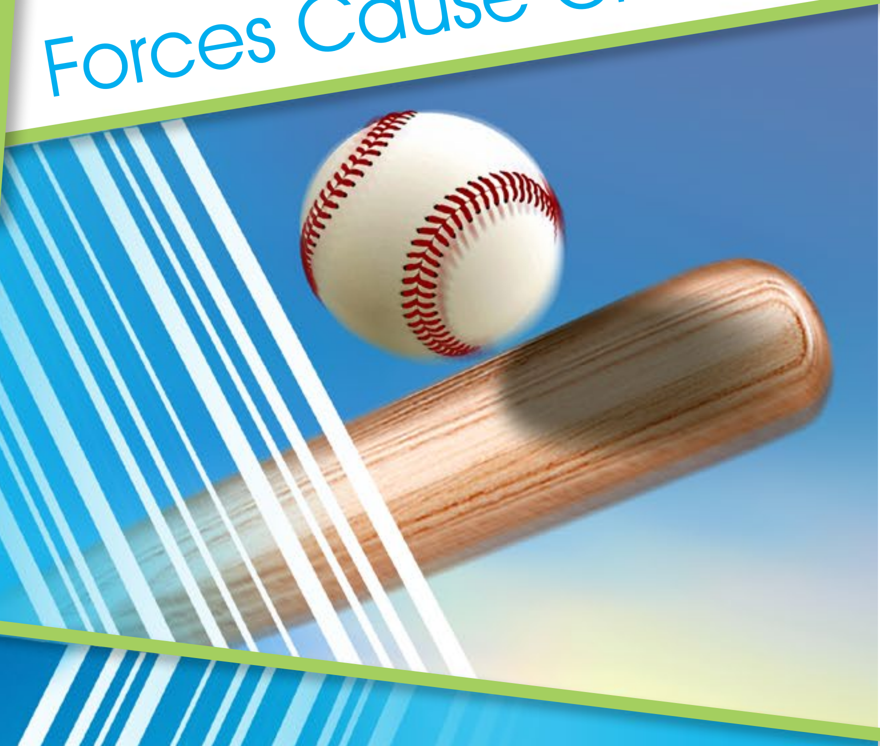
Speed Reading

Forces Cause Change



The force of a bat hitting a baseball causes the baseball to change direction.

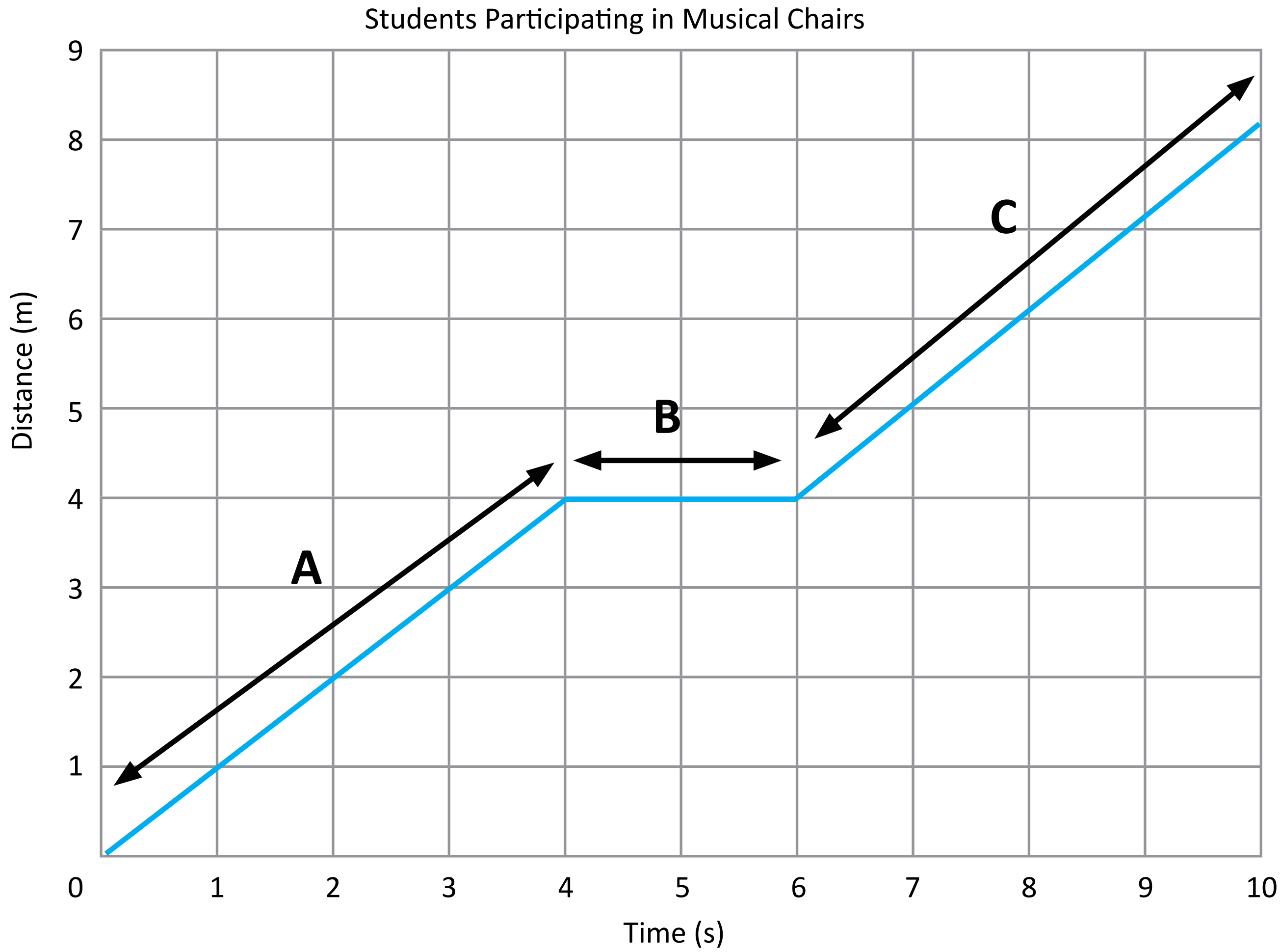
The force of the wind blowing can cause a sailboat to change position as the sail is pushed.

The force of friction between tires and the road can cause a car's speed to change.

Distance-Time Graphs

Forces are all around us and cause change. Sometimes, graphs are created to show how and where the change in motion of an object occurs.

Observe the graph.



What happens when kids play musical chairs? They move around a circle of chairs while the music plays but must quickly find a chair to sit in when the music stops. When the music begins playing, the students stand up and move around the circle again. Is that what the student in this graph did? How do you know?

Let's say that 0 seconds is the starting point. The music begins playing and the student begins moving around the circle. How far did the student move and for how long?

Look at Section A on the graph. The student moved 4 meters away from the starting point in 4 seconds. So what happened in Section B? The student stayed at a distance of 4 meters for 2 seconds. That means the music must have stopped, so the student found a chair in which to sit!

What did the student do in Section C? The student moved 4 more meters in 4 seconds after the music began playing again. From this graph, we can see the student's movement and how it changed. What else can we tell from the graph?

1. We can calculate the student's speed in Sections A, B, and C.

$$\text{Speed in Section A} = \frac{\text{distance}}{\text{time}} = \frac{4\text{ m}}{4\text{ s}} = \frac{1\text{ m}}{1\text{ s}} = 1\text{ m/s}$$

The student's speed in Section A is 1 m/s. The student's speed is the same in Section C because the student traveled the same distance in the same amount of time as in Section A. The student was not moving in Section B because the line is flat. That means that the student remained at the same distance from the starting point during the fourth and fifth seconds.

2. We can calculate the student's average speed.

$$\text{Average Speed} = \frac{\text{total distance}}{\text{total time}} = \frac{8\text{ m}}{10\text{ s}} = \frac{0.8\text{ m}}{1\text{ s}} = 0.8\text{ m/s}$$

For total distance, remember to add the distance the student moved in Sections A, B, and C.

Distance in Section A + Distance in Section B + Distance in Section C = Total Distance

4 m + 0 m + 4 m = 8 m

For total time, look at when motion started and when it was completed. The line started at 0 s and stopped at 10 s. The total time is 10 s. The student's average speed is 0.8 m/s.

3. We can convert the student's average speed to km/hr.

$$\frac{0.8\text{ m}}{\text{s}} \bullet \frac{1\text{ km}}{1000\text{ m}} \bullet \frac{60\text{ s}}{1\text{ min}} \bullet \frac{60\text{ min}}{1\text{ hr}} = \frac{2{,}880\text{ km}}{1{,}000\text{ hr}} = \frac{2.9\text{ km}}{1\text{ hr}} = 2.9\text{ km/hr}$$

To convert 0.8 m/s to km/hr, we have to multiply by a ratio equal to 1 more than once. For example, look at the following equivalencies.

1,000 m = 1 km 60 s = 1 min 60 min = 1 hr

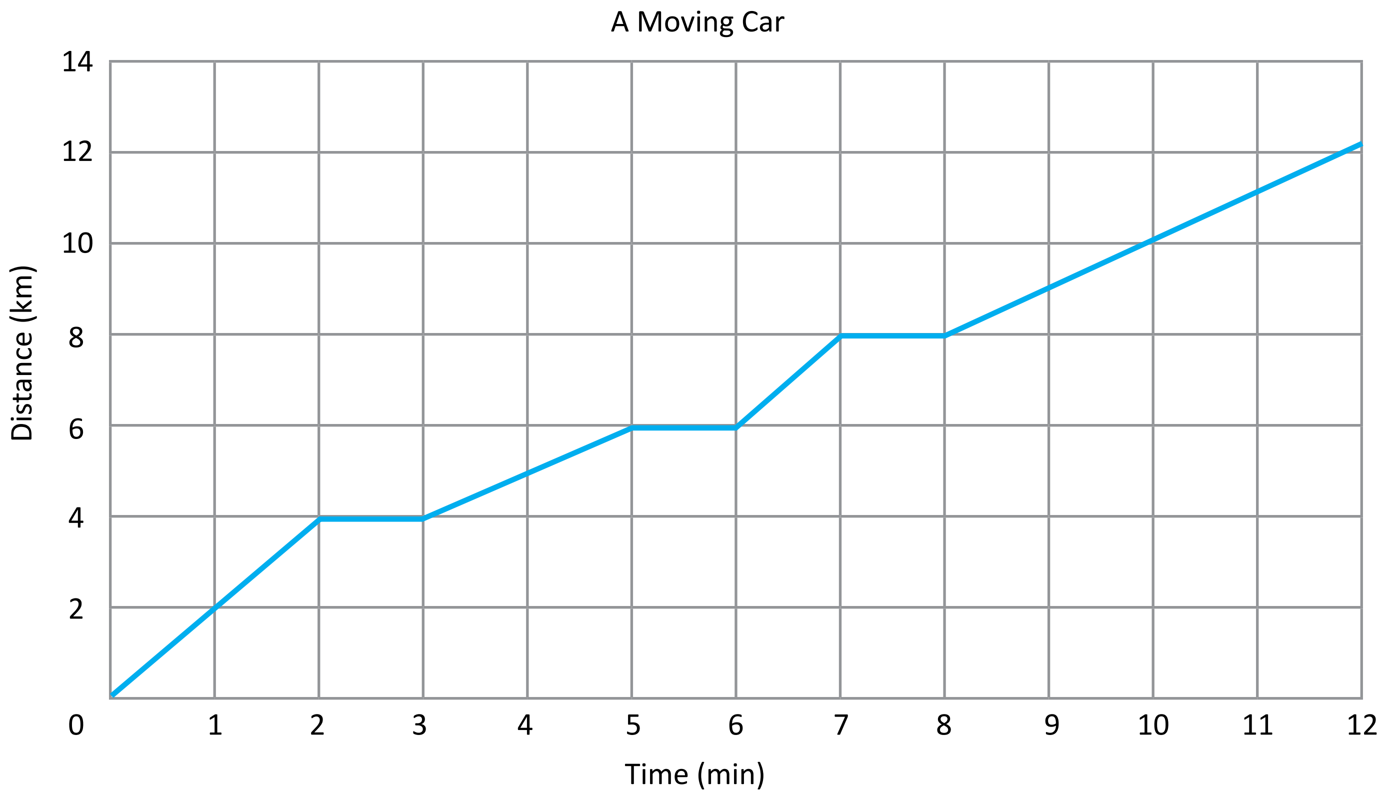
$$\frac{0.8\text{ m}}{\text{s}} \bullet \frac{1\text{ km}}{1000\text{ m}} \bullet \frac{60\text{ s}}{1\text{ min}} \bullet \frac{60\text{ min}}{1\text{ hr}} = \frac{2.9\text{ km}}{1\text{ hr}} = 2.9\text{ km/hr}$$

When multiplying by a ratio equal to 1, make sure you set up the units of measurement so that they are on opposite sides of the midline. This means they will simplify to 1.

$$\frac{0.8\text{ }\cancel{\text{m}}}{\cancel{\text{s}}} \bullet \frac{1\text{ km}}{1000\text{ }\cancel{\text{m}}} \bullet \frac{60\text{ }\cancel{\text{s}}}{\cancel{\text{min}}} \bullet \frac{60\text{ }\cancel{\text{min}}}{1\text{ hr}} = \frac{2.9\text{ km}}{1\text{ hr}} = 2.9\text{ km/hr}$$

Multiply the numerators, and then multiply the denominators. Divide the numerator by the denominator. Simplify the units to leave a ratio of km/hr.

Let's look at a different example.



The graph shows a car's change in distance over time. Again, the starting point is at (0, 0). Judging by the line, is the car traveling on a city street or a freeway? If you think the car is traveling on a city street, you may be correct. If you think the car is traveling on a freeway, you may also be correct. So, why might both answers be right?

By looking at the line on the graph, we can determine what was happening. Between 2 and 3 minutes, the car remains at 4 km, indicating that it is stationary, or not moving. Why might the car be stopped for 1 minute? Did you say because of a stoplight or maybe traffic? If so, either explanation is reasonable. Drivers encounter stoplights on city streets and traffic on freeways that may cause them to stop. The constant stops and starts shown by the line help us infer that if the car is on a city street, more than one stoplight exists. If the car is on the freeway, the driver is experiencing stop-and-go traffic.

When is the car traveling fastest? The car is traveling fastest between 6 and 7 minutes. We know this because the line on the graph is steeper than anywhere else on the graph. The car travels 2 km in 1 minute.

What is the total distance and time the car travels? The car travels 12 km away from the starting point in 12 minutes.

What is the car's average speed?

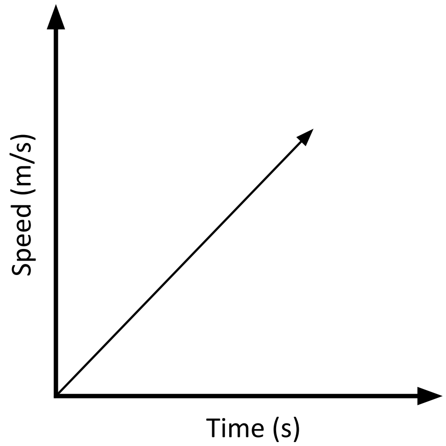
$$\text{Average Speed} = \frac{\text{total distance}}{\text{total time}} = \frac{12\text{ km}}{12\text{ min}} = \frac{1\text{ km}}{1\text{ min}} = 1\text{ km/min}$$

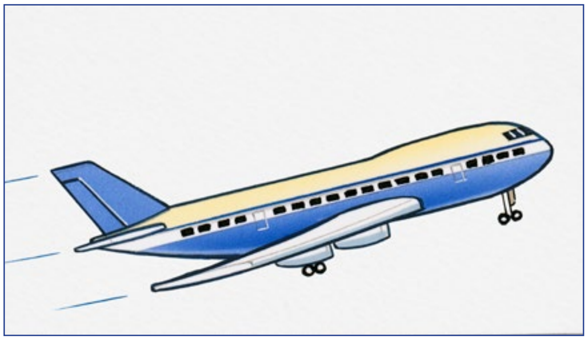
What is the car's average speed in km/hr?

$$\frac{1\text{ km}}{\text{min}} \bullet \frac{60\text{ min}}{1\text{ hr}} = \frac{60\text{ km}}{1\text{ hr}} = 60\text{ km/hr}$$

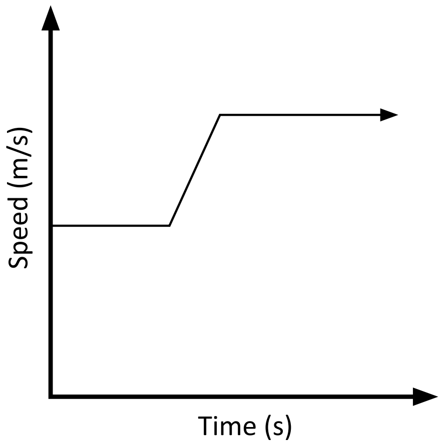
Speed-Time Graphs

Now, let's think about and observe graphs that show speed.

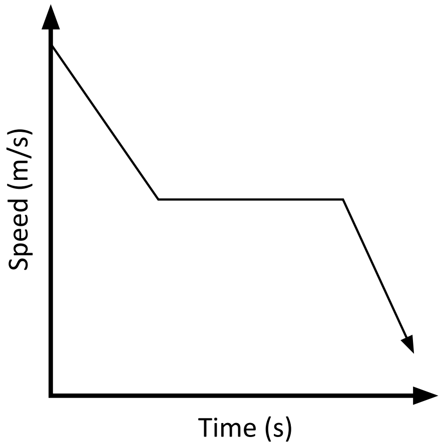




What does the line on the graph mean? If the line is going up, speed is increasing over time. This could represent a plane taking off or a train leaving a station.



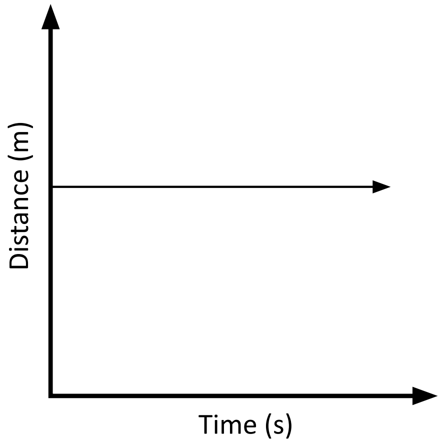
If an increasing line means increasing speed, what does it mean when the line is horizontal, or flat? A horizontal, or flat, line means the speed is not changing; the object is maintaining a constant speed. What could this line represent? A car traveling down the freeway may travel at a constant speed and then increase in speed to change lanes. After changing lanes, the car may resume a constant speed.



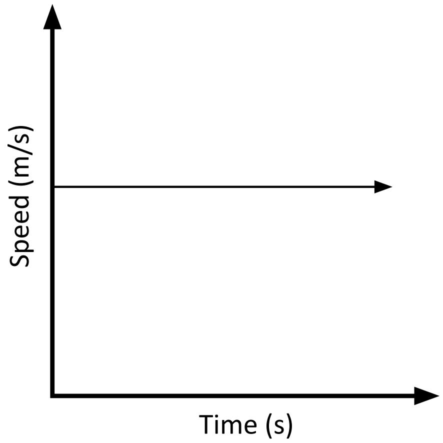
If an increasing line means increasing speed and a horizontal line means no change in speed, what does a decreasing line mean? A decreasing line means a decrease in speed. If a person is running and becomes tired, he or she will slow down to conserve energy. At that point, the runner might maintain the same speed until he or she becomes fatigued again. When that happens, he or she might decrease his or her speed again.

Distance-Time Versus Speed-Time Graphs

Let's take a second to think about distance-time graphs versus speed-time graphs. What is the main difference between a horizontal line on a distance-time graph versus a speed-time graph?



A horizontal line on a distance-time graph means an object is not moving because distance is not changing. For example, a car that is stopped or parked would be represented by a horizontal line.



A horizontal line on a speed-time graph means an object's speed is constant, neither increasing nor decreasing. For example, a car traveling down a freeway maintains a constant speed if there is no road construction or traffic.

What causes distance and speed to change over time? Remember, forces are all around us and cause change, such as in distance and speed. Friction, gravity, magnetism—any force that pushes or pulls—can cause change in the motion of an object, including position, direction, and speed.

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