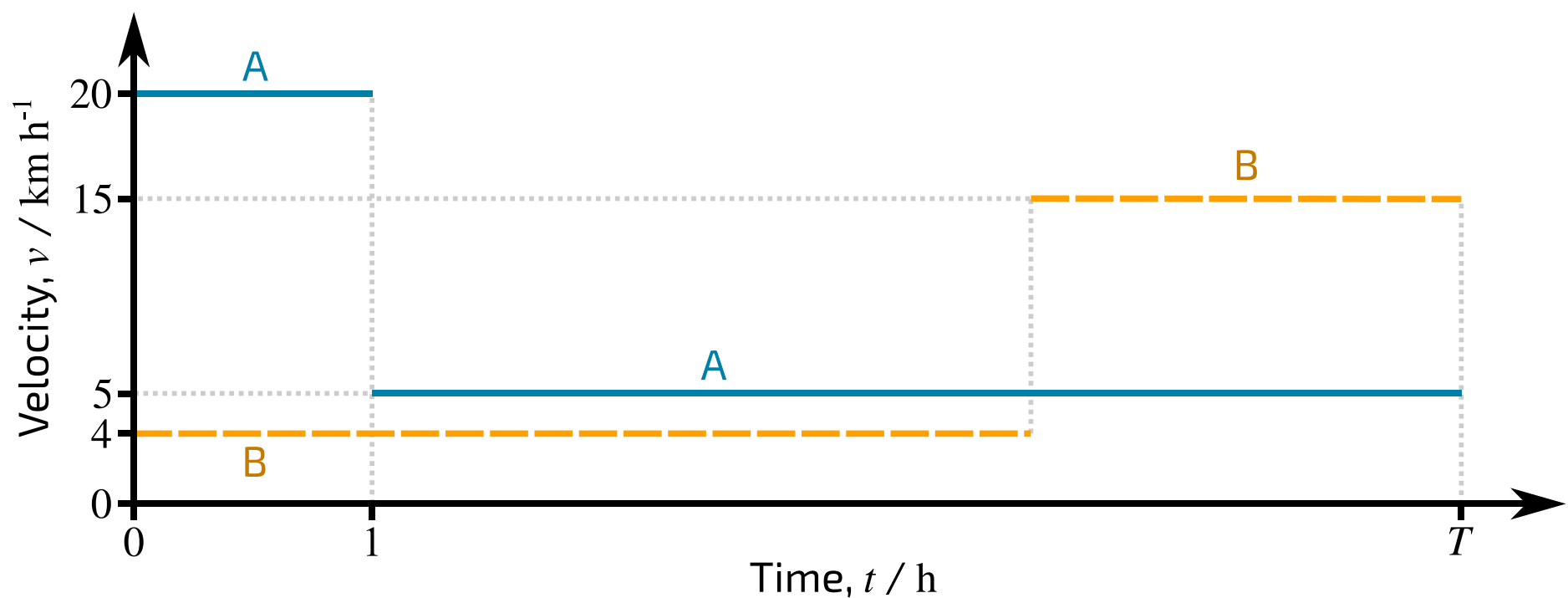




STEM SMART Double Maths 5 - Kinematics

## General Kinematics 2ii

Subject & topics: Maths      Stage & difficulty: A Level P1



**Figure 1:** Velocity-time graph of two travellers A and B along a long straight road.

Two travellers A and B make the same journey on a long straight road. Each traveller walks for part of the journey and rides a bicycle for part of the journey. They start their journeys at the same instant, and they end their journeys simultaneously after travelling for  $T$  hours. A starts the journey cycling at a steady  $20 \text{ km h}^{-1}$  for 1 hour. A then leaves the bicycle at the side of the road, and completes the journey walking at  $5 \text{ km h}^{-1}$ . B begins the journey walking at a steady  $4 \text{ km h}^{-1}$ . When B finds the bicycle where A left it, B cycles at  $15 \text{ km h}^{-1}$  to complete the journey.

### Part A

#### Distance cycled and time

Calculate the distance A cycles.

Hence, find the period of time, in hours, for which B walks before finding the bicycle.

Part B

Completion time

Find  $T$  in hours.

Part C

Total distance

Calculate the distance A and B each travel.

Used with permission from UCLES, A-level, June 2015, OCR M1, Question 3

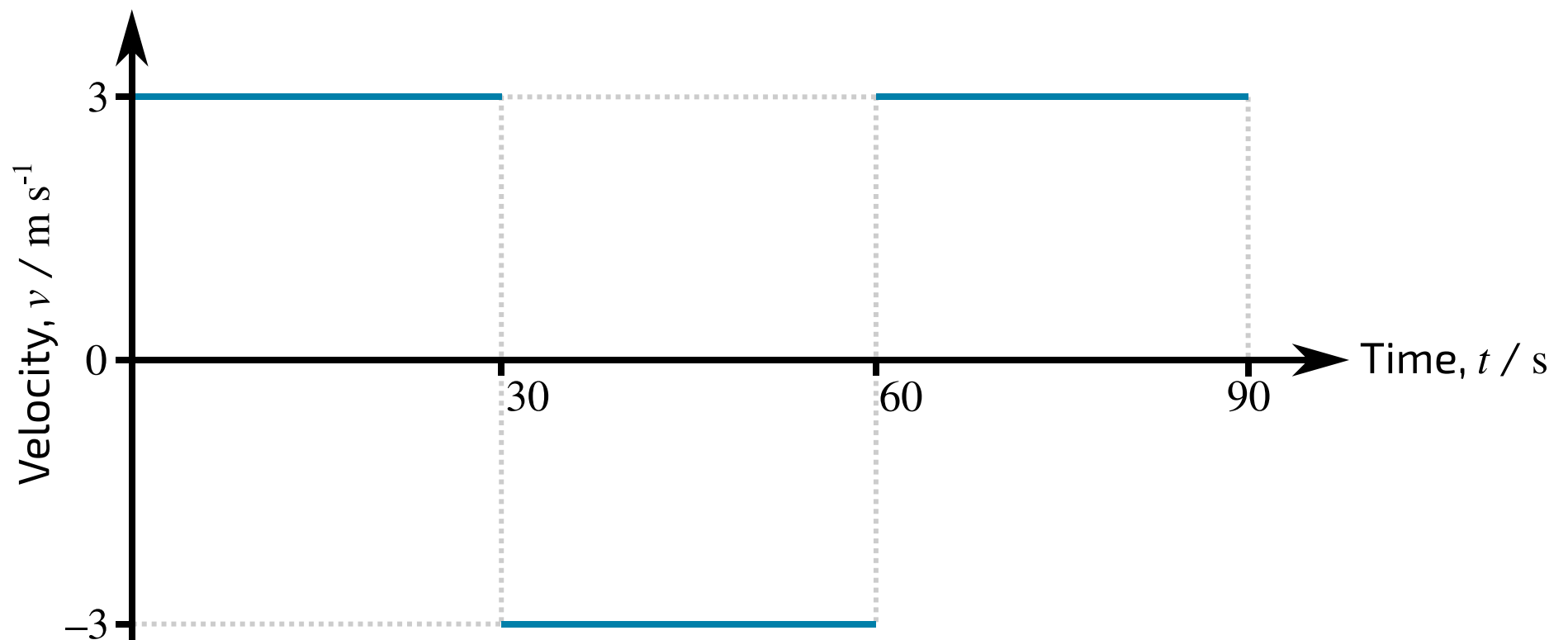


STEM SMART Double Maths 5 - Kinematics

## General Kinematics 3ii

Subject &amp; topics: Maths

Stage &amp; difficulty: A Level P1



**Figure 1:** Velocity-time graph of a woman running between A and B.

A woman runs from A to B, then from B to A and then from A to B again, on a straight track, taking 90 s. The woman runs at a constant speed throughout.

### Part A

#### Total distance

Find the total distance run by the woman.

## Part B

## Distances

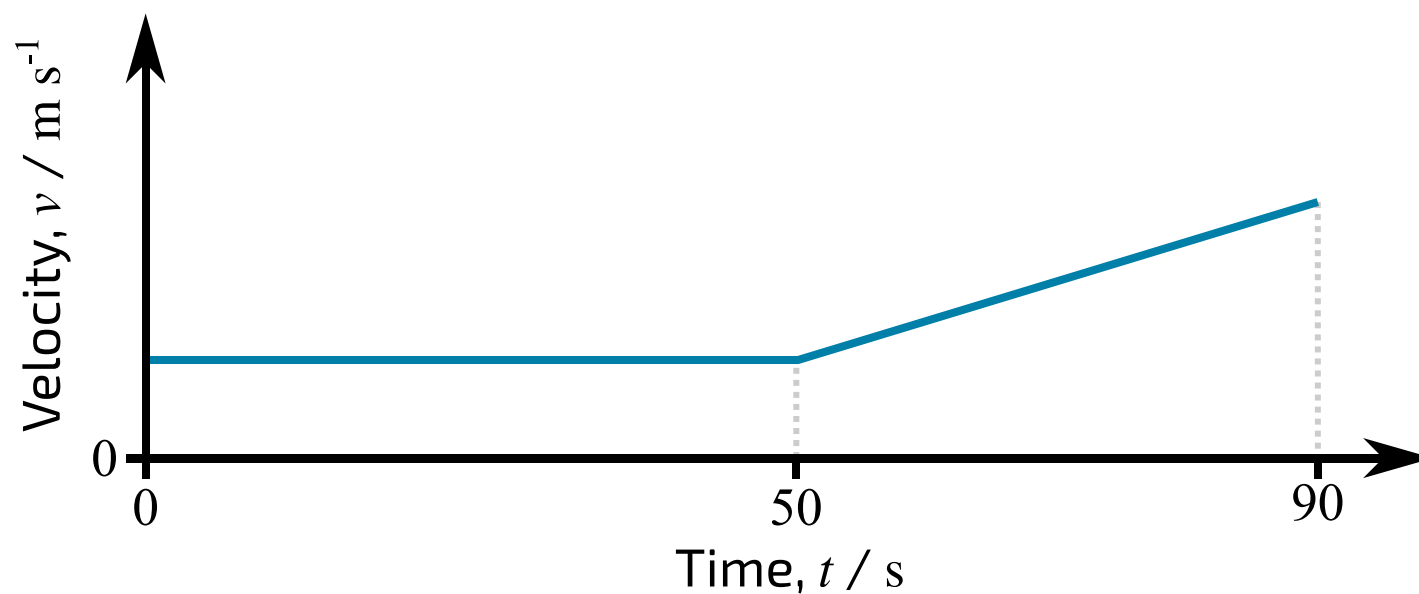
Find the distance of the woman from A when

$t = 50$ :

$t = 80$ :

## Part C

## Child's speed



**Figure 2:** Velocity-time graph of a child moving from A along AB.

At time  $t = 0$ , a child also starts to move, from A, along AB. The child walks at a constant speed for the first 50 s and then at an increasing speed for the next 40 s.

At time  $t = 50$ , the woman and the child pass each other, moving in opposite directions. Find the speed of the child during the first 50 s.

Part D

Overtaking

At time  $t = 80$ , the woman overtakes the child. Find the speed of the child at this instant.

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Question deck:

**STEM SMART Double Maths 5 - Kinematics**

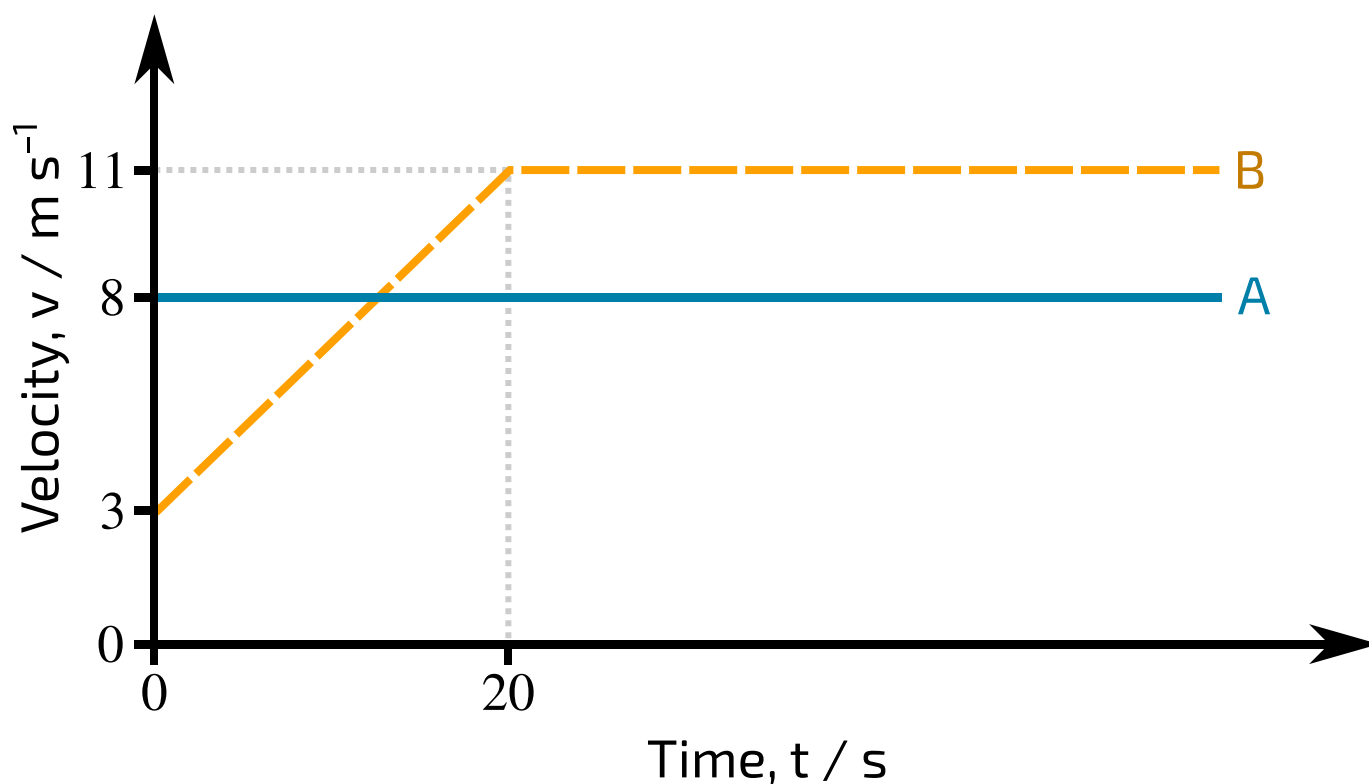


STEM SMART Double Maths 5 - Kinematics

## General Kinematics 3i

Subject &amp; topics: Maths

Stage &amp; difficulty: A Level P1



**Figure 1:** Velocity-time graph of the motion of two cyclists A and B racing.

**Figure 1** shows the motion of two cyclists A and B who are travelling along a horizontal straight road. At time  $t = 0$ , A, who cycles with constant speed  $8 \text{ m s}^{-1}$ , overtakes B who has initial speed  $3 \text{ m s}^{-1}$ . From time  $t = 0$ , B cycles with constant acceleration for 20 s. When  $t = 20$  her speed is  $11 \text{ m s}^{-1}$ , which she subsequently maintains.

### Part A

#### Same speed

Find the value of  $t$  when A and B have the same speed. Give your answer to 2 significant figures.

**Part B****Time of overtaking**

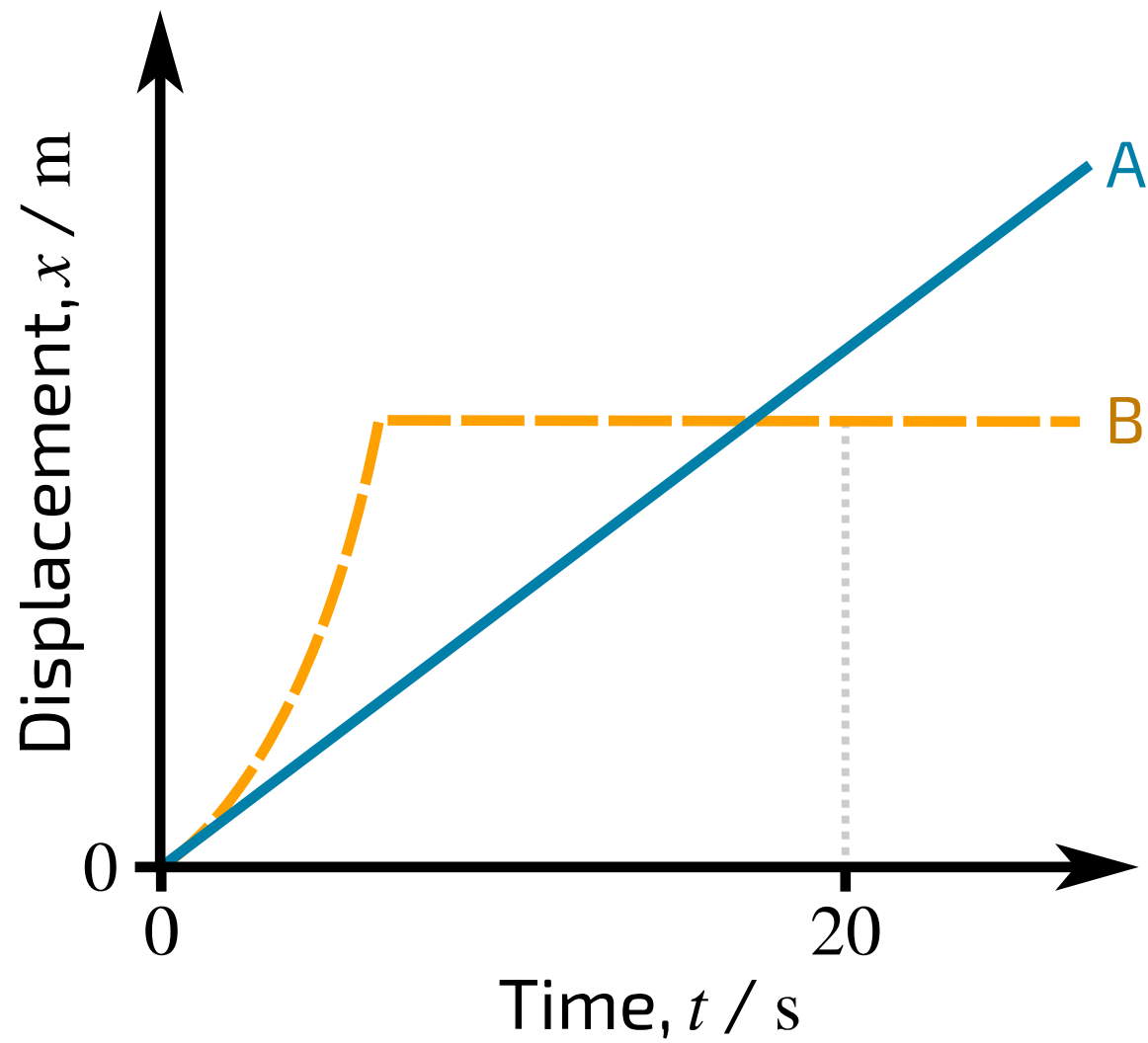
Calculate the value of  $t$  when B overtakes A. Give your answer to 2 significant figures.

## Part C

## Displacement-time graph

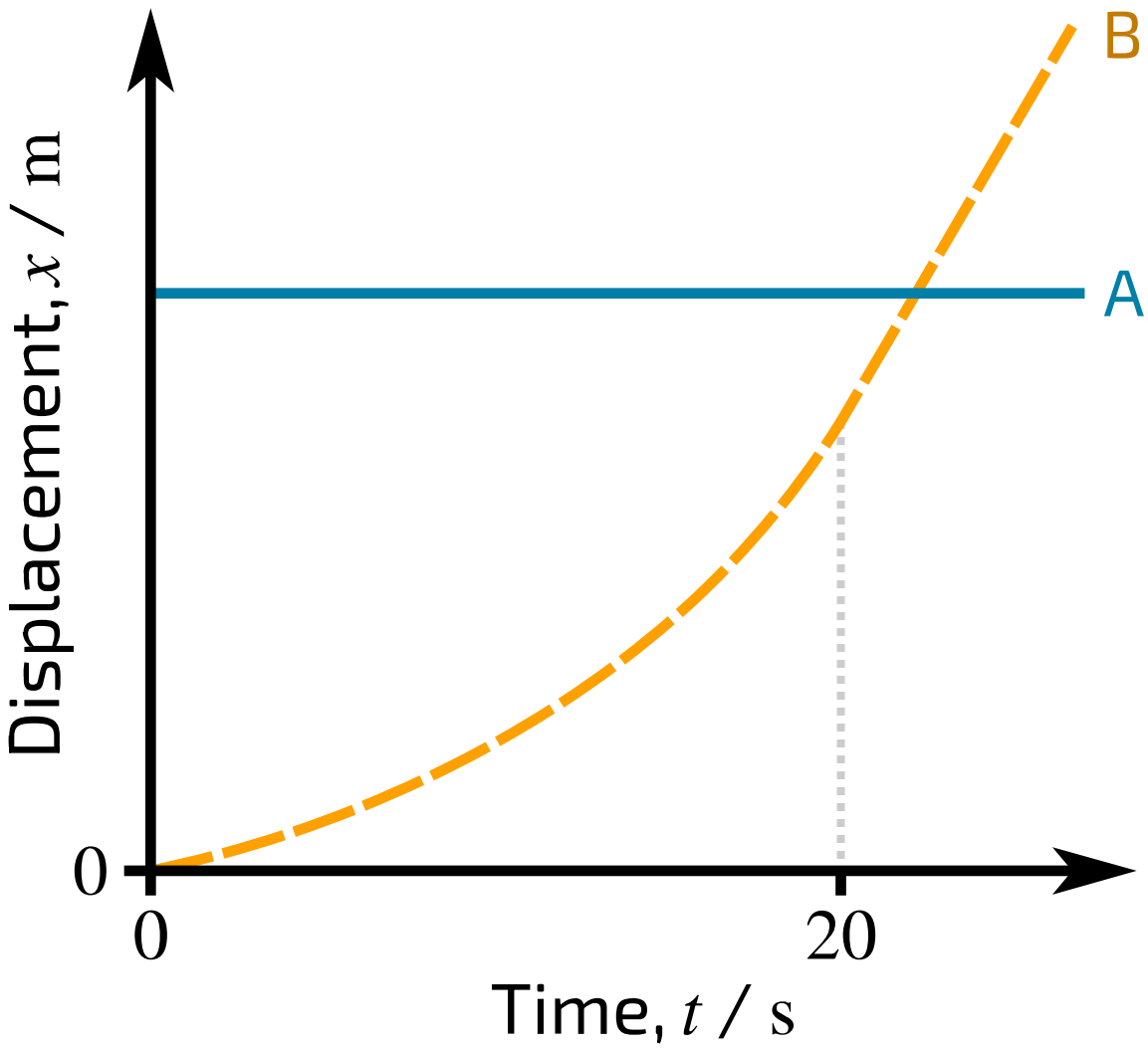
On a single diagram, sketch the  $(t, x)$  graphs for the two cyclists for the time from  $t = 0$  until after B has overtaken A.

Choose the correct option from the sketches below.

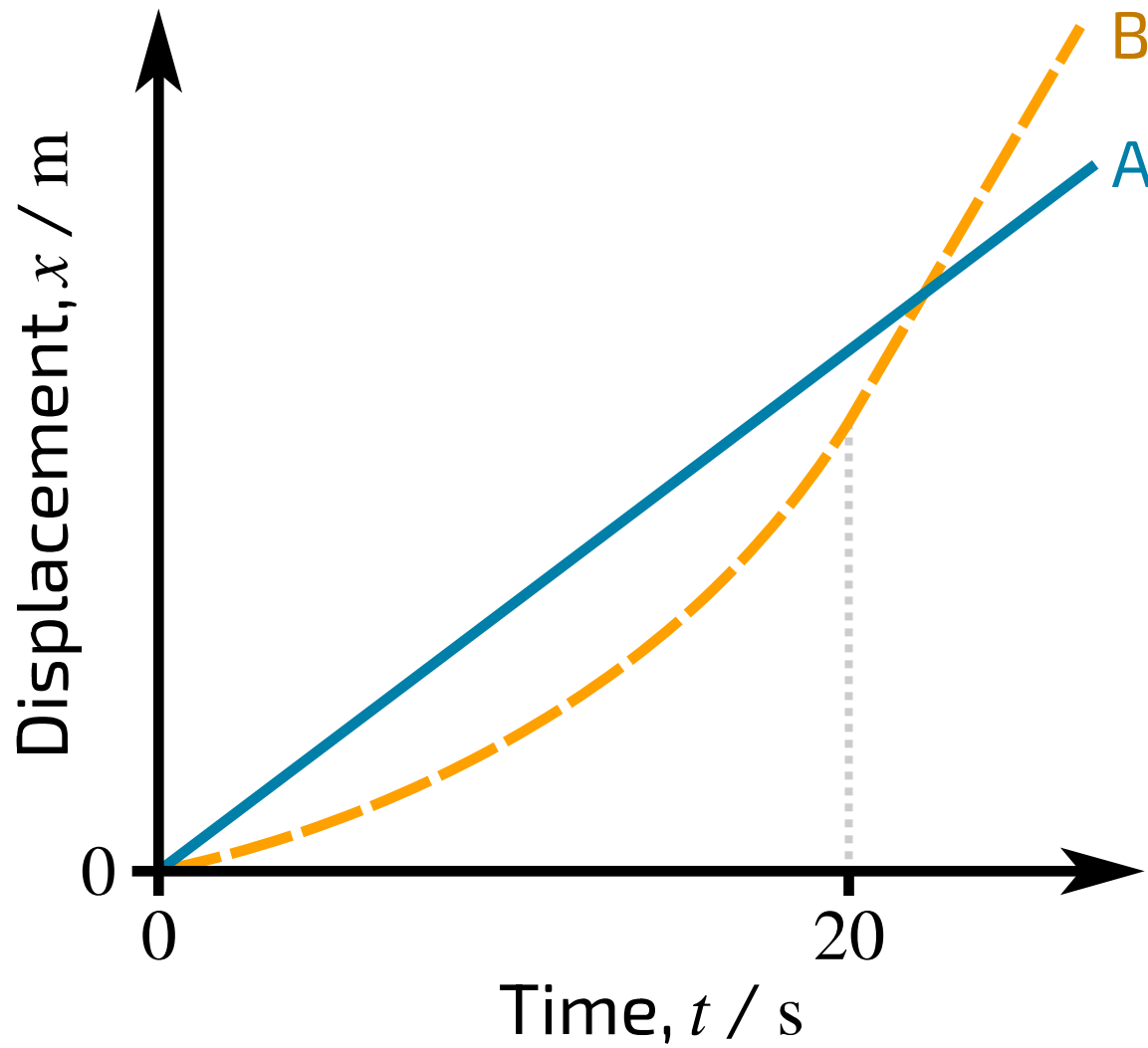


Option 1



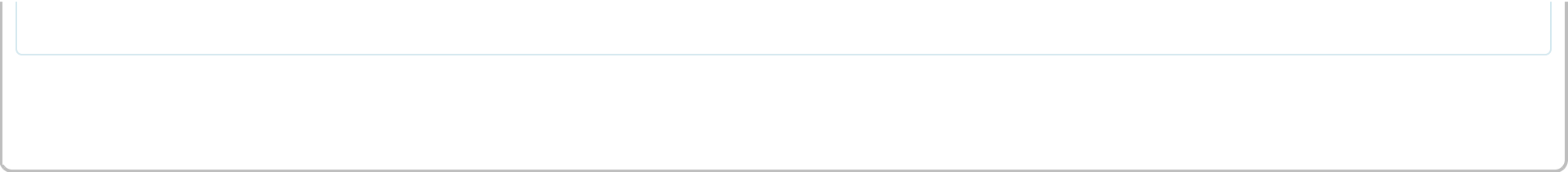


Option 2



Option 3

- ☐ Option 1
- ☐ Option 2
- ☐ Option 3



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STEM SMART Double Maths 5 - Kinematics

## Gravity & Projectiles (1D) 3i

**Subject & topics:** Maths    **Stage & difficulty:** A Level P2

A particle is projected vertically upwards, from the ground, with a speed of  $28 \text{ m s}^{-1}$ . Ignore air resistance throughout this question.

**Part A****Maximum height**

Find the maximum height reached by the particle.

**Part B****Speed at 30 m**

Find the speed of the particle when it is 30 m above the ground.

**Part C****Time taken**

Find the time taken for the particle to fall from its highest point to a height of 30 m.

Part D

Length of time

Find the length of time for which the particle is more than 30 m above the ground.

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Question deck:

**STEM SMART Double Maths 5 - Kinematics**



STEM SMART Double Maths 5 - Kinematics

## Gravity & Projectiles (1D) 2i

**Subject & topics:** Maths**Stage & difficulty:** A Level P2

An object is projected vertically upwards, from a position  $1.5\text{ m}$  above horizontal ground, with speed  $17.5\text{ m s}^{-1}$ .

**Part A****Speed of object**

Calculate the speed of the object when it is  $6.1\text{ m}$  above the point of projection. Give your answer to 3 significant figures.

**Part B****Greatest height**

Calculate the greatest height above the point of projection reached by the object. Give your answer to 3 significant figures.

**Part C****Time at  $15.1\text{ m s}^{-1}$** 

Calculate the time after projection when the object is travelling downwards with speed  $15.1\text{ m s}^{-1}$ . Give your answer to 3 significant figures.

**Part D****Height at  $15.1 \text{ m s}^{-1}$** 

Calculate the height above ground level of the object when it is moving downwards at  $15.1 \text{ m s}^{-1}$ . Give your answer to 3 significant figures.

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## Gravity & Projectiles (1D) 1i

**Subject & topics:** Maths    **Stage & difficulty:** A Level P2

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A particle P is projected vertically upwards, from horizontal ground, with speed  $8.4 \text{ m s}^{-1}$ . Throughout this question use  $g = 9.8 \text{ m s}^{-2}$ .

### Part A

#### The greatest height

Find the greatest height above the ground reached by P. Give your answer to 2 significant figures.

### Part B

#### A second particle

A particle Q is projected vertically upwards, from a point 2.0 m above the ground, with speed  $u$ . The greatest height **above the ground** reached by Q is 3.6 m.

Find the value of  $u$ . Give your answer to 2 significant figures.

**Part C****Same height, same speed**

It is given that P and Q are projected simultaneously.

Show that, at the instant when P and Q are at the same height, the particles have the same speed and are moving in opposite directions. Find this speed. Give your answer to 2 significant figures.

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Question deck:

**STEM SMART Double Maths 5 - Kinematics**





STEM SMART Double Maths 5 - Kinematics

## Projectiles: Trajectories 1ii

**Subject & topics:** Maths    **Stage & difficulty:** A Level P2

A ball is projected from a point  $O$  on the edge of a vertical cliff. The horizontal and vertically upward components of the initial velocity are  $7 \text{ m s}^{-1}$  and  $21 \text{ m s}^{-1}$  respectively. At time  $t$  seconds after projection the ball is at the point  $(x, y)$  referred to horizontal and vertically upward axes through  $O$ . Air resistance may be neglected.

### Part A

#### Equations of motion

Express  $x$  and  $y$  in terms of  $t$ . For this question you can use  $g \approx 9.8 \text{ m s}^{-2}$ .

Express  $x$  in terms of  $t$ .

The following symbols may be useful:  $t$ ,  $x$

Express  $y$  in terms of  $t$ .

The following symbols may be useful:  $t$ ,  $y$

Hence, find an expression for  $y$  in terms of  $x$ .

The following symbols may be useful:  $x$ ,  $y$

Part B

Horizontal distance travelled

The ball hits the sea at a point which is 25 m below the level of O.

Find the horizontal distance between the cliff and the point where the ball hits the sea. Give your answer to 3 significant figures.

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STEM SMART Double Maths 5 - Kinematics

## Projectiles: Trajectories 2ii

**Subject & topics:** Maths    **Stage & difficulty:** A Level P2

A particle is projected with speed  $u \text{ m s}^{-1}$  at an angle of  $\theta$  above the horizontal from a point O. At time  $t \text{ s}$  after projection, the horizontal and vertically upwards displacements of the particle from O are  $x \text{ m}$  and  $y \text{ m}$  respectively.

### Part A

#### Equations of motion

In this question, use  $g$  to represent the magnitude of the acceleration under gravity.

Express  $x$  in terms of  $u$ ,  $t$  and  $\theta$ .

The following symbols may be useful:  $\cos()$ ,  $\sin()$ ,  $t$ ,  $\tan()$ ,  $\theta$ ,  $u$ ,  $x$

Express  $y$  in terms of  $u$ ,  $t$  and  $\theta$ .

The following symbols may be useful:  $\cos()$ ,  $g$ ,  $\sin()$ ,  $t$ ,  $\tan()$ ,  $\theta$ ,  $u$ ,  $x$

Hence find an equation for  $y$  in terms of  $u$ ,  $x$  and  $\theta$ .

The following symbols may be useful:  $\cos()$ ,  $\operatorname{cosec}()$ ,  $\cot()$ ,  $g$ ,  $\sec()$ ,  $\sin()$ ,  $\tan()$ ,  $\theta$ ,  $u$ ,  $x$ ,  $y$

**Part B****Value of  $\theta$** 

In this part, use  $g = 9.8 \text{ m s}^{-2}$ .

In a shot put competition, a shot is thrown from a height of  $2.1 \text{ m}$  above horizontal ground. It has initial velocity of  $14 \text{ m s}^{-1}$  at an angle of  $\theta$  above the horizontal. The shot travels a horizontal distance of  $22 \text{ m}$  before hitting the ground.

Find the value of  $\theta$  correct to 3 significant figures.

**Part C****Time of flight**

Find the time of flight of the shot correct to 3 significant figures.

Used with permission from UCLES, A Level, January 2013, OCR M2, Question 7

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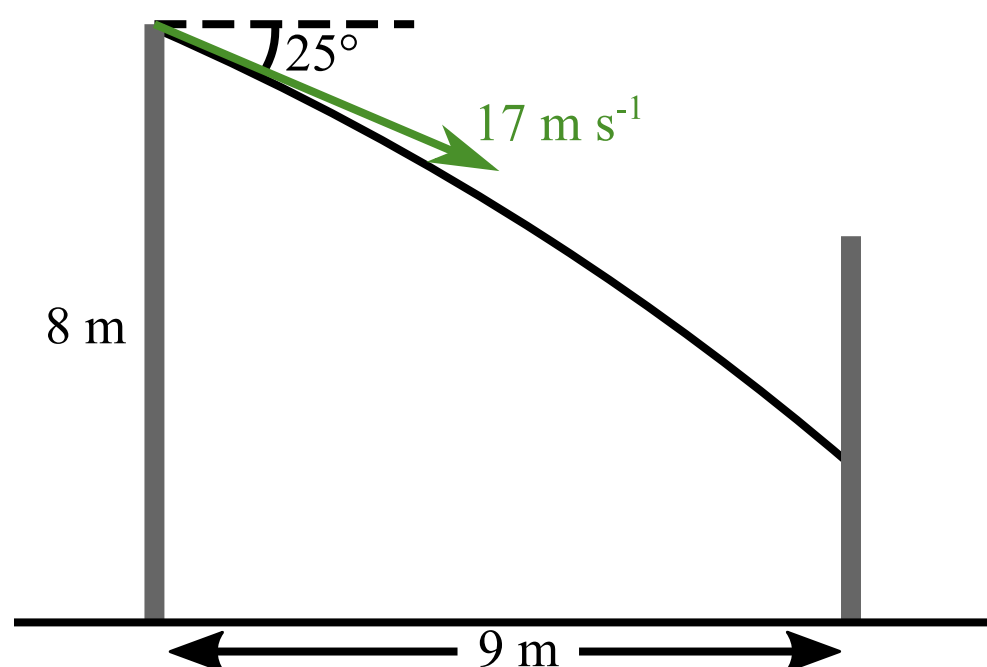


STEM SMART Double Maths 5 - Kinematics

## Projectiles: Trajectories 3ii

Subject &amp; topics: Maths

Stage &amp; difficulty: A Level P2



**Figure 1:** A ball projected from a horizontal point on the top of a vertical wall.

A ball is projected with an initial speed of  $17 \text{ m s}^{-1}$  at an angle of  $25^\circ$  below the horizontal from a point on the top of a vertical wall. The point of projection is  $8 \text{ m}$  above horizontal ground. The ball hits a vertical fence which is at a horizontal distance of  $9 \text{ m}$  from the wall.

### Part A

#### Height above ground

Calculate the height above the ground of the point where the ball hits the fence. Give your answer to 3 significant figures.

Part B

Direction of motion

Calculate the direction of motion of the ball immediately before it hits the fence. Give your answer as an angle below the horizontal.

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STEM SMART Double Maths 5 - Kinematics

## Shooting a Balloon

**Subject & topics:** Physics | Mechanics | Kinematics      **Stage & difficulty:** A Level C2

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The points **A** and **B** are a distance  $a$  apart and **AB** is horizontal. A shot is fired from **A** with velocity  $\sqrt{\lambda ag}$  at an angle  $\theta$  to the horizontal. At the same instant a balloon is released from rest at **B** and rises vertically with constant acceleration  $(\mu - 1)g$ , where  $1 < \mu < \lambda$ . The shot hits the balloon.

For  $\lambda = 10$  and  $\mu = 5.0$  find the possible values of  $\theta$ .

Enter the two values of  $\theta$  (to 2 significant figures).

(lower value)

(higher value)

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