PHYS 1403 Stars and Galaxies

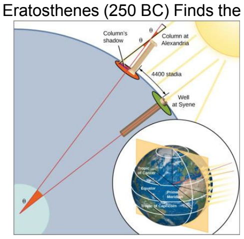
Questions for Today' Class

1. Who are the important early Greek astronomers and what was their work?
2. Who are the Renaissance Astronomers and what was their work?
3. How do we describe Motion of Objects in Space?
4. What is Galileo's law of falling body?
5. What are Newton's Laws of Motion?
6. What are Kepler's laws of planetary motion?

Who are the early Greek astronomers and what was their work?

- Aristotle (350 BC): Uses lunar eclipses to show that the Earth is a sphere

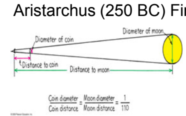
- Eratosthenes (250 BC) Finds the diameter of Earth



Earth's Average Diameter 7917.5 mi or 6370 km Average because Earth is not a perfect soccer ball shape

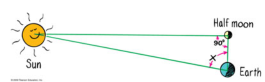
Who are the early Greek astronomers and what was their work?

- Aristarchus (250 BC) Uses lunar eclipse to find the relative diameter of the moon.
  Moon diameter is (6370×2)/3.5=3640km
- Aristarchus (250 BC) Finds the relative distance of the Moon.



Moons distance = 110(3640)=400,400km

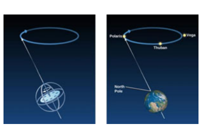
- Aristarchus (250 BC) Finds the relative distance of the Sun using quarter phase of the moon.
  Sun is 93 million miles from earth (150 million km)



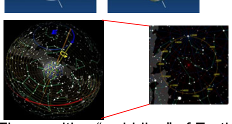
Source: Paul Hewitt – Conceptual Physics

Who are the early Greek astronomers and what was their work?

- Aristarchus (250 BC) finds relative diameter of sun.
  150,000,000 km(1/110)= 1363636.3636 = 2(681,818km) = 1.4×10^6 km
- Hipparchus (134 BC) Discovers Precession



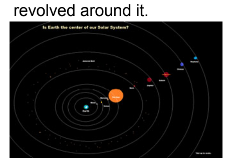
Source: Paul Hewitt – Conceptual Physics



The resulting "wobbling" of Earth's axis of rotation around the vertical with respect to the Ecliptic (takes about 26,000 years)

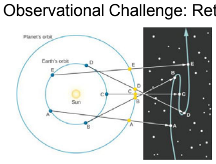
Who are the early Greek astronomers and what was their work?

- Geocentric Model: The early Greek philosophers believed that the Earth was in the center of the solar system and all the planets and sun revolved around it.



http://ecsst.blogspot.com/

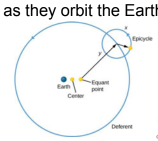
- Observational Challenge: Retrograde Motion of Mars



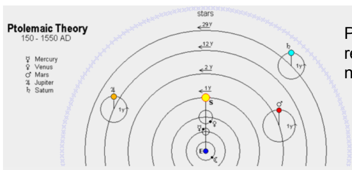
Observations show that motion of Mars did not follow the Geocentric model.

Who are the early Greek astronomers and what was their work?

- Ptolemy's Modification (100 AD): Epicycles – Planets rotate in small circles as they orbit the Earth



- Ptolemy's Model



Ptolemy's model explains retrograde motion but it is not completely correct

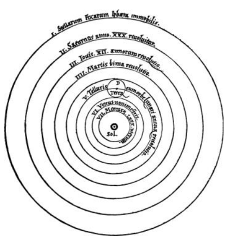
http://www.qmview.net/harmonies.htm

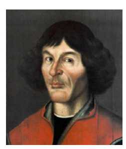
The Renaissance Astronomers

- Nicolaus Copernicus (1473 -1543)
- Galileo Galilei (1564 -1642)
- Isaac Newton (1643–1727)
- Tyco Brahe (1546–1601) and
- Johannes Kepler (1571–1630).

The Renaissance Astronomers

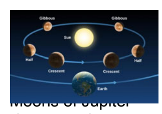
- Nicolaus Copernicus (1473 -1543) Proposes that the Earth revolves around the Sun.
  - But does not provide any proof
- Copernican Model





The Renaissance Astronomers

- Galileo Galilei (1564 -1642): Provides the proof's
- Phases of Venus
  Only possible if the Venus orbits the Sun



- Moons of Jupiter
  If Moons of Jupiter can orbit Jupiter, why can't planets Orbit the Sun

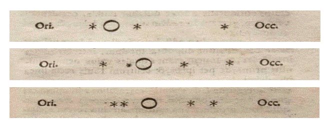


Image Credit: Octavo Corp./Warnock Library

How do we describe motion of objects in space?

1. Speed
2. Velocity
3. Acceleration
4. Momentum
5. Force

Motion

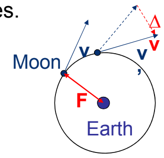
- Motion is one of the most necessary functions of all living things. $S = d/t$
- **Speed:** The most simple definition is called speed. S=distance/time
  Example A friend takes 2.0 hours to drive from his house in Stephenville to DFW airport at an average speed of 65 mi/h. How far is the airport from the friends house.
  Answer: 130 mi
- **Velocity (v):** For speed we did not put any importance to the direction of motion. The friend would travel the same distance from DFW to Stephenville. When we associate direction with a number then the speed changes its name from speed to velocity.
  - SI units of velocity are meters/second (m/s)

How is velocity different from speed?

- Example : A runner makes one lap around a 200 m track in a time of 25 seconds. What is the runner's average speed and average velocity.

  Speed = 200/25 = 8 m/s

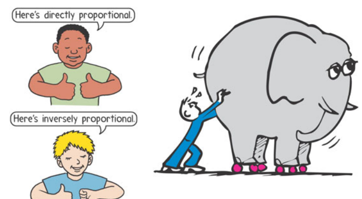
  Velocity = 0/25 = 0 m/s
- Velocity is with respect to reference point whereas speed is not.
- The moon orbits the Earth with constant speed but its velocity is different as time passes.



What happens when velocity changes with times?

- Acceleration (a): We define a quantity called acceleration (a).
- acceleration (m /s ^{2}) = change in velocity (m/s) / time interval (s)

  $a = \Delta v / \Delta t$
- i.e. how fast is velocity changing. A very common experience is when you step on a car's accelerator.



Mass is a intrinsic property of matter and provides resistance to motion

Inertia is a measure of resistance to motion

Acceleration depends on Mass

Why does Mass Matter?

- If two different vehicles move with the constant velocity and hit a wall, which vehicle will cause the most damage?
- We use the term Momentum to describe such interactions.

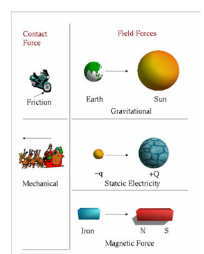
  Momentum = Mass x Velocity = mv

  SI units of momentum is kg.m/s

  Example: An 18-wheeler will have a different impact on a wall compared to a car.
- Momentum is very important in describing motion of objects and its interaction with matter.

Force

- Force: It is a push or a pull.
- Force has both magnitude and direction.
- SI units of force are Newtons (N)
- Types of Forces

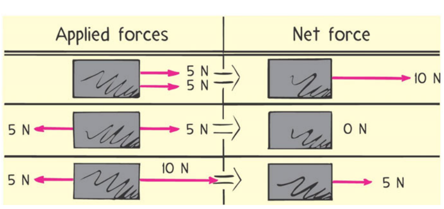


Contact Forces: Force is due to physical contact between the bodies.
Example mechanical forces.

Field Force: No physical contact is necessary to experience the force.
Examples are Gravitational, Electrical, Magnetic, and Nuclear Forces.

Adding Forces -> Net Force

- What is a Net force?

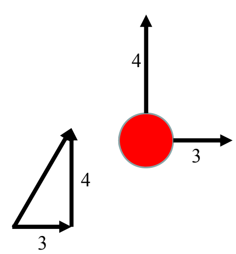


Force at other angles can also be added but calculations gets complex for this class

Adding Forces

Two forces are shown on a spacecraft. What is the net force acting on the ball? (NASA engineers use this concept as gravity assist to veer spacecraft towards other planets without using fuel)

a) 3
b) 4
c) 5
d) 0
e) -5



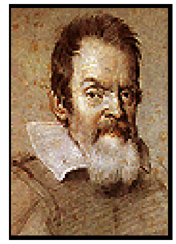
What is Galileo's Law of Falling Body?

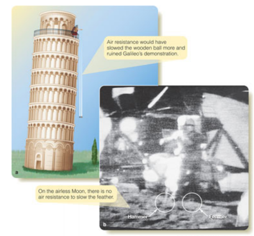
Topics

1. Galileo's Observation of Motion
2. Law of Falling Body
3. Acceleration Due to Gravity

Galileo's Observations of Motion

- The acceleration of a freely falling body due to force of gravity is independent of the mass (weight), or shape of the falling object



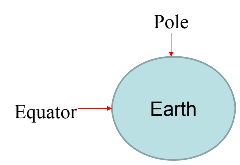


Galileo and the Law of Falling Body

- Galileo found that the speed of the falling object increases (acceleration) by 9.8 m/s after every second
- Galileo called this acceleration due to gravity of Earth
  $g = 9.8$ m/s^2
- The distance the object drops in meters from its starting point is $d = 4.9t^2$
  Example:
  A ball is dropped from the top of a building, How far has it dropped in meters after 2 seconds
  $D = 4.9t^2$
  $D = 4.9 \times 2 \times 2 = 19.6$ meters

Acceleration due to Gravity (*g*)

- The value of g is different for different planets, and on the same planet its value varies from one place to another. In case of planet Earth, for the purpose of computations we approximate the value of *g* to 9.8 m /s^2.
- Moon's acceleration due to gravity is 1/6 that of Earth.



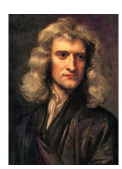
What are Newton's Law's of Motion?

Topics

1. Law of Inertia
2. Law of Force
3. Law of Action and Reaction
4. Difference between mass and weight
5. Work, Energy and Power

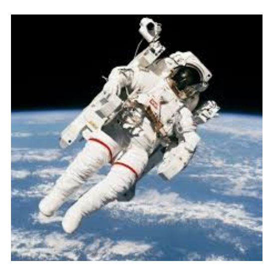
Newton's Laws of Motion

Law of Inertia: A body continues at rest or in uniform motion in a straight line unless acted upon by some net force.



Isaac Newton (1643–1727), 1689 Portrait by Sir Godfrey Kneller.

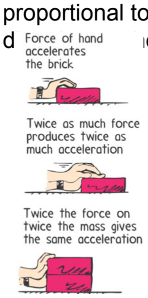
An astronaut floating in space will continue to float forever in a straight line unless some **external force** is accelerating him/her.



Astronaut Bruce McCandless II ...nasa.gov

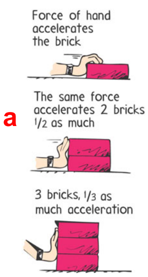
Newton's Laws of Motion

The Law of Force: The *acceleration* **a** of a body is inversely proportional to its *mass* m, directly proportional to the *net force* **F**, and in the same d



e net force.

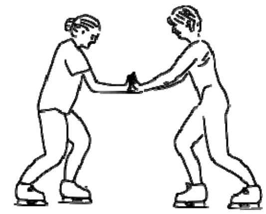
$\mathbf{a} = \mathbf{F}/m \Leftrightarrow \mathbf{F} = m\,\mathbf{a}$



Newton's Laws of Motion

The Law of Action and Reaction: To every action, there is an equal and opposite reaction.

The same force that is accelerating the boy forward, is accelerating the skateboard backward.



http://en.wikipedia.org/wiki/Image:Skaters_showing_newtons_third_law.png CC BY-SA 3.0

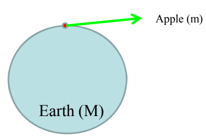
https://www.youtube.com/watch?v=PrJnWTcW55s

Difference between mass and weight

Weight is a Force = mass x acceleration due to gravity

Weight in Newtons = mass in kg x 9.8 m/s^2 for Earth

Mass is a property of matter, it is not equal to weight



Weight of apple = mg = m x 9.8 m/s^2 = F_g

Work and Energy and Power

- **Work:** Work = Force x distance
  SI units: Newton's x meter = Joules
  - Example: A 1 kg object at a height of 1 m from ground experience a force of 9.8 N, when it falls to the ground it does work that is W = 9.8 N x 1 m = 9.8 N.m = 9.8 J
- **Energy:** Ability of a body to do work
  Kinetic Energy Work due to motion is called Kinetic Energy (KE)
  KE = ½ x mass x velocity^2 measured in Joules
  - Example: If a 1 kg object fall from a height of 1 m with a velocity of 4.43 m/s
    KE = ½ x 1kg x (1 m/s)^2 = 9.8 J
- Gravitation Potential Energy Work due to Gravity is called Gravitational Potential Energy (GPE) measured in Joules
  GPE = mass x g x h (h = height with respect to a reference point)
  - If a 1 kg object falls from a height of 1 m, its GPE is
    GPE = 1kg x 9.8m/s^2 x 1m = 9.8 J

Fundamental Law of Nature

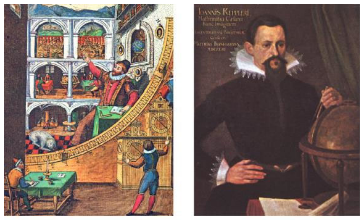
- **Conservation of Energy:** In all the three examples above we find that Work = KE = GPE
  Energy can neither be created or destroyed: It only transforms from one form to the other.
  Example: Dropping a ball converts GPE to KE and at impact KE to heat, sound and work
- **Power:** Rate at which energy is expended
  Power (P) = Work / time = Joules /seconds = watts (w)

What are Kepler's Laws of Planetary Motion?

Topics

1. Tycho's Work
2. Conic Sections
3. Law of Ellipses and Geometry of the Ellipse
4. Eccentricity
5. Law of Equal Areas
6. Law of Periods

Tycho Brahe



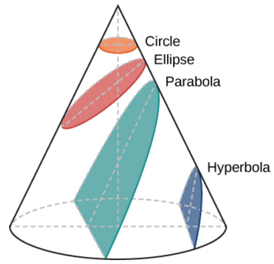
(a) (b)

Tycho Brahe (1546–1601) and Johannes Kepler (1571–1630).

(a)A stylized engraving shows Tycho Brahe using his instruments to measure the altitude of celestial objects above the horizon. The large curved instrument in the foreground allowed him to measure precise angles in the sky. Note that the scene includes hints of the grandeur of Brahe's observatory at Hven.

(b)Kepler was a German mathematician and astronomer. His discovery of the basic laws that describe planetary motion placed the heliocentric cosmology of Copernicus on a firm mathematical basis.

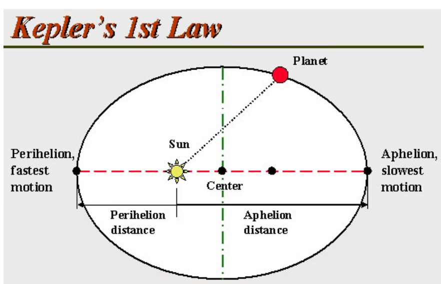
Where do Circles, Ellipse, Parabola and Hyperbola com from?



Conic Sections. The circle, ellipse, parabola, and hyperbola are all formed by the intersection of a plane with a cone. This is why such curves are called conic sections.

Kepler's Laws of Planetary Motion

The orbits of the planets are **ellipses** with the sun at one focus.



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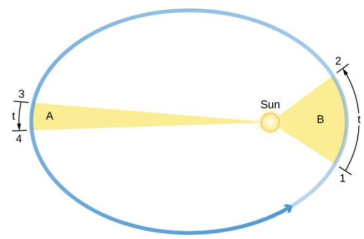
Kepler's 2nd Law



Kepler's Second Law: The Law of Equal Areas. The orbital speed of a planet traveling around the Sun (the circular object inside the ellipse) varies in such a way that in equal intervals of time (t), a line between the Sun and a planet sweeps out equal areas (A and B). Note that the eccentricities of the planets' orbits in our solar system are substantially less than shown here.

Kepler's 3rd Law

A planet's orbital period (P) squared is proportional to its average distance from the sun (a) cubed:

(P_y = period in years; a_{AU} = distance in AU)

$$P_y^2 = a_{AU}^3$$

If you know the period you can find the distance

Wednesday class this week

- Complete Class Assignment 3

Acknowledgment

- The slides in this lecture is for Tarleton: PHYS1411/PHYS1403 class use only
- Images and text material have been borrowed from various sources with appropriate citations in the slides, including PowerPoint slides from adopted text book.