EE229: Signal Processing-I

Lecture #3

Dept of Electrical Engineering
I.I.T. Bombay

Chapter 1: So far…

- Signals of various types and their relevance in the real world
- Useful measures (Energy, Power) defined for signals
- Simple transformations of the independent variable and math representations

Textbook

Alan V. Oppenheim and Alan S. Willsky with S.H. Nawab, Signals and Systems, Second Edition, PHI (Indian reprint: 2014)

Reference

B.P. Lathi, Principles of Signal Processing and Linear Systems, Oxford University Press, International Version 2009.

Some special signals

- Serve to represent other more general signals
- Can simplify system implementation
- Unit impulse, Unit step
- Exponential, Sinusoid

$$x(t) = e^{(\sigma + j\omega)t}$$

ω = 0

σ = 0

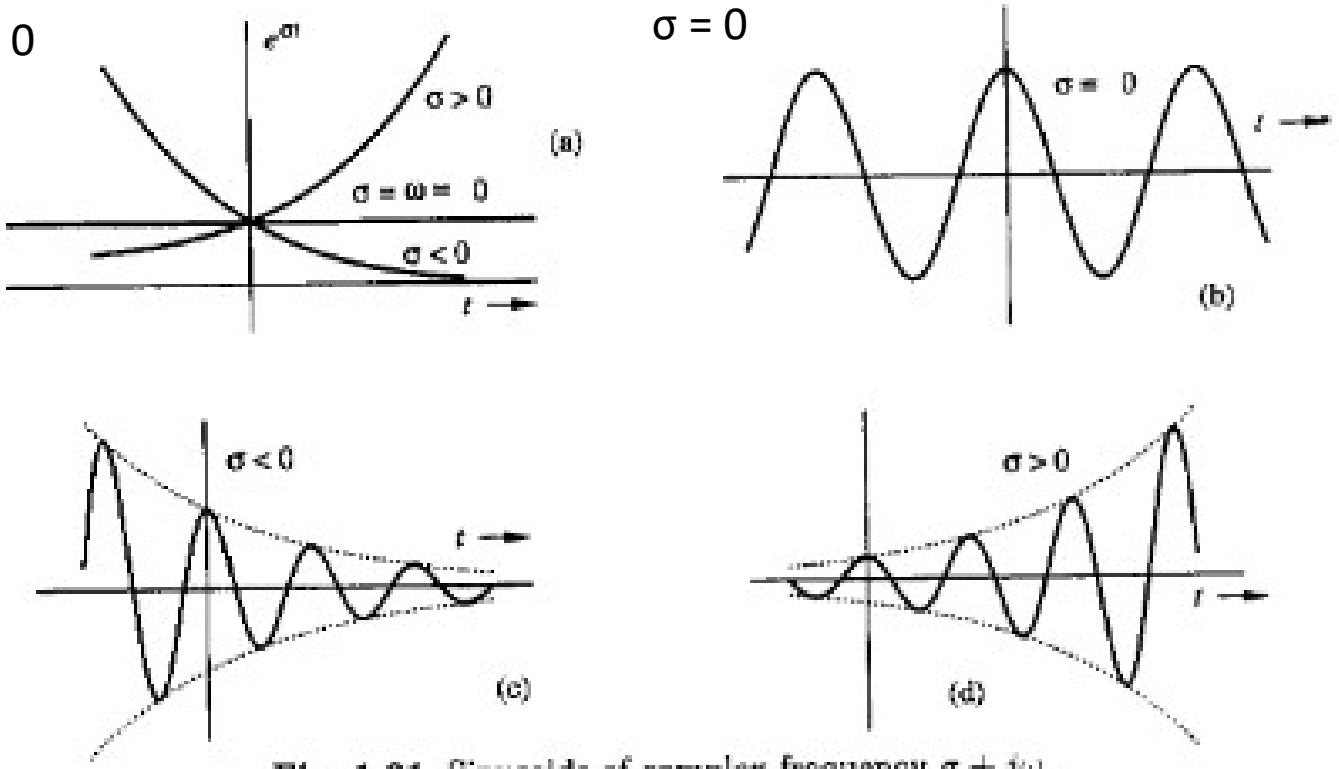
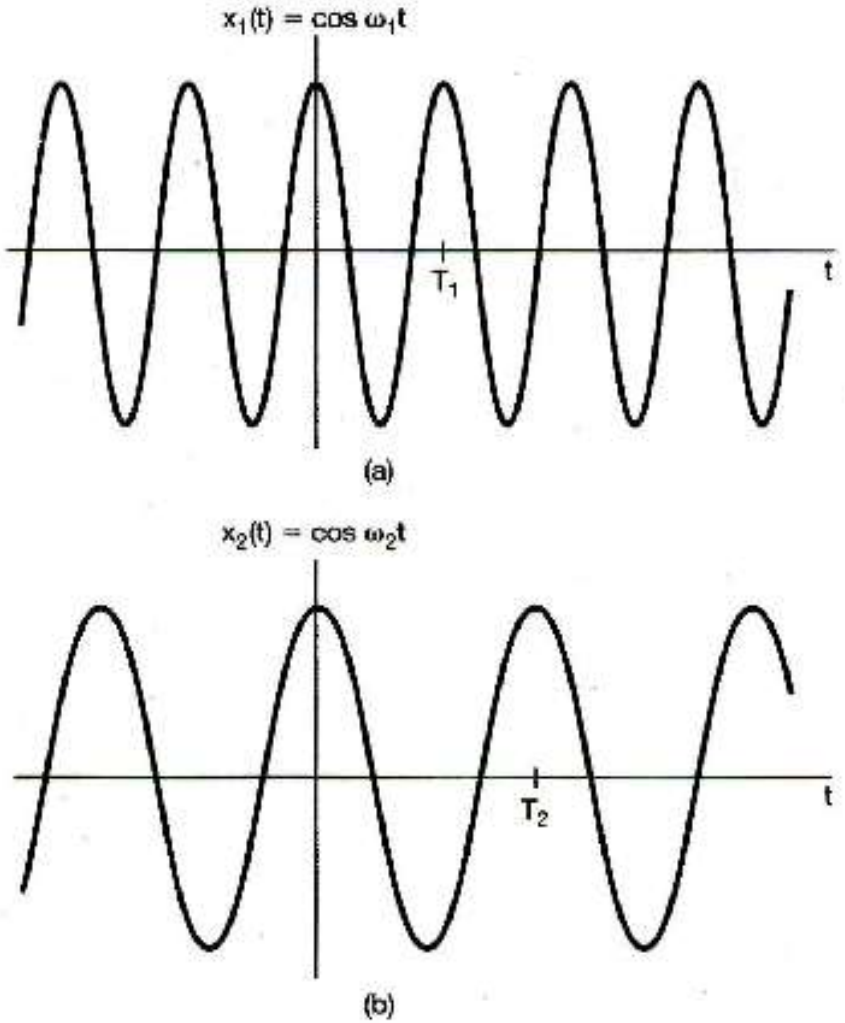
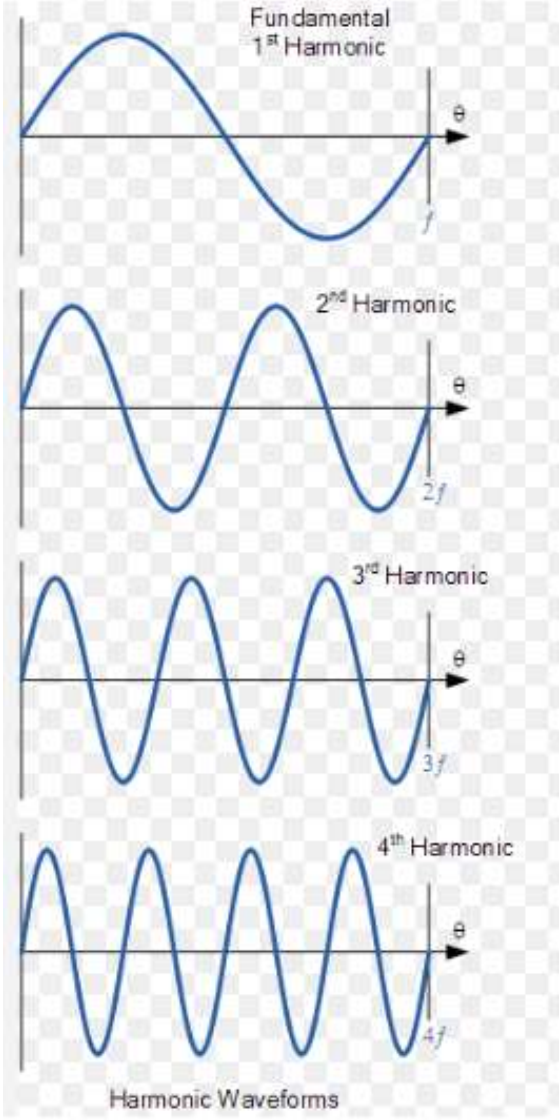


Fig. 1.21 Sinusoids of complex frequency $\sigma + j\omega$.

$\omega_1 > \omega_2$





Harmonic Waveforms

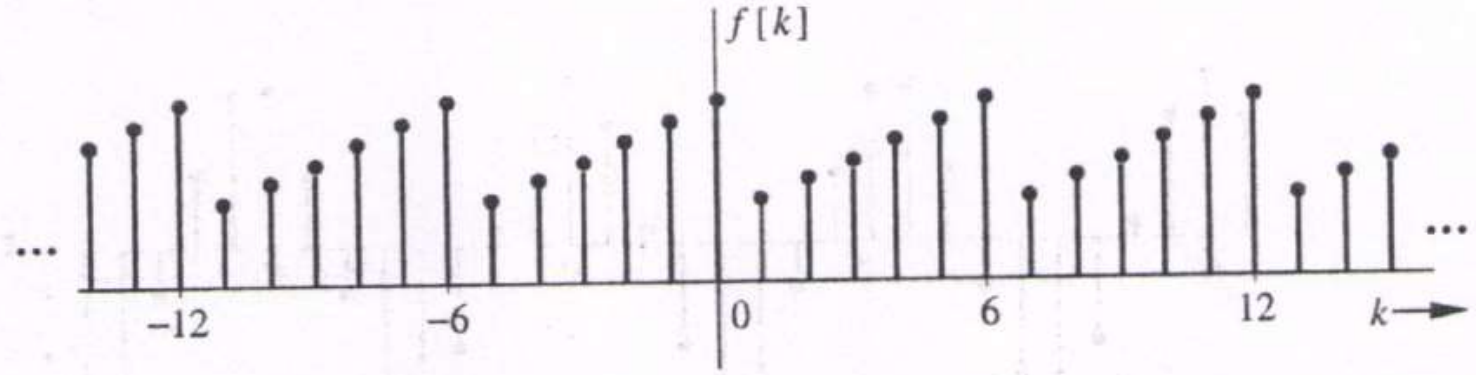
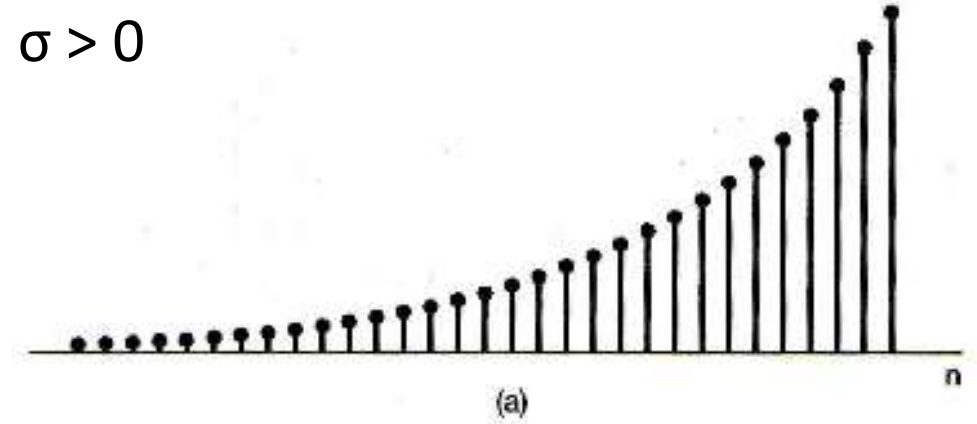


Fig. 8.9 Discrete-time periodic signal.

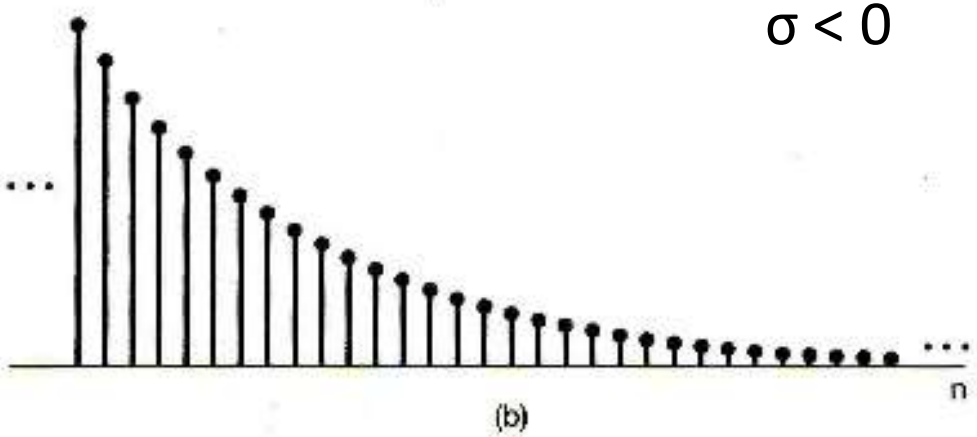
$x[n] = e^{\lambda n}$ $\lambda = \sigma + j\omega$

$\omega = 0$

$\sigma > 0$

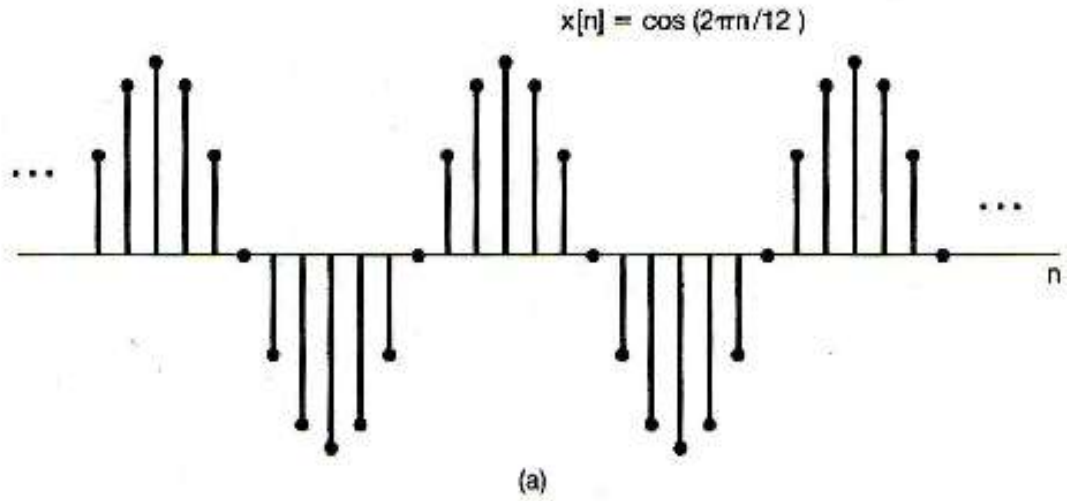


$\sigma < 0$



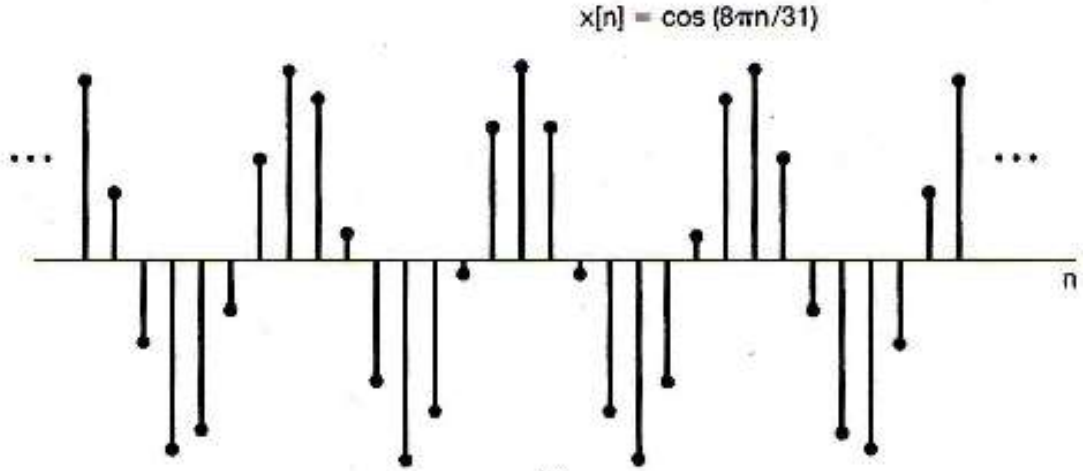
$x[n] = \cos(\omega n)$

$\omega = \frac{2\pi}{12}$ rad/sample



(a)

$\omega = \frac{8\pi}{31}$ rad/sample



(b)

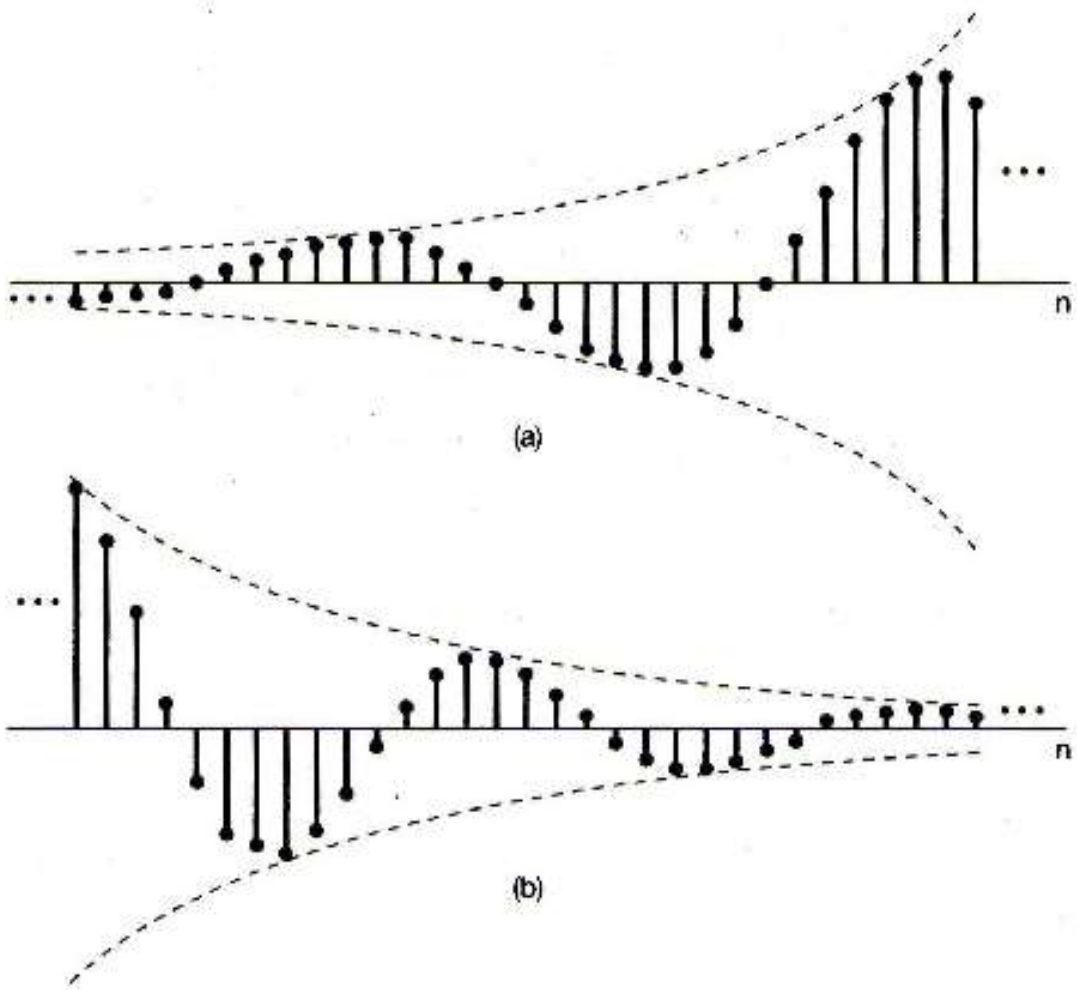


Figure 1.26 (a) Growing discrete-time sinusoidal signals; (b) decaying discrete-time sinusoid.

Properties of d-t sinusoids

- Periodicity
- Non-uniqueness

$x[n] = \cos(\omega n)$

$\omega = \frac{\pi}{4}$

$\omega = \frac{4\pi}{17}$

$\omega = 0.8$

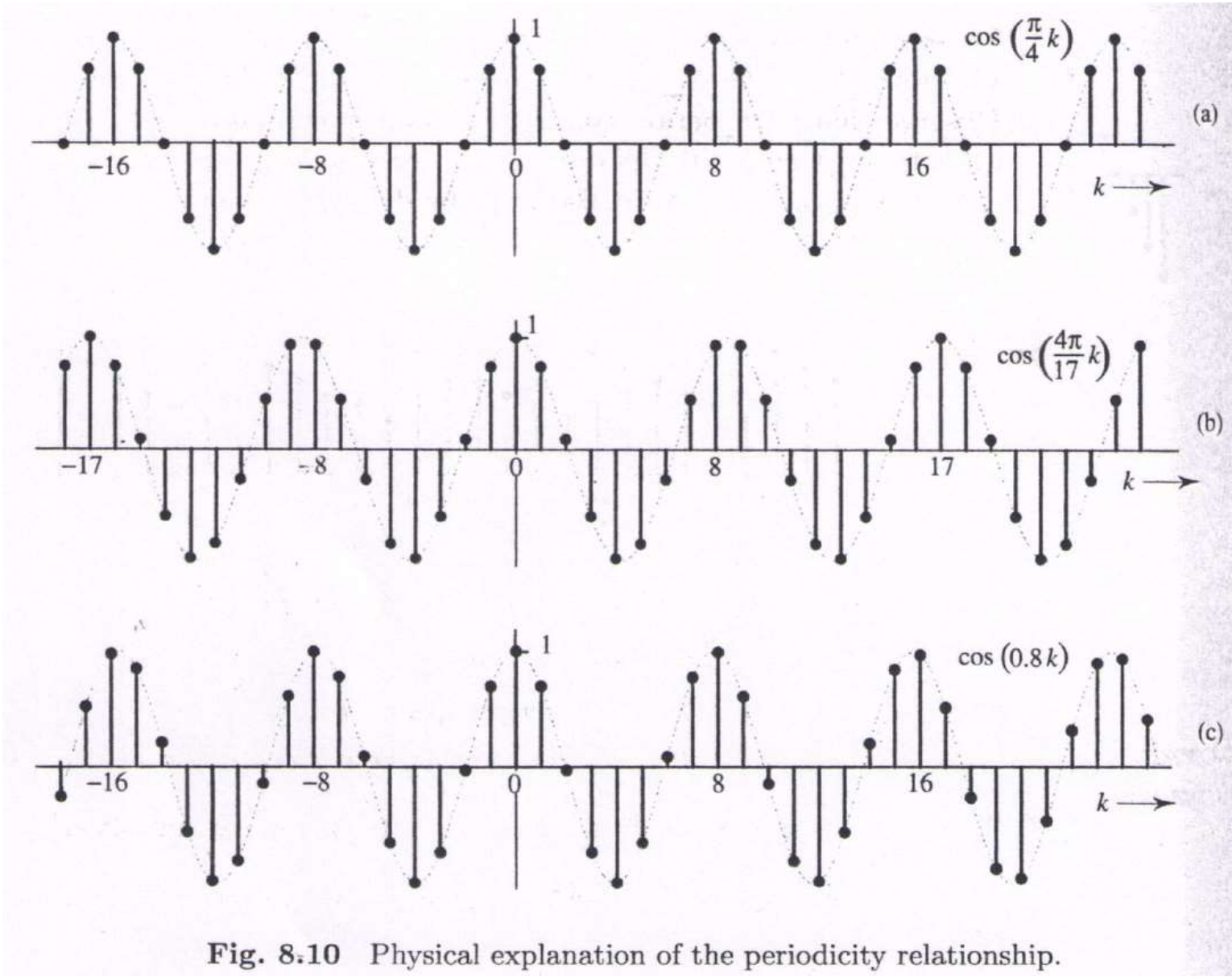
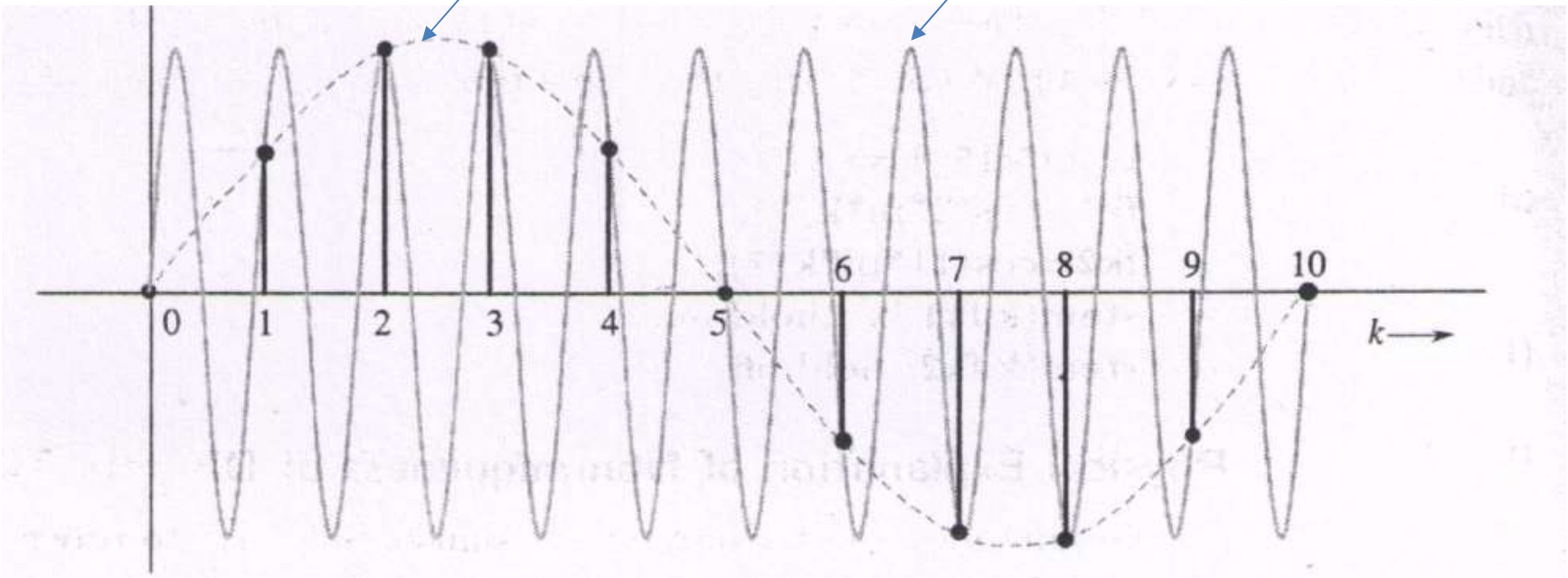


Fig. 8.10 Physical explanation of the periodicity relationship.

Non-uniqueness of D-T sinusoids

$x[n] = \sin(\omega n)$ $\omega_1 = \frac{2\pi}{10}$ $\omega_2 = \frac{2\pi}{10} + 2\pi$



g. 8.12 Physical explanation of nonuniqueness of Discrete-time sinusoid waveforms.

Some distinct d-t sinusoids from low to high freq.

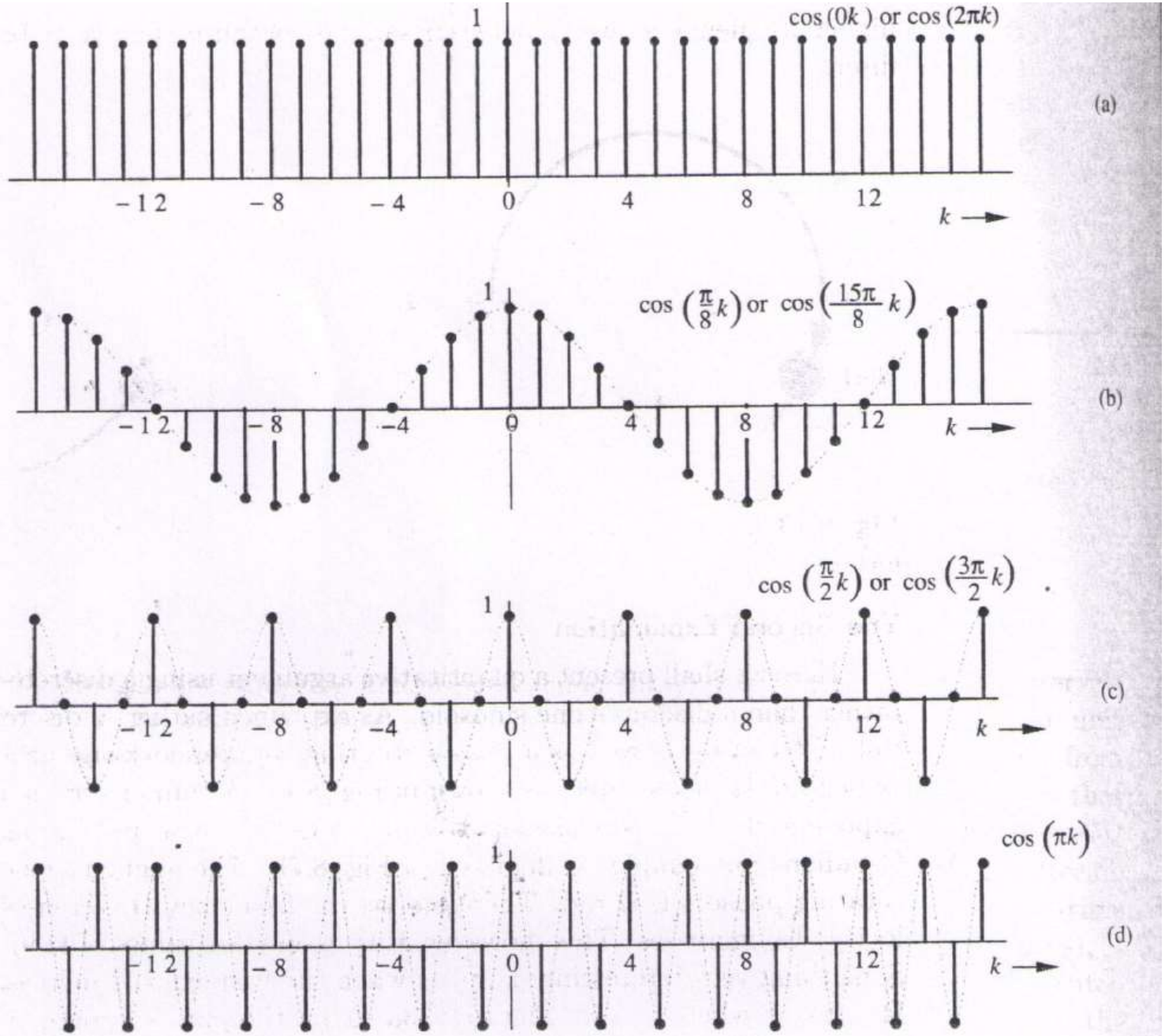


Fig. 8.14 Highest Oscillation Rate in a Discrete-Time sinusoid occurs at $\Omega = \pi$.