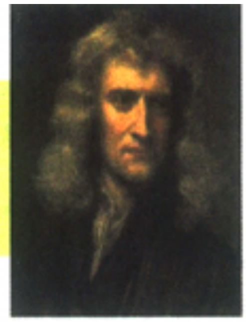
2 MOTION



Isaac Newton discovered the laws of motion

TYPES OF MOTION

OBJECTIVES

At the end of the topic students should be able to:

- list most of the motions in a given environment;
- classify a list of familiar motions into random, rotational, oscillatory and translational motion;
- explain relative motion.

The universe, beginning from the galaxies to the atoms, are in a state of motion. The galaxies, the planetary systems down to the atoms, perform one type of motion or the other. The planets orbit the sun at great speeds and spin about their axes, the electrons revolve round the nucleus, the molecules or atoms of solids vibrate about a fixed position, dust particles drift aimlessly when viewed in a beam of light. Living things move about (change their position). All these examples involve one type of motion or the other.

Motion is the change of position of an object with time.

Dynamics is the study of motion of objects and the forces acting on them. Machines were designed based on the principles of dynamics.

Kinematics is the study of motion without considering the forces causing it.

(a) Translational or linear motion

Fig 2.1 Examples of translational motion

Translational motion is the movement of a body from one place to another. When the motion is on a straight line, then it is called linear motion. Examples of translational include:

(i) an airplane flying from Kano to Lagos;
(ii) an athlete running in a hundred metre (100m) race;
(iii) an ant crawling from one end of the classroom to another end;
(iv) motion of a ball after being kicked by a player;
(v) a horse running from one town to another.

(b) Rotational or circular motion

The motion of a body in a circular or elliptical path is called **rotational** or **circular motion.**

These types of motion include:

(i) motion of planets round the sun;
(ii) electrons revolving round the nucleus;
(iii) the blades of an electric fan spinning about its axis;
(iv) motion of a rolling tyre;
(v) Rotation of the earth about its axis.

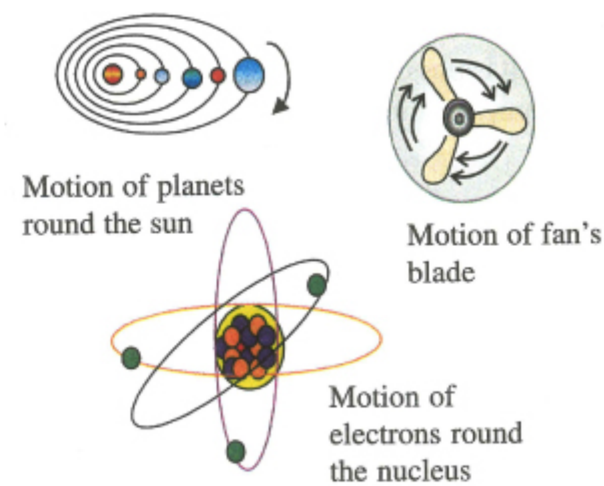


Figure 2.2 Examples of rotational or circular motion

(c) Vibratory or oscillatory motion

An object vibrates if it moves forward and backward, or to and fro about a fixed point. A body performing vibratory motion repeats the same pattern of back and forth movement about a fixed point in the same time intervals. Examples are:

(i) The motion of simple pendulum about a fixed point;
(ii) Vibration of a mass hanged on a spiral spring;
(iii) Vibration of the string fixed at both ends;
(iv) The vibration of the skin of a talking drum when it is beaten;
(v) The beating of the heart;
(vi) Movement of a disturbed diving board.

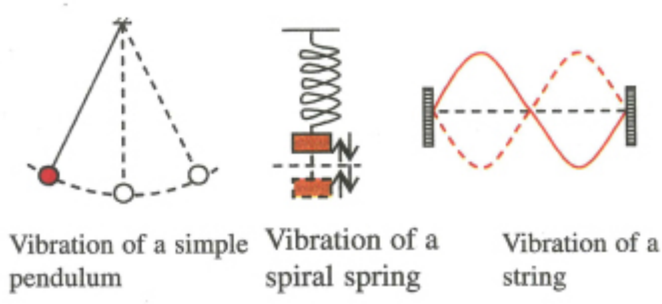


Figure 2.2 Examples of vibratory or oscillatory motion

(d) Random motion

The motion of a particle whose direction is difficult to specify is called ***random motion. A*** particle undergoing random motion has no definite direction. The direction of such a particle changes continuously such that it follows no particular path. Some examples of random motions are:

(i) The motion of dust particles when it is viewed in a light beam in a dark room;

(ii) Motion of insects flying around a bright light source in the night;

(iii) Movement of dust particles suspended in air;

(iv) Movement of gas molecules in a glass container. When the gas molecules are viewed with the microscope, their motion is zigzag. This is called ***Brownian motion.*** Brownian motion is a type of random motion.

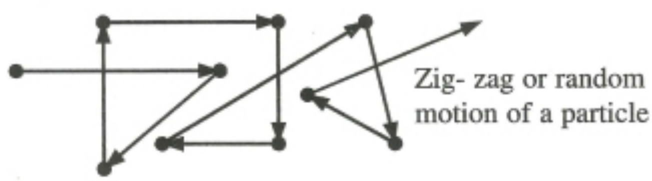


Figure 2.3 Random motion

It is possible for an object to combine two of the four motions described above simultaneously. Examples are:

(i) A rolling tyre or ball combines both translational and rotational motions. The tyre spins about its axis and at the same time, moves forward in a straight line.

(ii) The wings of a flapping bird combine both the translational and vibratory motions. The wings move up and down about the body of the bird and move forward from one place to another.

Relative motion

The motion as seen by an observer depends on his frame of reference. A frame of reference is the position from which the observer sees the event. Two observers A and B will see the same event from different frame of reference, if observer A is at rest relative to the earth while the frame of reference of B is a car travelling at a speed of $35ms^{-1}$ towards the north. Relative to the car, the observer B is at rest but relative to the earth, he is travelling at a speed of $35ms^{-1}$ towards the north. The observer A sees the car and B moving towards the north at a speed of 35 m s^{-1} but the observer B sees himself at rest relative to the car. To him, A and every other object on the earth are moving past him towards the south at a speed of $35ms^{1}$. The speed of the observer is relative to the position of the observer.

If the two observers see another car C moving towards the south with a speed of 55 m s^{-1} relative to the earth (figure 2.4), the observer A sees car C travelling towards the south at a speed of 55 m s^{-1}. To observer B, the car C is travelling at a speed of $90ms^{-1}$. If the cars B and C are travelling in the same direction, the observer B sees the car C moving past him with a speed of 20 m s^{-1} while the observer in car C, the car B is moving backward with a speed of 20 m s^{-1}.

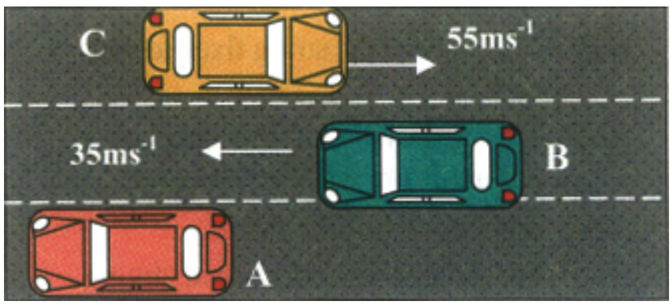


Figure 2.4 Relative motion

Therefore, if two bodies are travelling in the opposite direction their relative velocity is the sum of their velocities. When they move in the same direction, their relative velocity is the difference of their velocities.

Summary

- Motion is the change of position of an object with time. Different types of motion are linear motion, rotational motion, vibratory or oscillatory motion and random motion.
- All motions are relative, absolute motion does not exist in the universe.
- If two bodies travel in the opposite direction, their relative speed is the sum of their individual speeds. If they travel in the same direction, their relative speed is the difference of their individual speeds.

Practice questions 2a

1. What is motion? List different types of motion and give an

example of each type.

2. Explain the term relative motion. State the reason why absolute rest is not possible on earth.
3. An airplane flies due north with a velocity of 1350 km h^{-1} passes a saloon car travelling at 250 km h^{1}. What is their relative velocity if :

   i. The car is travelling due south?

   ii. The car is travelling due north?

LINEAR MOTION

OBJECTIVES

At the end of the topic students should be able to:

- distinguish between distance and displacement in a translational motion;
- distinguish between speed and velocity;
- plot a distance-time graph and deduce the speed of motion from the gradient or slope of the graph;
- determine speed and velocity when simple problems are set involving distance or displacement and time;
- explain the concept of uniform motion and determine acceleration from a velocity-time graph.

Scalars and vectors

A scalar is a quantity that can be specified with number and unit only. It has only magnitude or size. It has no directions. Distance, mass, speed, time, work, energy, pressure, temperature, etc., are examples of scalar. A vector is a quantity that has both magnitude and direction. Examples of vectors are force, velocity, displacement, acceleration, momentum, etc.

Distance and displacement

Distance is the total length of the path travelled without specifying the direction.

The car in Figure 2.5 covers a distance as it moves from A through B to C because its direction is changing as it moves from A to C. The distance covered is a scalar because its direction is not constant. The direction of motion is not considered.

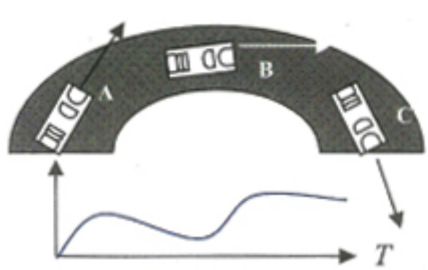


Figure 2.5 Distance is a scalar quantity

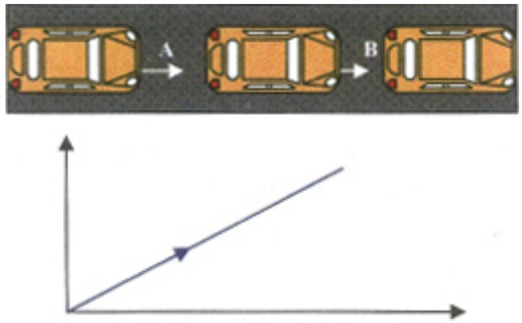


Figure 2.6 Displacement is a vector

Displacement is the distance travelled in a given or specified direction.

The distance travelled from A to B is called displacement because the car is travelling in a specific direction as it moves from A to B. See Fig 2.6

Speed and velocity

Speed is the time rate of change of distance or distance travelled per unit time.

It is the term used to describe the motion of a body when the direction of movement is not considered. Speed is a scalar quantity.

$$\text{Speed} = \frac{\text{Distance travelled}}{\text{Time taken}}$$

$$v = \frac{s}{t} \Rightarrow \quad s = v \times t$$

The unit of speed is metre per second (ms^{-1}) or km/h. However, you need to convert km/h to m/s whenever you are calculating.

Types of speed

Average speed: To move a body between two points A and B, Figure 2.5, the speed may vary continuously between the two points. The average speed of the body between the points is therefore defined by:

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

Uniform speed: When the time rate of change of distance is constant the body moves with a constant or uniform speed. Such a body covers the same distance during the same time interval.

$$\text{Uniform speed} = \frac{\text{Distance travelled}}{\text{Time taken}} = \text{a constant}$$

Time (s)	0	10	20	30
Distance(s)	0	200	400	600

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}} = \frac{600-200}{30-10} = 20\, m\, s^{-1}$$

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}} = \frac{200}{10} = 20\, m\, s^{-1}$$

The speed is the same no matter which pair of time and distance is used. Uniform speed (v) = $20ms^{-1}$ = a constant.

Instantaneous speed: This is the time rate of change of distance at an instant. The speed registered by the speedometer of a car at the time you look at it is the instantaneous speed. Suppose a body covers very small distance **ds** in a short time interval **dt,** the instantaneous speed is defined by:

$$\text{Instantaneous speed} = \frac{\text{Distance covered}}{\text{Short time interval}} \qquad v = \frac{ds}{dt}$$

Velocity

Velocity is speed measured in a given direction. It is defined as time rate of change of displacement

Velocity is a vector quantity because it has both magnitude and direction.

$$\text{Velocity} = \frac{\text{Displacement}}{\text{Time}}$$

$$v = \frac{s}{t} \Rightarrow s = v \times t$$

The unit of velocity is metre per second ($m\ s^{-1}$). Different types of velocity include:

Average velocity: The average velocity during a given time interval, is the total displacement per total time.

$$\text{Average velocity} = \frac{\text{Total displacement}}{\text{Total time taken}}$$

Uniform velocity: Velocity is said to be uniform if the time rate of change of displacement is constant through out the journey. The body covers equal displacement in equal time interval.

$$\text{Uniform velocity} = \frac{\text{Displacement}}{\text{Time}} = \text{a constant}$$

Acceleration

A body accelerates anytime the velocity increases.

Acceleration is the time rate of increase in velocity.

Acceleration is a vector quantity. The unit of acceleration is metre per second per second (ms^{-2}).

$$\text{Acceleration} = \frac{\text{Increase in velocity}}{\text{Time to increase}}$$

$$a = \frac{\Delta v}{\Delta t} = \frac{v - u}{t_2 - t_1}$$

v = final velocity, u = initial velocity

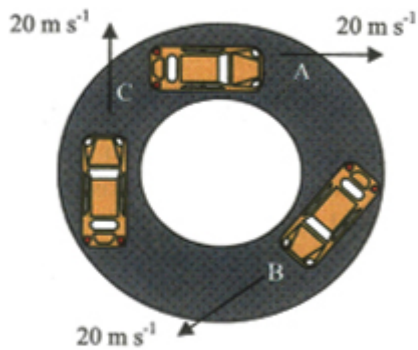


Figure 2.7 Constant speed but changing velocity

When a body moves round a circular path with a constant speed it accelerates. This is because velocity is a vector quantity, its value changes with change in magnitude or change in direction. The velocity of a body moving in a circle with a constant speed changes, because the direction is changing continuously. **The acceleration produced by such a body points towards the centre of the circle.** The velocities of the car at the positions A, B and C point in different directions but the magnitude is the same ($20ms^{-1}$) as shown in Figure 2.7. The velocity is called non-uniform velocity.

Positive and negative acceleration

Acceleration is positive if the time rate of change of velocity is positive. The body increases its velocity from rest or from an initial velocity as time increases.

Time (s)	0	5	10	15	20
Velocity (ms^{-1})	0	25	50	75	100

$$\text{acceleration} = \frac{\Delta v}{\Delta t} = \frac{25}{5} = 5\,m\,s^{-2}$$

The acceleration of 5 m s^{-2} is positive since the body increases its velocity from rest. This describes the motion of a body moving with a constant acceleration.

Acceleration becomes negative if the rate at which the velocity is changing is negative. *Negative acceleration means that the body slows down from an initial velocity such that its velocity decreases with time. Negative acceleration is called* **deceleration** *or* **retardation**.

Time (s)	0	5	10	15	20
Velocity (ms^{-1})	100	75	50	25	0

$$\text{deceleration} = \frac{\Delta v}{\Delta t} = \frac{75-100}{5} = \frac{-25}{5} = 5\,m\,s^{-2}$$

The table above describes the motion of a body decelerating uniformly from an initial velocity of 100 m s^{-1} to rest in 20s.

Uniform and non-uniform acceleration

A body accelerates uniformly when the velocity increases at a constant *time rate*. The time rate of increase in velocity is constant as long as the motion lasts. This means that the velocity increases by equal amount in equal time intervals.

$$\text{Uniform acceleration} = \frac{\text{Increase in velocity}}{\text{Time}} = \text{a constant}$$

$$\text{Uniform dcceleration} = \frac{\text{Dcrease in velocity}}{\text{Time}} = \text{a constant}$$

The motion of a body is non – uniform if the time rate at which the velocity changes is not constant. The increase or decrease in velocity is not the same for the same time intervals.

Worked examples

1. A boy walks a total distance of 48 km in 4 hours. Calculate his average speed for the whole journey in

   (i) kilometre per hour (ii) metre per second.

Solution

(i) $$\text{Average speed} = \frac{\text{Total distance covered}}{\text{Time taken}}$$

$$v = \frac{48 \text{ km}}{4 \text{ hr}} = 12 \text{ km hr}^{-1}$$

(ii) $$\text{Average speed} = \frac{48 \times 1000 \text{ m}}{4 \times (60_{m} \text{ x } 60)\text{s}}$$

$$= \frac{48 \times 1000 \text{ m}}{4 \times 3600} = 3.33 \text{ m s}^{-1}$$

2. A train starts from rest and uniformly increases its velocity until it attains a velocity of 40 m s^{-1} in 5 seconds. Find the acceleration of the train.

Solution

$$\text{Acceleration} = \frac{\text{Increase in velocity}}{\text{Time}}$$

$$a = \frac{40 - 0}{5} = 8\, m\, s^{-2}$$

3. A bus initially travelling at 70 m s^{1} slows down until it comes to rest in 20 seconds. What is the deceleration of the bus?

Solution

$$\text{Deceleration} = \frac{\text{Decrease in velocity}}{\text{Time}}$$

$$a = \frac{0 - 70}{20} = -3.5\, m\, s^{-2}$$

Summary

- Distance is the total length of the path travelled without specifying its direction. Displacement is the distance travelled in a given or specified direction.
- Speed is the time rate of change of distance. Velocity is speed measured in a given direction. It is defined as time rate of change of displacement.
- Acceleration is the time rate of increase in velocity. When a body moves round a circular path with a constant speed, it accelerates. The acceleration produced by such a body points towards the centre of the circle. Negative acceleration means that the body slows down from an initial velocity such that its velocity decreases with time. Negative acceleration is called

deceleration or **retardation**.

- A body accelerates uniformly when the velocity increases at a constant rate. The acceleration of a body is non – uniform if the time rate at which the velocity changes is not constant.

Practice questions 2b

i. Distinguish between the following:

ii. Displacement and distance.

iii. Velocity and speed.

1. Explain what happens when the earth revolves round the sun with a constant speed but accelerates towards the centre of the sun.
2. What do you understand by the term velocity and acceleration? An athlete ran 100 m race in 10.08 seconds, calculate his average velocity.
3. Explain the term uniform acceleration. A bus accelerates uniformly from an initial velocity of $25ms^{-1}$ to $52m\ s^{-1}$ in 35 seconds, calculate the acceleration of the bus.

DISPLACEMENT OR DISTANCE-TIME GRAPH

OBJECTIVES

At the end of the topic students should be able to:

- plot a distance-time graph and deduce the speed of motion from the gradient or slope of the graph;
- determine acceleration and distance covered from a velocity-time graph;
- interpret the distance-time graph and speed-time graph.

Displacement–time graph is obtained by plotting displacement against time. The type of graph obtained depends on if the body is moving with a uniform (constant) speed or with a changing speed. Two types of displacement (distance) – time graphs are:

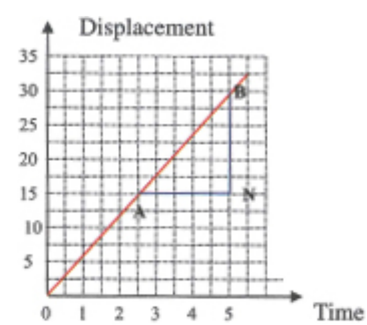


Figure 2.8 (a) Displacement – time graph for a body moving with a constant velocity from rest

Displacement (distance) – time graphs for a body

moving with uniform (constant) velocity

When a body moves with a uniform or constant velocity, it covers equal distances in equal time intervals. The displacement – time graph is a straight line.

If the body starts its motion from rest, the straight-line graph passes through the origin or it cuts the displacement axis at the position when time is zero if it is already in motion. This is illustrated in Figure 2.8.

The slope (gradient) of a straight-line displacement–time graph represents uniform velocity.

$$\text{Slope (gradient)} = \frac{BN}{AN}$$

$$\text{Slope (s)} = \frac{\text{Increase in displacement}}{\text{Increase in time}}$$

Slope (gradient) = uniform velocity

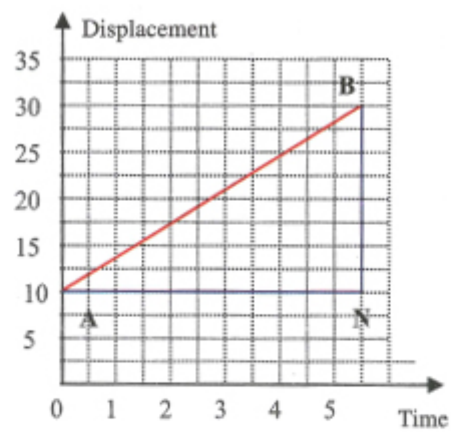


Figure 2.8 b Displacement – time graph for a body moving with a constant velocity beginning from an initial velocity

The slope of Î± straight-line distance – time graph represents uniform speed.

Displacement (distance) – time graphs for a body changing its velocity

When a body increases its velocity, it accelerates. The displacement – time graph is a curve: the slope or gradient varies along the curve. The velocity at a given point Ï is found by drawing a tangent at the point.

$$\text{Slope(gradient)} = \frac{YZ}{ZX}$$

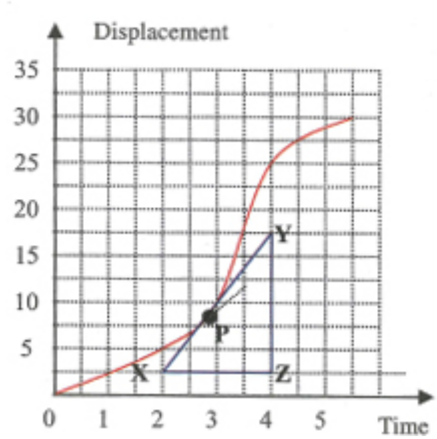


Figure 2.9 Displacement – time graph for a body changing its velocity

The velocity is obtained by evaluating the slope of the tangent at P. This is called **the instantaneous velocity.**

Instantaneous velocity is the time rate of change of displacement at an instant.

Velocity – time graph

The velocity – time graph is very useful for finding the total distance covered and acceleration of the moving body.

Distance covered from the velocity – time graph

The area under the line or curve on a velocity – time graph represents the total distance covered during the motion. The total distance travelled in a given time interval is found by evaluating the area under the line or curve of v–t graph. To explain further let us consider four different cases:

(a) A body moving with a constant or steady velocity

When a body travels at a steady or constant speed between two points R and S, the acceleration is zero (0). The total distance covered during this interval is the area of rectangle PRST.

In Figure 2.10, the body moves with a constant velocity of 30 m s^{-1}, the total distance covered is given by:

Distance covered = Area of rectangle PRST
Distance covered = PR x RS
Distance covered = Velocity Ã— time
Velocity = RS and time = (PT)
Distance covered = 30 Ã— 4 = 120 m

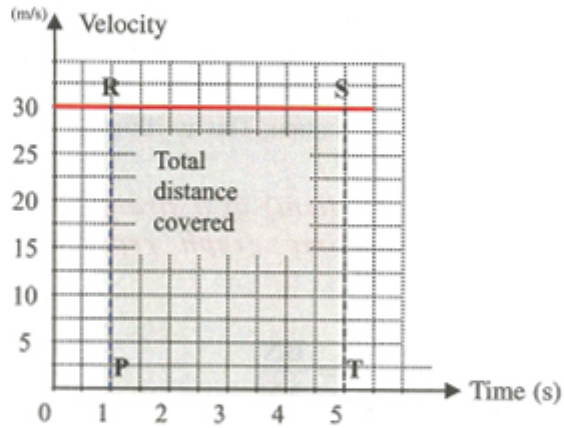


Figure 2.10 A body moving with constant velocity

(b) A body increasing its velocity (moving with a uniform acceleration)

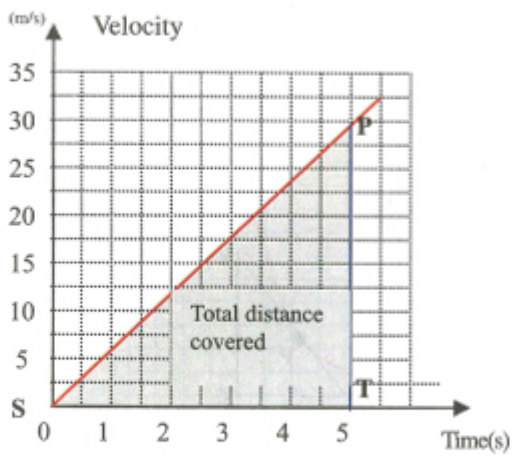


Figure 2.11 Constant acceleration from rest

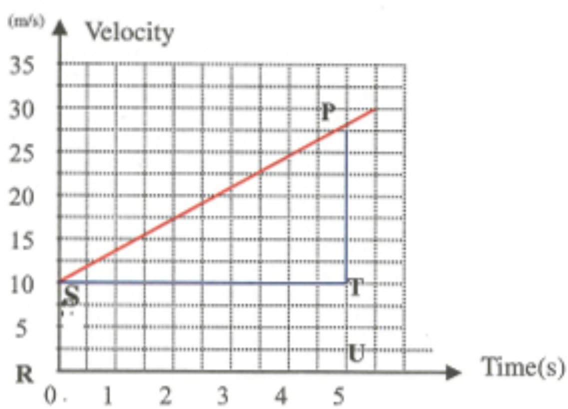


Figure 2.12 Constant acceleration from an initial

If the velocity increases as time increases, the body accelerates. ***The slope (gradient) of the Î½ -t graph represents the acceleration of the body. If the v – t graph is a straight line the slope is uniform acceleration.***

Uniform acceleration = slope of a v – t graph

$$= \text{slope (gradient) of line Sp} = \frac{PT}{ST} = \frac{\text{Increase in velocity}}{\text{Time taken}}$$

The distance covered within the same time interval is the area of triangle SPT (the area under the line SP). This evaluated as follows:

$$\text{Distance covered} = \text{Area of triangle SPT}$$
$$= \tfrac{1}{2}(PT \times ST)$$
$$= \text{Velocity} \times \text{time}$$
$$\therefore \quad \text{Distance covered} = \tfrac{1}{2} \times 30 \times 5 = 75\,m$$

The total distance travelled in Figure 2.12 during the first 5 seconds is the area of trapezium RSPU (area under the line SP).

$$\text{Distance travelled} = \text{Area of trapezium RSPU}$$
$$= \tfrac{1}{2}(RS + PU)RU$$
$$\therefore \text{Distance travelled} = \frac{1}{2}(10 + 27.5\text{m})5 = 93.75$$

(c) A body decreasing its velocity (moving with uniform deceleration)

A body decelerates if its velocity decreases as time increases (the body slows down from an initial velocity). Figure 2.12 shows the v – t graph for a body slowing down from an initial velocity of 25 m s^{-1} in 6 seconds. The deceleration is the slope (gradient) of the line AB.

$$\text{Slope of line AB} = \frac{AO}{OB} = \frac{\text{Velocity increase}}{\text{Time}}$$

Slope or gradient = uniform deceleration The total distance covered is the area of triangle OAB.

Distance covered = Area of triangle OAB

$$= \tfrac{1}{2} \times 25 \times 6 = 75\,m.$$

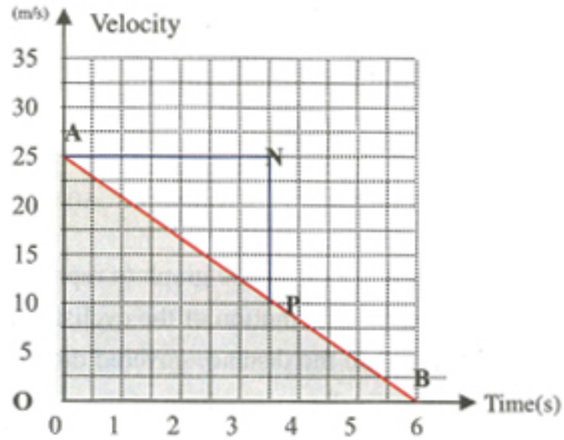


Figure 2.12 Constant deceleration to rest

(d) A body increasing its velocity (moving with non – uniform velocity)

The acceleration of a body is non – uniform if the velocity does not increase or decrease in steps. The rate of change of velocity increases or decreases with time, therefore, the Î½ – t graph is a curve. The acceleration at any time is obtained by evaluating the slope of Î½ – t graph at that point, see Figure 2.13.

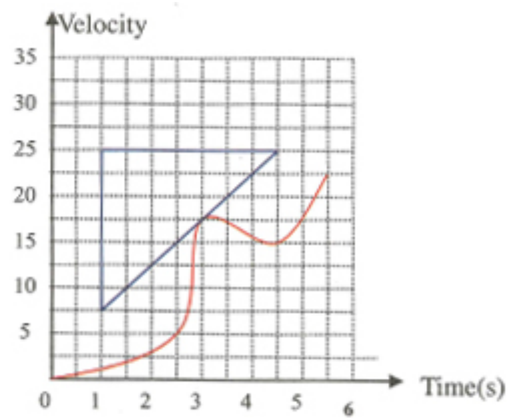


Figure 2.13 Increasing acceleration

Velocity – time graph for variable acceleration

It is possible for the acceleration of a body to change between two points. The increase or decrease in velocity varies between the points for the same time interval. The velocity – time graph is a curve or a combination of a curve and a straight line. This is illustrated in Figure 2.16.

The velocity varies along the curve and the acceleration at different points C, R, Q and Ï on the curve varies. The acceleration at each point C, R, Q and Ï can be obtained by evaluating the slope at these points. The distance or displacement covered in the time interval EN is the area under the curve between C and P.

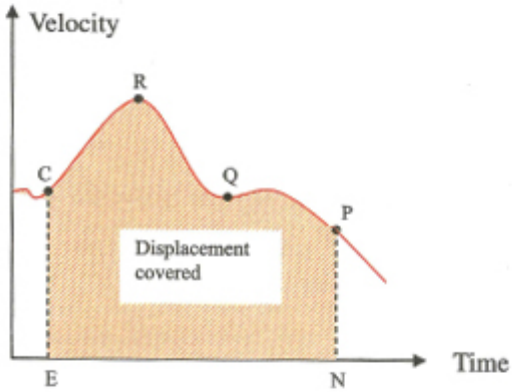


Figure 2.16 V-t graph for a variable acceleration

Worked examples

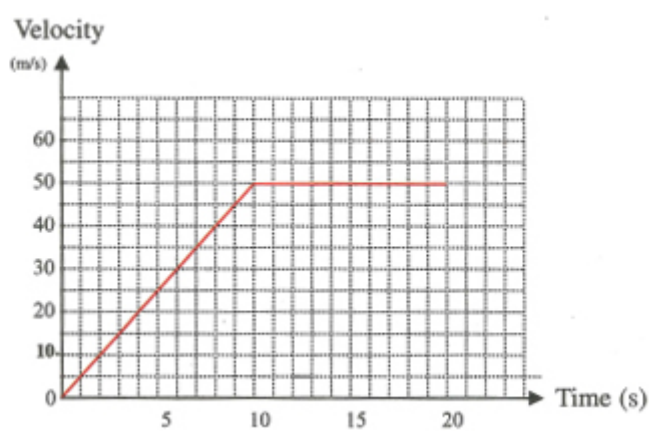
1. The table below shows the velocity of a cyclist as it was recorded from rest at intervals:

t (s)	0	2	4	6	8
V (m s^{-1})	0	10	20	30	40

10	12	14	16	18	20
50	50	50	50	50	50

(a) Plot a velocity-time graph to represent the motion of the cyclist.
(b) Describe the motion of the cyclist during each stage.
(c) Calculate the distance covered during each stage.
(d) What is the acceleration of the cyclist in the first 10 seconds?

Solution (a)



(b) During the first stage of the motion, the cyclist increases his speed from 0 to 50 m s^{-1} in 10 seconds (the cyclist is moving with uniform acceleration). During the second stage of motion, the cyclist cycles with uniform or constant speed.

(c) The distance covered during the first stage of the motion is the area of triangle OAD.

Distance covered = $\frac{1}{2}$ x 50 x 10 = 250m

The distance covered during the second stage of the motion is the area of rectangle ABCD.

Distance covered = 50 Ã— 10 =500 m.

(d) Acceleration is the slope OA of the Î½ – t graph.

$$\text{Acceleration} = \frac{AD}{OD} = \frac{50}{10} = 5\ m\ s^{-2}$$

2. The table below shows the velocity with time of Olympic gold medal winner in a 100 m race:

Time(s)	0	1	2	3	4	5	6	7
Velocity ($m\ s^{-1}$)	0	4	8	12	16	16	16	16
Time(s)	8	9	10	11	12			
Velocity	16	16	16	18	0			

(a) Plot the Î½ – t graph of the motion.

(b) From your graph, find;

(i) his acceleration and deceleration.

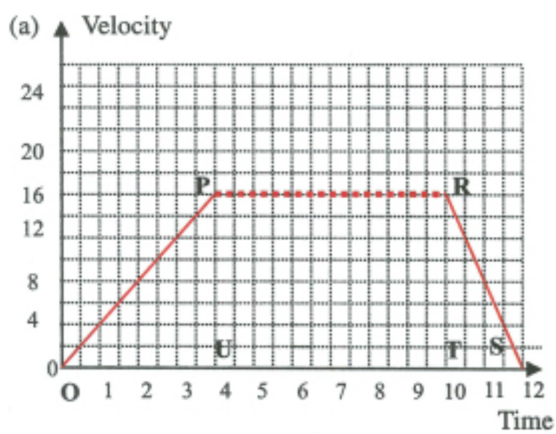
(ii) the total distance covered before coming to rest.

(iii) his average speed for the whole race.

(c) Find the time he braced the tape to win the race.

Solution

(a)



(b) (i) Acceleration = Slope (gradient) of line OP

$$\text{Acceleration} = \frac{UP}{OU} = \frac{16}{4} = 4\ m\ s^{-2}$$

Deceleration = Slope (gradient) of line RS

$$\text{Deceleration} = \frac{TR}{TS} = \frac{0-16}{12-10} = -8\ m\ s^{-2}$$

(ii) Total distance covered = Area of trapezium OPRS

$$= \tfrac{1}{2}(PR+OS)PU$$

$$= \frac{1}{2}(8+12)\ 16 = 160m$$

(iii)

$$\text{Average speed} = \frac{\text{Total distance covered}}{\text{Time taken}}$$

$$\frac{160}{12} = 13.33\text{ms}^{-1}$$

(c) He embraced the tape after covering a distance of 100 m. If the time to complete the race is t seconds then:

$$\text{Distance covered} = \tfrac{1}{2}(t + t - 4)16 = 100\text{ m}$$

$$\therefore\ 16\,t - 32 = 100\text{ m}$$

$$t = \frac{132}{16} = 8.25\,s$$

3. A bus started from rest and moved with a constant acceleration of 2 m s^{-2} until it reached a maximum speed in 20 seconds. It maintained the speed attained for 70 seconds before coming to rest in 10 seconds.

(a) Sketch the Î½ – t graph of the motion.

(b) Use your graph to find:

i the maximum speed reached by the bus;

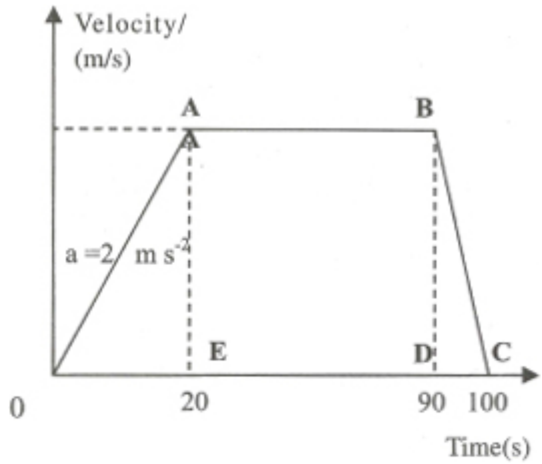
ii the deceleration;

iii the total distance traveled;

iv the average speed of the bus during the journey.

Solution

(a)



(b)

(i) Acceleration = Slope of line OA

$$a = \frac{AE}{OE} \Rightarrow \quad 2 = \frac{v}{20} \quad \therefore \quad v = 40\, m\, s^{-1}$$

(ii) Deceleration = Slope of line BC

$$a = \frac{BD}{CD} = \frac{0-40}{100-90} = \frac{-40}{10} = -4\, m\, s^{-2}$$

(iii) Total distance covered =
Area of trapezium OABC

$$= \tfrac{1}{2}(AB + OC)AE$$

$$= \tfrac{1}{2}(70 + 100)40$$

$$= 3400 \text{ m}$$

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

(iv)
$$= \frac{3400}{100} = 34\, m\, s^{-1}$$

Summary

- The slope (gradient) of a straight-line displacement – time graph represents the uniform velocity.
- The slope of a straight line **distance – time** graph represents **uniform speed.**
- Instantaneous velocity is the change in displacement per unit time when the change occurs in a very short time interval.
- The area under the line or curve on a velocity – time graph represents the total distance covered during the motion.

Practice questions 2c

1. What do you understand by uniform speed? Explain how to obtain uniform speed from a distance – time graph.
2. The distance covered by a cyclist from rest is given in the table below.

Time (s)	0	10	20	30
Distance (m)	0	50	100	150

Time (s)	40	50	60	70	80
Distance	200	250	250	250	250

(a) Plot the distance – time graph of the motion of the cyclist.

(b) Use your graph to find the speed of the cyclist in the first 50 seconds.

(c) Describe each stage of the motion of the cyclist.

3. Explain the terms *average velocity* and uniform *acceleration*.
4. A train starting from rest, attained a velocity of 20 m s^{-1} in 4 seconds. It continued with velocity attained for the next 16 seconds and was finally brought to rest in another 5 seconds. Sketch the velocity – time graph of the motion. Use your graph to evaluate:

(a) Acceleration of the train.

(b) The total distance travelled.

(c) The average speed of the train.

5. (a) Draw a sketch of velocity-time graph for body which begins its motion from rest.

(b) Use your sketch to explain how to find:

(i) uniform acceleration;

(ii) distance covered.

(c) the speed-time graph of a particle is shown in the table below.

t/s	0	5	10	15	20	25	30
v/m s^{-1}	0	20	40	60	60	60	0

(i) Plot the graph of speed against time.

(ii) Use your graph to determine the average speed of the particle, the acceleration and the retardation.

6. (a) What is retardation?

(b) A train travelling from Jos to Kano was moving at a constant speed of 45 m s^{-1} when its brake was applied. After 3 seconds, the speed was uniformly reduced to 15 m s^{-1}, sketch the speed-time graph of the motion. Use your graph to find:

(i) the retardation of the train;

(ii) the distance covered after 3 seconds;

(iii) the time it takes the train to come to rest.

7. Distinguish between speed and velocity.

Past questions

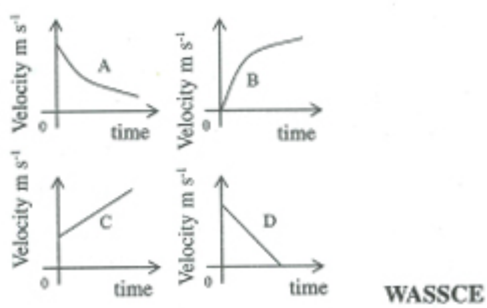
1. The speed of an object in rectilinear motion can be determined from the
   A. area under a velocity-time graph.
   B. area under a distance-time graph.
   C. slope a distance-time graph.
   D. slope a velocity -time graph.

WASSCE

2. A body is said to be moving with uniform acceleration if it experiences equal
   A. increases in velocity at equal time intervals.
   B. decreases in velocity at equal time intervals.
   C. increases in speed at equal time intervals.
   D. decreases in speed at equal time intervals.

WASSCE

3. Which of the following graphs below shows the motion of a body with uniform retardation?



WASSCE

4. The motion of a cylindrical object rolling down an inclined plane is
   A. translational only.
   B. rotational and translational.
   C. circular and translational.
   D. rotational only.

WASSCE

5. An object is said to have uniform acceleration if its
   A. displacement decreases at a constant rate.
   B. speed is directly proportional to time.
   C. velocity increases by equal amount in equal time intervals.
   D. velocity varies inversely with time.

WASSCE

6. The area under the curve of a velocity-time graph represents
   A. acceleration.
   B. distance covered.
   C. instantaneous speed.

D. time taken.

E. work done.

NECO

7. A man was moving round a circular path continuously for 4 minutes and covered the following distances in the time stated below:

Distance (m)	200	400	600	800
Time (s)	1	2	3	4

Which of the following statements is correctabout the motion of the man?

A. The man was moving with uniform speed but non uniform velocity.

B. The speed was changing constantly.

C. It was an instance of motion in which both speed and velocity are the same.

D. The man was with non-uniform speed.

WASSCE

8. Which of the following statements is correct about speed and velocity?

A. Speed and velocity are scalar quantities.

B. Speed and velocity have the same units.

C. Velocity relates to translational motion while speed relates to circular motion.

D. Velocity and speed cannot be represented graphically.

9. The slope of a distance-time graph for a uniform rectilinear motion of a body represents

A. its acceleration.

B. its total distance travelled.

C. its speed.

D. The force causing the motion.

WASSCE

10. The distance travelled by a train may be calculated from the area under its

A. velocity-time graph.

B. acceleration-time graph.

C. displacement -time graph.

D. distance-graph.

WASSCE

11.(a) Explain the following terms:

(i) uniform acceleration (ii) average speed.

(b) (i) List **TWO** types of motion.

(ii) Explain briefly each of them giving in each case **ONE** example.

(c) A car starts from rest at a check point **A** and comes to rest at the next check point, 6km, in 3 minutes. It has first, a uniform acceleration for 40s, then a constant speed, and is brought to rest with a uniform retardation after 20s. Sketch a velocity-time graph of the motion. Determine:

(i) the maximum speed (ii) the retardation.

NECO

12 (a) (i) Define velocity and acceleration.

(ii) List **two** physical quantities that can be deduced from a velocity-time graph.

(b) List **three** types of motion and give **one** example of each.

(c) A car starts from rest and accelerates uniformly for 10s, until it attains a velocity of $25ms^{-1}$; it then travels with uniform velocity for 20s before decelerating uniformly to rest in 5s.

(i) Calculate the acceleration during the first 10s

(ii) Calculate the deceleration during the last 5 s

(iii) Sketch a graph of the motion and calculate the total distance covered throughout the motion.

WASSCE

13. (a) Explain the terms *uniform acceleration* and *average speed*.

(b) A body at rest is given an initial uniform acceleration of $8.0ms^{-2}$ for 30 seconds after which the acceleration is reduced to $5.0ms^{-2}$ for the next 20 seconds. The body maintains the speed for 60 seconds after which it is brought to rest in 20 seconds. Draw the velocity – time graph of the motion using the information given above.

(c) Using the graph, calculate the:

(i) maximum speed attained during the motion;

(ii) average retardation as the body is being brought to rest;

(iii) total distance travelled during the first 50s;

(iv) average speed during the same interval as in (iii).

WAEC


Isaac Newton discovered the laws of motion