

Feb 5th, 2011

## P340: Homework Assignment No. 2

**DUE DATE: Wednesday, 23rd FEB. 2011**

Please note that late assignments will not be marked

**(1) Faith, Reason, and Observation:** In the period spanned by Copernicus, Kepler, Galileo, Bacon, Descartes, and Newton, a clash occurred between those who believed in the primacy of reason in arriving at conclusions about how the world worked, and those who believed in the primacy of observation. This clash between "*a priori* reasoning" and the "experimental philosophy" was not necessarily over religious faith (although the Catholic church foolishly turned it into one); it involved a fundamental difference of epistemological belief, about how one comes to 'truths' about the world, and to what extent these are certain. Consider some examples:

(i) Imagine a discussion between Galileo and a cardinal of the church. The latter maintains that the images shown by Galileo's telescope are tricks, and that one cannot learn about the world by use of artificial devices - instead, one has to arrive at conclusions from *a priori* reasoning, starting from the arguments of, eg., Aristotle.

Explain the arguments that you think Galileo could have used (including a description of his telescopic observations) to rebut the cardinal. Explain in particular how you would deal with the argument that the telescope is an artificial device (you may find it necessary here to explain briefly how the telescope works), and with the more serious argument raised by the cardinal, viz., that the results clashed with Aristotle's reasoning. Explain why you think Galileo's observations refuted arguments starting from very general Aristotelian or Platonic principles.

(ii) the observations of Tycho Brahe and Kepler did not use telescopes. Explain first of all what Kepler actually found, and how he found it. Then explain in what way this disagreed with the ideas of Aristotle.

(iii) Explain how Galileo established how falling bodies fell, and balls rolled down inclined planes. What measurements did he make, how did he make them, and what results did he find (and how did he define time and distance)? In what way did these results contradict the ideas of Aristotle?

**(2) Newtonian Dynamics:** Newton's greatest achievements were in the explanation of the motion of solid and liquid bodies. Let us first understand the way in which the concepts of force and mass were introduced.

(i) Explain Newton's 2nd and 3rd Laws of motion. Then, using the possibility of experiments involving interacting masses, explain how the concept of mass is defined.

(ii) Now explain Newton's Law of universal Gravitation. To show how it works, then consider a situation in which two asteroids pass each other at high velocity, without colliding. Suppose that after they have separated, one of them has changed its velocity by 0.8 km/sec. How would you determine the ratio of their masses? Suppose this ratio was 3:1 (with the second mass being smaller); what would have happened to the 2nd mass? Now, suppose you wanted to find out how big each mass was - describe how, by doing experiments on earth between 2 large bodies, you could determine the force between these bodies, and hence what should be the forces between the 2 asteroids. You may find it helpful to draw some pictures here.

(iii) Briefly describe Newton's 'rotating bucket' thought experiment, and why it led him to the idea of 'Absolute space'. What, in essence, was Leibnitz's objection to this?

**(3) Nature of Light:** The fascinating argument between Newton and Huyghens led, 230 years later, to an extraordinary resolution in quantum mechanics. For this reason alone it is worth understanding.

(i) Describe an experiment in which one sees simultaneous refraction and reflection of light. You should definitely draw a figure to show how this works and what one would see.

(ii) Now explain how Newton explained this result using a particle theory of light; and how Huyghens explained it using a wave theory. Again, pictures will be essential.

What were the main objections that each had against the ideas of the other?