

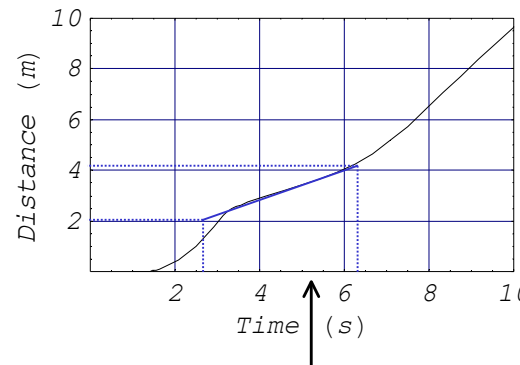


# Today

- Announcements:
  - HW#2 is due Wednesday by 8:00 am
  - Extra Credit project #1 in on the LONCAPA website. Length should be about 1 paragraph. An excellent description will get 4 points.
- Review
- What is Force? Introduction



# Review



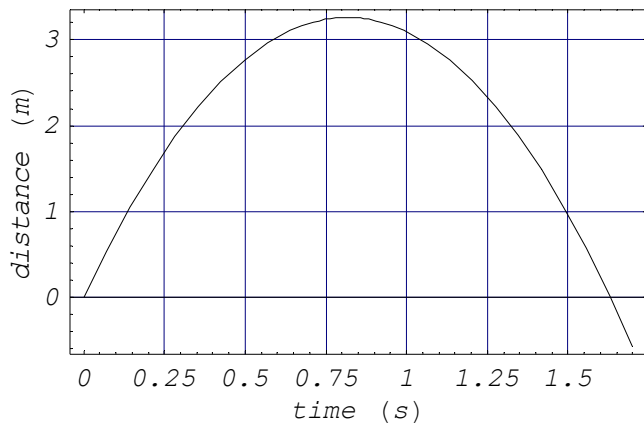
Steps in calculating rates of change:

- Draw a line tangent to the curve at the time you want. The line can be any length.
- Find the slope of the line.

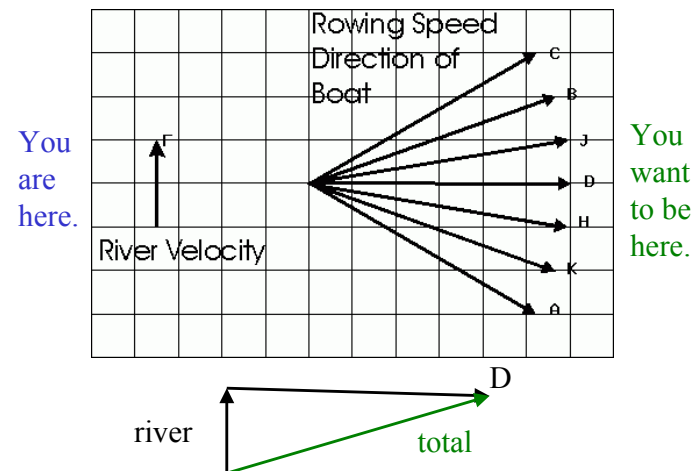
Find the speed at 5.1 s.



# Picture of the flight of a ball



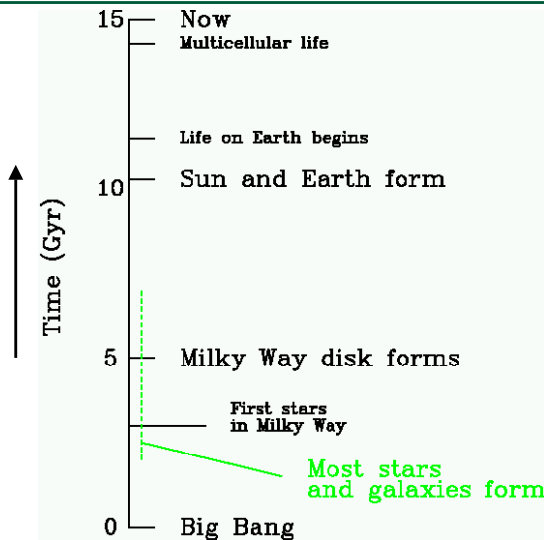
# Vectors



You are here.

You want to be here.

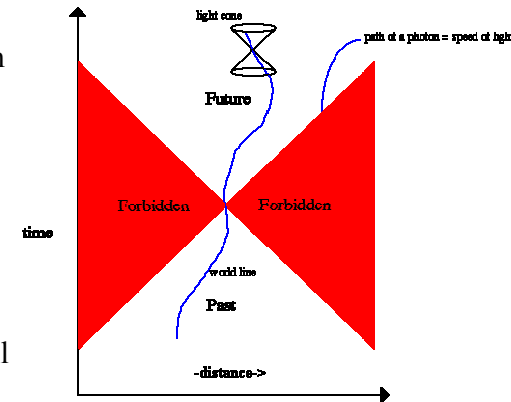
## Time-lines



-5-

## Time-Lines and World Diagrams

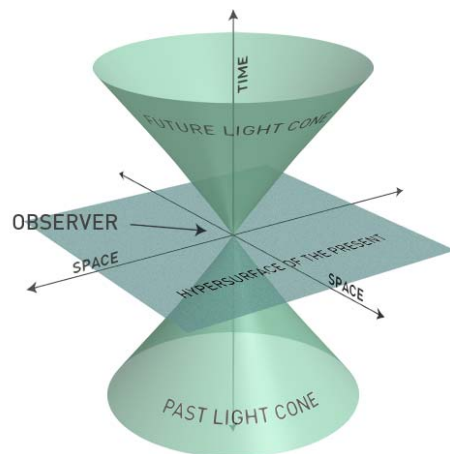
- A world diagram is a plot of time vs. position.
- Nothing can go faster than the speed of light, hence all events must fall within a “light cone”
- The path of an object is called the world line
- Usually the time axis is given in units where a particle moving at  $c$  will fall along a 45 degree line, e.g., if we plotted years vs. light years .



ISP209f5 Lecture 3

-6-

## World Diagrams



ISP209f5 Lecture 3

-7-

## What is a Force?

- A force is a push or pull.
- Force is a vector, it has a magnitude and a direction.
- A better definition is given by Newton’s Three Laws of Force (my versions)
  - If the net force on an object is zero the object will not accelerate.
  - The amount of acceleration depends on the mass of the object and the amount of the applied force:  $F = ma$  .
  - For every force, there is an equal and opposite force.
- Improved definition: Force is the rate of change of momentum.

ISP209f5 Lecture 3

-8-



## What is momentum?

- Momentum is mass times velocity.
- Momentum is a vector.
- $p=mv$
- Momentum is the modern analog to Galileo's idea of inertia.



## Momentum Problems

Hint: Force is the rate of change of momentum.

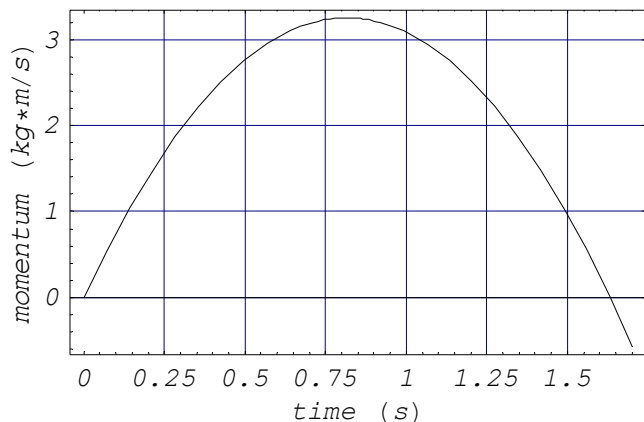
$$\vec{F} = \frac{\Delta \vec{p}}{\Delta t} = \frac{\vec{p}_f - \vec{p}_i}{t_f - t_i}$$

$$\text{magnitude of } F \text{ for motion in one dimension} = \frac{p_f - p_i}{t_f - t_i}$$

Note: A negative slope means the direction of the force is toward  $-x$ .



## Momentum Problem Picture



## What is a force (continued)?

- These laws let us recognize a force, but what causes a force?
  - The modern view is related to field theory.
  - Forces are the result of an exchange of particles.
- To understand field theory, we have to start with energy (see the next lecture).