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 ($30 from ASA)
   - Samuel Temkin (Wiley)
2. Foundations of Engineering Acoustics (PU library download)
   - Frank J. Fahy (Elsevier)
3. Acoustics – An introduction to its Physical Principles and Applications ($46.94 Amazon)
   - Pierce (Acoustical Society of America)
4. The Foundations of Acoustics (free download from Springer.com)
   - Eugen Skudrzyk (Springer-Verlag)

Other References

Acoustics and Industrial Noise Control
- 19 lectures

Course Coordinator:
Prof. Amiya R. Mohanty
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Youtube playlist:

https://goo.gl/B1yB6b

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 - propagating fluctuations in an elastic medium from 20 Hz to 20 kHz

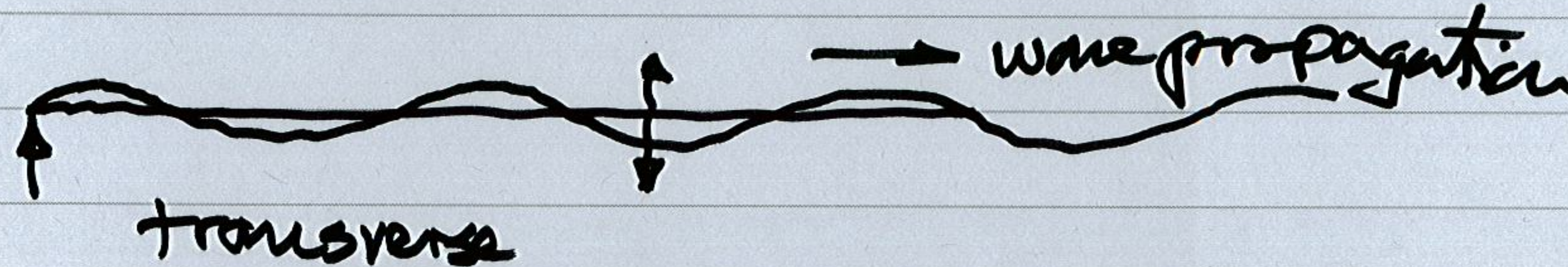
For sound to propagate a medium must have
- stiffness
- inertia

Sources of Sound
- vibration of solids
- interaction of flow & solids
- flow turbulence
- thermal - localized heat
  CNT loudspeakers

General Approach

(i) Deriving or identifying governing eqns
(ii) Combine to form a wave equation
(iii) Identify possible solutions
(iv) Application of b.c.'s to ~~so~~ select appropriate from all possible solutions

Types of Waves



longitudinal wave propagation

- medium moves back + forth in the direction of wave propagation
- medium oscillates around equil.

compare & contrast

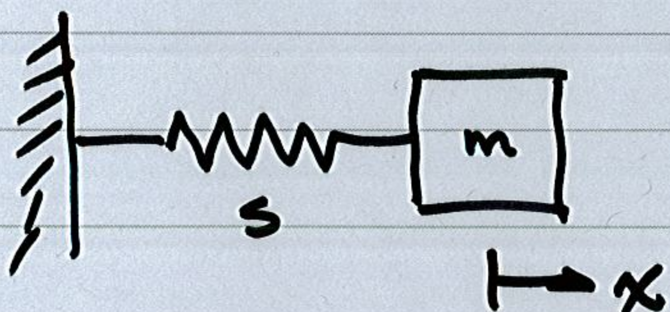
- wave propagation approach
- modal approach

1. Fundamentals of Vibration

Chapter 1 (1.1 → 1.11, 1.13 + 1.14)

SDOF's – single degree of freedom systems

1.1 Simple undamped oscillator

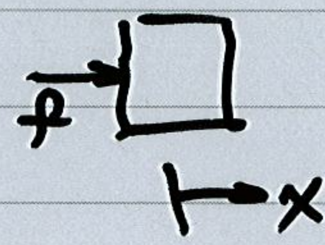


Generally gravity is ignored

1.1.1 Governing Eqns

(i) Equation of motion EOM

$f = ma$



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

(ii) Restoring force Eqn

$$f = -sx \quad (2)$$

(iii) sub (2) into (1)

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

$\div m \qquad \dfrac{d^2x}{dt^2} + \left(\dfrac{s}{m}\right) = 0 \qquad\qquad \dfrac{s}{m} = \omega_0^2$

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

2nd order ODE

solution features 2
arbitrary constants

1.1.2 Allowed solutions

$$\omega_0 = \sqrt{\frac{s}{m}}$$

$$x = A_1 \cos \gamma t$$ sub into (3)

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

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

Assumed soln is acceptable

if $\gamma^2 = \omega_0^2$

$x = A_2 \sin \gamma t$ is also acceptable so long as $\gamma^2 = \omega_0^2$

Complete solution

$$x = A_1 \cos \omega_0 t + A_2 \sin \omega_0 t$$