004600-001 MATLAB Exercise 1

1. For the sinusoidal waves represented by the following, draw the waveforms for each given condition

$$x(t) = A\cos(2\pi f_0 t + \phi)$$

1) sinusoidal waves of different amplitudes: $f_0 = 1,\ \phi = 0,\ A = 1, 2, 3$

2) sinusoids with different phases: $A = 1,\ f_0 = 1,\ \phi = 0, -\frac{\pi}{3}, \frac{\pi}{3}$

3) sinusoids with different frequencies: $A = 1,\ \phi = 0, f_0 = 1, 2, 3$

4) discrete sinusoids with different sampling periods: $f_0 = 1, \phi = 0,\ A = 1, 2, 3$
(hint. use `stem`)

2. For the following signal, draw the waveform of the signal and find energy and power.

$$x(t) = 3\pi \sin(8\pi t + 1.3)\cos(4\pi t - 0.8)\, e^{\sin(12\pi t)}$$

$$y(t) = \begin{cases} x(t), & 0.2 \le t \le 0.7 \\ 0, & otherwise \end{cases}$$

3. Draw the waveforms of the following signals in the range $-10 \le n \le 10$, but show the waveforms of all signals in one plot window. (hint. use `subplot`)

1) impulse: $\delta[n]$

2) step: $u[n+5]$

3) rectangular: $\mathrm{rect}\left[\frac{n}{8}\right]$

4) sinc: $\mathrm{sinc}\left(\frac{n}{3}\right)$

4. A signal mixed with noise $n(t)$ can be expressed as $x(t) = s(t) + an(t)$. Here, the magnitude of the noise varies depending on the signal-to-noise ratio (SNR), and its value is as follows.

$$a = \frac{\sigma_s/\sigma_n}{10^{SNR/20}},$$

where σ_s and σ_n are the standard deviations of the signal and noise, respectively. Draw the waveforms for cases where zero-mean uniform white noise and zero-mean white Gaussian noise are mixed with the sinusoidal signal $s(t) = \cos(2\pi t)$. The SNR for uniform white noise is 15 dB, and the SNR for white Gaussian noise is 10 dB. Also, determine the noise magnitude a for each case. (hint. use `rand` and `randn`)

5. Create an animation of the rotation of $e^{j\theta}$ in the complex plane. (unit circle animation)

6. Find the projection of a 2D orthogonal vector example (e.g., [1,0], [0,2]).

7. Plot the comparison results showing the following two cases:

    1) (time) constant ↔ (frequency) single-frequency spike

    2) (time) impulse ↔ (frequency) flat spectrum.

8. Approximate a 2π-periodic square wave using a Fourier series. (Compare all cases when the partial sum order is 1, 3, and 9.)

9. Implement the discrete Fourier transform (DFT) yourself and compare it to the `fft` fucntion, especially the computation time for N=1024 and above.

10. Plot the magnitude and phase of the DFT for a step function of length 4 (for $N = 64$), and unwrap the phase.