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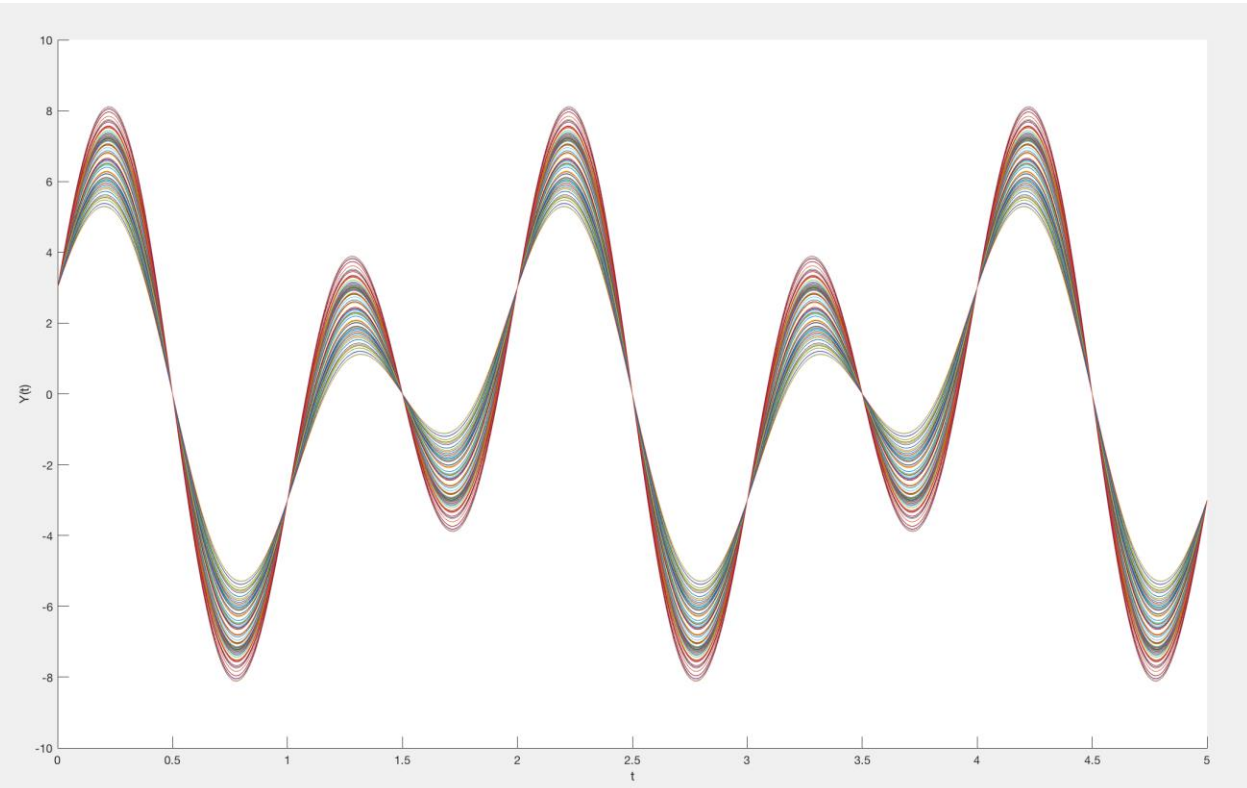
ESE 306
MatLab Project



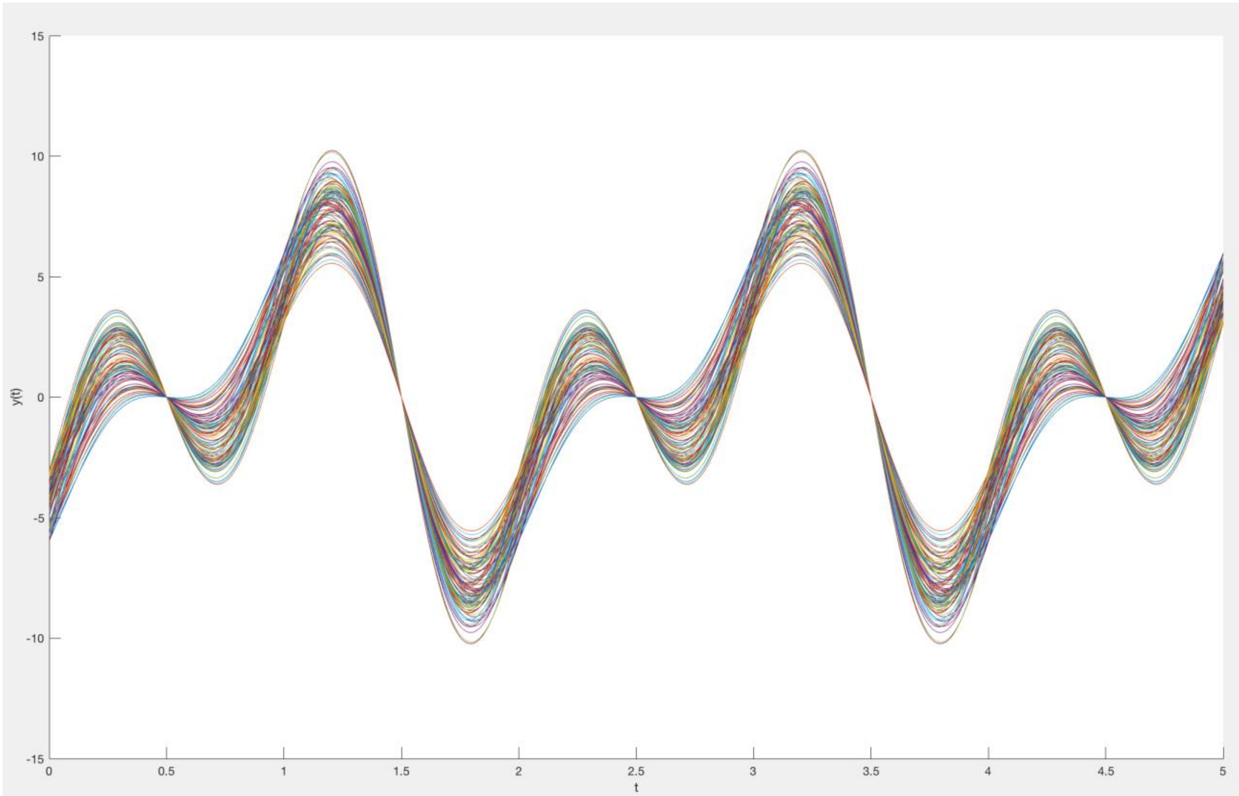
This is plot represents part 1 of Question 1, where we had to plot 100 realizations of the following function

$$X(t) = A\sin(2\pi f_1 t + \phi_1) + B\cos(2\pi f_2 t + \phi_2)$$

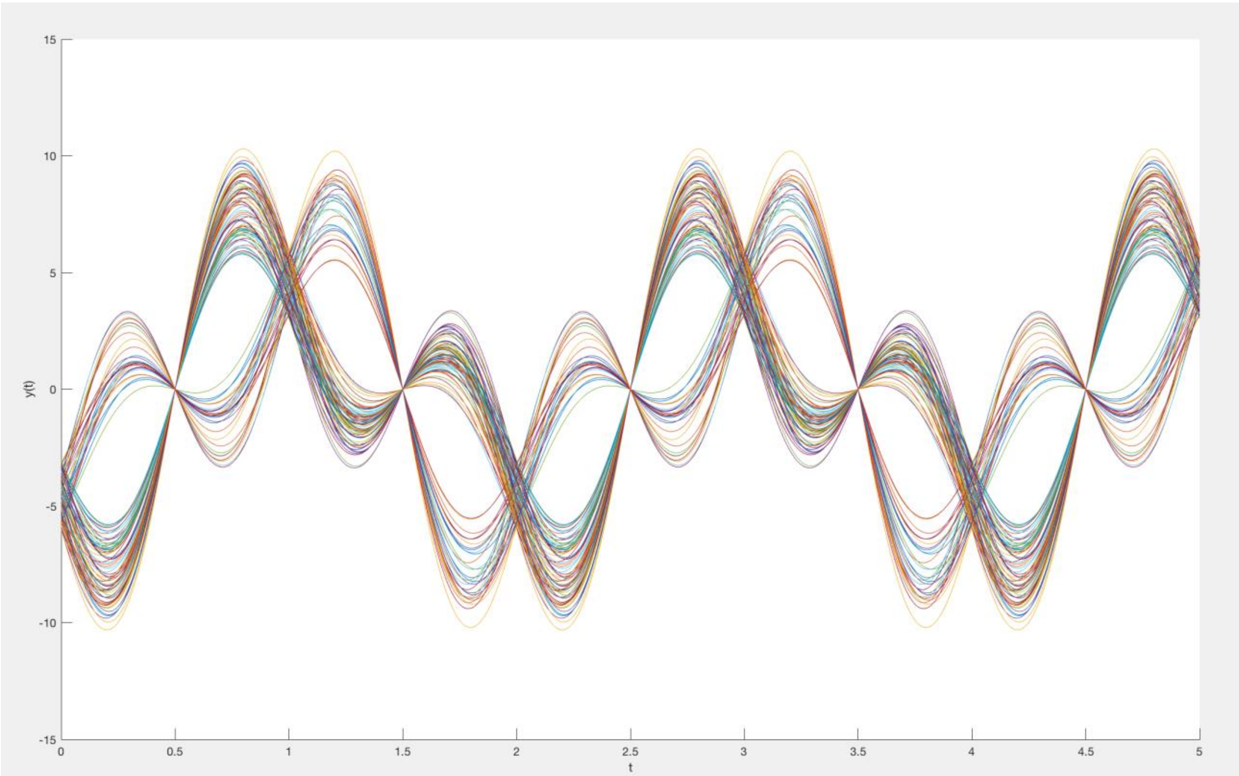
B = 3, f1 = 1, f2 = .5, phi1 = phi2 = 0

Where all the parameters were static except "t" and "A". Time (t) was going from 0 to 5 with an increment of .001. A was randomly chosen from 3 to 6 (followed uniform distribution from 3 to 6). For each of the 100 realizations, a value was randomly chosen from 3 to 6 for A.

Note : We represented the function above as Y(t) instead of X(t).



For the second part of question 1, this plot was obtained. In this part, B was not static anymore. The value for B was taken randomly from -3 to -6 (uniform distribution between -3 and -6). Both A and B were randomly chosen to plot 100 realizations.

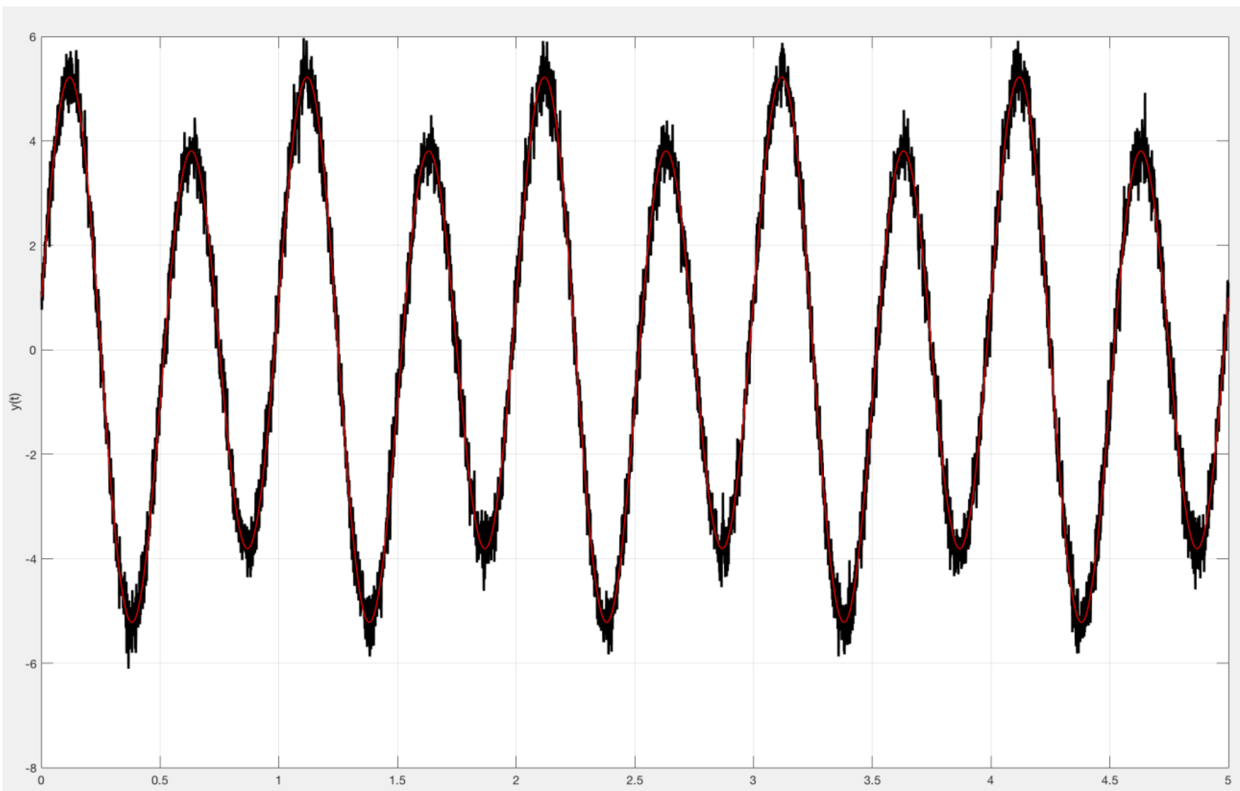


For this part, phi1 was allowed to take in 3 discrete values, phi1 = {-pi ,0, pi}. Note that phi1 does not follow uniform distribution like A and B. Phi1 must take in a value from the illustrated set with equal probability. Meaning the probability to pick each one of the elements in the set {-pi,0, pi} are equal (1/3). 100 realizations were plotted.

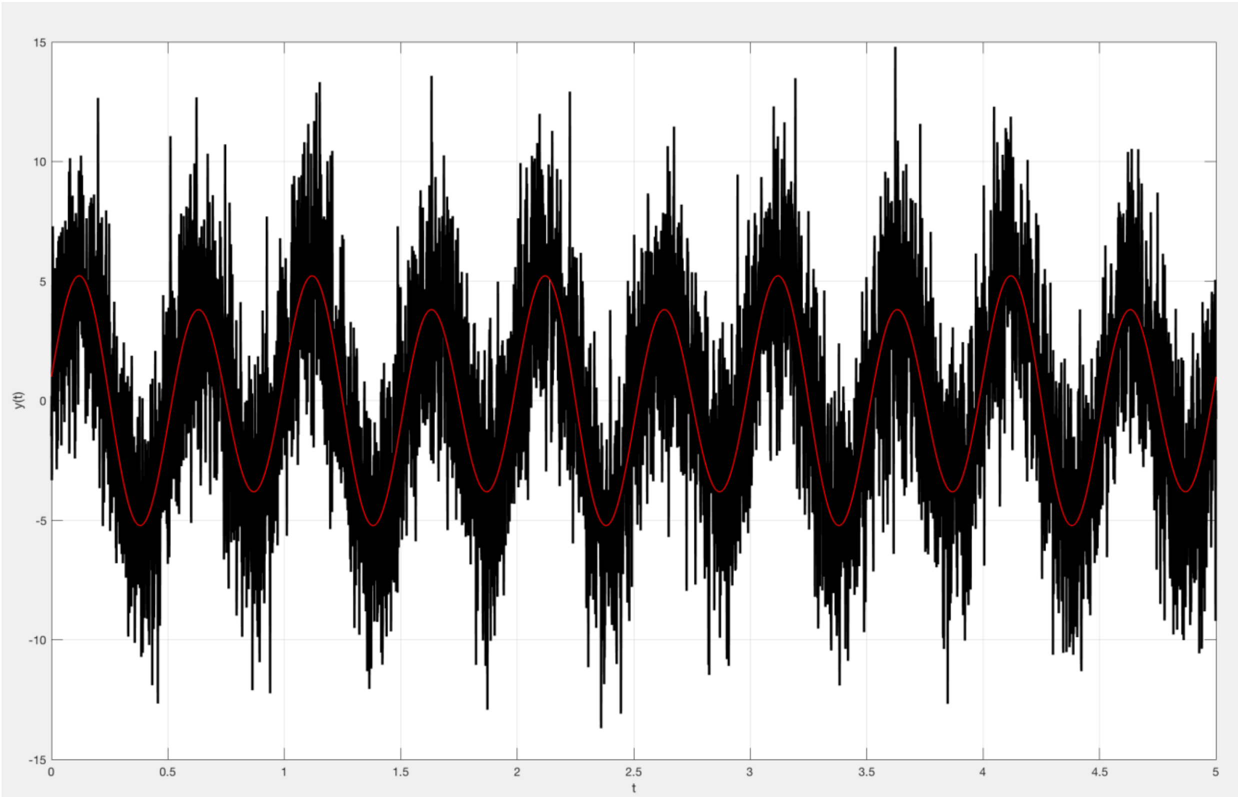
For the second question, we had to work with the following equation

$$Y(t) = X(t) + \varepsilon_t \ , \quad \varepsilon_t \sim \mathcal{N}(0, \sigma^2)$$

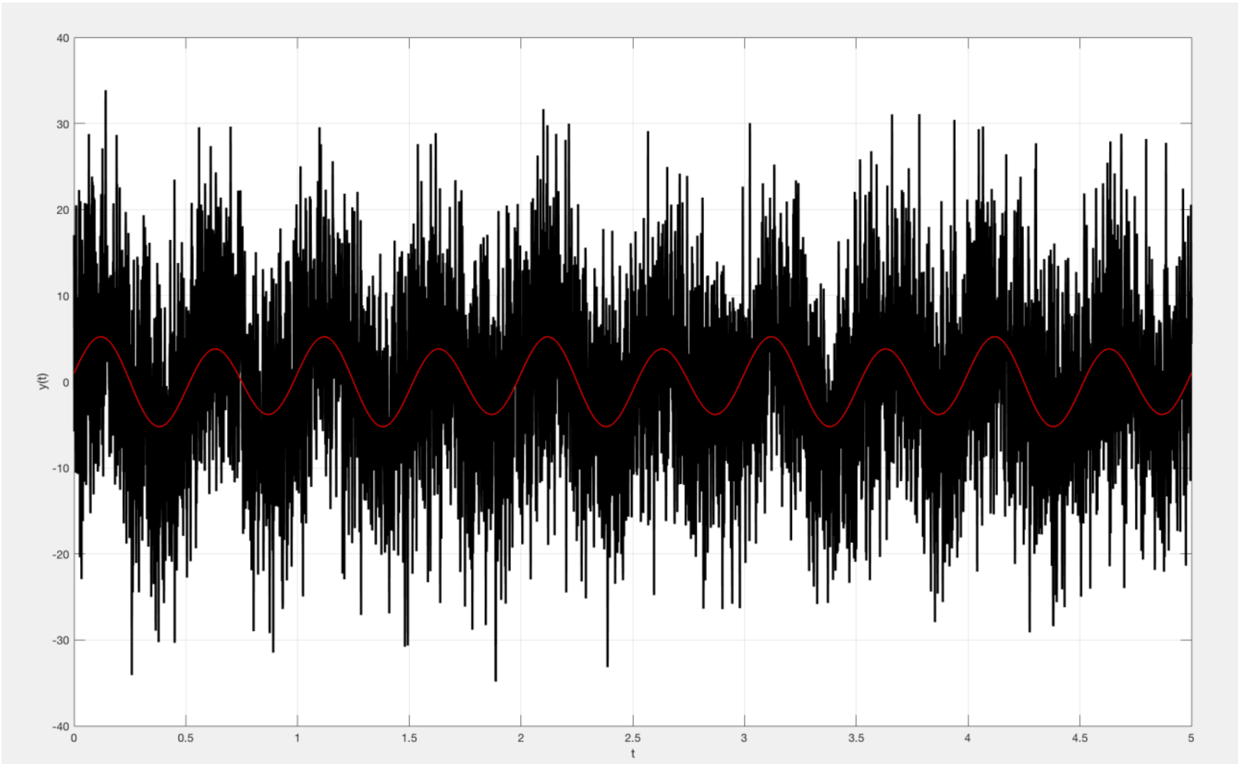
Where X(t) is the same function from Question 1, and Et represents the parameter of Gaussian distribution. Y(t) is basically a signal with Gaussian white noise. We can see two parameters in Et, one of which is zero, which is representing the mean and sigma^2 is represents the variance.



The above plot represents two signals, the true signal (colored in red) and the true signal with Gaussian white noise introduced to it (colored in black). For this part (part 2) of the second question, the mean was kept at 0, and variance was set to .1. Since Matlab does not take in sigma^2 , we sent in square root of .1, which is the standard deviation. The noise was added to the true signal at each instant of time (we defined time as range in our code). To make this happen, normrnd function was used, which returned random numbers chosen from a Gaussian distribution. The normrnd functions returns the value in an array. The length of the time(range) was taken into account.



This plot represents the 3rd part of Question 2. In this part, the standard deviation sigma was changed to square root of 10 from square root of .1. This clearly denotes that increasing the standard deviation makes the true signal noisy. The lower the value of sigma is, the better the true signal will be.



For the last part of Question 4, sigma was changed to square root of 100. The true signal got even more chaotic.

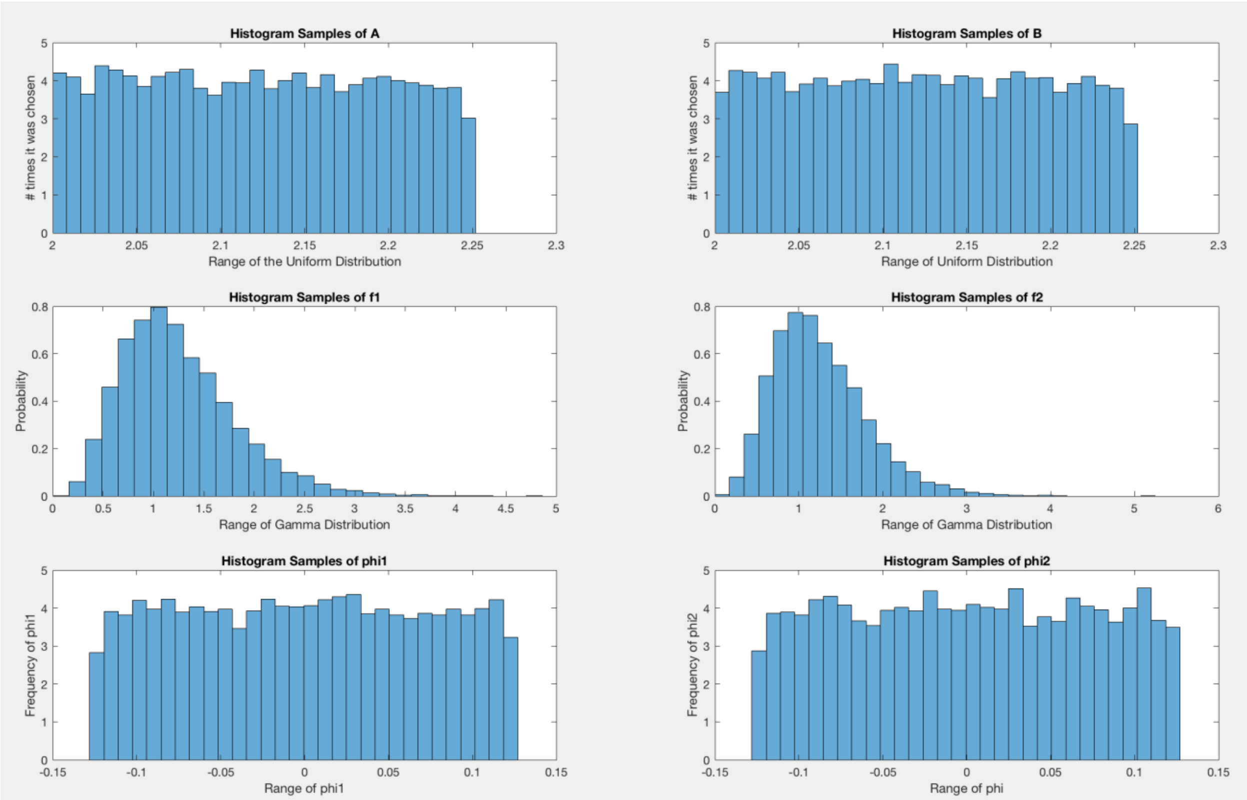
$$A, B \sim \mathcal{U}(2, 2.25)$$

$$f_1,\ f_2 \sim \text{Gamma}(5, \frac{1}{4})$$

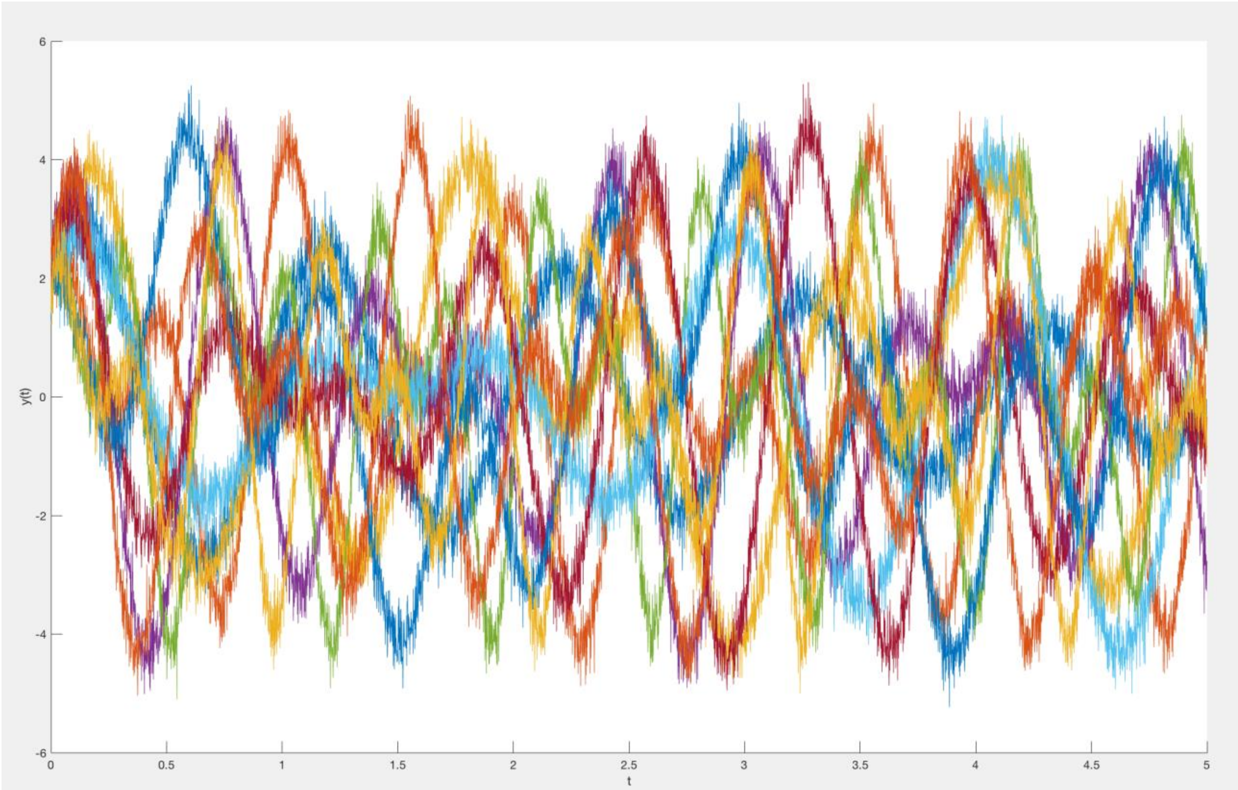
$$\phi_1,\ \phi_2 \sim \mathcal{U}(-\frac{\pi}{25}, \frac{\pi}{25})$$

$$\varepsilon_t \sim \mathcal{N}(0, 0.1)$$

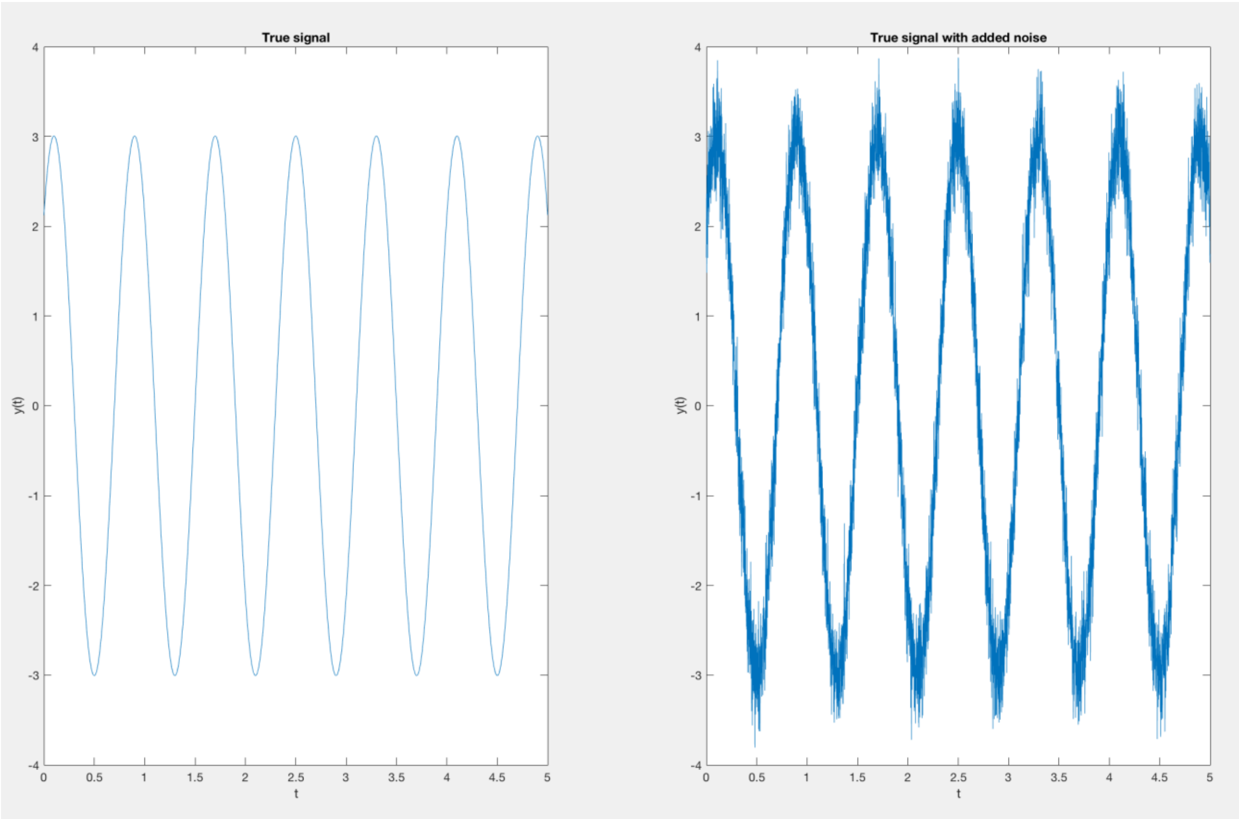
The parameters above were used to for Question 3. A, B, phi1 and phi2 follows uniform distribution, while f1 and f2 follows gamma distribution. Et follows Gaussian distribution.



10000 samples from each of the parameters were drawn. They were plotted in a histogram.



10 realizations of the random process are illustrated by the plot above.



The last part of the question 3 is illustrated by the plot above. The true signal was plotted with the mean value of each of the parameters. The left plot is the true signal without the noise, and right plot is the true signal with the noise.

Question 4:

Approaches:

In Florida, the chances of hurricane strike is 1 on average every year.

From given information above, one can model number of hurricane taking place in Florida in certain given year(s) using Poisson Distribution. The equation derived from this analysis follows

$$P(k \text{ events in interval}) = e^{-\lambda} \frac{\lambda^k}{k!}$$

where, k = # of hurricanes in given a year and λ = average number of hurricane in certain time interval.

1) Using Possion distribution we are able to model a real life random process, the equation follows

$$X(t) = e^{-\lambda} \frac{\lambda^k}{k!}$$

We have chosen Lambda to be static 5, to keep the solution simple. Therefore, K is the only random parameter. Using built in Matlab function poissrnd(lambda), it is possible to randomly choose k centering around lambda(5 in this case).

Noise was introduced in following manner,

Y(t) = poissrnd (at+b)

where, at+b = represent variances of lambda, which is now function of random variables *a* and *b* . Noise follows a uniform random distribution. In real life scenario, noise can be caused by various weather effect on our measuring instruments leading to meaningless data.