Atoms to Universe
Physics 340
Assignment 4

1. How did Newton use Galileo's work to develop his dynamics?

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1) Compound motion: Forces and accelerations are independent in the various perpendicular directions.

2) acceleration in gravity– all things fall in the same way, and have the same accelerations. This means that the force of gravity has to be proportional to the mass of the body, so that gravity just affects accelerations.

3) Centrifugal force– Huygens showed that Galileo's description of acceleration perpendicular to the natural straight line motion allowed one to calculate the centrifugal acceleration of an object in circular motion. Newton used this crucially in determining the motions of the planets and the forces needed.

4) Gelilean relativity– Newton used this principally in objecting to it. He believed that there was a specific thing which was at rest with respect to space, despite not being able to find any evidence for it in his laws.

5) Tides. He realised that Galileo's explanation was nonsense, and came up with a much better explanation.

2. If you rotate a bucket of water around the vertical axis of the bucket, what happens to the water surface as the speed of rotation increases? How does this relate to the rotating earth?

The water needs a force to get the water to travel in a circle. The only way that the water can do so is to exert a pressure on the inner water. The only way to increase the pressure is to make the water deeper– so the water on the outside must get deeper – the surface goes up– in order to exert and inward pressure on the water closer to the center. The surface becomes curved up from the center to the edge.

Similarly in the earth the water needs to build up in the outside parts of the rotation in order to exert pressures on the water nearer the axis to allow it move in a circle.

3. Newton rejected Galilean relativity and argued that there was a universal rest frame which he thought was the center of mass of the solar system. See https://archive.org/stream/100878576#page/400/mode/2up page 401 of the Principia Hypothesis i and Proposition XI. What do you make of this argument.

Also argue that his three laws of motion actually support Galilean relativity.

This is probably the most unsatisfactory part of the Principia, because all he does is to assume, or state as self evident, despite Galileo's arguments, that there must be somewhere that is at rest with respect to space. His next argument that this must be the center of mass of the whole solar system is again an entirely circular argument, but purely a matter of opinion. I make of it that it is nonsense.

4. Show that the earth and the outer planets obey Kepler's third law (the cube of the radius of the orbit over the square of the period of the planet is the same for all of the planets) Find the periods and radiuses of the orbits on the web.

See for example https://en.wikipedia.org/wiki/Keplerwith the data table.

5. In the Principia https://archive.org/stream/100878576#page/384/mode/2up page 384 Newton gives his rules of Philosophy for studying Nature. Comment on them.

I am not going to parse these rules since I think he states them pretty clearly himself. themain purpose of this question is to have you read them and think about them.

It is not entirely clear that he always followed them. His argument for a thing of absolute rest for example (problem 3) really had absolutely no support in any observation. As his interactions with Hooke (and alsto with Flamstead the astronomer Royal, and with Leibnitz) he was very resistant to changing his mind or in having his views be contradicted.

One can argue that the observations (for example of Kepler) were sufficient for the hypothesis of the universal law of gravity that he found in them.

His comments about inertia (Rule III) is somewhat disingenuous, since Aristotle has concluded from the same kinds of observations that the natural state of motion was to be at rest, rather than that the natural state was to be in uniform straight line motion. He really raises the problem of induction, and whether one can ever say that induction is necessitated by observations.

[Brief table of commonly used prefixes: n = nano = 10^{-9} = 1/1,000,000,000
μ = micro = 10^{-6} = 1/1,000,000
m = milli = 10^{-3} = 1/1,000
c = centi = 10^{-2} = 1/100
d = deci = 10^{-1} = 1/10
h = hecta= 10^{2} = 100
K = kilo = 10^{3} = 1000
M = Mega = 10^{6} = 1,000,000
G = giga = 10^{9} = 1,000,000,000]

It is interesting that in scientific notation, names are given only up to Y= Yotta= 10^{24}, whereas in classical Japanese there are names for numbers at least all the way up to 10^{52}.

http://en.wikipedia.org/wiki/Japanese_numerals.

(The Japanese use $10000=10^4$ as the multiple for names, rather than our 1000.) Why in the 16th century anyone would need to give such a large number a name I do not know. This aside is of course totally irrelevant to the course.