Class 8

Force and motion

Introduction to Force
Definition: Force is defined as any influence that causes an object to undergo a change in its state of rest or motion. It is a vector quantity, meaning it has both magnitude (how strong it is) and direction (where it acts). Forces are measured in units called Newtons (N), named after Sir Isaac Newton, who revolutionized our understanding of motion.
Types of Forces:
Contact Forces: These require direct physical contact between objects. Examples include muscular force (when you push a door), frictional force (resistance when sliding), and normal force (the support force from a table on a book).
Non-Contact Forces: These act at a distance without touching. Examples are gravitational force (Earth pulling objects down), magnetic force (attracting iron nails), and electrostatic force (repelling like charges on a balloon).
Balanced and Unbalanced Forces: When forces on an object balance each other out (equal in magnitude and opposite in direction), there is no net change in motion. Unbalanced forces cause acceleration, deceleration, or a change in direction. For instance, in a tug-of-war with equal pulling, forces are balanced; if one side pulls harder, it's unbalanced.
Deep Insight: Force is central to Newton's First Law of Motion, also known as the Law of Inertia. Inertia is the tendency of an object to resist changes in its state of motion. Mass determines inertia; a heavier object (like a truck) has more inertia than a lighter one (like a bicycle), making it harder to start or stop. This concept explains why passengers lurch forward in a sudden brake— their bodies want to keep moving.
Historical Context: Ancient philosophers like Aristotle thought forces were needed to keep objects moving, but Galileo and Newton disproved this, showing forces cause changes, not sustain motion.
Real-Life Examples: Pushing a shopping cart (muscular force), a magnet lifting paper clips (magnetic force), or wind blowing leaves (air resistance, a type of force).
Effects of Force
Change in Shape: Forces can deform or reshape objects. Elastic forces allow recovery (e.g., stretching a rubber band), while plastic deformation is permanent

(e.g., bending metal). This is why a sponge squishes under pressure but returns to shape when released.
Change in Size: Compressing a spring or squeezing a balloon reduces its volume due to applied force. This is common in hydraulic systems, where pressure changes size.
Change in Direction: A force can alter an object's path without changing its speed. For example, when you swat a flying insect, the force from your hand changes its direction mid-flight.
Change in Speed: Forces cause acceleration (speeding up) or deceleration (slowing down). Braking a bicycle applies a force that reduces speed, while pedaling increases it.
Deep Insight: All these effects are governed by Newton's Second Law: Force (F) = Mass (m) × Acceleration (a), or F = ma. Acceleration is the rate of change of velocity, which includes both speed and direction. If mass is constant, a larger force means greater acceleration. This law explains why a light ball accelerates faster than a heavy one when kicked with the same force.
Applications: In sports, forces change ball directions (e.g., tennis serve). In engineering, forces design bridges to withstand wind or earthquakes.
Examples: Hammering a nail changes its shape; gravity changes a falling apple's speed; a fan's force changes air direction.
Motion and Its Types
Definition: Motion is the change in position of an object with respect to time. It can be described using concepts like distance (total path length, scalar), displacement (straight-line distance with direction, vector), speed, velocity, and acceleration.
Types of Motion:
Linear Motion: Movement in a straight line, like a car on a highway or a bullet from a gun. It can be uniform (constant speed) or non-uniform (varying speed).
Circular Motion: Movement along a circular path, such as a Ferris wheel, a spinning top, or Earth orbiting the Sun. Centripetal force keeps it circular.
Oscillatory Motion: Back-and-forth movement around a fixed point, like a pendulum swing, a vibrating guitar string, or a bouncing ball. It repeats periodically.
Random Motion: Irregular, unpredictable movement, such as Brownian motion (tiny particles in liquid) or a bee buzzing randomly.
Deep Insight: Motion is relative, as described by Galileo. For example, you seem stationary on a moving bus relative to other passengers, but moving to someone outside. This relativity is key in physics and explains why the Earth seems flat from our perspective.
Factors Affecting Motion: Forces, mass, and environment (e.g., friction on rough surfaces slows motion).

Real-Life Examples: Linear: Arrow flight; Circular: Merry-go-round; Oscillatory: Heartbeat; Random: Smoke particles in air.
Measurement: Use rulers for distance, stopwatches for time, and GPS for tracking.
Speed, Velocity, and Acceleration
Speed: The rate of distance covered per unit time. It is a scalar quantity (no direction). Formula: Speed (v) = Distance (d) / Time (t). Units: meters per second (m/s), kilometers per hour (km/h). Example: A cyclist covers 10 km in 1 hour; speed = 10 km/h.
Velocity: The rate of displacement per unit time, including direction. It is a vector. Formula: Velocity (v) = Displacement (s) / Time (t). Example: A car moves 50 km north in 1 hour; velocity = 50 km/h north.
Acceleration: The rate of change of velocity. It can be positive (speeding up), negative (slowing down, deceleration), or zero (constant velocity). Formula: Acceleration (a) = (Final Velocity - Initial Velocity) / Time. Units: m/s^2. Example: A ball from 0 to 10 m/s in 2 s; $a = (10-0)/2 = 5\ m/s^2$.
Average Speed: Total distance divided by total time, useful for varying speeds. Formula: Average Speed = Total Distance / Total Time. Example: Drive 100 km in 2 hours at varying speeds; average = 50 km/h.
Relative Velocity: The velocity of one object as seen from another. Formula: Relative Velocity = Velocity of A - Velocity of B (if in same direction). Example: A train at 60 km/h east, another at 40 km/h east; relative velocity of second w.r.t. first = 60 - 40 = 20 km/h (catching up).
Deep Insight: Acceleration due to gravity ($g \approx 9.8\ m/s^2$) causes free fall; all objects fall at the same rate ignoring air resistance (Galileo's experiment). Graphs visualize: Distance-time graph's slope is speed; velocity-time graph's area is displacement.
Mathematical Problems:
Speed: A runner covers 200 m in 25 s. Speed = 200 / 25 = 8 m/s.
Velocity: Displacement 300 m east in 20 s. Velocity = 300 / 20 = 15 m/s east.
Acceleration: Car from 20 m/s to 40 m/s in 10 s. $a = (40-20)/10 = 2\ m/s^2$.
Average Speed: Walk 3 km in 45 min, rest 15 min. Total time = 60 min = 1 h; average = 3 km/h.
Relative Velocity: Boat at 10 m/s upstream, current 2 m/s downstream. Relative to shore: 10 - 2 = 8 m/s upstream.
Real-Life Examples: Speed in traffic; velocity in navigation; acceleration in roller coasters.
Friction and Gravity
Friction: The force that opposes motion between two surfaces in contact. Types: Static (prevents starting motion, e.g., book on table), Kinetic (opposes moving objects, e.g., sliding box), Rolling (e.g., wheels on road, less than kinetic).

Advantages and Disadvantages: Helps in walking (grip), writing (pen on paper), and braking; disadvantages include wear and tear (shoe soles), energy loss (heat in engines), and inefficiency.
Reducing Friction: Use lubricants (oil on hinges), ball bearings (in fans), streamlining (aeroplane shapes), or rollers (suitcases).
Gravity: The non-contact force of attraction between any two objects with mass. On Earth, it pulls objects toward the center. Free fall: Objects accelerate at $g = 9.8$ m/s^2, regardless of mass (ignoring air resistance).
Deep Insight: Friction converts kinetic energy into heat, explaining why sliding stops. Gravity is universal (Newton's law: $F = G\, m1\, m2 / r^2$); weight ($W = mg$) varies with g (heavier on Earth than Moon). Inertia and gravity explain orbits.
Examples: Friction in car tires; gravity in tides (Moon's pull); reducing friction with skis on snow.
Newton's Laws of Motion
First Law (Law of Inertia): An object at rest stays at rest, and an object in motion stays in motion at constant speed in a straight line unless acted upon by an unbalanced force. Inertia depends on mass.
Second Law ($F = ma$): The acceleration of an object is directly proportional to the net force and inversely to its mass. $F = ma$.
Third Law (Action-Reaction): For every action, there is an equal and opposite reaction. Forces come in pairs.
Deep Insight: These laws form the foundation of mechanics. First law explains seatbelts (inertia keeps you moving in a crash); second, why rockets need thrust; third, walking (push ground, ground pushes back).
Examples: Inertia in a ball rolling on grass; F=ma in kicking a football; action-reaction in jumping (push down, jump up).
Applications: Car safety, sports physics, space travel.
Simple Machines and Force
Definition: Simple machines are basic devices that make work easier by changing the direction, magnitude, or distance of a force. Work = Force × Distance (in direction of force). They don't create energy but amplify effort.
Types and Examples:
Lever: A rigid bar pivoted at a fulcrum. Classes: 1st (seesaw, fulcrum in middle), 2nd (wheelbarrow, load in middle), 3rd (tweezers, effort in middle). Mechanical advantage = Load arm / Effort arm.
Pulley: A wheel with a rope; changes direction. Fixed (flag hoist), movable (lifts load with less effort).
Inclined Plane: A sloped surface (ramp) reduces effort for lifting. E.g., loading a truck.
Wheel and Axle: Wheel attached to axle; e.g., bicycle, doorknob. Wheel radius / Axle radius gives advantage.

Screw: An inclined plane wrapped around a cylinder; e.g., jar lid, increases force.
Wedge: Two inclined planes back-to-back; splits or lifts. E.g., axe, knife.
Principle: Mechanical advantage = Output force / Input force. Efficiency = Useful work / Total work × 100%.
Deep Insight: Machines trade force for distance; e.g., a lever lifts heavy load with small effort over long distance. Compound machines (e.g., bicycle) combine simples.
Examples: Levers in scissors; pulleys in elevators; wedges in doors.
Applications and Importance
Forces and motion explain everyday phenomena: Vehicles (engines provide force), sports (projectiles), machines (tools). Conservation laws: Kinetic energy ($KE = 1/2\ mv^2$) converts to potential ($PE = mgh$).
Deep Insight: In projectiles, motion combines horizontal (uniform) and vertical (accelerated by gravity). Understanding prevents accidents (e.g., inertia in collisions) and aids innovation (e.g., aerodynamics).
Real-Life Examples: Gravity in apple falling; friction in brakes; inertia in magic tricks.
Key Formulas and Units
Force: $F = ma$ (N)
Speed: $v = d/t$ (m/s)
Velocity: $v = s/t$ (m/s)
Acceleration: $a = (v-u)/t$ (m/s^2)
Average Speed: Total d / Total t
Work: $W = F \times d$ (J)
Power: $P = W/t$ (W)
Momentum: $p = mv$ (kg m/s)
Relative Velocity: $v_A - v_B$
Important Diagrams and Concepts
Force vectors: Arrows for magnitude/direction.
Distance-time graphs: Straight for uniform speed.
Velocity-time graphs: Slope = acceleration.
Simple machines: Labeled with fulcrum/effort/load.
Free-body diagrams: All forces on an object.
Deep Insight: Projectile motion parabola; inertia demonstrations.
Exam Tips
Memorize laws, formulas, examples; practice calculations.
Draw diagrams; relate to Nepal (e.g., mountain motion).
Common mistakes: Confusing scalars/vectors; forgetting directions.
Important Questions for Exams (Class 7 Level)
Very Short Answer Questions (1-2 words or simple phrases)
What is force?

Name a non-contact force.
What is inertia?
Define acceleration.
What is average speed?
Short Answer Questions (1-2 sentences)
Explain balanced and unbalanced forces with an example.
How does gravity affect motion?
State Newton's Third Law with an example.
Describe one effect of force on an object.
What is relative velocity? Give an example.
Long Answer Questions (Detailed explanations, 4-6 sentences)
Explain Newton's three laws of motion with examples and their importance in daily life.
Describe the types of motion and give real-life examples for each. Explain how motion is relative.
Discuss the effects of force on objects. How are these related to Newton's Second Law?
What is friction? Explain its types, advantages, disadvantages, and methods to reduce it.
Define speed, velocity, and acceleration. Explain how they differ, with examples, formulas, and solve one mathematical problem for each.