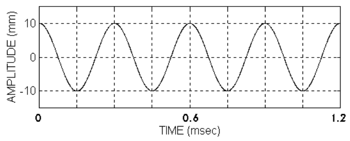
DIMENSIONS OF THE SINE WAVE

- dimensions of sine waves
  - Amplitude
  - Phase
  - Frequency/Period: f = 1 / T or T = 1 / f

Note: when a sine wave represents something in space, wavelength is used instead of period.



Ch2-1

Units of Measure For Frequency and Period

- Frequency (f)
  - Hz to kHz: Divide by 1,000
  - kHz to Hz: Multiply by 1,000
- Period (T)
  - s to ms: Multiply by 1,000
  - ms to s: Divide by 1,000
- f = 1/ T and T = 1/ f

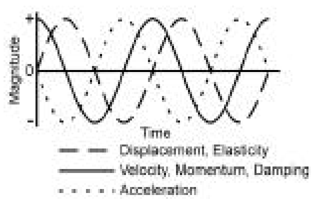
Table 2-3. Standard units of measure for frequency and period

FREQUENCY	MULTIPLIER	PERIOD	MULTIPLIER
Hertz (Hz		second (s)	1
)	1,000		.
Megahertz (MHz		microsecond (µs)	.000001
GHz)	1,000,000,000	nanosecond (	

Ch2-2

Important Phasic Relations

- Displacement (Elasticity)
- Velocity (Momentum; Damping)
- Acceleration
- Relations:
  - c leads x by 90°
  - a leads c by 90°, and
  - a leads x by 180°



Ch2-3

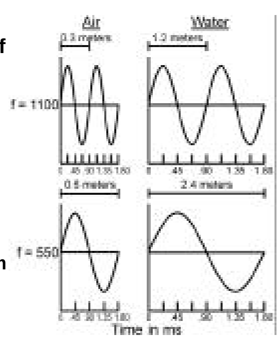
DIMENSIONS OF THE SINE WAVE

- (5) WAVELENGTH (λ)
- Two quantities are measured with respect to time
  - Frequency (f)
  - Speed of sound (s)

Ch2-4

Wavelength

- Wavelength (λ) relates frequency and speed of sound
- λ = distance traveled during one period
- λ = s / f
- Examples
  - In air: f = 1100 Hz, s = 340 m / s; λ = ?
    - λ = 340 / 1100 = .3 m
  - In air: f = 550 Hz, s = 340 m / s; λ = ?
    - λ = 340 / 550 = .6 m



Ch2-5

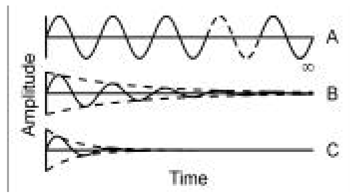
DAMPING/ Effects of Friction on Vibratory Motion

- Oscillating systems encounter opposition to motion: friction, or frictional resistance
- Friction limits velocity
- Amplitude of vibration diminishes over time
- Vibrations are damped

Ch2-6

The Magnitude of Damping

- In Figure,
  - Panel A: lossless system
  - Panel B: low-damped system
  - Panel C: high-damped system



ACOUSTIC IMPEDANCE

- System engages in SHM: it vibrates <u>freely</u> at its natural frequency (f_{nat})
- $f_{nat} = \sqrt{s/m}$
- What are the concepts involved in this oscillation?
  - ☑ elasticity / restoring force (spring)
  - ☑ inertia / momentum (mass)
  - ☑ friction / damping

ACOUSTIC IMPEDANCE

- Forces exist that <u>oppose</u>, or <u>impede</u>, motion: Impedance (Z)
- Total impedance has <u>two components</u>:
  - resistance R (friction)
  - reactance X
    - > mass reactance X_m (mass)
    - > compliant reactance X_c (spring)

Impedance

Resistance (R)

- Friction, or frictional resistance, occurs: kinetic energy is transformed to thermal energy
- Resistance measured in ohms (Ω)
- Resistance is <u>independent of frequency</u>!

Reactance (X)

- Forces that oppose motion in a frequency selective way: <u>frequency dependent</u>
- With X, <u>energy is stored</u>
- With R, <u>energy is dissipated from motion</u>

Two Components of Impedance

- 1. Energy-dissipating: What is it?
  - ☑ Resistance (R), which is independent of frequency
- 2. Energy-storage: What is it?
  - ☑ Reactance (X), which is dependent on frequency
- Impedance: Complex sum of R & X

Crucial Phasic Relations

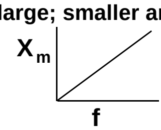
- Opposition to motion from Resistance is <u>in phase</u> with <u>velocity</u>
  - Resistance: in phase with c, M, and damping
- Opposition to motion from Compliance is <u>in phase</u> with <u>elasticity</u>; <u>lags</u> Resistance by 90^o
  - Compliance: in phase with E and x
- Opposition to motion from Mass is <u>in phase</u> with <u>acceleration</u>;
  - leads resistance by 90^o

Two Components of X: X_m and X_c

- When one reactance component stores energy, the other gives up energy
- They are 180^{o} out of phase with one another
- They act in opposition to one another

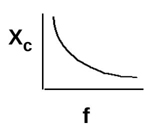
Mass Reactance: X_m

- X_m is directly proportional to frequency
- At low frequencies,
  - ♦ X_m negligible; larger amplitude of vibration
- At high frequencies,
  - ♦ X_m large; smaller amplitude of vibration
-



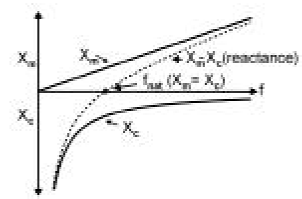
Compliant Reactance: X_c

- At low frequencies,
  - ♦ X_c large; smaller amplitude of vibration
- At high frequencies,
  - ♦ X_c negligible; larger amplitude of vibration
- X_c is inversely proportional to frequency
-



Mass Reactance (X_m) and Compliant Reactance (X_c)

- What if $X_m = X_c$?
  - ♦ If $X_m = X_c$, X = 0
  - ♦ Z = R
  - ♦ Impedance is minimal
  - ♦ Amplitude of vibration is largest
  - ♦ f_{nat}



Impedance (Z)

(What to remember)

- R causes energy to be dissipated
  - ie. resistance from friction)
- X causes energy to be stored
  - ♦ X_m leads R by 90^{o}
    - ie. Reactance from mass
  - ♦ X_c lags R by 90^{o}
    - ie. Reactance from compliance (spring)
  - ♦ X_m leads X_c by 180^{o}