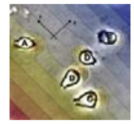
Physics 131- Fundamentals of Physics for Biologists I



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9/7/2012
Main Topic: Motion

-How can we describe motion (Kinematics)

- What is responsible for motion (Dynamics)

Movie of the Day
Starling Kinematics

Velocity

- Average velocity is defined by

$$\langle\vec{v}\rangle = \frac{\Delta\vec{r}}{\Delta t} = \frac{\text{vector displacement}}{\text{time it took to do it}}$$

Note: an average velocity goes with a <u>time interval</u>.

- Instantaneous velocity is what we get when we consider a very small time interval (compared to times we care about)

$$\vec{v} = \frac{d\vec{r}}{dt}$$

Note: an instantaneous velocity goes with a <u>specific time</u>.

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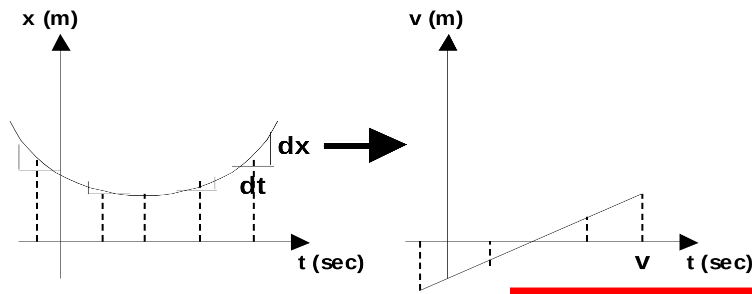
Position to velocity



$$v(t) = \frac{dx}{dt}$$

Ratio of change in position that takes place to the (small) time interval

Difference of two positions at two (close) times

$$v(t) = \frac{x(t + \Delta t/2) - x(t - \Delta t/2)}{\Delta t}$$

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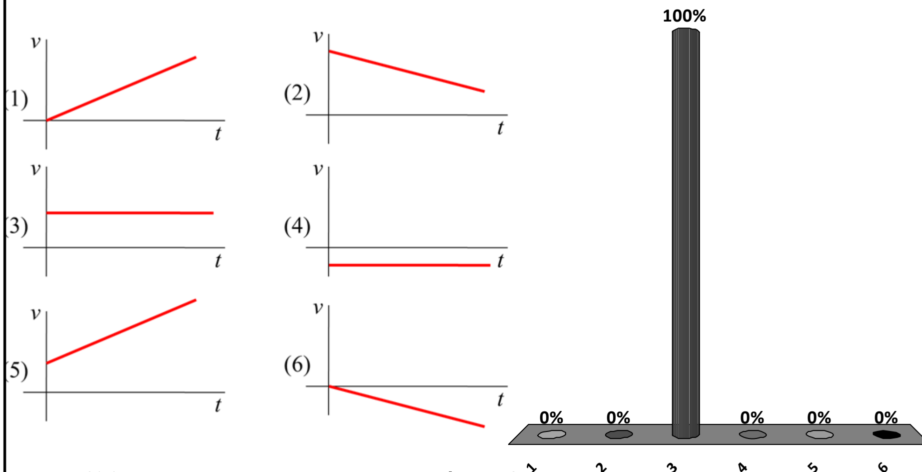
- If you walk slowly at almost a constant velocity what will the **velocity** graph look like?

Velocity graph



1.
2.
3.
4.
5.
6.

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Multiple representations of Motion

- Words
- Diagrams
- Videos
- Graphs
  - Position
  - Velocity
  - acceleration

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Predicting the Future with differential equations

Suppose we know the value of something as a function of time at a given time, *f*(*t*), and we know its derivative, *df/dt* at that time. We can use that to predict the future!

$$\frac{df}{dt} = \frac{\Delta f}{\Delta t} = \frac{f_{end} - f_{beginning}}{\Delta t}$$

$$f_{end} - f_{beginning} = \left(\frac{df(t)}{dt}\right)\Delta t$$

$$f(t+\Delta t) - f(t) = \left(\frac{df(t)}{dt}\right)\Delta t$$

$$f(t+\Delta t) = f(t) + \left(\frac{df(t)}{dt}\right)\Delta t$$

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An example: Predicting the future in epidemiology

$$\frac{dI(t)}{dt} = AI(t) - BI(t)$$

$A =$ rate at which population gets infected

$B =$ rate at which infected people are cured (or die)

$$\frac{dI}{dt} = (A-B)I$$

$$I(t+\Delta t) = I(t) + \left(\frac{dI}{dt}\right)\Delta t$$

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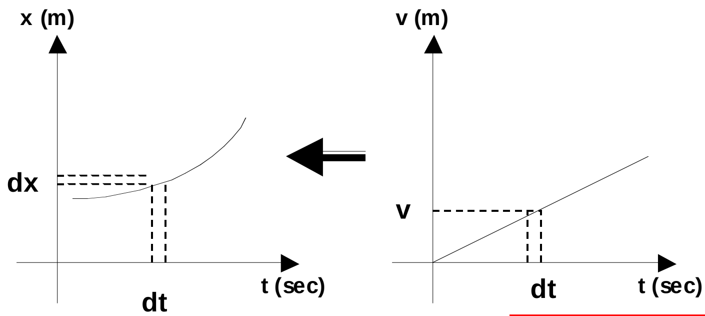
Velocity: predicting the future (future position that is)



$$dx = v(t)\ dt$$

change in position that takes place in a small time interval

$$x = \sum dx = \int v(t)\ dt$$

sum ("Σ") in the changes in position over many small time intervals

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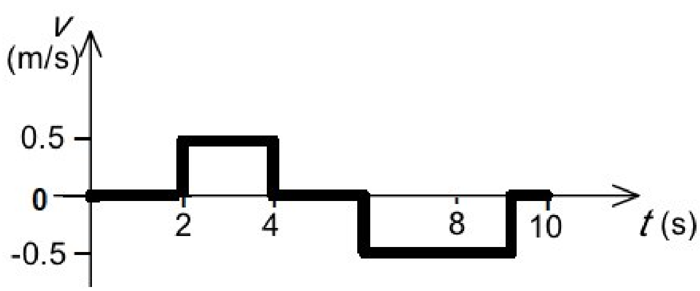
Example

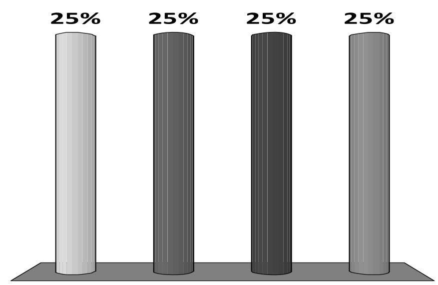
- How do you have to walk to make the sonic ranger produce the following velocity graph?



- Draw the position graph.

Position graph

1. 1
2. 2
3. 3
4. 4



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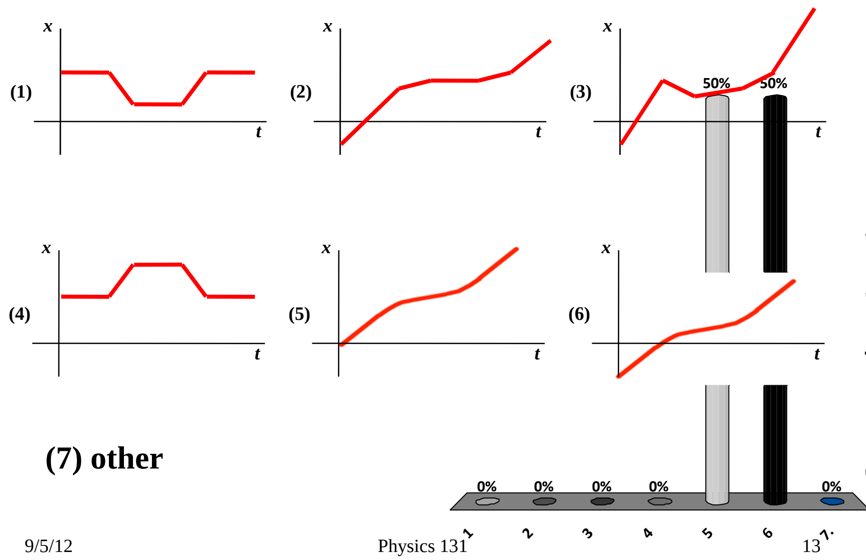
Example

A ball rolls is rolling at a constant speed along the horizontal part of the track.
It comes to a hill and has enough speed to get over it. By thinking about its speed as it goes, sketch a graph of the <u>position</u> of the ball as a function of time.

Position graph

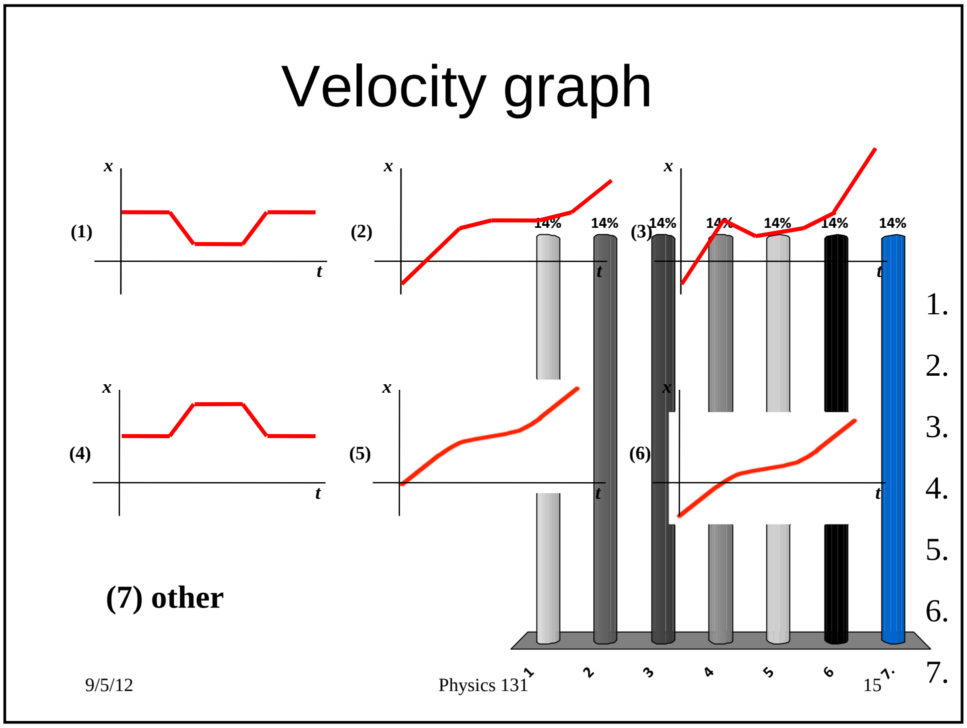


(7) other

1.
2.
3.
4.
5.
6.
7.

Example

A ball rolls is rolling at a constant speed along the horizontal parts of the track. It comes to a hill and has enough speed to get over it. By thinking about its speed as it goes, sketch a graph of the <u>velocity</u> of the ball as a function of time.


Velocity graph
(1)
(2)
(3)
(4)
(5)
(6)
x
t
14%
1.
2.
3.
4.
5.
6.
7.
(7) other
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