Intermediate Lab

PHYS 3870

CONVEYIMG INFORMATION

Gathering Information

An Exercise in DataThief, Plotting and Curve Fitting

References:

PHYS 3870 Web Site

USU Library Class Web Site

DataThief Manual

DataThief Web Site

Introduction to Scientific Computing

PHYS 2500

An Exercise In Data Analysis

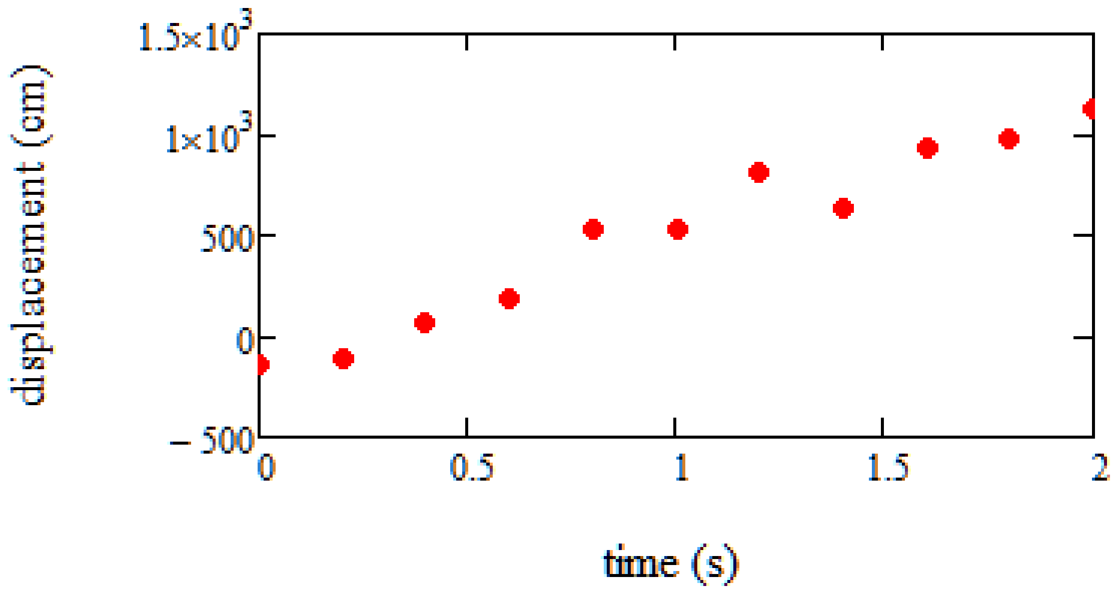
➢ **Use *DataThief* to "steal" data from the graph in *DennisonInFreefall.jpg* and save the data in the file *YOURNAMEInFreefall.txt*:**

➢ **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.

Data for An Exercise In Data Analysis

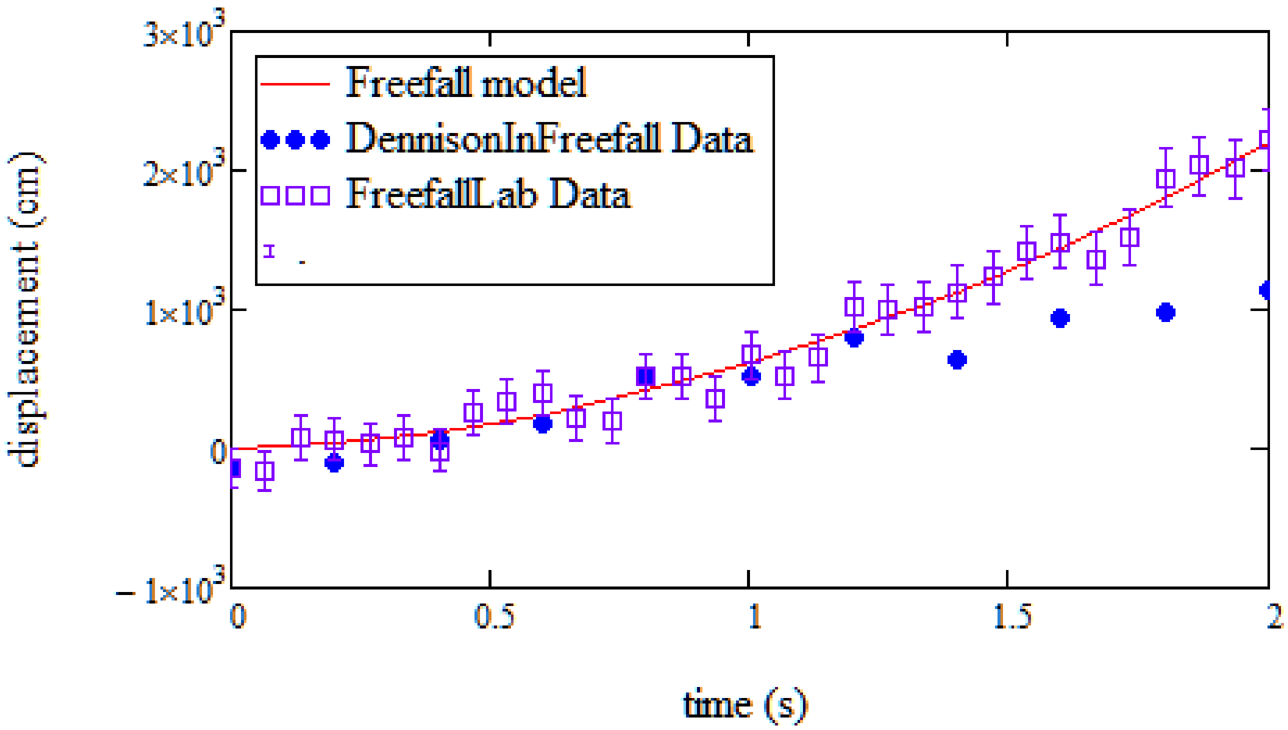
DennisonInFreefall.jpg



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

Results for An Exercise In Data Analysis



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

Intermediate Lab

PHYS 3870

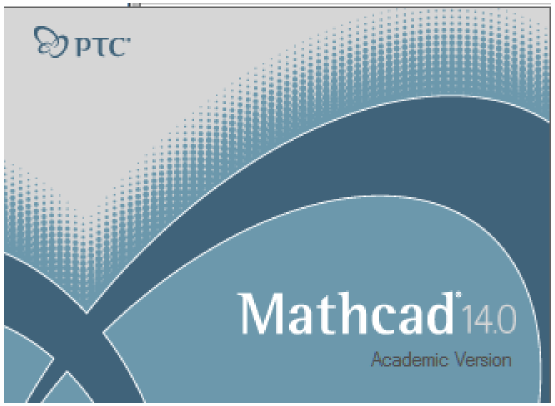
CONVEYIMG INFORMATION

Analyzing and Plotting Data with Mathcad

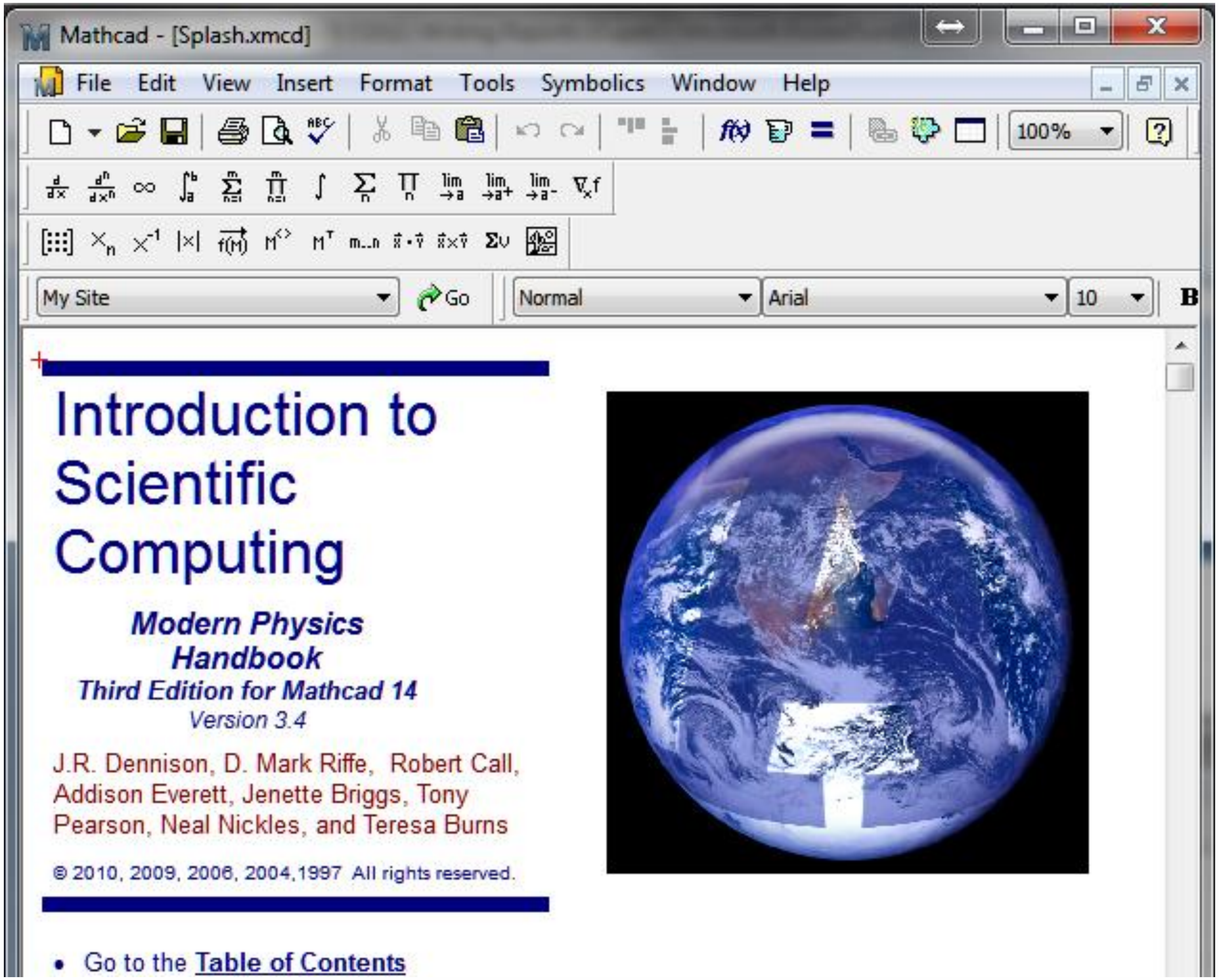
References:

PHYS 3870 Web Site

USU Library Class Web Site



PHYS 2500 Introduction to Scientific Computing Mathcad Tutorials



PHYS 2500 Introduction to Scientific Computing Mathcad Tutorials

Intermediate Lab

PHYS 3870

CONVEYIMG INFORMATION

Analyzing and Plotting Data with Excel

References:

PHYS 3870 Web Site

USU Library Class Web Site

Instructions for an Excel Tutorial Exercise

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

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*".

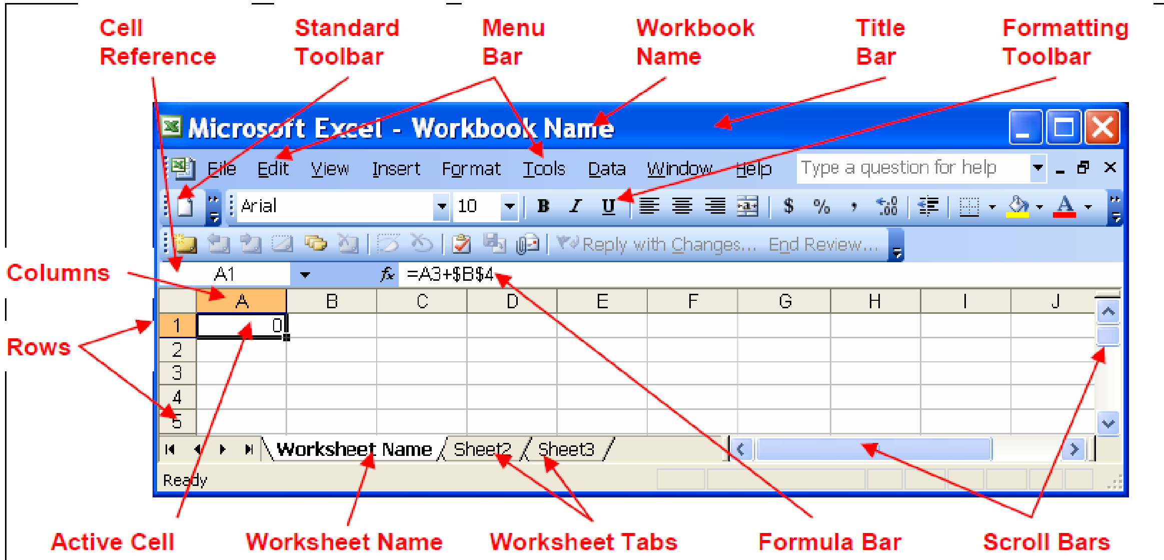


Figure 1 shows a screen shot of an Excel *Workbook* file and identifies the key components.

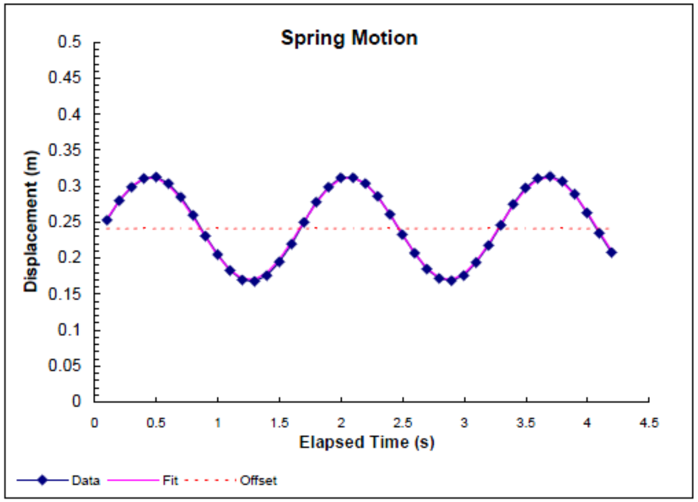
Report from an Excel Tutorial Exercise

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

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.



Summary of Results
Add a paragraph describing the results of your experiment.

Summary of Fit
###

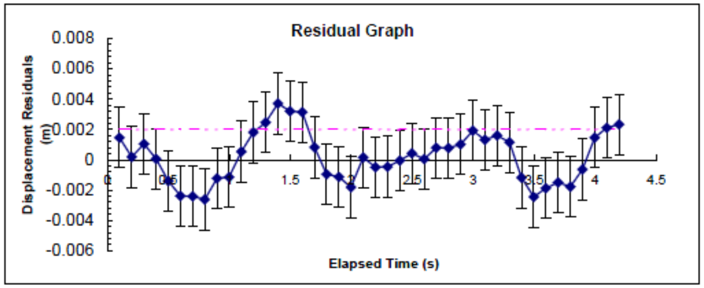
Fitting Function
y(t)=A*sin(w*t+θ)+yo

Fitting Parameters

Parameter	Symbol	Value	Units
Amplitude	A	0.0715	m
Angular frequency	w	3.9026	Hz
Phase	θ	-0.21	
Offset	yo	0.2412	m

Goodness of Fit

Number of Data Points	41
Number of Fitting Parameters	4
Degrees of Freedom	37
Chi Squared Value for Fit	29.24653
Reduced Chi Squared Value	0.790447



Excel File for 2500 Ch 11-JR.xls   Project Report   1   11/23/2009

Intermediate Lab

PHYS 3870

CONVEYIMG INFORMATION

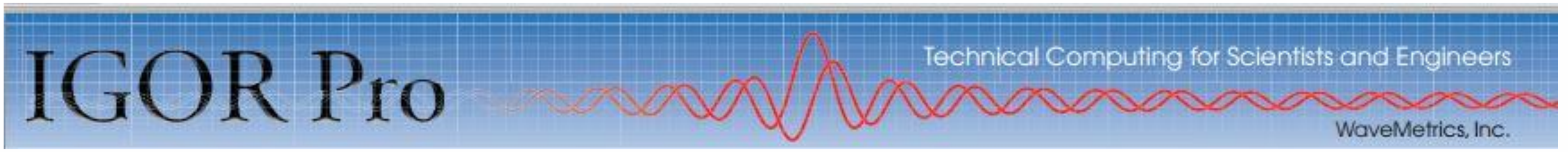
Analyzing and Plotting Data with IGOR Pro

References:

PHYS 3870 Web Site

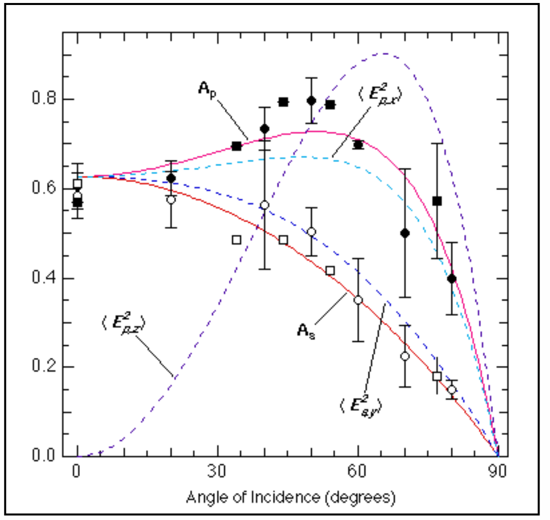
USU Library Class Web Site

IGOR Pro https://www.wavemetrics.com



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.



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

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

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:

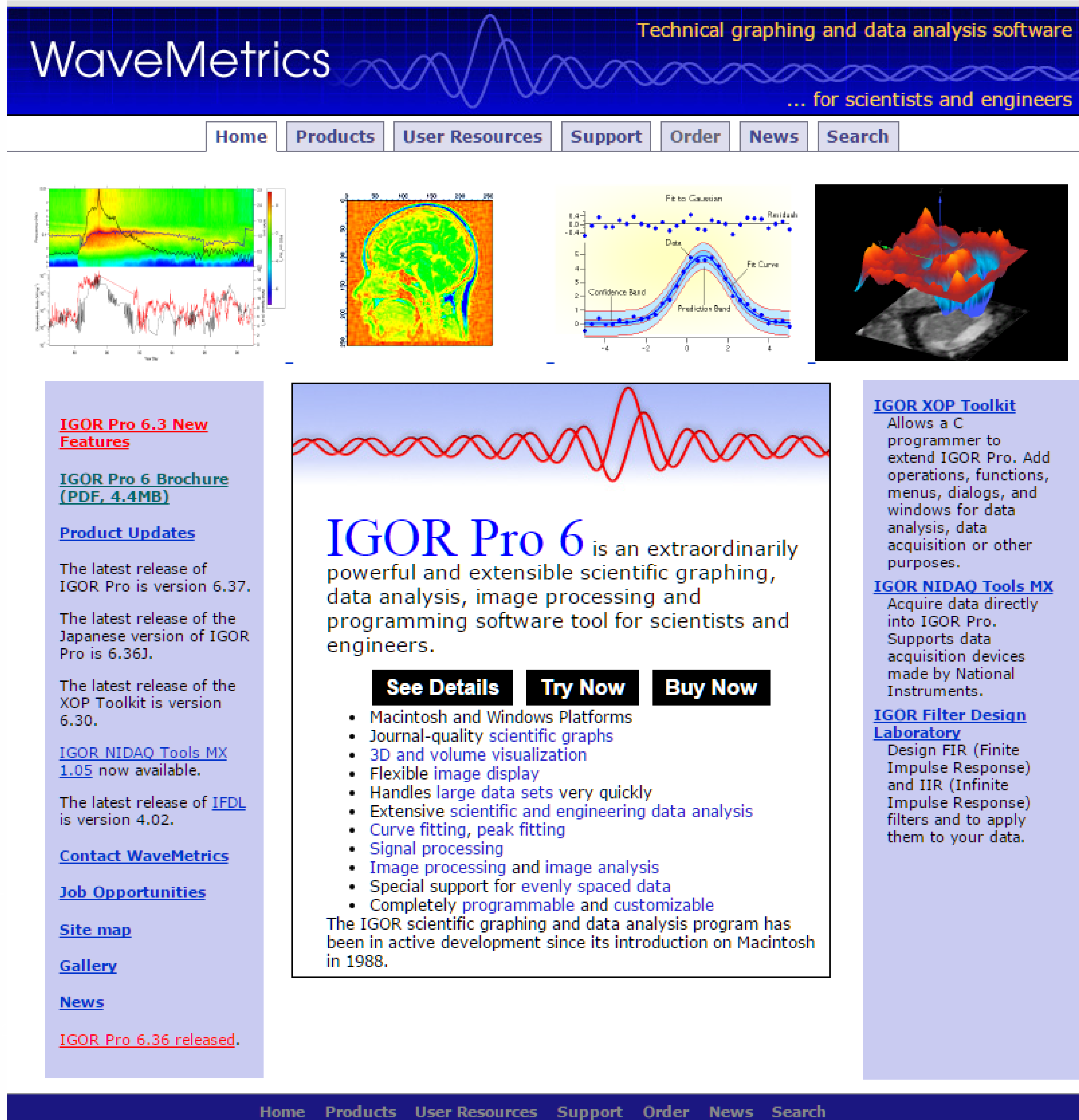
- **The software may be used only by students and only for assigned coursework. It may not be used for research.**
- **All technical support must go through a single individual who is usually the instructor/ registered licensee.**
- **The license covers both Macintosh and Windows operating systems.**
- **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 https://www.wavemetrics.com/order/order_igordownloads.htm
The activation information for our IGOR Pro license is available from the USU Physics Department.

IGOR Pro Web Site

Additional information is available at the Wavemetrics web site https://www.wavemetrics.com/ shown at right.

This is an excellent resource!



IGOR Pro Tutorials

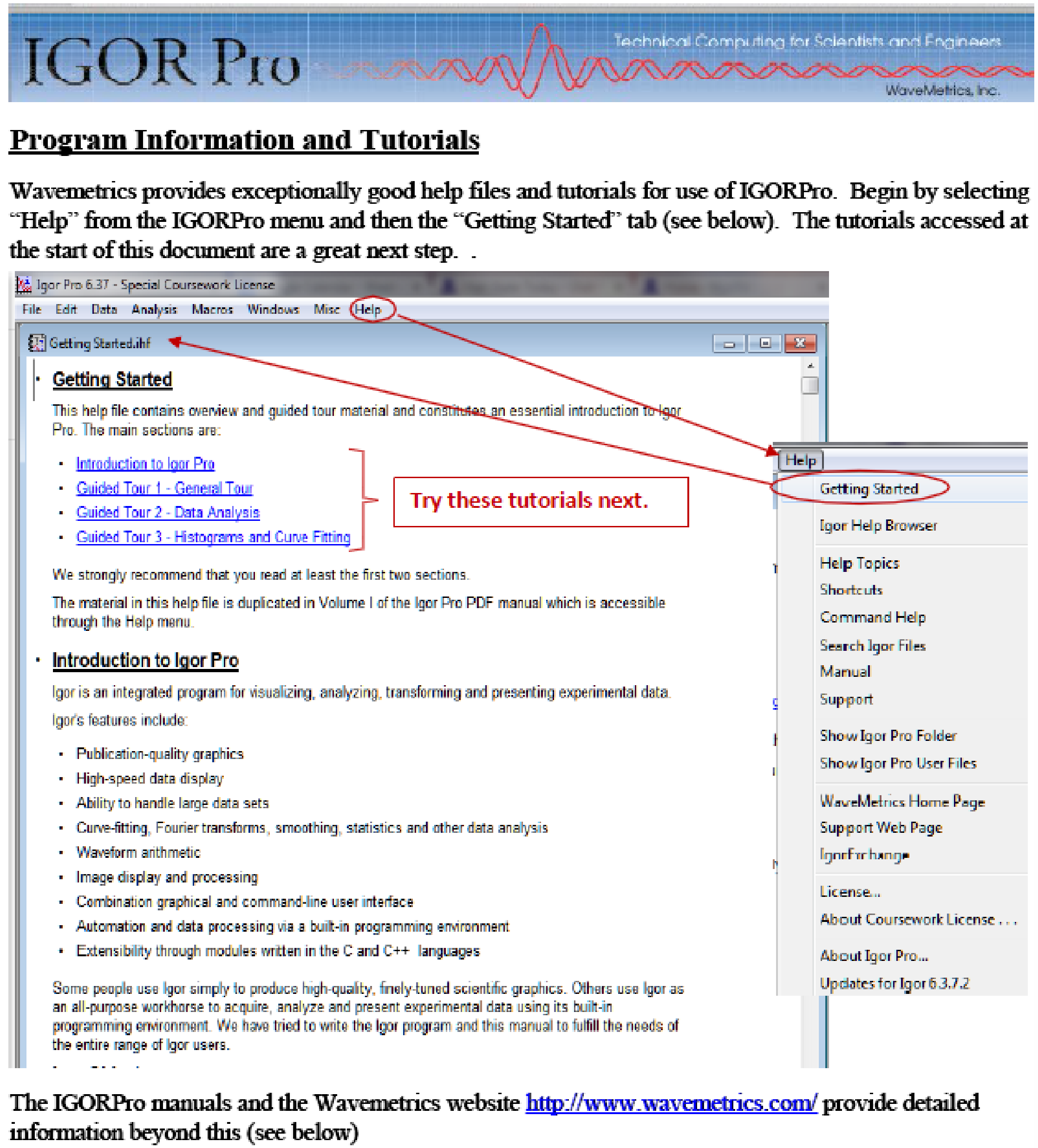
IGOR Pro offers excellent tutorials accessed through the *Help* menu of the program under *Getting Started*.

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 https://www.wavemetrics.com/.

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!)**


IGOR Pro

Technical Computing for Scientists and Engineers

WaveMetrics, Inc.

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. .

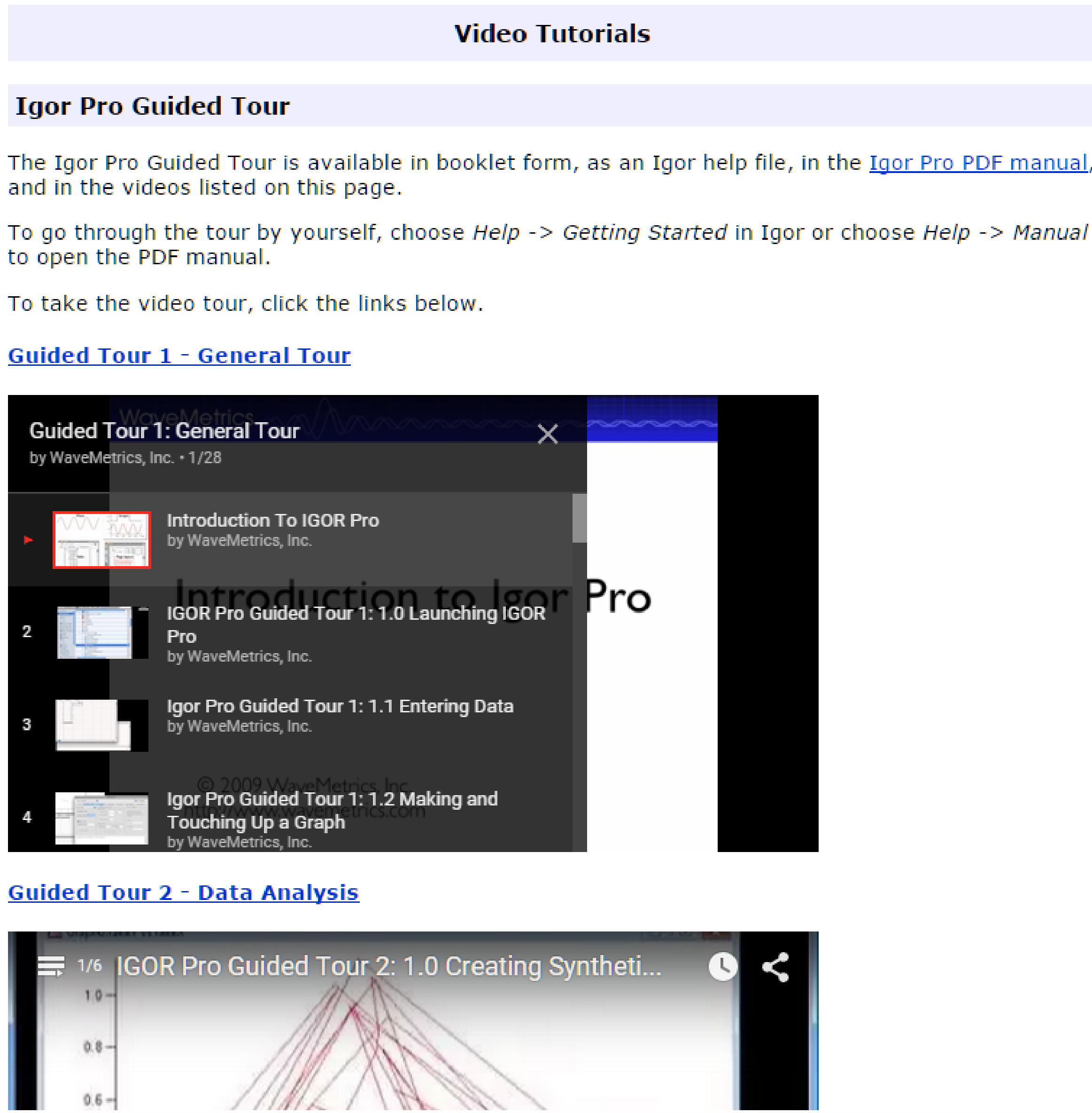
The IGORPro manuals and the Wavemetrics website http://www.wavemetrics.com/ provide detailed information beyond this (see below)

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 Igor Pro PDF manual, 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

IGOR Pro Manual

Table of Contents

IGOR Pro

Version 6.37

WaveMetrics, Inc.

Manual Revision: June 2, 2015 (6.37)

Printed in the United States of America.

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http://www.wavemetrics.net/doc/igorman/IgorMan.pdf

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*

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www.wavemetrics.com

Graphing

- 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, 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.
- Apply weighting and linear constraints.
- Levenberg-Marquardt method for nonlinear fitting.
- Orthogonal distance regression, errors in X, global analysis.
- Built-in fits: linear, polynomial (1D & 2D), exponential, double exponential, power law, sine, gaussian (1D & 2D), lorentzian, lognormal, Hill equation, sigmoid.
- Outputs include parameter values, standard deviation and confidence intervals; model curves; residuals; confidence bands; covariance matrix; chi-square.

Presentation

Layouts

- Use page layouts to precisely arrange graphs, tables, pictures, annotations, and drawing elements for printing or export.

Notebooks

- IGOR Pro notebooks provide a built-in, programmable word-processor; use them to record experiment results using text, tables and graphs.

Export

- Print at high resolution.
- Export high-resolution graphics in EPS, PDF, enhanced metafile, TIFF, PICT, BMP, and PNG formats.

Analysis & Statistics

- Single and multidimensional mixed-radix FFTs, continuous and discrete wavelet transforms, Hilbert, Hough, Wigner and Fast Gauss Transforms.
- Smoothing (binomial, Savitzky-Golay, box, median, Loess), integration, differentiation, IIR and FIR filtering, convolution, ordinary differential equations, histograms, sorting, area, mean, array arithmetic, windowing, peak and level detection.
- Full suite of matrix operations using standard LAPACK routines.
- Find function roots or extrema using direct methods or simulated annealing.
- Special functions and orthogonal polynomials.
- Probability distribution functions, cumulative and inverse cumulative distribution functions.
- Statistical analysis including moments, quantiles, correlations and serial randomness.
- Statistical tests including ANOVA, Bartlet, Cochran, Chi-squared, F, Jarque-Bera, Kolmogorov-Smirnov, Levin, Scheffe, t, and Tukey.
- Statistical multi-comparison tests.
- Non-parametric hypothesis tests including Friedman, Mann-Kendal, Kruskal-Wallis, Spearman and Wilcoxon's.
- Statistical analysis for angular data.
- Random number generators for various distributions.
- Cluster analysis with K-means and farthest-point algorithms.
- Computational geometry including 2D and 3D triangulation and interpolation.

Image Analysis

- Full suite of tools for image filtering, manipulation, and quantification.
- Image thresholding: iterated, bimodal, adaptive, fuzzy entropy, and fuzzy means.
- 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 QuickTime 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 (equally-spaced) 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.
- 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 Acquisition

- 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

IGOR 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.

IGOR NIDAQ Tools MX

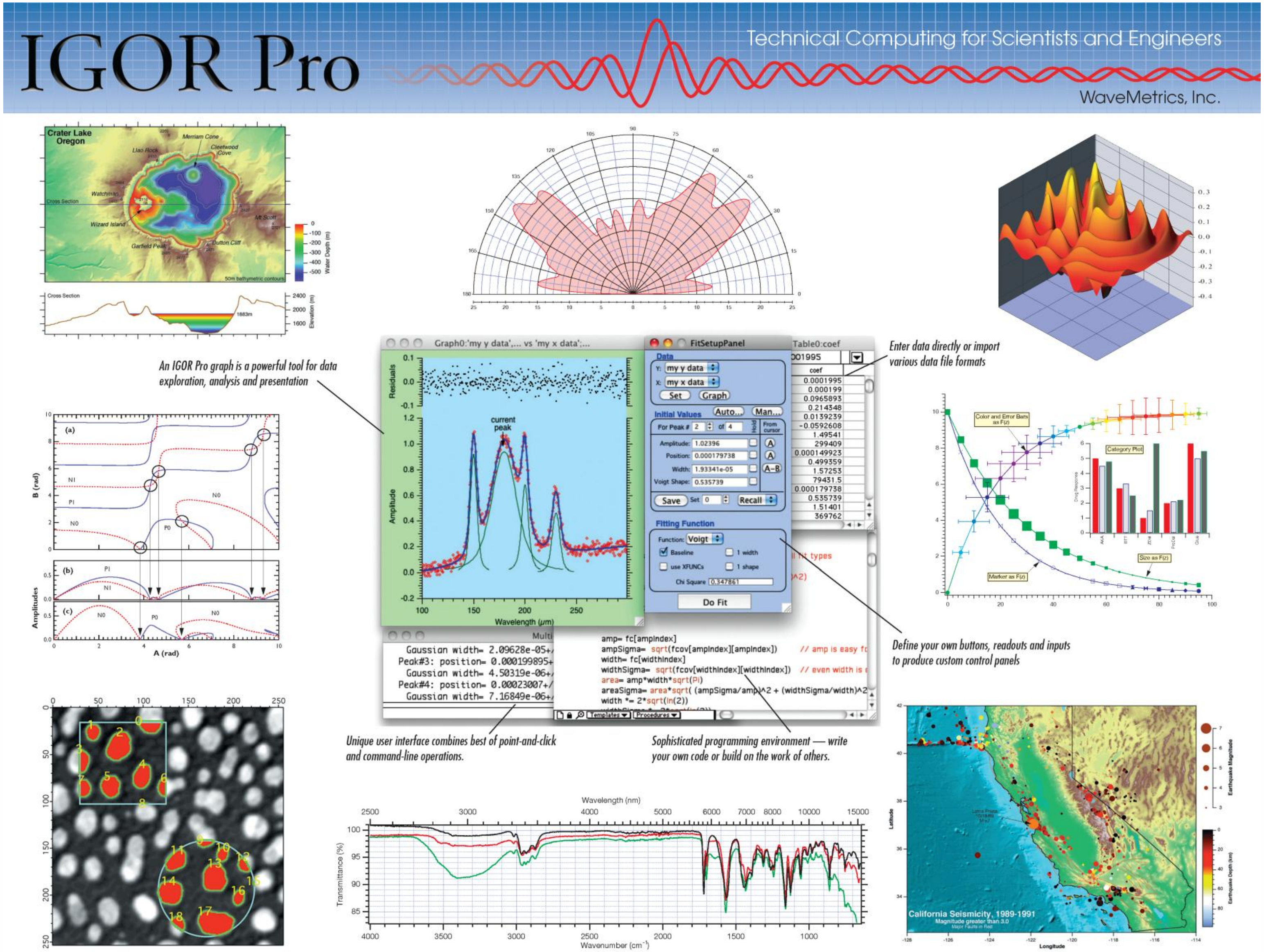
- Acquire data directly into IGOR Pro using National Instruments "multifunction" data acquisition boards.

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.

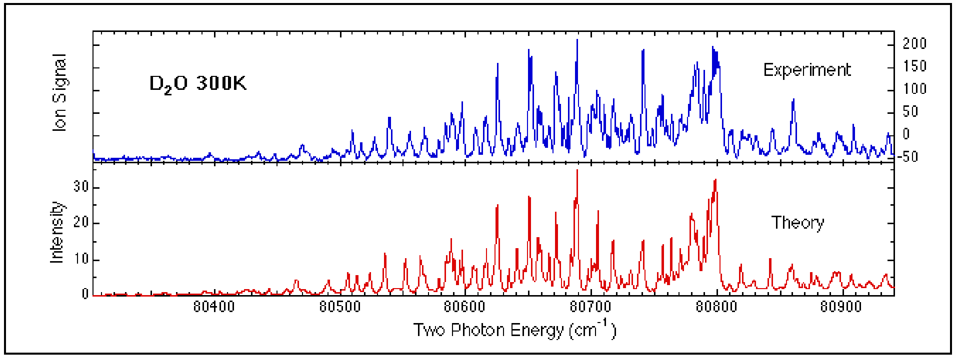
For more information visit our web site at www.wavemetrics.com

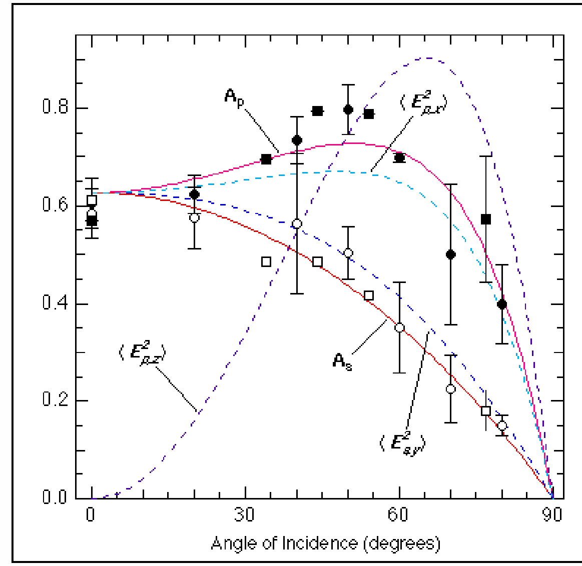
See Igor6Brochure.pdf at https://www.wavemetrics.com/products/igorpro/Igor6Brochure.pdf



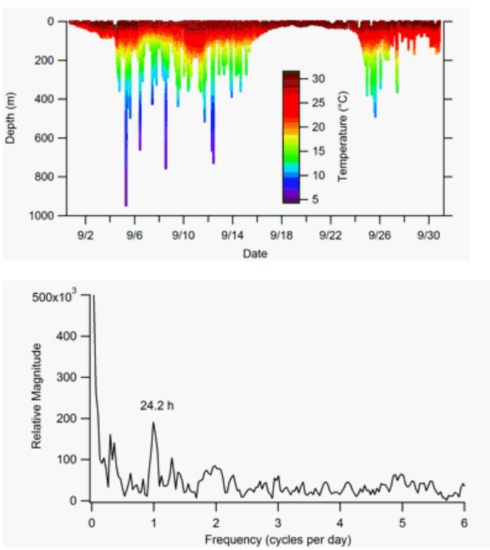
See Igor6Brochure.pdf at https://www.wavemetrics.com/products/igorpro/Igor6Brochure.pdf

Example of Publication Quality Graphs with IGOR Pro

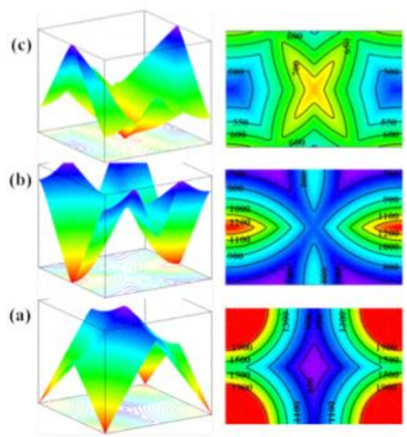




Whale sharks diving behavior results



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.

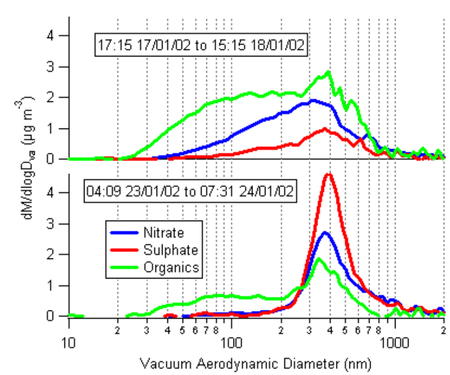


Dispersion surfaces of a rectangular lattice 2D photonic crystal. (a) first band, (b) second band, (c) third band.

More examples at

https://www.wavemetrics.com/products/igorpro/gallery/user.htm

Comparison of two case studies



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

Introduction to Scientific Computing

PHYS 3870

An Exercise in Analyzing and Plotting Data with IGOR Pro

References:

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Introduction to Scientific Computing

PHYS 2500

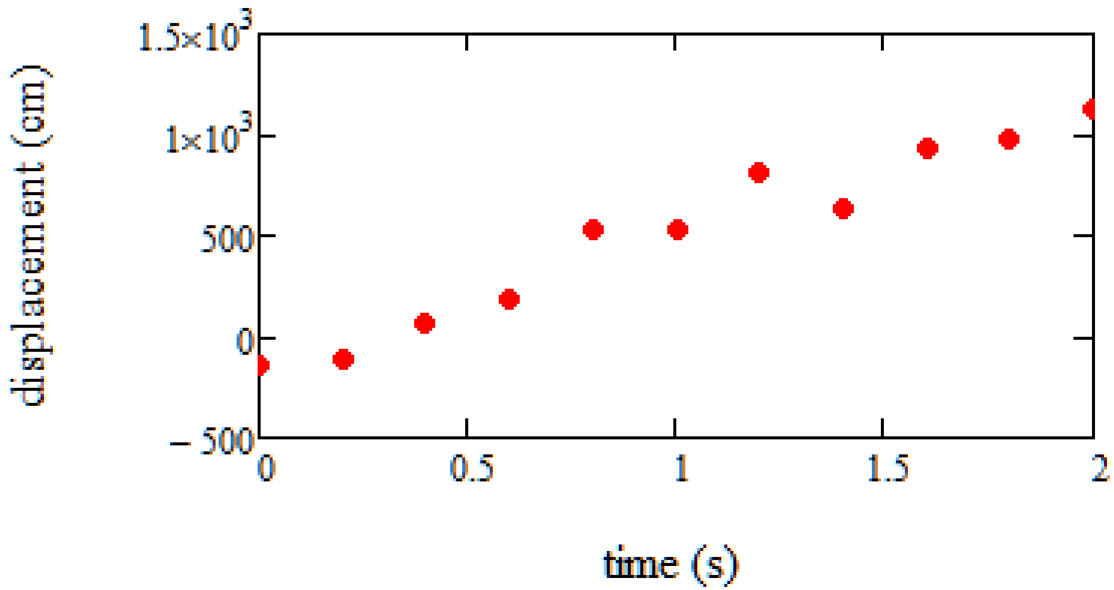
An Exercise In Data Analysis
Using *IGOR Pro*

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).

Data for An Exercise In Data Analysis Using IGOR Pro

DennisonInFreefall.jpg



Freefall.txt

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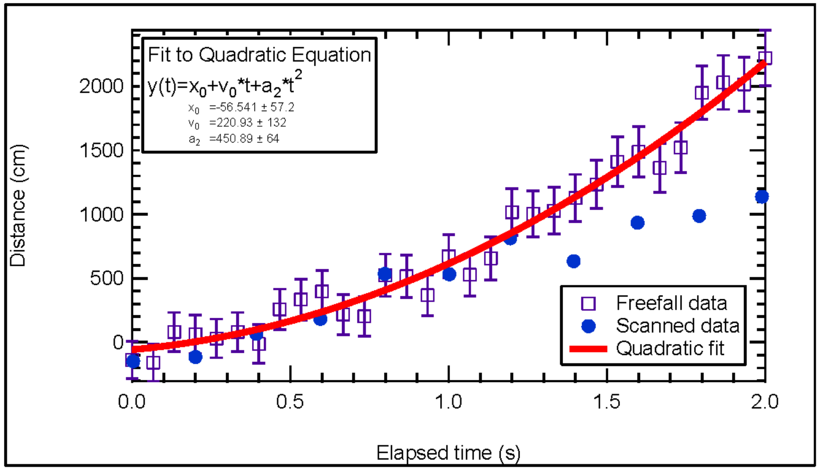
1.733	1521	195.6
1.8	1949	208.5
1.867	2031	210.9
1.933	2016	210.5
2	2222	216.6

JR Dennison
PHYS 2500
10/2/2015

Results for An Exercise In Data Analysis Using IGOR Pro

IGOR Pro Exercise

Freefall Data



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 $y(t)=at^2 + v_o t + x_o$