

Astronomy 161, Winter 2008
Prof. Terndrup
Answers to Exam #1

Exam #1 – Friday, January 18, 2008

Enter your name here _____

All questions are worth 10 points each. Write your answer in the space provided.

If you are asked to explain, do so in one or two sentences.

1. (a) Define retrograde motion and describe what it looks like.
(b) Pick either the Ptolemaic or the Copernican model and state how retrograde motion was explained in that model. (Also state which model you are describing.)

Retrograde motion is the apparent westward motion of a planet with respect to the background stars, in contrast to its normal eastward motion. The latter is termed *prograde* motion.

In the Ptolemaic model, each planet was imagined to orbit on a small circle, called the *epicycle*, at constant speed. The center of the epicycle traced out a large orbit around the earth; this orbit is called the *deferent*. The Earth was commonly offset slightly from the center of the deferent.

In the Copernican model, the inner planets orbit the Sun at a higher speed than the outer planets. Retrograde motion occurs when the Earth overtakes and passes an outer planet.

2. Why do we have seasons?

The seasons are caused by the varying illumination from the Sun during the year. In the summer, when the Sun is high in the sky during the day, sunlight strikes the ground at an angle that is not far from the vertical. The rate that energy arrives at the Earth, expressed in Watts/square meter, is higher the summer than in the winter, when the sunlight arrives at a shallower angle and is more spread out when it hits the ground.

3. Why is the synodic month longer than the sidereal month?

The sidereal month is the period of the Moon's orbit with respect to the stars. Consider a moment in time, when the Sun and the Moon are at a particular angle with respect to one another. After one sidereal month, the Earth has moved in its orbit around the Sun, and the angle between the Moon and the Sun is no longer

what it was the previous month. Therefore the Moon has to orbit another couple of days before it returns to the original angle (i.e., original moon phase).

4. You discover a solar system object in a highly elliptical orbit with a period of 8 yr. What is the size of this object's orbit? Define specifically what you mean by "size."

The size of an orbit is the length of its semimajor axis. This length a in astronomical units (au) is related to the period P in years by Kepler's formula

$$P^2 = a^3.$$

We have $P = 8$ yr, so $a^3 = P^2 = 64$, and so $a = 4$ au. It does not matter that the orbit is elliptical, since this number does not enter into the equation we used.

5. Explain why an object in a circular orbit is experiencing an acceleration, even if it is moving at constant speed.

Acceleration is the rate of change of velocity. Velocity has two components: speed and the direction of motion. In a circular orbit, the direction of motion is constantly changing, even if the speed is not, so the object is experiencing an acceleration.

6. Consider the gravitational force between the earth and the moon. The moon experiences a gravitational force that has a size \mathbf{F} .
- What is the direction of this force?
 - The Earth also experiences a force. Is it larger than \mathbf{F} , smaller, or what? What is the direction of this force?

- The force on the Moon is directed at the Earth (i.e., it points at the Earth).
- The force on the Earth is the same size but it points in the opposite direction, namely it is directed at the Moon.

7. Describe an experiment or phenomenon which shows that the Earth actually moves as proposed by Copernicus.

There are three:

- Foucault's pendulum, whose plane of motion slowly rotates during the day;
- The aberration of starlight, a small change in the direction of (certain) stars caused by the Earth's orbital motion; and
- The rotation of large storms on the Earth from the Coriolis effect.

8. What is the phase of the moon during a lunar eclipse? What is the phase of the moon during a solar eclipse?

During a lunar eclipse, the Moon is full. During a solar eclipse, we see a New

moon.

9. What is the difference between speed and velocity?

Speed is the rate of change of an object's position. The concept of velocity combines the speed with the direction of the object's motion.

10. Below is a figure illustrating an orbit.

- Mark the place where the planet is experiencing the largest acceleration.
- Consider point marked with an \times . Mark where the planet will be one half of an orbital period later.

According to Newton's law of gravity, the acceleration is largest when the gravitational force is largest. The force gets stronger as the distance decreases, so the largest acceleration happens at closest approach (point A in the diagram below).

By the law of equal areas, the time from closest approach to farthest approach is half the orbital time. The object moves fastest when closest, so the time half an orbit later than point \times is somewhere in the vicinity of point B on the diagram.

