Homework 1

Student Name: _____

AuE 8200: Machine Perception and Intelligence
Instructor: Dr. Bing Li, Clemson University, Department of Automotive Engineering

* Refer to Syllabus for homework grading, submission and plagiarism policies;
* Submission to Canvas (Due: Mon. Jan. 31, 2022 11:59 pm), including:
  - This document (with answers), and with your program results/visualization;
  - A .zip file of source code (and data if any) with names indicating question number;

1. a) Visualize continuous period signal $x(t) = 2 + 3 * \cos(500 \pi t) + 2 * \cos(1000 \pi t) + 3 * \sin(2000 \pi t)$ in time-domain (axis: Amplitude and t) (5 points)
   b) visualize its digital Fast Fourier transform (axis: Amplitude and f). Given Sampling frequency as 1K HZ. (5 points)

2. a) Visualize the discrete signal $x(k) = 0$ for $k \in [0\ 499]$ & $x(k) = 1$ for $k \in [500\ 1000)$ μs (sampling frequency as 1M HZ) in time-domain (Amplitude and t) (5 points);
   b) Visualize its digital Fast Fourier transform (Amplitude and f), find its -3dB (called half-power) bandwidth frequencies (f_low, f_high) in frequency spectrum. (15 points)

3. For discrete signal $x(k) = 20$ for $k \in [0\ 499]$, add a normally distributed random noise n(k) (mean 0, variance 1) to the signal, and get $x'(k) = x(k) + n(k)$. Then, apply a normalized (mean 0, standard deviation 1) Gaussian kernel (windows size 3 and 11 respectively as a low pass filter, then rescale all elements to make sure the sum is 1) to perform convolution $y(k) = x'(k) * h(k)$ (h presents the impulse response, and in this case it's the filter) by using basic arithmetic operations only. (Implement the convolution without using library API)
   a) Visualize both x(k) and x'(k) in one figure (10 points)
   b) Visualize both x(k), and y(k) based on kernel window size 3 in one figure (15 points)
   c) Visualize both x(k), and y(k) based on kernel window size 11 in one figure (5 points)
   Tip: You may consider using zero-padded for edges during convolution operation

4. Write a 2~3 pages of survey on the sensing and measurement of a specific 1D physical quantity related to the automotive (vehicles, manufacturing, etc) such as: vibration, friction, temperature, speed, or distance. The grading of this question is based on the contents which the survey covers (40 points):
   - The importance of measuring this physical quantity (5 points);
   - The challenges of measuring this physical quantity (5);
   - Existing approaches of measuring this physical quantity (15);
   - Existing problems of these existing approaches (10);
   - There will be other grading factors (such as novelty, organization, et al) (5);
   * Attention: You are encouraged to include any drawing/table in the report;
   * This survey is more focusing for the sensing and measurement of a 1D physical quantity, rather than comparing multiple 1D signals.
   * You should not literally copy sentences from reference, and use "…" [1] to mark it if you really have to literally cite few sentences. For citations, use brackets (e.g. [1]) in the end of your statements, with reference list in the end of the report.