ME 513
Engineering Acoustics

MWF 11:30 - 12:20

Prof. J. Stuart Bolton
Office: HLAB 2002
E-mail: bolton@purdue.edu
Phone: (765) 494-2139

TA: TBD

Website: https://engineering.purdue.edu/ME513/

Ray. W. Herrick Laboratories
School of Mechanical Engineering
Purdue University

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 free download)
   - Frank J. Fahy (Elsevier)
3. Acoustics – An introduction to its Physical Principles and Applications ($46.94 Amazon)
   - Allan D. 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
Mechanical Engineering
Indian Institute of Technology Kharagpur

International Faculty:
Prof. J. Stuart Bolton
Ray W. Herrick Laboratories
School of Mechanical Engineering
Purdue University

Youtube playlist:

https://goo.gl/B1yB6b

Prerequisite:

Undergraduate linear systems or controls course

- Frequency domain analysis
- Complex analysis
- Vectors

Course Assessment:

- Homework 25% (5 or 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

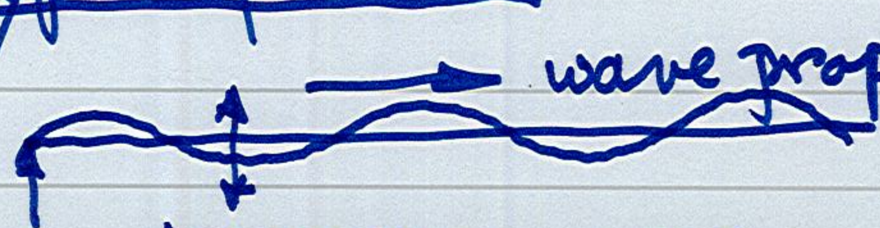
For to propagate a medium must have - stiffness
- inertia

Sources of Sound
- vibration of solids
- interaction of flow and solids
- flow turbulence
- thermal - localized heat sources CNT

General Approach

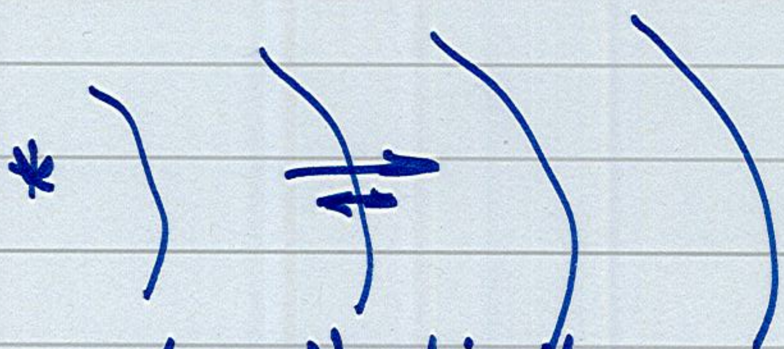
(i) Derive or identify governing eqns
(ii) Combine them to form a wave eqn
(iii) Identify possible solutions
(iv) Application of b.c.'s to select appropriate solution from all the possible solutions

Types of waves

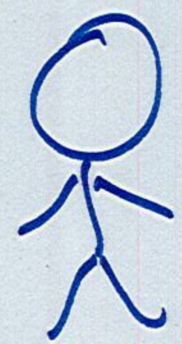


transverse wave

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



longitudinal



Compare & Contrast
- wave propagation

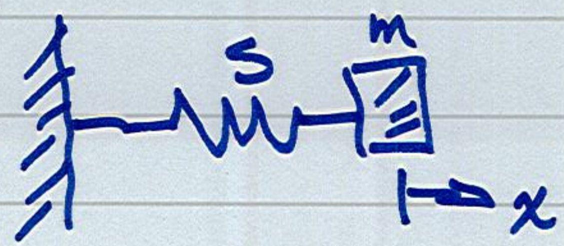
- modal approach

1. Fundamentals of Vibration

Chapter 1 (1.1 – 1.11, 1.13 & 1.14)

SDOF – single degree of freedom

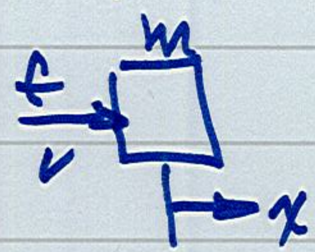
1.1 Simple undamped oscillator



Generally gravity is ignored

1.1.1 Governing Eqns

(i) Equation of motion



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

(ii) Restoring ~~Eq~~ Force Eqn

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

Sub (2) into (1)

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

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

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

2nd order ODE

$\Rightarrow$

Solution features 2 arbitrary constants

1.1.2 Allowed solutions

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

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

$$\frac{d^2x}{dt^2} + \omega_0^2 x = 0$$

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

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

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

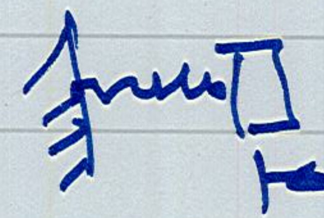
Assumed soln is acceptable if $\gamma^2 = \omega_0^2$

$x = A_1 \cos\omega_0 t$

$x = A_2 \sin \gamma t$ also acceptable so long as

$x = A_2 \sin \omega_0 t$ $\qquad \gamma^2 = \omega_0^2$

complete solution



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