# Intermediate Lab PHYS 3870

# **CONVEYIMG INFORMATION**

# **Gathering Information** An Exercise in DataThief, Plotting and Curve Fitting

References: PHYS 3870 <u>Web Site</u> USU Library Class Web Site

DataThief Manual DataThief Web Site





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### Introduction to Scientific Computing PHYS 2500

# **An Exercise In Data Analysis**

Use DataThief to "steal" data from the graph in DennisonInFreefall.jpg and save the data in the file YOURNAMEInFreefall.txt:

### > In your favorite plotting and curve fitting program:

- Import the data from DennisonInFreefall.jpg stored in YOURNAMEInFreefall.txt
- Import the data from *FreefallLab.txt*
- Create a single graph of position vs time with:
  - Data points and error bars from FreefallLab.txt
  - Data points (the slacker has no error estimates here!) from DennisonInFreefall.jpg
  - · A mathematical model for free fall plotted as a line
  - · List your best estimates for values and errors for you model fitting parameters
- BONUS:
  - Lineraize your model, that is plot the dependant variable versus some function (e.g., square, square root) of the dependant variable such that the plot yields a straight line
  - Plot both data sets (with appropriate errors) and your linear model on a linearized graph
  - Do an automated fit with your linear model to the FreefallLab data. List your best estimates of the slope and intercept (with errors) and from these the best estimates (with errors) for you original model fitting parameters.



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### **Data for An Exercise In Data Analysis**

### Freefall.txt



time(s)	disp(m)	error(m)
0	-137.5	145.9
0.06667	-157.6	145.3
0.1333	81.61	152.4
0.2	62.14	151.9
0.2667	30.93	150.9
0.3333	81.17	152.4
0.4	-12.04	149.6
0.4667	258.4	157.8
0.5333	334.6	160
0.6	398.2	161.9
0.6667	218.3	156.5
0.7333	202.9	156.1
0.8	524.1	165.7
0.8667	516.4	165.5
0.9333	368.3	161
1	672	170.2
1.067	527.9	165.8
1.133	656.7	169.7
1.2	1018	180.5
1.267	1004	180.1
1.333	1029	180.9
1.4	1128	183.8
1.467	1234	187
1.533	1412	192.4
1.6	1489	194.7
1.667	1364	190.9
1.733	1521	195.6
1.8	1949	208.5
1.867	2031	210.9
1.933	2016	210.5
2	2222	216.6

### DennisonInFreefall.jpg



displacement (cm)

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### **Results for An Exercise In Data Analysis**



Model is  $y(t)=(1/2)at^2 + v_ot + y_o$ 



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# **CONVEYIMG INFORMATION**

## **Analyzing and Plotting Data with Mathcad**

References: PHYS 3870 <u>Web Site</u> USU <u>Library Class Web Site</u>





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### PHYS 2500 Introduction to Scientific Computing Mathcad Tutorials





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# **PHYS 2500 Introduction to Scientific Computing**

### **Mathcad Tutorials**

Chapter Summaries	Table of Contents         Preface to the First Edition         Preface to the Second Edition         Preface to the Third Edition         About the Authors         Installation of the Handbook Files         Software Used in the Handbook         1. INTRODUCTION TO SCIENTIFIC COMPUTING         1.0 Overview of Software for Scientific Computing         1.1 Mathcad Survival Skills         1.2 Mathcad Worksheet Management	<ul> <li>i. ARRAYS AND 3D GRAPHING</li> <li>ch. 6</li> <li>i. Tutorial</li> <li>6.2 Exercises</li> <li>6.3 Problems</li> <li>6.4 Additional Matrix Operations</li> <li>6.5 Vector Field and Contour Plots</li> <li>Evaluation Form</li> <li>v. SYMBOLIC PROCESSING AND NUMERICAL ANALYSIS</li> <li>ch. 7</li> <li>ch. 7</li> <li>ch. 7</li> </ul>	<ul> <li>PSTONE MATHCAD PROJECT</li> <li>10.1 Capstone Project-Observation of Planets in Our Galaxy</li> <li>10.1.1 Relevant Equations</li> <li>10.1.2 Most Recent Information on Exoplanets</li> <li>10.2 Resources for Scientific Reports</li> <li>10.2.1 Searching Bibliographic Databases-Google Schola</li> <li>10.2.2 Organizing Bibliographic Materials-EndNote Web</li> <li>10.2.3 Data Acquisiton for References-DataThief</li> <li>Evaluation Form</li> <li>Course Evaluation Form</li> </ul>
Ch. 2	2. MATHCAD BASICS 2.1 Tutorial 2.2 Exercises 2.3 Problems Evaluation Form	7.2 Exercises         7.3 Problems         7.4 Exercise: Working with Complex Numbers         7.5 Exercise: Finding Eigenvalues and Eigenfunctions         Evaluation Form	<ul> <li>FA ACQUISITION AND ANALYSIS</li> <li>11.1 Introduction to Data Acquisition and Analysis Exercises</li> <li>Data Acquisition with Data Studio</li> <li>11.2 Data Studio Multimedia Tutorial</li> <li>11.3 Data Studio Analog Interface Tutorial</li> <li>11.4 Data Studio Digital Interface Tutorial</li> </ul>
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### **Analyzing and Plotting Data with Excel**

References: PHYS 3870 <u>Web Site</u> USU <u>Library Class Web Site</u>





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### **Instructions for an Excel Tutorial Exercise**

#### Instruction for Data Analysis with EXCEL

#### **Overview of Excel Spreadsheets**

We begin by reviewing some basic concepts for spreadsheet programs, starting from the full program and gradually zooming in to the details. But first, open the Excel *Workbook* file named "*Excel Data Analysis*" and save your *Workbook* with a new name by selecting **File>Save As** from the Menu Bar and giving the file the name "*Your\_Last\_Name-Excel Data Analysis*".





Follow the

detailed (if

instructions

to create an

worksheet to

plot a sample

data set and

prepare a

simple

report.

analyze and

boring)

Excel

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### **Report from an Excel Tutorial Exercise**

#### PHYS 2500 EXCEL DATA ANALYSIS PROJECT REPORT

Name: Enter name here Date: Enter current date here

Experiment Description

Add a paragraph describing the experiment performed.

Follow the detailed (if boring) instructions to create an Excel worksheet to analyze and plot a sample data set and prepare a simple report.







Excel File for 2500 Ch 11-JR.xls

Project Report

1 11/23/2009



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# **CONVEYIMG INFORMATION**

### **Analyzing and Plotting Data with IGOR Pro**

References: PHYS 3870 <u>Web Site</u> USU <u>Library Class Web Site</u>

IGOR Pro https://www.wavemetrics.com





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### **IGOR Pro Overview**

IGOR Pro 6 is an extraordinarily powerful and extensible scientific graphing, data analysis, image processing and programming software tool for scientists and engineers. It combines both a graphical interface for quick plotting and a command line interface that can be easily used to create script macros for repeated analysis of similar data. The outputs are extremely versatile and of the highest publication quality.



WaveMetrics, Inc

Refer to <u>https://www.wavemetrics.com/products/igorpro/Igor6Brochure.pdf</u> for a summary of the capabilities of IGORPro.

Additional information is available at https://www.wavemetrics.com/ .



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**IGOR** Pro

#### Technical Computing for Scientists and Engineers

WaveMetrics, Inc

### **Program Installation**

The USU Physics Department has a department Coursework License site IGOR Pro 6.3

The special coursework license is intended to facilitate the use of Igor as a teaching tool and to introduce students to Igor under the following conditions:

• The software may be used only by students and only for assigned coursework. It may not be used for research.

• All technical support must go through a single individual who is usually the instructor/ registered licensee.

• The license covers both Macintosh and Windows operating systems.

• Igor Pro can be installed on multiple computers. All that is required is that you make a good-faith effort to ensure that the license is used for coursework only. The terms of the license require that if they want to use Igor for research, they can purchase a student or academic license.

• WaveMetrics offers an inexpensive student personal purchase copy of IGOR Pro which students can purchase with their own personal funds for their own personal work when their use of IGOR extends beyond assigned coursework.

To install the software, please visit the Wavemetrics web page to download the latest version of IGOR Pro 6.3 at <a href="https://www.wavemetrics.com/order/order\_igordownloads.htm">https://www.wavemetrics.com/order/order\_igordownloads.htm</a> The activation information for our IGOR Pro license is available from the USU Physics Department.



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**IGOR** Pro



https://www.wavemetrics.com/

This is an excellent resource!

shown at right.

### **WaveMetrics**

Home

Technical graphing and data analysis software

Search

... for scientists and engineers

Additional information is available at the Wavemetrics web site



User Resources

Products



Order

News

Support



IGOR Pro 6.3 New Features

> IGOR Pro 6 Brochure (PDF, 4.4MB)

#### Product Updates

The latest release of IGOR Pro is version 6.37.

The latest release of the Japanese version of IGOR Pro is 6.36J.

The latest release of the XOP Toolkit is version 6.30.

IGOR NIDAQ Tools MX 1.05 now available.

The latest release of <u>IFDL</u> is version 4.02.

Contact WaveMetrics

Job Opportunities

<u>Site map</u> Gallery

News

IGOR Pro 6.36 released.



IGOR Pro 6 is an extraordinarily powerful and extensible scientific graphing, data analysis, image processing and programming software tool for scientists and engineers.

#### See Details Try Now



- Macintosh and Windows Platforms
- Journal-quality scientific graphs
- 3D and volume visualization
- Flexible image display
- · Handles large data sets very quickly
- · Extensive scientific and engineering data analysis
- Curve fitting, peak fitting

٠

- Signal processing
- Image processing and image analysis
- Special support for evenly spaced data

 Completely programmable and customizable
 The IGOR scientific graphing and data analysis program has been in active development since its introduction on Macintosh in 1988. IGOR XOP Toolkit Allows a C programmer to extend IGOR Pro. Ac

extend IGOR Pro. Add operations, functions, menus, dialogs, and windows for data analysis, data acquisition or other purposes.

IGOR NIDAQ Tools MX

Acquire data directly into IGOR Pro. Supports data acquisition devices made by National Instruments.

#### IGOR Filter Design Laboratory

Design FIR (Finite Impulse Response) and IIR (Infinite Impulse Response) filters and to apply them to your data.

Home Products User Resources Support Order News Search



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#### WRITING REPORTS

Lecture 6 Slide 14

inities

### **IGOR Pro Tutorials**

IGOR Pro offers excellent tutorials accessed through the *Help* menu of the program under *Getting Started*.

### For PHYS 2500 the recommended tutorials include:

- Introduction to IGOR Pro
- Guided Tour 1: General Tour (up to Offsetting a Trace)
- Guided Tour 2: Data Analysis

The same material in the written tutorials is available in video (YouTube) format at the Wavemetrics web site <u>https://www.wavemetrics.com/</u>.

There is an extensive manual available in PDF format accessible from the IGOR Pro Help menu.

### This same menu offers:

- A Help Browser
- Explanation of shortcut key strokes
- Command help
- Example files
- Access to excellent User Group
- Wavemetric support (they actually respond to your queries!)



#### Program Information and Tutorials

Wavemetrics provides exceptionally good help files and tutorials for use of IGORPro. Begin by selecting "Help" from the IGORPro menu and then the "Getting Started" tab (see below). The tutorials accessed at the start of this document are a great next step.

å Igar Pro 6.37 - Special Coursework License	
File Edit Data Analysis Macros Windows Misc Help	
🕼 Getting Started.ihf 🔸 📃 💷	
Getting Started This help file contains overview and guided tour material and constitutes an essential introduction to log The main sections are:	<u></u>
Introduction to Igor Pre	Help
Cuided Tour 1 - General Tour     Guided Tour 2 - Data Analysis     Try these tutorials next.	Getting Started
<u>Guided Tour 3 - Histograms and Curve Fitting</u> We strongly recommend that you read at least the first two sections.	Help Topics
The material in this help file is duplicated in Volume I of the Igor Pro PDF manual which is accessible through the Help menu.	Command Help Search long Files
<ul> <li>Introduction to Igor Pro Igor is an integrated program for visualizing, analyzing, transforming and presenting experimental data.</li> </ul>	Manual Support
Igor's features include:	Show Igor Pro Folder
High-speed data display	Show Igor Pro User Files
Ability to handle large data sets	WaveMetrics Home Page
Curve-nung, Fourier dansioning, sincouning, statistics and other data analysis     Waveform anthmetic	Igorfichange
Image display and processing     Combination practical and command-line user interface	License
Automation and data processing via a built-in programming environment	About Coursework License
Extensibility through modules written in the C and C++ languages	About Igor Pro
Some people use Igor simply to produce high-quality, finely-tuned scientific graphics. Others use Igor as an all-purpose workhorse to acquire, analyze and present experimental data using its built-in programming environment. We have tried to write the Igor program and this manual to fulfill the needs of the entire range of Igor users.	Updates for Igor 6.3.7.2

The IGORPro manuals and the Wavemetrics website <u>http://www.wavemetrics.com/</u> provide detailed information beyond this (see below)



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### **IGOR Pro Tutorials**

#### IGOR Pro offers excellent tutorials accessed through the Wavemetrics web site at

https://www.wavemetrics.com/.

# For PHYS 2500 the recommended video (YouTube) tutorials include:

• Introduction to IGOR Pro (Part of the General Tour) (~13 min)

• Guided Tour 1: General Tour (Through Video 2.1 and Video 3.0 (~30 min)

Guided Tour 2: Data Analysis (~15 min)

#### **Video Tutorials**

#### Igor Pro Guided Tour

The Igor Pro Guided Tour is available in booklet form, as an Igor help file, in the <u>Igor Pro PDF manual</u>, and in the videos listed on this page.

To go through the tour by yourself, choose *Help -> Getting Started* in Igor or choose *Help -> Manual* to open the PDF manual.

To take the video tour, click the links below.

#### Guided Tour 1 - General Tour



#### Guided Tour 2 - Data Analysis





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### IGOR Pro Manual

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# IGOR Pro

### Version 6.37 WaveMetrics, Inc.

Manual Revision: June 2, 2015 (6.37)

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#### http://www.wavemetrics.net/doc/igorman/lgorMan.pdf

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#### **Technical Computing for Scientists and Engineers**

### IGOR Pro

- Runs on Mac OS X and Windows
- Fast Display of Large Data Sets
- Interactive Data Exploration
- Journal–Quality Graphics
- Powerful Curve Fitting
- Extensive Data Analysis & Statistics
- Image Processing
- Data Acquisition Support
- Built-In Programming Environment Supports Analysis and Automation
- Customizable User Interface
- Used by Scientists and Engineers Worldwide Since 1989

WaveMetrics, Inc. P.O. Box 2088 Lake Oswego, OR 97035 USA

Phone: 503 620 3001 Fax: 503.620.6754 sales@wavemetrics.com www.wavemetrics.com

#### Presentation Layouts

Notebooks

Export

tables and graphs.

· Print at high resolution.

BMP and PNG formats

Analysis & Statistics

Fast Gauss Transforms.

level detection.

mials.

functions

ness.

· Use page layouts to precisely arrange

graphs, tables, pictures, annotations, and

drawing elements for printing or export.

· IGOR Pronotebooks provide a built-in,

programmable word-processor; use them

to record experiment results using text,

· Export high-resolution graphics in EPS,

PDF, enhanced metafile, TIFF, PICT,

· Single and multidimensional mixed-radix

FFTs, continuous and discrete wavelet

Smoothing (binomial, Savitzky-Go-

lay, box, median, Loess), integration,

differentiation, IIR and FIR filtering,

convolution, ordinary differential equa-

tions, histograms, sorting, area, mean,

array arithmetic, windowing, peak and

· Full suite of matrix operations using

· Find function roots or extrema using

direct methods or simulated annealing.

· Probability distribution functions, cumu-

· Statistical analysis including moments,

· Statistical tests including ANOVA,

· Statistical multi-comparison tests.

Scheffe, t, and Tukey.

Bera, Kolmogorov-Smirnov, Levin,

· Non-parametric hypothesis tests includ-

· Random number generators for various

Wallis, Spearman and Wilcoxon's.

· Statistical analysis for angular data.

· Cluster analysis with K-means and

farthest-point algorithms.

ing Friedman, Mann-Kendal, Kruskal-

Special functions and orthogonal polyno-

lative and inverse cumulative distribution

quantiles, correlations and serial random-

standard LAPACK routines.

transforms, Hilbert, Hough, Wigner and

- · Built-in graph types include highly customizable X-Y plots, contour, image,
- category, waterfall plots. Create interactive 3D visualization graphics. · Choose from 62 built-in marker symbols,

Graphing

- text markers (either a character or from other data), arrow markers, error bars, 17 dashed line types; customizable dashes. Specify marker color, marker size, or
- marker type as functions of other data. 72 fill patterns, positive and negative fills, fill between curves
- · Interactively zoom and pan. Use cursors to inspect data values. · Text annotations, legends, and color scale bars. Use subscripts, superscripts, mixed
- fonts and styles. · High resolution drawing tools.
- · Fully customizable and unlimited numbers of axes. Date and time axes in a wide
- variety of formats. Image Plots · Image plots from matrix and XYZ data.
- · Display images using 58 built-in color tables. Create indexed or custom color tables. Limit colors to a range of data.
- · Fully customizable color scale bars. Contour Plots · Automatic and user-defined, arbitrary
- contour levels. · Color contours according to level, indexed from data, or all the same.
- · Control contour label style, appearance, and position. 3D Visualization
- · Create surface, 3D path, and ribbon plots, 3D scatter and object plots, iso-surface
- voxelgrams and volume slices. · Use the power of OpenGL to add transparencies and textures.

#### **Curve Fitting**

- Fit data using built-in and arbitrarily complex user-defined functions with unlimited independent variables and fit parameters; fit to arbitrary subsets; hold coefficients, using multiple threads.
- · Levenberg-Marquardt method for nonlin-
- · Orthogonal distance regression, errors in X, global analysis.
- · Built-in fits: linear, polynomial (1D & 2D), exponential, double exponential, power

#### lognormal, Hill equation, sigmoid.

· Outputs include parameter values, standard deviation and confidence intervals; model curves: residuals; confidence

- · Operations for image arithmetic, arbitrary non-contiguous region of interest (ROI) masking, background removal, color segmentation, windowing (Hanning, Hamming, Bartlett, Blackman, Kaiser), blending, histograms, equalization, stack focus, registration, rotation, statistics, · Particle analysis: number, area, perimeter,
- circularity, rectangularity, location, raw moments
- · Image morphology: binary and grayscale erosion, dilation, close, open, watershed, tophat, seed fill
- · Edge detection using canny, Frei, Kirsch, Marr, Prewitt, Roberts, Shen, and Sobel methods
- Image transformations include FFT Hartley, Hough, convolution filters (gauss, gradients, median, sharpen, thin, min rank, max rank) color space conversions (RGB, HSL, XYZ), derivatives, correlations, extract and manipulate image data.
- · Image import and export using Quick-Time technology: JPEG, PNG, PICT, TIFF, BMP, QuickTime, Targa, Silicon Graphics, PhotoShop,
- Capture images from live video.

#### Data Formats/Import/Export

- · Millions of data points; 1-4 dimensions. · Two floating-point and six integer formats, strings, date and time data.
- · Special support for waveform (equallyspaced) data.
- · Handle files in general binary, delimited text, Excel, Fortran fixed-field, FITS, HDF5, JCAMP, MatLab, Nicolet, TDM, JPEG, PICT, TIFF, BMP, Targa, Photoshop, SGI, Sun Raster, DEM, SDTS (and other GIS) data formats, multi-channel MP3, AIFF, and WAVE sound files.
- Access SQL databases through ODBC.
- Bartlet, Cochran, Chi-squared, F, Jarque-· Create and control QuickTime movies.
  - Data Browser organize data into a meaningful hierarchy, graphical previews of data, view and edit wave and variable properties.
  - Write your own procedures to import/export custom file formats, or move, copy, and delete files and folders.
  - Extract data using regular expressions ("grep").

#### **Data Acavisition**

- · Acquire data from instruments through the serial port or through National Instruments GPIB boards. Use the optional NIDAQ Tools to acquire data directly from National Instruments boards.
  - Acquire data using VISA through GPIB, serial port, TCP/IP, and other VISA-capable hardware.

Create custom instrument user interfaces and automate data collection, retrieval, and analysis.

#### Programmability

- · A full-featured structured programming language to control virtually all aspects of IGOR Pro with over 965 built-in functions and operations
- · Automate data analysis and acquisition tasks.
- · Multi-processor and threading support for built-in and user-defined routines.
- Symbolic debugger
- · Create custom interfaces using control panels with buttons, popup menus, lists, sliders, inputs, outputs. Add your own menus, completely or selectively replace Igor's built-in menus
- · Scriptable via AppleEvents, ActiveX Automation, and DDE.

#### Documentation

· Complete IGOR Pro manual online in fully-searchable, cross-referenced PDF format.

#### **Optional Packages** GOR XOP Toolkit

#### Enhance IGOR Pro's capabilities with

external code modules by combining your own C or C++ code with the IGOR XOP Toolkit's source files. Create portable XOP modules for yourself and others to add customized functions, data loaders, data acquisition systems, etc., with their own menus, dialogs, and windows.

#### GOR NIDAQ Tools MX

Acquire data directly into IGOR Pro using National Instruments "multifunction" data acquisition boards.

#### IGOR Filter Design Lab

- Design, apply, and evaluate Finite and Infinite Impulse Response (FIR and IIR) filters in IGOR Pro.
- FIR Filters include Kaiser's Maximum Flatness design, McClellan-Parks-Rabiner equiripple method, window method design (Hanning, Kaiser, Parzen, Welch, etc.).
- IIR Filters include Bessel, Butterworth,
- Chebyshev and Notch-only.
- View magnitude, phase, group delay,
- impulse, and step responses.
- Apply designed filters to your data and view the results

For more information visit our web site at www.wavemetrics.com

#### See Igor6Brochure.pdf at https://www.wavemetrics.com/products/igorpro/Igor6Brochure.pdf



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#### Lecture 6 Slide 18

· Apply weighting and linear constraints.

- ear fitting
- law, sine, gaussian (1D & 2D), lorentzian,

- bands; covariance matrix; chi-square.

#### Computational geometry including 2D

#### and 3D triangulation and interpolation.

#### **Image Analysis**

distributions

· Full suite of tools for image filtering, manipulation, and quantification. · Image thresholding: iterated, bimodal, adaptive, fuzzy entropy, and fuzzy means.

# IGOR Pro -

Technical Computing for Scientists and Engineers

WaveMetrics, Inc.



See Igor6Brochure.pdf at https://www.wavemetrics.com/products/igorpro/Igor6Brochure.pdf



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#### WRITING REPORTS

### **Example of Publication Quality Graphs with IGOR Pro**







(c) (b) (a)

Dispersion surfaces of a rectangular lattice 2D photonic crystal. (a) first band, (b) second band, (c) third band.

Results from a recovered pop-up satellite archival tag attached to a 6 m male whale shark (Rhincodon typus) off the Yucatan Peninsula, Mexico. Ambient temperature and depth data recorded by the tag are shown for the entire 31-day track (top). The fast Fourier transform-generated periodogram from an analysis of these same fine-scale depth data are also demonstrated (bottom). The high amplitude peak at 1 cycle per day is indicative of a significant diel rhythm in the vertical movements of this shark.

#### More examples at

https://www.wavemetri cs.com/products/igorpr o/gallery/user.htm



#### Comparison of two case studies 4 17:15 17/01/02 to 15:15 18/01/02 3 2 (µ 8 m <sup>3</sup>) dM/dlogD<sub>va</sub> 04:09 23/01/02 to 07:31 24/01/02 4 3 Nitrate Sulphate 2 Organics 0 4 5 6 7 8 ' 1000 3 4 5 6 7 8 ź 100 10 Vacuum Aerodynamic Diameter (nm)

Comparison of two case studies from size and chemically-resolved atmospheric particle mass concentrations measured in Manchester, UK using an Aerodyne Aerosol Mass Spectrometer.

J Geophys Res-Atmos 108 (D3) 4090 & 4091 (2003) doi:10.1029/2002JD002358 & 10.1029/2002JD002359



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#### WRITING REPORTS

#### Lecture 6 Slide 20

Fall 2015

# Introduction to Scientific Computing PHYS 3870

# An Exercise in Analyzing and Plotting Data with IGOR Pro

References: PHYS 3870 <u>Web Site</u> USU <u>Library Class Web Site</u>

IGOR Pro https://www.wavemetrics.com





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### Introduction to Scientific Computing PHYS 2500

# An Exercise In Data Analysis Using *IGOR Pro*

### In the IGOR Pro plotting and curve fitting program:

- Import the data derived from the *DataThief* exercise from *DennisonInFreefall.jpg* stored in *YOURNAMEInFreefall.txt*.
- Import the data from *FreefallLab.txt*
- Do an automated fit with a quadratic model to the FreefallLab data.
- Create a single graph of position vs time with:
  - Data points and error bars from *FreefallLab.txt*
  - Data points from DennisonInFreefall.jpg
  - A mathematical model for free fall plotted as a line
  - List your best estimates for values and errors for you model fitting parameters
- Create an *IGOR Pro* layout displaying the graph, data table and annotations exactly as shown on the next page. Print the layout page as a pdf file.
- Save the IGOR Pro experiment.
- Submit the *IGOR Pro* experiment file (LastnameFI\_IGOR.pxp) and the layout page printout (LastnameFI\_IGOR.ppt).



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### Data for An Exercise In Data Analysis Using IGOR Pro

### Freefall.txt



time(s)	disp(m)	error(m)
0	-137.5	145.9
0.06667	-157.6	145.3
0.1333	81.61	152.4
0.2	62.14	151.9
0.2667	30.93	150.9
0.3333	81.17	152.4
0.4	-12.04	149.6
0.4667	258.4	157.8
0.5333	334.6	160
0.6	398.2	161.9
0.6667	218.3	156.5
0.7333	202.9	156.1
0.8	524.1	165.7
0.8667	516.4	165.5
0.9333	368.3	161
1	672	170.2
1.067	527.9	165.8
1.133	656.7	169.7
1.2	1018	180.5
1.267	1004	180.1
1.333	1029	180.9
1.4	1128	183.8
1.467	1234	187
1.533	1412	192.4
1.6	1489	194.7
1.667	1364	190.9
1.733	1521	195.6
1.8	1949	208.5
1.867	2031	210.9
1.933	2016	210.5
2	2222	216.6





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JR Dennison PHYS 2500 10/2/2015

### Results for An Exercise In Data Analysis Using IGOR Pro



IGOR Pro Exercise

Point	time_s_	disp_m_	error_m_	Time2	Distance2
0	0	-137.5	145.9	0.00329	-148.5
1	0.06667	-157.6	145.3	0.1998	-114.2
2	0.1333	81.61	152.4	0.3926	65.95
3	0.2	62.14	151.9	0.5945	182.5
4	0.2667	30.93	150.9	0.798	534.7
5	0.3333	81.17	152.4	1.0018	531.7
6	0.4	-12.04	149.6	1.1945	812.8
7	0.4667	258.4	157.8	1.3948	634.1
8	0.5333	334.6	160	1.5965	934.0
9	0.6	398.2	161.9	1.7913	987.
10	0.6667	218.3	156.5	1.9895	1137.
11	0.7333	202.9	156.1		
12	0.8	524.1	165.7		
13	0.8667	516.4	165.5		
14	0.9333	368.3	161		

### Model is $y(t)=at^2 + v_ot + x_o$

![](_page_23_Picture_5.jpeg)

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