# COMS20011 – Data-Driven Computer Science

## Problem Sheet MM02

1 – Using *sin(2πnx)*, demonstrate the concept of superposition as follows:

(a) first plot three sine functions over the range ±3 in steps of 0.1 using *n={1/4,1,2}*. Note, plots should appear in the same graph to give a better sense of what is happening.

(b) Now plot in a different colour the sum of all the sines above.

(c) Add more sine functions over the same range and repeat step (b).

**Answer (Matlab):**

(a) First define the range, say x = [-3:0.1:3]
The sine function plot over the specified range with *n=1/4* is then "plot(sin(2*pi*x*1/4))"
Hold the plot. Now plot again for the other values of *n*.

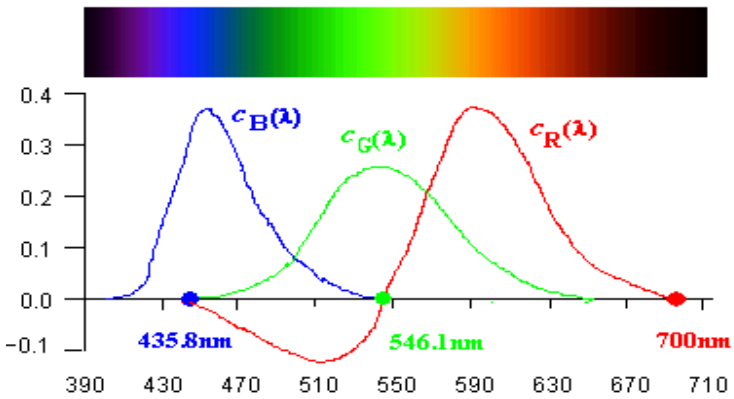
(b) Add the sines from (a) and plot the new function using 'r' as a parameter of the plot function to draw in red. See *help plot* if unsure of the syntax.

**Answer (Python): see sines.py**

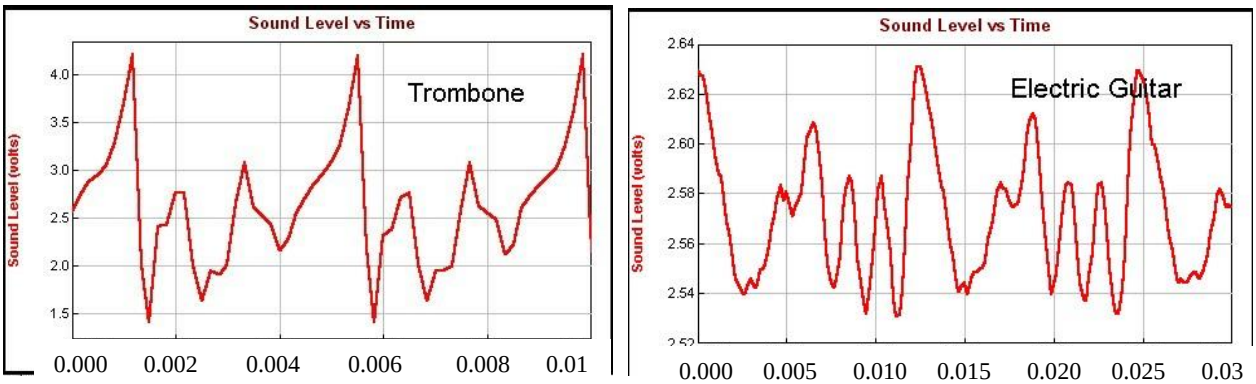
2 – What is White Light? Illustrate your answer with an approximate graph.

**Answer:**

White light is made up of a linear combination of variable wavelengths of each component colour (i.e. R,G, and B). Many (but not all) other colours can be induced by some linear combination of these three components, e.g. in digital terms, to get the colour *turquoise* you might mix 0.25*R+0.88*G+0.79*B. 'By superimposing all of them in equal amounts we get a spectral profile with energy distributed more or less uniformly over the whole visible spectrum, so it is perceived as white light.'
Source: *http://www.mathpages.com/home/kmath578/kmath578.htm*

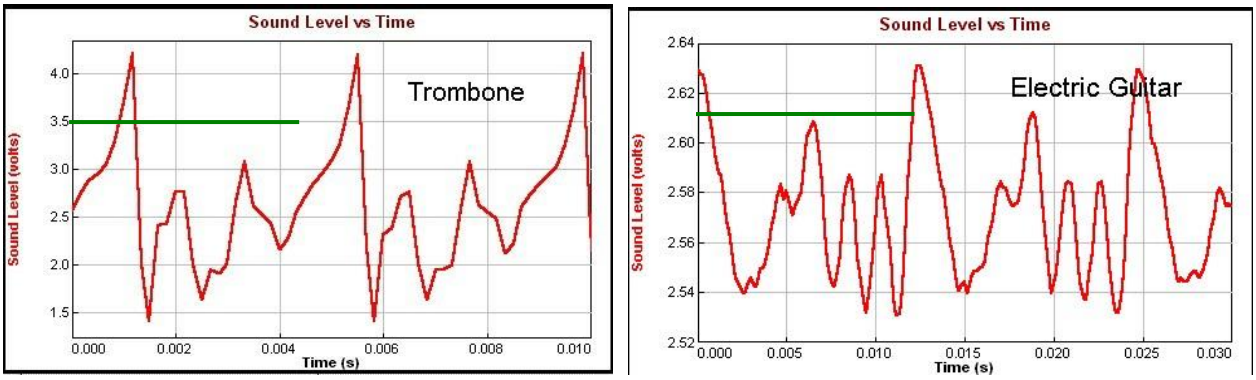



3 – The graphs below display the amplitude of the sound wave for a Trombone and an Electric Guitar as a function of time. The y-axis is the amplitude axis and the x-axis is the time axis. Notice that each one is plotted over a different length of time.



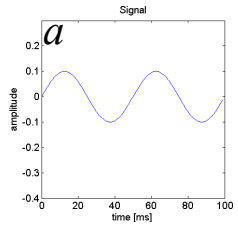

(a) Mark the period of the signal for each instrument.
(b) Approximately, how many periods are shown in these graphs for each instrument?
(c) Approximately, what is the peak amplitude in each case?
(d) Approximately, what is the frequency given the signal period in each case?
(e) Which signal contains higher frequency information? Why?

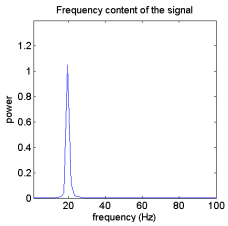
**Answer:**



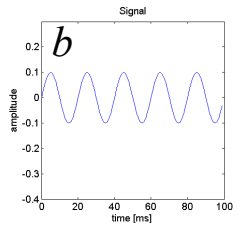

(a) Marked in Green in the diagram above, about 0.0045 and 0.012 respectively.
(b) In both cases around 2 and a bit.
(c) Trombone: about 4.2 EG: about 2.63
(d) f = 1/T so 1/0.0045 = 222.2 and 1/0.012 = 83.3 respectively.
(e) The Trombone as it cycles more frequently than the EG over the same time period.

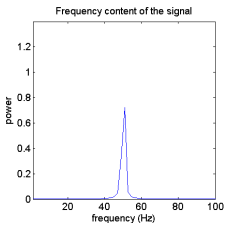
4- Consider the three signals $a$, $b$, and $c$ below, and their addition $d$.



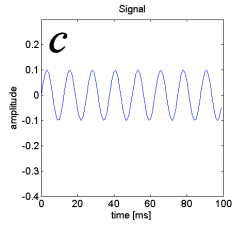



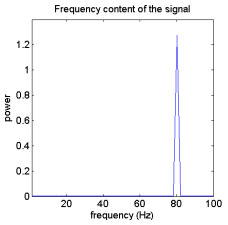

time domain frequency domain



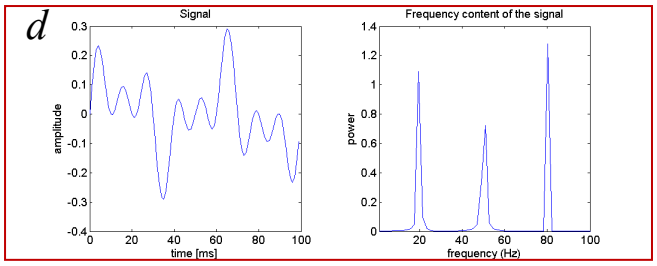

time domain frequency domain




time domain frequency domain

$d = a + b + c$




time domain frequency domain

(a) What would the frequency of the signal $d = a + b + c$ look like?

(b) How many oscillations per second does signal $a$ have?

(c) How can you determine the frequency of signal $c$ if you did not have the frequency domain plot of that signal?

(a) The frequency of signal $d$ would simply include the frequencies of the constituent sinusoids.

(b) Signal $a$ has a peak frequency of 20Hz, so there are 20 oscillations per second.

(c) Looking at the time domain plot of the signal, we can count that it repeats around 8 times per 100ms, so it repeats 80 times in 1 second, and so it's an 80Hz signal.

5 – The following gene sequence contains significant frequencies. Design two different symbolic encodings and in each case apply your encoding to extract some of these frequencies.

**ACAGAGATACAGAGATACAG . . . . .**

*A=1, G=C=T=0 ➔ 1010101010101010101… so period is 2, f=1/2*

*A=1,G=2,C=3,T=4 ➔ 1213131412131314121 3… so period is 8, f=1/8*