

ECE 313 Lecture Notes

Lecture 5 on Sampling & Reconstruction Part 2

Thursday, September 29, 2026

By TA Alice Liu

...

Audio effects: [TV Girl - cigarettes out the window](#) first 15 seconds (suggested by a Fall 2026 student)

...

Midterm #1 on Thursday, Oct. 1, 11am to 12:15pm. Open book/notes/laptop. No networking and no AI tools. More info at end of notes. See [midterm #1 page](#) for more info.

...

Sampling Theorem – Recap

1. Oversampling (no aliasing) according to Sampling Theorem ($f_s > 2f_{max}$)
 - a. Enables perfect frequency reconstruction for conversion between Continuous Time and Discrete Time

Slide 6-5

$$x(t) = \cos(2\pi f_0 t)$$
$$x[n] = x(t) \Big|_{t=nT_s} = \cos\left(2\pi f_0 \left(\frac{n}{f_s}\right)\right)$$
$$x[n] = \cos\left(2\pi \frac{f_0}{f_s} n\right)$$
$$\hat{\omega}_0 = 2\pi \frac{f_0}{f_s}$$

T_s sampling period
 f_s sampling rate
 f_0 frequency of CT sinusoid.

Sampling Theorem

$$f_s > 2f_0$$
$$f_0 < \frac{1}{2}f_s$$
$$-\frac{1}{2}f_s < f < \frac{1}{2}f_s$$
$$-\pi < \hat{\omega} < \pi$$

Fundamental interval

$$\cos(\hat{\omega} n T_s) = \frac{1}{2} e^{j\hat{\omega} n T_s} + \frac{1}{2} e^{-j\hat{\omega} n T_s}$$

- b. Note: Even without aliasing, the spectrum still replicates! (Due to Sampling)
 - i. Thus, we must disregard frequencies that are outside the range defined by the Sampling Theorem

Three Major Differences	
Continuous-Time	Discrete-Time
1. time is real-valued	time is integer-valued (discrete grid)
2. origin in time @ $t=0$ seconds affects initial cond.	origin in time @ $n=0$ samples affects initial cond.
3. frequency domain aperiodic / non-periodic	frequency domain periodic @ 2π rad/sample

2. Undersampling (aliasing – no folding) ($f_s \leq 2f_{max}$)
 - a. We see the aliased frequency components instead of the desired signal frequency components
 - b. We don't sample fast enough, and so the reconstructed signal's frequency does not match the desired signal's frequency
3. Undersampling (aliasing – with folding) ($f_{max} < f_s \leq 2f_{max}$)
 - a. Special case of Undersampling (aliasing – no folding)
 - b. In this case of aliasing, we see the positive & negative frequency components swap places (or change sign)
 - c. Positive frequency -> shift graphically to the negative frequencies
 - d. Negative frequency -> shift graphically to the positive frequencies

...

Discrete to Continuous Conversion (Signal Reconstruction from Samples)

- Interpolation is a sum of weighted pulses
- Interpolation types
 - o Rectangular (sample and hold)
 - o Triangular (linear)
 - o Sinc pulse (this is NOT sine/cosine sin function!)
 - Sinusoidal signal
 - Decays over time
 - Sinc pulse is very important going forward in the course

...

In-class [DSP First Reconstruction Demo](#)

...

Midterm #1 logistics/review

- See the [midterm #1 page](#) for more info.
- ZIP file of all content on Canvas made available to students later this afternoon
 - o Students will have local copy of all course material
- Midterm example walkthrough (Midterm #1 Fall 2025 Problem 1.3)
 - o Discuss expectations of work to show
 - o Discuss awarding of partial credit
 - o Discuss usage of MATLAB on the exam (not required)