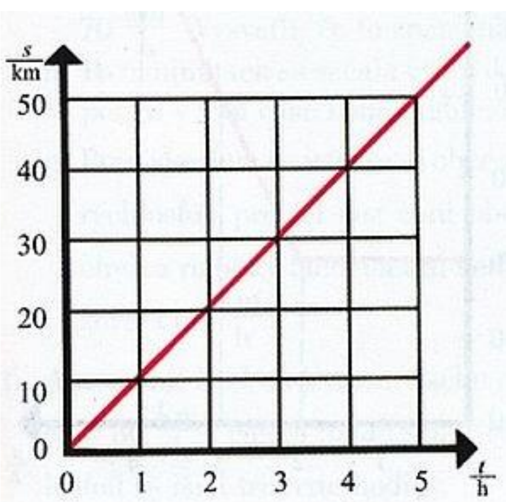
Example 1

Arphy is standing on a platform and is watching a train passing by. There is his friend on the train. How would Arphy and his friend describe the movement:

1. Arphy would see the train as moving past him and a friend on the train would see him standing on the platform.
2. Arphy would see the train as moving past him and a friend on the train would see him as moving past the train.
3. Arphy would see the train as stationary and a friend on the train would see him as moving past the train.
4. Arphy would see the train as stationary and a friend on the train would also see him stationary.

Example 2

When hiking we use direction arrows to figure out which way to go and how long it will take to reach our destination. Our walking speed is about 4km/h. So, if it signposts says it takes 1 hour and 30 minutes to walk to our destination, then our trip is about 6 km long. We calculate the distance by multiplying our walking speed by the time, supposing we walk at a steady pace. You can see it on the graph below:

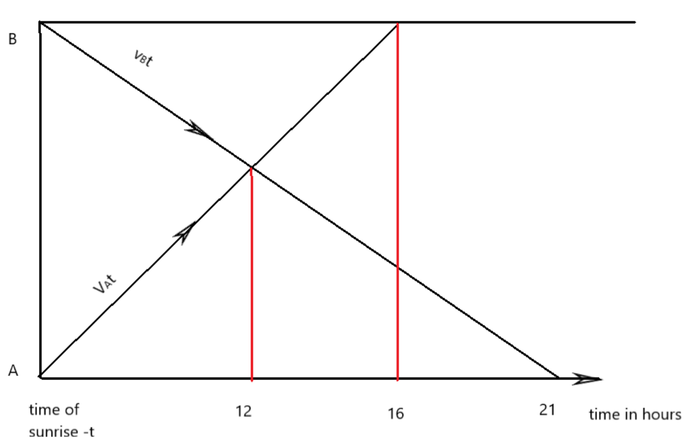


Example 3

This is a famous example from Vladimir Arnold (1937-2010), an outstanding Russian mathematician who did a lot of important work in different areas of math and physics. Another thing he was known for was making math interesting and easy to understand. He had a knack for creating examples that helped people appreciate the beauty of mathematics and physics, ultimately showing how graphs can be truly helpful.

In the story, there are two women who started walking at sunrise. They walked at a constant speed, one from point A to point B and the other from point B to point A. They met each other exactly at noon. After a quick meeting, they continued walking without any breaks. The woman who started at point B arrived at point A at 4 p.m., while the other woman, who started at point A, arrived at point B at 9 p.m.

Now, here is a tricky question: What time did the sunrise occur on that particular day?



We can use a graph to help us figure it out.

The distance $|\mathrm{AB}|$ can be expressed in four different ways:

$|\mathrm{AB}| = v_A(16 - t)$ (1)

$|\mathrm{AB}| = v_B(21 - t)$ (2)

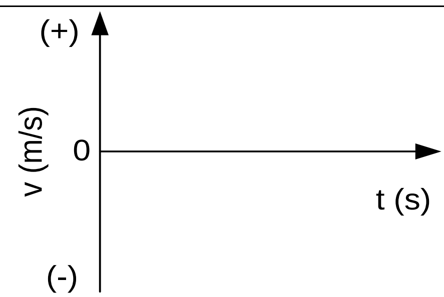
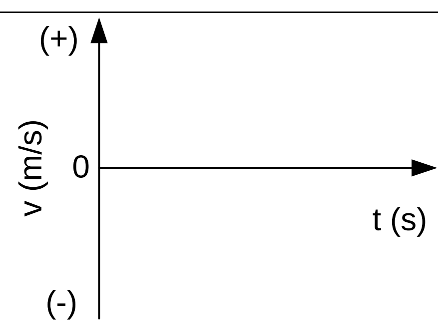
$|\mathrm{AB}| = v_A(12 - t) + v_B(12 - t)$ (3)

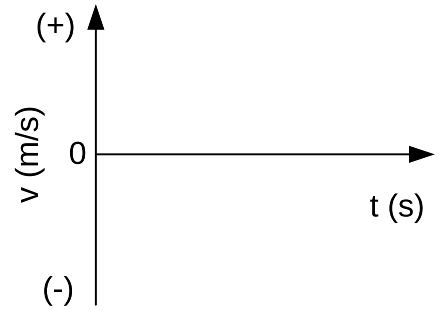
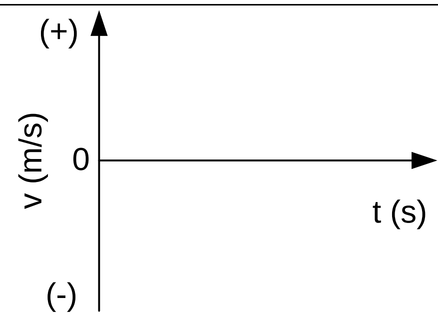
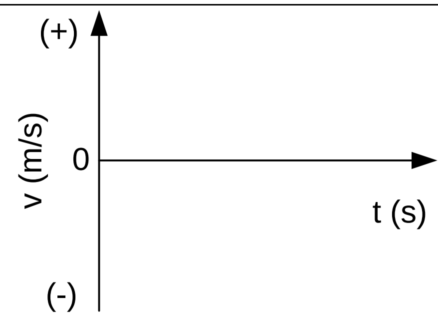
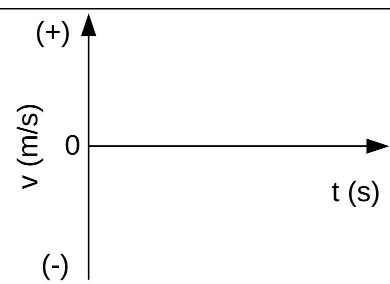
$|\mathrm{AB}| = v_A(16 - 12) + v_B(21 - 12)$ (4)

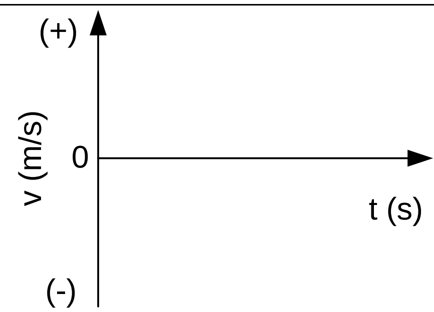
In these four equations we have four unknown distance $|\mathrm{AB}|$, v_A, v_B, t.

To solve this problem and find answers, we need more advanced math. But do not worry. Sometimes, when things seem tough, it is not the physics or the problem itself that is the trouble. It is just that we need more math knowledge to solve it. We can always ask a teacher or someone else who knows more to help us. In the scientific world, we need experts from different field to work together and figure out challenging problems.

Examples 4-10

The problem	v vs t graph	Solution
4. A poorly tuned car can accelerate from rest to a speed of 28 m/s in 20 s. a) What is the average acceleration of the car? b) What distance does it travel in this time?		
5. At t = 0 a car has a speed of 30 m/s. After 6 s, its speed is 15 m/s. What is its average acceleration during this time interval?		

6. A bear spies some Honey and takes off from rest, accelerating at a rate of 2.0 m/s^2. If the honey is 10 m away, how fast will his snout be going at the moment of ecstasy?		
7. A bus moving at 20 m/s (t = 0) slows at a rate of 4 m/s each second. a) How long does it take the bus to stop? b) How far does it travel while braking?		
8. A car whose initial speed is 30 m/s slows uniformly to 10 m/s in 5 seconds. a) Determine the acceleration of the car. b) Determine the distance it travels in the 3rd second.		
9. A physics student skies down a slope accelerating at a constant acceleration 2.0 m/s^2. If it takes her 15 s to reach the bottom, what is the length of the slope		

10. A mountain goat starts a rock-slide and the rocks crash down the slope 100 m. If the rocks reach the bottom in 5 s, what is its acceleration?		

Example 11

Air bags.

Air bags were designed to protect the driver and co-driver in a head-on collision in 100 km/h. Important is to know how fast must the air bag inflate to protect the driver and co-driver. What is the role of seat belts?

Let us do some calculations using constant acceleration and a stopping distance of 1 meter after the collision.

$$a = \frac{\Delta v}{\Delta t} = \frac{v_{final-}v_{initial}}{t_{final-}t_{initial}}$$

$$d = \frac{1}{2}at^2$$

$$t = \sqrt{\frac{2d}{a}}$$

$$a = \frac{v_{final} - v_{initial}}{\sqrt{\frac{2d}{a}}}$$

$$a = \frac{\left(v_{final-}v_{initial}\right)^2}{2d} = \frac{(0 - 28m.s^{-1})^2}{2m} = -390m.s^{-2}$$

This acceleration happens in a time *t* :

$$t = \frac{v_{final} - v_{initial}}{a} = \frac{0 - 28m.s^{-1}}{-390m.s^{-2}} = 0{,}07s$$

We can see that the airbag should inflate in less than 0,07 s. When the airbag inflates it spreads the force over a bigger area of the chest, protecting us from getting hurt by the steering wheel. The role of the seat belts is crucial too, they keep us in a stable position against the inflating air bag.