back to the ground after you swing it over your head.
- The force that causes a lock of your hair to fall to the floor after it has been cut off.
- The force that causes a rock to roll downhill.

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Project code: 2021-1-FR01-KA220-SCH-000027775