PHY1033C HIS 3931 IDH 3931
Discovering Physics: The Universe and Humanity’s Place In It
Fall 2016

Problem set 3 Solutions
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1. (2 pts.) Based on the reading in Gregory and Copernicus’ preface to *de Revolutionibus*, give two reasons why one might consider Copernicus to be the last of the ancient astronomers and two ways he might be considered the first of the moderns. Which, in your view, is the stronger case?

**Copernicus as last of ancients:**
- Used epicycles, deferents, eccentric circles to adjust orbits
- Assumed orbits were perfect circles and planets moved at uniform velocities
- Assumed Aristotle’s physics of motion
- Got rid of “horrid equant” (which violated uniform velocity requirement)
- Assumed finite cosmos, heavens unchanging

**Copernicus as first of moderns:**
- Put earth in multiple motions and constructed a planetary system in which that fit
- Argued that the earth’s atmosphere was carried with the earth
- Rejected Ptolemy’s unharmonious system in which the orbits of each planet were treated in isolation from others
- Expanded the size of the cosmos
- Provided the foundation for subsequent development of solar system by Galileo, Kepler, and Newton

2. (2 pts) Study the diagram below, which shows the horizon for an observer at latitude $\lambda$ degrees and the altitude of the pole star $\alpha$. Show that the altitude of the pole star is equal to an observer’s latitude. This fact was extremely important for ancient navigators.
Equator
To Polaris
The task is to prove that angle $\alpha$ and angle $\lambda$ are equal. Here’s one way: first continue the line of sight to the pole star backwards until it intersects the equator. This must make a right angle, since the line to the pole star and the equator are perpendicular by definition. Consider the triangle shown above including the angle $\lambda$, which is a right triangle, so $\lambda + 90 + \gamma = 180$ degrees, where $\gamma$ is the remaining angle. The line to the pole star and the zenith are now seen to subtend the same angle $\gamma$, which is the complement of the angle $\alpha$. Since $\gamma$ is the complement of both $\lambda$ and $\alpha$, $\lambda = \alpha$.

3. (2 pts) What were some of the main motivations of the royal and noble families who chose to fund voyages of exploration in the 15th-18th centuries?

   a) Find sea routes to spices (India, Moluccas, China…)
   b) Find gold --- rumors
   c) Find Prester John, mysterious biblical figure, possibly John the Baptist, in Africa
   d) Make Christian converts

4. (2 pts) A car travels down I-75 going south at 60 mph for 10 miles, then hits traffic. The next 10 miles take the car 40 minutes.

   a. What is its average speed? Velocity?

   Average speed equals total distance divided by total time. The total distance = 20 miles. Total time = the time spent at 60 mph + the time spent at 30 mph. Time spent at 60mph = 10/60 = 1/6 hour. Times spent on the next leg is 40 minutes, or 2/3 hour. Total time = 1/6 + 2/3 = 5/6 hour. Therefore average speed = 20/(5/6) = 24 mph. Since the direction of the travel remains the same, this is also the average velocity, but we must be sure to specify the direction, south.

   b. Would you describe this motion as uniform, accelerated, or both?

   Each segment of the trip involves uniform motion (const. speed), but at the point where the speed changes, there must be an acceleration, which is taken to be instantaneous in this problem (unphysical!).
c. Make an x vs. t plot of its motion, labeling x and t axes with both numbers and units, making sure the lines you draw have the correct slopes and intercepts.

![Graph showing x vs. t plot](attachment:image.png)

You may wish to refer to
http://www.phys.ufl.edu/~pjh/teaching/phy1033/kinematics_Jan22.pdf

5. (2 pts) Cannonballs.

a. Make a plot of the trajectory of a cannonball coming out of a cannon fired at an angle of 45 degrees. Make sure it looks like a modern cannonball trajectory, not one from Aristotle or Jean Buridan. For several points on the “modern” curve, add an arrow representing the velocity of the cannonball at that instant of time. Remember the arrow you draw should point in the direction of the instantaneous velocity of the cannonball.
b. Now draw on the same plot, with the same initial velocity coming out of the cannon’s muzzle, the curve that either Aristotle or Buridan would have drawn. Label your curves so that I can see which is which, and explain why the person in question felt that the cannonball would travel that way.