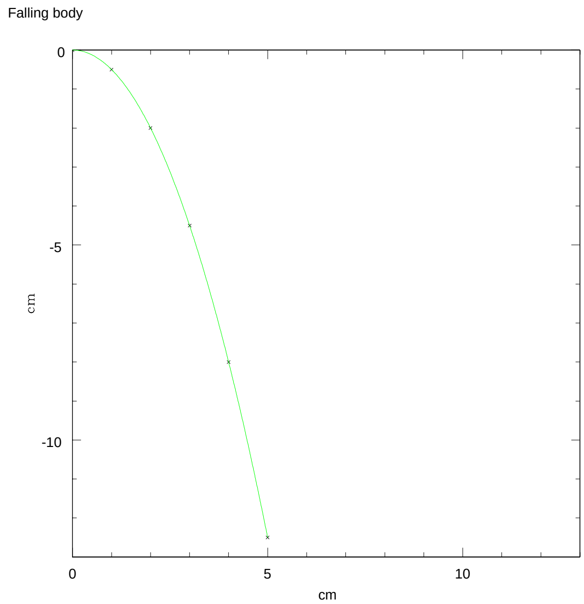

Figure 1:

Atoms to Universe
Physics 340
Assignment 3

1)Compound motion: Consider Galileo's description of a body which both falls and travells horizontally at the same time. Assume that horizontally the body travels 1 cm in a unit of time and vertically it falls .5 cm in the first unit of time. Plot the trajectory of the body for at least 5 units of time.

In the horizontal direction the body will move uniformly, the same distance (1cm) in each unit of time. In the vertical direction, the ratio of the distance moved to the distance moved in the first unit of time is 4 times in the second, 9 times in the third, 16 times in the fourth and 25 times in the fifth. Sine the distance moved in the first was .5 cm, the distance in the second will the 4x.5cm=2cm, in the third 9x.5cm=4.5cm, 16x.5cm=8cm and 25x.5cm=12.5cm Plotting this we get

2) Give Galileo's argument that all bodies fall in the same way "in the void". If you take into account the air, do you expect bodies to behave in thesame way? What effect (qualitatively) would you expect the air to have on the falling of different bodies?

No, the air is pushed out of the way by the body as it falls, which will slow down the body. This will depend on the size of the body (the larger the body, the more air needs to be pushed away) and shape (which can for the same size, require more air to be pushed away) etc. Thus a feather which has a large size for its weight would be more affected than would a piece of iron.

3) Why was Galileo's theory of tides in contradiction with his theory of "relativity".

Galileo's theory of tides was that the tides were caused by the earth's rotation being in the same direction as the motion around the sun in part of the day, and in the opposite direction in the other part of the day, and this back and forth motion of the surface of the earth would incite tide. HOwever, we can regard the orbital motion of the earth as being like his ship. From the viewpoint of the "ship" the earth does not slosh back and forth. It simply rotates uniformly There is no sloshing. It is all uniform motion. You would not expect such uniform motion to do anything to the water on the earth. His "relativity" argument would say that there is no experiment which could tell tha tthe earth was moving (in its orbit) while the tides here would be a way of showing that the earth moved (which was his purpose). That the argument fit with his prejudices meant that, as with so many of us, that he really did not give it is the critical examination that it should have received.

4) Two bodies, one with mass twice that of the other, travel toward each other. You have measured that if the heavier one has a speed of 1m/sec and the lighter has a speed of 2m/sec, both directed toward the collision point, the heavier one bounces back with a speed of 1m/sec, and the light one bounces back with a speed of 2m/s. Use Huygen's argument to determine what would happen if the light one hit the heavier one, which is at rest, with a speed of 3m/sec. What would the speed and direction of the boat need to be for the person in the boat to see the original collision as having these values?

On the boat a body travelling with the boat (according to the person on land) will appear to travel more slowly than it does to the person on land, while the body travelling against the boat's motion will seem to travel more quickly. Thus if the boat travels at the same speed as the big ball does initially, namely 1m/s, the big ball will appear at rest, while the little one will appear to be travelling at 3m/s. After the collision on land, the big ball is travelling at 1m/s in the opposite direction while the small one travels at 2m/s in the direction that the big one travelled in initially. Thus the small ball will appear to travel at 1m/s while the big one will travel at 2m/s.

Thus, in a collision of a big ball at rest and a small one at 3m/s after the collision the big ball will travel at 2m/s in the direction wile the small one will be travelling at 1m/s in the opposite direction.

5) With what speed would a canon ball have to travel just above the surface of the earth (assuming the earth to be a perfect sphere) so as to have its

centrifugal acceleration to be just equal to the Galileo's falling acceleration? (Remember that Huygens showed that the centrifugal acceleration is the velocity squared over the radius of the circle, and Galileo's acceleration down to the earth at the earth's surface is 10m/(second squared) . How long would it take such a canon ball to circle the earth? Compare this to how long it takes the International Space Station to circle the earth? (You can look that up on Wikipedia).

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The centrifugal (for Huygens, centripital for Newton– they both mean the same thing) acceleration of a body going in a circle is, according to Huygens $\frac{velocity^2}{radius} = \frac{v^2}{r}$ where v is the velocity of the object in its orbit and r is the radius of the orbit, which is the radius of the earth. The radius of the earth is approx 6400 Km= 6400000meters. The acceleration of at the surface of the earth accoding to Galileo is about 10m/sec^2 (actually closer to 9.8) Thus,

$$v^2 = 10m/sec^2 \cdot 6400000m = 64000000m^2/sec^2$$

Thus the velocity will be the square root of this or 8000m/s or 8km/s.

The circumference of the earth is 2π times the radius or$40000km$ and the time to go this distance is 40000/8=5000 sec. An hour is 3600 sec, so this is 5000/3600=1.39hr or 83 min.

Low earth satellites, like Sputnik I had a period of about 96 min. but its orbit ranged from about 200 to 900 km above the surface of the earth (which, since it spends more time further from the earth, would be expected to have a longer period than one in circular obit just above the earth)

[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.