Q1. (14 %) Delta Function: based on Figure1,

a) For c = b, if δ(t) is a Delta Function

1. The requirement for b
2. Please calculate the relationship of "a" and "b".
   Note: To get points, you need to provide proper calculation procedure.

b) If c = 0 and $b \neq 0$, will δ(t) still be a delta function, please validate that.

c) How to represent a signal f(t) using the delta function?

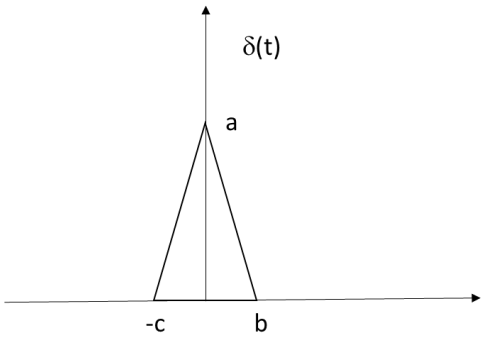


Figure 1

Q2. (8 %) Convolution: For a LTI system, $z = x * y$, if **x**={1,2,2,1} and **z**={1,6,12,a,b,c}, please calculate **y** and **z**

Q3. (12 %) System Function (Laplace Transform): For a LTI system with input x(t) and output y(t), please calculate the system function H(s) and its h(t) based on following information.

- The system is causal
- The system function is rational and has only two poles at s= - 1 and s = -3
- If x(t) = 1, then y(t) = 0
- The values of the impulse response at t =0^+ is 3

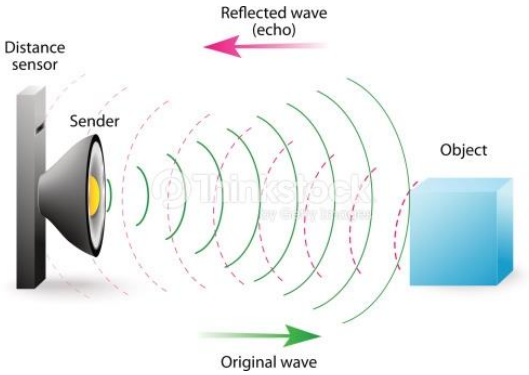
Q4. (33%) A radar system works by transmitting a pre-defined signal to the target and detect the echo signal bounced back by the object to determine the distance. A describing schematic is shown below.

(a) (9%) Formulate a signal model for the radar system. Please explain your formulations clearly.

(b) (8%) Assume that the transmitted signal occupies the bandwidth below 10 MHz, and it is our intention to digitally process the received radar signal. Please specify the minimal requirements on the analog-to-digital converter in the radar system.

(c) (8%) Let $x[n]$ be a sequence. Express the z-transform and DTFT of another sequence $y[n] = ax[n - D]$, with a and D being scalars, in terms of that of $x[n]$.

(d) (8%) One way for the radar to determine the distance is to detect when the echo signal is received. This can also be done by processing the DTFT in the frequency domain. Explain how.



Q5. (**33%**) Given the following specifications

$$\left|H\left(e^{j\omega}\right)\right| \geq -3 \text{ dB}, \quad \text{for } 0.4\pi \leq \omega \leq 0.55\pi,$$

$$\left|H\left(e^{j\omega}\right)\right| \leq -29 \text{ dB}, \quad \text{for } |\omega| \leq 0.3\pi \text{ or } 0.7\pi < |\omega| < \pi,$$

design a bandpass discrete-time filter using the window method, where $h[n] = w[n]h_d[n]$ is the impulse response of the actual filter, with $w[n]$ and $h_d[n]$ being the finite-duration window and impulse response of the desired filter. The table below may be useful.

a) (**5 %**) Based on the specifications, what is the best selection for $H_d(e^{j\omega})$, the DTFT of $h_d[n]$?

b) (**8 %**) Obtain an expression for $h_d[n]$.

c) (**10 %**) What should be the shape of $w[n]$ that will **just** meet the specifications? For the chosen $w[n]$, what should be its length?

d) (**10 %**) Using your previous results, obtain an expression for $h[n]$.

Note: (*Please write ALL of your answer in English*)