CHAPTER -9 "Force & Laws Of Motion"

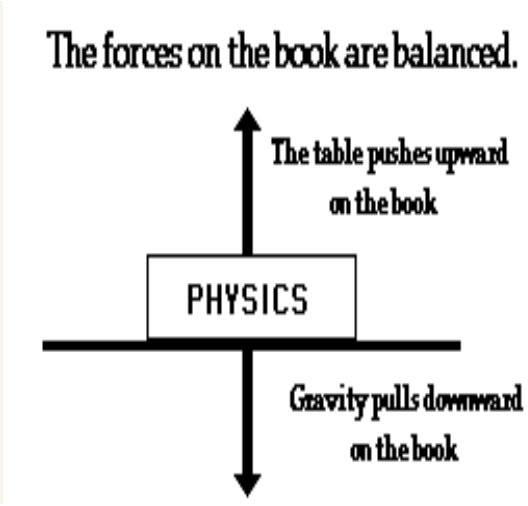
KEY CONCEPTS ***[*rating as per the significance of concept]***

1	**Balanced and Unbalanced Forces**	***
2	**Laws of Motion**	*****
3	**Inertia and Mass**	*****
4	**Conservation of Momentum**	****

1 **Balanced and Unbalanced Forces**

Balanced Forces The net force is when two or more forces are applied on the same object and at the same time. The applied forces combined are called the net force. = 0 25 N 25 N

Balanced Forces The force I apply in one direction plus the force you apply in the opposite direction are added together. 25 N -25 N = 0 Because the forces are equal and balanced…just like a balanced scale…this is an example of balanced forces. Unbalanced Forces What does it mean to have something unbalanced? Unequal, not the same, different How could we have unbalanced forces?



Unbalanced Forces A force is applied in one direction and either another smaller or larger force is applied in the opposite direction or no force is applied at all in the opposite direction.

Unbalanced Forces If I have a chair and I push on one side of it with a force

of 50 N and you push on the other side, with a force of 25 N, will the chair move? Which way will it move? The direction in which the most force is applied. What is the net force? 50 N 25 N.

Unbalanced Forces 50N -25N = 25N These forces are unequal so the forces are considered unbalanced forces. 50 N 25 N = 25 N

Unbalanced Forces If I push the chair in one direction with 25 N force and you push the chair in same direction with 25 N force, will the chair move? Why? Because the applied net force is UNBALANCED!

Unbalanced Forces 25 N 25 N = 50 N The result would be the chair moving in the direction it was pushed with a combined force of 50 N.

Test Yourself

1. An object of 5 kg is acted upon by two forces, 70 N each in opposite directions. What is its acceleration?

2. Why does an object accelerate during free fall?

2 ## Laws of Motion

Newton's First Law

1st Law – An object at rest will stay at rest, and an object in motion will stay in motion at constant velocity, unless acted upon by an unbalanced force.

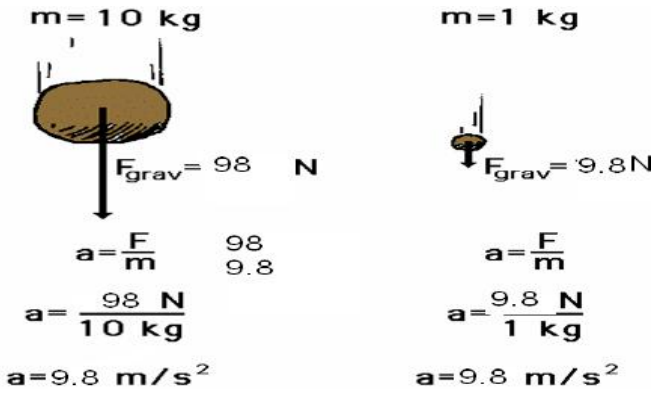
An object at rest will stay at rest, and an object in motion will stay in motion at constant velocity, unless acted upon by an unbalanced force.

Newton's Second Law

"If the net force on an object is not zero, the object will accelerate. The direction of the acceleration is the same as the direction of the net force. The magnitude of the acceleration is directly proportional to the net force applied, and inversely proportional to the mass of the object."

Mathematical symbols provide a convenient shorthand for all of this:

$$a = \frac{F_{net}}{m} \quad \text{or} \quad F_{net} = ma$$



The Effect of Mass

A force applied to an automobile will **not** have the same effect as the same force applied to a pencil. An automobile resists accelerating much more than a pencil does, because it has more inertia, or mass.

The acceleration of an object depends not only on how hard you push on it, but also on how much the object resists being pushed.

What is the effect of mass on acceleration? This, too, turns out to be quite simple (I wonder why...). For the same force, an object with twice the mass will have half the acceleration. If it had three times the mass, the same force will produce one-third the acceleration. Four times the mass gives one-fourth of the acceleration, and so on.

This type of relationship between quantities (double one, get half the other) is called an *inverse proportion or inverse variation.* In other words, then:

Newton's Second Law of Motion The acceleration of an object is dependent upon both force and mass. Thus, if the colliding objects have unequal mass, they will have unequal accelerations as a result of the contact force which results during the collision.

Newton's Third Law

Newton's Third Law is stated as:

For every action there is an equal and opposite reaction.

"action...reaction" means that forces always occur in pairs. (Forces are interactions between objects, like conversations are interactions between people.)

Single, isolated forces never happen. The two forces involved are called the "action force" and the "reaction force."

These names are unfortunate for a couple of reasons :

Either force in an interaction can be the "action" force or the "reaction" force

The action and reaction forces exist at the same time.

"equal" means

Both forces are exactly the same size. They are equal in magnitude.

Both forces exist at exactly the same time. They both start at exactly the same instant, and they both stop at exactly the same instant. They are equal in time.

"opposite" means that the two forces always act in opposite directions - exactly 180^{o} apart.

Newton's third law of motion In every interaction, there is a pair of forces acting on the two interacting objects. The size of the force on the first object equals the size of the force on the second object. The direction of the force on the first object is opposite to the direction of the force on the second object. Forces always come in pairs - equal and opposite action-reaction force pairs.

Newton's third law of motion applied to collisions between two objects. In a collision between two objects, both objects experience forces which are equal in magnitude and opposite in direction. Such forces cause one object to speed up (gain momentum) and the other object to slow down (lose momentum). According to Newton's third law, the forces on the two objects are equal in magnitude.

Test Yourself

1. Can action reaction balance each other?

2. What does a force do?

3 **Inertia and Mass**

Inertia is the tendency of an object to resist any change in its motion. An object will continue to move at the same speed in the same direction

unless acted upon by an unbalanced force. Inertia & Mass

Inertia & Mass of a bowling ball rolled down the road would eventually come to a stop. Friction is an unbalanced force that causes the ball to stop or slow down. Without friction, the ball would keep going.

Inertia & Mass of a bowling ball and a tennis ball have the same inertia.

Inertia & Mass If you had a tennis racket and I threw tennis ball at you, what would happen? If you had a tennis racket and I threw a bowling ball at you, what would happen? Why could you change the motion of the tennis ball but not the motion of the bowling ball?

Mass is the amount of matter in an object. A bowling ball has more mass than a tennis ball. The greater the mass of an object the greater its inertia. Mass is the measurement of inertia.

Test Yourself

1. Why do we fall forward if we alight from a moving bus?

2. Why does an athlete run for some distance before long jump?

4 Conservation of Momentum

Law of Conservation of Momentum

In a closed system, the vector sum of the momenta before and after an impact must be equal.

Before After

$m_1v_1 + m_2v_2 = m_1v_1' + m_2v_2'$

Internal and External Forces

QUESTION BANK

One Mark questions

1. Define momentum.
2. State first law of motion.
3. What is inertia?
4. Can action and reaction balance each other?
5. How does one climb up a rope?
6. Why cannot we walk in space?

7. What does rate of change of momentum represent?

8. Why do we continuously paddle to keep the cycle moving?

9. Why does a scooter tend to skid while executing a sharp turn?

10. Which one would have more inertia : 10 kg mass & 5 kg mass?

Two Marks questions

1. Explain the functioning of shockers in cars.

2. How much force is needed to pull an object of mass 40 kg in vertically upward direction with acceleration of 2.2 m / s^2.

3. Why does a fan keep moving for sometime when switched off?

4. What do you mean by conservation of momentum?

5. Inflated balloon lying on the surface of a floor moves forward when pricked with a pin. Why?

Three Marks questions

1. An iron sphere of mass 10 kg is dropped from a height of 80 cm, if 'g' = 10 m / s^2. Calculate the momentum transferred to the ground by the body.

2. What would be the force required to stop a car of mass 1000 kg and a loaded truck of mass 10,000 kg in 2 seconds each moving with velocity 5 m / s.

3. Deduce law of conservation of momentum using third law of motion.

Five Mark questions

1. Name and define three different types of inertia & give an example of each.

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CBSE Test Paper 01

Chapter 09 Forces and Laws of Motion

1. On a 3 kg mass, 5 newton of force acts for 0.1 second. The impulse imparted to the mass is (in kg m/s) **(1)**
   a. 0.16
   b. 1.0
   c. 1.5
   d. 0.5
2. A force of 5 N applied on m_1 produces an acceleration of 8 m/s^2 and when applied on m_2 produces an acceleration of 24 m/s^2. When they are tied together, the acceleration will be **(1)**
   a. 3 m/s^2
   b. 16 m/s^2
   c. 6 m/s^2
   d. 8 m/s^2
3. Which of the following is not used to reduce friction **(1)**
   a. using ball bearing
   b. using grease between contact surfaces
   c. using oil between contact surfaces
   d. making scratches on the contact surfaces
4. Water drops sticking to the wheel come out along the tangential line due to **(1)**
   a. inertia
   b. acceleration
   c. momentum
   d. force
5. “Internal forces are forces which bodies exert on each other when the bodies are part of the system” is **(1)**
   a. false
   b. partially false

c. partially true
d. true

6. What is the total momentum of a bullet and a gun before firing? **(1)**
7. State Newton's first law of motion. **(1)**
8. What do you mean by a resultant force? **(1)**
9. What do balanced forces usually do to a body? **(1)**
10. State the meaning of recoil velocity of a gun? **(1)**
11. A certain particle has a weight of 30 N at a place where the acceleration due to gravity is 9.8 m/s^2 **(3)**
    a. What are its mass and weight at a place where acceleration due to gravity is 3.5 m/s^2.
    b. What will be its mass & weight at a place where acceleration due to gravity is zero.
12. A bullet of mass 0.02 kg is fired from a gun weighing 7.5 kg. If the initial velocity of the bullet is 200 m/s, calculate the speed with which the gun recoils. **(3)**
13. Explain, why is it difficult for a fireman to hold a hose, which ejects large amounts of water at a high speed. **(3)**
14. A body of mass 2 Kg is at rest at the origin of a frame of reference. A force of 5 N acts on it at t = 0. The force acts for 4 s and then stops. **(5)**
    i. What is the acceleration produced by the force on the body?
    ii. What is the velocity at t = 4 s
    iii. Draw the vt graph for the period t = 0 to t = 6 S.
    iv. Find the distance travelled in 6 s.
15. A 8000 kg engine pulls a train of 5 wagons, each of 2000 kg, along a horizontal track. If the engine exerts a force of 40000 N and the track offers a frictional force of 5000 N, then calculate: (**5)**
    a. the net accelerating force;
    b. the acceleration of the train; and
    c. the force of wagon 1 on wagon 2.

CBSE Test Paper 01

Chapter 09 Forces and Laws of Motion

Answers

1. d. 0.5

   Explanation: Impulse can also be expressed as rate of change of momentum.

   And Momentum= force × time =5×0.1

   = 0.5 kg m/ s

2. c. 6 m/s^2

   Explanation: For the first body,

   $F = m_1a_1$

   So, $5 = m_1 * 8$

   So, $m_1 = 5/8$ kg

   For second body,

   $F = m_2a_2$

   So, $5 = m_2 * 24$

   So, $m_2 = 5/24$ kg

   Combined mass of both bodies, m_1+m_2

   = 5/8 + 5/24 = 20/24 kg

   Now, m = 20/24 kg

   F = 5N

   a = ?

   F =ma

   So, 5 = 20/24 * a

   So, a = 5*24/20

   So, a = 6m/s^2

3. d. making scratches on the contact surfaces

   Explanation: To reduce the friction, oiling between contact surfaces can be done, besides we can use ball bearing or grease between contact surfaces. Making scratches between contact surfaces will make the surface rough and so,

will increase the friction.

4. a. inertia

   Explanation: Inertia is the resistance of any physical object to any change in its state of motion. This includes changes to the object's speed, direction, or state of rest.

5. d. true

   Explanation: Internal forces are those forces which are exerted on each other when the bodies are part of the system. The forces acting between the atoms of molecules that keep them together are example of internal force.

6. Zero. Before firing, both the gun and the bullet are at rest and therefore the total initial momentum is zero.

7. Newton's first law of motion states that, 'Everybody continues to be in its state of rest or of uniform motion in a straight line unless it is compelled by some external applied force to change that state.'

8. When two or more forces act on a body simultaneously, then the single force which produces the same effect as produced by all the forces acting together is known as the resultant force.

9. Balanced forces usually change the shape of the body but not the direction of the moving body. They do not change the state of motion of the body,nor they produce any acceleration.

10. The velocity with which a gun moves backward after firing a bullet is called the recoil velocity of a gun.

11. Weight of particle,W= 30 N

    Acceleration due to gravity,g = 9.8 m/s^2

    Let, m be the mass of particle

    From the relation, W = mg

    $30 = m \times 9.8$

    $\Rightarrow m = \frac{30 \times 10}{98}$

    $\Rightarrow m = \frac{300}{98} Kg = 3.06\ kg$

a. W = mg'

g'=3.5 m/s^2

$W = \frac{300}{98} \times \frac{35}{10}$

= 10.71 N

b. Mass at the place = 3.06 Kg (mass is always constant)

At a place where g= 0

$W = m \times 0 = 0$

But Mass = 3.06 Kg(mass is a constant quantity)

12. Here, the mass of the bullet, m_1 = 0.02 kg

Mass of gun, m_2 =7.5kg

Velocity of bullet, $v_1 = 200 m/s$

and the speed of gun, $v_2 = ?$

According to law of conservation of momentum, we have

Total momentum of system before firing = Total momentum of system after firing

i.e., $m_1 v_2 + m_2 v_2 = 0$

(since initial velocities of gun and bullet before firing is zero.)

$\Rightarrow$ 0.02 $\times$ 200 + 7.5 $\times v_2 = 0$

$\Rightarrow$ 7.5 $\times v_2$ = - 0.02 $\times$ 200

$\Rightarrow v_2 = -\frac{4}{7.5} = -0.533$

$\Rightarrow v_2$ = -0.53 m/s

Here, negative sign indicates that the direction of the recoil force is in the opposite direction.

Therefore, recoil velocity of the gun is 0.53 ms^{-1}

13. It is based on the law of conservation of momentum. When water comes out of the hose, with certain momentum in the forward direction, the hose, in order to converse momentum moves backward. This makes it difficult for the fireman to hold the hose.

14. Force, F = 5N

Mass, m = 2 kg

i. $F = m \times a1$

$\Rightarrow 5 = 2 \times a$

$\Rightarrow a = 2.5\ m/s^2$

Therefore,acceleration produced by the body is 2.5 ms^{-2}

ii. Final velocity,v = 0

Initial velocity ,u = 0 (body starts from Rest)

Time,t = 4 s

From the relation,

$v = u + at$

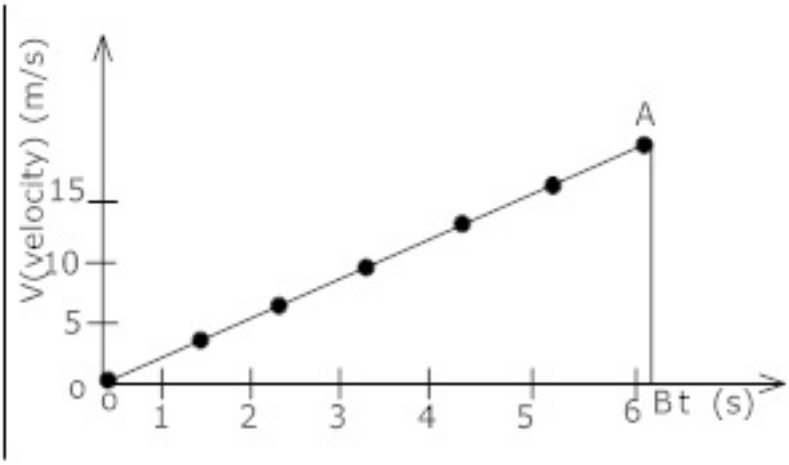
$\Rightarrow v = 2.5 \times 4$

$\Rightarrow v = 10\ m/s$

Therefore,the velocity at t=4 s is 10ms^{-1}

iii.

For t = 0	1	2	3	4	5	6
V = 0	2.5	5	7.5	10	12.5	15



iv. Distance Travelled = Area under v/t curve = Area of ΔAOB

$= \frac{1}{2} \times \text{Base} \times \text{Height}$

$= \frac{1}{2} \times OB \times AB$

$= \frac{1}{2} \times 6 \times 15$

$= 45\,m$

Therefore, distance travelled in 6 s is 45 m.

15. Force exerted by the engine,F' = 40,000 N

Frictional force offered by the track in the direction opposite of the motion,F'' = -5,000 N

a. The net accelerating force, F = F'+F''= 40,000 N + (-5,000 N) = 35,000 N
b. Mass of each wagon of the train = 2000 kg

   Number of wagons = 5

   Therefore, Mass of the train,m= 2,000 kg $\times$ 5= 10,000 kg.

   Net accelerating force acting on the train,F= 35000 N

   From Newton's second law of motion, acceleration

   $a = \frac{F}{m} = \frac{35{,}000\ N}{10{,}000\ kg} = 3.5\ ms^{-2}$
c. Mass of 1 wagon= 2000 kg

   acceleration of the train= 3.5 ms^{-2}

   From the relation, F =ma,we get

   F= 2000 kg $\times$ 3.5 ms^{-2}

   F= 7000 N

   Force exerted by wagon 1 on wagon 2

   = Net accelerating force - Force acting on wagon 1= 35000 N - 7000 N= 28000 N

   Therefore, the required answer is 28000 N.

Physics

Chapter: - Force & laws of Motion

Topic	Link
1) Define Balanced and unbalanced force.	https://youtu.be/VvQZ3ZLnaMo
2) Define laws of Motion and their application	https://youtu.be/cwLMejalz-E
3) Define Inertia and mass	https://youtu.be/7UFSqc-kzwM
4) Define Momentum	https://youtu.be/FCUN6HEmnz8
5) Derive law of Conservation of Momentum	https://youtu.be/5fcVDF4DNXE
6) What does the rate of change of Momentum represent?	https://youtu.be/zaAET9vd9cM
7) Try to solve the Blue text question and exercise question from NCERT book	

Assignment

1. What do you mean by law of conservation of momentum?
2. Why do roads on mountains have inward inclination at sharp turns?
3. Why is it dangerous to jump out of a moving bus?
4. How do safety belts of cars help in preventing accidents?
5. Explain how momentum gets conserved in collision of two bodies?
6. How are Newton's three laws of motion related?
7. Explain inertia and momentum in detail.
8. Define force and its various types. What is its unit?
9. Give three examples exhibiting inertia in our daily life
10. What change will a force bring in a body?
11. Explain how Newton's second law of motion is used in sports?