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

Course Website:
engineering.purdue.edu/ME513/

Other References

1. **Elements of Acoustics**
   - Samuel Temkin (Acoustical Society of America)
2. **Foundations of Engineering Acoustics**
   - Frank J. Fahy (Academic Press)
3. **Engineering Noise Control: Theory and Practice**
   - David Bies and Colin Hansen (CRC Press)
4. **Acoustics – An introduction to its Physical Principles and Applications**
   - Pierce (Acoustical Society of America)

Go to acousticalsociety.org for a selection of classic books

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

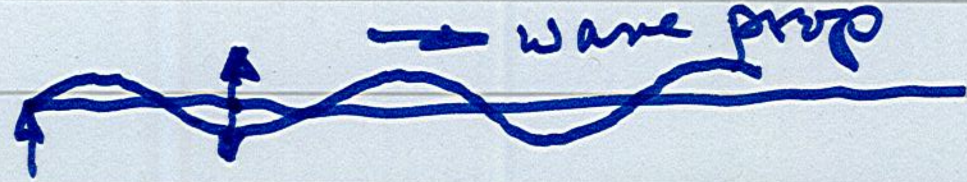
Sources of sound
- vibration of solids
- interaction of flow with solids

- flows
- Thermal - localized heating

General Approach

(i) Derive governing eqns
(ii) Combine to form a wave equation
(iii) identify possible solutions
(iv) Application of BC's to ~~so~~ select appropriate solution

types of waves



transverse wave prop

longitudinal wave propagation

medium oscillates
around an equilibrium position

Compare and contrast

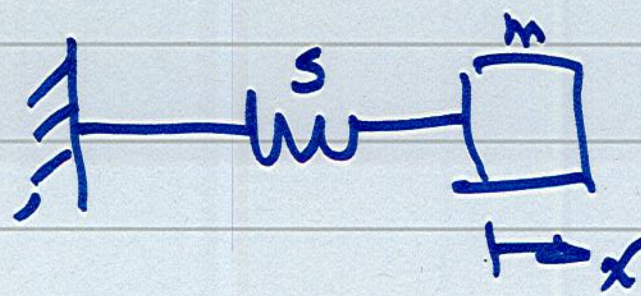
- wave propagation approach]
- modal approaches

1. Fundamentals of Vibration

Chapter 1 (1.1 – 1.11, 1.13 – 1.14)

SDOF – single degree of freedom

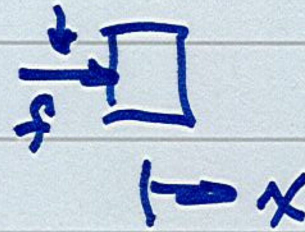
1.1 Simple undamped oscillator



1.1.1 Governing Eqns

(i) Equation of Motion EOM

$$f = ma \qquad (1)$$



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

(ii) $f = -sx$ (2)

(iii) sub (2) → (1)

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

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

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

2nd order ODE

solution features 2
arbitrary constants

1.1.2 Allowed Solutions

$x = A_1 \cos \gamma t$ sub into 13)

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

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

Assumed soln is
acceptable if $\gamma^2 = \omega_0^2$

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

so long as

$x = A_1 \cos \gamma t = A_1 \cos \omega_0 t$ $\quad \gamma^2 = \omega_0^2$

$x = A_2 \sin \gamma t = A_2 \sin \omega_0 t$

complete solution

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