# EE102

Lecture 4

# EE102 Announcements

- Syllabus link is tinyurl.com/ucla102
- CCLE difficulties, please email help@seas.ucla.edu
- My office hour meeting minutes are sent out weekly
- **First Homework due this Friday**

**Slide Credits**: This lecture adapted from Prof. Jonathan Kao (UCLA) and recursive credits apply to Prof. Cabric (UCLA), Prof. Yu (Carnegie Mellon), Prof. Pauly (Stanford), and Prof. Fragouli (UCLA)

# Sidebar: Regarding Periodic Signals

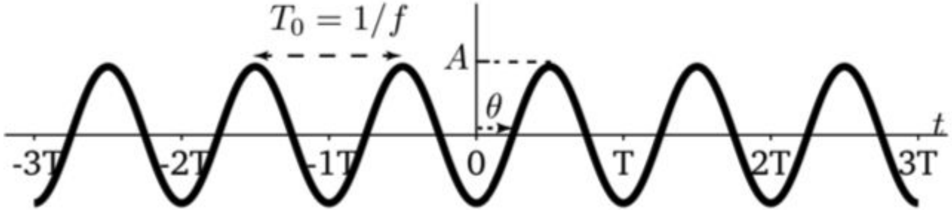
The sum or product of a periodic signal is itself periodic if:

# Signal Models

## Real sinusoids (cont.)

We illustrate a sinusoid signal below:

$$x(t) = A\cos(\omega t - \theta)$$



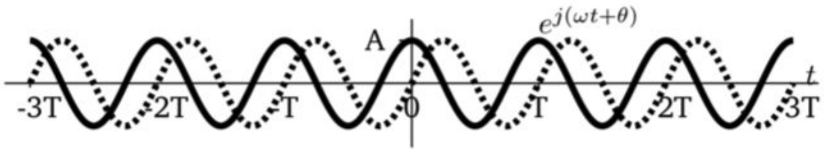
# Signal Models

## Complex sinusoids

The complex sinusoid is given by:

$$Ae^{j(\omega t+\theta)} = A\cos(\omega t+\theta) + jA\sin(\omega t+\theta)$$

We draw complex signals with dotted lines.




The real part of the complex sinusoid (solid line) is:

$$\Re\left(Ae^{j(\omega t+\theta)}\right) = A\cos(\omega t+\theta)$$

The imaginary part of the complex sinusoid (dotted line) is:

$$\Im\left(Ae^{j(\omega t+\theta)}\right) = A\sin(\omega t+\theta)$$

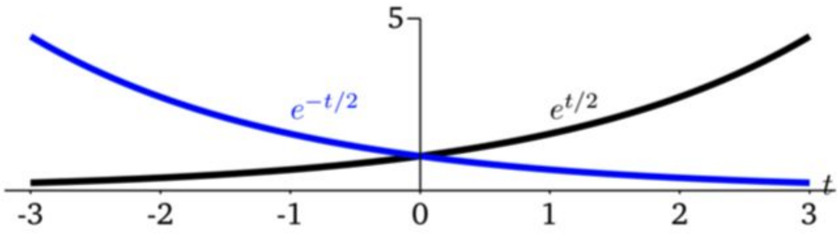
# Signal Models

## Exponential

An exponential signal is given by

$$x(t) = e^{\sigma t}$$

- If $\sigma > 0$, this signal grows with increasing $t$ (black signal in plot below). This is called exponential growth.
- If $\sigma < 0$, this signal decays with increasing $t$ (blue signal in plot below). This is called exponential decay.



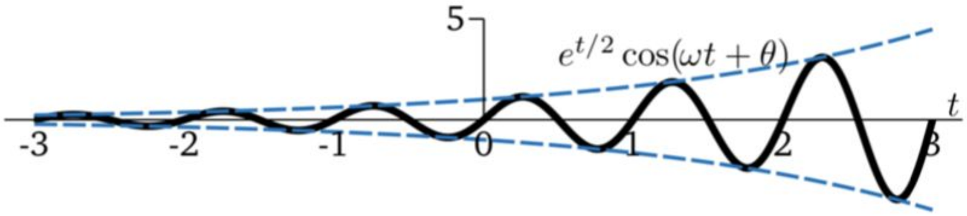
# Signal Models

## Damped or growing sinusoids

A damped or growing sinusoid is denoted

$$x(t) = e^{\sigma t} \cos(\omega t + \theta)$$

The sinusoid will grow exponentially if $\sigma > 0$ and decay exponentially if $\sigma < 0$.

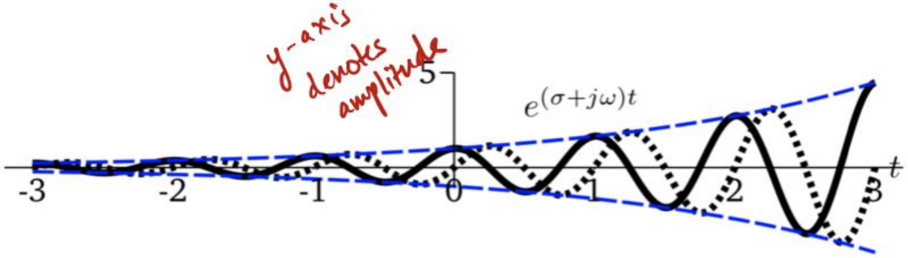


## Complex exponential

A complex sinusoid is denoted

$$x(t) = e^{(\sigma + j\omega)t}$$

It is a combination of the complex sinusoid and an exponential. All prior signals are special cases of the complex exponential signal.



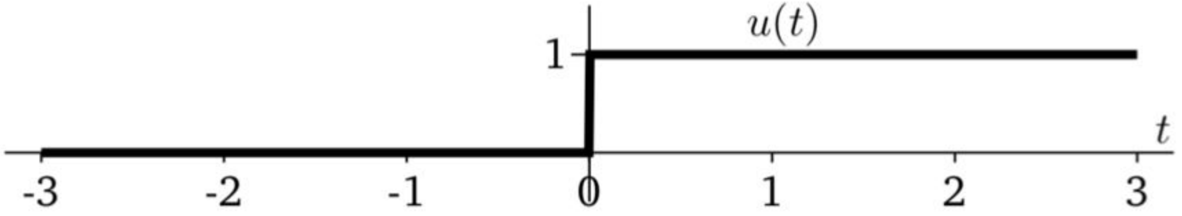

It is helpful to think of $\sigma$ and $j\omega$ in the complex plane. $\sigma$ is the x-axis and $j\omega$ is the y-axis. Then complex exponentials in the left complex plane are decreasing signals and those in the right are increasing signals.

# Heaviside Step Function

The unit step function, denoted $u(t)$ in this class, is given by

$$u(t) = \begin{cases} 1, & t \geq 0 \\ 0, & t < 0 \end{cases}$$

It is also called the Heavyside step function. Drawn below:



# Unit Rectangle

$$\mathrm{rect}(t) = \begin{cases} 1, & |t| \leq 1/2 \\ 0, & \text{else} \end{cases}$$

# Unit Ramp Function

# Unit Triangle

# Impulse Function (Important!)

# Impulse Function (intuition)

# Impulse Function Intuition

# Impulse Sampling Property

# Impulse Sampling Property

# Impulse Sifting Property

# Impulse Sifting Property

# CYU: Calculate

$$\int_{-2}^{3+} f(t)\left[1 + \delta(t+1) - 3\delta(t-1) + 2\delta(t+3)\right] dt$$

# CYU: Integral of an Impulse

$$\int_{-\infty}^{t} \delta(\tau) d\tau =$$

# CYU (Visual)

Suppose $x(t) = 1 + \delta(t-1) - 2\delta(t-2)$ then what is $y(t) = \int_0^t x(\tau) d\tau$

# Systems

A system transforms an input signal, $x(t)$, into an output signal, $y(t)$.

Systems, like signals, are similar to functions. However, they map a signal to another signal, so the term we might use is “operator”.

For EE102, we will not nitpick this distinction and focus on SISO systems.