

Kepler's Laws

The Laws of Planetary Motion

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Kepler's Laws

Tycho Brahe

- ♣ Born Denmark 1546
- ♣ College in Germany
- ♣ Supernova of 1572
- ♣ Uraniborg
- ♣ Died Prague 1601

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Kepler's Laws

Uraniborg


No telescope!
Main task: Careful measurements of positions of planets and stars

The Mural Quadrant

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Kepler's Laws

Johannes Kepler



- ✦ Born 1571 Swabia, Germany
- ✦ University of Tübingen
- ✦ Graz, Austria 1594-1600
 - ✦ *Mystery of the Cosmos*
- ✦ Prague 1600-1612
 - ✦ *Astronomia Nova* (1609)
- ✦ Linz, Austria 1612-1626
 - ✦ *Harmony of the World* (1618)
 - ✦ *Rudolphine Tables* (1627)
- ✦ Died Bavaria 1630

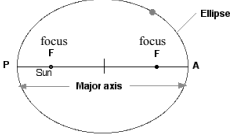
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Kepler's Laws

Kepler's First Law

The orbits of the planets are ellipses with the Sun at one of the foci.

1 focus
2 foci

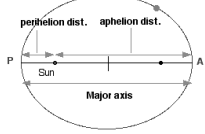


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Kepler's Laws

Perihelion and Aphelion

- ✦ *Helios* = Sun
- ✦ **Perihelion** = closest to Sun
- ✦ **Aphelion** = farthest from Sun



Perihelion dist. + Aphelion dist. = major axis

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Kepler's Laws

Semi-axis Major

the size of the ellipse

- ☛ **semi-axis major** = half of major axis
- ☛ s.a.m. = average of perihelion dist & aphelion dist
- ☛ s.a.m. = average of min. & max. distance

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Kepler's Laws

Eccentricity

shape of the ellipse

eccentricity = $\frac{\text{distance between foci}}{\text{major axis}}$

$e = 0$: circle
 $e = 1$: line

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Kepler's Laws

Eccentricity & Perihelion

- ☛ aphelion dist. = (s.a.m.)(1+eccentricity)
- ☛ perihelion dist. = (s.a.m.)(1-eccentricity)

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Kepler's Laws

Kepler's 2nd Law

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

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Kepler's Laws

Kepler's 3rd Law

A relation among the planets.

- ☛ Take any 2 planets
- ☛ **Period** = orbital period
- ☛ Period & s.a.m. are related:

$$\frac{\text{PERIOD}_A^2}{\text{PERIOD}_B^2} = \frac{\text{S.A.M.}_A^3}{\text{S.A.M.}_B^3}$$

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Kepler's Laws

The Astronomical Unit (AU)

- ☛ ...a unit of distance.
- ☛ ...the s.a.m. of the Earth's orbit.
- ☛ ...average dist. between the Earth and the Sun.
- ☛ = 150,000,000 km = 150 Gm

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Kepler's Laws

Kepler's 3rd Law

Simple Form

(period)² = (s.a.m.)³
period in years
s.a.m. in AUs

← *Applies only to planets orbiting the Sun.*

Implication: *some underlying force governs the motions of the planets.*

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