1

Introduction

This first lecture is intended to broadly introduce the scope and direction of the course. We are concerned, of course, with signals and with systems that process signals. Signals can be categorized as either continuous-time signals, for which the independent variable is a continuous variable, or discrete-time signals, for which the independent variable is an integer. Examples of continuous-time signals include the sound pressure at a microphone as a function of time or image brightness as a function of two spatial variables. In the first case the signal is a one-dimensional signal, in the second a two-dimensional signal. Common examples of discrete-time signals are economic time series, such as the daily or weekly stock market index, antenna arrays, etc. While these examples include both one-dimensional and two-dimensional signals, our detailed discussions in this course focus only on one-dimensional signals. Many of the general concepts and results, however, will be illustrated with two-dimensional signals, specifically images.

There are some very strong similarities and also some very important differences between discrete-time signals and systems and continuous-time signals and systems. Discussing both classes together provides an opportunity to share intuition and to use both the similarities and the differences as a further emphasis of important concepts. Furthermore, as we will see as the course proceeds, current technology provides an important mechanism—through the concept of sampling—for converting between continuous-time and discrete-time signals. It is often very advantageous to process continuous-time signals by first converting them to discrete time.

For the most part, our discussion of systems throughout is restricted to a specific class, namely linear, time-invariant systems. Extremely powerful tools and techniques exist for both analysis and design of this class of systems. In particular, in discussing this class of systems we develop signal and system representations in both the *time domain* and the *frequency domain*. These two domains of representation are tied together through the Fourier transform, which we discuss and exploit in considerable detail.

As I emphasize in this lecture, it is extremely important to use both the course text and the video course manual in conjunction with watching the tapes. The material presented in the lectures is very closely tied to the text. In addition, the recommended and optional problems in the video course manual have been carefully chosen to emphasize and amplify important issues raised in the associated lecture. Consequently, it is extremely important that, in addition to watching a taped lecture, you do the accompanying suggested reading and recommended problems before proceeding to the next lecture.

Suggested Reading

Chapter 1, page 1

Section 2.0, Introduction, page 7

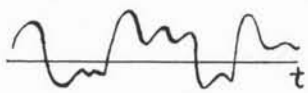
Section 2.1, Signals, pages 7–12

MARKERBOARD 1.1 (a)

Signals

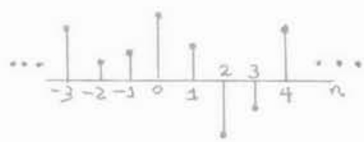
continuous-Time

$x(t)$ one dimensional



Discrete-Time

$x[n]$



images two dimensional

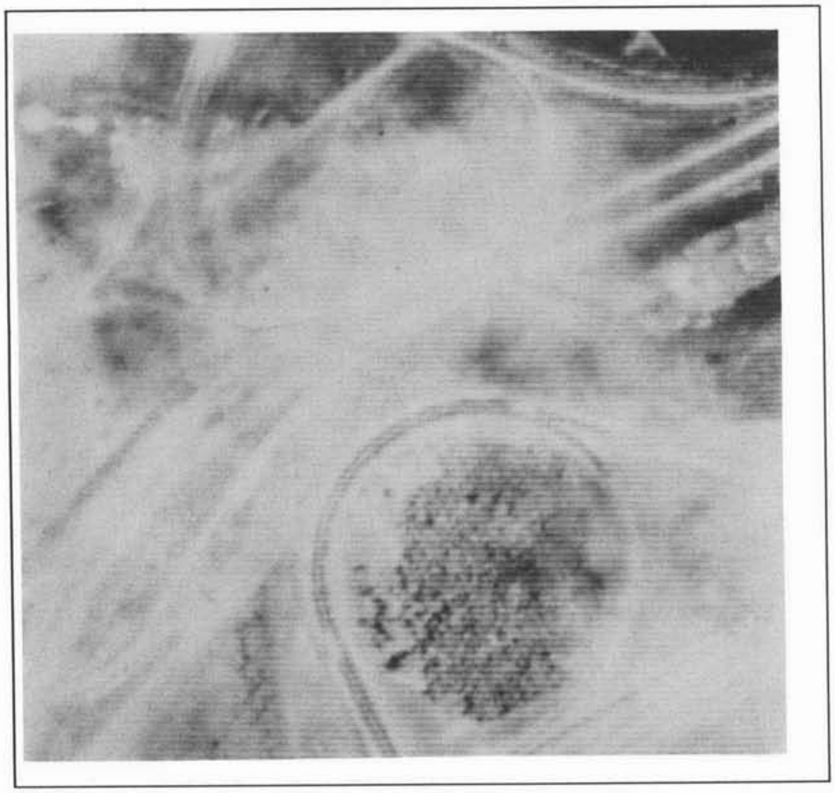
brightness (horiz., vert.)

Multi-dimensional

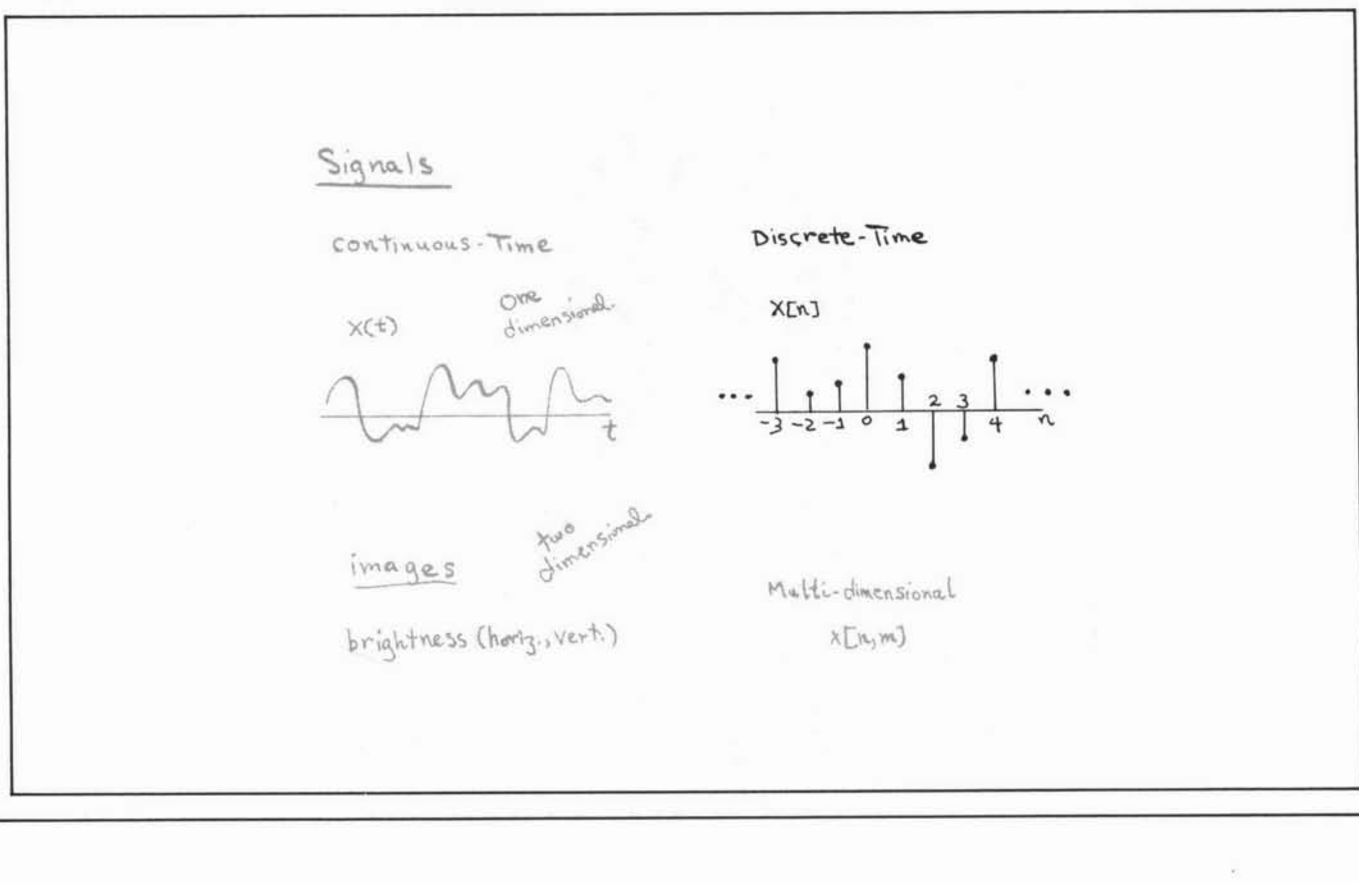
$x[n,m]$

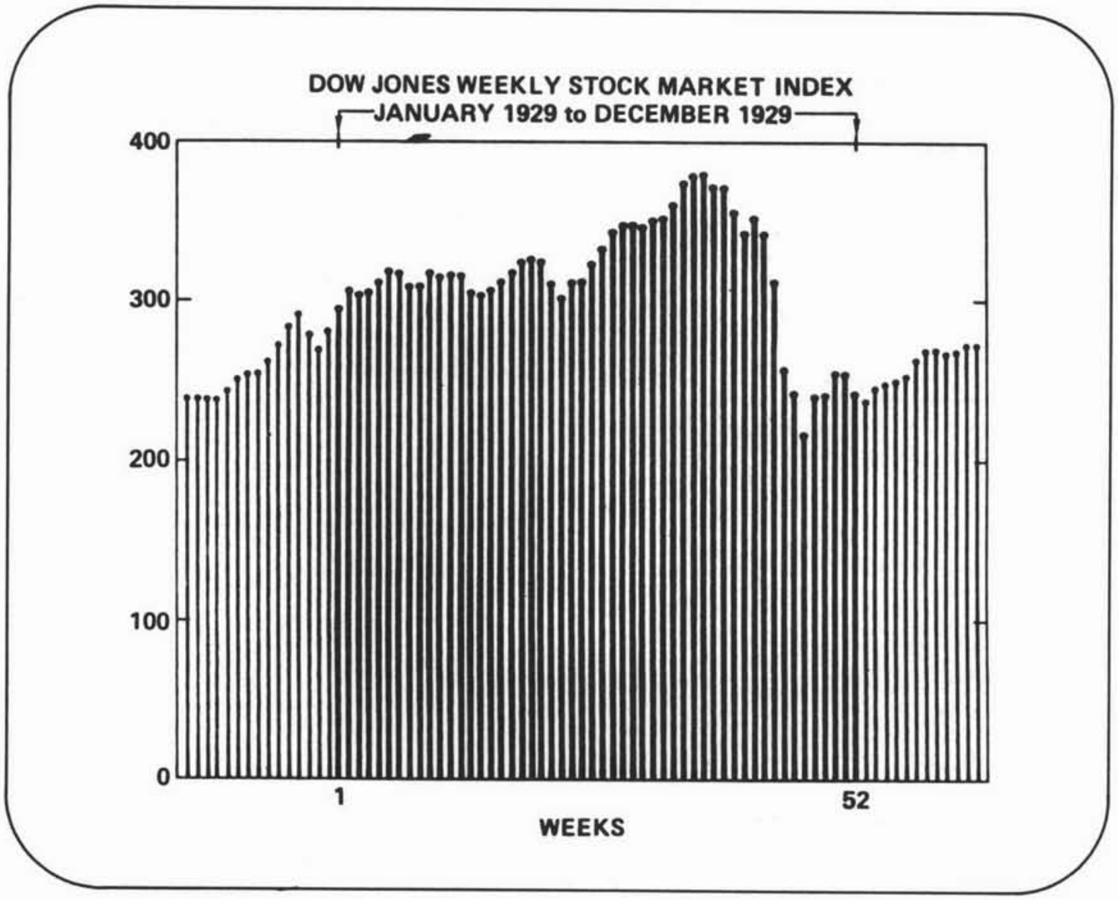
DEMONSTRATION 1.1
An example of an image. [Jean Baptiste Joseph Fourier from *Oeuvre de Fourier*, Vol. II (Paris: Gauthier-Villars et Fils, 1890).]

DEMONSTRATION 1.2
Aerial photograph of roads with cloud cover.



MARKERBOARD 1.1 (b)





TRANSPARENCY 1.1
Dow Jones weekly stock market index over a $1\frac{1}{2}$-year period.

MARKERBOARD 1.1 (c)

Signals

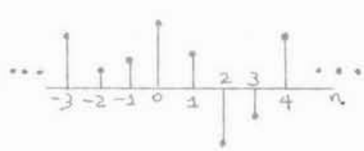
Continuous-Time

x(t)

one dimensional

Discrete-Time

x[n]



images

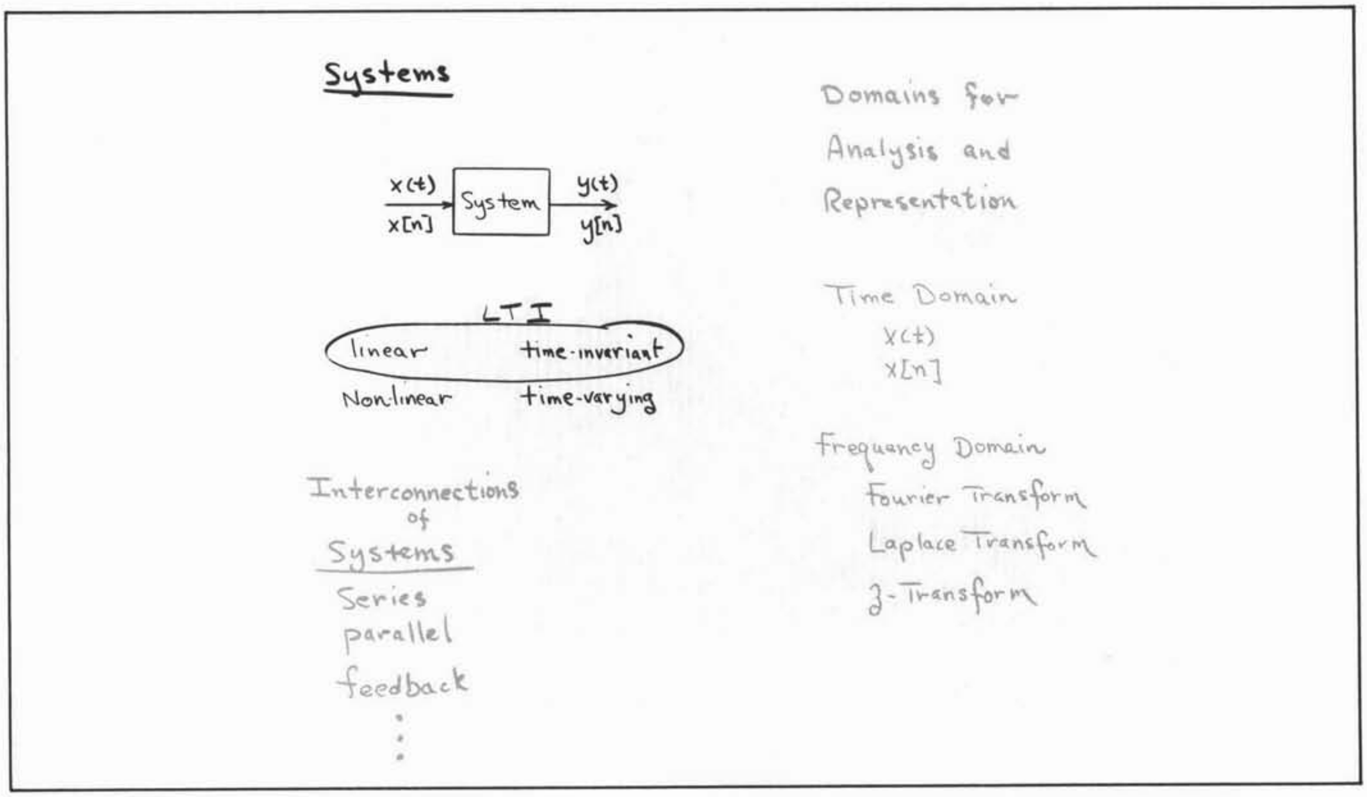
two dimensional

brightness (horiz., vert.)

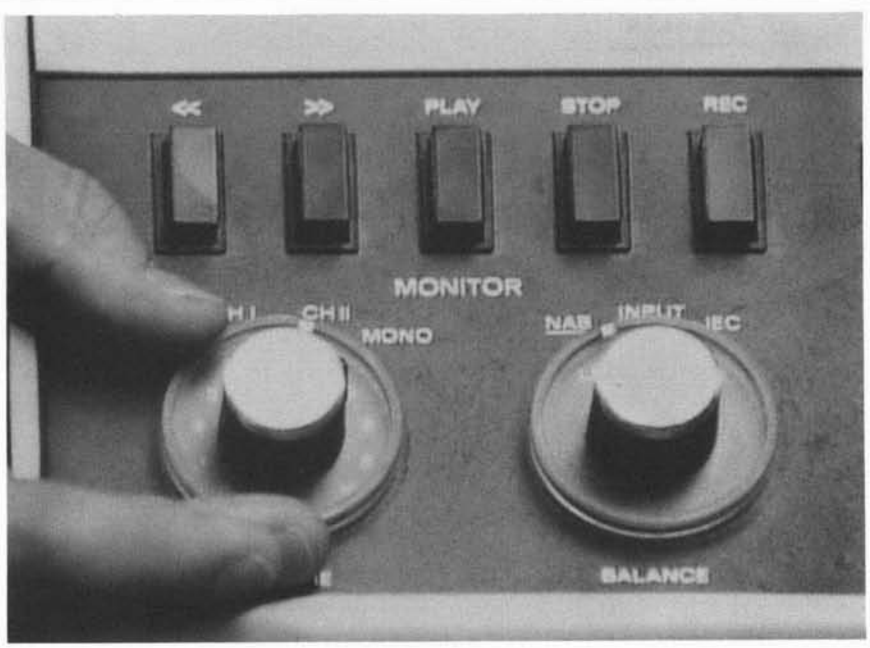
Multi-dimensional

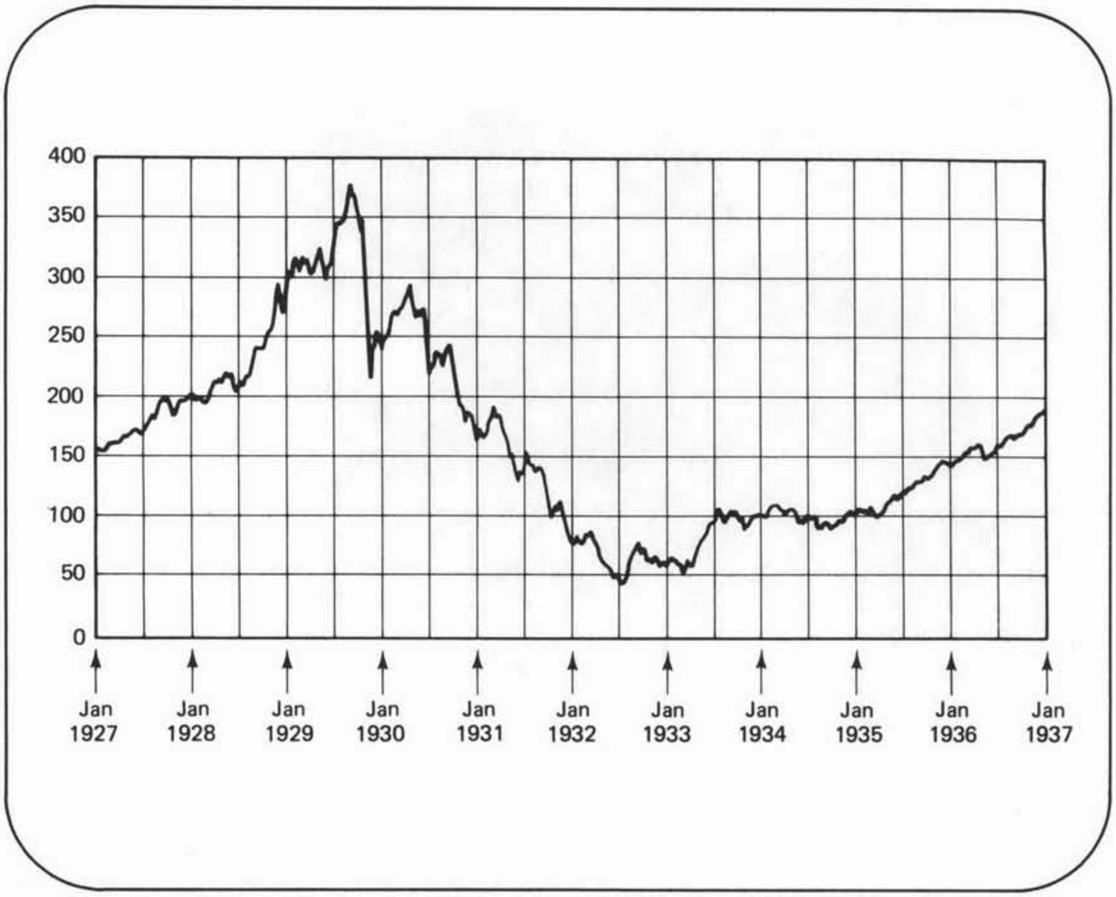
x[n, m]

MARKERBOARD
1.2 (a)

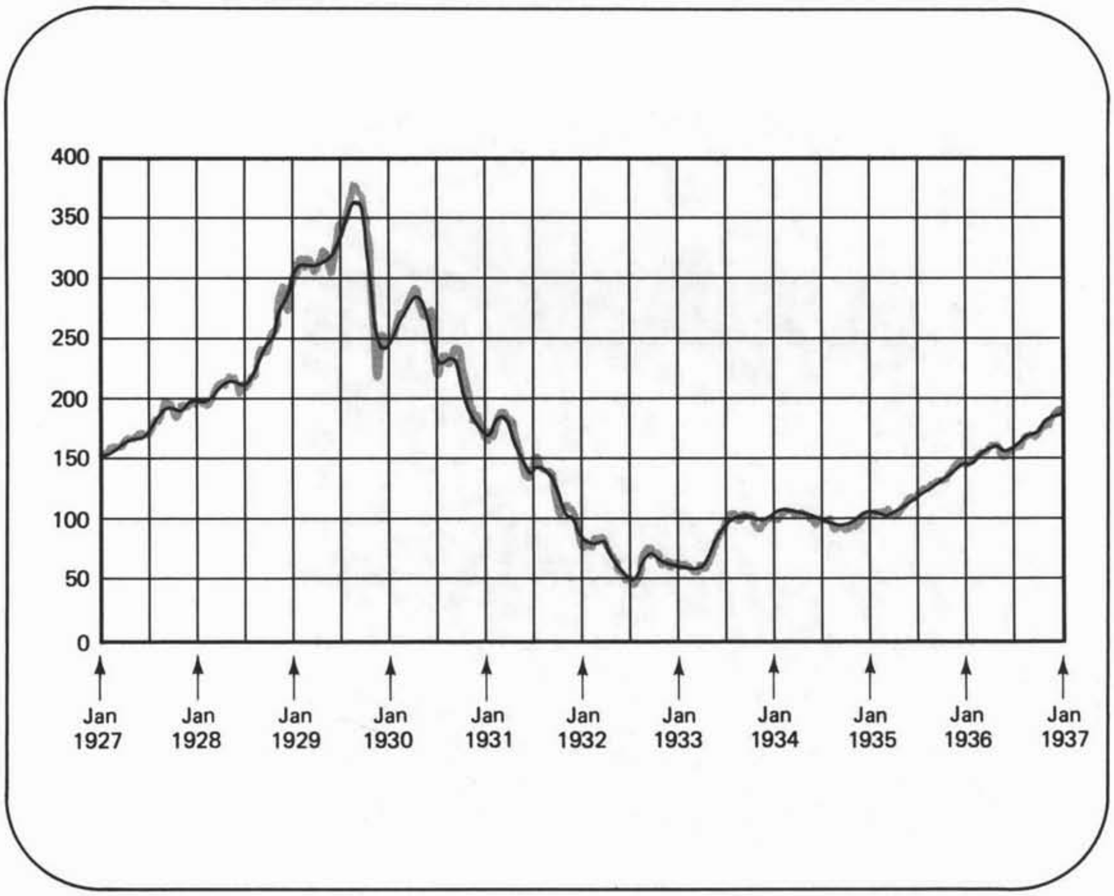


DEMONSTRATION
1.3
Demonstration of the enhancement of Caruso recordings.



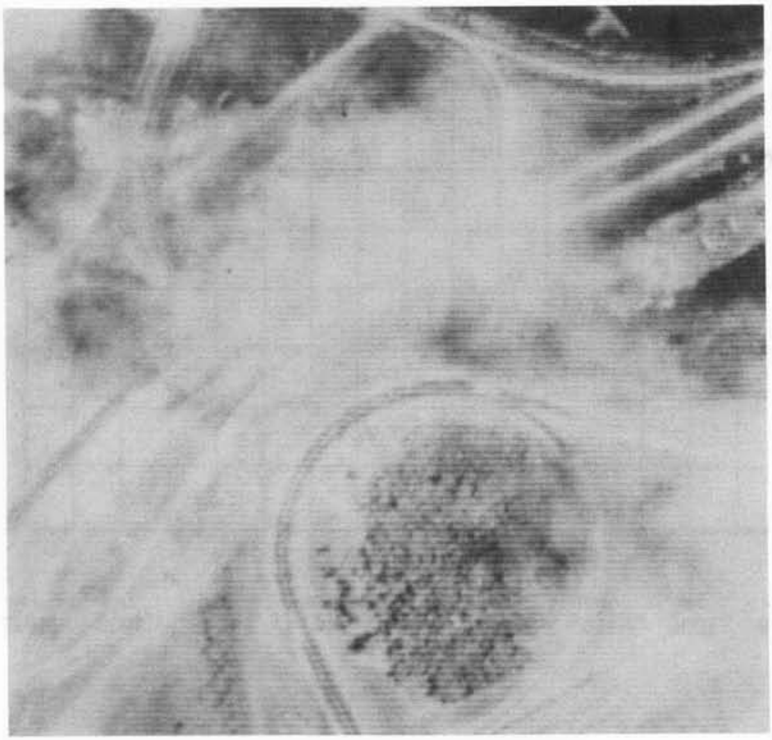


TRANSPARENCY 1.2
Dow Jones weekly stock market index over a 10-year period.

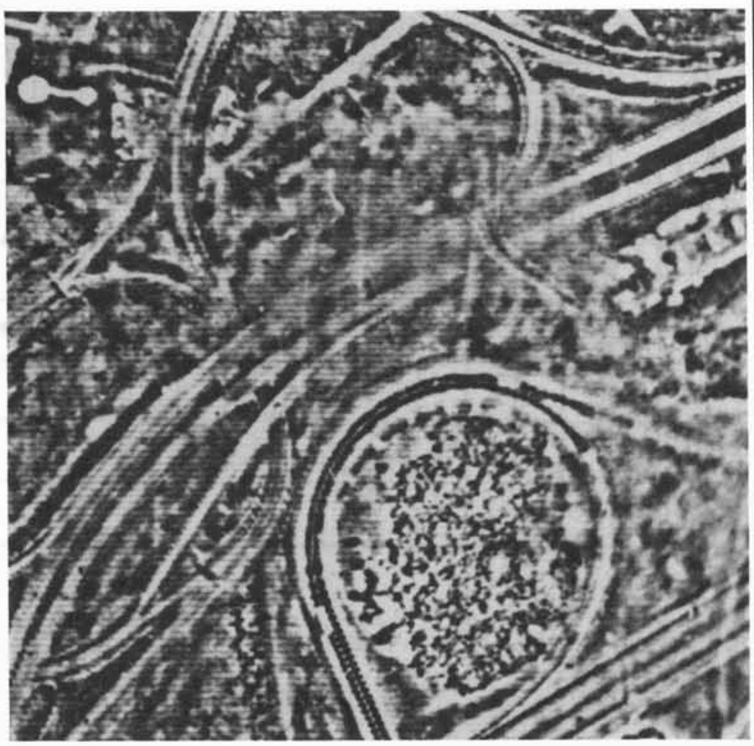


TRANSPARENCY 1.3
The effect of filtering the Dow Jones weekly stock market index.

DEMONSTRATION 1.4
Aerial photograph of roads with cloud cover.



DEMONSTRATION 1.5
Enhancement of the aerial photograph shown in Demonstration 1.4.



MARKERBOARD 1.2 (a)

Systems

$$\begin{array}{c} x(t) \\ x[n] \end{array} \longrightarrow \boxed{\text{System}} \longrightarrow \begin{array}{c} y(t) \\ y[n] \end{array}$$

LTI

linear — time-inveriant

Non-linear — time-varying

Interconnections of Systems

Series
parallel
feedback
⋮

Domains for Analysis and Representation

Time Domain
$x(t)$
$x[n]$

Frequency Domain
Fourier Transform
Laplace Transform
z-Transform

MARKERBOARD 1.2 (b)

Systems

$$\begin{array}{c} x(t) \\ x[n] \end{array} \longrightarrow \boxed{\text{System}} \longrightarrow \begin{array}{c} y(t) \\ y[n] \end{array}$$

LTI

linear — time-inveriant

Non-linear — time-varying

Interconnections of Systems

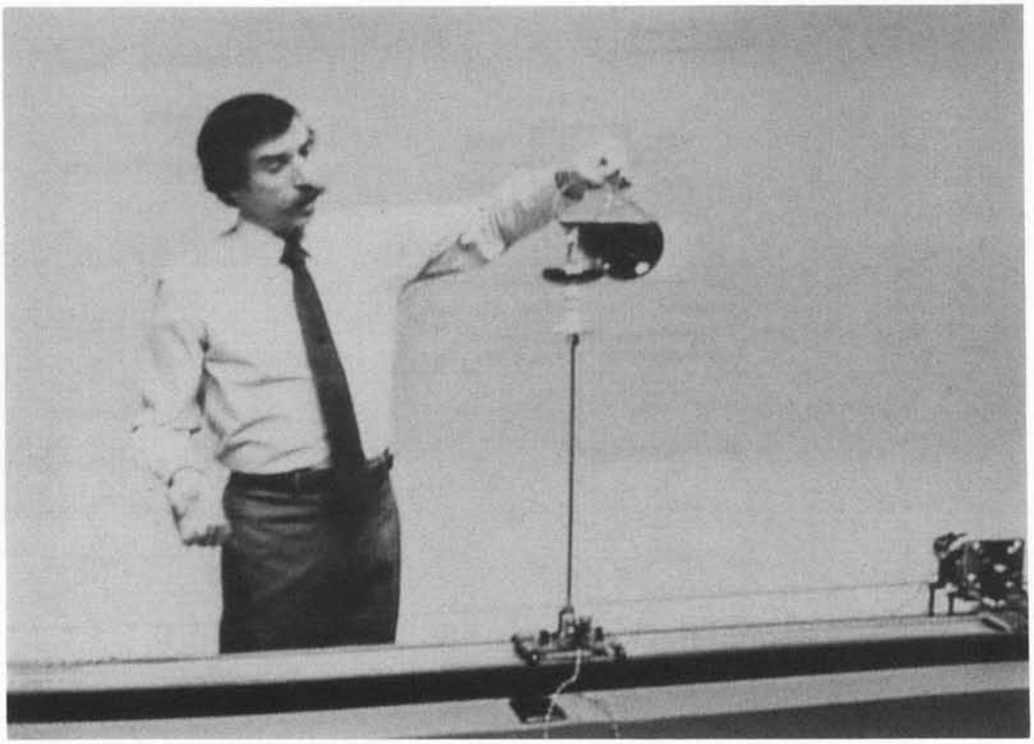
Series
parallel
feedback
⋮

Domains for Analysis and Representation

Time Domain
$x(t)$
$x[n]$

Frequency Domain
Fourier Transform
Laplace Transform
z-Transform

DEMONSTRATION
1.6
Preview of inverted pendulum demonstration.



MARKERBOARD
1.2 (c)

Systems

x(t) → System → y(t)
x[n] → System → y[n]

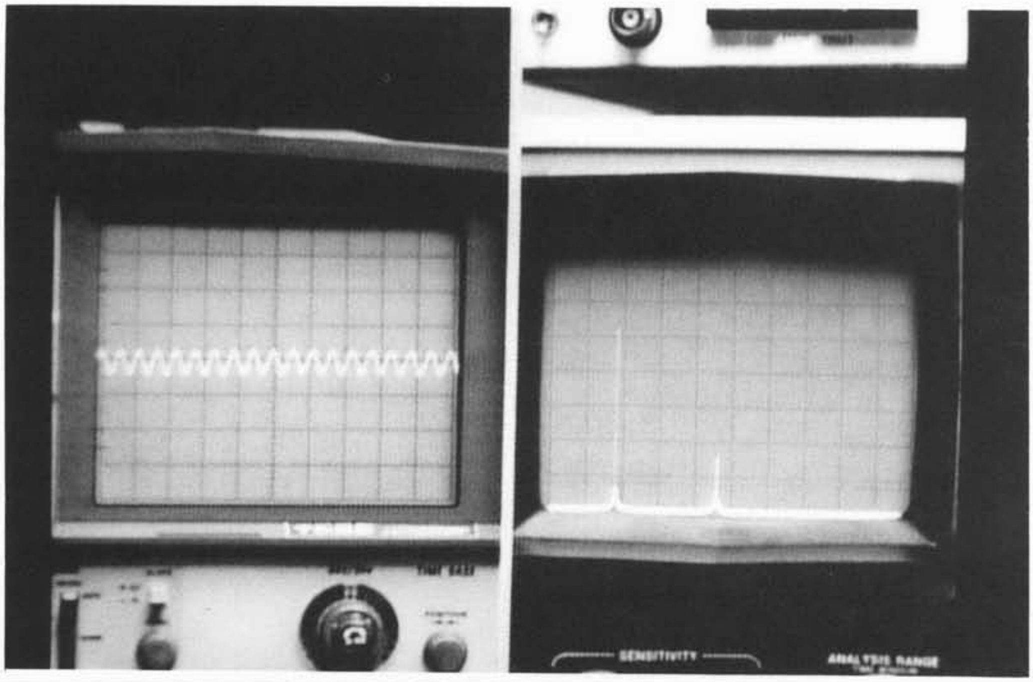
LTI
linear time-invariant
Non-linear time-varying

Interconnections of Systems
Series
parallel
feedback
⋮

Domains for Analysis and Representation

Time Domain
x(t)
x[n]

Frequency Domain
Fourier Transform
Laplace Transform
z-Transform



DEMONSTRATION 1.7
Preview of glockenspiel note demonstration.