Astronomy

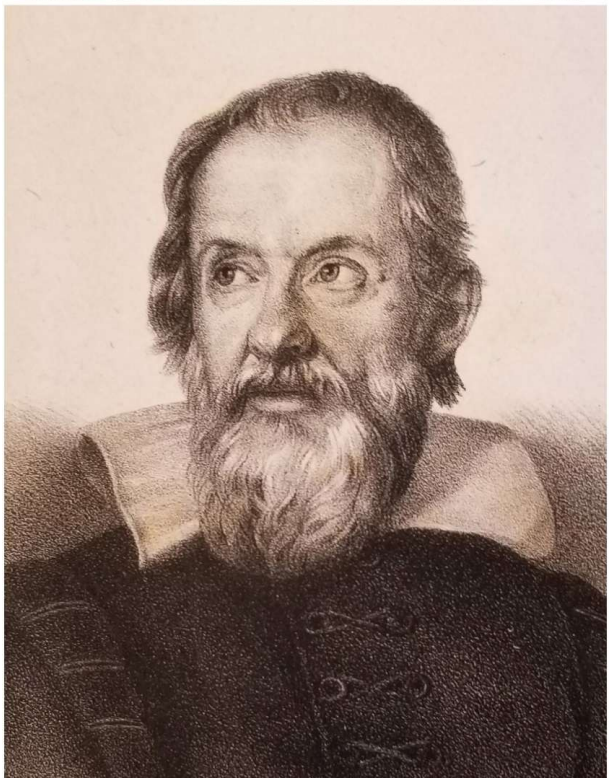
Fall 2025

Weeks 11 - 12

Monday / Tuesday (Oct 20 - 21)

- T: **(7) Science concepts. The student knows our relative place in the solar system. The student is expected to:**
- **7B** model the scale, size, and distances of the Sun, Earth, and Moon system and identify the limitations of physical models; and
- **(11) Science concepts. The student uses models to explain the formation, development, organization, and significance of solar system bodies. The student is expected to:**
- **11A** relate Newton's law of universal gravitation and Kepler's laws of planetary motion to the formation and motion of the planets and their satellites;
- O: I will be able to explain gravity as it pertains to all matter
- D: by discussing the notes, completing a PhET simulation and an Actively Learn article.
- A: gravity, universal gravitational constant
- Y: Which factor has more affect on gravity, mass or distance?

The Problem of Astronomical Motion

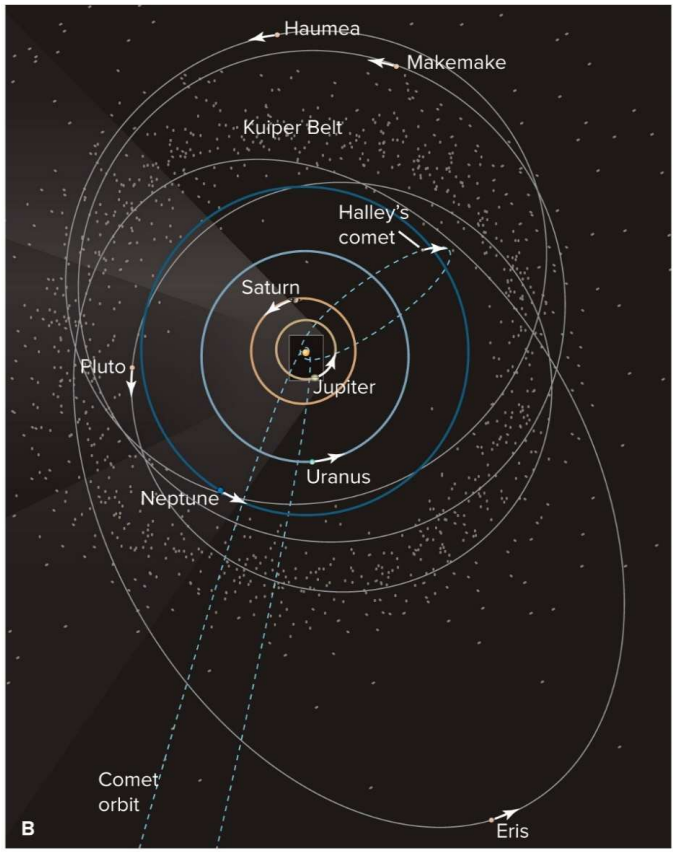


- Astronomers of antiquity did not connect gravity and astronomical motion.
- Galileo investigated this connection with experiments using projectiles and balls rolling down planks.
- He put science on a course to determine laws of motion and to develop the scientific method.

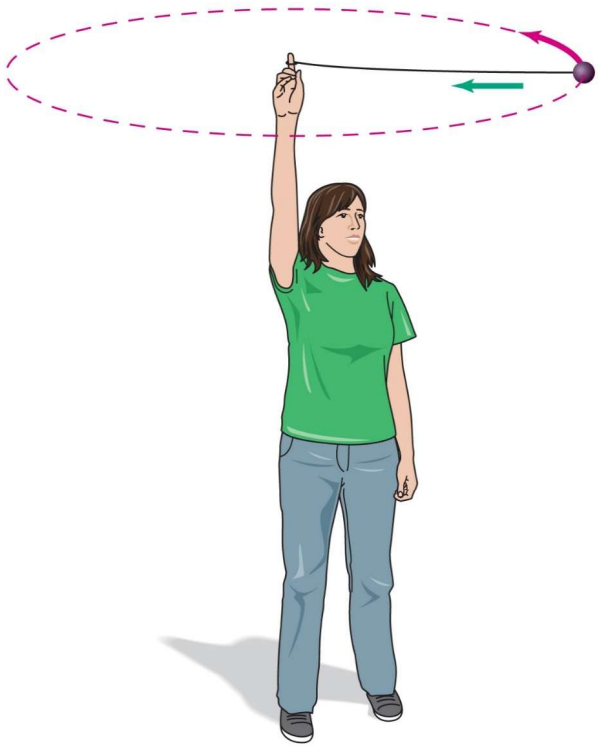
- Le opere di Galileo Galilei: Opere astronomiche. 1842 to 1853

Astronomical Motion

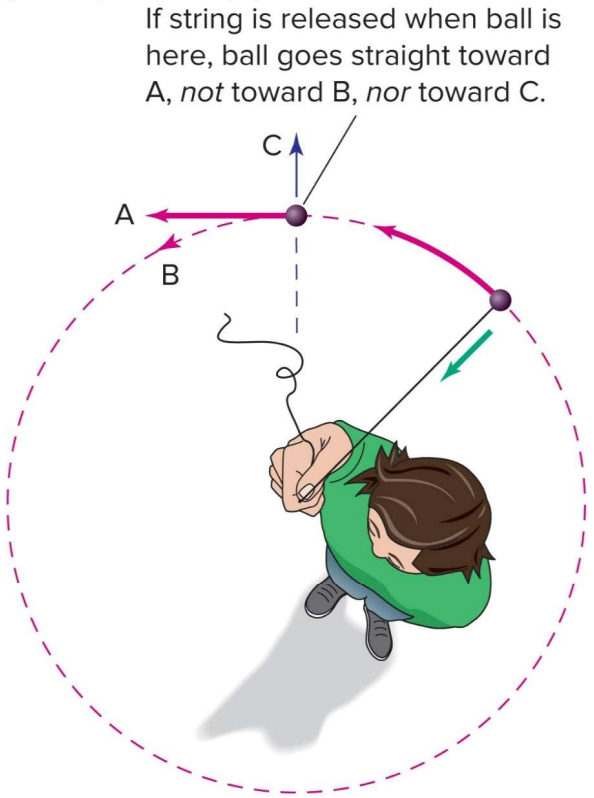
- As seen earlier, planets move along curved (elliptical) paths, or orbits.
- Speed and direction is changing.
- Must there be a force at work?
- Yes!



Gravity is that Force!



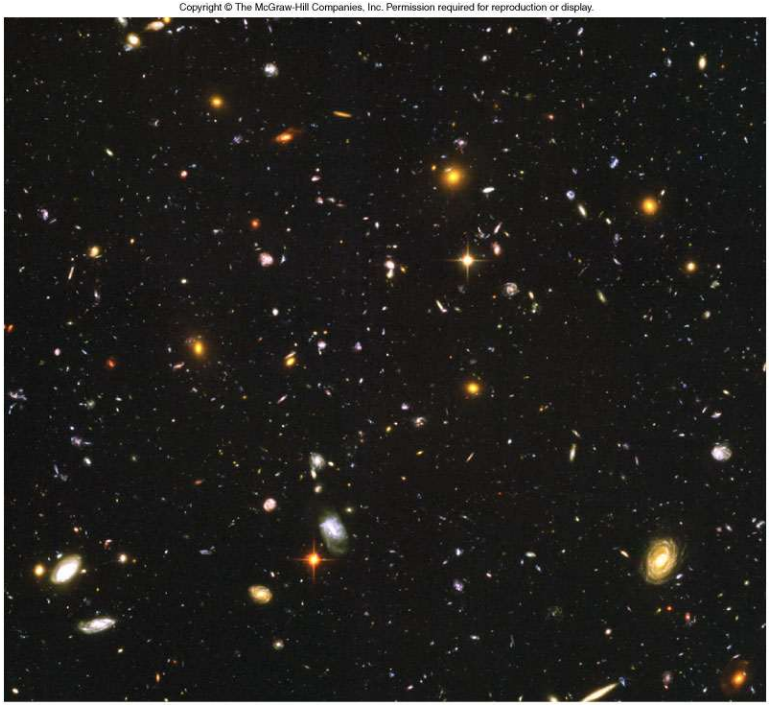
Side view



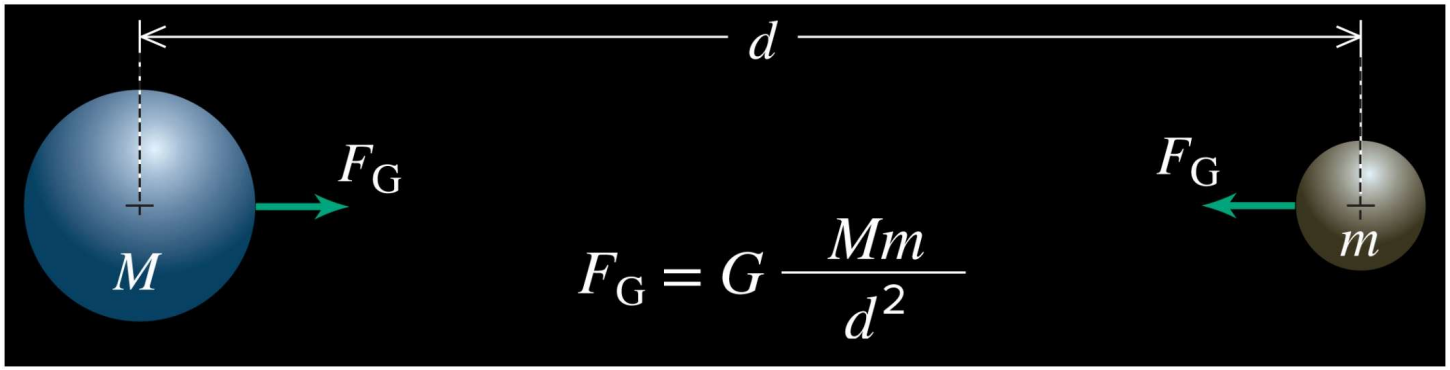
Top view

Gravity

- Gravity gives the Universe its structure.
- all objects to pull on all other objects everywhere.
- It holds objects together.



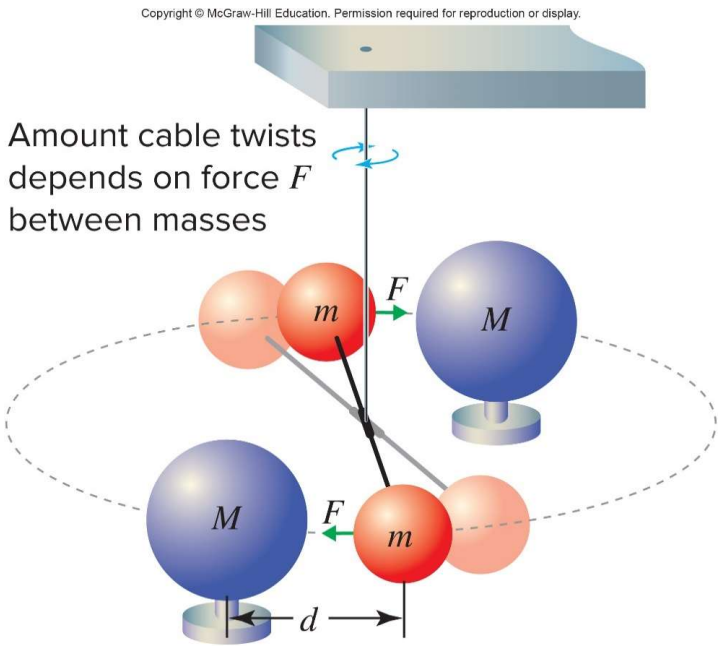
Newton's Law of Universal Gravity



- Everything attracts everything else!

G – The Gravitational Constant

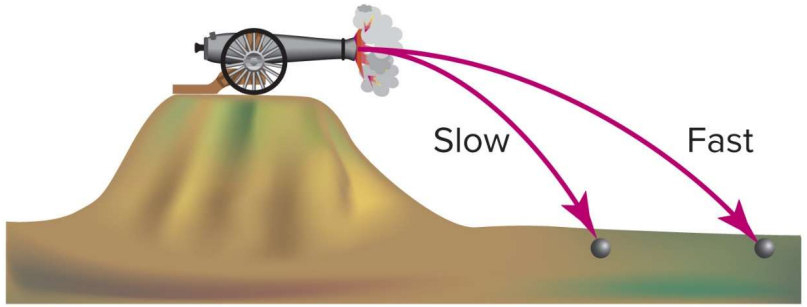
- Henry Cavendish measured G in 1798.
- $G = 6.67 \times 10^{-11}$ N·m/kg^2.
- Determining the value of G is not easy because the gravitational force is very weak!



Orbital Motion and Gravity

- Although not the first to propose gravity as being responsible for celestial motion, Newton was the first to:
- Spell out the properties of gravity.
- Write the equations of gravity-induced motion.
- Newton deduced that:
- The Moon's motion could be explained by the existence of a force (to deviate the Moon from a straight inertial trajectory) and that such a force decreased with distance.
- Orbital motion could be understood as a projectile moving "parallel" to Earth's surface at such a speed that its gravitational deflection toward the surface is offset by the surface's curvature away from the projectile.

Thought Experiment: A Cannon on a Mountain



A

- A cannonball fired at slow speed experiences one force – gravity, pulling it downward.
- A cannonball fired at a higher speed feels the same force, but goes farther.

Wednesday / Thursday (Oct 22 – 23)

- Surface Gravity

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11A relate Newton's law of universal gravitation and Kepler's laws of planetary motion to the formation and motion of the planets and their satellites;

- O:
- D:
- A: gravity, acceleration, mass
- Y: How does mass affect the gravitational force of an object?

Surface Gravity

- *Surface gravity* is the acceleration a mass undergoes at the surface of a celestial object (e.g., an asteroid, planet, or star).
- Surface gravity:
- Determines the weight of a mass at a celestial object's surface.
- Influences the shape of celestial objects.
- Influences whether or not a celestial object has an atmosphere.

Surface Gravity Calculations

- Surface gravity is determined from Newton's Second Law and the Law of Gravity:

$$ma = \frac{GMm}{R^2}$$

where M and R are the mass and radius of the celestial object, and m is the mass of the object whose acceleration *a* we wish to know

- The surface gravity, denoted by *g*, is then:

$$g = \frac{GM}{R^2}$$

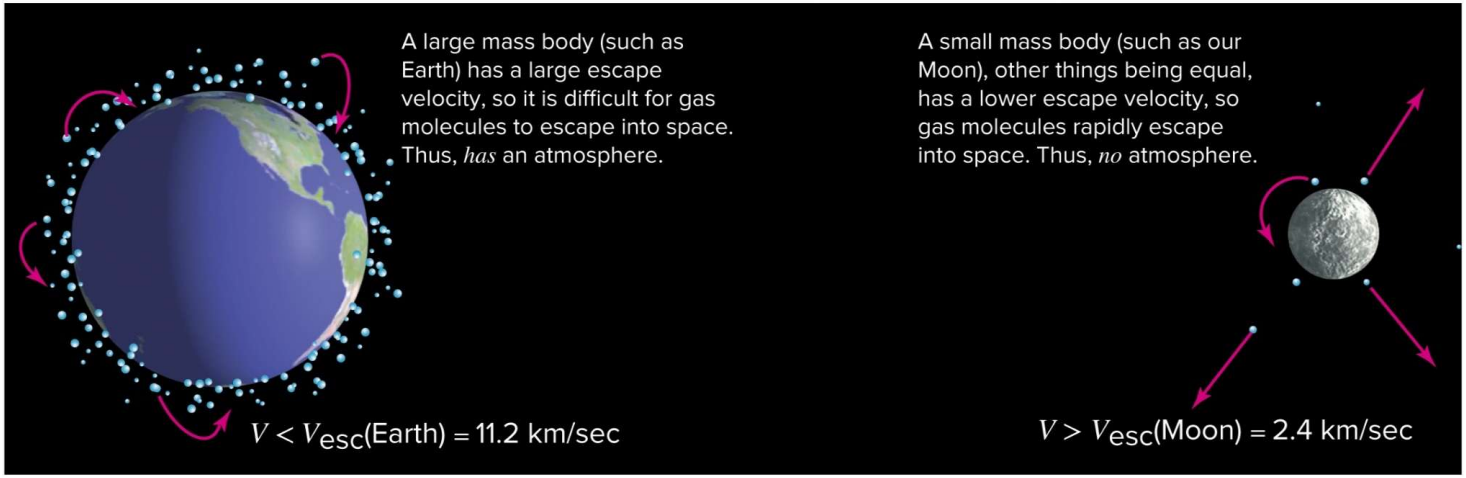
Notice dependence of g on M and R, but not m

- $g_{Earth} = 9.8 m/s^2$
- $\frac{g_{Earth}}{g_{Moon}} = 5.6$ and $\frac{g_{Jupiter}}{g_{Earth}} = 3$

Escape Velocity

- To overcome a celestial object's gravitational force and escape into space, a mass must obtain a critical speed called the *escape velocity.*
- Escape velocity:
- Determines if a spacecraft can move from one planet to another.
- Influences whether or not a celestial object has an atmosphere.
- Relates to the nature of black holes.

Uses of Escape Velocity Concept



Escape Velocity Calculation

- The escape velocity, v_{esc}, is determined from Newton's laws of motion and the Law of Gravity and is given by:

$$v_{esc} = \sqrt{\frac{2GM}{R}}$$

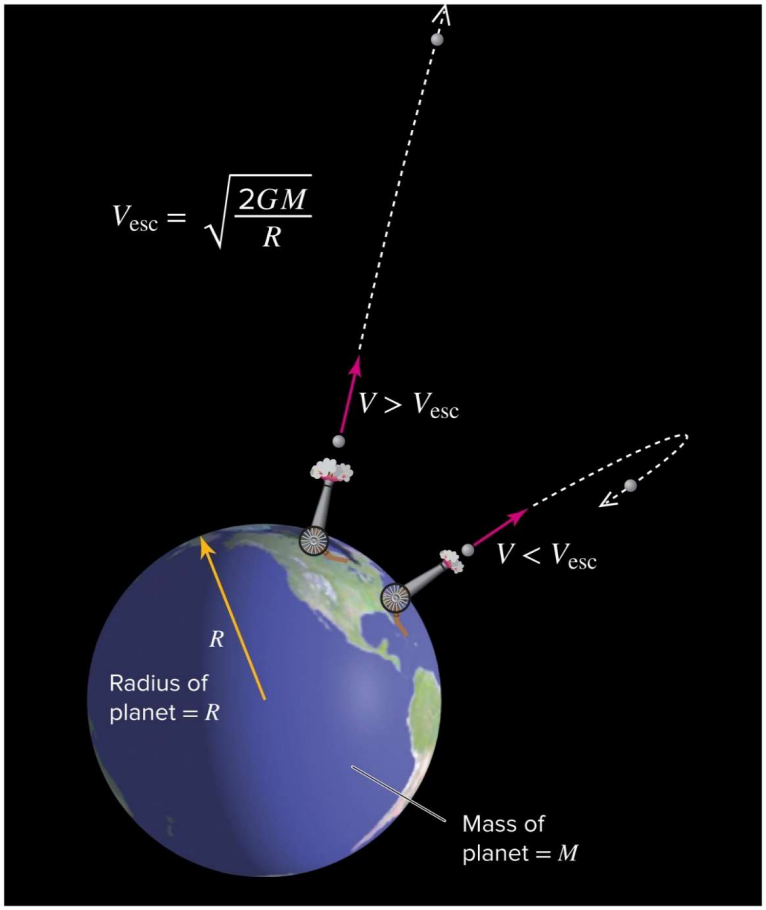
where M and R are the mass and radius of the celestial object from which the mass wishes to escape.

- Notice dependence of V_{esc} on M and R, but not m.

- $V_{esc,\,Earth} = 11 km/s.$

- $V_{esc,\,Moon} = 2.4 km/s.$

The Escape Velocity Formula



Monday / Tuesday (Oct 27 – 28)

- Unit 3 Test Review (SmartBook)

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11A relate Newton's law of universal gravitation and Kepler's laws of planetary motion to the formation and motion of the planets and their satellites;

- O: I will ensure my understanding of gravity, orbit, and escape velocity
- D: by completing my smartbook chapter 3 assignment
- A: gravity, acceleration, mass
- Y: How does mass affect the gravitational force of an object?

Wednesday / Thursday (Oct 29 – 30)

Unit 3 Test

- T: **(7) Science concepts. The student knows our relative place in the solar system. The student is expected to:**

7B model the scale, size, and distances of the Sun, Earth, and Moon system and identify the limitations of physical models; and

(11) Science concepts. The student uses models to explain the formation, development, organization, and significance of solar system bodies. The student is expected to:

11A relate Newton's law of universal gravitation and Kepler's laws of planetary motion to the formation and motion of the planets and their satellites;

- O: I will demonstrate my understanding of gravity, orbit, and escape velocity
- D: by taking the Unit 3 Test.
- A: gravity, acceleration, mass
- Y: How does mass affect the gravitational force of an object?

Friday (10/31)

- C-day – Last day of the 2nd Six-weeks.