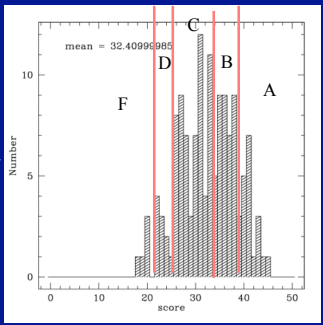
Test results

Last day to drop without a grade is Oct. 3

Grades posted in cabinet and online

If you are not properly registered then come see me for your grade



Clicker Question:

A bullet is fired from a gun. Complete the following sentance to form a true statement. The speed of the bullet will be about the same as the speed of the recoiling gun

A: because velocity is conserved.

B: because momentum is conserved.

C: because both velocity and momentum are conserved.

D: if the mass of the bullet equals the mass of the gun.

Clicker Question:

Which of the following is a scalar quantity (independent of direction):?

A: velocity

B: momentum

C: force

D: kinetic energy

Newton's Law of Gravity

For two objects of mass m_1 and m_2, separated by a distance R, the force of their gravitational attraction is given by:

$$F = \frac{G\, m_1\, m_2}{R^2}$$

F is the gravitational force.

G is the "gravitational constant".

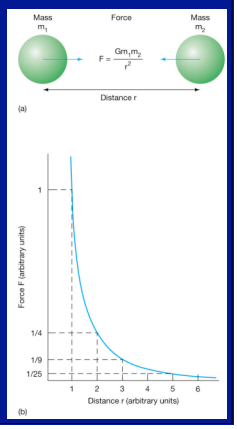
An example of an "inverse-square law".

Gravitational force is not constant, but differences "close" to Earth are negligible

Someone who weighs 300 N at sea level weighs 299 N atop Mt. Everest

Gravitational Force

- The gravitational force is always attractive
- The strength of the attraction decreases rapidly (as the square of) increasing distance

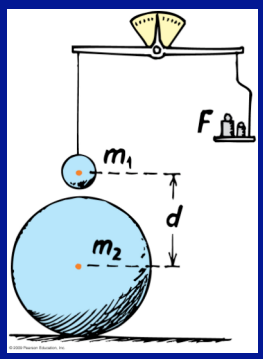


Inverse Square law Demo

Angular size of an object ~ 1/distance
Angular area of an object ~ 1/distance^2

1) Take two dollar bills out
2) Fold one along its middle, then again lengthwise so that it has 1/4 of the original area
3) Hold them in front of your eyes so that they occupy equal angular area.
4) Get your neighbor to tell you the ratio of the distances
5) If we could fold a dollar bill into 1/64 of its original area, what would be the ratio of the distances?

Measuring Newton's Constant



Tides

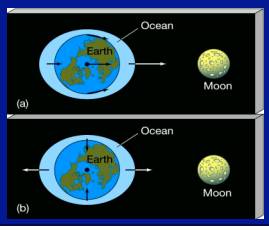
- What causes the tides?
- Under what conditions should we expect the highest and lowest tides to occur?

Tides

Two high and two low tides per day.

Tides are due mainly to Moon's gravitational pull being stronger on side of Earth closest to it.

Gravitational influence of Sun is 180 times greater than that of the moon, but its tidal influence is only about one-half that of the moon. Why?



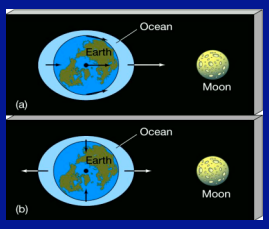
Side of Earth closest to Moon feels slightly stronger pull => bulges towards it. Other side feels weaker pull => bulges away compared to rest of Earth.

Why are there two high tides and two low tides each day?

Tides

Two high and two low tides per day.

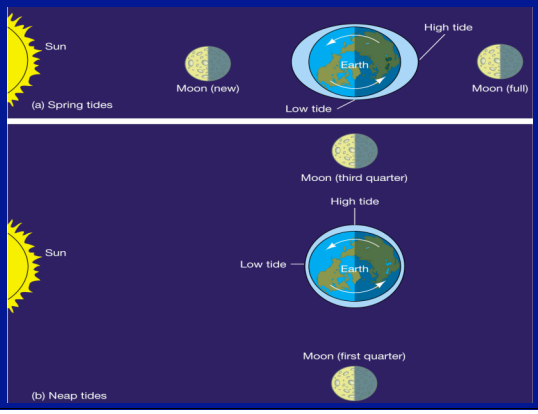
Tides are due to Moon's gravitational pull being stronger on side of Earth closest to it (Sun also influences tides).



Side of Earth closest to Moon feels slightly stronger pull => bulges towards it. Other side feels weaker pull => bulges away compared to rest of Earth.

The Earth spins once a day while the bulge always points towards and away from the Moon => two high and two low tides each day.

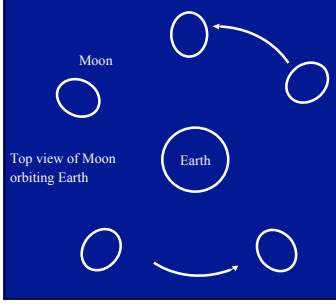
Tides (cont.)



We always see the same face of the Moon.

So period of orbit = period of rotation

Why?



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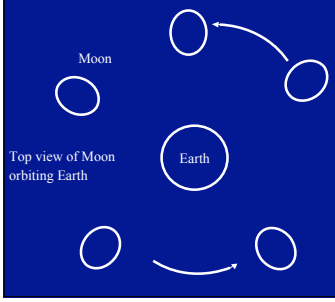


Tidal Locking

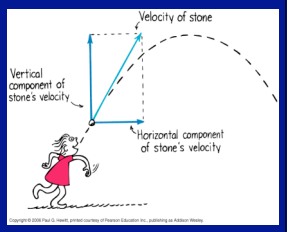
The tidal bulge in the solid Moon elongates it slightly (2-3 km) along an axis pointing to Earth.

If orbit period faster than spin period, tidal bulge would have to move around surface of Moon, creating friction, which slows the Moon down until tidal bulge no longer migrates around.

Similar effect is slowing Earth's rotation!

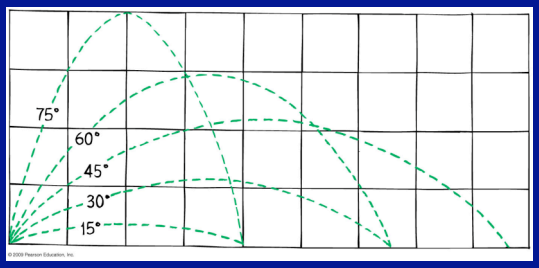
Projectile Motion

- How will the vertical component of the stone's velocity change with time?
- What about the horizontal component?
- The overall behavior of the stone is a combination of what two types of motion?



Projectile Motion

- What is the angle that results in the greatest horizontal distance travelled?



Concept Check

- Is the force that holds you to the Earth and makes apples fall from trees really the same force that keeps the Moon in orbit around the Earth?

Rubber Sheet Demo

Clicker Question:

Why is the Earth round?

A: Because rocks are round and the Earth is mostly made up of rocks

B: Because all parts of the Earth are pulled together by gravity

C: Because of surface tension in the oceans

D: Because of weathering by meteors

Clicker Question:

Where do you weigh the most?

A: Standing on top of Mt. Everest

B: Standing on the beach at the Equator

C: Standing at UNM

D: Standing at the North Pole

Clicker Question:

Where do you weigh the least?

A: Standing on top of Mt. Everest

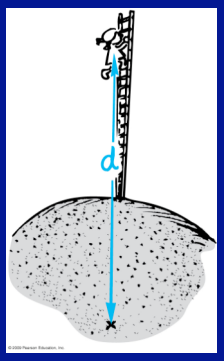
B: Standing on the beach at the Equator

C: Standing at UNM

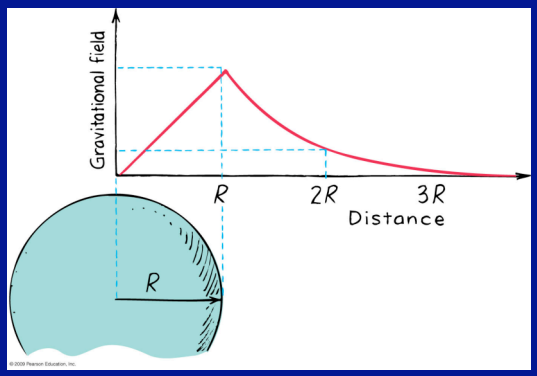
D: Standing at the North Pole

Gravity and Orbits

- Gravity decreases as you climb out of the "potential well"

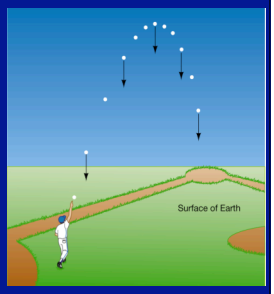


Gravity and Orbits



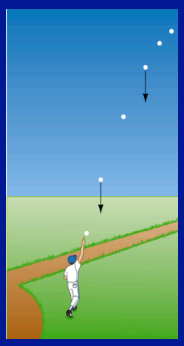
Gravity and Orbits

- Throwing an object fast enough (about 8 km/s = 18,000 miles/hr) will put the object into orbit! (Neglecting air resistance)
- Moon is continually "falling" towards the Earth in its orbit and missing!



Escape Velocity

- Speed at which an object can permanently escape from a body determined by strength of the gravitational force
- Earth: 11 km/s
- Moon: 2.4 km/s
- Sun: 42.5 km/s
- Explains why moon has no atmosphere!



Escape Velocity

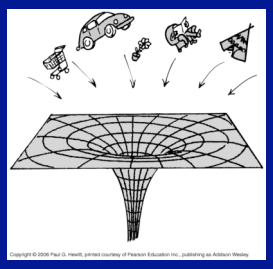
Velocity needed to completely escape the gravity of a planet.
The stronger the gravity, the higher the escape velocity.
Examples:

Earth	11.2 km/s
Jupiter	60 km/s
Deimos (moon of Mars)	7 m/s = 15 miles/hour

Consider Helium Gas at room temperature (300 K)
$E = kT = 4.1 \times 10^{-14}$ erg
$E = 0.5\ m\ v^2 = 4.1 \times 10^{-14}$ erg
so $v = 1$ km/sec on average, but sometimes more

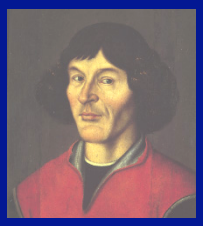
Black Holes

- If escape velocity exceeds the speed of light (300,000 km/s = 186,000 miles/s), then not even light can escape
  - Black hole
- Crush Earth to size of a grape or our Sun to a radius of less than 3 km, get a black hole



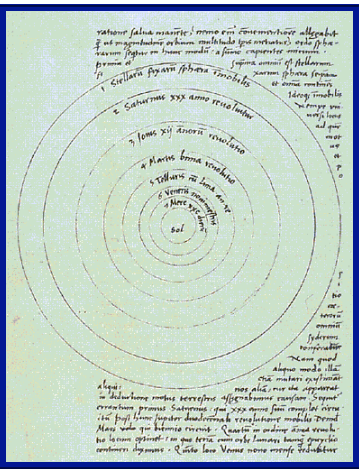
"Heliocentric" Model

- Rediscovered by Copernicus in 16th century.
- Put Sun at the center of everything.
- Much simpler.
- But orbits circular in his model. In reality, they're elliptical, so it didn't fit the data well.
- Not generally accepted at the time.



Copernicus 1473-1543

Illustration from Copernicus' work showing heliocentric model.

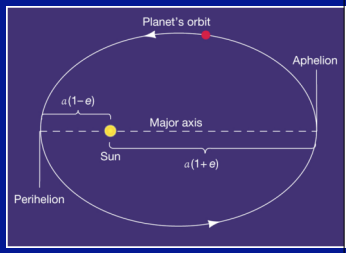


Kepler's Laws

- What are the shapes and important properties of the planetary orbits?
- How does the speed of a planet vary as it orbits the sun?
- How does the period of a planet's orbit depend on its distance from the Sun?

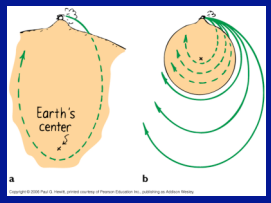
Kepler's First Law

- The orbits of the planets are elliptical (not circular) with the Sun at one focus of the ellipse.



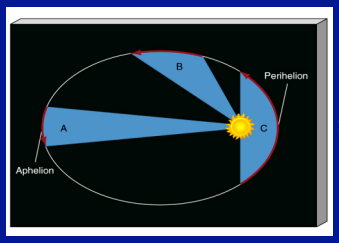
Projectile Motion and Orbits

- Parabolic path of a projectile is nothing but part of an elliptical orbit with the Earth's center at one focus!
  - Earth gets in the way and prevents object from completing its orbit



Kepler's Second Law

A line connecting the Sun and a planet sweeps out equal areas in equal times.

slower  faster

Translation: planets move faster when closer to the Sun.

Kepler's Third Law

The square of a planet's orbital period is proportional to the cube of its semi-major axis.

P^2 is proportional to a^3

or

P^2 (in Earth years) = a^3 (in A.U.)

1 A.U. = 1.5×10^8 km

Translation: The further the planet is from the sun, the longer the period.

Newton's Law of Gravity

For two objects of mass m_1 and m_2, separated by a distance R, the force of their gravitational attraction is given by:

$$F = \frac{G m_1 m_2}{R^2}$$

F is the gravitational force.

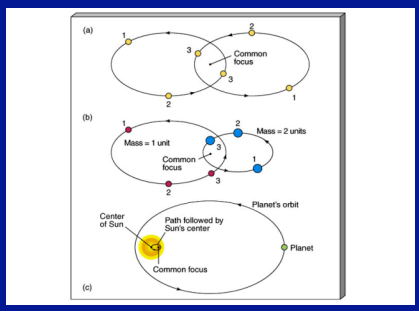
G is the "gravitational constant".

An example of an "inverse-square law".

Your "weight" is just the gravitational force between the Earth and you.

Newton's Correction to Kepler's First Law

The orbit of a planet around the Sun has the common center of mass (instead of the Sun) at one focus.



Clicker Question:

A flaw in Copernicus's model for the solar system was:

A: It didn't explain retrograde motion.

B: He used circular orbits.

C: The Earth was still at the center.

D: He used the same mass for all the planets.

E: All of the above

Clicker Question:

How long does it take the space shuttle to orbit the Earth once?

A: 10 minutes

B: 90 minutes

C: 1 day

D: 1 week

Clicker Question:

Suppose Matt weighs 120 lbs on his bathroom scale on Earth, how much will his scale read if he standing on a platform 6400 km high (1 Earth radius above sea-level)?

A: 12 lbs

B: 30 lbs

C: 60 lbs

D: 120 lbs

E: 240 lbs