Digital Signal Processing

Topic：Sampling

(From Continuous-Time Signal to Discrete-Time Signal)

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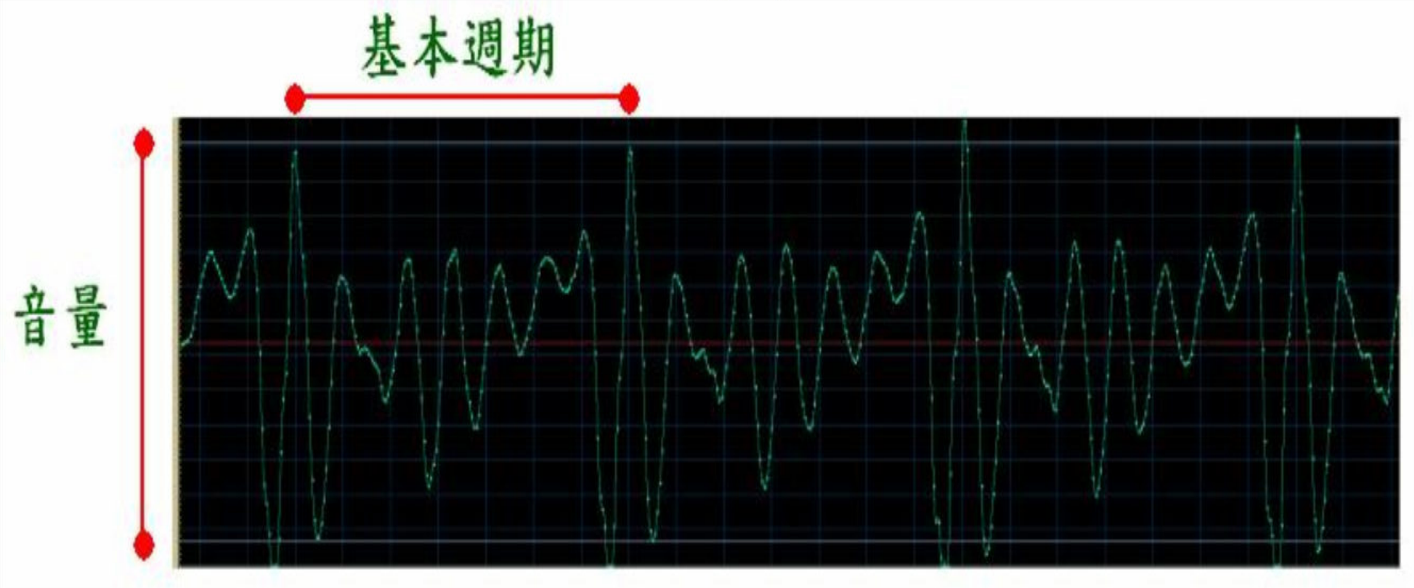
FIGURE 1-1 Applications of DSP.

- Touch-Tone™ telephones
- Edge detection in images
- Digital signal and image filtering
- Seismic analysis
- Text recognition
- Speech recognition
- Magnetic resonance image (MRI) scans
- Music synthesis
- Bar code readers
- Sonar processing
- Satellite image analysis
- Digital mapping
- Cellular telephones
- Digital cameras
- Detection of narcotics and explosives
- Speech synthesis
- Echo cancellation
- Cochlear implants
- Antilock brakes
- Signal and image compression
- Noise reduction
- Companding
- High definition television (HDTV)
- Digital audio
- Encryption
- Motor control
- Remote medical monitoring
- Smart appliances
- Home security
- High speed modems

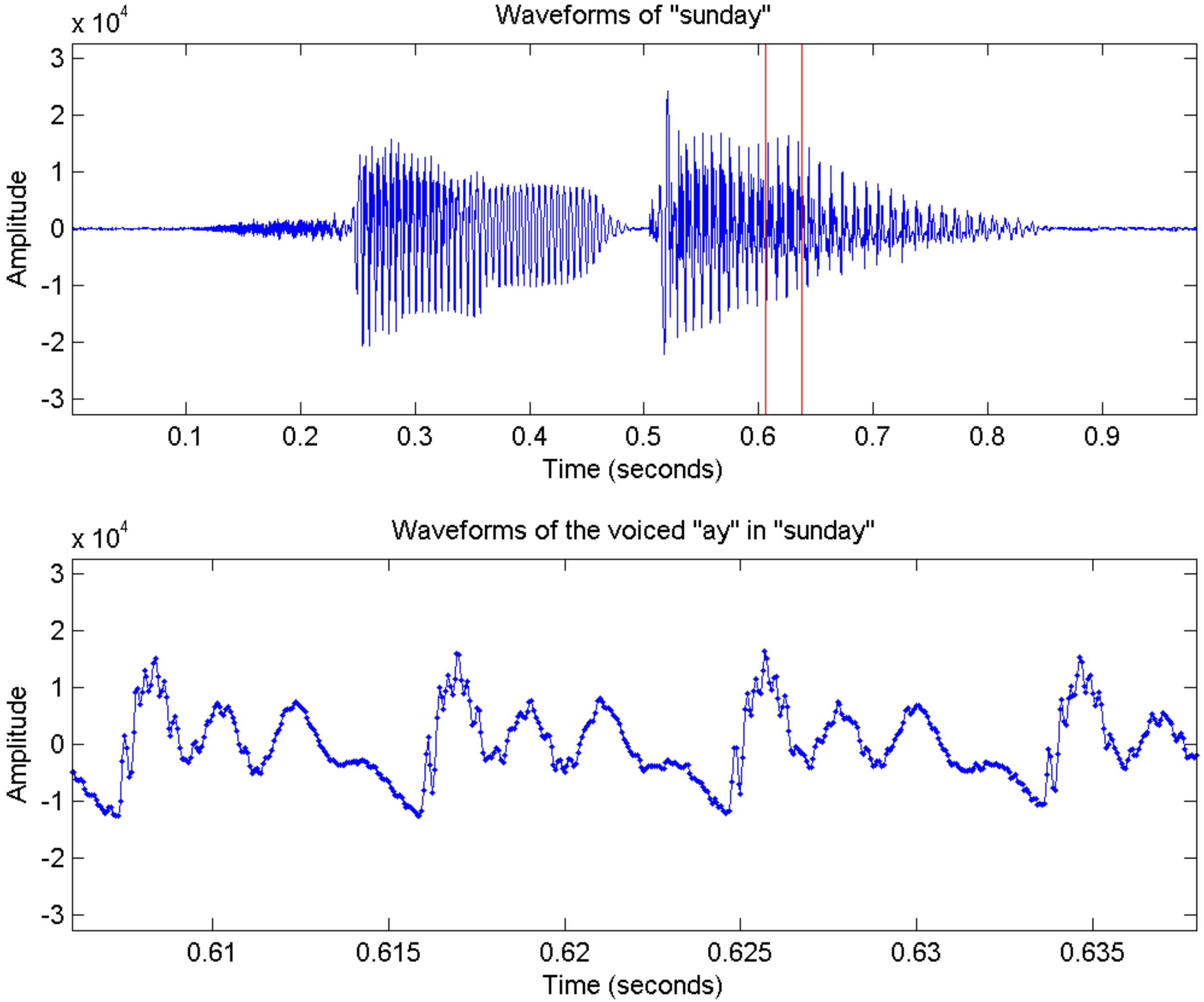
Basic Acoustic Features (基本聲學特徵)

- Volume: This feature represents the loudness of the audio signal, which is correlated to the amplitude of the signals. Sometimes it is also referred to as energy or intensity of audio signals.
- Pitch: This feature represents the vibration rate of audio signals, which can be represented by the fundamental frequency, or equivalently, the reciprocal of the fundamental period of voiced audio signals.
- Timbre: This feature represents the meaningful content (such as a vowel in English) of audio signals, which is characterized by the waveform within a fundamental period of voice signals.

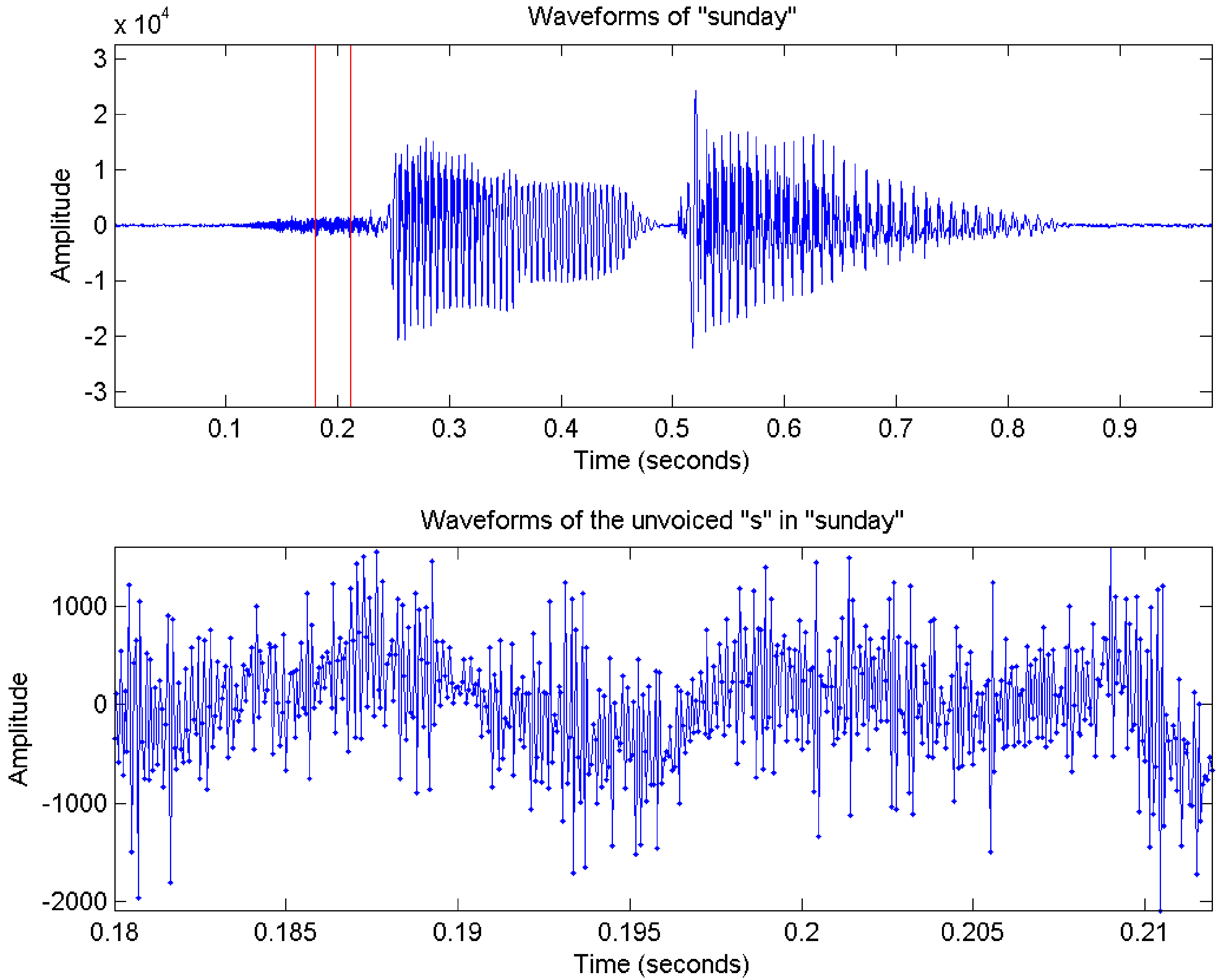
These three acoustic features can be related to the waveform of audio signals, as follows:



The voiced sound



The unvoiced sound



4.5 Sampling

♣ **Basic concept**

4.5.1 *Sampling Continuous-Time Signals*

1. $x(t)$ = CT signal, $x[n]$ = DT signal that is equal to the "samples " of $x(t)$ at integer multiples of a sampling interval T_s.

$$x[n] = x(nT_s)$$

FIGURE 2-2 Analog signal.

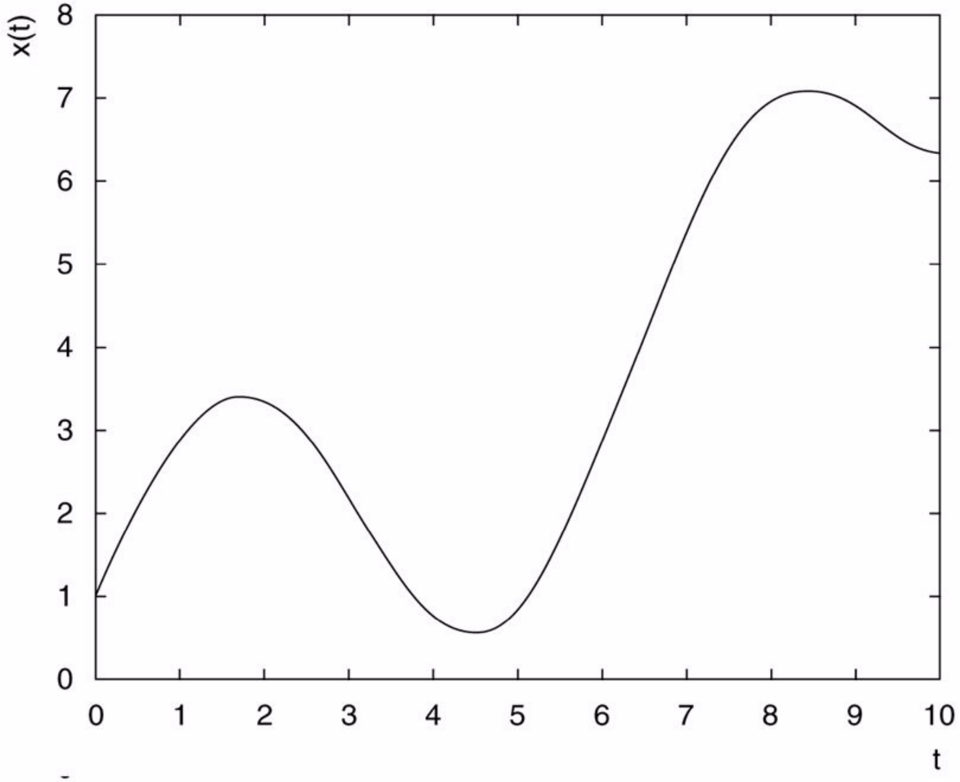


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FIGURE 2-3 Sample-and-hold signal (shown with analog signal).

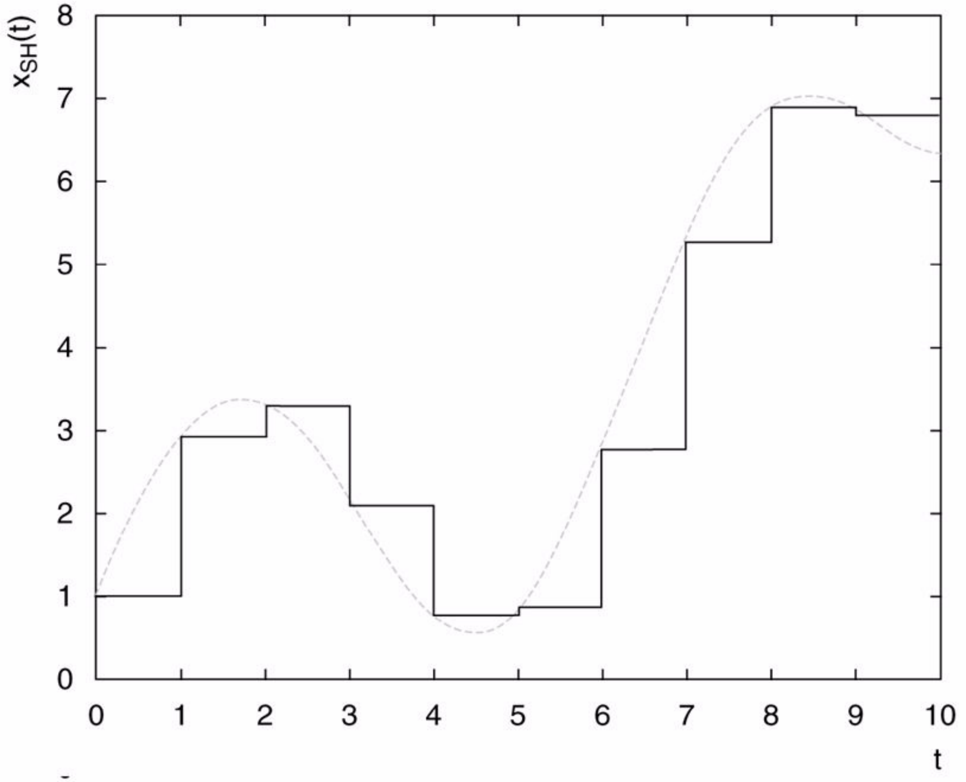

FIGURE 2-4 Discrete-Time signal (shown with sample-and-hold signal).

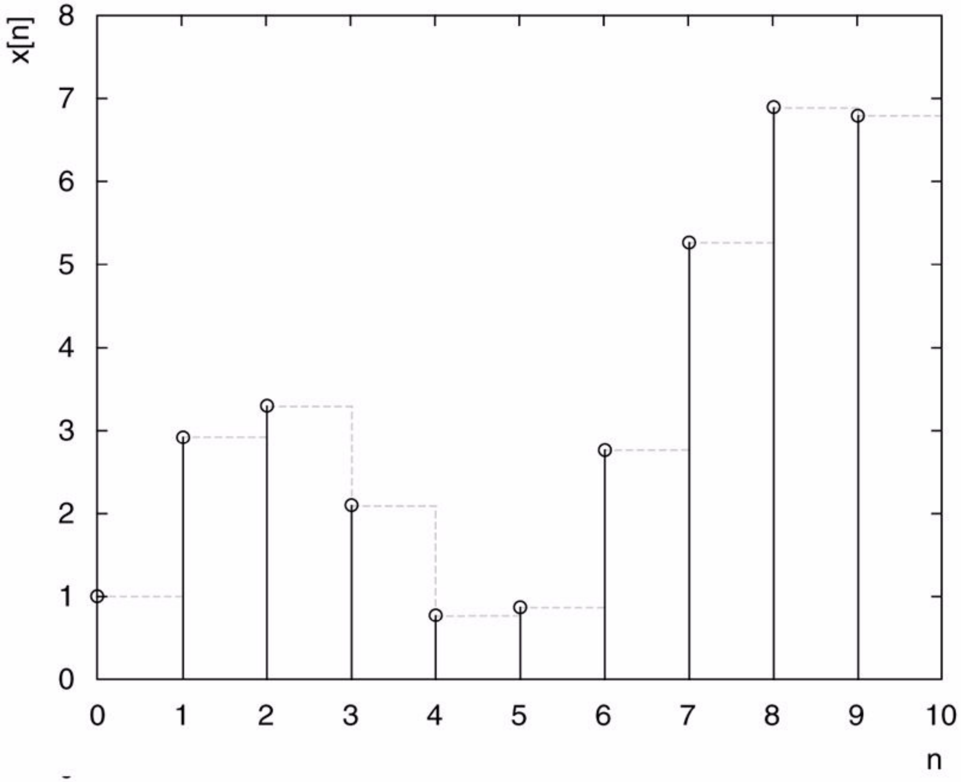

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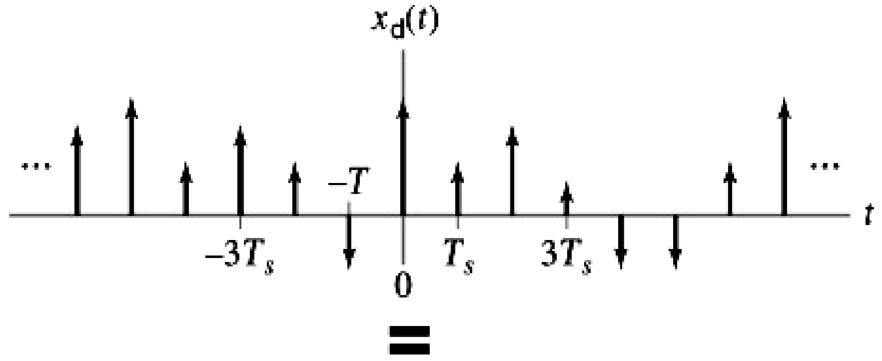
Figure 4.21 (p. 363) Mathematical representation of sampling as the product of a given time signal and an impulse train.



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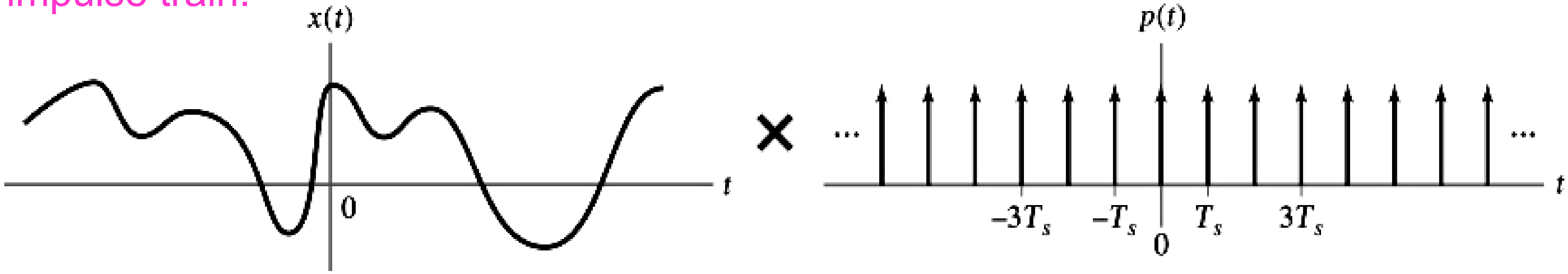


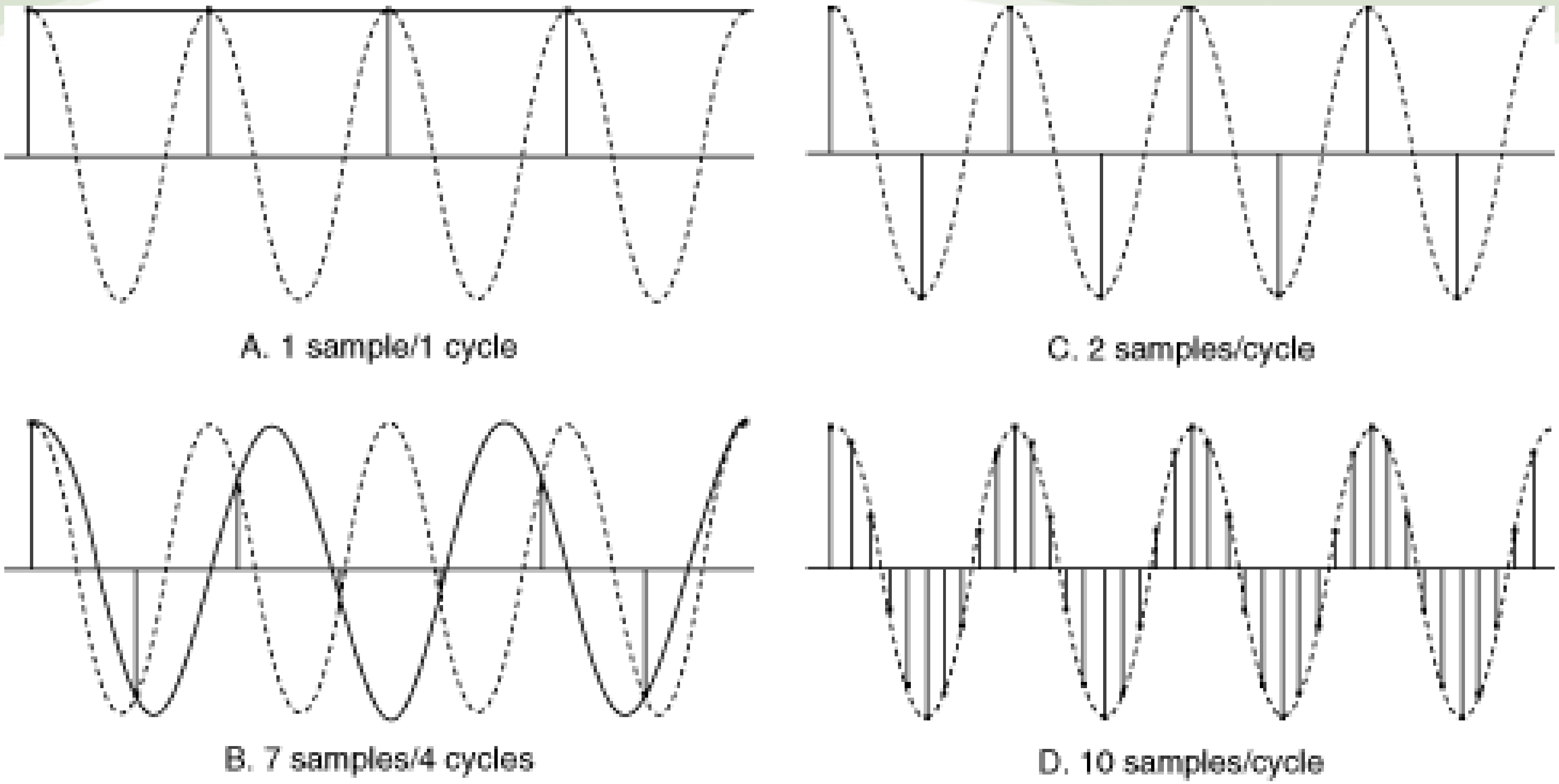
$$X_\delta(j\omega) = \frac{1}{2\pi} X(j\omega) * \frac{2\pi}{T_s} \sum_{k=-\infty}^{\infty} \delta(\omega - k\omega_s)$$

$\omega_s = 2\pi / T_s$

$$X_\delta(j\omega) = \frac{1}{T_s} \sum_{k=-\infty}^{\infty} X(j\omega - jk\omega_s). \qquad (4.23)$$

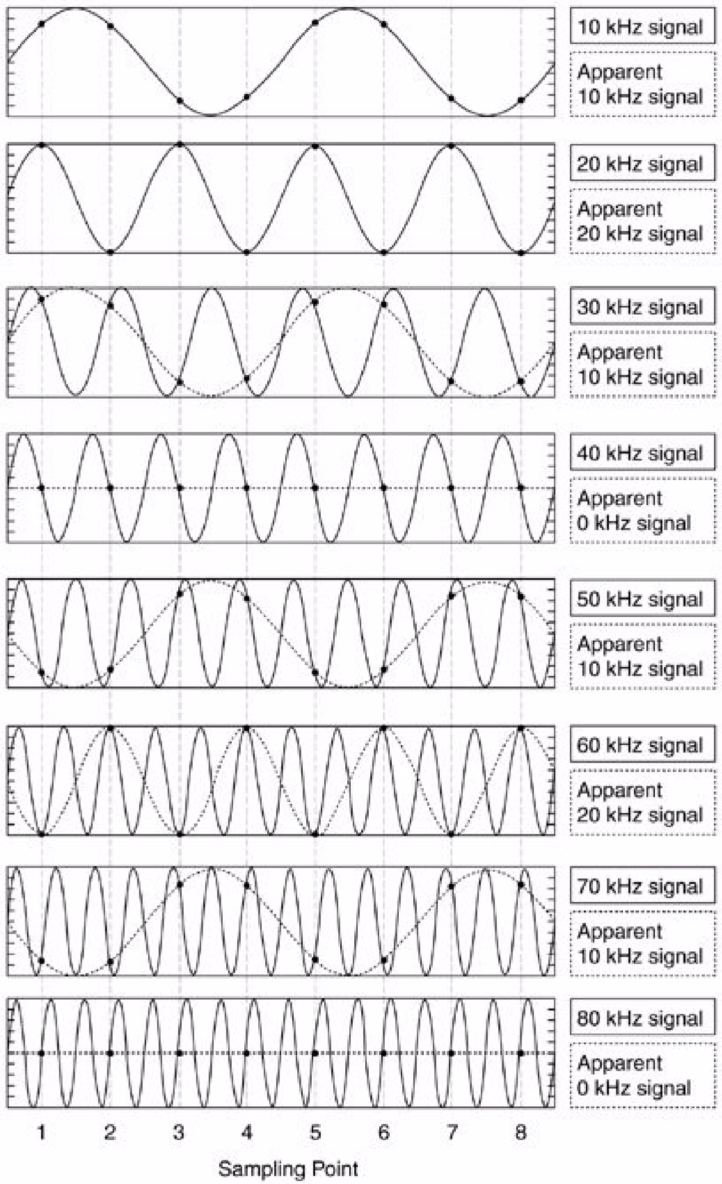
The Sampling Theorem

$fs \geqq 2\ fmax$



[Q]: Which one doesn't satisfy 'The Sampling Theorem'?

FIGURE 2-6 Aliasing in the time domain with 40 kHz sampling



Aliasing in daily life

Figure 4.25 (p. 368)

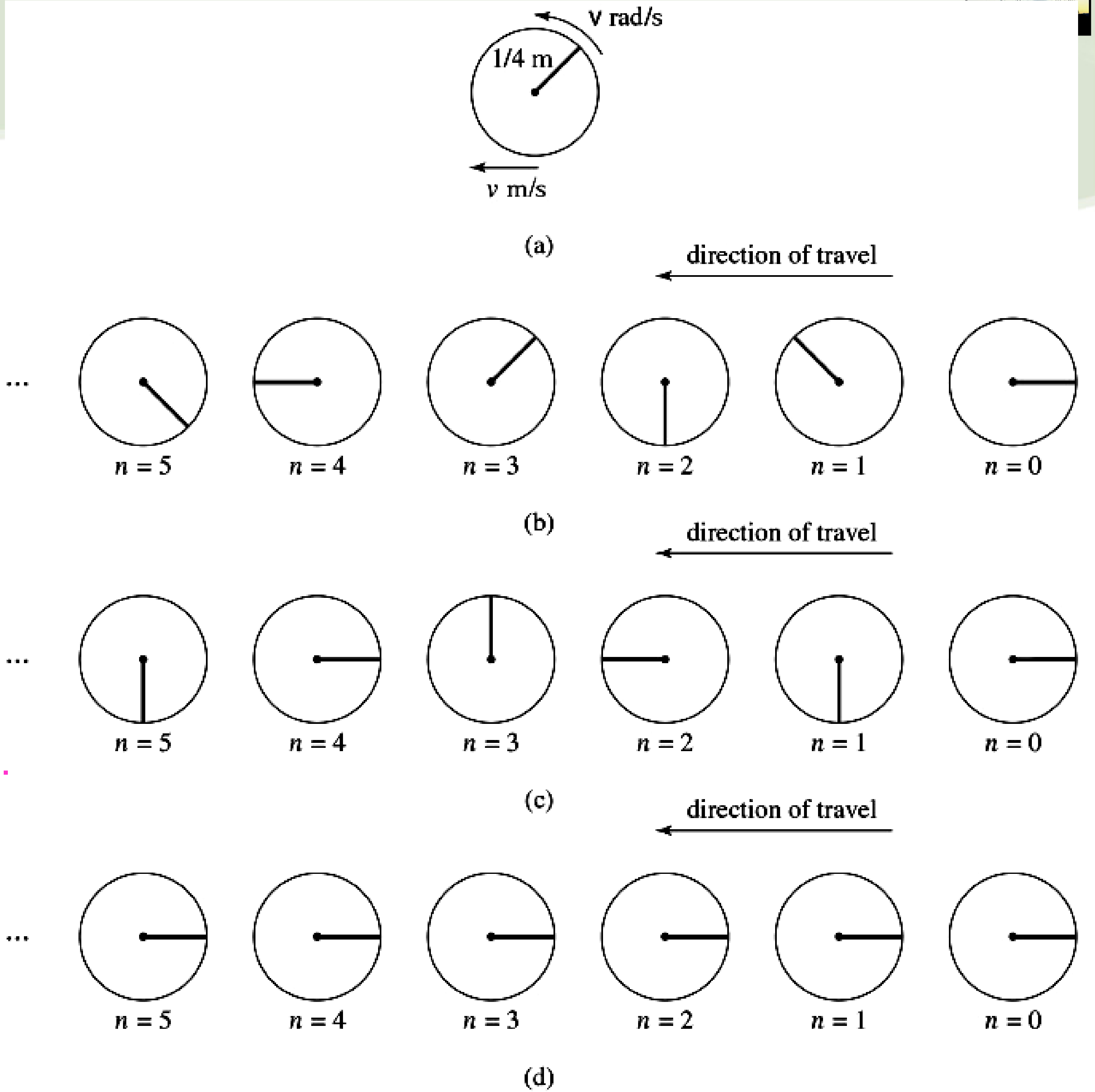
Aliasing in a movie.

(a) Wheel rotating at ω radians per second and moving from right to left at ν meters per second.

b) Sequence of movie frames, assuming that the wheel rotates less than one-half turn between frames.

(c) Sequences of movie frames, assuming that the wheel rotates between one-half and one turn between frames.

(d) Sequence of movie frames, assuming that the wheel rotates one turn between frames.




Thank you for listening!
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