Distances

How far away is Mars?

How big is Jupiter?

Questions
Many people find the Heavens to be incomprehensible because of the great range in sizes and distances. Even astronomers have a difficult time coming to grips with quantities like the distance from the Earth to the Sun when it is expressed as 93,000,000 miles (150,000,000 km). The way to comprehend sizes and distances is to use meaningful measurement units.

Distances

Here is an example. The distance from my house in Atlanta to my parents' house north of Nashville is about 17,740,000 inches – the number is correct but it is completely meaningless because we do not have a real-world feel for numbers that large.

I could state that the distance is about 280 miles. The number 280 is just on the verge of our ability to comprehend its magnitude.

An even better way of relating the distance between the houses is to say it takes me 4 hours to drive from one to the other. In expressing it that way, two things have happened: (1) the quantity of 4 hours is easily comprehensible and (2) the measurement units were switched from distance to time. Hopefully by this change in measurement units, you get a better feel for the distance between these two homes.
What is a Good Distance Unit?

Astronomers recognized the need for better distance measurement units in the Solar System, Galaxy, and the Universe, since the mile is just too short to be useful. The unit for the Solar System is based on the average distance from the Earth to the Sun.

Instead of using 93 million miles (150 million km), this distance is defined as equal to 1 and is called the Astronomical Unit (AU).

1 AU = 1.5 x 10^8 km

With this relative scale, we would say that the distance from the Sun to Mercury is 0.4 AU, to Mars it is 1.6 AU, to Jupiter it is 5.2 AU, and to Pluto it is on average about 40 AU.

Scale of the Solar System

Shrink the Sun down to the size of a basketball.
Put it on the 50 yard line of the GT football field.
Note the spacing of the inner planets – all would fit on the football field.
Note the spacing of the outer planets – much larger than the football field.

<table>
<thead>
<tr>
<th>PLANET</th>
<th>DISTANCE</th>
<th>DIAMETER</th>
<th>MASS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(AU)</td>
<td>(yd)</td>
<td>(E=1)</td>
</tr>
<tr>
<td>Mercury</td>
<td>0.39</td>
<td>10</td>
<td>0.38</td>
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<tr>
<td>Venus</td>
<td>0.72</td>
<td>18</td>
<td>0.95</td>
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<tr>
<td>Earth</td>
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<td>25</td>
<td>1.00</td>
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<tr>
<td>Mars</td>
<td>1.52</td>
<td>37</td>
<td>0.53</td>
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<td>Jupiter</td>
<td>5.20</td>
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<td>11.20</td>
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<td>9.54</td>
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<tr>
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<td>30.06</td>
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<tr>
<td>Pluto</td>
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<td>0.17</td>
</tr>
</tbody>
</table>
What About Angles on the Sky?

Angular Diameters

Full Moon = Sun
= 0.5°
= 30 arcmin
= 1,800 arcsec

Measuring Angles

Circle

360° in Circumference

\[ \frac{\alpha}{360^\circ} = \frac{x}{2\pi R} \]
Angular Measurements

Skinny Triangle

\[ \tan \alpha = \frac{D}{d} \]

[Diameter / distance]

\[ \alpha = \frac{D}{d} \text{ (radians)} \]