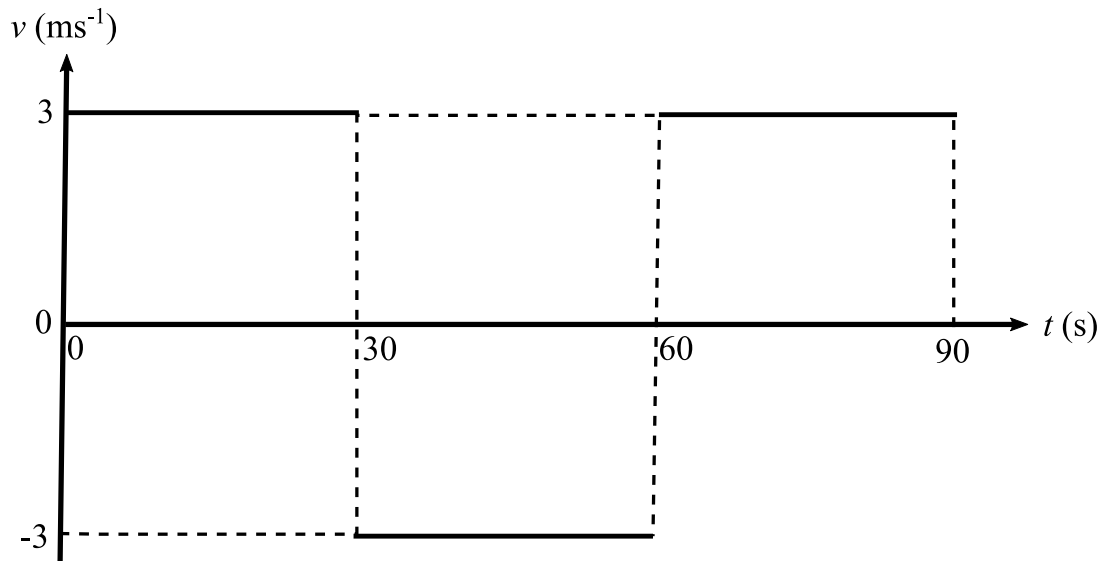


## General Kinematics 3ii



**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

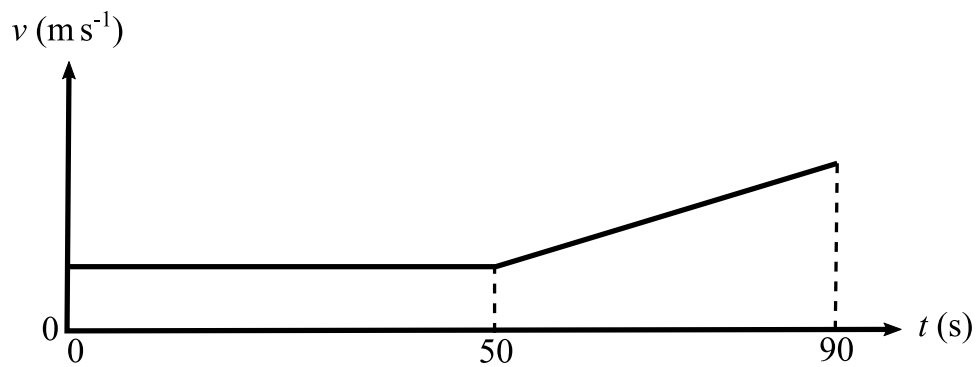
$$t = 50$$

---

$$t = 80$$

---

### 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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## Gravity & Projectiles (1D) 1i

---



A particle  $P$  is projected vertically upwards, from horizontal ground, with speed  $8.4 \text{ m s}^{-1}$ .

### 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  $2.0 \text{ m}$  above the ground, with speed  $u$ . The greatest height **above the ground** reached by  $Q$  is  $3.6 \text{ m}$ .

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.

---

## General Kinematics 2ii

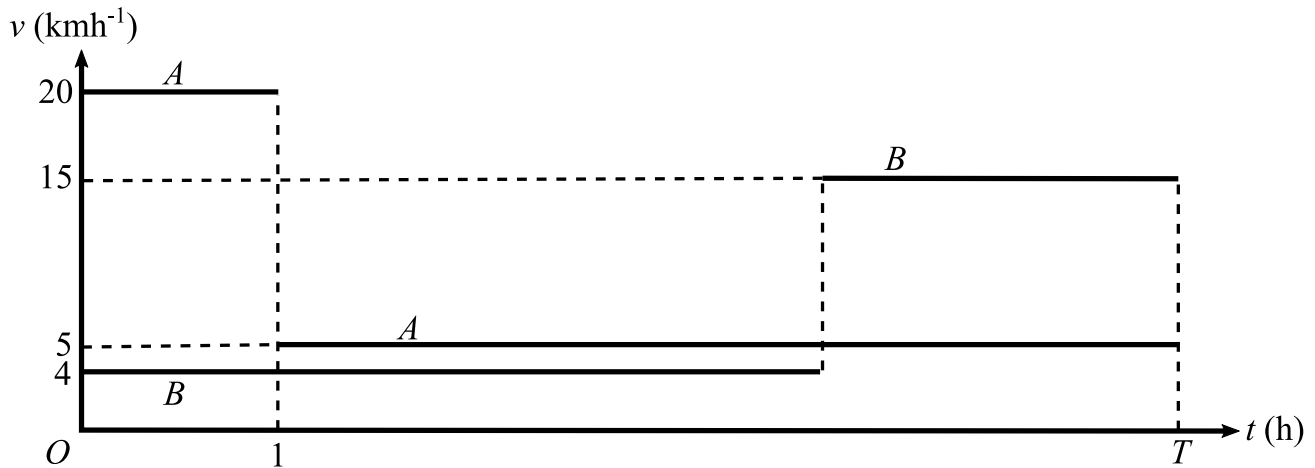


Figure 1: Velocity-time graph of two travellers  $A$  and  $B$  along a long straight road.

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.

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## Projectiles: Trajectories 1ii



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  $25 \text{ m}$  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.

---



## Projectiles: Trajectories 2ii



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 (positive) acceleration under gravity.

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

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

---

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

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

---

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

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

---

### 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.

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## Gravity & Projectiles (1D) 3i



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 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.

---



## Gravity & Projectiles (1D) 2i



An object is projected vertically upwards, from a position 1.5 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 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.

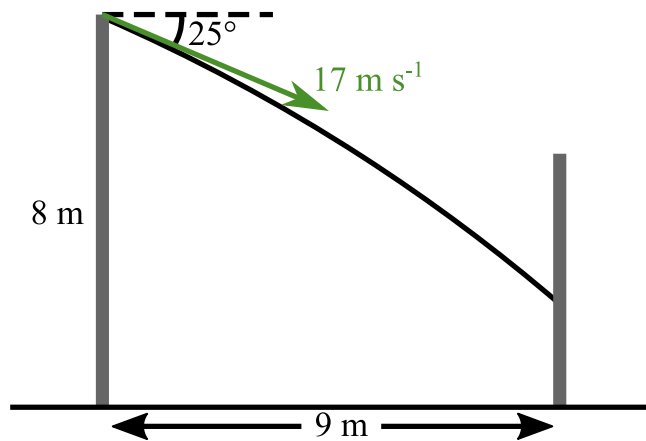
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### Part D Height at $15.1 \text{ m s}^{-1}$

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.

---

## Projectiles: Trajectories 3ii



**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 m above horizontal ground. The ball hits a vertical fence which is at a horizontal distance of 9 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.



## General Kinematics 3i



**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  $20 \text{ s}$ . 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 Distance 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  $A$ .

Easier question?