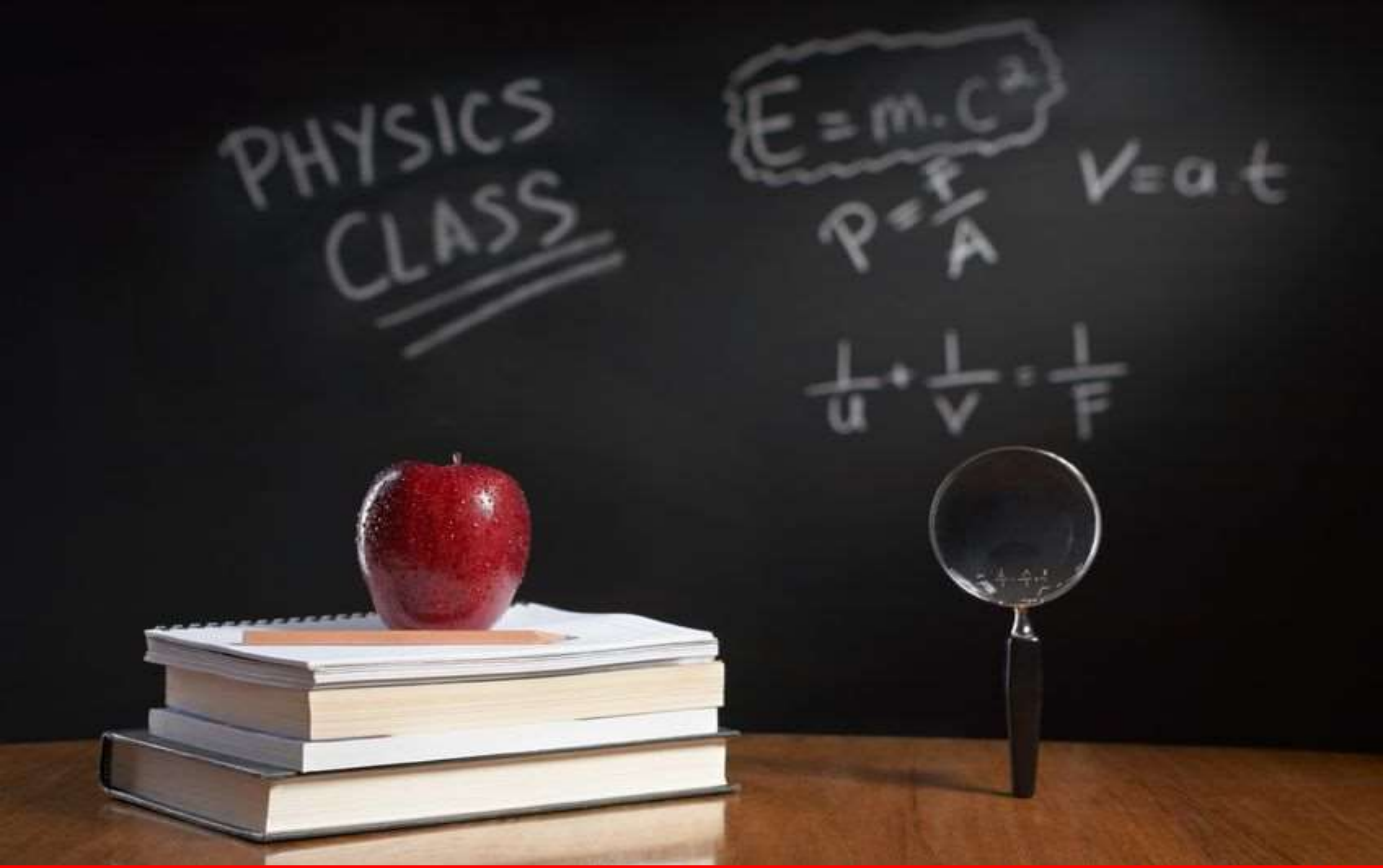


PHYSICS – Speed, velocity and acceleration

LEARNING OBJECTIVES

1.2 Motion	
Core • Define speed and calculate average speed from total time / total distance • Plot and interpret a speed-time graph or a distance- time graph • Recognise from the shape of a speed-time graph when a body is – at rest – moving with constant speed – moving with changing speed • Calculate the area under a speed-time graph to work out the distance travelled for motion with constant acceleration • Demonstrate understanding that acceleration and deceleration are related to changing speed including qualitative analysis of the gradient of a speed-time graph • State that the acceleration of free fall for a body near to the Earth is constant	**Supplement** • Distinguish between speed and velocity • Define and calculate acceleration using time taken change of velocity • Calculate speed from the gradient of a distance-time graph • Calculate acceleration from the gradient of a speed-time graph • Recognise linear motion for which the acceleration is constant • Recognise motion for which the acceleration is not constant • Understand deceleration as a negative acceleration • Describe qualitatively the motion of bodies falling in a uniform gravitational field with and without air resistance (including reference to terminal velocity)

$$\text{Average speed} = \frac{\text{Distance moved}}{\text{Time taken}}$$

A

$$\text{Average speed} = \frac{\text{Distance moved}}{\text{Time taken}}$$

Distance measured in metres (m)

Time measured in seconds (s)

Speed - metres per second (m/s)

$$\text{Average speed} = \frac{\text{Distance moved}}{\text{Time taken}}$$

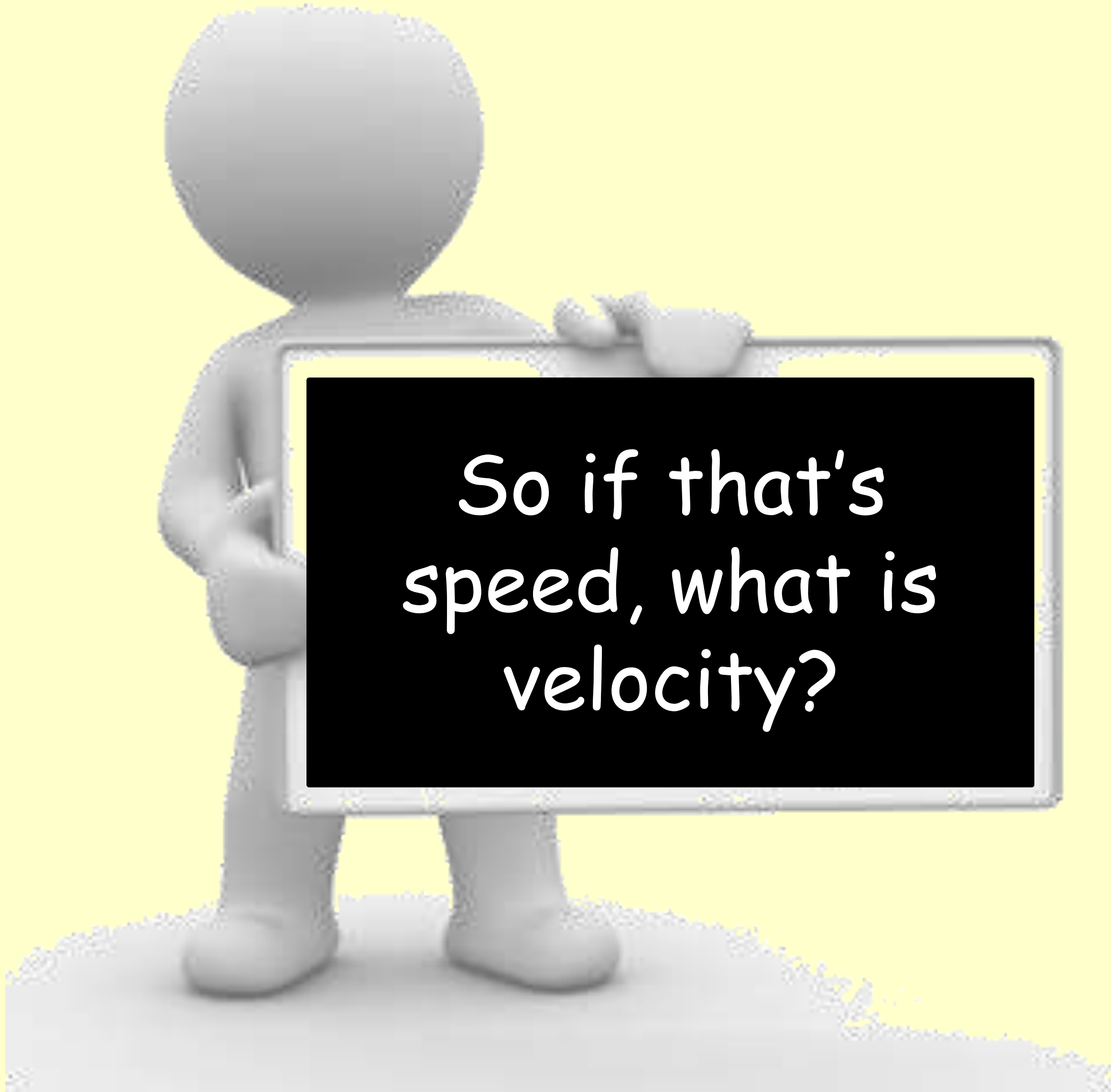
Example:

Car travels 50m

time 2s

speed = 50/2 = 25 m/s

25 $m.s^{-1}$


So if that's speed, what is velocity?

Velocity is speed in a given direction.

Velocity is speed in a given direction.

Velocity is 25m/s due west

Example:

Example:

Example:

Example:

Cyclist +10m/s to the right

Example:

Cyclist

+10m/s to the right

-10m/s to the left


What's your vector Victor?

What’s your vector Victor?

Quantities such as velocity are called **vectors** because they have size and direction

Acceleration is the rate at which an object increases speed or velocity.

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

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Also written as:

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

Acceleration is the rate at which an object increases speed or velocity.

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

Velocity measured in m/s
Time measured in s
Acceleration measured in m/s/s or m/s^2

Example: a drag car increases its velocity from zero to 60m/s in 3s.

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

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

$$a = \frac{60 - 0}{3}$$

$$a = \frac{60}{3} = 20 m/s^{-2}$$

Don't forget that acceleration is a vector – it has size and direction

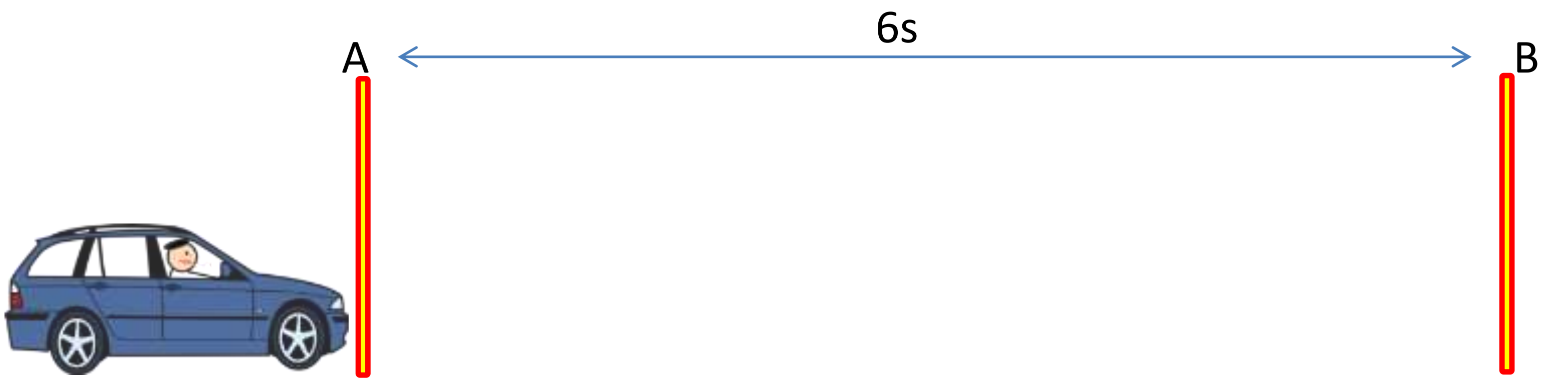
Deceleration (retardation)

Deceleration is negative acceleration – the object is slowing down. Eg. – 4m/s²

Constant acceleration example

Car passes point A with a velocity of 10m/s. It has a steady (constant) acceleration of $4 m/s^2$. What is the velocity when it passes point B?

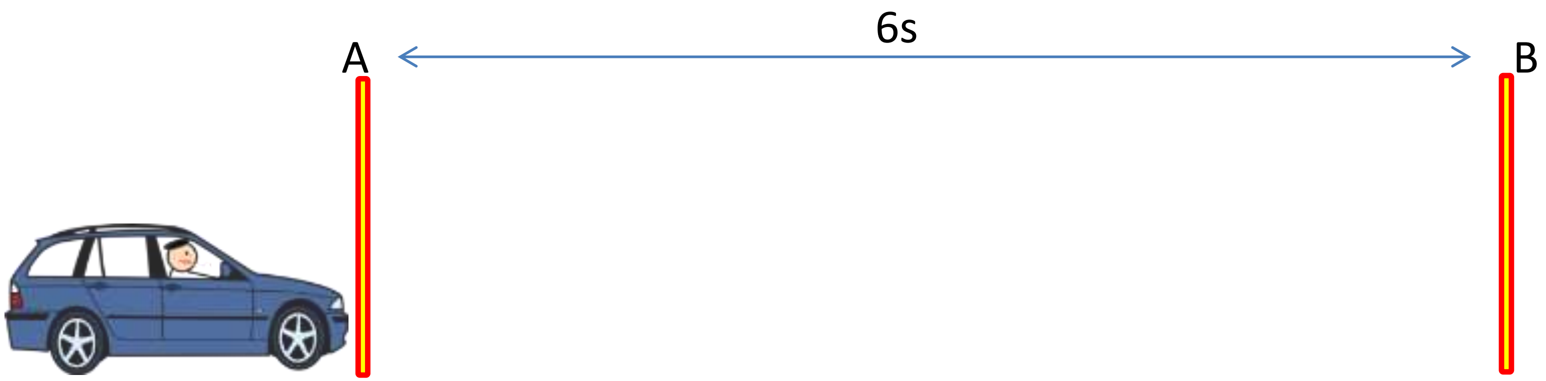
Constant acceleration example



Car passes point A with a velocity of 10m/s. It has a steady (constant) acceleration of $4 m/s^2$. What is the velocity when it passes point B?

Solution: car gains 4m/s of velocity every second. In 6s it gains an extra 24m/s.

Constant acceleration example



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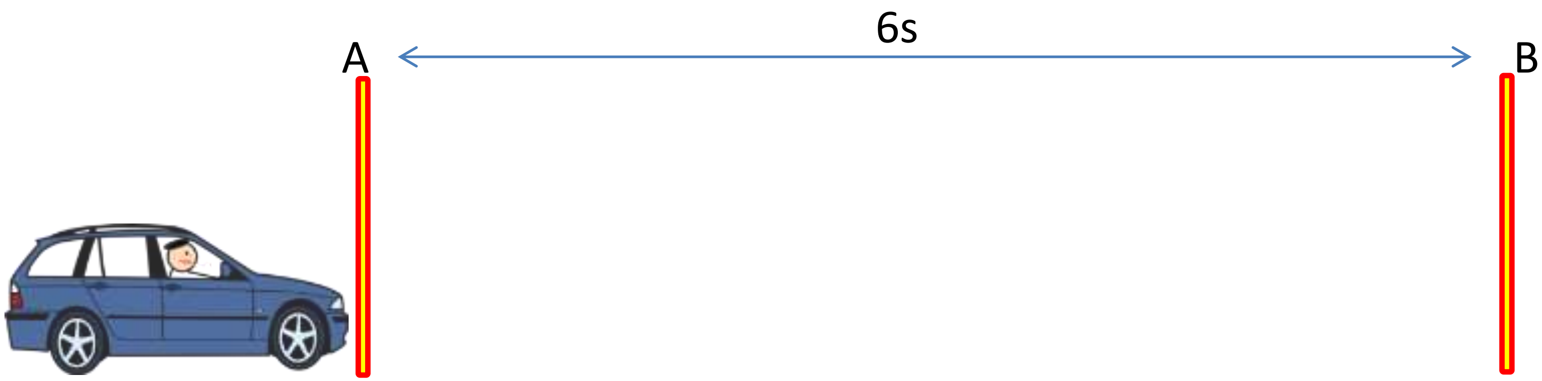
Final velocity = initial velocity + extra velocity

Constant acceleration example



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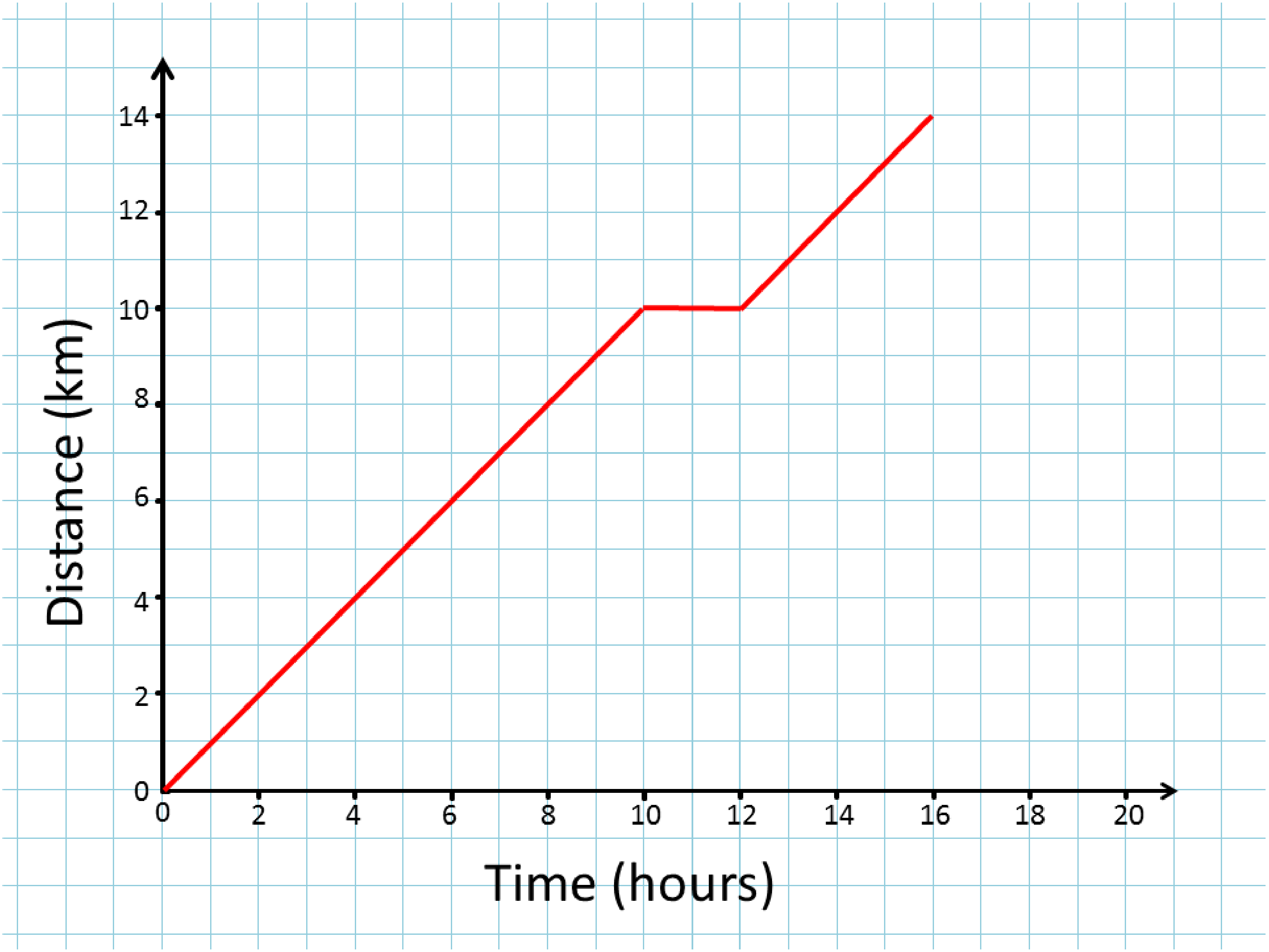
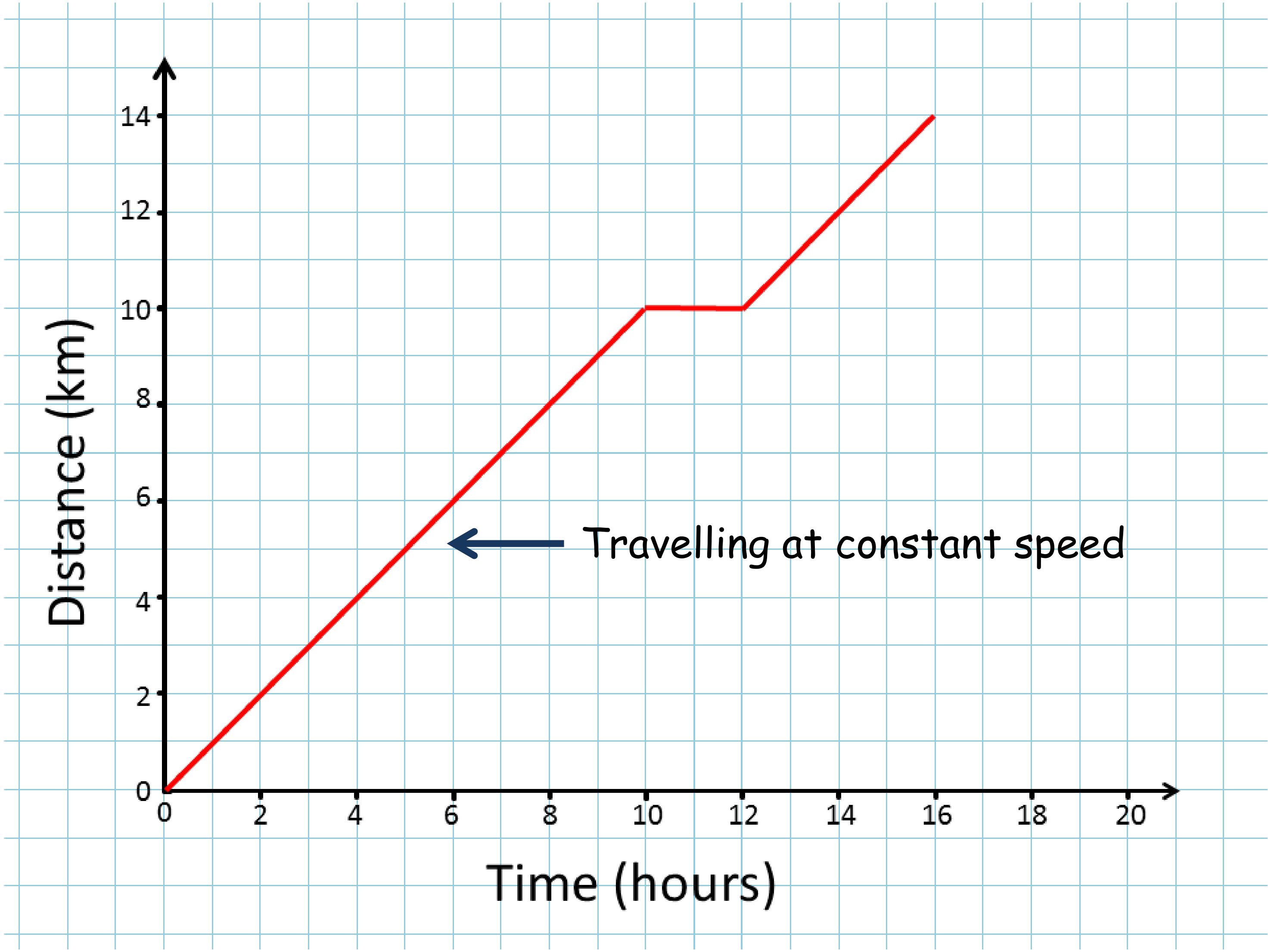
Final velocity = initial velocity + extra velocity

Final velocity = 10 + 24 = 34m/s

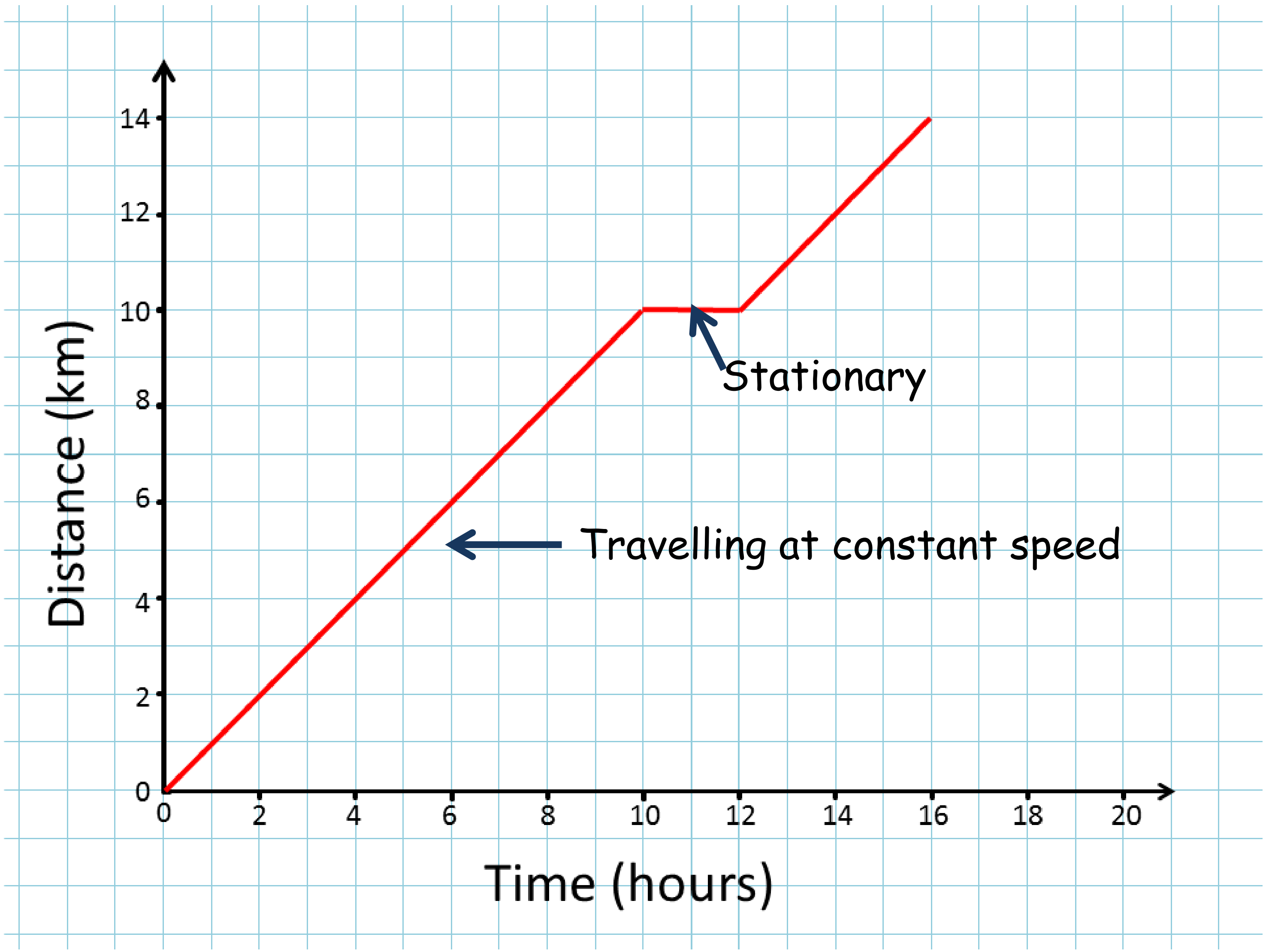
Motion graphs

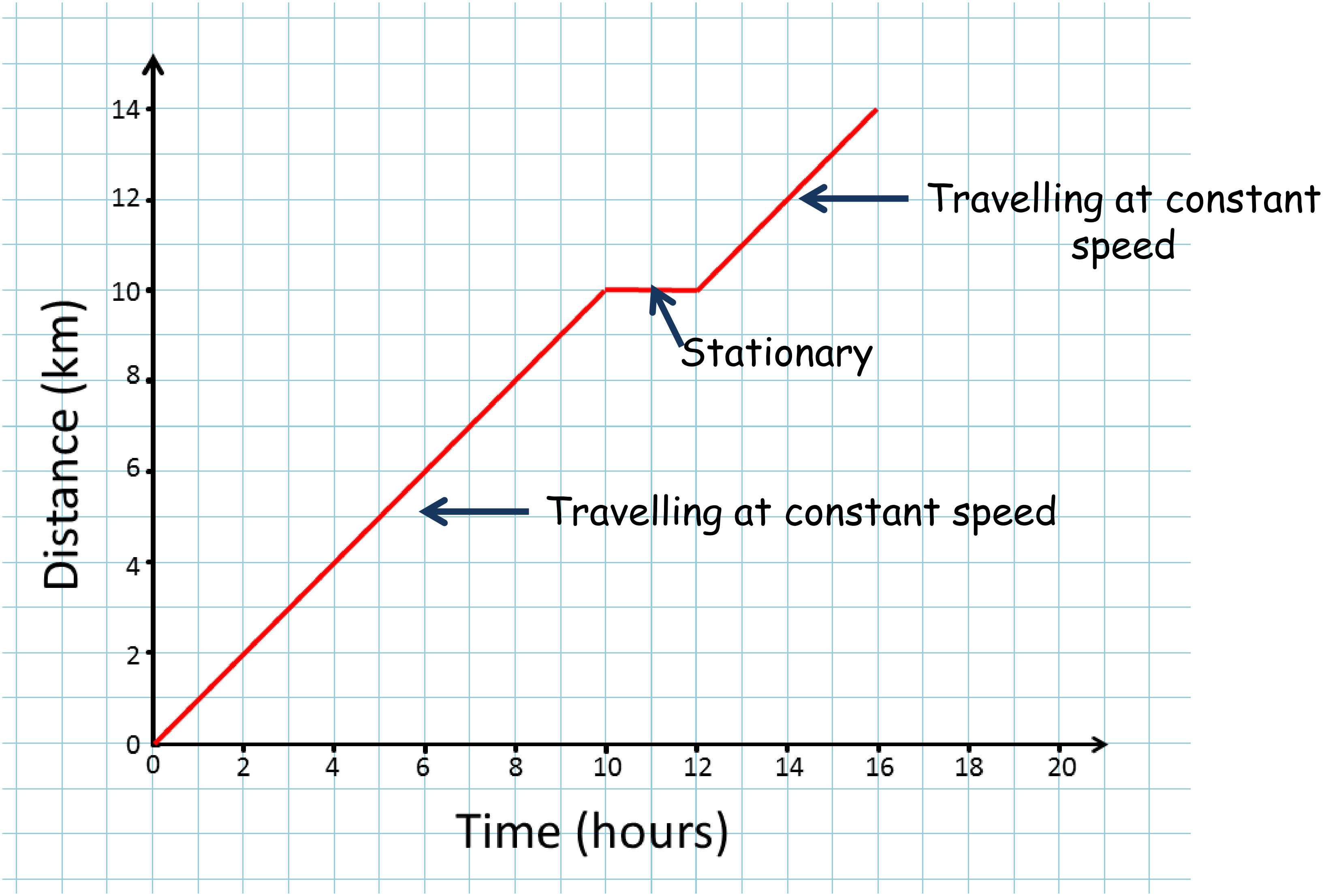


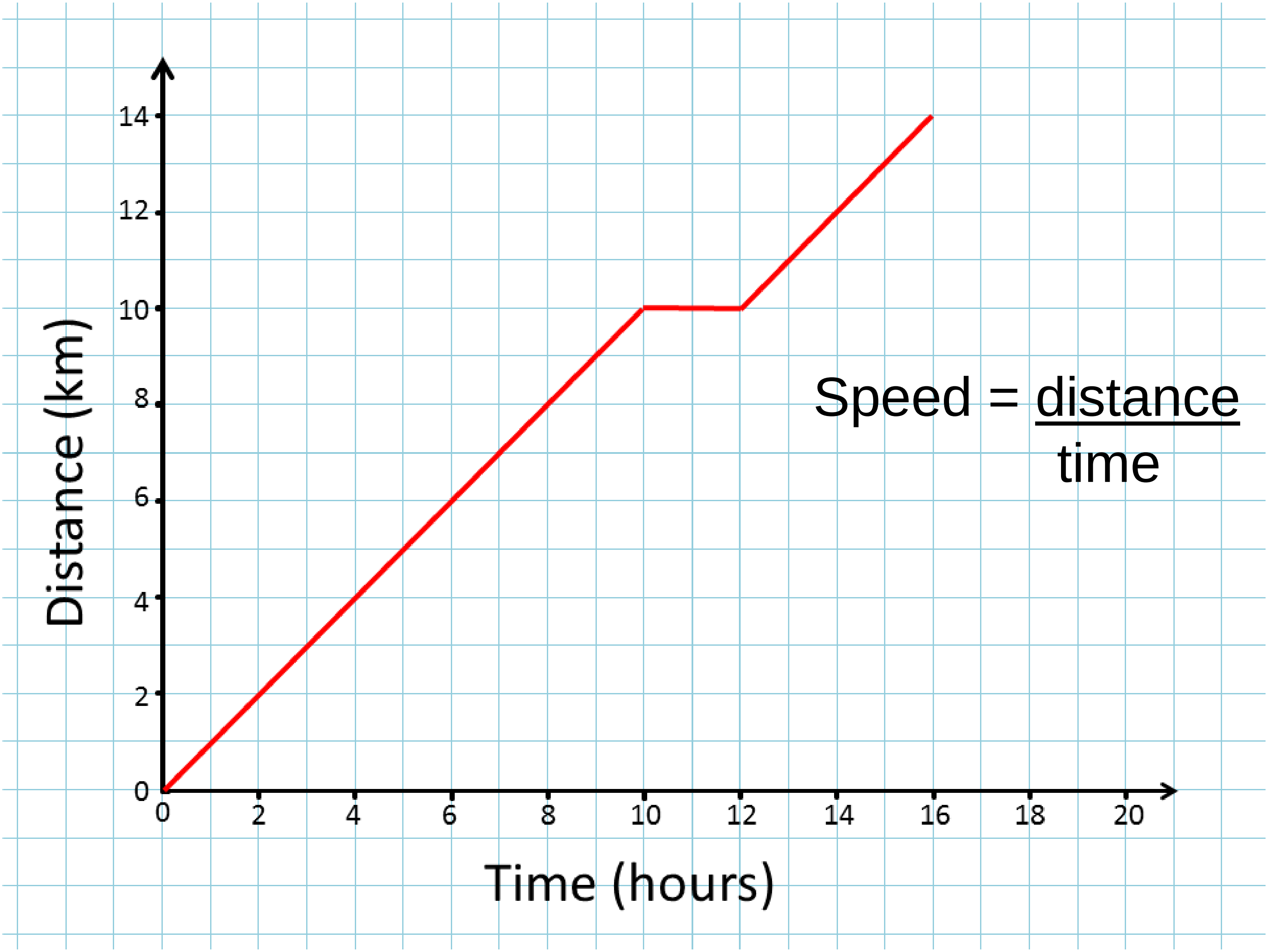
Distance (km)
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
16
18
20
Time (hours)



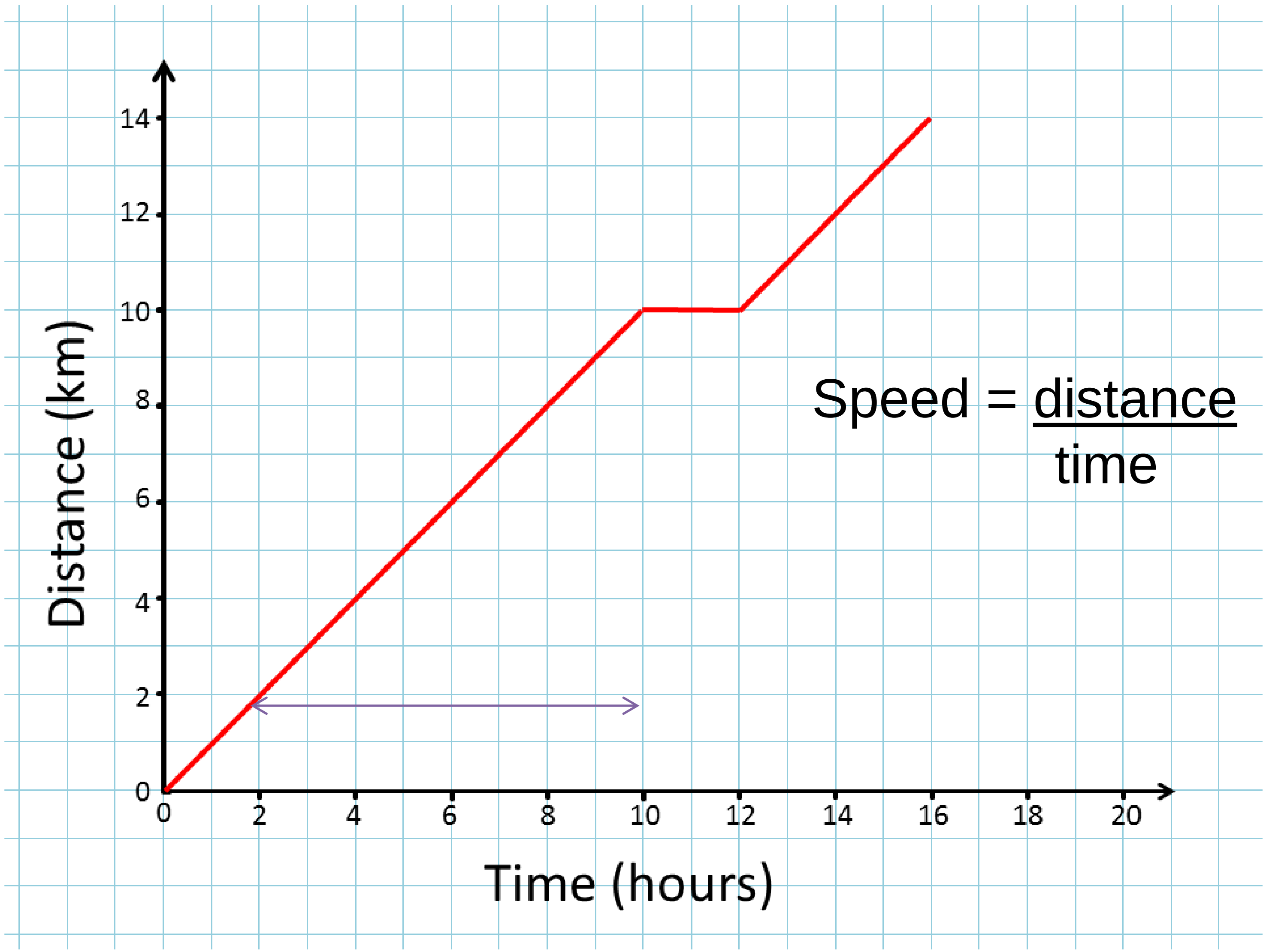
Distance (km)
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
16
18
20
Time (hours)
Travelling at constant speed


Distance (km)
14
12
10
8
6
4
2
0
Stationary
Travelling at constant speed
0
2
4
6
8
10
12
14
16
18
20
Time (hours)

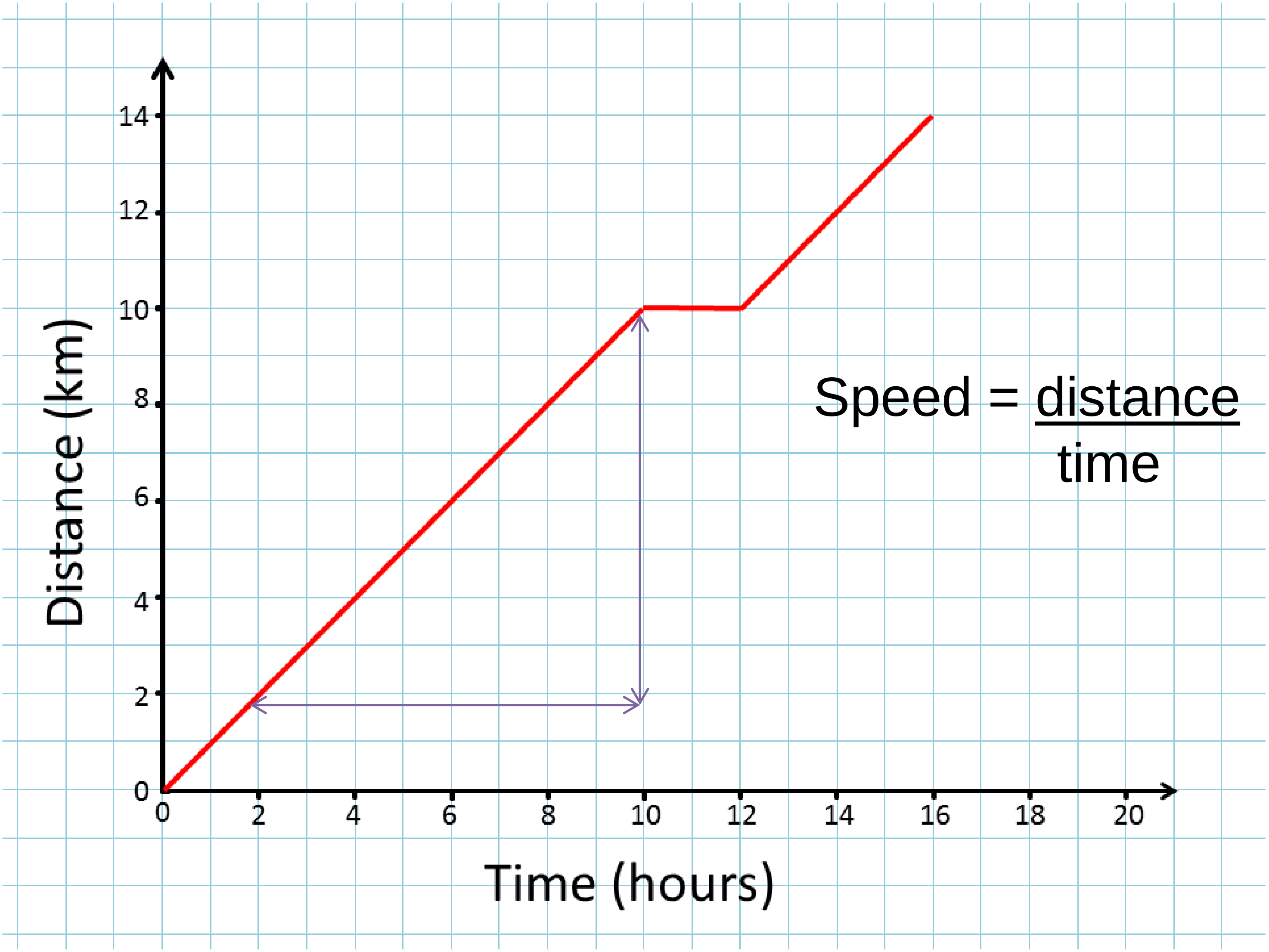

Travelling at constant speed
Stationary
Travelling at constant speed
Distance (km)
Time (hours)
0
2
4
6
8
10
12
14
16
18
20



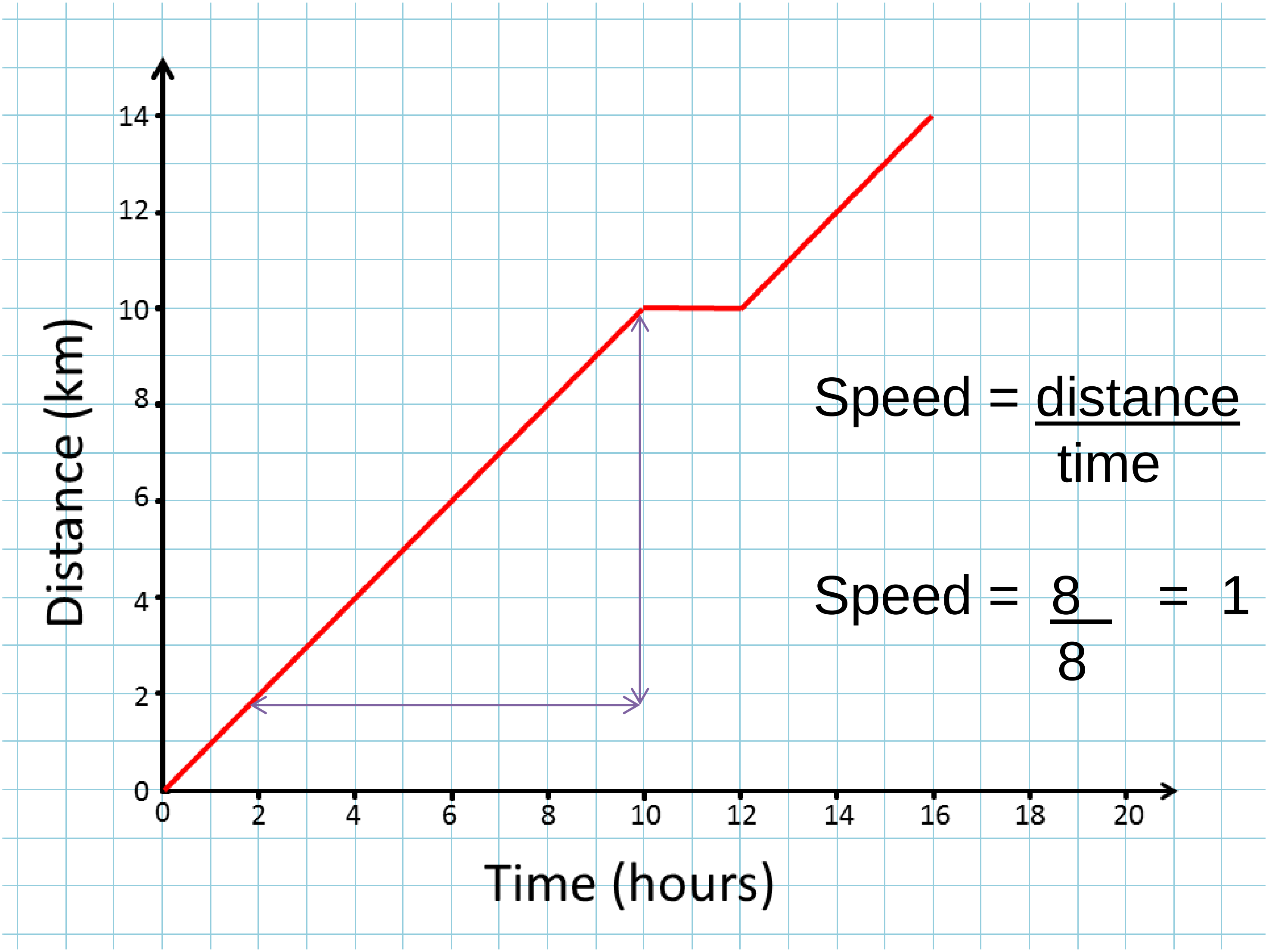
$$\text{Speed} = \frac{\text{distance}}{\text{time}}$$



Distance (km)
14
12
10
8
6
4
2
0
0
2
4
6
8
10
12
14
16
18
20
Time (hours)
Speed = distance / time



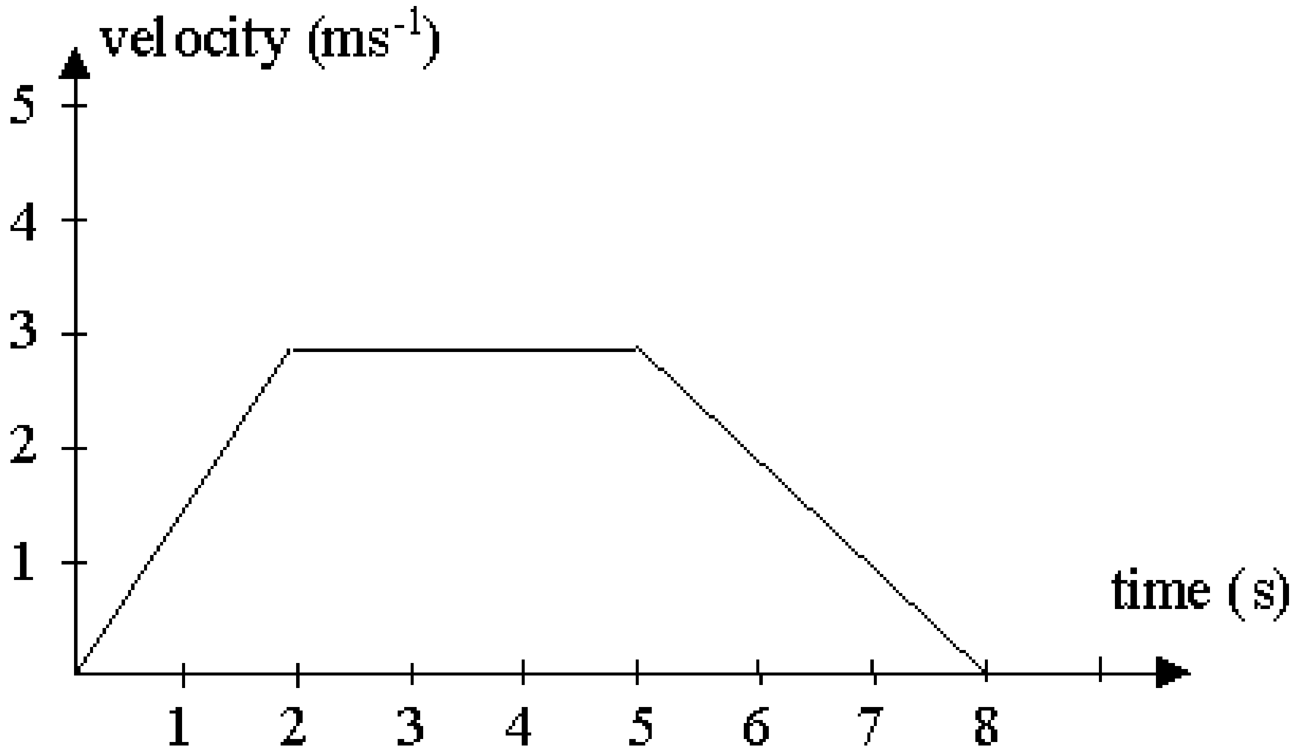
Speed = $\frac{\text{distance}}{\text{time}}$



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

Speed = $\frac{8}{8}$ = 1 km/h

Acceleration from velocity : time graph



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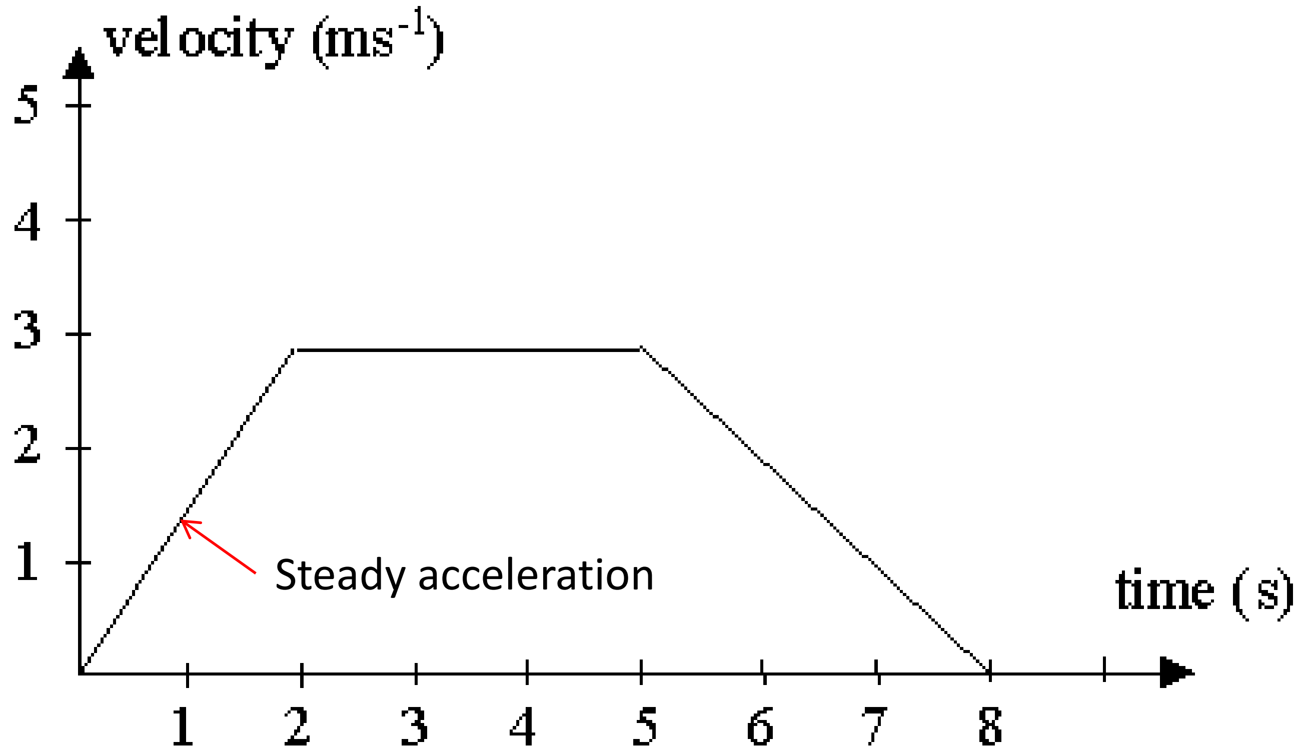
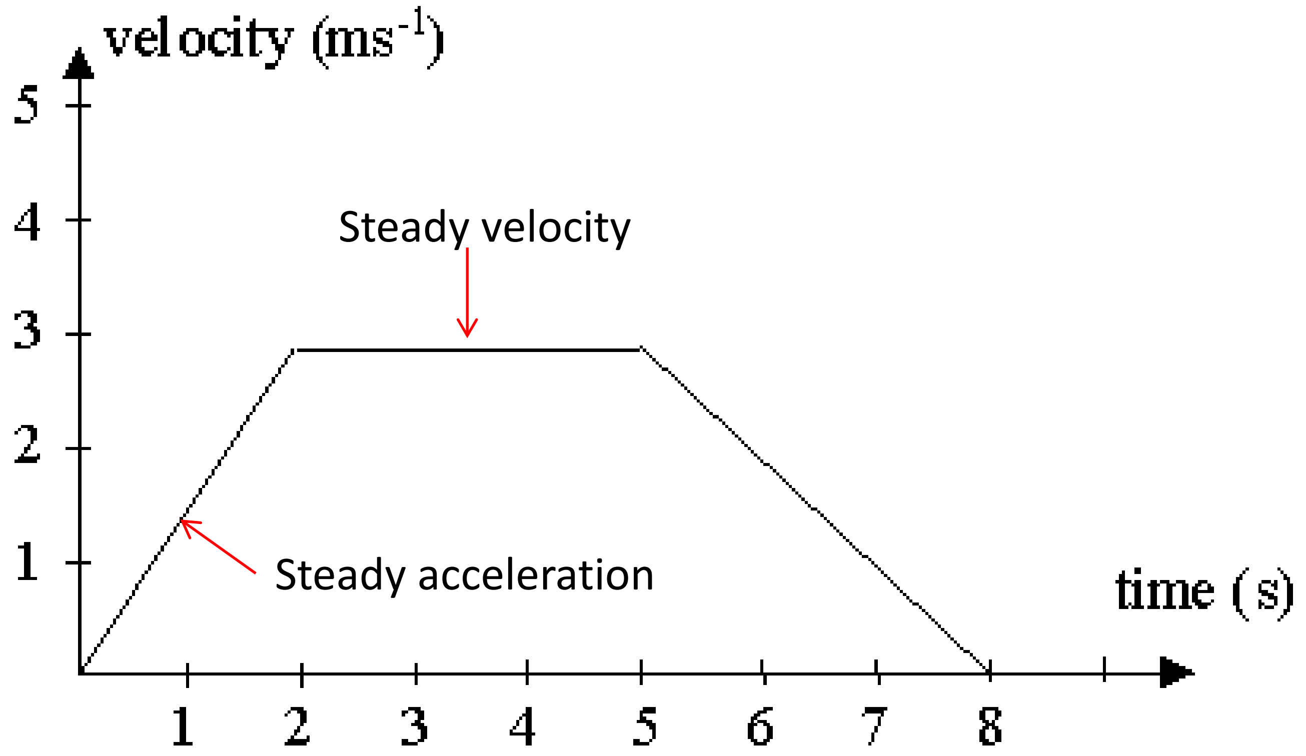
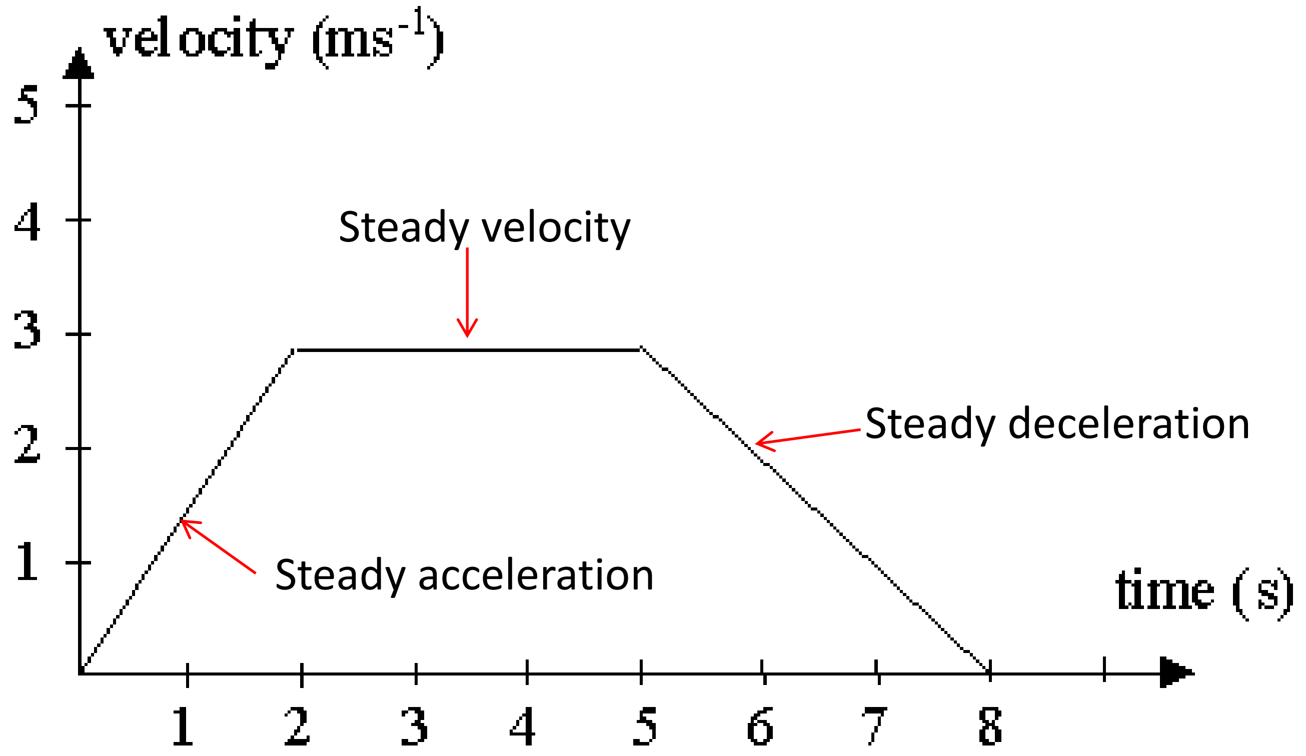


Acceleration from velocity : time graph



Acceleration from velocity : time graph



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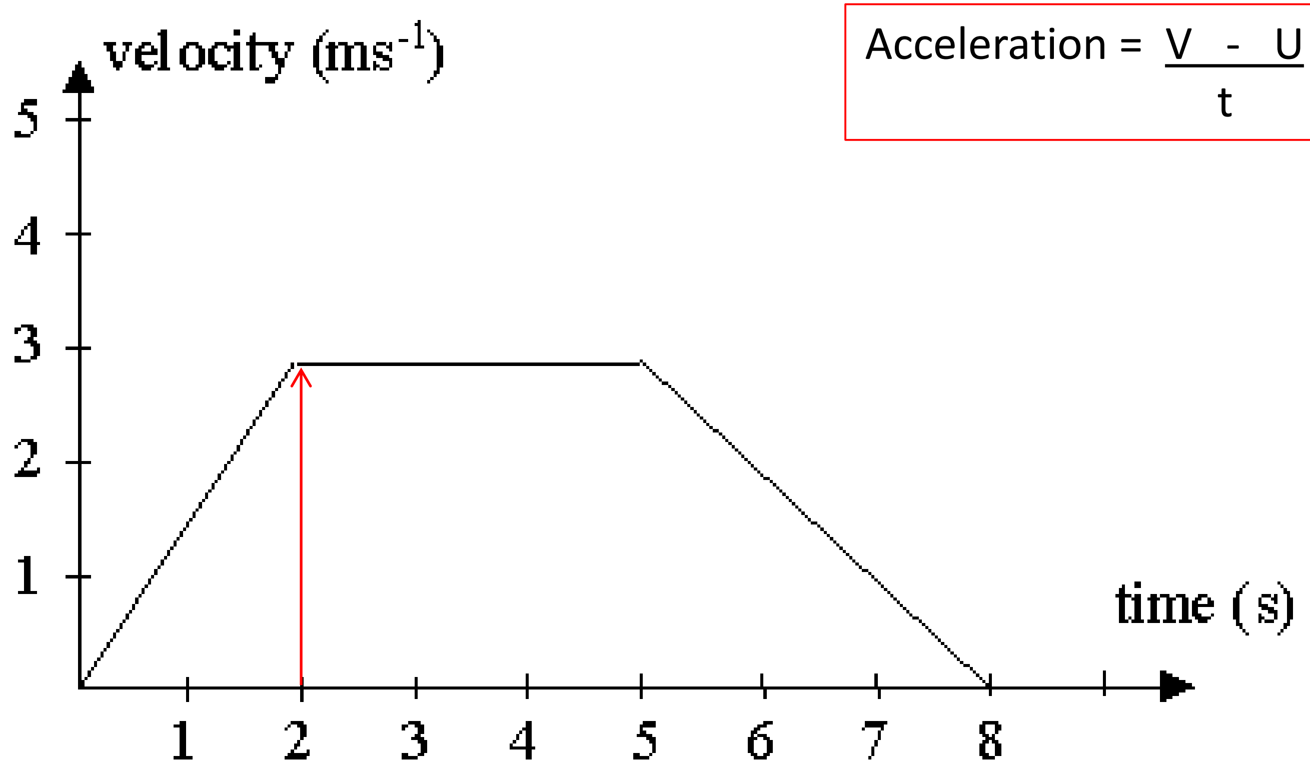
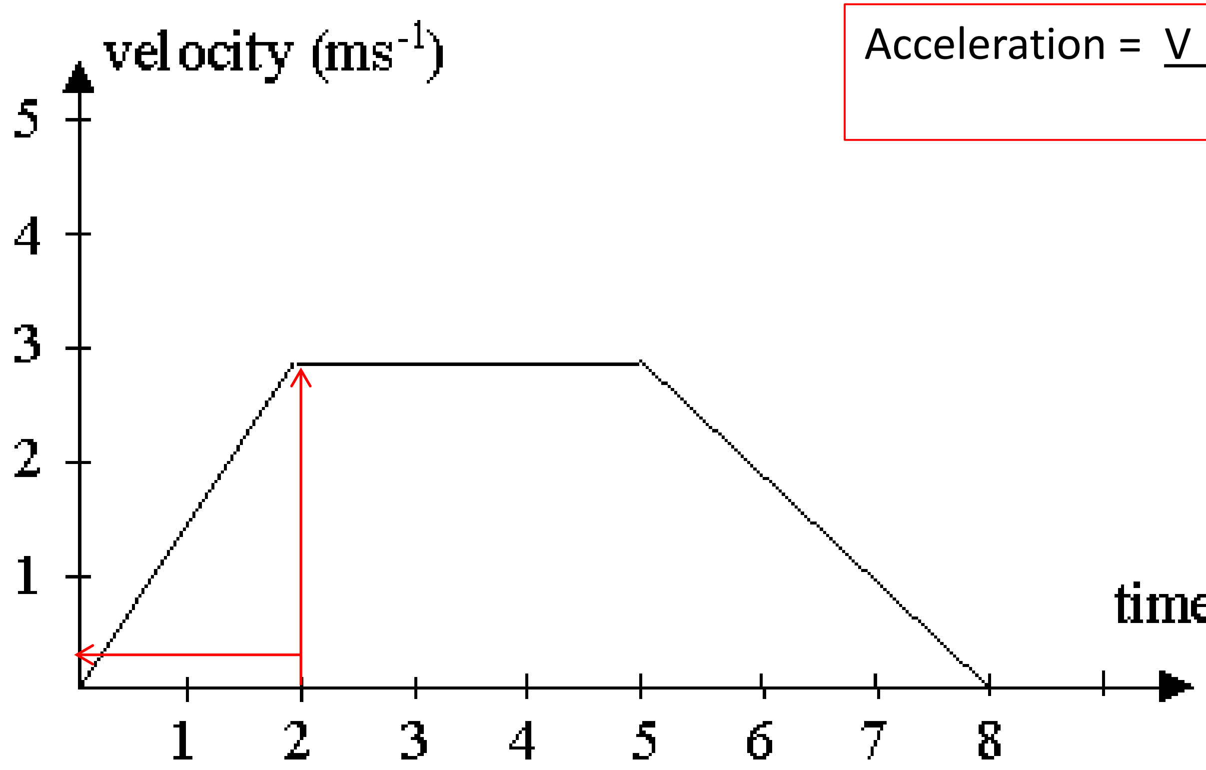


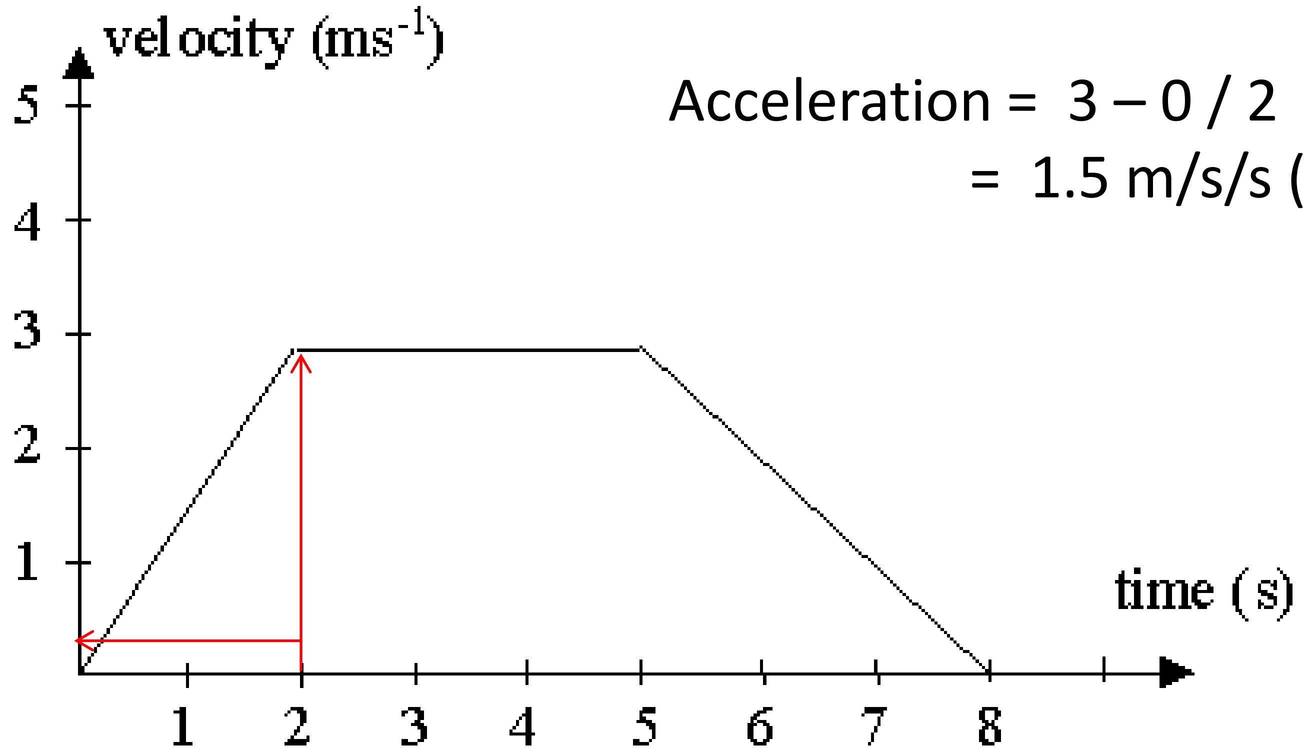
Acceleration = $\frac{V - U}{t}$

Acceleration from velocity : time graph

Acceleration = $\frac{V - U}{t}$



Acceleration from velocity : time graph

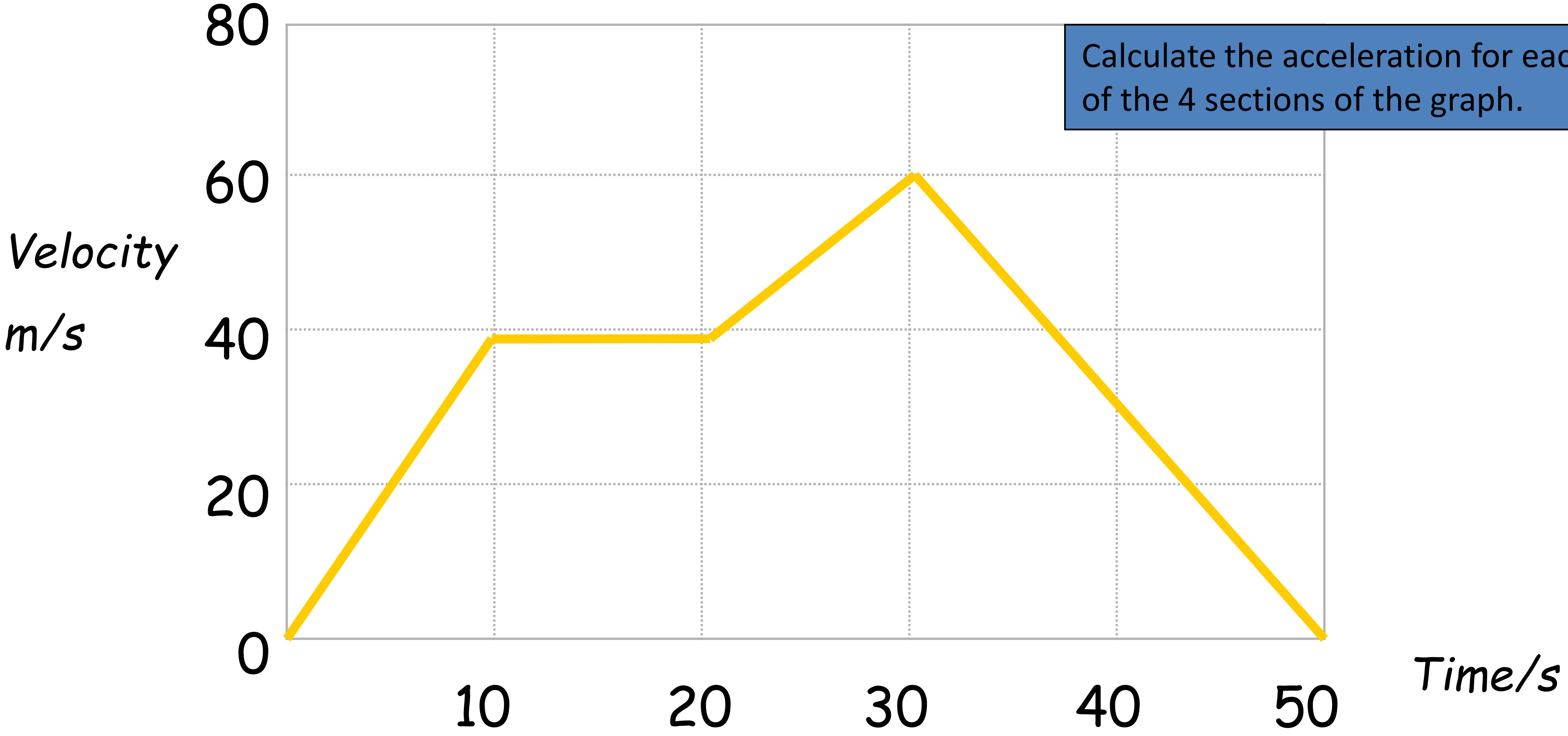


Acceleration = 3 – 0 / 2

= 1.5 m/s/s (m.s^{-2})

Velocity-time graphs

Acceleration can be calculated by the gradient of a velocity:time graph. (Remember gradient is the difference up divided by the difference across)



Calculate the acceleration for each of the 4 sections of the graph.

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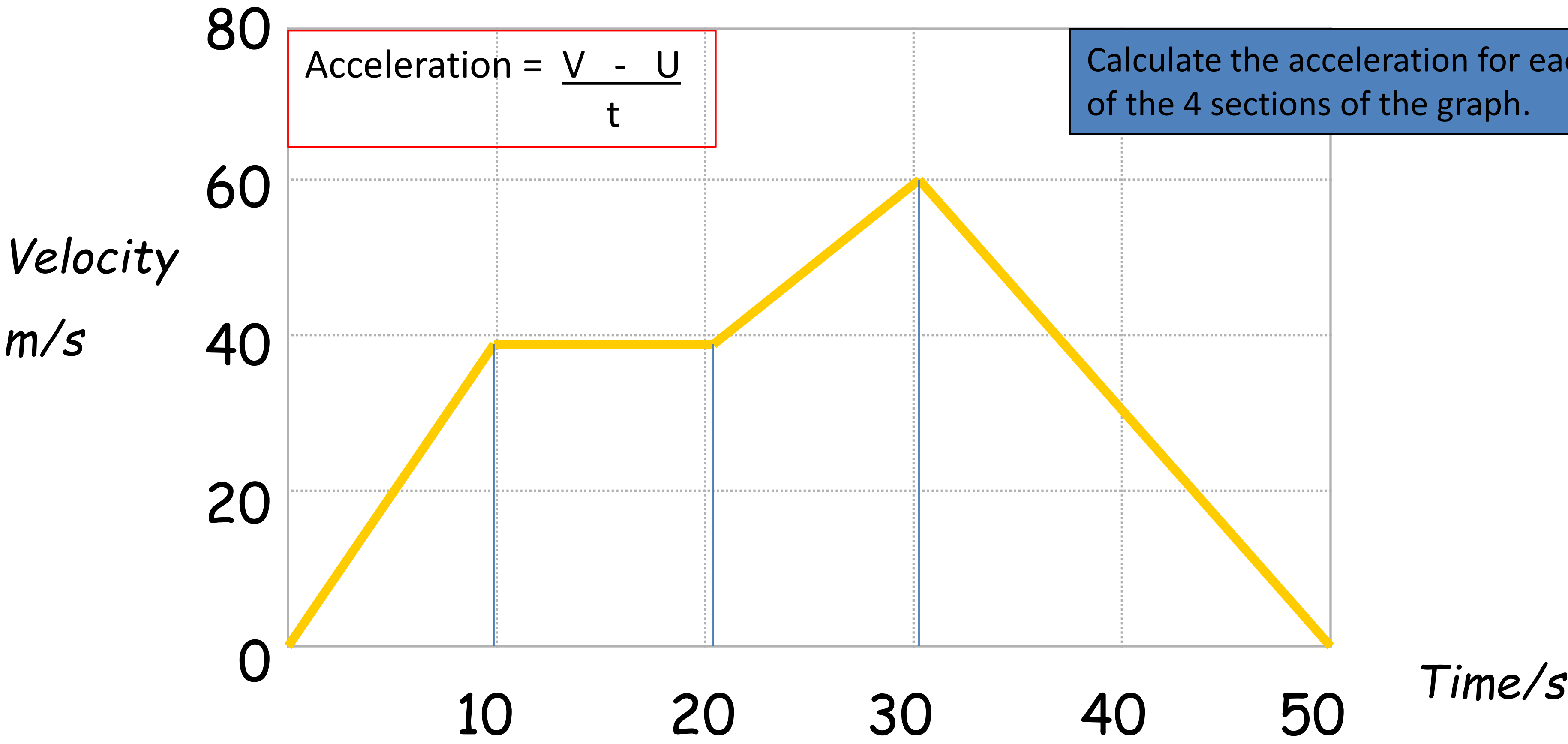

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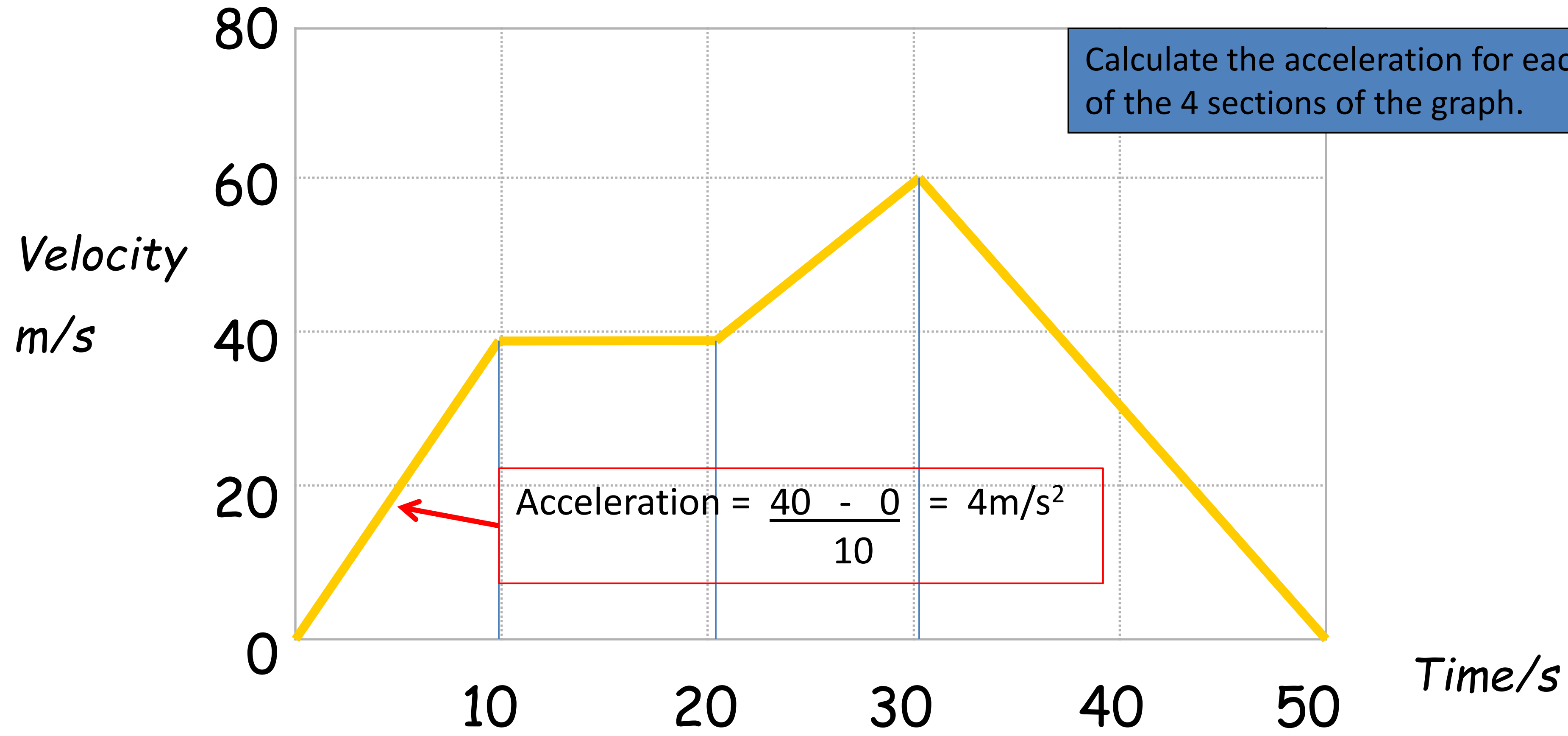

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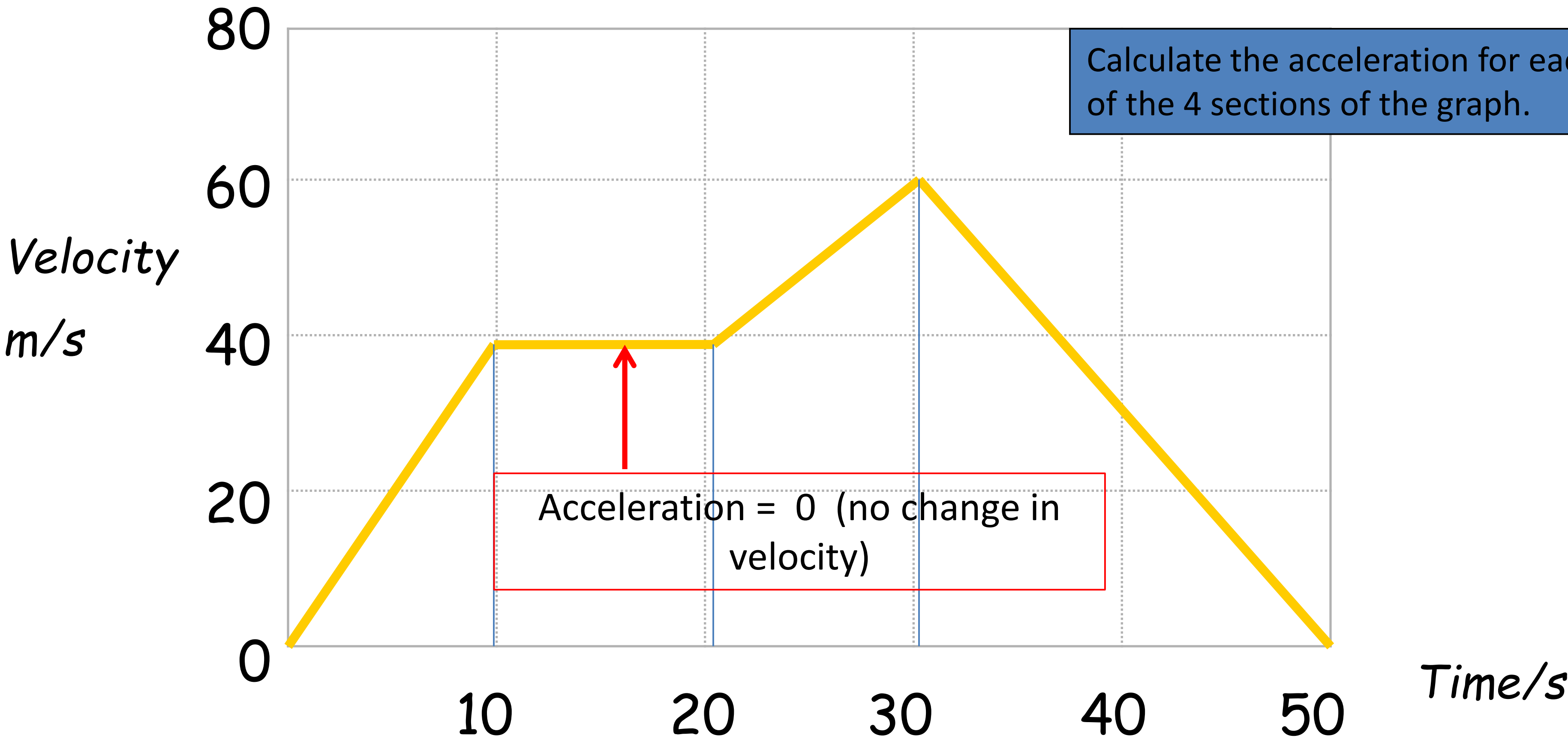

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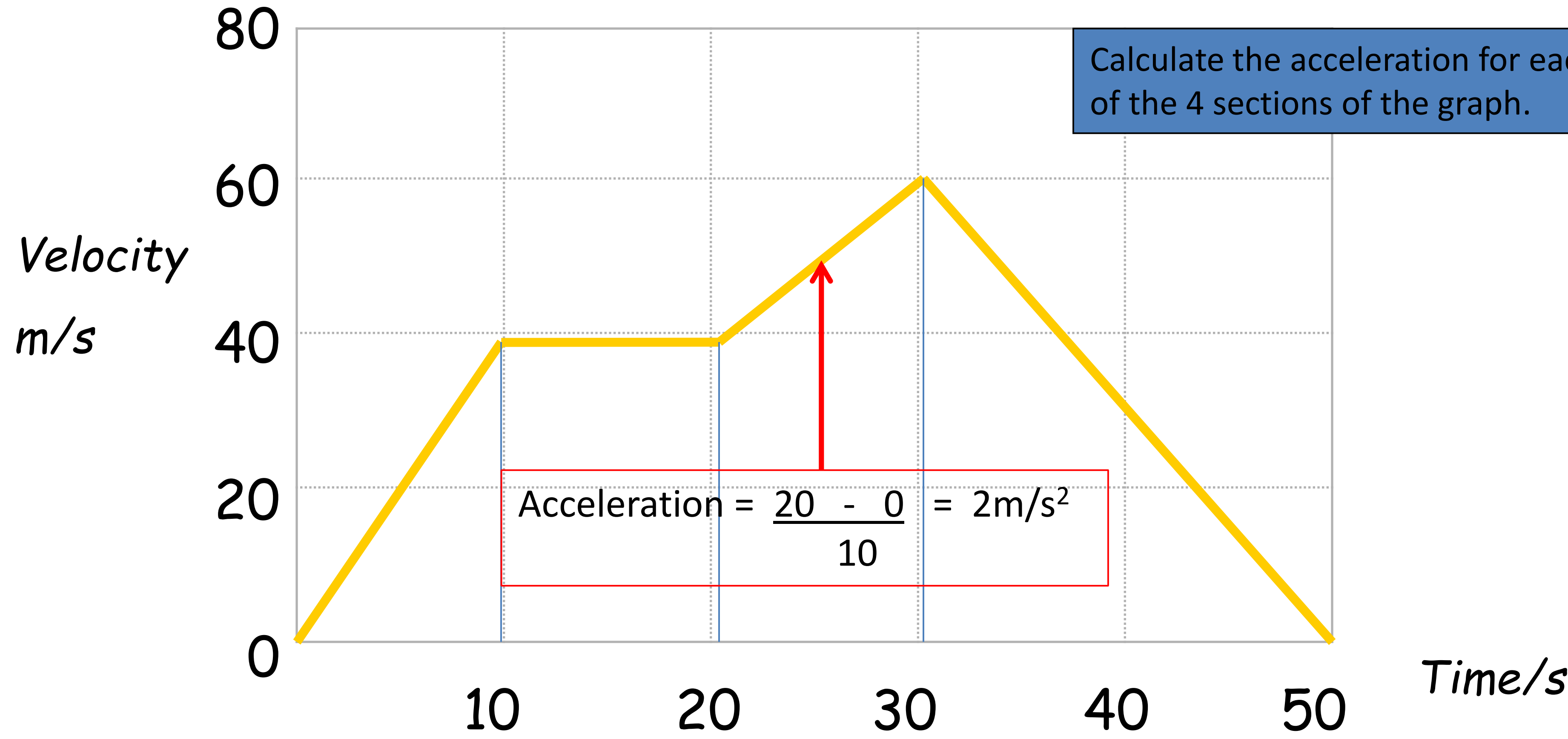

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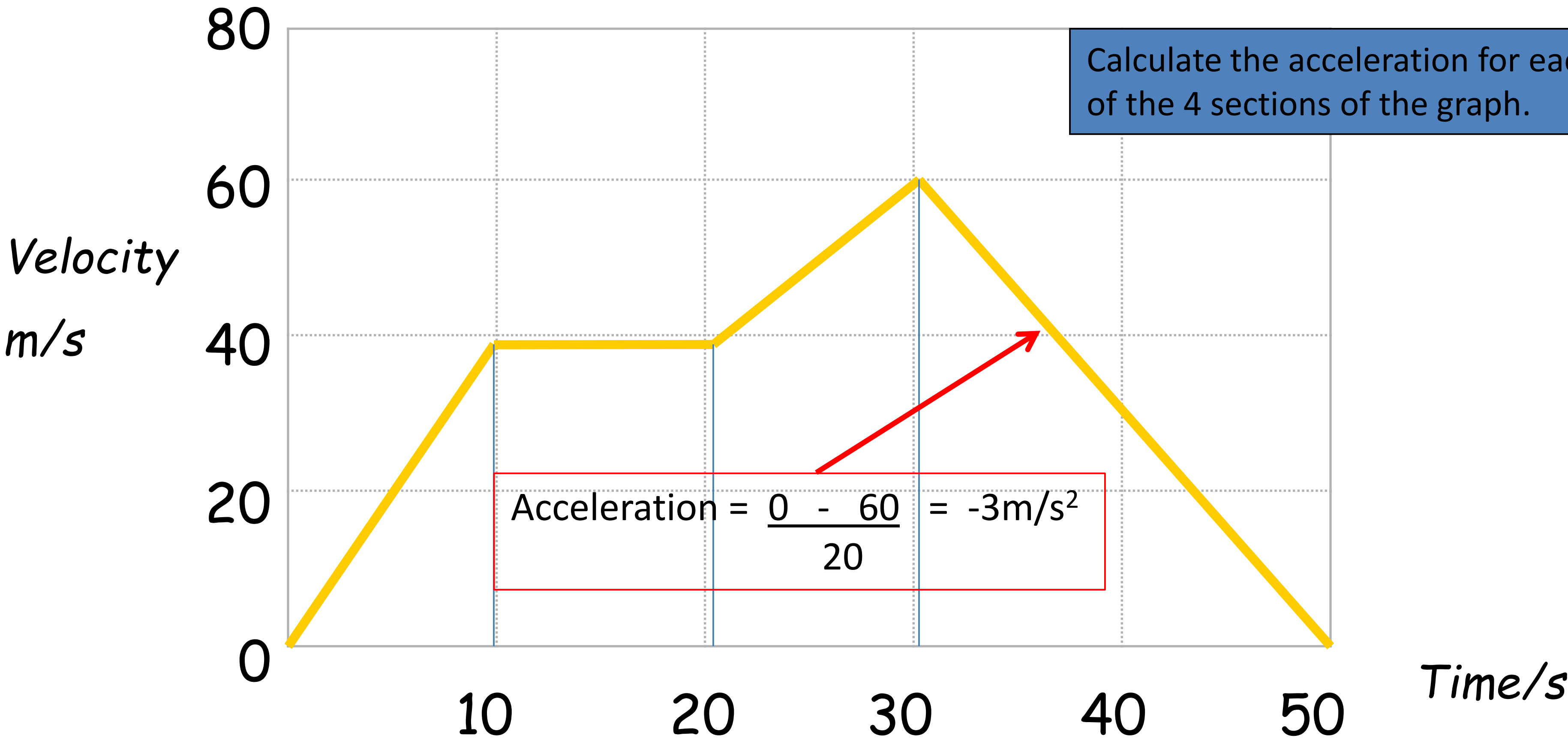
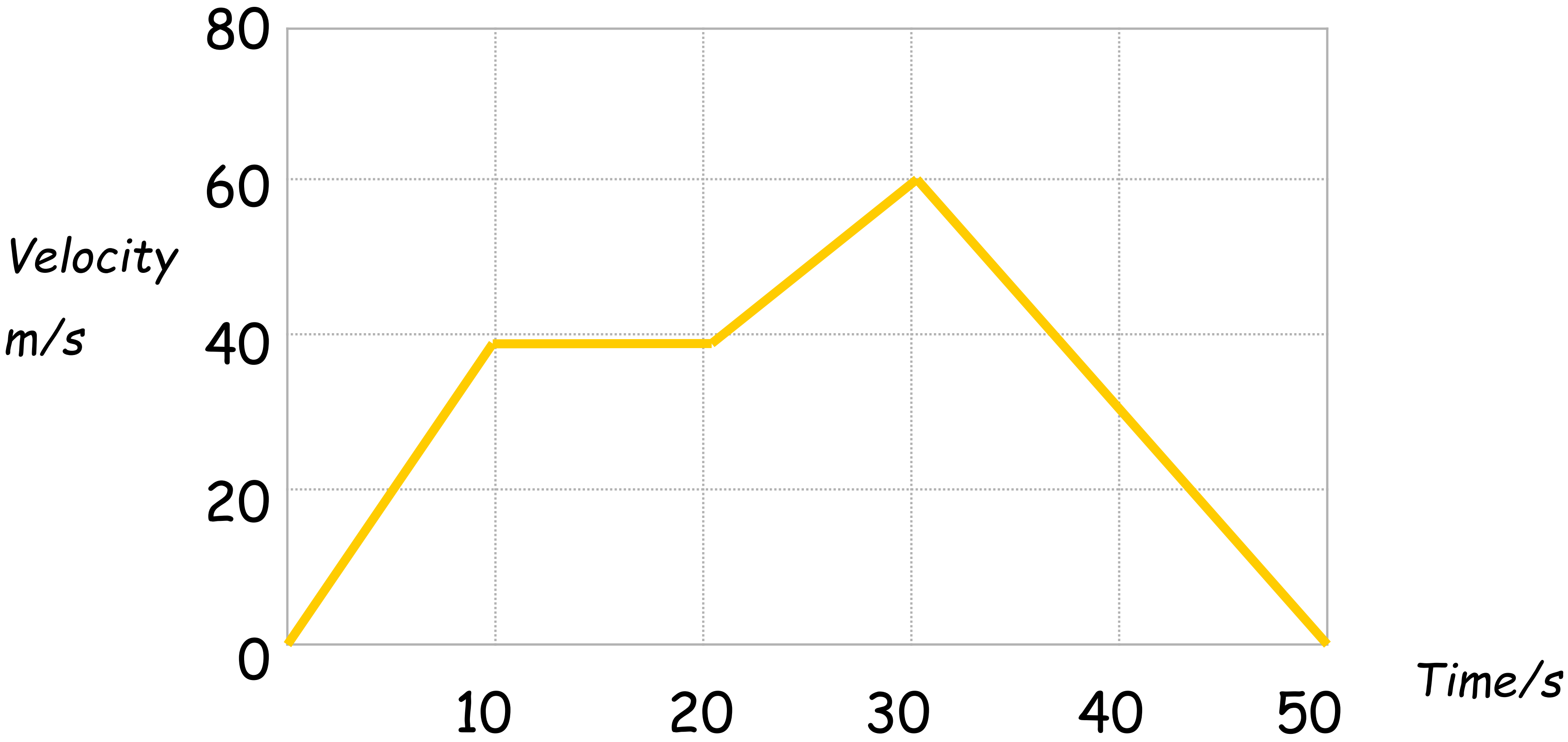


Velocity-time graphs

On a velocity – time (or speed – time) graph, the area under the line is numerically equal to the distance travelled.



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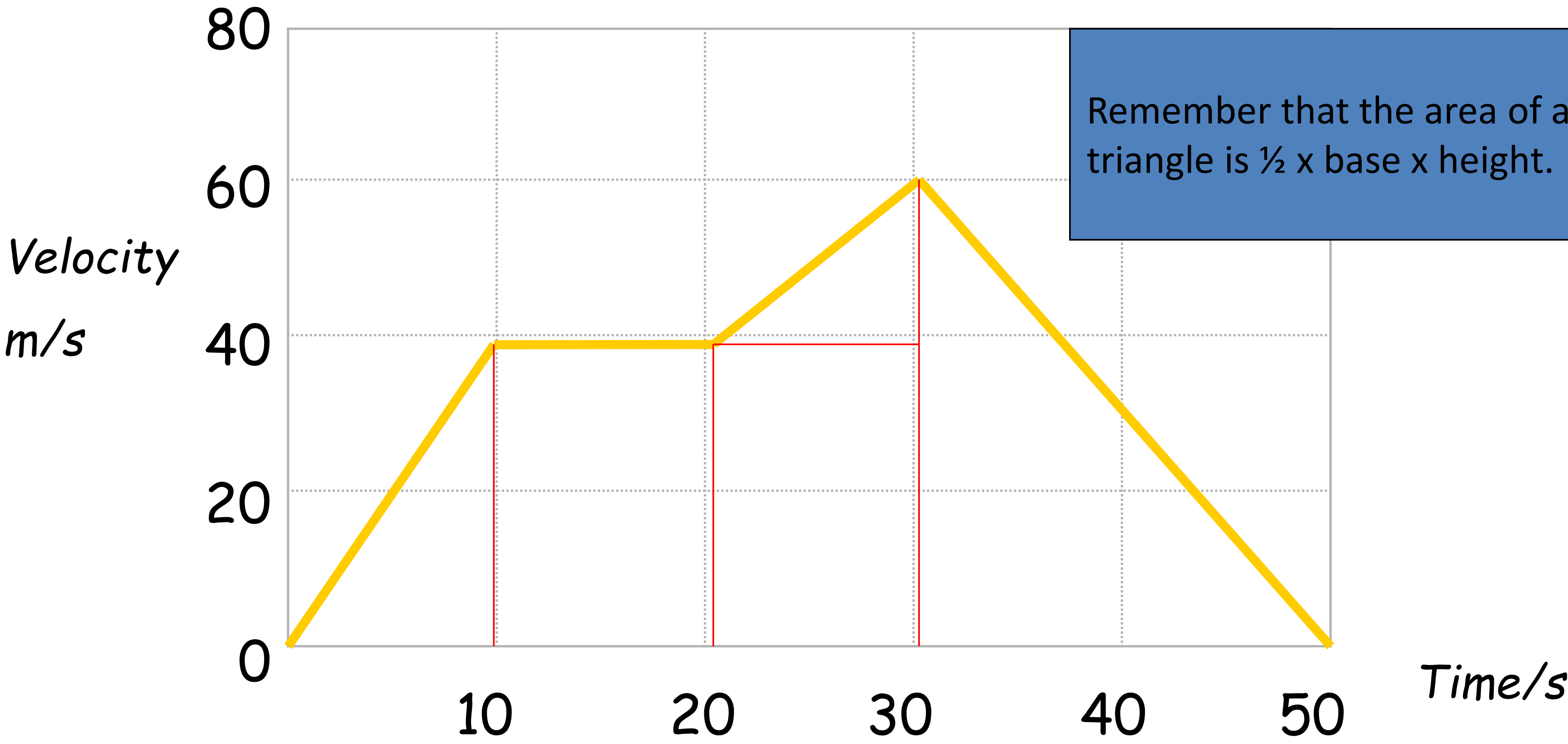

Remember that the area of a triangle is ½ x base x height.

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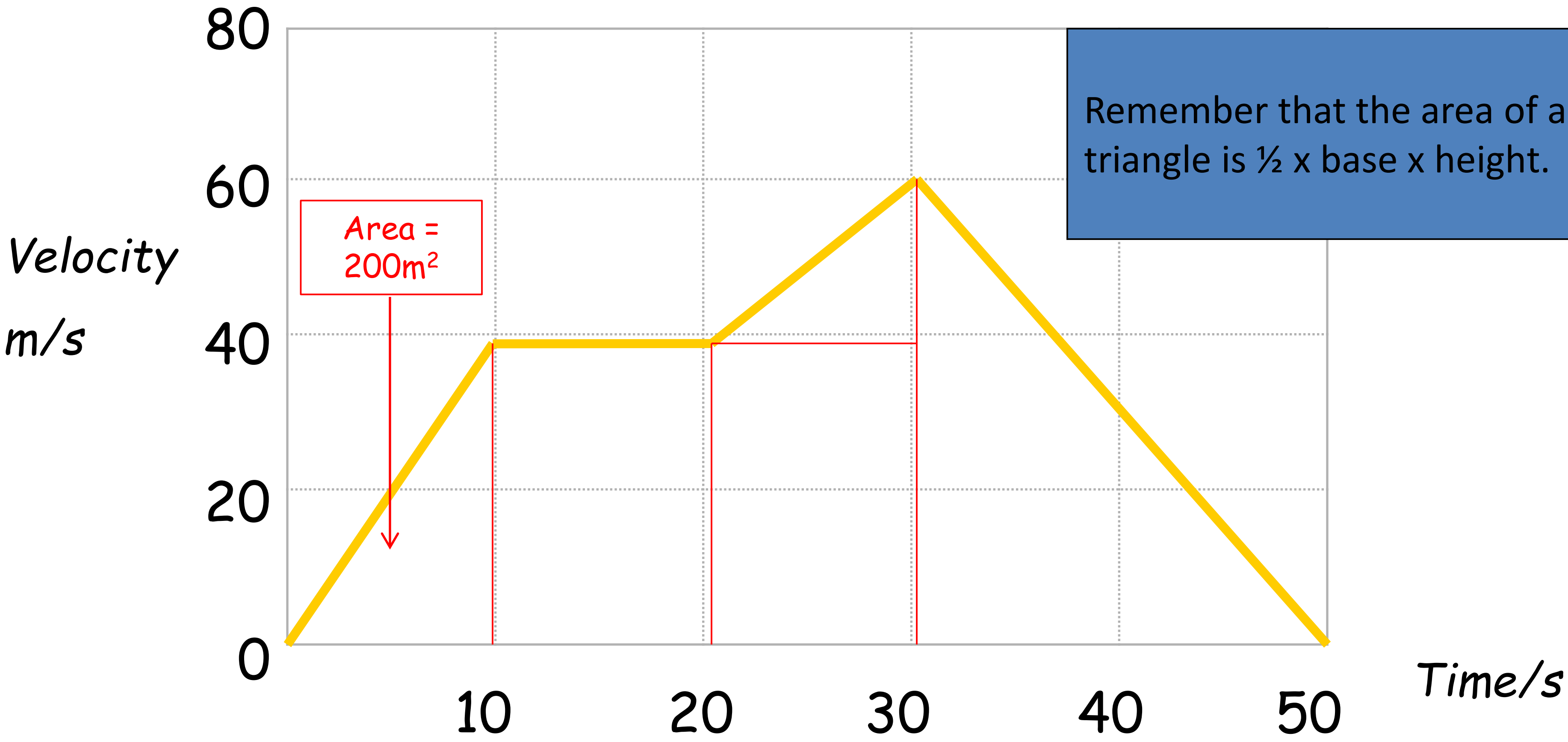

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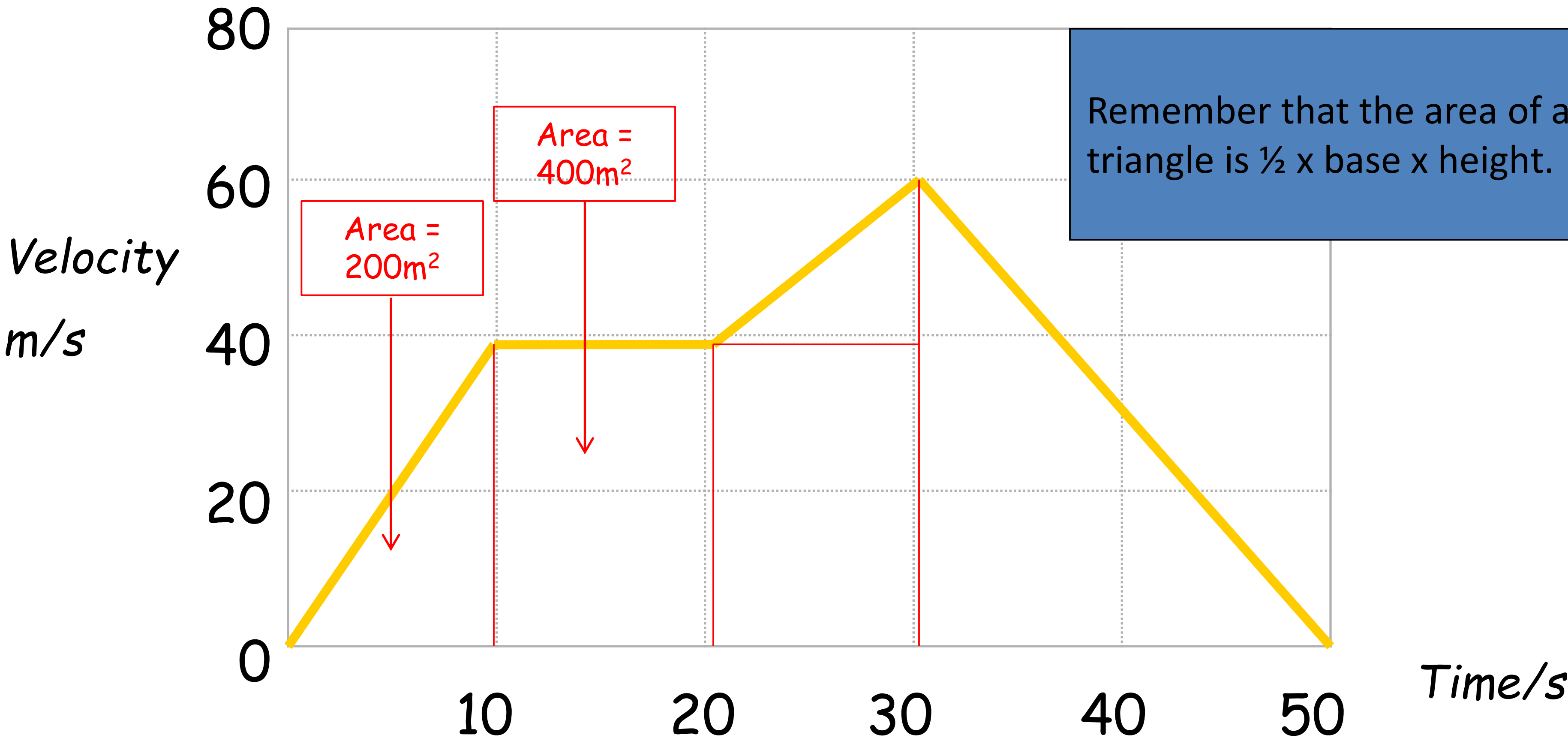

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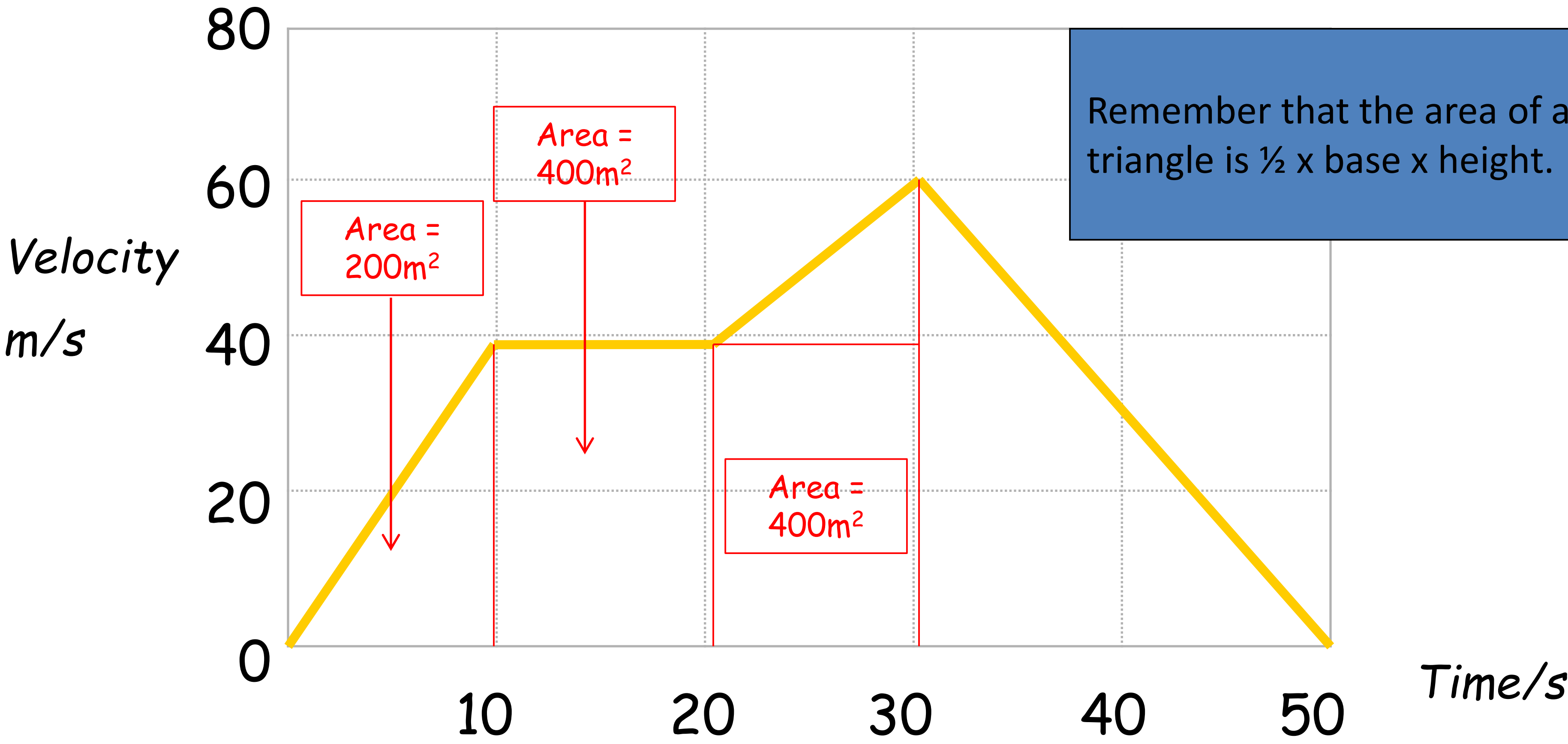

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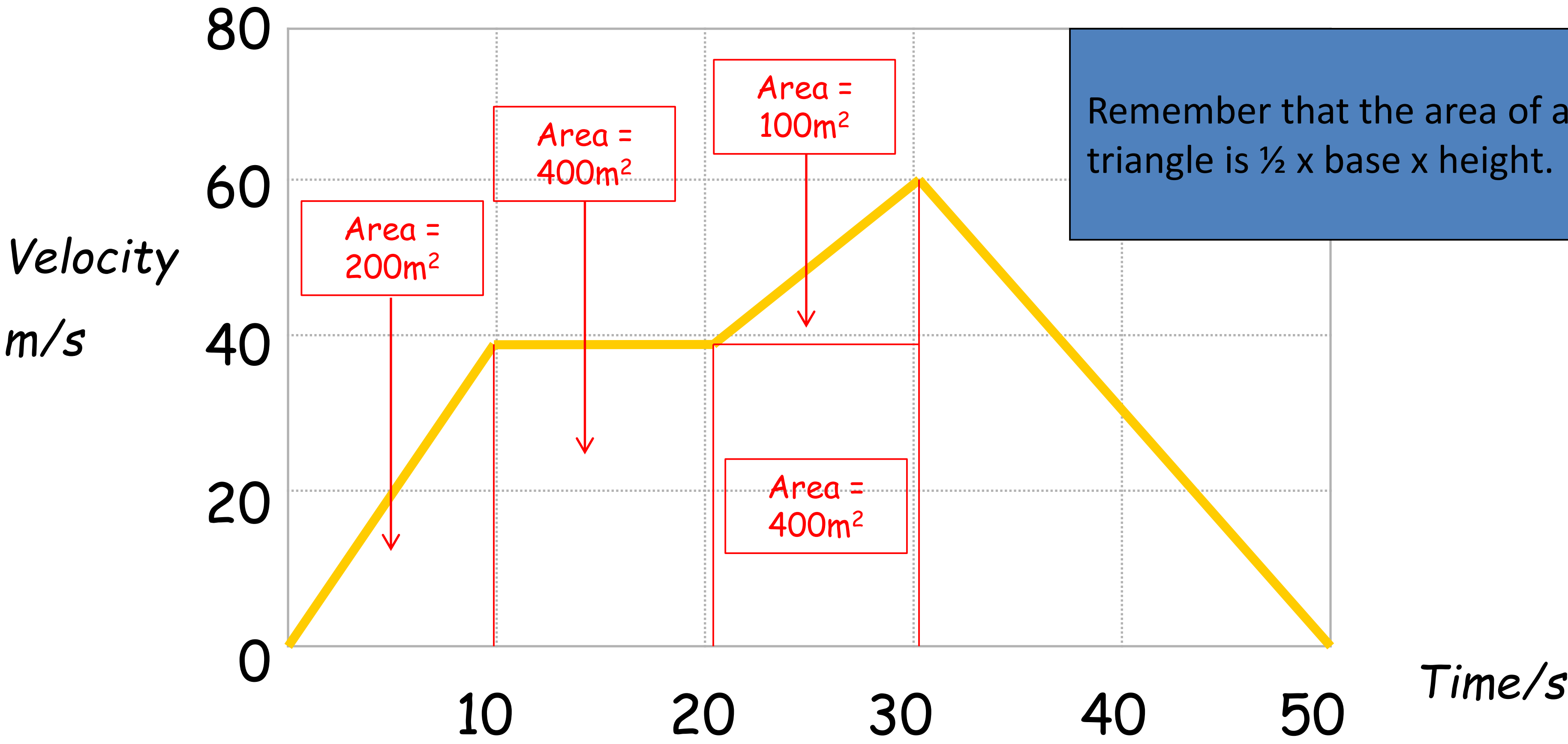

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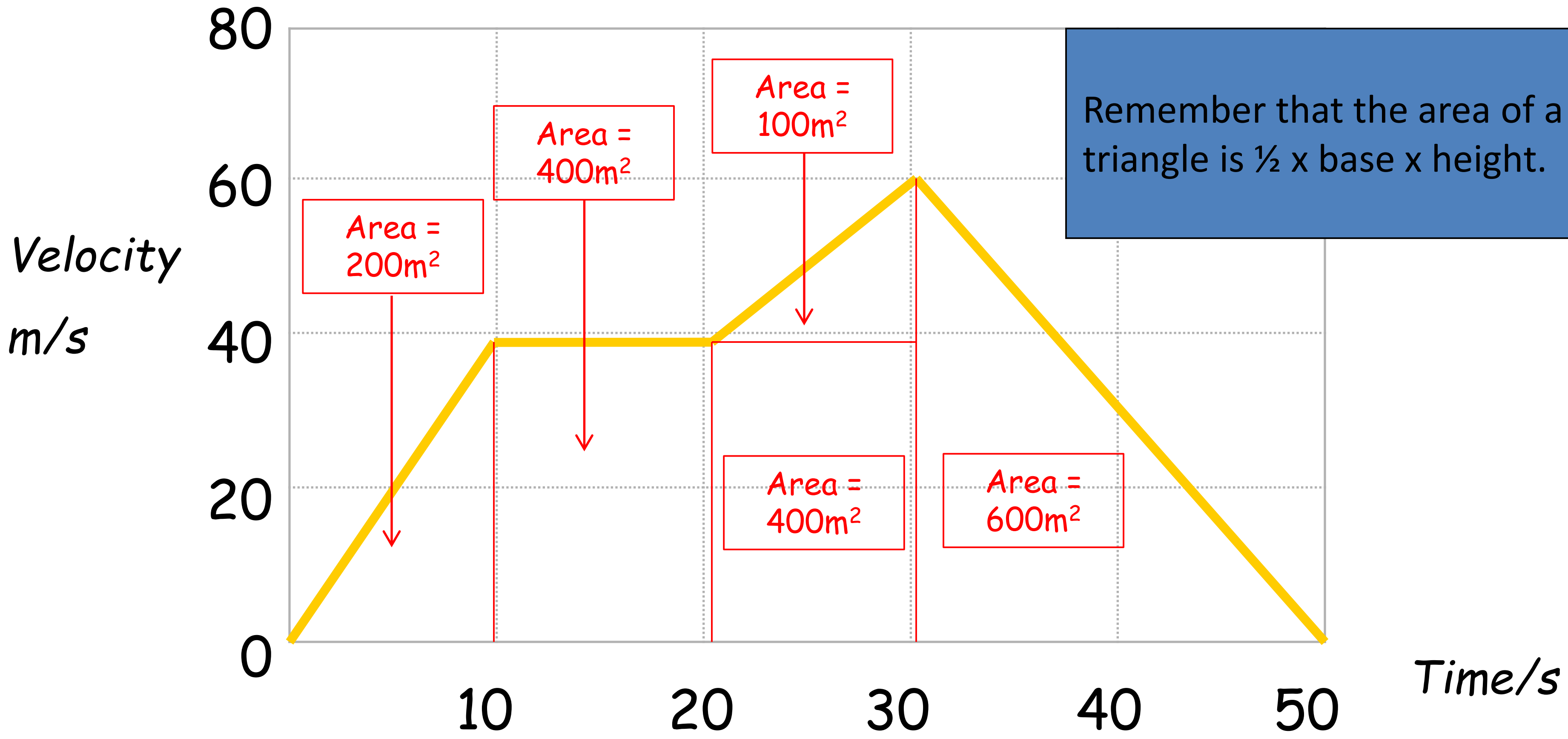

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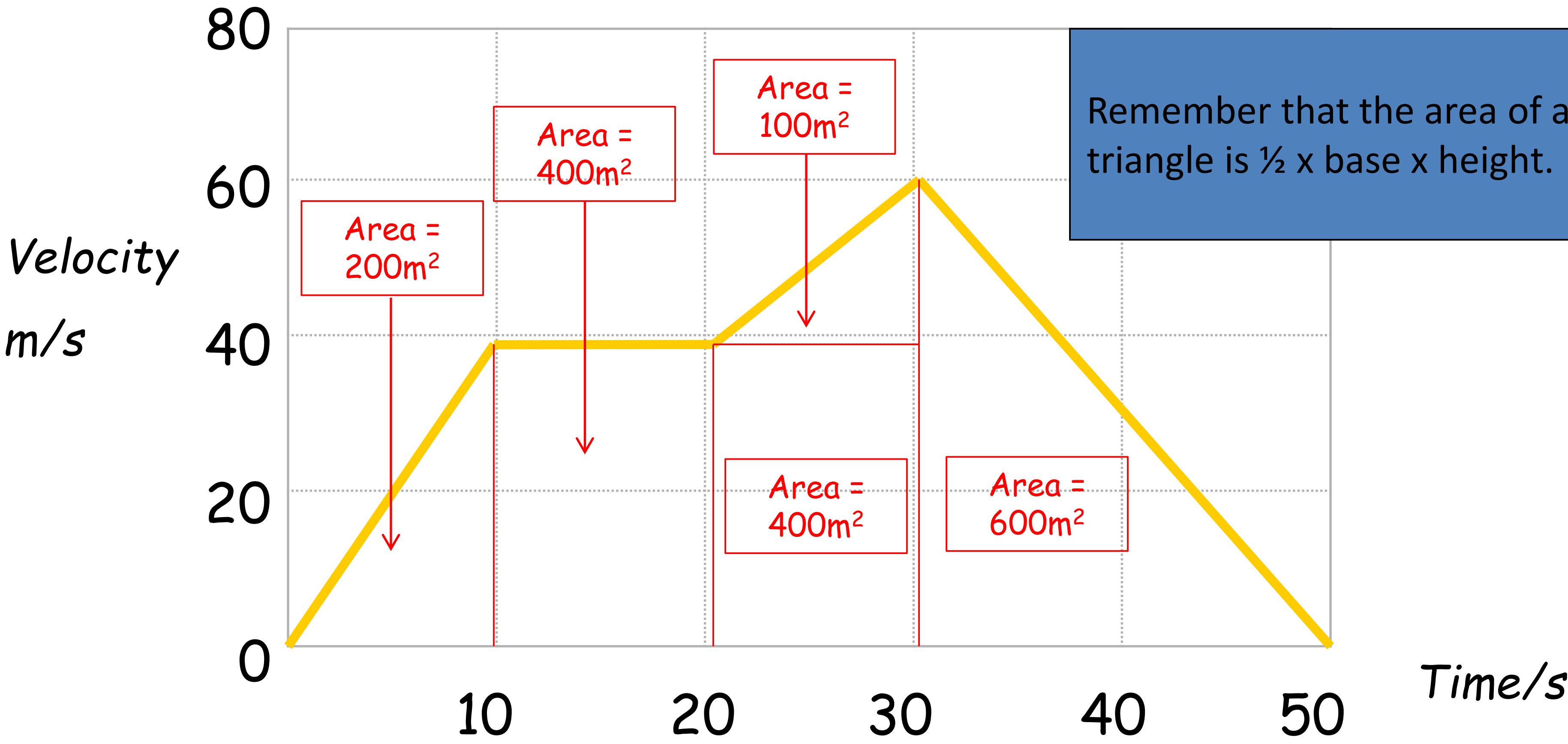
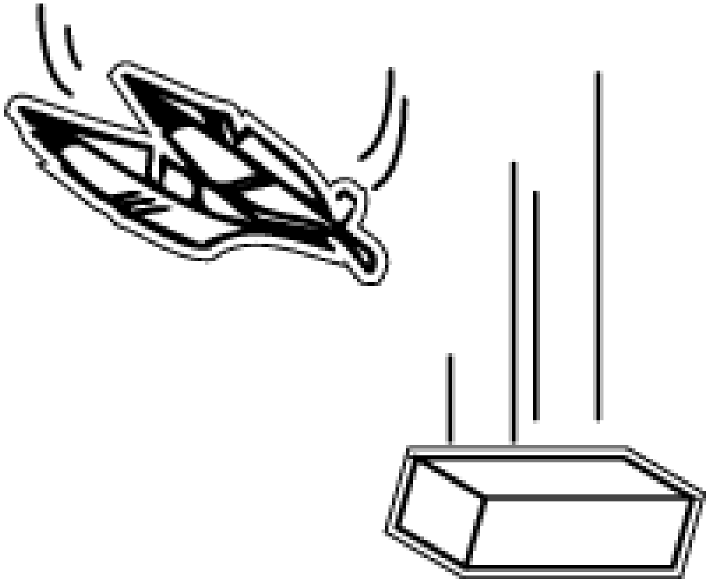


Remember that the area of a triangle is ½ x base x height.

The total distance travelled = 200 + 400 + 400 + 100 + 600 = 1700m

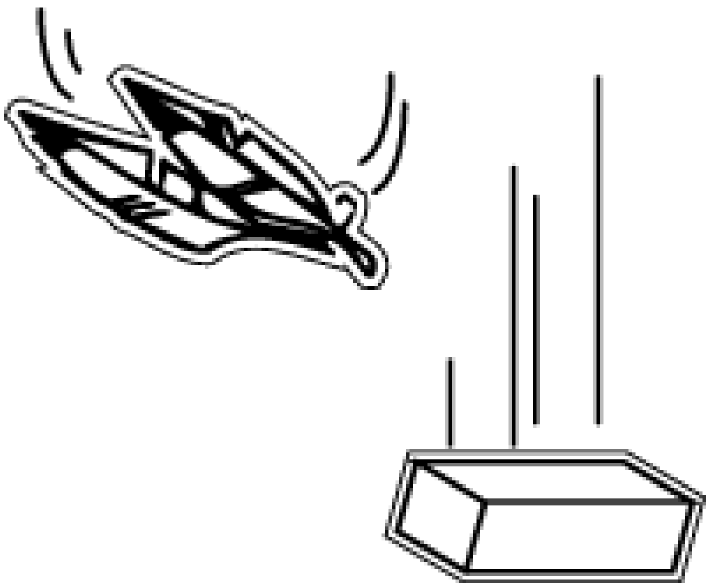
Free fall

Acceleration of free fall (g)



Which object will hit the ground first?

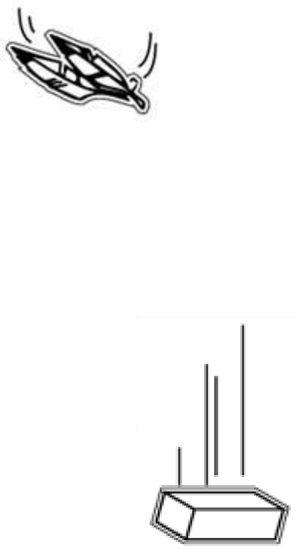
Acceleration of free fall (g)



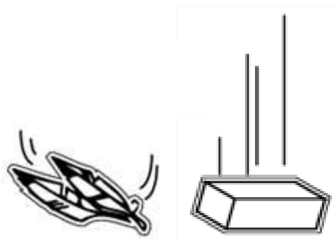
Which object will hit the ground first?

Obviously the brick (because the feather is slowed much more by the air)

Acceleration of free fall (g)



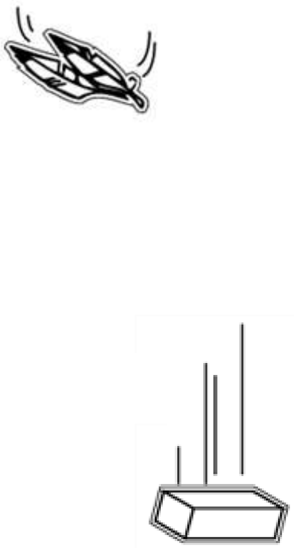
In air



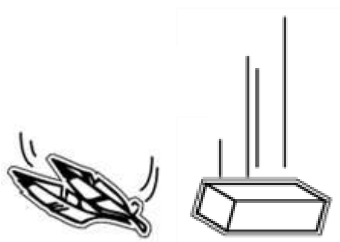
In a vacuum

No air resistance, objects both fall with the same downward acceleration.

Acceleration of free fall (g)



In air



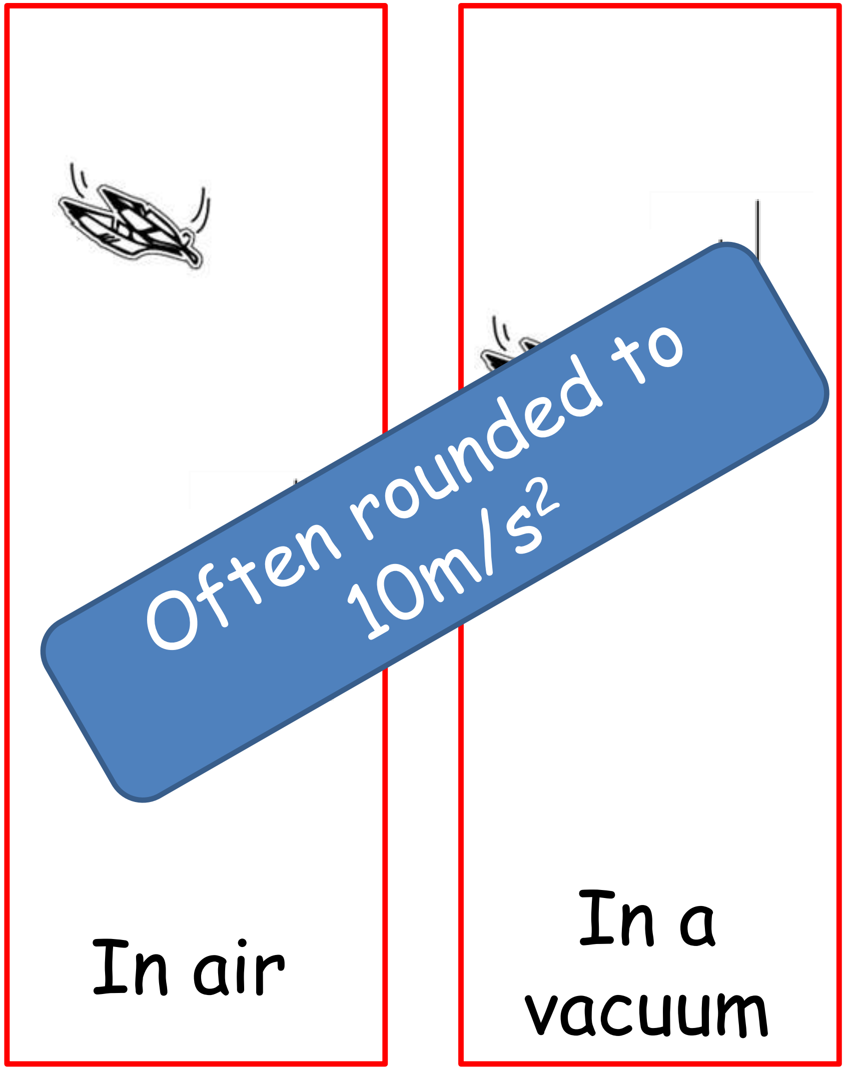
In a vacuum

No air resistance, objects both fall with the same downward acceleration.

Acceleration of free fall = $9.8 m/s^2$

Given the symbol 'g'

Acceleration of free fall (g)



Often rounded to $10m/s^2$

No air resistance, objects both fall with the same downward acceleration.

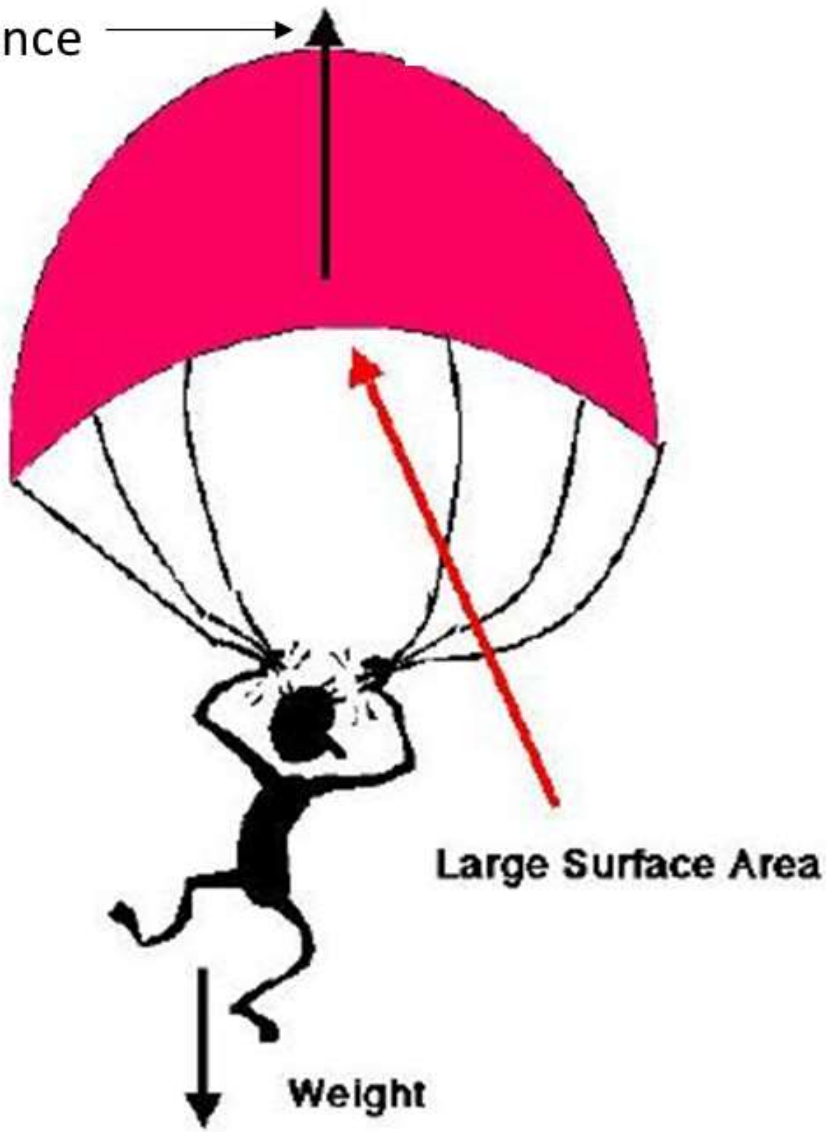
Acceleration of free fall = $9.8m/s^2$

Given the symbol 'g'

Acceleration and gravity

Acceleration and gravity

Falling objects accelerate towards the ground at 10m/s^2 due to gravity. The force of gravity always acts towards the centre of the Earth.



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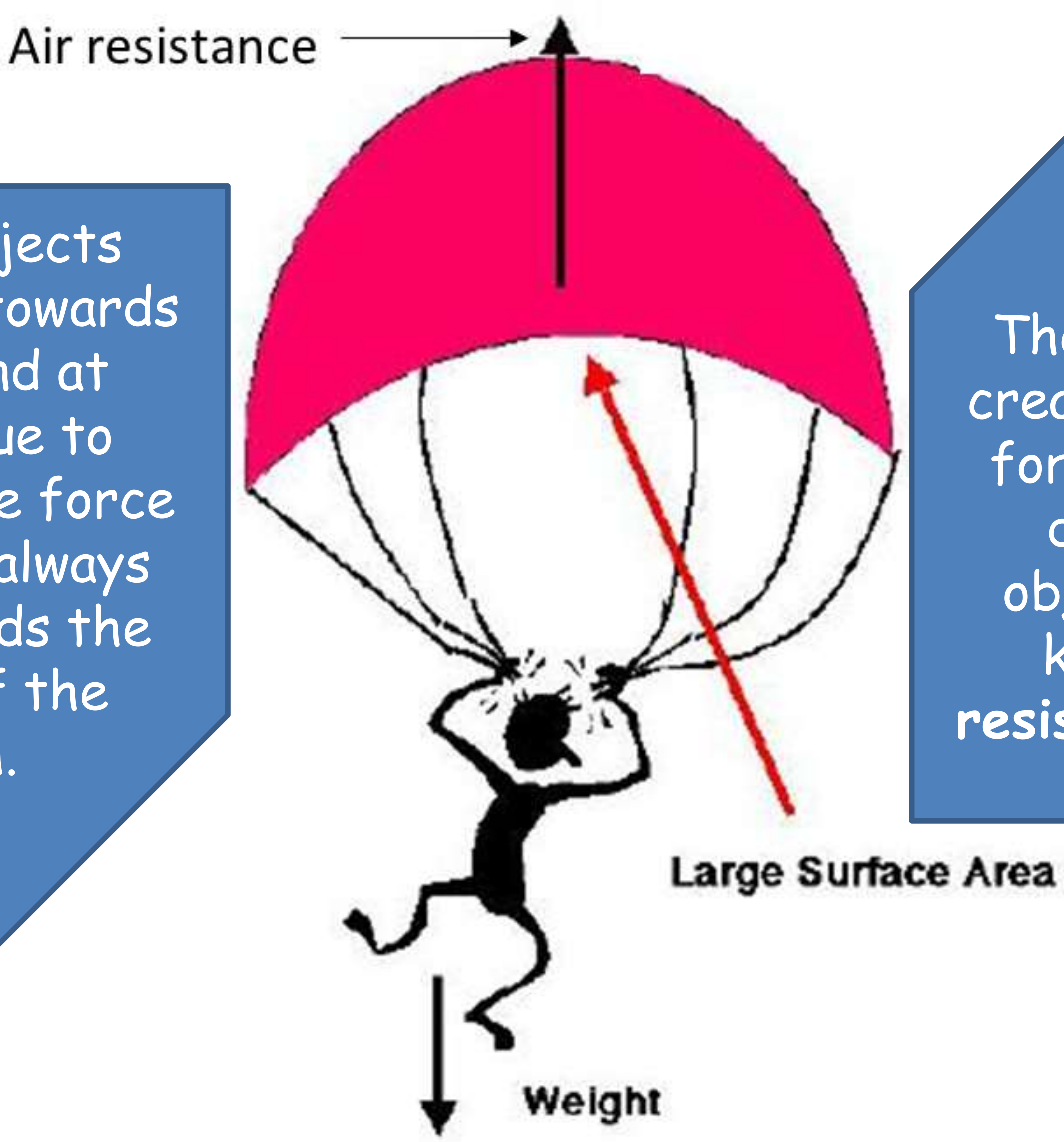

The atmosphere creates an upward force that slows down falling objects. This is known as **air resistance** or **drag**.

Acceleration and gravity

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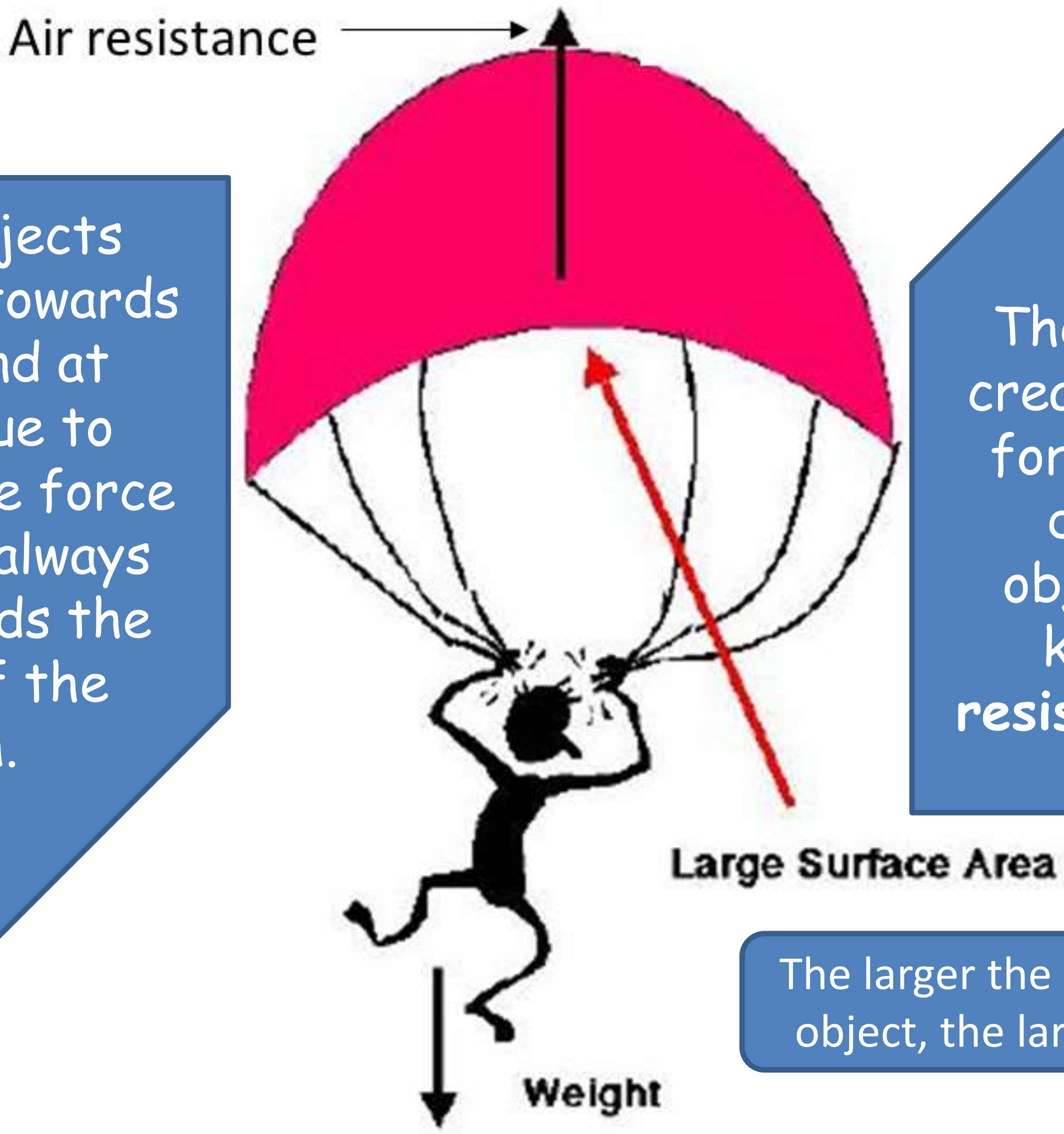
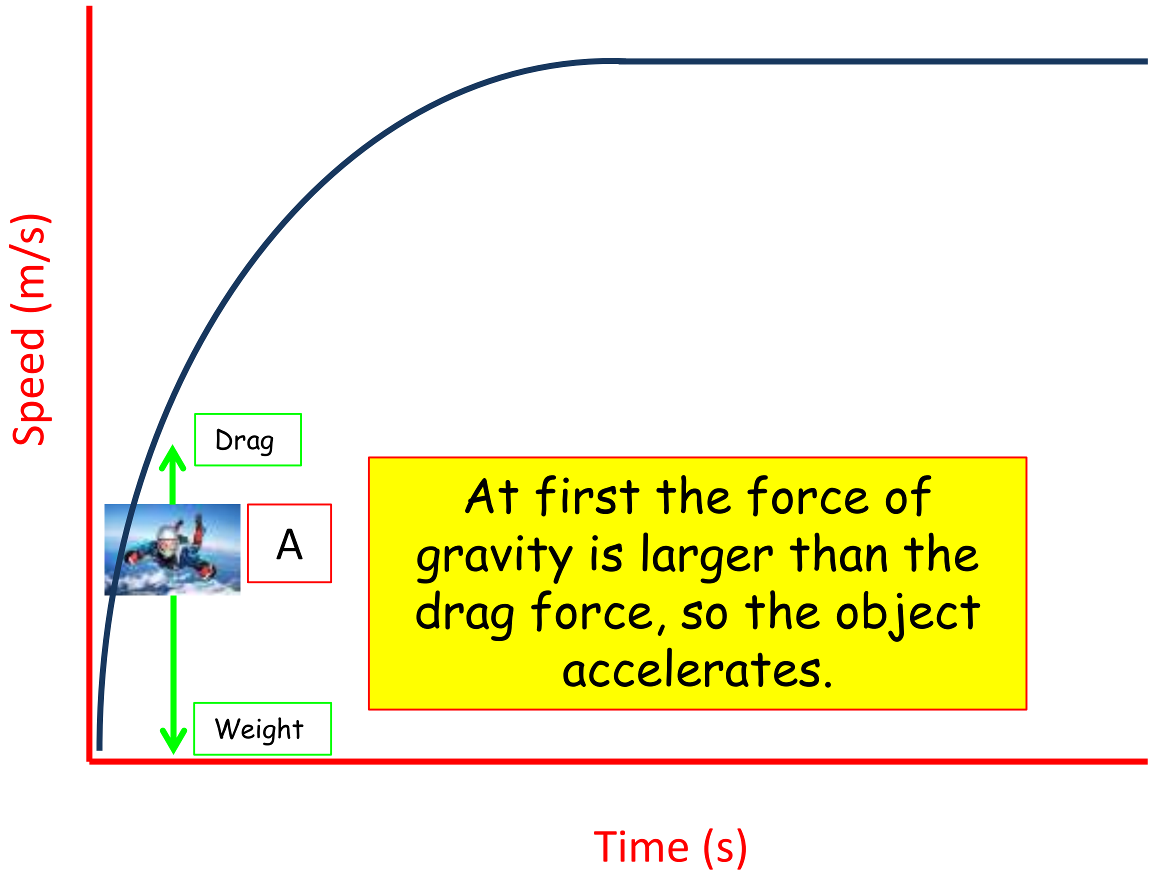


The atmosphere creates an upward force that slows down falling objects. This is known as **air resistance** or **drag**.

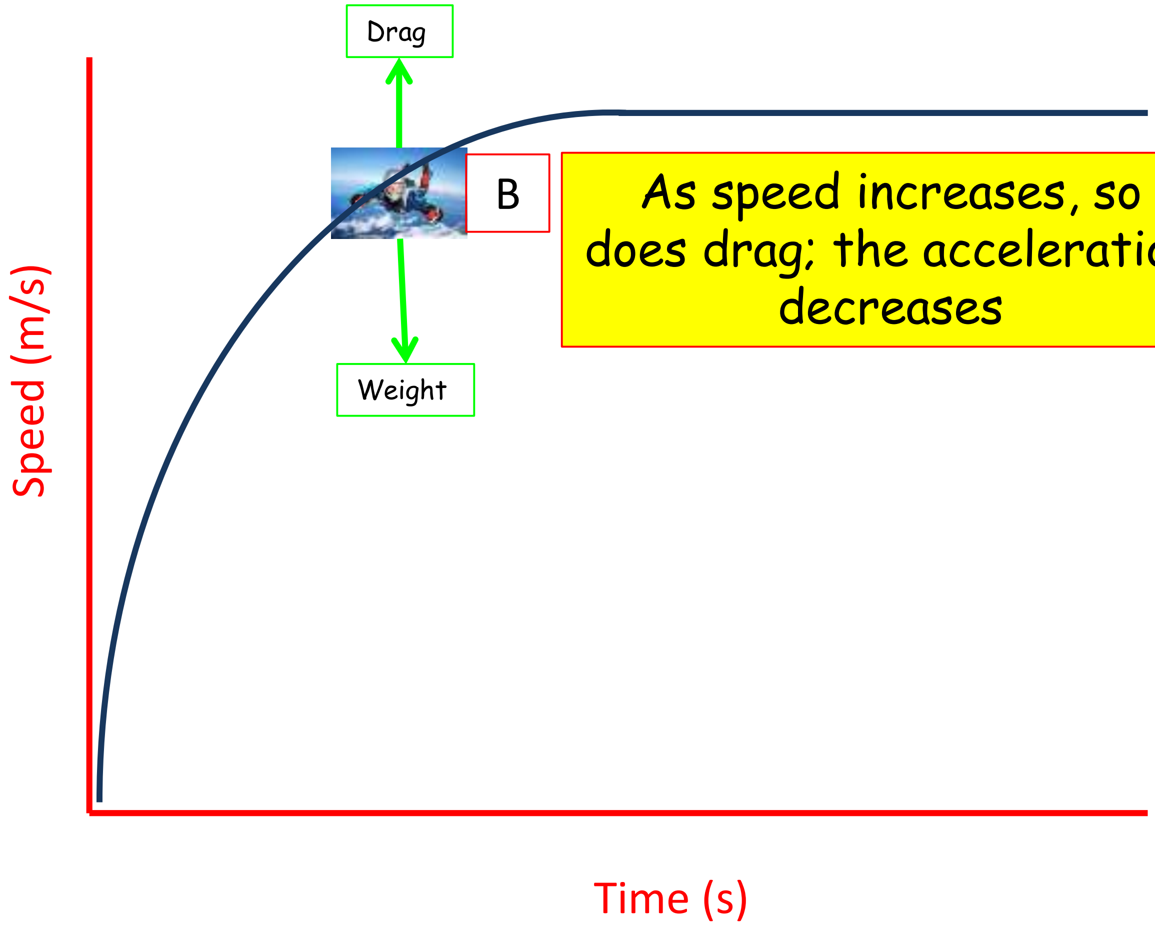
The larger the surface area of the object, the larger the drag force

Acceleration and gravity



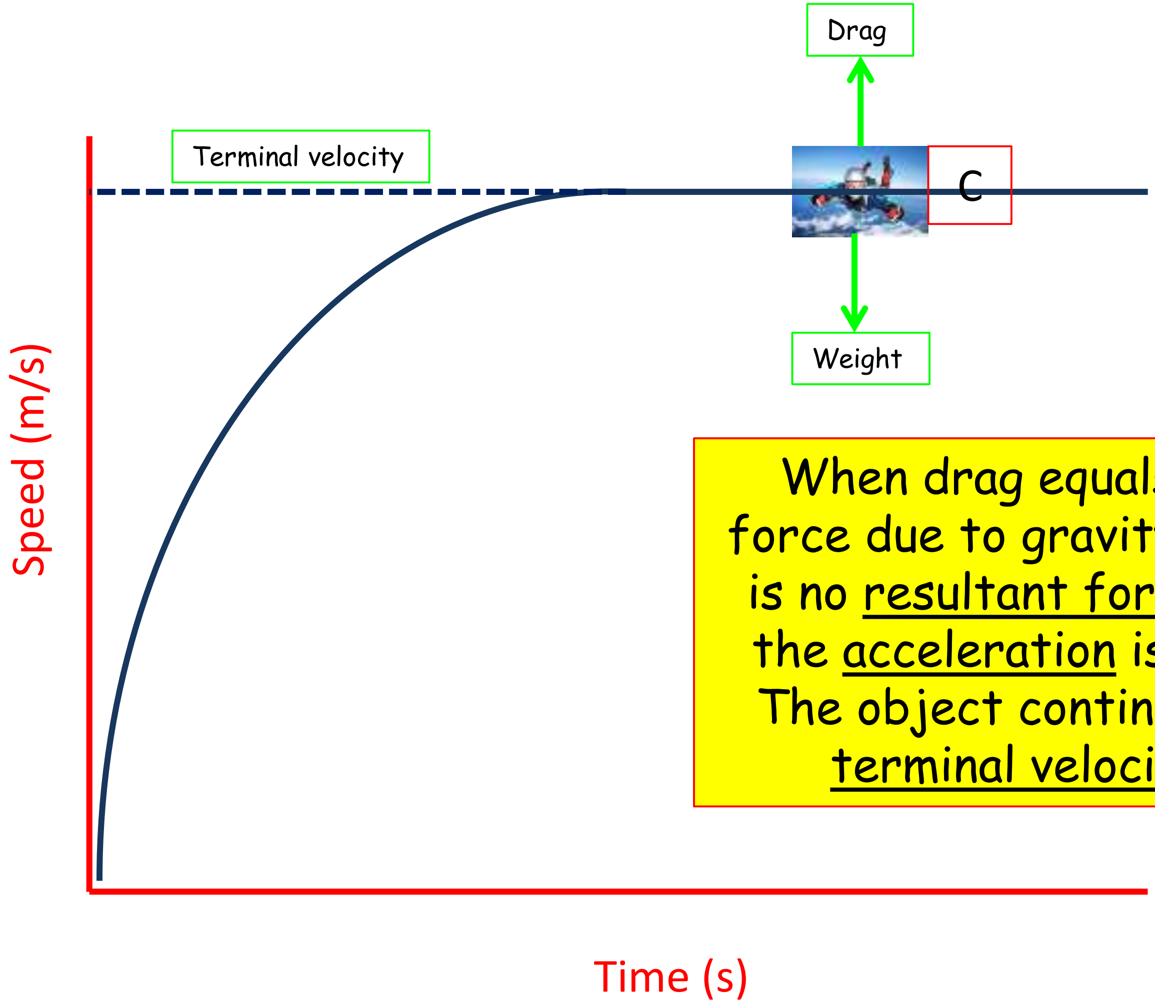
At first the force of gravity is larger than the drag force, so the object accelerates.

Acceleration and gravity



As speed increases, so does drag; the acceleration decreases

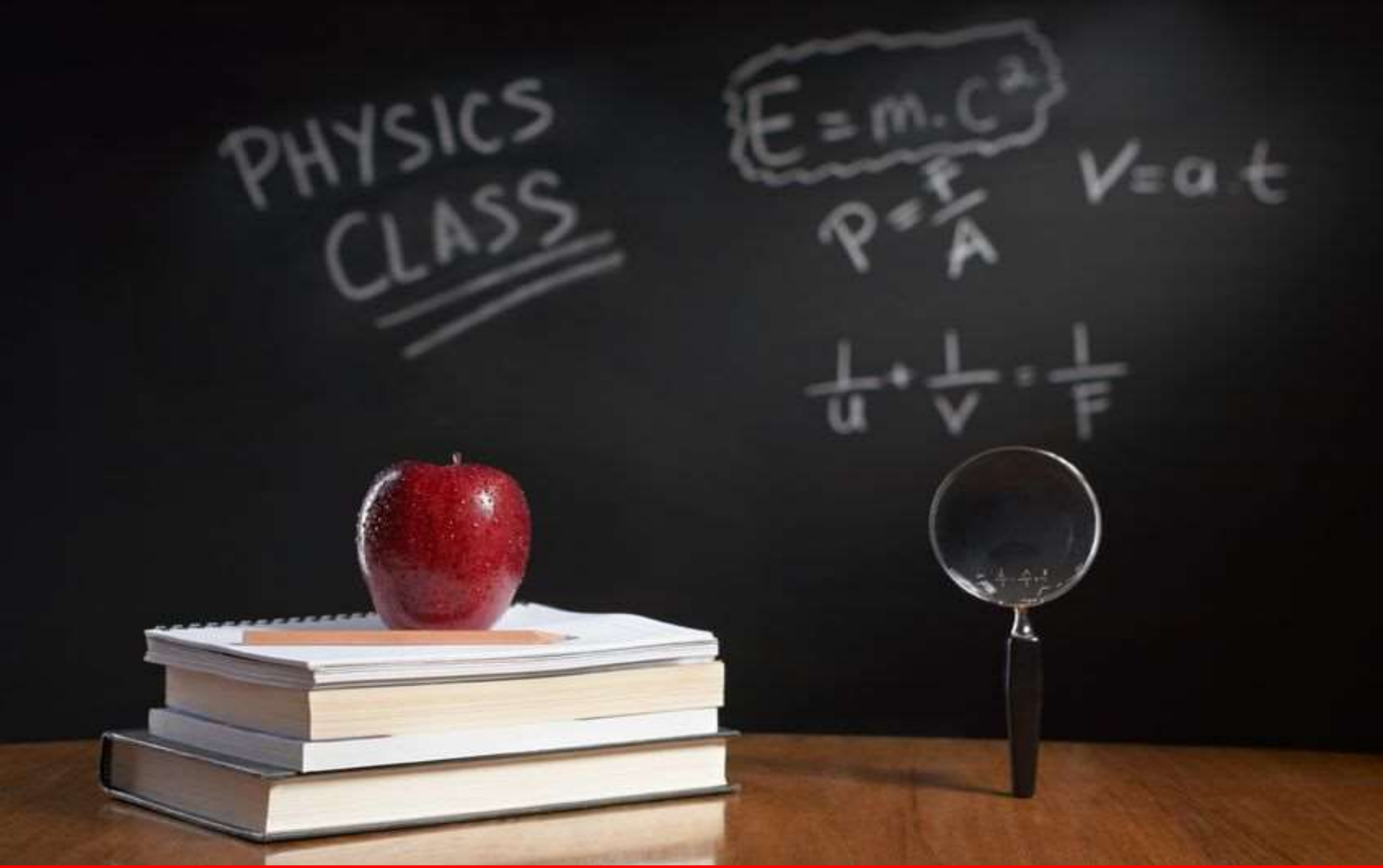
Acceleration and gravity



When drag equals the force due to gravity there is no <u>resultant force</u> and the <u>acceleration</u> is <u>zero.</u> The object continues at <u>terminal velocity.</u>

LEARNING OBJECTIVES

1.2 Motion **Core** • Define speed and calculate average speed from total time / total distance • Plot and interpret a speed-time graph or a distance- time graph • Recognise from the shape of a speed-time graph when a body is – at rest – moving with constant speed – moving with changing speed • Calculate the area under a speed-time graph to work out the distance travelled for motion with constant acceleration • Demonstrate understanding that acceleration and deceleration are related to changing speed including qualitative analysis of the gradient of a speed-time graph • State that the acceleration of free fall for a body near to the Earth is constant	**Supplement** • Distinguish between speed and velocity • Define and calculate acceleration using time taken change of velocity • Calculate speed from the gradient of a distance-time graph • Calculate acceleration from the gradient of a speed-time graph • Recognise linear motion for which the acceleration is constant • Recognise motion for which the acceleration is not constant • Understand deceleration as a negative acceleration • Describe qualitatively the motion of bodies falling in a uniform gravitational field with and without air resistance (including reference to terminal velocity)



PHYSICS – Speed, velocity and acceleration