Force And Motion

Force is basically a push or pull which acts on an object or energy as an attribute of physical action or movement. It happens when two entities are in contact. Further, motion is when a body is moving, it is in motion.

Force

The universal law of gravitation says that every object in this universe exerts a force on others. The force which acts on an object is given by the following parameter:

1. SI unit of Force is newton(N) or $kg.m/s^2$
2. Symbol of Force is F
3. Type of quantity is Vector quantity
4. Dimensional Formula is $M^1L^1T^{-2}$
5. Its other units are dyne, pound-force, kilopond, poundal, kip

Motion

Whenever a body is moving, we state that it is in motion.

The relation between Force and Motion

Force and motion deeply connect in nature. In other words, force is the cause of motion. If something is moving, we will say that some force is acting on it or some force must have acted on it which is producing this motion.

Newton's First Law of motion

Newton's first law of motion is based on Galileo's law of inertia. Galileo had observed that a body does not change its current state (of rest or uniform motion) unless an external unbalanced force compels it to do so. Based on this, Newton's First Law of motion states:

"A body continues to be in its state of rest or of uniform motion in a straight line unless compelled by some external force to act otherwise."

Whether a body is in a state of rest or uniform motion, the acceleration is zero. Hence, Newton's First Law can also be written as:

"If the net external force on a body is zero, its acceleration is zero. Acceleration can be non-zero only if there is a net external force on the body."

Newton's Second Law of motion

"The rate of change of momentum of a body is directly proportional to the applied force and takes place in the direction in which the force acts."

- If F = 0, the acceleration (a) is also zero. Hence, the second law is consistent with the first law.
  - The momentum of a body is the product of its mass and velocity.
  - p = mv

    where p = momentum, m = mass of the body, and v = velocity of the body. Momentum is a vector quantity; it is direction dependent.

Newton's Third Law of motion

"To every action, there is always an equal and opposite reaction."

- Forces always occur in pairs. The force exerted by an object A on an object B is equal and opposite to the force exerted on A by B.
  - There is no cause-effect relation implied by the law. For that matter, the force on A by B and that on B by A are exerted at the same instant.
  - These forces apply to two different bodies. However, if two bodies are components of a system, then they can add up to give a null force.

Banking of Roads

When a vehicle tends to make a turn along a curved road, there is a probability of it skidding. For making a safe turn, the vehicle requires a centripetal force. The banking of a road is done to provide that centripetal force. During a "banked" or inclined turn, the chances of skidding reduce.A turn is made inclined with the horizontal such that the outer edge is lifted up. For a particular angle of inclination, the maximum allowed speed of a vehicle is restricted. This maximum speed is independent of the mass of the vehicle. It depends on the banking angle, the coefficient of friction, and the radius of curvature.

Along a turn, the outer edge of a road is lifted up such that it is higher than the inner edge and the surface of the road looks like a slightly inclined plane. This is called banking of a road. The angle made by the surface with the horizontal, i.e. the angle of inclination, is referred to as the banking angle. While moving through such a curved road, the normal force acting on the vehicle has a horizontal component. This component provides the centripetal force to avoid skidding.

Importance of Banking of Road is a way of providing the required centripetal force to a vehicle to make a safe turn along a curved road.Banking helps to avoid skidding.Banking of roads helps to prevent overturning or toppling.

The maximum velocity of a vehicle (marginal value before skidding) is proportional to the banking angle. So, to turn at a high speed, the banking angle should also be large. This is why race bikers get inclined with much larger angles than regular bikers. The race tracks are banked with larger angles to allow greater speeds.

The maximum velocity for a particular banking angle does not depend on the mass of an object moving on the curved path.

It is not possible to turn on a perfectly smooth flat road.

Torque is the rotational analogue of force. It is also termed as the moment of force and denoted by τ.

$$\tau = r \times F = r\, F\, \mathrm{Sin}\theta$$

Torque is a vector quantity as it is defined by magnitude as well as direction. Its SI unit is Nm. The dimension of the torque is ML^2T^{-2}