Course Content : ME 626 Acoustics

Credits: 3-0-0-3

Prerequisites: Basic Engineering Mathematics. ME 602 Mechanical Vibration is desirable.

Intended for: MS and PhD students – SE, SCEE, B-Tech final and pre-final year students.

Distribution: Elective

Semester: Odd/Even

Preamble: The course is intended to give an in depth understanding of the science of acoustic wave propagation. The course will give practical engineering applications and understanding of how noise is quantified, how it is produced, how to mathematically express acoustic wave propagation, etc. The course will also give exposure to interesting and practical applications such as musical instruments – string, drums, mufflers/silencers, architectural acoustics (of concert halls), design of partitions, government regulations on acceptable noise levels, underwater acoustics, etc.

Course Outline:
The course starts with basics of acoustics and vibration, introducing students to frequency, Fourier series and transform, basics of one degree of freedom system, etc. The next module will introduce vibration of strings, bars and drums. Then the mathematical description of acoustic wave propagation is presented. Special topics such as waveguides and resonators are also considered. Then reflection and transmission of acoustic wave in different media is considered. What will happen when acoustic wave encounters different media? This question is answered. Next, how is acoustic wave produced and radiated is answered. In module 6, the mechanism by which humans hear acoustic wave is discussed. How do we perceive sound of different frequency and loudness, and how do we produce sound is discussed. Next, architectural and environmental aspects of acoustics are discussed. And lastly some special topics such as underwater acoustics or shock wave etc, may be discussed depending on time availability.

Modules :

Module 1: Basics of Acoustics and Vibration [5 hrs]
Introduction, frequency, Fourier series, FFT, loudness, decibel scale, octave, music scale. Vibration of one degree of freedom system. Brief introduction to multi degree of freedom system.

Module 2: Vibration of string, bars, membranes and plates [5 hrs]
One dimensional wave equation, general solution of wave equation, plucked string. Longitudinal vibration of bars, transverse vibration of beam. Wave equation for stretched membrane, normal modes of membrane. Vibration of plates.

Module 3: Acoustic wave equation and its solution [8 hrs]
Equation of state, continuity, Euler's equation. Linear wave equation, speed of sound in fluids. Acoustic intensity, specific acoustic impedance, spherical waves, cylindrical waves. Waveguides, transmission line equations. and resonators

Module 4: Reflection and transmission [4 hrs]
Changes in media, transmission from one fluid to another – normal and oblique incidence. Normal specific acoustic impedance, reflection from solid. Transmission through thin partition – mass law. **Perfectly matched layer.**

Module 5: Radiation and reception of acoustic waves [8 hrs]

Radiation from pulsating sphere, acoustic reciprocity, continuous line source, radiation from circular piston, radiation impedance. Models of electromechanical acoustic systems, Solution for a loudspeaker model, Microphones.

Module 6: Hearing and Speech [4 hrs]
The ear, fundamental properties of hearing – threshold, equal loudness level contours, critical bandwidth, masking, beats. Loudness level and loudness, pitch and frequency, voice.

Module 7: Environmental and Architectural acoustics [8 hrs]
Sound in enclosure, reverberation time, sound absorption materials, acoustics factors in architectural design. Speech interference, noise rating curves, highway noise, design of partitions.

Module 8: Special topics [2 hrs]
Underwater acoustics, shock waves and explosion. (can be in the form of seminars/presentation)

Text Books:

1. Fundamentals of Acoustics, Lawrence E. Kinsler, Austin R. Frey, 4th Ed., 2000 Wiley Publishers.
2. Noise and Vibration Control, Munjal M. L., World Scientific Publishers in Collaboration with IISc Press, Singapore, 2013

Reference:

1. Acoustics, Beranek Leo L., Acoustical Society of America, NY 11797, 1996.