- Aristotle’s view that a force is necessary to keep a body in uniform motion is wrong. A force is necessary in practice to counter the opposing force of friction.

- Galileo extrapolated simple observations on motion of bodies on inclined planes, and arrived at the law of inertia. Newton’s first law of motion is the same law rephrased thus: “Everybody 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”.

- In simple terms, the First Law is “If external force on a body is zero, its acceleration is zero”.
- Momentum (p) of a body is the product of its mass (m) and velocity (v) :

  $p = m v$

- Newton's second law of motion :

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

  F = k (dp/dt) = k ma

  where **F** is the net external force on the body and **a** its acceleration. We set the constant of proportionality k = 1 in S.I. Then

  F = dp/dt = ma

  The SI unit of force is newton: 1 N = 1 kg m s^{-2}.

  - The second law is consistent with the First Law (**F** = 0 implies **a** = 0)
  - It is a vector equation
  - It is applicable to a particle, and also to a body or a system of particles, provided **F** is the total external force on the system and **a** is the acceleration of the system as a whole.

- **F** at a point at a certain instant determines **a** at the same point at that instant. That is the Second Law is a local law; **a** at an instant does not depend on the history of motion.

- Impulse is the product of force and time which equals change in momentum. The notion of impulse is useful when a large force acts for a short time to produce a measurable change in momentum. Since the time of action of the force is very short, one can assume that there is no appreciable change in the position of the body during the action of the impulsive force.
- Newton's third law of motion:

  To every action, there is always an equal and opposite reaction.
- In simple terms, the law can be stated thus :Forces in nature always occur between pairs of bodies. Force on a body A by bodyB is equal and opposite to the force on the body B by A.Action and reaction forces are simultaneous forces. There is no cause-effectrelation between action and reaction. Any of the two mutual forces can becalled action and the other reaction. Action and reaction act on differentbodies and so they cannot be cancelled out. The internal action and reactionforces between different parts of a body do, however, sum to zero.

- Law of Conservation of Momentum

  The total momentum of an isolated system of particles is conserved. The lawfollows from the second and third law of motion.

- Friction

  Frictional force opposes (impending or actual) relative motion between twosurfaces in contact. It is the component of the contact force along the commontangent to the surface in contact. Static friction fs opposes impending relativemotion; kinetic friction fk opposes actual relative motion. They are independentof the area of contact and satisfy the following approximate laws:

  $f_s \leq (f_s)max = \mu_s R$

  $f_k = \mu_k R$

  μ_s (co-efficient of static friction) and μ_k (co-efficient of kinetic friction) are constants characteristic of the pair of surfaces in contact. It is found experimentally that μ_k is less than μ_s.

- Determine the maximumacceleration of the train in which a boxlying on its floor will remain stationary, given that the co-efficient of static frictionbetween the box and the train's floor is0.15.

Solution

Since the acceleration of the box is dueto the static friction,

$ma = f_s \le \mu_s N = \mu_s m g$

i.e. $a \le \mu_s g$

$\therefore a_{max} = \mu_s g = 0.15 \times 10 \text{ m s}^{-2}$

$= 1.5 \text{ m s}^{-2}$

- A bullet of mass 0.04 kg moving with a speed of 90 ms^{-1} enters aheavy wooden block and is stopped after a distance of 60 cm. What is the averageresistive force exerted by the block on thebullet?

Solution

$a = - u^2/2s$

$= - 90 * 90/2*0.6 = – 6750\ ms^{-2}$

The retarding force, by the Second Law ofmotion, is

$= 0.04\ kg \times 6750\ m\ s^{-2} = 270\ N$