Q1: Consider the analog signal, $x_a(t) = 3\cos(100\pi t)$.

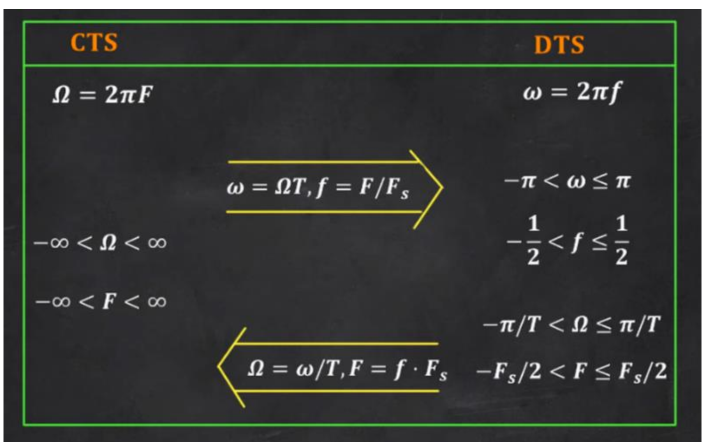
Part 1: Determine the minimum sampling rate required to avoid aliasing.

Part 2: Suppose that the signal is sampled at the rate $F_s = 200$ Hz. What is the discrete-time signal obtained after sampling? Graph the analog signal with the sampling points shown on it.

Part 3: Suppose the signal is sampled at the rate $F_s = 75$ Hz. What is discrete-time signal obtained after sampling? Graph the analog signal with the sampling points shown on it.

Part 4: What is the frequency $0 < F < F_s/2$ of a sinusoid that yields samples identical to those obtained in **Part 3**? Graph the analog signal with the sampling points shown on it and compare it with the results of **Part 3**.

You may use the following conversion table from CTS (Continuous-Time Signal) to DTS (Discrete-Time Signal), and vice versa.



Q2: Consider the analog signal, $x_a(t) = 3\cos(50\pi t) + 10\sin(300\pi t) - \cos(100\pi t)$

What is the Nyquist rate for this signal?

Q3: Consider the analog signal, $x(t) = 3\cos(2000\pi t) + 5\sin(6000\pi t) + 10\cos(12000\pi t)$

Part 1: What is the Nyquist rate for this signal?

Part 2: Assume now that we sample this signal using a sampling rate $F_s = 5000$ samples/s. What is the discrete-time signal obtained after sampling? Graph this signal.

Part 3: What is the analog signal $x(t)$ that we can reconstruct from the samples if we use ideal interpolation? Graph this signal and compare it with the results of **Part 2**.

Q4: Find the DTFS representation of the digital periodic signal x[k] using the inspection method. For inspection method, just use the Euler's formulas. Here, x[k] = $\sin(\Omega_0 k)$, where $\Omega_0 = \frac{N_0}{2\pi}$.

Use the given hints.

Definition

The DTFS representation of the periodic signal $x[k]$ with fundamental period N_0 (fundamental frequency $\Omega_0 = 2\pi/N_0$) is written as

$$x[k] = \sum_{r=0}^{N_0-1} \mathcal{D}_r e^{jr\Omega_0 k}$$

where $\mathcal{D}_r$ are the DTFS coefficients of the signal $x[k]$

Q5: You have been tasked with investigating the DTFS representation of the given digital signal x[k] using the definition of DTFS. Here, x[k] = $\sin(0.1\pi k)$, where $\Omega_0 = \frac{N_0}{2\pi}$.

Part 1:

Show that the signal, x[k], is periodic with a period of N_0 = 20.

Part 2:

Find the DTFS representation of the digital periodic signal x[k] using the definition. The sigma in D_m equation, the definition of DTFS representation, can have any lower limit and upper limit, as long as the length is 20.

Part 3:

Plot DT sinusoid, x[k], as a function of k using MATLAB.

Part 4:

Plot amplitude spectrum as a function of omega using MATLAB.

Part 5:

Plot phase spectrum as a function of omega using MATLAB.

Use the following hints:

The definition of DTFS representation:

$$\boxed{D_m = \frac{1}{N_0} \sum_{k=0}^{N_0-1} x[k] e^{-jm\Omega_0 k}}$$

Some useful formulas and concepts:

$$\sum_{N_0} e^{j\Omega_0 k (r-m)} = \begin{cases} 0 & r \neq m \\ N_0 & r = m \end{cases}$$

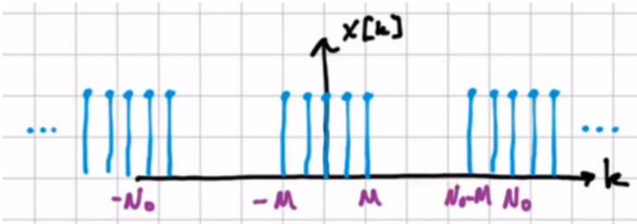
Definition

The DTFS representation of the periodic signal $x[k]$ with fundamental period N_0 (fundamental frequency $\Omega_0 = 2\pi/N_0$) is written as

$$x[k] = \sum_{r=0}^{N_0-1} \mathcal{D}_r e^{jr\Omega_0 k}$$

where $\mathcal{D}_r$ are the DTFS coefficients of the signal $x[k]$

Q6: You have been tasked with investigating the DTFS representation of the given digital signal x[k] using the definition of DTFS. As shown below, x[k] is a square wave signal.



Part 1:

Find D_r values.

Part 2:

For $N_0 = 50$, and $M = 4$, plot x[k] as a function of k, from k = 0 to k = 50. Also, plot amplitude spectrum. Use MATLAB.

Part 3:

For $N_0 = 50$, and $M = 12$, plot x[k] as a function of k, from k = 0 to k = 50. Also, plot amplitude spectrum. Use MATLAB.

Part 4:

Compare the results of **Part 2** with the results of **Part 3**.

Use the following hints:

The definition of DTFS representation:

$$\boxed{D_m = \frac{1}{N_0} \sum_{k=0}^{N_0-1} x[k] e^{-jm\Omega_0 k}}$$

Some useful formulas and concepts:

$$\sum_{n=0}^{N-1} \alpha^n = \frac{1-\alpha^N}{1-\alpha}$$

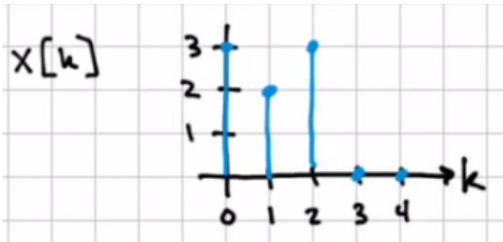
Definition

The DTFS representation of the periodic signal $x[k]$ with fundamental period N_0 (fundamental frequency $\Omega_0 = 2\pi/N_0$) is written as

$$x[k] = \sum_{r=0}^{N_0-1} \mathcal{D}_r e^{jr\Omega_0 k}$$

where $\mathcal{D}_r$ are the DTFS coefficients of the signal $x[k]$

Q7: This digital signal is given to us:



Part 1: Find the DFT of x[k]. That is, find X_0, X_1, and X_2.

Part 2: Find the X(Ω) equation.

Part 3: Find the $|X(\Omega)|$ equation and plot amplitude spectrum as function of Ω. Show DFT points on the same graph.

Use the following hint:

$$X_r = \sum_{N_0} x[k] e^{-jr\Omega_0 k}$$