# AQA 6.5 Forces

# Scalar and vector quantities

**Physical quantities**
A quantity is something that can be measured. Time, mass and force are all examples of quantities.

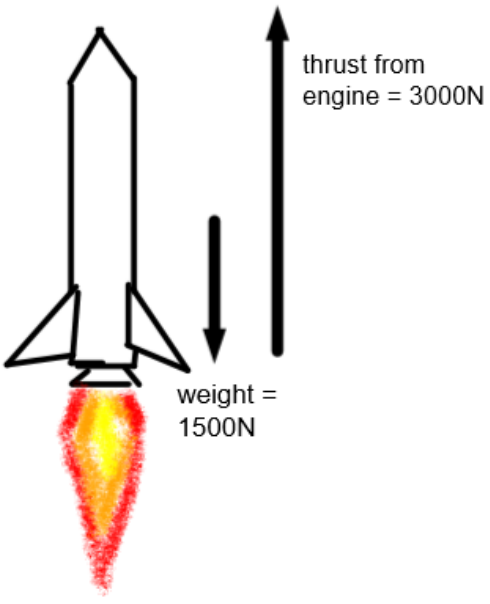
**Vector quantities**
Some quantities have a magnitude (size) and direction. These quantities are called vector quantities, or just vectors. Examples are displacement (distance and direction); velocity (speed and direction) and force.

Often vector quantities are sloppily given as just magnitude. We hear people saying, for example, “the object’s velocity was 14m/s” when really they should say “the object’s velocity was 14m/s to the right”, for example.

**Scalar quantities**
Other quantities have magnitude only. These are called scalar quantities. Examples include distance, speed and mass. It is incorrect to give these quantities a direction as it does not mean anything.

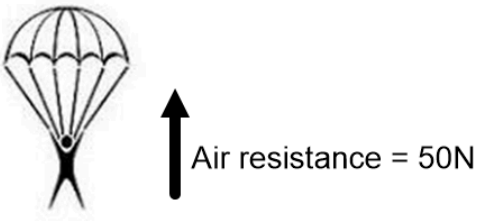
**Showing vectors using arrows**

We can use arrows to show vector quantities. The size of the arrow denotes the magnitude of the vector and the direction of the arrow shows the direction of the vector.




**<u>Questions</u>**

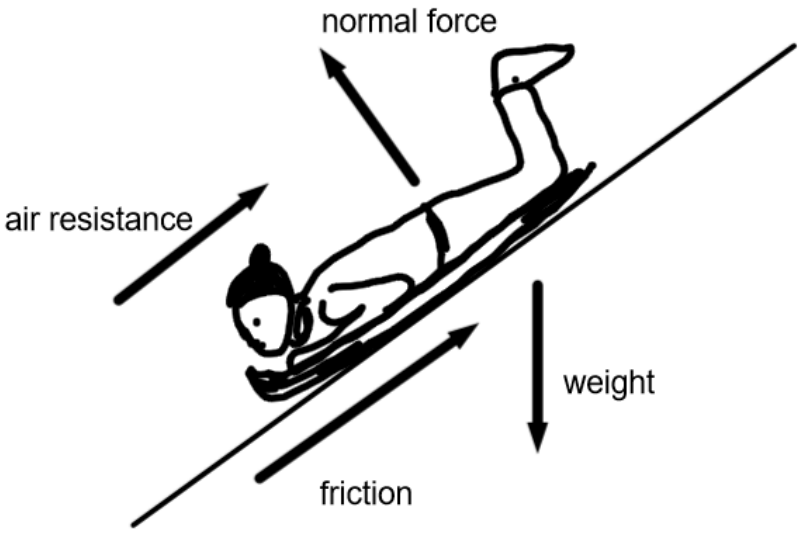
1. Define a vector quantity.
2. Define a scalar quantity.
3. Give three examples of vector quantities.
4. Give three examples of scalar quantities.
5. James says “the force of air resistance on the parachute is 50N”. What else should James say in order to be completely correct? Why does he need to add this information?




6. Molly says “the mass of the parachutist is 75kg towards the centre of the Earth”. What is wrong with this statement? Why is it wrong?

mass of parachutist = 75kg

7. Look at this diagram. Name the vector quantities shown.




8. “Energy” is a scalar quantity. Explain why.
9. “Acceleration” is defined as “rate of change of velocity”. Is acceleration a scalar or vector quantity? Explain why.
10. “Power” is defined as “rate of transfer of energy”. Is power a scalar or vector quantity? Explain why.
11. “Upthrust” is an example of a force. Is upthrust a scalar or vector quantity? Explain why.
12. “Area” is the product of two distances. Is area a scalar or vector quantity? Explain why.
13. Describe how vectors are sometimes stated sloppily and give an example.

## Answers

1. A quantity with both magnitude and direction

2. A quantity with magnitude only
3. Displacement, velocity and force
4. Distance, speed and mass
5. “The force is acting upwards” – he should say this because force is a vector quantity and so needs direction as well as magnitude.

6. The statement should just say the magnitude of the mass and not give a direction as mass is a scalar quantity.

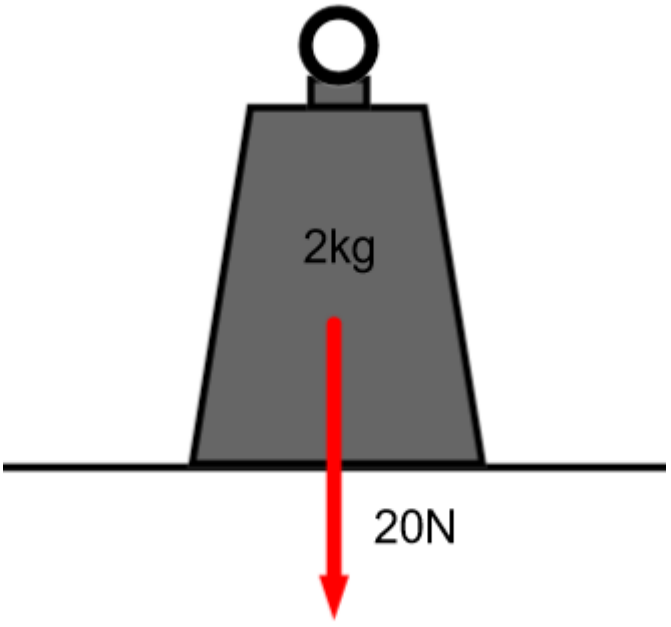
7. Push from slope on sledge P; weight of sledge and boy; resistive forces on sledge and boy.

8. Energy can only have magnitude not direction
9. A vector quantity as it is the rate of change of a vector quantity.
10. A scalar quantity as it is the rate of change of a scalar quantity.
11. Vector because it is a force.
12. Scalar because it is the product of two scalar quantities.
13. Vector quantities are sometimes given with just the magnitude e.g. “the velocity is 14m/s” but this is sloppy.

**Intervention Questions**

1. Define a vector quantity.
2. Define a scalar quantity.
3. Give three examples of vector quantities.
4. Give three examples of scalar quantities.
5. Jo says “the weight of the block is 20N”. What else should she say in order to be completely correct? Why does she need to add this information?

6. Ryan says says “the mass of the block is 2kg down”. What is wrong with this statement? Why is it wrong?




7. Look at this diagram. Name the vector quantities shown.

8. “Density” is a scalar quantity. Explain why.
9. “Momentum” is “force x time”. Is momentum a scalar or vector quantity? Explain why.
10. “Volume” has magnitude but not direction. Is volume a scalar or vector quantity? Explain why.
11. Friction has both magnitude and direction. Is friction a scalar or vector quantity? Explain why.
12. “Work done” has magnitude but not direction. Is work done a scalar or vector quantity? Explain why.
13. Describe how vectors are sometimes stated sloppily and give an example.

**Intervention Answers**

1. A quantity with both magnitude and direction
2. A quantity with magnitude only
3. Displacement, velocity and force
4. Distance, speed and mass

5. “The weight is acting downwards” because it’s a vector quantity.

6. Mass should have magnitude only, not direction, as it is a scalar quantity.

7. Drag, weight, friction and normal force

8. It has magnitude only and no direction.
9. Vector as force is a vector.

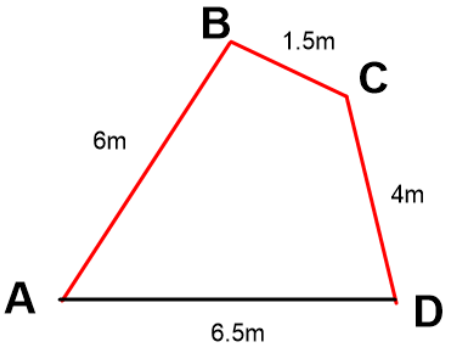
10. Scalar as it has magnitude but no direction.
11. Vector as it has magnitude and direction.
12. Scalar as it has magnitude only and no direction.
13. Sometimes vectors are sloppily given with only magnitude and no direction. For example, “acceleration of 2.5m/s/s”.

# Distance and displacement

An object has a **position** relative to its surroundings at any instant in time. When an object moves, it changes its position.

**Distance** is a **scalar** quantity that refers to “how much ground an object has covered” during its motion.

**Displacement** is a **vector** quantity that refers to “how far and in what direction the object’s position has changed”.

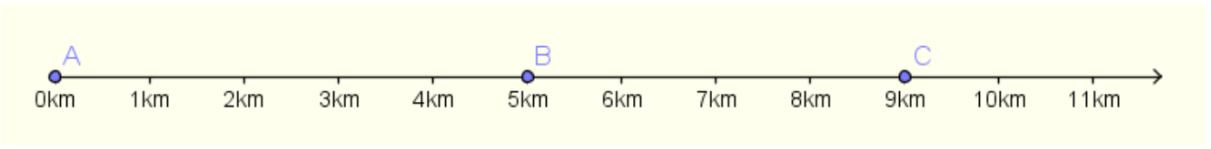



Consider an object that starts at position A, and then moves to B, C and finally to D.

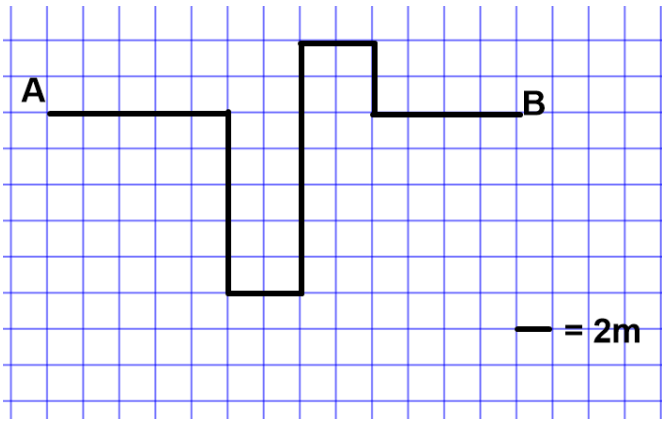
The distance travelled by the object is (6 + 1.5 + 4) = 11.5m.

The displacement of the object is 6.5m to the right.

**Questions**

1. Define “distance”
2. Define “displacement”.
3. Draw a diagram to show the difference between distance and displacement.
4. Which quantity is a vector quantity: distance or displacement?
5. When people say “As the crow flies” are they referring to distance or displacement?
6. True or false: For a single object in motion, displacement can be equal to distance but it can never be bigger.
7. 

A car starts at A and travels to B, then to C, and then back to B. What is a) the distance travelled and b) the displacement of the car?

8. 


a) What is the displacement from B to A? b) What is the distance?

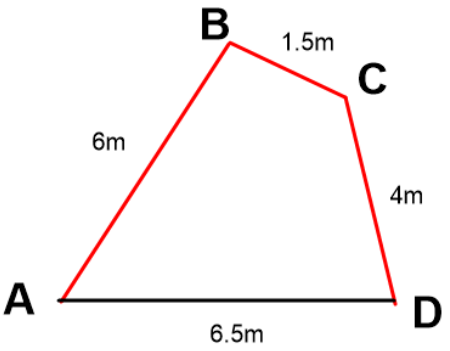
**Extension:**

A walker travels from A to B, C, D, E and F. What is the distance travelled? What is the displacement?

Answers:

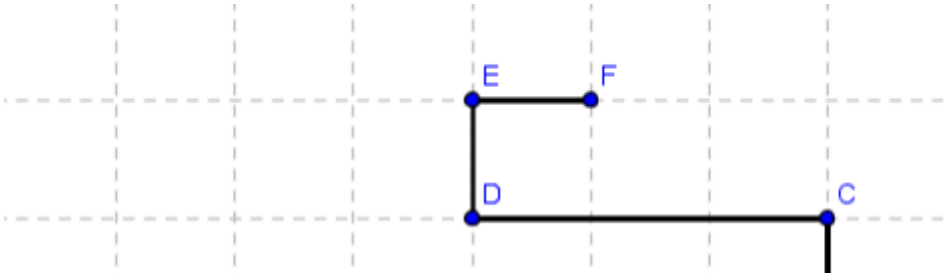
1. Distance is a scalar quantity that refers to “how much ground an object has covered” during its motion.
2. Displacement is a vector quantity that refers to “how far and in what direction the object’s position has changed”.

3. Travelling A – B – C – D: Distance travelled = 11.5m; displacement = 6.5m to the right
4. Displacement is a vector quantity
5. displacement
6. True
7. a) 14km b) 5km
8. a) 26m to the left; b) 27m



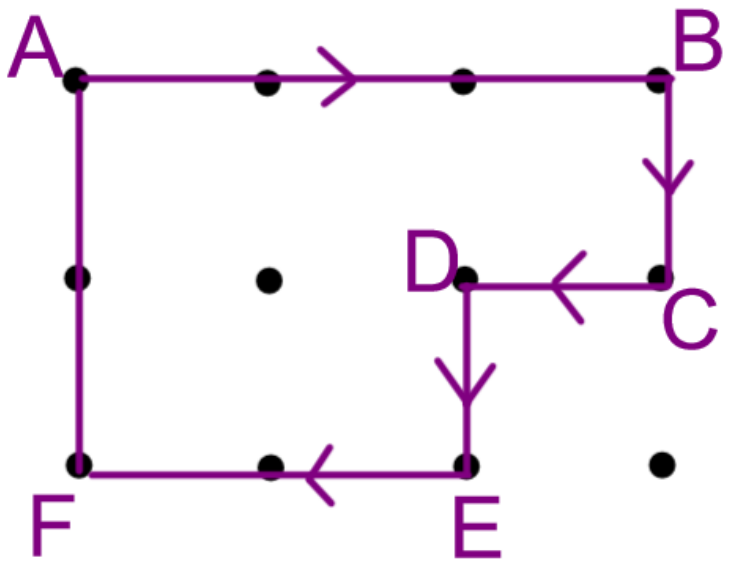

Extension:

Distance = 6.5km
Displacement = 2.5km

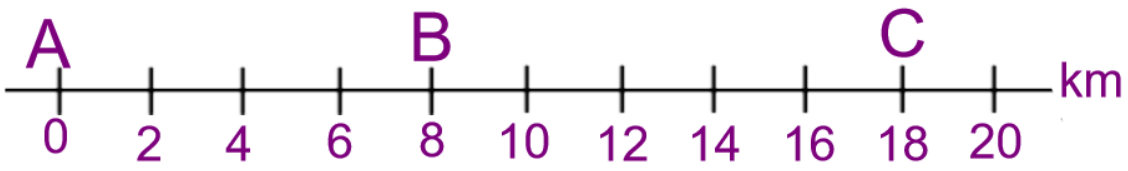


## Intervention Questions

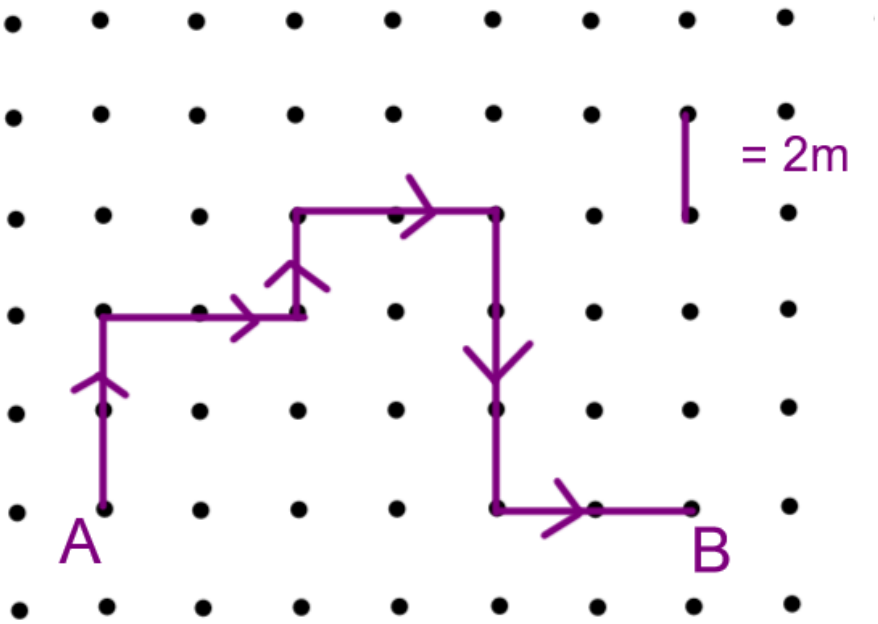
1. What does “distance” mean?
2. What does “displacement” mean?
3. Copy this diagram and use it to write an explanation of the difference between displacement and distance:




4. Which quantity is a scalar quantity: distance or displacement?
5. Why does “As the crow flies” refer to displacement?
6. Why can displacement never be bigger than distance for a particular journey?
7. 




A car starts at A and travels to B, then to C, and then back to B. What is a) the distance travelled and b) the displacement of the car?

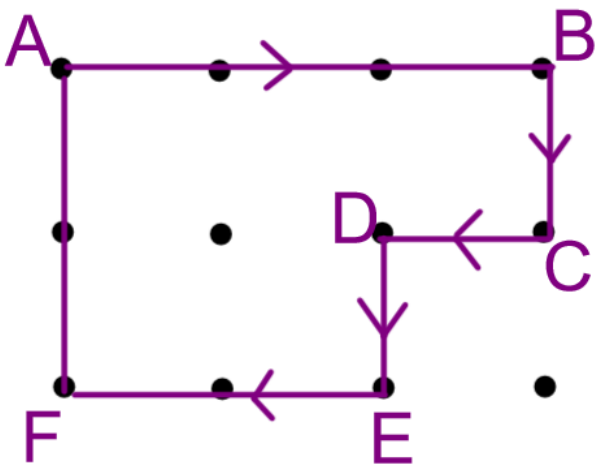



8.

a) What is the displacement from B to A? b) What is the distance?

**Intervention Answers**

1. How much ground an object has covered during its motion.
2. **Displacement** is a **vector** quantity that refers to "how far and in what direction the object's position has changed




3.

The distance from A to F is 8 spaces but the displacement from A to F is two spaces down.

4. Distance

5. Because it means “in a straight line from start to finish”
6. Because a straight line is the shortest distance between two points.
7. a) 28m b) 8m to the right
8. a) 12m to the left b) 24m

# Calculating velocity and speed

Speed is the rate of change of distance:

Speed = distance ÷ time
Distance = speed x time

Speed is a scalar quantity: it only has magnitude, e.g. 14m/s

Velocity is like speed, but it's a vector quantity, so it always has direction as well as speed. This is because velocity is rate of change of displacement and displacement is a vector quantity.

Velocity = displacement ÷ time
Displacement = velocity x time

However, people often use the word "velocity" without stating a direction – this is sloppy but very common.

**Questions**

1. Define speed
2. Define velocity
3. What is the difference between speed and velocity?
4. Find the velocity of a car which travels 25m to the right over a period of 10 seconds.
5. What is the velocity of a hot air balloon which travels 125m up in a time of 50 seconds?
6. A diver travels 640m down during a 16-second dive. Find his velocity.
7. What is the displacement of a rocket travelling at a velocity of 150m/s up for 30 seconds?
8. Find the displacement of a beetle crawling for 180 seconds at a velocity of 0.25m/s to the left.
9. A car has a velocity of 24m/s to the right and travels for 58 seconds. Find its displacement.
10. A car travelling at a velocity of 2.75m/s travels for 185 meters. What time was taken?
11. Find the time taken by a rocket travelling at a velocity of 240m/s to reach a displacement of 15,000m.
12. A snail travels with a velocity of 0.08m/s. It reaches a displacement of 0.2m. Find the time taken.

Answers

1. The rate of change of distance
2. The rate of change of displacement

3. Speed is a scalar quantity whereas velocity is a vector quantity.
4. 2.5m/s to the right
5. 2.5m/s up
6. 40m/s down
7. 4,500m up
8. 45m left
9. 1392m round
10. 67.27s
11. 62.5s
12. 2.5s

## Intervention Questions

1. What does “speed” mean?
2. What does “velocity” mean?
3. What is the difference between speed and velocity?
4. Find the velocity of a car which travels 35m to the right over a period of 40 seconds.
5. What is the velocity of a hot air balloon which travels 325m up in a time of 59 seconds?
6. A diver travels 645m down during a 12-second dive. Find his velocity.
7. What is the displacement of a rocket travelling at a velocity of 350m/s up for 20 seconds?
8. Find the displacement of a beetle crawling for 380 seconds at a velocity of 0.75m/s to the left.
9. A car has a velocity of 34m/s to the right and travels for 48 seconds. Find its displacement.
10. A car travelling at a velocity of 3.75m/s travels for 196 meters. What time was taken?
11. Find the time taken by a rocket travelling at a velocity of 170m/s to reach a displacement of 46,000m.
12. A snail travels with a velocity of 0.02m/s. It reaches a displacement of 0.4m. Find the time taken.

## Intervention Answers

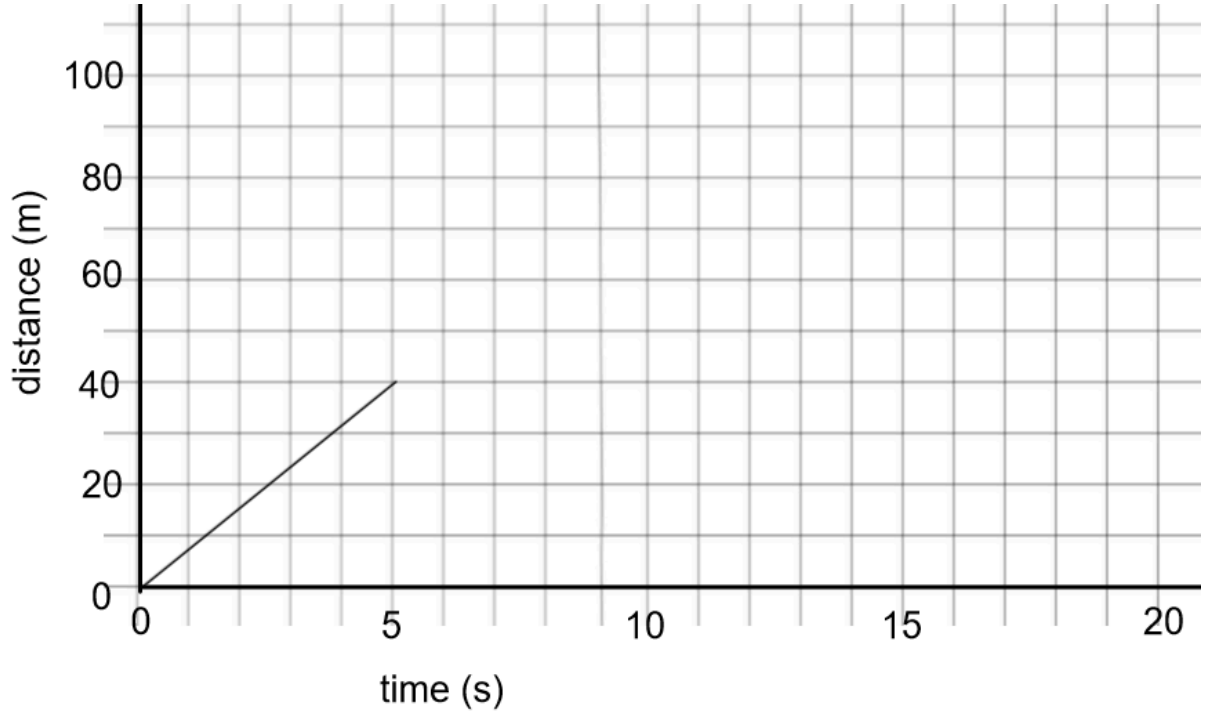
1. Rate of change of distance
2. Rate of change of displacement
3. Velocity is a vector quantity, speed is a scalar quantity
4. 0.88m/s
5. 5.51m/s
6. 53.75m/s
7. 7,000m
8. 285m

9. 1,632s
10. 52.27s
11. Find the time taken by a rocket travelling at a velocity of 170m/s to reach a displacement of 46,000m.
12. A snail travels with a velocity of 0.02m/s. It reaches a displacement of 0.4m. Find the time taken.

## Distance-time graphs

If an object moves along a straight line, the distance travelled can be represented by a distance–time graph. The speed of an object can be calculated from the gradient of its distance–time graph.

These graphs always have time on the X-axis. We can think of them as telling a story: what happened first, second, etc.



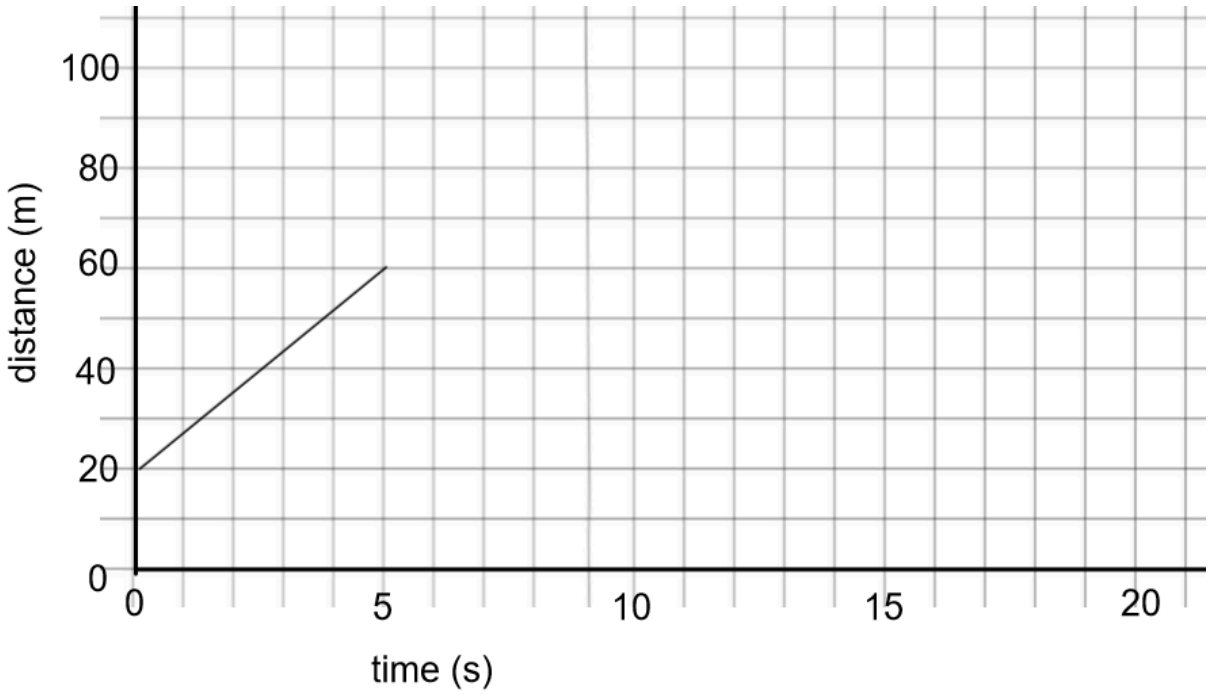

 This graph tells us that in 5 seconds an object travelled 40 metres.

Because speed = distance ÷ time, we can use values from the graph to calculate the speed:

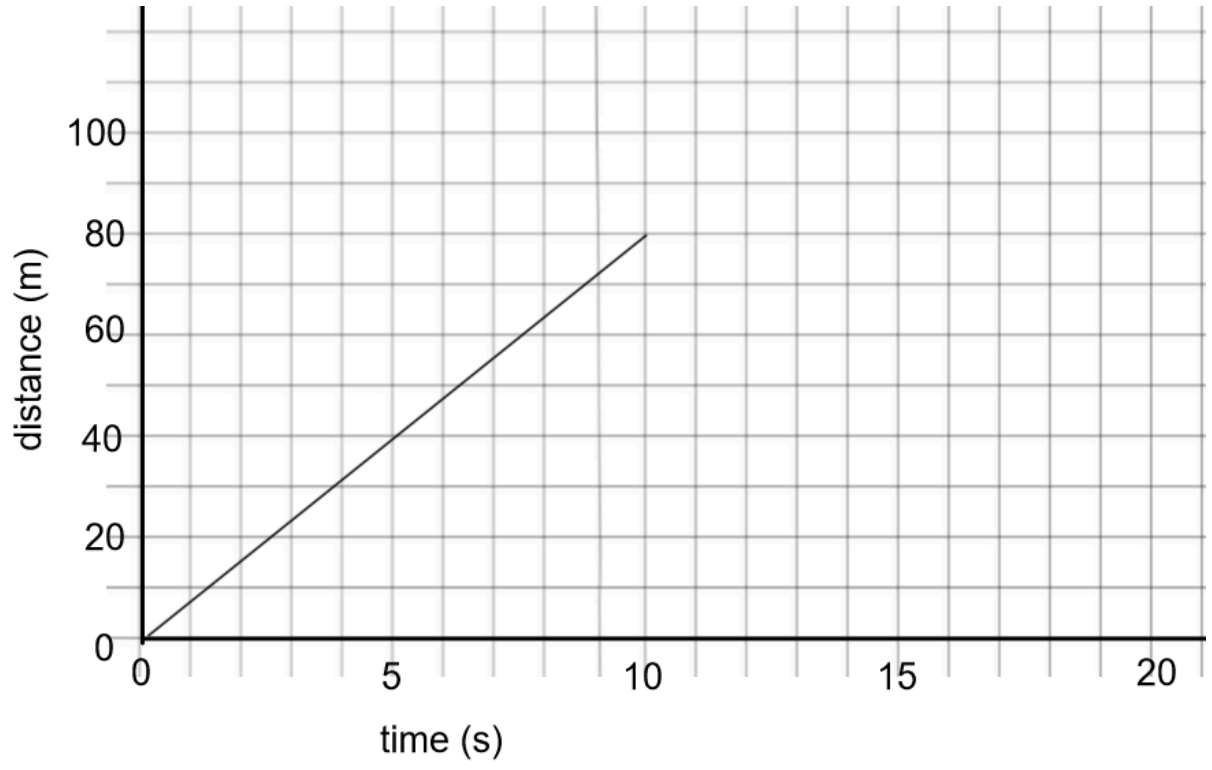
40 ÷ 5 = 8

Speed = 8m/s

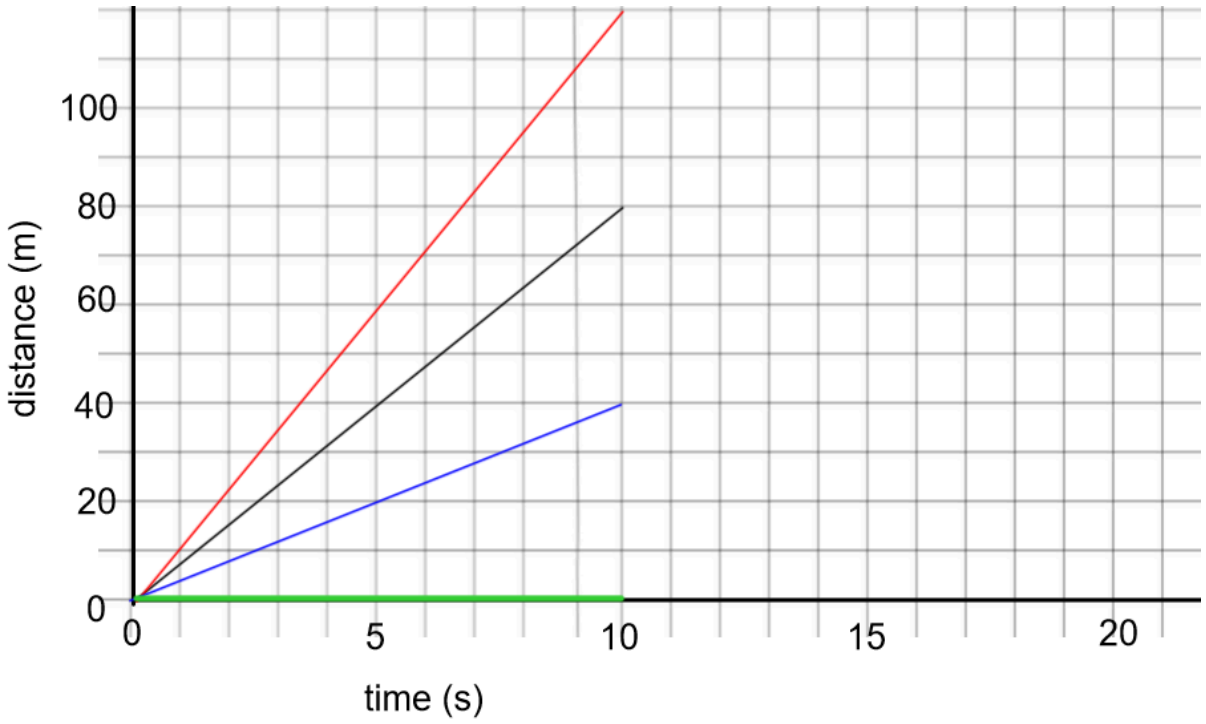
This is the same as the gradient: the gradient is the speed.




 This graph also shows us that an object travelled 40m in 5s. The gradient is the same. The difference is that the object started at 20m instead of 0.




 In this graph, the object travels 80m in 10s. The gradient is still 8 so the speed is still 8m/s.



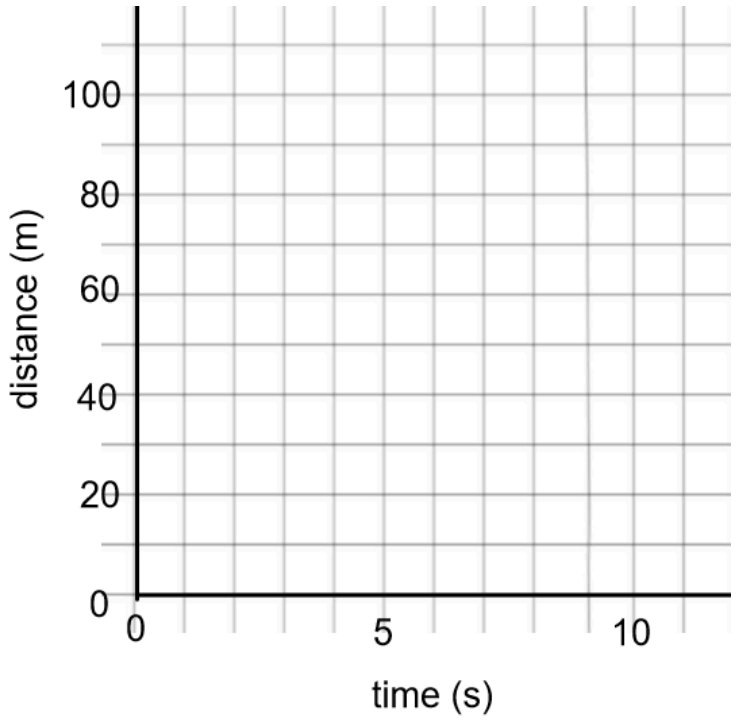

 A higher (steeper) gradient means a higher speed. In the graph above, the red line has a gradient of 120 ÷ 10 = 12m/s.

The blue line has a gradient of 40 ÷ 10 = 4m/s.

The green line has a gradient of 0, i.e. the object is stationary (stood still).

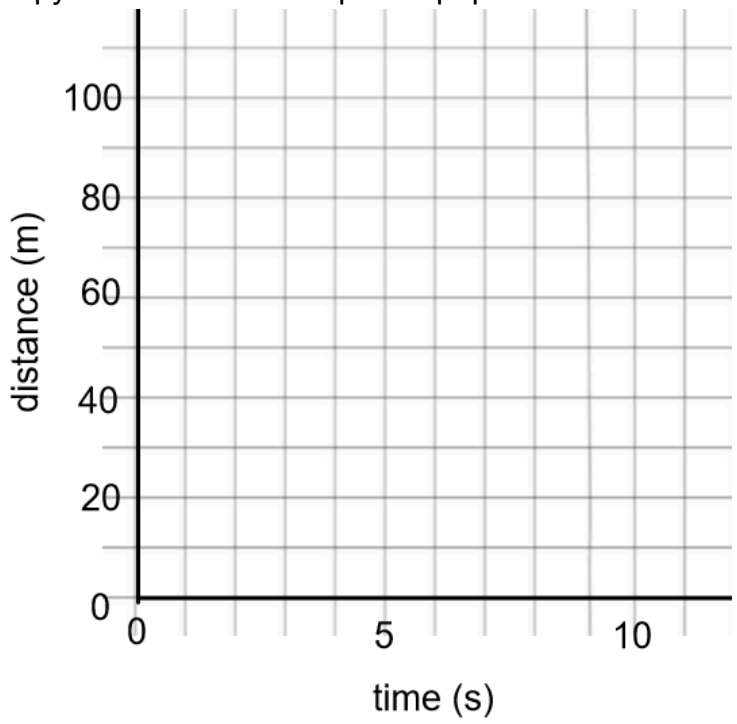
**Questions**

1. Copy the axes onto squared paper:




Draw lines to show the motion of an object that travels:

a) 60m in 5s
b) 100m in 5s
c) 20m in 5s
2. Find the speed for each of the objects in (1)
3. Copy these axes onto squared paper:




Draw lines to show the motion of:

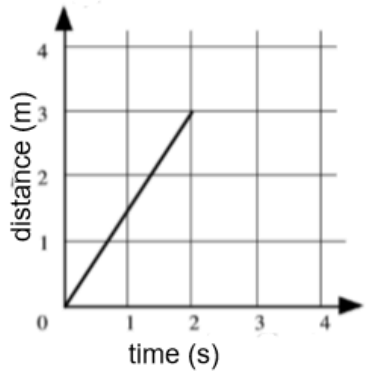
a) An object that travels 10m in 10s
b) An object that travels 100m in 10s

c) An object that travels 40m in 10s.

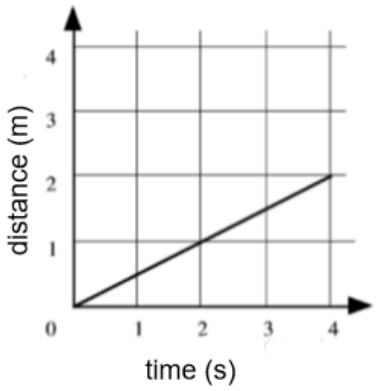
4. Find the speeds of each of these objects.

5. Find the speed of the following:

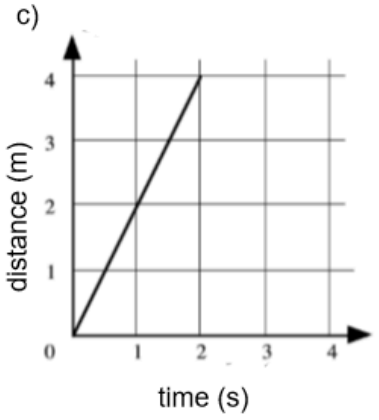
a)



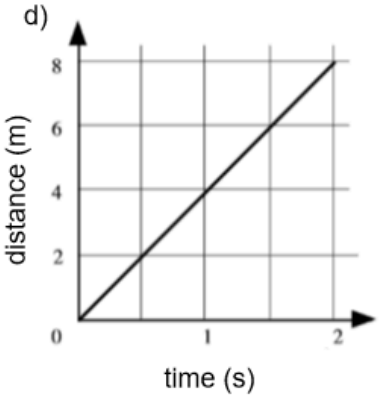

b)



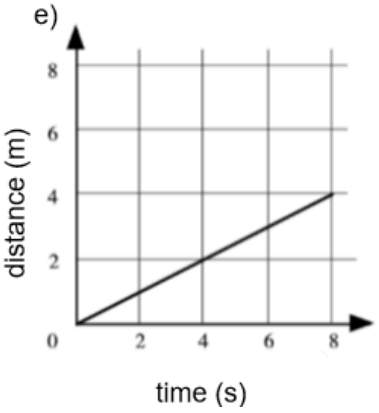

c)



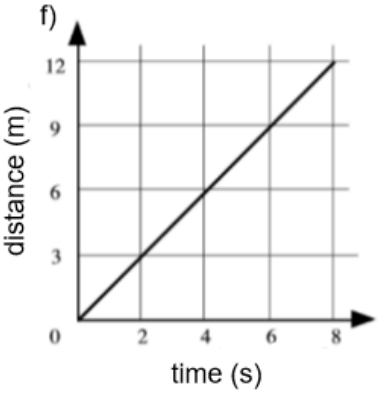

d)



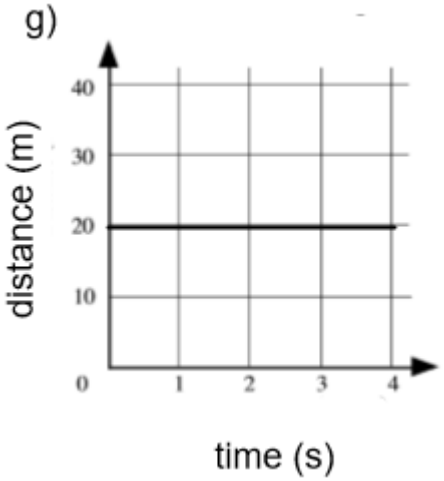

e)




f)

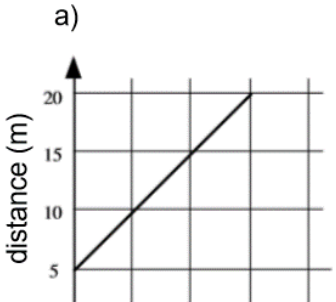



g)

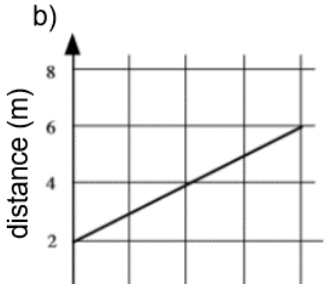



6. Find the speed of the following:

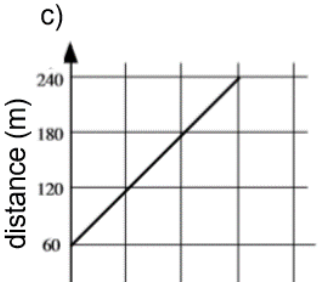
a)




b)



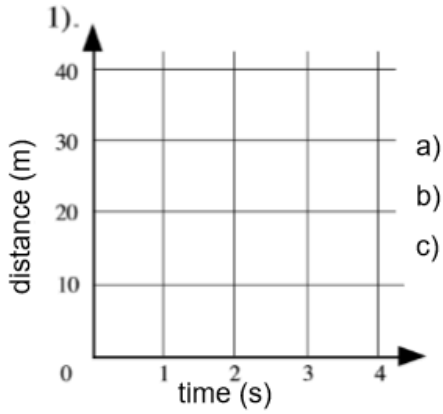

c)



**Extension**

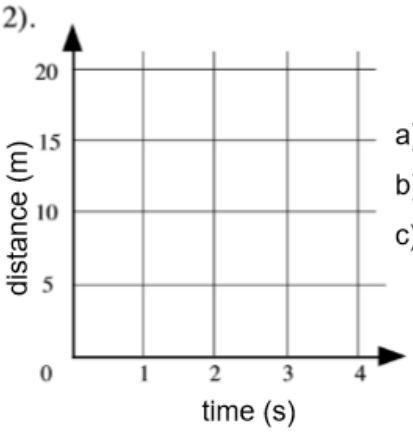
For each question, copy the axes onto squared paper, then draw a line to show an object moving at each of the three speeds given.

1).



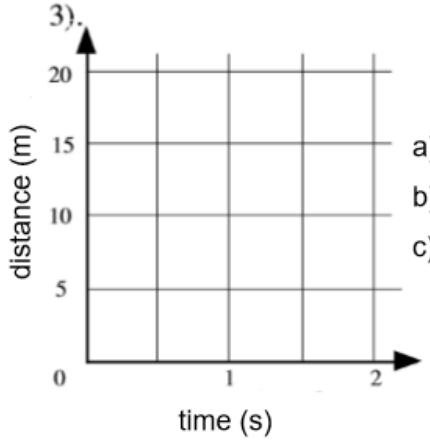

a) 10m/s
b) 40m/s
c) 5m/s

2).



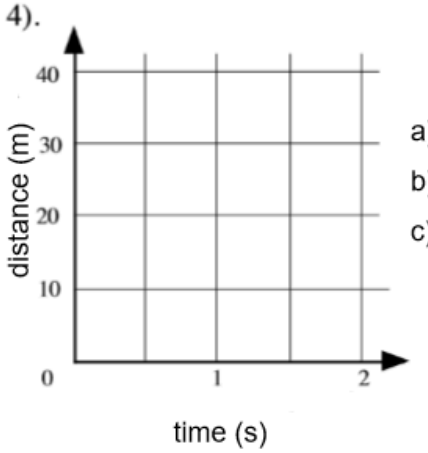

a) 20m/s
b) 10km/s
c) 2.5m/s

3).




a) 5m/s
b) 10m/s
c) 40m/s

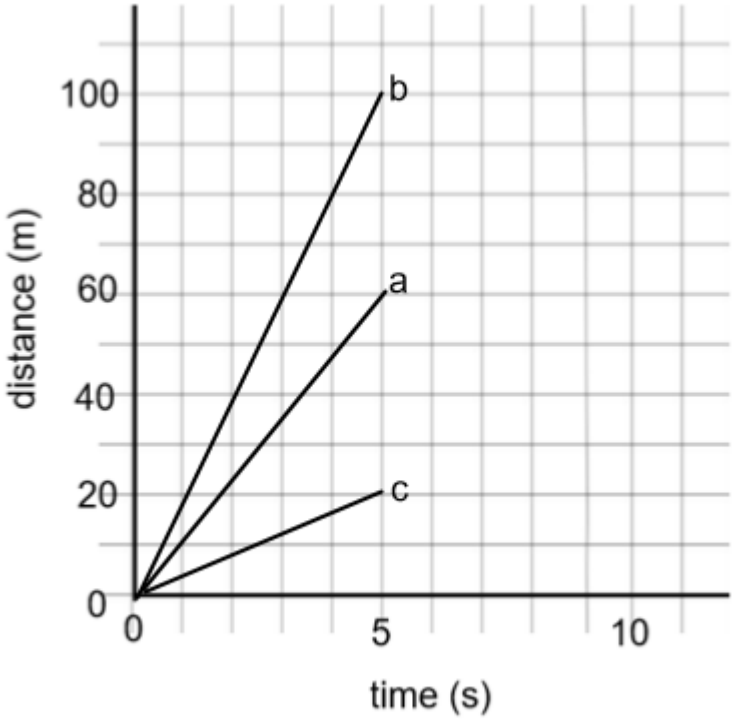
4).




a) 20m/s
b) 5m/s
c) 80m/s

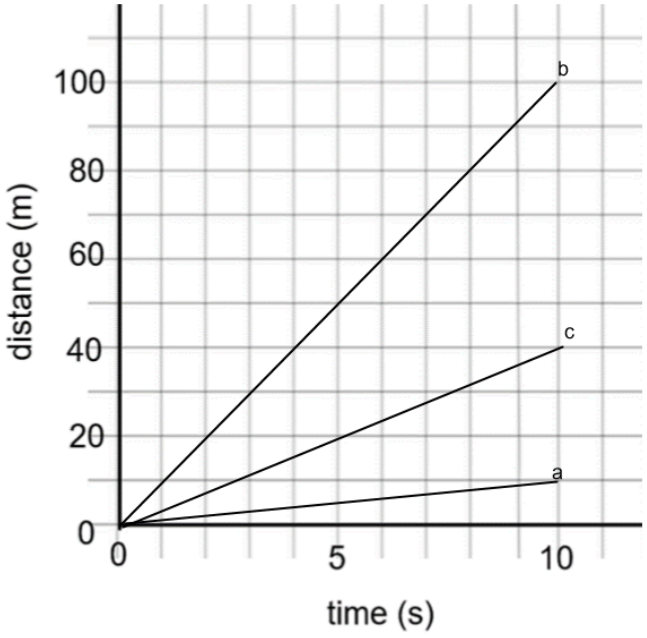
Answers

1.




a) 60m in 5s
b) 100m in 5s
c) 20m in 5s

2. a = 12m/s. b = 20m/s. c = 4m/s.




3.

4. A = 1m/s. b=10m/s. c=4m/s

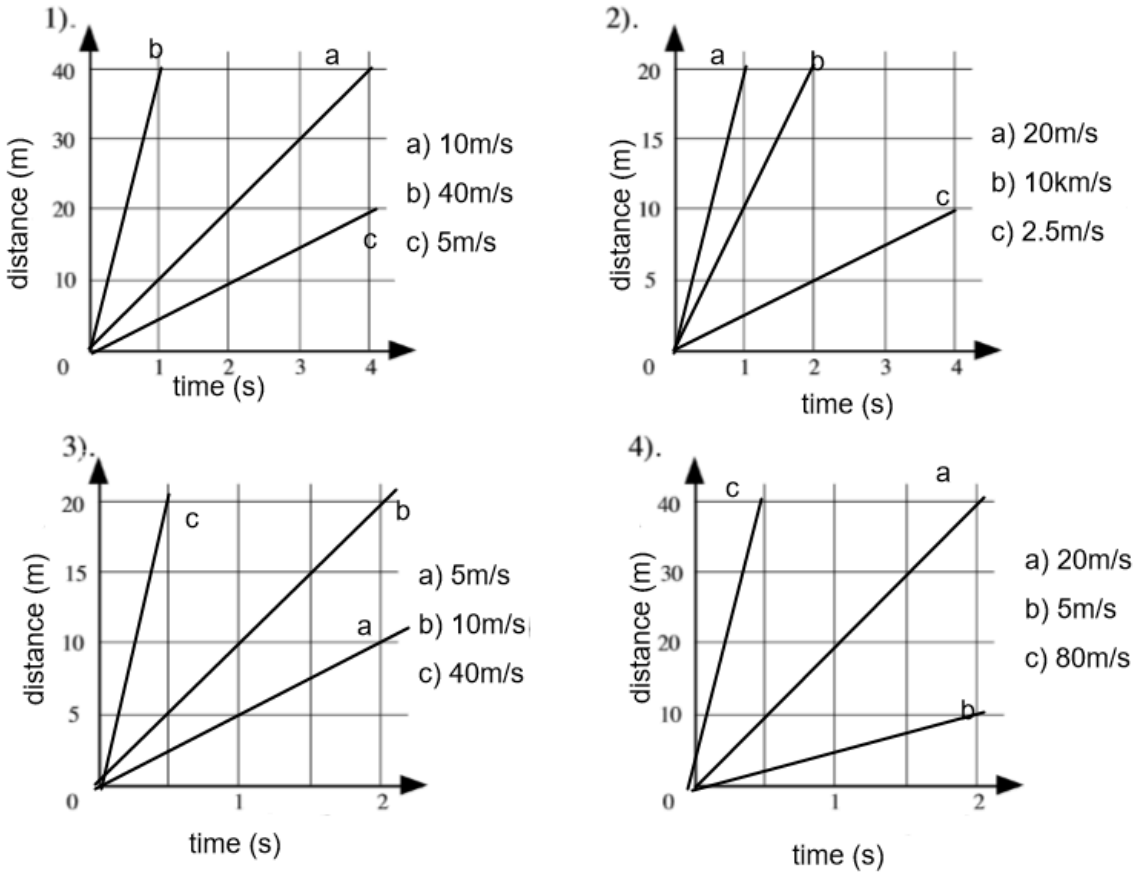
5.

A) 1.5m/s
B) 0.5m/s

C) 2m/s
D) 4m/s
E) 0.5m/s
F) 1.5m/s
G) 0ms

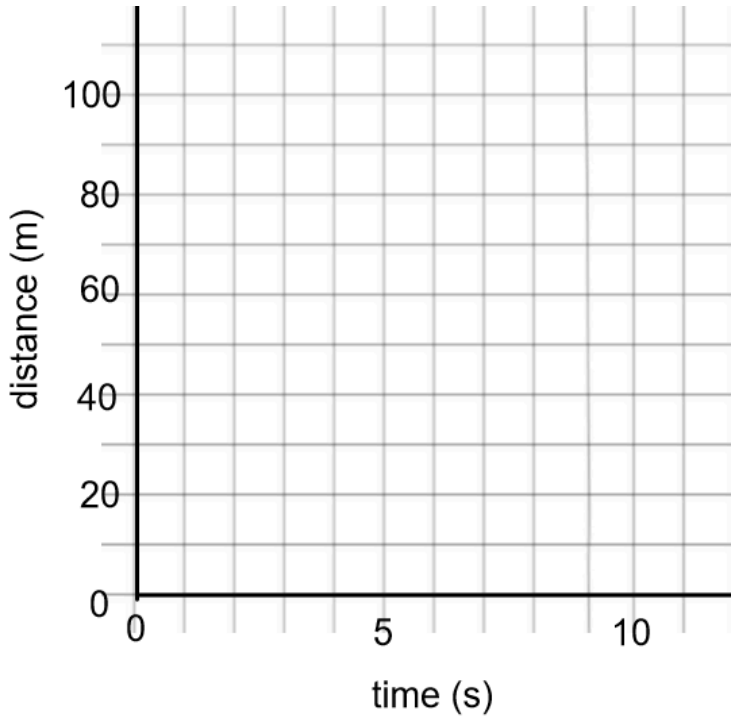
6. A = 2.5m/s. B= 1m/s. C= 20m/s

## Extension




## Intervention Questions

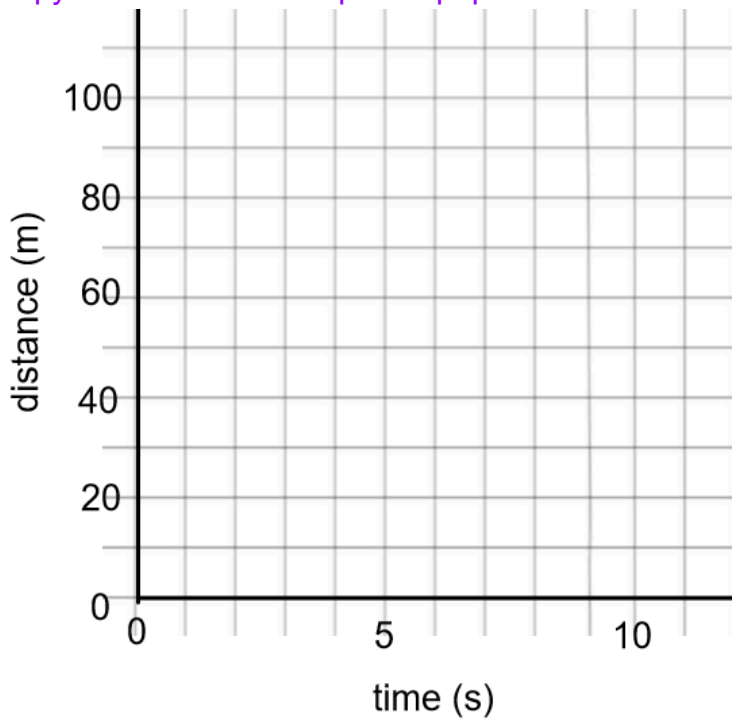
1. Copy the axes onto squared paper:




Draw lines to show the motion of an object that travels:

d) 40m in 5s
e) 80m in 5s
f) 60m in 5s

2. Find the speed for each of the objects in (1)
3. Copy these axes onto squared paper:




Draw lines to show the motion of:

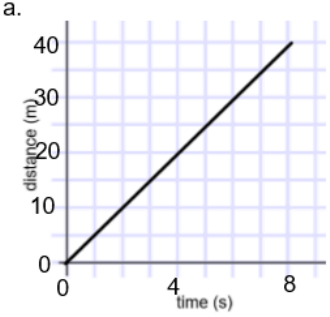
d) An object that travels 30m in 10s
e) An object that travels 60m in 10s

f) An object that travels 20m in 10s.

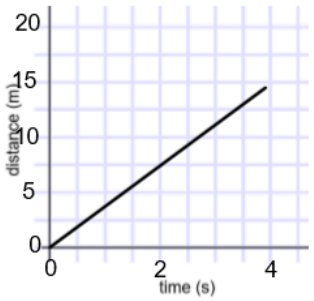
4. Find the speeds of each of these objects.

5. Find the speed of the following:

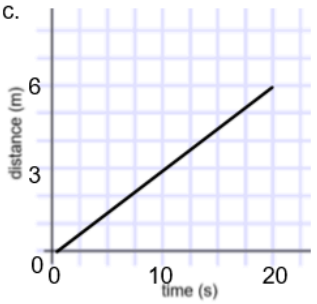
a.



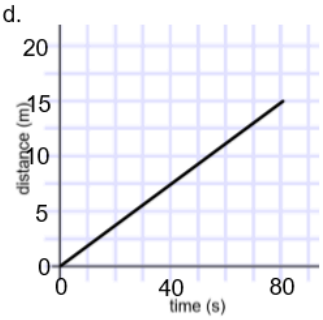

b.



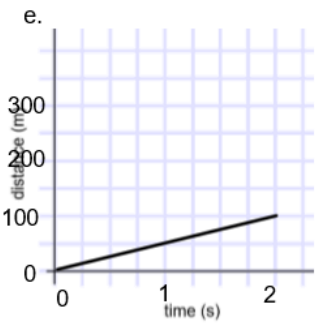

c.



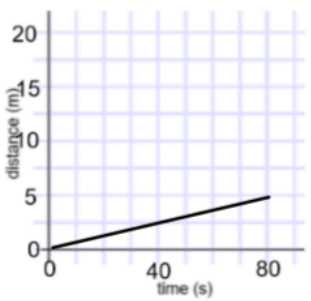

d.



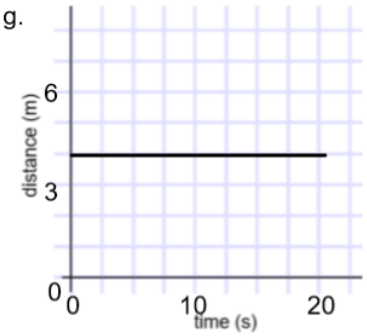

e.




f.

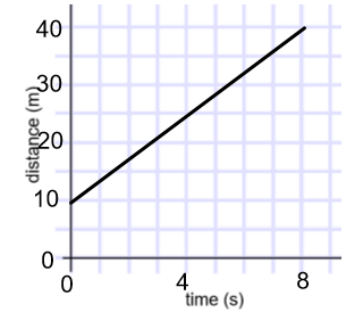



g.

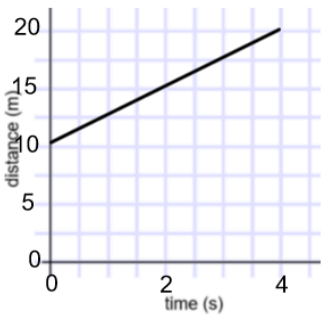



6. Find the speed of the following:

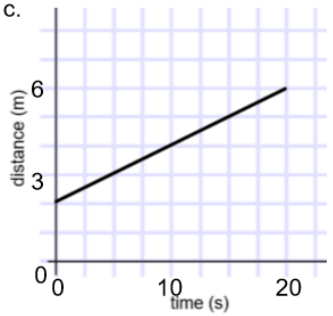
a.




b.

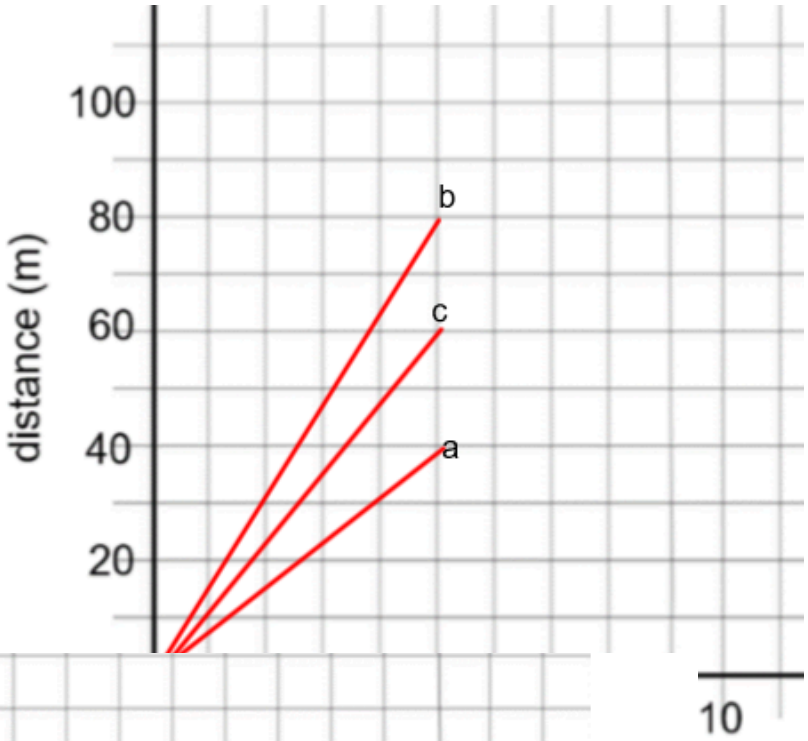



c.



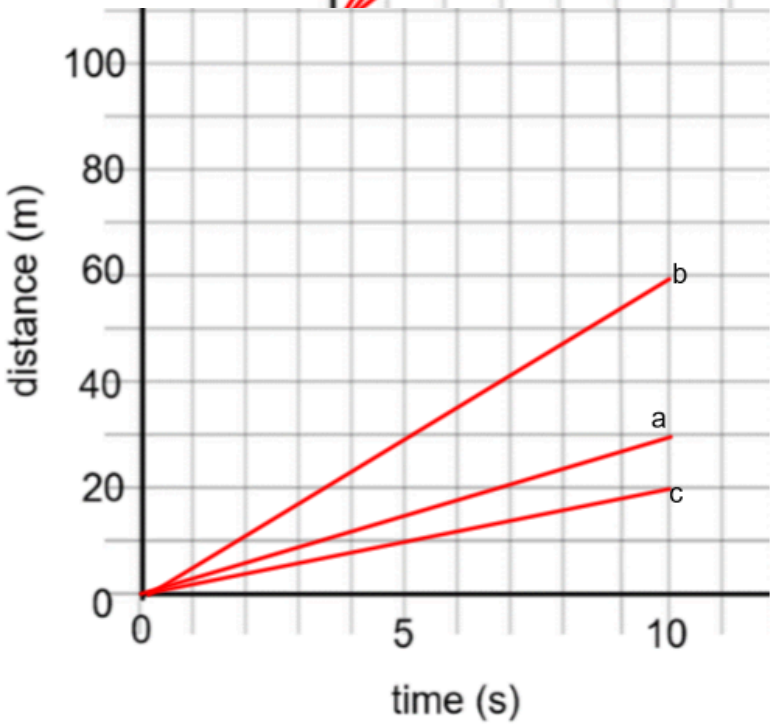
Intervention Answers

1.




2. a = 8m/s; b = 16m/s; c = 12m/s

3.




4. a = 3m/s; b = 6m/s; c = 2m/s

5. Find the speed of the following:

   a. 5m/s
   b. 3.75m/s
   c. 0.3m/s
   d. 0.19m/s
   e. 50m/s
   f. 0.06m/s

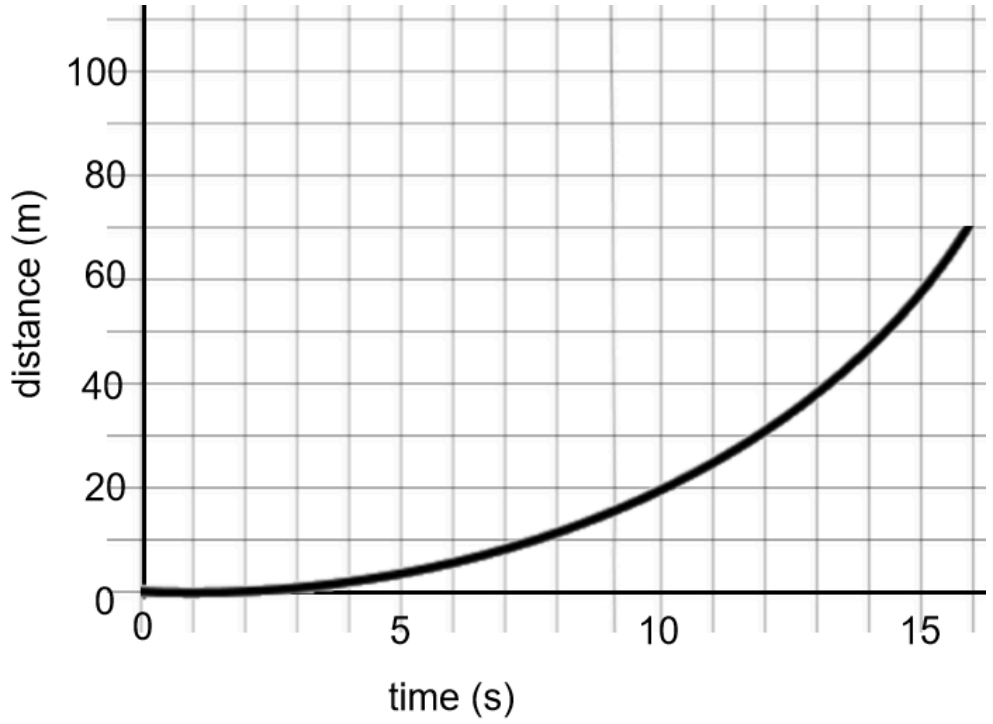
g. 4m/s

h.

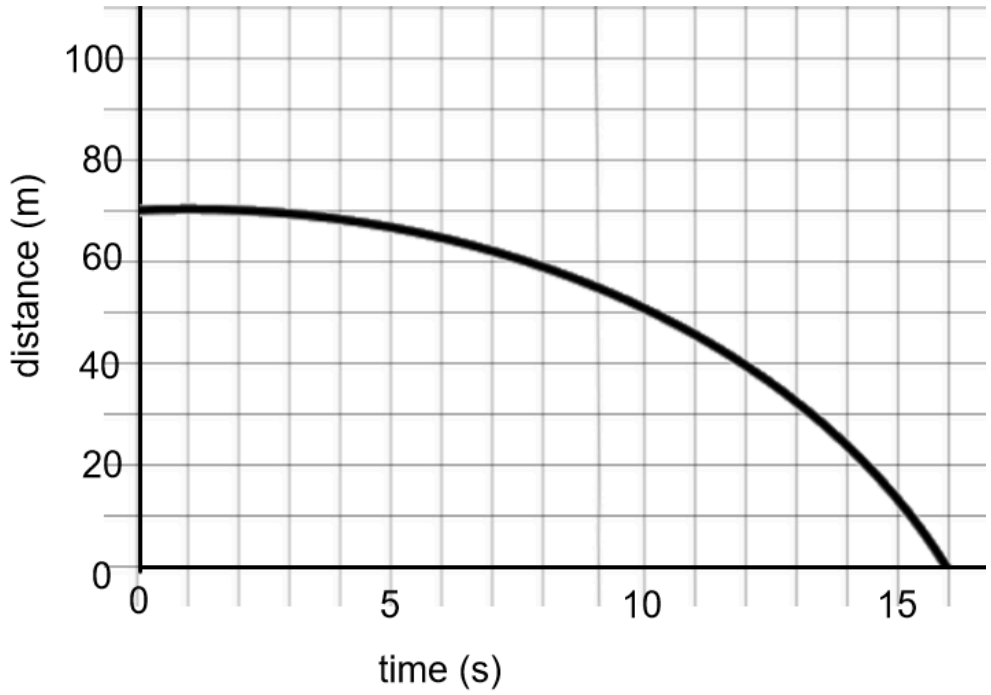
a. 3.75m/s
b. 2.5m/s
c. 0.15m/s

# Acceleration on a distance-time graph (HT)

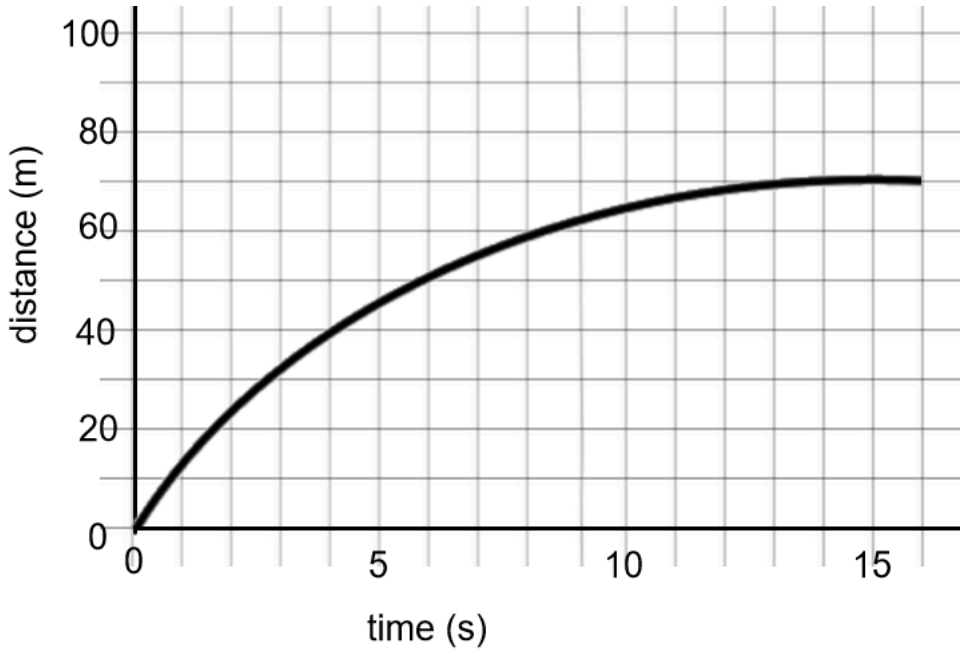
Acceleration is defined as rate of change of velocity. Since velocity is equivalent to the gradient on a distance-time graph, and accelerating object will have a changing gradient, i.e. a curved line:



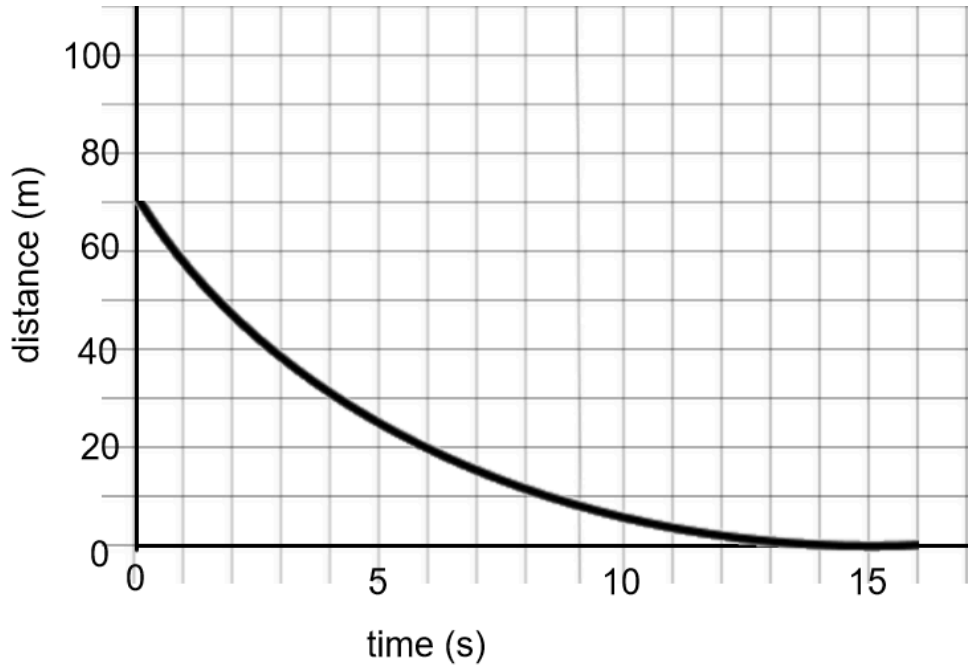

 This graph shows an object with increasing speed (positive acceleration) as the gradient is getting higher (steeper).




 This graph also shows an object with positive acceleration (increasing speed). It looks different because this object is travelling backwards instead of forwards.



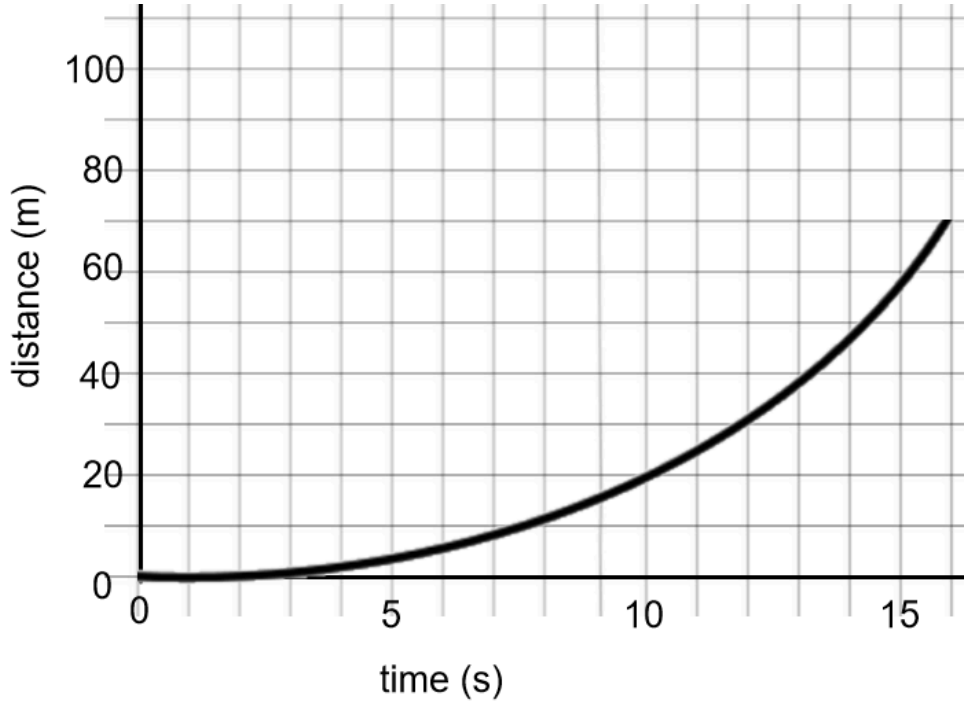

 This graph shows an object moving forward with negative acceleration, i.e. slowing down. The gradient is decreasing.

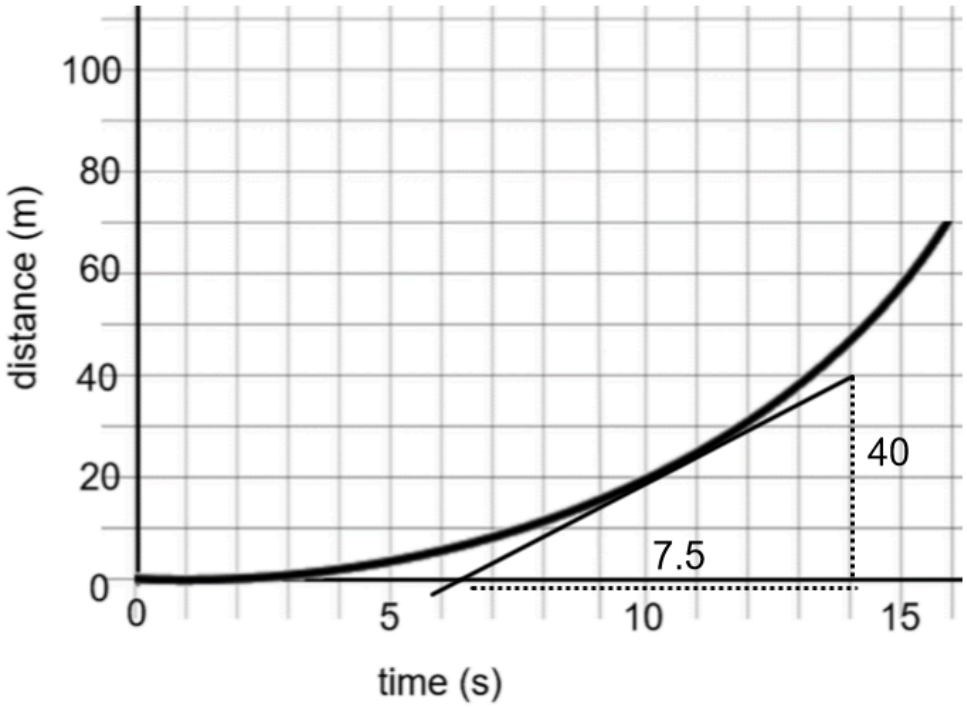



 This graph shows an object moving backwards with negative acceleration (slowing down).

To find the speed at any time, we can draw a tangent to the curve at that time, and find the gradient:

Example: Find the speed at 10 seconds:



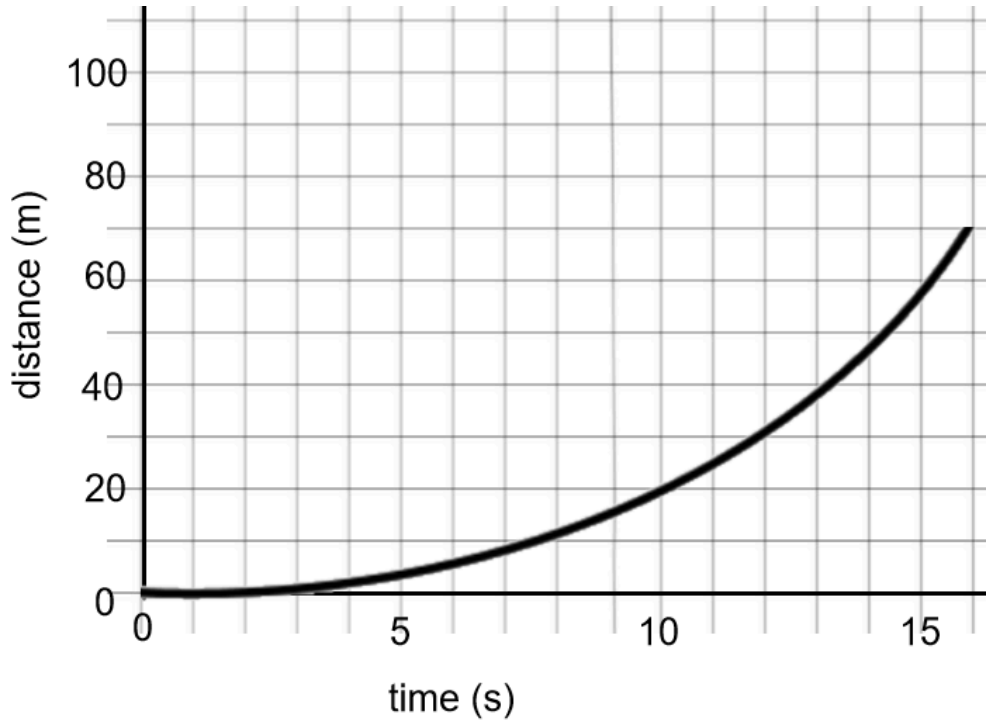



40 ÷ 7.5 = 5.33m/s

Questions:

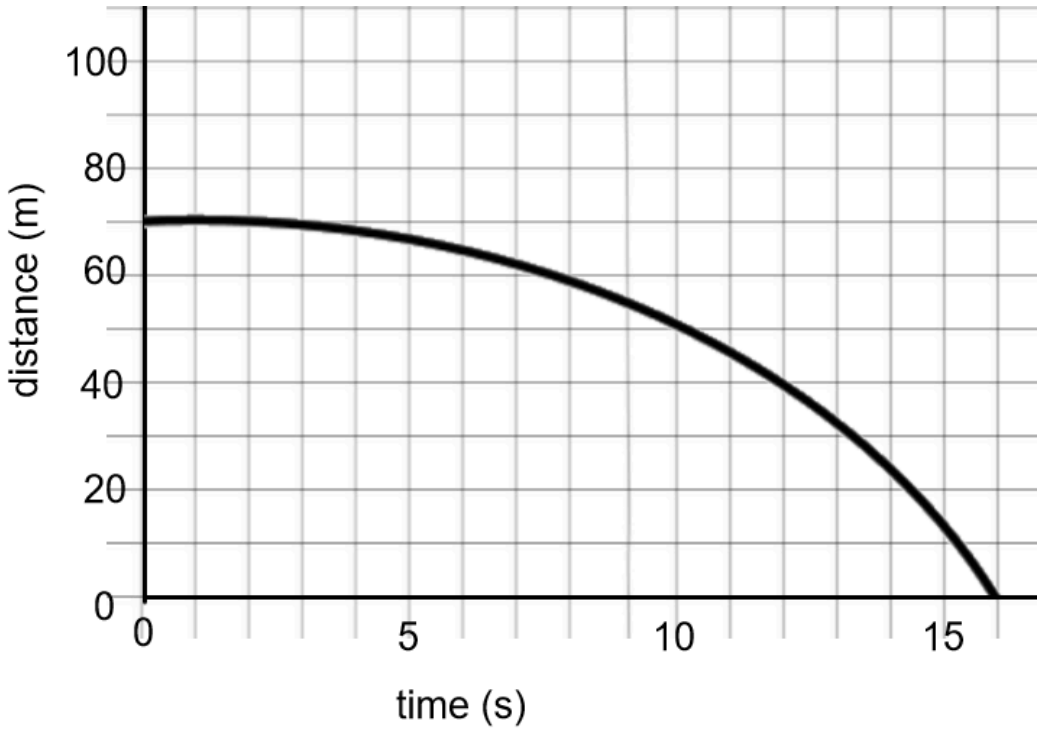
1. On a distance-time graph, what sort of line shows acceleration?
2. Sketch a d-t graph showing positive acceleration moving forwards
3. Sketch a d-t graph showing negative acceleration moving forwards
4. Sketch a d-t graph showing positive acceleration moving backwards
5. Sketch a d-t graph showing negative acceleration moving backwards
6. What happens to speed in positive acceleration?
7. What type of motion gives a positive gradient on a d-t graph?
8. What happens to speed in negative acceleration?
9. What type of motion gives a negative gradient on a d-t graph?
10. What is “negative acceleration” also known as?
11. How can we find momentary speed of an accelerating object from a distance-time graph?

12. Find the speed of the object in this graph:



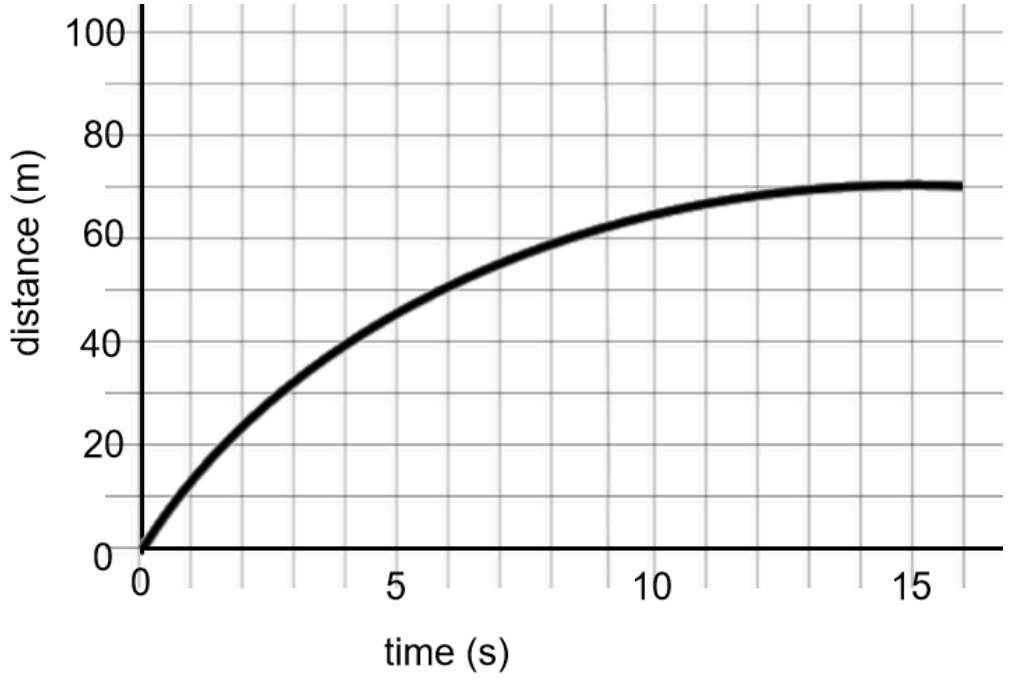

a. At 7 seconds
b. At 11 seconds
c. At 13 seconds
d. Is the object moving forwards or backwards?
e. Is the object accelerating or decelerating?

13. Find the speed of the object in this graph:




a. At 7 seconds
b. 10 seconds
c. 12 seconds
d. 14 seconds
e. Is the object moving forwards or backwards?
f. Is the object accelerating or decelerating?

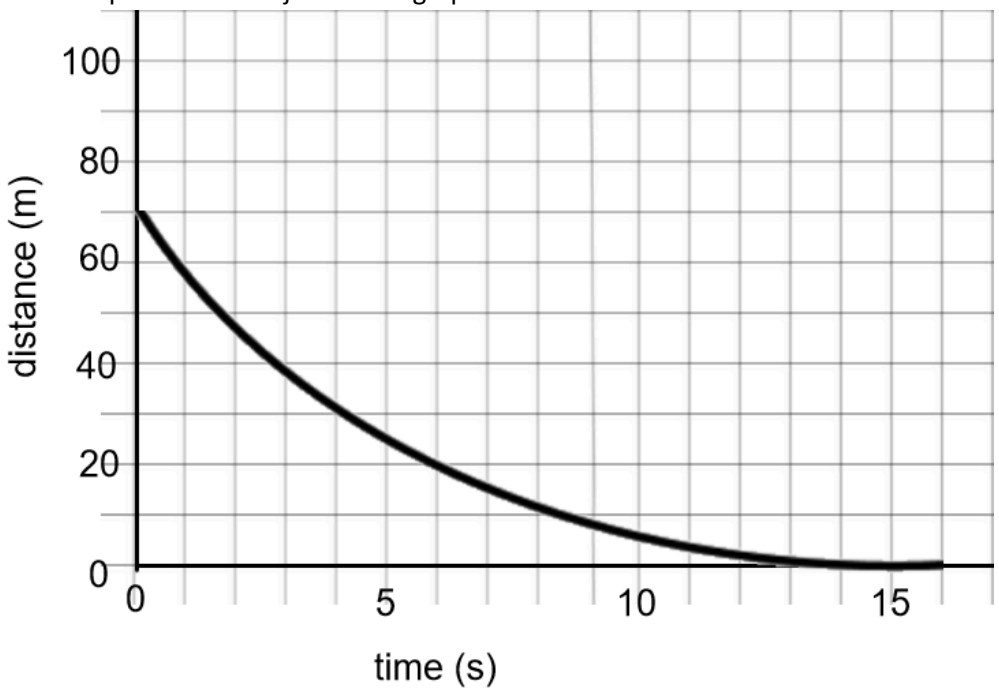
14. Find the speed of the object in this graph:




a. At 3 seconds

b. At 6 seconds
c. At 9 seconds
d. Is the object moving forwards or backwards?
e. Is the object accelerating or decelerating?

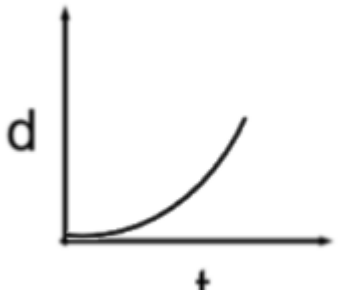
15. Find the speed of the object in this graph:



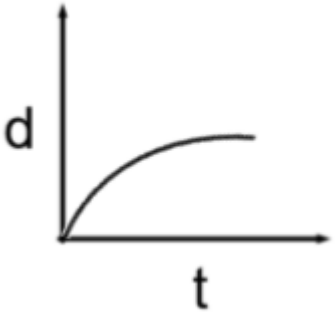

a. At 3 seconds
b. At 5 seconds
c. At 8 seconds.
d. Is the object moving forwards or backwards?
e. Is the object accelerating or decelerating?

Answers

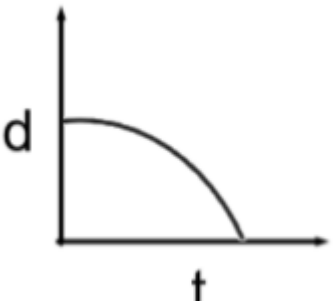
1. A curved line
2. Sketch a d-t graph showing positive acceleration moving forwards



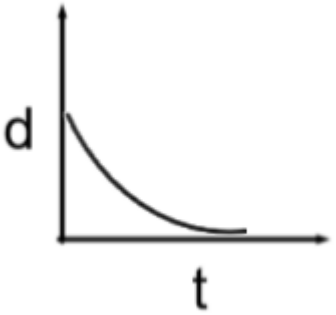

3. Sketch a d-t graph showing negative acceleration moving forwards



4. Sketch a d-t graph showing positive acceleration moving backwards




5. Sketch a d-t graph showing negative acceleration moving backwards




6. Increases
7. Acceleration
8. Decreases
9. Negative acceleration/ deceleration
10. Deceleration
11. Draw a tangent to the line at that moment
12. a. 3.16m/s

b. 4.35m/s
c. 8.57m/s
d. forwards
e. accelerating

13. a. -3.08s

b. -4.8m/s
c. -6.10m/s
d. -9.69m/s
e. backwards
f. accelerating

14. a. 7.5m/s

b. 4.89m/s
c. 3.08m/s
d. forwards
e. decelerating

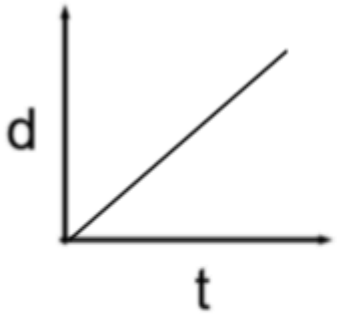
15. a. -7.46m/s

b. -5.21m/s

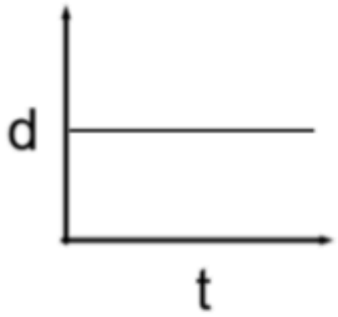
c. -3.33m/s
d. backwards
e. decelerating

Intervention Questions

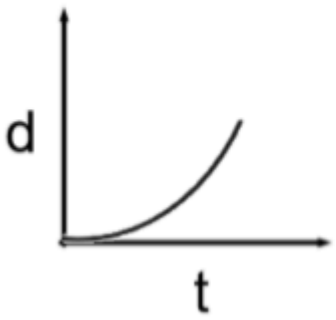
1. Copy and match:




stationary

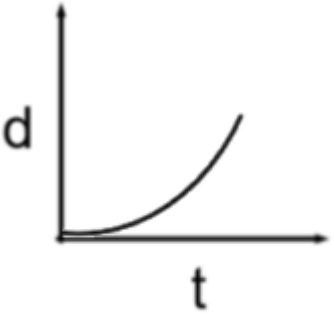



accelerating



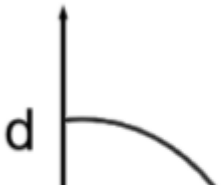

constant velocity

2. Copy and complete: Positive or negative acceleration? Moving forwards or backwards?

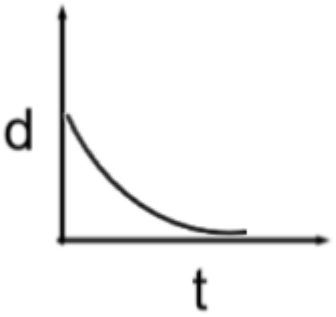


3. Copy and complete: Positive or negative acceleration? Moving forwards or backwards?


4. Copy and complete: Positive or negative acceleration? Moving forwards or backwards?




5. Copy and complete: Positive or negative acceleration? Moving forwards or backwards?



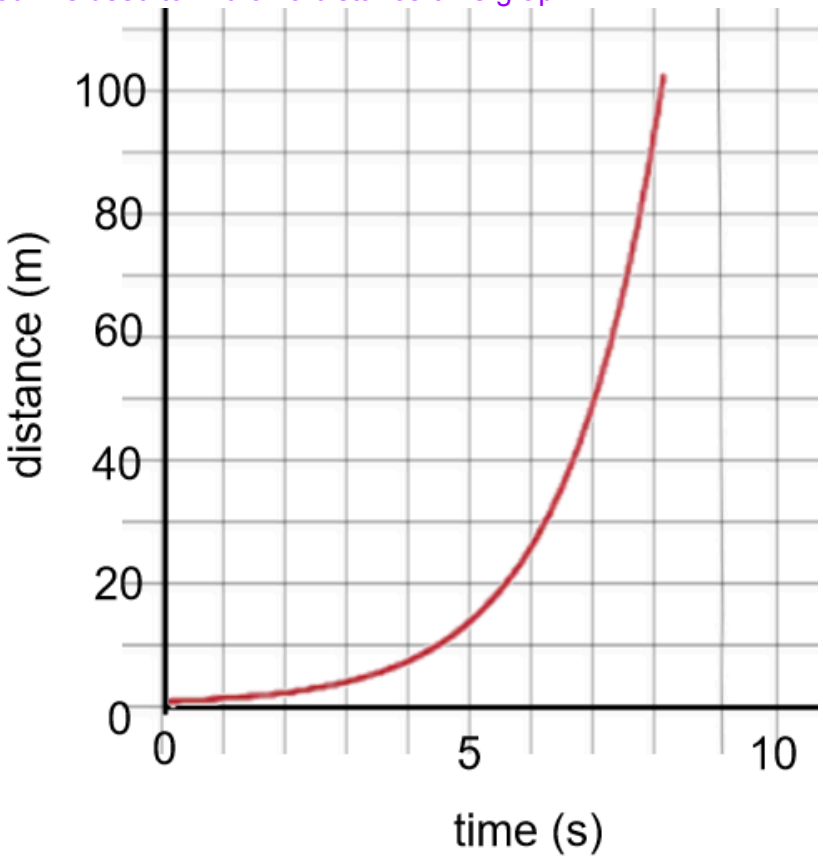

6. What happens to speed in positive acceleration?
7. What happens to gradient on a d-t graph for positive acceleration?
8. What happens to speed in negative acceleration?
9. What happens to gradient on a d-t graph for negative acceleration?
10. What is “negative acceleration” also known as?
11. What is a tangent to a curved line used to find on a distance-time graph?
12. Find the speed of the object in this graph: a) at 5s

b) at 6s

c) at 7s.

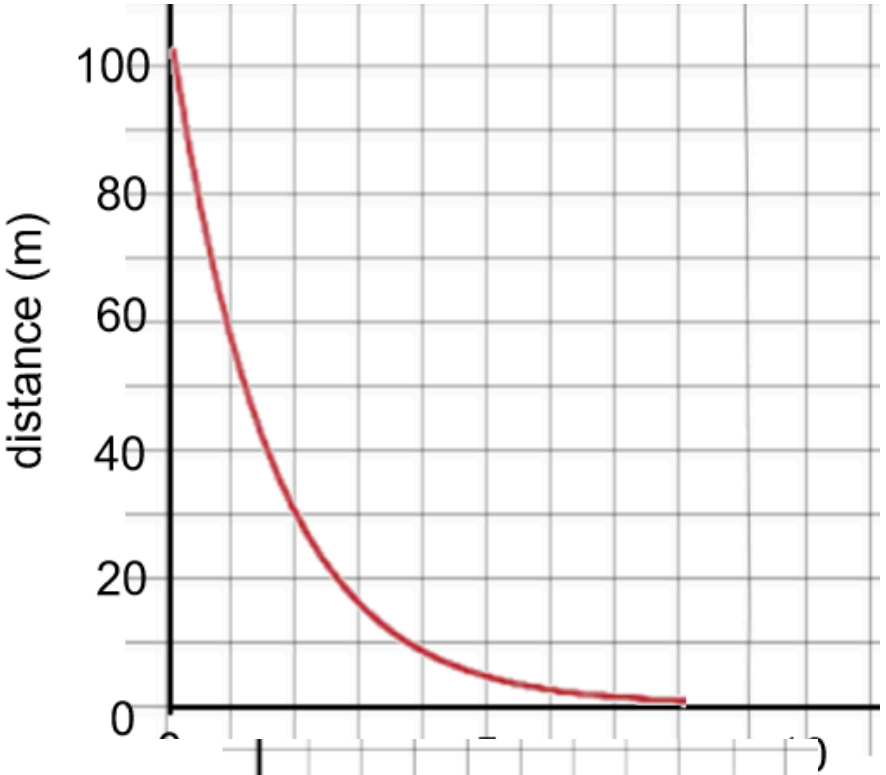
f. Is the object moving forwards or backwards?

g. Is the object accelerating or decelerating?



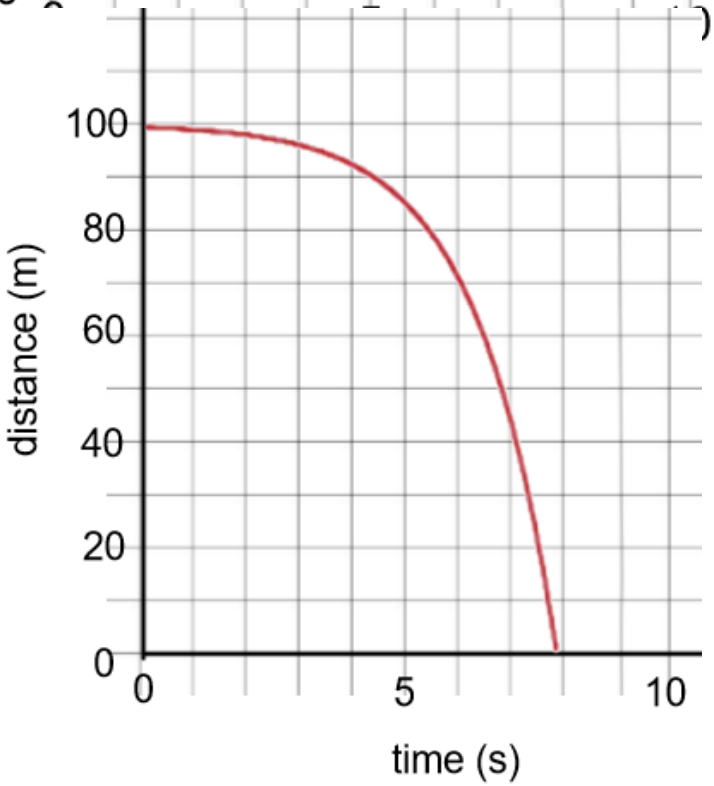
13. Find the speed of the object in this graph:

a) at 1s
b) at 2s
c) at 3s
d) Is the object moving forwards or backwards?
e) Is the object accelerating or decelerating?



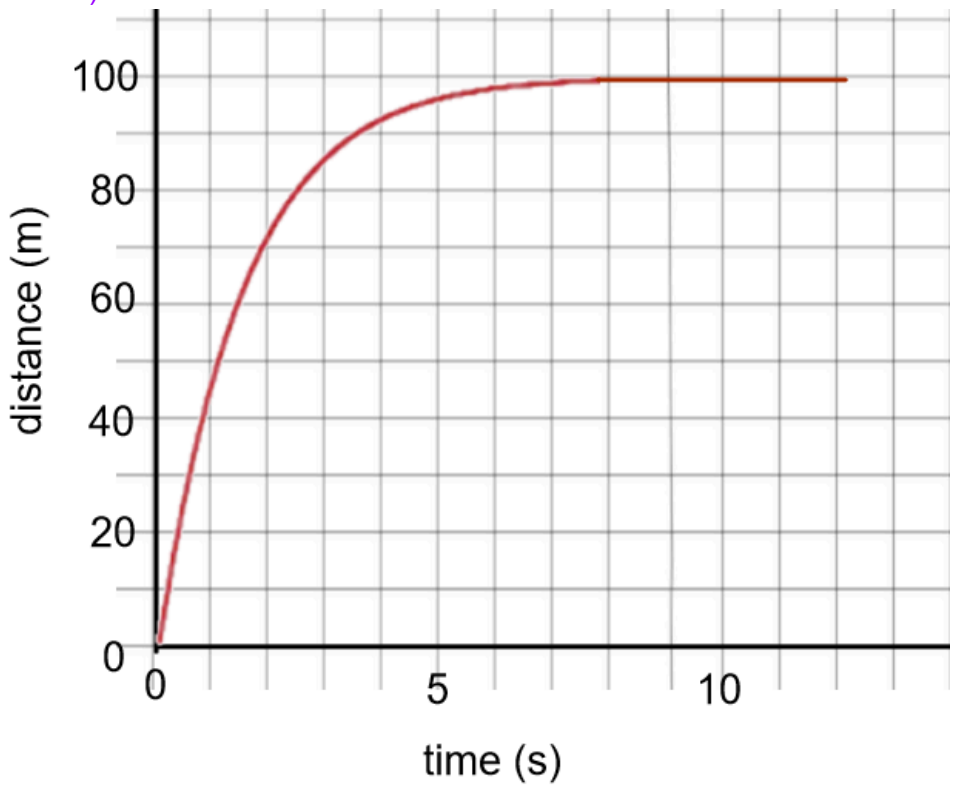

14. Find the speed of the object in this graph:

a) at 4s
b) at 5s
c) at 7s.
d) Is the object moving forwards or backwards?
e) Is the object accelerating or decelerating?

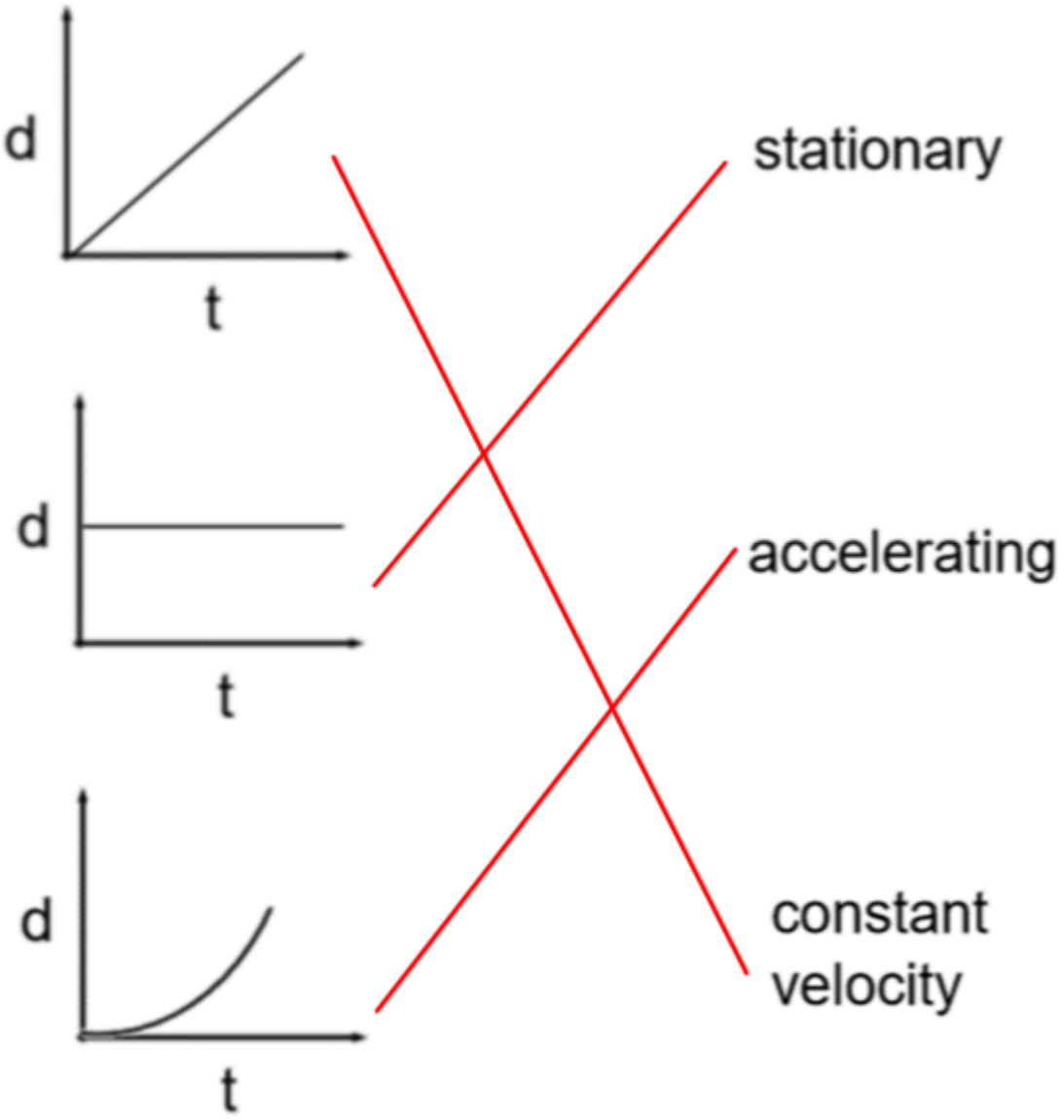



15. Find the speed of the object in this graph

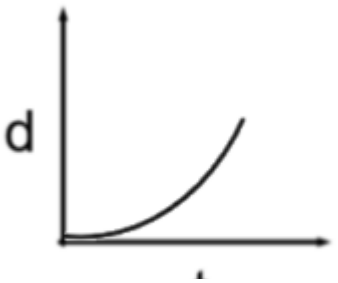
a) at 1s
b) at 4 s
c) at 10s




Intervention Answers

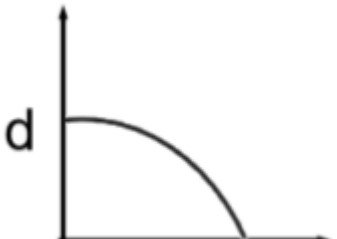



1.
2. Positive acceleration moving forwards

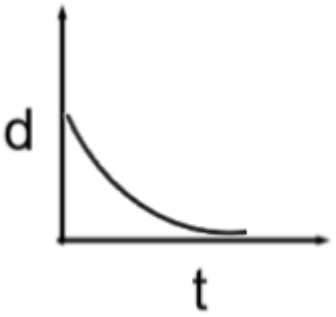



3. Negative acceleration moving forwards


4. Positive acceleration moving backwards



5. Negative acceleration moving backwards




6. Increases
7. Increases
8. Decreases
9. Decreases
10. Deceleration
11. Momentary speed
12. a. 7.72m/s

b. 14.58m/s
c. 30.56m/s
d. forwards
e. accelerating

13. a. -30.36m/s

b. -16.58m/s
c. -9.36m/s
d. backwards
e. decelerating

14. a. -4.62m/s

b. -10.78m/s
c. -40m/s
d. backwards
e. accelerating

15. a. 35m/s

b. 4.57m/s
c. 0m/s

# Acceleration

In everyday language, “accelerate” just means “go faster”. In Physics, it means more:

**Acceleration is defined as “rate of change of velocity (speed OR direction)”.**

Since velocity is both **speed and direction**, several different things count as acceleration:

- Speeding up (increasing speed)
- Starting to move from rest (increasing speed from 0)
- Changing direction of linear motion e.g. a ball bouncing (changing speed from + to – or vice versa)
- Slowing down (decreasing speed) – also called “deceleration”
- Stopping (decreasing speed to 0) – also called “deceleration”
- Turning a corner (changing direction)
- Circular motion (changing direction)

An acceleration always requires a **resultant force**. This is why you feel a force on you when you’re in a car and it speeds up, slows down or turns a corner.

The units for acceleration are $m/s^2$.

**Questions**

1. Define “acceleration”.
2. What is the unit for acceleration?
3. Explain why pressing the accelerator in a car causes the car to accelerate: what change is made to the velocity?
4. Explain why applying the brakes in a moving car causes it to accelerate: what change is made to the velocity?
5. Explain why the motion of a pebble dropped from a resting position is acceleration: what change is made to the velocity?
6. Explain why a pebble landing on the ground undergoes acceleration: what change is made to the velocity?
7. Explain why a bouncing ball is accelerating: what change is made to the velocity?
8. Explain why a car turning a corner is accelerating: what change is made to the velocity?
9. Explain why the Moon orbiting the Earth is accelerating.
10. What is the relationship between force and acceleration?

Answers

1. The rate of change of velocity (speed OR direction)
2. $m/s^2$
3. Increases the car's speed
4. Decreases the car's speed
5. Increases speed (from 0)
6. Decreases speed (to 0)
7. Changes direction
8. Changes direction
9. Changing direction
10. An acceleration always requires a resultant force.

**Intervention Questions**

1. The following definition of “acceleration” is not accurate. Write out the correct version:

“Acceleration is defined as the rate of change of speed”

2. What is acceleration measured in?
3. Explain why pedalling faster on a bike means the bike is accelerating: what change is made to the velocity?
4. Explain why a bike with the brakes applied is accelerating: what change is made to the velocity?
5. Explain why a bullet fired from rest is accelerating: what change is made to the velocity?
6. Explain why a bullet lodging in a sandbag is accelerating: what change is made to the velocity?
7. Explain why a bumblebee flying forwards and then backwards is accelerating: what change is made to the velocity?
8. Explain why a van turning a corner is accelerating: what change is made to the velocity?
9. Explain why the Earth orbiting the Sun is accelerating: what change is made to the velocity?
10. For the same mass, if you double the force, what happens to the acceleration?

**Intervention Answers**

1. Acceleration is rate of change of velocity (speed OR direction)
2. $m/s^2$
3. speed increased
4. speed decreased
5. speed increased
6. speed decreased
7. direction changed
8. direction changed
9. direction changed
10. double the acceleration

## Acceleration formula 1

Some typical accelerations:

Car: $3m/s^2$
Motorbike: $6m/s^2$
Object falling on Earth: $9.8m/s^2$
Space shuttle launch: $29m/s^2$

Average acceleration (or deceleration) can be calculated using the formula:

**Acceleration = change in velocity ÷ change in time**

And rearranged:

**Change in velocity = acceleration x time**

Which you need to memorise.

The change in velocity can be found using:

**Final velocity – initial velocity**

If an object is slowing down, the change in velocity will be a negative number. This gives a negative value for the acceleration. A negative acceleration is also called "deceleration".

**Questions**

1. Give typical accelerations for a car, motorbike, object falling on Earth and a space shuttle launch.
2. What formula links change in speed, acceleration and change in time?
3. An object accelerates from 5m/s to 10m/s over a period of 20s. Find the acceleration.
4. Find the acceleration of an object which starts at 0.2m/s and increases its speed to 12.5m/s over a period of 5s.
5. What acceleration takes an object to 8m/s from 20m/s over a period of 3s?
6. An object starts at 100m/s and decelerates to 75m/s over a period of 5 seconds. Calculate the deceleration.
7. Find the deceleration of an object starting out at 45m/s and reducing its speed to 13m/s over a period of 12s.
8. An object with initial velocity of 48m/s decelerates to 3m/s over a period of 30s. What is the deceleration?
9. An object starts at rest and accelerates to 14m/s over a period of 3.5s. Find the acceleration.
10. An object accelerates to 105m/s from rest in 55s. Calculate the acceleration.
11. What acceleration takes an object from rest to 64m/s in 4s?
12. An object travelling at 35m/s slows to a stop over a period of 70s. What is the deceleration?
13. Find the deceleration when an object comes to rest from 12m/s over a period of 2.5s.
14. What deceleration occurs when an object travelling at 58m/s comes to rest over a period of 4s?

15. How long would it take an object with deceleration $2m/s^2$ to go from 10m/s to 4m/s?
16. What time would it take an object with acceleration $4.3m/s^2$ to accelerate from 9m/s to 85m/s?
17. For an object with acceleration 0.45m/s, find the time taken to accelerate from rest to 3m/s.
18. For an object with an acceleration of $6m/s^2$, what is the change in velocity over 15s?
19. For an object with an acceleration of $-18m/s^2$, what is the change in velocity over 76s?
20. For an object with an acceleration of $0.9m/s^2$, what is the change in velocity over 200s?

Answers

1. Car: $3m/s^2$

Motorbike: $6m/s^2$
Object falling on Earth: $9.8m/s^2$
Space shuttle launch: $29m/s^2$

2. Change in speed = acceleration x time
3. $0.25m/s^2$
4. $2.46m/s^2$
5. $4m/s^2$
6. $-5m/s^2$
7. $-2.67m/^s$
8. $-0.53m/s^2$
9. $4m/s^2$
10. $1.91m/s^2$
11. $16m/s^2$
12. $-0.5m/s^2$
13. $-4.8m/s^2$
14. $-14.5m/s^2$
15. 3s
16. 17.67s
17. 6.67s
18. 90m/s
19. -1368m/s
20. 180m/s

Intervention Questions

1. Give typical accelerations for a car, motorbike, object falling on Earth and a space shuttle launch.
2. What formula links change in speed, acceleration and change in time?

3. An object accelerates from 3m/s to 9m/s over a period of 20s. Find the acceleration.
4. Find the acceleration of an object which starts at 0.3m/s and increases its speed to 16.5m/s over a period of 8s.
5. What acceleration takes an object to 5m/s from 30m/s over a period of 7s?
6. An object starts at 150m/s and decelerates to 65m/s over a period of 10 seconds. Calculate the deceleration.
7. Find the deceleration of an object starting out at 41m/s and reducing its speed to 23m/s over a period of 11s.
8. An object with initial velocity of 98m/s decelerates to 53m/s over a period of 60s. What is the deceleration?
9. An object starts at rest and accelerates to 140m/s over a period of 25s. Find the acceleration.
10. An object accelerates to 145m/s from rest in 65s. Calculate the acceleration.
11. What acceleration takes an object from rest to 34m/s in 24s?
12. An object travelling at 25m/s slows to a stop over a period of 30s. What is the deceleration?
13. Find the deceleration when an object comes to rest from 42m/s over a period of 5.5s.
14. What deceleration occurs when an object travelling at 68m/s comes to rest over a period of 7s?
15. How long would it take an object with deceleration $8m/s^2$ to go from 90m/s to 4m/s?
16. What time would it take an object with acceleration $1.3m/s^2$ to accelerate from 2m/s to 35m/s?
17. For an object with acceleration 4.45m/s, find the time taken to accelerate from rest to 5m/s.
18. For an object with an acceleration of $6m/s^2$, what is the change in velocity over 65s?
19. For an object with an acceleration of $-17m/s^2$, what is the change in velocity over 86s?
20. For an object with an acceleration of $0.9m/s^2$, what is the change in velocity over 210s?

Intervention Questions

1. Car: $3m/s^2$

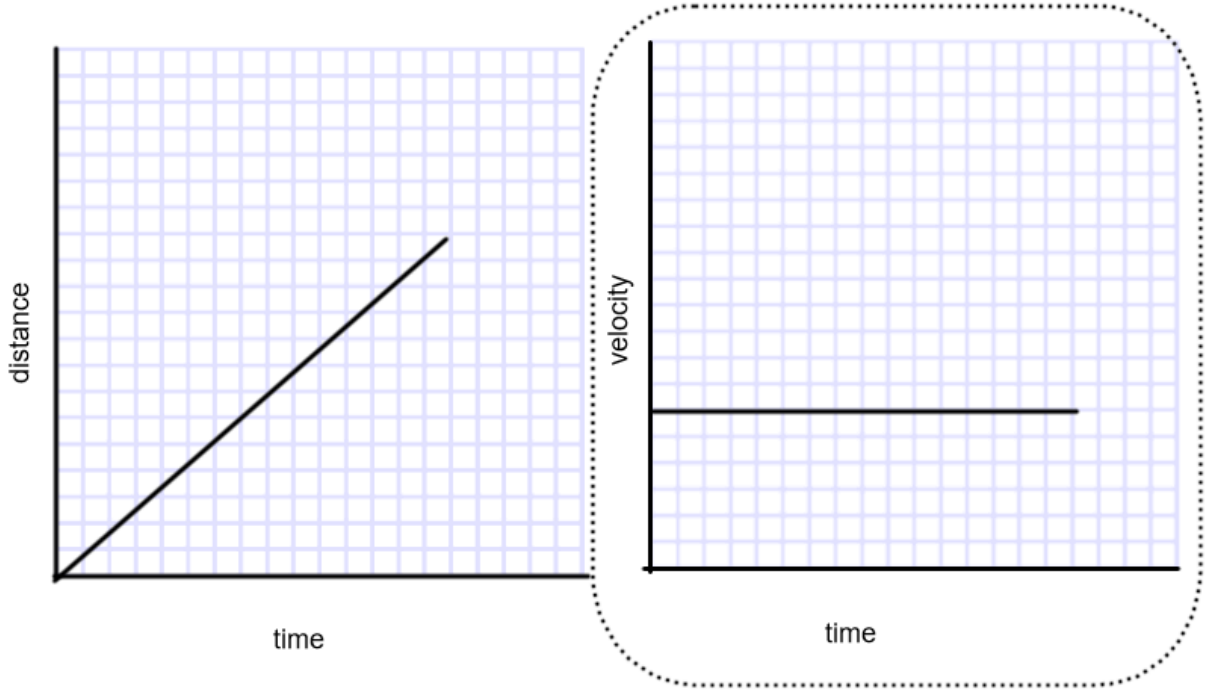
Motorbike: $6m/s^2$
Object falling on Earth: $9.8m/s^2$
Space shuttle launch: $29m/s^2$

1. acceleration = change in speed ÷ time
2. $0.3m/s^2$
3. $2.03m/s^2$
4. $-3.57m/s^2$
5. $-8.5m/s^2$
6. $-1.64m/s^2$
7. $-0.75m/s^2$

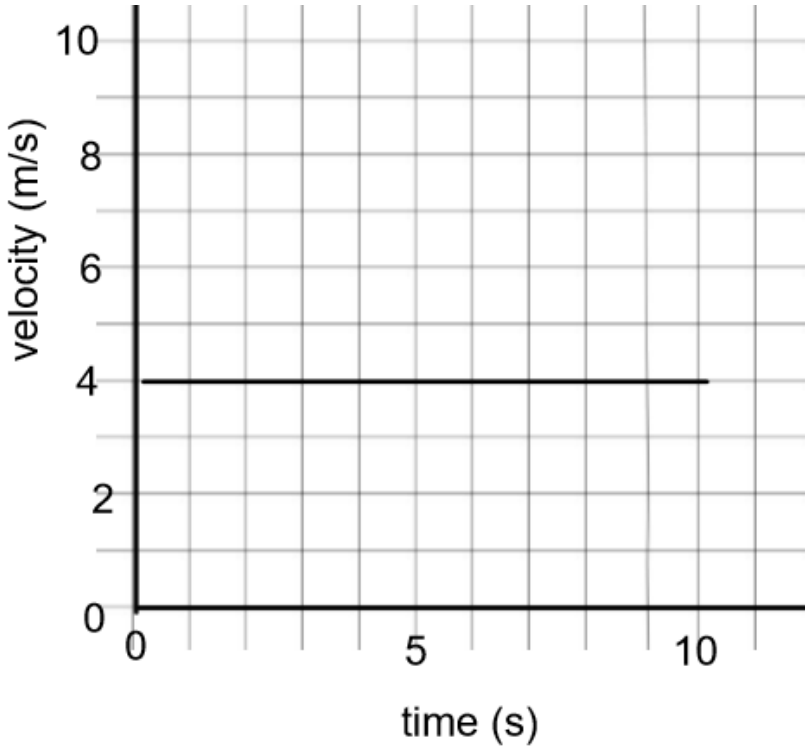
8. $5.6m/s^2$
9. $2.23m/s^2$
10. $1.42m/s^2$
11. $-0.833m/s^2$
12. $-7.64m/s^2$
13. $-9.71m/s^2$
14. 10.75s
15. 25.38s
16. 1.12s
17. 390m/s
18. -1,462m/s
19. 189m/s

# Velocity time graphs

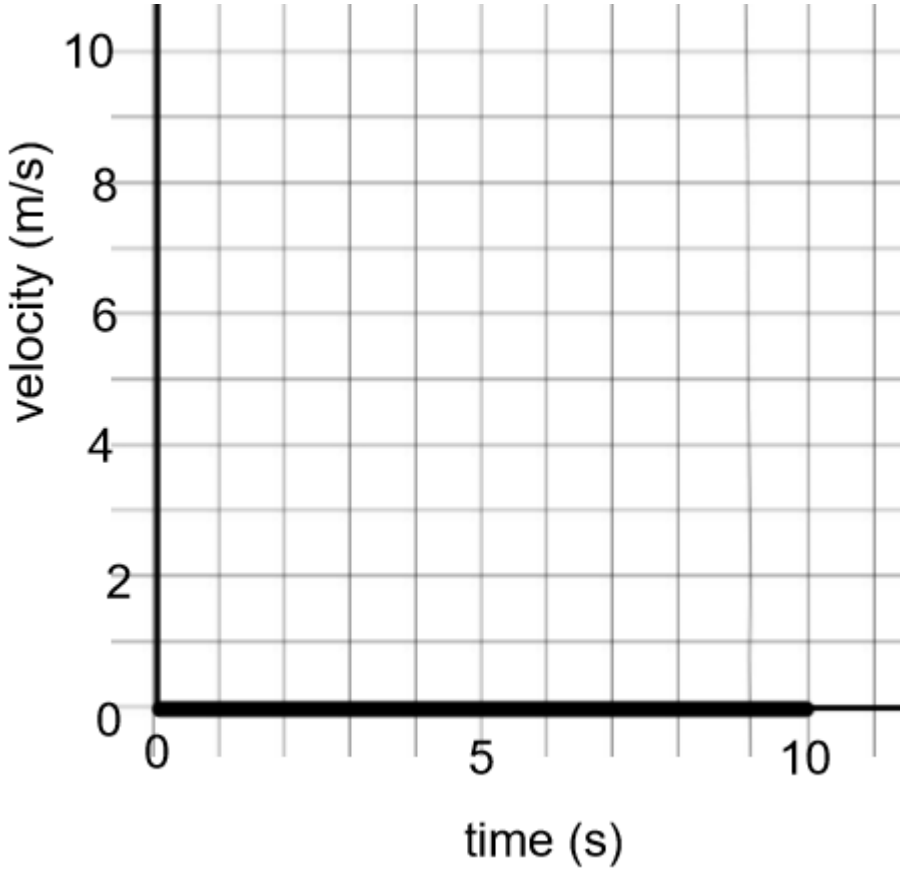
The motion of an object can be shown using a velocity-time graph:



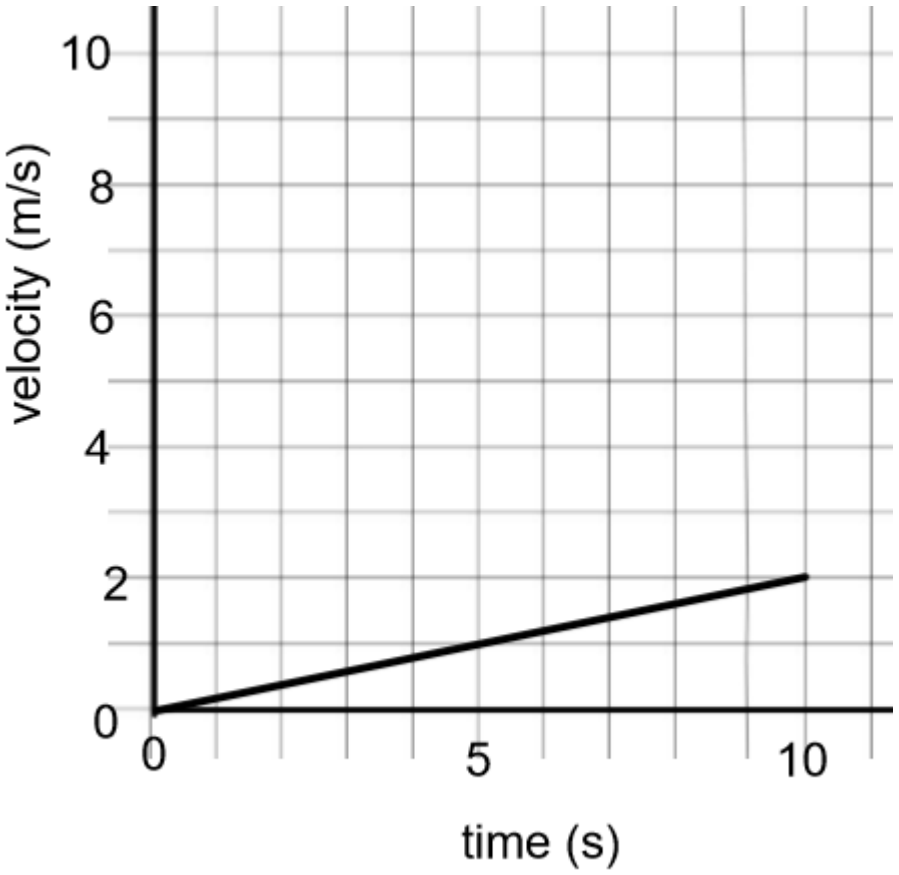

It's easy to confuse these with distance-time graphs, but it's important not to do so.



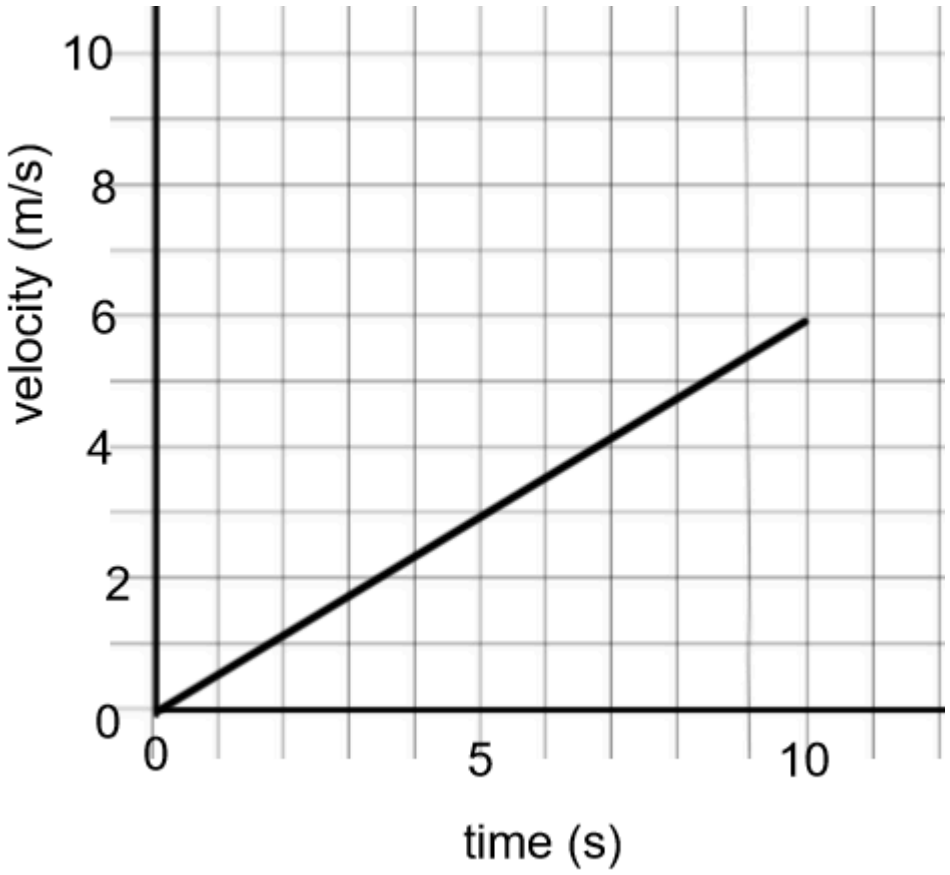
This graph shows an object moving at a constant velocity (steady speed). The gradient is 0 (horizontal line), so the acceleration is 0. Note this does **not** mean the object is stationary. In this example, the object is moving at a steady speed of 4m/s.



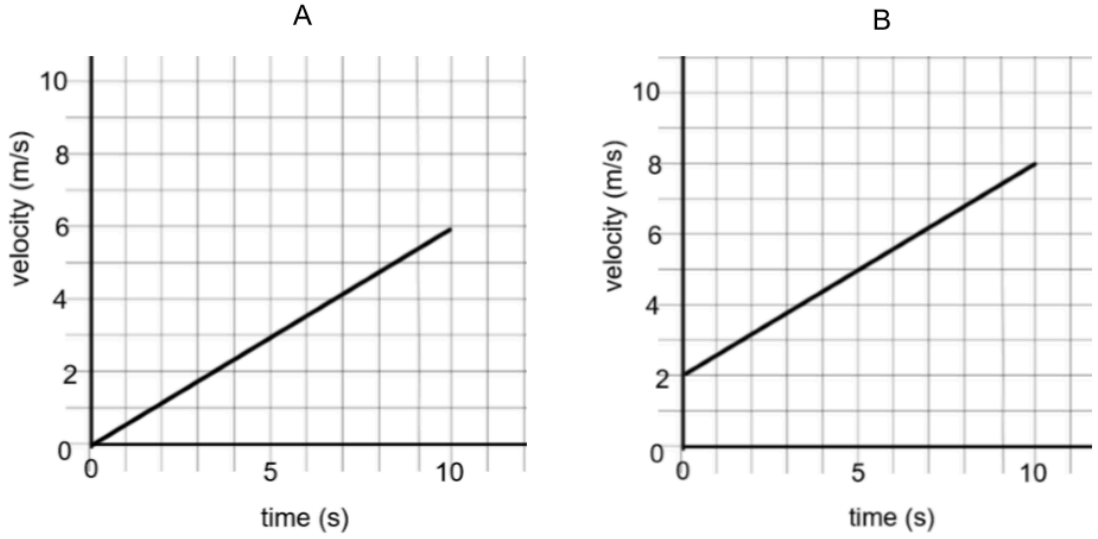

This graph shows an object which is stationary. The line shows the velocity stays at 0 for the time shown. Note that stationary is a form of constant velocity: the gradient is 0 (the line is horizontal).



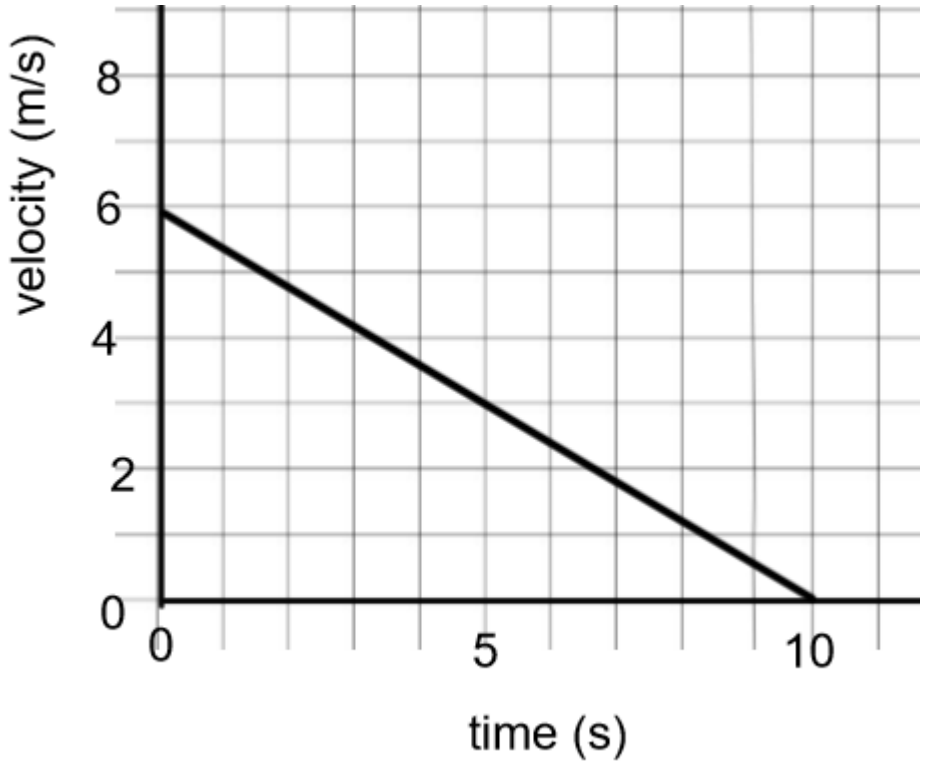

 This graph shows an object which is accelerating. The line has a gradient (it is sloping). The speed is changing. It starts off at 0m/s, and after 10 seconds it has increased to 2m/s.




 This graph shows an object with a higher acceleration, i.e. its speed is increasing more quickly. This object has only taken 3.5s to reach 2m/s. At 10s, its speed is 6m/s. The gradient is higher (the slope is steeper) because the acceleration is higher.




 The graphs above show two objects with the same accelerations but different starting (and therefore finishing) speeds.

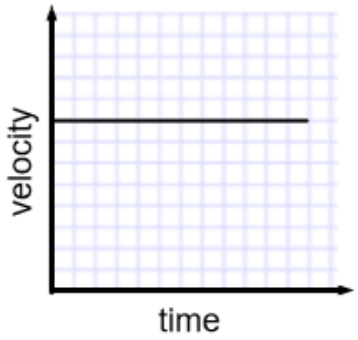



 This graph shows an object with negative acceleration (deceleration).

**Questions:**

State what each graph shows: acceleration, constant velocity, negative acceleration, or stationary:

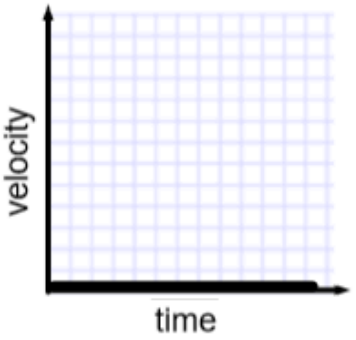
1.




2.


3.


4.




Answers:

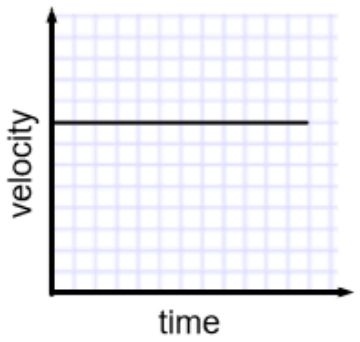
1. Constant velocity
2. Acceleration
3. Negative acceleration (deceleration)
4. Stationary

Intervention Questions:

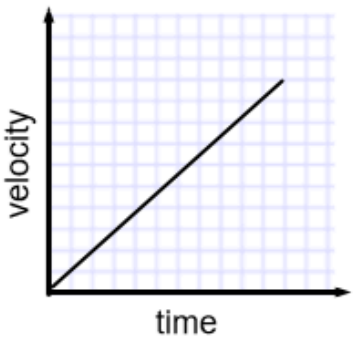
1. Sketch a velocity-time graph showing constant velocity
2. Sketch a velocity-time graph showing acceleration
3. Sketch a velocity-time graph showing deceleration
4. Sketch a velocity-time graph showing remaining stationary

Intervention Answers:

1.

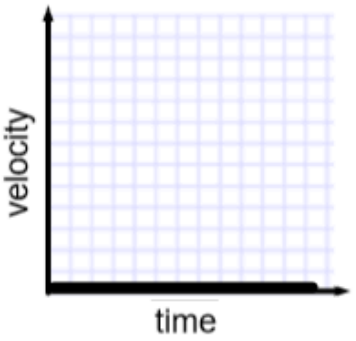



2.




3.


4.



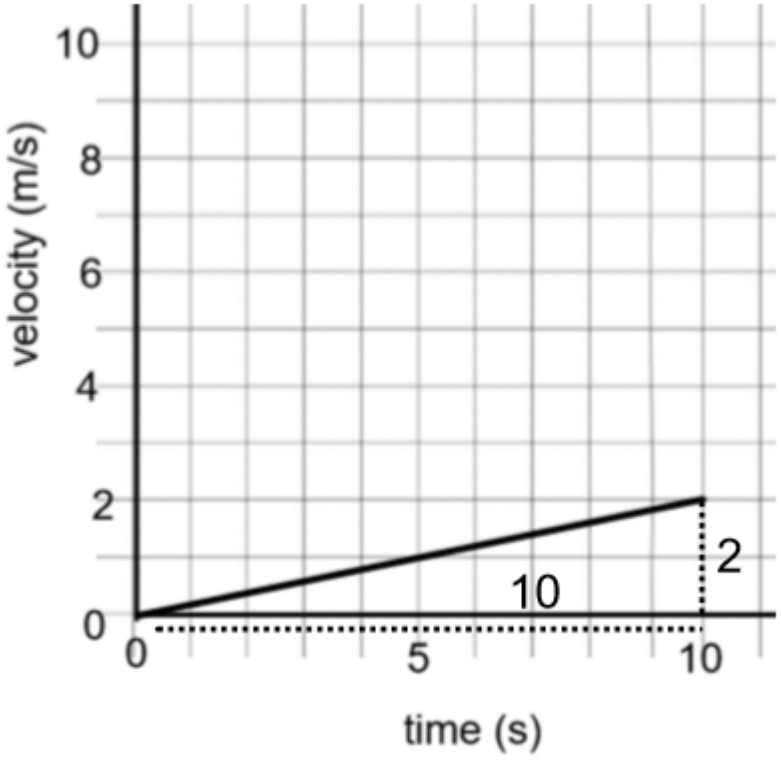

Finding acceleration from the gradient of a velocity-time graph

Because acceleration is change in velocity ÷ time, we can find acceleration of an object by finding the gradient of a velocity-time graph.

The first thing we need to know is that:

Change in velocity = final velocity – initial velocity

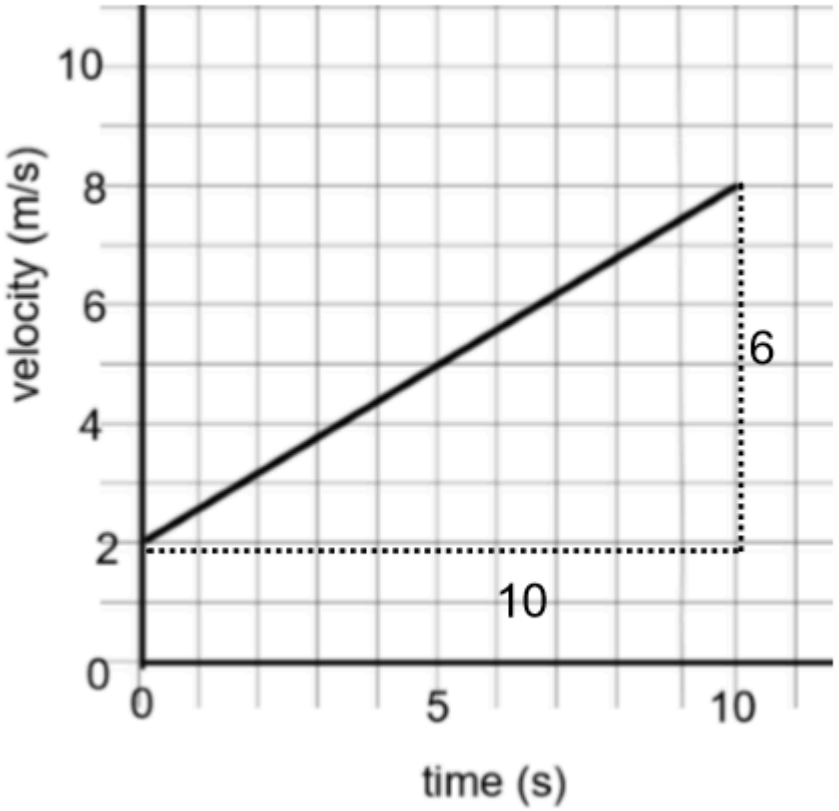
= end speed - starting speed




Change in velocity = 2 – 0  = 2m/s

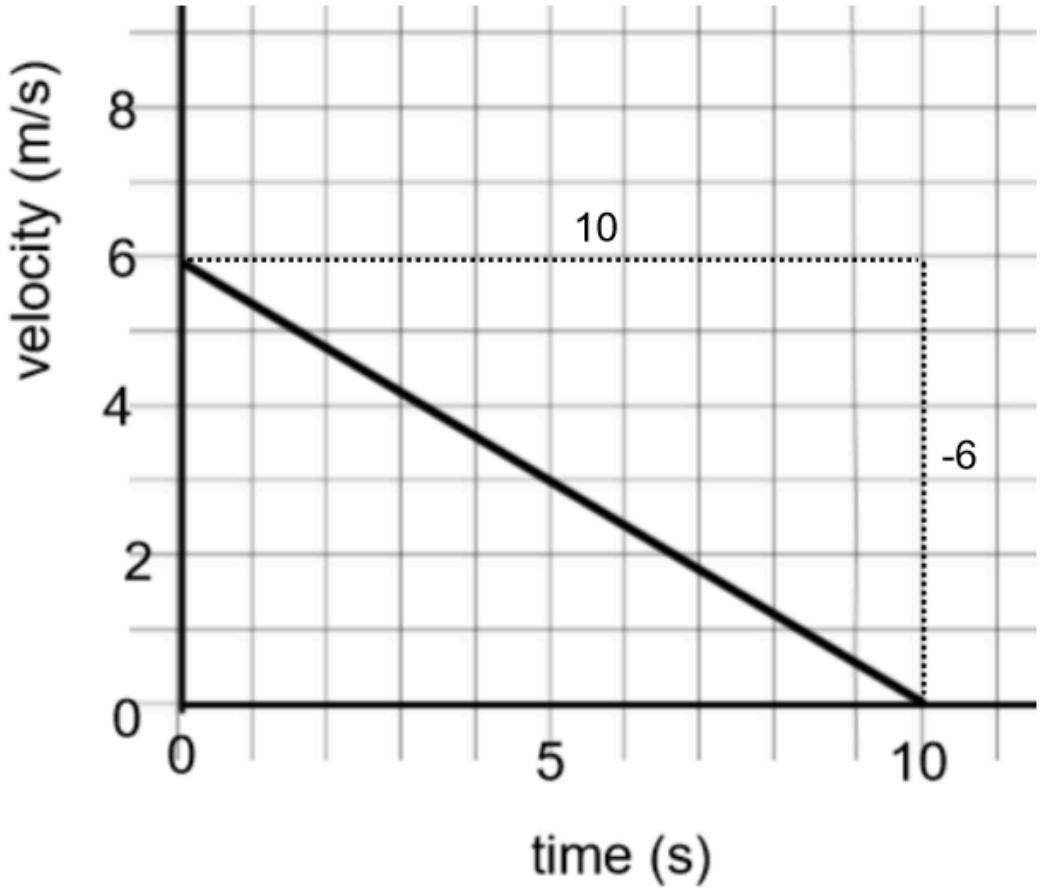
Acceleration = 2 ÷ 10 = 0.2m/s/s.

We have to be careful to use change in velocity, not final velocity:




Change in velocity = 8 – 2 = 6m/s
Acceleration = 6 ÷ 10 = 0.6m/s/s.

And if the gradient is negative:



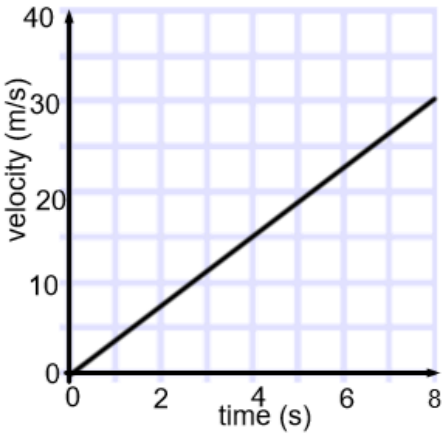

Change in velocity = 0 – 6 = -6

Gradient = -6 ÷ 10 = -0.6m/s/s
Acceleration = -0.6m/s/s

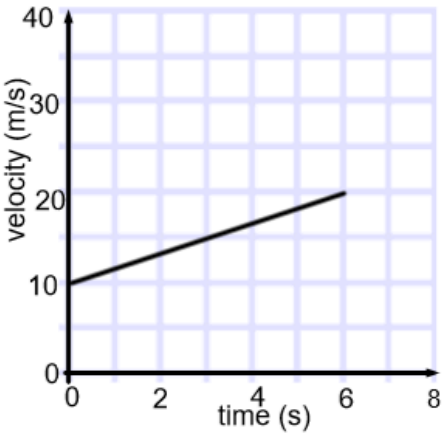
Questions:

Find the acceleration of the objects in the following graphs:

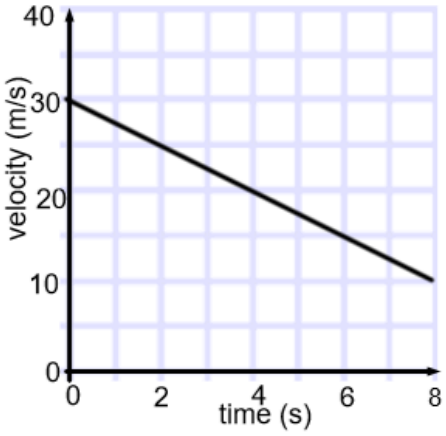
1.



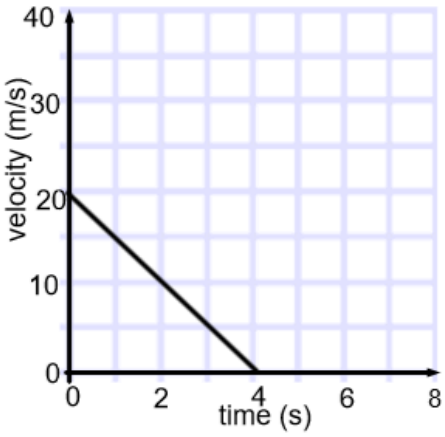

2.



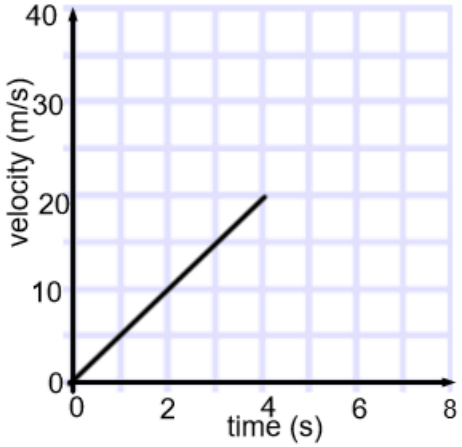

3.



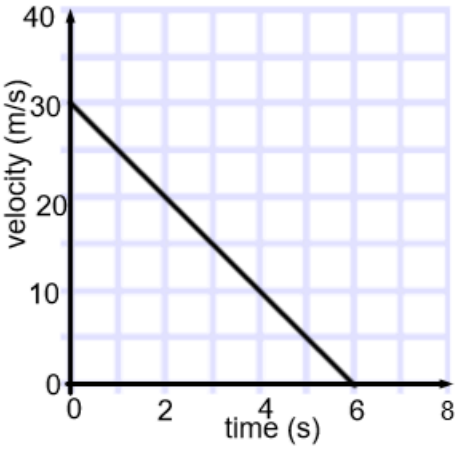

4.



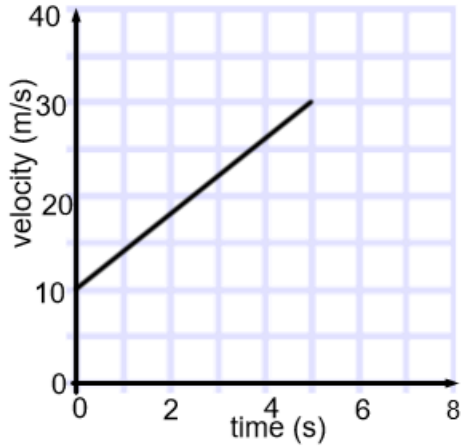
5.



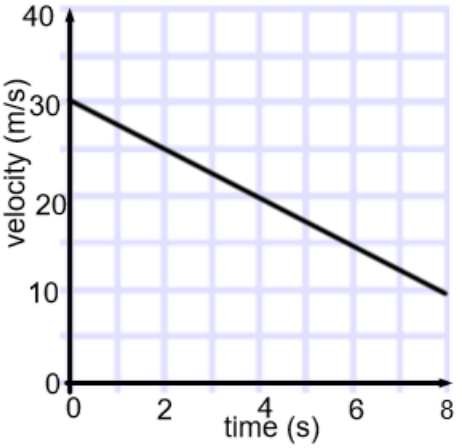

6.




7.




8.



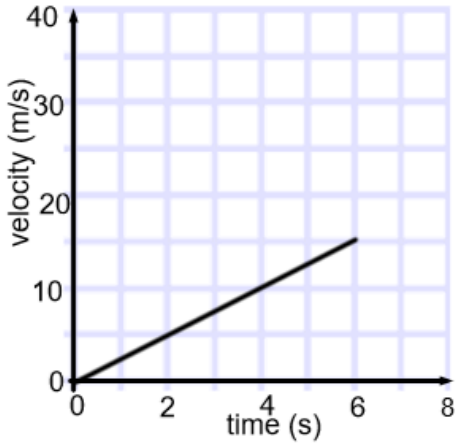

Answers

1. 3.75m/s$^2$
2. 1.67m/s$^2$
3. -2.5m/s$^2$
4. -5m/s$^2$
5. 5m/s$^2$
6. -5m/s$^2$
7. 4m/s$^2$
8. -2.5m/s$^2$

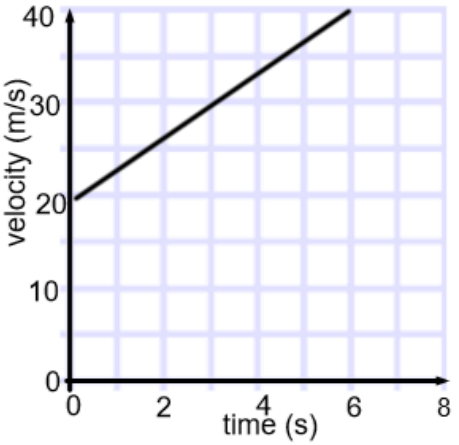
Intervention Questions

Find the acceleration shown in the following graphs:

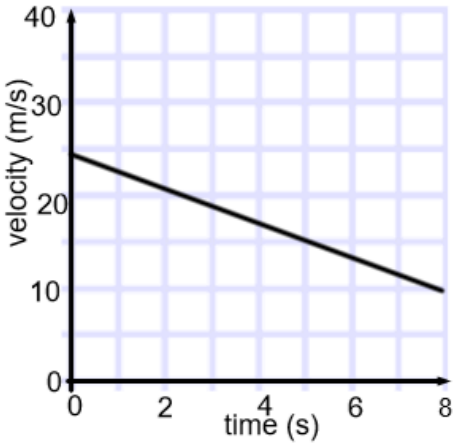
1.



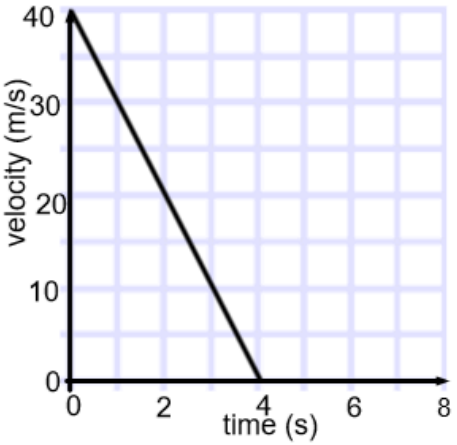

2.



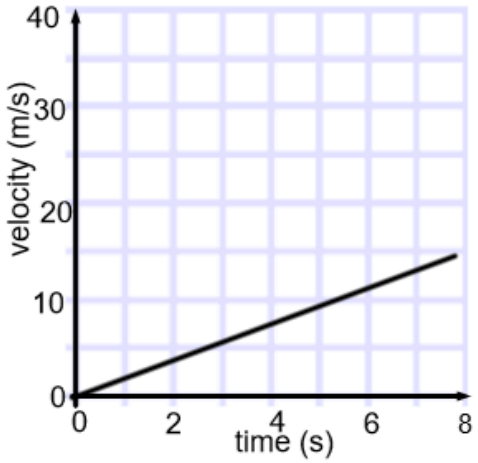

3.



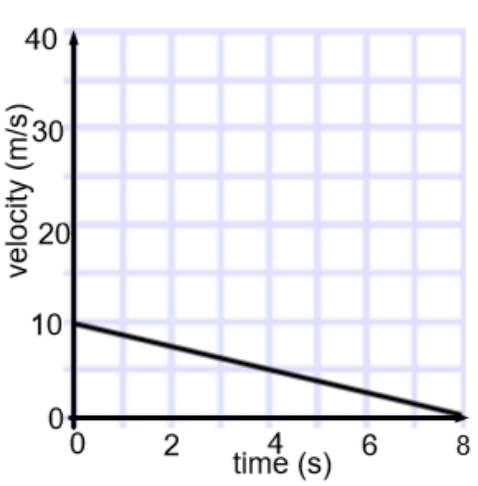

4.



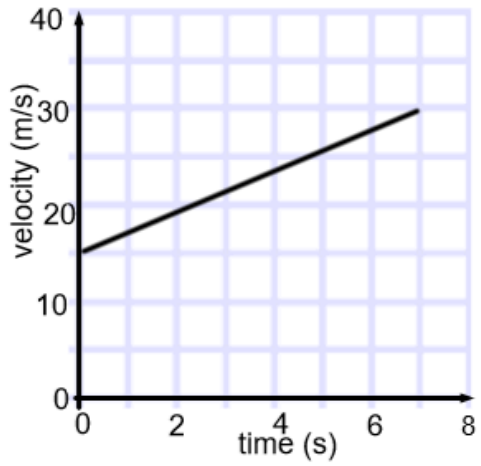
5.



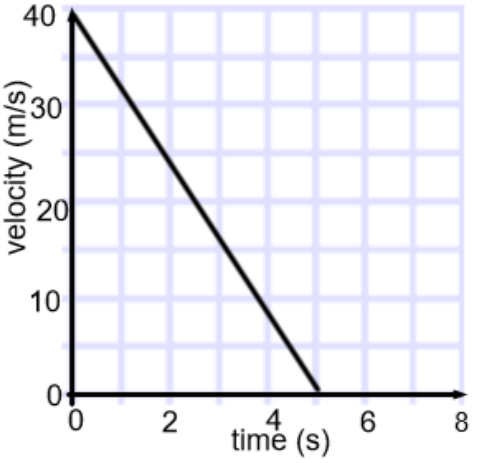

6.




7.




8.




Intervention Answers

1. 2.5m/s$^2$
2. 3.33m/s$^2$
3. -1.89m/s$^2$
4. -10m/s$^2$
5. 1.89m/s$^2$
6. -1.25m/s$^2$
7. 2.14m/s$^2$
8. -8m/s$^2$

## Acceleration formula 2

We can also use

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

Where:

$v$ = final velocity
$u$ = initial velocity
$a$ = acceleration
$s$ = displacement

This formula is given on the formula sheet.

This formula is useful when we don't know the time taken.

# Questions:

## A. The formula

1. Write out the formula $v^2 = u^2 + 2as$ and state what each letter stands for.

## B. Finding values for quantities

For the following questions, find initial velocity, final velocity, acceleration and displacement.

**Example:**

An object travelling with initial velocity 3m/s accelerates to a final velocity of 6m/s. If it has an acceleration of 1m/s$^2$, what distance does it travel?

“Initial velocity = 3
Final velocity = 6
Acceleration = 1
Displacement = ?”

(three of the quantities will be known [have a number] and one will be unknown [the question asks you to work it out])

2. “Find the final velocity of an object whose initial velocity is 9m/s, is travelling with an acceleration of 7.8m/s$^2$, and travels for 80m.”

Initial velocity =
Final velocity =
Acceleration =
Displacement =

3. “An object travels with an acceleration of 7m/s$^2$. After it has travelled for 500m, it has reached a velocity of 280m/s. Find its initial velocity.”

Initial velocity =
Final velocity =
Acceleration =
Displacement =

4. “An object accelerates at a rate of 0.8m/s$^2$. If it accelerates over a distance of 2500m, what must its initial velocity be in order to reach a final velocity of 560m/s?”

Initial velocity =
Final velocity =
Acceleration =
Displacement =

## C. Finding values for symbols

For the following questions find *v*, *u*, *a* and *s*.

**Example:**

“An object begins moving with a velocity of 2m/s and accelerates at 3m/s$^2$ until it reaches a velocity of 5m/s. What distance did it travel?”

*v* = 5
*u* = 2
*a* = 3
*s* = ?

5. “Find the final velocity of an object whose initial velocity is 1.2m/s, is travelling with an acceleration of 0.9m/s$^2$, and travels for 640m.”

*v* =
*u* =
*a* =
*s* =

6. “Find the initial velocity of an object travelling with an acceleration of 3.1m/s$^2$, which after having travelled for 800m, has reached a velocity of 207m/s.”

*v* =
*u* =
*a* =
*s* =

7. An object has initial velocity 20m/s, final velocity 300m/s, and an acceleration of 18m/s$^2$. Find the distance travelled.

$v$ =
$u$ =
$a$ =
$s$ =

## D. Substituting values into the formula

For the following questions, substitute the values into the formula
$v^2 = u^2 + 2as$

**Example:**

$v$ = 5
$u$ = 2
$a$ = 3
$s$ = ?

Substitution:

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

$5^2 = 2^2 + (2 \times 3 \times s)$

8. $v$ = 10
$u$ = 3
$a$ = 2.5
$s$ = ?

9. $v$ = ?
$u$ = 4
$a$ = 3.8
$s$ = 31

10. $v$ = 23
$u$ = ?
$a$ = 4.1
$s$ = 100

**Answers:**

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

$v$ = final velocity
$u$ = initial velocity
$a$ = acceleration
$s$ = displacement

2.

Initial velocity = 9m/s
Final velocity = ?
Acceleration = 7.8m/s2
Displacement = 80m

3.

Initial velocity = ?
Final velocity = 280m/s
Acceleration = 7m/s$^2$
Displacement = 500m

4.

Initial velocity = ?
Final velocity = 560m/s
Acceleration = 0.8m/s$^2$
Displacement = 560m

**E.**

5.

$v$ = ?
$u$ = 1.2m/s
$a$ = 0.9m/s$^2$
$s$ = 640m

6.

$v = 207\text{m/s}$
$u = ?$
$a = 3.1\text{m/s}^2$
$s = 800\text{m}$

7.

$v = 300\text{m/s}$
$u = 20\text{m/s}$
$a = 18\text{m/s}^2$
$s = ?$

**F.**

8.

$10^2 = 3^2 + (2 \times 2.5 \times s)$

9.

$v^2 = 4^2 + (2 \times 3.8 \times 31)$

10.

$23^2 = u^2 + (2 \times 4.1 \times 100)$

## Intervention Questions:

1. Write out the formula $v^2 = u^2 + 2as$ and state what each letter stands for.

2. "Find the final velocity of an object whose initial velocity is 5m/s, is travelling with an acceleration of $2.8\text{m/s}^2$, and travels for 60m."

Initial velocity =
Final velocity =
Acceleration =
Displacement =

3. “An object travels with an acceleration of $2m/s^2$. After it has travelled for 700m, it has reached a velocity of 980m/s. Find its initial velocity.”

Initial velocity =
Final velocity =
Acceleration =
Displacement =

4. “An object accelerates at a rate of $0.7m/s^2$. If it accelerates over a distance of 285m, what must its initial velocity be in order to reach a final velocity of 760m/s?”

Initial velocity =
Final velocity =
Acceleration =
Displacement =

5. “Find the final velocity of an object whose initial velocity is 1.6m/s, is travelling with an acceleration of $1.9m/s^2$, and travels for 540m.”

$v$ =
$u$ =
$a$ =
$s$ =

6. “Find the initial velocity of an object travelling with an acceleration of $2.1m/s^2$, which after having travelled for 300m, has reached a velocity of 407m/s.”

$v$ =
$u$ =
$a$ =
$s$ =

7. An object has initial velocity 10m/s, final velocity 30m/s, and an acceleration of 1.8m/s$^2$. Find the distance travelled.

$v$ =
$u$ =
$a$ =
$s$ =

8. $v$ = 11
$u$ = 5
$a$ = 1.5
$s$ = ?

9. $v$ = ?
$u$ = 3
$a$ = 2.8
$s$ = 51

10. $v$ = 33
$u$ = ?
$a$ = 3.1
$s$ = 200

# Intervention Answers

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

$v$ = final velocity
$u$ = initial velocity
$a$ = acceleration
$s$ = displacement

2.

Initial velocity = 5
Final velocity = ?
Acceleration = 2.8
Displacement = 60

3.

Initial velocity = ?
Final velocity = 980
Acceleration = 2
Displacement = 700

4.

Initial velocity = ?
Final velocity = 760
Acceleration = 0.7
Displacement = 285

5.

$v$ = ?
$u$ = 1.6
$a$ = 1.9
$s$ = 540

6.

$v$ = 407
$u$ = ?
$a$ = 2.1
$s$ = 300

7. An object has initial velocity 10m/s, final velocity 30m/s, and an acceleration of 1.8m/s$^2$. Find the distance travelled.

$v = 30$
$u = 10$
$a = 1.8$
$s = ?$

8.

$11^2 = 5^2 + (2 \times 1.5 \times s)$

9.

$v^2 = 3^2 + (2 \times 2.8 \times 51)$

10.

$33^2 = u^2 + (2 \times 3.1 \times 200)$

## Rearranging *v2 = u2 + 2as*

**G. When *v* is the unknown:**

u = 5
a = 3.8
s = 14
v = ?

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

$$v^2 = 5^2 + (2 \times 3.8 \times 14)$$

$$v^2 = 131.4$$

$$v = \sqrt{131.4}$$

$$v = 11.46 m/s$$

1. u = 2
a = 30
s = 45
v = ?

2. u = 40
a = 6.8
s = 230
v = ?

3. u = 650
a = 1,300
s = 490
v = ?

4. Find the final velocity of an object whose initial velocity is 3m/s, is travelling with an acceleration of 4.8m/s$^2$, and travels for 24m.

5. Find the final velocity of an object whose initial velocity is 25m/s, is travelling with an acceleration of 0.5m/s$^2$, and travels for 200m.
6. Find the final velocity of an object whose initial velocity is 0.2m/s, is travelling with an acceleration of 1.9m/s$^2$, and travels for 140m.

**H. When *u* is the unknown:**

a = 6
s = 800
v = 390
u = ?

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

$$390^2 = u^2 + (2 \times 6 \times 800)$$

$$390^2 - (2 \times 6 \times 800) = u^2$$

$$142{,}500 = u^2$$

$$\sqrt{142{,}500} = u$$

$$377.49 = u$$

$$u = 377.49 \text{m/s}$$

**Questions**

7. v = 135.7
a = 22.1
s = 100
u = ?

8. v = 655
a = 25
s = 239

u = ?

9. v = 0.64

a = 0.21
s = 0.31
u = ?

10. An object travels with an acceleration of 3.1m/s$^2$. After it has travelled for 700m, it has reached a velocity of 207m/s. Find its initial velocity.
11.

Find the initial velocity of an object travelling with an acceleration of 2.1m/s$^2$, which after having travelled for 900m, has reached a velocity of 607m/s.

12. An object accelerates at a rate of 1.8m/s$^2$. If it accelerates over a distance of 1600m, what must its initial velocity be in order to reach a final velocity of 560m/s?

**I. When *a* is the unknown:**

u = 13
v = 39
s = 14.5
a = ?

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

$$39^2 = 13^2 + (2 \times a \times 14.5)$$

$$39^2 - 13^2 = (2 \times a \times 14.5)$$

$$1352 = 29a$$

$$1352 \div 29 = a$$

$$46.62 = a$$

$$a = 46.62 m/s^2$$

**Questions:**

**13. v = 560**
**u = 352**
**s = 28**
**a = ?**

**14. v = 28.3**
**u = 15.1**
**s = 0.7**
**a = ?**

**15. v = 1,560**
**u = 1,550**
**s = 145**
**a = ?**

16. An object begins with an initial velocity of 12m/s and ends with a velocity of 63m/s. If the distance travelled is 125m, what is the acceleration?
17. What acceleration is needed to bring an object from a speed of 1.8m/s to a speed of 15.9m/s over a distance of 35m?
18. An object is accelerated from 105m/s to 110m/s over a distance of 13m. What is the acceleration?

### J. When *s* is the unknown

u = 0.6
v = 11.5
a = 2.3
s = ?

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

$$11.5^2 = 0.6^2 + (2 \times 2.3 \times s)$$

$$11.5^2 - 0.6^2 = (2 \times 2.3 \times s)$$

$$131.89 = 4.6s$$

$$131.89 \div 4.6 = s$$

$$28.67 = s$$

$$s = 28.67\text{m}$$

**Questions**

19. v = 30
u = 26
a = 0.6
s = ?

20. v = 490
u = 445
a = 36
s = ?

21. v = 15.9
u = 15.4
a = 0.3
s = ?

22. An object has initial velocity 2m/s, final velocity 3m/s, and an acceleration of 0.25m/s$^2$. Find the distance travelled.

23. What distance is travelled by an object travelling first at 6m/s, accelerating at 4m/s$^2$ to a final velocity 30m/s?
24. An object has initial velocity 20m/s, final velocity 300m/s, and an acceleration of 18m/s$^2$. Find the distance travelled.

### K. Deceleration

In cases where the final velocity (v) is lower than the initial velocity (u), acceleration will be negative as the object is reducing in speed.

25. v = 20
u = 30
s = 5
a = ?

26. v = 605
u = 611
a = -1.5
s ?

27. u = 88
a = -2.4
s = 50
v = ?

28. An object has initial velocity 4m/s, final velocity 3m/s, and an acceleration of -0.25m/s$^2$. Find the distance travelled.
29. Find the final velocity of an object whose initial velocity is 400m/s, is travelling with an acceleration of -14.8m/s$^2$, and travels for 240m.
30. An object travels with an acceleration of -3.1m/s$^2$. After it has travelled for 700m, it has reached a velocity of 207m/s. Find its initial velocity.
31. What acceleration is needed to bring an object from a speed of 98m/s to a speed of 15.9m/s over a distance of 35m?

**When u or v = 0:**
An object starting at rest has initial velocity (u) = 0.
An object slowing to a stop has final velocity (v) = 0.

**Questions:**

32. v = 20
u = 0
s = 12
a = ?

33. v = 36
u = 0

a = 4
s = ?

34. s = 208
v = 0
a = -5
u = ?

35. a = -11
v = 0
u = 12.5
s = ?

36. An object accelerates from rest to a velocity of 5m/s. If the acceleration is $0.9m/s^2$, calculate the distance travelled.
37. An object accelerates from rest to an unknown speed. If the object accelerates at $5m/s^2$ and travels for a distance of 15m, what is the final speed?
38. An object at rest begins to move and reaches a final speed of 165m/s after accelerating over a distance of 30m. What is the acceleration?
39. A moving object slows to a standstill at an acceleration of $-20m/s^2$. If the distance travelled is 60m, find the initial velocity of the object.
40. A car travelling at 35m/s crashes into a wall and is stopped over a distance of 10.2m. Find the acceleration of the car.
41. A stone is dropped and is travelling at a speed of 1.3m/s just before it hits the ground. If the acceleration is $-135m/s^2$, find the distance travelled into the ground by the stone.

## Answers

Answers

1. 52m/s
2. 68.76m/s
3. 1302.50m/s
4. 15.47m/s
5. 28.72m/s
6. 23.07m/s
7. 118.30m/s
8. 645.82m/s
9. 0.53m/s

10. 196.24m/s
11. 603.88m/s
12. 554.83m/s
13. 313,488m/$s^2$

14. 409.2m/$s^2$

15. 107.24m/$s^2$

16. 15.3m/$s^2$
17. 3.57m/$s^2$
18. 41.35m/$s^2$

19. 186.67m

20. 584.38m

21. 26.08m

22. 10m
23. 108m
24. 2,488.89m

25. -50m/$s^2$

26. 2,432m
27. 89.35m/s
28. 14m
29. 391m/s
30. 217.23m/s
31. -133.59m/$s^2$

32. 16.67m/$s^2$

33. 162m

34. 45.61m/s

35. 7.10m

36. 16m
37. 12.25m/s
38. 453.75m/$s^2$
39. 48.99m/s
40. -60.05m/$s^2$
41. 6.26x$10^{-3}$m

## Intervention Questions

1. u = 3
a = 20
s = 65
v = ?

2. u = 30
a = 9.8
s = 530
v = ?

3. u = 250
a = 4
s = 590
v = ?

4. Find the final velocity of an object whose initial velocity is 4m/s, is travelling with an acceleration of 5.8m/s$^2$, and travels for 64m.

5. Find the final velocity of an object whose initial velocity is 15m/s, is travelling with an acceleration of 2.5m/s$^2$, and travels for 900m.

6. Find the final velocity of an object whose initial velocity is 0.8m/s, is travelling with an acceleration of 7.9m/s$^2$, and travels for 540m.

7. v = 195.7
a = 2.1
s = 180
u = ?

8. v = 650
a = 2
s = 139
u = ?

9. v = 18.64
a = 0.51
s = 9.31

u = ?

10. An object travels with an acceleration of 10.1m/s$^2$. After it has travelled for 700m, it has reached a velocity of 307m/s. Find its initial velocity.
11. Find the initial velocity of an object travelling with an acceleration of 1.5m/s$^2$, which after having travelled for 800m, has reached a velocity of 417m/s.
12. An object accelerates at a rate of 0.8m/s$^2$. If it accelerates over a distance of 160m, what must its initial velocity be in order to reach a final velocity of 240m/s?

13. **v = 760**
**u = 552**
**s = 280**
**a = ?**

14. **v = 58.3**
**u = 15.9**
**s = 4.7**
**a = ?**

15. **v = 2,560**
**u = 2,550**
**s = 345**
**a = ?**

16. An object begins with an initial velocity of 13m/s and ends with a velocity of 66m/s. If the distance travelled is 225m, what is the acceleration?
17. What acceleration is needed to bring an object from a speed of 3.8m/s to a speed of 15.3m/s over a distance of 37m?
18. An object is accelerated from 205m/s to 210m/s over a distance of 14m. What is the acceleration?

19. v = 40
u = 36
a = 0.5
s = ?

20. v = 690
u = 645
a = 37
s = ?

21. v = 18.9
u = 17.4
a = 3
s = ?

22. An object has initial velocity 3m/s, final velocity 5m/s, and an acceleration of $0.35m/s^2$. Find the distance travelled.
23. What distance is travelled by an object travelling first at 4m/s, accelerating at $9m/s^2$ to a final velocity 20m/s?
24. An object has initial velocity 22m/s, final velocity 300m/s, and an acceleration of $15m/s^2$. Find the distance travelled.

25. v = 25
u = 36
s = 8
a = ?

26. v = 650
u = 670
a = -1.5
s ?

27. u = 88
a = -3.4
s = 40
v = ?

28. An object has initial velocity 5m/s, final velocity 4m/s, and an acceleration of $-0.35m/s^2$. Find the distance travelled.
29. Find the final velocity of an object whose initial velocity is 200m/s, is travelling with an acceleration of $-15.8m/s^2$, and travels for 340m.
30. An object travels with an acceleration of $-6.1m/s^2$. After it has travelled for 500m, it has reached a velocity of 307m/s. Find its initial velocity.

31. What acceleration is needed to bring an object from a speed of 18m/s to a speed of 15m/s over a distance of 3m?

32. v = 30
u = 0
s = 22
a = ?

33. v = 46
u = 0
a = 6
s = ?

34. s = 308
v = 0
a = -4
u = ?

35. a = -16
v = 0
u = 19.5
s = ?

36. An object accelerates from rest to a velocity of 9m/s. If the acceleration is 0.6m/s$^2$, calculate the distance travelled.
37. An object accelerates from rest to an unknown speed. If the object accelerates at 2m/s$^2$ and travels for a distance of 12m, what is the final speed?
38. An object at rest begins to move and reaches a final speed of 265m/s after accelerating over a distance of 300m. What is the acceleration?
39. A moving object slows to a standstill at an acceleration of -10m/s$^2$. If the distance travelled is 40m, find the initial velocity of the object.
40. A car travelling at 25m/s crashes into a wall and is stopped over a distance of 11.2m. Find the acceleration of the car.
41. A stone is dropped and is travelling at a speed of 2.3m/s just before it hits the ground. If the acceleration is -155m/s$^2$, find the distance travelled into the ground by the stone.

## Intervention Answers

1. 51.08m/s

2. 106.24m/s

3. 259.28m/s

4. 27.54m/s
5. 68.74m/s

6. 92.36m/s

7. 193.05m/s

8. 649.57m/s

9. 18.38m/s

10. 283.04m/s
11. 414.11m/s.
12. 239.47m/s

13. 487.31m/s$^2$
14. 334.69m/s$^2$
15. 74.06m/s$^2$
16. 9.30m/s$^2$
17. 2.97m/s$^2$
18. 74.11m/s$^2$

19. 304m
20. 811.83m
21. 9.08m
22. 3.97m
23. 21.33m
24. 2983.87m

25. $-41.94 m/s^2$
26. 8,800m
27. 86.44m/s
28. 12.86m
29. 171.04m/s
30. 313m/s
31. $-16.5 m/s^2$

32. $20.45 m/s^2$
33. 176.33m

34. 15.70m/s
35. 11.88m

36. 67.5m
37. 6.93m/s
38. $117.04 m/s^2$
39. 28.28m/s
40. $-27.90 m/s^2$
41. 0.02m (0.017m)