Class 1  Introduction, Background  History of Modern Astronomy  The Night Sky, Eclipses and the Seasons  Kepler’s Laws  Newtonian Gravity  General Relativity  Matter and Light  Telescopes

Class 2  Solar System  Characteristics  Formation  Exosolar Planets

Class 3  Stars  The Sun  Stellar Evolution of Low and High Mass Stars  Deaths of Stars  Exotic Stars

Class 4  Galaxies  Galaxy Classification  Formation of Galaxies  Galactic Evolution

Class 5  Cosmology  Large-Scale Structure of the Universe  Big Bang Cosmology

Class 6  Special Topics  Requested Topics for Discussion  Observing with a Telescope
Interplanetary Matter: Asteroids and Comets

Planets: Terrestrial and Jovian planets
Interplanetary Matter

asteroids
Interplanetary Matter

comets
The planets

### Planetary attributes

<table>
<thead>
<tr>
<th>Name</th>
<th>Equatorial diameter[a]</th>
<th>Mass[a]</th>
<th>Orbital radius (AU)</th>
<th>Orbital period (years)</th>
<th>Inclination to Sun's equator (°)</th>
<th>Orbital eccentricity</th>
<th>Rotation period (days)</th>
<th>Named moons[c]</th>
<th>Rings</th>
<th>Atmosphere</th>
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</thead>
<tbody>
<tr>
<td>Mercury</td>
<td>0.382</td>
<td>0.06</td>
<td>0.39</td>
<td>0.24</td>
<td>3.38</td>
<td>0.206</td>
<td>58.64</td>
<td>no</td>
<td>no</td>
<td>minimal</td>
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<td>Venus</td>
<td>0.949</td>
<td>0.82</td>
<td>0.72</td>
<td>0.62</td>
<td>3.86</td>
<td>0.007</td>
<td>-243.02</td>
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<td>no</td>
<td>CO₂, N₂</td>
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<td>Earth[b]</td>
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<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
<td>7.25</td>
<td>0.017</td>
<td>1.00</td>
<td>1</td>
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<td>N₂, O₂</td>
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<tr>
<td>Mars</td>
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<td>0.11</td>
<td>1.52</td>
<td>1.88</td>
<td>5.65</td>
<td>0.093</td>
<td>1.03</td>
<td>2</td>
<td>no</td>
<td>CO₂, N₂</td>
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<tr>
<td>Jupiter</td>
<td>11.209</td>
<td>317.8</td>
<td>5.20</td>
<td>11.86</td>
<td>6.09</td>
<td>0.048</td>
<td>0.41</td>
<td>49</td>
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<td>Saturn</td>
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<td>95.2</td>
<td>9.54</td>
<td>29.46</td>
<td>5.51</td>
<td>0.054</td>
<td>0.43</td>
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<tr>
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<td>19.22</td>
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<td>6.48</td>
<td>0.047</td>
<td>-0.72</td>
<td>27</td>
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<td>Neptune</td>
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<td>30.06</td>
<td>164.8</td>
<td>6.43</td>
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<td>13</td>
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</tr>
<tr>
<td>Ceres</td>
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<td>0.000 2</td>
<td>2.5–3.0</td>
<td>4.60</td>
<td>10.59</td>
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<td>0.38</td>
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<td>none</td>
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<td>29.7–49.3</td>
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<td>17.14</td>
<td>0.249</td>
<td>-6.39</td>
<td>3</td>
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<td>Haumea</td>
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<td>35.2–51.5</td>
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<td>28.19</td>
<td>0.189</td>
<td>0.16</td>
<td>2</td>
<td></td>
<td></td>
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<tr>
<td>Makemake</td>
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<td>0.000 7</td>
<td>38.5–53.1</td>
<td>309.88</td>
<td>28.96</td>
<td>0.159</td>
<td>?</td>
<td>0</td>
<td>?</td>
<td>?</td>
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<td>Eris</td>
<td>0.19</td>
<td>0.002 5</td>
<td>37.8–97.6</td>
<td>~557</td>
<td>44.19</td>
<td>0.442</td>
<td>~0.3</td>
<td>1</td>
<td>?</td>
<td>?</td>
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</table>

[a] Measured relative to the Earth.

[b] Measured relative to the Earth.

[c] Measured relative to the Earth.

[d] Measured relative to the Earth.

See Earth article for absolute values.

Jupiter has the most secured satellites (63) in the solar system.[61]

Like Pluto, when near perihelion, a temporary atmosphere is suspected.
mercury
venus
earth
jupiter
saturn
uranus
neptune

The Great Dark Spot, discovered by Voyager 2 in 1989, is comparable in size to Earth.

Jovian planets share many atmospheric features: Jupiter's Great Red Spot is about twice the size.
Formation of our Solar System

Rotation axis

Condensation of different chemicals

Temperature (K)

Distance from Sun (AU)
The Orion Nebula is an archetypical example of a stellar nursery where new stars are being born, from the massive, young stars that are shaping the nebula to the pillars of dense gas that may be the homes of budding stars. Observations of the nebula have revealed approximately 700 stars in various stages of formation within the nebula.

The Solar System formed from the gravitational collapse of a fragment of a giant molecular cloud which likely was several light-years across. The initial cloud was roughly 90% hydrogen, 9% helium with small amounts of heavier elements (iron, carbon, oxygen, ...).
Studies of ancient meteorites reveal traces of short-lived isotopes such as iron-60 which only form in exploding, short-lived stars. This indicates that one or more supernovae occurred near the Sun while it was forming. Spitzer reveals infrared radiation coming from dust particles heated by the supernova's shock wave.
As the cloud shrinks (diameter of between 7000 and 20,000 astronomical units (AU) and a mass just over that of the Sun), it starts to spin faster (conserving angular momentum).

Over about 100,000 years, the contracting nebula flattens into a spinning protoplanetary disc with a hot, dense protostar (a star in which hydrogen fusion has not yet begun) at the center. This protostar, a T Tauri star, has a central temperature that is too low for hydrogen fusion to take place.
Planets form from protoplanets and the light gas gets blow away from the inner region.
Condensation of different chemicals

- Tungsten
- Aluminum oxide
- Iron
- Silicates
- Carbon-rich silicates
- Asteroids
- Jupiter
- Saturn
- Uranus
- Ices
- Neptune

Temperature (K) vs. Distance from Sun (AU)
Solar System Exosolar Planets

Bar chart of exoplanet discoveries by year, through 2009-10-19.

Color key regards the discovery method:
- radial velocity = dark blue
- transit = dark green
- timing = dark purple
- astrometry = dark yellow
- direct imaging = dark red
- microlensing = dark orange
**Detection Methods**

* Radial velocity or Doppler method:

Variations in the speed with which the star moves towards or away from Earth — that is, variations in the radial velocity of the star with respect to Earth — can be deduced from the displacement in the parent star’s spectral lines due to the Doppler effect. This has been by far the most productive technique used.

[http://astro.unl.edu/classaction/animations/light/radialvelocitydemo.html](http://astro.unl.edu/classaction/animations/light/radialvelocitydemo.html)
* Pulsar timing:

A pulsar (the small, ultradense remnant of a star that has exploded as a supernova) emits radio waves extremely regularly as it rotates. Slight anomalies in the timing of its observed radio pulses can be used to track changes in the pulsar's motion caused by the presence of planets.

This method was not originally designed for the detection of planets, but is so sensitive that it is capable of detecting planets far smaller than any other method can, down to less than a tenth the mass of Earth.
* Transit method:

If a planet crosses (or transits) in front of its parent star's disk, then the observed brightness of the star drops by a small amount. The amount by which the star dims depends on its size and on the size of the planet.
* Circumstellar disks: Disks of space dust surround many stars, and this dust can be detected because it absorbs ordinary starlight and re-emits it as infrared radiation. Features in dust disks may suggest the presence of planets.

* Eclipsing binary: In an eclipsing double star system, the planet can be detected by finding variability in minima as it goes back and forth. It is the most reliable method for detecting planets in binary star systems.

* Orbital phase: Like the phase of the Moon and Venus, extrasolar planets also have phases. Orbital phases depend on the inclination of the orbit. By studying orbital phases, scientists can calculate particle sizes in the atmospheres of planets.

* Polarimetry: Stellar light becomes polarized when it interacts with atmospheric molecules, which can be detected with a polarimeter. So far, one planet has been studied by this method.

* Direct Imaging
Astrometry consists of precisely measuring a star's position in the sky and observing the ways in which that position changes over time. If the star has a planet, then the gravitational influence of the planet will cause the star itself to move in a tiny circular or elliptical orbit about their common center of mass (see animation on the right).
* Gravitational microlensing:

Microlensing occurs when the gravitational field of a star acts like a lens, magnifying the light of a distant background star. Possible planets orbiting the foreground star can cause detectable anomalies in the lensing event light curve.