PHYS-302 Physics of Waves

2007 catalog data:
Credit: (4-0-0-4)
Prerequisites: PHYS-224, Electricity and Magnetism; PHYS-225, Electricity & Magnetism Laboratory; MATH-203, Multivariate Calculus
Corequisites: MATH-204, Differential Equations and Laplace Transforms

The phenomena of vibration and waves provide a fundamental background necessary to approach a wide variety of applications in physics and engineering. The first part of this course will introduce students to the basics of vibration, including the effects of real damping, response to driving forces, nonlinear oscillation and application to several acoustical, optical, electrical, and mechanical systems. After this introduction to vibration, the course will focus on wave motion. The behavior of non-dispersive waves in solids, acoustic sound waves, electromagnetic waves, and transverse waves on a string will be discussed along with an introduction to Fourier analysis as a means of analyzing wave signals. Non-dispersive waves in non-uniform media will also be explored with applications to several different types of waves occurring in nature. Basic wave phenomena including reflection, refraction, diffraction and interference will be discussed with respect to a variety of wave types. Students successfully completing this course will be well prepared for further study in optics, acoustics, vibration, and electromagnetic wave propagation

Textbook(s): *Introduction to Wave Phenomena*, A. Hirose and K.E. Lonngren, (Krieger Publishing Co., 2003)

References:
Electromagnetic Vibrations, Waves and Radiation — George Bekefi and Alan H. Barrett (MIT Press, 1977)
Vibrations and Waves in Physics, Iain G. Main, 3rd edition (Cambridge University Press, 1993)
The Physics of Vibrations and Waves, 6th ed., H. J. Pain, (John Wiley & Sons, 2005)
Vibrations and Waves, A. P. French, (W.W. Norton & Company, 1971)

Coordinator(s): D. Russell, Associate Professor of Applied Physics

Course learning objectives:
A student who successfully completes this course will be able to:
1. Describe the behavior of a vibrating system subjected to damping and external driving forces.
2. Apply the principles of damped and driven oscillation to a variety of problems in mechanical, electrical, acoustical and optical systems.
3. Understand what properties of a vibrating system are likely to cause the system to exhibit nonlinear behavior.
4. Explain the meaning of the general non-dispersive wave equation and show how the solutions to this wave equation indicate wave motion.
5. Discuss the behavior of longitudinal waves in solids, acoustic sound waves in air,

electromagnetic waves, and transverse waves on a string.
6. Use Fourier theory to analyze a periodic wave signal into its harmonic components, to explain modulation, and to apply Fourier analysis to pulses and group waves.
7. To explain the dispersive nature of waves in stiff media, non-uniform (lumpy) media, evanescent waves in solids, and surface waves in water.
8. Explain the behavior of electromagnetic waves in a vacuum, in dispersive dielectric media, and how they propagate through the atmosphere.
9. Understand the basic fundamentals of wave propagation in a crystal lattice, and the behavior of solitary waves in a nonlinear medium.
10. Explain the phenomena of reflection and refraction and apply it to various problems involving standing waves.
11. Explain the phenomena of far-field diffraction and interference as it applies to a variety of different wave types.

Prerequisites by topic:
1. Basic mathematical skills: algebra, trigonometry, geometry, and calculus
2. First and second derivatives; partial derivative
3. Mechanics of linear and circular motion; Newton's laws, conservation of energy and momentum
4. Electric and magnetic field concepts

Topics covered:
1. Free vibration, damped vibration, forced vibration
2. Applications of vibration to acoustical, mechanical, electrical and optical systems
3. Nonlinear vibration
4. Waves in non-dispersive media with applications to several fields of physics
5. Fourier analysis of wave motion
6. Dispersive effects and examples of dispersive waves in several fields of physics
7. Reflection and Refraction of waves with application to sound waves, electromagnetic waves, and matter waves
8. Far-field diffraction and interference of waves with applications to acoustics, optics, deBroglie waves and the wave nature of matter

Schedule: Two 120 minute class periods or four 60 minute class periods per week

Computer usage: Software for this course: Excel, Maple, Web browser with JAVA

Laboratory projects:
1. Interactive classroom demonstrations.

Relationship to professional component: Four credits of Basic Science

Prepared by: Dan Russell **Date:** 06 November 2006