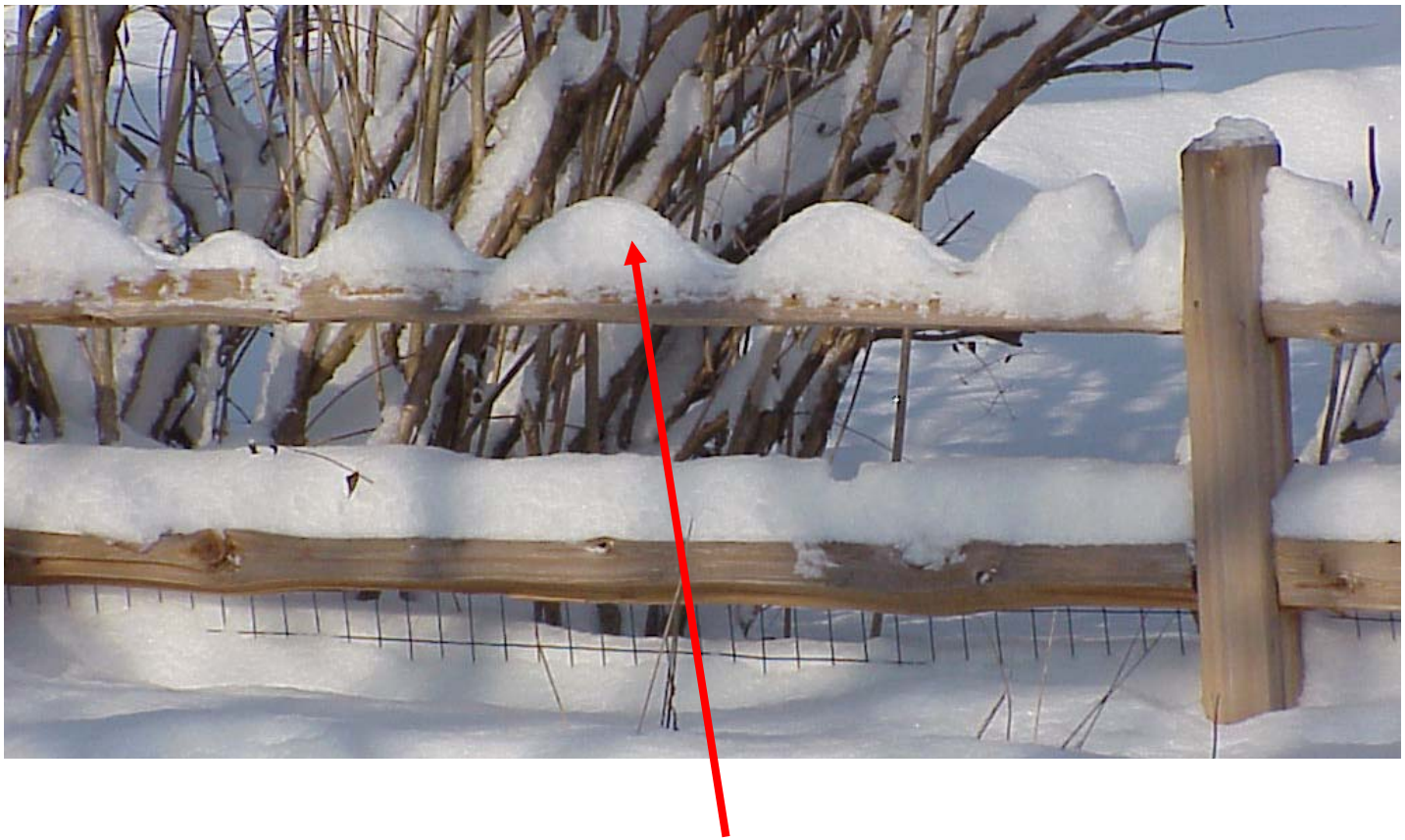
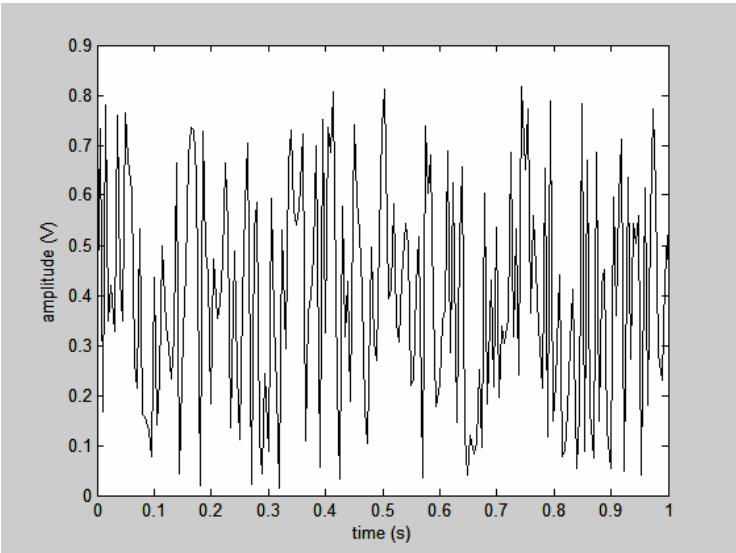
Signal Characteristics



What caused this pattern?

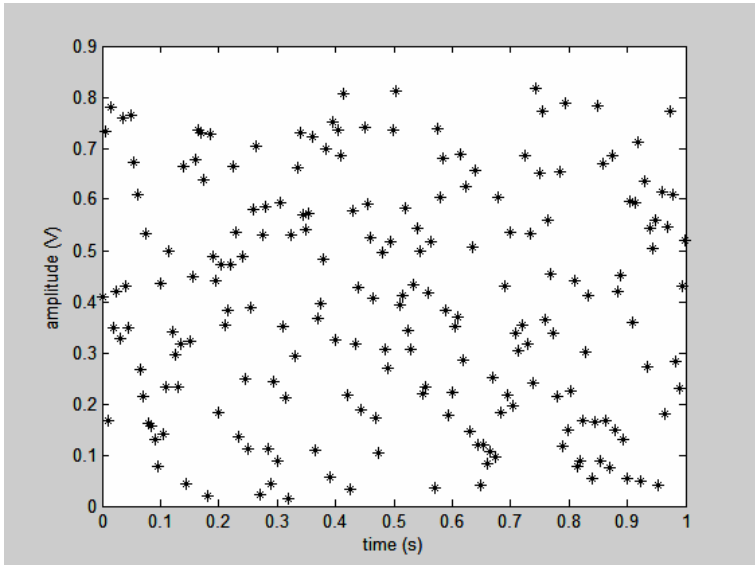
Signal Characterization

- A *signal* is the temporal variation of a physical variable's magnitude as represented by the output of a measurement system.



Input to measurement system

A_{in}



Output of measurement system

A_{out}

Signal Characterization

- Let us assume for now that the measurement system is perfect, $A_{out} = A_{in}$, although we know that, realistically, this can not be.

- The goal is to extract as much information as possible from the signal to understand thoroughly the physical process being investigated.

- Typical information includes the relations between amplitude, time and frequency.

- To start, we first must understand the types of signals and then how we can determine the ‘measures’ of the physical process.

- Let us consider some ‘real world’ examples.

Detecting a sound heartbeat

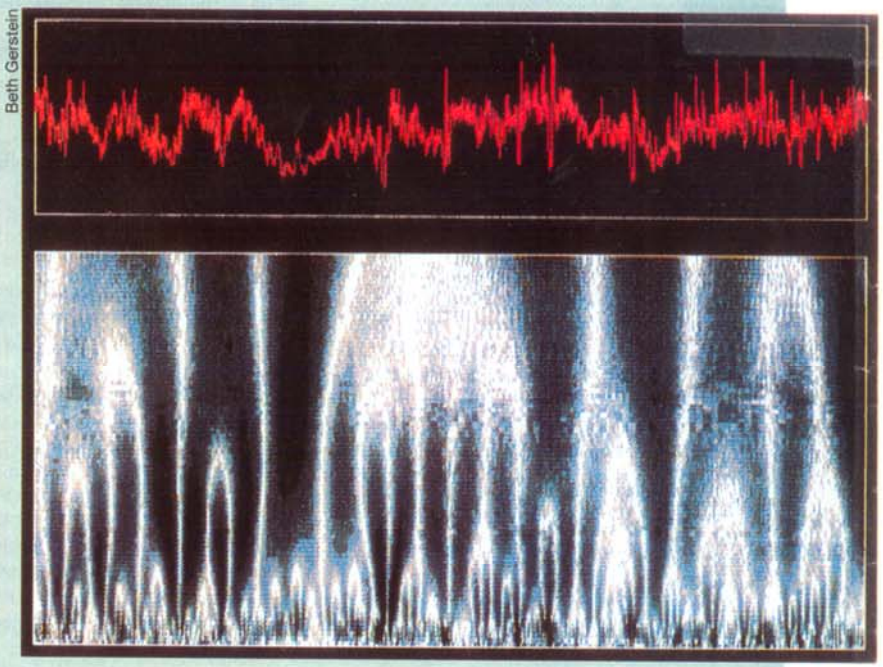
At roughly one beat per second, the rhythm of the human heart can serve as a reasonably steady timekeeper. Subtle variations in that rhythm, however, may signal whether or not a heart is healthy.

Reporting in the Sept. 26 NATURE, Plamen C. Ivanov of Boston University and his coworkers have developed a mathematical technique for finding patterns in a sequence of beat-to-beat intervals. These patterns enable the researchers to distinguish between healthy people and those suffering from certain heart irregularities.

Ivanov and his colleagues start by measuring for each person the time intervals between successive beats on an electrocardiogram (EKG). These values, derived from 6 hours of heartbeat data, are then plotted against time (top).

The researchers use a technique, based on mathematical forms called wavelets, that enables them to identify large-scale patterns even when the signals change as a result of background influences. For a healthy heart, these correlations appear as arches in plots displaying the wavelet analysis (bottom). Data from sick hearts lack these arches. —I. Peterson

Beth Gerstein

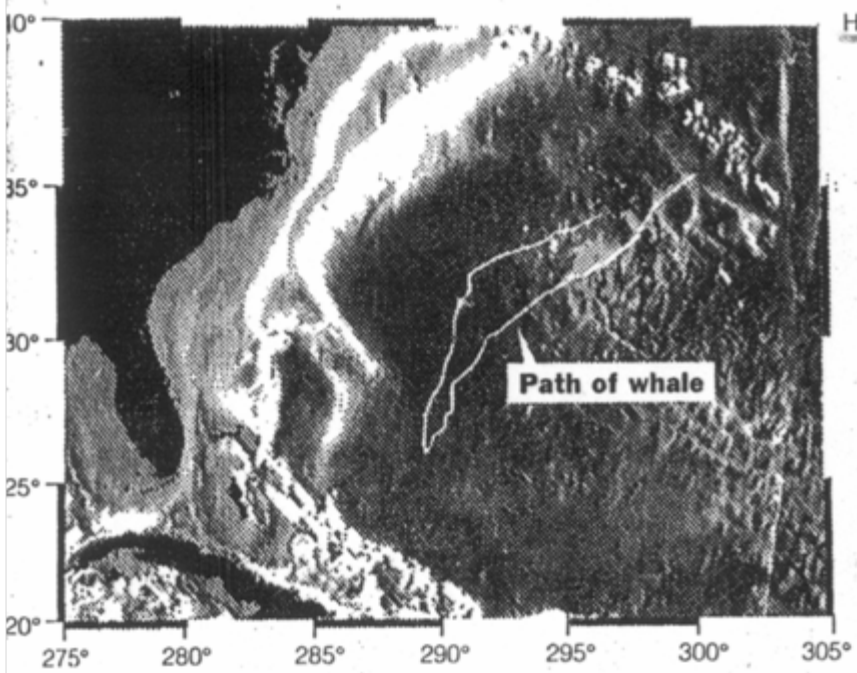


amplitude vs time

frequency ↑

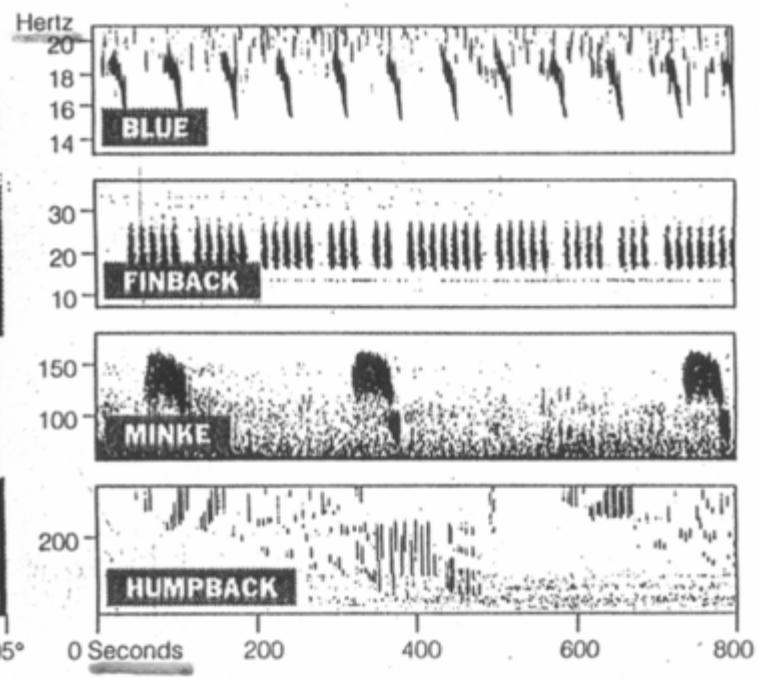
time →

t



Leviathan's Travels

Scientists tracked a single blue whale during a journey of nearly 2,000 miles as it swam southwest from Bermuda and back.



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A Chorus of Cetaceans

Distinctive voice prints allow researchers to identify different species of whales.

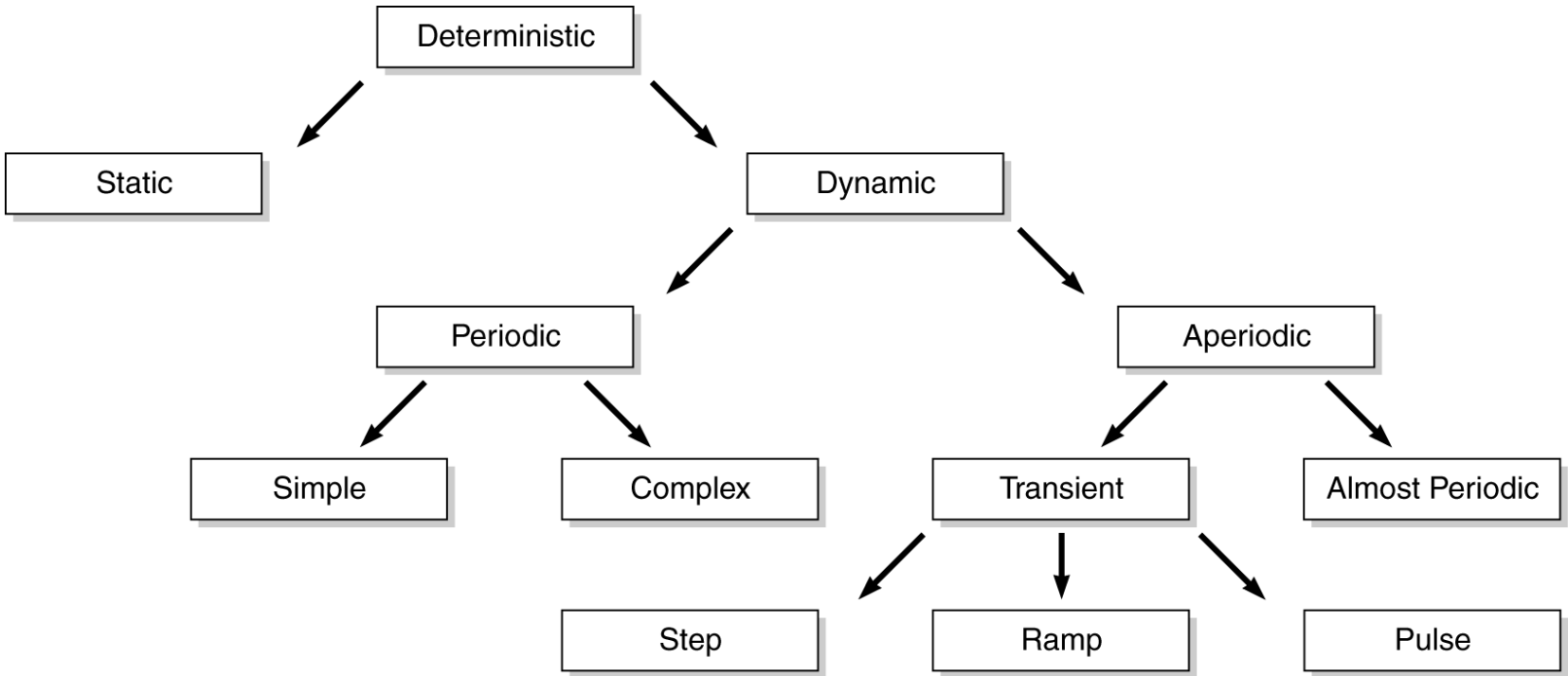
The New York Times

TUESDAY, JULY 2, 1996

Signal Classifications

- A *deterministic* signal is predictable in time or space.

Figure 11.2



Signal Classifications

- A *nondeterministic* signal is random and not predictable in time or space.

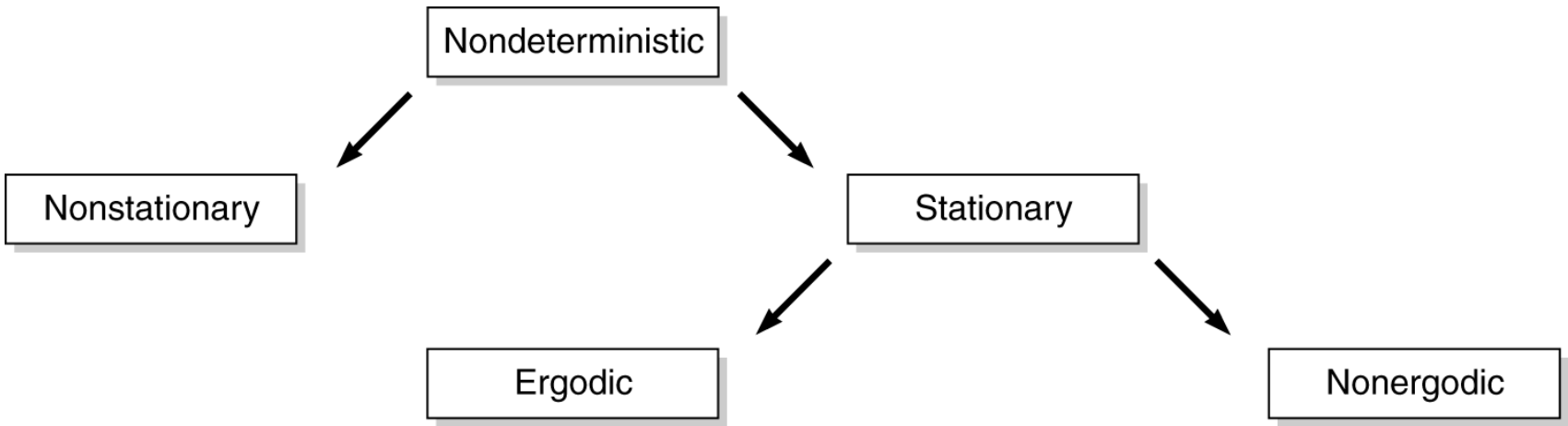


Figure 11.3

The Ensemble

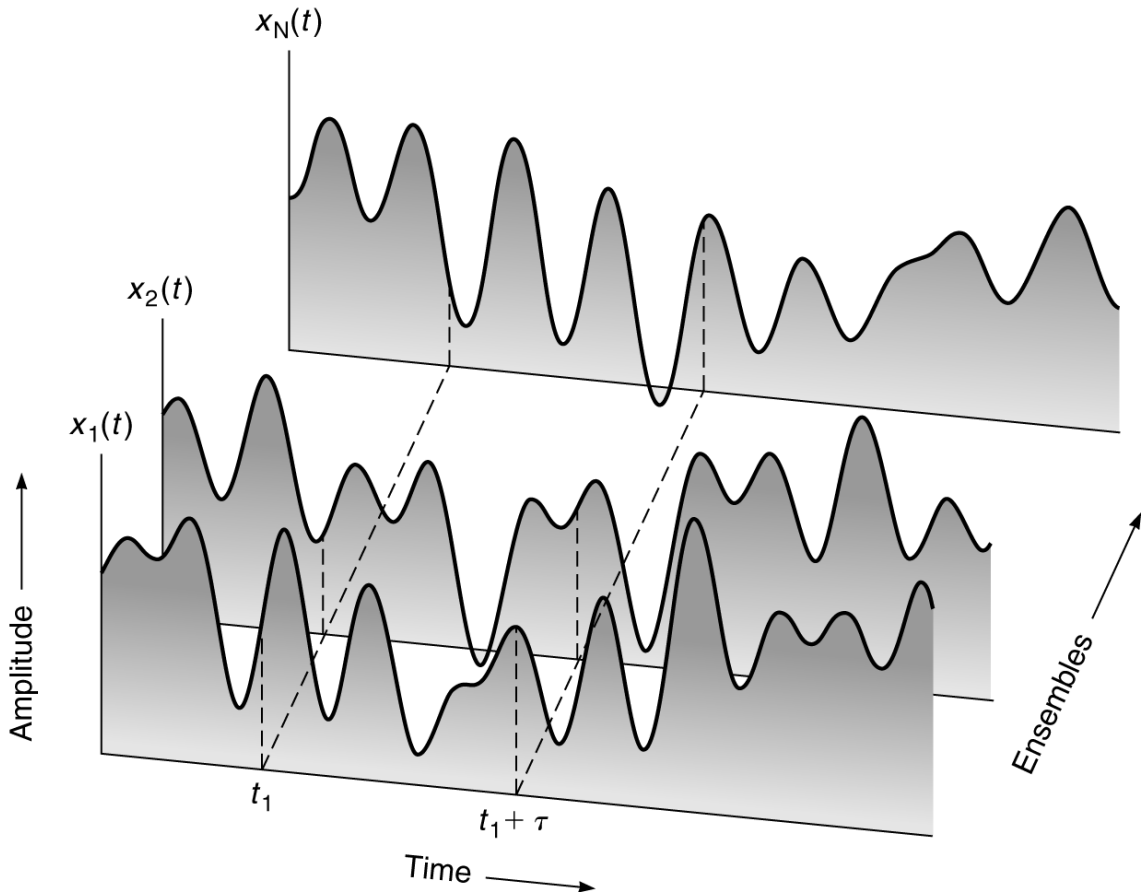


Figure 11.1

- When the ensemble-averaged values of a random signal equal the corresponding average values computed over time for an arbitrary, single time history in the ensemble, the signal is *ergodic*.

Signal Variables

- Consider the waveform $y(t) = A\cos(n\omega t) + B\sin(n\omega t)$.
- The variables and their units are:

- This waveform can be rewritten as $y(t) = C\cos(\omega t - \phi)$, where $C = \sqrt{A^2 + B^2}$

Some Signal Conditioning

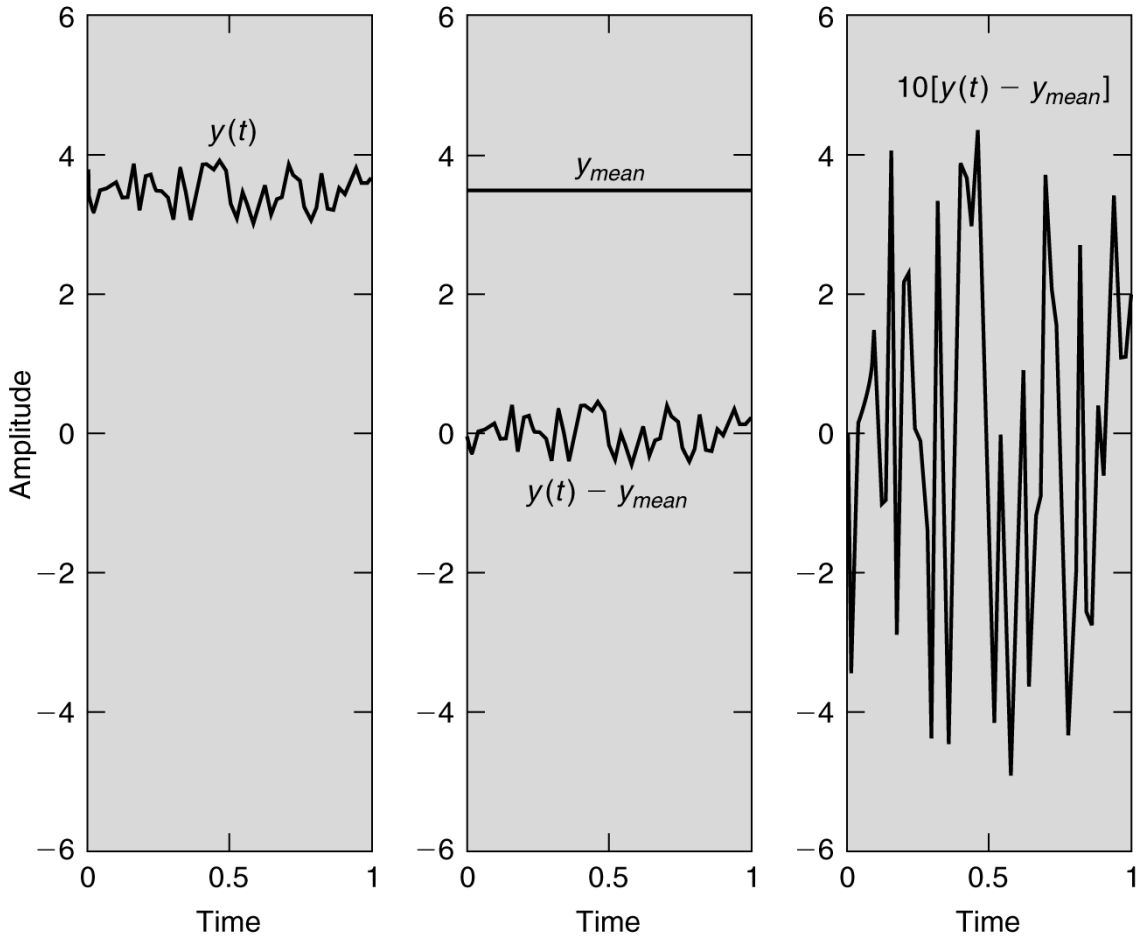


Figure 11.7