3 Force

We all know that force is a push-pull forces acting; "Forces acts almost everywhere and in whichever activity you do". When we think of a **force**, we usually imagine a push or a pull exerted on some object. For instance, you exert a force on a ball when you throw it or kick it, and you exert a force on a chair when you sit down on it. What happens to an object when it is acted on by a force depends on the magnitude and the direction of the force. Force is a vector quantity; thus, we denote it with a directed arrow, just as we do velocity and acceleration.

- A man pulls the door of the room.
- A bull is pulling the cart due with force.
- Squeezing of wet clothes to make it dry.
- A moving bike stops when brakes are applied.
- Gravitational force attracting the ball moving up.
- A boy put his drawing paper by inserting a board pin with it on the notice board.
- Two team of the players are pulling with enough force the rope in a tug of war game.
- A football is kicked harder. It moves faster later after some time its force decreases due to friction.
- A glass rod is rubbed with silk so that it attracts the tiny parts of the paper towards itself. It is the example of action at a distance force.

Newton's three laws of motion are basic in our lives first law affirms that an object at rest will remain at rest unless otherwise an external force will cause it to move. An object in motion will remain in uniform motion following a straight line unless it is acted on by an external motion which causes it to change in direction or to decrease its speed.

A car travelling on a highway at a fixed rate tends to maintain its motion and everything else inside the car are also moving at the same velocity as the car. When there is an outside force applied to the car in motion, like a sudden change in direction, although the car itself will respond to this sudden change, the passengers in the car or objects inside it are still responding to inertia, as such their motion will still be in a straight line when in fact the direction has already shifted causing the passengers or the objects to be thrown off.

Note

Suppose you are sitting in a rowboat on a sandy beach. Your friends get behind the boat and push it toward the water. The force of their push and the force of the sand on the boat act against each other. Your friends push with a greater force than the friction force of the sand. The boat moves because the two opposing force are unbalanced. When two opposing forces are unbalanced, the combined, or net, force is determined by subtracting the small force from the large one.

Point Mass

- An object can be considered as a point object if during motion in a given time, it covers distance much greater than its own size.
- Object with zero dimension considered as a point mass.

Inertia

Inertia is not a physical quantity, it is only a property of the body which depends on mass of the body and cannot change their state of rest or uniform motion along a straight line by their own is called inertia. Inertia has no units and no dimensions.

Linear Momentum

- Linear momentum of a body is the quantity of motion contained in the body.
- It is measured in terms of the force required to stop the body in unit time.
- It is also measured as the product of the mass of the body and its velocity *i.e.*, Momentum = mass × velocity.
- If a body of mass m is moving with velocity $\vec{v}$ then its linear momentum $\vec{p}$ is given by $\vec{p} \quad m\vec{v}$.
- It is a vector quantity and it's direction is the same as the direction of velocity of the body.
- Units : *kg-m/sec* [SI], *g-cm/sec* [CGS].
- Dimension : $[MLT^{-1}]$
- If two objects of different masses have same momentum, the lighter body possesses greater velocity.

$$p = m_1 \upsilon_1 = m_2 \upsilon_2 = \text{constant}$$

$$\therefore \frac{v_1}{v_2} = \frac{m_2}{m_1}$$

i.e. $v \propto \frac{1}{m}$ [As p is constant]

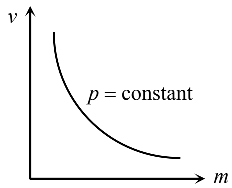


Figure: 3.1

For a given body $p \propto \upsilon$

For different bodies moving with same velocities $p \propto \upsilon$

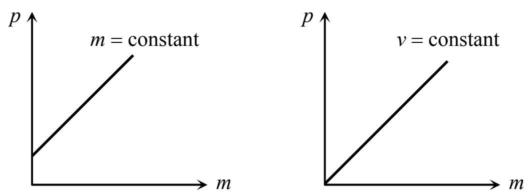


Figure: 3.2

Newton's First Law (Law of Inertia)

If the net force $\sum F$ exerted on a object is zero, the object continues in its original state of motion. That is if $\sum F = 0$, an object at rest remains at rest and object moving with some velocity continues with that same velocity.

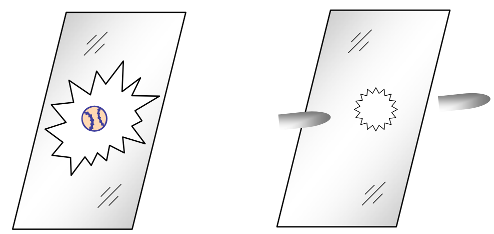
A body continue to be in its state of rest or of uniform motion along a straight line, unless it is acted upon by some external force to change the state.

- If no net force acts on a body, then the velocity of the body cannot change *i.e.* the body cannot accelerate.
- Newton's first law defines inertia and is rightly called the law of inertia. Inertia are of three types: Inertia of rest, Inertia of motion and Inertia of direction.

Mass and Inertia

A bowling ball and a golf ball lie side by on the ground. Newton's first law tells us that both remain at rest as long as no external force acts on them. Now imagine supplying a net force by striking each ball with a golf club. Both balls resist your attempt to change their state of motion. But you know from everyday experience that if the two are struck with equal force, the golf ball will travel much farther than the bowling ball. That is, the bowling ball is more successful in maintaining its original state of motion. The tendency of an object to continue in its original motion is called **inertia**.

- A person who is standing freely in bus, thrown backward, when bus starts suddenly.
- When a horse starts suddenly, the rider tends to fall backward on account of inertia of rest of upper part of the body as explained above.
- A bullet fired on a window pane makes a clean hole through it, while a ball breaks the whole window. The bullet has a speed much greater than the ball. So its time of contact with glass is small. So in case of bullet the motion is transmitted only to a small portion of the glass in that small time. Hence a clear hole is created in the glass window, while in case of ball, the time and the area of contact is large. During this time the motion is transmitted to the entire window, thus creating the cracks in the entire window.



Cracks by the ball　　Hole by the bullet

Figure: 3.3

In the arrangement as shown in the figure; If the string B is pulled with a sudden jerk then it will experience tension while due to inertia of rest of mass M this force will not be transmitted to the string A and so the string B will break. If the string B is pulled steadily the force applied to it will be transmitted from string B to A through the mass M and as tension in A will be greater than in B by Mg (weight of mass M), the string A will break.

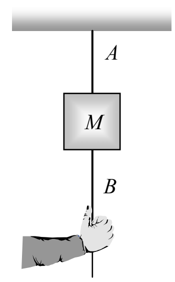


Figure: 3.4

- If we place a coin on smooth piece of card board covering a glass and strike the card board piece suddenly with a finger. The cardboard slips away and the coin falls into the glass due to inertia of rest.
- The dust particles in a carpet falls off when it is beaten with a stick. This is because the beating sets the carpet in motion whereas the dust particles tend to remain at rest and hence separate.

Newton's Second Law

The rate of change of linear momentum of a body is directly proportional to the external force applied on the body and this change takes place always in the direction of the applied force.

Newton's first law explains what happens to an object when no force acts on it: The object either remains at rest or continues moving in a straight line with constant speed. Newton's second law answers the question of what happens to an object that has a net force acting on it.

If a body of mass m, moves with velocity $\vec{v}$ then its linear momentum can be given by $\vec{p} = m\vec{v}$ and if force $\vec{F}$ is applied on a body, then

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

or $\vec{F} = \dfrac{d\vec{p}}{dt}$ ($K = 1$ in CGS and SI units)

or $\vec{F} = \dfrac{d}{dt}(m\vec{v}) = m\dfrac{d\vec{v}}{dt} = m\vec{a}$

(As $a = \dfrac{d\vec{v}}{dt}$ = acceleration produced in the body)

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

Force = mass × acceleration

Newton's Third Law

To every action, there is always an equal (in magnitude) and opposite (in direction) reaction**.** According the Newton, the hammer exerts a force on the nail and nail exerts a force on the hammer. You can tell that there is clearly a force exerted by the nail on the hammer, because the hammer rapidly slows down after coming into contact with the nail.

- When a body exerts a force on any other body, the second body also exerts an equal and opposite force on the first.
- A force in nature always occurs in pairs. A single isolated force is not possible.
- Any agent, applying a force also experiences a force of equal magnitude but in opposite direction. The force applied by the agent is called '*Action*' and the counter force experienced by it is called '*Reaction*'.
- Then according to Newton's third law of motion $\vec{F}_{AB} = -\vec{F}_{BA}$

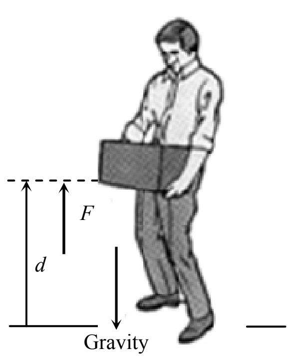


Figure: 3.5

As the system is at rest, net force on it is zero. Therefore force of action and reaction must be equal and opposite.

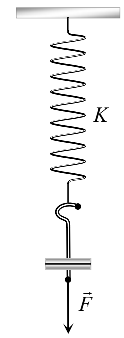


Figure: 3.6

- When a gun is fired, the bullet moves forward (action). The gun recoils backward (reaction).
- While walking a person presses the ground in the backward direction (action) by his feet. The ground pushes the person in forward direction with an equal force (reaction). The component of reaction in horizontal direction makes the person move forward.
- It is difficult to walk on sand or ice.
- Driving a nail into a wooden block without holding the block is difficult.
- Newton's III law $\vec{F}_{12} = -\vec{F}_{21}$
- Net force on a body $F = m\vec{a}$

  Force constant of a given spring is inversely proportional to its length i.e. $k = \dfrac{1}{l}$ or kl = constant.
- If F is force applied on a spring and spring is stretched by x, then restoring force in spring $= -kx$ and for equilibrium external force $F \quad kx$.

Apparent Weight of a Body in a Lift

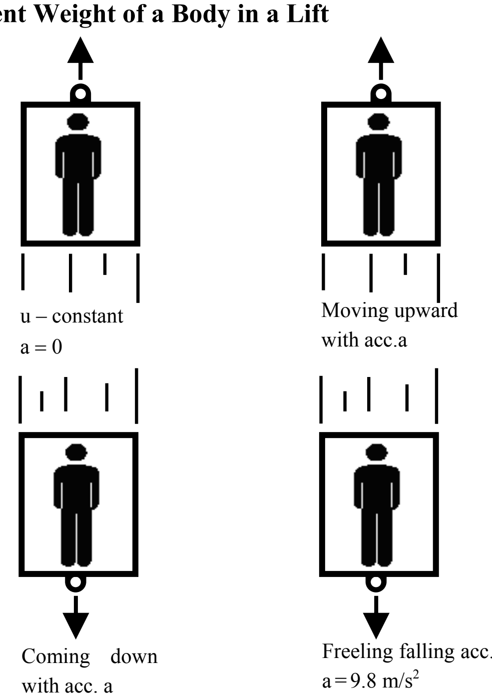


Figure: 3.7

- When the lift is at rest or moving with uniform velocity i.e., $a = 0$

  $mg - R = 0,\ R = mg$ or $W_{app} = W_0$

  Where, $W_{app} = R =$ reaction of supporting surface and

  $W_0 = mg =$ true weight.

- When the lift moves upwards with an acceleration a:

  $R = mg = ma$ or $R = m(g+a) = mg\left(1+\frac{a}{g}\right)$

$\therefore\ W_{app} = W_0\left(1+\frac{a}{g}\right)$

- When the lift moves downwards with an acceleration a:

  $mg - R = ma$ or $R \quad m \;\; g - a \quad mg \;\; 1 \;\; \frac{a}{g}$

$\therefore\ W_{app} = W_0\left(1-\frac{a}{g}\right)$

  Here, if $a > g, W_{app}$ will be negative. Negative apparent weight will mean that the body is pressed against the roof of the lift instead of floor. When the lift falls freely, i.e., $a = g$:

  $R = mg(g-g) = 0$ or $W_{app} = 0$

If the carriage/lift begins to fall freely, then the tension in the string becomes zero. Mass m experiences a pseudo force ma opposite to acceleration; the mass m is in equilibrium inside the carriage and $T\sin\theta = ma, T\cos\theta = mg$, i.e., $T = m\sqrt{g^2+a^2}$; The string does not remain vertical but inclines to the vertical at angle $\theta = \tan^{-1}(a/g)$ opposite to acceleration. This arrangement is called accelerometer and can be used to determine the acceleration of a moving carriage from inside by noting the deviation of a plumb line suspended from it.

Example 1. A force F_1 acting on a body of 2 kg produces an acceleration of 2.5 ms². An other force F_2 acting on the another body of mass 5 kg produces an acceleration of 2 m/sec². Find the ratio $\frac{F_2}{F_1}$.

Solution: For fist body $F = ma$, $F_1 = 2\times 2.5 = 5N$

For second body $F_2 = 5\times 2 = 10N$

So, $\frac{F_2}{F_1} = \frac{10}{5} = 2.$

Example 2. A force of 20 N acting on a mass m_1 produces an acceleration of 4 ms^{-2}. The same force is applied on mass m_2 then the acceleration produced is 0.5 ms^{-2}. What acceleration would the same force produce, when both masses are tied together?

Solution: For mass

$m_1 = F = 20N,\ a = 4ms^{-2}$ then $m_1 \quad \frac{F}{a} \quad \frac{20}{4} \quad 5\,kg$

For mass $m_2 : F \quad 20N,\ a \quad 0.5\,ms^{\ 2}$

then $m_2 \quad \frac{F}{a} \quad \frac{20}{0.5} \quad 40\,kg$

When m_1 and m_2 are tied together:

Total mass $\quad m_1 \quad m_2 \quad 45kg,\ F \quad 20\,N$

then $\quad a \quad \frac{F}{m_1 \quad m_2} \quad \frac{20}{45} \quad 0.44\,ms^{\ 2}$

Example 3. A field gun a mass 1.5 t fires a shell of mass 15 kg with a velocity of 150 m/s. Calculate the velocity of the recoil of the gun.

Solution: Mass of gun = 1.5 t = 1.5 × 1000 kg = 1500 kg

Mass of shell = 15 kg

Velocity of shell = 150 m/s.

Velocity of recoil of the gun =?

Momentum of gun = Mass of gun × velocity of recoil of the gun = 1500 V kg m/s

Momentum of shell = Mass of shell × velocity of shell = 15 × 10 kg m/s.

By the law of conservation of momentum:

Momentum of gun = Momentum of shell

1500 V = 15 × 150 or $V \quad \frac{15 \quad 150}{1500} \quad 1.5\ m/\sec$

The recoil velocity of gun = 1.5 m/sec.

Example 4. A hunter of 45 kg is standing on ice fires a bullet on 100 g with a velocity of 500 ms^{-1} by a gun of 5 kg. Find the recoil velocity of the hunter.

Solution: The initial momentum of the system, P_1 = Momentum of hunter + momentum of gun + momentum of bullet

or P_1 + 45 × 0 + 5 × 0 + 0.1 × 0 = 0 . . . (1)

Final momentum of the system, P_1 = Momentum of hunter + Momentum of gun + momentum of bullet

$P_2 =$ 45 V + 5 V + 0.1 × 500 (Here, V is the recoil velocity of gun with hunter).

$P_2 =$ 50 V + 50 . . . (2)

By the conservation of momentum $P_1 = P_2$

0 = 50 V + 50 or $V = -1$ m/s.

The recoil velocity of gun with hunter is 1 m/s.

Multiple Choice Questions

1. If A and B two objects with masses 10 kg and 30 kg respectively then:
a. A has more inertia than B
b. B has more inertia than A
c. A and B have the same inertia
d. None of the two have inertia

2. First law of motion defines:
a. inertia **b.** force
c. both inertia and force **d.** neither inertia nor force

3. Newton's first law of motion is:
a. qualitative
b. quantitative
c. both qualitative and quantitative
d. neither qualitative nor quantitative

4. Inertia depends upon :
a. acceleration of the body **b.** velocity of the body
c. shape of the body **d.** mass of the body

5. Which of the following has largest inertia?
a. A pin **b.** An ink pot
c. Your physics book **d.** Your body

6. When a bus starts suddenly the passengers standing on it, lean backwards in the bus. This is an example of:
a. Newton's first law
b. Newton's second law
c. Nekton's third law
d. None of the above

7. The law which defines force is:
a. Newton's third law **b.** Newton's first law
c. Newton's second law **d.** None of these

8. Inertia of rest is the property by virtue of which the body is unable to change by itself:
a. the state of rest only
b. the state of uniform linear motion
c. the direction of motion only
d. the steady state of rest

9. An iron ball and aluminium ball has same mass:
a. inertia of iron is greater than aluminium
b. both the ball have same inertia
c. inertia of iron is less than that on Aluminium
d. None of these

10. Mass measure amount of ____ in a body:
a. inertia **b.** motion
c. velocity **d.** acceleration

11. Newton's second law of motion:
a. defines force **b.** defines inertia
c. gives measure of force **d.** none of these

12. Newton's second law of motion is:
a. qualitative
b. quantitative
c. both qualitative and quantitative
d. neither qualitative nor quantitative

13. Momentum measures amount of _______ in a body
a. inertia **b.** motion **c.** velocity **d.** acceleration

14. Force measures rate of change of ____ of a body :
a. mass **b.** inertia
c. velocity **d.** momentum

15. CGS unit of force is:
a. m/s **b.** s/m **c.** dyne **d.** Newton

16. Momentum has same unit as:
a. impulse **b.** torque
c. moment of force **d.** couple

17. When force of 1 N acts on mass of 1 kg. Which is able to move freely, the object moves with a /an:
a. speed of 1 ms^{-1} **b.** speed of 1 kms^{-1}
c. acceleration of 10 ms^{-2} **d.** acceleration of $1ms^{-2}$

18. The net force acting on a body of mass of 1 kg moving with a uniform velocity of 5 ms^{-1} is:
a. 5 N **b.** 0.2 N
c. 0 N **d.** None of these

19. A body of mass 20 kg moves with an acceleration of $2ms^{-2}$. The rate of change of momentum is S.I. unit is:
a. 40 **b.** 10 **c.** 4 **d.** 1

20. A body of mass M strikes against wall with a velocity *v* and rebounds with the same velocity. Its change in momentum is:
a. zero **b.** Mv **c.** –Mv **d.** –2 Mv

21. Gram weight is a unit of:
a. mass **b.** weight
c. **a.** and **b.** both **d.** neither **a.** nor **.**

22. 9.8 N is equal to:
a. 1 kgf **b.** 1 kgwt
c. **a.** and **b.** both **d.** Neither **a.** nor **b.**

23. A body of mass 5 kg undergoes a change in speed from 20 m/s to 0.20 m/s. The momentum:
a. increases by 99 kgm/s **b.** decreases by 99 kgm/s
c. increases by 101 kgm/s **d.** decreases by 101 kgm/s

24. The combined effect of mass and velocity is taken into account by a physical quantity called:
a. torque **b.** moment of force
c. momentum **d.** all of them

25. How many dynes are equal to 1N?
a. 10^8 **b.** 10^4 **c.** 10^5 **d.** 10^3

26. Choose correct relation:
a. $a = F/m$ **b.** $aF = m$
c. $m = F \times a$ **d.** None of these

27. If a moving ball A collides with another moving ball B, then
a. momentum of A = momentum of B
b. (momentum A + momentum of B) before collision = (momentum A + momentum of B) after collision
c. neither A nor B
d. A or B both are possible

28. When a bullet is fired from a gun. The gun recoils to:
a. conserve mass **b.** conserve momentum
c. conserve K.E. **d.** none of these

29. A bullet is motion hits and gets embedded in a solid resting on a frictionless table. What is conserved?
a. Momentum and K.E. **b.** Momentum alone
c. K.E. alone **d.** None of these

30. A bullet of mass 0.01 kg is fired from a gun weighing 5.0 kg. If the initial speed of the bullet is 250 m/s, calculate the speed with which the gun recoils :
a. – 0.50 m/s **b.** – 0.25 m/s
c. + 0.05 m/s **d.** + 0.25 m/s

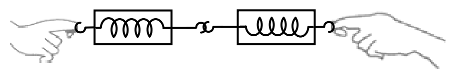
31. Forces of action and reaction are:
a. equal and in same direction
b. equal and in opposite direction
c. unequal and in same direction
d. unequal and opposite.

32. Forces of action and reaction act:
a. one after the other on same body
b. simultaneously on same body
c. one after the other on different bodies
d. simultaneously on different bodies

33. A man is standing on a boat in still water. If he walks towards the shore the boat will:
a. more away from the shore **b.** remain stationary
c. move towards the shore **d.** sink

34. In the action and direction were to act on the same body:
a. the resultant would be zero
b. the body would not move at all
c. both **a.** and **b.** are correct
d. neither **a.** nor **b.** is correct

35. Consider two spring balances hooked as shown in the figure. We pull them in opposite directions. If the reading shown by A is 1.5 N, the reading shown by B will be:



a. 1.5 N **b.** 2.5 N **c.** 3.0 N **d.** Zero

36. Newton used, quantity of motion' for:
a. momentum
b. force
c. acceleration due to gravity
d. none of these

37. A cannon after firing recoils due to:
a. conservation of energy
b. backward thrust of gases produced
c. Newton's first law of motion
d. Newton's' third law of motion

38. The forces of action and reaction have ____ magnitude but ____ direction:
a. same, same **b.** same, opposite
c. opposite, same **d.** opposite, opposite

39. Choose correct statement:
a. Action and reaction forces act on same object.
b. Action and reaction forces act on different objects.
c. a. and **b.** both are possible.
d. Neither **a.** nor **b.** is correct.

40. Newton's first law of motion describes which of the following?
a. Energy **b.** Work
c. Inertia **d.** Moment of inertia

41. A person sitting in an open car moving at constant velocity throws a ball vertically up into air. The ball falls
a. outside the car
b. in the car ahead of the person
c. in the car to the side of the person
d. exactly in the hand which threw it up

42. A bird weighs 2 *kg* and is inside a closed cage of 1 *kg*. If it starts flying, then what is the weight of the bird and cage assembly
a. 1.5 *kg* **b.** 2.5 *kg*
c. 3 *kg* **d.** 4 *kg*

43. A particle is moving with a constant speed along a straight line path. A force is not required to
a. Increase its speed
b. Decrease the momentum
c. Change the direction
d. Keep it moving with uniform velocity

44. When a bus suddenly takes a turn, the passengers are thrown outwards because of

a. Inertia of motion **b.** Acceleration of motion
c. Speed of motion **d.** Both **b.** and **c.**

45. Newton's second law gives the measure of

a. Acceleration **b.** Force
c. Momentum **d.** Angular momentum

46. A force of 100 dynes acts on mass of 5 gm for 10 sec. The velocity produced is:

a. 2 cm/sec **b.** 20 cm/sec
c. 200 cm/sec **d.** 2000 cm/sec

47. An object will continue moving uniformly until

a. The resultant force acting on it begins to decrease
b. The resultant force on it is zero
c. The resultant force is at right angle to its rotation
d. The resultant force on it is increased continuously

48. A diwali rocket is ejecting 0.05 *kg* of gases per second at a velocity of 400 *m/sec*. The accelerating force on the rocket is:

a. 20 *dynes* **b.** 20 *N* **c.** 22 *dynes* **d.** 1000 *N*

49. A body of mass 2 *kg* is hung on a spring balance mounted vertically in a lift. If the lift descends with an acceleration equal to the acceleration due to gravity '*g*', the reading on the spring balance will be:

a. 2 *kg* **b.** $(4\times g)kg$
c. $(2\times g)kg$ **d.** Zero

50. In the above problem, if the lift moves up with a constant velocity of 2 *m/sec*, the reading on the balance will be:

a. 2 *kg* **b.** 4 *kg* **c.** Zero **d.** 1 *kg*

51. In the above problem if the lift moves up with an acceleration equal to the acceleration due to gravity, the reading on the spring balance will be:

a. 2 *kg* **b.** $(2\times g)kg$
c. $(4\times g)kg$ **d.** 4 *kg*

52 A force of 5 *N* acts on a body of weight 9.8 *N*. What is the acceleration produced in $m/\sec^2$?

a. 49.00 **b.** 5.00
c. 1.46 **d.** 0.51

53. A body of mass 40 *gm* is moving with a constant velocity of 2 *cm/sec* on a horizontal frictionless table. The force on the table is:

a. 39200 *dyne* **b.** 160 *dyne*
c. 80 *dyne* **d.** Zero *dyne*

54. When 1 *N* force acts on 1 *kg* body that is able to move freely, the body receives

a. A speed of 1 *m/sec*
b. An acceleration of 1 $m/\sec^2$
c. An acceleration of $980\,cm/\sec^2$
d. An acceleration of 1 $cm/\sec^2$

55. An object with a mass 10 *kg* moves at a constant velocity of 10 *m/sec*. A constant force then acts for 4 seconds on the object and gives it a speed of 2 *m/sec* in opposite direction. The acceleration produced in it, is:

a. $3\,m/\sec^2$ **b.** $-3\,m/\sec^2$
c. $0.3\,m/\sec^2$ **d.** $-0.3\,m/\sec^2$

56. In the above question, the force acting on the object is:

a. 30 *N* **b.** – 30 *N* **c.** 3 *N* **d.** – 3 *N*

57. In the above question, the impulse acting on the object is:

a. 120 newton × sec **b.** – 120 newton × sec
c. 30 newton × sec **d.** – 30 newton × sec

58. Swimming is possible on account of

a. First law of motion
b. Second law of motion
c. Third law of motion
d. Newton's law of gravitation

59. When we jump out of a boat standing in water it moves

a. Forward **b.** Backward
c. Sideways **d.** None of these

60. You are on a frictionless horizontal plane. How can you get off if no horizontal force is exerted by pushing against the surface?

a. By jumping
b. By spitting or sneezing
c. By rolling your body on the surface
d. By running on the plane

61. On a stationary sail-boat, air is blown at the sails from a fan attached to the boat. The boat will

a. Remain stationary
b. Spin around
c. Move in a direction opposite to that in which air is blown
d. Move in the direction in which the air is blown

62. A man is at rest in the middle of a pond on perfectly smooth ice. He can get himself to the shore by making use of Newton's

a. First law **b.** Second law
c. Third law **d.** All the laws

63. A man is standing on a balance and his weight is measured. If he takes a step in the left side, then weight

a. will decrease

b. will increase

c. remains same

d. first decreases then increases

ANSWERS

1.	**2.**	**3.**	**4.**	**5.**	**6.**	**7.**	**8.**	**9.**	**10.**
b	c	a	d	d	a	b	d	b	a
11.	**12.**	**13.**	**14.**	**15.**	**16.**	**17.**	**18.**	**19.**	**20.**
c	b	b	d	c	a	d	c	a	d
21.	**22.**	**23.**	**24.**	**25.**	**26.**	**27.**	**28.**	**29.**	**30.**
b	c	b	c	c	a	b	b	b	a
31.	**32.**	**33.**	**34.**	**35.**	**36.**	**37.**	**38.**	**39.**	**40.**
b	d	a	c	a	a	d	b	b	c
41.	**42.**	**43.**	**44.**	**45.**	**46.**	**47.**	**48.**	**49.**	**50.**
d	c	d	a	b	c	b	b	d	a
51.	**52.**	**53.**	**54.**	**55.**	**56.**	**57.**	**58.**	**59.**	**60.**
d	b	a	b	b	b	b	c	b	b
61.	**62.**	**63.**							
a	c	c							

SOLUTIONS

17. **(d)** $F = ma$

Given $F = 1N,\ m = 1kg \Rightarrow a \quad \frac{F}{m} \quad \frac{1N}{1kg} \quad 1\,ms^{\ 2}$

18. **(c)** As v = constant $a = 0$, Therefore $F = ma = 0$

19. **(a)** $F = \frac{dp}{dt} = ma = 20\times 2 \quad 40\,N$

20. **(d)** $\Delta P = M(v_f - v_i) \Rightarrow v_f = -v \Rightarrow \Delta P = -2Mv$

23. **(b)** $\Delta P = mv_f - mv_i = 5(0\cdot 20 - 20) = -99$

30. **(a)** From conservation of momentum $P_f = P_i$

$\Rightarrow \quad P_i = 0$

$P_f = m_g \cdot v_g + m_b \cdot v_b = 0$

$\Rightarrow \quad v_g = -\frac{m_b v_b}{m_g} \quad \frac{0\ \ 01\ \ \ 250}{5} \Rightarrow v_g \quad 0.5\ m/\sec$

35. **(a)** $|F_A| = |-F_B|$. In magnitude

40. **(c)** Newton's first law of motion defines the inertia of body. It states that every body has a tendency to remain in its state (either rest or motion) due to its inerta.

41. **(d)** Horizontal velocity of ball and person are same so both will cover equal horizontal distance in a given interval of time and after following the parabolic path the ball falls exactly in the hand which threw it up.

42. **(c)** When the bird flies, it pushes air down to balance its weight.

So the weight of the bird and closed cage assembly remains unchanged.

43. **(d)** Particle will move with uniform velocity due to inertia.

46. **(c)** Acceleration $a = \frac{F}{m} = \frac{100}{5} = 20\ cm/s^2$

Now $v = at = 20\times 10 = 200\,cm/s$

48. **(b)** $F = u\left(\frac{dm}{dt}\right) = 400\times 0.05 = 20N$

49. **(d)** Reading on the spring balance $= m\,(g - a)$ and since $a = g$

$\therefore$ Force = 0

50. **(a)** The lift is not accelerated, hence the reading of the balance will be equal to the true weight.

$R = mg = 2g$ Newton or $2kg$

51. **(d)** When lift moves upward then reading of the spring balance, $R = m(g + a) = 2(g + g) = 4g\ N = 4kg$

[As $a = g$]

52. **(b)** As weight = 9.8 N

$\therefore$ Mass = 1 kg

Acceleration $= \frac{\text{Force}}{\text{Mass}} = \frac{5}{1} = 5\ m/s^2$

53. **(a)** Force on the table $= mg = 40\times 980 = 39200\ dyne$

54. **(b)** $a = \frac{F}{m} = \frac{1\ N}{1\ kg} = 1\ m/s^2$

55. **(b)** $\vec{a} = \frac{\vec{v}_2 - \vec{v}_1}{t} = \frac{(-2) - (+10)}{4} = \frac{-12}{4} = -3\ m/s^2$

56. **(b)** $F = ma = 10\times(-3) = -30\,N$

57. **(b)** Impulse = Force × Time $= -30\times 4 = -120\ Ns$

58. **(c)** Swimming is a result of pushing water in the opposite direction of the motion.

59. **(b)** Because for every action there is an equal and opposite reaction takes place.

61. **(a)** The force exerted by the air of fan on the boat is internal and for motion external force is required.

□ □ □