

Tune-Up Tuesday for September 10, 2024

% Copy this file into a Matlab script window, add your code and answers to the
% questions as Matlab comments, hit "Publish", and upload the resulting PDF file
% to this page for the tune-up assignment. Please do not submit a link to a file
% but instead upload the file itself. **Late penalty:** 2 points per minute late.

% (a) Copy, paste and run the Matlab code from lecture slide 1-18 to generate
% the cosine signal $x(t) = \cos(2 \pi f_0 t)$ with $f_0 = 440$ Hz and play it as an audio
% signal for 3s at a sampling rate of $f_s = 8000$ Hz. (Using a higher standard
% audio sampling rate such as 96000 Hz would give a smoother plot in part (d)).

```
% (a) 'A' note on Western scale in 4th octave (A4) at 440 Hz
f0 = 440;           % note 'A4'
fs = 8000;         % sampling rate
Ts = 1/fs;        % sampling time
t = 0 : Ts : 3;   % 3 seconds
x = cos(2*pi*f0*t);
sound(x, fs);
pause(3);
```

% (b) Add to the code in (a) to generate a new signal $y(t) = \cos(2 \pi f_0 t) \cos(2 \pi f_1 t)$
% with $f_1 = 110$ Hz by using the same sampling rate of $f_s = 8000$ Hz.

```
% (b) Multiply cosine at 440 Hz and cosine at 110 Hz
% Modified code from left side of lecture slide 3-3.
f1 = 110;           % 'A' in the second octave
x1 = cos(2*pi*f1*t);
y = x .* x1;
```

% (c) Add to the code in (b) to playing $y(t)$ as an audio signal.

% Describe what you hear.

% Express $y(t)$ as a sum of two sinusoids.

```
% (c) Play y(t) at a sampling (playback) rate of 8000 Hz.
% I hear two notes/tones at a lower pitch than 440 Hz.
% The product can be written as a sum of two cosines.
% Using lecture slide 3-2,
%  $y(t) = 0.5 \cos(2 \pi 330 t) + 0.5 \cos(2 \pi 550 t)$ 
% Tones at 330 Hz (E 4th octave) and 550 Hz (C# 5th octave)
% are harmonics of 110 Hz. See Piano frequencies.
sound(y, fs);
```

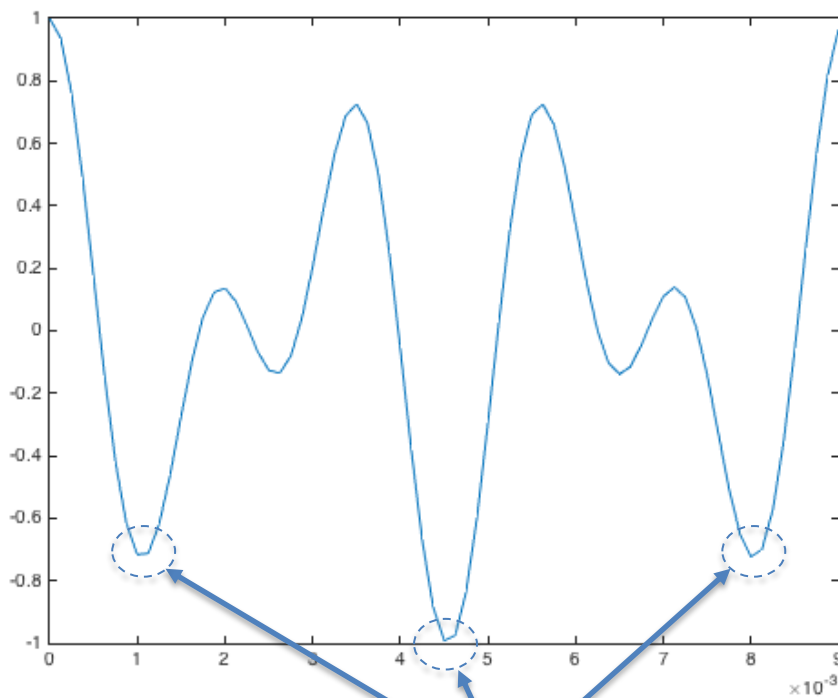
```
% Note: The product  $\cos(2\pi*f_0*t) \cos(2\pi*f_1*t)$  will have
% amplitudes on [-1, 1] because each cosine has amplitudes
% on [-1, 1]. Hence, the sound command can be used without
% clipping amplitude values.
```

```
% Note: Playing a tone at 110 Hz may not be audible when
% played back on a laptop. Many laptop playback systems
% have very low volume outputs for frequencies below 200 Hz.
```

% (d) Plot one period of $y(t)$. We'll need to find the periodicity of $y(t)$.
% The product of two sinusoids at frequencies f_0 and f_1 produces
% frequencies at f_0+f_1 and f_0-f_1 . You could modify the code from the
% bottom right side of lecture slide 3-3.

```
ffund = gcd(f0+f1, f0-f1); % 440 Hz +/- 110 Hz
Tfund = 1/ffund;
n = round(Tfund / Ts); % Tfund / Ts isn't an integer.
plot( t(1:n), y(1:n) );
```

% See below for the plot. The plot has several artifacts as noted below.



Non-smooth
troughs