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PHYSICS DEPARTMENT

E-Content

On

MOTION, REST AND FRAME OF REFERENCE & Newton's Laws

(Part-I)

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MOTION, REST AND FRAME OF REFERENCE & NEWTON'S LAWS

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Summery: In this content we will discuss about the terms motion and rest**,** how motion and rest are relative terms, frame of reference and types of frame of reference, Newton's laws of motion and their limitations.

MOTION AND REST:

If an object changes its position with respect to its surroundings with passing of time then it is called in motion where as if it does not change its position with time then it is called in rest.

RELATIVITY OF MOTION AND REST:

No any object in universe is absolutely in rest or in motion.

For example –

1. A man sitting on a chair in his room is in rest with respect to earth and is in motion with respect to sun because he revolves the sun with the earth.

2. If two buses on the road moving in same direction with same velocity then they are in rest with respect to each other and they are in motion with respect to the poles and a man standing outside on the road.

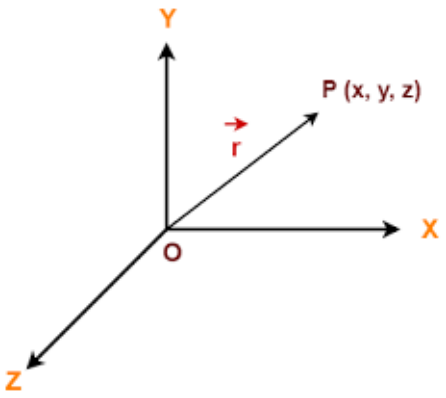
So it can say that the motion or rest of an object is depending on the fact that what point of reference is taken to define the state of any object. i.e. we have to consider a point of reference to describe the state of rest and state of motion of an object .so it is obvious that it cannot be possible to define the state of motion and rest of any object without any point of reference. Hence motion and rest are the relative terms.

FRAME OF REFERENCE:

As we know, a point of reference is required to define the state of motion and rest of an object. A Cartesian coordinate system of three axes is considered attached with this point of reference. This is known as ***frame of reference***. The origin point of the frame is situated on the

point of reference. With respect to this frame of reference, we can determine the position, velocity, and acceleration etc of any object.

With respect to the frame of reference we can describe the position of an object in position coordinate (x, y, z). If we have to describe the time too on a particular position of the particle then four coordinates (x, y, z, t) are require. Such type of frame of reference is called space-time frame of reference.



If any particle is present at a point **P** at time **t,** the position of the particle is represented by-

$$\vec{r} = x\hat{\imath} + y\hat{\jmath} + z\hat{k}$$

The velocity of the particle,

$$\vec{v} = \frac{d\vec{r}}{dt} = \frac{dx}{dt}\hat{\imath} + \frac{dy}{dt}\hat{\jmath} + \frac{dz}{dt}\hat{k}$$

Acceleration of the particle,

$$\vec{a} = \frac{d\vec{v}}{dt} = \frac{d^2\vec{r}}{dt^2} = \frac{d^2\hat{x}}{dt^2}\hat{\imath} + \frac{d^2y}{dt^2}\hat{\jmath} + \frac{d^2z}{dt^2}\hat{k}$$

INERTIAL AND NON-INERTIAL FRAMES:

Frames of reference will in the state of rest or moves with a constant velocity if no external force will act on the frame. Such type of frames are called inertial frame of reference. Newton's laws of motion are followed in these type of frames.

The frame will accelerated if any external force will act on this. Such type of frame is called non-inertial frames. Newton's laws of motion are not followed in these types of frame of reference.

NEWTON'S LAWS OF MOTION

Newton's Law's of motion are the laws of classical mechanics. There are three laws as following:

(1) First law or Law of Inertia:

As per the law, if a body is at rest or moving at a constant speed in a straight line, it will remain at rest or keep moving in a straight line at constant speed unless it is acted upon by a force. This law is also known as law of motion because it is similar to **the law of inertia**. This law of inertia is first formulated by **Galileo Galilee.** In mathematical form,

If $\overrightarrow{F} = 0$, then $\vec{a} = 0$.

According to first law if we want to make a change the state of any object it is only possible by acting a force on that object. Therefore first law also gives the definition of force.

(2) Second law:

As per this law, the rate of change of momentum is directly proportional to applied force and the direction of change of momentum is same as applied force. In mathematical form,

$$\vec{F} \propto \frac{d\vec{p}}{dt} \; or \; \vec{F} = K\frac{d\vec{p}}{dt}$$

Where K is constant.

If mass of the body is $\boldsymbol{m}$ and velocity is $\vec{\boldsymbol{v}}$ then the momentum,

$\overrightarrow{P} = m\vec{v}$

Therefore,

$$\vec{F} = K\frac{d(m\vec{v})}{dt}$$

$$\vec{F} = km\frac{d\vec{v}}{dt}$$

$$\vec{F} = Km\vec{a}$$

If m = 1 kg, a = 1 m/sans F = 1N then K = 1 and hence,

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

i.e. Force = mass × acceleration

Actually Newton's second law is the basic law of classical mechanics. First and second laws are included in second law.

(3) Third law:

As per this law, for every action in nature there is an equal and opposite reaction. In other words, if object A exerts a force $\vec{F}_{AB}$ on object B, then object B also exerts an equal and opposite force $\vec{F}_{BA}$ on object A at the same time. i.e.

$$\vec{F}_{AB} = \vec{F}_{BA}$$

Remember that action and reaction forces are not worked at same object rather they act on different objects. Therefore action and reaction forces are not cancelled out i.e. they act in the form of pair.

Limitations of Newton's law:

These are as follows,

I. Newton's laws are followed by inertial frames, be not applied in non-inertial frames.
II. Newton's laws are not applied in relative motions.
III. Newton's laws are not applied in such type of system in which mass varies.
IV. Newton's third law stated that there is no time interval between action and reaction but as per modern thoughts there should be a time interval between action and reaction.