ACOUSTICS (ACS)

ACS 501: Elements of Acoustics and Vibration

3 Credits

Vibrational acoustics including mechanical oscillation, forced and damped response, vibration of strings, membranes, rods, bars, and plates. ACS 501 Elements of Acoustics and Vibration (3) Acoustics is a broad subject that crosses and interacts with many engineering, science, mathematics, medical, and artistic disciplines. This course provides a thorough foundation necessary for studying structural acoustics and vibration problems and the exploration of acoustic waves in solids. A detailed analysis of the single-degree-of-freedom mechanical mass-spring system provides the building block for exploring lumped-element models of more complicated acoustic systems and the phenomena of resonance for forced and damped systems. Multiple-degree-of-freedom mechanical systems are used to investigate the coupled oscillation between oscillating systems, the design of vibration absorbers, and methods for modeling the low frequency behavior of guitars, violins, and vented-boxed loudspeakers. Extending the mass-spring model to an infinite number of degrees-of-freedom leads to a development of the wave equation and its solutions for longitudinal acoustic waves in elastic solids. Boundary conditions and the concept of mechanical impedance are used to explore standing waves in a bounded elastic medium and the transmission of waves between media with different elastic properties. Transverse waves on an elastic string, while fundamentally different from longitudinal waves, obey the same differential equation of motion and the same application of boundary conditions and mechanical impedance. For both longitudinal and transverse wave systems, the mechanical impedance approach and the method of separation of variables are used to study systems with specified boundary conditions. Longitudinal and transverse waves in structures with varying cross-section, density, or elastic properties are also explored. Torsional waves in elastic solids are explored with application to systems with various cross-sectional shapes. Membranes serve as a two-dimensional extension of transverse waves on an elastic string, and provide mode shapes which may be described using rectangular and cylindrical coordinates (with Bessel function solutions). The fourth-order differential equation of motion for flexural bending vibrations of thin beams is derived and solutions are explored using the separation of variables approach for boundary value problems. Finally, the flexural vibration of two-dimensional rectangular and circular plates are investigated. Homework problem sets will illustrate theory and applications to real world problems.

ACS 502: Elements of Waves in Fluids

3 Credits

Thermodynamic and hydrodynamic foundations of linear acoustics in fluids with applications to lumped-elements, reflection, refraction, radiation, attenuation, enclosures, and waveguides. The purpose of this course is to provide the foundation for understanding the behavior of waves in fluids in the "linear acoustic" limit for first-year graduate students entering the Graduate Program in Acoustics. The course provides a common ground for students coming from a broad range of varying undergraduate programs in sciences, engineering, mathematics, and the arts. This self-consistent foundation will be built upon an understanding of thermodynamics and the consequences for the behavior of gases and gas mixtures (i.e., ideal gas equations-of-state, heat capacity), and hydrodynamics (both dissipative and non-dissipative) as expressed from the Eulerian perspective. This perspective will be used to develop techniques for understanding oscillations in lumped-element acoustical networks that are smaller than the wavelength of sound and will be applied to extended media in which waves propagate, are reflected and transmitted through interfaces between media with different acoustical properties, and are refracted through media with continuously-varying acoustical properties. The same equations will be applied to the excitation of sound waves that propagate in 3-dimensions by vibrating bodies that are smaller than the wavelength of sound. Those results will be extended by superposition of such "compact sources" to produce both discrete and continuous one- and two-dimensional arrays. The directional properties and strength of such extended sources will be examined. The behavior of sound within 3-dimentional rectangular enclosures is studied via the method of "separation of variables" to identify the sound modes in such enclosures, their characteristic frequencies, and the selective excitation and detection of such modes. The frequency dependence of the density of modes is introduced to motivate the relationship between the modal and raytracing (i.e., ballistic) perspectives. The techniques of "statistical energy analysis" will be applied such enclosures to quantify architectural phenomena such as reverberation time and critical distance. Those results will be extended to non-rectangular enclosures and to rectangular and cylindrical waveguides, focusing on the concept of group and phase speed and the coupling of sources to planewave and higher-order waveguide modes. Attenuation of sound waves is also treated from the hydrodynamic perspective and results are derived for boundary-layer dissipation, classical thermoviscous sound absorption within bulk fluids, and the relaxation-time approximation is applied for sound absorption by chemical association-dissociation in seawater and the effects of humidity on collision-times in air. Problem sets that illustrate the theory and applications are a central component of this course.

ACS 503: Signal Analysis for Acoustics and Vibration

3 Credits

This course will provide students with an in-depth treatment of time/frequency analysis of acoustic or vibration signals with direct connection to physical measurements. Students will build an awareness of the various techniques of signal analysis and a proficiency with these techniques and the language of signal analysis, skills that will facilitate their independent reading and learning beyond this course. Students will develop their ability to check answers for validity. Applications will be discussed in the context of actual measurements as students explore the implications and limitations of conventional techniques as applied to real signals in the background of real noise. Building on these insights, the students will demonstrate proficiency in the application of the techniques of signal analysis using common analysis-software packages and will develop proficiency in interpretation of the results.

ACS 505: Experimental Techniques in Acoustics

2 Credits

Properties of acoustical and vibrational transducers, electronic and other instrumentation used in fundamental data measurement, acquisition and analysis.

Prerequisite: ACS 501 , ACS 502

ACS 513: Digital Signal Processing

1-3 Credits

Discrete linear systems, transforms, digital filter design and applications, discrete fourier transforms, spectrum analysis.

ACS 514: Electroacoustic Transducers

3 Credits

The theory, design, and calibration of passive, linear, reciprocal electroacoustic transducers for use in both air and water media.

Prerequisite: PHYS 443

ACS 515: Acoustics in Fluid Media

3 Credits

Wave propagation in stationary and moving fluids; acoustic radiation and scattering; standing waves in ducts and cavities.

Prerequisite: E MCH524A ; PHYS 443

ACS 516: Acoustical Data Measurement and Analysis

2-3 Credits/Maximum of 3

Presents the engineering applications of recent developments in correlation and spectral analysis to acoustical measurement problems.

ACS 519: Sound-Structure Interaction

3 Credits

Acoustic radiation from and effects of fluid-loading on vibrating infinite and finite plates and shells. Acoustic transmission through and reflection from elastic plates and shells, acoustic excitation of elastic plates and coupling between panels and acoustic spaces.

Prerequisite: ACS 501 , ACS 502 , E MCH524B

ACS 521: Stress Waves in Solids

3 Credits

Recent advances in Ultrasonic Nondestructive Evaluation: waves; reflection and refraction; horizontal shear; multi-layer structures; stress; viscoelastic media; testing principles.

Prerequisite: E MCH524A , E MCH524B
Cross-listed with: EMCH 521

ACS 523: Signal Analysis for Acoustics and Vibration II

3 Credits

This course is concerned with the time and frequency-domain analysis of discrete-time signals and discrete-time linear systems, with an emphasis on developing and applying analysis techniques with applications in acoustics and vibrations. In this course, students will learn how to apply amplitude and frequency modulation to signals, evaluate the stability and causality of systems, extract features from measured acoustic signals, and design and use common filters (i.e. infinite impulse response, finite impulse response, adaptive, and tracking).

Prerequisite: ACS 503

ACS 524: Transducers II and Acoustics System Modeling

3 Credits

The course covers current research in the design analysis and performance prediction for acoustic transducers and acoustical systems that include transducers. Examples of such systems are microphones, loudspeakers, piezoelectric sources and sensors, and systems that include one or more of these devices. This course builds on the understanding developed in ACS 514 to synthesize knowledge necessary for understanding and analyzing the nonlinearities in transducer systems to enable improved designs with reduced distortion or compensation for nonlinear behavior.

Prerequisite: ACS 514

ACS 530: Flow-Induced Noise

3 Credits

Introduction to the basic and applied aspects of flow-induced noise created by subsonic flows of various complexities. ACS 530ACS 530 Flow-Induced Noise (3) The objective of this course is to introduce the basic and applied aspects of flow noise created by subsonic flows of various complexities. Basic concepts of noise and pressure fluctuations induced by unsteady fluid flows are discussed, including theoretical as well as experimental approaches. For a given class of flow, mechanisms for the creation of unsteady wall pressures and forces, radiated sound, and fluid-structure interactions are detailed. Various prediction schemes are presented which range from purely theoretical to empirical. The intent is to keep the material practical while at the same time introducing the student to a wide variety of specific topics. Some of the topics to be presented include: basic fluid mechanics, fundamental flow noise theory, flow noise measurement issues including wave vector-frequency spectral estimates of unsteady pressures and forces, compact Green's functions, unsteady forces and noise created by bluff bodies in flow, vortex shedding noise, wall pressure fluctuations and acoustics associated with turbulent boundary layers, including separated layers and transition zones, unsteady forces and noise due to flow over lifting surfaces, edge acoustic scattering mechanisms, axial-flow fan noise, rotor/flow interactions, turbulence ingestion, centrifugal blower noise, and noise generated by flow in pipes. The prerequisite for this course is a solid understanding of the fundamentals of acoustics, as demonstrated by successful completions of ACS 501 and 502. Students with a minor in Acoustics from accredited universities may also have the proper background to take this course. Although basic fluid mechanics is covered in the course, any previous courses or experience in this area will be beneficial. Homework problems will be assigned weekly and graded. Some of the homework may involve reading technical papers and providing a written synopsis. The average of all homework grades will constitute one-third of the final course grade. Another third will come from the mid-term exam and the final third from the final exam.

Prerequisite: ACS 501 and ACS 502

ACS 537: Noise Control Engineering I

3 Credits

As the first of three courses, this course provides an orientation to the program and covers fundamentals of noise control. ACS 537 Noise Control Engineering I (3) This course will introduce students to the application of acoustic and vibration fundamentals to the analysis and reduction of noise and vibration problems in industrial and residential settings. Topics will include: source-path-receiver model, human hearing and psychoacoustics, human response to noise and vibration, sound quality metrics and criteria for quantifying noise, acoustic standards related to noise and vibration control, instrumentation for measuring and analyzing noise and vibration, noise sources (distributed sources, impact sources, flow noise), absorption (materials, measurement, placement), control of sound in large and small rooms, partitions and barriers, mufflers, and vibration control techniques. Homework will combine problem solving with analysis of case studies. Group projects may be used to encourage collaborative approaches to problem solving.

Prerequisite: BS in engineering or related field, or instructor approval

ACS 542: Physical Principles in Biomedical Ultrasonics

3 Credits

Physical principles of advanced ultrasonic imaging and quantitative data acquisition techniques in fields of biology and medicine. E MCH (ACS) 542 Physical Principles in Biomedical Ultrasonics (3) This course focuses on the phenomenon of ultrasound in the context of medical and biological applications, systematically discussing physical principles and concepts. Concepts of wave acoustics are examined and practical implications are explored - first, the generation and nature of acoustic fields and then their formal descriptions and measurement. Real tissues attenuate and scatter ultrasound in ways that have interesting relationships to their physical chemistry, and the course includes coverage of these topics. This course also includes critical accounts and discussions of the wide variety of diagnostic and investigative applications of ultrasound that are available in medicine and biology. The course encompasses the biophysics of ultrasound and its practical applications to therapeutic and surgical objectives. The course utilizes finite element methods for simulation.

Cross-listed with: EMCH 542

ACS 580: Contemporary Research in Acoustics

1 Credits

Contemporary research activities in acoustics: major research thrusts, including current research methodologies and their limitations.

Prerequisite: ACS 501, ACS 502, ACS 505, ACS 590, ACS 594 or equivalent

ACS 590: Colloquium

1-3 Credits/Maximum of 3

Continuing seminars which consist of a series of individual lectures by faculty, students, or outside speakers.

ACS 594: Research Topics

1-15 Credits/Maximum of 15

Supervised student activities on research projects identified on an individual or small-group basis.

ACS 596: Individual Studies

1-9 Credits/Maximum of 9

Creative projects, including nonthesis research, which are supervised on an individual basis and which fall outside the scope of formal courses.

ACS 597: Special Topics

1-9 Credits/Maximum of 9

Formal courses given on a topical or special interest subject which may be offered infrequently; several different topics may be taught in one year or term.

ACS 598: Special Topics

1-9 Credits/Maximum of 9

Formal courses given on a topical or special interest subject which may be offered infrequently; several different topics may be taught in one year or semester.

ACS 600: Thesis Research

1-15 Credits/Maximum of 999

No description.

ACS 601: Ph.D. Dissertation Full-Time

0 Credits/Maximum of 999

No description.

ACS 610: Thesis Research Off Campus

1-15 Credits/Maximum of 999

No description.

ACS 611: Ph.D. Dissertation Part-Time

0 Credits/Maximum of 999

No description.