Orbits...the celestial paths of planets

But first, things for you to read on your own

• Difference between mean solar time and apparent solar time
• Time zones (central standard time, mountain standard time, etc).
• Be sure and read material on eclipses, fill out presentation in class

The science of orbits...what are the properties of the paths followed by the planets around the Sun?

What is shown in this egg-shaped figure?
Laws of orbits which are still used today were stated by Johannes Kepler in about 1600.

Kepler was a contemporary of Galileo.

Properties of orbits were expressed in terms of Kepler’s Laws of Planetary motion (3 of ‘em).

Kepler’s 1st Law: orbits are ellipses with the Sun at one focus.

Remember your high school math: ellipses are plane figures…agrees with observed fact that orbits lie in a plane.
Kepler’s 1st Law of Planetary Motion

Definitions of particular importance

- Major axis (like the diameter of a circle)
- Semimajor axis (like the radius of a circle)
- Eccentricity (how elliptical or non-circular the ellipse is). Eccentricity can vary from 0 to 0.9999999….

Kepler’s 2nd Law: a line from the Sun to a planet sweeps out equal areas in equal time intervals

Kepler’s 2nd Law of Planetary Motion (the equal area law)
Kepler’s 3rd Law: the harmonic law. The semimajor axis of an orbit, and the orbital period are not independent. They are related by a simple equation.

$A^3 = P^2$

Planetary data (I love tables with data)

<table>
<thead>
<tr>
<th>Planet</th>
<th>Semimajor Axis (a)</th>
<th>Orbital Period (y)</th>
<th>Orbital Speed (km/s)</th>
<th>Orbital Eccentricity (e)</th>
<th>Inclination of Orbit to Ecliptic (°)</th>
<th>Rotation Period (days)</th>
<th>Inclination of Equator to Orbit (°)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>0.3871</td>
<td>0.2408</td>
<td>10.79</td>
<td>0.206</td>
<td>7.00</td>
<td>58.68</td>
<td>0</td>
</tr>
<tr>
<td>Venus</td>
<td>0.7233</td>
<td>0.6152</td>
<td>13.79</td>
<td>0.007</td>
<td>3.39</td>
<td>-243.01°</td>
<td>177.3</td>
</tr>
<tr>
<td>Earth</td>
<td>1.000</td>
<td>1</td>
<td>29.8</td>
<td>0.017</td>
<td>0.00</td>
<td>0.987</td>
<td>23.4</td>
</tr>
<tr>
<td>Mars</td>
<td>1.5273</td>
<td>1.8809</td>
<td>24.1</td>
<td>0.093</td>
<td>1.85</td>
<td>1.025°</td>
<td>25.2</td>
</tr>
<tr>
<td>Jupiter</td>
<td>5.2003</td>
<td>11.862</td>
<td>15.1</td>
<td>0.046</td>
<td>1.31</td>
<td>0.410°</td>
<td>3.1</td>
</tr>
<tr>
<td>Saturn</td>
<td>9.5826</td>
<td>29.460</td>
<td>9.0</td>
<td>0.026</td>
<td>2.49</td>
<td>0.048°</td>
<td>26.7</td>
</tr>
<tr>
<td>Uranus</td>
<td>19.1914</td>
<td>84.01</td>
<td>6.8</td>
<td>0.046</td>
<td>0.77</td>
<td>-0.740°</td>
<td>97.9</td>
</tr>
<tr>
<td>Neptune</td>
<td>30.0811</td>
<td>164.79</td>
<td>5.4</td>
<td>0.010</td>
<td>1.77</td>
<td>0.716°</td>
<td>29.8</td>
</tr>
<tr>
<td>Pluto</td>
<td>39.3294</td>
<td>248.54</td>
<td>4.7</td>
<td>0.248</td>
<td>17.15</td>
<td>-6.38°</td>
<td>122.5</td>
</tr>
</tbody>
</table>

Applications of Kepler’s Laws: variations in the opposition of Mars

Another application of Kepler’s 1st Law: the orbit of the Earth’s Moon. Explains difference between total and annular solar eclipses
Another important fact in eclipses: Moon’s orbit inclined by 5 degrees with respect to ecliptic.

Gravity and Orbits...how and why the planets move the way they do.

Isaac Newton...beginning of modern physics

Newton’s laws of motions: the foundation of physics and the start for our understanding of orbits.

The net force is what moves things.
Centripetal acceleration and central force

The gravitational force from spherical object