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

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.
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

\[ m = \text{speed} = \frac{d_2 - d_1}{t_2 - t_1} = \frac{6 - 2}{9.3 - 2.5} = 0.59 \text{ m/s} \]
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.
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?

\[ F = \text{mass} \times \text{acceleration} = 80.0 \text{ kg} \times 9.81 \text{ m/s}^2 = 785. \text{ N} \]
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

\[ \text{momentum (kg} \cdot \text{m/s)} \]

\[ \text{time (s)} \]
Momentum Problems

Hint: Force is the rate of change of momentum.

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

magnitude of \( \vec{F} \) 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 understand field theory, we have to talk about energy and quantum mechanics (later in the term).