

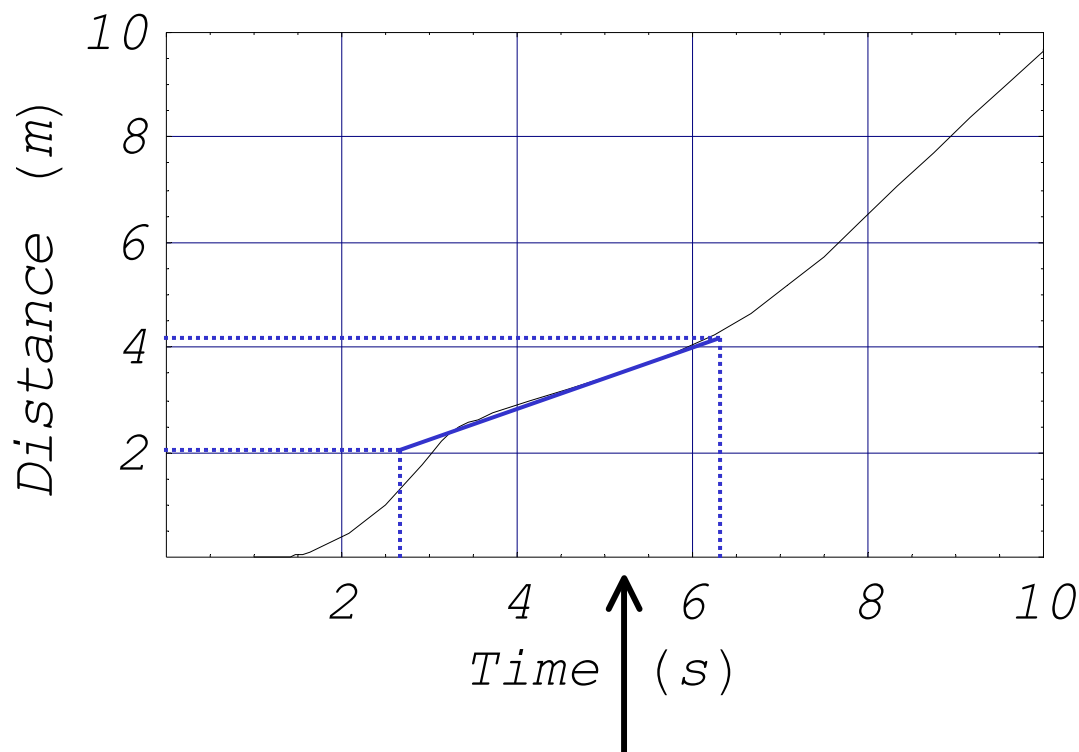


Today

- 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



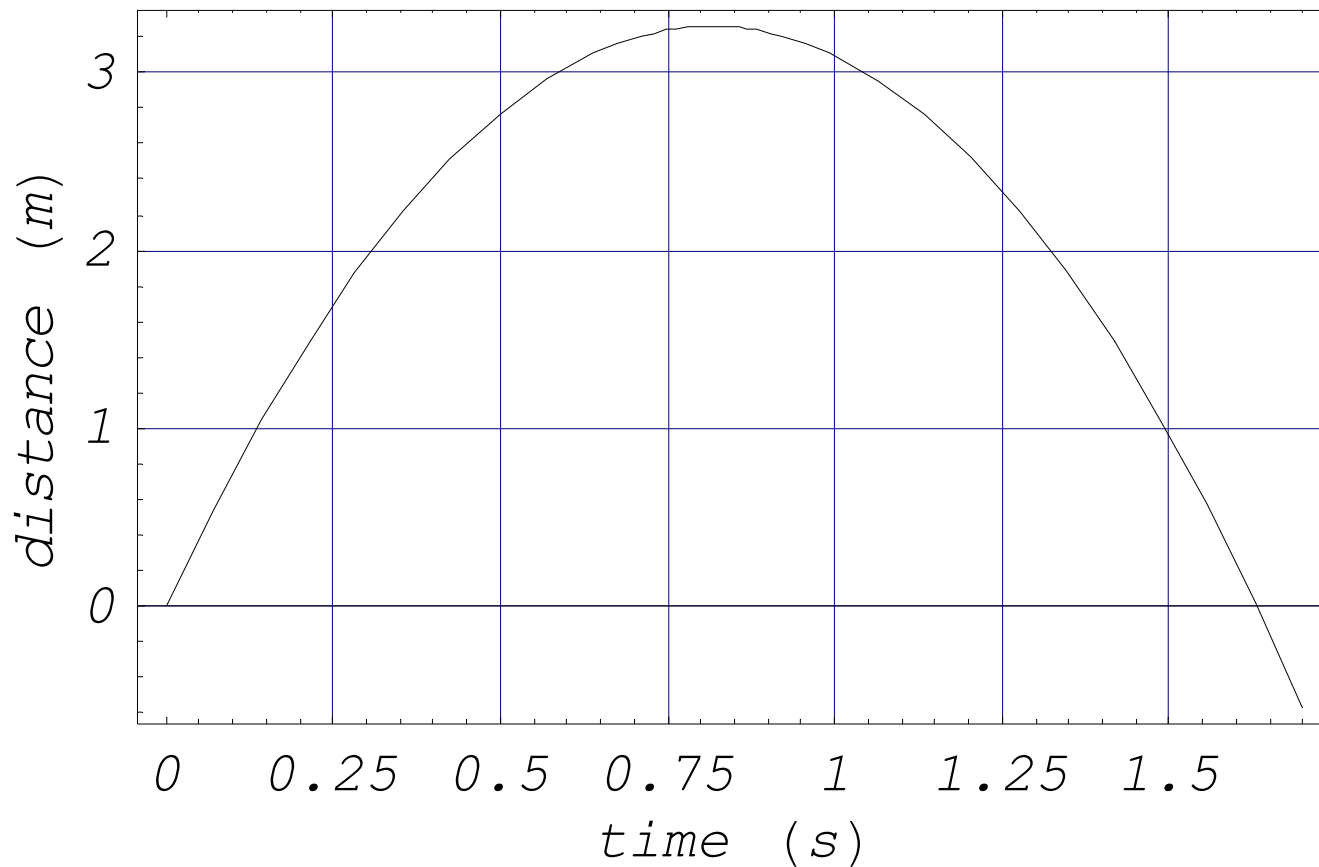
Find the speed at 5.1 s.

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.



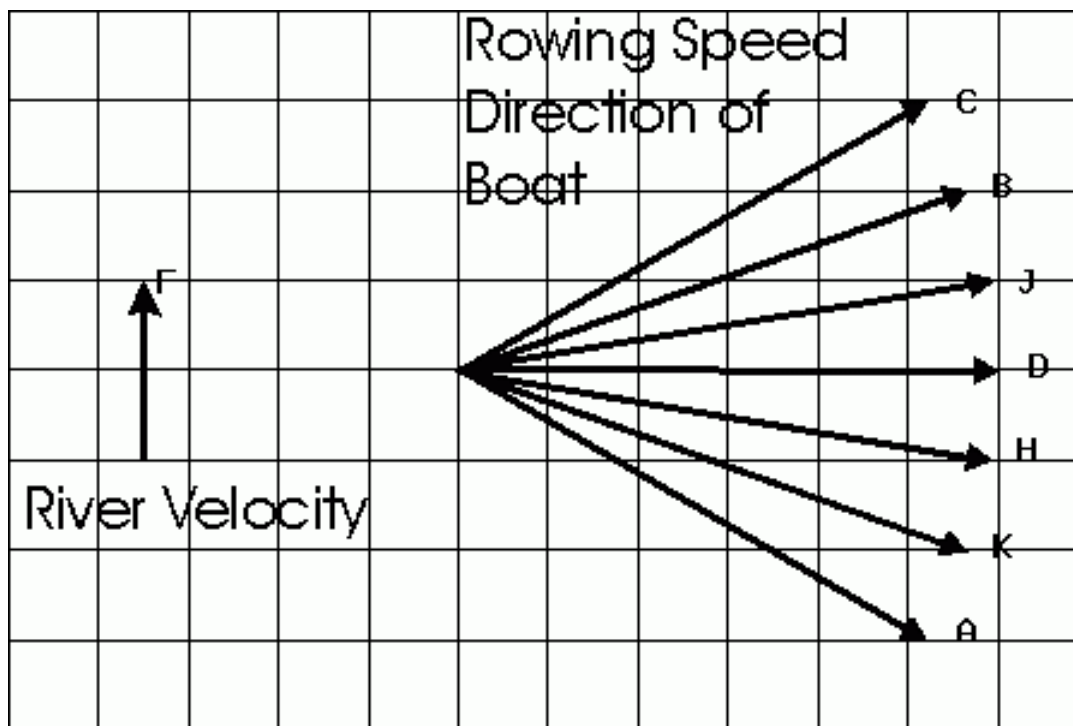
Picture of the flight of a ball



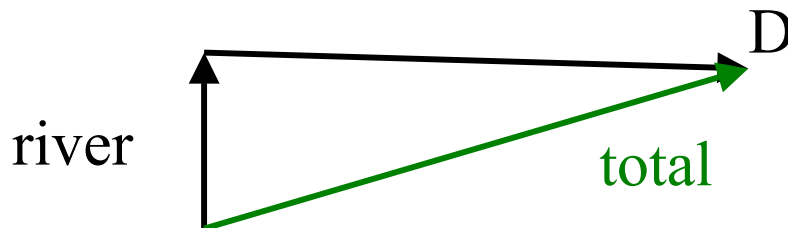


Vectors

You are here.

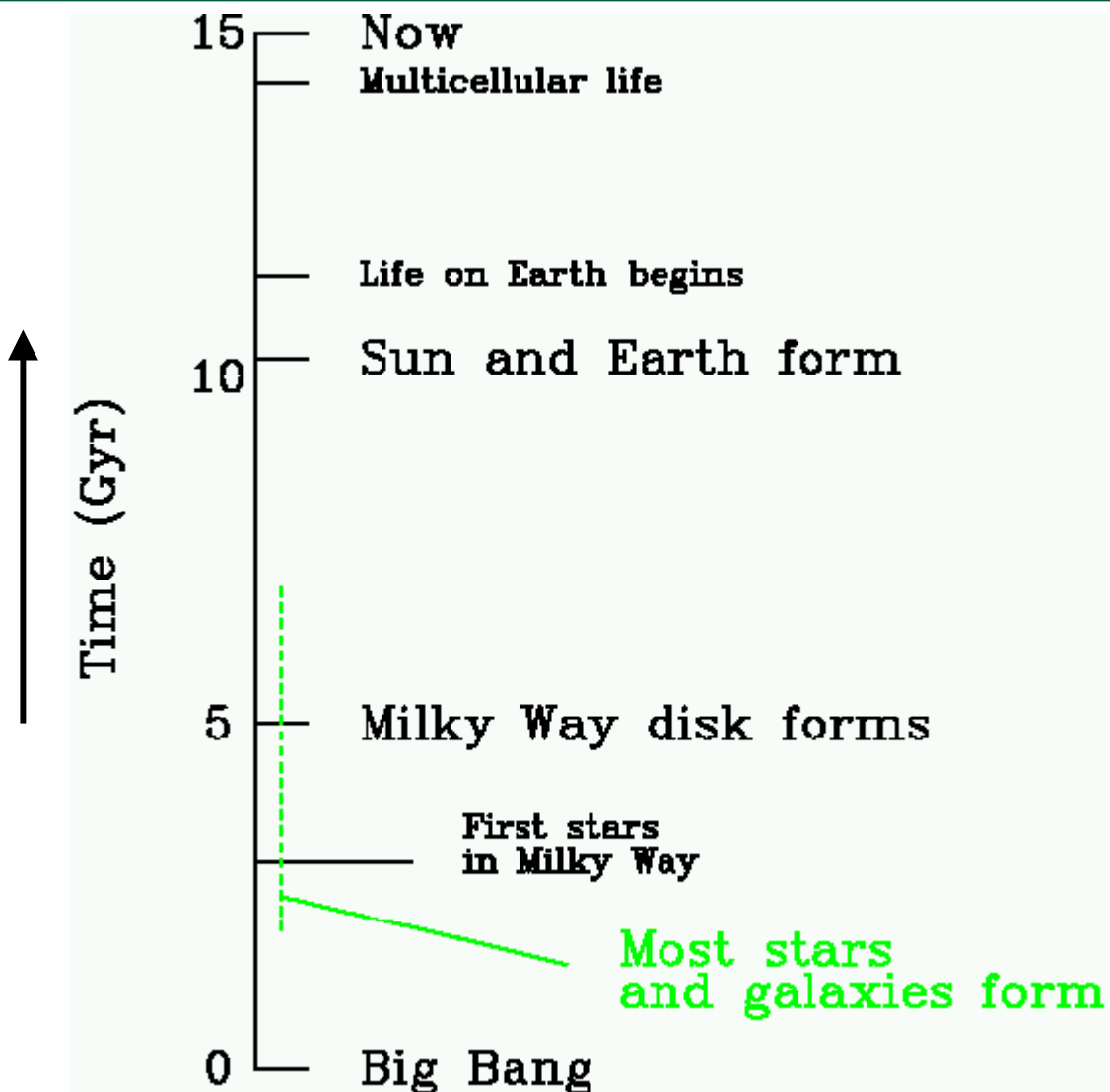


You want to be here.



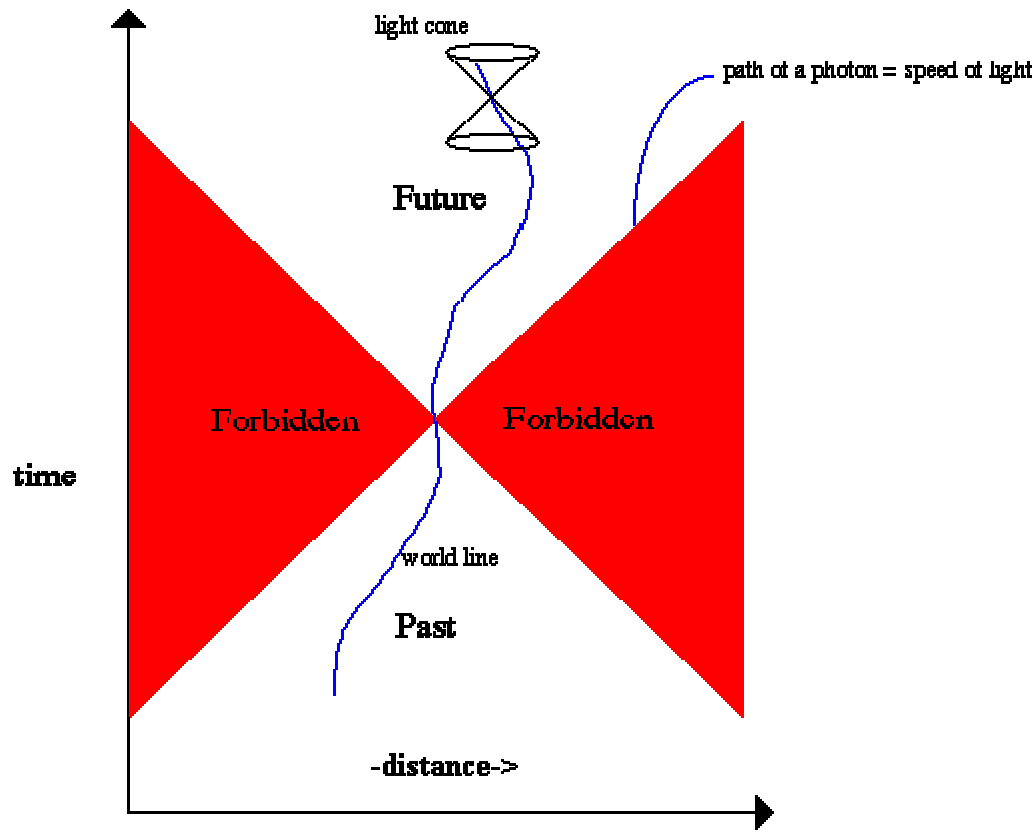


Time-lines

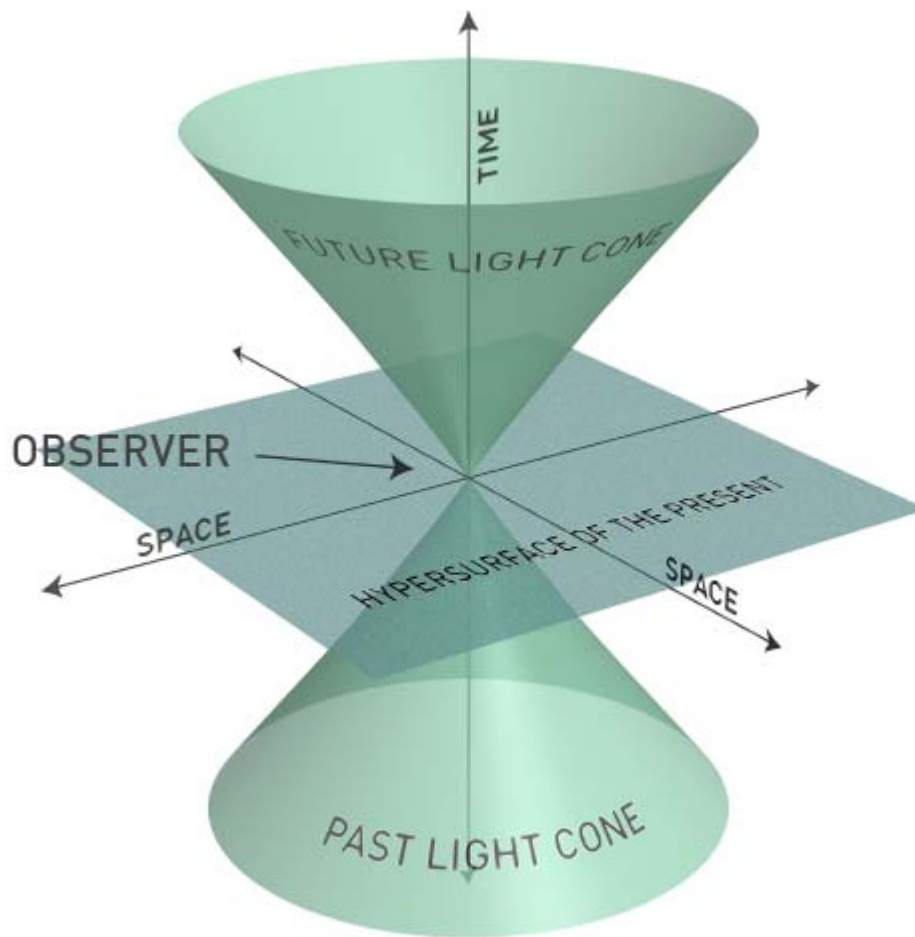


Time-Lines and World Diagrams

- 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 .



World Diagrams





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: $\mathbf{F} = \mathbf{ma}$.
 - For every force, there is an equal and opposite force.
- Improved definition: Force is the rate of change of momentum.



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.

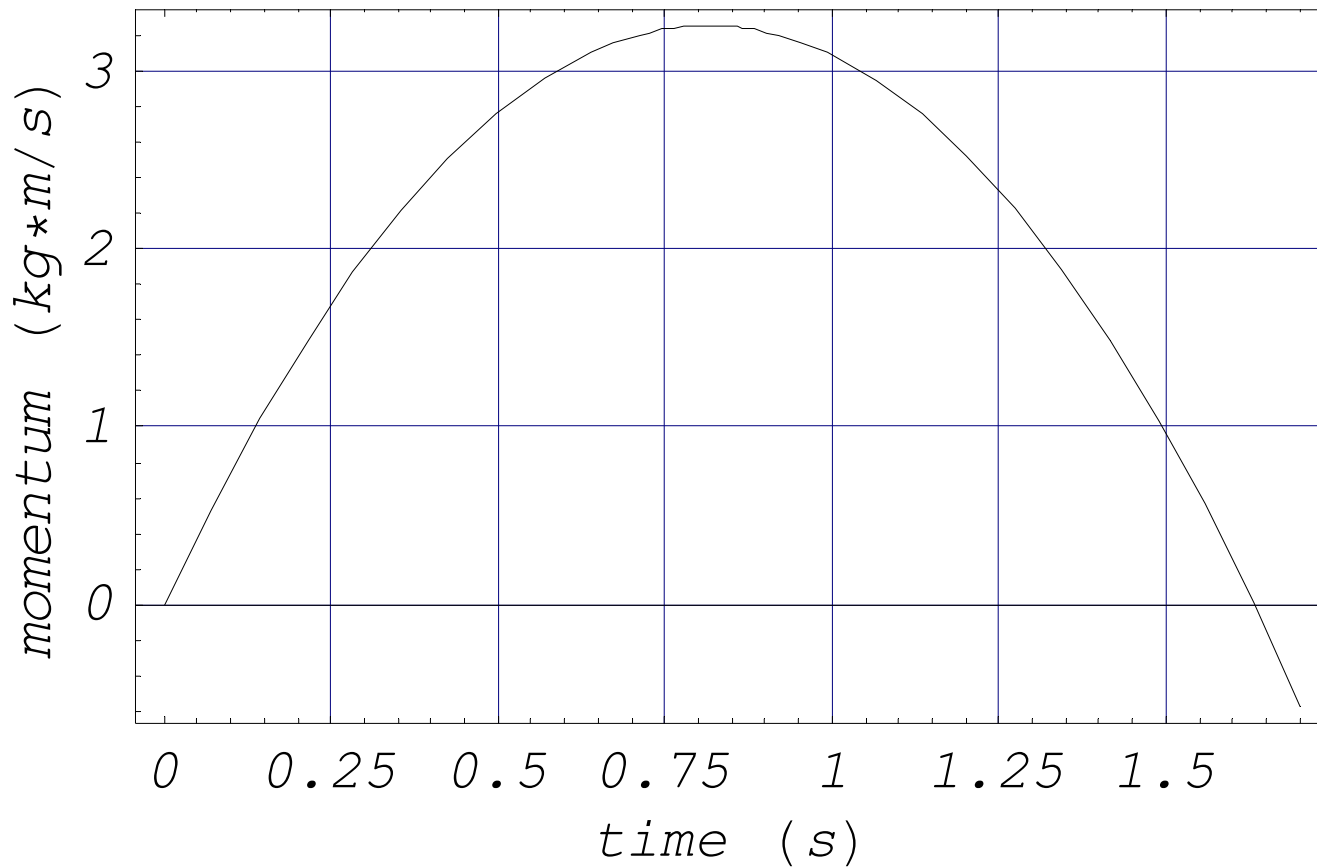
$$\vec{F} = \frac{\Delta \vec{p}}{\Delta t} = \frac{\vec{p}_f - \vec{p}_i}{t_f - t_i}$$

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

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).