LESSON 1
LINEAR MOTION

Introduction

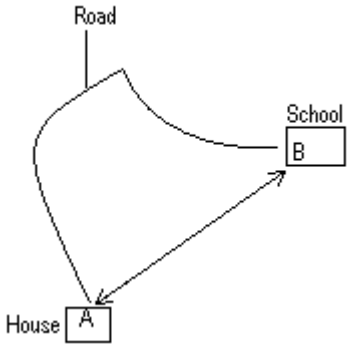
Linear motion is the motion a straight line and the movement in a direction where forwards is positive and backwards is negative.
Kinematics is the section of physics which studies the motions of objects without considering the effects that produce the motion. The study generally involves the analysis of the position of an object in relation to time.
Dynamics is the section of physics which studies the causes of motion of an object.

Distance ,d and Displacement, s

Distance ,d is how far a body travels during a motion without considering any particular direction **or** the length of the path of an object.
Distance is a scalar quantity and the value always positive.
The unif of distance is metre (m)

Displacement , s is distance traveled in a particular direction.
Displacement ,s = final position – initial position
Displacement is a vector quantity and the value can be positive and negative depend on their directions.
The unif of dispacement is metre (m)

Diagram below shows the difference between distance and displacement.



Distance = Length of the road
Displacement = Length of the line AB

If the motion in a straight line and in one direction , the magnitude of distance is same as the magnitude of displacement .

Speed and Velocity ,v

Speed is the rate of change of distance.

$$\text{Speed} = \frac{\text{distance travelled}}{\text{time taken}}$$

$$\text{Average speed} = \frac{\text{total distance traveled}}{\text{total time taken}}$$

Speed is a scalar quantity and the value always positive.
The unif of speed is metre per second ($m\ s^{-1}$)

Velocity is the rate of change of displacement.

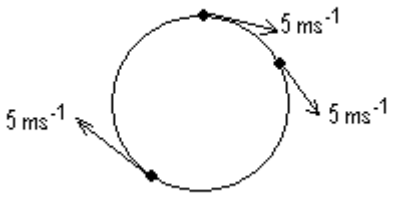
$$\text{Velocity} = \frac{\text{displacement}}{\text{time taken}}$$

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

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

Velocity is a vector quantity and the value can be positive and negative depend on their directions.
The unif of velocity is metre per second ($m\ s^{-1}$)

If an object moves in a circle with constant speed , it has different velocities at different points along the circle because the direction and hence the velocity of the object is always changing as shown in the following diagram.



Acceleration,a and Decelaration(Retardation)

Acceleration is the rate of change of velocity.

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

$$\text{Acceleration} = \frac{\text{final velocity – initial velocity}}{\text{time taken}}$$

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

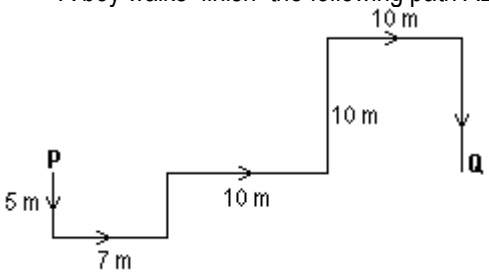
Negative acceleration is called as deceleration (retardation)
Acceleration is a vector quantity
The unif of acceleration or deceleration is metre per second per second (ms^{-2})

Extra notes

1 **uniform = constant = same**
2 **increasing velocity = acceleration**
3 **decreasing velocity (slow down) = deceleration**
4 **zero velocity = the object is stationary (at rest)**
5 **negative velocity = the object moves in opposite direction**
6 **uniform velocity = zero acceleration**
7 **negative acceleration = deceleration (retardation)**

Example 1

A boy walks finish the following path AB.



Find
(a) total dinstance traveled
(b) displacement

Solution

Example 2

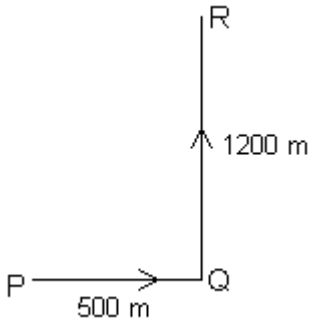


Figure above shows runner runs 500 m towards east in 2 minutes and 1200m towards north in 4 minutes.
Calculate his
(a) average speed
(b) average velocity

Solution

Example 3

An object accelerates uniformly along a straight line from a velocity of 10 m s^{-1} until 25 m s^{-1} in 5 s.
Calculate
(a) the acceleration of the object
(b) the velocity of the object during the first 10 s of motion
(c) the time taken to reach a final velocity 50 ms^{-1}

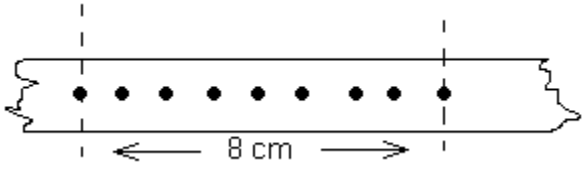
Solution

Using a ticker timer to analysing the motion

A ticker timer is connected to an alternating electricity supply (a.c.) and uses the mains electricity frequency of 50 Hz to make 50 ticks or vibrations every second.
1 tick is the time interval between one dot and the next dot on the tape.

50 ticks = 1 s
1 tick = 0.02s

Example 4



Based on the ticker tape above calculate
(a) time taken
(b) average volocity

Solution

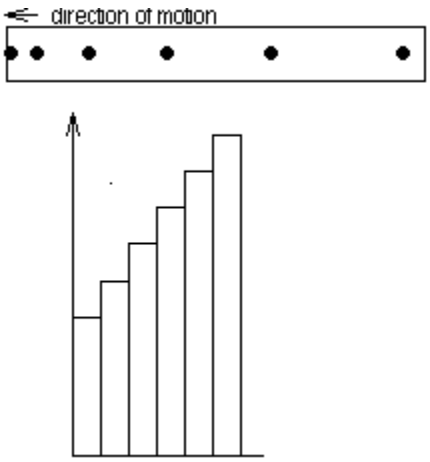
The type of motion based on ticker tape or tape chart

(a)

The type of motion is

velocity	acceleration

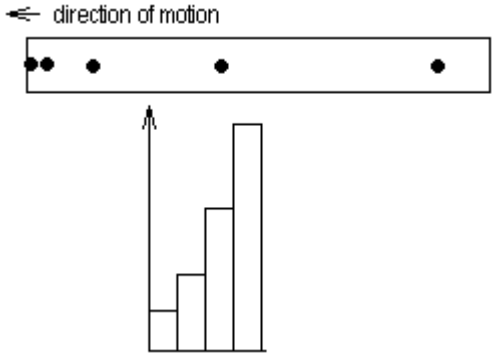
(b)



The type of motion is

velocity	acceleration

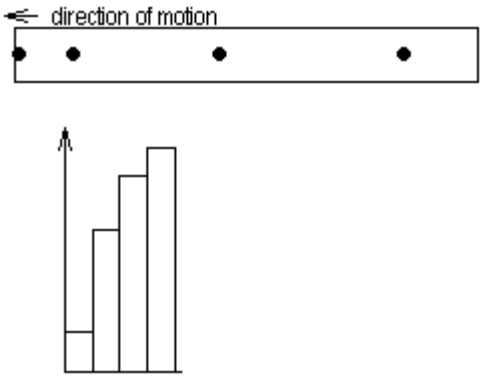
(c)



The type of motion is

velocity	acceleration

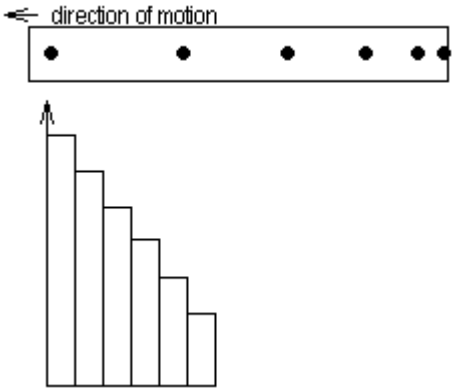
(d)



The type of motion is

velocity	acceleration

(e)



The type of motion is

velocity	acceleration

Using Equations of Linear Motion with Uniform Acceleration

The various equations of linear motions of an object with uniform acceleration are given as follows:

$v = u + at$ ……(1)

$s = \left(\frac{u + v}{2}\right) t$ ……..(2)

$s = ut + \frac{1}{2} at^2$ ……..(3)

$v^2 = u^2 + 2as$ ……..(4)

Where s :……
u :……..
v :……..
a :……
t :……

Extra notes:

moves from rest : ……
finally it stops/brakes:……..
released from a height / fall freely from rest :……
thrown vertically upwards:……..
at maximum height :……

Example 10

A car accelerates from rest to 25 m s^{-1} in 4 s.
Find the acceleration of the car.

Solution

Example 11

A bus accelerates uniformly along a straight line from a velocity 20 ms^{-1} until 30 ms^{-1} in 5 s.
Calculate,
(a) the acceleration
(b) the total displacement travelled by the bus

Solution

Example 12

A construction worker accidentally knocks a brick from a building so that it falls in 4 s to the ground. Calculate
(a) the velocity of the brick as it hits the ground
(b) the distance fallen of the brick

Solution

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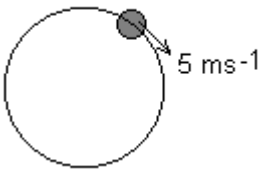
1 A car moves with a constant velocity. The acceleration of the car is

A increased **B** decreased
C zero **D** uniformly

2 Deceleration means the velocity of an object is

A negative **B** positive
C increased **D** decreased

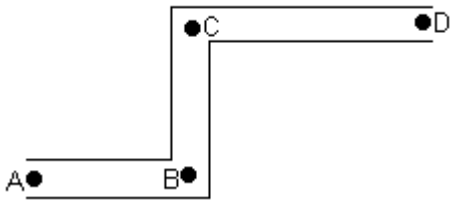
3 The following figure shows an object moves with a constant speed 5 m s^{-1} in a circle.



The object is also moves with

A an acceleration
B zero acceleration
C constant velocity

4 The figure shows a path of a moving object.



If AB = 5m , BC = 5m and CD = 7m ,find the total displacement of the object if it moves from A to D.

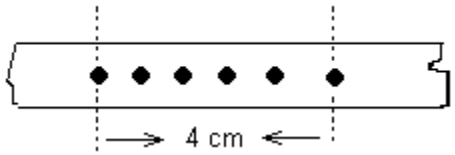
A 3m **B** 7m
C 13 m **D** 17 m
E 20 m

5 A tick on the ticker tapes is

A the speed of the ticker timer
B the frequency of the ticker timer
C the dinstace between two consecutive dots
D the time interval between two consecutive dots

6 The frequency of a ticker timer is 50 Hz. The time interval between two consecutive dots is

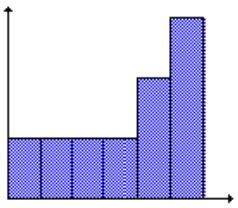
A 0.60 s **B** 0.44 s
C 0.32 s **D** 0.30 s
E 0.20 s



7 Based on the figure above , calculate the average velocity.

A 0.2 ms^{-1} **B** 0.3 ms^{-1}
C 0.4 ms^{-1} **D** 0.5 ms^{-1}
E 0.5 ms^{-1}

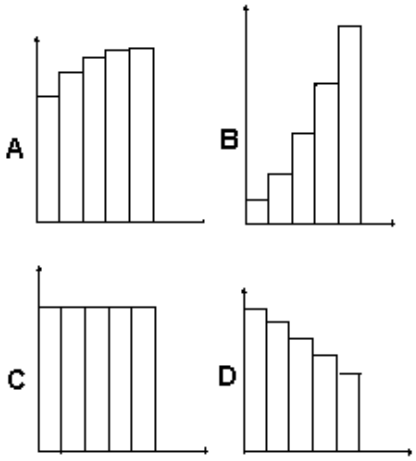
8 The following figure shows a tape chart.



Based on figure , which of the following is true?

	At the beginning of motion	At the end of motion
A	the velocity unchanged	the acceleration increases
B	the velocity increases	the acceleration increases
C	the velocity increases	the acceleration unchanged
D	the velocity unchanged	the acceleration unchanged

9 Which of the following shows an object moving with decreasing acceleration ?



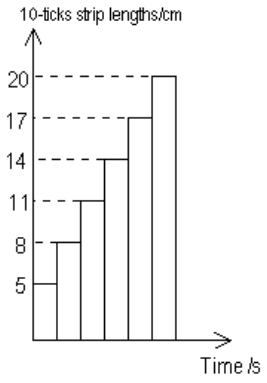
10 A cyclist riding at a velocity 8 ms^{-1} and is accelerating with 4 ms^{-2} . What is the velocity of the cyclist after 5 s .

A 16 ms^{-1} **B** 20ms^{-1}
C 24 ms^{-1} **D** 28 ms^{-1}
E 32 ms^{-1}

11 A car starts from rest and accelerates uniformly and after travels at distance 45m the velocity of the car is 20 ms^{-1} . What is the time taken?

A 4.5 s **B** 9.0 s
C 13.5 s **D** 18.0 s
E 22.4 s

12 The following figure shows a tape chart . The chart is produced by the motion of a trolly.The ticker timer used a supply voltage 12 V a.c. at 50 Hz.



(a) Describe the type of motion is shown in the tape chart.

.....

.....

(b) What is the time interval between two consecutive dots ?

.....

(c) Calculate

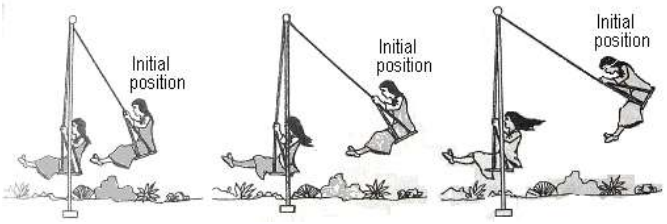
(i) the minimum velocity

(ii) the maximum velocity

(iii) the average velocity.

(iv) the acceleration.

13 Each figure below shows two positions of a student on a swing. The initial position in each figure is different.



Observe the positions of each of the swing in each diagram and the appearance of the student when she swings.
Based on the observations:

(a) State **one** suitable inference that can be made.
(b) State **one** appropriate hypothesis for an investigation.
(c) With the use of apparatus such as trolley, ticker timer and other apparatus , describe an experimental framework to test your hypothesis.
In your description , state clearly the following:
(i) Aim of the experiment
(ii) Variables in the experiment
(iii) List of apparatus and materials
(iv) Arrangement of the apparatus
(v) The procedure of the experiment which include the method of controlling the manipulated variable and the method of measuring the responding variable.
(vi) Way you would tabulate the data
(vii) Way you would analysis the data