

Monday, Sep. 15

Syllabus, class notes, and homeworks are at:

www.as.utexas.edu → courses → AST 301, Lacy

Reading for this week: chapter 5

The exam this Friday will cover ch. 1-4.

Get a review sheet in back on your way out.

The observing homework is due this Friday. You should have seen the Moon several times. Say what you saw of the planets (even if you didn't see much).

The Wednesday help session has been moved to GRG 424 at 5:00 (for the entire semester).

Note the new time and place.

Topics for last week and today

Describe the models of Aristotle, Copernicus, and Kepler.

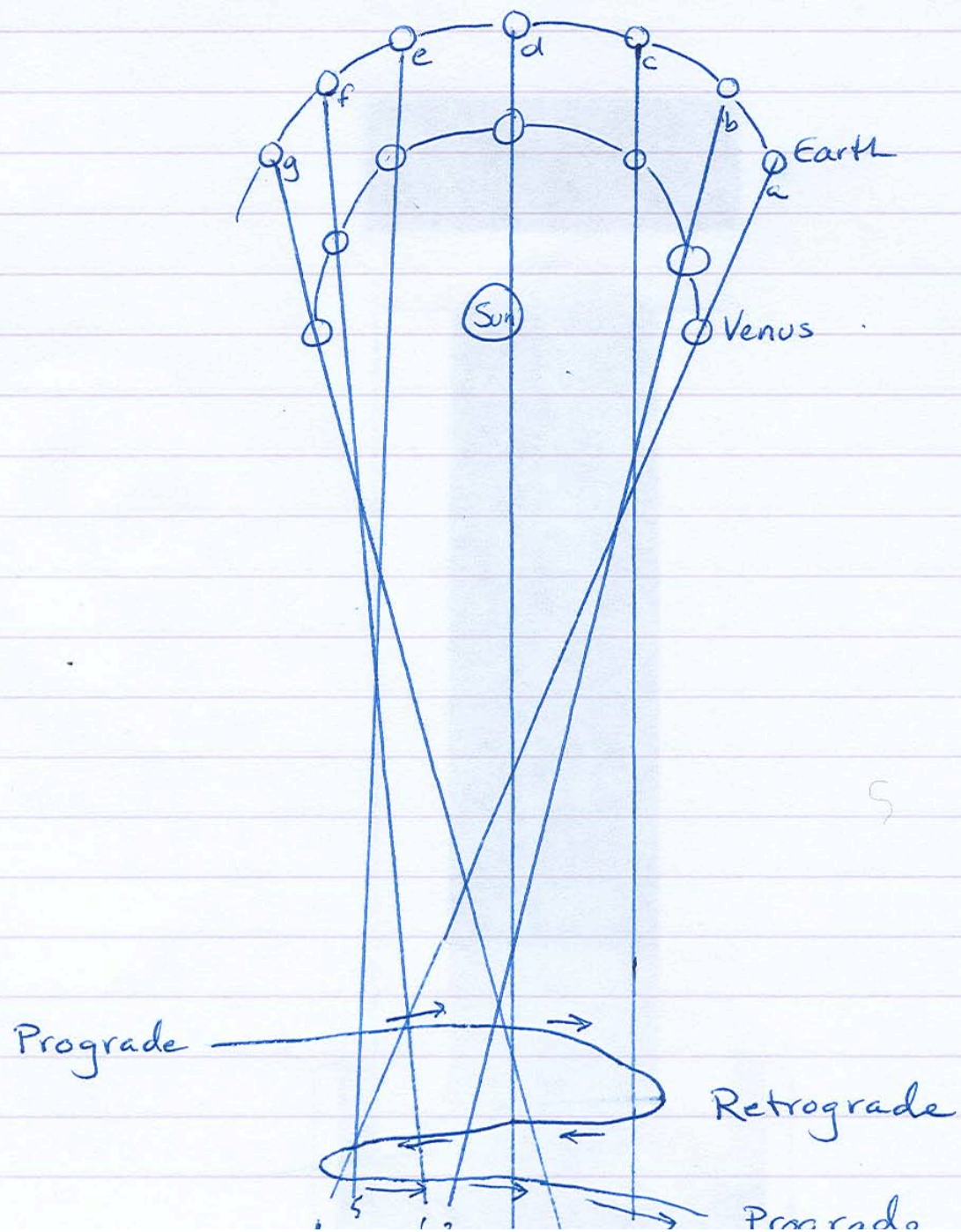
How correct and how accurate was each? How did each explain retrograde motion of the planets?

State each of Kepler's 3 laws and be able to use them to compare speeds of different planets and of one planet at different points in its orbit.

What arguments did Galileo make in favor of the Copernican model?

State Newton's 4 laws. Know what the words in each mean. Apply them to the problem of falling balls.

What did Newton add to our understanding of Kepler's laws?



Retrograde and prograde motion

Mars' normal (prograde) motion is caused by its counterclockwise motion around the Sun.

Mars moves in the retrograde direction when the Earth passes it up, making it appear to move in a clockwise direction.

Venus' prograde motion is caused by the Earth's motion around the Sun. This causes a counterclockwise apparent motion of Venus (and the Sun). Venus moves in the clockwise (retrograde) direction when it passes us.

Kepler's laws (or rules)

1. The planets move on elliptical paths with the Sun at one focus of the ellipse for each planet.

2. The speed of a planet changes during its orbit, moving fastest when it is closest to the Sun and slowest when it is farthest from the Sun.

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

3. Different planets move at different speeds, with a planet in a smaller orbit moving faster than one in a larger orbit.

The time for a planet to orbit the Sun depends on the size of its orbit according to the rule:

$$P^2 = a^3, \text{ where } P \text{ is in years and } a \text{ is in AU}$$

Kepler's 2nd law

A simpler, although not exact, way to state Kepler's second law is to say:

The distance traveled by a planet in a given time is inversely proportional to the planet's distance from the Sun during that time.

Or the speed of a planet is inversely proportional to its distance from the Sun.

This means that if at one time a planet is twice as far from the Sun as at a second time, it is moving $\frac{1}{2}$ as fast.

Or: closer to Sun means faster.

twice as close means twice as fast

twice as far means $\frac{1}{2}$ as fast

Proportional thinking

The distance you travel in a day is proportional to your speed.

This means that if you drive at 30 mph on Saturday and 60 mph on Sunday (and you drive for the same time on both days) you will travel twice as far on Sunday.

Written as an equation:

$$\frac{\text{distance on Sunday}}{\text{distance on Saturday}} = \frac{\text{speed on Sunday}}{\text{speed on Saturday}}$$

The time to get someplace is inversely proportional to your speed.

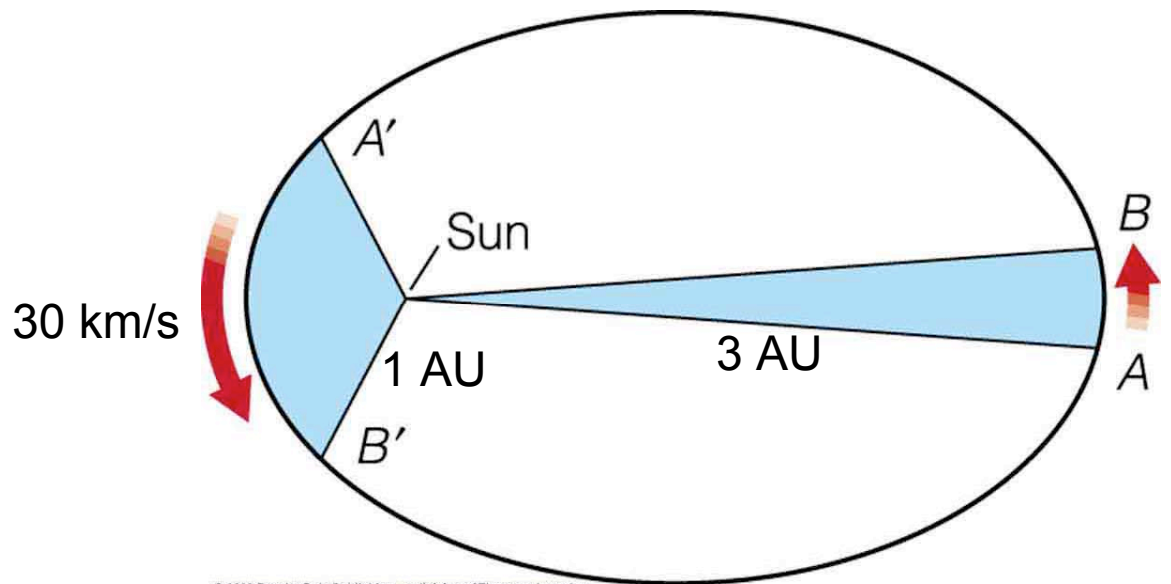
If you drive the same distance on Saturday and Sunday, but drive twice as fast on Sunday, it will take you twice as long to get there on Saturday.

$$\frac{\text{time on Sunday}}{\text{time on Saturday}} = \frac{\text{speed on Saturday}}{\text{speed on Sunday}}$$

Quiz

If the speed of the planet between A' and B' is 30 km/s, what is its speed between A and B?

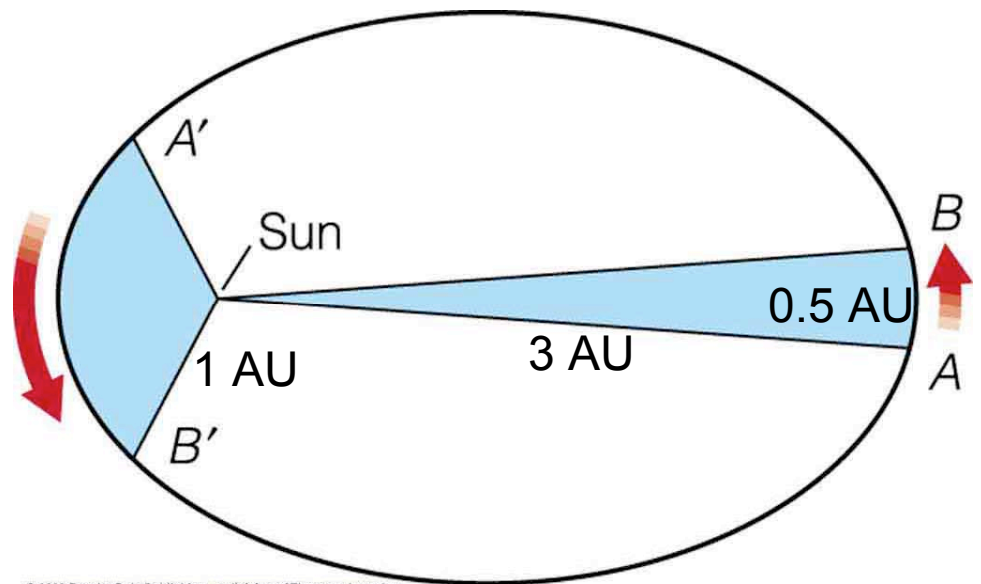
- A. 10 km/s
- B. 28 km/s
- C. 32 km/s
- D. 90 km/s



Quiz

In the figure below, given that the distance from the Sun to points A and B is 3 AU, the distance to points A' and B' is 1 AU, and the distance from A to B is 0.5 AU, what is the distance from A' to B' (along the orbit)?

- A. 0.5 AU
- B. 1 AU
- C. 1.5 AU
- D. 3 AU



Galileo

Lived about 400 years ago, while Kepler lived.

Made several observations and arguments which supported the Copernican model:

Venus has phases like the Moon's, which can only be explained if it orbits the Sun, not a point between the Earth and the Sun.

Jupiter has moons, which orbit it, not the Earth.

The Moon has mountains, so is imperfect, like the Earth.

More generally, Galileo argued for basing science on observations and experiments, not pure thought.

Newton's theory of motion

Common experience tells us that you have to push on an object to make it move and the harder you push the faster it goes.

If you stop pushing on an object it will stop moving.

Newton realized that this is a result of a complicated situation involving friction.

In a simple situation (like an object in space or a very smooth ball rolling) the rules are different.

And the rules for simple situations can be combined to explain motion in complicated situations.

Newton also realized that his laws of motion when applied to the planets could explain Kepler's laws.

Newton's laws of Motion

1. If there are no forces acting on an object, if moving it will continue to move with constant speed and in the same direction. If not moving, it will remain stationary.
2. If a force is acting on an object, the object's acceleration (the rate of change in its speed or direction of motion) is proportional to the force acting on it and is inversely proportional to its mass.
$$a \propto F / m$$
3. If an object exerts a force on a second object, the second object necessarily exerts the same force on the first, but in the opposite direction.

Definitions

speed: distance traveled / time spent traveling

acceleration: change of speed / time spent changing
(can also be a change in direction of motion)

force: how hard one object pushes or pulls on another

mass: is best defined by Newton's 2nd law, but is
proportional to the amount of matter in an object

volume: the amount of space an object takes up
for a box: height x width x depth

Quiz

If I step on my brakes and slow down from 60 mph to 30 mph, am I accelerating?

A. yes

B. No

By scientists' definition any change in speed is called acceleration, whether an increase or a decrease.

If I take my foot off of the gas and coast around a corner at constant speed, am I accelerating?

A. yes

B. no

A change in direction is also considered an acceleration, even if speed stays constant.

Quiz

If I push on my car for 5 seconds I can make it move at 2 mph. If I pushed for an additional 5 seconds with the same force, how fast would it then be going? Ignore all other forces acting on the car.

- A. 2 mph
- B. 4 mph
- C. 7 mph
- D. 10 mph

Quiz

If I push on my car for 5 seconds I can make it move at 2 mph. If two identical cars were lined up bumper-to-bumper, how fast could I make them move by pushing for 5 seconds?

- A. 0 mph
- B. 1 mph
- C. 2 mph
- D. 4 mph