Tune-Up Tuesday for September 7, 2021

% (a) Copy, paste and run the Matlab code from lecture slide 1-16 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) @ 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 @ 440 Hz and cosine @ 110 Hz
% Modified code from left side of lecture slide 3-3.
f1 = 110;
x1 = cos(2*pi*f1*t);
y = x .* x1;
```

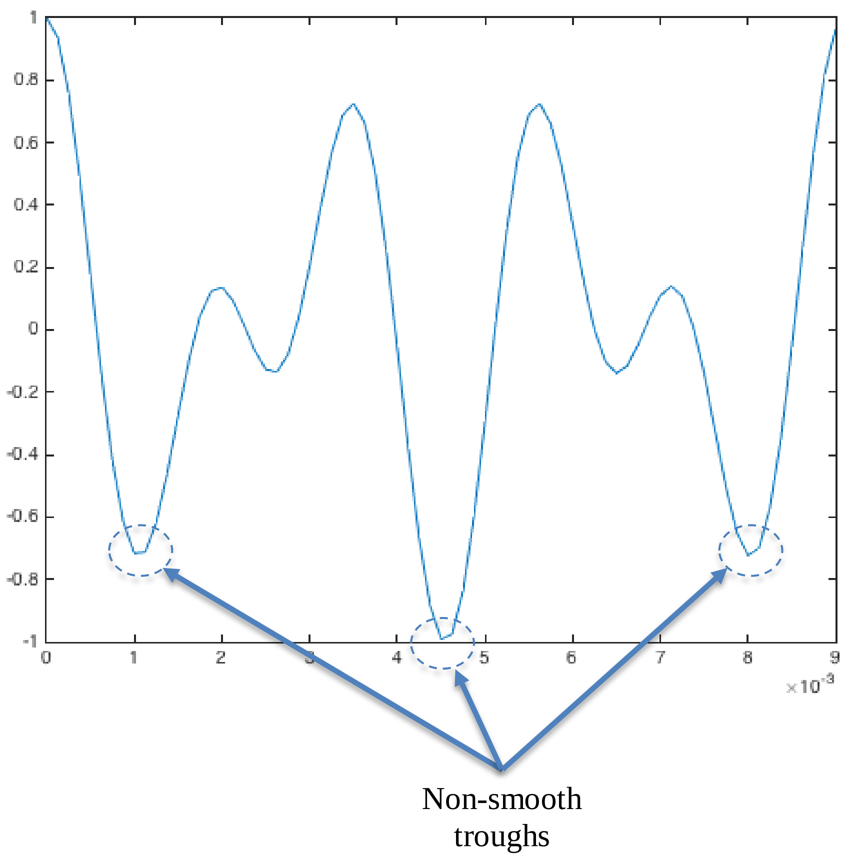
% (c) Add to the code in (b) to playing $y(t)$ as an audio signal.
%   Describe what you hear.
%   Express y(t) as a sum of two sinusoids.

```
% (c) Play y(t) at a sampling (playback) rate 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 the result from lecture slide 3-2,
%     y(t) = 0.5 cos(2 pi 330 t) + 0.5 cos(2 pi 550 t)
%     Tones at 330 Hz (E4) and 550 Hz (C#5) are
%     harmonics of 110 Hz. See Piano frequencies.
sound(y, fs);
```

% (d) Plot one period of y(t). We'll need to find the periodicity of y(t).
% The product of two sinusoids at frequencies f0 and f1 produces
% frequencies at f0+f1 and f0-f1. You could modify the code from the
% bottom right side of lecture slide 3-3.

```
ffund = gcd(f0+f1, f0-f1); % 110 Hz which is note 'A2'
Tfund = 1/ffund;
n = round(Tfund / Ts);     % Tfund / Ts isn't an integer.
plot( t(1:n), y(1:n) );
```

% See the next page for the plot.



1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
0
1
2
3
4
5
6
7
8
9
$\times 10^{-3}$
Non-smooth troughs