Homework 3 (Due: 5/7th)

(1) Write a Matlab or Python program that can convert a numbered musical notation (簡譜) into a music file (*.wav).

Example: (Twinkle twinkle little stars)

```
score = [1, 1, 5, 5, 6, 6, 5];     % 1: Do, 2: Re, 3: Mi, …..
beat=[ 1, 1, 1, 1, 1, 1, 2];       % 拍子
name= 'twinkle';
getmusic(score, beat, name)    % generate the music file twinkle.wav
```

Do = 261.63 Hz

再利用每差一個半音就乘上 2^{1/12} 的公式（p.240）

- Do 也可以選擇不同的基頻

上週 demo 時 cosine 乘上的 alpha 都是 1，但是通常一首歌一開始 amplitude 較高，也可以把這個考慮進去 （考慮六個滿分）

The Matlab / Python code should be handed out by NTUCool.

With basic requirement (score, beat, name): 24 scores

程式的功能越多，考慮的因素越多，分數越高

程式的功能要清楚說明以方便助教批改 (30 scores)

(2) (a) Determine 2^{700} mod 67.

(b) Find an integer x between 0 and 2800 that satisfies (i) x mod 43 = 4 and (ii) x mod 67 = 15 (Hint: Using the Chinese remainder theorem).

(c) Determine 39! mod 43 (Hint: Using the Wilson theorem). (12 scores)

(3) Given $M = 11$, $\alpha = 8+6i$, and $N = 12$. Determine the complex number theoretic transform (CNT) of $\mathbf{x}$ where

$$\mathbf{x} = \begin{bmatrix} 0 & 1 & 0 & 0 & 0 & 1 & 0 & 1 & 0 & 0 & 0 & 1 \end{bmatrix}^T$$

Hint: fft($\mathbf{x}$) is as follows. It is Ramanujan's sum.

$$fft(\mathbf{x}) = \begin{bmatrix} 4 & 0 & 2 & 0 & -2 & 0 & -4 & 0 & -2 & 0 & 2 & 0 \end{bmatrix}^T$$ (8 scores)

(4) What is the Legendre sequence corresponding to $p = 11$? (Hint: The sequence should have 11 entries). (10 scores)

p.194

delay: 20, 30

(5) Suppose that there is a multipath system $y[n] = x[n] + 0.4x[n\text{-}20] + 0.2x[n\text{-}30]$. (a) Find $p[n]$ such that $y[n] = x[n] * p[n]$. (b) Design the lifter to remove the effect of $p[n]$ and try to not destroy $x[n]$ as possible. (10 scores)

在 cepstrum 有能量的地方設為 0

(6) (a) Is it possible for humans to hear the voice with the frequency of 19Hz?
Why?

(b) In the noiseless case, in what condition we cannot use the variation of amplitude to separate a speech signal into several syllables?

(c) Why a music signal always has the chord (和弦) phenomenon? (15 scores)

如果基頻為 f_0，則在 f_0 的整數倍都會有相當的能，這就叫做 chord

ex: 如果一間教室裡的椅子都是白色的，就不用一張一張濟椅子的顏色，只要一句話「教室裡的椅子都是白色的」即可，這就是資料的一致性

(7) (a) What is the way to measure the uniformity (一致性) in mathematics?

(b) Why the compression ratio of an image can be higher than that of the vocal signal?

discrete cosine transform

(c) In addition to the DCT, which is adopted by MP3, write at least three possible ways that can compress a music signal more efficiently. (15 scores)

(Extra): Answer the questions according to your student ID number.
(ended with 0, 1, 3, 4, 5, 6, 8, 9)