Feb 2nd, 2014

P340: Homework Assignment No. 2

DUE DATE: Monday, 23rd Feb. 2015

Please note that late assignments will not be marked

(1) Observer and Observed: *A big objection to the idea that science is discovering the 'truth' about the world comes from noting that an "observation" is a complicated process in which an "observer" is supposed to interact indirectly with some observed object, rather than a process of* "Immaculate Perception".

(i) Describe Galileo's key telescopic observations - his observations of the sun, the moon, and of the moons of Jupiter; and explain also why each of these was a challenge to prevailing beliefs. In the case of moons of Jupiter, you need to explain both what he saw, and how he was able to infer that he was seeing moons orbiting Jupiter.

(ii) In what way did Galileo's observations refute Aristotelian or Platonic principles? You should explain what principles were involved, and why Galileo's observations were a challenge to these.

(iii) Many felt that both Galileo's telescopic images and his experiments with rolling or falling balls were just tricks. Moreover, Aristotle had argued that one cannot learn about the world by use of artificial devices - one has to observe the world in its "natural" state. This was an discussion about the relationship between observations, experiments, and the "real world".

Try to describe, in the most advantageous possible terms, the argument that Galileo's telescopic observations were tricks, and that that the telescope is just an artificial device. Once you have done this, discuss how you would deal with this argument. thus, in the 1st part of this question, you can play the Church's advocate, and in the 2nd, Galileo's advocate (or the devil's advocate, if you prefer).

(iv) Give your view on what role you think our own sensory and mental capacities play in the images we see, and what we then infer about the objects we think we are seeing. You can if you wish use a modern understanding of how vision and other senses work, and also of how the brain works, but this is not essential - the question is really one about how we infer the existence of things from what we sense, and about the models we devise.

(2) Laws of Motion: *Both Galileo and Newton tried to understand how object move in space and time. A key question faced by both was the definition of temporal and spatial intervals, as well as the definition of space and time themselves; in fact, they had to give a kind of operational definition of what they meant by time and space. But Newton went much further, in tying together his definitions with his laws of motion.*

(i) First, explain in detail how Galileo defined and measured intervals of time. Why was his definition of time interval superior to, eg., the use of a heartbeat? What do you think would have been the best way to measure spatial intervals in the time of Galileo?

(ii) To understand Newton's way of doing things, we begin with his laws. Explain how it is that, using Newton's laws, and assuming we already have a way of measuring time and distance intervals, we can measure the mass ratio of any 2 objects, and thereby set up an operational definition of mass. Then assuming we have some value for Newton's gravitational constant G, we can then determine the masses of the planets and the sun.

(iii) Now consider the difference between Newton's theory of dynamics and that of Kepler. What were Kepler's laws, and how did they differ in spirit from those of Newton? Describe a situation in which you would expect them to give completely different predictions for the motion of objects in the heavens.

(iv) Finally: what are we really measuring, when we say we are measuring time? This is a somewhat philosophical question - if you measure something, what are you measuring, and how do you know it really exists? To get going on this, consider a few examples of things we claim to measure, and ask which of these refer to real properties of the world. Why do we sometimes imagine we are measuring something that is not there? How can we decide whether it really is there? Once you've thought this through, you can focus on the specific example of time.

(3) Light: Waves vs. particles: *The "wave-particle debate' between Newton and Huyghens is worth understanding, as one of the most important debates in the history of physics. It was eventually resolved by the discovery of EM fields, and of Quantum Mechanics.*

(i) Describe an experiment in which one sees simultaneous refraction and reflection of light at an interface between 2 materials. You should draw figures to show how this works and what one would see, for different angles of incidence of the light at the interface.

(ii) Now we wish to explain these observations, comparing the idea so Newton and Huyghens. In what follows you need to explain, for each theory, what light was, how it interacted with matter, how one explained refraction and reflection, and the fact that they occurred simultaneously, and what happened to the light during these processes. The key role of the aether in each theory should also be explained.

First, explain Newton's theory, answering these questions; and also explain how in this theory light corpuscles kept moving, and how fast they moved.

Second, explain Huyghens's theory, and also make sure you explain how waves moved through the aether in this theory.

Figures will be extremely useful in answering these questions.

(iii) Each of these 2 theories had an important problem to deal with, which apparently undermined them. What were these 2 problems? How did Newton and Huyghens try to overcome them? Here you have to give the explanation they gave in their theories which answered the problems.

Finally, discuss what key differences existed between the predictions of these 2 theories.

(iv) In 1801, roughly a century after the theories of Newton and Huyghens, Thomas Young performed a key '2-slit' experiment to decided between these 2 theories.

Show how this experiment worked, using diagrams, and explain why it is apparently impossible to understand in a particle theory, but how one can understand the results if light is a wave.