Physics of Music
Physics 341
Assignment 1

1) An apple hangs on a tree branch. The wind causes the apple on the branch to oscillate up and down. A squirrel lands onto the branch. What happens to the frequency of oscillation. The squirrel eats the apple while sitting still on the branch. What happens to the oscillation. The squirrel now pecks part way through the the branch behind itself thinning the branch (closer to the tree). What happens to the frequency? It finally hops off the branch. Same question.

The mass of the apple, or after the squirrel lands on the branch, the mass of the apple plus squirrel are the mass of the oscillator. The stiffness of the branch is the stiffness. So anything that changes eitehr of these will alter the frequency of oscillation. When the squirrel arrives, it increases the mass, and thus lowers the freq. When the squirrel eats the apple, the mass does not change - it simply goes from hanging from the branch to being in the squirrel's stomach. Now if the squirrel for example is sitting nearer the trunk end of the branch, the motion of the squirrel might be less than that of the hanging apple, meaning that when the squirrel eats the apple it goes from a place where it oscillates a lot to one where it oscillates less, decreasing the moving mass, but the problem gives no indication of that. When the squirrel gnaws the branch it thins the branch. While this might have a very minor effect on the moving mass, it has a far greater effect on the stiffness (a narrow branchis much easier to bend than a thick one). Ie, the stiffness goes down and the frequency goes down. Finally when the squirrel leaves with the apple in its stomach, the mass goes down a lot (to less than it was when just the apple was hanging) so the frequency goes up a lot.

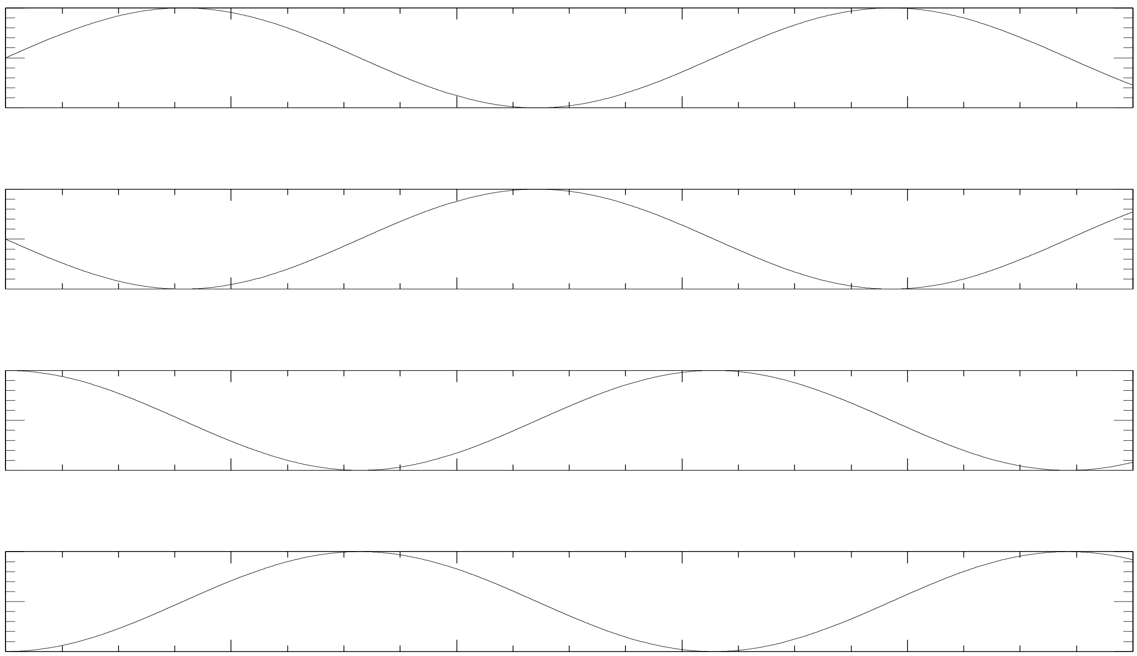
2) A car's dampers (shock absorbers) are shot, so the car oscillates up and down on its springs a lot. Four of my friends jump into the car. What happens to the oscillation? We are joyriding and finally manage to flip the car. The wheels now oscillate on those springs. What is the relation between the frequency of the wheels' oscillation and that of the car previously?

When the frinds jump it the mass increases a lot. The frequency drops. When the car flips, the moving mass is now the wheels not the car and contents (which do not move since they are in contact with teh earth.) Ie, the moving mass drops "massively" and the frequency goes way up.

3) A heavy aluminium lid of some cooking pots makes a wonderful bell. While taking a bath I like to play with the lid– hitting it and dipping it sideways into the bath water. What happens to the pitch of the note as I dip it into the water? What happens to the damping? (You should try it. It is a great sound.)

Clearly the damping will go up, and the lid will ring for a shorter time. However the main influence of the water is that while the lid oscillates, some water "sticks" to the lid (the water is caused to move by the lid). This increases the moving mass, and the frequency drops. (Is there any effect on the stiffness? Well water itself has no bending stiffness. There is some compression stiffness, and if the amount of water that is caused to move gets large– if the wavelength is much smaller than the size of the plate, then there could also be an effect on the stiffness from the compression of the water. However for the conditions stated, this effect is very small. The mass effect wins out by a lot.)

4) In the following set of four graphs, what is the phase shift of each of the graphs 2, 3, and 4 with respect to the graph 1? (Numbering starts from the top graph down)



The phase shift is by what fraction of a cycle (multiplied by 360 degrees) one wave is shifted with respect tot he other. If the shift is toward the future, (one wave "starts" after the other– ie has its maximum for example to the future– the shift is usually called positive.)

Thus wave 2 is half a cycle, or 180 degrees– whtehr to the future or to the past is of course ambiguous. So it could be +180 or -180. The third is 1/4 or 90 and starts earlier– ie it is -90 degrees of +270 degrees. The last one is 90 degrees into the future so is +90 (or it could also be called -270 degrees)

5) The Q of a note of 100 Hz is 100 while that of a 4000 Hz vibration is 500. Which rings for a longer time? What are the times in each case for the amplitude to drop to 1/4 of its original value? (Remember what the definition of Q is.)

The Q is related to the number of cycles not the time. Thus in the first case, the amplitude would fall by a factor of 2 each 25 (100/4) cycles. Since each cycle is 1/100 of a second, this would be about 1/4 of a second (25 times 1/100). For the second case, the sound would drop to 1/2 in about 1/4000 times 500/4 or about .032 sec. Ie this sound would last a much shorter time than the first, even though its Q is higher.

To drop to 1/4, it needs two time time periods during each of which it drops to 1/2 each time. In the first case the 1/2 time was about 1/4 sec, so it would take 2/4=1/2 sec to drop to 1/4. In the second case it would take about .064 sec or .06 sec.

6) As you empty a wine bottle, the tone you get when you blow across it changes. How does it change and why? (Note assume that the tone you get while blowing is the same as you would get by "popping" the top of the bottle. While true, the reason will only come up later in the course).

The oscillating mass is the air in the neck of the bottle. This does not change. The stiffness is the response of the air in the bottle to the motion of the air in the neck. as the air in the neck moves into the bottle , the air inside is compressed. For a given motion of the air in the neck, the compression of the air inside is greater if there is less air in the bottle. Ie the less air the greater the stiffness, and thus the higher the frequency.

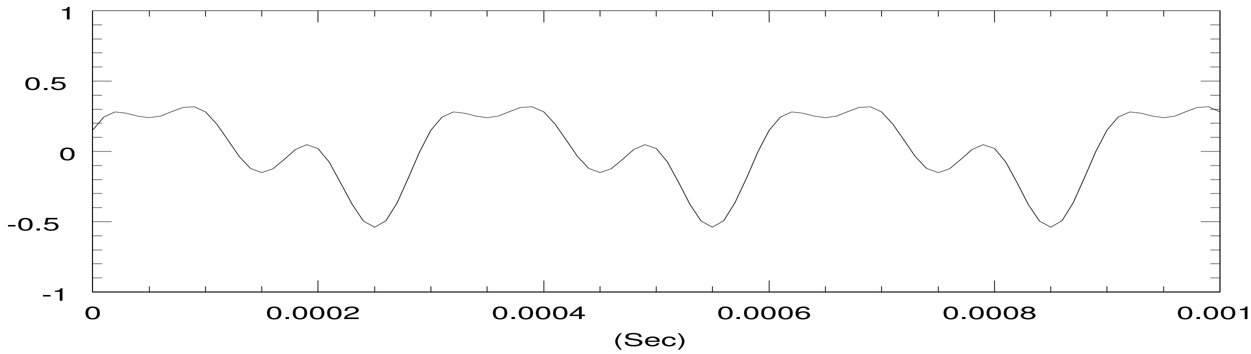
The water's role is simply to change the volume of air in the bottle. While the water itself is slightly compressible, its compressibility is so much less, that its volume does not change appreciably when the air moves up and down in the neck and its effect can be completely neglected.

7)A note has a frequency of 400Hz. What is its period? Another vibration has a period of 50ms (1ms= 1/1000 sec). What is its frequency?

The period is how long each cycle takes. if there are 400 cycles per second, each cycle takes 1/400 of a second or .0025 sec.

If the period is 50ms, or .05 sec, the number of cycles per second is 1/.05=20Hz

8) In the following figure, what is the period, the frequency and the amplitude of the signal?



Period = .0003 sec (eg from the lowest minimum at .00025 sec to the next time it is lowest at .00055 sec). This gives a frequency of 1/.0003= 3333 Hz(or to the accuracy to which one can read the graphs, 3300 Hz)

The amplitude depends on which amplitude one wants. The peak to peak amplitude goes from -.5 to +.3 or .8 The average amplitude would be something like about .15 (the average displacement above zero when it is above zero.) The RMS is about .2 (the square root of the average of the squares of the amplitude)

[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.