**Task list:**

**1. Basic 1 (30 points)** : A random signal

𝑋(𝑡) =

where =100 ,=150, is White Gaussian Noise, and =0.1.

A) Generate the signal for 2s, and use appropriate sample rate to do the sampling. Plot the periodogram with different window (using the Matlab library function), and compare the results, describe the differences.

B) Analyze the effects of sampling rate, signal length, FFT length and the value of on the estimation of the power spectrum using the periodogram (Just use one window).

* **Requirement**：

1. Your code must be runnable (no error, warning accepted).
2. Explain the phenomenon of your experiment figures.

**2. Basic 2 (20 points)**:

According to (11-1) and (11-2), design your own Periodogram and Correlogram function, and compare the difference of two methods. Replace these two functions with the Matlab library function in Basic 1. 1)

(11-1)

(11-2)

* **Requirement**：

1. Your code must be runnable (no error, warning accepted).
2. Explain the phenomenon of your experiment figure.

**3. Advance (50 points)**:

A chirp signal 𝑋(𝑡) = , where =1000Hz, =9000Hz, and the signal starts from 0 to 0.1s. The frequency of chirp signal will change with time.

A) According to Nyquist theorem, calculate the lowest sampling frequency (theoretical calculation), use 5 times the minimum sample rate to do the sampling, and generate this discrete signal in matlab. Finally, calculate average power of this signal =𝑬(). (10 points) (Hint : The derivative of the phase is the angular frequency)

B) Supposed the signal is transmitted from time 0s (duration: 0 to 0.1s), and received by a receiving system. The system receives the signal Y(t) for 1 second (duration: 0 to 1s), the chirp signal is received within this period. Therefore, we have where is the chirp signal but will be placed in this 0 to 1s, thus the end point of the received chirp signal is between 0.1s and 1s (following a uniform distribution between (0.1, 1)s), and there is no signal elsewhere. For the whole 0 to 1s, a white Gaussian noise N(t) is received. (30 points)

[Hint: Use the =𝑬() in 1)]

2.1 Design a matched filter for this chirp signal using Matlab.

2.2 Use this matched filter to **estimate** the end time of this system and tested the estimation result under different signal-to-noise ratios (SNR = ), where is the average power of the signal. The range of the SNR can be designed by yourself but should be appropriate. Finally, calculate the MSE and success rate of this system.

Definition:

a. MSE = , is estimated time, is true time

b. Success rate P =K/N, when <0.03, it is successful, otherwise, it is failed. K represent the number of successes.

In a and b, N is the number of tests. N = 500.

2.3 Calculate the MSE and success rate under different SNR, and use figures or tables to show the results. And analyze the results.

C) A chirp signal (𝑡) = , where =1000Hz, =9000Hz is now used to substitute the previous one, with others unchanged. Use the matched filter designed in 2) (note that it is not matched filter of (𝑡)). Test the results under different SNR, and the value of SNR should be the same as those in 2)(10 points)

3.1 Calculate the MSE and success rate under different SNR, and use figures or tables to show the results.

3.2 Compare the results to 2), and analyze it.

* **Requirement:**

1. Your code must be runnable (no error, warning accepted).
2. Explain your program with flowchart, output the figures, and give analysis.

**Extra (10 points)** :

A chirp signal (𝑡) = , where is a random phase uniformly distributed between (,). This signal is no longer a deterministic signal, but a random process. In each random experiment, the value of is random. Only and are fixed as =1000Hz, =9000Hz, and the signal starts from 0 to 0.1s. The others are the same as the previous experiment.

* **Requirement:**

1. Design a filter that can correctly estimates the end time of a signal.
2. Explain your filter and analyze the phenomenon of your experiment