Oct 13th, 2012

P340: Homework Assignment No. 2

DUE DATE: Monday, 29th October 2012

Please note that late assignments will not be marked

(1) Space, Time, Mass, and Force: The ideas we have of space and time, of inertial and gravitational mass, and of the concept of 'force', were first clearly formulated by Galileo and Newton.

(i) Describe how Galileo measured the way in which balls rolled down inclined planes. What measurements did he make, how did he make them, and what results did he find?

- To make these measurements, Galileo had to define both distance and time, and also measure distance and time intervals. Explain how he did this.

(ii) Explain Newton's 2nd and 3rd Laws of motion. Then, using the possibility of experiments involving interacting masses, explain how the concepts of mass and force are then defined. To do this you should consider how they would be measured in these experiments.

- Newton was actually very concerned to find some way of understanding what time and length were, independently of the way they were measured. He therefore defined what he called "Absolute Space" and Absolute Time". Explain what he meant by this, and also explain the 'Rotating Bucket' thought experiment he used to demonstrate the existence of absolute space.

(2) The Heavens: The objects we see in the sky, and the question of what they may be, has doubtless human interest since before recorded history began - the first real understanding of this began also with Galileo and Newton.

(i) Imagine that you are Galileo, and you are demonstrating to some of the cardinals of the church what you can see - the moons of Jupiter, spots on the sun and craters on the moon, ships disappearing over the horizon, etc. Now, bearing in mind that (i) we do experience hallucinations, and that one does require a telescope to see all of these things; and (ii) that our senses and minds certainly only give us a rather limited understanding of what is 'really there'; try to give an argument of no more than 300 words to justify your assertion that what is being seen is real.

(ii) Consider the following three assertions:

- there is life on at least one other planet within 1000 light years of the earth, that is in at least some respects similar to what we have on earth.
- there is life on at least one other planet within 1000 light years of the earth, that is however totally different to what we have on earth - so different that we may not even recognize it as such.
- all planets within this volume (containing several billion planets) are devoid of life.

Consider each of these possibilities, and explain in perhaps 100 words for each one, how you interpret it, and how likely you think it is. What is crucial here is not the opinion you have, but your reasons and arguments for justifying it!

(iii) Explain Kepler's 1st and 2nd laws, using accurately drawn diagrams where necessary. There is no need to go into great detail - the key is to make things clear.

- Now let's consider a case where they will go wrong. Imagine a situation where we have 2 planetary orbits in the same plane around a star, one of which is roughly circular, and other of which is highly elliptical, so that the 2 orbits cross each other. Now suppose that at some time, they happen to both arrive at a crossing point at almost the same time (but not close enough to collide). What do you think will happen next? Show in an accurately drawn diagram what you think the planets will do, using your knowledge of Newton's 2nd and 3rd laws, and also his law of gravitation. Explain the reasoning you use to get the resulting picture you show of the planetary motion. This example shows the big difference between Kepler's laws, which were really just a set of rules, and Newton's laws, which provided a universal mechanical explanation of motion.

(2) Optics and Light: A problem of key importance at the time of Newton was the nature of light - his conclusions were very different from those of Huyghens.

(i) In the Newtonian picture light, like matter, was made from tiny corpuscles having mass. Explain in general

terms how Newton thought about the motion of light. What caused refraction and reflection, what happened to the light corpuscles during this process, and why was it that some light corpuscles were refracted and others reflected? What was it that kept light corpuscles moving, and how fast did they move; and what did they interact with? The key role of the aether, and how Newton thought about it, should be explained here. Finally, explain what you think were the weaknesses of this theory (without assuming things that were not known at the time of Newton).

(ii) Now explain the picture that Huyghens gave for light. How did his picture explain refraction and reflection, and what happened to the light during these processes? And how is that one obtained simultaneous refraction and reflection in this picture? And how did light interact with matter? Again, the role played by the aether, and the way in which Huyghens thought about it, needs to be explained here. Finally, explain what you think were the weaknesses of this theory (without assuming things that were not known at the time of Huyghens).

(iii) Explain one way in which you think one can distinguish between the predictions of Newton, and those of Huyghens, for the properties of light.