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CHAPTER NOTES

How Forces Affect Motion Class 9 Notes | CBSE Science Chapter 6

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Ask me anything from this chapter. A concept, a numerical, or that one doubt you did not want to raise in class. Pick one to start:

Explain How Forces Affect Motion simply

What can the board exam ask?

Most important formulas

Quiz me on this chapter

Ask Ira anything...



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How Forces Affect Motion Class 9 Notes | CBSE Science Chapter 6

How Forces Affect Motion is Chapter 6 of CBSE Class 9 Science (Exploration, 2026-27). In Chapter 4 you learnt to describe motion with position, velocity and acceleration. This chapter asks what causes a change in motion. It starts with force as a quantity with magnitude and direction, measured in newtons with a spring balance, then covers balanced and unbalanced forces, the net force, friction, and Newton's three laws of motion. It ends by treating two connected boxes as a single system.

School exams test this chapter through net-force calculations, $F = ma$ numericals that use the kinematic equations from Chapter 4, and reasoning questions on everyday events such as catching a cricket ball, airbags, walking, rowing a canoe and rocket launches. The ideas here are the foundation for the physics you study in Class 10 and beyond, so learn each law in its exact wording and practise writing units at every

Quick Answer - How Forces Affect

Force has magnitude and direction; its effects on one object are balanced and give zero net force. **First law:** with zero net force, an object remains at rest or moves with constant velocity. **Second law:** a net force produces acceleration $a = F/m$ where $m = 1 \text{ kg}$ and $\text{weight} = mg$. **Third law:** for every action, there is an equal and opposite reaction. Two different objects, so they never cancel each other out.



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All Key Formulas at a Glance

Quantity	Formula	SI Unit
Net force, two forces in the same direction	$F_{\text{net}} = F_1 + F_2$	newton (N)
Net force, two forces in opposite directions	$F_{\text{net}} = F_1 - F_2$, along the larger force	newton (N)
Newton's second law	$a = F / m$, or $F = ma$	F in N, m in kg, a in m s^{-2}
One newton	$1 \text{ N} = 1 \text{ kg} \times 1 \text{ m s}^{-2} = 1 \text{ kg m s}^{-2}$	newton (N)
Gravitational force (weight)	$F = mg$	newton (N)
Acceleration due to gravity	$g = 9.8 \text{ m s}^{-2}$	m s^{-2}
Acceleration of two connected boxes	$a = \frac{F}{m_1 + m_2}$	m s^{-2}
Kinematic equations used with $F = ma$	$v = u + at$ $s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$	m s^{-1} , m, s
Momentum (Ready to Go Beyond)	$p = mv$	kg m s^{-1}



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Key Concepts

1. Force and Its Measurement

A force is a push or a pull. It can make an object start moving, stop moving, or change the speed or direction of a moving object (a ball being kicked, squeezing a lemon).

Every force has a direction. Friction acts opposite to the direction of motion, air resistance acts opposite to the direction of motion, and a liquid pushes an object in it up.

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with a **magnitude**, a **direction** and a **unit**, like displacement, velocity and acceleration in Chapter 4. If the magnitude, the direction, or both change, the effect of the force also changes.

The **SI unit of force is the newton**, symbol **N**. It is named after Isaac Newton. When a unit is named after a person, its full name starts with a small letter (newton) and its symbol with a capital (N).

A **spring balance** measures the magnitude of a force. It measures weight (the gravitational force with which the Earth pulls an object), and it also measures any pull applied to its free end.

Force scale	Size
Smallest forces we can directly feel (a light touch)	of the order of millinewtons, 10^{-3} N
Smallest forces measured in specialised experiments (as of 2026)	
Upward force of your palm holding a 100 g mass	

2. Balanced and Unbalanced Forces

Usually more than one force acts on an object. For example, a ball on a rough surface experiences friction backwards. A ball floating on water experiences a buoyant force upwards.

In a tug of war, if both teams pull with equal **magnitude but opposite in direction** are balanced. If the forces are **unbalanced** and the rope moves towards the stronger team.

Arrangement
Same direction (two people pushing a stalled car)
Opposite directions, unequal
Opposite directions, equal



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Worked illustration: three students push a cart eastwards with 40 N, 30 N and 20 N, and friction of 60 N acts westwards. Net force = $(40 + 30 + 20) - 60 = 30$ N towards the east.

A weightlifter holding a barbell steady is a balanced case: the Earth pulls the barbell down and the lifter pushes it up with an equal force. **Multiple forces may act on an object, but its motion depends only on the net force.**

Forces acting at an angle, and equal and opposite forces on the two ends of a handlebar or tap that make it turn, are studied in higher classes.

3. The Force of Friction

A heavy box often does not move when pushed gently. The **force of friction** between the box and the floor acts opposite to your push. The box moves only when your push is larger than friction, so that a net force acts in the direction of motion. Its weight (downwards) and the **normal force** from the surface (upwards, perpendicular to the surface) are balanced.

Stop pedalling a bicycle and it slows down moving only to counter friction; without the object to rest.

Activity 6.1: a stack of four ₹10 coins is placed on a fixed mark and released on a wooden table. When the block moves with neither increasing nor decreasing velocity, the spring's pull equals friction. The reading on the spring scale is the force of friction.

Activity 6.2: a wooden block is pulled along a surface. When the block moves with neither increasing nor decreasing velocity, the spring's pull equals friction. The reading on the spring scale is the force of friction.

Conclusion: when friction is smaller, the velocity is larger distance before stopping. In the act of sliding on the polished floor.

Thought experiment: on a perfectly smooth surface, a released object down, so it would keep moving.



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Friction can also help motion. When you walk, friction from the ground pushes your foot forwards. Grooves on shoe soles and treads on tyres increase friction. Wet polished floors, ice and roads covered with water or snow give little friction, so walking or driving on them is risky. Unwanted friction is reduced with lubricants, coatings, surface texturing, streamlining and magnetic levitation.

4. Newton’s First Law of Motion

For ages people believed a force was needed to keep an object moving at constant velocity. In the 17th century Galileo Galilei argued, through thought experiments, that a body moving on a horizontal plane with all impediments removed would continue to move indefinitely.

Newton’s first law of motion: An object at rest remains at rest, and an object in motion continues to move with a constant velocity, unless a net force acts upon the object.

If the net force on an object is zero, it cannot begin to move or change its velocity, so its **acceleration is zero**. “At rest” means zero magnitude or direction, so a moving object with no net force may act and still cancel.

Inertia: Newton used this word for the tendency of an object to remain at rest or uniform motion. He presented his three laws of motion.

With zero friction, a net force is needed or to start it, to change its velocity, or to stop it. No force is needed to keep it moving at a constant velocity.

State (zero net force)	Position-time graph
At rest	Straight line parallel to time axis
Constant velocity	Straight line inclined to time axis

A curved position-time graph means the velocity is changing.

NCERT Example 6.2: a person pushes a book on a table. The forces are equal and opposite, the book moves with constant velocity.



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Which situations are possible with zero net force? Staying at rest: possible. Moving with constant velocity: possible. Moving with constant acceleration: not possible.

5. Newton's Second Law of Motion

A change in velocity is acceleration, so a **force produces acceleration**. Two classroom demonstrations find the relationship.

Activity 6.3 (mass fixed): a cardboard-box cart on wheels is pulled along a table by a thread that runs over a pipe at the far end and holds a paper cup with coins. The falling cup pulls the cart with a constant force. A slow-motion video gives the time T_1 to cover the table. The mass in the cup is doubled and the new time T_2 is recorded. The cart starts from rest and covers the same distance s , so $s = \frac{1}{2}a_1T_1^2 = \frac{1}{2}a_2T_2^2$, giving $a_1/a_2 = T_2^2/T_1^2$. The larger force gives a shorter time and a larger acceleration.

Activity 6.4 (force fixed): the cup's mass is kept the same and the cart's mass is doubled. The cart takes longer, so its acceleration is smaller.

Ideally, doubling the force doubles the acceleration. In practice, the two values differ slightly because of measurement errors.

Newton's second law of motion: When a net force F acts on a mass m , the direction of the net force. The magnitude of the net force and is inversely proportional to the mass.

$a = F / m$ or $F = ma$, where F is the net force, a is the acceleration in m s^{-2} , along the net force.

One newton: with $m = 1 \text{ kg}$ and $a = 1 \text{ m s}^{-2}$, produces an acceleration of 1 m s^{-2} on an object.

Weight: the acceleration of a falling object is g (about 9.8 m s^{-2}). $W = mg$, the gravitational force on a mass m is W (where g is the acceleration due to gravity, estimates). g is nearly constant near the Earth's surface. The weight of the object. A 100 g mass has weight $0.1 \times 9.8 = 0.98 \text{ N}$.



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Change	Effect on acceleration
Force doubled, mass same	Doubles
Mass doubled, force same	Halves
Force and mass both doubled	Unchanged
Force tripled, mass halved	Becomes 6 times

Stopping gently: if a moving object is brought to rest over a **longer time**, its acceleration is smaller, so the force needed is smaller.

- **Catching a cricket ball:** the fielder pulls the hands back with the ball, increasing the stopping time, reducing the force and the risk of injury.
- **Airbags:** in a collision the passenger's head hits a hard steering wheel or dashboard. The airbag exerts a smaller force on the person, which lowers the risk of injury. A seat belt is also worn.
- **Bubble wrap or hay** around glass and other fragile objects in the same way.
- **Cracking a coconut:** it hits a hard surface. The ground exerts a very large force that cracks the coconut.

Beyond this class: momentum is the product of mass and velocity. The complete second law says the rate of change of momentum takes place in its direction, which also means that the force is in the same direction.

6. Newton's Third Law of Motion

At least two objects must interact for a force to be exerted. For example, a ball pushes on your foot.

Activity 6.5: sitting on a wheeled chair with your back to a table, push the chair backwards; pull the table and the chair moves in the opposite direction.

Activity 6.6: two identical spring balances are connected. One end of one is pulled. Both readings are equal. The forces on the other are equal in magnitude and opposite in direction.



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Newton’s third law of motion: Whenever one object is exerting a force on a second object, the second object is simultaneously exerting an equal and opposite force on the first object.

The forces always occur in pairs and act on **two different objects**, so they do not balance each other. Equal and opposite forces on the **same** object do balance.

Feature	Balanced forces	Third-law pair
Magnitude and direction	Equal, opposite	Equal, opposite
Act on	The same object	Two different objects
Cancel?	Yes, net force zero	No
Example	Equal pulls on a tug-of-war rope	Paddle on water, water on

- **Walking and cycling without pedalling** pushes you forwards through friction. V
- **Climbing a coconut tree:** the legs push an equal force. Smooth trunks are hard
- **Rowing a canoe:** the paddle pushes wa canoe forwards. Pushing harder gives a increases. Drag, currents, the canoe’s r
- **Balloon on a string (Activity 6.7):** the s pushes the balloon the other way, and i
- **Rocket:** the engine expels gas downwa force is larger than the rocket’s weight, direction of motion slows a craft down; landing near the Moon’s south pole.
- **Fire hose:** the pipe pushes water forwa

The third law holds for contact and non-co bar magnets, two similarly charged balloo opposite forces on each other.

Equal forces, unequal accelerations: the object accelerates more. The Earth’s mass is so large that its acceleration towards a falling fruit



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cannot be noticed. A light bullet gets a large acceleration while the heavier gun gets a small one.

7. Forces Acting on a System of Objects

Two boxes of masses m_1 and m_2 on a frictionless horizontal surface are joined by a string, and a force F pulls Box 1 to the right. Box 1 pulls Box 2 through the string, and by the third law Box 2 pulls Box 1 back with an equal force, the **tension** T . On Box 1, F acts right and T acts left; on Box 2, T acts right.

You could find the net force on each box separately. It is simpler to treat both boxes and the string as **one system**. Forces between its parts are **internal forces** (tension) and are ignored. Only **external forces** from outside matter (here F):

$$a = F / (m_1 + m_2)$$

The system accelerates like one object of mass $m_1 + m_2$. The other external forces, total weight $(m_1 + m_2)g$ downwards and total normal force upwards, cancel.

Worked illustration: $m_1 = 4$ kg, $m_2 = 6$ kg, $F = 20$ N. Box 1 pulls Box 2 only by the string, so $T = 6 \times 2 = 12$ N; on Box 1, $F - T = 8$ N.

In the same way your whole body can be treated as one system. Physics work from everyday objects to planets and galaxies, and from massive objects, near the speed of light and



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Formula and Reaction Sheet

Relation	Formula	Units and notes
Net force, same direction	$F_{\text{net}} = F_1 + F_2$	N; direction of the two forces
Net force, opposite directions	$F_{\text{net}} = F_1 - F_2$ ($F_1 > F_2$)	N; direction of the larger force
Balanced forces	$F_{\text{net}} = 0$, so $a = 0$	At rest or constant velocity
Second law	$a = F / m$, so $F = ma$	a in m s^{-2} , same direction as F
Unit of force	$1 \text{ N} = 1 \text{ kg m s}^{-2}$	Force giving 1 kg an acceleration of 1 s^{-2}
Weight	$F =$	
Third law	F_{AB}	
Accelerations in a third-law pair	a_1 / m_1	
Connected system	$a = m_2)$	
Ratio of accelerations from times (same s , $u = 0$)	a_1 / T_1^2	

Here F_{AB} means the force exerted by object A on object B. If the objects are in opposite direction.

Important Definitions

- **Force:** a push or pull that can make an object start moving, stop a moving object, or change its shape. It has magnitude and direction.



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- **Newton (N):** the SI unit of force. One newton is the force that produces an acceleration of 1 m s^{-2} on an object of mass 1 kg .
- **Weight:** the gravitational force with which the Earth pulls an object, $F = mg$.
- **Balanced forces:** forces on an object that are equal in magnitude but opposite in direction, so the net force is zero.
- **Net force:** the overall force on an object when all the forces on it are combined.
- **Force of friction:** the force between two surfaces in contact that acts opposite to the direction of motion (or attempted motion). It depends on the nature of the surfaces.
- **Normal force:** the force exerted by a surface on an object placed on it, acting perpendicular to the surface.
- **Inertia:** the tendency of objects to resist a change in their state of rest or uniform motion.
- **Newton's first law:** An object at rest remains at rest, and an object in motion continues to move with a constant velocity, unless a net force acts upon the object.
- **Newton's second law:** When a net force acts on an object, the acceleration of the object is in the direction of the net force. The magnitude of the acceleration is directly proportional to the magnitude of the net force and is inversely proportional to the mass of the object.
- **Newton's third law:** Whenever one object exerts a force on a second object, the second object simultaneously exerts a force of equal magnitude and opposite direction on the first object.
- **Acceleration due to gravity (g):** the acceleration of an object towards the Earth, about 9.8 m s^{-2} near the surface.
- **Tension:** the force transmitted through a rope, cable, or string when pulled by forces acting from opposite ends.
- **Internal force:** a force between parts of the same object.
- **External force:** a force that acts on the object from outside.



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Solved Examples (NCERT)

Example 1: Pushing a block against a wall

Question: A student pushes a stationary block against a wall. The force of friction opposing the motion is 50 N . Find the minimum force the student must apply in the forward direction. (i) 50 N , (ii) 55 N , in the forward direction.

Solution (i): The push equals the maximum static friction. The net force is zero. The block stays stationary: **displacement = 0**.

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Solution (ii): Net force = $55\text{ N} - 50\text{ N} = 5\text{ N}$ forwards.

$$a = F/m = 5\text{ N} / 25\text{ kg} = 0.2\text{ m s}^{-2}.$$

$$u = 0, t = 2\text{ s}. s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2} \times 0.2 \times (2)^2 = 0.1 \times 4 = \mathbf{0.4\text{ m in the forward direction.}}$$

Example 2: Force on a sports car from its motion (NCERT Example 6.6)

Question: A sports car of mass 1500 kg moves towards the east. From its velocity-time graph: from 0 s to 5 s its velocity rises uniformly from 0 to 10 m s^{-1} ; from 5 s to 10 s it stays at 10 m s^{-1} ; from 10 s to 15 s it falls uniformly from 10 m s^{-1} to 0 . Find the force on the car in each interval.

(i) 0 s to 5 s : $u = 0, v = 10\text{ m s}^{-1}, t = 5\text{ s}$. From $v = u + at$: $10 = 0 + a \times 5$, so $a = 2\text{ m s}^{-2}$. $F = ma = 1500 \times 2 = \mathbf{3000\text{ N towards the east.}}$

(ii) 5 s to 10 s : the graph is parallel to the time axis, so velocity is constant and $a = 0$. **No net force** acts on the car.

(iii) 10 s to 15 s : $u = 10\text{ m s}^{-1}, v = 0, t = 5\text{ s}$. From $v = u + at$: $0 = 10 + a \times 5$, so $a = -2\text{ m s}^{-2}$. $F = ma = 1500 \times (-2) = -3000\text{ N}$. The minus sign means the force is $\mathbf{3000\text{ N towards the west.}}$

Example 3: Recoil of a gun (NCERT Example 6.7)

Question: When a 0.1 kg bullet is fired from a gun of mass 4 kg , the acceleration of the bullet is 5000 m s^{-2} . What are the magnitudes of initial accelerations of the gun and the bullet?

Solution: By the third law, the recoil force on the gun is equal in magnitude to the force on the bullet.

$$\text{Acceleration of the gun} = \text{force} / \text{mass of gun}$$

$$\text{Acceleration of the bullet} = \text{force} / \text{mass of bullet}$$

The forces are equal, but the acceleration of the gun is 40 times lighter, so its acceleration is 50 times smaller than that of the bullet.

Example 4: The snake boat race (NCERT Example 6.8)

Question: While practising for the snake boat race, a team of 10 rowers is rowing a boat together. Out of these, 95% row in the same direction. By mistake, 5 oarsmen row in the opposite direction. If each oarsman exerts a force of 200 N , what is the net force on the snake boat?



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Solution: Forward force = $95 \times 200 \text{ N} = 19000 \text{ N}$. Backward force = $5 \times 200 \text{ N} = 1000 \text{ N}$.

Net force = $19000 \text{ N} - 1000 \text{ N} = \mathbf{18000 \text{ N}}$ in the forward direction.

Example 5: Stopping a bullet in a wooden block (NCERT Exercise 12)

Question: A bullet of mass 50 g moving with a speed of 100 m s^{-1} enters a heavy stationary wooden block and stops after penetrating a distance of 50 cm . Estimate the stopping force acting on the bullet (assume that the bullet undergoes constant acceleration within the block).

Solution: Convert units: $m = 50 \text{ g} = 0.05 \text{ kg}$, $s = 50 \text{ cm} = 0.5 \text{ m}$. $u = 100 \text{ m s}^{-1}$, $v = 0$.

$v^2 = u^2 + 2as$ gives $0 = (100)^2 + 2 \times a \times 0.5$, so $0 = 10000 + a$, and $a = -10000 \text{ m s}^{-2}$.

$F = ma = 0.05 \times (-10000) = -500 \text{ N}$. The stopping force is **500 N, opposite to the bullet's motion**.

Example 6: Time of contact in a penalty

Question: An ace footballer converted a penalty by kicking the ball with a speed of 30 km h^{-1} . The estimated force they imparted on the ball was 800 N . Calculate the time of contact between the foot and the ball.

Solution: For a penalty the ball starts at rest. $u = 0$. $v = 30 \text{ km h}^{-1} = 8.33 \text{ m s}^{-1}$.

$a = F/m = 800 \text{ N} / 0.4 \text{ kg} = 2000 \text{ m s}^{-2}$.

$v = u + at$ gives $30 = 0 + 2000 \times t$, so $t = 0.0167 \text{ s}$.

Example 7: Object on a rough patch

Question: An object of mass 2 kg moving with a speed of 10 m s^{-1} enters a rough patch where the force of friction on it is a constant force of 3 N opposing the motion. Calculate the distance it travels on the patch, how much distance does the object travel before it stops?

Solution: Both forces oppose motion, so the net force is -10 N .

$a = -10 \text{ N} / 2 \text{ kg} = -5 \text{ m s}^{-2}$. $u = 10 \text{ m s}^{-1}$, $v = 0$.

$v^2 = u^2 + 2as$ gives $0 = 100 + 2 \times (-5) \times s$, so $10s = 100$ and **$s = 10 \text{ m}$** .



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Example 8: Tractor, harrow and trolley (NCERT Exercise 15)

Question: A tractor pulls a harrow (a ploughing tool) of mass m_1 with a net force F resulting in an acceleration of a_1 . The same tractor pulls a trolley of mass m_2 with a force F producing an acceleration of a_2 . If the tractor now pulls the trolley with the harrow placed on it (with the same force F), then obtain an expression for the resulting acceleration in terms of a_1 and a_2 . Ignore friction.

Solution: From $F = ma$: $m_1 = F/a_1$ and $m_2 = F/a_2$.

The harrow on the trolley moves as one system of mass $m_1 + m_2$. So $a = F / (m_1 + m_2) = F / (F/a_1 + F/a_2)$.

Cancel F : $a = 1 / (1/a_1 + 1/a_2) = a_1 a_2 / (a_1 + a_2)$.

Check: if $a_1 = a_2$, the total mass doubles and the formula gives $a = a_1/2$, as expected.

Competency-Based Questions

1. Case-based: Pushing a cupboard

Riya pushes a 40 kg cupboard across her room. The cupboard does not move. She increases her push. Now the force of friction on it is 80 N.

(a) What is the friction on the cupboard while it is at rest? (b) What is the acceleration of the cupboard while she is pushing? (c) What force should she apply to keep it moving at constant velocity?

Answer: (a) The cupboard is at rest, so the friction is 0 N. (b) Net force = 100 N - 80 N = 20 N. Acceleration = $20/40 = 0.5 \text{ m/s}^2$. (c) Constant velocity needs zero net force, so she should apply 80 N.

2. Case-based: Airbags and seat belts

In a collision a car stops abruptly. An airbag inflates. The passenger's head and chest push into the airbag. The passenger's head and chest push into the dashboard.



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(a) Which quantity does the airbag increase? **(b)** Use Newton's second law to explain how this reduces injury. **(c)** Name one other everyday use of the same idea.

Answer: (a) The time over which the passenger's velocity drops to zero. (b) The same change in velocity over a longer time means a smaller acceleration. By $F = ma$, a smaller acceleration means a smaller force on the person, which lowers the risk of serious injury. (c) A fielder pulling the hands back while catching a fast ball, bubble wrap around glass items, or a landing mat in the high jump.

3. Source-based: Activity 6.3 data

A class pulls a cart over the same distance from rest using a hanging cup. With the first cup mass the cart takes $T_1 = 2.0$ s. With double the cup mass it takes $T_2 = 1.5$ s.

(a) Find the ratio a_2/a_1 . **(b)** The ideal value is 2. Give two reasons why the measured value differs.

Answer: (a) From $s = \frac{1}{2}at^2$ for the same s , $a \propto 1/t^2$. So $a_2/a_1 = (T_1/T_2)^2 = (2.0/1.5)^2 = 1.78$. (b) Friction between the cart's wheels and the table, and errors in timing.

4. Assertion-Reason

Assertion (A): An object moving with constant velocity has no net force on it. **Reason (R):** A net force acting on an object changes its direction.

(a) Both A and R are true and R is the correct explanation of A. (b) Both A and R are true but R is not the correct explanation of A. (c) A is true and R is false. (d) A is false and R is true.

Answer: (a). Constant velocity means zero acceleration. A net force would produce an acceleration, so there is no net force.

5. Assertion-Reason

Assertion (A): The force exerted by a paddle on water and the force exerted by water on the paddle cancel each other. **Reason (R):** The two forces act in opposite directions.

Options as in Question 4.

Answer: (d). A is false: the two forces act on different objects. R is true, as stated by the text.



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6. Assertion-Reason

Assertion (A): When a fruit falls, the Earth does not seem to move towards the fruit. **Reason (R):** The force exerted by the fruit on the Earth is much smaller than the force exerted by the Earth on the fruit.

Options as in Question 4.

Answer: (c). A is true. R is false: the two gravitational forces are equal in magnitude. The Earth's acceleration ($a = F/m$) is extremely small because its mass is so large.

7. Reasoning: A spacecraft far from any planet

A spacecraft is moving in a region of space where the gravitational force on it is negligible. **(a)** If its engines are switched off, how will it move? **(b)** Suggest how it can change its velocity.

Answer: (a) With no net force it continues with constant velocity, by the first law. (b) It fires its engine to expel gas. To speed up, gas is expelled backwards. To slow down, the engine fires it forwards. To change its direction, the engine fires it sideways. To land on the Moon, the engine pushes the craft towards the opposite side.

8. Competency MCQ: Hand carts

A hand cart loaded with vegetables collides with an empty cart. Which cart experiences a larger collision:

(i) the loaded cart exerts a force of larger magnitude on the empty cart
(ii) the empty cart exerts a force of larger magnitude on the loaded cart
(iii) both exert forces of equal magnitude on each other
(iv) the loaded cart and the empty cart, both experience the same acceleration

Answer: (iv). By the third law the forces are equal. The empty cart, with less mass, gets the larger acceleration.

Important Questions for

1-Mark Questions

1. What is the SI unit of force? The newton



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2. **An object is moving with a constant velocity. Is there a net force acting upon it?** No. Constant velocity means zero acceleration, so the net force is zero.
3. **A toy car of mass 100 g is moving with a constant velocity of 0.5 m s^{-1} . What is the net force acting on the toy car?** Zero, because its velocity is constant.
4. **When a net force acts on an object, it accelerates: (i) opposite to the force, with acceleration proportional to the force; (ii) opposite to the force, with acceleration proportional to the mass; (iii) in the direction of the force, with acceleration inversely proportional to the force; (iv) in the direction of the force, with acceleration proportional to the force. (iv).**
5. **Using a horizontal force F , a table is moved across the floor at a constant velocity. How much is the frictional force exerted by the floor on the table?** F , acting opposite to the applied force.

2-Mark Questions

6. **Distinguish between balanced forces and opposite. Balanced forces act on the third-law pair acts on two different objects.**
7. **Two children of different masses are sitting on a swing. For which child would you expect a larger acceleration, for which child would you expect a smaller acceleration? From $F = ma$, for the same force, the lighter child would have a larger acceleration.**
8. **Why does a fielder pull the hands back while catching a ball? It increases the time in which the ball stops. The force on the hands is smaller and in the opposite direction.**
9. **Why does a fireperson sometimes struggle to push a large amount of water forward? The fireperson pushes the water forward, and the water pushes the fireperson backwards with an equal force, so the fireperson struggles to move forward.**



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3-Mark Questions

10. **A sailor jumps out from a small boat to move? If yes, in which direction and with what force? No. To jump, the sailor pushes the boat away from the shore. The boat pushes the sailor forwards with an equal and opposite force. The boat on water, sets it moving backwards.**
11. **Define one newton and find the force required to accelerate a mass of 1200 kg at 1.5 m s^{-2} . One newton is the force that produces an acceleration of 1 m s^{-2} in a mass of 1 kg. $F = ma = 1200 \times 1.5 = 1800 \text{ N}$.**

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2. **A net force of 12 N acts on a 4 kg trolley at rest for 5 s. Find its acceleration, its final velocity and the distance covered.** $a = 12/4 = 3 \text{ m s}^{-2}$. $v = u + at = 0 + 3 \times 5 = 15 \text{ m s}^{-1}$. $s = ut + \frac{1}{2}at^2 = 0 + \frac{1}{2} \times 3 \times 25 = 37.5 \text{ m}$.
3. **When the pole of a bar magnet is brought close to a magnetic compass, the magnet and the compass needle exert equal and opposite forces on each other. However, the compass needle moves, whereas the bar magnet does not move. Explain why.** The forces are equal in magnitude, but equal forces do not produce equal accelerations when the masses differ ($a = F/m$). The compass needle has a very small mass and turns freely on its pivot, so the force gives it a noticeable acceleration and it swings. The bar magnet has a much larger mass, so the same force gives it only a very small acceleration. It is also usually held in the hand or rests on a table, where the hand or friction balances this small force. So the bar magnet shows no noticeable motion.

5-Mark Questions

4. **State Newton's second law of motion. Describe an activity to show that, for a fixed mass, a larger force produces a larger acceleration.** the object accelerates in the direction of the net force. Acceleration is directly proportional to the magnitude of the net force. Activity: a wheeled cart is pulled by a string attached to a hanging paper cup with coins. Using a slow-motion video. Double the force, the acceleration doubles. For the same s , $a_1/a_2 = T_2^2/T_1^2$. T_2 is shorter.
5. **State Newton's third law of motion. Explain (a) rowing a canoe, (b) the launch of a rocket.** Whenever one object is exerting a force on another, the second object is simultaneously exerting an equal and opposite force on the first. (a) The oar pushes water backwards; the water pushes the oar forwards; the oar pushes the boat forwards. (b) The engine pushes gas backwards; the gas pushes the rocket upwards. Pushing harder gives a larger force. (c) The engine pushes gas downwards; the gas pushes the rocket upwards. When the upward force is greater than the downward force, the rocket moves upwards and it lifts off. The two forces do not cancel; only forces on the same object cancel.
6. **A 1000 kg car moving at 20 m s⁻¹ brakes to a stop in 5 s. Find (a) its deceleration, (b) the braking force, (c) the distance it travels before it stops, (d) the time it takes to stop if it carried extra load so that its mass became 2000 kg. (a) $a = (v - u)/t = (0 - 20)/5 = -4 \text{ m s}^{-2}$. (b) $F = ma = 1000 \times (-4) = -4000 \text{ N}$, opposite to the motion. (c) $s = ut + \frac{1}{2}at^2 = 20 \times 5 + \frac{1}{2}(-4) \times 25 = 40 \text{ m}$. (d) The same deceleration is -4 m s^{-2} .**



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Common Mistakes and Examiner Tips

1. **Mistake:** saying a moving object needs a force to keep moving. **Fix:** a force is needed only to overcome friction or to change velocity. With zero net force, a moving object keeps a constant velocity (first law).
2. **Mistake:** writing "no force acts" when the velocity is constant. **Fix:** write "no *net* force acts". Friction, weight and the normal force may all be acting and cancelling.
3. **Mistake:** adding forces that act in opposite directions. **Fix:** subtract them and give the direction of the larger force. Add only forces in the same direction.
4. **Mistake:** saying action and reaction cancel. **Fix:** they act on two different objects, so they never cancel. Only forces on the same object can balance.
5. **Mistake:** thinking the heavier object exerts a larger force in a collision or in gravity. **Fix:** the forces in a pair are always equal. The lighter object has the larger acceleration because $a = F/m$.
6. **Mistake:** using the applied force in $F = \dots$ (applied force minus friction), then dividing by 5/18) before substituting. $50 \text{ g} = 0.05 \text{ kg}$.
7. **Mistake:** forgetting unit conversion. **Fix:** convert to SI units before substituting.
8. **Mistake:** dropping the minus sign of a force. **Fix:** keep the sign in the work. direction (for example, "3000 N toward").
9. **Mistake:** writing the unit as Newton or newton. **Fix:** the unit is N (capital).
10. **Mistake:** believing g depends on the mass of the object near the Earth's surface. The weight is proportional to mass.
11. **Mistake:** including tension when finding the net force on a system. **Fix:** tension is internal. Use a free-body diagram.
12. **Tip:** write the three laws in the exact text: "an object remains at rest or in uniform motion unless a net force acts", "in the direction of the net force", "the acceleration is directly proportional to the net force".



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Quick Revision Points

- A force can start motion, change speed

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- Force has magnitude and direction. SI unit: newton (N). Measured with a spring balance.
- Equal and opposite forces on the same object are balanced: net force zero.
- Same direction: add forces. Opposite directions: subtract, direction of the larger force.
- An object's motion depends only on the net force.
- Friction acts opposite to motion and depends on the nature of the surfaces.
- Smaller friction: velocity falls more slowly and the object travels farther.
- Galileo: with all impediments removed, a body on a horizontal plane moves indefinitely.
- First law: at rest stays at rest, moving keeps constant velocity, unless a net force acts.
- Inertia: the tendency to resist a change in the state of rest or uniform motion.
- Zero net force: zero acceleration. Position-time graph is a straight line.
- Second law: acceleration is along the net force, proportional to it and inversely proportional to mass.
- $a = F/m$, $F = ma$, $1 \text{ N} = 1 \text{ kg m s}^{-2}$.
- Weight $F = mg$, $g = 9.8 \text{ m s}^{-2}$, independent of mass.
- Longer stopping time means smaller acceleration. Air in a car's tyre, bubble wrap.
- Very short stopping time means a very large acceleration.
- Third law: forces come in equal and opposite pairs.
- A third-law pair never cancels.
- Walking, pushing a bicycle along with your feet, a rocket engine, a car's wheels are third-law examples.
- The third law holds for contact and non-contact forces.
- Equal forces, unequal accelerations: gun and bullet.
- Connected objects: $a = F / (m_1 + m_2)$; ignore internal forces.



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Weightage and Exam Pattern

Class 9 has no board exam. This chapter is important for internal assessments (term and annual papers), and the NCERT source books (problems and exercises, statements of laws, reasoning about everyday phenomena, and kinematic equations of Chapter 4).

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Question type	What this chapter typically supplies
MCQ and one-word	SI unit of force, net force at constant velocity, which law applies, equal forces in a collision
Assertion-Reason	Balanced forces versus third-law pairs, zero net force and constant velocity, Earth and falling fruit
Short answer	Net force from several forces, catching a ball, fire hose, sailor jumping from a boat, choosing the larger force for a heavier object
Long answer	Statement of a law with an activity, third-law examples, multi-step numericals using $F = ma$ with $v = u + at$ or $v^2 = u^2 + 2as$
Case-based	Airbags and seat belts, pushing furniture against friction, rockets and spacecraft, connected boxes

This chapter is the foundation for Class 10 before substituting and naming the direction on force and motion.



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