NEWTON'S LAWS OF MOTION

Learning objectives:

- Newton's first law of motion.
- Force and Concept of inertia.
- Linear momentum.
- Newton's second law of motion.
- Impulse.
- Newton's third law of motion.
- Law of Conservation of linear momentum.
- What is Free Body Diagram(FBD)
- Drawing free body diagram in different situations
- Motion of bodies kept in contact
- Motion of bodies connected by string

Real time Applications:

- Importance of seatbelts headrests and airbags in vehicles is the application of I law only
- Inertia explains what happens when a car takes sudden turn or stops suddenly.
- second law is useful in industries to know how much force the machine has to apply in order to move a body.
- In space field newton's third law and law of conservation of energy playing a wide role in sending a rocket to it's target
- Usefull in understanding motion of bodies bodies in contact with several other bodies.
- Usefull in finding motion of bodies connected by string

Important Formulae:

1. P= mv
2. F= ma
3. $F = \frac{mv - mu}{t}$
4. $F = m\frac{dv}{dt}$
5. $F = v\frac{dm}{dt}$
6. $F = u\frac{dm}{dt}$
7. $\left(\frac{dm}{dt}\right)u$ = Mg,
8. $\left(\frac{dm}{dt}\right)u$ = Mg + Ma
9. $m_1u_1+m_2u_2 = m_1v_1+m_2v_2$
10. If $\vec{F} = 0$ then $\vec{p} =$ constant
11. $\vec{V} = \frac{-m\vec{v}}{M}$
12. $\frac{V_1}{V_2} = \frac{-m_2}{m_1}$.
13. When two masses m_1 & m_2 kept in contact, and a force F acts on m_1, then acceleraion of the system a= $\frac{F}{m_1+m_2}$, contact force $\frac{m_2F}{m_1+m_2}$
14. When two masses m_1 & m_2 are connected by light string , and a force F pulls m_1 acceleraion of the system a= $\frac{F}{m_1+m_2}$, tension in the connected string $\frac{m_2F}{m_1+m_2}$

Worksheet-1

Newton's Laws of Motion:

Newton has given three laws to describe the motion of bodies. These laws are known as Newton's laws of motion.

Newton's First law: If no external force acts, a body continues to be in its state of rest or of uniform motion along a straight line. (OR)

If no external force acts, we can also say that "bodies" go on doing what they are doing.

Linear momentum :-

Consider two balls A and B. Let ball A be heavier than the ball B. i.e. mass (m_1) of ball A is greater than the mass (m_2) of the ball B. Suppose both balls are moving with same velocity $\vec{v}$. The force require to stop ball A is more than the force required to stop ball B. This shows that the heavier ball has more quantity of motion than the lighter ball. **Thus, quantity of motion of a body is directly proportional to the mass of the body.**

Now consider two balls of same mass moving with different velocities. The force required to stop the fast moving ball is more than the force required to stop the slow moving ball. So the quantity of motion of the body is directly proportional to the velocity of the ball.

Conclusion : The quantity of motion of the moving body is proportional to

(i) mass of the body

(ii) velocity of the body.

This quantity of motion possessed by a moving body is known as momentum of the body. (or) The total quantity of motion contained in a body is called momentum.

Mathematical expression : Momentum of a body is equal to the product of the mass (m) of the body and the velocity $(\vec{v})$ of the body. It is denoted by $\vec{P}$.

Thus, momentum = mass × velocity

$$\vec{p} = m\vec{v}$$

* momentum is a vector quantity

Note :- The direction of momentum of a body is same as that of the direction of the velocity of the body.

Units of momentum : S.I. unit of momentum = S.I unit of mass × S.I unit of velocity = kg × m/s = kg m/s. Similarly C. G. S. unit of momentum is **g cms^{-1}.**

Change of momentum : If 'u' and 'v' are the initial and final velocity of a body then its, initial momentum = mu final momentum = mv

Now change of momentum = final momentum – initial momentum = mv – mu

§§ CHANGE IN MOMENTUM OF A BODY IN DIFFERENT CASES

Consider a body of mass m moving with velocity $\vec{V}_i$ and momentum $\vec{P}_i$. Due to a collision (or) due to the action of a force on it suppose its velocity changes to $\vec{V}_f$ and momentum changes to $\vec{P}_f$ in a small time interval Δt.

Change in momentum of body = $\Delta\vec{P} = \vec{P}_f - \vec{P}_i$

$= m\vec{V}_f - m\vec{V}_i \quad |\Delta\vec{P}| = |\vec{P}_f - \vec{P}_i| = \sqrt{P_f^2 + P_1^2 - 2P_f P_i \cos\theta}$

where θ = angle between $\vec{P}_f$ and $\vec{P}_i$

Case (i) : Consider a body of mass m moving with velocity $V\hat{i}$. If it hits a rigid surface (or) a wall and comes to rest. Change in momentum of the body =

$\overrightarrow{\Delta P} = \vec{P}_f - \vec{P}_i = 0 - (mv)\hat{i}$

$= -(mv)\hat{i} \quad |\overrightarrow{\Delta P}| = mv$

Note : From law of conservation of linear momentum, theoretically, Change in mo mentum of surface / wall = $+(mv)\hat{i}$

Case(ii) : In the above case if the body rebounds with same speed V then $\theta = 180^0$

$\overrightarrow{\Delta P} = \vec{P}_f - \vec{P}_i = \left[-(mv)\hat{i}\right] - \left[(mv)\hat{i}\right] = -(2mv)\hat{i}$

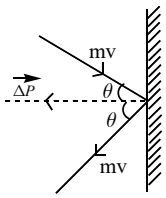
$\therefore \ |\overrightarrow{\Delta P}| = 2mv$

Case (iii) : If a body of mass m moving with velocity $V_1\hat{i}$ hits a rigid wall and rebounds with speed V_2 then $\theta = 180^0, \overrightarrow{\Delta P} = \vec{P}_f - \vec{P}_i$

$= \left[-(mv_2)\hat{i}\right] - \left[(mv_1)\hat{i}\right] \quad |\overrightarrow{\Delta P}| = m(V_2 + V_1)$

Case (iv) : A body of mass m moving with speed V hits a rigid wall at an angle of incidence θ and reflects with same speed V $\overrightarrow{\Delta P}$ of body is along the normal, away from the wall

$|\overrightarrow{\Delta P}| = 2mv\cos\theta$



Case(v) : In the above case if θ is the angle made by $\vec{V}_i$ with wall then $|\overrightarrow{\Delta P}| = 2mv\sin\theta$

NEWTON'S SECOND LAW OF MOTION

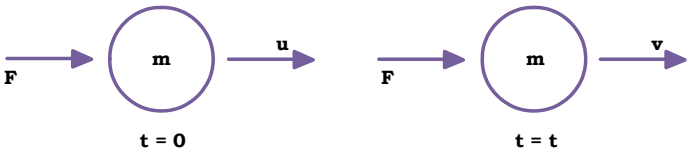
1. The rate of change of momentum of a body is directly proportional to the external force and the change in momentum takes place in the direction of the force.
2. Newton's second law of motion leads to a formula useful for measuring force. $\overline{F} = m\,\overline{a}$.
3. Force is a vector. It is always in the direction of change in momentum. Force is also always in the direction of acceleration.
4. SI unit of force is *newton* (N). If a force acting on a mass of 1 kg produces in it an acceleration of 1 m s^{-2} in its direction, it is called a *newton*.
5. CGS unit of force is dyne. If a force acting on a mass of 1 gm produces in it an acceleration of 1 cm s^{-2} in its direction, it is called a *dyne*.
6. One *newton* = 10^5 *dyne*.

7. **Gravitational units of force:** kilogram weight (kg.wt) and gram weight (gm.wt) are called the gravitational units of force. 1 kg.wt or kg. f = 9.8 N,
1 gm.wt or gm.f = 980 dyne.

8. To calculate a force '*F*', there are several useful variants of the formula $\bar{F} = m\,\bar{a}$.

9. $F = \frac{mv - mu}{t}$, 10. $F = m\frac{dv}{dt}$ s , 11. $F = v\frac{dm}{dt}$

Derivation of F = ma : Consider a body of mass 'm' moving with initial velocity u. Let a force F acts on the body for time 't' so that the velocity of the body after time 't' is v.



Initial momentum of the body (P_i) = m u

Final momentum of the body (P_f) = m v

Now, change in momentum of the body = $P_f - P_i$ = mv – mu = m (v – u)

Time taken for this change in momentum = (t – 0) = t

$\therefore$ Rate of change of momentum = $\frac{\text{change of momentum}}{\text{time taken}} = \frac{m\,(v-u)}{t}$ = m a

$\left(\because a = \frac{(v-u)}{t}\right)$

EXAMPLE

√ **Example-1**

Two forces having magnitude 3F and 2F, when act in the same direction simulataneously on a body gives a net force equal to 25 N. Find the value of F.

Solution :

Net force = sum of the two forces = 3F + 2F = 5F

$\therefore 5F = 25$

$\Rightarrow F = \frac{25}{5} = 5N$

√ **Example-2:**

A car changes its speed from 20 km h^{-1} to 50km h^{-1} of mass 3600 kg in 5s. Determine the net external force applied on the car.

Solution: $F = m\left(\frac{v-u}{t}\right) = 3600\left(\frac{50-60}{5}\right)\times\frac{15}{18}$

= 600 x 30 = 1800 N.

√ **Example-3:**

If a force of 50 N is applied on a body and it is still at rest then find the magnitude of static fricational force acting on it.

Solution: The magnitude of the force acting on the body (f) = 50 N.

Due to application of this force, the body tends to move but is not set in motion. and hence, the applied force is equal in magnitude and opposite in direction to static firctional force.

$\therefore$ The magnitude of static frictional force = 50 N.

√ **Example-4:**

The speed of a car weighing 1000 kg increases from 36 km/h to 108 km/h. Calculate the change in momentum.

Solution: Mass of the car (m) = 1000 kg

initial velocity (v) = 36 km / h (1 km/h = 5 /18 m/s)

= 36 x 5/ 18 m/s

= 10 m/s

Final Velocity (v) = 108 km/h = 108 x 5 / 18 m/s

= 6 x 5

= 30 m/s

Change in momentum = mv -mu

= m(v - u)

= 1000 (30 - 10)

= 1000 x 20

=20000

√ **Example-5:**

An object requries the force of 100 N to gain an acceleration 'a'. If the mass of the object is 500 kg what will be the value of 'a'?

Solution: According to the question,

mass (m) = 500 kg,

Force (F) = 100 N,

Acceleration (a) = ?

We know that, Force = Mass x Acceleration

Or F = m x a

Therefore,100 N = 500 kg x a

a = 100 N / 500 kg

a = 100 kg ms^{-2} / 500 kg

a = 0.2 ms^{-2}

Thus,acceleration of the vehicle = 0.2 ms^{-2}

√ **Example-6:**

A Hockey player hits a ball (m = 100 g) lying on ground with his stick. It is found that the ball starts moving with a velocity of 40 ms^{-1}. Find

a) The impluse of the force exerted by the stick on the ball.

b) If the stick was in contact with the ball for 1 ms then find the magnitude of the force acting on the ball

Solution: a) Impulse = F x t

= ma x t

$$m = \frac{(v-u)}{t} \times t$$ =m (v-u)

=0.1 kg (40 ms^{-1} - 0)

= 4 kg ms^{-1}

b) I = F x t

4 kg ms^{-1} = F x 1 x 10^{-3} s

$$F = \frac{4\,kgms^{-1}}{1\times10^{-3}\,s}$$

= 4 x 10^3 kgms^{-2}

F = 4 x 10^3 N

√ **Example-7:**

When a car weighing 800 kg was moving on a horizontal road with 30 ms^{-1} velocity its breaks stopped working. The car came to rest after travelling a distance of 150 m. Find i) the retardation of the car ii) frictional force exerted by the ground on the car .

solution: i) Given u = 30 ms-1

v = 0

s = 150 m a = ?

We know that $v^2 = u^2 + 2as$

$\Rightarrow$ 0 = (30)^2 + 2 x a x 150

$\therefore$ -300 a = 900

$\therefore$ a = -3 ms^{-2}

ii) We know that F = ma

= 800 x -3

F = -2400 N

Negative sign implies that it is a retardation force. This force which opposes the motion of a car on the ground is a frictional force.

$\therefore$ Frictional force exerted by ground on car = 2400 N.

√ **Example-8:**

If a bullet of mass 5 g moving with a velocity of 100m/s penetrates a wooden block upto 6cm. Find the average force imposed.

Solution:

u = 100 m/s, v = 0

S = 6 × 10^{-2} m , a = ?

v^2 - u^2 = 2as

0^2 - (100)^2 = 2 × a × 6 × 10^{-2}

$$a = \frac{-100\times100}{2\times6\times10^{-2}}$$

$$\boxed{a = \frac{-1}{12}\times10^{6}\ \text{m/s}}$$

$$F = ma = 5\times10^{-3}\times\left[\frac{-1}{12}\times10^{6}\right]$$

$$F = \frac{-5000}{12} = -417\ N$$

Retarding force F = 417 N

√ ***Example-9:***

batsman hits 150 gm ball moving horizontally at 20m/s back to bowler at 12m/s. If contact of cricket ball lasts for $\frac{1}{25}$ *sec with the bat,find the average force that the bats man exerts*

Solution. The change in momentum of ball

$\Delta p = m(v-u) = 150\times10^{-3}$ [20 – (– 12)]

= $32\times15\times10^{-2} = 4.8N\times S$

given, $\Delta t = \frac{1}{25}\text{sec}$ $\therefore$ $F = \frac{\Delta p}{\Delta t} = 120N$

√ ***Example-10:***

A force produces acceleration16 m/s² in a mass 0.5 kg and an acceleration 4.0 m/s² in an unknown mass when applied seperately. If both masses are tied together, what will be the acceleration under same force?

Solution. Force is, F = ma = $0.5\times16 = 8$ N when both masses are joined and same force act, acceleration is $a' = \frac{F}{m+m'} = \frac{8}{0.5+8/4} = \frac{8}{2.5} = 3.2m/s^2$

√ ***Example-11:***

A force of 100 dyne acts on a mass of 5 grams for 10 sec. Find the velocity produced.?

Solution : $a = \frac{F}{m} = \frac{100}{5} = 20\ \text{cm/s}^2$

v = u + at

v = 0 + 20 × 10 = 200 cm/sec.

√ ***Example -12:***

Gravel is dropped on a conveyer belt at the rate of 0.5 kg/sec. Find the extra force required in Newton to keep the belt moving at 2 m/sec.

Solution : $F = \left(\frac{dm}{dt}\right)\times v$

F = 0.5 × 2 = 1 N

√ ***Example -13***

A body of mass 5 kg starts from the origin with an initial velocity of $\bar{U} = (30\hat{i} + 40\hat{j})\ m/s$. ***A*** *constant force of* $F = (-\hat{i} - 5\hat{j})\ N$ *acts on the body. Find the time in which the y-component of the velocity becomes zero.*

Solution :

$\bar{u}$ = 30i + 40 j.....(1)

$u = u_x\hat{i} + u_y\hat{j}$ .....(2)

$F = -\hat{i} - 5\hat{j}$.....(3)

$F = F_x\hat{i} + F_y\hat{j}$.....(4)

comparing (1) and (2), (3) and (4)

we have

u_y = 40 m/s

F_y = – 5N

$F_y = ma_y$

$\boxed{a_y = -1\ m/s^2}$

$v_y = u_y + a_y \times t$

$0 = 40 - 1 \times t$

t = 40 sec

√ ***Example -14***

A satellite in force free space sweeps stationary interplanetary dust at a rate $\frac{dM}{dt} = \alpha v$ *where m is mass, v is the velocity of the satellite and* α *is a constant. What is the deceleration of the satellite.*

Solution : $F = \frac{dp}{dt} \Rightarrow \quad F = v.\frac{dM}{dt}$

$F = v(\alpha v) \Rightarrow F = \alpha v^2$

$Ma = \alpha v^2$

$a = \frac{\alpha v^2}{M}$

√ ***Example -15***

A particle of mass 0.3 kg is subjected to a force F = kx with k = 15 N/m. What will be its initial acceleration, if it is released from a point 20 cm away from the origin ?

Solution :

$a = \frac{F}{M} = \frac{kx}{M} = \frac{15 \times 0.2}{0.3}$ = 10 m/s²

TEACHING TASK

Single correct option questions:

1. A force of 100 N acts on a body of mass 2kg fgor 10s . the change in momentum of the body is.....
A) 100 Ns B) 250Ns C) 500Ns D) 1000Ns

2. A mass of 2 kg at rest travels for 4 sec with an acceleratio of 1.5 m/s^2. The gain of momentum of the body is
A) 5 kgm/s B) 10 kgm/s C) 12 kgm/s D) 14 kgm/s

3. If a constant force acts on a body initially kept at rest, the distance moved by the body in time 't' is proportional to
A) t B) t^2 C) t^3 D) t^4

4. A force produces an acceleration of 0.5 m/s^2 in a body of mass 3.0 kg. If the same force acts on a body of mass 1.5 kg the acceleration produced in it is
A) 3.0 m/s^2 B) 1.0 m/s^2 C) 5.0 m/s^2 D) 7 m/s

5. The force produces an acceleration of 2.0 m/s^2 in a body A and 5.0 m/s^2 in another body B. The ratio mass of A to the mass of B is
A) 5:2 B) 3:5 C) 2:5 D) 4:5

6. A block of mass 2 kg is moving with an accelertion of 1 m/s^2 under the action of a constant horizontal foce. A similar block of mass 2 kg is gently glued over the moving block and the two blocks are now moving as a single unit. Find the acceleration of the combination if the same force continuous to act
A) 0.2 m/s^2 B) 0.1 m/s^2 C) 0.5 m/s^2 D) 1 m/s^2

7. A block of mass 2 kg is moving on a smooth surface with constant speed. A constant horizontal force F acts on the body for 2 s during which its speed increases by 3 m/s. Find F
A) 2 N B) 4 N C) 3 N D) 1 N

8. A force of 1.0 N acts on a body of mass 10 kg. The body covers 100 cm in 4 seconds moving along a straight line. The initial velocity is
A) 2 cm/s B) 4 cm/s C) 6 cm/s D) 5 cm/s

9. If a force of 15 N acts upon a mass of 20 kg kept on a smooth horizontal surface, what velocity does it generate in 8 s
A) 5 m/s B) 3 m/s C) 1 m/s D) 6 m/s

10. A block of mass 2 kg is lying on a smoth horizontal surface. A constant horizontal force F starts acting on the block and speed of the block becomes 3 m/s over the distance 1 m. Find F
A) 10 N B) 7 N C) 9 N D) 5 N

11. An open carriage in a goods train is moving with a uniform velocity of 5 ms^{-1}. If the rain adds water with zero velocity at the rate of 5 kg s^{-1}, then the additional force applied by the engine to maintain the same velocity of the train is
A) 0.5 N B) 2.0 N C) 50 N D) 25 N

12. A balloon has 8 gram of air. A small hole is pierced into it. The air escapes at a uniform rate of 7cm/s. If the balloon shrinks in 5.6 sec then the average force acting on the balloon is
A) 10^{-4} N B) 10^{-2} dyne C) 56 dyne D) 10^{-6} N

13. Bullets of 0.03 kg mass each hit a plate at the rate of 200 bullets per second with a velocity of 30 m/s. They average force acting on the plate in newton is
A) 120 B) 180 C) 300 D) 480

14. A machine gun fires a bullet of mass 40g with a velocity 1200 ms^{-1}.The man holding it can exert a maximum force of 144 N on the gun.How many bullets can he fire per second at the

most?

A) One B) Three C) Two D) Four

More than one correct option questions

- *This section contains multiple choice questions. Each question has 4 choices (A), (B), (C),(D), out of which **ONE or MORE** is correct. Choose the correct options*

15. Choose the correct option

a) The acceleration produced in a body is directly proportional to the force acting on it

b)The acceleration produced in a body is inversely proportional to the mass of the body

c) 1 newton = 10^5 dyne d) 1 newton = 1 kg ms^{-2}

A) a,b,c B) a,b C) a,b,d D) all

16. 1 gm weight =

a)980gcm/s^2 b) 980 dyne c)9800gm/s^2 d) 98 dynes

A) a,b,c correct B) a,b correct C) a,b,d correct D) all correct

17. Which of the following are correct?

a) F=ma b) $F = u\frac{dm}{dt}$ c) F=u dm X dt d) P=mv

A) a,b,c B) b,c,d C) a,b,d D) all

Assertion - A and Reason - R:

- *This section contains certain number of questions. Each question contains Statement – 1 (Assertion) and Statement – 2 (Reason). Each question has 4 choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct Choose the correct option.*

A) Both A and R are true and R is the correct explanation for A.
B) Both A and R are true and R is not correct explanation of A.
C) A is true but R is false. D) A is false but R is true

18. **A:** If the velocity of a body is zero then it's momentum is equal to zero.
R: Momentum is the product of mass and acceleration of a body.

19. **A:** Newton's second law gives the measurement of force.
R: Newton's first law gives the defination of force.

20. **A:** Newton's second law gives the concept of momentum.
R: Newton's second law gives the concept of inertia.

Match the following

- *This section contains Matrix-Match Type questions. Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in **Column–I** have to be matched with statements (p, q, r, s) in **Column–II**. The answers to these questions have to be appropriately bubbled as illustrated in the following example.*

*If the correct matches are A-p,A-s,B-r,B-r,C-p,C-q and D-s,then the correct bubbled 4*4 matrix should be as follows:*

21.

Set-A	Set-B
a) Initial momentum of body	1) mv-mu
b) Rate of change of momentum	2) m(v-u)/t
c) change in momentum of body	3) mv
d) final momentum of body	4) mu

A) a-1,b-4,c-2,d-3 B) a-3,b-1,c-2,d-4
C) a-2,b-1,c-4,d-3 D) a-4,b-2,c-1,d-3

Comprehension type questions:

- *This section contains paragraph. Based upon each paragraph multiple choice questions have to be answered. Each question has 4 choices (A) , (B) ,(C) and (D) out of which **ONLY ONE i**s correct. Choose the correct option.*

22. A body of mass 10kg is at rest on a smooth horizontal surface. A person applies a force of 20N horizontally. Due to the action of force body moves with avelocity of 30m/s.

i) Final momentum of the body is
A) 0 B) 300 kgm/s C) 30kg m/s D) 2000 kgm/s

ii) Initial momentum of body is
A) 0 B) 200kgm/s C) 300 kgm/s D) 7.5kgm/s.

iii) Acceleration of the body is
A) 1m/s^2 B) 5m/s^2 C) 2m/s^2 D) 10m/s^2

KEY

ΦΦ TEACHING TASK :

1) D, 2) C, 3) B, 4) B, 5) A, 6) C, 7) C, 8) D, 9) D, 10) C, 11) D, 12) A, 13) B, 14) B, 15) D, 16) B, 17) C, 18) C, 19) B, 20) B, 21) D, 22) i) B, ii) A, iii) C

LEARNER'S TASK

BEGINNERS(Level - I)

Single correct option questions:

1. A body of mass 10kg moves with a velocity of 2m/s. Its momentum is ..... kgm/s
A) 20 B) 10 C) 5 D) None

2. A body of mass 10kg moves with a velocity of 50cm/s its momentum is ....
A) 5kgm/s B) 7kg/s C) 10kgm/s D) none

3. A force of 100N applied on a body of mass 20kg at rest. What is the acceleration acquired by the body ?
A) 2m/s^2 B) 4m/s^2 C) 5m/s^2 D) 10m/s^2.

4. What will be the force required to accelerate rocket of mass of 50kg by 15m/s^2 ?
A) 750 N B) 0.3 N C) 65 N D) 35 N

5. A body of mass 2 kg is sliding with a constant velocity of 4 m/s on a friction less horzontal table. Find the force required to keep the body moving with he same velocity
A) 0 B) 2 N C) 4 N D) 1 N

6. Find the amount of force required to impart an acceleration of 2 m/s^2 in a body of mass 1.5 kg lying on a smooth horizpntal surface
A) 1 N B) 2 N C) 3 N D) 4 N

7. A constant horizontal force F imparts an accelertion of 1 m/s^2 in a block of mass 500 g lynig on a horzontal surface. The force is
A) 0.1 N B) 0.4 N C) 0.2 N D) 0.5 N

8. A force produces an acceleration of 5.0 cm/s^2 when it acts on a body of mass 20 g. The force in netwon is
A) 2 x 10^{-3} N B) 4 x 10^{-3} N C) 1.0 x 10^{-3} N D) 5 x 10^{-3} N

9. Find the amount of force required to produce an acceleration of 3 cm/s^2 in a body of mass

250 g

A) 75 x 10^{-4} N B) 25 x 10^{-4} N C) 50 x 10^{-4} N D) 15 x 10^{-4} N

10. If same force is applied on the bodies of masses 2kg and 3kg, what is the ratio of their accelerations ?

A) $a_1 : a_2 = 1 : 2$ B) $a_1 : a_2 = 3 : 2$ C) $a_1 : a_2 = 2 : 3$ D) $a_1 : a_2 = 2 : 1$

11. A force acts on a particle of mass 200 g. The velocity of the particle changes from 15 m/s to 25 m/s in 2.5 sec. Assuming the force to be constant, it magnitude is

A) 0.4 N B) 0.6 N C) 0.8 N D) 0.5 N

12. A force acting on a particle of mass 200 g displaces it through 400 cm in 2 sec. The magnitude of the force if the initial velocity of the particle is zero is

A) 0.1 N B) 0.3 N C) 0.4 N D) 0.5 N.

13. A block of metal weighing 2 kg is resting on a frictionless plane. It is struck by a jet releasing water at a rate of 1 kg s^{-1} and at a speed of 5 ms^{-1}. The initial acceleration of the block will be

A) 2.5 ms^{-2} B) 5.0 ms^{-2} C) 10 ms^{-2} D) 10^3 km h^{-2}

14. An open carriage in a goods train is moving with a uniform velocity of 10 ms^{-1}. If the rain adds water with zero velocity at the rate of 5 kg s^{-1}, then the additional force applied by the engine to maintain the same velocity of the train is

A) 0.5 N B) 2.0 N C) 50 N D) 25 N

EXPLORERS

More than one correct option questions

- *This section contains multiple choice questions. Each question has 4 choices (A), (B), (C),(D), out of which **ONE or MORE** is correct. Choose the correct options*

15. 1 Newton =

a) 1 kgm/s^2 b)1000g×100cm/s^2 c) 100000gcm/s^2 d) 10^5gcm

A) a,b,c correct B) a,b correct C) a,b,d correct D) b, c correct

16. The unit of momentum

a) $gcms^{-1}$ b) $gcms^{-2}$ c) $kgms^{-1}$ d) $kgms^{-2}$

A) a,b,c correct B) a,c correct C) a,b,d correct D) b, c correct

17. Choose the correct option

a) P=mv b) $a = \frac{v-u}{t}$ c) v=Pm d) $V = \frac{a-u}{t}$

A) a,b,c B) a,b C) a,b,d D) b, c

18. linear momentum of a body is the product of its

a) velocity b) volume c)mass d)area

A) a,b,c correct B) a,b correct C) a,b,d correct D) a, c correct

Assertion - A and Reason - R:

- *This section contains certain number of questions. Each question contains Statement – 1 (Assertion) and Statement – 2 (Reason). Each question has 4 choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct Choose the correct option.*

A) Both A and R are true and R is the correct explanation for A.
B) Both A and R are true and R is not correct explanation of A.
C) A is true but R is false. D) A is false but R is true.

19. **A:** Momentum is a vector quantity.
R: p=mv.

20. **A:** Mass is the measure of force.

R: Mass is the measure of inertia.

21. **A:** Force is the rate of change in momentum.
R: Foce is a vector quantity.

Match the following

- *This section contains Matrix-Match Type questions. Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in **Column–I** have to be matched with statements (p, q, r, s) in **Column–II**. The answers to these questions have to be appropriately bubbled as illustrated in the following example.*

  *If the correct matches are A-p,A-s,B-r,B-r,C-p,C-q and D-s,then the correct bubbled 4*4 matrix should be as follows:*

22.

Physical quantity	***S.I unit***
a) Displacement	1) m/s
b) Speed	2) N
c) Force	3) m
d) momentum	4) Ns

A) a-1,b-4,c-2,d-3 B) a-3,b-1,c-2,d-4 C) a-2,b-1,c-4,d-3 D) a-4,b-1,c-3,d-2

Comprehension type questions:

- *This section contains paragraph. Based upon each paragraph multiple choice questions have to be answered. Each question has 4 choices (A) , (B) ,(C) and (D) out of which **ONLY ONE i**s correct. Choose the correct option.*

23. A ball of mass 2kg moving with an initial velocity 5m/s is hit by a bat for 0.1s, then the ball velocity becomes 6ms^{-1}.

i) Find the initial momentum of the ball in kgms^{-1}
A) 5 B) 10 C) 1.25 D) 2.5

ii) Find the final momentum of the ball in kgms^{-1}
A) 5 B) 10 C) 12 D) 2.

iii) Find the change in momentum of the ball in kgms^{-1}
A) 0.5 B) 1 C) 2 D) 4

iv) Find the force acted on the ball in newton.
A) 5 B) 10 C) 15 D) 20

KEY

ΦΦ LEARNER'STASK :

- **BEGINNERS :** 1) A, 2) A, 3) C, 4) A, 5) A, 6) C, 7) D, 8) C, 9) A, 10) B, 11) C, 12) C, 13) A, 14) C,
- **EXPLORERS:** 15) D, 16) B, 17) B, 18) D, 19) B, 20) D, 21) B, 22) B, 23) i) B, ii) C, iii) C, iv) D

Worksheet-2

Newton's Third Law:

To every action there is always an equal and opposite reaction

Φ Action and reaction do not occur on the same body they act on different bodies at same instant of time.

Φ Action and reaction, known as pair of forces, equal in magnitude opposite in directions

acting on diffrerent bodies in interaction. So they never cancel each other.

¶¶ **Limitation of Newton's Third law**

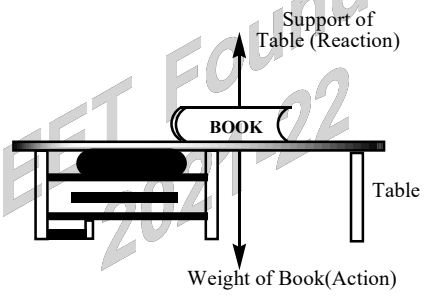
a) Newtons third law is not strictly applicable for the interaction between two bodies seperated by larger distances, of the order of astronomical units.
b) It does not apply strictly when the objects move with velocity nearer to that of light of light.
c) It does not apply where the gravitational fields are very strong.

¶¶ **Characterstics of action and reaction :**

1) Action and reaction are equal in magnitude and opposite in direction
2) Action and reaction do not act on the same body, therefore they do not cancel each other
3) Action and reaction are mutual and simultaneous. This means they always exist in pairs and one exists only as long as the other exists.
4) The force of action and reaction may appear due to actual physical contact of the two bodies or even from a distance. But they are always equal and opposite.
5) When taken together action and reaction be come internal forces.

Some of the examples of Newton's third law of motion are given below:

1. **Book kept on a table.** A book lying on a table exerts a force on the table, which is equal to the weight of the book.This may be called the force of action. The table supports the book,by exerting an equal force on the book.This is the force of reaction,



Since the book is observed to be at rest, the net external force on it must be zero.This implies that the normal reaction must be equal and opposite to the weight of the book.

2. **Walking :** 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 the horizontal direction makes the person move forward.

3. **Swimming.** A swimmer pushes the water backwards (action).The water pushes the swimmer forward(reaction) with the same force.Hence the swimmer swims

4. **Firing from a gun.** When a gun is fired, the bullet moves forward (action).The gun recoils backwards (reaction)

5. **Flight of jet planes and rockets.**The burnt fuel which appears in the form of hot and highly compressed gases escapes through the nozzle (action) in the backward direction. The escaping gases push the jet plane or rocket forward (reaction)with the same force.Hence the jet or rocket moves.

6. **Rebounding of a rubber ball**. When a rubber ball is struck against a wall or floor, it exerts a force on wall (action).The ball rebonds with an equal force (reaction) exerted by the wall or floor on the ball.

7. **It is difficult to walk on sand or ice**. This is because on pushing sand gets displaced and

reaction from sandy ground is very little.In case of ice, force of reaction is again small,because friction between our feet and ice is very little.

§§ ***Law of conservation of linear momentum:***

Collision: If a number of bodies collide with one another then total momentum of the bodies, just before collision is equal to the total momentum just after collision.

i.e. $m_1u_1+m_2u_2 = m_1v_1+m_2v_2$

i) In the absence of an external force, the linear momentum of a particle or a body remains constant i.e. if $\vec{F} = 0$ then $\vec{p} =$ constant

ii) In the absence of external force, the linear momenta of individual particles can change but the total linear momentum of the whole system remains constant.

iii) The law of conservation of linear momentum is based on the Newton's third law of motion. This is the fundamental law of nature and there is no exception to it.

iv) This law is valid only for linear motion.

v) Internal forces cannot change the total momentum of the system, however they may change the momentum of each particle of the system.

vi) Motion of a rocket, firing of a bullet from a gun and explosion of a shell fired from a cannon are some examples where we can apply the law of conservation of linear momentum

§§ **APPLICATIONS OF THE PRINCIPLE OF CONSERVATION OF LINEAR MOMENTUM**

1) Recoiling of a gun. When a bullet is fired from a gun, the gun recoils i.e. moves in a direction opposite to the direction of motion of the bullet. The recoil velocity of the gun can be calculated from the principle of conservation of linear momentum.

Suppose m_1 = mass of bullet,

m_2 = mass of gun,

$\vec{v}_1$ = velocity of the bullet,

$\vec{v}_2$ = velocity of recoil of the gun.

Before firing, the gun and the bullet both, are at rest. Therefore , total linear momentum before firing = 0. Therefore, total linear momentum before firing = 0. The vector sum of linear momenta on firing $m_1\vec{v}_1 + m_2\vec{v}_2 = 0$. According to the principle of conservation of linear momentum, total linear momentum after firing should also be zero.

$\therefore m_1\vec{v}_1 + m_2\vec{v}_2 = 0$

or $m_2\vec{v}_2 = -m_1\vec{v}_1$ ..... (25)

or $\vec{v}_2 = -\frac{m_1\vec{v}_1}{m_2}$ ..... (26)

The negative sign shows that direction of $\vec{v}_2$ is opposite to the direction of $\vec{v}_1$ i.e. the gun recoils. Further, as $m_2 >> m_1$ therefore , $\vec{v}_2 << \vec{v}_1$ i.e. velocity of recoil of the gun is much

smaller than the velocity of the bullet .

From eq. (26) , $v_2 \propto \frac{1}{m_2}$

It means that a heavier gun will recoil with a smaller velocity and vice-versa.

Initial K.E of the system is zero, as both the gun and the bullet are at rest. Final K.E. of the system = $\left(\frac{1}{2}m_1v_1^2 + \frac{1}{2}m_2v_2^2\right) > 0$. Thus K.E of the system increases (and is not constant).

If P.E. is assumed to be constant, mechanical energy(=K.E = P.E) will also increase.

As M.E. is conserved, therefore, chemical energy of gun powder must have been converted into K.E.

While firing the gun must be held tightly to the shoulder. This would save hurting the shoulder. When the gun is held tightly, the body of the shooter and the gun behave as one body. Total mass becomes large and therefore, recoil velocity of the body and the gun becomes too small.

2) **Flight of rockets and jet planes.** In rockets and jet planes,the fuel is burnt in the presence of some oxidising agent in combustion chamber. The hot and highly compressed gases escape through the narrow opening (i.e., exhaust nozzle) with large velocity. As a result of it, the escaping gases acquire a large backward momentum. This in turn, imparts an equal forward momentum to the rocket in accordance with the law of conservation of linear momentum.

3) **When a man jumps out of a boat to the shore,** the boat is pushed slightly away from the shore. The momentum of the boat is equal and opposite to that of the man in accordance with the law of conservation of linear momentum.

4) **Explosion of bomb.** When a bomb falls vertically downwards its horizontal velocity is zero and hence its horizontal momentum is zero. When bomb explodes, its pieces are scattered horizontally in different directions so that the vector sum of momenta of these pieces becomes zero in accordance with the law of conservation of linear momentum.

EXAMPLE

√ **Ex-1:** A man weighing 60 kg runs along the rails with the velocity of 18 km hr-1 and jump in to a car of the mass 1 quintal standing on the rails. calculate the velocity with which the car will start travelling along the rails.

Sol : Here, mass of man, $m_1 = 60$ kg.

initial velocity of man, u_{-1} 18 km/ 1 h = 18 x 1000 m / 60 x 60 s = 5 ms^{-1}

Mass of a car , m_2 = 1 quintal = 100 kg.

Initial velocity of a car, $u_{-2} = 0$

After a man jumps into a car, let their common velocity be v

Applying the principle of conservation of momentum

Total momentum after jump = Total momentum before jump

$(m_1 + m_2)\, v = m_1 u_1 + m_2 u_2$

$(60 \times 100)\, v = 60 \times 5 + 100 \times 0$

OR $v = \frac{300}{160} = 1.8$

√ **Ex-2:** A toy rocket weighing 500 g is standing vertically on ground .How much force should act on it so that it starts ascending with a uniform acceleration of 5 ms^{-2} (Take g = 10 ms^{-2})

Sol : To go up, the upwards force should acting on the rocket must be greater than its weight 'mg'.

Net force acting on rocket

$F_{net} = F_{up} - mg$ (i)

By Newton's II law,

$F_{net} = ma$ (ii)

From equation (i) and (ii),

$F_{up} - mg = ma$

$F_{up} = mg + ma$

$= m(g + a)$ $= 0.5 \text{ kg } (10 +5) \text{ ms}^{-1}$ $= 0.5 \times 15 \text{ kgms}^{-2}$

$= 7.5$ N

√ **Ex-3:** Two body s of mass 4 kg , 8kg are traveling in the same direction with a speed of 4 m/s and 2m/s they collide as a result of their collision 8 kg object start moveing with 8 m/s in the same direction so the speed of 6 kg mass of the body after collision

Sol: $m_1 = 6$ kg, $m_2 = 8$ kg, $u_1 = 4$ m/s

$m_1u_1+m_2u_2 =m_1v_1+m_2v_2$

$6 \times 4 +8 \times 2 = 6 \times v_1 + 8 \times 8$

$24 + 16 = 6v_1 + 64$

$= 40 - 64 = 6v_1$

$v_1 = -24/6 = -4$m/s

√ **Ex- 4:** A gun fires a bullet of mass 100 g with a velocity of 60 m/s becauseof this gunpush back with a velocity of 2 m/s then the mass of the gun is ?

Sol: M = ?

m = 100g $= 100 \times 10^{-3}$ kg

V = 2 m/s

v = 60 m/s

M V = - m v

M = - mv /V = $60 \times 100 \times 10^{-3} kg$ /2 = 3 k g

√ **Ex 5:** Bullet of mass of 40 g is fired from a Riffle of mass 16 kg with a velocity 200 m/s the recoli velcity of gun ?

Sol : M = 16kg, m=40g =40 x 10^{-3}kg, V=?

v = 200ms^{-1}

MV= -mv

$V= \frac{-mv}{M} = -\frac{40 \times 10^{-3} \times 200}{16} \Rightarrow \frac{1}{4} \Rightarrow 0.25 ms^{-1}$

TEACHING TASK

Single correct option questions:

1. A base ball of mass 150 gm travelling at 20 m/s is caught by a fielder and brought to rest in 0.04s. the force applied to the ball and the distance over which this force acts are respectively
A) 75 N, 0.8 m B) 37.5 N, 0.4 m C) 75 N, 0.4 m D) 37.5 N, 0.8 m

2. A ball of mass 0.05 kg travelling at 4 ms^{-1} hits a wall and rebounds without any change in its speed. If the ball remains in contact with the wall for 0.01 s, then the force exerted by the ball on the wall is
A) 0.05N B) 0.01N C) 50 N D) 40 N

3. A 6 kg mass 'A' moving with a velocity of 2 m/s collids with a 4 kg mass 'B' moving with a velocity of 1.5 m/s in the opposite direction in a straight line. If the two mass get stuck, then the velocity of the combination is
A) 0.4 m/s B) 0.2 m/s C) 0.1 m/s D) 0.6 m/s

4. A 6kg mass collides with a body at rest. After collision they travel together with a velocity one third the velocity of 6 kg mass. The mass of the second body is
A) 6 kg B) 3 kg C) 12 kg D) 18 kg

5. A shot moving with a velocity 140 ms^{-1} collides a wooden block and comes to rest in it. If mass of the block is 13 times the mass of the shot, velocity of the block is
A) 14ms^{-1} B) 10 ms^{-1} C) 4 ms^{-1} D) 2.5ms^{-1}

6. Two bodies of masses 2kg and 4kg travelling in same direction with speed 6m/s and 2m/s collide. As a result of this collision 4kg object starts moving with 4m/s in same direction. Speed of 2kg body after collision is
A) 1m/s B) 2m/s C) 3m/s D) 4m/s

More than one correct option questions

- *This section contains multiple choice questions. Each question has 4 choices (A), (B), (C),(D), out of which **ONE or MORE** is correct. Choose the correct options*

7. The change in momentum per unit time of a body represents
a) Force b) massxacceleration c) Impulse d) velocity.
A) a,b correct B) b,c,d correct C) a,b,d correct D) all correct

8. Regarding linear momentum of a body
a. It is a measure of quantity of motion contained by the body
b. Change in momentum is the measure of impulse
c. Impulse and acceleration act in opposite direction to the change in momentum
d. In the case of uniform circular motion the linear momentum is conserved.
A) a,b,c correct B) a,b correct C) a,b,d correct D) all correct

9. Which of rthe following is correct?
a) Action reaction pairs acts on a same body.
b) Rocket works on the principle of newton's third law and law of conservation of linear momentum.
c) Action reaction pairs acts on different bodies.
d) Rocket works on the principle of newton's second law and law of conservation of energy.
A) a,b,c B) a,b C) a,b,d D) all

Assertion - A and Reason - R:

- *This section contains certain number of questions. Each question contains Statement – 1*

*(Assertion) and Statement – 2 (Reason). Each question has 4 choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct Choose the correct option.*

A) Both A and R are true and R is the correct explanation for A.
B) Both A and R are true and R is not correct explanation of A.
C) A is true but R is false. D) A is false but R is true

10. **A:** If the force varies with time in a complicated way then the net force is measured by the total change inmomentum of the body
R: Change in momentum and force are numerically equal.

11. **A:** For every action there is an equal and opposite reaction.
R: In the absence of external force the linear momentum of a body remains constant.

Match the following.

- *This section contains Matrix-Match Type questions. Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in **Column–I** have to be matched with statements (p, q, r, s) in **Column–II**. The answers to these questions have to be appropriately bubbled as illustrated in the following example.*

*If the correct matches are A-p,A-s,B-r,B-r,C-p,C-q and D-s,then the correct bubbled 4*4 matrix should be as follows:*

12.

Set-A	***Set-B***
a) momentum	1)Ns
b) Force	2) N
c) Rocket	3) Variable mass system.
d) Table fan	4) Isolated mass system.

A) a-1,b-4,c-2,d-3 B) a-3,b-1,c-2,d-4
C) a-2,b-1,c-4,d-3 D) a-1,b-2,c-3,d-4

Comprehension type questions:

- *This section contains paragraph. Based upon each paragraph multiple choice questions have to be answered. Each question has 4 choices (A) , (B) ,(C) and (D) out of which **ONLY ONE i**s correct. Choose the correct option.*

13. If a number of bodies collide with one another then total momentum of the bodies, just before collision is equal to the total momentum just after collision.
If Two bodies of masses 1 kg and 3kg travelling in same direction with speed 9m/s and 3m/s collide. As a result of this collision 3kg object starts moving with 2m/s in same direction.
i) Total momentum of the two bodies, just before collision is...
A) 18 Ns B) 3 Ns C) 27Ns D) 32 Ns
ii) Speed of 1kg body after collision is
A) 10m/s B) 12m/s C) 13m/s D) 4m/s

KEY

ΦΦ TEACHING TASK :

1) C, 2) D, 3) D, 4) C, 5) B, 6) B, 7) A,
8) A, 9) B, 10) C, 11) B, 12) D, 13 i) A , ii) B.

LEARNER'S TASK

BEGINNERS (Level - I)

Single correct option questions:

1. A body of mass 300 g is kept at rest breaks into two parts due to internal forces. One part of mass 200 g is found to move at a speed of 12 m/s towards west. The velocity of other part is

A) 24 m/s towards the east B) 14 m/s towards the west
C) 34 m/s towards the noth D) 54 m/s towards the south

2. A 2kg shot is fired from a cannon of mass 198 kg with a velocity 50 ms^{-1} w.r.t. the gun.Then the velocity of recoil of the gun is

A) $-0.5ms^{-1}$ B) $0.1ms^{-1}$ C) $0.25ms^{-1}$ D) 1 ms^{-1}

3. A shell of mass M moving with a velocity v explodes into two parts and one of the part of mass m is left stationary after explosion. The velocity of the other part is

A) $\frac{mv}{M}$ B) $\frac{Mv}{m}$ C) $\frac{Mv}{M-m}$ D) $\frac{Mv}{M+m}$

4. A truck of mass 1200 kg is moving with a speed of 7 ms^{-1} when it collides with a second truck of mass 1600kg which is stationary. If the two trucks are automatically coupled together on impact, the speed with which combination moves is

A) 2 m/s B) 3 m/s C) 1.5 m/s D) 6 m/s

ACHIEVERS (Level - II)

Solve the following:

5. A 1.5kg hammer moving with velocity 10ms^{-1} strikes a nail for 0.005seconds. Average force exerted on the nail is

6. A space craft of mass 2000 kg moving with a velocity of 600m/s suddenly explodes into two pieces. One piece of mass 500 kg is left stationary. The velocity of the other part must be

7. A bullet of mass 20gm is fired from a riffle of mass 8 kg with a velocity of 100m/s. The velocity of recoil of the refle is

8. A ball of mass 10 gm hits vertically a hard surface with a speed of 5 ms^{-1} and rebounds with the same speed. The ball remains in contact with the surface for 1/100 sec. The average force exerted by the surface on the ball is

9. A person weighing 60 kg in a small boat of mass 140 kg that is at rest,throws a 5 kg stone in the horizontal direction with a velocity of $14\ ms^{-1}$.The velocity of the boat immediately after the throw is

10. A man and a cart move towards each other. The man weighs 64 kg and the cart 32kg. The velocity of the man is 5.4 km/hr and that of the cart is 1.8 km/hr. When the man approaches the cart, he jumps on to it. The velocity of the cart carrying the man will be

EXPLORERS (Level - III)

More than one correct option questions

- *This section contains multiple choice questions. Each question has 4 choices (A), (B), (C),(D), out of which **ONE or MORE** is correct. Choose the correct options*

11. Which of rthe following are correct?
a) Both action and reaction are forces.b) Action and reaction act simultaneously

c) Action and reaction acts on different bodies.

d) Action and reaction forces occur in pairs only.

A) a,b,c B) a,b C) a,b,d D) all

12. Which of the following works on the principle of Newton's III law

a) Jet aeroplane b) rockets c) gun d) Rowing of a boat

A) a,b,c B) a,b C) a,b,d D) all

Assertion - A and Reason - R:

A) Both A and R are true and R is the correct explanation for A.

B) Both A and R are true and R is not correct explanation of A.

C) A is true but R is false. D) A is false but R is true

13. **A:** newton-sec is the unit of momentum.
R: momentum is the product of mass and velocity.

14. **A:** Both impulse and change in momentum have the same units.
R: The dimensional formula for momentum is MLT^{-1}.

15. **A:** Newton's third law gives the concept of linear momentum.
R: When a stationary shell breaks into two fragments the two fragments will have same magnitude of linear momentum.

16. **A:** Action and reaction forces are equal in magnitude but opposite in direction
R: Newton's third law defines the force.

17. **A:** According to Newton's third law, the sum of action and reaction will becomes zero
R: For every action there is an equal and opposite reaction.

Match the following.

- *This section contains Matrix-Match Type questions. Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in* ***Column–I*** *have to be matched with statements (p, q, r, s) in* ***Column–II****. The answers to these questions have to be appropriately bubbled as illustrated in the following example.*

  *If the correct matches are A-p,A-s,B-r,B-r,C-p,C-q and D-s,then the correct bubbled 4*4 matrix should be as follows:*

18.

Physical quantity	*S.I unit*
a) velocity	1) kgs^{-1}
b) dm/dt	2) kg
c) mass	3) ms^{-1}
d) acceleration	4) ms^{-2}

A) a-1,b-4,c-2,d-3 B) a-3,b-1,c-2,d-4

C) a-2,b-1,c-4,d-3 D) a-1,b-2,c-3,d-4

19.

Set-A	***Set-B***
a) action= - reaction	1) Newtons first law
b) F=0	2) Newton's second law
c) Definition of force	3) Conservation of linear momentum.
d) Measurement of force	4) Newton's third law.

A) a-1,b-4,c-2,d-3 B) a-3,b-1,c-2,d-4

C) a-2,b-1,c-4,d-3 D) a-4,b-3,c-1,d-2

20.

Set-A	Set-B
a) W	1) law of conservation of momentum
b) F	2) ma
c) mv-mu	3) change in momentum
d) Newton's third law	4) mg

A) a-1,b-4,c-2,d-3 B) a-3,b-1,c-2,d-4

C) a-2,b-1,c-4,d-3 D) a-4,b-2,c-3,d-1

Comprehension type questions:

- *This section contains paragraph. Based upon each paragraph multiple choice questions have to be answered. Each question has 4 choices (A) , (B) ,(C) and (D) out of which* ***ONLY ONE is*** *correct. Choose the correct option.*

21. In the absence of any external force the total linear momentum of a body remains constant is called law of conservation of linear momentum.

i) A gun fires a bullet of mass 50 gm with a velocity of 30 ms $^{-1}$. Because of this the gun is pushed back with a velocity of 1 ms $^{-1.}$ Mass of the gun is

A) 1.5 Kg B) 30 Kg C) 15 Kg D) 20 Kg

ii) A machine gun of mass 10 kg, fires 10 gm bullets with a velocity of 400m/s at the rate of one every second. The velocity of recoil of the gun after four bullets are fired is

A) 0.4 m/s B) 0.8 m/s C) 1.6 m/s D) 3.2 m/s

KEY

ΦΦ LEARNER'STASK :

☐ **BEGINNERS :**	1) A ,	2) A,	3) C,	4) B,	
☐ **ACHIEVERS :**	5)3000N,	6)800 m/s,	7)0.25 m/s,	8) 10 N,	9) $0.35\ ms^{-1}$, 10) 3 km/hr
☐ **EXPLORERS:**	11) D,	12) D,	13) A,	14) B,	15) B,
	16)C,	17) A,	18) B,	19) D,	20) D,
	21) i) A, ii) C.				

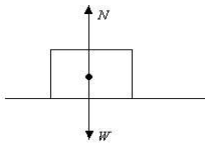
Worksheet-3

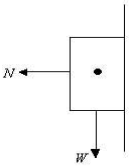
§§ **Free Body diagram**: When several bodies are connected by strings, springs, surfaces of contact, then all the forces acting an a body are considered and sketched on the body under considerationn by just isolating it. Then the diagram so formed is called Free Body Diagram (FBD).

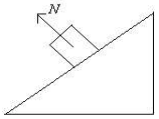
While drawing FBD he following points should be kept in mind:

1) We have to **represent weight for every body**. (If we assume pulleys are massless then we will not represent weight)
2) Observe whether the body is in **contact** with the other body(surface).If it is in contact with any surface then we have to represent **normal reaction force** and **frictional force [if any]**. (The reaction force also called Normal Reaction (N) always acts normal to surface on which the body is kept).

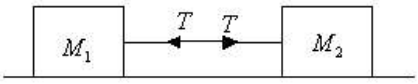
Note: Number surfaces in contact is equal to number of Normal forces.

(a) 

(b) 

(c) 

3) Tension in a string arises due to the restoring force created by intermolecular forces of interaction. Tension is the force exerted by one part of the string on the other part. Tension always acts towards the support (support may be a hand or a pulley)

Ex: 

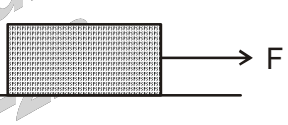
In the above illustration the tension in the string for block M_1 is towards M_2. For block M_2 , it is towards M_1

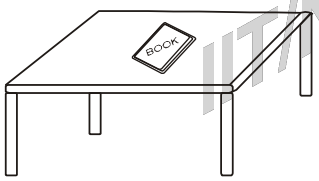
Note: while drawing an FBD, it is important to remember that tension in each branch of the string must form action-reaction pair.

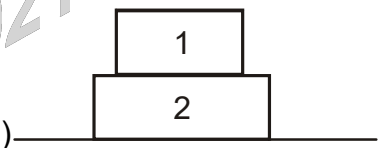
4) While drawing FBD, always take into account the forces which are acting on a body Never take into account the forces which the body is exerting on others

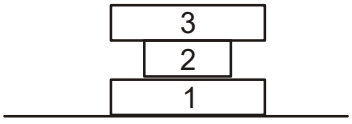
I. Draw the free body diagram of every object in each of the following :
(Assume that friction is absent everywhere, strings are massless and pulleys are light and frictionless)

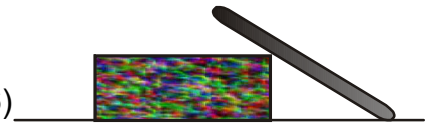
1) 

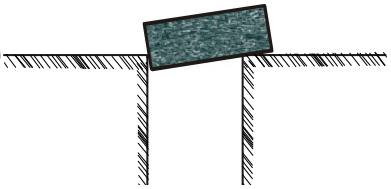
2) 

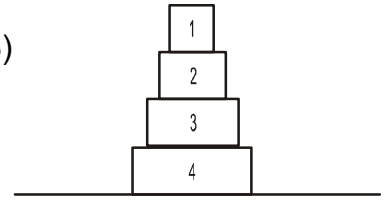
3) 

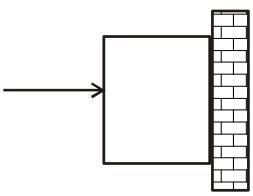
4) 

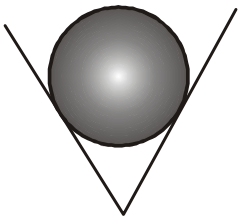
5) 

6) 

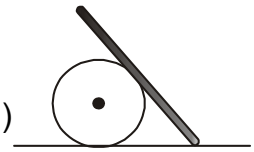
7) 

8) 

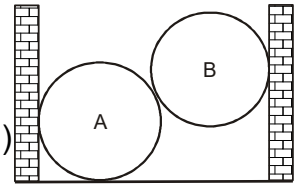
9) F 

10) 

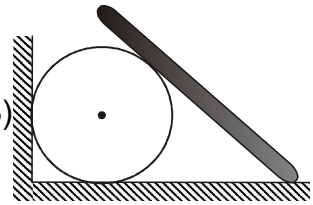
11)



12)



13)



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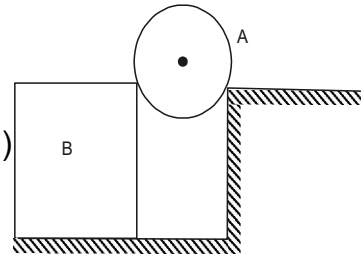
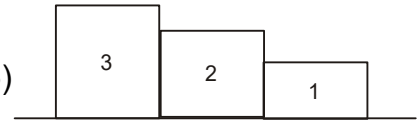
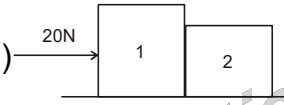


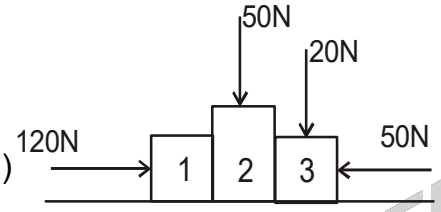
15)



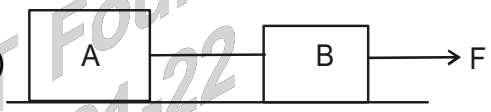
16)



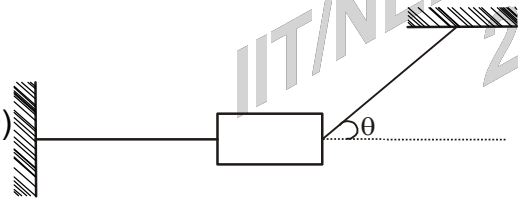
17)



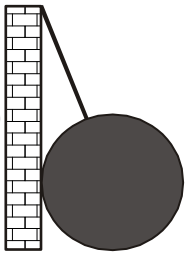
18)



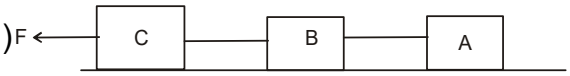
19)



20)



21)



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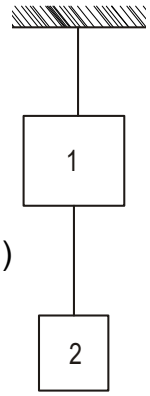

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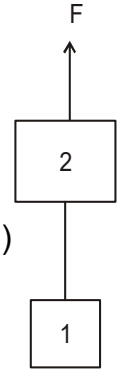

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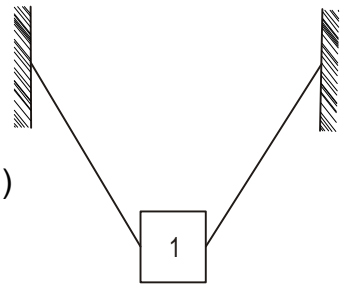
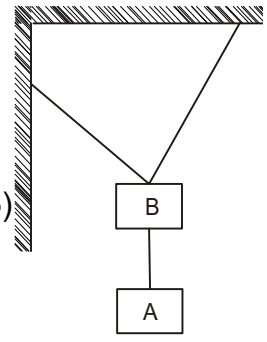


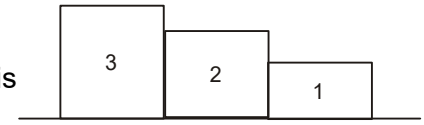
25)

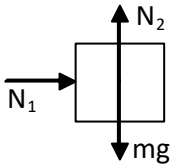


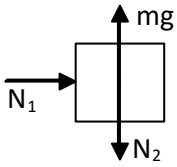
TEACHING TASK

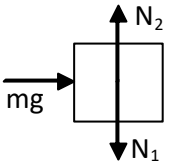
Choose the correct option:

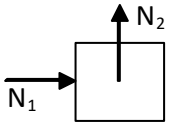
1. The free body diagram of the middle mass is



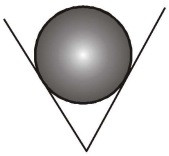
A) 

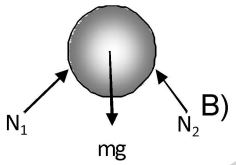
B) 

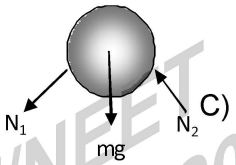
C) 

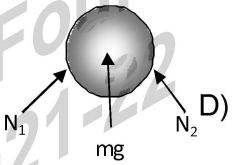
D) 

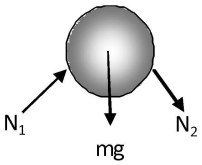
2. The free body diagram of the ball as shown is



A) 

B) 

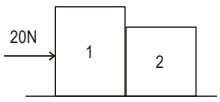
C) 

D) 

Assertion A and Reason R:

- *This section contains certain number of questions. Each question contains Statement – 1 (Assertion) and Statement – 2 (Reason). Each question has 4 choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct Choose the correct option.*

3. A : In the picture shown the contact force by first body on second



body is equal to contact force applied by second body on first body.
R : For every action there is equal and opposite reaction
A) Both 'A' and 'R' are true and 'R' is the correct explanation of 'A'
B) Both 'A' and 'R' are true and 'R' is not correct explanation of 'A'
C)'A' is true and 'R' is false
D) 'A' is false and 'R' is true

Multiple option type:

- *This section contains multiple choice questions. Each question has 4 choices (A), (B), (C),(D), out of which **ONE or MORE** is correct. Choose the correct options*

4. Pick out the correct statement from the following

a) Normal force is the component of the contact force parallel to the surface of contact.
b) Frictional force is the component of the contact force parallel to the surface of contact.
c) If a string is mass less, the tension in it is same everywhere, However, if a string has a mass, tension at different points will be different.

d) If a string is mass less, the tension in it is same everywhere, However, if a string has a mass, tension at different points will be same.

A) a, b B) b, c C) c, d D) a, d

Fill in the blanks :

5. Weight is a kind of field force , it 's direction is always ----------

6. Action and reaction pairs acts on ----------

7. W = mg in units 'w' stands for ----------

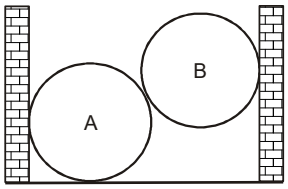
8. Normal force acts in ---------- direction

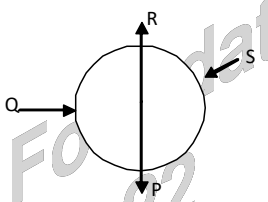
Match the following:

- *This section contains Matrix-Match Type questions. Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in **Column–I** have to be matched with statements (p, q, r, s) in **Column–II**. The answers to these questions have to be appropriately bubbled as illustrated in the following example.*

  *If the correct matches are A-p,A-s,B-r,B-r,C-p,C-q and D-s,then the correct bubbled 4*4 matrix should be as follows:*

9. In the figure shown, match the forces acting on ball A





a) P 1) weight of the body

b) Q 2) normal force applied by the vertical wall

c) R 3) Normal force applied by the horizontal surface

d) S 4) Normal force applied by the ball B

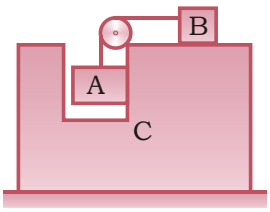
A) a-1, b-2, c-3, d-4 B) a-4, b-2, c-3, d-1

C) a-1, b-2, c-4, d-3 D) a-4, b-3, c-2, d-1

Comprehention type:

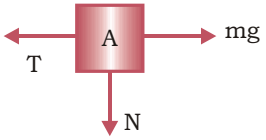
- *This section contains paragraph. Based upon each paragraph multiple choice questions have to be answered. Each question has 4 choices (A) , (B) ,(C) and (D) out of which **ONLY ONE i**s correct. Choose the correct option.*

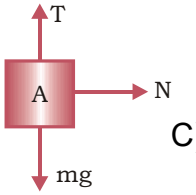
10. In the system shown in figure c

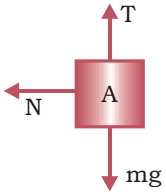


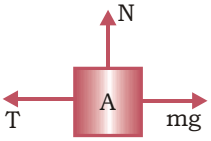
Friction is absent everywhere. String is light and inextensible.

i) The free body diagrame of block A

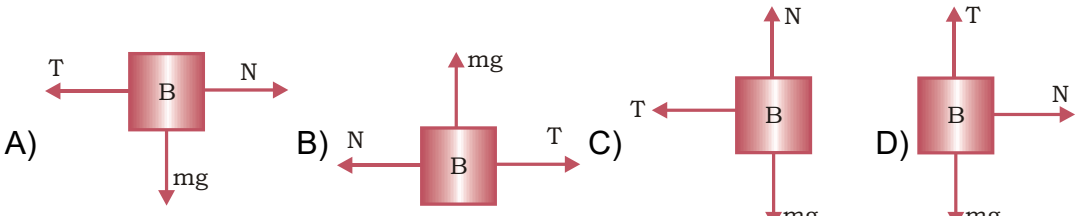
A) 

B) 

C) 

D) 

ii) The free body diagrame of block B



KEY

ΦΦ TEACHING TASK :

1) A, 2) A, 3) A, 4) B, 5) Down ward 6) Different , 7)Weight , 8) Up word, 9) A, 10) i) C, ii) C

LEARNER'S TASK

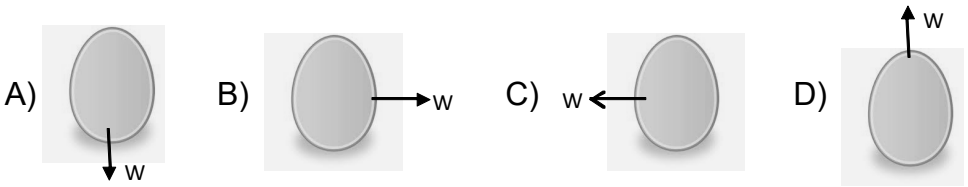
BEGNNERS

Choose the correct option:

1. While drawing free body diagram, weight of the body always should be represented
A) upward B) downward C) towards left D) towards right

2. When a body is in contact with another surface or body, the reaction force acting perpendicular to the surfaces in contact is called
A) weight B) Tension C) normal force D) none

3. An egg is free-falling from a nest on a tree. Neglect air resistance. Draw FBD for the egg, falling freely from a nest.



EXPLORERS

Assertion A and Reason R:

- *This section contains certain number of questions. Each question contains Statement – 1 (Assertion) and Statement – 2 (Reason). Each question has 4 choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct Choose the correct option.*

4. ***A :*** Weight is a kind of field force. It's direction is always downward direction.

R : Weight is a kind of field force. It's direction is always upward direction.

A) Both 'A' and 'R' are true and 'R' is the correct explanation of 'A'
B) Both 'A' and 'R' are true and 'R' is not correct explanation of 'A'
C) 'A' is true and 'R' is false
D) 'A' is false and 'R' is true

Multiple option type:

- *This section contains multiple choice questions. Each question has 4 choices (A), (B), (C),(D), out of which **ONE or MORE** is correct. Choose the correct options*

5. Choose the the correct in the case of drawing free body diagram
a) for evrey mass wieght should be represented
b) if body in contact with other bodies, contact force should be represented
c) if body is connected by string, tension should be represented
A) only a, b are correct B) only b, c are correct
C) only a, c are correct D) all a, b, c are correct

Fill in the blanks :

6. For avery action there is ---------- and ---------- reaction

7. While drawing free body diagram weight of the body always should be represented ----------

8. When a body is in contact with another surface or body, the reaction force acting perpendicular to the surfaces in contact is called ----------

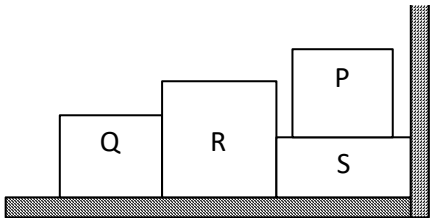
9. Weight is a kind of field force . It 's direction is always ----------

Match the following:

- *This section contains Matrix-Match Type questions. Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in **Column–I** have to be matched with statements (p, q, r, s) in **Column–II**. The answers to these questions have to be appropriately bubbled as illustrated in the following example.*

  *If the correct matches are A-p,A-s,B-r,B-r,C-p,C-q and D-s,then the correct bubbled 4*4 matrix should be as follows:*

10. Observe the picture given aside



Body	Number of normal forces acting
a) P	1) one
b) Q	2) two
c) R	3) three
d) S	4) four

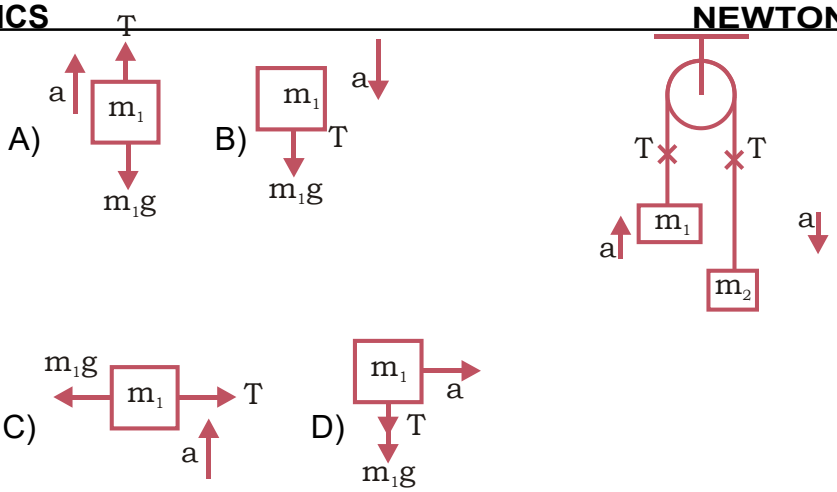
A) a-1,b-2, c-3, d-4 B) a-1, b-2, c-3, d-4
C) a-1, b-3, c-2, d-4 D) a-4, b-3, c-2, d-1

Comprehention type:

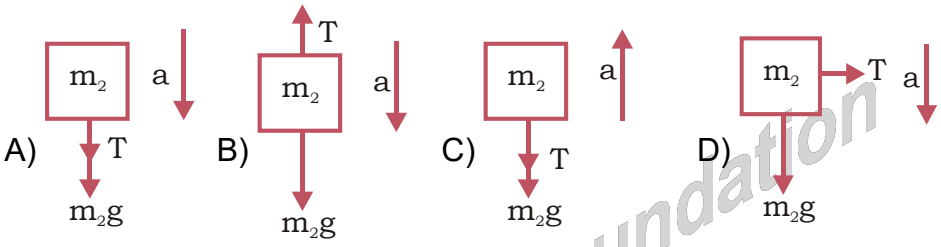
- *This section contains paragraph. Based upon each paragraph multiple choice questions have to be answered. Each question has 4 choices (A) , (B) ,(C) and (D) out of which **ONLY ONE i**s correct. Choose the correct option.*

11. Observe the picture given aside

i) The free body diagram of 'm_1'



ii) The free body diagram of 'm_2' is



KEY

ΦΦ LEARNER'STASK :

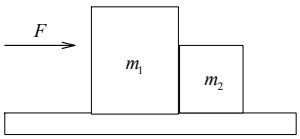
- **BEGINNERS :** 1) A, 2) B, 3) A,
- **EXPLORERS:** 4) C, 5) D, 6) equal, opposite 7) Down ward 8)Normal force 9) Down ward. 10) A, 11) i) A, ii) B.

Worksheet-4

MOTION OF BODIES IN CONTACT :

If two bodies with masses m_1 and m_2 are lying in contact on a horizontal smooth table and a force F is applied on the mass m_1, then equal acceleration is produced in both the bodies.

a) Acceleration produced in both bodies :



$$a = \frac{F}{m_1 + m_2}$$

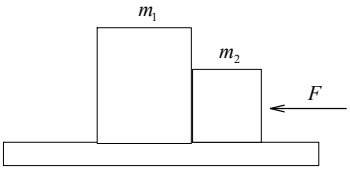
Force exerted on m_2 is $F^1 = m_2 \times a = m_2 \times \frac{F}{m_1 + m_2}$

Reaction force on exerted on m_1 by m_2 is

$F^1 = \frac{m_2 F}{m_1 + m_2}$ (opposite in direction), Contact force between the blocks = $\frac{m_2 F}{m_1 + m_2}$

b) When the force F acts on the body with mass m_2 :

The acceleration produced in the bodies $a = \frac{F}{(m_1 + m_2)}$

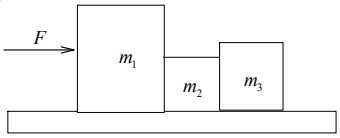


Force exerted on m_1 is $F^1 = m_1 a = F\frac{m_1}{m_1 + m_2}$

Reaction force acting on m_2 is $F^1 = F\left(\frac{m_1}{m_1 + m_2}\right)$ (but opposite in direction)

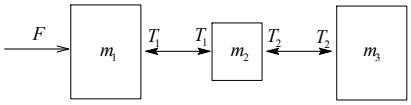
c) When three bodies of masses m_1, m_2 and m_3 are lying in contact on a horizontal smooth table and a horizontal force F on a body of mass m_1

Acceleration of the system $a = \frac{F}{m_1 + m_2 + m_3}$



The contact force between m_1 and m_2 is T_1 then $T_1 = (m_2 + m_3)a$

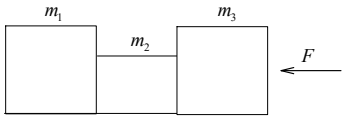
The contact force between m_2 and m_3 is $T_2 = m_3 a$



$T_1 = \frac{(m_2 + m_3)F}{m_1 + m_2 + m_3}; T_2 = \frac{m_3 F}{m_1 + m_2 + m_3}$

d) If the force F acts on the body with mass m_3 :

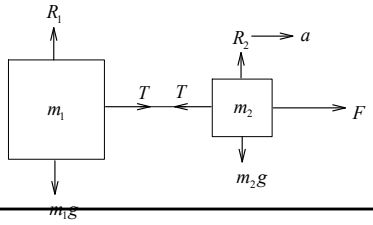
$T_1 = \frac{m_1 F}{m_1 + m_2 + m_3}; T_2 = \frac{(m_1 + m_2)F}{m_1 + m_2 + m_3}$



MOTION OF BODIES CONNECTED BY STRINGS

i) When two bodies of masses m_1 and m_2 are tied to the ends of a light string placed on the smooth horizontal surface, these are pulled by a force F.

acceleration of the system $a = \frac{F}{m_1 + m_2}$

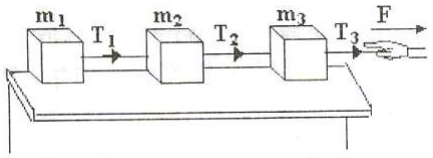


Tension in the string $T = m_1 a$

$$T = \frac{m_1 F}{m_1 + m_2}$$

ii) If in the above example three bodies are pulled with a force F.

Acceleration produced in the system $a = \frac{F}{m_1 + m_2 + m_3}$



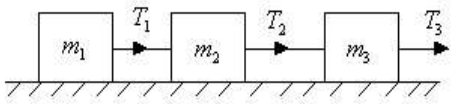
Tension produced in the string between the blocks m_1 and m_2 is $T_1 = m_1 a = \frac{m_1 F}{m_1 + m_2 + m_3}$

Tension produced in the string between m_2 and m_3

$$T_2 = (m_1 + m_2)\, a \,; T_2 = \frac{(m_1 + m_2) F}{m_1 + m_2 + m_3} (\because F - T_2 = m_3 a)$$

EXAMPLE

√ **Ex 1:** Three blocks of masses m_1, m_2 and m_3 are connected by a massless string as shown in figure on a frictionless table. They are pulled with a force $T_3 = 60N$. If $m_1 = 5kg$, $m_2 = 8kg$ and $m_3 = 2kg$, then tension T_2 will be



sol: F = 60 N

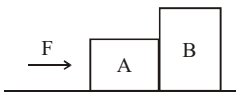
$m_1 = 5kg$, $m_2 = 8kg$ and $m_3 = 2kg$

T_2 = ? $a = \frac{F}{m_1 + m_2 + m_3} = \frac{60}{5+8+2} = \frac{60}{15} = 4\, ms^{-2}$

T_2= (m1+ m2) a, T_2= 52 N

√ **Ex 2:** In the figure, F = 20N, A and B have masses 2kg and 3kg. The force applied by A on B is

Sol: F= 20 N, m_1 = 2kg, m_2 = 3kg



$$a = \frac{F}{m_1 + m_2} = \frac{20}{2+3} = \frac{20}{5} = 4\ ms^{-2}$$

The force applied by A on B is = m_2 X a = 3 X 4 = 12 N

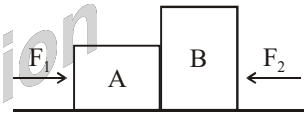
√ **Ex 3:** Three blocks of masses 5kg, 3kg and 1kg are placed side by side in contact with each other on a smooth horizontal surface with the 5 kg block on the left extreme and 1 kg block on the right extreme. A horizontal force of 90 N is applied on the 3 kg block pushing it towards the 2 kg block. What is the acceleration of the system?

Sol: F = 90 N, m_1 = 5 kg, m_2 = 3kg, m_3 = 1kg, a = ?

$$a = \frac{F}{m_1 + m_2 + m_3} = \frac{90}{5+3+1} = \frac{90}{9} = 10\ ms^{-2}$$

√ **Ex 4:** In the adjacent figure F_1 = 500N F_2 = 300N. A and B have 2Kg and 3kg. What is The net force acting on the system. what is the acceleration of the system?

Sol: F1 =500 N, F2 =300 N, m1 =2 kg, m2 =3 kg,



Net force = ?, a = ?

Net force = F1-F2 =500-300 =200 N

$$a = \frac{F_{net}}{m_1 + m_2} = \frac{200}{2+3} = \frac{200}{5} = 40\ ms^{-2}$$

√ **Ex 5:** A 120N force pulls a system of three equal masses are connected by a string on a horizontal frictionless surface it accelerate 2 ms^{-2}. What is the mass of the system?

Sol: F = 120 N, a = 2 ms^{-2}, m1 = m2 = m3 =?

$$a = \frac{F}{m_1 + m_2 + m_3} \Rightarrow \quad 2 = \frac{120}{m+m+m} = \frac{120}{3m} \Rightarrow m = 20\ k$$

TEACHING TASK

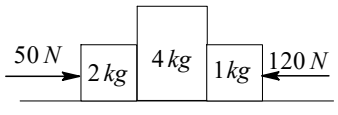
Choose the correct option:

1. Three blocks of masses 3kg, 2kg and 1kg are placed side by side in contact with each other on a smooth horizontal surface with the 3 kg block on the left extreme and 1 kg block on the right extreme. A horizontal force of 12 N is applied on the 3 kg block pushing it towards the 2 kg block, the contact force between the 2 kg block and 1 kg block is

A) 6 N B) 4 N C) 2N D) 8 N

2. Three blocks of masses 1kg, 4kg and 2 kg are placed on a smooth horizontal surface as shown in the figure. Two horizontal forces 120 N and 50N are applied on the system. The acceleration of the system is

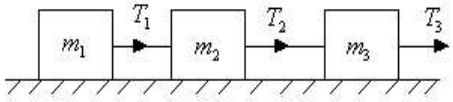
A) 17.5 ms^{-2} B) 10 ms^{-2} C) 24.3 ms^{-2} D) 70 ms^{-2}



3. A block of mass 20Kg is suspended through two light spring balances as shown in the figure.

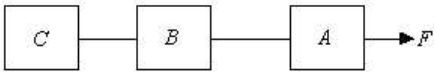
A) both the scales will read 20kg
B) both the scales will read 10kg
C) the upper scale will read 20kg and the lower zero
D) the readings may be anything but their sum will be 20kg

4. Three blocks of masses m_1, m_2 and m_3 are connected by a massless string as shown in figure on a frictionless table. They are pulled with a force $T_3 = 40N$. If $m_1 = 10kg$, $m_2 = 6kg$ and $m_3 = 4kg$, then tension T_2 will be



A) 10 N B) 20 N C) 30 N D) 40N

5. Three equal masses A, B and C are pulled with a constant force F. They are connected to each other with strings. The ratio of the tension between AB and BC is.

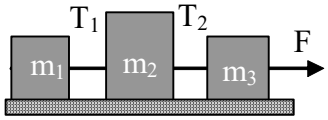


A) 1:2 B) 2:1 C) 3:1 D) 1:1

Assertion A and Reason R:

- *This section contains certain number of questions. Each question contains Statement – 1 (Assertion) and Statement – 2 (Reason). Each question has 4 choices (A), (B), (C) and (D) out of which **ONLY ONE** is correct Choose the correct option.*

6. **A:** When a force of F acts as shown on three different bodies connected by string then $T_1=T_2$



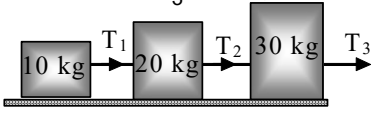
R: All bodies move with same acceleration.

A) Both 'A' and 'R' are true and 'R' is the correct explanation of 'A'
B) Both 'A' and 'R' are true and 'R' is not correct explanation of 'A'
C)'A' is true and 'R' is false
D) 'A' is false and 'R' is true

Multiple option type:

- *This section contains multiple choice questions. Each question has 4 choices (A), (B), (C),(D), out of which **ONE or MORE** is correct. Choose the correct options*

7. Three connected bodies are lying ona smooth surface as shown. If force of T_3=60 N, then choose the correct



i) a = 1 m/s^2 ii) T_1=10 N
iii) T_2=30 N iv) $T_3=T_1+T_2$

A) i only true B) i, ii only true C) i, ii, iii only true D) all are ture

Fill in the blanks :

8. When two bodies of masses m_1 and m_2 are tied to the ends of a light string placed on the smooth horizontal surface, these are pulled by a force F. then Acceleration of the system a = ----------

9. When two bodies of masses m_1 and m_2 are tied to the ends of a light string placed on the smooth horizontal surface, these are pulled by a force F then Tension in the string T = ----------

10. When three boidies of masses m_1 , m_2 and m_3 are lying in contact on a horizontal smoothtable and a horozontal force F on a body of mass m_1 ----------

11. Two bodies are conected by mass less string . Then tenson in the string every where is ----------

Match the following:

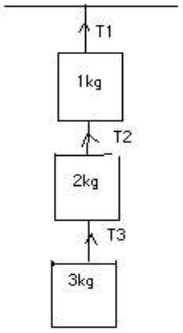
- *This section contains Matrix-Match Type questions. Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in **Column–I** have to be matched with statements (p, q, r, s) in **Column–II**. The answers to these questions have to be appropriately bubbled as illustrated in the following example.*

*If the correct matches are A-p,A-s,B-r,B-r,C-p,C-q and D-s,then the correct bubbled 4*4 matrix should be as follows:*

12. Consider three blocks of different masses 1kg, 2kg, and 3kg connected by string and the system is rest for different masses.Then

a) acceleration of system 1) 30N
b) T_1 2) 50N
c) T_2 3) 60N
d) T_3 4) 0 m/s^2

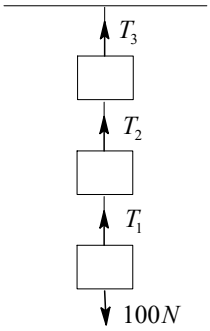
A) a - 1, b - 2, c - 3, d - 4 B) a - 4, b - 3, c - 2, d - 1
C) a - 3 , b - 4, c - 1, d - 2 D) a - 4, b - 1, c - 3, d - 2



Comprehention type:

- *This section contains paragraph. Based upon each paragraph multiple choice questions have to be answered. Each question has 4 choices (A) , (B) ,(C) and (D) out of which **ONLY ONE i**s correct. Choose the correct option.*

13. Three blocks of equal masses (each 3kg) are suspended by weightless strings as shown. If applied force is 100N as, shown (g= 10m/s^2)



i) Then tension T_1 is equal to

A) 130N B) 190N C) 100N D) 160N

ii) Tension T_2 is equal to

A) 130N B) 190N C) 100N D) 160N

iii) Tension T_3 is equal to

A) 130N B) 190N C) 100N D) 160N

KEY

ΦΦ TEACHING TASK :

1) C, 2) B, 3) A, 4) C, 5) B, 6) D, 7) C, 8) $\frac{F}{m_1+m_2}$, 9) $T=\frac{m_1F}{m_1+m_2}$,

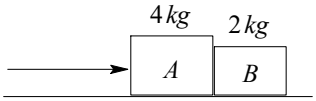
10) $T=\frac{F}{m_1+m_2+m_3}$ 11)Same , 12) B, 13) i) A, ii)D, iii) B

LEARNER'S TASK

BEGINNERS

Single correct answer type:

1. A horizontal force F pushes on a 4 kg block (A) which pushes against a 2 kg block (B) as shown. The blocks have an acceleration of 3m/s^2 to the right. There is no friction between the blocks and the surfaces on which they slide. What is the net force B exerts on A?



1) 6 N to the right 2) 12 N to the right

3) 6 N to the left 4) 12 N to the left

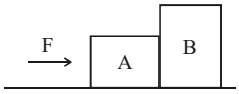
2. Three blocks of masses 3kg, 2kg and 1kg are placed side by side in contact with each other on a smooth horizontal surface with the 3 kg block on the left extreme and 1 kg block on the right extreme. A horizontal force of 12 N is applied on the 3 kg block pushing it towards the 2 kg block. the contact force between the 2 kg block and 1 kg block is

1) 6 N 2) 4 N 3) 2N 4) 8 N

3. A block of mass 3 kg is in contact with a block of mass 2 kg. Both the blocks rest on a frictionless floor. A horizontal force of 10 N is applied to push the block of mass 3 kg. The force with which the first block pushes the second block is

1) 0 N 2) 4 N 3) 6 N 4) 10 N

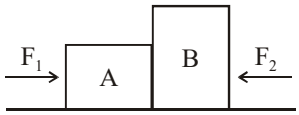
4. In the figure, F = 20N, A and B have masses 2kg and 3kg. The force applied by A on B is



1) 16 N 2) 18N

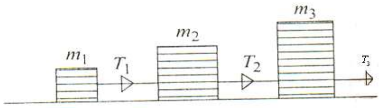
3) 15 N 4) 12N

5. In the adjacent figure F_1 = 20N F_2 = 10N. A and B have 2Kg and 3kg. The force applied by A on B is



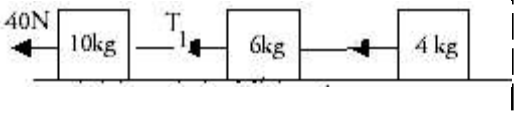
1) 16 N 2) 18N 3) 15 N4) 12N

6. Three bodies are lying on a frictionless horizontal table and these are connected as shown in the figure. They are pulled towards right with a force $T_3 = 60N$. If m_1, m_2 and m_3 are equal to 10kg, 20kg and 30kg respectively, then the values of T_1 and T_2 will be



1) 10 N, 10 N 2) 30N, 10N
3) 10N, 30N 4) 30N, 30N

7. A 40 N force pulls a system of three masses on a horizontal frictionless surface as shown in the fig. Tension T_1 is

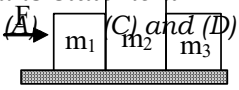


1) 40 N 2) 20 N 3) 10 N 4) 5 N

EXPLORERS

Assertion A and Reason R:

- *This section contains certain number of questions. Each question contains Statement – 1 (Assertion) and Statement – 2 (Reason). Each question has 4 choices (A), (B), (C) and (D) out of which* ***ONLY ONE*** *is correct Choose the correct option.*



1. **A:** When three bodies of different masses are in contact as shown, a force F acts on first body then same force acts on remaining bodies

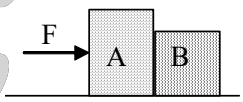
R: Three bodies move combindly with same acceleration

A) Both 'A' and 'R' are true and 'R' is the correct explanation of 'A'
B) Both 'A' and 'R' are true and 'R' is not correct explanation of 'A'
C)'A' is true and 'R' is false
D) 'A' is false and 'R' is true

Multiple option type:

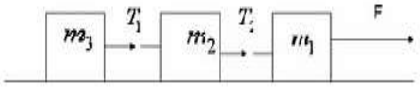
- *This section contains multiple choice questions. Each question has 4 choices (A), (B), (C),(D), out of which* ***ONE or MORE*** *is correct. Choose the correct options*

2. Two masses A and B kept on smooth surface as shown. If a force of F acts on A then
i) A applies force on B



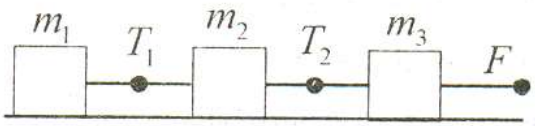
ii) B applies force on A
iii) Both A and B moves with same acceleration
A) i only true B) i, ii only true C) ii, iii only true D) all are ture

3. Three masses m_1,m_2,and m_3 are connected by a string as shown in the figure then
a) The tension between m_1 and m_2, m_2 and m_3 is same
b) The acceleration of all masses of the system is same
c) The tension between m_1,and m_2, m_2 and m_3 is different.
d) The acceleration of m_1, m_2,and m_3 is different.



A) a,b,c,d are correct B) a,b,c are correct
C) b,c are correct D) c,d are correct

4. Consider three blocks of mass m_1, m_2, m_3 interconnected by strings which are pulled by a common force F on a fricitonless horizontal table as in the figure. The tension T_1 and T_2 are also indicated



a) $T_2 > T_1$ if $m_2 > m_1$ b) $T_2 = T_1$ if $m_2 = m_1$

c) $T_2 > T_1$ always d) acceleration of the system = $\frac{F}{m_1 + m_2 + m_3}$

A) only a, b are correct B) only b, d are correct
C) only a, d are correct D) only c, d are correct

Fill in the blanks :

5. A block of mass 20 kg is suspended through two light spring balances , Then shows the reading of the spring balance is ---------- .

6. Three equal masses A,B and C are pulled with a constant force F , They are connected to each other with strings the ratio of the tension between Ab and BC is .
---

7. When a force of F acts as shown on three diffrent bodies connected by string if tension is same then all bodies move with same ----------

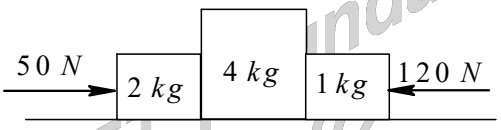
8. Acting on the body normal force and gravitational forces equal in magnitude but ---------- in direction

Match the following:

- *This section contains Matrix-Match Type questions. Each question contains statements given in two columns which have to be matched. Statements (A, B, C, D) in **Column–I** have to be matched with statements (p, q, r, s) in **Column–II**. The answers to these questions have to be appropriately bubbled as illustrated in the following example.*

  *If the correct matches are A-p,A-s,B-r,B-r,C-p,C-q and D-s,then the correct bubbled 4*4 matrix should be as follows:*

9. Three blocks of masses 1kg, 4kg and 2 kg are placed on a smooth horizontal surface as shown in the figure. Two horizontal forces 120 N and 50N are applied on the system.



Then match the following:

a) Net force acting on the system is 1) 70 N SI units

b)acceleration of the system is 2) 10 SI units

c) force bewtween 2 kg and 4 kg is 3) 110 SI unis

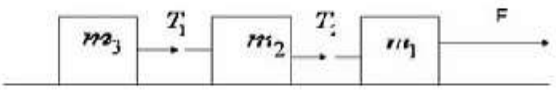
d) force between 4 kg and 1 kg is 4) 70 SI units

A) a-1, b-2, c-3, d-4 B) a-1, b-2, c-4, d-3 C) a-4, b-3, c-2, d-1 D) a-4, b-2, c-3, d-1

Comprehention type:

- *This section contains paragraph. Based upon each paragraph multiple choice questions have to be . Each question has 4 choices (A) , (B) ,(C) and (D) out of which **ONLY ONE i**s correct. Choose the correct option.*

10. If $m_1 = 20Kg, m_2 = 30Kg, m_3 = 50Kg$, and F = 200N, Then



i) Tensions T_1 in the string is

A)160N B)100N C)160N D)100N

ii) Tensions T_2 in the string is

A) 100N B)160N C) 0 D) 120N

RESEARCHERS

I) Single correct answer type:

1. A retardating force of 150 N is applied to a body of mass 50 kg .which is moving with a speed of 30 m/s.the time taken by the body to com to rest is... **[NTSE 2018]**
A) 20s B)30s C) 5s D)10s

2. Which of the following statement is INCORRECT ? **(NSEJS 2010-11)**
A) If the net force on a body is zero, its velocity is constant or zero.
B) If the net force on a body is zero, its acceleration is constant and nonzero.
C) If the velcoity of a body is constant, its acceleration is zero
D) A body may have a varying velocity yet a constant speed.

3. A certain force applied to a body A gives it an acceleration of 10 m/s^2. The same force is applied to body B gives it an acceleration of 15 m/s^2. If the two bodies are joined together and the same force is applied to the combination, the acceleration will be **(NSEJS 2011-12)**
A) 6 ms^{-2} B) 25 ms^{-2} C) 12.5 ms^{-2} D) 9 ms^{-2}

4. What is the reading of the spring balance shown in the figure below?

(NSEJS 2012-13)
A) 0 B)2N C) 4N D)6N

5. When a car turns on a curved road, you are pushed against one of the doors of the car because of **(NSEJS 2012-13)**
A) inertia B) the centripetal force C) the centrifugal force D) the frictional force

6. If two bodies of different masses, initially at rest, are acted upon by the same force for the same time, then both bodies acquire the same **(NSEJS 2014-15)**
A) Velocity B) momentum C) acceleration D) kinetic energy

7. The "reaction" force does not cancel the "action" force because **(NSEJS 2015-16)**
A) the action force is greater than the reaction force
B) the reaction force exists only after the action force is removed
C) the reaction force is greater than the action force
D) they act on different bodies

8. A body is in equilibrium under the combined action of several forces then
A) all the forces must be applied at the same point **(NSEJS 2015-16)**
B) all the forces form pairs of equal and opposite forces
C) the sum of the torques about any point must always be equal to zero
D) the lines of action of all the forces must pass through the centre of gravity of the body.

9. The object at rest suddenly explodes into three parts with the mass ratio 2:1:1. The parts of equal masses move at right angles to each other with equal speed V. The speed of the third part after the explosion will be **(2008 M)**
A) 2V B) $V/\sqrt{2}$ C) V/2 D) $\sqrt{2}\,V$

10. A rifle of 20kg mass can fire 4 bullets per second. The mass of each bullet is $35\times10^{-3}kg$ and its final velocity is $400ms^{-1}$. Then what force must be applied on the rifle so that it does not move backwards while firing the bullets ? **(2007 E)**
A) 80 N B) 28 N C) -112 N D) -56 N

11. A bullet of mass 10gm of fired horizontally with a velocity $1000ms^{-1}$ from a rifle situated at a height 50 m above the ground. If the bullet reaches the ground with a velocity $500ms^{-1}$, the

work done against air resistance in the trajectory of the bullet is (in joules) $\left(g = 10ms^{-2}\right)$ **(2006 E)**

A) 5005 B) 3755 C) 3750 D) 17.5

12. A gravel is dropped into a conveyor belt at a rate of 0.5 kg/s.The extra force required in N to keep the belt moving at 2 m/s is

A) 2 B) 1 C) 4 D) 5 **(1983 E)**

13. A boat of mass 3000 kg,initially at rest is pulled by a force of 1.8 x 10^4 N through a distance of 3m.Assuming that the velocity of air resistance as zero,velocity of boat is

A) 2 m/s B) 4m/s C) 3 m/s D) 6 m/s **(1983 E)**

14. A machine gun fires a bullewt of mass 40g with a velocity of 1200m/s.A man holding it can exert a maximum force of 144 N on the gun. How many bullets can he fire per sec atmost. **(AIEEE-2004)**

A) 2 B) 4 C) 1 D) 3

15. A bomb of mass 16kg at rest explodes into 2 pieces of masses 4kg and 12kg.The velocity of 12kg mass is 4m/s.The K.E. of other mass is **(AIEEE-2006)**

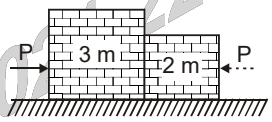
A) 144J B) 288J C) 192J D) 96J

II) ADDITIONAL PROBLEMS

1. A horizontal force of 300N pulls a blocks of masses m_1=10kg which is connected by a string to m_2=20kg, if both are lying on horizontal frictionless surface, what is tension in the string. [A: 200 N]

A) 200N B) 300N C) 100N D) 500N

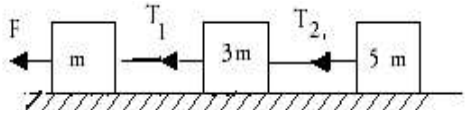
2. Two blocks of masses '3*m'* and '2*m'* are in contact on a smooth table. A force P is first applied horizontally on block of mass '3m' and then on mass '2m'. The contact forces between the two blocks in the two cases are in the ratio



A) 1 : 2 B)2 : 3 C)3 : 2 D)5 : 3

3. The fig. Shows a system of three masses being pulled with a force F. The masses are connected to each other by strings. The horizontal surface is frictionless. The tension T_1 in the first string is 16 N. The acceleration of the system is

A) 1 m/s^2 B) 2 m/s^2 C) 3 m/s^2 D) 4 m/s^2



KEY

ΦΦ LEARNER'STASK :

- **BEGINNERS :** 1-3, 2-3, 3-2, 4-4, 5-1, 6-3, 7-2
- **EXPLORERS:** 1) D, 2) D, 3) C, 4) D, 5) Same , 6)2:1 , 7)acceleration, 8)Opposite , 9) B, 10) i) b, ii) B
- **RESEARCHERS:**

I) 1) D, 2) B, 3) A, 4) C, 5) A, 6) B 7) D, 8) B, 9) A, 10) D, 11) D, 12) B, 13) D, 14) D, 15)B

II) 1-A, 2-B, 3-B