

PHY 1033 HIS 3931 IDH 331
Mid-term exam solutions
Exam was Oct. 20, 2016
Solutions posted Oct. 23, 2016

Part I (30 points) Multiple choice. Choose the best selection

1. Which of the following did Aristotle **not** teach?
 - a. Rest is a natural state and need not be explained further
 - b. The speed of motion is directly proportional to the mover's force ($v \propto F$)
 - c. The speed of motion is inversely proportional to the resistance of the medium through which the motion occurs ($v \propto 1/R$)
 - d. All motion requires a mover
 - ☒ e. Uniform motion is a natural state and need not be explained further.
2. Who first reached India by sailing around the South African Cape?
 - a. Ferdinand Magellan
 - ☒ b. Prince Henry of Portugal
 - c. Vasco da Gama
 - d. Christopher Columbus
 - e. Bartholomew Dias
3. Galileo was aware that the Roman Catholic church was monitoring his teaching involving Copernicanism. How did he try to circumvent its dictate not to advocate that the Earth went around the sun?
 - ☒ a. He wrote Dialogue Concerning the two Chief World Systems in the form of a discussion among three characters.
 - b. He wrote exclusively in the vernacular, which the church authorities were unable to read.
 - c. He published his work in northern Germany, where the protestant church was in the ascendant
 - d. He did not discuss the Earth's motion at all, but focused on the moons of Jupiter.
 - e. He argued that scripture, in particular the story of Joshua, was wrong.

4. The new star (supernova) of 1572 discovered by Tycho was startling to astronomers because
- a. It moved rapidly across the background of fixed stars in one night.
 - b. It appeared in the southern sky opposite Polaris, & so could be used for navigation.
 - c. Its colors were unlike any ever seen before.
 - d. No parallax was observable, so the change was taking place above the orb of the moon, in contrast to Aristotelian teachings.
 - e. It pulsed rapidly, with a period of approximately 1 second.
5. Which of the following Aristotelian elements can be found in the heavens?
- a. water
 - b. fire
 - c. air
 - d. quintessence (also called aether)
 - e. all of them
6. Kepler is known for introducing a new approach to the analysis of the solar system. What did it involve?
- a. He discredited Copernicus's system by proving Tycho correct
 - b. He incorporated ancient Aristotelian aspects of motion into his theory
 - c. He asked for the first time what caused the planets, including the Earth, to move
 - d. His 5-solid theory accurately accounted for the individual sizes of planetary orbits
 - e. He showed that the period of a planet was proportional to the square of its distance from the sun ($T \propto R^2$)
7. Why do historians feel that astronomy was in a "crisis state" on the eve of Copernicus' writings?
- a. The expanding maritime sector demanded better ways to locate position on the ocean
 - b. Fog banks over Europe in the 16th century prevented careful astronomical observation
 - c. Inaccuracies in the astronomical calendar had led to church festivals falling on the wrong dates
 - d. both a & b
 - e. both a & c
8. Galileo mistakenly thought he had empirical evidence that the earth moved. On what was it based?
- a. His telescopic observations
 - b. His theory of tides
 - c. His theory of circular inertial motion
 - d. His theory of sunspots
 - e. His theory of floating bodies

9. The condemnations of 1277 represented the reaction of the Roman Catholic church to teachings of Aristotelians that they regarded as counter to scripture. What did they forbid?

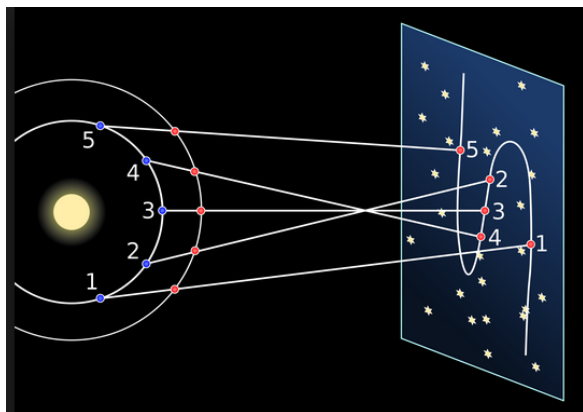
- a. advocating that god could *not* make other worlds
- b. advocating that the universe was eternal, and had always existed
- c. advocating that the Earth went around the Sun
- d. both a and b
- e. both b and c

10. What argument did Osiander make in the preface to *De Revolutionibus Orbium Coelestium* to try to soften Copernicus' message?

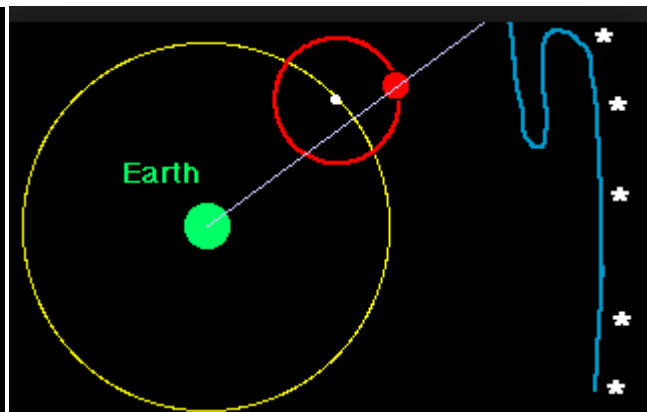
- a. Copernicus had always been an exemplary Christian
- b. Copernicus' system was equivalent to Tycho's
- c. Copernicus was proposing his system only as a calculational scheme
- d. A heliocentric system did not contradict scripture because the bible should not be taken literally
- e. None of the above

Part II (40 points) Short answer questions. Answer the following as briefly as possible. You should not need more than one or two sentences and/or a small sketch, as appropriate.

1. Explain with words and two diagrams the phenomenon of **retrograde motion of planets** in a) Ptolemy's model; and b) Copernicus' model

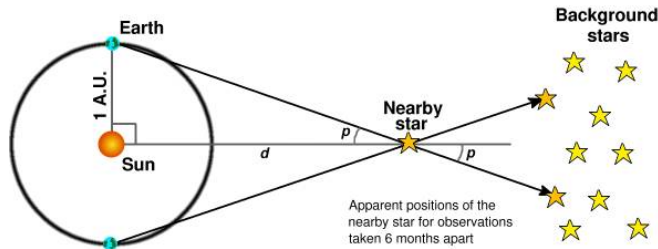


Heliocentric



Geocentric

In the heliocentric picture, the differing speeds of the planets on their orbits provides a natural explanation of the apparent retrograde motion with respect to the fixed stars. In the geocentric, e.g. Ptolemaic system, the planet moves on an epicycle which may give retrograde motion if the epicyclical and deferential velocities are chosen correctly. Other geocentric schemes, e.g. that of Eudoxus, were also acceptable as answers here.



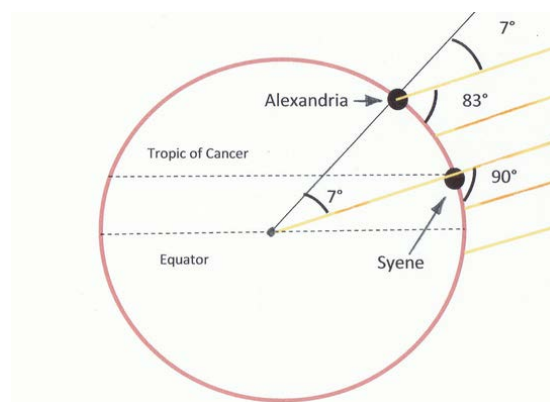
2. The Earth is 93 million miles (1astronomical unit, or AU) from the Sun. Suppose you measure with a telescope the angle in the sky to a nearby star in both July and January, and find that the difference between the two measurements is 1.0×10^{-7} Radian. How far away is the star in miles?

$\tan p = r/d = 93 \times 10^6 \text{ miles}/d$. The “difference between the two measurements” is $2p = 1.0 \times 10^{-7}$ Radian, so $p = 5 \times 10^{-8}$ Radian, and $\tan p = 5 \times 10^{-8}$ Radian as well by small angle approximation. So $d = 93 \times 10^6 \text{ miles}/(5 \times 10^{-8} \text{ Radian}) = 1.86 \times 10^{15} \text{ miles}$ (300 light years).

3. Average velocity. On I-75 heading northwest, your pickup travels 20 mi at 40 mi/h, at which point you run out of fuel. You walk 1 mi farther, to the nearest gas station, in 30 min. What is your average velocity, in mi/hr? Show your work.

Use $\Delta x = v \Delta t$. On the first part of the trip, it took $\Delta t = \Delta x/v = 20/40 = 1/2 \text{ h}$. On the 2nd part, it took $30 \text{ min} = 1/2 \text{ hr}$. So total distance $\Delta x = 20 \text{ mi} + 1 \text{ mi} = 21 \text{ mi}$. Total time $= 1/2 \text{ h} + 1/2 \text{ h} = 1 \text{ h}$. So the average speed is $v_{\text{avg}} = \Delta x / \Delta t = 21 \text{ mi/h}$.

4. With a clear, careful diagram, show how Eratosthenes measured the circumference of the Earth.

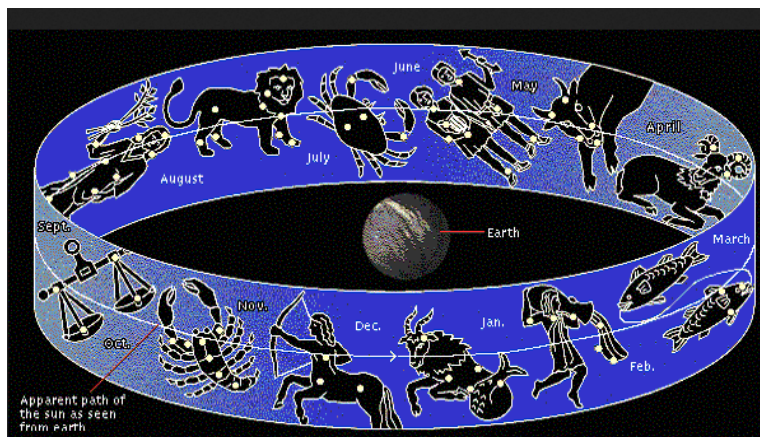


Knowing the distance between Alexandria and Syene roughly, and measuring the angle in Alexandria that the shadow of a tall stick made on the surface of the Earth as shown, Eratosthenes deduced that the angle (7 degrees) was the fraction of the circumference of the Earth represented by the A-S distance. Multiplying by the distance by $360/7$, he got the full circumference.

5. Explain why, according to *modern understanding*, the lengths of the seasons (time between equinox and solstice) are not quite equal.

The seasons would all be equal if the Earth's orbit were circular. Because (as Kepler showed), the orbit is elliptical with the Sun at one focus, the Earth spends (northern hemisphere) winter closer to the sun, during which it is moving faster, so season is shorter than summer, when it is far away and moving more slowly.

6. How long does it take the sun to complete one trip through the zodiac? Draw a picture from the *Earth's perspective*, indicating the plane of the ecliptic.



1 year. See homework 2.

7. Acceleration. If a rocket initially at rest accelerates at a constant rate of 50 m/s^2 for one minute, what is its final speed, in m/s ? Show your work.

$$\Delta v = a \Delta t = (50 \text{ m/s}^2)(60 \text{ s}) = 3000 \text{ m/s}.$$

8. Space station. In designing a rotating space station, you would like the centripetal acceleration of a person standing on the edge to be equal to $g=10\text{m/s}^2$, so that it feels like normal gravity to her. A station is built as a ring of radius 30 m.

a) How fast must it rotate so that gravity is properly simulated (find v)?

Centripetal acceleration v^2/R at rim must be g ($\sim 10\text{m/s}^2$) to simulate gravity.
($v^2/30=10$) $\Rightarrow v=\sqrt{300}=17.3\text{ m/s}$.

b) What is the corresponding angular velocity (find ω)

$$\omega=v/R=17.3/30 = 0.58 \text{ Rad/s}$$

Part III. (30 pts) Essay. Choose **either** A **or** B (Do not do both). Write in blue book.

A. Summarize what Aristotle had to say about the motion of objects, how his medieval followers adjusted Aristotle's ideas, and how Galileo's explanation of motion differed from both Aristotle and his medieval followers.

B. In what ways was Copernicus the last of the ancient astronomers and in what ways was he the first of the moderns? Which, in your view, is the stronger case?