Position-Time Graphs

Suppose that a man is jogging at a constant velocity of $5.0 \text{ m/s}$. A data table representing the man’s motion is shown below:

<table>
<thead>
<tr>
<th>Time (s)</th>
<th>Position (m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
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<tr>
<td>1.0</td>
<td>5.0</td>
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<tr>
<td>2.0</td>
<td>10.0</td>
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<tr>
<td>3.0</td>
<td>15.0</td>
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<tr>
<td>4.0</td>
<td>20.0</td>
</tr>
<tr>
<td>5.0</td>
<td>25.0</td>
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</tbody>
</table>

If we plot this data on a graph, we get:

A graph that shows how position varies with time is known as a **position-time graph**. This type of graph is very useful, as there is a great deal of information you can get from the graph, either directly or indirectly.
Some of the things you can determine directly from a graph of position versus time include:

- describing the motion of the object
  - based on the shape of the graph
- determining the position at a given time
  - by reading the graph
- determine the time when the object was at a given position
  - by reading the graph

Some of the things you can determine indirectly — that is, by doing some calculations — from a position-time graph include:

- determining the distance traveled
- determining the displacement for an interval of time
  - subtract the starting position from the ending position
- determining the velocity of the object at a given instant (instantaneous velocity)
  - slope of the graph at that instant
  - if the graph is curved, use a tangent line to find the slope
- determining the velocity of the object over a given time interval (average velocity)
  - slope of the chord joining the point on the graph at the start of the interval to the point on the graph at the end of the interval
Example 1
Use the position-time graph below to answer the questions. **Note:** Right is the positive direction.

1. Describe the motion of the object.
2. What is the position of the object at $t = 30 \, s$?

3. At what time is the object 100 $m$ to the right of the starting position?

4. What is the total distance the object moved?

5. What is the object’s net displacement?

6. What is the object’s velocity at $t = 30 \, s$?

7. What is the average velocity of the object from $t = 10 \, s$ to $t = 45 \, s$?
Position-Time Graph Worksheet

The position-time graph below represents the motion of a remote-controlled toy truck as it moves back and forth along a straight line path. The origin marks the position of the boy who controls the truck. A positive position is to the right of the boy, and a negative position is to the left of the boy.

1. During which time intervals is the truck
   a) to the right of the boy?

   ________________________________

   ________________________________

   b) to the left of the boy?

   ________________________________

   ________________________________

   c) moving in the positive direction?

   ________________________________

   ________________________________

   d) moving in the negative direction?

   ________________________________

   ________________________________
e) not moving? 

2. What is the position of the truck at 
   a) 0 seconds? 
   b) 15 seconds? 
   c) 30 seconds? 
   d) 45 seconds? 

3. How far did the truck travel during the following time intervals? 
   a) 0–10 s 
   b) 10–15 s 
   c) 15–25 s 
   d) 25–35 s 
   e) 35–40 s 
   f) 40–50 s 

4. What was the displacement of the truck during the following intervals? 
   a) 0–10 s 
   b) 10–15 s 
   c) 15–25 s 
   d) 25–35 s 
   e) 35–40 s 
   f) 40–50 s 

5. Average speed is given by the distance traveled divided by the time interval. Calculate the average speed for each interval. 
   a) 0–10 s 
   b) 10–15 s 
   c) 15–25 s 
   d) 25–35 s 
   e) 35–40 s 
   f) 40–50 s
6. Average velocity is given by the displacement of the truck divided by the time interval. It can also be determined by calculating the slope of the line segment on a position-time graph. Calculate the average velocity for each time interval by calculating the slope.

<table>
<thead>
<tr>
<th>Run = Δt</th>
<th>Rise = Δd</th>
<th>Slope = v</th>
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</thead>
<tbody>
<tr>
<td>Time Interval</td>
<td>Displacement</td>
<td>Velocity</td>
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7. How do the signs of the velocities in #6 compare to the direction of motion in #1?

8. In terms of the truck’s motion,
   a) what does a negative velocity mean? ____________________________
   b) what does a positive velocity mean? ____________________________
   c) what does a velocity of zero mean? ____________________________