Reminder: no food or drinks in the planetarium!

Astronomy 4 - *Solar System Astronomy*
Reminders

Instructor: Dr. Ann Marie Cody

codyannmarie@fhda.edu

-Feel free to email me about course questions or astronomy in general.

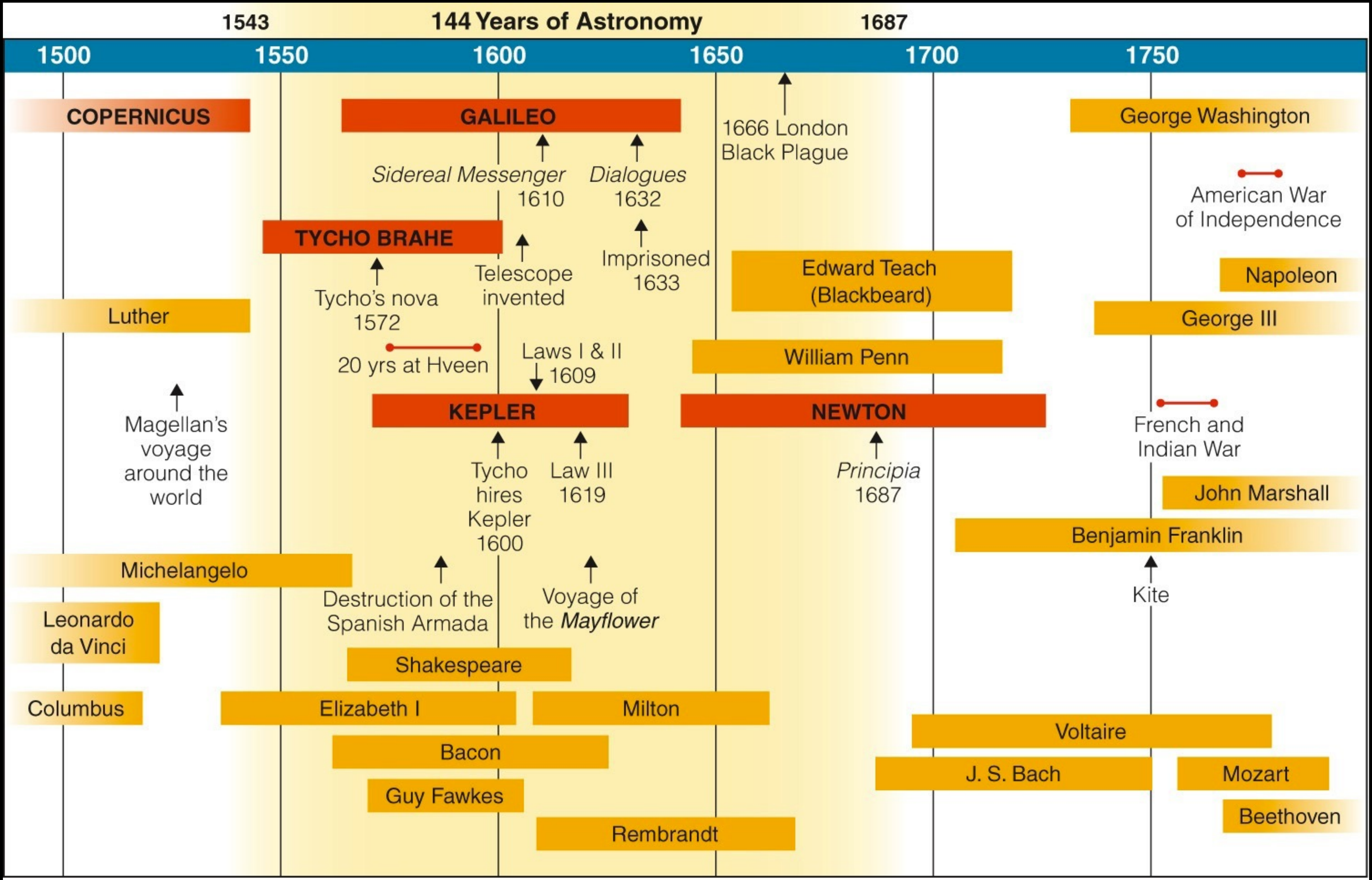
Class website:

-*https://amcody.github.io/astro4*

Your one-stop shop for anything course related, including homework readings and exam practice material.

Lost and found:

-At the end of class, check to make sure you aren't leaving anything behind. Any items will be added to the Lost and Found box in back.


144 Years of Astronomy
1543
1687
1500
1550
1600
1650
1700
1750
COPERNICUS
GALILEO
Sidereal Messenger 1610
Dialogues 1632
Imprisoned 1633
1666 London Black Plague
George Washington
American War of Independence
TYCHO BRAHE
Tycho's nova 1572
Telescope invented
20 yrs at Hveen
Laws I & II 1609
Edward Teach (Blackbeard)
Napoleon
Luther
George III
William Penn
Magellan's voyage around the world
KEPLER
NEWTON
French and Indian War
Tycho hires Kepler 1600
Law III 1619
Principia 1687
John Marshall
Benjamin Franklin
Michelangelo
Kite
Destruction of the Spanish Armada
Voyage of the Mayflower
Leonardo da Vinci
Shakespeare
Columbus
Elizabeth I
Milton
Voltaire
Bacon
J. S. Bach
Mozart
Guy Fawkes
Beethoven
Rembrandt

Johannes Kepler
1571 - 1630

Johannes Kepler 1571 - 1630 -

1. Was a priest and Lawyer
2. Had artificial wooden and silver noses
3. Probably died of Mercury poising
4. Rumored to have died when his bladder burst
5. Was blind at the time of his death
6. Was labeled a heretic by the church

Johannes Kepler 1571 - 1630 -

None of these.

He was a deeply religious man and a family man.

He was rumored to have hated Tycho Brahe and was in the relationship for the data. With that data he changed the understanding of motion of heavenly bodies forever.

He was also a writer, who wrote children's stories about the heavens.

Johannes Kepler 1571 - 1630
is known for -

1. First telescope observations of the sun
2. First sun centered scientific model of the solar system or universe
3. Being the world’s best naked-eye astronomer
4. Creating first a theoretical model to explain planetary motions
5. Creating first a theoretical model for explaining gravity

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Johannes Kepler
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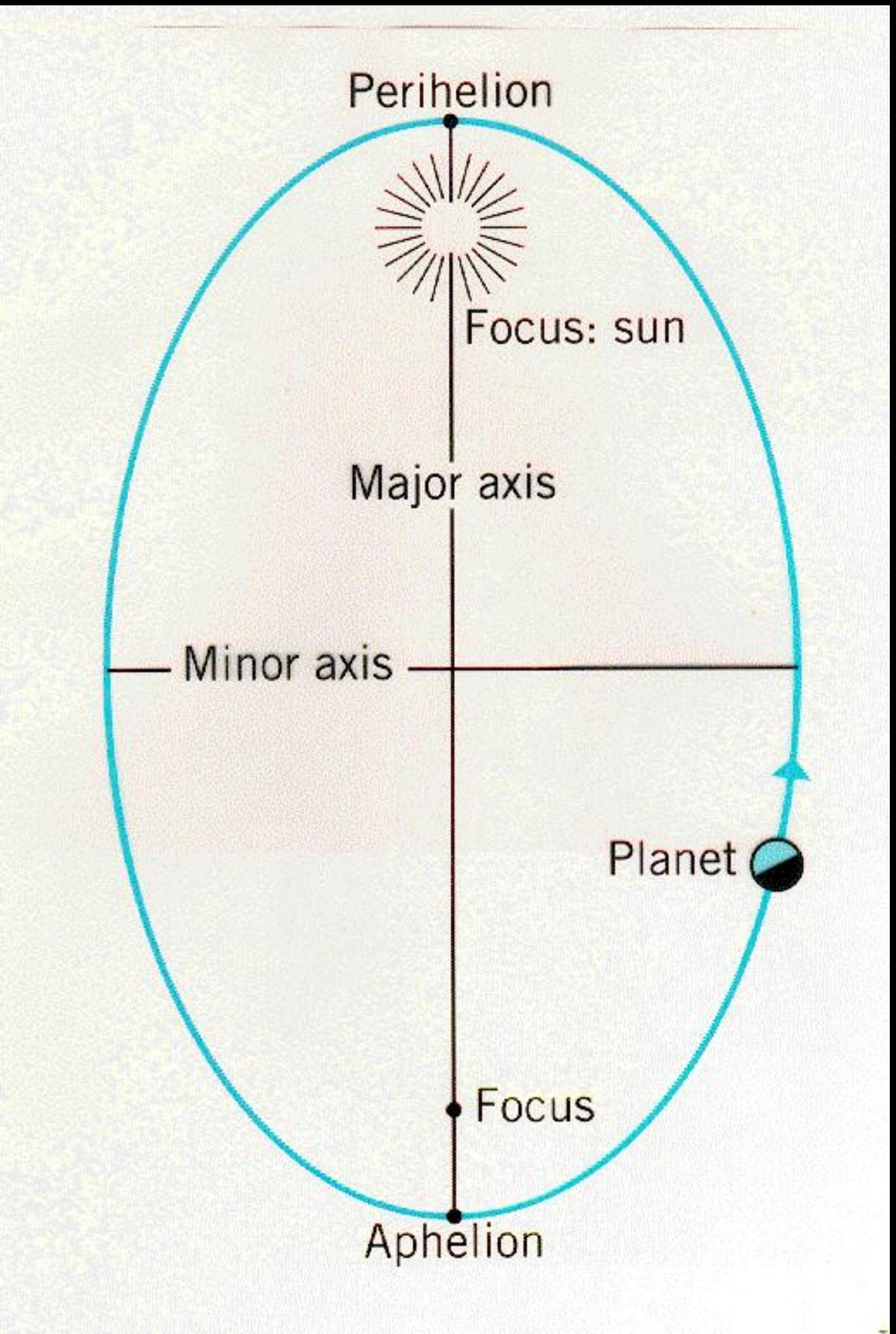
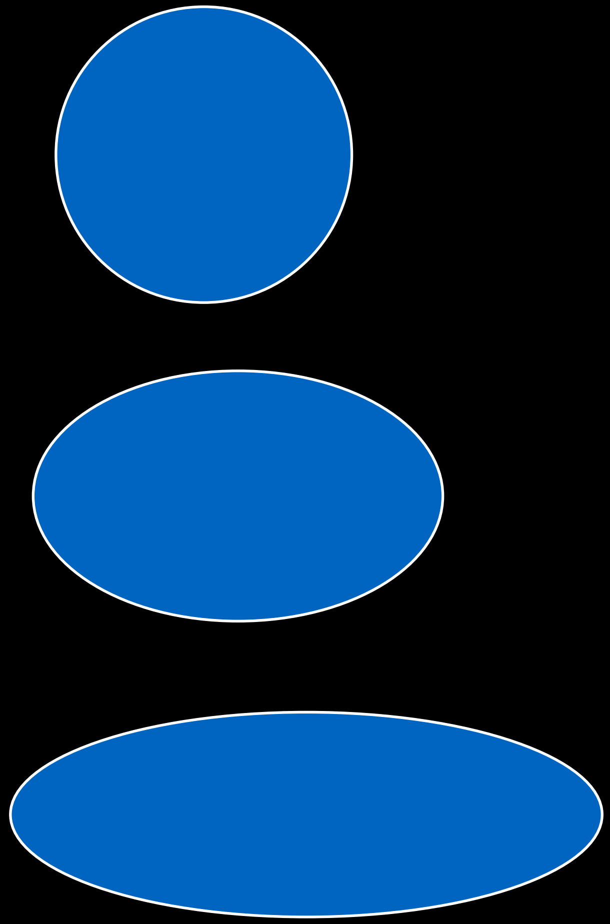
Kepler's Three Laws of Planetary Motion

Eccentricity, e



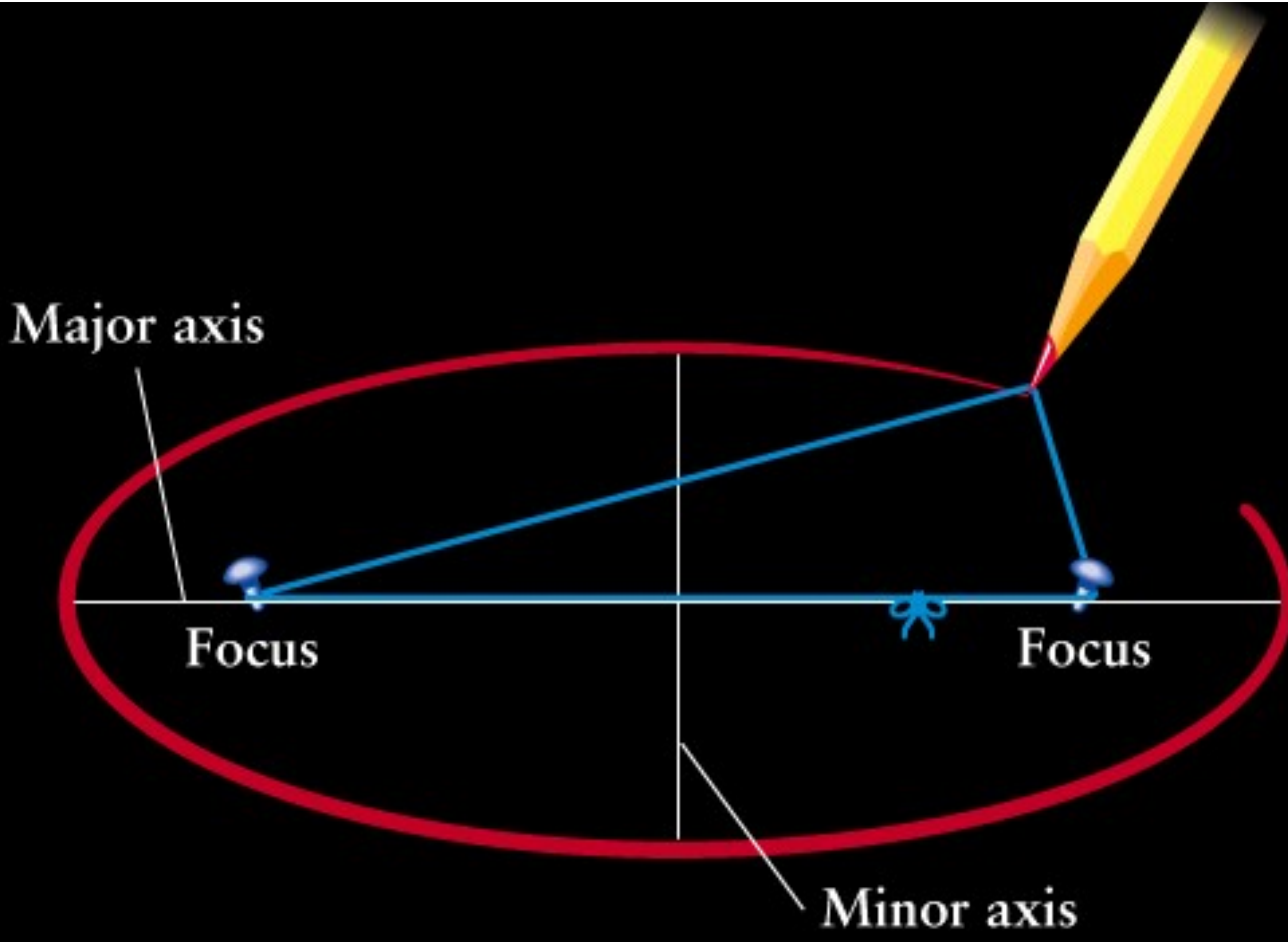
- how squashed or out of round the ellipse is
- a number ranging from 0 for a circle to 1 for a straight line



e = 0.02

e = 0.7

Kepler's First Law: The orbit of a planet about the Sun is an ellipse with the Sun at one focus.

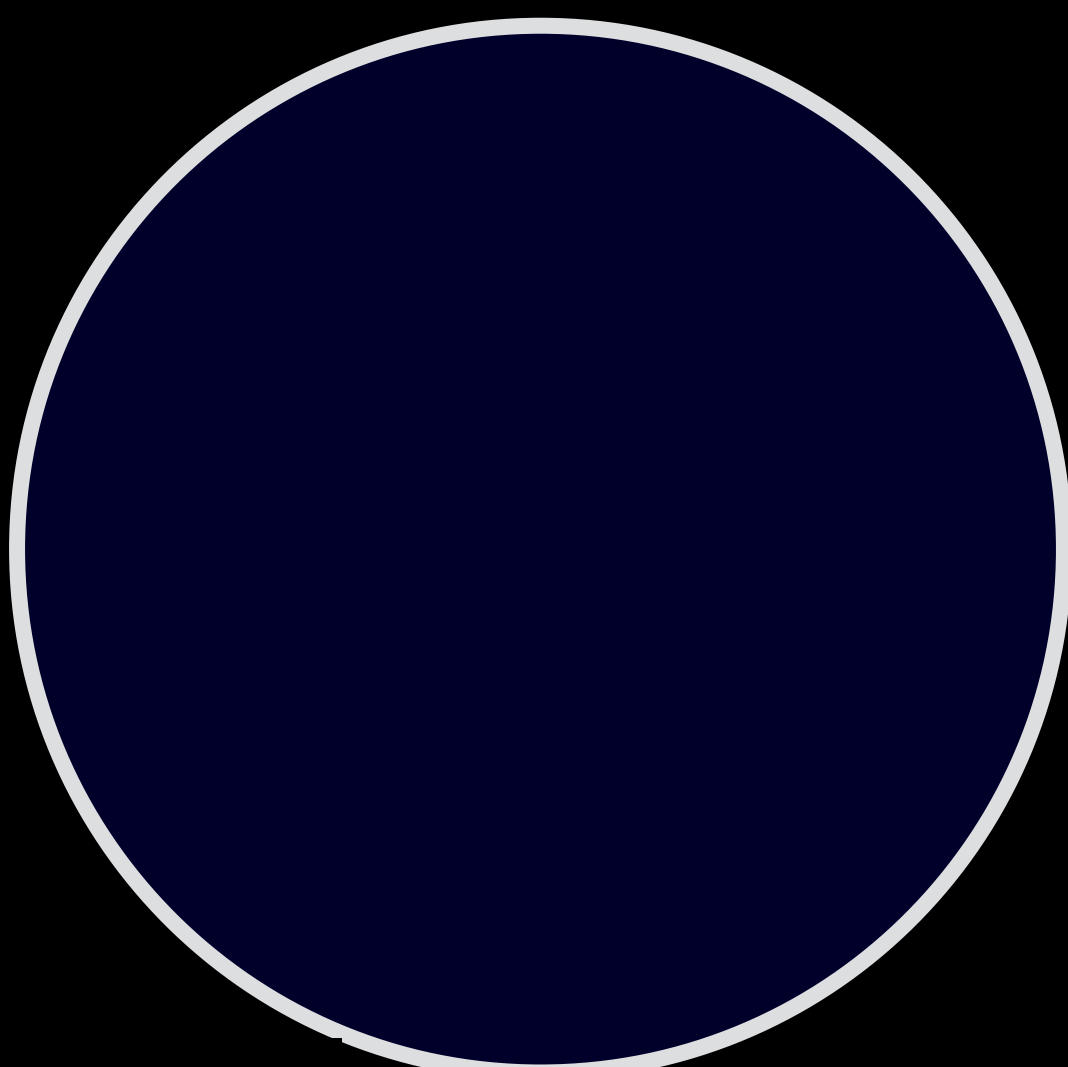


What is the shape of Earth's orbit around the Sun?

Earth, $e = 0.016$

What is the shape of Earth’s orbit around the Sun?

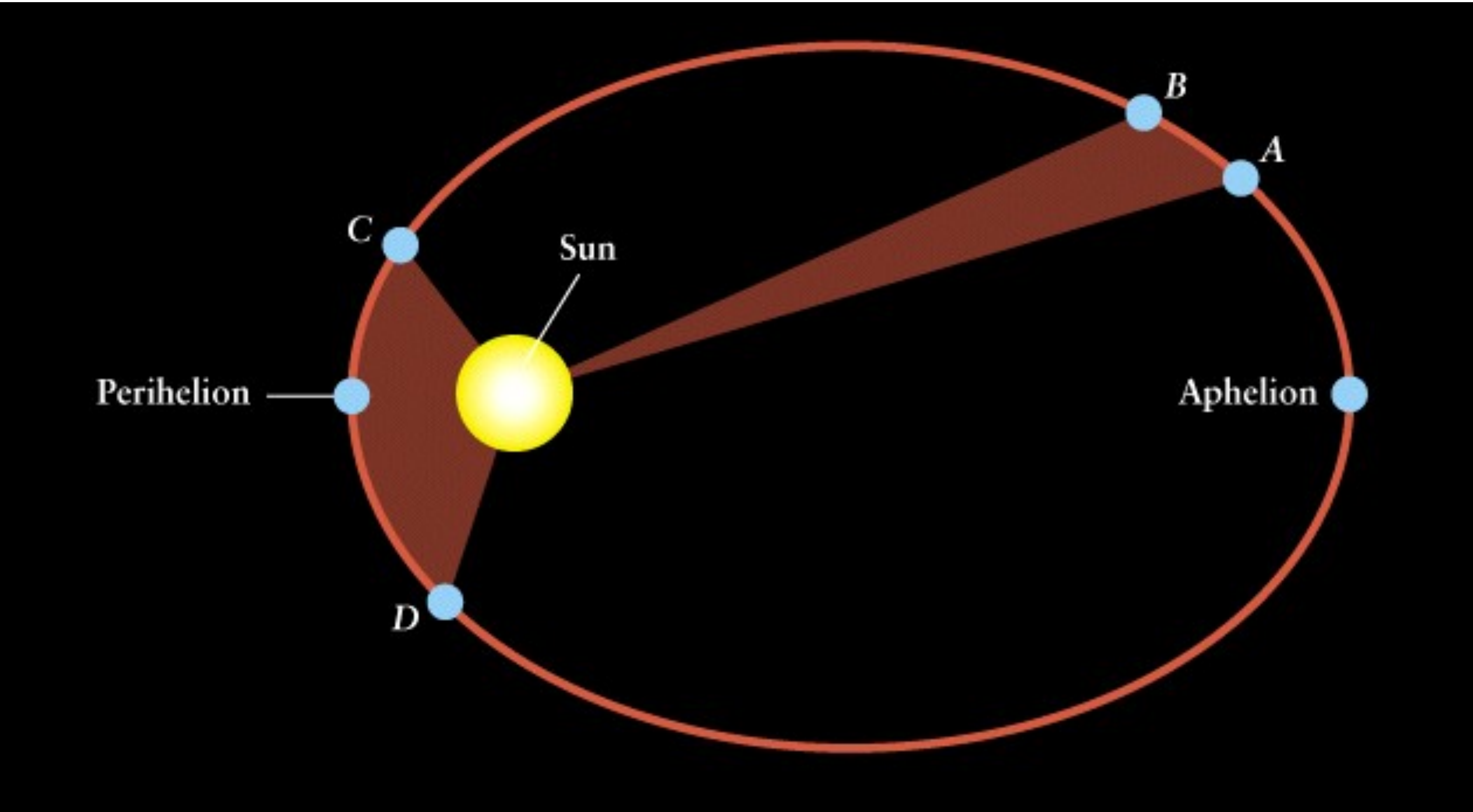
Earth, e = 0.016



SECOND LAW

- A line drawn from the planet to the Sun sweeps out equal areas in equal times

Kepler's Second Law: A line joining a planet and the Sun sweeps out equal areas in equal intervals of time.



SECOND LAW

- A line drawn from the planet to the Sun sweeps out equal areas in equal times
- **orbital speed is not constant for an ellipse only for a circle**
- **planets move faster when near the Sun (perihelion)**
- **planets move slower when they are far from the Sun (aphelion)**

THIRD LAW

- The size of the orbit determines the orbital period
  - planets that orbit near the Sun orbit with shorter periods than planets that are far from the Sun

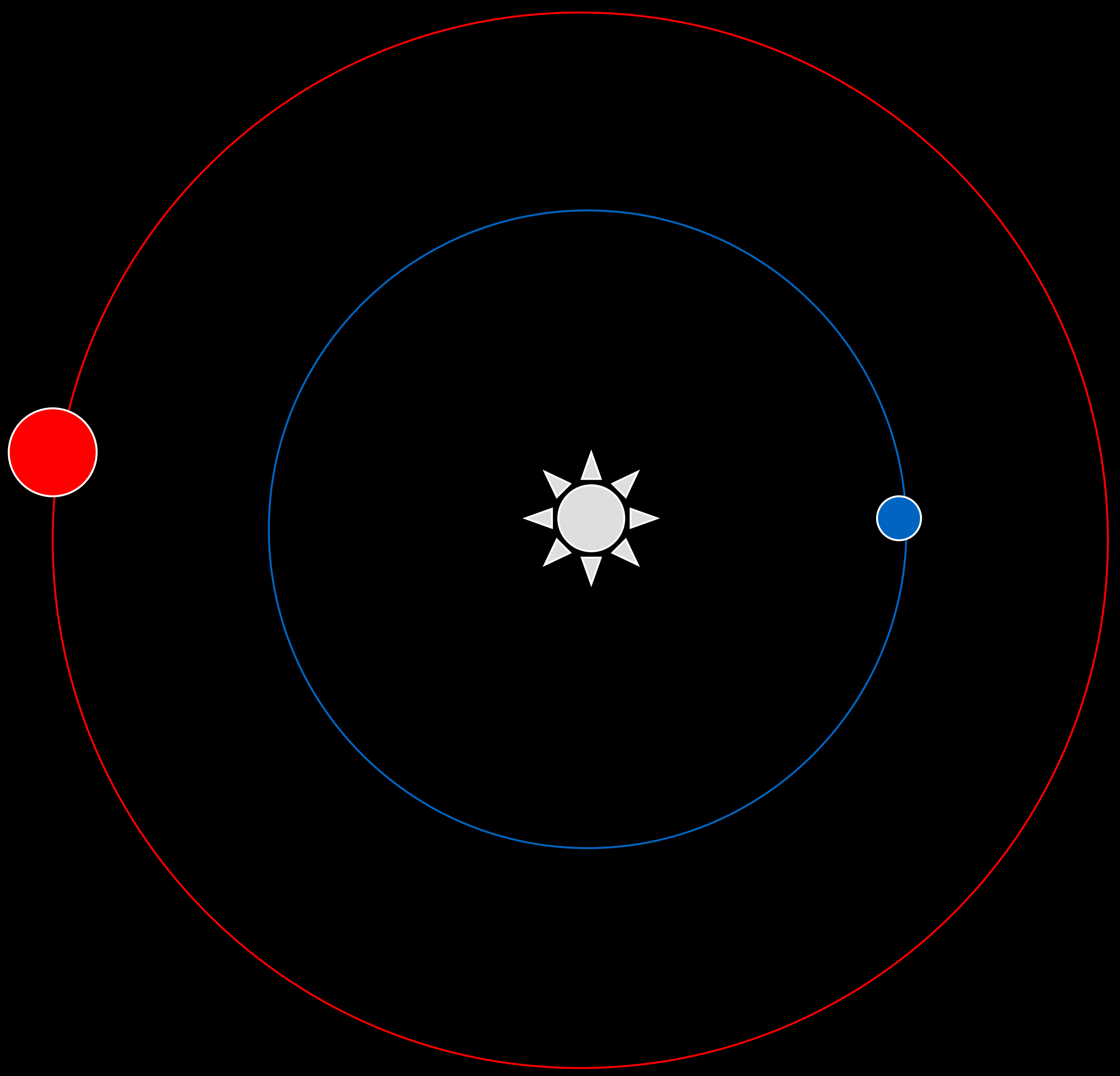
$$\boxed{a^3_{AU} = P^2_{years}}$$

For example, Jupiter’s average distance from the Sun is 5.2 AU.

- The semi-major axis cubed would be about 140.6.
- So, the period must be the square root of 140.6 or roughly 11.8 years.

THIRD LAW

- The size of the orbit determines the orbital period
  - planets that orbit near the Sun orbit with shorter periods than planets that are far from the Sun.



Kepler's Third Law: The square of a planet's sidereal (orbital) period is proportional to the cube of the length of its orbit's semimajor axis ($p^2 \approx a^3$).

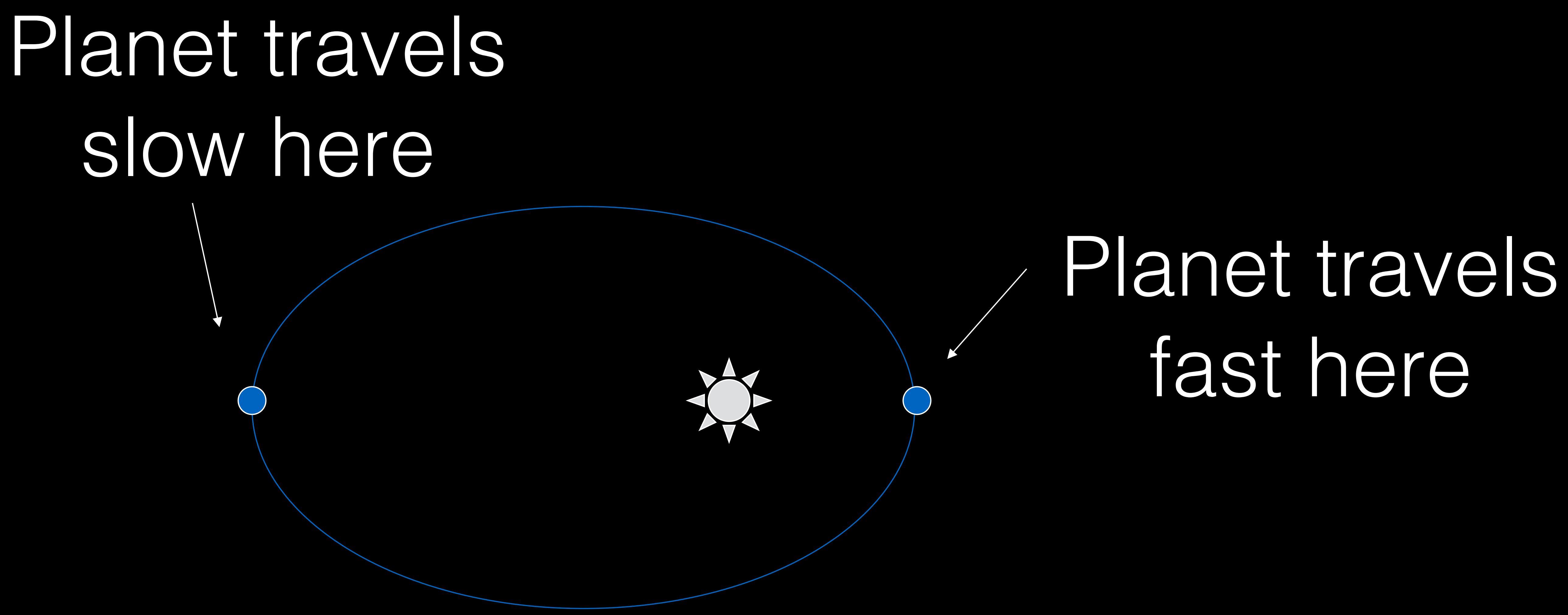
	Sidereal period P (yr)	Semimajor axis a (AU)	P^2	=	a^3
Mercury	0.24	0.390	.06		0.06
Venus	0.61	0.72	0.37		0.37
Earth	1.00	1.00	1.00		1.00
Mars	1.88	1.52	3.53		3.51
Jupiter	11.86	5.20	140.7		140.6
Saturn	29.46	9.54	867.9		868.3
Uranus	84.01	19.19	7,058		7,067
Neptune	164.79	30.06	27,160		27,160
Pluto	248.54	39.53	61,770		61,770

The Second and Third Laws

- The Second Law tells us what a particular planet does when it orbits a Star
  - The planet will move faster when it is close to the Sun and slower when it is farther from the Sun
- The Third Law how the orbital periods are related to the orbital distances for all the planets in the Solar System
  - planets that are in an orbit located near the Sun have short orbital periods
  - planets that are in an orbit located far from the Sun have long orbital periods

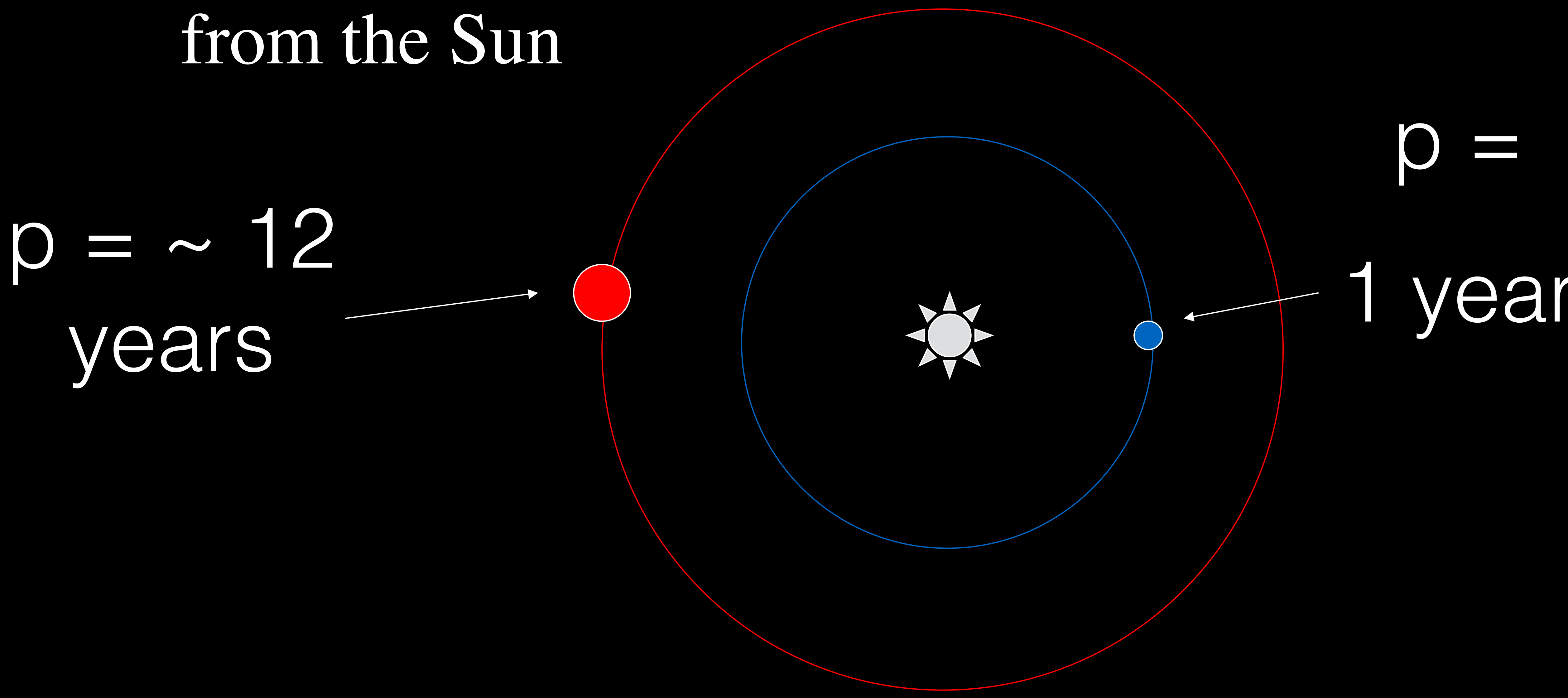
SECOND LAW

- The speed a planet travels during its orbit is related to the distance from the star
  - When the planet is near the sun the planet goes faster than when the planet is farther from the sun



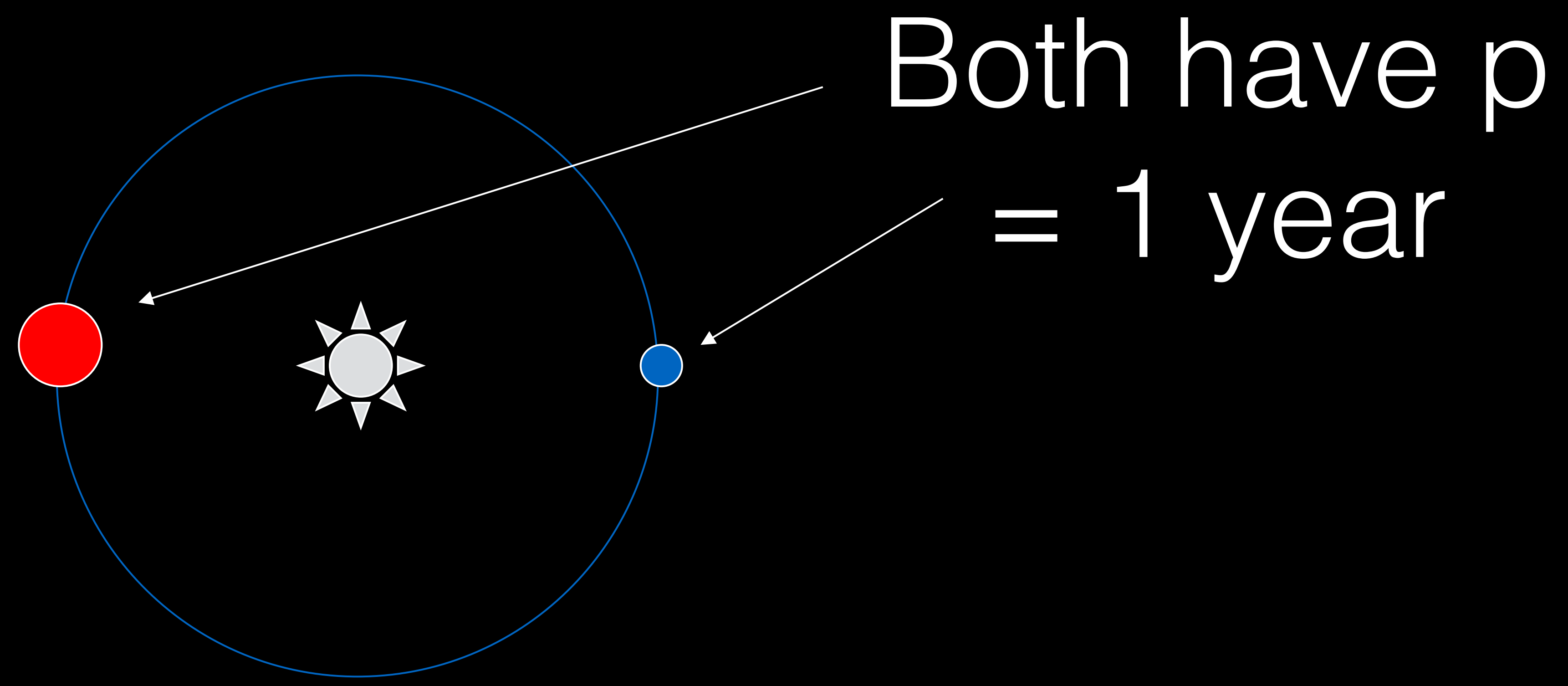
THIRD LAW

- The size of the orbit determines the orbital period
  - planets that orbit near the Sun orbit with shorter periods than planets that are far from the Sun



THIRD LAW

- The size of the orbit determines the orbital period
  - planets that orbit near the Sun orbit with shorter periods than planets that are far from the Sun
  - MASS DOES NOT MATTER



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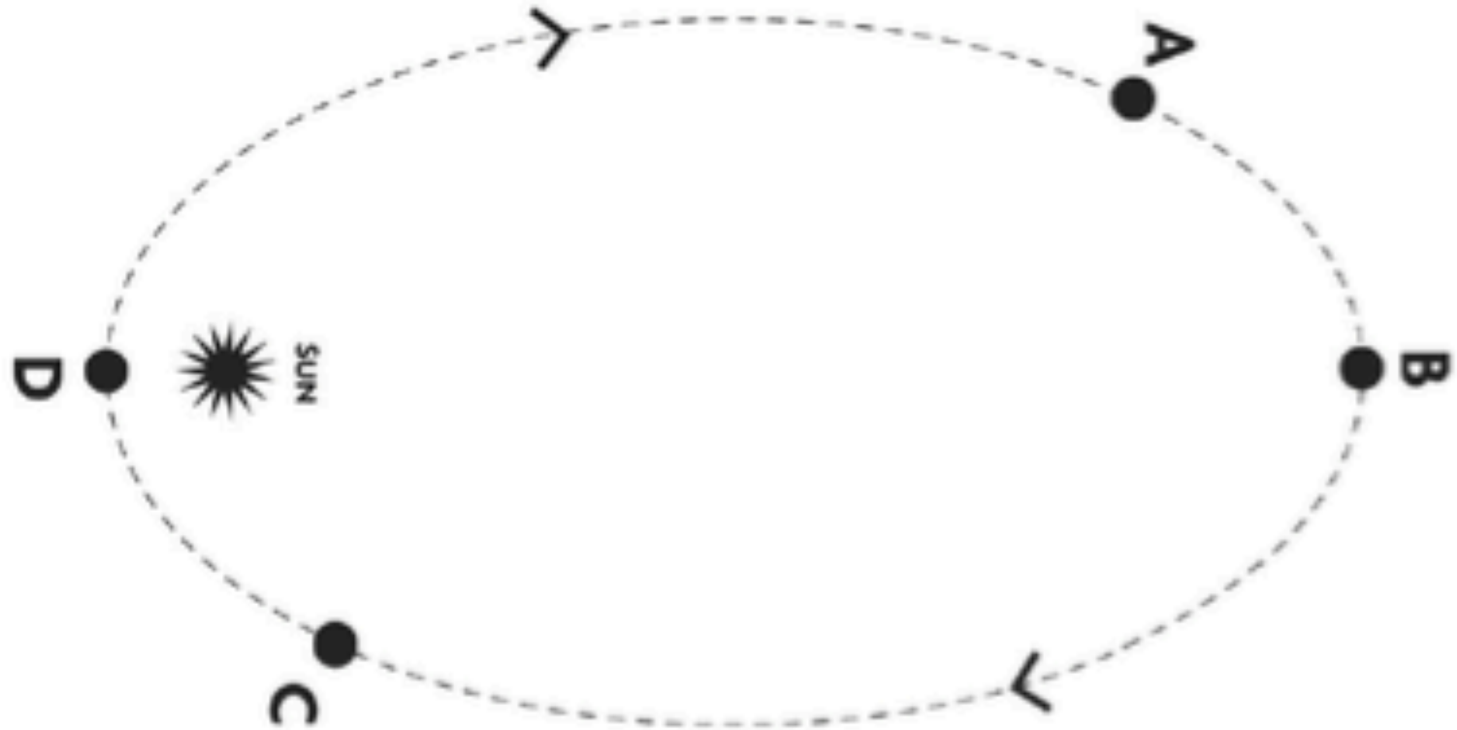
According to Kepler's second law, a planet with an orbit like Earth's would:

1. move faster when further from the Sun.
2. move slower when closer to the Sun.
3. experience a dramatic change in orbital speed from month to month.
4. experience very little change in orbital speed over the course of the year.
5. none of the above.

Description: The figure below shows four locations (A – D) of an asteroid during its elliptical orbit around the Sun.



Ranking Instructions: Rank the speed (from fastest to slowest) that the asteroid would have at each of the four locations.

Ranking Order: Fastest 1 ____ 2 ____ 3 ____ 4 ____ Slowest

Which of the following best describes what would happen to a planet’s orbital speed if it’s mass were doubled but it stayed at the same orbital distance?

1. It would orbit half as fast.
2. It would orbit less that half as fast.
3. It would orbit twice as fast.
4. It would orbit more than twice as fast.
5. It would orbit with the same speed.

Kepler's second law says "a line joining a planet and the Sun sweeps out equal areas in equal amounts of time." Which of the following statements means nearly the same thing?

1. Planets move fastest when they are moving toward the Sun.
2. Planets move equal distances throughout their orbit of the Sun.
3. Planets move slowest when they are moving away from the Sun.
4. Planets travel farther in a given time when they are closer to the Sun.
5. Planets move the same speed at all points during their orbit of the Sun.

If a small weather satellite and the large International Space Station are orbiting Earth at the same altitude above Earth's surface, which of the following is true?

1. The large space station has a longer orbital period.
2. The small weather satellite has a longer orbital period.
3. Each has the same orbital period

Check out the planet orbit simulator!

https://astro.unl.edu/naap/pos/animations/kepler.html

Isaac Newton, Gravity, and Orbits

- Galileo died in January 1642.
- Some 11 months later, on Christmas day 1642, Isaac Newton was born in the English village of Woolsthorpe.

- Famous for

1) Physics
2) Telescope
3) Calculus

Isaac Newton (1642 – 1727) is known for -

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Newton's Three Laws of Motion

First Law - A body remains at rest or moves in a straight line at a constant speed unless acted upon by an outside (net) force.

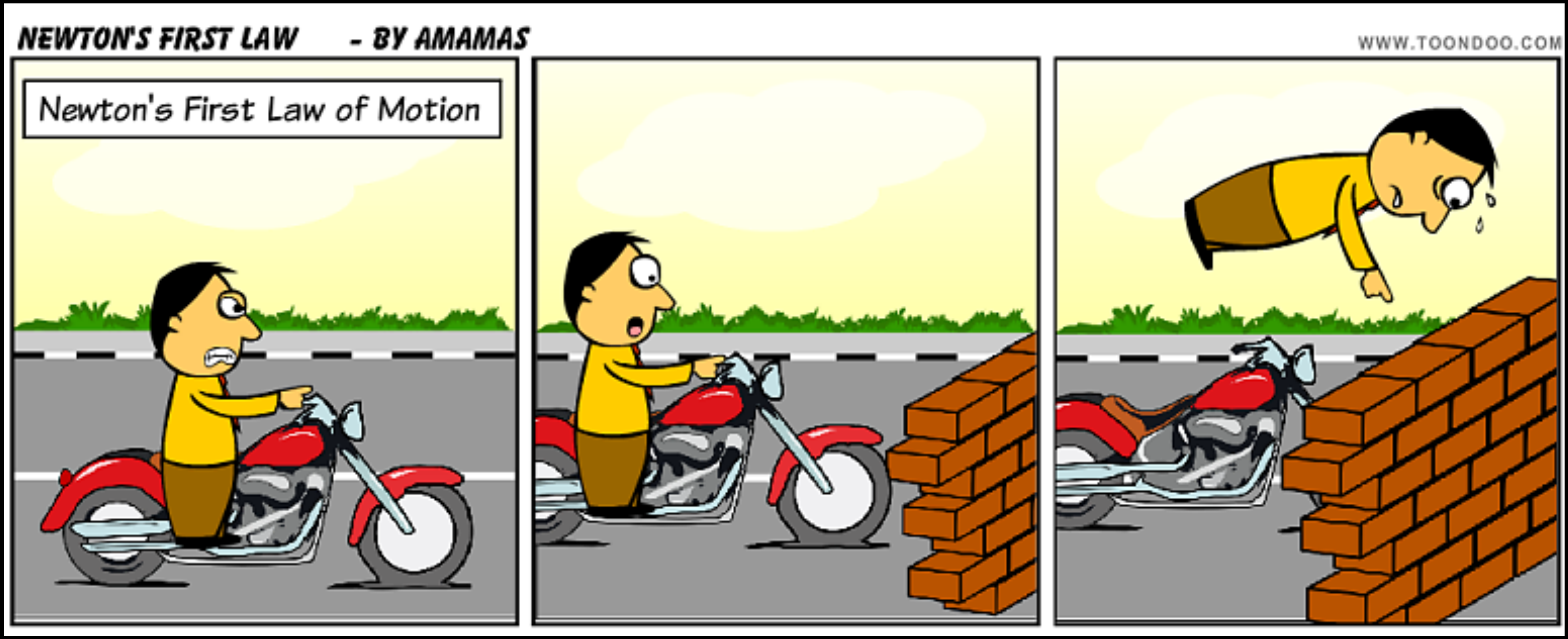
Second Law - (net) Force = mass x acceleration

Third Law - Whenever one body exerts a force on a second body, the second body exerts an equal and opposite force on the first body.

Newton's First Law

- A body remains at rest or moves in a straight line at a constant speed unless acted upon by an outside (net) force.
- A rockets will coast in space along a straight line at constant speed.
- A hokey puck glides across the ice at constant speed until it hits something

Newton's First Law

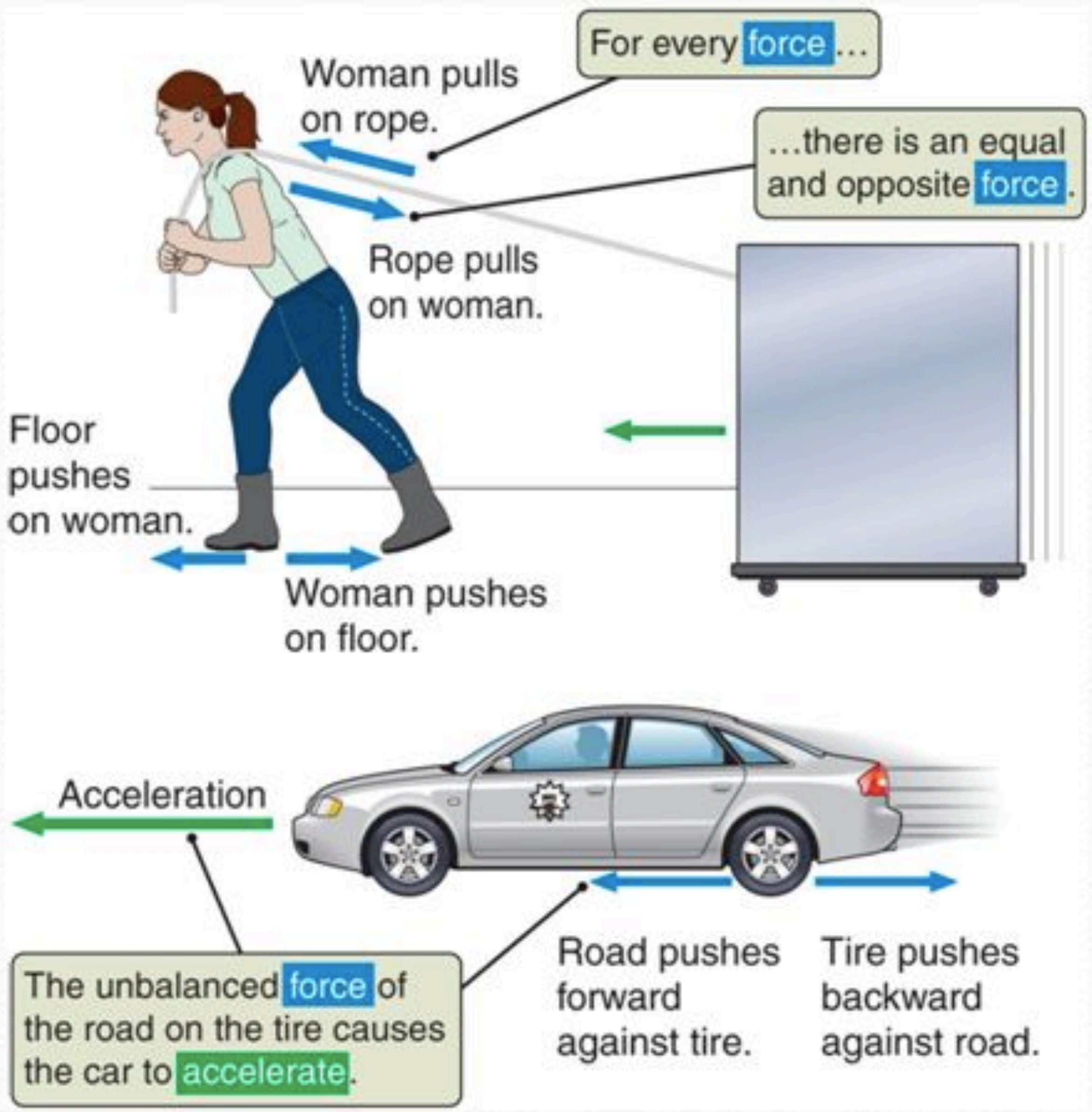


Newton’s Second Law of Motion

- (net)Force = mass x acceleration or
  $F_{net} = m \times a$
- Acceleration is the rate of change in velocity – or how quickly your motion is changing.
- Three accelerators in your car!!

Newton’s Third Law of Motion

- Whenever one body exerts a force on a second body, the second body exerts an equal and opposite force on the first body.
- Don’t need a rocket launch pad!
- The Bug and the Windshield – who is having the worse day?



- **Newton's third law of motion**: For every force, there is an equal and opposite force.
- The two forces have the same size.
- The two have opposite directions.

Newton's Laws and Kepler's Laws

- Newton's law of gravitation and his three laws of motion prove all of Kepler's laws

Imagine that you throw a ball directly upward. Which of the following statements best describes how Newton’s Second Law accounts for the motion of the ball when it reaches its maximum height?

A. The ball has a velocity that is zero and an acceleration that is zero.
B. The ball has a velocity that is upward and an acceleration that is downward.
C. The ball has a net force that is downward and an acceleration that is downward.
D. The ball has a net force that is downward and a velocity that is downward.
E. The ball has a net force that is downward and an acceleration of zero.

Can an object that is not moving be accelerating?

A. No, to accelerate you have to be moving
B. Yes, but only if it has never moved before
C. Yes, objects are always accelerating
D. Yes, it could be changing direction