



Signals & Systems (ECN-203)

Lecture 1 (Course introduction)

Dheeraj Kumar

dheeraj.kumar@ece.iitr.ac.in

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- 1 What are “Signals” and “Systems”
- 2 What problems to be addressed concerning “Signals and Systems”?
- 3 Why you as a CSE students should study this course?
- 4 Course content (tentative)

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Signals



- ❑ Mathematical definition: A function of one or more independent variables
- ❑ From the perspective of application: Contains some information about the behavior or nature of some phenomenon
- ❑ Examples:
 - ❑ Voltage, current, and power as a function of time in an electrical circuit
 - ❑ Pressure on the accelerator pedal of an automobile
 - ❑ Electrocardiogram of a person
 - ❑ Light from different sources and reflected from objects



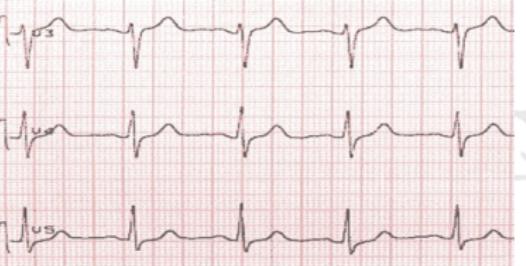
Dependent and independent variables



Signal	Independent variables	Dependent variables
<p>$v(t)$ $i(t)$ $p(t)$</p>	Time	Voltage Current Power
<p>Time</p>		Pressure

Dependent and independent variables



Signal	Independent variables	Dependent variables
	Time	ECG voltage
	Time Space (x,y,z)	Light intensity Colors

The information component

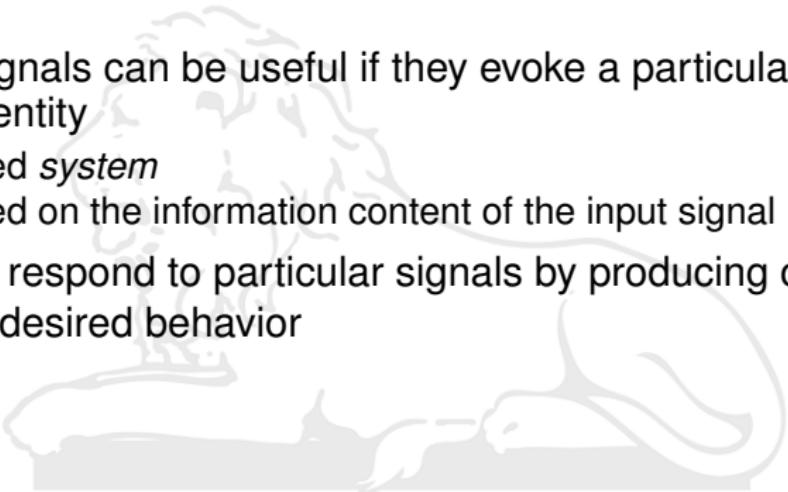


- ❑ Voltage, current, and power in an electrical circuit
 - ❑ A bit (0/1) stored in a memory element
 - ❑ Robot arm movement
- ❑ Pressure on the accelerator pedal of an automobile
 - ❑ Driver wants to accelerate/decelerate
- ❑ Electrocardiogram of a person
 - ❑ Various heart functions
 - ❑ Indication of a disease
- ❑ Light from different sources and reflected from objects
 - ❑ The scene

So, what do we do with all these signals?



- ❑ These signals can be useful if they evoke a particular response from an entity
 - ❑ Called *system*
 - ❑ Based on the information content of the input signal
- ❑ Systems respond to particular signals by producing other signals or some desired behavior



Systems for these signals



- ❑ Signal: Voltage, current, and power
 - ❑ System: The circuit which responds to applied voltage and currents
- ❑ Signal: Pressure on the accelerator pedal
 - ❑ System: The automobile, which responds by increasing the speed of the vehicle
- ❑ Signal: Electrocardiogram
 - ❑ System: A computer program for the automated diagnosis of various heart ailments
 - ❑ Produces estimates of parameters such as heart rate
- ❑ Signal: Light from different sources and reflected from objects
 - ❑ System: A camera that produces a photograph/video of the scene

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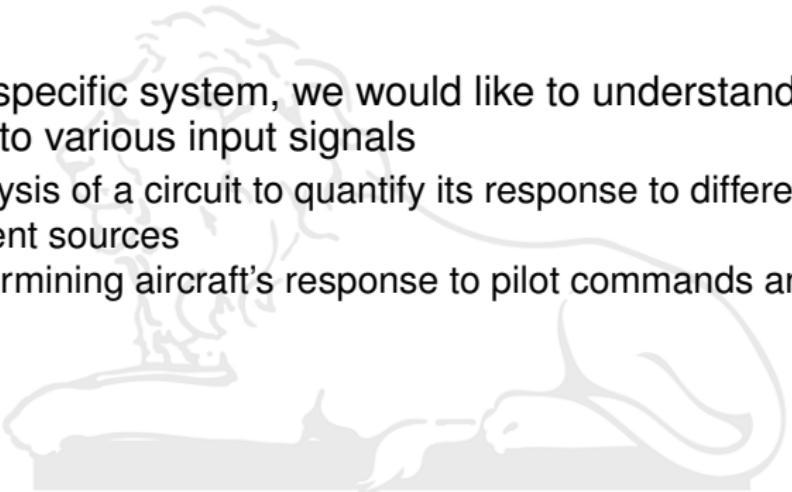


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System characterization



- ❑ Given a specific system, we would like to understand how it will respond to various input signals
 - ❑ Analysis of a circuit to quantify its response to different voltage and current sources
 - ❑ Determining aircraft's response to pilot commands and wind gusts



System designing



- ❑ Designing systems to process signals in particular ways
- ❑ Design of systems to enhance or restore signals that have been degraded in some way
 - ❑ Noise removal in a communication system
 - ❑ e.g., mobile phone, pilot communicating to traffic control, etc.
 - ❑ Image restoration and enhancement
 - ❑ e.g., images from deep space probes or earth-observing satellites
- ❑ Extract specific pieces of information from signals
 - ❑ Estimation of heart rate from an electrocardiogram signal
 - ❑ Machine learning applications (speech recognition, computer vision)

Signal designing



- ❑ Design of signals with particular properties so that it can be fed as input to a given system
 - ❑ Designing transmission signal for successful transmission through a communication system
 - ❑ Feature selection for better performance of a machine learning system

Control systems



- ❑ Modify or control the characteristics of a given system
 - ❑ Using specific input signals or by combining the system with other systems
- ❑ Control systems to regulate chemical processing plants
 - ❑ Variety of sensors that measure physical parameters to provide input signals
 - ❑ Control system responds to these signals to regulate the ongoing chemical process
- ❑ Aircraft autopilots and computer control systems
 - ❑ Signals: aircraft speed, altitude, and heading
 - ❑ System adjusts variables such as throttle speed and the position

And many more...



- ❑ The concepts of signals and systems stems from a diversity of phenomena and processes
- ❑ Collection of ideas, analytical techniques, and methodologies, that are generic in nature
- ❑ History of this development extends back over many centuries
 - ❑ Most of this work was motivated by specific applications
 - ❑ They can be applied to far larger variety of contexts
- ❑ Fourier analysis was developed by Babylonians to study the problems of astronomy
 - ❑ It is now a central technique in designing communication systems and feature vectors

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Motivation for CSE students



- ❑ This course is rich at both theoretical and practical levels
 - ❑ Includes advanced mathematical concepts such as linear algebra, calculus, and probability and statistics
- ❑ Applied to virtually every domain of science and technology
- ❑ Machine learning
 - ❑ Time series analysis
 - ❑ Radar/sonar signals
 - ❑ Medical instruments (imaging or 1D such as ECG, EEG, etc.)
 - ❑ IoT
 - ❑ Cryptography and security
- ❑ Knowledge base developed through this course will be helpful in other domains

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Topics to be covered

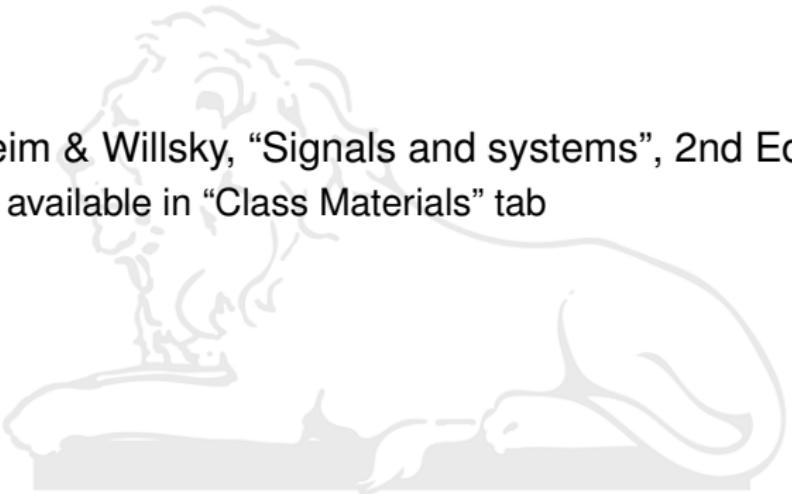


- ❑ Introduction to signals and systems
- ❑ Linear time-invariant systems
- ❑ Continuous-time signals
 - ❑ Fourier series representation of continuous-time periodic signals
 - ❑ The continuous-time fourier transform
 - ❑ The laplace transform
- ❑ Discrete-time signals
 - ❑ Fourier series representation of discrete-time periodic signals
 - ❑ The discrete-time fourier transform
 - ❑ Sampling
 - ❑ The z-transform

Suggested books



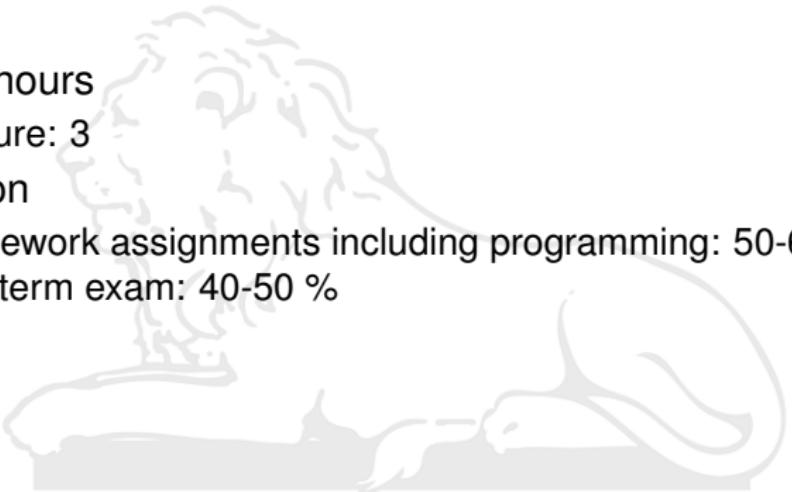
- ❑ Oppenheim & Willsky, "Signals and systems", 2nd Edn.
 - ❑ PDF available in "Class Materials" tab



Contact hours and evaluation



- Contact hours
 - Lecture: 3
- Evaluation
 - Homework assignments including programming: 50-60%
 - End term exam: 40-50 %



Thanks.