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# Newtonian Mechanics

Kinematics

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## Syllabus content

Section		AS	A2
II Newtonian mechanics	3. Kinematics	✓	
	4. Dynamics	✓	
	5. Forces	✓	
	6. Work, energy, power	✓	
	7. Motion in a circle		✓
	8. Gravitational field		✓

### Section II: Newtonian mechanics

#### Recommended prior knowledge

Candidates should be able to describe the action of a force on a body.

They should be able to describe the motion of a body and recognise acceleration and constant speed.

They should be able to use the relationship  $\text{average speed} = \text{distance} / \text{time}$ .

### 3. Kinematics

#### Content

- 3.1 Linear motion
- 3.2 Non-linear motion

#### Learning outcomes

Candidates should be able to:

- (a) define displacement, speed, velocity and acceleration
- (b) use graphical methods to represent displacement, speed, velocity and acceleration
- (c) find displacement from the area under a velocity-time graph
- (d) use the slope of a displacement-time graph to find velocity
- (e) use the slope of a velocity-time graph to find acceleration
- (f) derive, from the definitions of velocity and acceleration, equations that represent uniformly accelerated motion in a straight line
- (g) solve problems using equations that represent uniformly accelerated motion in a straight line, including the motion of bodies falling in a uniform gravitational field without air resistance
- (h) recall that the weight of a body is equal to the product of its mass and the acceleration of free fall
- (i) describe an experiment to determine the acceleration of free fall using a falling body
- (j) describe qualitatively the motion of bodies falling in a uniform gravitational field with air resistance
- (k) describe and explain motion due to a uniform velocity in one direction and a uniform acceleration in a perpendicular direction.

# Mechanics

The study of *Physics* begins with mechanics.

*Mechanics* is the branch of physics that focuses on the motion of objects and the forces that cause the motion to change.

There are two parts to mechanics: *Kinematics* and *Dynamics*.

*Kinematics* deals with the concepts that are needed to describe motion, without any reference to forces.

*Dynamics* deals with the effect that forces have on motion.

# Introduction

**Kinematics is the science of describing the motion of objects using words, diagrams, graphs, and equations.**

The goal of kinematics is to develop mental models to describe the motion of real-world objects.

We will learn to describe motion using:

1. Words
2. Diagrams
3. Graphs
4. Equations

# Describing Motion with words

The motion of objects can be described by words.

Even a person without a background in physics has a collection of words, which can be used to describe moving objects. For example, going faster, stopped, slowing down, speeding up, and turning provide a sufficient vocabulary for describing the motion of objects.

In physics, we use these words as the language of kinematics.

- 1. Distance and Displacement**
- 2. Speed and Velocity**
- 3. Acceleration**

These words which are used to describe the motion of objects can be divided into two categories.

The quantity is either a vector or scalar.

**1. Scalars are quantities which are described by a magnitude only.**

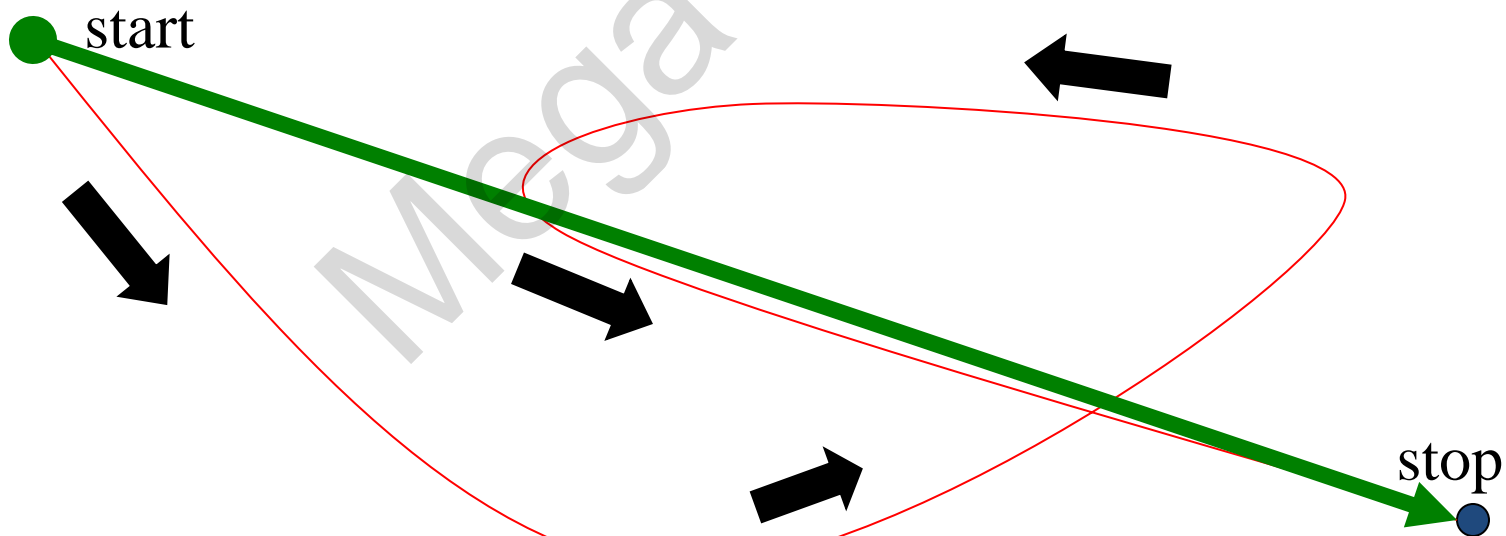
**2. Vectors are quantities which are described by both a magnitude and a direction.**

<b>Distance</b>	<b>Displacement</b>
<p>Distance refers to <b>the total length of travel irrespective of the direction of the motion.</b></p> <p>It is a <b>scalar quantity.</b> SI unit: metre (m) Other common units: kilometre (km), centimetre (cm)</p>	<p>Displacement refers to <b>the distance moved in a particular direction.</b> It is the object's overall change in position.</p> <p>It is a <b>vector quantity.</b> SI unit: metre (m) Other common units: kilometre (km), centimetre (cm)</p>



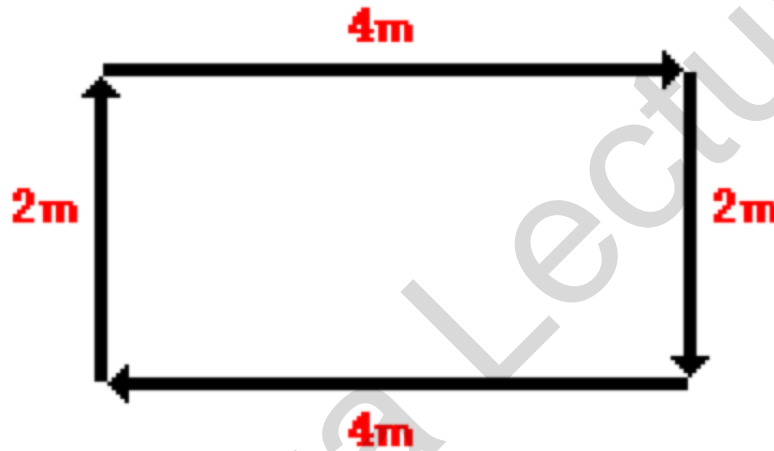
# Distance vs. Displacement

- You drive the path, and your odometer goes up (your distance).
- Your displacement is the shorter directed distance from start to stop (green arrow).



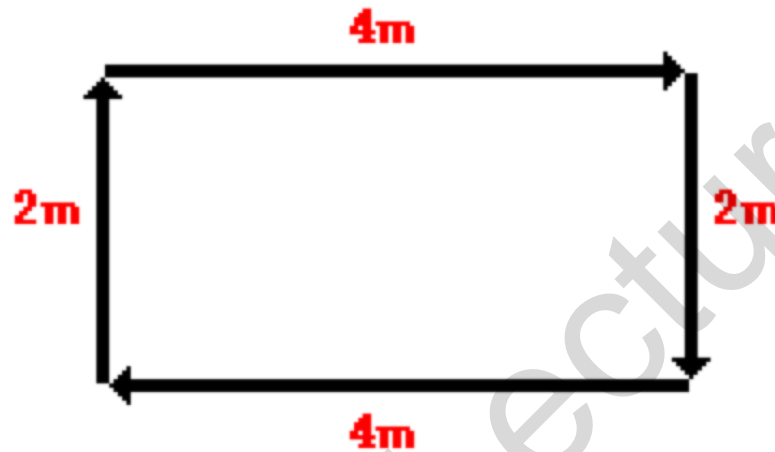
### Example 1

A student walks 4 m East, 2 m South, 4 m West, and finally 2 m North.



Total distance = 12 m

During the course of his motion, the total length of travel is 12 m.



Total displacement = 0 m

When he is finished walking, **there is no change in his position.**  
The 4 m east is “canceled by” the 4 m west; and the 2 m south is “canceled by” the 2 m north.

<b>Speed</b>	<b>Velocity</b>
<p>Speed is <b>the rate of change of distance.</b></p> <p>It is a <b>scalar quantity.</b></p> $\text{Speed} = \frac{\text{distance travelled}}{\text{time taken}}$	<p>Velocity is the <b>distance travelled in a specific direction.</b></p> <p>It is also defined as <b>the rate of change of displacement.</b></p> <p>It is a <b>vector quantity.</b></p> $\text{Velocity} = \frac{\text{change in displacement}}{\text{time taken}}$

When evaluating the velocity of an object, one must keep track of direction.

The direction of the velocity vector is the same as the direction which an object is moving. (It would not matter whether the object is speeding up or slowing down.)

**For example:**

If an object is moving rightwards, then its velocity is described as being rightwards.

Boeing 747 moving towards the west with a speed of 260m/s has a velocity of 260m/s, west.

Note that speed has no direction (it is a scalar) and velocity at any instant is simply the speed with a direction.

## Instantaneous Speed and Average Speed

As an object moves, it often undergoes changes in speed.

The speed at any instant is known as the **instantaneous speed**.

(From the value of the speedometer)

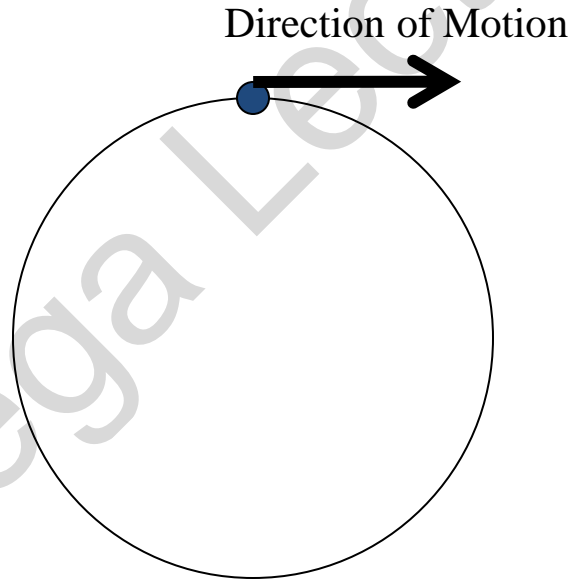


The **average speed of the entire journey** can be calculated:

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

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**Speed Vs Velocity**

An object is moving in a circle at a **constant speed** of  $10 \text{ m s}^{-1}$ .  
We say that it has a constant speed but **its velocity is not constant**.  
Why?



The direction of the object keeps changing.

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**Acceleration**

- An object whose velocity is changing is said to accelerate.
- If the direction and / or speed of a moving object changes, the object is accelerating
- Acceleration is the rate of change of velocity

Time (s)	Velocity (m/s)
0	0
1	10
2	20
3	30
4	40
5	50



# Acceleration

Acceleration is a vector quantity

SI unit:  $\text{ms}^{-2}$

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

where  $a$  = acceleration,  $v$  = final velocity,  $u$  = initial velocity and  $t$  = time.

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

# Describing Motion with Graphs

1. Plot and interpret a distance-time graph and a speed-time graph.
2. Deduce from the shape of a **distance-time graph** when a body is:
  - (a) at rest
  - (b) moving with uniform speed
  - (c) moving with non-uniform speed
3. Deduce from the shape of a **Velocity-time graph** when a body is:
  - (a) at rest
  - (b) moving with uniform speed
  - (c) moving with uniform acceleration
  - (d) moving with non-uniform acceleration
4. Calculate the area under a speed-time graph to determine the distance travelled for motion with uniform speed or uniform acceleration.

## Key Concepts

### Distance-time Graph

Gradient of the Distance-time Graph is the speed of the moving object

### Speed-time Graph

Gradient of the Speed-time Graph is the acceleration of the moving object.

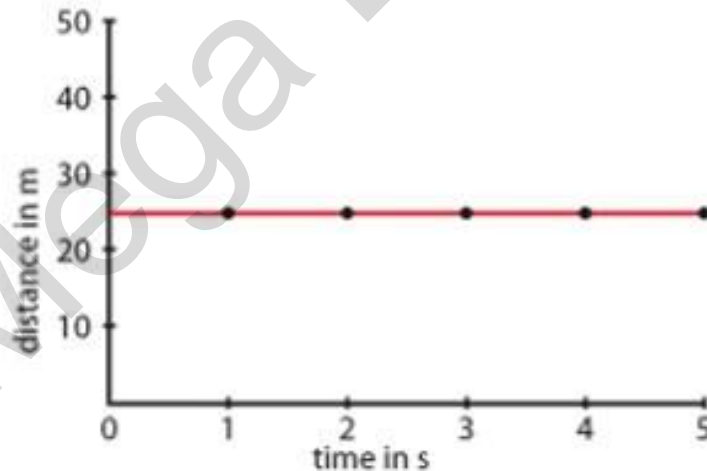
Area under the Speed-time Graph is the distance travelled.

# Distance-time Graph

A car has travelled past a lamp post on the road and the distance of the car from the lamp post is measured every second. The distance and the time readings are recorded and a graph is plotted using the data. The following pages are the results for four possible journeys. The steeper the line, the greater the speed.

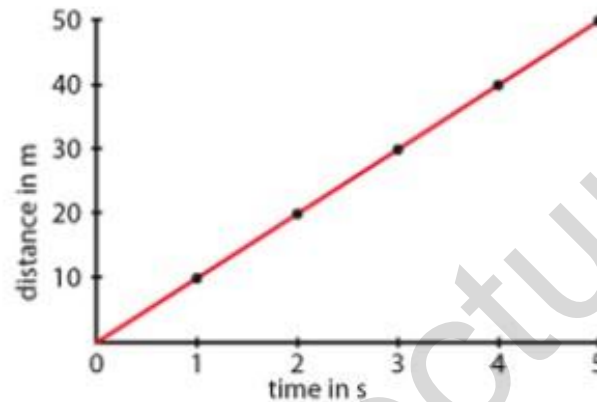
(a) Car at rest

Time in s	0	1	2	3	4	5
Distance in m	25	25	25	25	25	25



The car is parked 25 m from the post, so the distance remains the same.

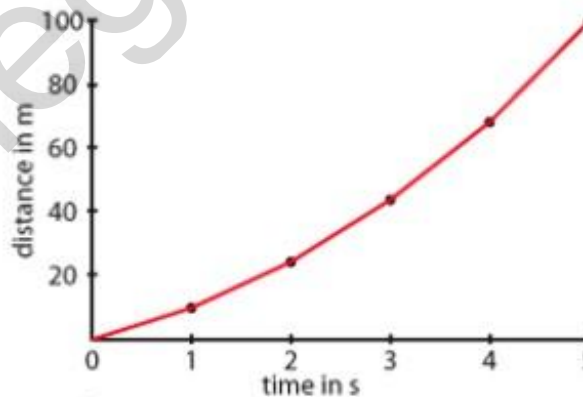
Time in s	0	1	2	3	4	5
Distance in m	0	10	20	30	40	50



Distance increases 10 m for every 1 s.

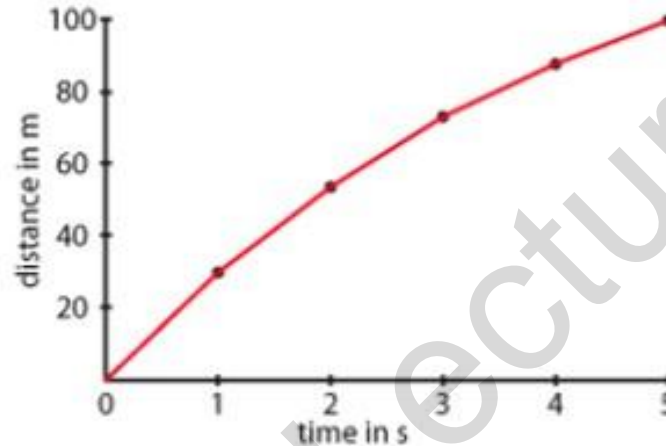
- (c) Car moving with non-uniform speed  
 (i) Car accelerating

Time in s	0	1	2	3	4	5
Distance in m	0	10	25	45	70	100



Speed increases, so the car travels a longer distance as time increases.

Time in s	0	1	2	3	4	5
Distance in m	0	30	55	75	90	100

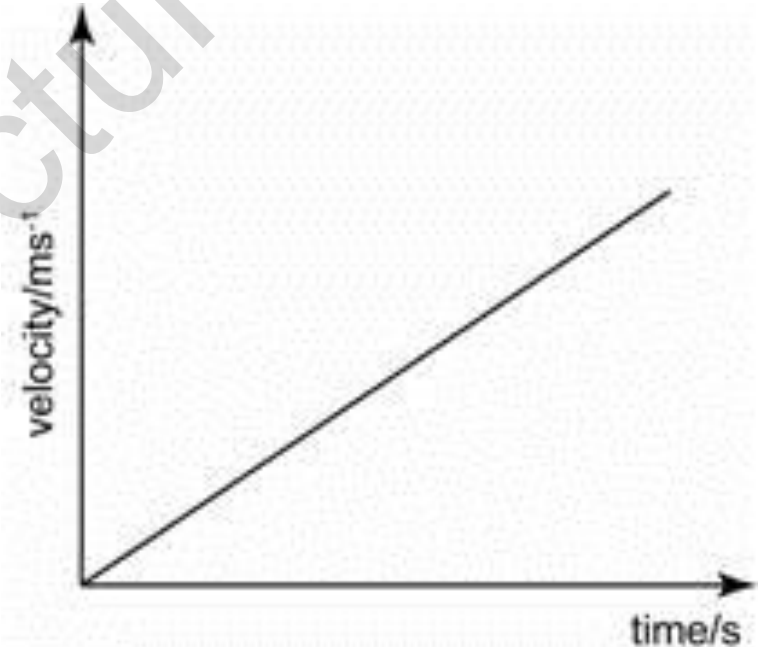


Speed decreases, so the car travels a shorter distance as time increases.

The gradient of the distance-time graph gives the speed of the moving object.

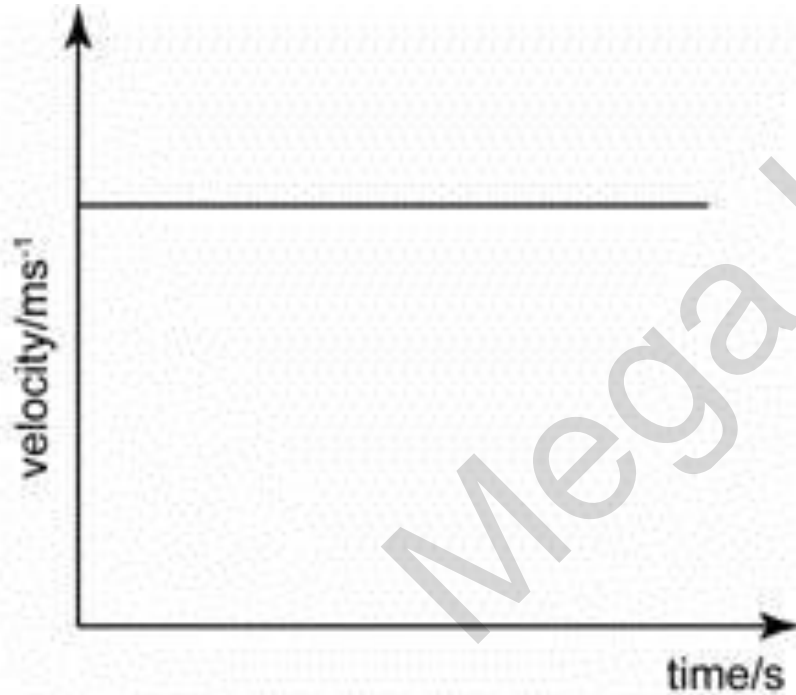
# Velocity - Time Graph

- The **gradient** of the velocity-time gradient gives a value of the changing rate in velocity, which is the **acceleration** of the object.
- The **area** below the velocity-time graph gives a value of the object's **displacement**.

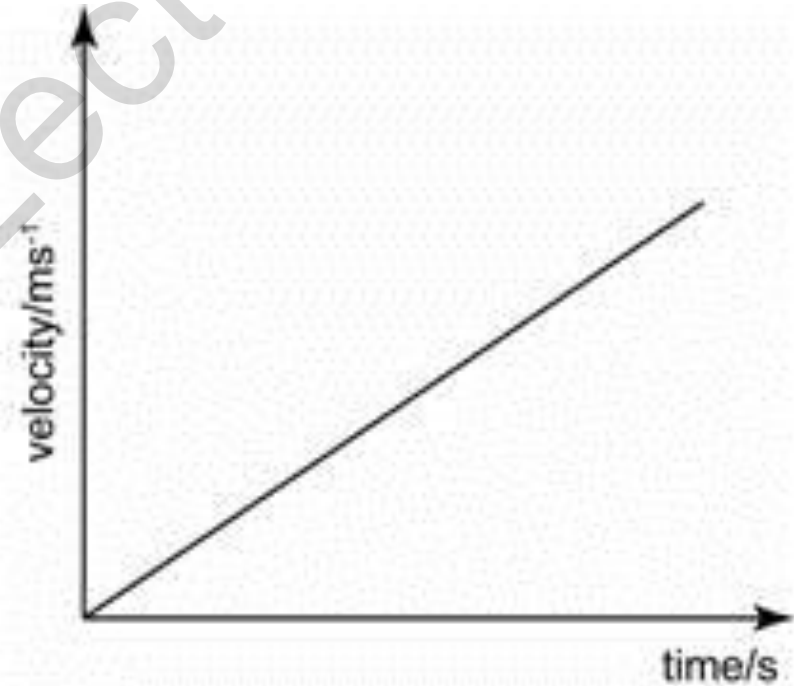


# Analysing Velocity - Time Graph

- Uniform Velocity



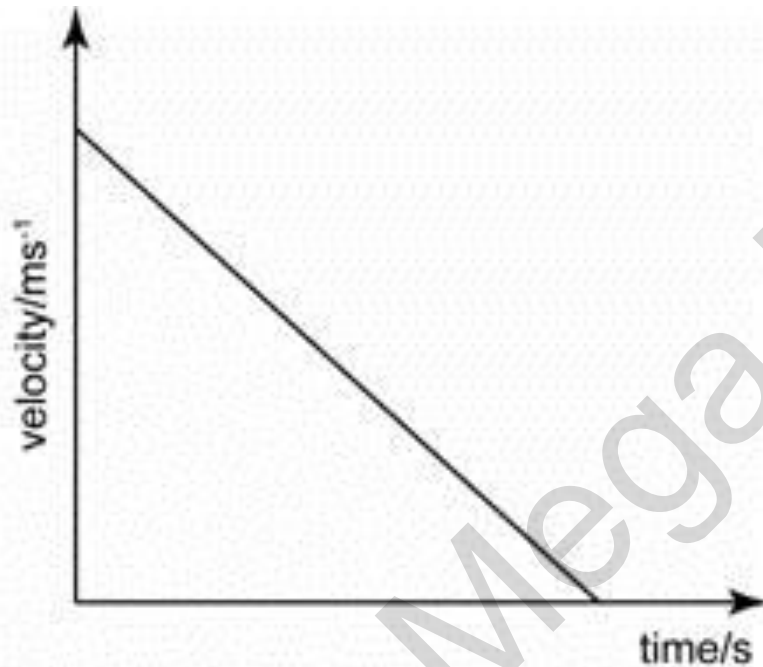
- Uniform Acceleration



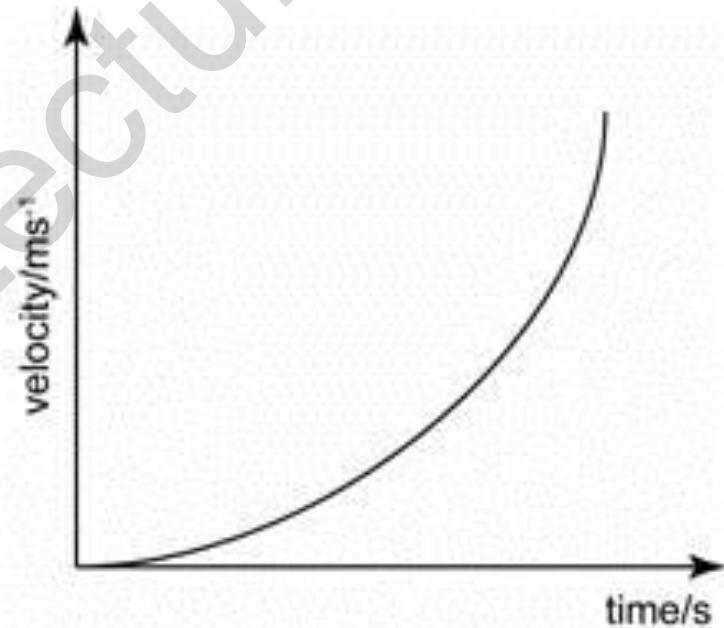


# Analysing Velocity - Time Graph

- Uniform deceleration

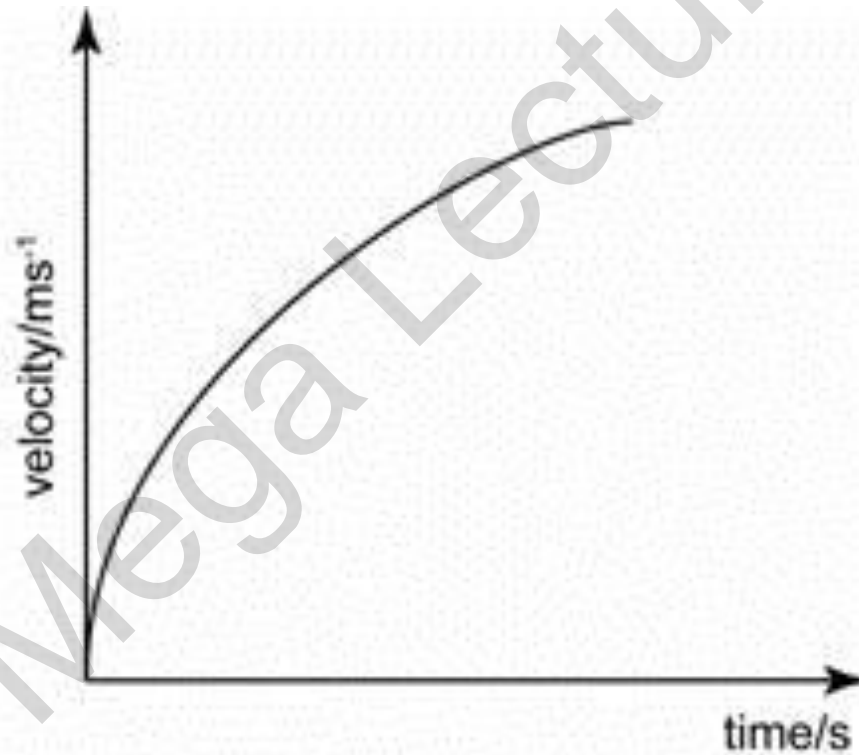


- Increasing acceleration



# Analysing Velocity - Time Graph

Decreasing acceleration



## How do you find the gradient of velocity-time graph?

- You need to select two points on the graph, for example  $(x_1, y_1)$  and  $(x_2, y_2)$ .
- Once you have selected the points you put them into the equation  $m = (y_2 - y_1) / (x_2 - x_1)$
- **$m =$  the gradient**
  - The gradient represents the acceleration.
  - In other words, We take the vertical reading from the graph where the acceleration finishes and divide it by the horizontal reading where the acceleration finishes.

## Example 1

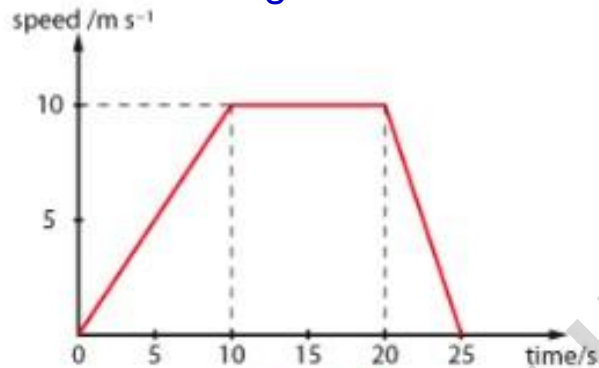


Figure 2.14

- What is the maximum speed of the lift?
- For how many seconds does the lift move?
- How much speed does the lift gain in the first 10 seconds?  
What is its acceleration?
- What is the deceleration of the lift in the last 5 seconds?

### **Solution**

- The maximum speed of the lift is  $10 \text{ m s}^{-1}$ .
- The lift moves for 25 s.
- The lift gains  $10 \text{ m s}^{-1}$  in the first 10 s.

$$\begin{aligned}\text{Acceleration} &= \frac{10 - 0}{10} \\ &= 1 \text{ m s}^{-2}\end{aligned}$$

- Acceleration =  $\frac{0 - 10}{5}$   
 $= -2 \text{ m s}^{-2}$

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Therefore the deceleration is  $2 \text{ m s}^{-2}$

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## Example 2

Figure 2.15 shows the speed-time graph for the journey of a boy from his house to school. Look at the shape of the graph and describe the type of motion in each stage.

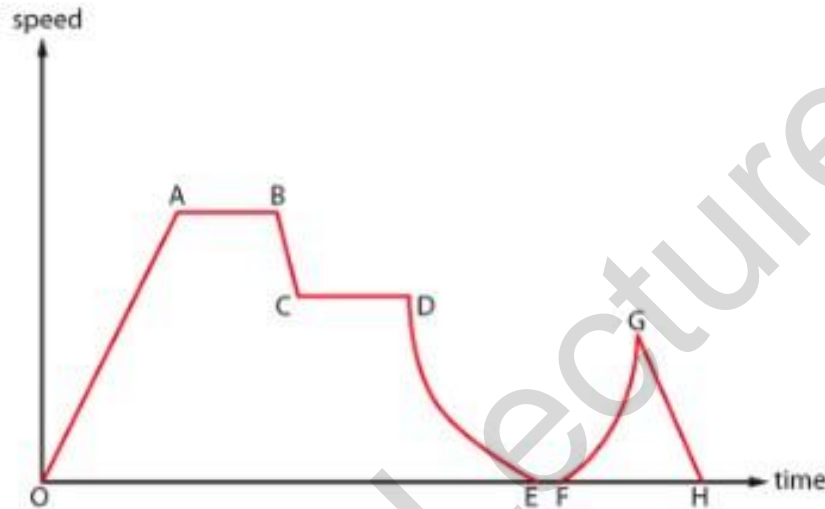


Figure 2.15

### Solution

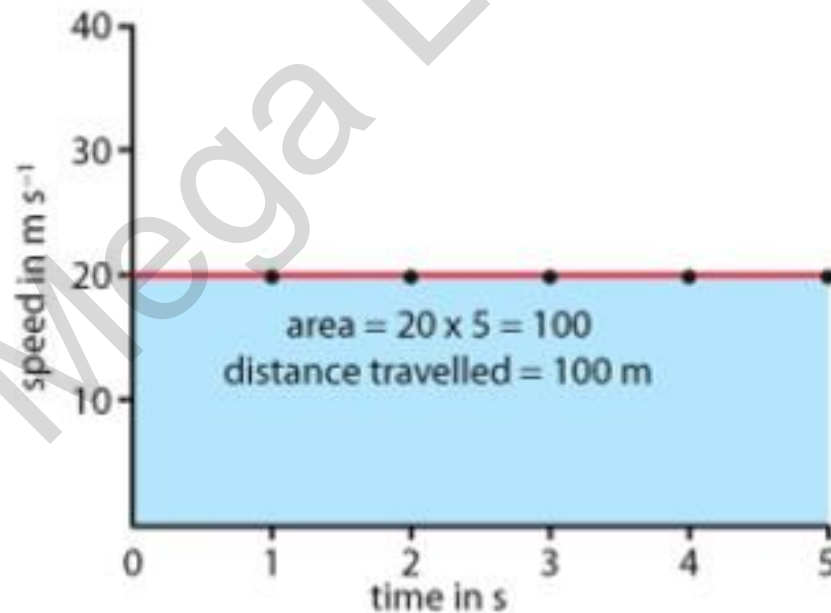
- O left home
- O-A moving with uniform acceleration
- A-B moving with uniform speed
- B-C moving with uniform deceleration
- C-D moving with uniform speed (speed lower than A-B)
- D-E moving with non-uniform deceleration (decreasing deceleration)
- E-F not moving
- F-G moving with non-uniform acceleration (increasing acceleration)
- G-H moving with uniform deceleration
- H reached school

The figure below shows the speed-time graph of a car travelling with a uniform speed of  $20 \text{ ms}^{-1}$ . The distance travelled by the car is given by:

$$\begin{aligned}\text{Distance} &= \text{speed} \times \text{time} = 20 \times 5 \\ &= 100 \text{ m}\end{aligned}$$

The same information of distance travelled can also be obtained by calculating the area under the speed-time graph.

The area under a speed-time graph gives the distance travelled.



## Example 3 - Question

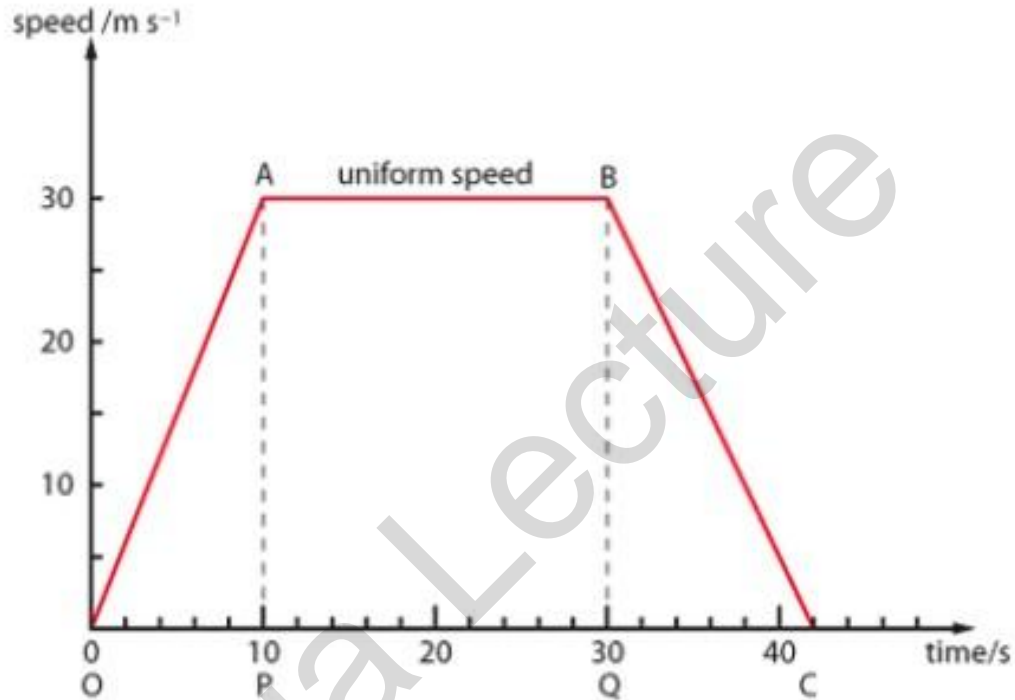


Figure 2.17 Speed-time graph of a car accelerating, moving with uniform speed and then decelerating

Figure 2.17 shows the speed-time graph of a car travelling along a straight road.

- What is the distance travelled during the first 10 s?
- What is the total distance travelled?
- What is the time taken for the whole journey?
- What is the average speed for the whole journey?

## Example 3 - Solution

### Solution

(a) During the first 10 s, distance travelled = area of triangle OAP

$$= \frac{1}{2} \times 10 \times 30$$

$$= 150 \text{ m}$$

(b) Total distance travelled = area of trapezium OABC

$$= \frac{1}{2} \times (20 + 42) \times 30$$

$$= 930 \text{ m}$$

(c) Time taken for the whole journey = 42 s

(d) Average speed for the whole journey =  $\frac{\text{Total distance travelled}}{\text{Total time taken}}$

$$= \frac{930}{42}$$

$$= 22.1 \text{ m s}^{-1}$$



# Fall freely.....

- <http://www.youtube.com/watch?v=go9uekKOcKM>
- <http://www.youtube.com/watch?v=FHtvDA0W34I>

# Uniformly accelerated motion

- **Free fall** is motion with no acceleration other than that provided by gravity.



In other words.....



- **A free-falling object is an object which is falling under the sole influence of gravity.**
- **Any object which is being acted upon only by the force of gravity is said to be in a state of free fall.**

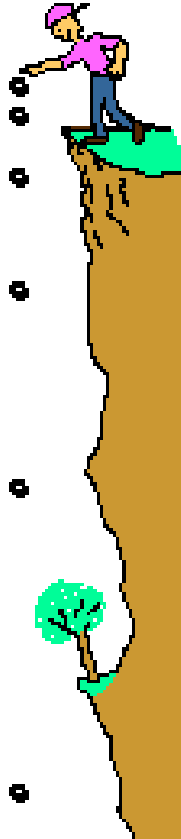
Any object which is moving and being acted upon only by the force of gravity is said to be "in a state of free fall."

- all objects fall freely at  $g \approx 10 \text{ m s}^{-2}$  when near the earth and air resistance is negligible.
- speed of a free-falling body increases by  $9.8 \text{ m s}^{-1}$  every second or when a body is thrown up, its speed decreases by  $9.8 \text{ m s}^{-1}$  every second.

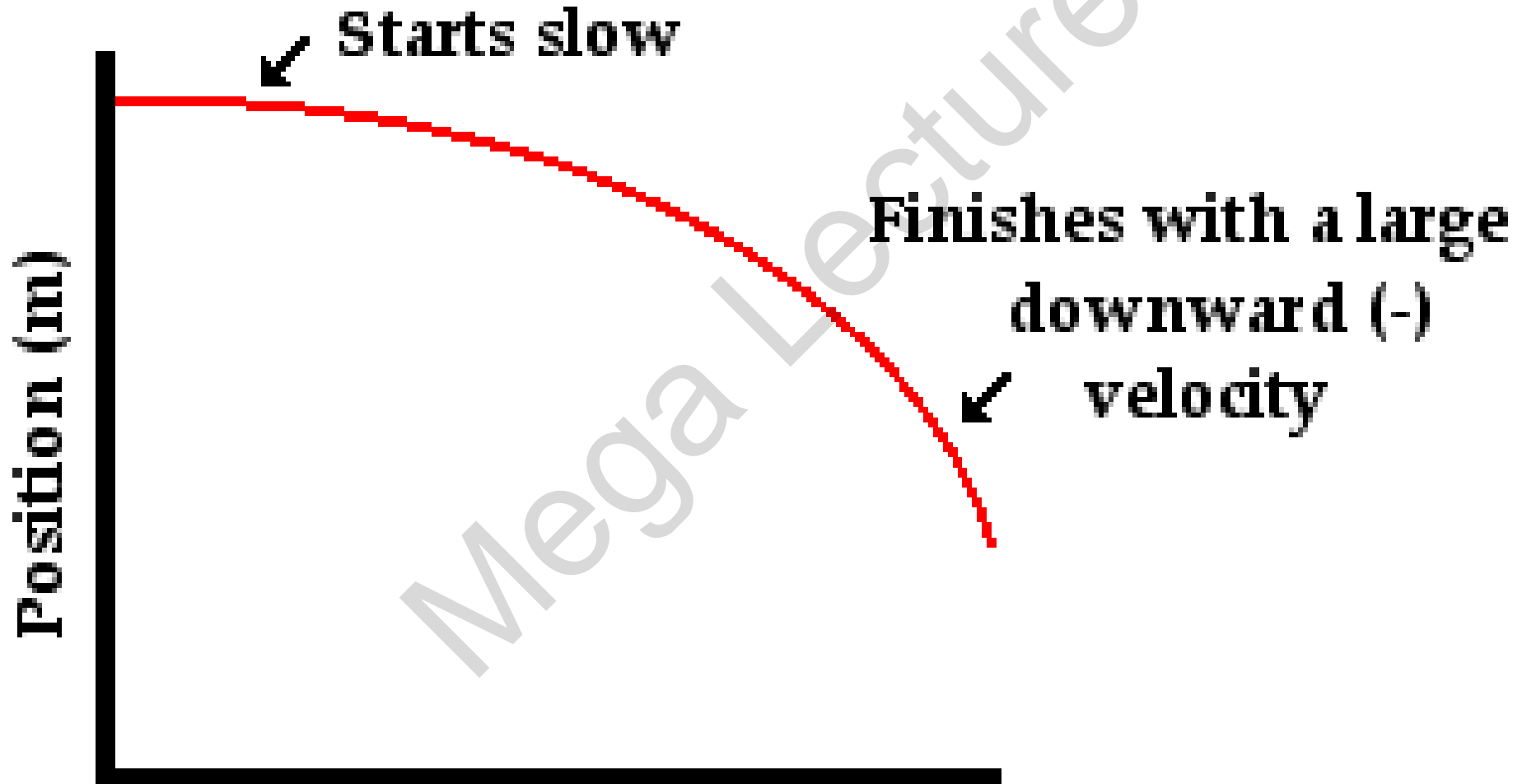
Although the acceleration due to gravity is considered constant, it tends to vary slightly over the earth since the earth is not a perfect sphere.

# Examples

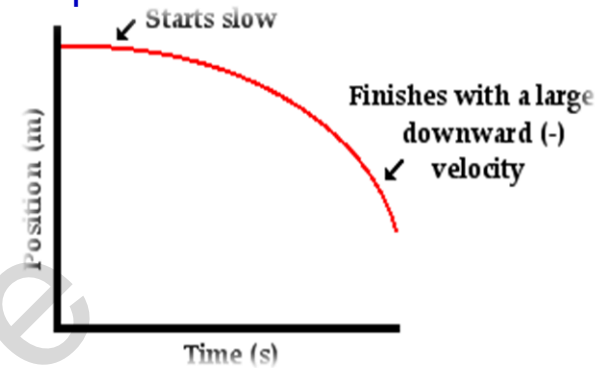
- Examples of objects in Free fall
  - A spacecraft (in space) with its rockets off (e.g. in a continuous orbit, or going up for some minutes, and then down)
  - The Moon orbiting around the Earth.
- Examples of objects not in Free fall
  - Standing on the ground: the gravitational acceleration is counteracted by the normal force from the ground.
  - Flying horizontally in an airplane: the wings' lift is also providing an acceleration.



# Representing Free Fall by Graphs



# Free fall graphs shows :



- ▶ The line on the graph curves.
- ▶ A curved line on a position versus time graph signifies an accelerated motion.
- ▶ The position-time graph reveals that the object starts with a small velocity (slow) and finishes with a large velocity (fast).

Check your  
Understanding !!



# Questions to answer !

- **“Doesn't a more massive object accelerate at a greater rate than a less massive object?” “Wouldn't an elephant free-fall faster than a mouse?”**

- **The answer to the question (doesn't a more massive object accelerate at a greater rate than a less massive object?) is absolutely NOT!**

- That is, absolutely not if we are considering the specific type of falling motion known as free-fall.
- Free-fall is the motion of objects which move under the sole influence of gravity; free-falling objects do not encounter air resistance.
- More massive objects will only fall faster if there is an appreciable amount of air resistance present.

## Force of gravity means the dog accelerates



To start, the dog is falling slowly (it has not had time to speed up).

There is really only one force acting on the dog, the force of **gravity**.

The dog falls faster (**accelerates**) due to this force.

# Gravity is still bigger than air resistance



As the dog falls faster, another force becomes bigger – **air resistance**.

The force of gravity on the dog of course stays the same

The force of gravity is still **bigger** than the air resistance, so the dog continues to accelerate (get faster)

# Gravity = air resistance

## Terminal Velocity



As the dog falls faster and air resistance increases, eventually the **air resistance** becomes as big as (**equal to**) the force of **gravity**.

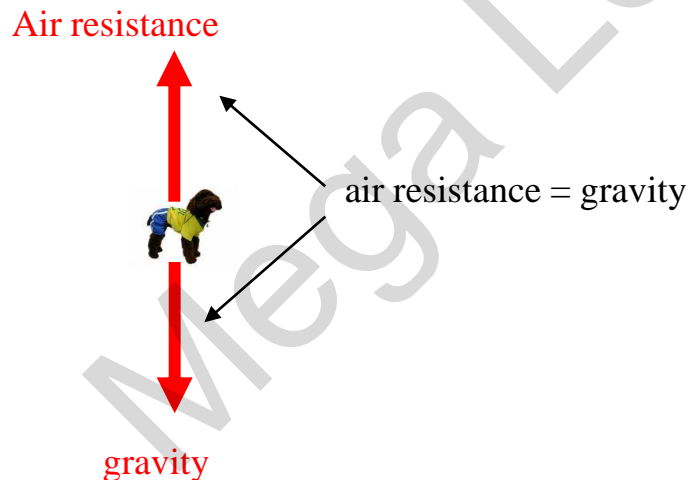
The dog stops getting faster (accelerating) and falls at **constant speed**.

This velocity is called the **terminal Velocity**

# Terminal Speed



The dog will continue to fall at constant speed (called the terminal speed) until.....



# Uniformly Accelerated Motion

- Acceleration is defined as the rate of change of velocity with respect to time, in a given direction. The SI units of acceleration are  $\text{ms}^{-2}$ .
- This would mean that if an object has an acceleration of  $1 \text{ ms}^{-2}$  it will increase its velocity (in a given direction)  $1 \text{ ms}^{-1}$  every second that it accelerates.

It means that acceleration is constant.

This meaning that velocity is varying with respect to time, we see this by this formula  $(v - u) / t$  (Time).



# It means....

- If an object is held stationary in a uniform gravitational field and when it is released, it will fall. It will do so with uniform acceleration.
- Near the surface of the earth the acceleration is approximately  $9.8 \text{ ms}^{-2}$ .
- This means that every second that the object falls its velocity will increase by  $9.8 \text{ ms}^{-1}$ .

# Check your understanding !

- What happens if an object is thrown up?

# What happens if an object is thrown up?

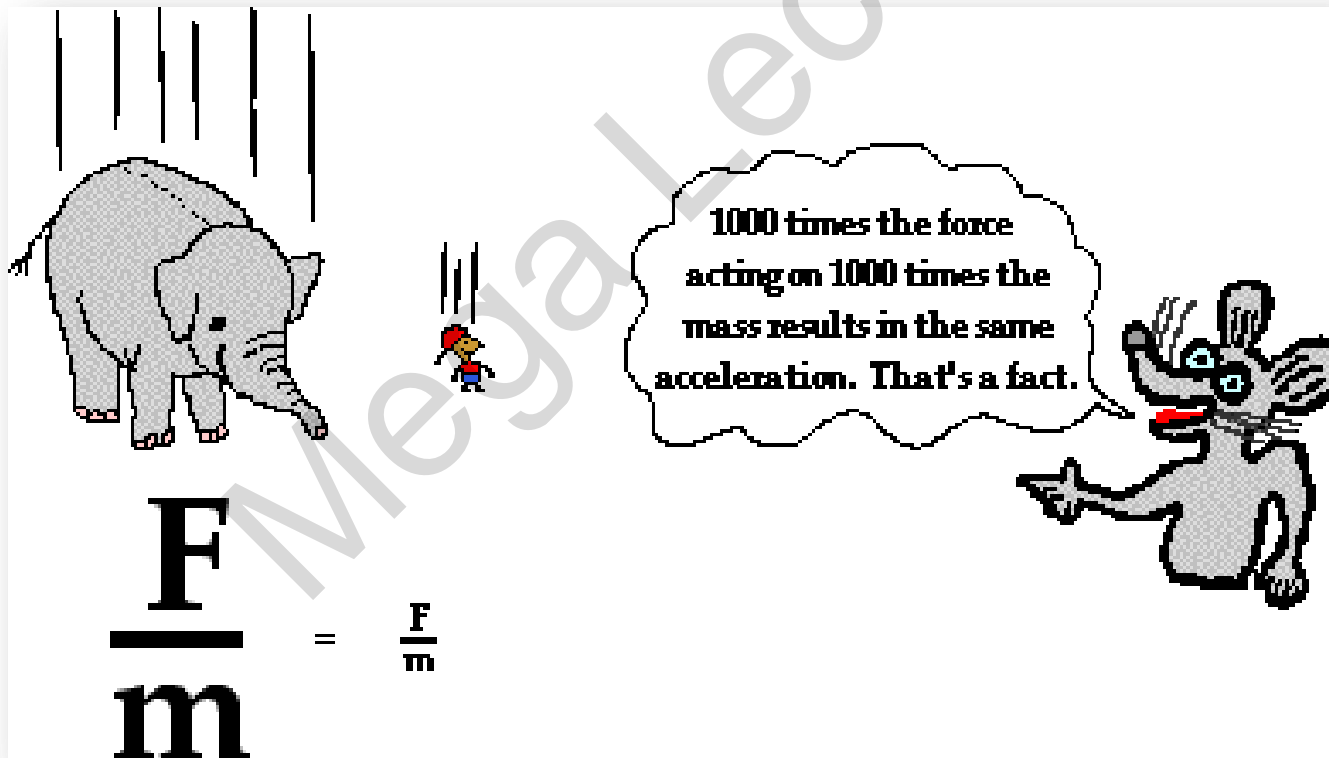
- The acceleration is still downward. If an object is thrown up with an initial velocity of  $30 \text{ ms}^{-1}$ , after one second it will only be going  $20 \text{ ms}^{-1}$  up, after 2 seconds it will only be going  $10 \text{ ms}^{-1}$ , after 3 seconds the object will have zero velocity!
- Even if the objects velocity is zero the acceleration is not zero.

# An experiment with 'g'.

- College building
- Stop watch
- A group of students on top floor
- A group of students on ground floor
- Need to check the distance between top floor and ground, time to calculate velocity.
- (This experiment will be carried out during next lesson)
- Upon investigation, g constant is found with one of the equations we have derived and it is as follows :

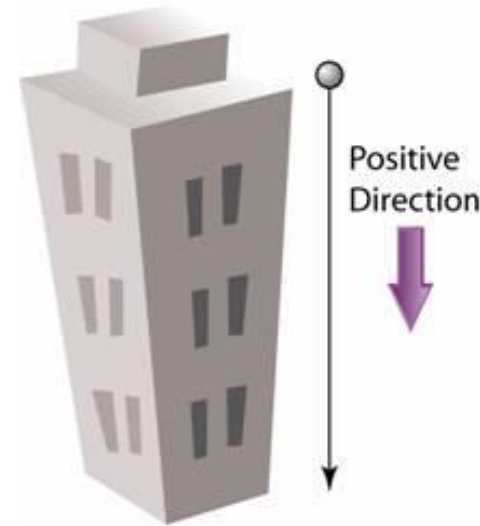
## Remember (will study in Ch.4 Dynamics)

- The actual explanation of why all objects accelerate at the same rate involves the concepts of force and mass.

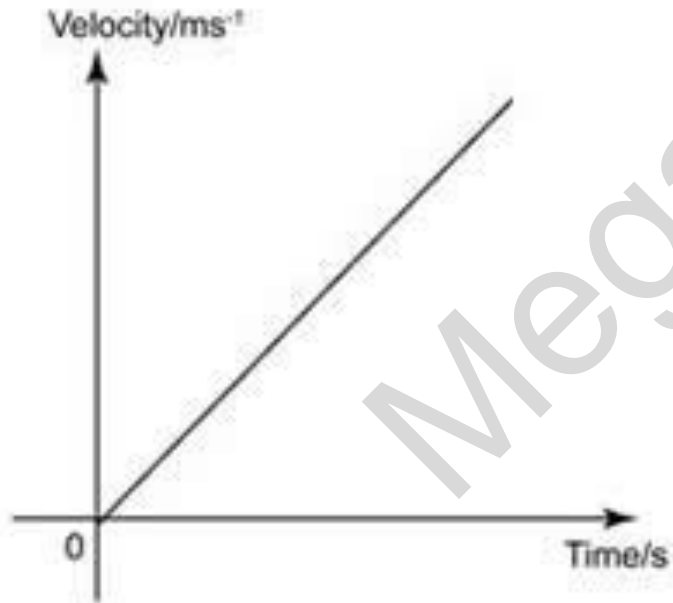


Graph of free falling :

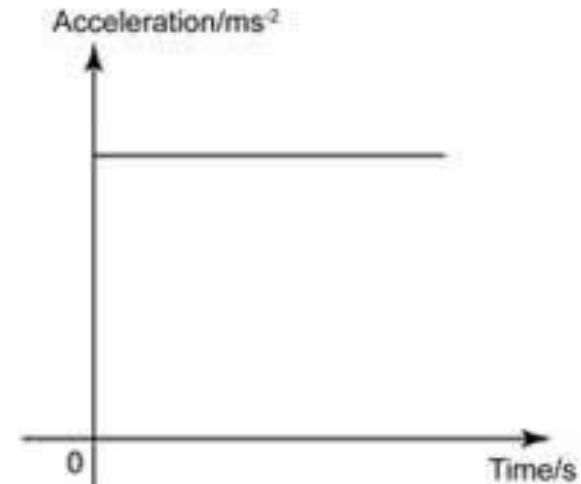
## 1. Dropping an object from high place



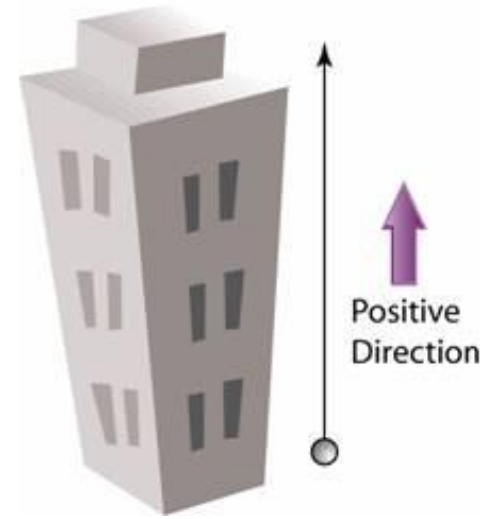
- Velocity - Time Graph



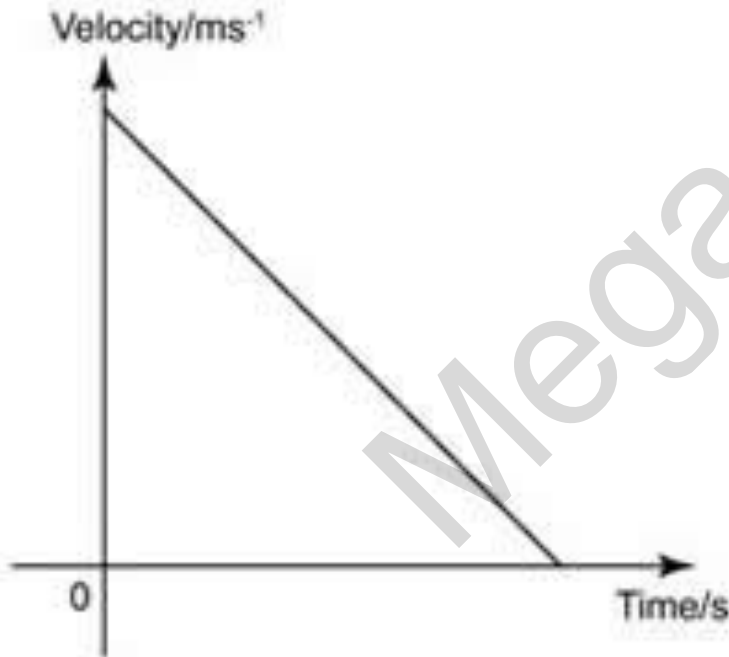
- Acceleration - Time Graph



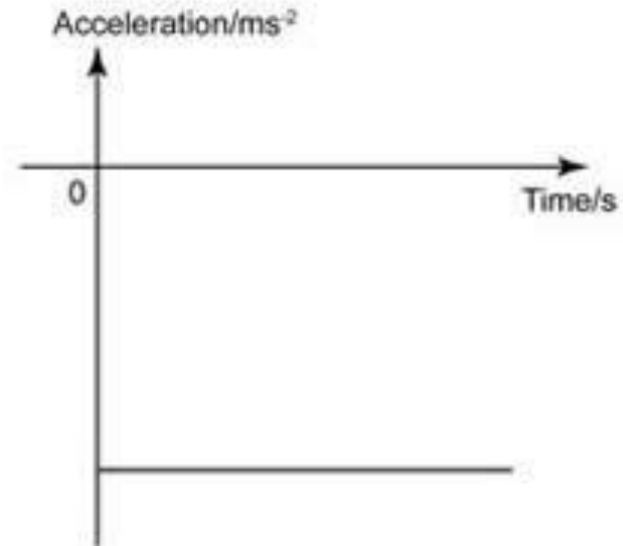
## Graph of free falling : 2. Launching Object Upward



- Velocity - Time Graph

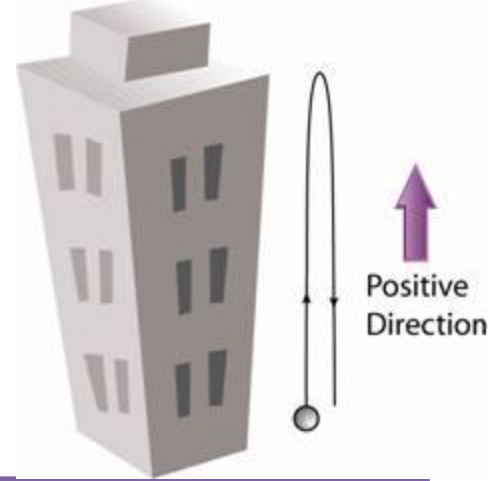


- Acceleration - Time Graph

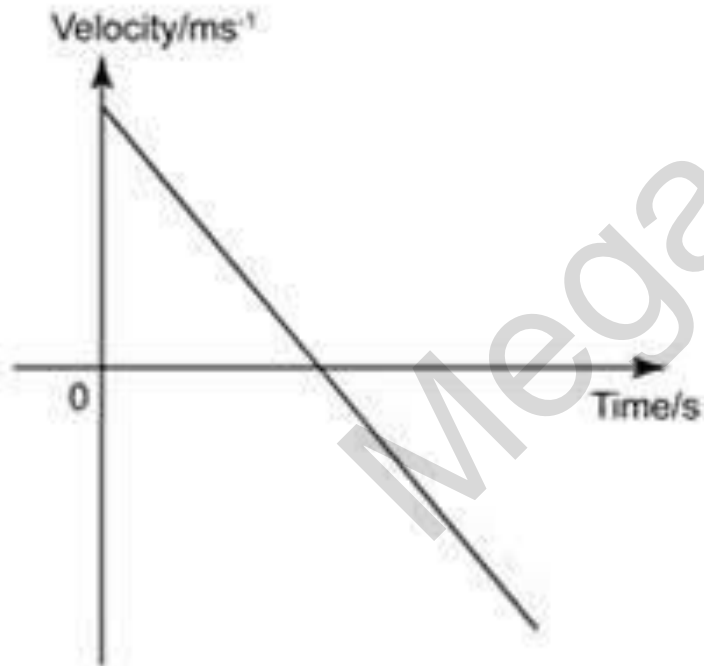


Graph of free falling :

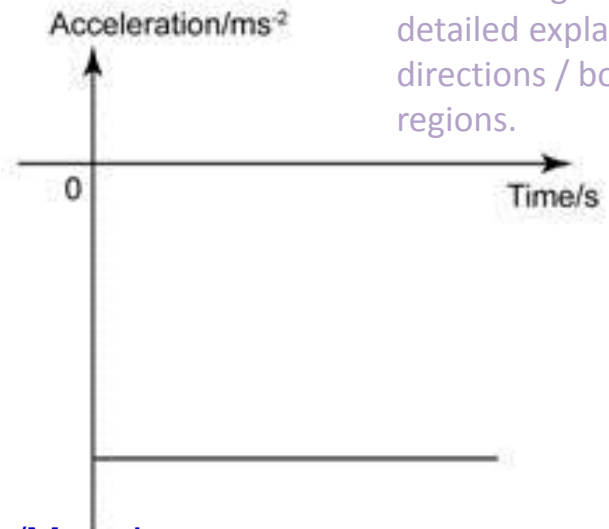
### 3 . Object moving upward and fall back to the ground



#### • Velocity - Time Graph



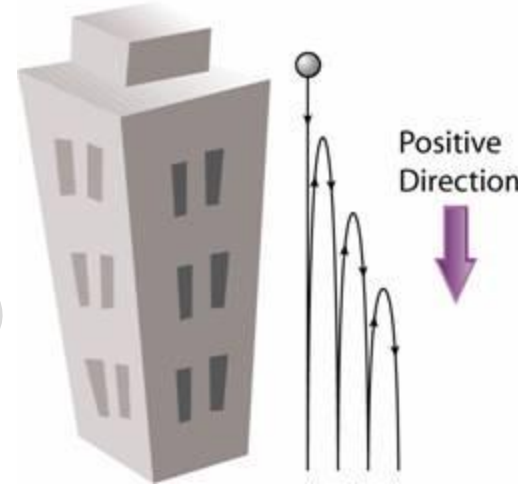
#### • Acceleration - Time Graph



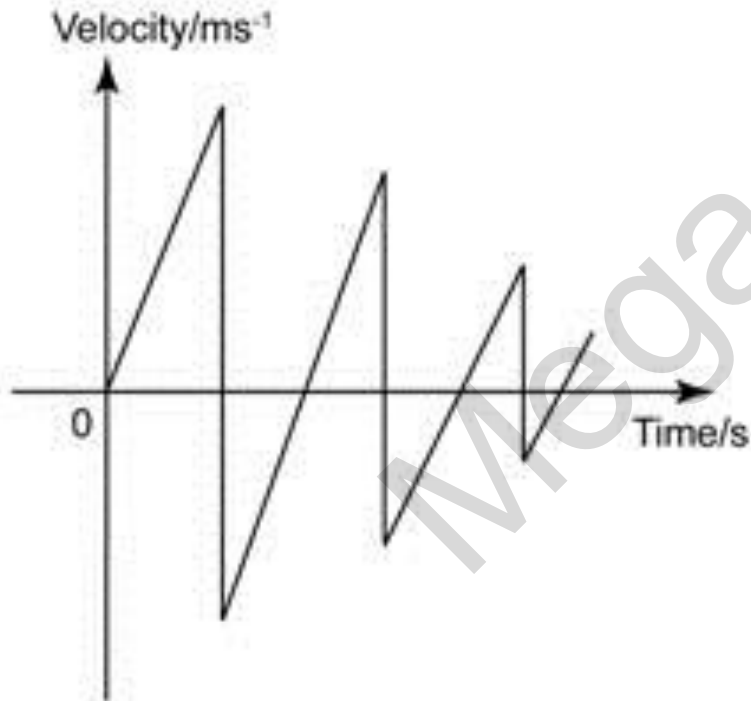
Note : The graph here is to show that the acceleration remains same. The following slides will give a detailed explanation on directions / both regions.



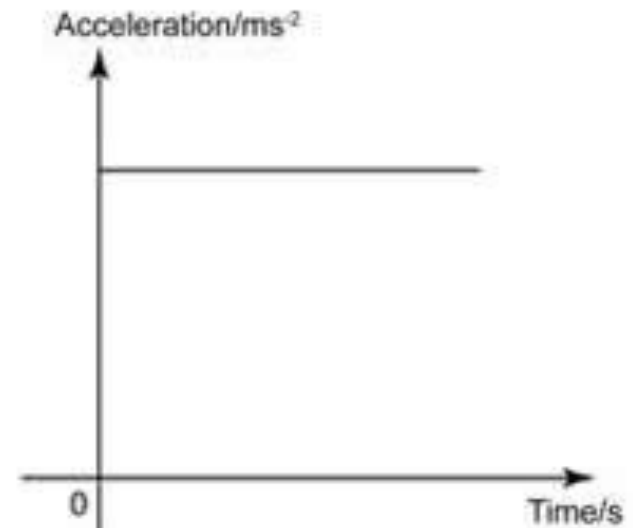
## Graph of free falling : 4. Object falling and bounces back

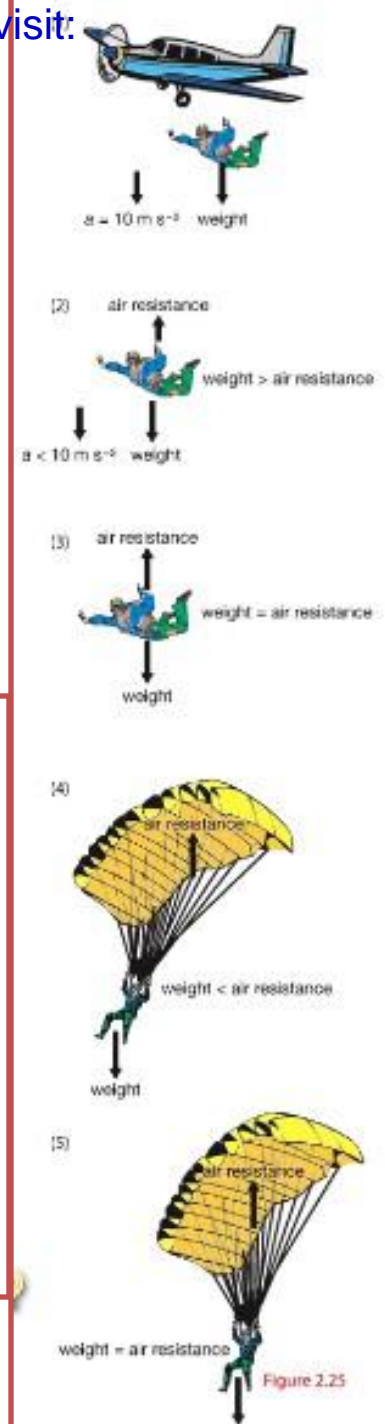
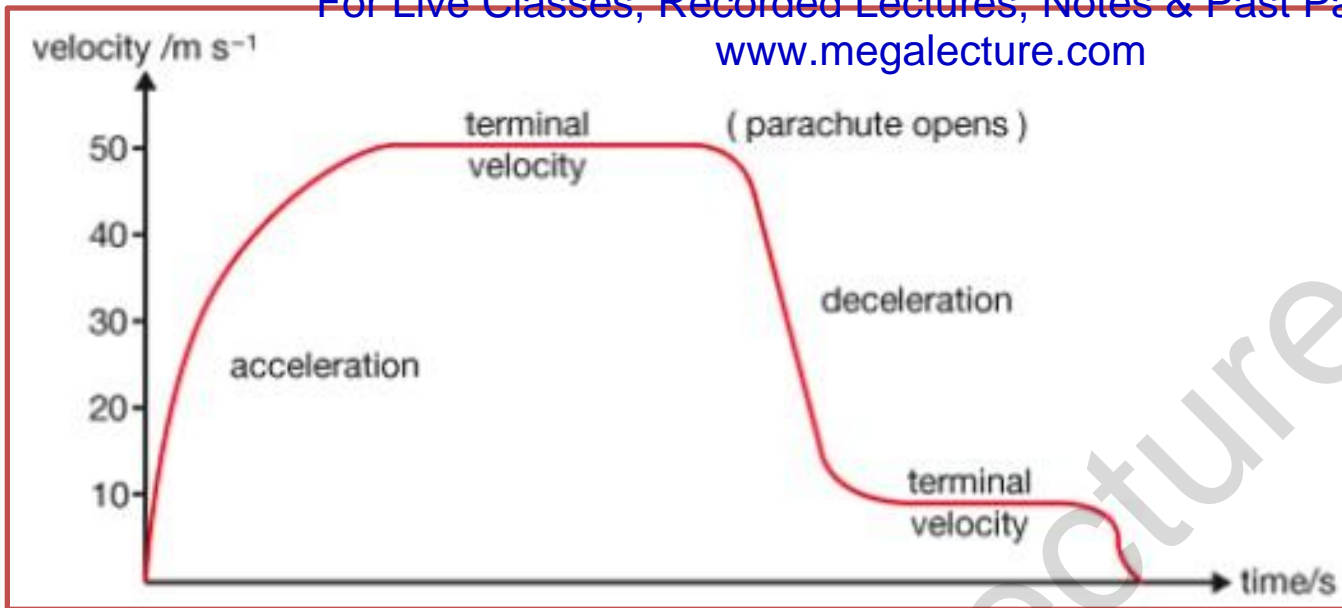


- Velocity - Time Graph



- Acceleration - Time Graph





At the point when the air resistance equals to the weight, there is no acceleration and the object will fall with “**terminal velocity**”.

A small dense object, like a steel ball bearing, has a high terminal velocity. A light object, like a raindrop, or an object with large surface area like a piece of paper, has a low terminal velocity.

# Positive Velocity & Negative Velocity

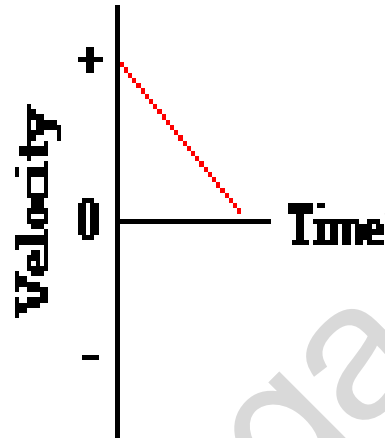
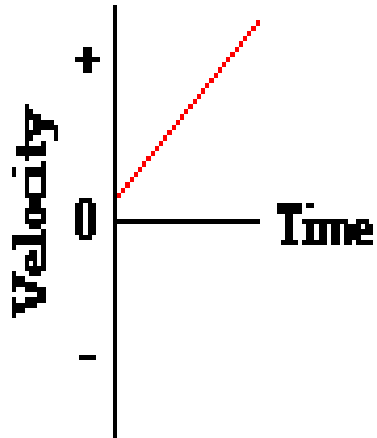
- How can one tell whether the object is moving in the positive direction (i.e., positive velocity) or in the negative direction (i.e., negative velocity)?
- And how can one tell if the object is speeding up or slowing down?

## Positive Velocity & Negative Velocity

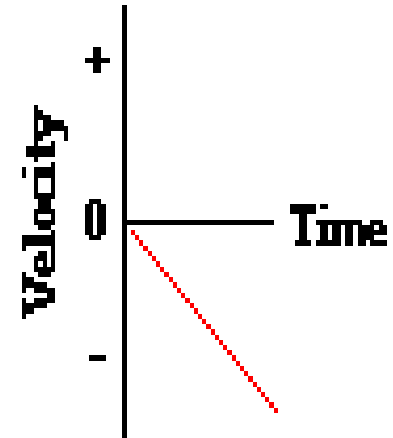
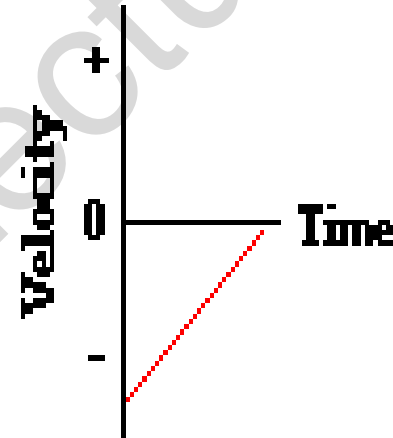
- Since the graph is a velocity-time graph, the velocity would be positive whenever the line lies in the positive region (above the x-axis) of the graph.
- Similarly, the velocity would be negative whenever the line lies in the negative region (below the x-axis) of the graph.
- **A positive velocity means the object is moving in the positive direction; and a negative velocity means the object is moving in the negative direction.**
- So one knows an object is moving in the positive direction if the line is located in the positive region of the graph (whether it is sloping up or sloping down). And one knows that an object is moving in the negative direction if the line is located in the negative region of the graph (whether it is sloping up or sloping down).
- And finally, if a line crosses over the x-axis from the positive region to the negative region of the graph (or vice versa), then the object has changed directions.

# Positive Velocity & Negative Velocity

These objects are moving with a positive velocity.



These objects are moving with a negative velocity.

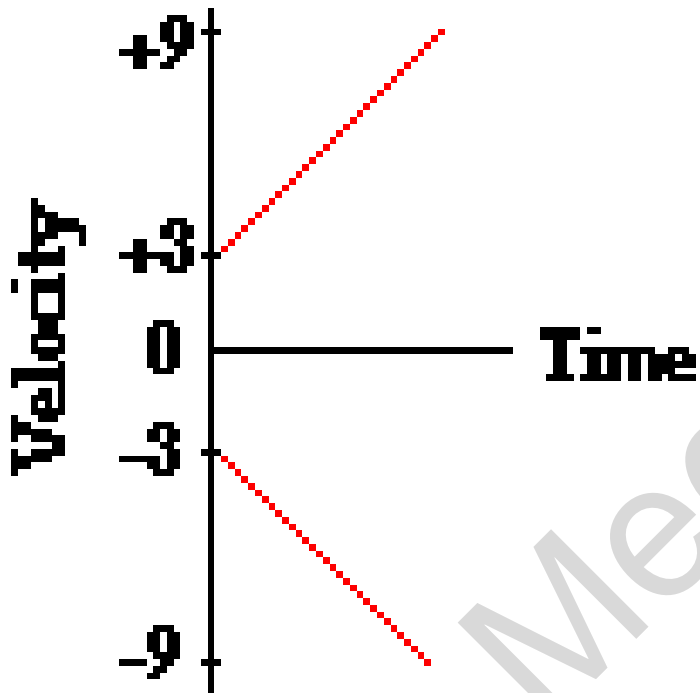


## Positive Velocity & Negative Velocity

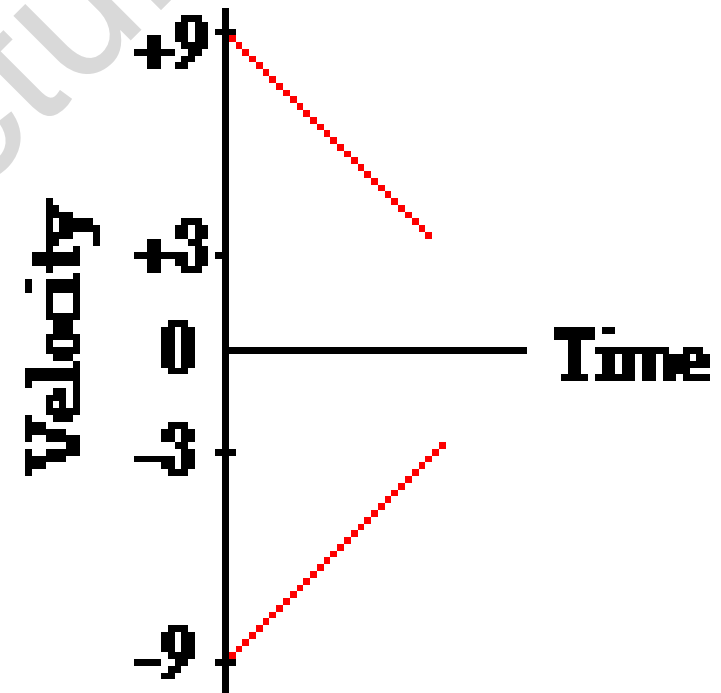
- Now how can one tell if the object is speeding up or slowing down?
- Speeding up means that the magnitude of the velocity is getting large. For instance, an object with a velocity changing from  $+3 \text{ m/s}$  to  $+9 \text{ m/s}$  is speeding up. Similarly, an object with a velocity changing from  $-3 \text{ m/s}$  to  $-9 \text{ m/s}$  is also speeding up.
- In each case, the magnitude of the velocity is increasing; the speed is getting bigger.
- Given this fact, one would believe that an object is speeding up if the line on a velocity-time graph is changing from near the 0-velocity point to a location further away from the 0-velocity point. That is, if the line is getting further away from the x-axis (the 0-velocity point), then the object is speeding up. And conversely, if the line is approaching the x-axis, then the object is slowing down.

# Positive Velocity & Negative Velocity

**Speeding Up**



**Slowing Down**



## Equations of Motion

There are 4 equations that you can use whenever an object moves with **constant, uniform acceleration in a straight line**. The equations are written in terms of the 5 symbols in the box:

$s$  = displacement (m)

$u$  = initial velocity ( $\text{ms}^{-1}$ )

$v$  = final velocity ( $\text{ms}^{-1}$ )

$a$  = constant acceleration ( $\text{ms}^{-2}$ )

$t$  = time interval (s)



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

$$\underline{v = u + at \dots (1)}$$

If acceleration is constant, the average velocity during the motion will be half way between  $v$  and  $u$ . This is equal to  $\frac{1}{2}(u + v)$ .

$$\frac{1}{2}(u + v) = s/t$$

$$\underline{s = \frac{1}{2}(u + v)t \dots (2)}$$

Using equation (1) to replace  $v$  in equation (2):

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

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

$$\underline{s = ut + \frac{1}{2}at^2 \dots (3)}$$

From equation (1),  $t = (v - u)/a$  [www.megalecture.com](http://www.megalecture.com)

Using this to replace t in equation (2):

$$s = \frac{1}{2}(u + v)[(v - u)/a]$$

$$2as = (u + v)(v - u)$$

$$2as = v^2 - u^2$$

$$\underline{v^2 = u^2 + 2as} \quad \dots (4)$$

**Note:**

- You can only use these equations only if the acceleration is constant.
- Notice that each equation contains only 4 of our 5 “s, u, v, a, t” variables. So if know any 3 of the variables, we can use these equations to find the other 2.

## **Example 4**

A cheetah starts from rest and accelerates at  $2.0 \text{ ms}^{-2}$  due east for 10 s. Calculate (a) the cheetah's final velocity, (b) the distance the cheetah covers in this 10 s.

### **Solution:**

(a) Using equation (1):  $v = u + at$

$$v = 0 + (2.0 \text{ ms}^{-2} \times 10 \text{ s}) = 20 \text{ ms}^{-1} \text{ due east}$$

(b) Using equation (2):  $s = \frac{1}{2}(u + v)t$

$$s = \frac{1}{2}(0 + 20 \text{ ms}^{-1}) \times 10 \text{ s} = 100 \text{ m due east}$$

You could also find the displacement by plotting a velocity-time graph for this motion. The magnitude of the displacement is equal to the area under the graph.

## **Example 5**

An athlete accelerates out of her blocks at  $5.0 \text{ ms}^{-2}$ . (a) How long does it take her to run the first 10 m? (b) What is her velocity at this point?

### **Solution:**

(a) Using equation (3):  $s = ut + \frac{1}{2}at^2$

$$10 \text{ m} = 0 + \left(\frac{1}{2} \times 5.0 \text{ ms}^{-2} \times t^2\right)$$

$$t^2 = 4.0 \text{ s}^2$$

$$t = 2.0 \text{ s}$$

(b) Using equation (1):  $v = u + at$

$$v = 0 + (5.0 \text{ ms}^{-2} \times 2.0 \text{ s})$$

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

## **Example 6**

A bicycle's brakes can produce a deceleration of  $2.5 \text{ ms}^{-2}$ . How far will the bicycle travel before stopping, if it is moving at  $10 \text{ ms}^{-1}$  when the brakes are applied?

### **Solution:**

Using equation (4):  $v^2 = u^2 + 2as$

$$0 = (10 \text{ ms}^{-1})^2 + (2 \times (-2.5 \text{ ms}^{-2}) \times s)$$

$$0 = 100 \text{ m}^2\text{s}^{-2} - (5.0 \text{ ms}^{-2} \times s)$$

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

### Example 7

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[www.megalecture.com](http://www.megalecture.com)

A student flips a coin into the air. Its initial velocity is  $8.0 \text{ ms}^{-1}$ . Taking  $g = 10 \text{ ms}^{-2}$  and ignoring air resistance, calculate: (a) the maximum height,  $h$ , the coin reaches, (b) the velocity of the coin on returning to his hand, (c) the time that the coin is in the air.

**Solution:** (upward motion to be negative)

(a)  $v^2 = u^2 + 2as$

$$0 = (8.0 \text{ ms}^{-1})^2 + (2 \times (-10 \text{ ms}^{-2}) \times h)$$

$$h = 3.2 \text{ m}$$

(b) The acceleration is the same going up and coming down. If the coin decelerates from  $8.0 \text{ ms}^{-1}$  to  $0 \text{ ms}^{-1}$  on the way up, it will accelerate from  $0 \text{ ms}^{-1}$  to  $8 \text{ ms}^{-1}$  on the way down. The motion is symmetrical. So the velocity on returning to his hand is  $8.0 \text{ ms}^{-1}$  downwards.

(c)  $v = u + at$

$$0 = 8.0 \text{ ms}^{-1} + (-10 \text{ ms}^{-2} \times t)$$

$$t = 0.8 \text{ s}$$

The coin will take the same time between moving up and coming down. So total time in the air =  $1.6 \text{ s}$ .

<https://www.youtube.com/c/MegaLecture>

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## You-tube videos links with explanation on : Newtonian Mechanism - Kinematics

- <http://www.youtube.com/watch?v=go9uekKOcKM>
- <http://www.youtube.com/watch?v=xE71aKXjs0&feature=related>

# Any Questions?

