Spring 2019

PHYS 114-002: Introduction to Data Reduction with Applications

Andrew J. Gerrard

New Jersey Institute of Technology- Spring 2019

PHYS 114 – INTRODUCTION TO DATA REDUCTION WITH APPLICATIONS (3-0-3)

Topics: An introduction to both the theory and application of error analysis and data reduction methodology. Topics include the binomial distribution and its simplification to Gaussian and Poisson probability distribution functions, estimation of moments, and propagation of uncertainty. Forward modeling, including least-squares fitting of linear and polynomial functions are discussed. The course enables students to apply the concepts of the data reduction and error analysis using data analysis software to real data sets found in the physical sciences.

Objectives: By the end of the course, students should
a) Be able to address the pros and cons of various methods of measurement
b) Be conversant with the data reduction and error analysis concepts mentioned above,
c) Be able to analyze 1D and 2D data sets to find computational estimates of PDFs, moments, and to address the appropriateness of various forward models,
d) Be familiar with various measurement techniques so as to best experimentally determine PDFs, moments, and the appropriateness of various forward models,
e) Be able to create figures that are journal-quality,
f) Be extremely familiar with the agreed upon software package so as to utilize it in subsequent classes and research endeavors.

Instructor: Andrew J. Gerrard, Ph.D., Professor
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Office Hours: TBD

Co-requisite: MATH 111

Course Materials: Bevington, P.R. and D. K. Robinson, *Data reduction and error analysis for the physical sciences, 3rd ed.*, McGraw-Hill, Boston, 2003.

Licensed use of MatLAB or ???

Course Requirements and Grading Policy:

Homework: 30%

Homework is given every week and is considered an important part of the class. The homework usually consists of reading the text, short answer questions, and numerous mathematical calculations; often requiring MATLAB. An assignment is given on the first lecture of the week [when theoretical material is covered] and may require measurements to be performed during that week either at the second lecture or outside of class. Students *are encouraged to work together* on the homework problems, though each student is responsible for handing in an *individual* homework set.

3 Exams (2 during the semester worth 15% each, and 1 final worth 30%): 60%

The purpose of the exams is to test the *individual* student's progress in the class. Exams are closed book/notes, but the student is allowed to bring in one 8.5x11 inch sheet of notes for each exam. Later exams can make use of previous note sheets (i.e., the note sheets are cumulative). Exams will be announced ahead of time.

Class participation 10%

Attendance at lecture is expected.

THE NJIT HONOR CODE WILL BE STRICTLY ENFORCED AND ANY VIOLATIONS WILL BE BROUGHT TO THE IMMEDIATE ATTENTION OF THE DEAN OF STUDENTS.

Week	Date	Topic
1	Jan 20	INTRODUCTION TO CLASS
2	Jan 27	Software Review of MatLAB: capabilities and use Review of MatLAB: programming environment APPLICATION: Write a basic MatLAB program
3	Feb 3	Undergraduate Research 101 Basic matrix/array operations for reading in data and graphical output APPLICATION: Write a basic MatLAB program to read in real data and make a plot
4	Feb 10	Uncertainties in Measurement: Chap 1 Parent distributions Sample mean + sample standard deviation Percent error, SNR, dB/dBi APPLICATION: Given a counting experiment [e.g., PMT] find various quantities
5	Feb 17	Probability Distribution Functions: Chap 2 Binomial Gaussian, Poisson, Other [Lorentzian, Cauchy, etc.] Moments, focusing on the first and second moments APPLICATION: Determine the PDF for 3-4 different random variables [temperature, PMT photon count from previous week, resonance scattering]
6	Feb 24	**EXAM 1**
7	Mar 3	Error Analysis: Chap 3 Statistical uncertainty Bias Propagation of Errors APPLICATION: Propagation of errors in a "complex" measurement: Measurements from a CCD
8	Mar 10	Estimators: Chap 4 Mean and variance APPLICATION: Expected photon counts from "The Lidar Equation"
9	Mar 17	**SPRING BREAK**
10	Mar 24	The Forward Model I: Chap 6-8 Linear forward model Least-squares fitting to a linear data set Polynomial forward model Least-squares fitting to a polynomial data set Generalized forward model Generalized Least-squares fitting
11	Mar 31	Testing the Fit II: Chap 11 [and some Chap 5] Correlation Analysis Chi-square Monte-Carlo methods
12	Apr 7	**EXAM 2**
13	Apr 14	Random Variables and Stochastic Processes
14	Apr 21	Introduction to DSP FT vs. DFTs vs. FFTs FTs of common functions
15	Apr 28	PSD estimation Filtering Concepts
16	May 5	**LAST DAY OF CLASS + REVIEW**