Signal Processing

Laboratory on Discrete Time Signals

1) Understanding properties of Discrete Time Sinusoidal signals
    a. Plot the discrete time real sinusoidal signal $x[n] = 10\beta^n$ for positive C when,
        i. $\beta < -1$
        ii. $-1 < \beta < 0$
        iii. $0 < \beta < 1$
        iv. $\beta > 1$
    b. Plot $x[n]$ and $x(t)$ in the same plot for the following sinusoidal signals. Let $n = kT$ where $T = 5s$ and $k \in Z$. That is $x[n]$ is obtained by sampling $x[t]$ at every 5 seconds. Determine the theoretical fundamental period of each signal.
        i. $x[n] = \cos\left(\frac{2\pi n}{12}\right), x[t] = \cos\left(\frac{2\pi t}{12}\right)$
        ii. $x[n] = \cos\left(\frac{8\pi n}{31}\right), x[t] = \cos\left(\frac{8\pi t}{31}\right)$

        Is the observed period of the signal from the plot always equal to the theoretical period?
    c. Plot the following nine discrete time signals in the same graph (use subplot command)
        i. $x[n] = \cos(0.n)$
        ii. $x[n] = \cos\left(\frac{\pi n}{8}\right)$
        iii. $x[n] = \cos(\frac{\pi n}{4})$
        iv. $x[n] = \cos(\frac{\pi n}{2})$
        v. $x[n] = \cos(\pi n)$
        vi. $x[n] = \cos(\frac{3\pi n}{2})$
        vii. $x[n] = \cos(\frac{7\pi n}{4})$
        viii. $x[n] = \cos(\frac{15\pi n}{8})$
        ix. $x[n] = \cos(2\pi n)$
    d. By observing the plots you have obtained in question 1.c, what can you tell about the shape of the signal as discrete frequency is varied?

2) Discrete convolution
    a. Write a matlab function to implement discrete convolution for $n > 0$. Note that $y[n] = x[n] * h[n]$ is given by the convolution summation $y[n] = \sum_{k=-\infty}^{\infty} x[k]h[n-k]$
    b. Using the function written in section a, convolve $x[n] = 0.5^n u(n)$ with $h[n] = u[n]$. Plot the output signal along with the two input signals.
    c. Consider the following two signals
        i. X[n] = [1 1 1 1 1 0 0 0 0 0 0 0 0 0 0]
        ii. h[n]= [2 4 8 16 32 64 0 0 0 0 0 0 0 0 0]
        iii. Convolve the two signals using the function written in part a. Use matlab conv command to verify your answer.
        iv. Considering the shape of the signal h[n] and the output signal, what sort of a transformation has been applied through the convolution operation?

3) LTI Systems
    a. Consider the following processes. Identify intput x[n] and the output y[n] for each case. Implement a matlab function to implement the given system.
        i. An investor is maintaining a bank account. The bank pays him a monthly interest of 1%. It is given that the net savings he makes is P. Write a function to calculate his current bank balance B in terms of B and P.
        ii. A merchant earns M amount of money monthly. He spends half of it and retains the rest of it as savings. Write a function to calculate the amount of money he has as savings.
    b. Find the impulse response of the above two LTI systems. Hint: you may use convolution function to obtain the impulse response.
    c. Based on the results obtained at part b, classify the two LTI systems into IIR or FIR.