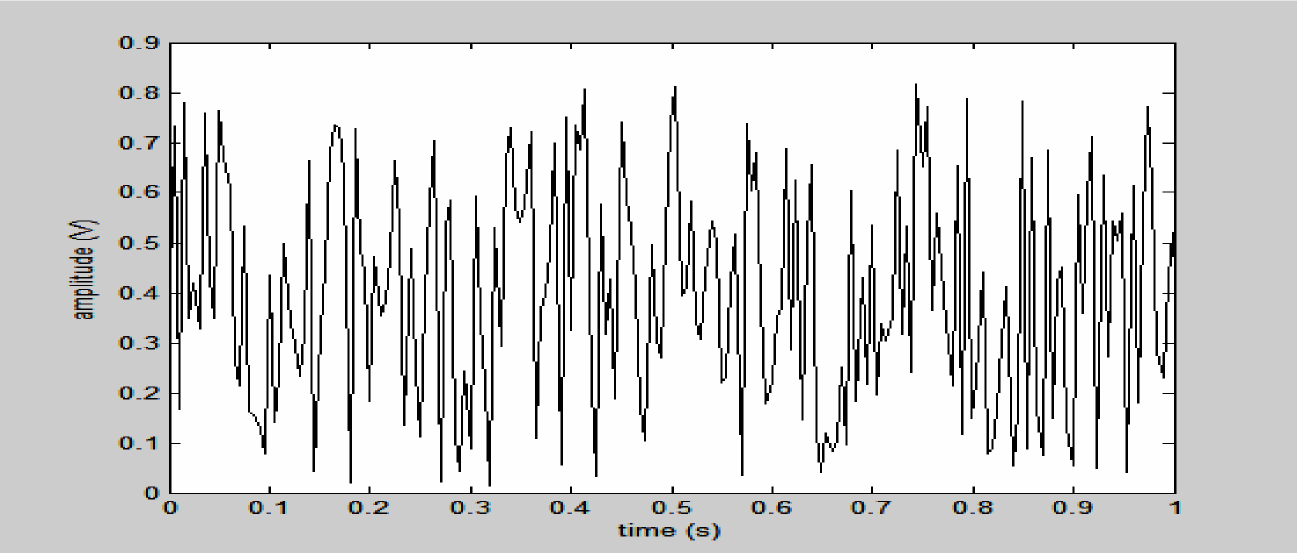
Examining the Signal



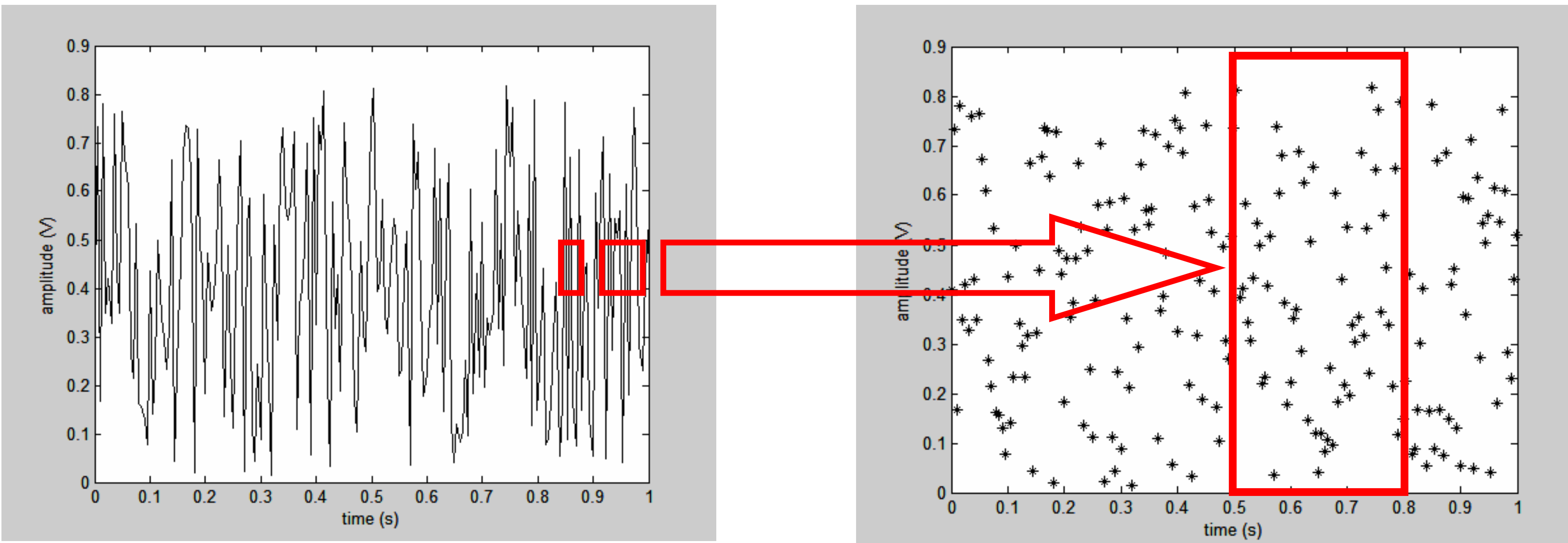
- Examine the signal using a very high-speed system, for example, a 50 MHz digital oscilloscope.

- How is the signal characterized?

- What is the order of the signal's frequency range (f_{min} to f_{max})?

Setting the Sampling Conditions

• In most circumstances, as when using computers, sampling is DIGITAL.



• What resolution in time and/or frequency is required ?

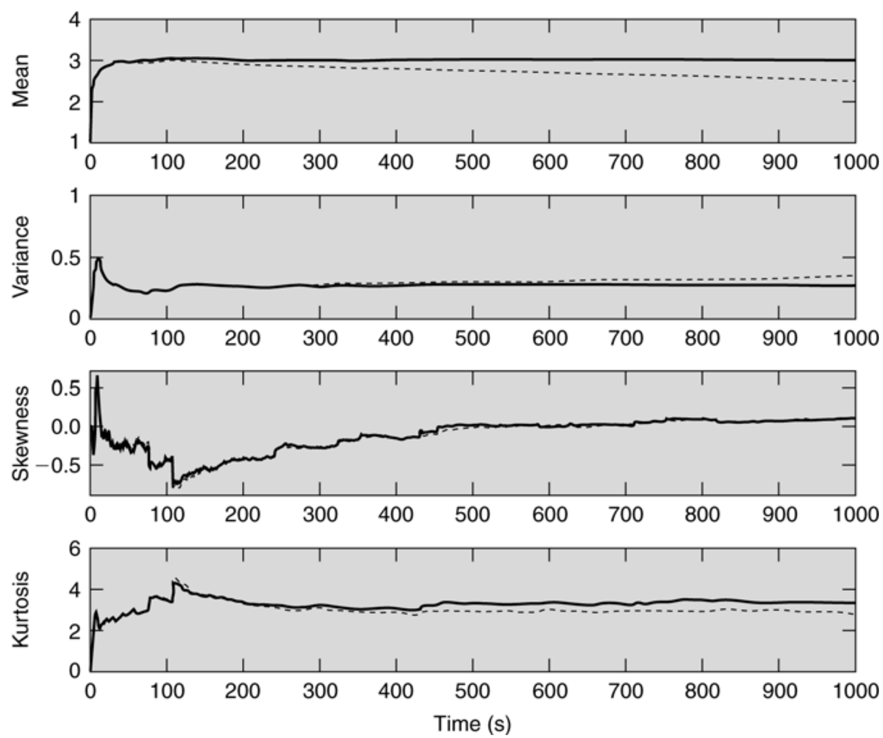
• How many samples (data points) should be taken ?

The Number of Samples

- The number of required samples depends upon what information is needed

→ there is *not* one specific formula for N..

- For example, consider two different signals

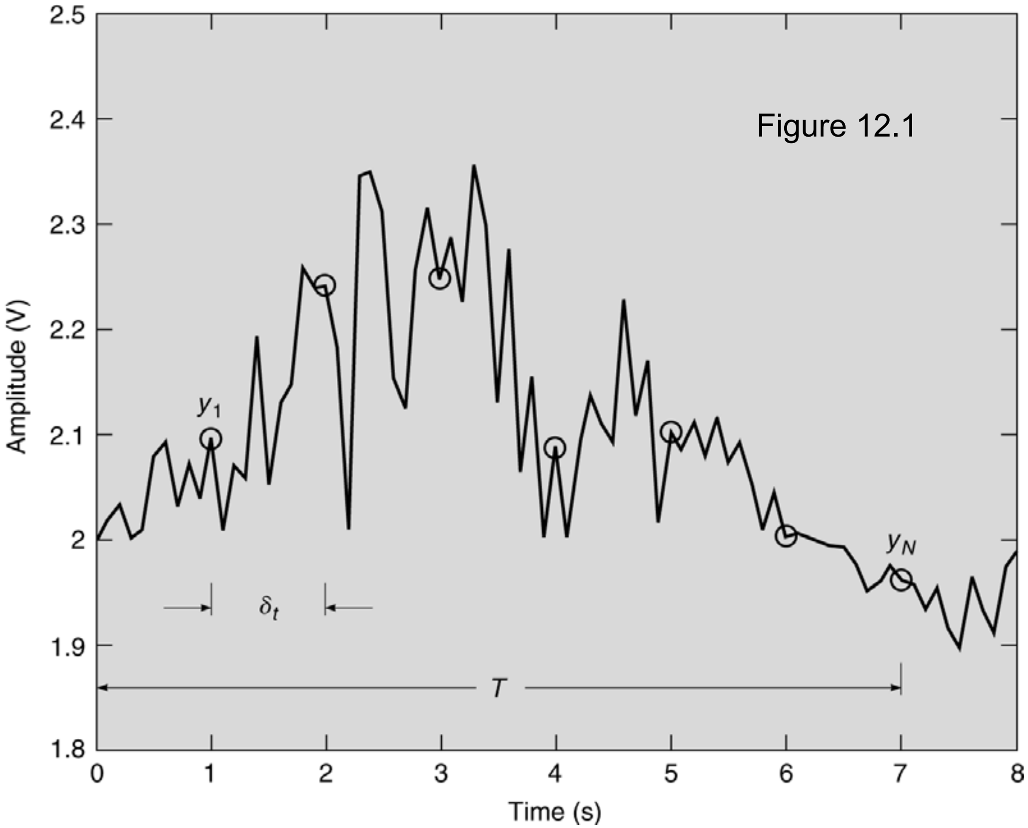


Solid: ‘normal’ (random) population with mean =3 and standard deviation = 0.5

Dotted: same as solid but with 0.001/s additional amplitude decrease

Digital Sampling

- The *analog* signal, y(t), is sampled every δt seconds, N times for a period of T seconds, yielding the *digital* signal y(rδt), where r = 1, 2, …, N.



- For this situation:

Digital Sampling Errors

- When is signal is digitally sampled, erroneous results occur if either one of the following occur:
    - the sampling rate is too low
    - the sample period is incorrect
- To avoid aliasing, set $f_s > 2\ f_{max}$.
- The maximum frequency of interest, f_{max}, also is called the Nyquist frequency, f_N.
- So, to avoid aliasing, set $f_s > 2\ f_N$.
- Aliased frequencies can be determined using the *folding diagram*.

Digital Sampling Errors

- To avoid amplitude ambiguity, set the sample period equal to the **least common (integer) multiple** of *all* of the signal's contributory periods.

> The **least common multiple** or **lowest common multiple** or **smallest common multiple** of two integers *a* and *b* is the smallest positive integer that is a multiple of both *a* and *b*. Since it is a multiple, *a* and *b* divide it without remainder. For example, the least common multiple of the numbers 4 and 6 is 12. (Ref: Wikipedia)

- For a signal with only *one* period, T_1, set $T = mT_1 = m/f_1$.

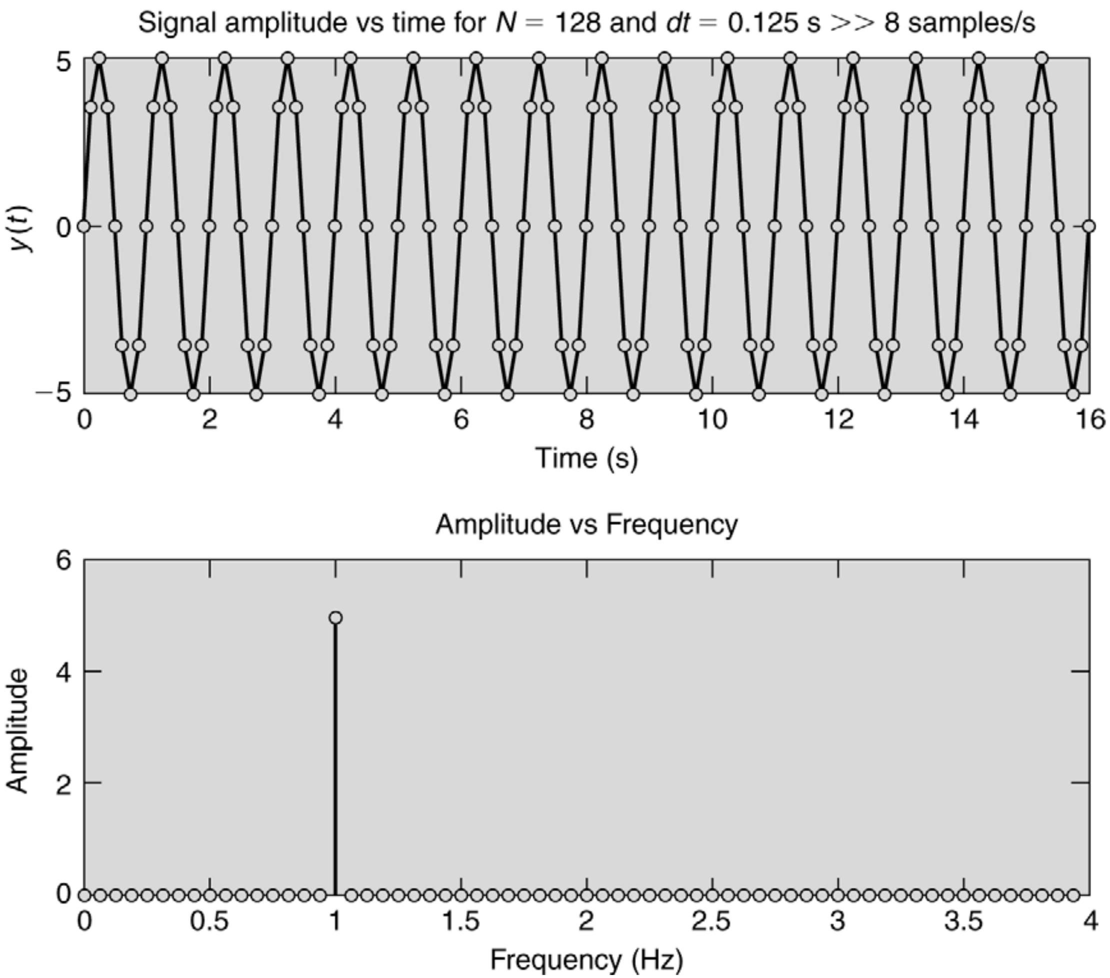
Recall $T = N\delta t = N/f_s$. $\longrightarrow$ $f_s = (N/m)\, f_1$.

Digital Sampling Errors

- If all of the frequencies are known (deterministic, simple or complex periodic signals), the sample period can be determined exactly and amplitude ambiguity can be eliminated.

- If some of the frequencies are not known (nondeterministic signal), amplitude ambiguity can not be eliminated but can be minimized by ‘windowing’ the signal.

Illustration of Correct Sampling



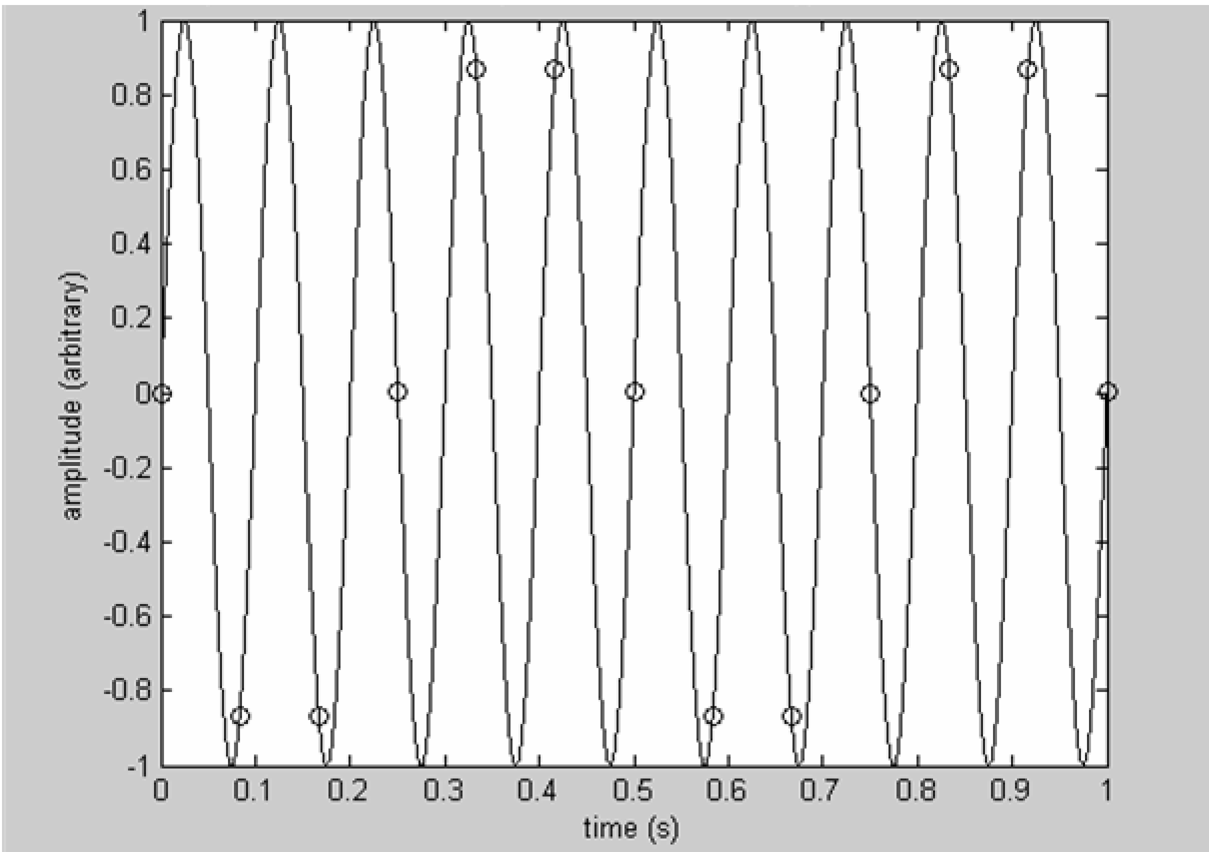
$y(t) = 5\sin(2\pi t)$

$\rightarrow f = 1$ Hz

with $f_s = 8$ Hz

Figure 12.7

Aliasing of sin(20πt)



$y(t) = \sin(20\pi t)$

$\rightarrow f = 10$ Hz
with
$f_s = 12$ Hz