Session 1 8/19/13 1

ME 513
Engineering Acoustics

MWF 11:30 - 12:20

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Fundamentals of Acoustics (4th Edition)

L. E. Kinsler, A. R. Frey, A. B. Coppens and J.V. Sanders

John Wiley and Sons
ISBN: 0-471-184789-5

Other References

1. Elements of Acoustics
    - Samuel Temkin (Wiley)
2. Sound and Sources of Sound
    - Dowling and Ffwocs-Williams (Ellis Horwood)
3. Acoustics – An introduction to its Physical Principles and Applications
    - Pierce (Acoustical Society of America)

Prerequisite:

Undergraduate linear systems or controls course

- Frequency domain analysis
- Complex analysis
- Vectors

Course Assessment:

- Homework 25% (6 assignments)
- Mid-term Exam 25%
- Comprehensive Final 50%

Acoustics:

Study of generation, transmission and reception of energy in the form of vibrational waves in matter.

Sound:

Propagating fluctuations (in pressure, density, velocity, temperature) in a elastic medium in the frequency range of 20 Hz to 20 kHz

Course Objective

To introduce the basic concepts of acoustical analysis to engineers and specifically to study wave propagation, sound radiation, absorption and transmission in a matter directly relevant to noise control practice. Information of this sort is required to design effective noise control treatments.

Course Content

- Simple Mechanical Systems
  - SDOF (Chapter 1)
  - Strings (Chapter 2)
- Acoustic Wave Equation and Simple Solutions (Chapter 5)
- Transmission Phenomena (Chapter 6)
- Sound Radiation from Simple Sources (Chapter 7)
- One-dimensional Systems (Chapter 9 and 10)
  - Ducts
  - Silencers
- Room Acoustics (Chapter 12)

sound: <u>propagating</u> <u>fluctuations</u> in an <u>elastic medium</u> from 20 Hz to 20 kHz.

For sound to propagate a medium must possess

- stiffness
- inertia

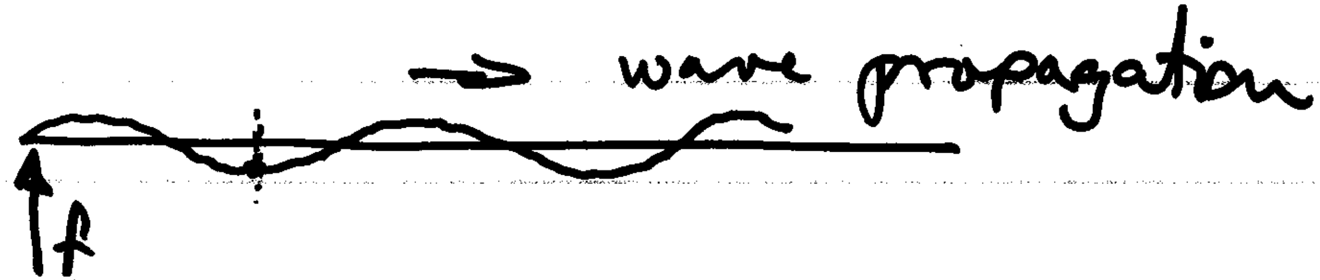
sources of sound

- vibration of solids
- interaction of flows with solids
- flows

- localized heating

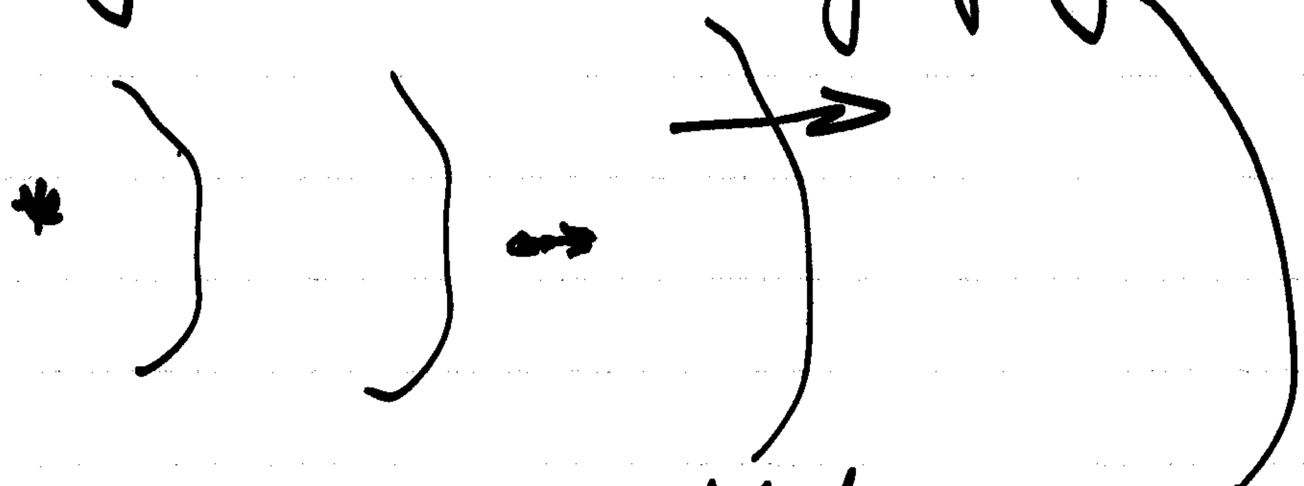
General Approach

(i) deriving governing equations
(ii) wave equation
(iii) identify possible solutions
(iv) Application of boundary conditions



transverse wave propagation

longitudinal wave propagation



- medium oscillate around an equilibrium position

Compare & Contrast

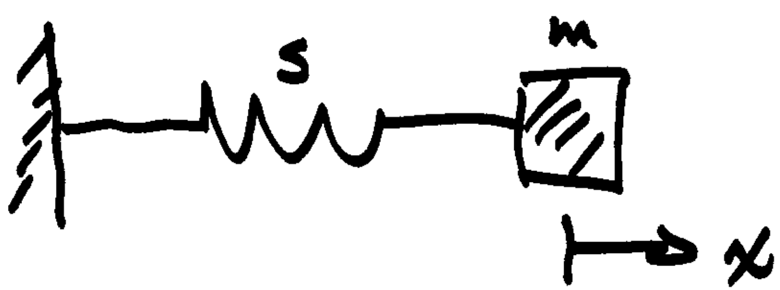
- ~~Wave~~ Wave propagation approach]
- modal approach]

1. Fundamentals of Vibration

Chapter 1 (1.1 – 1.11, 1.13 – 1.14)

- SDOF single degree of system

1.1 Simple undamped oscillator

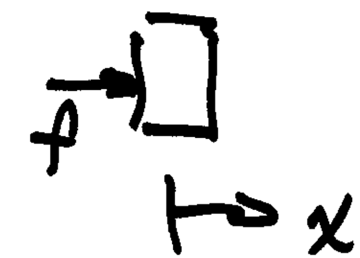


1.1.1 Governing Eqns

(i) Equation of Motion (EOM)

$$f = ma$$

$$= m\frac{d^2x}{dt^2} \qquad (1)$$



(ii) $$f = -s x \qquad (2)$$

(iii) sub (1) into (2)

$$m\frac{d^2x}{dt^2} + sx = 0$$

$\div m$ $\quad \frac{d^2x}{dt^2} + \frac{s}{m}x = 0$ $\qquad \frac{s}{m} = \omega_0^2$

$$\boxed{\frac{d^2x}{dt^2} + \omega_0^2 x = 0} \qquad (3) \qquad \omega_0 = \sqrt{\frac{s}{m}}$$

2nd order ODE

2 arbitrary constants.

1.1.2 Allowed Solutions

$x = A_1 \cos \gamma t$

sub into (3)

$$\frac{d^2x}{dt^2} = -\gamma^2 A_1 \cos \gamma t \qquad \frac{d^2x}{dt^2} + \omega_0^2 x = 0$$

$$-\gamma^2 A_1 \cos \gamma t + \omega_0^2 A_1 \cos \gamma t = 0$$

$$-\gamma^2 + \omega_0^2 = 0 \qquad \omega_0 = \sqrt{\frac{s}{m}}$$

Assumed form acceptable if $\rightarrow \gamma^2 = \omega_0^2$

$x = A_2 \sin \gamma t$ also acceptable.

$x = A_1 \cos \omega_0 t$

$x = A_2 \sin \omega_0 t$

Complete solution

$x = \underline{A_1} \cos \omega_0 t + \underline{A_2} \sin \omega_0 t$