

CLASS 9 SCIENCE — CHAPTER 6

HOW FORCES AFFECT MOTION

 **New *Exploration* Science Textbook | 2026–27**

Chapter 6 introduces **force, balanced and unbalanced forces, friction, inertia, Newton's three laws, momentum, gravitational force, and forces acting on systems of objects.**

 **Formula format:** All formulas are written in simple **text format**, as requested.

1. What Is Force?

We push or pull objects every day.

-  Opening a door
-  Kicking a football
-  Pushing a trolley
-  Hitting a cricket ball
-  Pulling a suitcase

All these actions involve:

Force

Definition

Force is a push or pull that can change the state of motion or shape of an object.

Force can:

-  Start motion
-  Stop motion
-  Change speed
-  Change direction
-  Change shape

The textbook examples include kicking or striking a ball and squeezing an object to demonstrate these effects.

2. Force Is a Vector Quantity

Force has:

 **Magnitude**

and

 **Direction**

Therefore:

★ **Force is a vector quantity.**

3. SI Unit of Force

The SI unit of force is:

Newton (N)

It is named after:

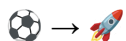
 **Sir Isaac Newton**

4. Effects of Force

A force can produce several effects.

1 Change the state of rest

A stationary ball can start moving when kicked.



2 Change the speed

A moving bicycle can speed up when the rider pedals harder.

3 Stop a moving object

🛑 Brakes apply force to slow and stop a vehicle.

4 Change direction

A batsman changes the direction of a cricket ball by applying force.

5 Change shape

🍋 Squeezing a lemon changes its shape.



5. Balanced Forces

When two or more forces acting on an object cancel each other, the:

Net force = 0

These are called:

Balanced forces

Example

A book is lying on a table.

⬇️ Weight

⬆️ Normal force

These forces are equal and opposite.

Therefore:

Net force = 0



6. Unbalanced Forces

When the forces acting on an object do not cancel each other, the net force is:

Not zero

These are called:

Unbalanced forces

An unbalanced force can change the motion of an object.

Example:

If you push a box harder than friction resists it:



Net force acts forward.

The box accelerates.



7. Net Force

When several forces act on an object, we consider their combined effect.

This combined force is called:

Net force

For forces acting in the same direction:

$$\text{Net Force} = F_1 + F_2$$

For opposite directions:

$$\text{Net Force} = \text{Larger Force} - \text{Smaller Force}$$

Example

Two forces act on a box:



50 N

← 20 N

Therefore:

Net Force = 50 – 20

Net Force = 30 N to the right



8. Balanced vs Unbalanced Forces

Balanced Forces

Net force = 0

No acceleration

Motion does not change due to net force

Forces cancel

Unbalanced Forces

Net force $\neq$ 0

Acceleration occurs

Motion can change

Forces do not cancel

★ Important

A balanced force does **not necessarily mean that the object is at rest.**

An object can move with constant velocity when the net force is zero.



9. Contact and Non-Contact Forces

Forces can broadly be classified as:



Contact forces

and



Non-contact forces

10. Contact Forces

Contact forces act when objects are in physical contact.

Examples:

Muscular force

Force applied using muscles.

Frictional force

Force that opposes relative motion between surfaces in contact.

Tension

Force transmitted through a stretched string, rope or thread.

11. Non-Contact Forces

These forces can act without direct physical contact.

Examples:

 Gravitational force

 Magnetic force

 Electrostatic force

12. Friction

Definition

Friction is a force that opposes relative motion between surfaces in contact.

Friction generally acts opposite to relative motion.

Example

A book sliding across a table eventually stops because friction acts opposite to its motion.



13. Why Is Friction Important?

Friction is not always harmful.

It is necessary for many activities.



Walking

Friction between our shoes and the ground helps us walk without slipping.



Driving

Friction between tyres and road provides grip.



Writing

Friction between pencil/pen and paper allows writing.



Braking

Friction helps vehicles slow down.



14. Disadvantages of Friction

Friction can also:



Produce heat



Cause wear and tear



Waste energy



Reduce efficiency of machines

Therefore, engineers try to reduce unwanted friction.



15. Increasing and Reducing Friction

To increase friction:



Use rough shoe soles



Use suitable tyre treads



Make surfaces sufficiently rough for grip

To reduce friction:



Use lubricants



Use ball bearings



Use wheels

The nature of the surfaces is one factor that affects friction.



16. Inertia

Objects tend to resist changes in their state of motion.

This property is called:

Inertia

Definition:

Inertia is the tendency of an object to resist a change in its state of rest or uniform motion.

Newton's first law is closely associated with the concept of inertia.

17. Inertia of Rest

An object at rest tends to remain at rest.

Example

When a stationary bus suddenly starts moving:

Passengers may lean backward.

Why?

Their bodies tend to remain at rest while the bus moves forward.

18. Inertia of Motion

A moving object tends to continue moving.

Example

When a moving bus suddenly stops:

Passengers may lean forward.

Their bodies tend to continue moving forward.

19. Inertia of Direction

An object tends to continue moving in the same direction.

Example

When a car suddenly turns:

Passengers may lean towards the outside of the turn.

Their bodies tend to continue in the original direction.



20. Mass and Inertia

★ **Greater mass → Greater inertia**

A heavy object is more difficult to change from its state of rest or motion than a lighter object.

Therefore:

Mass is a measure of inertia.



21. Newton's First Law of Motion

Newton's first law states:

An object remains at rest or continues to move with uniform velocity in a straight line unless acted upon by a net external force.

This is also called:

Law of Inertia



22. Examples of Newton's First Law

Bus suddenly starts 

Passengers lean backward.

Bus suddenly stops 

Passengers lean forward.

Dusting a carpet 

Dust particles tend to remain in their original state of motion when the carpet is beaten.

Seat belts 🚗

Seat belts restrain passengers when a vehicle suddenly stops.

The chapter specifically explains that a seat belt reduces the forward motion caused by inertia when a car stops.

⚡ 23. Net Force and Acceleration

Newton's laws tell us that:

Net force produces acceleration.

If:

Net Force = 0

then:

Acceleration = 0

If:

Net Force $\neq$ 0

then:

Acceleration $\neq$ 0

🚀 24. Newton's Second Law of Motion

Newton's second law explains how force, mass and acceleration are related.

Formula:

$F = ma$

Where:

F = Net force

m = Mass

a = Acceleration



25. Rearranged Forms

From:

$$\mathbf{F = ma}$$

we can write:

Acceleration:

$$\mathbf{a = F / m}$$

Mass:

$$\mathbf{m = F / a}$$

These are useful for numerical problems.



26. SI Units in F = ma

Mass:

kg

Acceleration:

m/s²

Force:

N

Therefore:

$$1 \text{ N} = 1 \text{ kg m/s}^2$$



27. Example — Finding Force

$$\text{Mass} = 5 \text{ kg}$$

$$\text{Acceleration} = 3 \text{ m/s}^2$$

Using:

$$F = ma$$

$$F = 5 \times 3$$

$$F = 15 \text{ N}$$



28. Example — Finding Acceleration

$$\text{Force} = 60 \text{ N}$$

$$\text{Mass} = 20 \text{ kg}$$

Using:

$$a = F / m$$

$$a = 60 / 20$$

$$a = 3 \text{ m/s}^2$$



29. Example — Finding Mass

$$\text{Force} = 50 \text{ N}$$

$$\text{Acceleration} = 5 \text{ m/s}^2$$

Using:

$$m = F / a$$

$$m = 50 / 5$$

$$m = 10 \text{ kg}$$



30. Important Relationship

For a fixed mass:

Force $\propto$ Acceleration

Therefore:

If force doubles:

Acceleration doubles.

If force becomes three times:

Acceleration becomes three times.



31. Effect of Mass

For the same force:

Acceleration $\propto 1 / \text{Mass}$

Therefore:

Greater mass $\rightarrow$ Smaller acceleration

Smaller mass $\rightarrow$ Greater acceleration

This follows directly from:

$$a = F / m$$



32. Everyday Example

Suppose you push:



An empty trolley

and



A heavily loaded trolley

with the same force.

The empty trolley accelerates more because its mass is smaller.



33. Newton's Third Law of Motion

Newton's third law states:

When one object exerts a force on another object, the second object exerts an equal and opposite force on the first object.

This is commonly expressed as:

Every action has an equal and opposite reaction.



34. Action-Reaction Pairs

Action and reaction forces:

- ✓ Are equal in magnitude.
- ✓ Are opposite in direction.
- ✓ Act on two different objects.



Very important:

They **do not cancel each other** because they act on different objects.

The textbook's questions specifically emphasize that action and reaction act on two different objects.

35. Examples of Newton's Third Law

Walking

You push the ground backward.

The ground pushes you forward.

Swimming

A swimmer pushes water backward.

Water pushes the swimmer forward.

Rocket

The rocket pushes exhaust gases downward.

The gases exert an upward force on the rocket.

Recoil

A gun pushes a bullet forward.

The bullet exerts an equal and opposite force on the gun.

The gun moves backward.

Jumping from a Boat

A person pushes the boat backward while jumping forward.

The boat moves backward.

36. Gravitational Force

Earth attracts objects towards its centre.

This attractive force is called:

Gravitational force

It acts on objects even without physical contact.

37. Weight

The gravitational force acting on an object is called its:

Weight

Formula:

Weight = Mass × Acceleration due to gravity

or

$$\mathbf{W = mg}$$

Where:

W = Weight

m = Mass

g = Acceleration due to gravity

Near Earth's surface:

$$\mathbf{g \approx 9.8 \text{ m/s}^2}$$



38. Example — Weight

Mass = 30 kg

$g = 9.8 \text{ m/s}^2$

Using:

$$W = mg$$

$$W = 30 \times 9.8$$

$$W = 294 \text{ N}$$



39. Mass vs Weight

Mass	Weight
Amount of matter	Gravitational force acting on an object
Scalar	Vector
Unit = kg	Unit = N
Remains essentially constant	Can vary with gravitational field
Measure of inertia	Measure of gravitational force



40. Momentum

A moving object has:

Momentum

Momentum depends on:



Mass

and

 Velocity

Formula:

Momentum = Mass × Velocity

or

$p = mv$

Where:

p = Momentum

m = Mass

v = Velocity



41. SI Unit of Momentum

Mass:

kg

Velocity:

m/s

Therefore:

SI unit of momentum = kg m/s

The direction of momentum is the same as the direction of velocity.



42. Example — Momentum

Mass = 4 kg

Velocity = 3 m/s

Using:

$$p = mv$$

$$p = 4 \times 3$$

$$p = 12 \text{ kg m/s}$$



43. Another Momentum Example

Mass = 10 kg

Velocity = 5 m/s

$$p = 10 \times 5$$

$$p = 50 \text{ kg m/s}$$



44. Change in Momentum

Change in momentum is:

Change in momentum = Final momentum – Initial momentum

or:

$$\Delta p = p_2 - p_1$$

Since:

$$p = mv$$

we can write:

$$\Delta p = mv - mu$$

for constant mass.

Therefore:

$$\Delta p = m(v - u)$$

45. Force and Change in Momentum

Newton's second law can also be expressed using momentum.

Formula:

F = Change in momentum / Time

or:

$$\mathbf{F = \Delta p / \Delta t}$$

For constant mass:

$$\mathbf{F = m(v - u) / t}$$

Since:

$$\mathbf{a = (v - u) / t}$$

we get:

$$\mathbf{F = ma}$$

46. Newton's Laws — Summary

1 First Law

Inertia

An object maintains its state unless a net external force acts.

2 Second Law

$$\mathbf{F = ma}$$

Net force produces acceleration.

3 Third Law

Action and reaction

Forces between interacting objects are equal and opposite.



47. Newton's Three Laws — Quick Table

Law	Main Idea	Key Concept
1st Law	Objects resist change	Inertia
2nd Law	Force produces acceleration	$F = ma$
3rd Law	Forces occur in pairs	Action-Reaction



48. Tension

When a string or rope is stretched, it can exert a pulling force.

This force is called:

Tension

Tension acts along the string or rope.

Example:

Two boxes connected by a string:



If one box is pulled, the string transmits tension to the other box.



49. Forces Acting on a System

Sometimes several objects are connected together.

Instead of studying each object separately, we can treat them as:

One system

For example:



can be considered as one system.

The textbook uses two boxes connected by a string to introduce this idea.



50. Internal and External Forces

Internal forces

Forces acting between objects within the system.

Example:

 Tension between two connected boxes.

External forces

Forces acting on the system from outside.

Example:

 An external pulling force.

When treating the boxes as one system, internal forces need not be considered separately.



51. Acceleration of a System

Suppose two objects have masses:

m_1 and m_2

and an external force:

F

acts on the system.

Total mass:

Total mass = $m_1 + m_2$

Therefore:

$a = F / (m_1 + m_2)$

The textbook demonstrates that connected objects accelerate like a single object whose mass is the sum of their masses.



52. Example — Two-Object System

Two boxes have masses:

$m_1 = 2 \text{ kg}$

$m_2 = 3 \text{ kg}$

External force:

$F = 20 \text{ N}$

Total mass:

$m_1 + m_2 = 2 + 3 = 5 \text{ kg}$

Using:

$a = F / (m_1 + m_2)$

$a = 20 / 5$

$$a = 4 \text{ m/s}^2$$

53. Important Idea About Systems

When several connected objects are considered as one system:

Total mass = Sum of individual masses

Net external force determines acceleration.

Internal forces cancel within the system when considering the system as a whole.

54. Force and Motion

Remember:

Net force = 0

→ Acceleration = 0

→ Velocity remains constant.

Net force $\neq$ 0

→ Acceleration occurs.

→ Velocity changes.

55. Force and Acceleration

For a fixed mass:

$$F \propto a$$

Therefore:

Force $\uparrow \rightarrow$ Acceleration $\uparrow$

Force $\downarrow \rightarrow$ Acceleration $\downarrow$



56. Mass and Acceleration

For a fixed force:

$$a \propto 1/m$$

Therefore:

Mass $\uparrow \rightarrow$ Acceleration $\downarrow$

Mass $\downarrow \rightarrow$ Acceleration $\uparrow$



57. Important Formula Sheet

Force

$$F = ma$$

Acceleration

$$a = F / m$$

Mass

$$m = F / a$$

Weight

$$W = mg$$

Momentum

$$p = mv$$

Change in momentum

$$\Delta p = mv - mu$$

Force using momentum

$$F = \Delta p / \Delta t$$

Acceleration

$$a = (v - u) / t$$

Net force

Net Force = Sum of all forces

For opposite forces:

Net Force = Larger Force – Smaller Force

Two-object system

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



58. Important Units

Quantity	SI Unit
Force	Newton (N)
Mass	kilogram (kg)
Acceleration	m/s ²
Velocity	m/s
Momentum	kg m/s
Weight	Newton (N)
Gravitational acceleration	m/s ²



59. Competency-Based Question

A box is acted upon by two forces:

→ 55 N

← 50 N

Find the net force.

$$\text{Net Force} = 55 - 50$$

$$\text{Net Force} = 5 \text{ N to the right}$$

If mass = 25 kg:

$$a = F / m$$

$$a = 5 / 25$$

$$a = 0.2 \text{ m/s}^2 \text{ to the right}$$



60. Competency-Based Question

A force of 30 N acts on an object of mass 10 kg.

Find its acceleration.

$$a = F / m$$

$$a = 30 / 10$$

$$a = 3 \text{ m/s}^2$$



61. Competency-Based Question

A force of 1500 N acts on a car of mass 1500 kg.

The car starts from rest and reaches 10 m/s in 5 seconds.

Step 1: Find acceleration

$$a = (v - u) / t$$

$$a = (10 - 0) / 5$$

$$a = 2 \text{ m/s}^2$$

Step 2: Find force

$$F = ma$$

$$F = 1500 \times 2$$

$$F = 3000 \text{ N}$$



62. Common Mistakes to Avoid

✗ Mistake 1

Balanced forces mean the object must be at rest.

✓ Correct

Balanced forces mean:

$$\text{Net force} = 0$$

The object can be at rest **or moving with constant velocity**.

✗ Mistake 2

Action and reaction forces cancel each other.

✓ Correct

They act on **different objects**, so they do not cancel when analysing one object.

Mistake 3

More mass always means more acceleration.

Correct

For the same force:

$$a = F / m$$

Greater mass means smaller acceleration.

Mistake 4

Friction always stops objects.

Correct

Friction opposes relative motion and can be useful, such as for walking, braking and gripping.

Mistake 5

Mass and weight are the same.

Correct

Mass is measured in **kg**.

Weight is a gravitational force measured in **N**.



63. Important Exam Questions

Q1. What is force?

Force is a push or pull that can change the state of motion or shape of an object.

Q2. What is the SI unit of force?

Newton (N).

Q3. What are balanced forces?

Forces whose resultant or net force is zero.

Q4. What are unbalanced forces?

Forces whose resultant or net force is not zero.

Q5. What is friction?

Friction is a force that opposes relative motion between surfaces in contact.

Q6. What is inertia?

Inertia is the tendency of an object to resist a change in its state of rest or uniform motion.

Q7. What is Newton's first law?

An object remains at rest or in uniform straight-line motion unless acted upon by a net external force.

Q8. State Newton's second law.

The net force on an object is equal to the product of its mass and acceleration.

$$F = ma$$

Q9. State Newton's third law.

When two objects interact, they exert equal and opposite forces on each other.

Q10. What is momentum?

Momentum is the product of mass and velocity.

$$p = mv$$

Q11. What is the SI unit of momentum?

kg m/s

Q12. What is weight?

Weight is the gravitational force acting on an object.

$$W = mg$$

64. QUICK REVISION

- ★ Force = Push or pull.
- ★ Force can change motion or shape.
- ★ Force is a vector quantity.
- ★ SI unit of force = Newton.
- ★ Balanced forces $\rightarrow$ Net force = 0.
- ★ Unbalanced forces $\rightarrow$ Net force $\neq$ 0.
- ★ Friction opposes relative motion.
- ★ Inertia = Resistance to change.
- ★ Mass is a measure of inertia.
- ★ Newton's First Law $\rightarrow$ Law of Inertia.
- ★ Newton's Second Law $\rightarrow F = ma$.
- ★ Newton's Third Law $\rightarrow$ Equal and opposite interaction forces.
- ★ Action and reaction act on different objects.
- ★ Weight = mg .
- ★ Momentum = mv .
- ★ SI unit of momentum = kg m/s .
- ★ Greater mass $\rightarrow$ Greater inertia.
- ★ For same force, greater mass $\rightarrow$ Smaller acceleration.
- ★ For fixed mass, greater force $\rightarrow$ Greater acceleration.

- ★ Internal forces act within a system.
 - ★ External forces act on a system from outside.
 - ★ Connected objects can be treated as one system.
-

65. MEMORY TRICKS

Newton's Laws

- 1 First Law → INERTIA
 - 2 Second Law → $F = ma$
 - 3 Third Law → ACTION + REACTION
-

Force

Force → Mass × Acceleration

$$F = ma$$

Momentum

Momentum → Mass × Velocity

$$p = mv$$

Weight

Weight → Mass × Gravity

$$W = mg$$

Types of Forces

Contact → Touch required

-  Friction
-  Muscular force
-  Tension

Non-contact → No touch required

-  Gravity
 -  Magnetism
 -  Electrostatic force
-

66. CHAPTER 6 — FINAL TAKEAWAY

Force is one of the most important ideas in mechanics. 

A force can:

-  Start motion
-  Stop motion
-  Change speed
-  Change direction
-  Change shape

Newton's three laws help us understand how forces affect motion:

1 First Law

Objects resist changes in their state of motion.

2 Second Law

Force determines acceleration:

$$\mathbf{F} = m\mathbf{a}$$

3 Third Law

Interactions always involve equal and opposite forces acting on different objects.

And remember the three most important formulas:

★ $F = ma$

★ $p = mv$

★ $W = mg$

The new textbook also extends Newton's laws to **systems of connected objects**, where the acceleration can be found using the total external force and total mass.