Laws of Motion

1. **(a)** *Define force.*

(b) *State four effects, which a force can bring about, giving two examples in each case.*

Ans. **(a)** **Force :** An external cause, which changes or tends to changes the state of rest or uniform motion of a body or bends or deforms a body is called force.

(b) **(1)** Force produces motion in a body.

Examples :

(i) The force exerted by a horse makes a horse cart move.

(ii) The force exerted by a player, sets a ball in motion.

(2) Force can stop a moving body.

Examples :

(i) A speeding car is stopped by the force of friction of brakes.

(ii) A ball thrown vertically upwards is stopped by the force due to gravity.

(3) Force can change the speed or direction of a moving body.

Examples :

(i) A stone projected horizontally changes its speed and direction due to the force of gravity.

(ii) A moving car changes its direction when force is applied on its steering wheel.

(4) Force changes dimensions of a body.

Examples :

(i) A spring shortens in length, if compressive force is applied.

(ii) Silver flattens to form thin leaves, when hammered.

2. **(a)** *By giving two examples, state what do you understand by the term contact force.*

(b) *By giving two examples, state what do you understand by the term force at distance.*

Ans. (a) **Contact force :** A force which is applied to another body through a rigid or non-rigid connector is called contact force.

Examples :

(i) The force applied by bullocks on a bullock cart.

(ii) Hammer hitting a nail.

(b) **Force at distance :** A force which acts upon a body, without the aid of a connector is called force at distance.

Examples :

(i) A stone falls towards earth due to force of gravitation.

(ii) A piece of iron is attracted towards a powerful magnet due to the magnetic force of the magnet.

3. *Give two examples of each of the following :*

(a) Force which pulls *(b) Force which pushes*

(c) Force which attracts *(d) Force which compresses*

(e) Force which stretches *(f) Force which deforms a body.*

Ans. (a) **1.** A bullock pulling a cart.

2. Two teams pulling a rope in the tug of war.

(b) **1.** Pushing a pin into sheaf of papers.

2. Pushing a wheel barrow.

(c) **1.** A magnet attracting a piece of iron.

2. A stone falling freely towards ground.

(d) **1.** Compressing a spring of an air gun.

2. Doctor compressing the plunger of syringe while injecting .

(e) **1.** Stretching the spring of chest expander.

2. Stretching a rubber balloon, before inflating.

(f) **1.** Hammering a stone.

2. Hammering a metal into thin foil.

4. *Classify the following forces into contact forces and forces at distance.*

(a) Frictional force *(b) hydraulic force*

(c) Gravitational force *(d) Mechanical force*

(e) Electrostatic force *(f) Magnetic force.*

Ans. **Contact forces** are **(i)** Frictional force **(ii)** Hydraulic force **(iii)** Mechanical force.

Forces at distance are **(i)** Gravitational force **(ii)** Electrostatic force **(iii)** Magnetic force.

5. *Name two effects of force applied to non rigid body. Support your answer by an example.*

Ans. **(i)** It can deform the non-rigid body.

(ii) It changes size of non-rigid body.

Example : Cotton on spinning into yarn changes in size and shape.

6. *Name two effects of force applied to a rigid body. Support your answer by an example.*

Ans. **(i)** It sets a stationary body in motion or stops a moving body. For example, a ball is set into motion on hitting with hockey stick.

(ii) It can deform the body. For example an iron nail flattens on hammering.

7. **(a)** *What do you understand by the term inertia?*

(b) *What determines the inertia of a body?*

(c) *Define two kinds of inertia. Support your answer with one example each.*

Ans. **(a)** The tendency of a body to continue in its state of rest or uniform motion in a straight line, even on the application of external force is called inertia.

(b) The mass of body determines its inertia i.e. inertia is directly proportional to the mass of body.

(c) **(i)** **Inertia of rest :** The tendency of a body to continue in its state of rest, even on the application of external force is called inertia of rest.

Example : A rider sitting on a horse back falls backward, if the horse gallops off suddenly. It is because when the horse suddenly sets itself in motion, the rider on account of inertia of rest, tends to continue in the state of rest. Thus, the rider is left behind the horse and hence falls.

(ii) Inertia of motion : The tendency of a body to continue in its state of uniform motion, even on the application of external force is called inertia of motion.

Example : The passengers in a running bus fall in the forward direction, when brakes are applied suddenly. It is because when the bus suddenly comes to rest, the passengers on account of inertia of motion, tend to continue to move in forward direction and hence fall forward.

8. *Explain the following :*

(i) *Why do we jerk wet clothes before spreading them on line?*

(ii) *Why does dust fly off when carpet is hit with stick?*

(iii) *Why do the fruits fall off the branches of a tree in strong wind?*

(iv) *Why does a pillion rider falls forward, when a driver of a two seater vehicle suddenly applies brakes?*

(v) *Why do the doors of a corridor train open or shut, when the train starts or stops?*

(vi) *Why is it necessary to run along with moving bus and in the same direction of bus, while alighting from it?*

(vii) *Why does a player run for some distance, before taking a long jump?*

(viii) *Why does a person fall off the back of a stationary horse, if the horse darts off suddenly?*

(ix) *Why a neat hole is formed in the glass pane, if a bullet is fired on it from a close range?*

Ans. (i) Initially, the water and clothes are in the state of rest. When the clothes are suddenly jerked, the water in them, on account of inertia of rest, tends to continue in its state of rest. Thus, the droplets of water are left behind and fall off the clothes. Removal of water from clothes helps them to dry quickly.

(ii) Initially, the loose dust and carpet are in the state of rest. When the carpet is hit with a stick, it is suddenly set into motion, but not the dust particles, on account of inertia of rest. As dust particles are left behind the carpet, therefore they fly off.

(iii) Initially, the fruits, and branches are in the state of rest. When strong wind sets the branches in motion, the fruits on account of inertia of rest, tend to continue in their state of rest. Thus, a lot of strain builds up at the junction of fruit and branch and hence the fruits drop down.

(iv) Initially, the driver and the pillion rider are in the state of motion. When the driver applies brakes and brings machine to halt, the body of pillion rider continues moving forward on account of inertia of motion. Thus, the pillion rider falls in the forward direction.

(v) When the train starts suddenly, the sliding doors tend to continue in their state of rest, on account of inertia of rest. Thus, in way doors move backward with respect to the motion of train and hence close.

When the train stops suddenly, the doors continue moving forward on account of inertia of motion. Thus, as the doors move in the direction of train, and hence open.

(vi) A person in a moving bus possesses inertia of motion. Thus, if he simply jumps out, his feet suddenly come to rest, but his body continues moving in the direction of bus. Thus, he can fall headlong and seriously injure himself. However, if the person starts running in the direction of the bus, his body will not come to rest. Thus, he will not fall in the forward direction.

(vii) In running some distance, the player picks up inertia of motion. Thus, during jumping this inertia of motion carries him forward over a longer distance.

(viii) Initially, the person and the horse are in the state of rest. When the horse darts off suddenly, the person on account of inertia of rest, tends to continue in its state of rest. Thus, the person is left behind relative to horse and hence falls in the backward direction.

(ix) When bullet strikes the glass pane, it suddenly sets only that part into motion. However, rest of the glass pane on account of inertia of rest tends to continue in its state of rest. Thus, a neat hole is made in the glass pane as the rest of pane does not get disturbed.

9. **(a)** *What do you understand by the term momentum ?*

(b) *State two factors which determine momentum of a body?*

Ans. **(a)** The force possessed by a moving body at some particular instant during its course of motion is called momentum.

(b) **(1)** Momentum is directly proportional to the mass of body.

(2) Momentum is directly proportional to the velocity of body.

10. *State Newton's second law of motion.*

Ans. The rate of change of momentum is directly proportional to applied force and takes the direction in which the force is applied.

11. *Show that rate of change of momentum is the product of mass and acceleration.*

Ans. Consider a body of mass 'm' initially moving with a velocity 'u'. Let the body be acted upon by a force 'F' for time 't' (in seconds), such that its final velocity is 'v'.

$\therefore$ Initial momentum of body $= mu$.

Final momentum of body $= mv$.

$\therefore$ Change in momentum in time $t = mv - mu$

$$\therefore \quad \text{Rate of change of momentum} = \frac{m(v - \mathrm{u})}{t}.$$

But $a = \dfrac{v - \mathrm{u}}{\mathrm{t}}$, where a is acceleration

$\therefore$ Rate of change of momentum $= ma$.

According to Newton's second law.

Rate of change of momentum $\propto$ force (F)

$\therefore \quad \mathrm{F} \propto ma$

or $\quad \mathrm{F} = \mathrm{K}ma$, [where K is constant of proportionality]

If there be a body of unit mass, having a unit acceleration, such that force possessed by the body is also unit, then :

$$1 = K \times 1 \times 1$$
$$K = 1.$$
$$\therefore \quad F = ma.$$

12. *Name and define absolute units of force in **(a)** C.G.S. system **(b)** S.I. system.*

Ans. (a) Dyne : It is an absolute unit of force in C.G.S system. When a body of mass 1g, moves with an acceleration of 1 cm s^{-2}, the force possessed by it is said to be one dyne.

(b) Newton (N) : It is an absolute unit of force in S.I. system. When a body of mass 1 kg, moves with an acceleration of $1ms^{-2}$, the force possessed by body is said to be one Newton.

13. *Name and define gravitational units of force in (a) C.G.S. system (b) S.I. system.*

Ans. (a) Gram-force (gf) : It is gravitational unit of force in C.G.S. system. When a body of mass 1 g, moves with acceleration due to gravity (980 cms^{-2}), the force possessed by it is called gram-force.

$$1gf = 980 \text{ dynes.}$$

(b) Kilogram-force (kgf) : It is a gravitational unit of force in S.I. system. When a body of mass 1 kg, moves with acceleration due to gravity (9.8 ms^{-2}), the force possessed by it is called kilogram-force.

$$1gf = 9.8 \text{ dynes.}$$

14. Prove 1 N = 10^5 dynes.

Ans.
$$\begin{aligned} 1 \text{ N} &= 1 \text{ kg} \times 1 \text{ ms}^{-2} \\ &= 1000\, g \times 100 \text{ cms}^{-2} \\ &= 100000 \text{ gcms}^{-2} \\ &= 10^5 \text{ dynes.} \end{aligned}$$

15. *State Newton's third law of motion.*

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

16. *Explain the following :*

(a) *Why a boatman pushes the bank backward with a long bamboo pole, on launching his boat in water?*

(b) *Why does a boat tend to leave the shore, when passengers are alighting from it? How does boatman overcome above difficulty?*

(c) *Why are wet surfaces more slippery?*

(d) *Why does a gun recoil back, when fired?*

(e) *How do the rockets operate in space?*

(f) *Why is it difficult to walk on marshy ground?*

(g) *Why does an air filled balloon rise up slightly when punctured from below?*

(h) *Why does a swimmer push water backward with his hands, in order to swim in forward direction?*

Ans. (a) When the boatman pushes the bank with pole in the backward direction, the bank reacts back according to Newton’s third law and pushes the pole in the opposite direction. As the pole is in the hands of boatman, who is standing in the boat, therefore, whole system moves in the opposite direction i.e. in the forward direction.

(b) When the passengers are alighting from boat, they push the boat in the backward direction while walking on it. As the boat is in water, therefore, it has a tendency to slip back in water.
The boatman overcomes this difficulty by tying the boat to some solid support on the bank so that it does not slip back.

(c) When one walks over wet surface by pushing it backward with feet, the surface does not react back with the same force, owing to the presence of water. Thus, as there is not sufficient reaction, therefore one tends to slip backward.

(d) When the gun powder within the cartridge explodes, it pushes the bullet in the forward direction. However, at the same time it reacts back on the gun, which in turn recoils back according to Newton’s third law.

(e) When the fuel burns in the ignition chamber of a rocket, the hot gases pass out from its exhaust with a certain momentum in backward direction. Thus, in order to conserve momentum the rocket moves with the same momentum in forward direction.

(f) When we walk on the marshy ground, we push it backward with our feet. However, the ground being soft, does not react back, but yields. As there is not sufficient reaction to propel us in the forward direction, therefore, it becomes difficult to walk on marshy ground.

(g) When the air at the point of puncture moves out with a certain momentum in the downward direction, in order to conserve momentum the balloon moves with the same momentum in opposite direction Thus, balloon rise up slightly, before falling down.

(h) When the swimmer pushes the water backward, then according to Newton's third law the water reacts back and pushes the swimmer in forward direction.

17. *Two bodies P and Q are of the same mass, but are moving with velocities of v and 5 v respectively. Compare their (i) inertia (ii) momentum.*

Ans. (i) The inertia of a body is directly proportional to its mass. As the mass of bodies P and Q is same, therefore ratio of inertia of **P** and **Q** = **1 : 1.**

(ii) Momentum of body **P** = mv

Momentum of body **Q** = $m \times 5v = 5mv$

$\therefore$ Ratio of momentum of **P** and **Q** = $mv : 5\ mv$ = **1 : 5.**

18. *Two bodies **A** and **B** are of mass m and 5 m and their velocities are 5v and v respectively. Assuming bodies are moving with uniform velocities, compare their (i) interia (ii) momentum (iii) force required to stop them.*

Ans. (i) Inertia of a body is directly proportional to its mass.

$\therefore$ Ratio of inertia of A and B = $m : 5m = 1 : 5$

(ii) Momentum of a body is equal to product of mass and velocity.

$\therefore$ Momentum of A : momentum of B

$= m \times 5v : 5\,m \times v$

$=$ **1 : 1.**

(iii) Force of a body is directly proportional to its mass.

$\therefore$ Force of A : Force of B = $m : 5\,m =$ **1 : 5.**

19. *Select the correct answer from the following :*

(a) *The unit of momentum is :*

(i) $kg\ m\ s^{-2}$ *(ii)* NS *(iii)* $kg\ m^2S^{-2}$ *(iv)* $kg^2\ m\ s^{-1}$

(b) *The correct relationship between force (F), mass (m) and acceleration (a) is*

(i) $F = \dfrac{a}{m}$ *(ii)* $F = ma^2$ *(iii)* $F = ma$ *(iv)* $F \times a = m.$

(c) *Relation between Newton and dyne is :*

(i) 10^7 *dynes = 1N* *(ii)* 10^{-5} *dynes = 1N*

(iii) 10^5 *dynes = 1N* *(iv)* 10^3 *dynes = 1N.*

(d) *Relation between kilogram force and newton is*

(i) 1 kgf = 1 N *(ii) 9.8 kgf = 1N* *(iii) 1 kgf = 980 N*

(iv) 1 kgf = 9.8 N.

(e) *One newton is a force which produces.*

(i) *An acceleration of 1 cm* s^{-2} *in a body of mass 1 g.*

(ii) *An acceleration of 1* ms^{-2} *in a body of mass 1 g.*

(iii) *An acceleration of 1* ms^{-2} *in a body of mass 1 kg.*

(iv) *An acceleration of 1* cms^{-2} *in a body of mass 1 kg.*

(f) *Based on Newton's third law, which statement is true?*

(i) *The action and reaction act on the same body in same direction.*

(ii) *The action and reaction act on the same body but in opposite direction.*

(iii) *The action and reaction act on different bodies in opposite directions.*

(iv) *The action and reaction act on different bodies in same direction.*

Ans. (a) Ns.

(b) F = ma

(c) 10^5 dynes = 1N

(d) 1 kgf = 9.8 N

(e) An acceleration of 1 ms^{-2} in a body of mass 1 kg.

(f) The action and reaction act on different bodies in opposite direction.

20. *(a) What do you understand by the term "force of gravitation"?*

(b) Is the force of gravitation attractive or repulsive force?

(c) Does the force of gravitation exists at all places in the universe? Explain your answer.

Ans. (a) The mutual force of attraction between any two bodies is called force of gravitation.

(b) Force of gravitation is always attractive, irrespective of shape, size or location of bodies.

(c) Force of gravitation exists throughout the universe. It is this force which gives rise to galaxies, solar system etc., in the universe.

21. *(a) State Newton's law of gravitation.*

(b) Derive mathematical expression for the gravitational force based on universal law of gravitation.

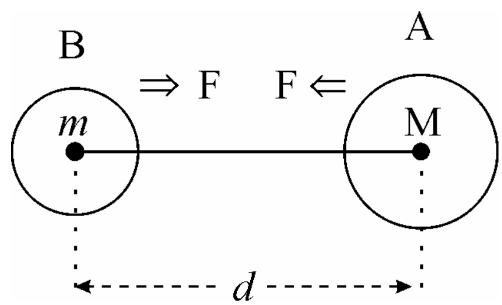
Ans. (a) Every body in this universe attracts every other body with a force which is directly proportional to the products of masses and inversely proportional to the square of distance between their centres.

(b) Consider two bodies A and B of mass M and m respectively, such that d is the distance between their centres and F is the mutual force of attraction.

Then, according to Newton's law of gravitation.

$$F \propto M \times m \qquad \ldots (1)$$

$$F \propto \frac{1}{d^2} \qquad \ldots (2)$$



Combining (1) and (2)

$$F \propto \frac{M \times m}{d^2}$$

$$F = G.\frac{M \times m}{d^2}$$

where, G is the constant of proportionality, commonly called gravitational constant.

22. *(a)* *Define the term gravitational constant.*

(b) *State the value of gravitational constant in (i) SI system (ii) CGS system.*

Ans. (a) Gravitational constant is equal to the force of attraction between two unit masses, when they are separated by a unit distance, as measured from their centres.

(b) The value of gravitation constant in :

(i) SI system is 6.67×10^{-11} Nm^2 kg^{-2}.

(ii) CGS system is 6.67×10^{-8} dyne cm^2 g^{-2}.

23. *What do you understand by the statement that gravitational constant is 6.67×10^{-11} Nm^2 kg^{-2}?*

Ans. From the above statement, it implies that when two bodies of mass 1 kg each are separated by a distance of 1 m as measured from their centres, then the force of attraction between them is 6.67×10^{-11} N.

24. *(a)* *What do you understand by the term force of gravity?*

(b) *When do we use the term force of gravity, rather than force of gravitation?*

Ans. (a) Force of gravity is a special case of force of gravitation, when one among the two bodies has an infinitely large mass as compared to the other body.

(b) We know all bodies fall towards the earth due to the force of gravitation between them and the earth. However, earth is too big as compared to the bodies on or around its surface. In such a situation the force of gravitation acting on a body is called force of gravity due to the earth.

Similarly, on the surface of moon, the force of gravitation acting on the bodies is called force of gravity due to moon.

25. *How does acceleration due to gravity vary from place to place on the surface of earth?*

Ans. Acceleration due to gravity at the geographic poles and at sea level is maximum.

Its value decreases and is least at sea level on the equator.

Its value decreases, if the body moves away from the surface of earth, i.e., at higher altitudes.

Its value decrease, if the body is taken deep inside the mine.

Its value is zero, at the centre of earth.

26. *If the distance between two bodies is increased 4 times, by which factor, should the mass of one body be altered, so that gravitational force between them remains same.*

Ans. Let F be the force of attraction between the two bodies of mass M and *m*, where '*d*' is the distance between them.

$$\therefore \quad F = G.\frac{Mm}{d^2} \quad \ldots(1)$$

when d becomes 4*d*, let $m = x$.

$$\therefore \quad F = \frac{GMx}{(4d)^2} = \frac{GMx}{16d^2} \quad \ldots(2)$$

Comparing (2) and (1)

$$\frac{GMx}{16d^2} = \frac{GMm}{d^2}$$

$$\therefore \quad x = 16m$$

Thus, mass of one body be increased by 16 times.

27. *(a) What do you understand by the term mass of body?*
(b) Is mass a scalar or vector quantity?
(c) What is the unit of mass in SI and CGS system?
(d) How does mass of a body change when taken into deep space?

Ans. (a) The amount of matter contained in a body is called mass.
(b) Mass has no direction and hence is a scalar quantity.
(c) SI unit of mass is kilogram (kg) and CGS unit is gram (g).
(d) Mass of body does not change, with the change in the position or surroundings.

28. *(a) What do you understand by the term weight?*
(b) How is weight of a body related to its mass?
(c) What is the unit of weight in SI and CGS system?
(d) Is weight a scalar or vector quantity?
(e) How does the weight of a body change, if it is taken far away from the earth?

Ans. (a) The pull of the earth (or any other heavenly body) acting on the body is called its weight.
(b) Weight of a body is the product of mass and acceleration due to gravity.
(c) Unit of weight in SI system is newton (N) and in CGS system dyne.
(d) Weight is a vector quantity as the force is directed towards the centre of earth.
(e) The weight of body decreases. It is because the acceleration due to gravity decreases with the increase of distance from the centre of earth.

29. Give four differences between mass and weight of a body.

Ans.

Mass	Weight
1. Mass is the amount of matter contained in a body. 2. Mass of a body is a constant quantity and does not change with location of body. 3. Mass is measured in kilograms or grams. 4. Mass is a scalar quantity.	1. Weight is the pull of earth acting on the body. 2. Weight of a body is a variable quantity and changes with the change in acceleration due to gravity. 3. Weight is measured in newton or dyne. 4. Weight is a vector quantity.

Numerical Problems

30. *A body having a velocity of 200 ms^{-1} has a momentum of 5 Ns. Find the mass of body.*

Ans. $m = ?$; $v = 200\ ms^{-1}$; $p = 5$ Ns

Now, $p = mv$

$5\ Ns = m \times 200\ ms^{-1}$ $\therefore$ $m =$ **0.025 kg**

31. *Calculate the momentum of an electron of mass 9×10^{-31} kg and velocity $6 \times 10^{-7}\ ms^{-1}$.*

Ans. $m = 9 \times 10^{-31}$ kg; $v = 6 \times 10^{-7} ms^{-1}$; $p = ?$

$\therefore$ Momentum $(p) = mv = 9 \times 10^{-31}\ (kg) \times 6 \times 10^{-7}\ (ms^{-1})$

$= \mathbf{5.4 \times 10^{-37}}$ **Ns.**

32. *What force will produce acceleration of 3.5 ms^{-2} in a body of mass 12.5 kg?*

Ans. F = ?; $a = 3.5\ ms^{-2}$; $m = 12.5$ kg

$\therefore F = ma = 12.5\ (kg) \times 3.5\ (ms^{-2}) = 43.75$ N

33. *Calculate the mass of a body, when a force of 525 N produces an acceleration of 3.5 ms^{-2}.*

Ans. m = ?; F = 525 N; a = 3.5 ms^{-2}

$$\text{Mass of body } (m) = \frac{F}{a} = \frac{525(N)}{3.5(ms^{-2})} = \mathbf{150\ kg}$$

34. *A force of 50 kgf acts on a body of mass $\frac{1}{2}$ t. Find the acceleration produced in the body. [Take g = 10 N kg^{-1}]*

Ans. F = 50 kgf = 50 (kg) × 10 (N kg^{-1}) = 500 N

$$m = \frac{1}{2}t = \frac{1}{2} \times 1000 \text{ kg} = 500 \text{ kg.}$$

$$\therefore \text{ Acceleration } (a) = \frac{F}{m} = \frac{500(\text{N})}{500(\text{kg})} = 1 \text{ ms}^{-2}$$

35. *What is the mass of a body, which is moving with an acceleration of 1.4 ms^{-2}, when a force of 50 kgf acts on it. [Take g = 9.8 ms^{-2}]*

Ans. F = 50 kgf × 9.8 (ms^{-2}) = 490 N; a = 1.4 ms^{-2}

$$\text{Mass } (m) = \frac{F}{a} = \frac{490\text{N}}{1.4(\text{ms}^{-2})} = \mathbf{350\ kg}$$

36. *A car initially at rest picks up a velocity of 72 kmh^{-1} is 20 s. If the mass of car is 1000 kg. Calculate (i) force developed by its engine, (ii) distance covered by the car.*

Ans. u = 0; v = 72 kmh^{-1} = 20 ms^{-1}; t = 20 s; m = 100 kg

F = ?; S = ?

Applying :
$$v = u + at$$
$$20 = 0 + a \times 20$$
$$\therefore\ a = 1 \text{ ms}^{-2}$$

(i) Force developed by engine (F) = ma = 1000 kg× 1 ms^{-2} = **1000 N**

(ii) Applying : $v^2 - u^2 = 2aS$

$$\therefore (20)^2 - (0)^2 = 2 \times 1 \text{ s}$$

$$\therefore \text{S} = \frac{400}{20} = \mathbf{20}\ \boldsymbol{m}.$$

37. *A golfer hits a golf ball at rest, such that the contact between the ball and golf club is 0.1 s. If the golf ball covers a linear distance of 400 m in 2 s. Calculate the magnitude of force applied. The mass of golf ball is 50 g.*

Ans. $u = 0$; $t = 0.1$ s; S = 400 *m*; time for linear distance = 2 s, $m = 50\ g = 0.05$ kg; F = ?

Linear distance covered by ball in 2 *s* = 400 *m*

$\therefore$ Linear distance covered by ball in 1 *s* = $\dfrac{400\ m}{20\ s}$ = 200 m/s

Final velocity of ball (v) = 200 m/s

Applying : $v = u + at$

$200 = 0 + a \times 0.1$

$\therefore \quad a = \dfrac{200}{0.1} = 2000\ \text{ms}^{-2}$.

Force acting on ball (F) = ma

$= 0.05\ \text{kg} \times 2000\ \text{ms}^{-2}$

= **100 N**

38. *A car of mass 800 kg moving with 54 kmh^{-1} is brought to rest over a distance of 15 m. Calculate the retarding force developed by the brakes.*

Ans. $m = 800$ kg; $u = 54\ \text{km h}^{-1} = 15\ \text{ms}^{-1}$; $v = 0$; a = ?; R.F. = ?

Applying : $v^2 - u^2 = 2aS$

$(0)^2 - (15)^2 = 2 \times a \times 15$

$\therefore \quad a = \dfrac{-15 \times 15}{15 \times 2} = -7.5\ \text{ms}^{-2}$

$\therefore$ Retardation $= -(a) = -(-7.5\ \text{ms}^{-2}) = 7.5\ \text{ms}^{-2}$

$\therefore$ Retarding force (R.F.) = m × Retardation

$= 800\ (\text{kg}) \times 7.5\ (\text{ms}^{-2}) = 6000\ \text{N}$

39. *A cricket player takes a catch by moving his hands backward by 0.75 m. If the mass of ball is 100 g and its initial velocity is 108 km h^{-1}, what is the retarding force applied by the player.*

Ans. m = 100 g = 0.1 kg; S = 0.75 m; u = 108 kmh^{-1} = 30 ms^{-1}; v = 0;
Retarding force = ?

Applying $v^2 - u^2 = 2aS$

$$(0)^2 - (30)^2 = 2 \times a \times 0.75$$

$$a = \frac{-30 \times 30}{1.50} = -600 \text{ ms}^{-2}$$

$\therefore$ Retardation $= -(a) = -(-600 \text{ ms}^{-2}) = 600 \text{ ms}^{-2}$

Retardation force = Mass × Retardation

$= 0.1 \text{ (kg)} \times 600 \text{ ms}^{-2} =$ **60 N**

40. *A force of 0.6 gf acts on a glass ball of mass 200 g for 12 s. If initially the ball is at rest, calculate the final velocity and distance covered. (Take g = 1000 cm s^{-2})*

Ans. F = 0.6 gf = 0.6 × 1000 = 600 dynes; u = 0; m = 200 g; t = 12 s; v = ?; S = ?

Applying F = ma

$$600 = 200 \times a$$

$$\therefore \quad a = \frac{600}{200} = 3 \text{ cm s}^{-2}$$

$\therefore$ Applying, $v = u + at$

$$v = 0 + 3 \times 12 = 36 \text{ cm s}^{-1}$$

$\therefore$ Applying $S = ut + \frac{1}{2}at^2$

$$= 0 \times 12 + \frac{1}{2} \times 3(12)^2 = \mathbf{216\ cm}$$

41. *A bullet of mass 30 g and moving with velocity x, hits a wooden target with a force of 187.5 N. If the bullet penetrates 80 cm in the target, what is the magnitude of x.*

Ans. m = 30 g = 0.03 kg; v = 0; F = –187.5 N; S = 80 cm = 0.80 m; a = ?; $u = x$;

Applying $a = \frac{F}{m} = \frac{-187.5 \text{ N}}{0.03 \text{ kg}} = -6250 \text{ ms}^{-2}$

Applying, $v^2 - u^2 = 2aS$

$(0)^2 - (x)^2 = 2 \times -6250 \times 0.8$

$-x^2 = -10000$

$x = \mathbf{100 \text{ ms}^{-1}}$

42. *A car of 1000 kg develops a force of 500 N, over a distance of 49 m. If initially the car is at rest, find (i) velocity; (ii) time for which car accelerates.*

Ans. m = 1000 kg; F = 500 N; S = 49 m; u = 0; v = ?; t = ?; a = ?

Applying $a = \frac{F}{m} = \frac{500 \text{ N}}{1000 \text{ kg}} = 0.5 \text{ ms}^{-2}$

(i) Applying, $v^2 - u^2 = 2aS$

$v^2 - (0)^2 = 2 \times 0.5 \times 49$

$v^2 = 49$

$v = \sqrt{49} = 7 \text{ ms}^{-1}$

(ii) Applying $v = u + at$

$7 = 0 + 0.5 \times t$

$t = \frac{7}{0.5} = \mathbf{14 \text{ s.}}$

43. *A bullet of mass 25 g is fired from the barrel of a gun of length 0.80 m with a velocity of 270 km h^{-1}. Find the force acting on the bullet.*

Ans. m = 25 g = 0.025 kg; S = 0.80 m; v = 270 kmh^{-1} = 75 ms–1; u = 0; a = ?; F = ?

$$\text{Applying,} \quad v^2 - u^2 = 2aS$$
$$(75)^2 - (0)^2 = 2 \times a \times 0.8$$
$$a = \frac{75 \times 75}{1.6} = 3515.625 \text{ ms}^{-2}$$

Force acting on bullet (F)

$$= m \times a$$
$$= 0.025 \text{ (kg)} \times 3515.625 \text{ ms}^{-2}$$
$$= 87.89 \text{ N}$$

44. *What extra force should an engine of a car develop, such that its velocity changes from 18 kmh^{-1} to 72 kmh^{-1} over a distance of 20 m, when the mass of car is 900 kg.*

Ans. u = 18 kmh^{-1} = 5 ms^{-1}; v = 72 kmh^{-1} = 20 ms^{-1}; S = 20 m; a = ?; m = 900 kg; F = ?

$$\text{Applying,} \quad v^2 - u^2 = 2aS$$
$$(20)^2 - (5)^2 = 2 \times a \times 20$$
$$375 = 40a$$
$$a = \frac{375}{40} = 9.375 \text{ ms}^{-2}$$

Extra force developed by car (F) = $m \times a$

$$= 900 \text{ (kg)} \times 9.375 \text{ ms}^{-2}$$
$$= \mathbf{8437.5 \text{ N}}$$