Unit:- 4 Work And Friction

Work:- Work is said to be done if a force acting on a body displaces the body to a certain distance and the force has some components along the displacement.

Work done is define as the dot product of force and displacements.

$W = \vec{F} \cdot \vec{s}$

$= FS\cos\theta$ ——— (i)

where, θ is the angle between direction of force and direction of displacement, Since work is the dot product of two vectors it is a scalar quantity.

Special Cases:-

1) positive work:-

If $\theta = 0°$

$\Rightarrow \cos\theta = 1$

$\Rightarrow W = FS$ ——— (ii)

When the force and displacement are in same direction work done is positive.

This work is said to be done upon the body.

Examples:- (i) Engine of a car exerts a force on the car in the direction of propagation. This work done by the engine is positive.

(ii) A Body falling freely under the action of gravity has positive work done by the gravitational force.

2) Zero Work:-

If $\theta = 90°$

$\Rightarrow \cos\theta = 0$

$\Rightarrow W = 0$ ——— (iii)

When the force acts in a direction at right angle to the direction of displacement, no work is done.

Examples:- (i) A student sitting on a chair and studing a book does no work since their is no displacement.

(ii) When a body is displaced along a horizontal surface, no work is done by it weight

force & is always perpendicular to the displacements.

(iii) Negative work:-

If $\theta = 180°$

$\Rightarrow \cos\theta = -1$

$\Rightarrow W = -FS$ ——(iv)

When force and displacement are in opposite direction, work done is negative. This work is said to be done by the body.

Eg:- (i) When two similar charges approach each other, they repel each other, in this case force and displacement are opposite to each other. Therefore the work done is negative.

Dimensions:- $[M^1L^2T^{-2}]$

unit of work:-

(a) S.I unit :- Joule.

1Joule = 1N × 1M = 1kg m²/sec²

Joule:- work done is said to be 1 Joule if a force of 1 Newton displaces a body to a distance of 1 metre along the direction of force.

b) C.G.S :- erg

1 erg = 1 dyne × 1 cm = 1 gm cm²/sec²

1 erg :- work done is said to be 1 erg if a force of 1 dyne displaces a body to a distance of 1 cm along the direction of force.

Relation Bet^n Joule and erg :-

1J = 1N × 1M

$= 10^5$ dyne × 10^2 cm ($\because$ 1N = 10^5 dyne)

$= 10^7$ dyne × cm.

$1\ J = 10^7\ erg$ —— (v)

Friction:-

Whenever a body tends to slide over another surface an opposing force called force friction comes into play. The force of friction is found to depend upon the following factors:-

(i) The nature of two surfaces in contact with each other.

(ii) Actual area of contact.

There are Three Types Of friction:-

(i) Sliding friction.

(ii) Rolling friction.

(iii) Fluid friction.

(i) Sliding Friction:-

The Force of friction which comes into play between two surfaces-when one tends to slide over the other is called sliding friction.

(ii) Rolling friction:-

The force of friction which comes into play between two surfaces while one is rolling over the other is called rolling friction.

(iii) Fluid friction:-

Fluid Friction is the opposing force which comes into play when a body moves through a fluid.

Another classification of friction is:-

(i) Static friction.

(ii) Dynamic friction.

(i) Static friction:- It is the force of friction between two surfaces so long as their is no ~~relation~~ relative motion between them. Static friction is always equal to the Applied force.

(ii) Dynamic friction:- It is the force of friction which comes into play betⁿ two surfaces when their is some relative motion between them.

Limiting friction:- # It is the maximum value of force of friction between two surface so long as their is no relative motion betⁿ them.

If applied force becomes more than the limiting friction, then the body starts moving.

Laws of Limiting friction:-

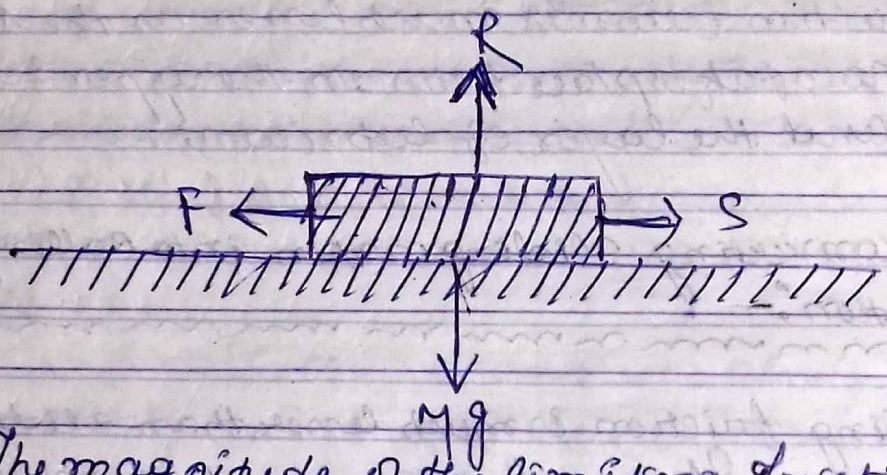
Statement about factors upon which the force of limiting friction of two surfaces depends are termed as laws of limiting friction.

They are stated below:-

(i) The direction of force of friction is always opposite the direction of motion.

(ii) The force of limiting friction depends upon the nature and the state of polish of the surface in contact and acts tangential to the interface between the two surfaces.

(iii) The magnitude of the limiting force of friction is directly proportional to the magnitude of the normal reaction 'R' between the two surfaces in contact. i.e.g $F \propto R$.



(iv) - The magnitude of the limiting friction between two surfaces is independent of the area and shape of the surfaces in contact so long as the normal reaction remains the same.

Coefficient Of Friction:-

* Coefficient of friction of a pair of surfaces in contact is defined as the ratio between the force of limiting friction 'F' to the normal Reaction 'R'. It is denoted by μ.

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

Methods Of Reducing friction:-

Friction can be reduced if we try to remove the cause of friction.

(i) By rubbing and polishing:-

* By rubbing the irregularities on the surfaces are smoothened thus reduces the friction.

(ii) By Lubricant :- A lubricant is an oil or a grease which when spread over the surfaces fills the irregularities and forms a thin layer between them. Thus the friction becomes much lesser as the sliding now takes place between the upper surface and the layer of lubricant.

(iii) By converting Sliding motion into Rolling motion :-

* Rolling friction is much lesser than sliding friction : Sliding friction can be converted into Rolling friction by means of a system known as ball bearing system. A number of steel balls are inserted between the cycle and the wheel which reduces the force of friction by considerable amount.

(iv) By Streamlining :-

As a body is driven through fluids, fluid friction depends upon the shape of the body. It is minimum for a shape known as stream-lined shape. This shape is a pinpointed one, that is why ? All high speed bodies, Aeroplanes, rockets, etc. have pinpointed.