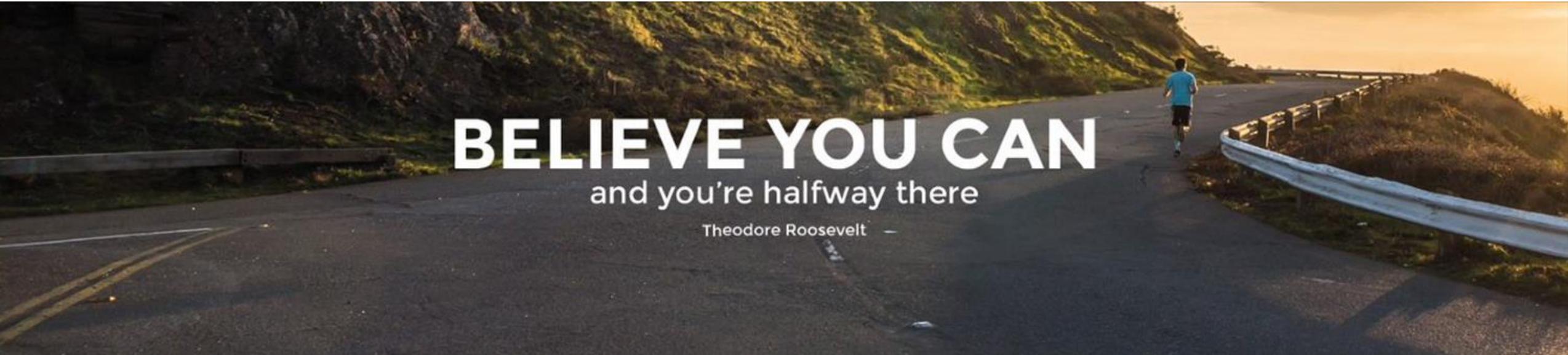


EB Education Revision Guide



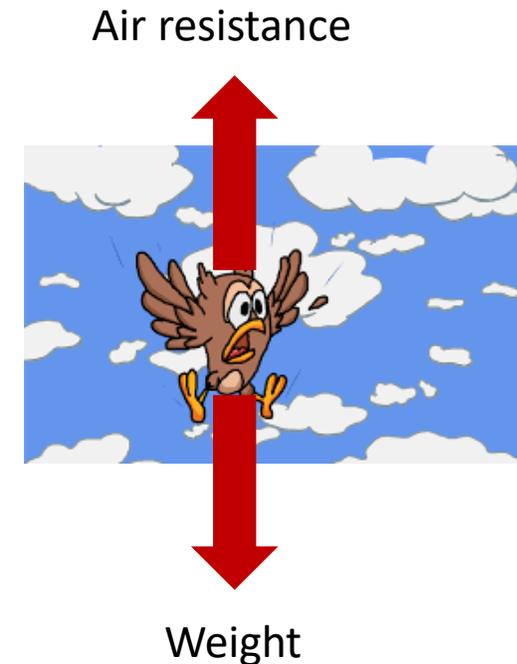
How to work with Terminal Velocity

Terminal Velocity

What is happening?

When an object is falling, there are two main forces which affect it:

- The **weight** of the object (this is caused by the Earth's **gravitational field** acting on the mass of the object, it acts downwards)
- **Air resistance** (this acts in the opposite direction to the movement, and is a frictional force – in a vacuum like space, there is not any air resistance)



Terminal Velocity

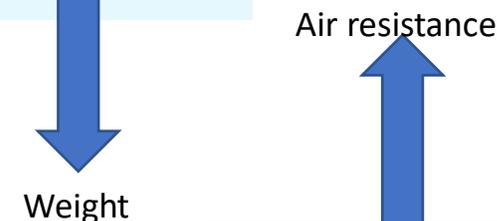
What is happening?

1. When an object first falls, it accelerates downwards due to its weight. At this stage, the air resistance is less than the gravitational force (weight), so the **resultant force** is downwards.
2. As the object accelerates, air resistance increases (because it's crashing into more air particles), but the weight stays the same. At this point, the resultant force is still downwards.
3. Eventually the air resistance increases until it is the same size as the weight. The resultant force is zero. The object has reached **terminal velocity** and will travel at a steady speed.

Stage 1: Air resistance is less than weight so the parachutist accelerates downwards.



Stage 2: the same situation as stage 1 but with a large air resistance



Stage 3: Air resistance is equal to weight so the parachutist travels at a steady speed. Terminal velocity has been reached.



Terminal Velocity

What is happening?

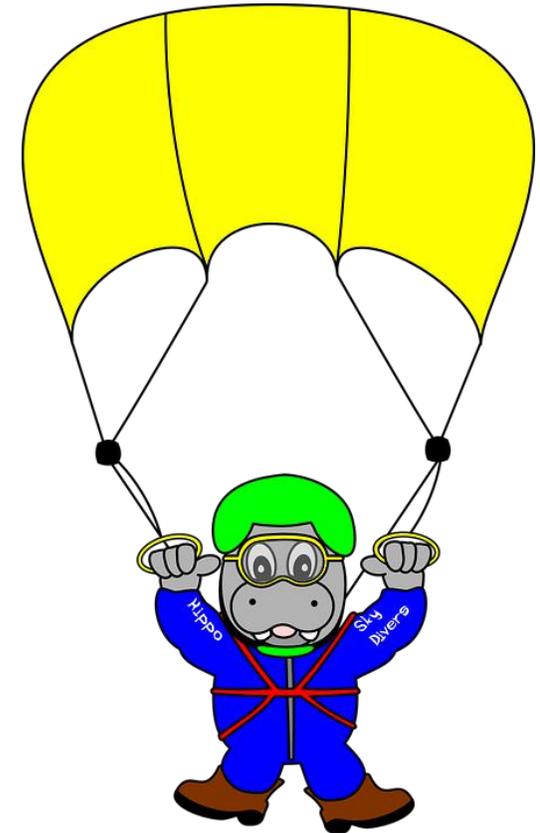
If a parachutist is falling, once they open the parachute, this increases the surface area of the parachutist.

The air resistance will now be much larger than the weight, and the resultant force will be upwards.

The parachutist will continue to fall downwards but will slow down whilst doing so.

Because the parachutist is slowing down, the air resistance starts to reduce. This will happen until a new terminal velocity is reached, and the parachutist will fall at a slower steady speed.

The parachute increases the surface area



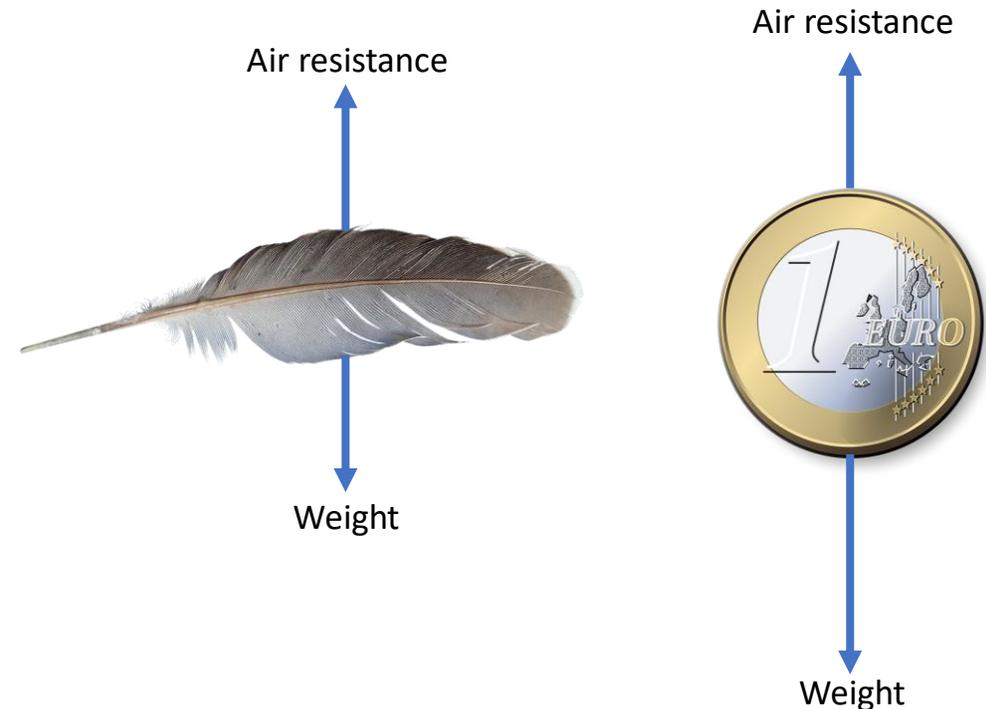
Air resistance

What is happening?

If you drop two objects together which have different masses, but roughly the same surface area, once they start falling, they will initially experience the same air resistance, and fall at the same speed.

As they fall, air resistance increases, and for the feather, the air resistance will quickly equal the weight and it will reach terminal velocity.

As the coin is heavier, it will need to travel much faster before air resistance EQUALS the weight. It is likely to hit the ground before it reaches terminal velocity.





1. Two sky-divers jump out of a plane.
The diagram shows the sky-divers.



Arrows A and B show two forces acting on them as they fall.

a) Name the forces A and B

A _____

B _____

b) Explain why force A acts in an upward direction.

c) Initially forces A and B are unbalanced.
Which of the forces is bigger?

How does this unbalanced force affect the movement of the skydivers?

Your turn:

The sky-diver pulls the rip cord and the parachute opens.
After a while forces A and B are balanced.

d) Underline the correct answer in each line.

Force A has increased / stayed the same / decreased.

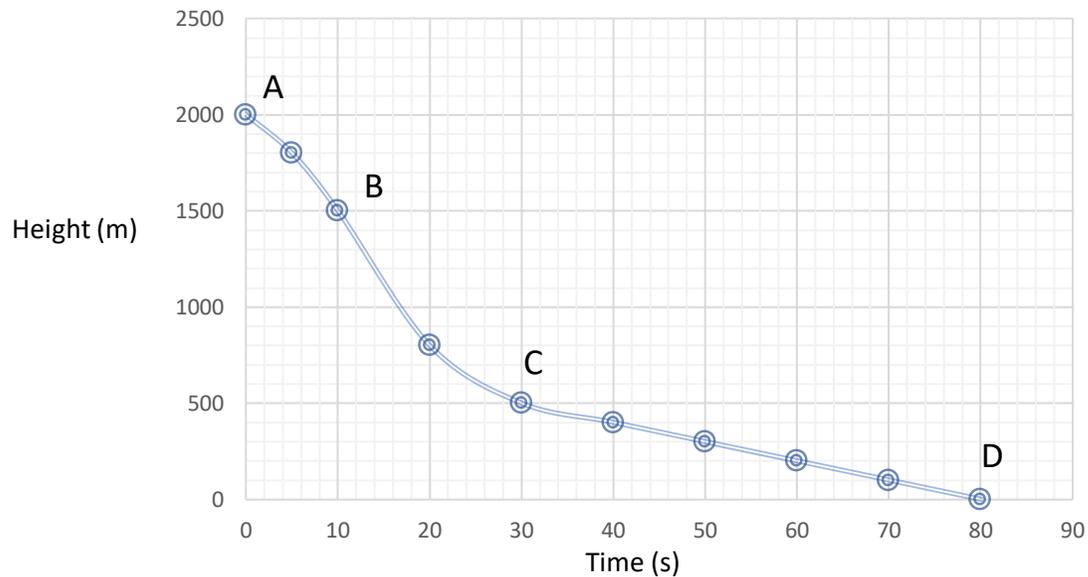
Force B has increased/ stayed the same/ decreased.

The speed of the sky-divers will increase/ stay the same / decrease.



Your turn:

e) The graph below shows how the height of the sky-divers changes with time.



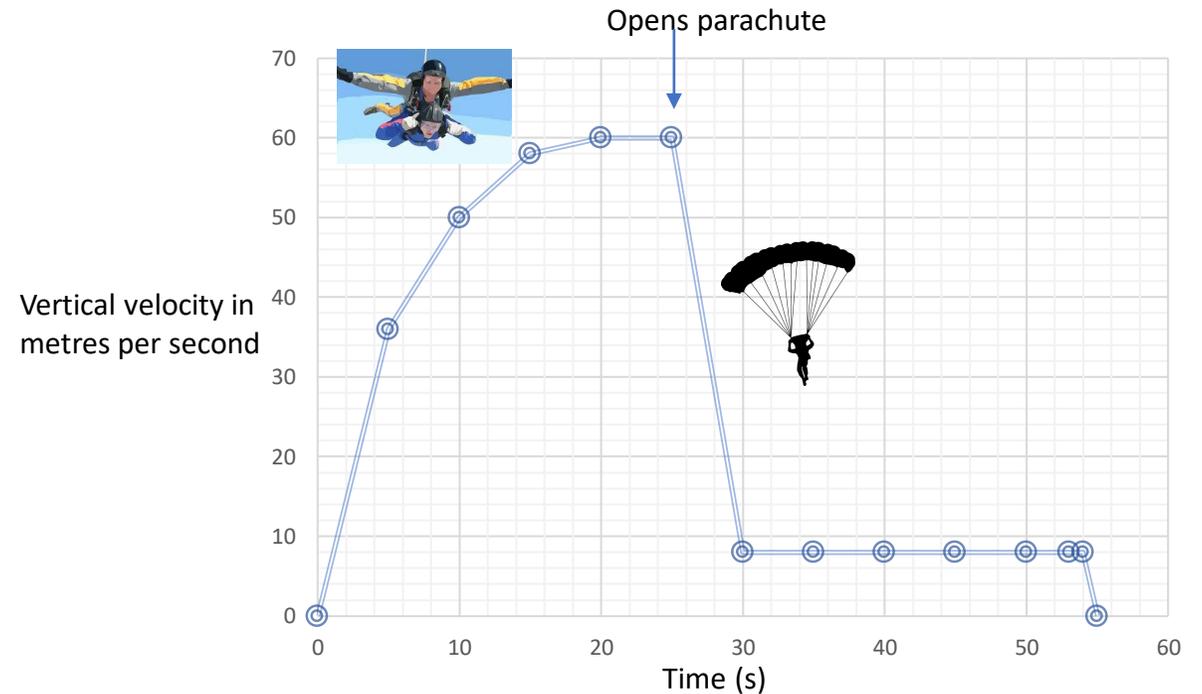
Which part of the graph, AB, BC or CD shows them falling at a constant speed?

What distance do they fall at a constant speed?

For how long do they fall at this speed?

Calculate the speed.

2. The graph below shows how the vertical velocity of a parachutist changes from the moment the parachutist jumps from the aircraft until landing on the ground.



Using the idea of forces, explain why the parachutist reaches a terminal velocity and why opening the parachute reduces the terminal velocity.



1. Two sky-divers jump out of a plane.
The diagram shows the sky-divers.



Arrows A and B show two forces acting on them as they fall.

a) Name the forces A and B

A Air resistance/drag

B Weight/gravity

b) Explain why force A acts in an upward direction.

Air resistance acts in the opposite direction to motion

c) Initially forces A and B are unbalanced.

Which of the forces is bigger? **B**

How does this unbalanced force affect the movement of the skydivers?

Resultant force is downwards so they will accelerate towards the Earth

Answers:

The sky-diver pulls the rip cord and the parachute opens.
After a while forces A and B are balanced.

d) Underline the correct answer in each line.

Force A has increased / stayed the same / decreased.

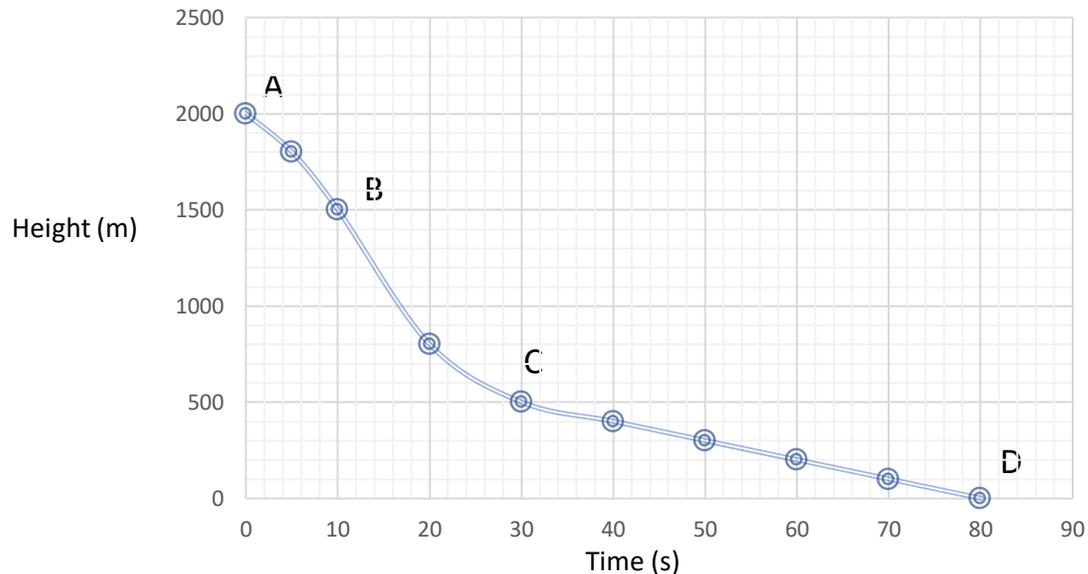
Force B has increased/ stayed the same/ decreased.

The speed of the sky-divers will increase/ stay the same / decrease.



Answers:

e) The graph below shows how the height of the sky-divers changes with time.



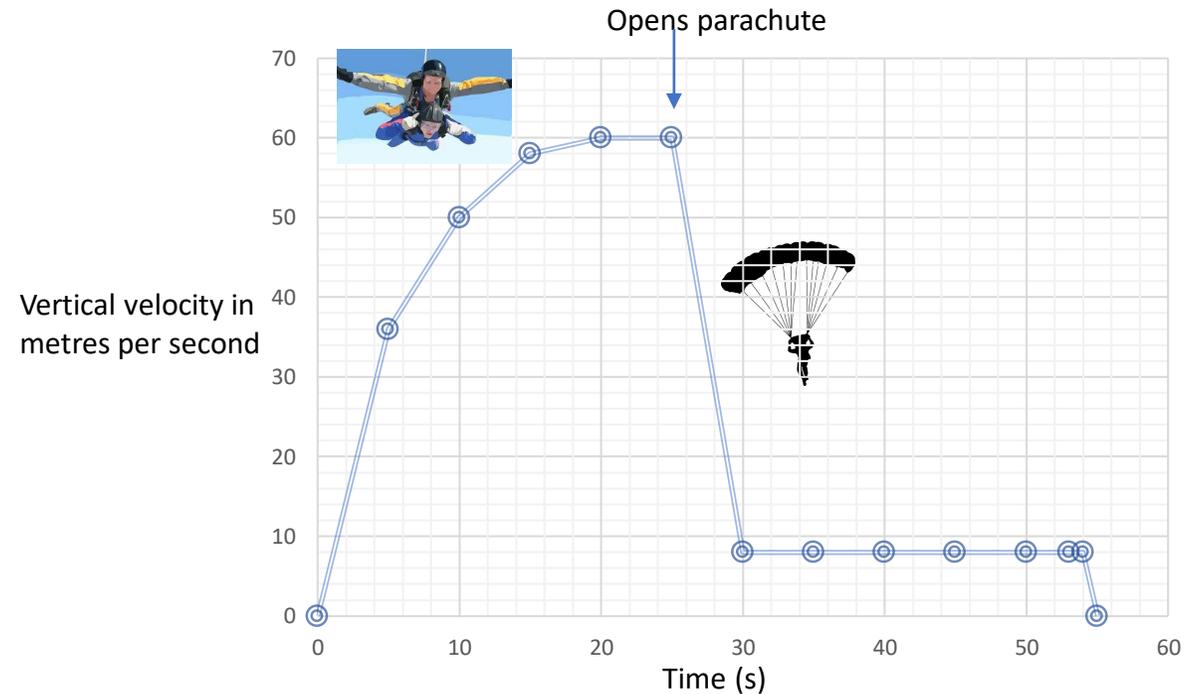
Which part of the graph, AB, BC or CD shows them falling at a constant speed?
CD

What distance do they fall at a constant speed?
500m

How long do they fall at this speed?
50s

Calculate the speed. **$500/50 = 10\text{m/s}$**

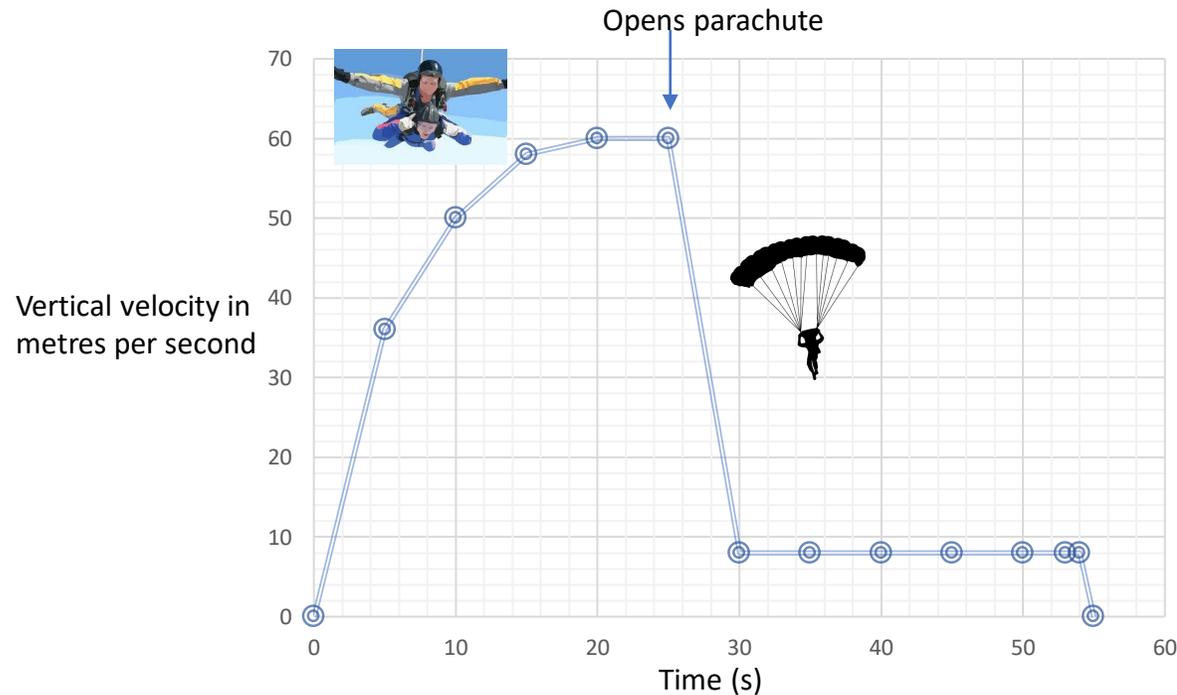
2. The graph below shows how the vertical velocity of a parachutist changes from the moment the parachutist jumps from the aircraft until landing on the ground.



Using the idea of forces, explain why the parachutist reaches a terminal velocity and why opening the parachute reduces the terminal velocity.



Your turn:



- As parachutists jump from the plane, weight is greater than air resistance
- They will accelerate downwards as resultant force is downwards
- As they accelerate, air resistance increases until the air resistance is equal to weight
- There is no resultant force and they travel at a steady speed as they have reached terminal velocity
- Opening the parachute increases the surface area, and therefore air resistance increases
- This results in a resultant force upwards, and they will slow down.
- Eventually a new terminal velocity will be reached which is lower than the initial terminal velocity

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contact us

www.ebeducationservices.co.uk

contact@ebeducationservices.co.uk

0161 442 5270