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S3 New Curriculum Physics

Theme: Mechanics and properties of Matter

Chapter 1 – Linear and non-linear motion



Linear motion

Deals with motion in a straight line

Terminologies

Distance(x) is the length between two points.

The SI unit is metres (m)

Displacement(x) is the length between two points in a specified direction.

The SI unit is metres (m)

Scalar and vector quantities

Scalar quantities are physical quantities that have **magnitude only**, but no direction, e.g. time, length, temperature, distance, speed etc.

Vector quantities are physical quantities that have **both magnitude and direction** e.g. force, velocity, displacement, momentum, acceleration etc.

Differences between distance and displacement

Distance	Displacement
It is the length between two points.	It is the length between two points in a specified direction.
Is a scalar quantity.	Is a vector quantity.

Speed

Speed is the rate of change of distance.

It is a scalar quantity because it has only magnitude but no direction

$$\text{Speed} = \frac{\text{Distance(m)}}{\text{Time(s)}} \\ = \frac{\text{m}}{\text{s}} = \text{ms}^{-1}$$

∴ the SI unit of speed is ms^{-1} .

Other units include: cms^{-1} , kmh^{-1} , etc.

Changing cms^{-1} to ms^{-1}

$$1\text{cm} = \frac{1\text{m}}{100}$$

$$\text{But } 1\text{cms}^{-1} = \frac{1\text{cm}}{1\text{s}} = \frac{1\text{m}}{100} \times 1\text{s}^{-1}$$

$$\text{So } 1\text{cms}^{-1} = \frac{1}{100} \text{ms}^{-1}$$

Example: Change 800cms^{-1} to ms^{-1}

$$800\text{cms}^{-1} = \frac{800}{100} = 8\text{ms}^{-1}$$

Changing kmh^{-1} to ms^{-1}

$$1 \text{ kmh}^{-1} = \frac{1\text{km}}{1\text{h}} = \frac{1000\text{m}}{(60 \times 60)\text{s}} = \frac{1000}{3600} \text{ms}^{-1}$$

Example 1

Change 72kmh^{-1} to ms^{-1}

$$1 \text{ kmh}^{-1} = \frac{1000}{3600} \text{ms}^{-1}$$

$$72 \text{ kmh}^{-1} = 72 \times \frac{1000}{3600} \text{ms}^{-1} = 20\text{ms}^{-1}$$

Note: If the distance which a body covers is not the same at every interval of time then the term average speed is applied.

$$\text{Average speed} = \frac{\text{Total distance travelled}}{\text{Total time taken}}$$

Example 2

Find the average speed of the car which travels 400m in 80s.

$$\text{Average speed} = \frac{\text{Total distance travelled}}{\text{Time taken}} = \frac{400\text{m}}{80\text{s}} = 5\text{ms}^{-1}$$

Example 3

A car is moving along a straight road through towns X, Y and Z. If the car maintains an average speed of 50kmh^{-1} between town X and Y which are 0.6km apart and maintains 72kmh^{-1} between town Y and Z which are 0.9km apart find

(a) time taken for the car to move from town X to Z

(b) the average speed of the car in ms^{-1} between town X and Z

Solution

Using Average speed = $\frac{\text{distance travelled}}{\text{Time taken}}$

For X and Y	For Y and Z
Time taken = $\frac{0.6}{50} = 0.012\text{h}$	Time taken = $\frac{0.9}{72} = 0.0125\text{h}$

Total time for the car to move from X to Z = $0.012 + 0.0125 = 0.0245\text{s}$.

Total distance = $0.9 + 0.6 = 1.5\text{km}$

Using Average speed between X and Z = $\frac{\text{distance travelled}}{\text{Time taken}} = \frac{1.5\text{km}}{0.0245\text{h}} = 61.2\text{kmh}^{-1}$.

$$1\text{kmh}^{-1} = \frac{1000}{3600} \text{ms}^{-1}$$

$$61.2\text{kmh}^{-1} = 61.2 \times \frac{1000}{3600} \text{ms}^{-1} = 17\text{ms}^{-1}.$$

Trial 1

Convert the following into units indicated brackets

(i) 40ms^{-2} (kmh^{-1}) [144ms^{-1}]

(iii) 90kmh^{-1} (ms^{-1}) [25ms^{-1}]

(ii) 5ms^{-1} (kmh^{-1}) [18ms^{-1}]

(iv) 120ms^{-1} (cms^{-1}) [12000cms^{-1}]

Velocity

It is the rate of change of displacement.

It is a vector quantity since it has both magnitude and direction

$$\text{Velocity} = \frac{\text{displacement(m)}}{\text{time taken(s)}}$$

The SI units of velocity is m/s or ms^{-1}

Velocity is a vector quantity

Difference between velocity and speed

Velocity	speed
is the rate of change of displacement.	is the rate of change of displacement
is a vector quantity.	is a scalar quantity.

Types of velocities

(a) Initial velocity “**u**” is the velocity with which a body starts motion in a given time interval.

Note:

1. For a body starting from rest, the initial velocity “**u**” must be zero i.e. $u = 0\text{ms}^{-1}$.
2. For anybody starting motion means that the body is starting from rest $u = 0\text{ms}^{-1}$
3. For a body travelling with a certain velocity, **X**, the initial velocity for such a body will be that certain velocity x so, $u=X$ e.g. A car travelling at 20ms^{-1} , has $u=20\text{ms}^{-1}$.

(b) **Final velocity: "v"** is the velocity with which a body ends motion for a given time interval.

Note: If a body is brought to rest, then the final velocity is zero i.e., $v = 0\text{ms}^{-1}$.

The units of velocity must either be ms^{-1} or kmh^{-1} or cms^{-1} .

Acceleration (a) is the rate of change in velocity with time.

$$\text{Acceleration} = \frac{\text{change in velocity}}{\text{time taken}}$$

Change in Velocity = Final velocity (v) - Initial Velocity (u)

The S.I unit for change in velocity is **m/s** or ms^{-1}

Example 4

A car starts from rest and it accelerates to 10ms^{-1} . Calculate the change in Velocity.

$$u=0\text{ms}^{-1} \quad v=10\text{ms}^{-1}$$

$$\text{Change in velocity} = v - u = 10 - 0 = \mathbf{10\text{ms}^{-1}}.$$

Note: The Velocity to which a body is accelerated becomes the final velocity for that given time interval.

From the definition of acceleration,

$$\text{Acceleration} = \frac{\text{change in velocity}}{\text{time taken}}.$$

The SI unit of acceleration is m/s^2 or ms^{-2}

$$a = \frac{v - u}{t}.$$

OR

$$\mathbf{v = u + at.}$$

This is called the first equation of motion

Example 5

A body starts from rest and accelerated uniformly at 2ms^{-2} for 3s. Calculate the final Velocity.

Solution

$$\begin{aligned}v &= u + at \\ &= 0 + 2 \times 3 \\ &= 6 \text{ m/s}\end{aligned}$$

Example 6

A body travelling at 10ms^{-1} is accelerated uniformly for 3 second 5ms^{-2} . Calculate the Velocity at the end of 5 seconds.

Solution

$$\begin{aligned}v &= u + at \\ &= 10 + 3 \times 5 \\ &= 25 \text{ m/s}\end{aligned}$$

Average Velocity

$$\text{Average velocity} = \frac{\text{Final velocity} + \text{initial velocity}}{2}$$

$$\text{But } v = u + at$$

$$\text{Average velocity} = \frac{u + at + u}{2}$$

$$\text{Average velocity} = \frac{2u + at}{2} = \frac{2u}{2} + \frac{at}{2}$$

$$\text{Average velocity} = u + \frac{1}{2} at$$

The S.I unit is ms^{-1} .

Example 7

A body travelling at 20ms^{-1} is accelerated for 4s at 5ms^{-2} . Calculate the average velocity,

Solution

$$u = 20\text{ms}^{-1}, a = 5\text{ms}^{-2}$$

$$\begin{aligned}\text{Average velocity} &= u + \frac{1}{2} at \\ &= 20 + (\frac{1}{2} \times 5 \times 4) \\ &= 30\text{ms}^{-1}\end{aligned}$$

NB: A decelerating body has a negative acceleration since velocity is decreasing.

Example 8

A car travelling at 90km/h is uniformly brought to rest in 40 seconds. Calculate the acceleration.

$$u = 90\text{kmh}^{-1} \text{ to } \text{ms}^{-1}$$

$$1\text{kmh}^{-1} = \frac{1000}{3600}$$

$$90\text{kmh}^{-1} = \frac{1000}{3600} \times 90 = 25\text{ms}^{-1}$$

From, $v = u + at$

$$0 = 25 + 40a$$
$$a = -625\text{ms}^{-2} \text{ (negative sign means deceleration)}$$

Displacement: “s” is length moved in specified direction.

Displacement, $s = \text{Average velocity} \times \text{time taken}$

But average velocity = $u + \frac{1}{2}at$

$$s = (u + \frac{1}{2}at) \times t$$

$s = ut + \frac{1}{2}at^2$: This is the 2nd equation of motion

This equation is mainly used when the question involves distance and time

Example 9

A body starts from rest and accelerates uniformly for 3s at 2m/s^2 . Calculate the total distance covered

$$\text{From, } s = ut + \frac{1}{2}at^2$$

$$u = 0, \quad a = 2\text{ms}^{-2}, \quad t = 3\text{s}$$

$$s = 0 \times 3 + \frac{1}{2} \times 2 \times 3 \times 3$$

$$= 9\text{m}$$

Calculations involving deceleration

When calculating problem involving deceleration: it should be remembered that the value of “a” should be negative

Example 10

A body moving at 40ms^{-1} decelerates uniformly for 20s at 3ms^{-2} . Calculate distance covered

$$u = 40\text{ms}^{-1}, \quad a = -3\text{ms}^{-2}, \quad t = 20\text{s}$$

$$s = ut + \frac{1}{2}at^2$$

$$= 40 \times 20 - \frac{1}{2} \times 3 \times 20 \times 20$$

$$= 800 - 600$$

$$= 200\text{m}$$

Example 11

A car traveling at 40ms^{-1} is uniformly decelerated to 25ms^{-1} for 5s. Calculate the total distance covered.

Solution

$$u = 40\text{ms}^{-1}, \quad v = 25\text{ms}^{-1}, \quad t = 5\text{s}$$

From $v = u + at$

$$25 = 40 + (a \times 5)$$

$$25 = 40 + 5a$$

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

$$s = 4t + \frac{1}{2}at$$

$$= 40 \times 5 + \frac{1}{2} \times -3 \times 5 \times 5$$

$$= 200 - 37.5$$

$$= 162.5\text{m}$$

Third equation of motion

$$v^2 = u^2 + 2as$$

This equation is applied when time is not given and not required

Example 12

Calculate the final (maximum) velocity of a body travelling at 4ms^{-1} when it accelerates at 2ms^{-2} and covers a distance of 5m.

Solution

$$u = 4\text{ms}^{-1}, \quad a = 2\text{ms}^{-2}, \quad s = 5\text{m}$$

$$v^2 = u^2 + 2as$$

$$v^2 = 4^2 + 2 \times 2 \times 5$$

$$= \sqrt{36}$$

$$= 6\text{m/s}$$

Example 13

A body travelling at 90kmh^{-1} is retarded to rest at 20ms^{-2} . Calculate the distance covered.

Solution

$$u = 90\text{kmh}^{-1} \text{ to } \text{ms}^{-1}$$

$$1\text{kmh}^{-1} = \frac{1000}{3600} \text{ms}^{-1}$$

$$\therefore 90\text{kmh}^{-1} = 90 \times \frac{1000}{3600} = 25\text{ms}^{-1}$$

$$v^2 = u^2 + 2as$$

$$0^2 = 25^2 + 2 \times -20 \times s$$

$$s = 15.625$$

Uniform velocity

Is when the rate of change of displacement is constant.

Or

Uniform velocity is when displacement divided by time taken is constant

The S.I unit is ms^{-1} .

When a body moves with uniform velocity, initial velocity (u) must be equal to final velocity i.e., $v = u$. For instance, a car travelling with uniform velocity of 20ms^{-1} has $u = 20\text{ms}^{-1}$

When a body moves with uniform velocity, its acceleration is 0 i.e. $a=0$

Example 14

A car travelling with a uniform velocity of 20ms^{-1} for 6s. Calculate its acceleration.

Solution

$$u = 20\text{ms}^{-1}, \quad t = 6\text{s}$$

$$v = u + at$$

$$20 = 20 + a \times 6$$

$$a = 0$$

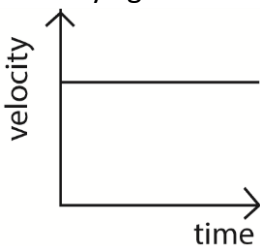
From the above example, it's noted that for a body moving with uniform velocity, its acceleration is 0 because the change in velocity becomes 0 as initial velocity is equal to final velocity.

Graphical presentation of uniform velocity

Uniform velocity can be represented on a 2 types of graphs

- (i) Velocity against time graph
- (ii) Distance against time

Velocity against time graph



Note: when a body maintains the same speed, it implies that it moves with uniform velocity.

Example 15

A car starts from rest and it accelerates uniformly for 5s at a rate of 4ms^{-2} . Calculate the final velocity.

Solution

$$u=0\text{ms}^{-1}, t=5\text{s}, a=4\text{ms}^{-2}, \quad v=?$$

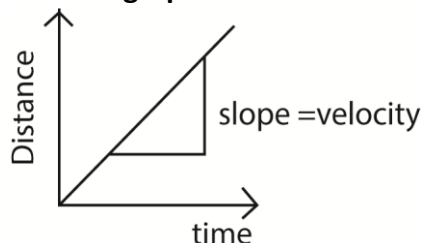
$$v=u + at$$

$$= 0 + 4 \times 5$$

$$= 20\text{ms}^{-1}$$

The car then maintains the maximum speed for 6s. This implies that the maximum velocity of 20ms^{-1} becomes the uniform velocity for the 6s.

A distance time graph to for uniform velocity



Uniform acceleration

Uniform acceleration is when the rate of change in velocity with time is constant.

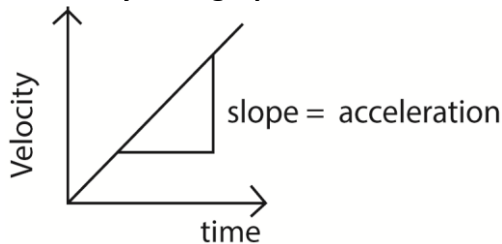
OR

Uniform acceleration is when the; change in velocity divided by time is constant.

When a body moves with uniform acceleration, the final velocity is not equal to initial velocity.

Uniform acceleration can be represented on velocity against time.

A velocity time graph for uniform acceleration



Example 16

A cyclist starts from rest and accelerates uniformly at 1m/s^2 for 20s.

Then maintains the maximum speed so reached for 1 minute and finally decelerates to rest uniformly for 10s. Draw a velocity against time graph for the motion of the body.

Solution

Stage1

$t=20\text{s}$

$u=0\text{m/s}$

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

$v=???$

$v=u+at$

$v=0+1 \times 20$

$v=20\text{m/s}$

Stage 2

$t=1\text{min}$

$1\text{min}=60\text{s}$

$u = 20\text{m/s}$

$v = 20\text{m/s}$

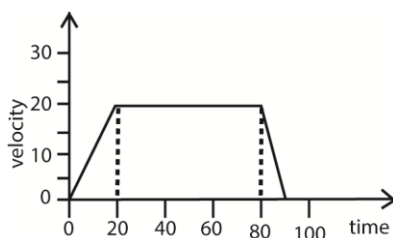
Stage3

$t=10\text{s}$

$u=20\text{m/s}$

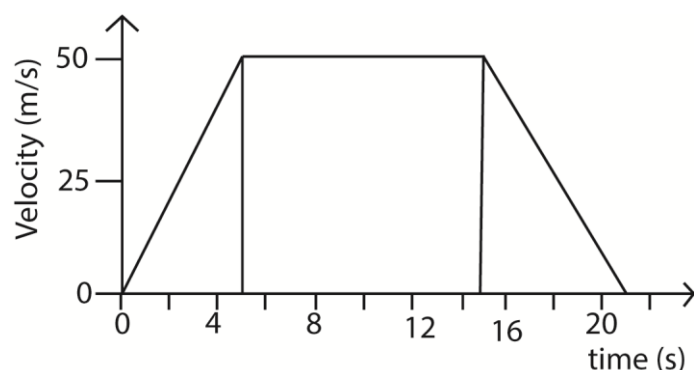
$v=0\text{m/s}$

A velocity against time graph



Example 17

Use the graph below to calculate the total distance covered.



$$\begin{aligned}\text{Total distance} &= \text{Area}(C+B+S) \\ &= \frac{1}{2} \times bh + lw + \frac{1}{2} \times bh \\ &= \frac{1}{2} \times 5 \times 50 + 50 \times 10 + \frac{1}{2} \times 6 \times 50 \\ &= 125 + 500 + 150 \\ &= 775\text{m}\end{aligned}$$

Trial 2

- (a) What do you understand by the following terms as applied to motion
 - Uniform velocity
 - Uniform acceleration
- (a) The table below shows the variation of velocity with time for a body which has been thrown vertically upwards from the surface of the planet.

Velocity (ms^{-1})	8	6	4	2	0	-2
Time (s)	0	1	2	3	4	5

- What does the negative velocity mean?
 - Plot a graph of velocity against time
 - Use the graph in (b)(i) to find the acceleration due to gravity on the planet [2ms^{-2}]
 - If the body weighs 34N on earth, what is the planet? [6.8N]
- (a) What is uniform acceleration?
 - A car travelling at 20ms^{-1} is accelerated for 10s at 2ms^{-2} . Calculate the total distance covered during this time. [300m]
 - (a) Define displacement.
 - Two vehicles A and B accelerate uniformly from rest. Vehicle A attains maximum velocity of 30ms^{-1} in 10s while vehicle B attains a maximum velocity of 40ms^{-1} in the same time. Both vehicles maintain these velocities for 6seconds. They then decelerate such that A comes to rest after 6 seconds, while B comes to rest after 4s.
 - Sketch on the same axes a velocity time graph of the vehicles

- (ii) Calculate the velocity of each vehicle 18 seconds after the start. [20ms⁻¹]
- (iii) How far will the two vehicles be from one another during this moment in (b)(ii) above. [120m]

Falling bodies

In a vacuum all bodies fall at the same rate. However in atmosphere different bodies fall at different rate because the air resistance is greater to light

Difference between acceleration and velocity

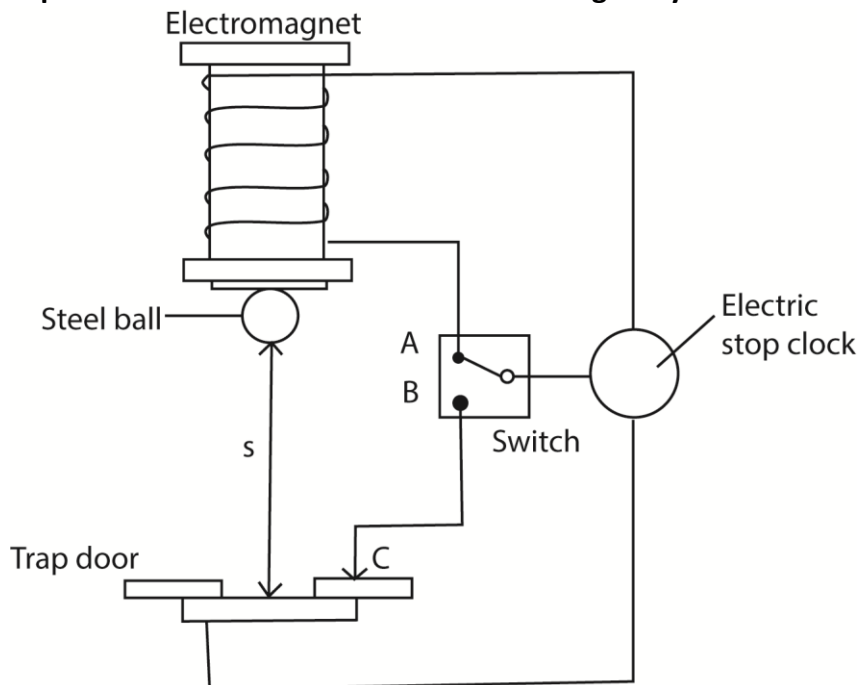
Velocity	Acceleration
(i) S.I unit is ms ⁻¹	(i) SI unit is ms ⁻²
(ii) Is the rate of change of displacement	(ii) Is the rate of change of velocity with time

Acceleration due to gravity

Acceleration due to gravity is the rate change in velocity with time for a body falling freely under the force of gravity.

Or Acceleration due to gravity = $\frac{\text{change in velocity}}{\text{time taken}}$

Experiment to measure acceleration due to gravity



Procedure

- Switch is in position A, the electromagnet holds up the small steel ball.
- The switch is moved quickly to B; the electromagnet releases; the steel ball and the clock starts timing.

- When the ball hits the trap door, the circuit is disconnected and the stop clock stops

Given that the distance moved is, s , and time taken is t the

$$s = \frac{1}{2}gt^2$$

$$g = \frac{2s}{t^2}$$

Example 19

A small iron ball dropped from the top of a vertical cliff takes 2.5seconds to reach the bottom of the cliff. Find

- (i) the speed with which it strikes the bottom.

$$\text{From } V = u + gt$$

$$V = 0 + 10 \times 2.5 = 25\text{ms}^{-1}$$

- (ii) the height of the cliff

$$\text{From } v^2 = u^2 + 2gs$$

$$s = \frac{25^2}{2 \times 10} = 31.25\text{m}$$

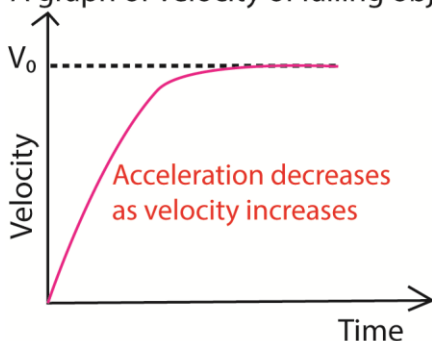
Trial 3

Describe a simple experiment to measure acceleration due to gravity.

Air resistance and motion

Air resistance—also known as *drag*—is a force that acts **opposite to the motion** of an object moving through air. It's a type of friction, and it plays a big role in how objects move, especially at higher speeds.

A graph of velocity of falling object with time



- As an object speeds up, **air resistance increases**. This is because the faster it moves, the more air particles it collides with.
- Eventually, a falling object may reach a point where the **force of air resistance equals the force of gravity** pulling it down. At this point, it stops accelerating and falls at a constant speed or **terminal velocity, V_0** .

- The **shape, size, and surface area** of an object affect how much air resistance it experiences. A flat sheet of paper falls slowly, while a crumpled one drops faster because it cuts through the air more easily.
- A heavier object attains a terminal velocity earlier than a lighter object.

Real-world examples:

- **Parachutes** use air resistance to slow a person's fall.
- **Cyclists** and race cars use streamlined shapes to reduce drag and move faster.
- **Skydivers** spread their limbs to increase air resistance and control their descent.

Momentum and mass

Momentum is the product of mass and velocity

The SI unit of momentum is kilogram metre per second (kgms^{-1})

Example 20

Calculate the momentum an object weighing 500g and moving at 72kmh^{-1} .

$$500\text{g} = \frac{500}{1000} = 0.5\text{kg}$$

$$72\text{kmh}^{-1} = \frac{72 \times 1000}{3600} = 20\text{ms}^{-1}$$

Momentum = mass x velocity

$$= 0.5 \times 20$$

$$= 10\text{kgms}^{-1}$$

Trial 4

1. Calculate the momentum of

- a man of 70kg running at a velocity of 5ms^{-1} [350kgms^{-1}]
- an elephant of mass 200kg running towards a hunter at speed of 6m/s. [1200kgms^{-1}]

2. At what speed would a $2.00 \times 10^4\text{kg}$ aircraft have to fly to have momentum of $1.60 \times 10^9\text{mgms}^{-1}$. [$80,000\text{ms}^{-1}$]

Newton's laws of motion

Newton's first law of motion

Newton's First Law of Motion—also called the **Law of Inertia**—states:

An object at rest stays at rest, and an object in motion stays in motion at constant velocity, unless acted upon by an external force.

In simpler terms, things don't start moving, stop moving, or change direction all by themselves. Something has to cause that change.

Real-Life Applications of Newton's First Law:

- **Seatbelts in cars:** When a car suddenly stops, your body wants to keep moving forward due to inertia. Seatbelts apply the external force needed to stop you safely.
- **Tablecloth trick:** Pulling a tablecloth quickly from under dishes works because the dishes tend to stay at rest due to their inertia.
- **Roller coasters:** Once in motion, the cars keep moving along the track unless brakes or friction slow them down.
- **Elevators:** The smooth start and stop of an elevator rely on managing inertia to avoid sudden jerks.

Mass and inertia

Mass is a measure of how much matter an object contains. It's a **scalar quantity**, meaning it has magnitude but no direction, and it's measured in kilograms (kg). Mass doesn't change depending on location—whether on Earth, the Moon, or floating in space, the mass of an object stays the same.

Inertia is an object's **resistance to changes in its state of motion**. If something is at rest, it wants to stay at rest. If it's moving, it wants to keep moving in the same direction and speed—unless a force acts on it. This is the essence of Newton's First Law of Motion.

The Connection:

Mass is the **quantitative measure of inertia**. The more mass an object has, the more inertia it has. That means:

- A heavy truck is harder to start or stop than a bicycle.
- A bowling ball resists changes in motion more than a tennis ball.

So, in short: **mass tells us how much inertia an object has.**

Newton's second law of motion

Newton's Second Law of Motion explains how the motion of an object changes when a force is applied. It states:

The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass.

In simple terms: **Force = Mass × Acceleration**, or **F = ma**.

This means:

- If you apply more force to an object, it accelerates more.
- If the object is heavier (more mass), it accelerates less for the same force.

Real-Life Applications:

- **Pushing a shopping cart:** An empty cart accelerates more easily than a full one when pushed with the same force.
- **Kicking a ball:** A stronger kick (more force) makes the ball accelerate faster.
- **Car engines:** A more powerful engine applies more force, making the car accelerate quicker.
- **Rocket launches:** Rockets need massive force to overcome their huge mass and Earth's gravity.

Newton's third law of motion

Newton's Third Law of Motion states:

For every action, there is an equal and opposite reaction.

This means that whenever one object exerts a force on another, the second object exerts a force of the same magnitude but in the opposite direction on the first.

Real-Life Applications:

- **Walking:** When you push backward on the ground with your foot, the ground pushes you forward with equal force. That's what propels you ahead.
- **Swimming:** one pushes water backward with his arms and legs, and the water pushes him forward.
- **Rocket launch:** The rocket expels gas downward (action), and the gas pushes the rocket upward (reaction).
- **Jumping off a boat:** You push the boat backward, and it pushes you forward—causing the boat to drift away.
- **Recoil of a gun:** When a bullet is fired forward, the gun experiences a backward force, causing it to kick back.

This law is all about **interactions**—forces always come in pairs, and they act on different objects. It's the reason motion feels balanced and predictable, even in the most dynamic situations.

Principle of conservation of momentum

The **principle of conservation of momentum** states that:

> In a closed and isolated system, the total momentum before an interaction is equal to the total momentum after the interaction—provided no external forces act on it.

In simpler terms: **momentum is never lost or gained, only transferred.**

Real-life examples:

- **Collisions:** In car crashes or billiard ball hits, momentum is redistributed between objects.
- **Rocket propulsion:** As gases shoot out of the back, the rocket moves forward—momentum is conserved between the rocket and the exhaust.
- **Jumping off a boat:** You move forward, the boat moves backward—again, total momentum stays the same.

Types of collision

There are two types of collisions

1. Elastic Collision

- Both **momentum and kinetic energy are conserved**, i.e.

$$m_1u_1 + m_2u_2 = m_1v_1 + m_1v_2$$

$$\frac{1}{2}mu_1^2 + \frac{1}{2}mu_2^2 = \frac{1}{2}mv_1^2 + \frac{1}{2}mv_1^2$$

- Objects bounce off each other without any lasting deformation or heat generation.
- Example: Two billiard balls striking each other.

2. Inelastic Collision

- **Momentum is conserved, but kinetic energy is not.**

$$m_1u_1 + m_2u_2 = m_1v_1 + m_1v_2$$

$$\frac{1}{2}mu_1^2 + \frac{1}{2}mu_2^2 \neq \frac{1}{2}mv_1^2 + \frac{1}{2}mv_1^2$$

- The objects **stick together** after impact.
- Some energy is lost as sound, heat, or deformation.
- Example: A lump of clay hitting and sticking to another lump.

Example 22

Two balls of mass 40kg and 20kg are travelling towards each other with velocities of 5ms^{-1} and 2ms^{-1} respectively. If after collision, the ball with mass 40kg travels at a velocity of 2ms^{-1} in the original direction, calculate the velocity of the second ball after collision. Identify the type of collision.

$m_1 = 40\text{kg}$, $m_2 = 20\text{kg}$, $u_1 = 5\text{ms}^{-1}$, $u_2 = -2\text{ms}^{-1}$ (negative because it is in opposite direction with u_1), $v_1 = 2\text{ms}^{-1}$ and $v_2 = ??$

By conservation of momentum

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

$$40 \times 5 + (20 \times -2) = 40 \times 2 + 20v_2$$

$$200 - 40 = 80 + 20v_2$$

$$20v_2 = 80$$

$$v_2 = 4\text{ms}^{-1}$$

Kinetic energy before and after collision

$$\begin{aligned}\text{Kinetic energy before collision} &= \frac{1}{2}mu_1^2 + \frac{1}{2}mu_2^2 \\ &= \frac{1}{2}40 \times 5^2 + \frac{1}{2}20 \times 2^2 \\ &= 540\text{J}\end{aligned}$$

$$\begin{aligned}\text{Kinetic energy after collision} &= \frac{1}{2}mv_1^2 + \frac{1}{2}mv_2^2 \\ &= \frac{1}{2}40 \times 2^2 + \frac{1}{2}20 \times 4^2 \\ &= 240\text{J}\end{aligned}$$

Since kinetic energy is not conserved, the collision is inelastic.

Trial 5

1. A bullet of mass 300g travelling at a speed of 8ms^{-1} hits a body of mass 450g moving in the same direction as the bullet at 1.5ms^{-1} . The bullet and the body move together after collision. Find the loss in kinetic energy. [Ans. 3.8025J]
2. A body of mass 50kg travelling at velocity 5ms^{-1} collides with a body of mass 30kg which is at rest. If the bodies now join and move together, find

- (i) Their common velocity [3.125ms^{-1}]
 - (ii) Kinetic energy after collision [390.625J]
3. A body of mass 80kg travelling at a velocity of 30ms^{-1} collides and stick to a body of mass 30kg travelling in opposite direction at a velocity of 40ms^{-1} . Find the common velocity after impact. [10.91ms^{-1}]

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Thanks

Dr. Bbosa Science