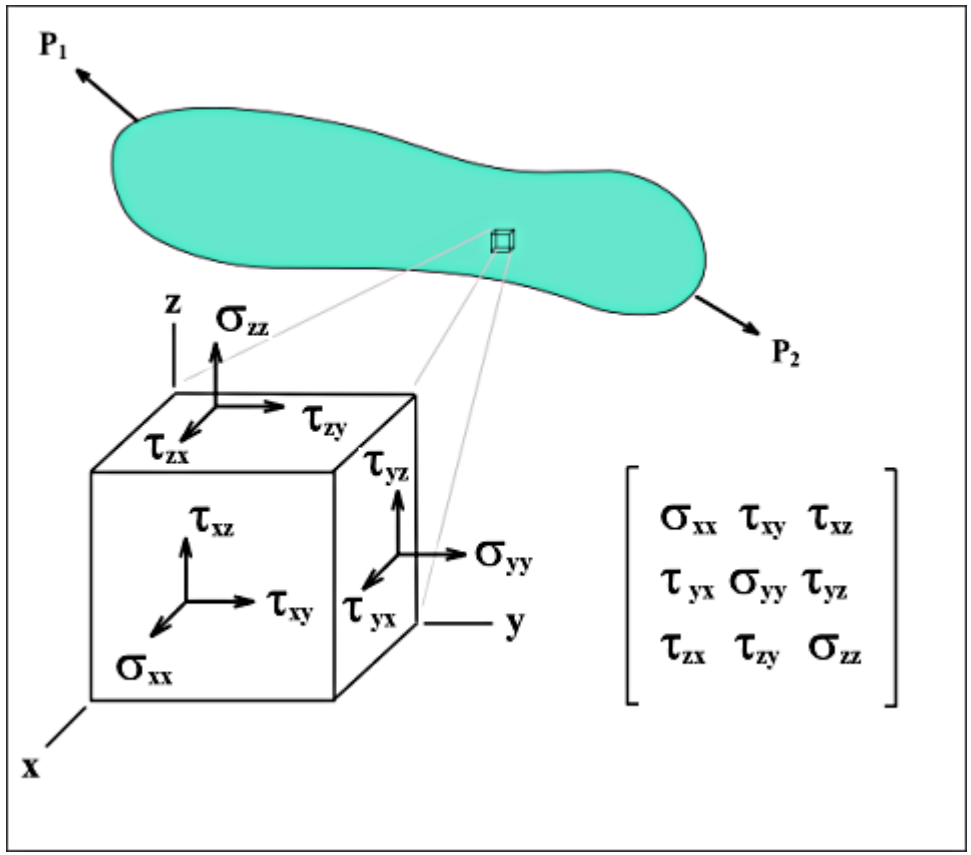
Today

- Announcements:
  - HW#2 is due Wednesday by 8:00 am
  - Extra Credit project #1 in on the LONCAPA website is also do next Wednesday at 8:00 am
- Review
- What is Force? Introduction

Scalars, Vectors, and Tensors (Stress tensor)

- Stress is defined as the force per unit area.
- In a solid object each point has three values of stress (up, left, right)
- The stress tensor describes the stress at all points in an object

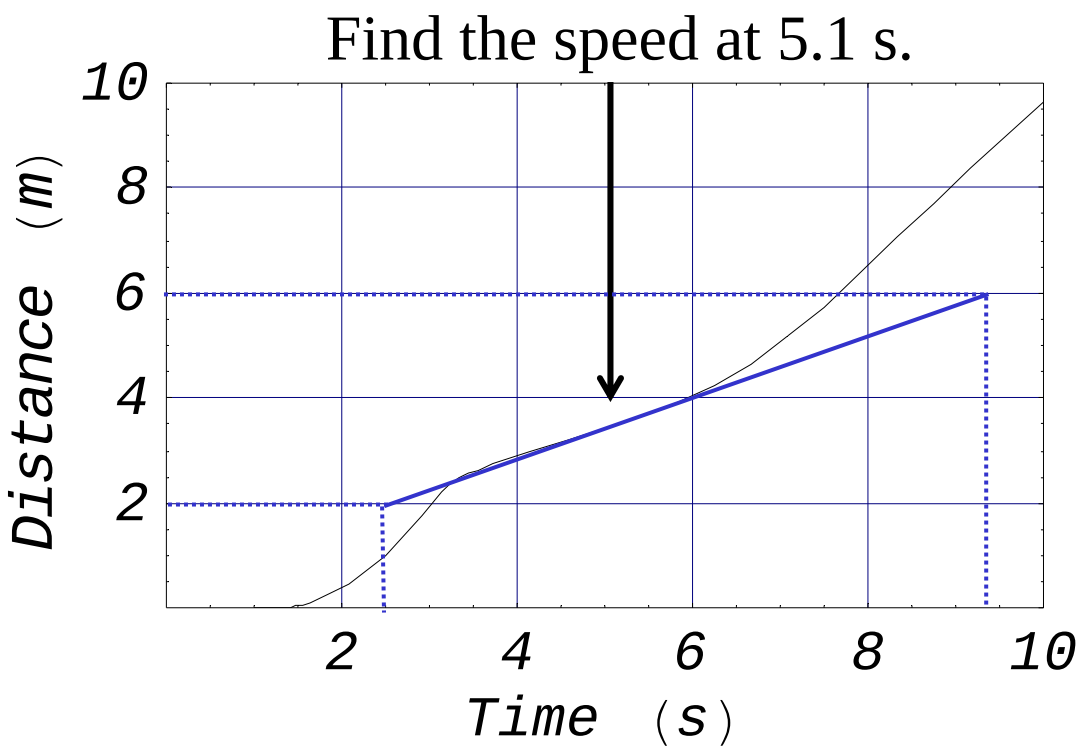


http://en.wikipedia.org/wiki/Image:Stress_tensor.png

Motion

- **Position** – location relative to the center of a coordinate system (0,0). 2 miles NE
- **Displacement** – the difference between two positions
- **Velocity** – rate of change of position. This means changing direction as well.
- **Acceleration** – rate of change of velocity. If either the magnitude of the velocity or its direction are changing, the object is accelerating.

Review

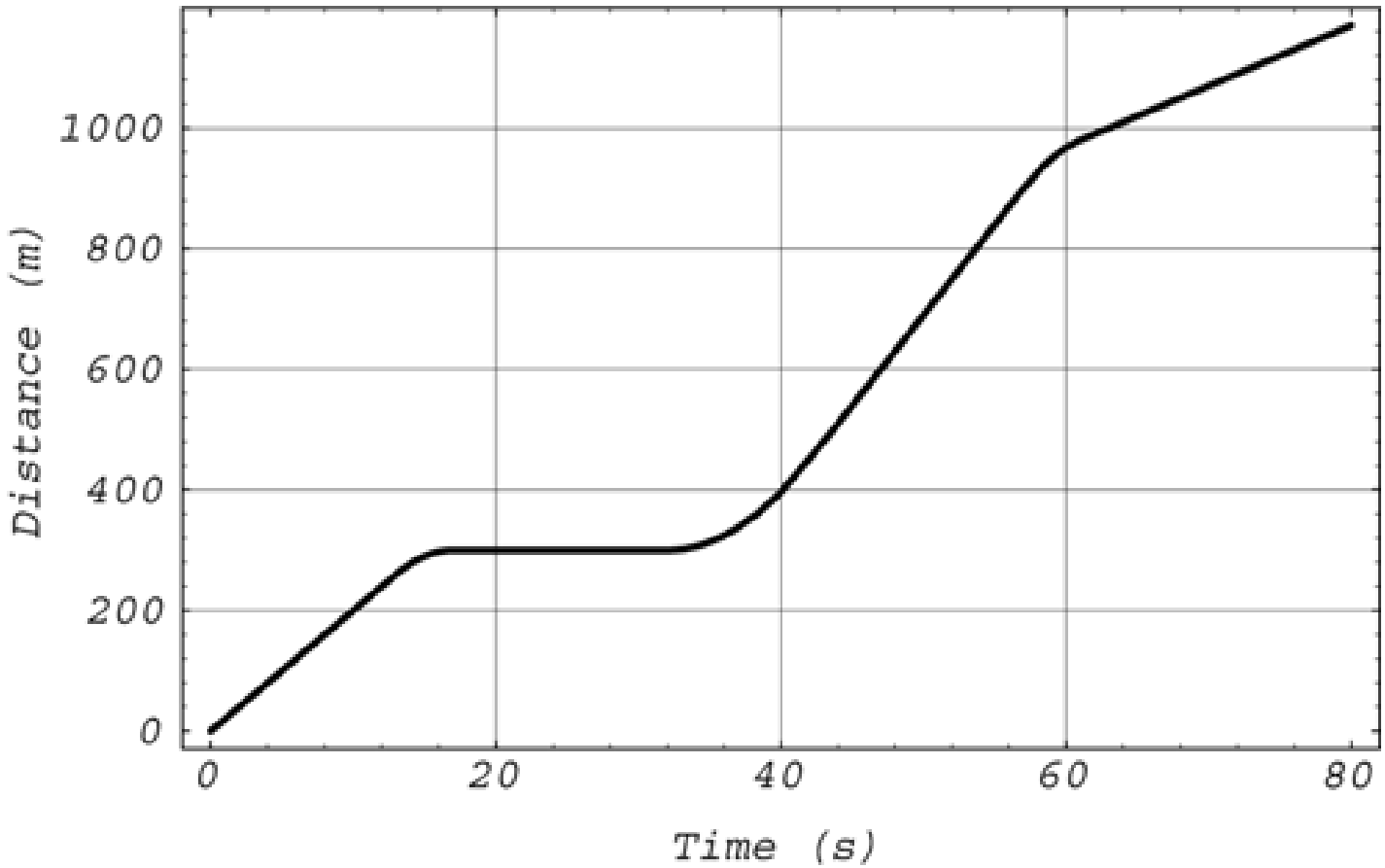


Steps in calculating rates of change:

- Draw a line tangent to the curve at the time you want. The line can be any length.
- Mark two points on the line and record the values.
- Calculate the slope

$$m = speed = \frac{d_2 - d_1}{t_2 - t_1} = \frac{6-2}{9.3-2.5} = 0.59\,m/s$$

Homework Problem Traveling Car



Speed increasing – acceleration and velocity in the same direction

Speed decreasing – opposite direction (deceleration)

History of our effort to understand motion

- Aristotle(384 BC – 322 BC)
  - Natural motions: items seek their natural locations
  - Violet motions like moving across the room require an agent
- Galileo (1564-1642)
  - Tried to deduce the laws of motion from experiments
  - Introduced the concept of inertia. (Inertia is not a well defined concept.)
  - He spent a great deal of effort trying to understand acceleration
- Isaac Newton (1643-1727)

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.

How much force?

Neglecting friction from the air, a 80.0 kg professor falls off a bench and accelerates toward the ground at 9.81 m/s^2.

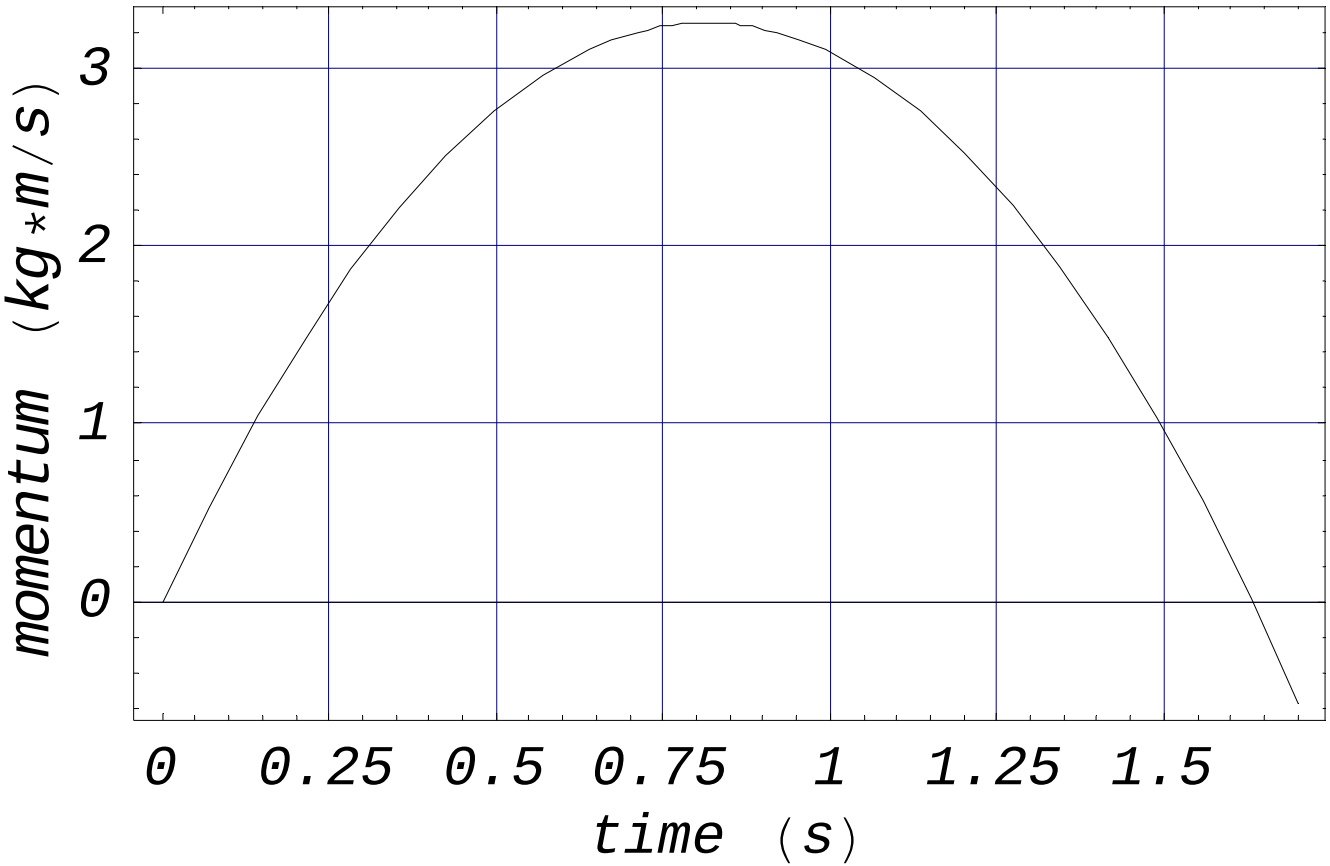
What is the magnitude of the force of gravity on the professor?

F = mass x acceleration = 80.0 kg x 9.81 m/s^2 = 785. N

What is momentum?

- Momentum is mass times velocity.
- Momentum is a vector. Often we write it as a “p” .
- $p = \text{mass} \cdot \text{velocity}$
- Momentum is the modern analog to Galileo's idea of inertia.

Momentum Problem Picture



Momentum Problems

Hint: Force is the rate of change of momentum.

$$\vec{F} = \frac{\Delta \vec{p}}{\Delta t} = \frac{\vec{p}_2 - \vec{p}_1}{t_2 - t_1}$$

$$\text{magnitude of } F \text{ for motion in one dimension} = \frac{p_2 - p_1}{t_2 - t_1}$$

Note: A negative slope means the direction of the force is toward –x. Force is a vector, and direction matters.

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 under stand field theory, we have to talk about energy and quantum mechanics (later in the term).