Tune-Up Tuesday for September 5, 2023

% 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 1-16 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;                % '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: In class, I mentioned needing to scale y before playback
% using the sound command.  It isn't needed.  The sound command
% will clip amplitudes of the signal outside [-1, 1].  The product
% cos(2*pi*f0*t) cos(2*pi*f1*t) will have amplitude on [-1, 1]
% because each cosine has amplitude on [-1, 1].
```

% (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); % 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 belowfor the plot. Plot has artifacts as noted below.