HNRS 227 Lecture #2
Chapter 2 – Ordered Universe

Main Concepts I will focus Upon from Chapter 2
- Speed vs. Velocity
- Acceleration
- Force
- Falling Objects
- Newton’s Laws of Motion
- Momentum
- Angular Momentum
- Universal Law of Gravity

Speed and Velocity
- Speed
  - distance traveled in a unit of time
  - a scalar quantity
- Velocity
  - speed and direction
  - a vector quantity

iClicker Question
What is the difference between speed and velocity?
A Speed is a vector and velocity is a scalar quantity.
B Speed is a scalar and velocity is a vector quantity.
C There is no difference between speed and velocity.
D All of the above are true statements.

Questions for Thought
What is acceleration?
A The change in distance per change in time.
B The change in position per unit of time.
C The ratio of the change in velocity per change in time.
D The change of time per unit of length.

Questions for Thought
An insect inside a bus flies from the back toward the front at 5.0 miles/hour. The bus is moving in a straight line at 50 miles/hour. What is the speed of the insect?
A The speed of the insect is 5 miles per hour relative to the bus.
B The speed of the insect is 55 miles per hour relative to the ground.
C The speed of the insect is 50 miles per hour relative to the ground.
D Both A and B above are true.
E A, B and C above are true.
**Force**

Definition of force
- Something that causes a change in the motion of an object
  - A push or pull
  - An electric, magnetic, gravitational effect
  - A vector quantity

Net force - Resultant Force

**Inertia**

Defining Inertia
- Tendency of an object to remain in its current state of motion
  - The more massive the more inertia
  - Think of stopping a car vs. truck

**Acceleration Due to Gravity**

Direction of acceleration due to gravity
- Directed to center of Earth

Think: scalar or vector?
- A vector quantity

Why?
- Has magnitude and direction

**Generalized Motion**

Motion can be viewed as a combination of movements
- Vertical component
  - Typically gravitational acceleration
- Horizontal component
  - Some force from muscle, gunpowder, etc.

**Question for Thought**

What happens to the velocity and acceleration of an object in free fall?
A The velocity decreases as the acceleration remains the same.
B The velocity increases as the acceleration remains the same.
C The velocity increases and the acceleration decreases.
D The velocity increases and the acceleration increases.
E Both velocity and acceleration decrease.

In the equation $d = \frac{1}{2}at^2$, if $a$ is 9.8 meters per second per second and $t$ is in seconds, what is the unit of $d$?
A Seconds
B Meters
C Kilometers
D Feet per second
E Meters per second
Question for Thought

Do you recall what inertia is?

Inertia is the property of matter that an object will remain in unchanging motion or at rest in the absence of an unbalanced force.

Question for Thought

Where does the unit $s^2$ (or concept of “square second”) come from?

Acceleration is change in velocity per change in time, with units of $(m/s)/s$. When the fraction is simplified, you get meters per second squared. The “seconds squared” indicates that something that changes in time is changing in time, that is, the ratio of change in distance per unit of time is changing in time.

Question for Thought

Neglecting air resistance, what are the forces acting on a bullet after it has left the barrel of a rifle?

A The force of air acting up and gravity acting down.

B Only the force of gravity acting straight down.

C There are no forces acting at this point.

D All of the above are true.

Question for Thought

How does the force of gravity on a ball change as a ball is thrown straight up in the air?

A The force of gravity increases.

B The force of gravity decreases.

C The force of gravity remains the same.

D The force of gravity increases then decreases.

E The force of gravity decreases then increases.

Sample Question

An object falls from a bridge and hits the water 2.5 seconds later.

A) With what velocity did it strike the water?

B) What is the average velocity during the fall?

C) How high is the bridge?
Newton’s Laws of Motion

- Newton’s First Law of Motion
  - A body at rest tends to stay at rest and a body in uniform motion will stay in a straight line uniform motion unless acted upon by an outside force.

- Newton’s Second Law of Motion
  - The acceleration of a body is proportional to the force being applied.
    \[ F = m \cdot a \]

- Newton’s Third Law of Motion
  - For every force there is an equal and opposite force (action and reaction).

Question for Thought

- How can there ever be an unbalanced force on an object if every action has an equal and opposite reaction?

  The action and reaction forces are between two objects that are interacting. An unbalanced force occurs on a single object as the result of one or more interactions with other objects.

Sample Question

- What force would an asphalt road have to be to give a 6,000 kilogram truck in order to accelerate it at 2.2 meters per second per second?

Sample Question Answer

\[ F = ma \]
\[ F = 6,000 \text{ kg} \times 2.2 \text{ m/s}^2 = 1.3 \times 10^5 \text{ N} \]

Momentum

- By definition momentum is the product of mass and velocity.

- Conservation of momentum
  - Total momentum of a closed system remains constant.
**Question for Thought**

Is it possible for a small car to have the same momentum as a large truck?

- **A** Yes
- **B** No

Yes, the small car would have to be moving with a much higher velocity, but it can have the same momentum since momentum is mass times velocity.

**Angular Momentum**

- **Torque**
  - Twisting force
- **Conservation of Angular Momentum**
  - “An object that is rotating will keep rotating unless a twisting force called a torque acts to make it stop”
  - Applications include
    - Ice skater
    - Inertial guidance systems

**Universal Law of Gravity**

- Newton’s Universal Law of Gravitational Attraction
  - Every object is attracted to every other object
  - The force is proportional to masses and inversely proportional to the distance squared:
    \[ F = \frac{G \times m \times M}{r^2} \]

**A Problem of Very Little Attraction**

What is the gravitational force between two 100 kilogram people separated by 1 meter?

**Really just a little**

Use the formula for the force of gravity:

\[ F = \frac{G \times m \times M}{r^2} \]

where \( G = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2 \)

and \( m = 100 \text{ kg} \)

and \( M = 100 \text{ kg} \)

and \( r = 1 \)

Then

\[ F = 6.67 \times 10^{-11} \text{ Nm}^2/\text{kg}^2 \times 100 \text{ kg} \times 100 \text{ kg} / (1 \text{ meter})^2 \]

\[ F = 6.67 \times 10^{-7} \text{ N} \]