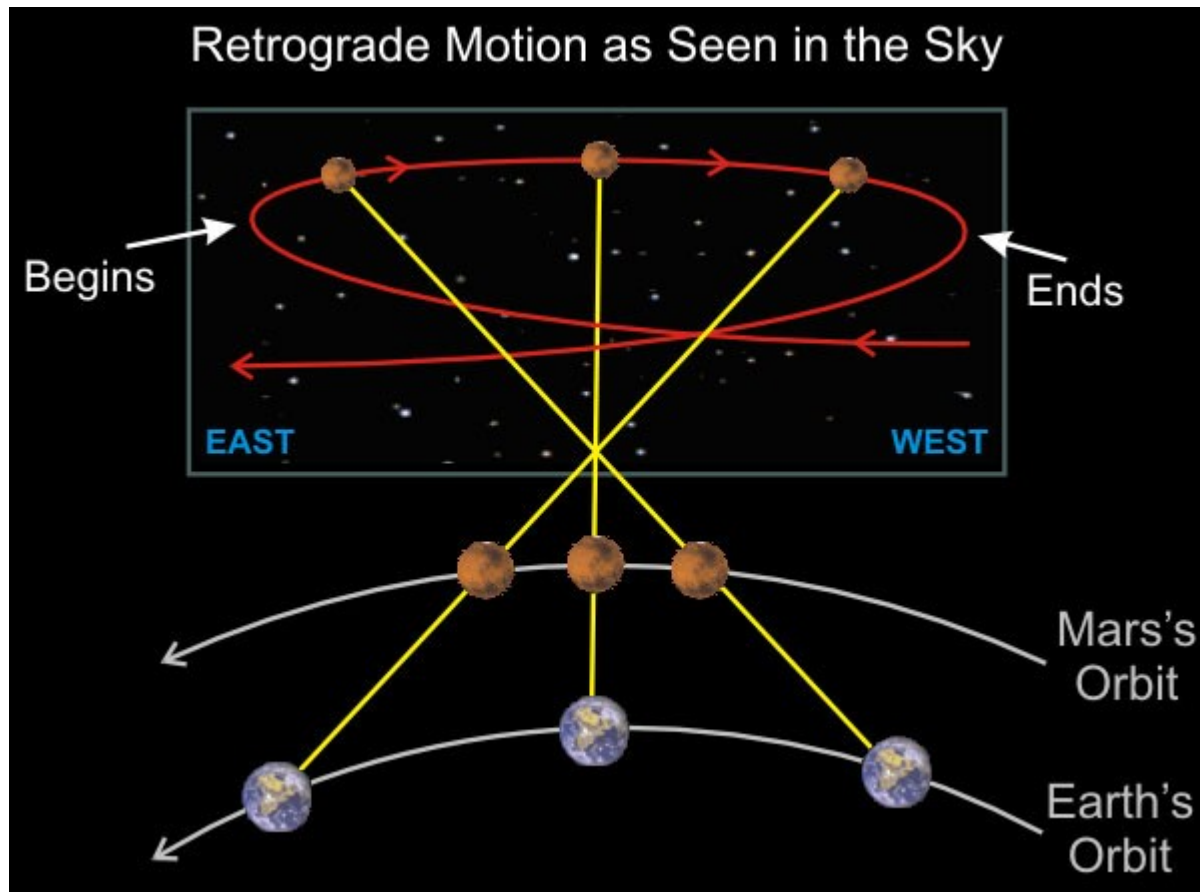


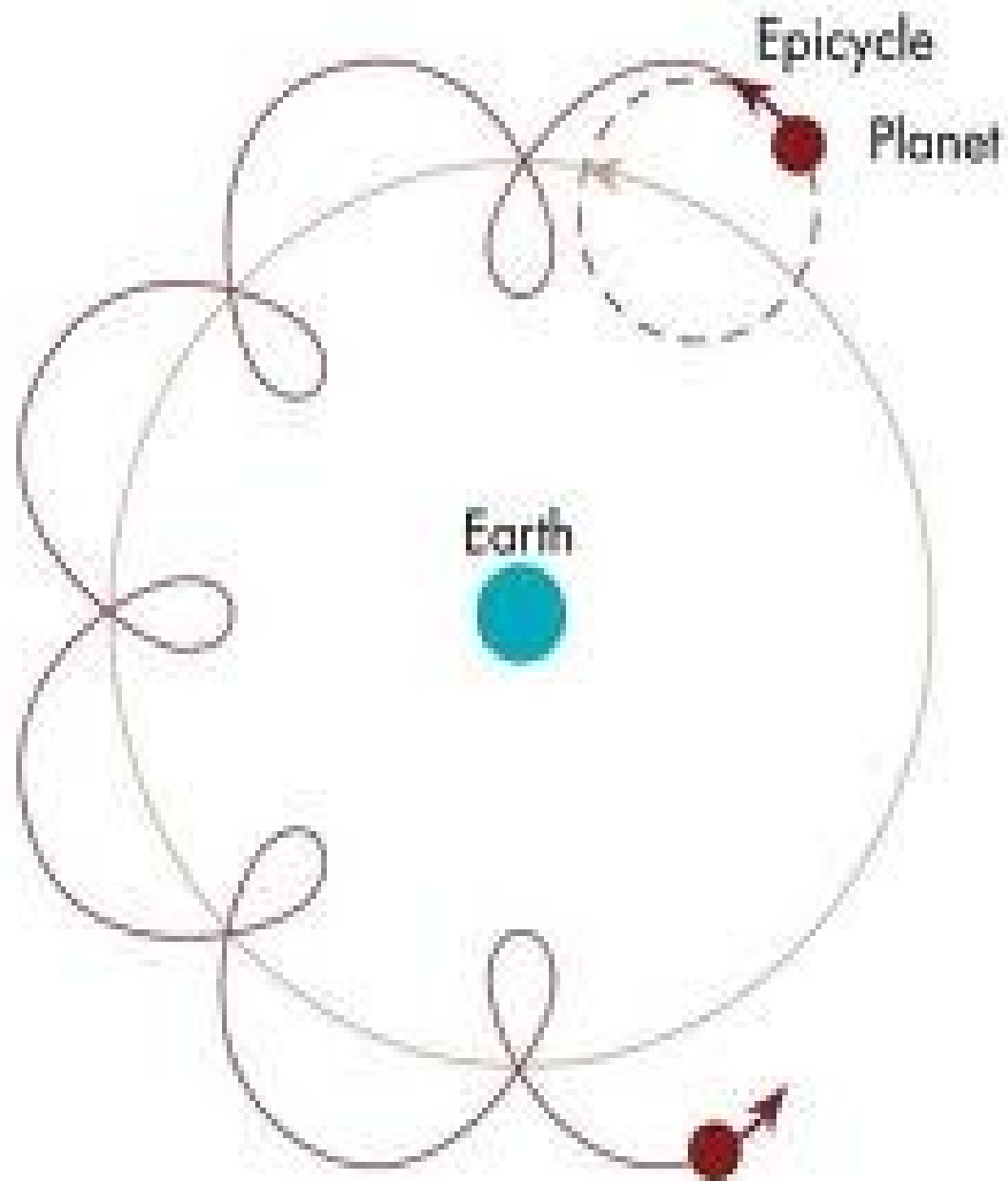
KEPLER'S THREE LAWS



He used the data collected by Tycho Brahe to compute the orbit of Mars around the Sun. He took him 10 years.
From these data he derived his 3 laws.

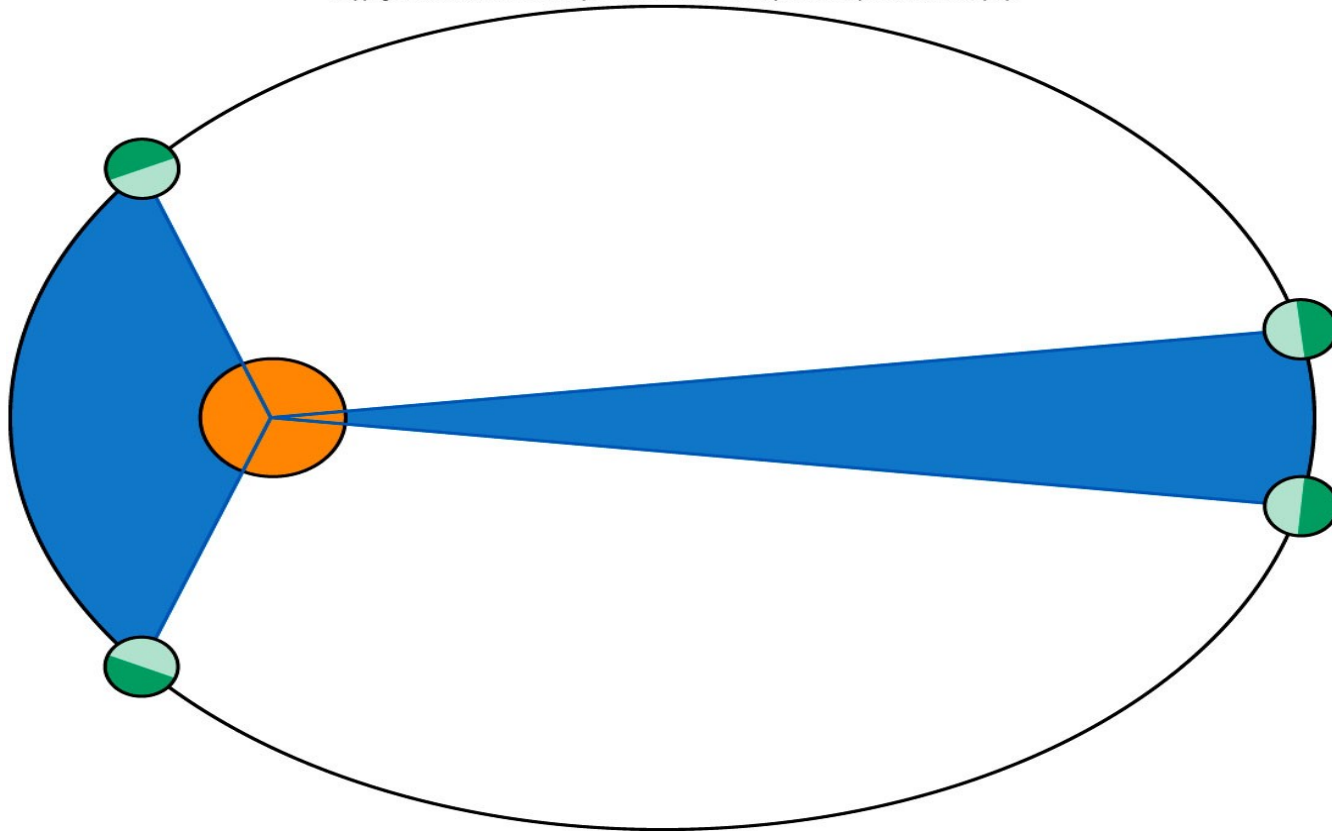
Tycho Brahe had the position (coordinates) of Mars as seen from Earth.





**Kepler had to change the reference frame and compute the orbit
Of Mars around the Sun !! It took him 10 years and almost went insane
Here is the orbit he gets :**

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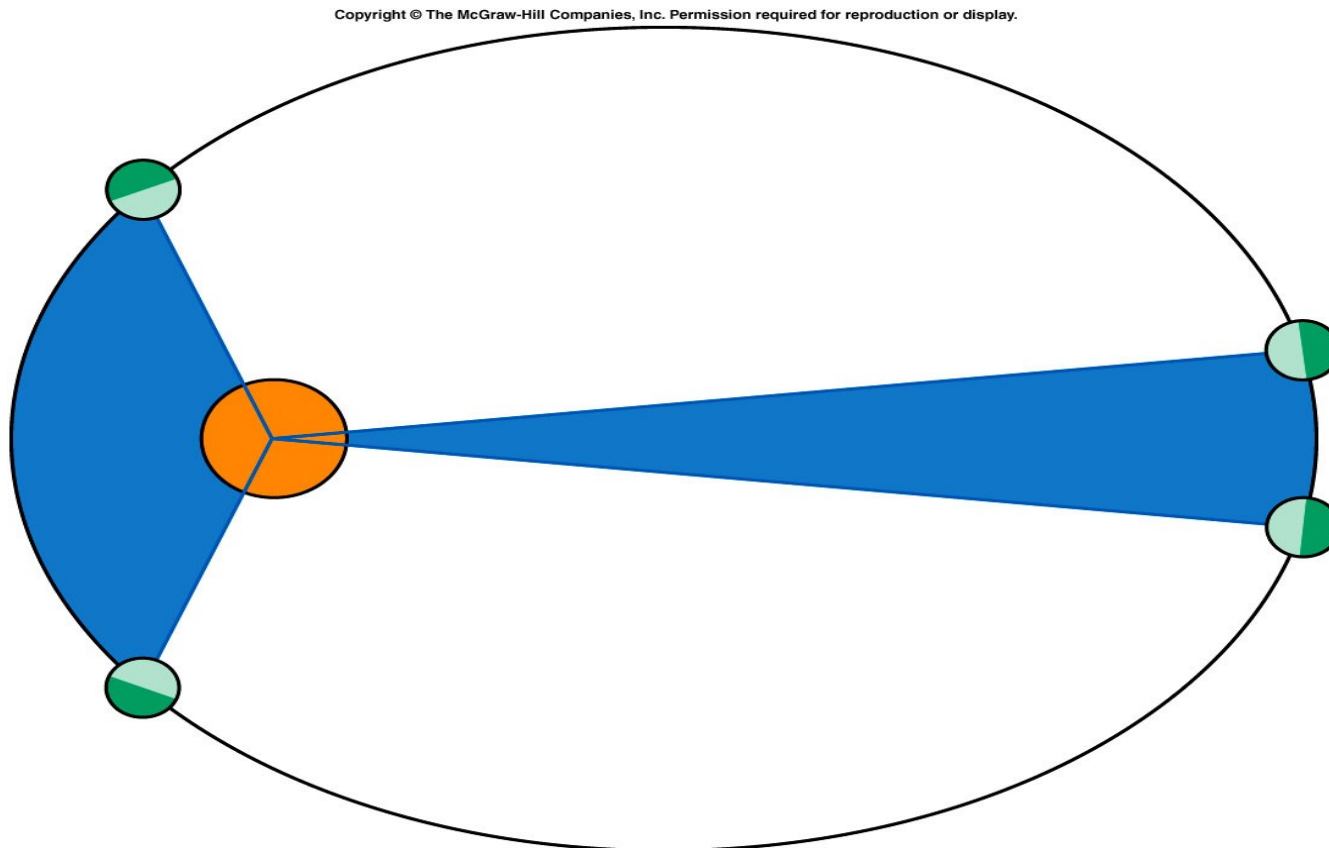


What kind of graph is it ?

He find the orbits of other planets and he derives his 3 laws :

1) The orbit are ellipses.

2) the area swept by the planet is the same for equal amount of time = the planet speeds up when it is closer to the Sun.



Kepler's 3rd Law

$$P^2 \propto R^3 \quad \text{In traditional form}$$

$$P_{\text{years}}^2 = R_{\text{AU}}^3$$

$$P^2 = \frac{4\pi^2}{GM} R^3$$

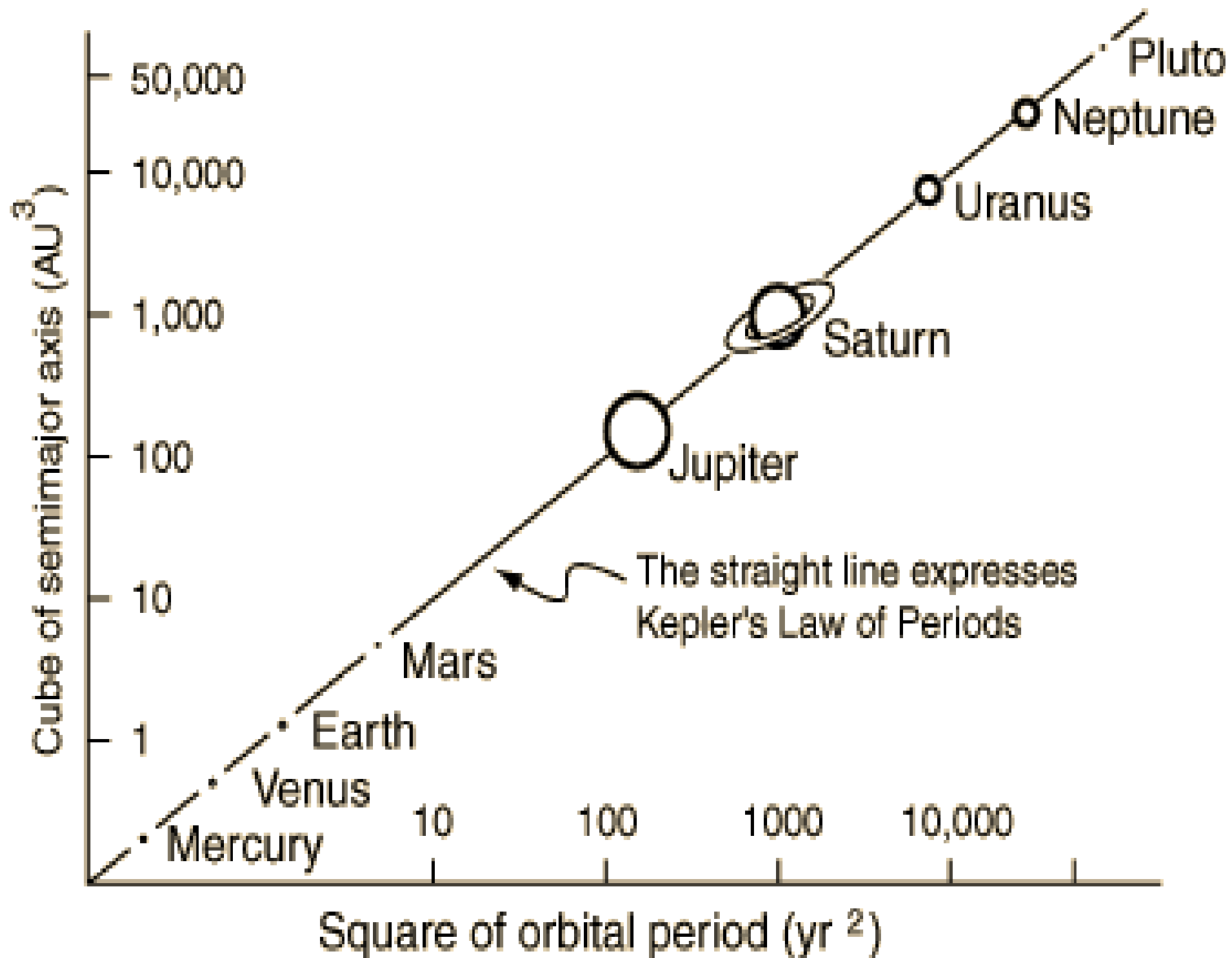
$$P = \frac{2\pi}{\sqrt{GM}} R^{3/2}$$

In Newtonian
forms

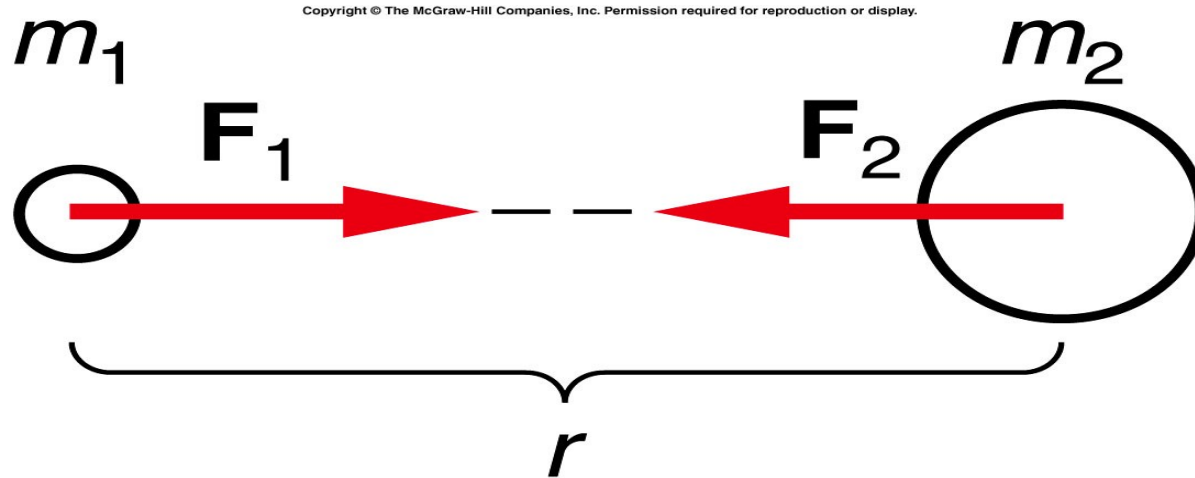
M is the mass of the
Sun and G is the
gravitational constant
as we'll see later.

If R in AU and p in years then :

$$R^3 = p^2$$



Newton's later invents calculus and explains the Kepler's law using his Law of Universal Gravitation



$$F = G \frac{m_1 m_2}{r^2}$$

He derives :

$$P^2 = \left[\frac{4\pi^2}{G(M + m)} \right] a^3$$

If $m \ll M$ then you
Get Kepler's third law.
 M is the mass of the Sun

Kepler's third law:

$$P^2 = \frac{4\pi^2}{G(m_1 + m_2)} R^3$$

R = distance between m_1 and m_2

P = orbital period

If $m_2 \ll m_1$ then ignore m_2

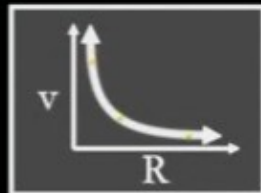
$$P^2 = \frac{4\pi^2}{Gm_1} R^3$$

Orbital Speeds of Planets

$$P^2 = \frac{4\pi^2}{GM_\odot} R^3$$

If orbit is roughly circular:

$$v \propto \frac{1}{\sqrt{R}}$$

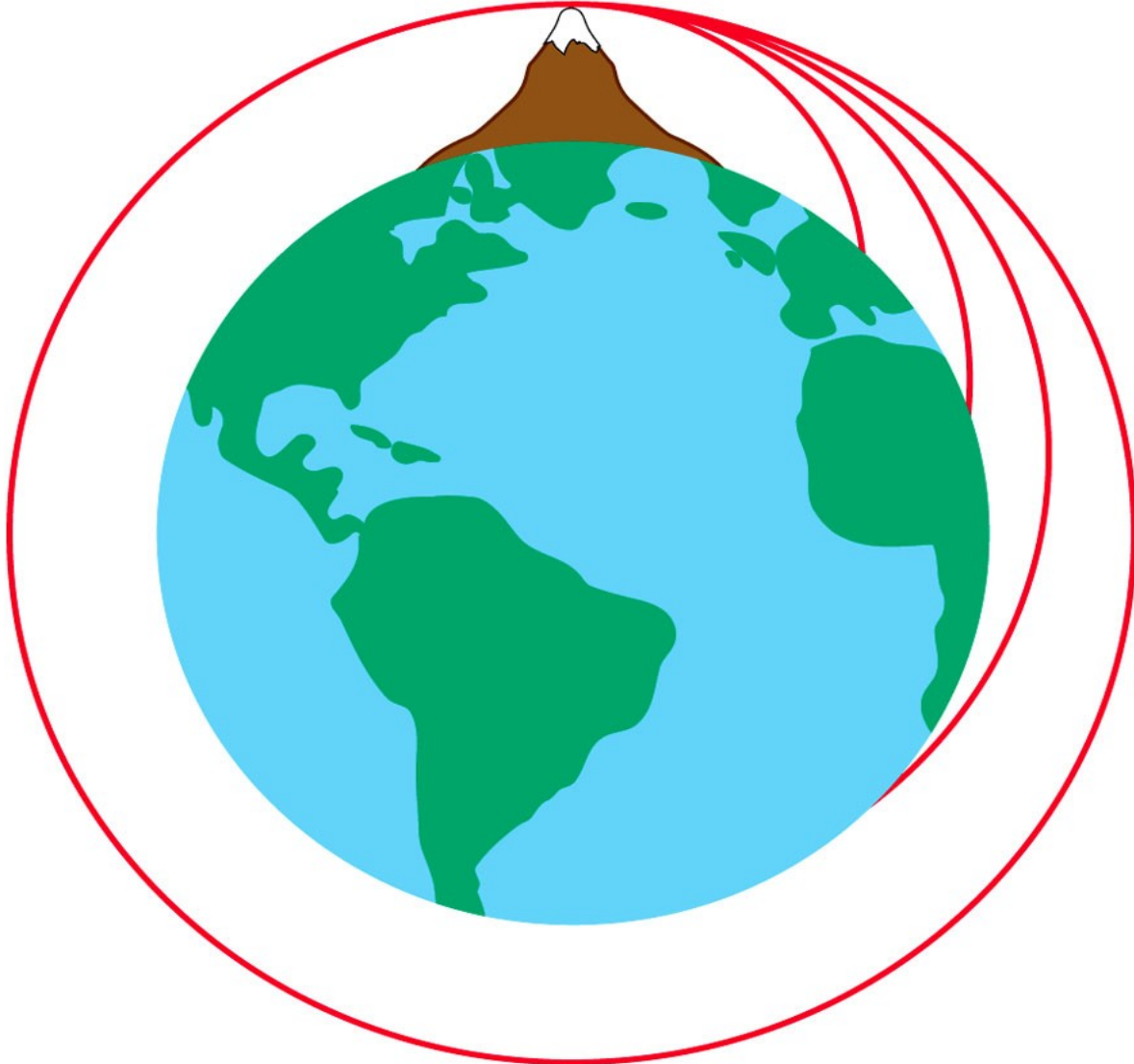


P = orbital period

R = distance from Sun

NEWTON UNIFIED MOTION on EARTH and in the HEAVEN

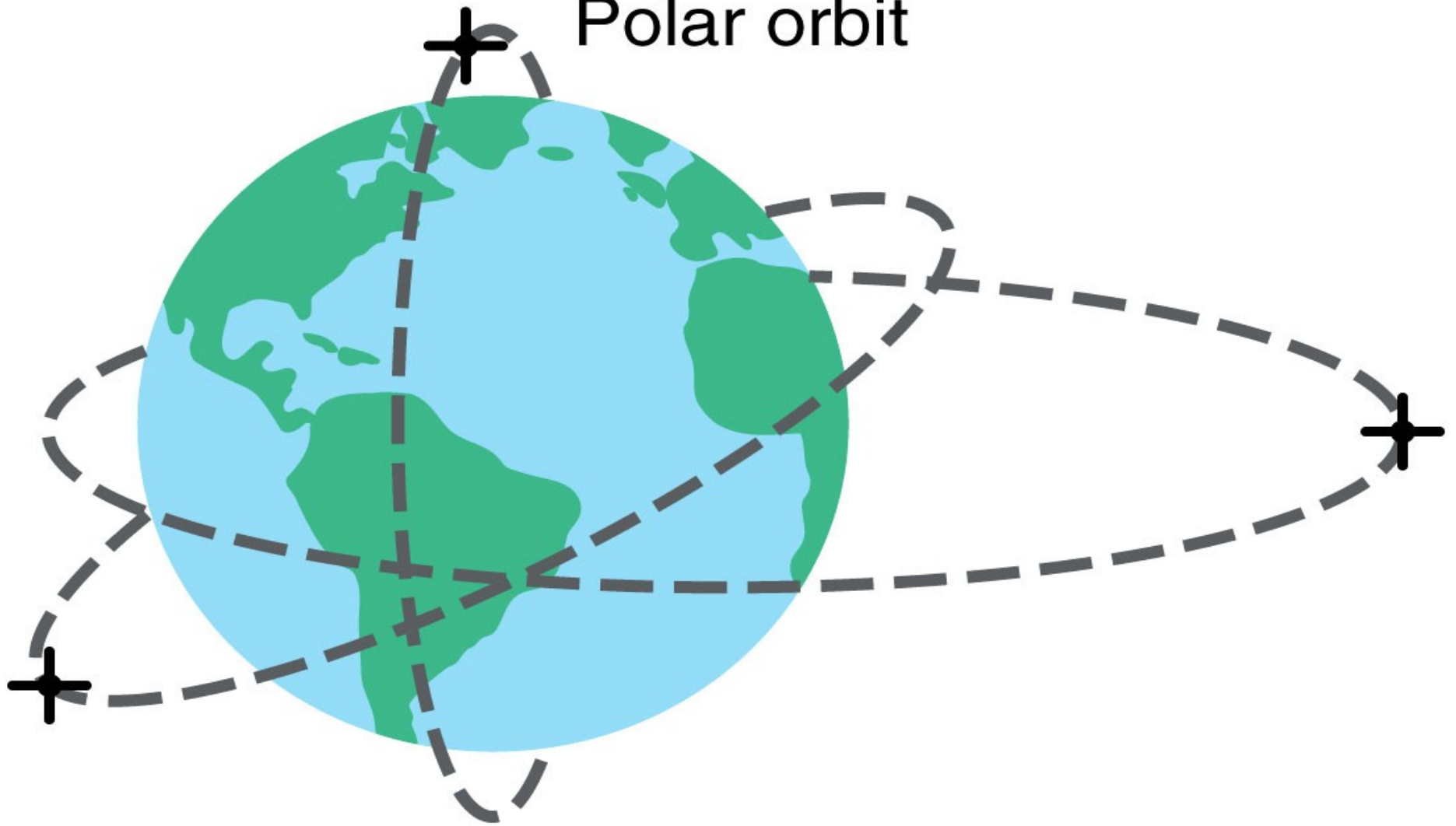
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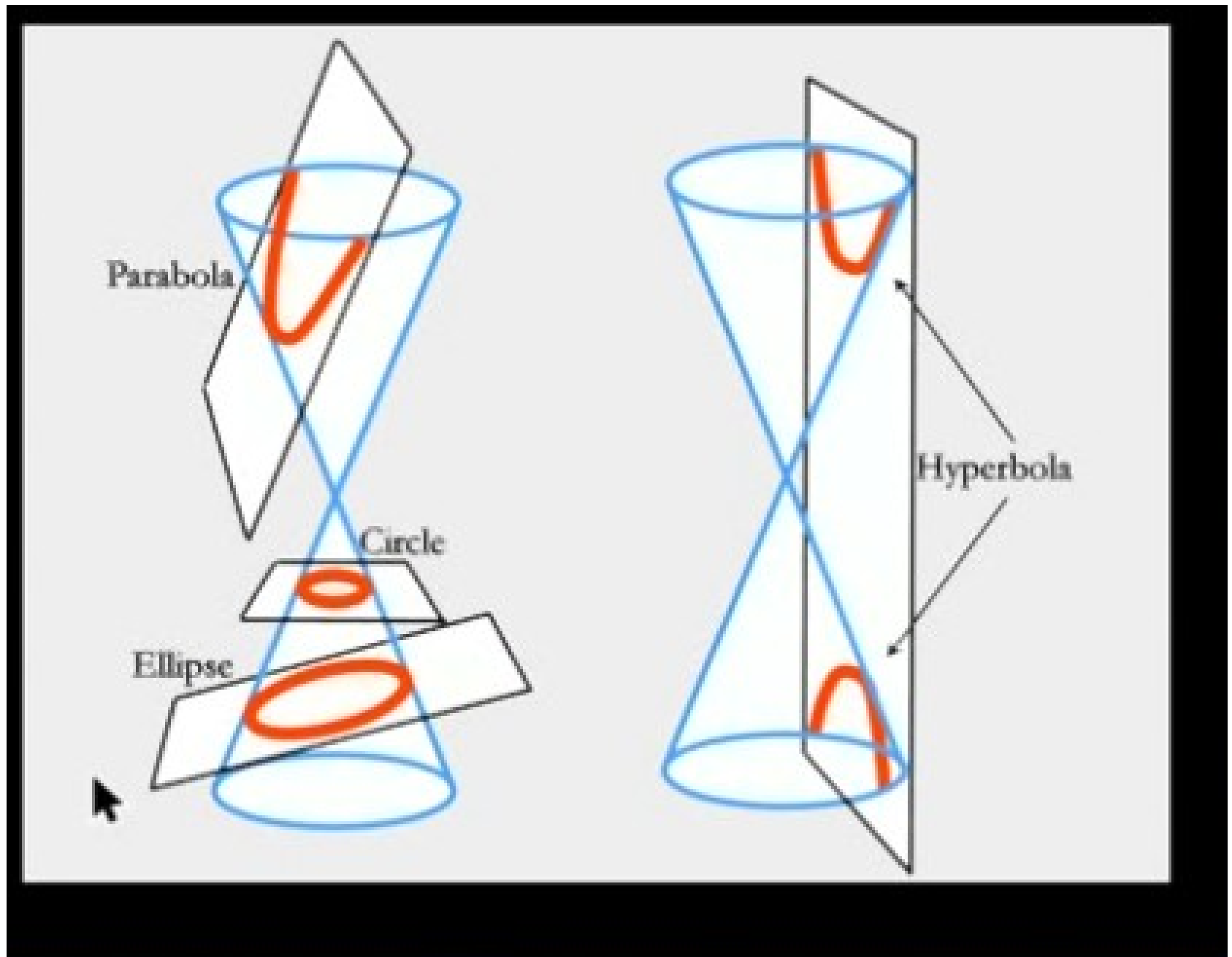
**YOUR WEIGHT =
FORCE OF GRAVITY =
SAME force that bring a apple
Back to earth=same
FORCE that explains projectile
Motion = same force
That keep the MOON
In orbit around the EARTH or
The EARTH around the SUN.**

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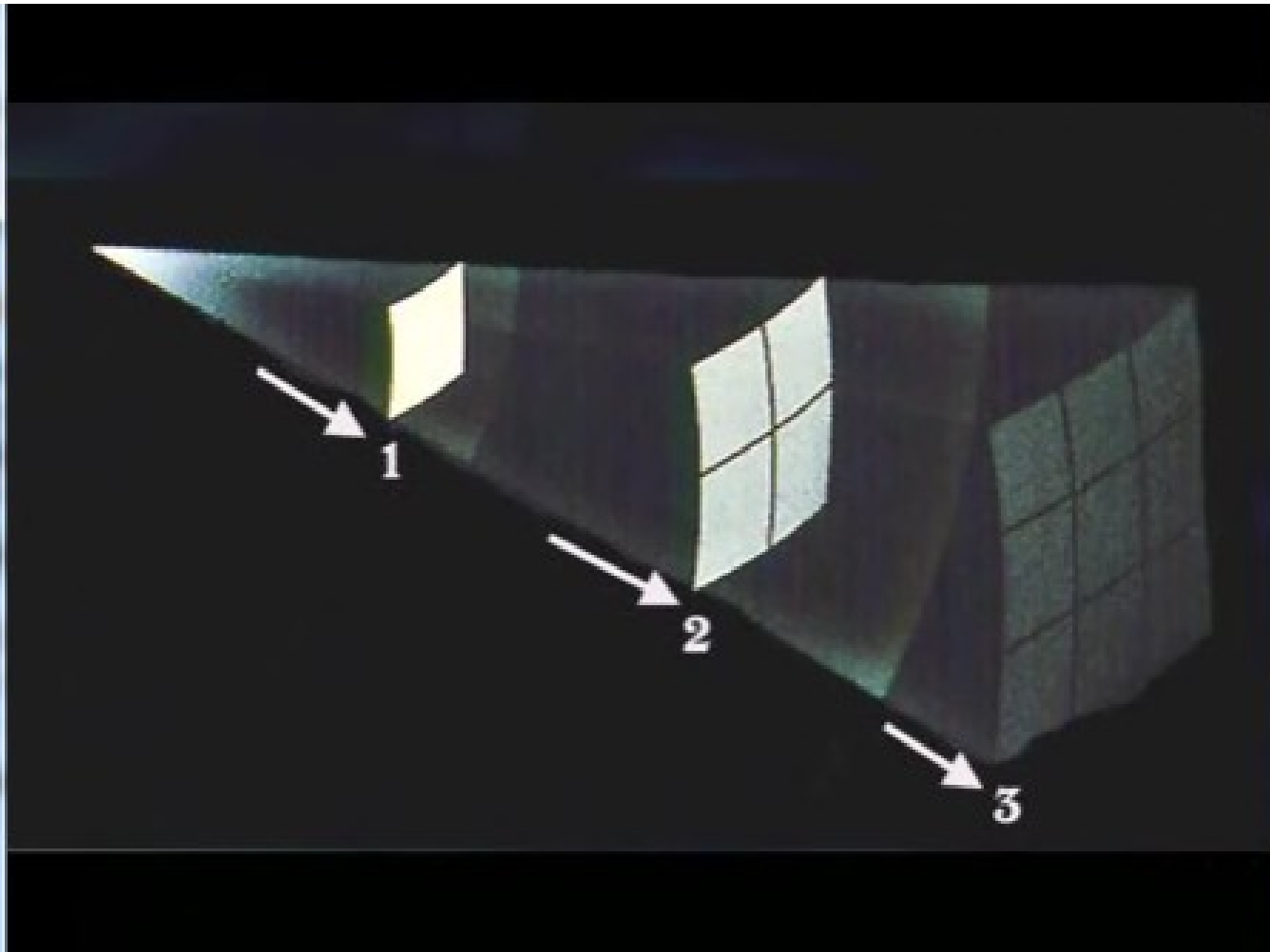
Polar orbit



ANY MOTION in UNIVERSE is a CONIC



Newtons found that the force of gravity is an inverse square law:
Multiply the distance by 2 and the force decreases by a factor of 4 !!!
The moon is at a distance 60 times the radius so it feels $1/60 \times 1/60$ the gravity
That we feel.



THE FORCE of GRAVITY is very WEAK unless the MASSES Are HUGE.

2 persons 150 pounds attract with a force of only 10^{-7} pounds !!!
(weight of a flea)

**The EARTH is about 10^{25} pounds. So replace ten 150 pounds by the Earth
And find the force between you (150 pounds) and the Earth (estimation)
You can do a proportion because the force is proportional to the
Product of the masses !!**

10N is about the force you need to lift 2 pounds .

<http://onlinephys.com/4forces.jpg>



<http://onlinephys.com/polargraph.pdf>