

# GPGN404 Digital Signal Analysis

## Course Syllabus, Fall 2011

**Department, number, and title:** Geophysics, GPGN404,  
Digital Signal Analysis

**Credit and contact hours:** 3 credit hours, 3 contact hours,  
Monday, Wednesday, Friday at 10:00 AM

**Instructor:** Dave Hale, C.H. Green Professor of Exploration Geophysics,  
Green Center 240G, dhale@mines.edu

**Catalog description:** The fundamentals of 1-D digital signal processing as applied to geophysical investigations are studied. Students explore the mathematical background and practical consequences of the sampling theorem, convolution, deconvolution, the Z and Fourier transforms, windows, and filters. Emphasis is placed on applying the knowledge gained in lecture to exploring practical signal processing issues. This is done through homework and in-class practicum assignments requiring the programming and testing of algorithms discussed in lecture.

**Prerequisites:** MATH213, MATH225, and MATH348 (or PHGN311), or consent of instructor. In addition, knowledge of a computer programming language is assumed.

**Textbook and/or other required materials:** Discrete-Time Signal Processing, 3rd Edition, by A.V. Oppenheim and R.W. Schaffer

**Topics covered:**

- Discrete-time signals and systems
- Linear time-invariant (LTI) systems and difference equations
- Continuous- and discrete-frequency Fourier transforms
- Z-transforms and regions of convergence
- Sampling in time and periodicity in frequency
- Reconstructing and resampling bandlimited digital signals
- Frequency responses of LTI and rational systems
- Design of finite-impulse response (FIR) filters
- Design of infinite-impulse response (IIR) filters
- Applications of discrete Fourier transforms

**Course objectives:** This senior-level undergraduate course builds on analytical skills learned in previous years by application of those skills to the analysis of digital signals. One objective of this course is that students learn how to reconstruct continuous signals from sampled ones, and the conditions under which this reconstruction is feasible. Another goal is that students learn the pitfalls and tradeoffs in the design of digital filters. Yet another objective is that students become adept at using discrete Fourier transforms in the analysis and processing of digital signals. In all of these subjects, students should learn and exploit the many similarities between concepts learned in calculus, differential equations, and elsewhere, and those same concepts as they appear in the context of digital signal analysis.

To help meet these objectives, students will independently design, develop and test computer programs to solve digital signal processing tasks, while using and understanding industrial-strength programs for those same tasks. Students are encouraged to be creative in their design of software to enhance real digital signals. A typical question might be whether to apply a conventional linear shift-invariant filter, or to implement and apply a non-linear system for signal enhancement. Students answer questions such as this by further developing and applying both analytical and computational skills developed in prior courses.

**Contribution of the course to the professional component:** This course contributes three credit hours to engineering topics, with a significant component of design.

**Course goals and ABET outcomes:**

This course contributes specifically to a student's abilities to:

- (a) apply knowledge of mathematics, science and engineering;
- (b) design and conduct experiments, as well as analyze and interpret data;
- (c) design a system, component, or process to meet desired needs within realistic constraints;
- (e) identify, formulate and solve engineering problems; and
- (k) use modern computing tools for engineering practice.

**Person who prepared this description and date of preparation:**

Dave Hale, August 21, 2011.