

Course overview

The key-points printable for <https://lessons.ihsan.cc/ece207/ece207-course-overview/> – what the course asks, one idea and equation per chapter, and what everything is worth.

Course page: ECE 207 at a glance

ECE 207 asks one question six times: given a system and an input, what comes out? Chapter 1 settles which systems the question applies to; the five chapters after answer it in a different setting, generated by two choices — continuous vs. discrete time, and time domain vs. frequency domain.

TABLE 1 *assessment*

COMPONENT	WEIGHT	WHEN	WHERE
5 homework assignments	15% total (3% each)	Not announced	Crowdmark
Midterm exam	35%	Oct 28	Not announced
Final exam	50%	Not announced	Not announced

No labs. The outline prints the midterm as 10/28/2025, a year from another offering, so confirm it in class. Late work costs 15% a day and is not accepted once solutions are discussed in class. The professor encourages AI for learning the material; only cheating on an assessment is off.

Chapter 1: Signals and systems

Which systems this course's machinery applies to.

A signal is continuous-time, $x(t)$, when time ranges over the reals, or discrete-time, $x[n]$, when it ranges over the integers. It is periodic when

$$x(t + T) = x(t)$$

for every t , with the smallest such T the fundamental period.

A signal's energy is $E = \int_{-\infty}^{\infty} |x(t)|^2 dt$; its power is that integrand's average over a growing window. No signal has both finite: an everlasting sinusoid has infinite energy and power half its amplitude squared.

A system is **linear** when it obeys superposition, and **time-invariant** when delaying the input only delays the output. LTI is the price of admission for everything after chapter 1. A system is **causal** when its output depends only on present and past input.

Check yourself

1. For $y(t) = t x(t)$, which of linearity and time invariance fails, and what does that cost you later?

Answer. Time invariance fails; linearity holds. With no time invariance there is no single impulse response that can be shifted around, so the output cannot be written as a convolution (chapter 2), and the transfer-function machinery of chapter 3 never gets started either.

Chapter 2: Time-domain analysis

Why the response to one sharp kick tells you the response to everything.

The unit impulse $\delta(t)$ is defined by the sifting property,

$$\int_{-\infty}^{\infty} x(t) \delta(t - t_0) dt = x(t_0),$$

which rewrites any signal as a continuum of weighted impulses. Push that through an LTI system: time invariance shifts the impulse response $h(t)$ (the response to $\delta(t)$), linearity adds the weighted pieces. Together,

$$y(t) = \int_{-\infty}^{\infty} x(\tau) h(t - \tau) d\tau = (x * h)(t),$$

the convolution integral. The full response is zero-input (stored energy) plus zero-state (the input, from rest); from rest, convolution is the whole answer.

The system is BIBO stable exactly when h is absolutely integrable,

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$$\int |h(t)| dt < \infty.$$

Chapter 3: Frequency-domain analysis

Trading calculus for algebra, and reading behaviour off poles.

The Laplace transform sends $x(t)$ to $X(s)$. Convolution becomes multiplication,

$$y = x * h \iff Y(s) = H(s) X(s),$$

with $H(s)$ (transform of h) the **transfer function**; and differentiation becomes multiplication by s , turning a differential equation into algebra. Getting back to time is partial-fraction expansion.

Writing $H(s)$ as a ratio of polynomials, the denominator's roots are the **poles**: the real part of a pole sets decay/growth, the imaginary part sets oscillation.

Check yourself

1. A system has poles at $s = -1 \pm 3j$ and no others. Is it stable, and what does its response look like?

Answer. Stable: both poles have real part $-1 < 0$, strictly left half-plane. The response is an oscillation at 3 rad/s inside an e^{-t} envelope — it rings, and the ringing dies away.

Chapter 4: Discrete time

The same two chapters again, with sums for integrals — and one thing that changes.

Linearity, time invariance, causality and BIBO stability transfer to sequences $x[n]$ unchanged. Sifting for sequences gives the **convolution sum**,

$$y[n] = \sum_{k=-\infty}^{\infty} x[k] h[n - k],$$

and the z -transform repeats chapter 3's move: $Y(z) = H(z)X(z)$.

TABLE 2 *continuous time versus discrete time*

CONTINUOUS TIME	DISCRETE TIME	CARRIES OVER?
Differential equation	Difference equation	Yes
Convolution integral	Convolution sum	Yes
Laplace transform, $H(s)$	z -transform, $H(z)$	Yes
Stable when all poles satisfy $\text{Re}(s) < 0$	Stable when all poles satisfy $ z < 1$	No

A pole at s contributes e^{st} (decays when $\text{Re}(s) < 0$); a pole at z contributes z^n (decays when $|z| < 1$) — the stable region is a half-plane in one setting and a disc in the other.

Check yourself

1. One system has poles at $z = 0.5$ and $z = 1.5$. Another has poles at $s = 0.5$ and $s = 1.5$. Which poles are the stable ones?

Answer. Only $z = 0.5$ is stable (magnitude < 1). Both s poles are unstable (real part > 0). Note $z = 0.5$ and $s = 0.5$ are the same number and land on opposite sides of the verdict — the plane you are in decides.

Chapter 5: Periodic inputs

Handling a periodic input one harmonic at a time.

Feed an LTI system $e^{j\omega t}$ and the output is the same exponential scaled by a complex number depending on ω alone:

$$e^{j\omega t} \mapsto H(j\omega) e^{j\omega t}$$

($H(j\omega)$, chapter 3's transfer function on the imaginary axis, is the frequency response). A periodic signal of period T_0 decomposes into a Fourier series at $\omega_0 = 2\pi/T_0$ and its whole multiples,

$$x(t) = \sum_{n=-\infty}^{\infty} D_n e^{jn\omega_0 t}, \quad D_n = \frac{1}{T_0} \int_{T_0} x(t) e^{-jn\omega_0 t} dt,$$

so the output is one complex multiplication per harmonic,

$$y(t) = \sum_{n=-\infty}^{\infty} D_n H(jn\omega_0) e^{jn\omega_0 t}.$$

Check yourself

1. A periodic signal's period is doubled. What happens to the spacing of the lines in its spectrum?

Answer. The spacing halves: the lines sit at multiples of $\omega_0 = 2\pi/T_0$, so doubling T_0 halves ω_0 . Chapter 6 is what happens when that process is continued.

Chapter 6: Non-periodic inputs

Letting the period run to infinity: filters, and radio.

As the period T_0 grows, the line spacing ω_0 shrinks to zero and the Fourier series becomes the Fourier transform:

$$X(\omega) = \int_{-\infty}^{\infty} x(t) e^{-j\omega t} dt, \quad x(t) = \frac{1}{2\pi} \int_{-\infty}^{\infty} X(\omega) e^{j\omega t} d\omega.$$

System analysis crosses the limit intact, $Y(\omega) = H(\omega) X(\omega)$. Designing $|H(\omega)|$'s shape is filtering; the ideal low-pass filter's impulse response is a sinc, nonzero for negative time, so it cannot be built. Amplitude modulation multiplies by $\cos(\omega_c t)$, which shifts the spectrum up to ω_c ; demodulation and a low-pass filter bring it back.

Check yourself

1. Why can the ideal low-pass filter not be built?

Answer. Its impulse response is a sinc, nonzero for negative time: the filter would have to respond before its input arrived, so it is not causal, and no physical system is non-causal.