

Physics: SS1 First Term

WEEK 5: Motion(ii): Force and Friction

Force

Definition of Force

Force can be defined as that which changes or tends to change the state of rest or uniform motion of a body. Force is a vector quantity and the S.I unit is Newton.

Force can cause a body at rest to move, it causes a moving object to accelerate, change direction, move in a curved path e.t.c.

Types of Forces

There are two types of forces, namely **contact force** and **force field**. Contact force is a force that exists between bodies by virtue of their contact. They are push, pull, normal reaction, tension in strings, wires or frictional force.

Force field/Non-contact force is the force that exists within a vector field such as gravitational field, magnetic field, Electric field, nuclear field. The forces are gravitational force, magnetic force, electrostatic force and nuclear force.

Gravitational force

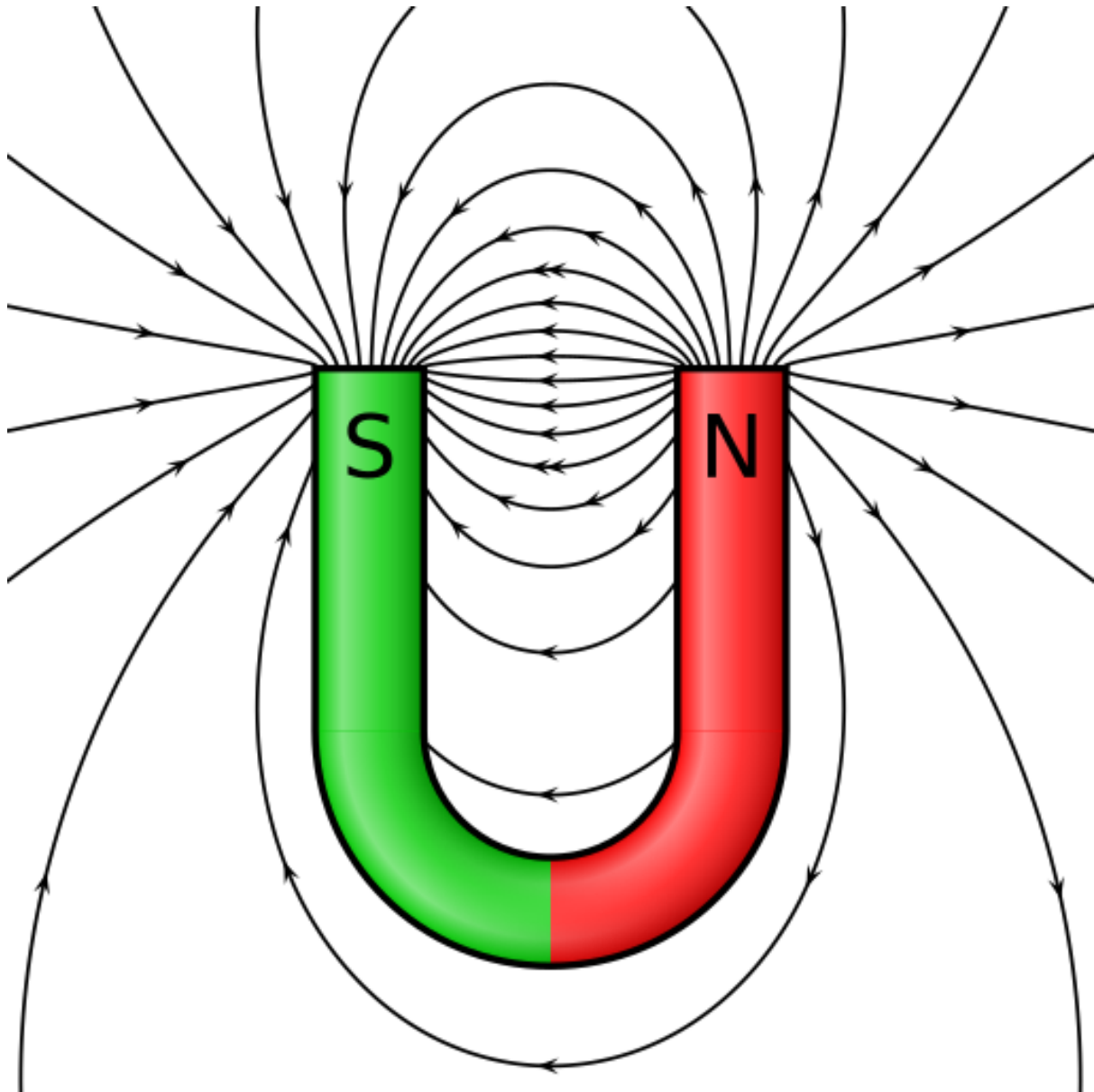
This is the force of attraction with which a planet attracts any object towards its centre or the force of attraction between any two masses. The earth is a gravitational field.

Electrostatic force

This is a force that exist round a charged body. The charged body could be positively charged or negatively charged.

Magnetic force

This is a force that exist around a magnet. A magnet always have the North pole and the South pole



Nuclear force:

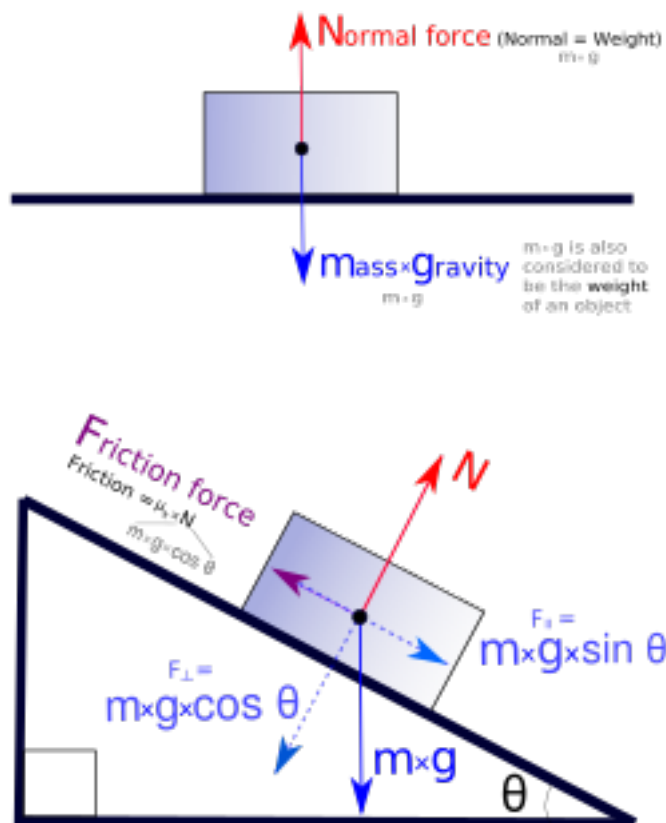
This is the force of attraction which holds the protons and neutrons in the nucleus of an atom.

Friction

Definition of Friction

Friction can be defined as the force that opposes the relative motion between any two surfaces in contact. There can be solid friction or fluid friction. Fluid friction is also called viscosity.

It acts whenever there is motion or tendency for something to move. i.e friction (or frictional force) is absent if there is no motion or if there is no force intending to cause motion. It stops your car when the brake is applied. It prevents your foot from slipping backward when you walk.



Types of Friction

There are two types of frictional force

1. **Static friction:** This is the frictional force that exists between two surfaces relatively at rest and preventing the motion of one surface over the other.
2. **Dynamic/kinetic friction:** This is the frictional force that exists between the two objects that are in relative motion to each other.

EVALUATION

1. What is force?
2. List the two types of forces and differentiate between the two.
3. What is friction?
4. Differentiate between static friction and dynamic friction.

The Laws of Solid Friction

1. It always opposes motion
2. It depends on the nature of surfaces in contact. Friction between rough surfaces is greater than the frictional force between smooth surfaces.
3. It does not depend on the relative speed between the two surfaces.
4. It does not depend on the area of the surface in contact.

It is directly proportional to the perpendicular force (normal reaction) between the two surfaces. (**R** is the perpendicular force between the two surfaces in contact)

$$F \propto R$$

$$F = \mu R$$

F – Frictional force, R – normal reaction, μ – coefficient of static friction

Note that $R = W$ for bodies on horizontal surfaces

Coefficient of friction

It is defined as the ratio of the frictional force to the normal reaction force between two surfaces. A high coefficient of friction implies that a large force is required to cause movement.

Question: A crate solid down an inclined plane such that the frictional force opposing its motion is 40N. If the normal reaction of the plane on the crate is 50N, calculate the coefficient of dynamic friction.

Solution: Frictional force $F = 40\text{N}$

Normal reaction $R = 50\text{N}$

Coefficient of friction $\mu = ?$

$$F = \mu R$$

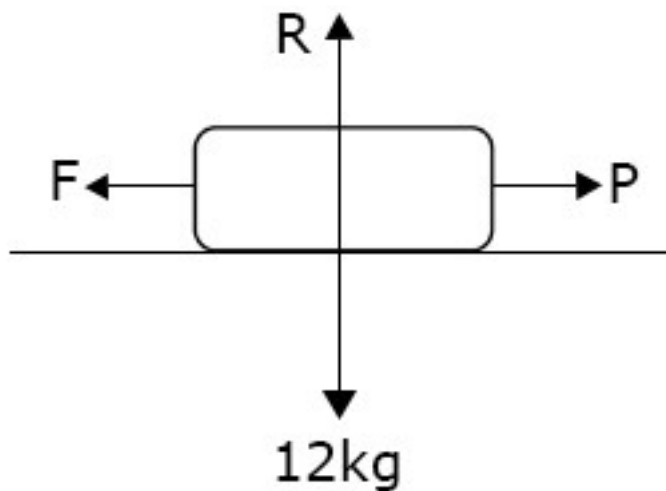
$$40 = \mu \times 50 \quad (\text{dividing both sides by } 50)$$

$$4050 = \mu$$

$$\mu = 0.8$$

$$\mu = 0.8$$

Question B. A block of mass 12kg rests on a horizontal floor, coefficient of friction is 0.35. Determine the minimum force required to move the block when pulling horizontally. ($g = 10\text{m/s}^2$)



Solution

$$W = mg = 12 \times 10 = 120\text{N}, \quad W = R = 120\text{N}$$

Where W – weight of the body, m – mass of the body, g is acceleration due to gravity and R is the normal reaction

$$F = \mu R$$

$$F = P = \mu R = 120 \times 0.35 = 42.0\text{N}$$

Question C. A metal block of mass 5kg lies on a rough horizontal platform. If a horizontal force of 8N applied to the block through its center of mass just slides the block on the platform. Calculate the coefficient of limiting friction between the block and the platform. ($g = 10\text{m/s}^2$).

Question D. A wooden block whose weight is 50N rests on a rough horizontal plane surface. If the limiting friction is 20N. Calculate the coefficient of static friction.

EVALUATION

1. Mention at least four characteristics/laws of solid friction.
2. A body of mass 40kg is given an acceleration of 10ms^{-2} on a horizontal ground for which coefficient of friction is 0.5. Calculate the force required to accelerate the body. ($g = 10\text{m/s}^2$).

Advantages and Disadvantages of Friction

Advantages of Friction (or Desirable Effects of Friction)

1. **Locomotion:** when we walk, friction between our shoes and the ground prevents our shoes from slipping backward.
2. **Enhances fastening:** friction between the bolt and the nut enhances their fastening ability. The friction between nails and wood also help the nail to hold woods together in firm position.
3. **Blending:** friction between the grinding stones helps in grinding pepper, tomatoes, this is also true of the friction between the two rough discs of the grinding machine.
4. **Stops motion:** friction between the car tyre and the road helps to stop the motion of a moving car when the brake is applied.
5. **Production of electric charge:** when certain materials are rubbed against each other, static electric charges is produced. This principle is applied in the Van de Graff generator.
6. **Ladder:** when a ladder to be used to climb over a wall rest on the wall, friction between the foot of the ladder and floor prevent the foot of the ladder from slipping.
7. **Making of fire:** matches sticks are ignited when they are rubbed against the side of the matches' box. Fire can also be made by striking two stones together.

Disadvantages of Friction (or Undesirable Effects of Friction)

1. **Wearing:** The tread pattern under your footwear soon wear out after a prolong use due to friction. This is also true of the tread on the tyre of cars and other automobile.
2. **Tearing/cutting:** you can easily cut a piece of rope or cloth by rubbing it repeatedly against the edge of the wall.
3. **Reduces efficiency of machines:** all machines have efficiency less than 100% due to friction between their moving parts. Friction causes waste of useful energy, therefore it reduces the output of the machine.

4. **Generation of undesirable heat and noise:** moving machine parts/machine itself soon becomes hot due friction and this may necessitate cooling of machine parts.

Methods of Reducing Friction

Due to the disadvantages of friction mentioned above, it is often necessary to reduce friction in machines. This is possible through any of the following methods:

1. **Lubrication:** this is the use of certain substances (called lubricants) to reduce the effects of friction. Examples of lubricants includes, grease, oil,... many of which are petroleum products.
2. **Streamlining:** This involves shaping an object in such a way that when the object is moving against direction of the wind or liquid, the surface in contact is minimal. That is the reason why ships, aircraft and submarines are made or designed after that of fish.
3. **Use of rollers/ball bearings:** This involves the use of rollers , ball bearings, wheels to reduce the surface area in contact between two surfaces.
4. **Use of belt/chain drive:** This can also be used to prevent two surfaces in contact.
5. **Smoothing/polishing:** This reduces projections on the surface thus reducing friction.