Displacement from a Velocity-Time Graph

by

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P2.2e Use the area under a velocity-time graph to calculate the distance traveled and the slope to calculate the acceleration.

Items:

1. Displacement: Area Under Velocity- Time Graph.

2. Uniform Motion Graph.

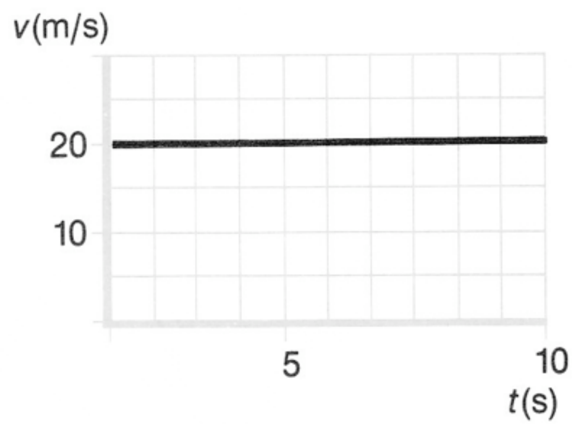
3. Changing Motion Graph.

Displacement from a Velocity-Time Graph

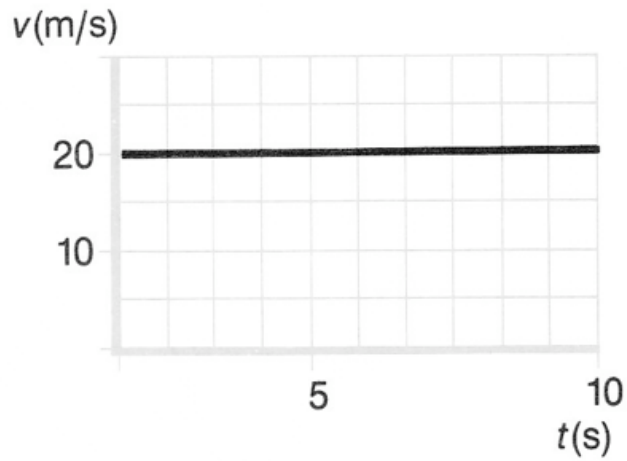
The displacement in any interval is given by the area under the velocity-time graph for that interval. This is valid in all cases, whatever the shape of the velocity-time graph.

Example 1: *A Uniform Motion:*

The graph below shows the motion of a car for a 10 s interval. What is the displacement of the car during this time interval? Use 2 different methods.



Method 1:



The graph shows a uniform velocity of 20 m/s for 10 S. we can use the equation of uniform velocity to calculate the displacement:

$$\overrightarrow{\Delta d} = \vec{v}\Delta t$$

In this case

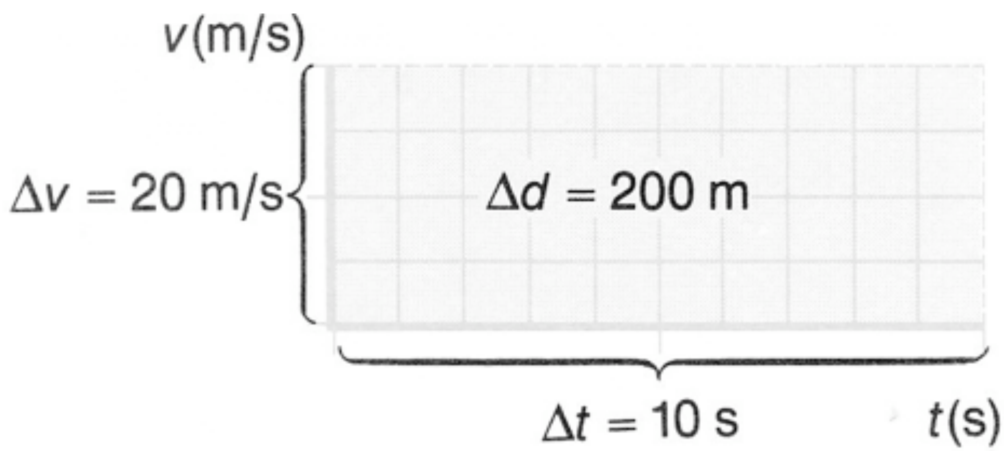
$$\vec{v} = 20 \text{ m/s}$$

$$\Delta t = 10 \text{ s}$$

then

$$\overrightarrow{\Delta d} = (20 \text{ m/s})(10 \text{ s}) = 200 \text{ m}$$

Method 2:

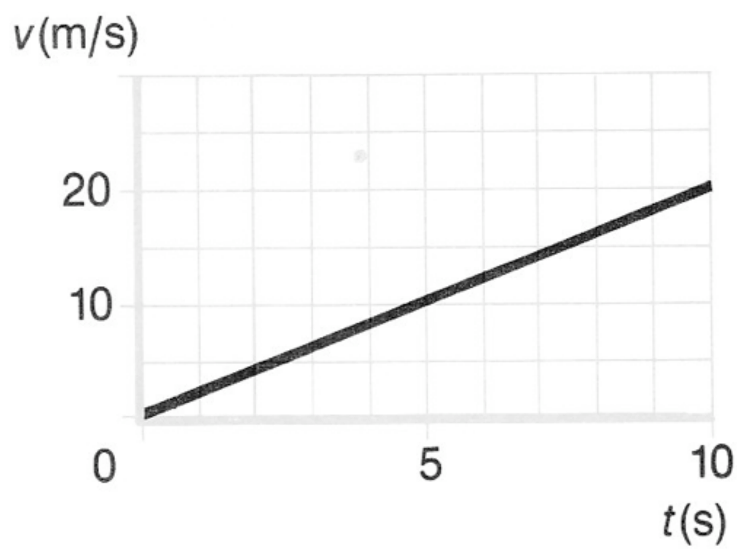


We could also look at this solution in another way. Δv and Δt are actually the length and width of the rectangle formed by the graph line and the time axis. The product of these two quantities gives us the area of the rectangle.

$$\Delta d = \Delta v \times \Delta t = 20 \times 10 = 200 \text{ m}$$

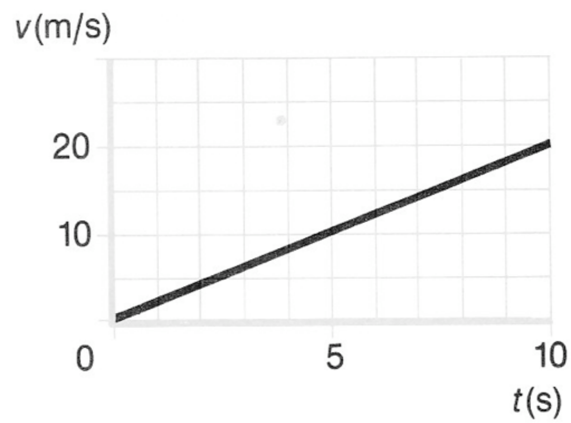
Example 2: *The motion is not uniform;*

The graph below shows the velocity of a ball that starts from rest and rolls down a long hill. What is the ball's displacement after 10s.



Since this graph does not involve uniform motion, we can not use

$$\Delta \vec{d} = \Delta t \times \vec{v}.$$



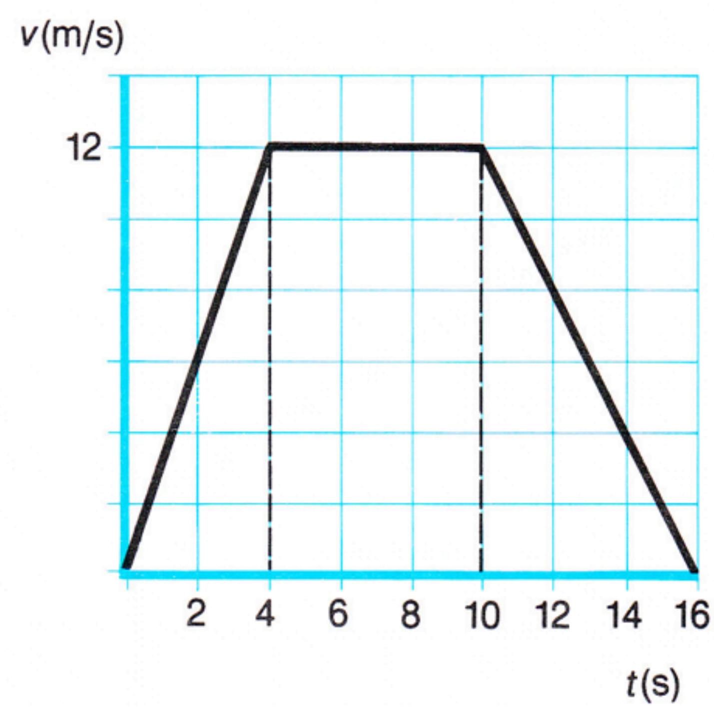
As in the previous example, the area between the time axis and the graph line represents the displacement for the interval. In this case the shape is a triangle. you recall that the area of a triangle equals 1/2 x base x height.

$$\overrightarrow{\Delta d} = \text{area of } \triangle = \frac{1}{2}bh$$
$$= \left(\frac{1}{2}\right)(10\text{ s})(20\text{ m/s})$$
$$= 100\text{ m}$$

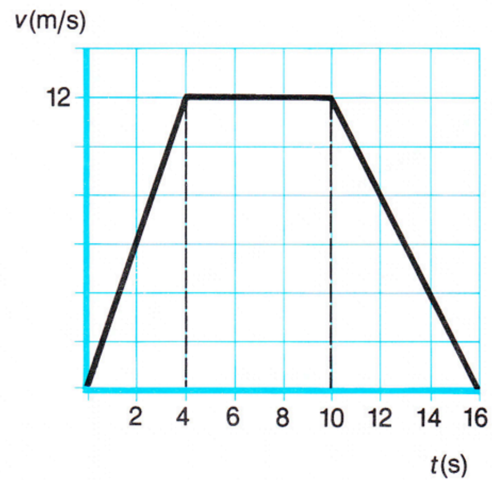
Therefore, the ball had a displacement of 100 m after it had rolled for 10 S.

Example 3: *Changing Motion;*

The graph shown below shows the motion of a dog running along the side of a straight road for a 16 s interval. What is its displacement for that time interval?



Again, we can find the displacement by finding the area under the graph line.

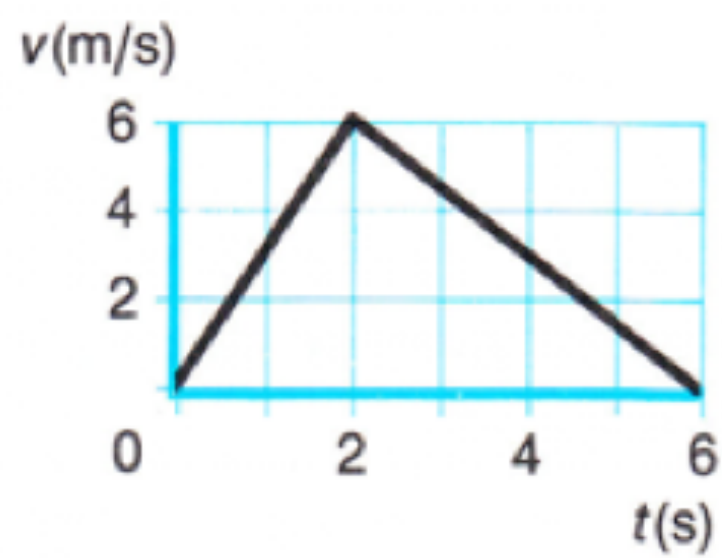


since the figure is complex, we can divide it into three figures, as shown by the black, dotted lines, to simplify the task. To find the total displacement, we find the total of the three areas.

$$\begin{aligned}\overrightarrow{\Delta d} &= \text{area}\,(\triangle + \square + \triangle)\\ &= \left(\frac{1}{2}\right)(4.0\ \text{s})(12\ \text{m/s}) + (6.0\ \text{s})(12\ \text{m/s}) + \left(\frac{1}{2}\right)(6.0\ \text{s})(12\ \text{m/s})\\ &= 24\ \text{m} + 72\ \text{m} + 36\ \text{m}\\ &= 132\ \text{m}\end{aligned}$$

Therefore, the dog has a displacement of 132 m for the interval.

Example 4:



The displacement is 18 m.

References:

1) Humanic. (2013). www.physics.ohio-state.edu/~humanic/. In Thomas Humanic Brochure Page.

Physics 1200 Lecture Slides: Dr. Thomas Humanic, Professor of Physics, Ohio State University, *2013-2014 and Current. www.physics.ohio-state.edu/~humanic/*

2) Cutnell, J. D. & Johnson, K. W. (1998). *Cutnell & Johnson Physics, Fourth Edition*. New York: John Wiley & Sons, Inc.

The edition was dedicated to the memory of Stella Kupferberg, Director of the Photo Department:"We miss you, Stella, and shall always remember that a well-chosen photograph should speak for itself, without the need for a lengthy explanation"

3) Martindale, D. G. & Heath, R. W. & Konrad, W. W. & Macnaughton, R. R. & Carle, M. A. (1992). *Heath Physics.* Lexington: D.C. Heath and Company

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