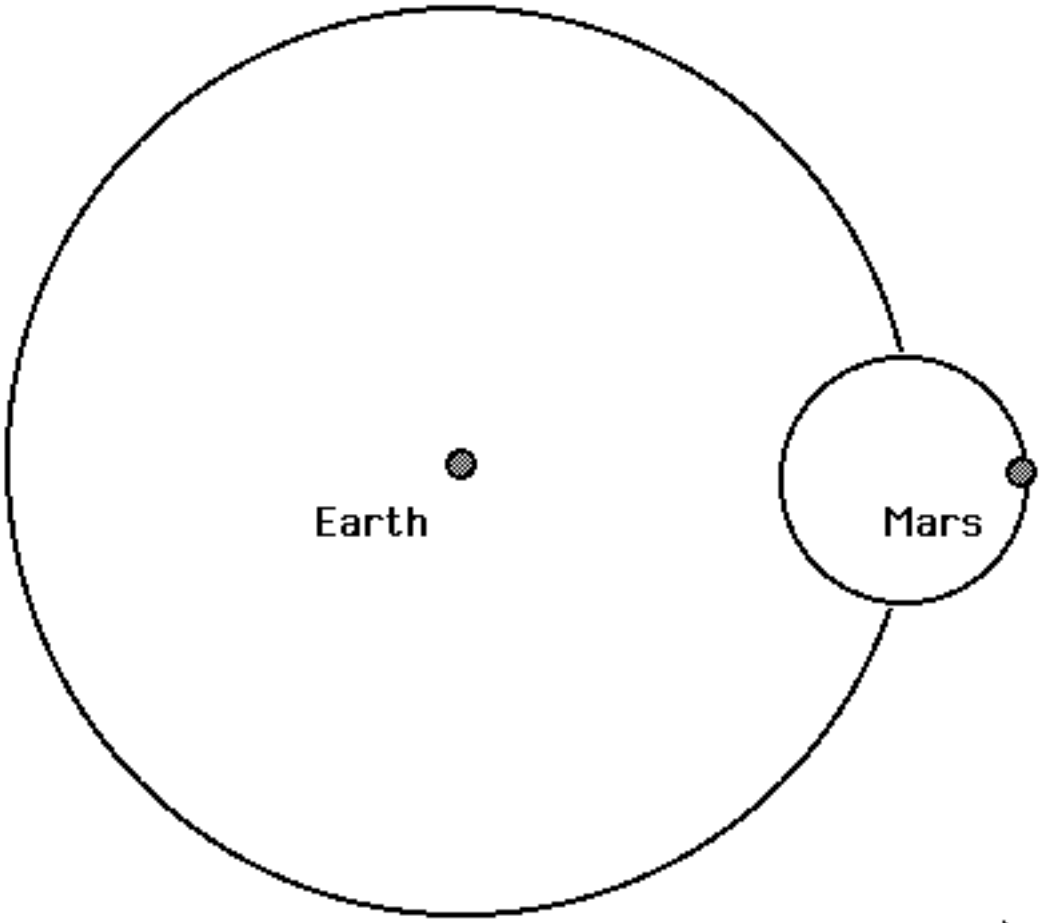
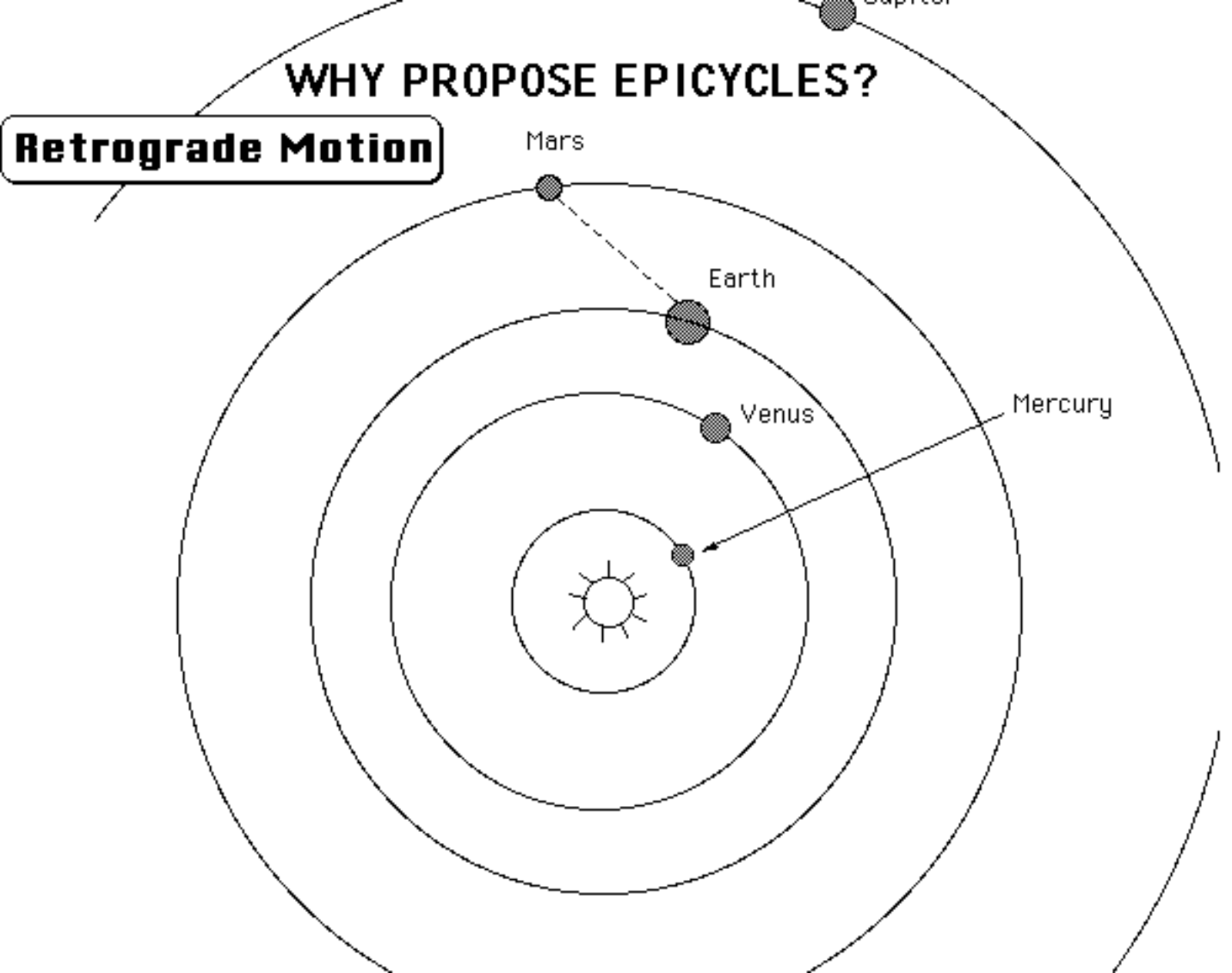
What is an epicycle? A circle within a circle.

Show epicycle



WHY PROPOSE EPICYCLES?

Retrograde Motion

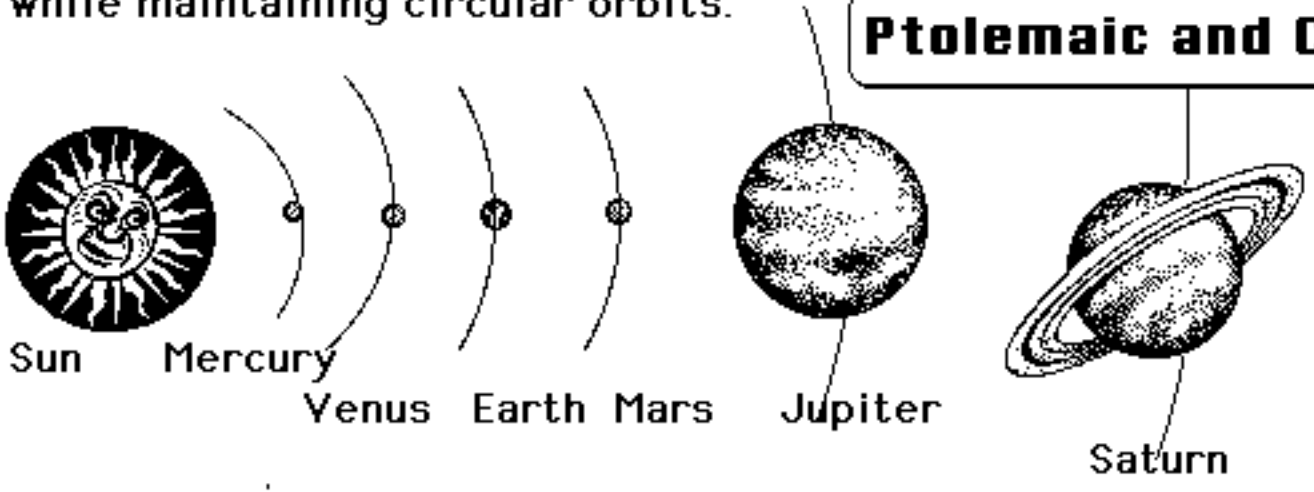


The Copernican system of the world:

Clockwork

Copernicus saw that the system could be greatly simplified by putting the sun, rather than the earth, in the center of the circular planetary orbits. The earth he assumed to move in the third circular orbit from the sun, and to rotate every twenty-four hours on its axis, thus accounting for day and night. It was a simpler system than Ptolemy's, while being equally accurate. It still depended on numerous epicycles to account for small irregularities while maintaining circular orbits.

Ptolemaic and Copernican



Galileo used a telescope to obtain evidence not consistent with the Ptolemaic system:

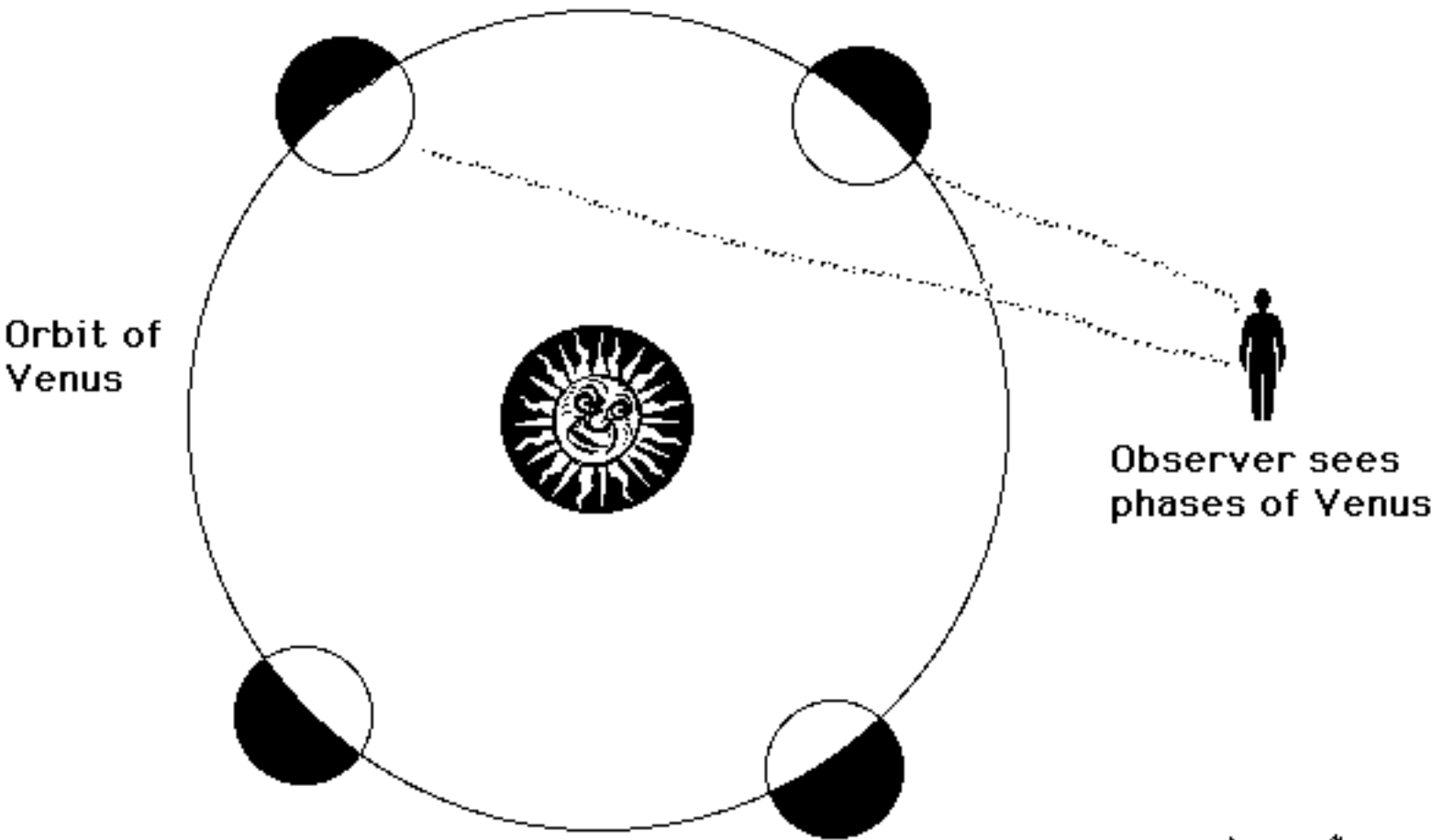
What Galileo saw:

1. **Mountains on the moon**
2. **The milky way**
3. **Phases of Venus**
4. **Moons of Jupiter**

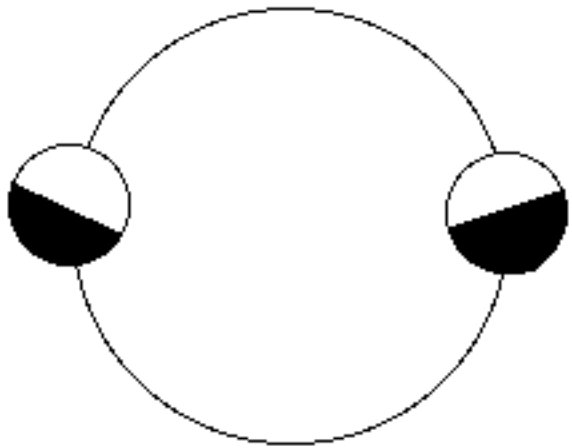
Galileo

Galileo's Time

Phases of Venus



In this geocentric system
venus will not show phases



Epicycle of Venus

Earth

Deduction – Given true premises, a rigorously true conclusion is reached:

A. If it has just rained, the streets are wet.
B. It has just rained
C. Therefore, the streets are wet

If A and B are true, then C is true.

Induction – The process of drawing general conclusions from particular instances

A. If it has just rained, the streets are wet.
B. The streets are wet
C. Therefore, it has just rained

If A and B are true, C may not be true. However, we may consider and rule out a number of other possibilities and conclude that is has indeed just rained. This is induction.

A. If the planetary system is heliocentric, Venus will show phases.

B. The planetary system is heliocentric.

C. Therefore, Venus will show phases.

This is true. However, consider the following:

A. If the planetary system is heliocentric, Venus will show phases.

B. Venus shows phases.

C. Therefore, the planetary system is heliocentric.

This does not prove a heliocentric system. It does rule out the Ptolemaic system but could be consistent with other geocentric systems (Propose one).

Statement by Pope Urban VIII

"Perhaps you can demonstrate heliocentrism by observation. But God is all powerful and it may please Him to have arranged the universe so that it only seems to be following your laws while it really follows His."

What answers can science have to statements such as this?

"Although you may find what appears to be evidence for evolution, it pleases the Creator to fashion life in the form we find it today."

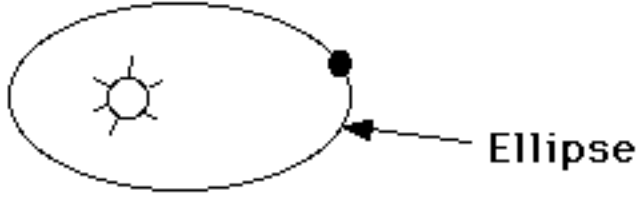
– Director, Institute for Creation Research

Kepler gets it right:

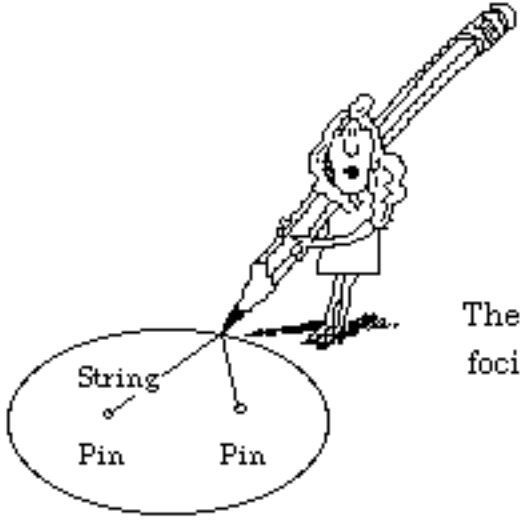
Copernicus/Kepler

Kepler's studies of the observational record convinced him that the path of Mars could not be a circle, but had to be an ellipse. He found that he could construct a simple accurate model with no epicycles needed if he assumed that all planets revolve in elliptical orbits that have the sun at one focus of the ellipse. He described the motions of the celestial spheres with unprecedented accuracy in three Laws of Planetary Motion:

1. LAW OF ELLIPSES: the orbits of planet are ellipses with the sun at one focus.

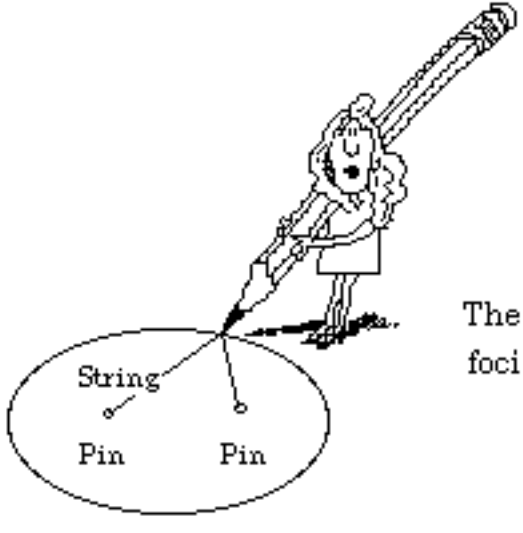


An **ellipse** is one of the "conic sections." Imagine slicing a cone with a plane that is tilted at some angle to its base. The smaller the angle of tilt, the closer the ellipse will be to a circle. The reason the idea of circular orbits worked so well for so long is that planetary orbits are very nearly circular. The angle is very small for all of them, but it is largest for Mars!



The pins become the foci of the ellipse

An ellipse is an elongated circle which may be drawn by attaching a string to two pins and using a pencil to trace out a closed curve. The two points of attachment of the string (the pins) are the foci of the ellipse. The closer the foci come together, the more the ellipse looks like a circle (when they coincide, it is a circle).



The pins become the foci of the ellipse

Ellipse Kepler

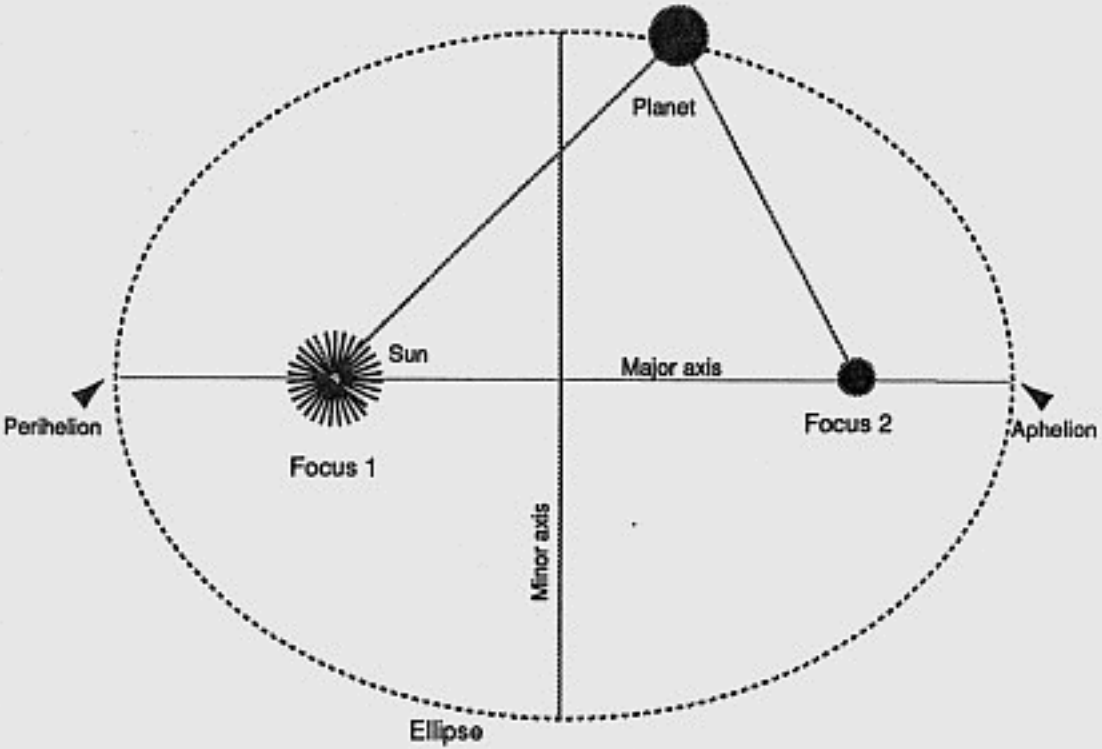
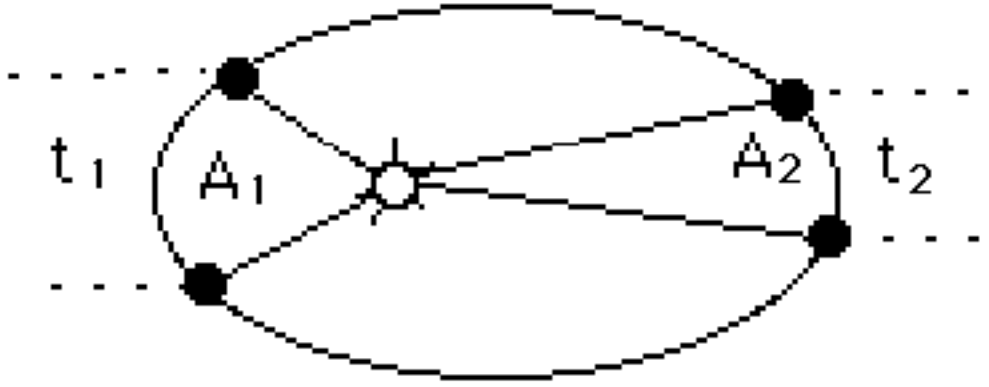


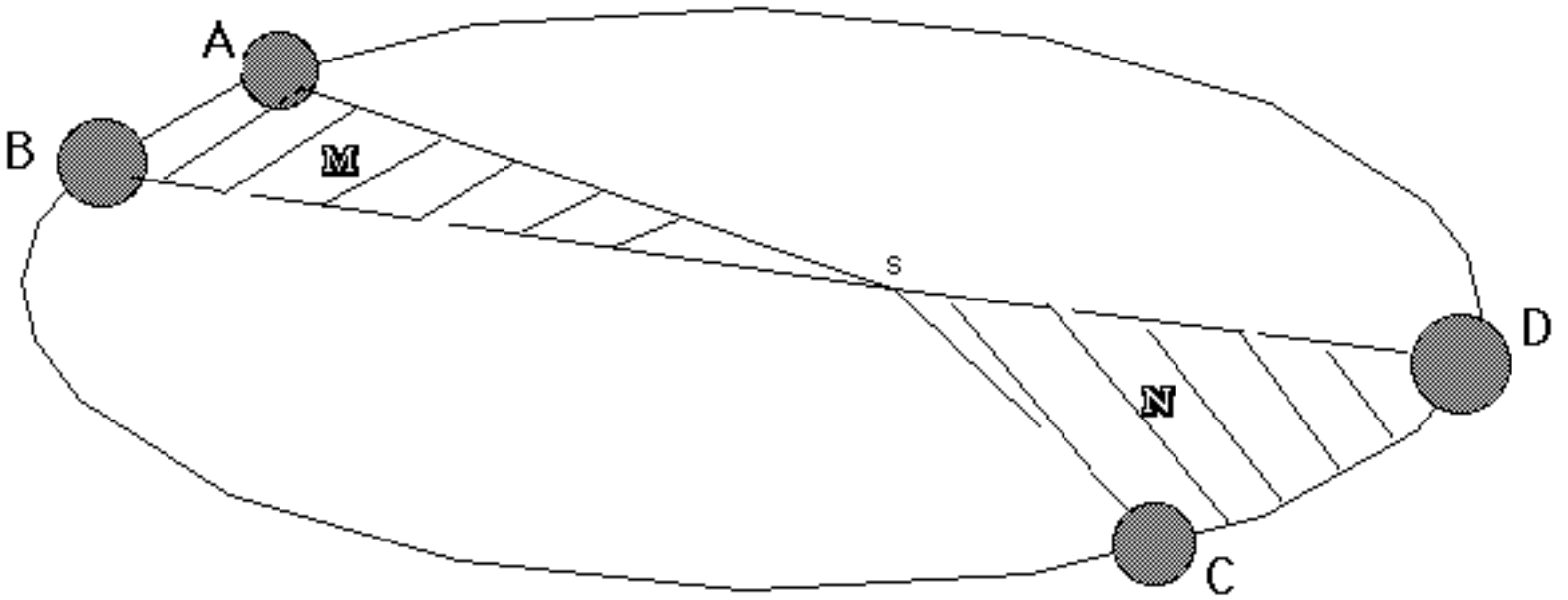
Figure 2–5 Kepler's First Law shown schematically. The orbit of every planet is an ellipse, although not as exaggerated as shown here. An ellipse is a geometrical figure in which the sum of the distances to two fixed points (each of which is called a focus) is always the same. For the planets, the Sun is at one focus of the ellipse.

2. LAW OF EQUAL AREAS: A line (radius vector) joining a planet to the sun sweeps out equal areas in equal intervals of time.



If $A_1 = A_2$ then $t_1 = t_2$

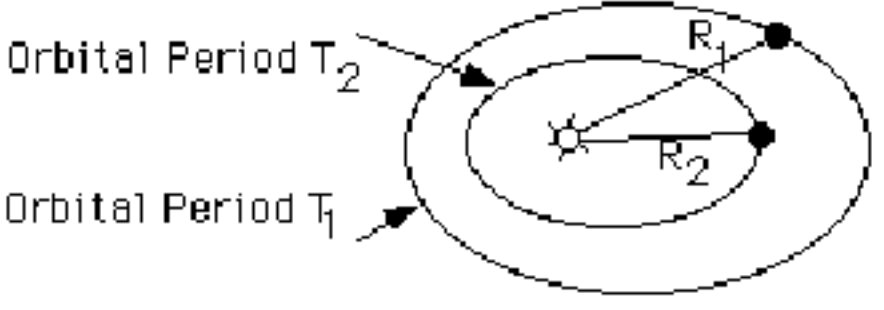
2. LAW OF EQUAL AREAS: A line (radius vector) joining a planet to the sun sweeps out equal areas in equal intervals of time.



If the time from A to B = time from C to D then

Area M = Area N

3. HARMONIC LAW: The ratio of the square of a planet's orbital period to the cube of its mean orbital radius is a constant for all planets in the solar system.



$$\frac{T_1^2}{R_1^3} = \frac{T_2^2}{R_2^3}$$

In reporting distances within the solar system, astronomers often use the distance from the earth to the sun of 93,000,000 mi as one astronomical unit (1 AU). If the distance from the sun to Jupiter is 5.2 AU, use Kepler's 3rd law to calculate how long it takes Jupiter to circle the sun (remember it takes the earth one year).

$$\frac{T_1^2}{R_1^3} = \frac{T_2^2}{R_2^3} \qquad \frac{1^2}{1^3} = \frac{T_2^2}{5.2^3}$$

The 100 – A Ranking of the of the most influential Persons in History
by Michael H. Hart

1. **Muhammad**
2. **Isaac Newton**
3. **Jesus Christ**
4. **Buddha**
5. **Confucius**
6. **St. Paul**
7. **Ts'ai Lun**
8. **Johann Gutenberg**
9. **Christopher Columbus**
10. **Albert Einstein**

12. **Galileo**
19. **Nicolaus Copernicus**
75. **Johannes Kepler**

Directly and inversely proportional:

$$A = \frac{B}{C}$$

A is directly proportional to B (when B gets bigger, A gets bigger)

A is inversely proportional to C (when C gets bigger, A gets smaller)

$$A = \frac{B^2}{C^2}$$

A is directly proportional to B^2 (when B gets bigger, A gets bigger faster)

A is inversely proportional to C^2 (when C gets bigger, A gets smaller faster)

The Law of Universal Gravitation

m = mass (So two masses can be designated as m_1 and m_2).
r = distance between the bodies (actually, between their centers of mass)
F = force of Gravity
G = the universal gravitational constant.

Now we can translate the words of the law into an equation:

$$F=\frac{Gm_1m_2}{r^2}$$

$$F=\frac{Gm_1m_2}{r^2}$$

We measure mass in kilograms (One kilogram of mass weighs about 2.2 pounds), distance in meters, and force in newtons. The value of G ("big G") in these units is 6.67×10^{-11} newton meters^2/kg^2. The tiny value of G indicates gravity is a very weak force. But the mass of the planet we live on is so large that it exerts quite a sizeable force on us. That is what we mean by our weight: the force of earth's gravity on us.

Force = any influence that can change the speed or direction of motion of an object

Force = Mass x acceleration (Newton's 2nd law)

Speed = velocity = distance/time (miles/hr; meters/sec)
The velocity of a car is 60 miles/hr

Acceleration = change in velocity/time = distance/$(\text{time})^2$
A car accelerates from 0 to 60 miles/hr in 10 sec

Force = Mass x acceleration = mass x distance/$(\text{time})^2$

1 kg x 1meter/1 sec^2 = 1 Newton (1N)

The force with which the earth attracts something is called its weight

What is the weight of a 100 kg person on the surface of the earth?

$$F=\frac{Gm_1m_2}{r^2}$$

mass of the earth = 6×10^{24} kg

radius of the earth = 6.4×10^{6} meter

G = 6.67×10^{-11} newton meters^2/kg^2

$$F=\frac{(6.67\times10^{-11}\frac{Nm^2}{kg^2})(6\times10^{24}kg)(1\times10^{2}kg}{(6.4\times10^{6})^2m^2}$$

F = 980 N