LAWS OF MOTION

COMMON FORCES IN MECHANICS

Common Forces in Mechanics

Study of Mechanics involves various forces which are classified into contact or non-contact forces which are further classified into Gravitation, Friction, Spring Force, and Tension.

Common Forces in Mechanics are those forces that are experienced by every single object on the earth. The most important of them is the gravitational force. This force is responsible for the controlling of planets in our galaxy as well as inside earth without any apparent contact. In addition to gravitational force, there are other forces which to act upon are the mechanical forces. These forces majorly include the frictional force, tension, spring force. The common forces in mechanics are also known as contact forces as they arise when one object is in contact whether it is solid or liquid.

We know that contact forces arise when two bodies are in contact irrespective of their state of matter (ie. e solid/fluid). Bodies in contact (e.g. a book resting on a table, a system of rigid bodies connected by hinges), mutual contact forces (for each pair) satisfies Newton's third law i.e Every action has an equal and opposite reaction. A normal reaction is said when the component of the contact force is perpendicular to the surface in contact. The component of the contact forces which is parallel to the surface is called the frictional force/ friction.

When a solid object is submerged in a fluid medium, there is an upward force that becomes equal to the weight of the fluid being displaced, this is also known as the buoyant force or buoyancy. The viscous force of the fluid or the air resistance examples of the common contact forces

Two other common forces include the tension force or tension in a string and the spring force. The different contact forces of mechanics fundamentally arise from electrical forces. This may seem surprising as we are talking about the uncharged and non-magnetic bodies in mechanics. But at the microscopic level, everybody is made up of charged particles which are the protons and electrons and the various other contact forces arising due to their elasticity, molecular collisions, etc. can therefore be traced to the electrical forces between the charged particles of the different bodies. The microscopic origin of these forces is complex and is not useful for handling issues in mechanics at the macroscopic scale. Hence they are treated as different types of forces with their empirical characteristic properties.

To understand the concept of the common forces in mechanics let us take a look at the different forces :

Friction

Let us take a body of mass m, resting on a horizontal table. The normal reaction force (N) of the table cancels the force of gravity (mg). We assume a force F is applied in the horizontal direction to the body. A smaller magnitude of the applied force may not be adequate to move the body. If the applied force F is the only external force acting on the body, it should move with an acceleration F/m irrespective of how small it is.

The body continues to be at rest as another force comes into play horizontally and opposite to the applied force F, resulting in a net force of zero on the body. This force fs which acts parallelly to the surface of the body in contact with the tabletop is called the frictional force or friction.

If the applied force F is increased, fs also increases as it is equal and opposite to the applied force to a certain limit to keep the body at rest. Hence, it is known as static friction. Static friction opposes the impending motion. The motion that would have taken place ideally under the force applied if frictional force remains absent is known as the impending motion.

We know that if the applied force crosses a certain limit, the body starts to move. Experimentally it is found that the limiting value of static friction $(f_s)_{max}$ is not dependent on the area of contact and therefore varies with the normal force(N) approximately as :

$(f_s)_{max} = \mu_s N$ …… (1)

μ_s = constant of proportionality which depends upon the nature of the surfaces in contact. The coefficient of static friction is expressed as μ_s. The law of static friction can be written as $f_s \leq \mu_s N$ …… (2).

If the applied force F goes beyond $(f_s)_{max}$, the body starts to slide on the surface.

Experimentally it is found that when the relative motion starts, the frictional force decreases from the static maximum value $(f_s)_{max}$.

The frictional force that acts opposite to the relative motion between surfaces in contact is known as kinetic or sliding friction, denoted by FK. Kinetic friction, like static friction, is independent of the area of contact and velocity. The law of kinetic friction is similar to that for static friction:

$F_K = \mu_k N$ ……(3)

μ_k = coefficient of kinetic friction, depending on the surfaces in contact. Experiments show us that μ_k is less than μ_s.

When relative motion begins, the acceleration of the body according to Newton's second law (i.e. the rate of change of momentum directly is proportional to the applied force and occurs in the direction in which the force acts) is $(F - F_K)/m$.

When a body is moving with constant velocity, F = FK. If the applied force is removed, its acceleration becomes $-F_K/m$ and the body eventually comes to a stop.

Friction is defined as the component of the contact force which acts parallel to the surfaces in contact opposing the impending or the relative motion between the two surfaces.

Spring Force

When spring is extended or compressed by a force from outside, there occurs the generation of a restoring force. This force is proportional to the compression or elongation in cases of small displacements. The spring force F is written as $F = – kx$ where $x =$ displacement and $k =$ force constant. The negative sign implies that the force is opposite to the displacement which took place from the unstretched state. The higher the ability of a string to be inextensible, the higher is the force constant. Spring is an item that is used in day-to- day lives. It is assumed to be massless as its inertia is overlooked at times. When a spring is stretched, displacement takes place, when it is contracted, compression takes place and when it is free, equilibrium position is acquired.

Therefore, a spring exerts an equal and opposite force on a body that contracts or expands it.

Tension

The restoring force in a string is called tension. Generally, a constant tension T throughout the string is maintained. This assumption is true when a string is of negligible mass. Tension force is the force produced when the load is put in the opposite direction to the cross-section of the body. Tension is commonly called a “pulling force”. For a tension force to be generated, the load applied on the material must be axially exerted.

Conclusion

Common forces in mechanics play a very important role in our day-to-day life. The movement of cars, bikes or the simple stretching of spring takes place when these forces act upon. Every being or object on Earth is governed by these forces in addition to the gravitational force. The common forces in mechanics or the contact forces arise when two bodies are in contact irrespective of their states of matter i.e. whether it is a solid or a liquid/fluid. The contact forces majorly include frictional force/friction, spring force, and tension. These are responsible for the movement of any object in any direction with due regard to gravity.