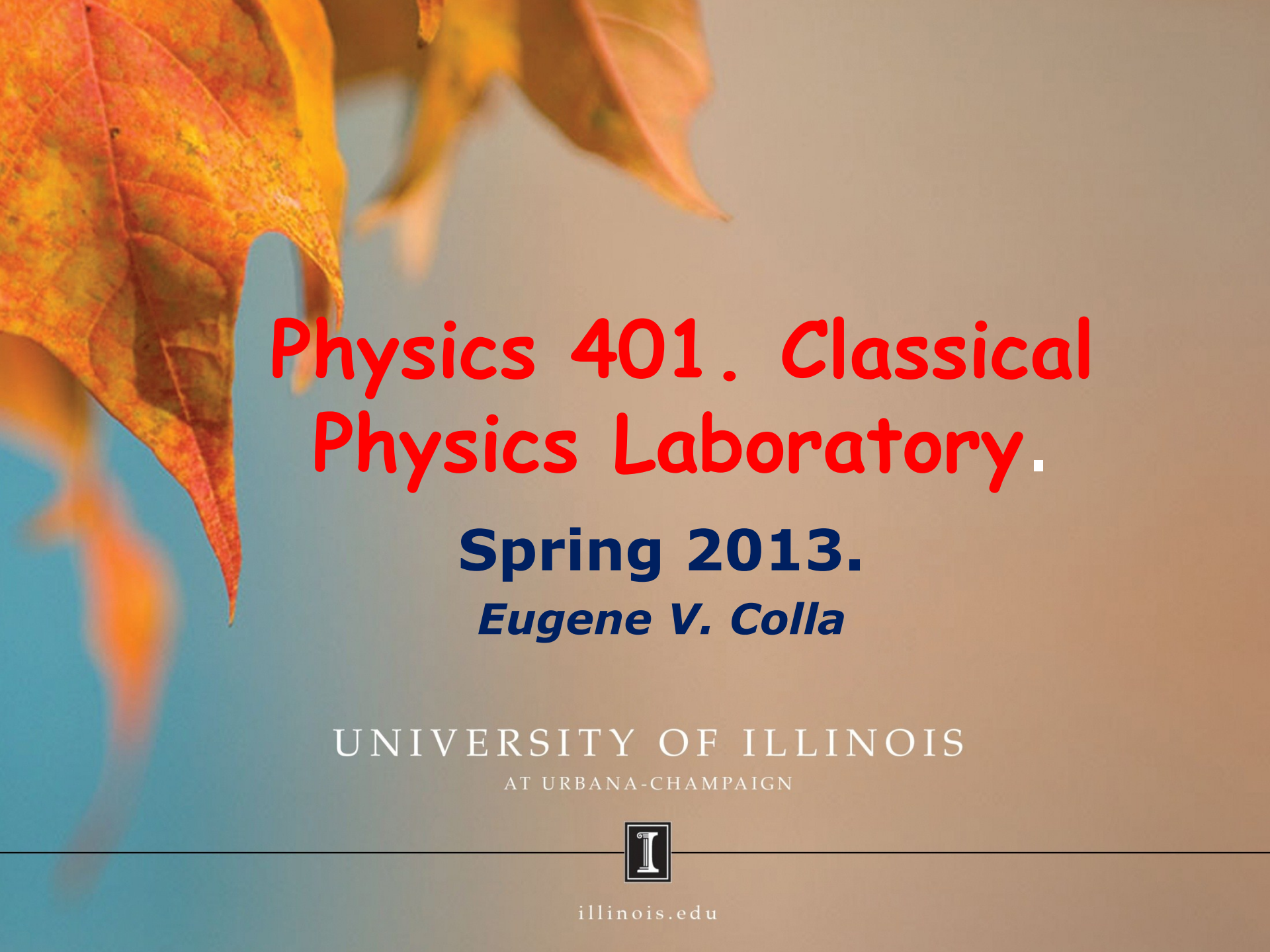


Physics 401. Classical Physics Laboratory.

Spring 2013.

Eugene V. Colla

UNIVERSITY OF ILLINOIS

AT URBANA-CHAMPAIGN

illinois.edu

Physics 401. Fall 2012

- Course Objective
- Organization
  - Times and locations
  - Physics 401 staff
- Semester Schedule
- Laboratory routine
- Grading scheme
- Section assignments
- Comments on the course objectives and
- Experimental physics in general

Course Objective.

- ✓ Lectures
- ✓ Laboratory section
- ✓ Laboratory notebook
- ✓ Laboratory report

Course Objective. *Lectures*

Lecture attendance is not an optional part of the course but a sort of assignment - each lecture corresponds to *5 credit points*.

Course Objective. *Lectures*

Lectures:

Lectures will cover the idea of experiment, measuring approach, used equipment, possible analysis of the results, presentation of data, error analysis.

***Typical lecture plan*:**

- briefly about physics of the experiment
- Experimental setup and equipment
- How to do the experiment, possible problems and difficulties
- Data analysis using Origin and data presentation
- Error analysis
- Questions, discussion

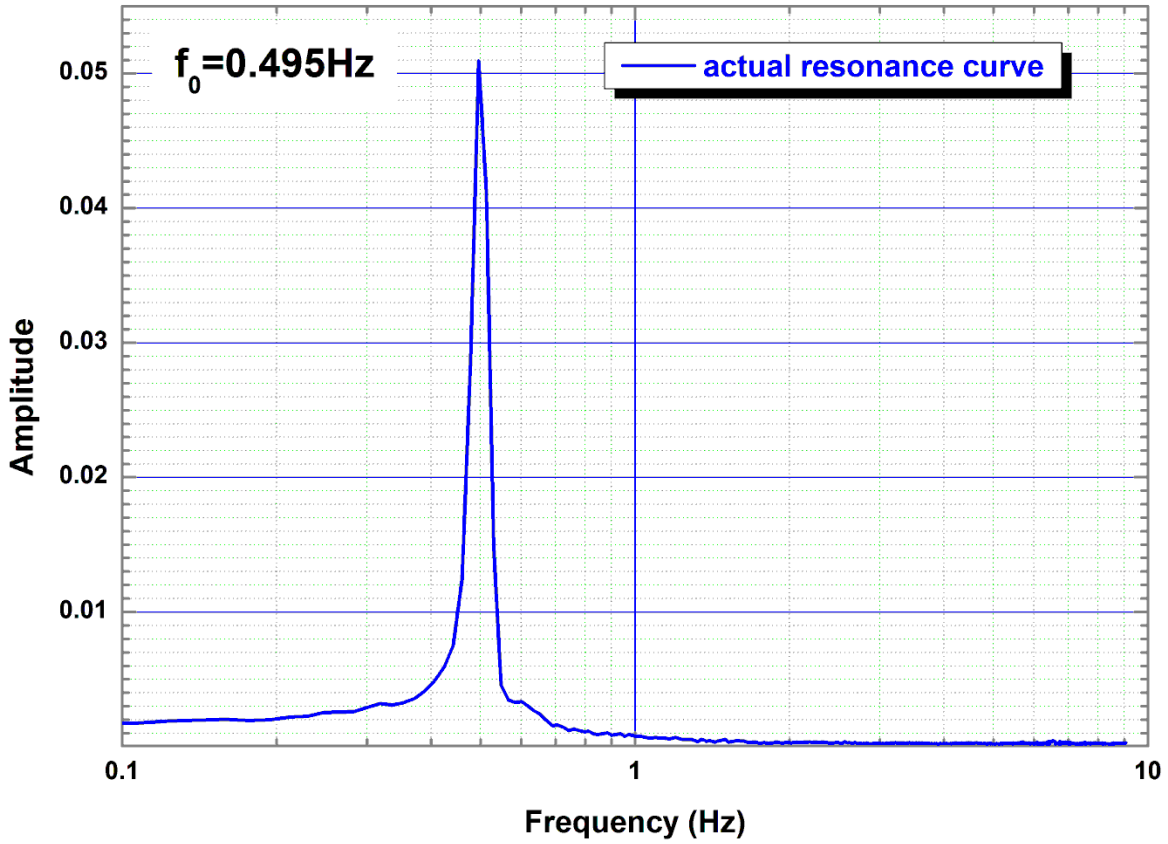
Course Objective. *Lab section*

Laboratory section:

Carry out experiment, briefly summarize experimental procedures and record observations and results in your laboratory notebook, carry out preliminary data analysis (*see comments in next slide!*).

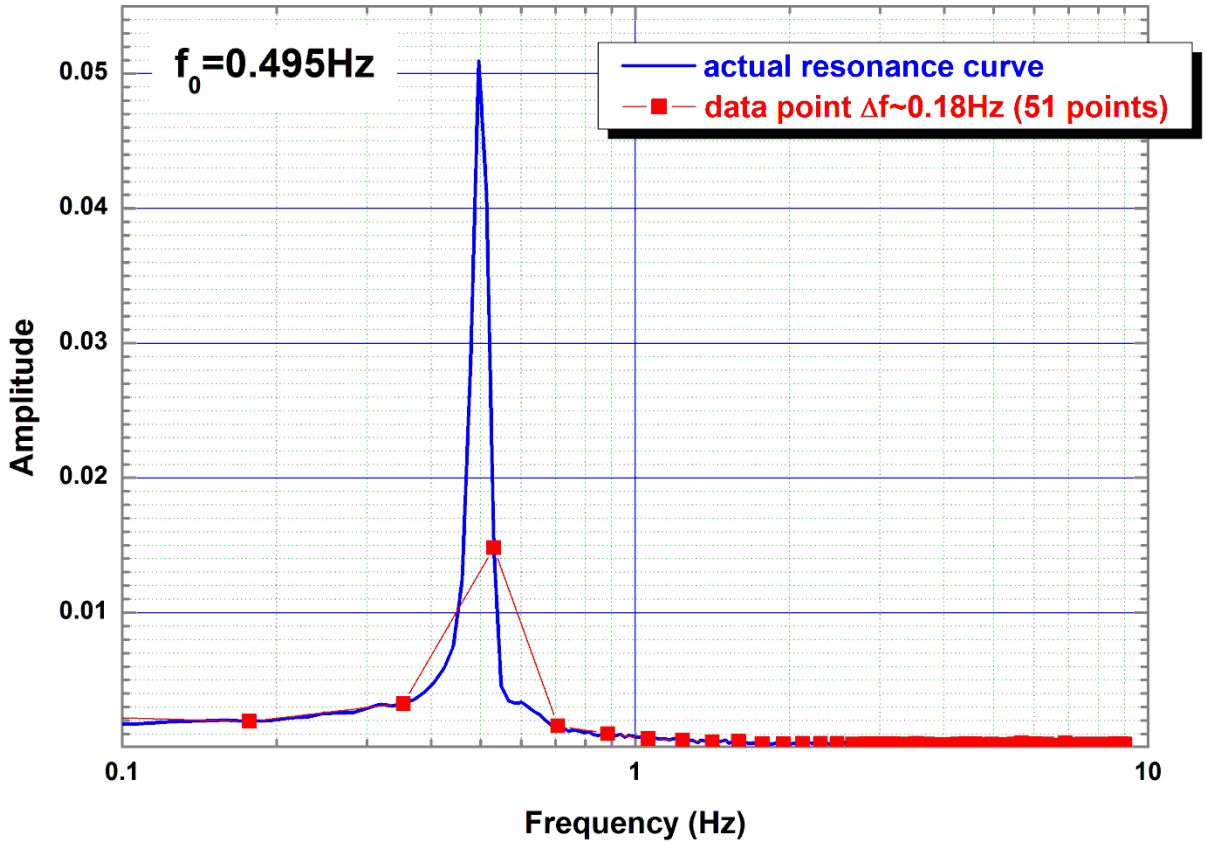
Course Objective. *Lab section.*

…carry out preliminary data analysis…



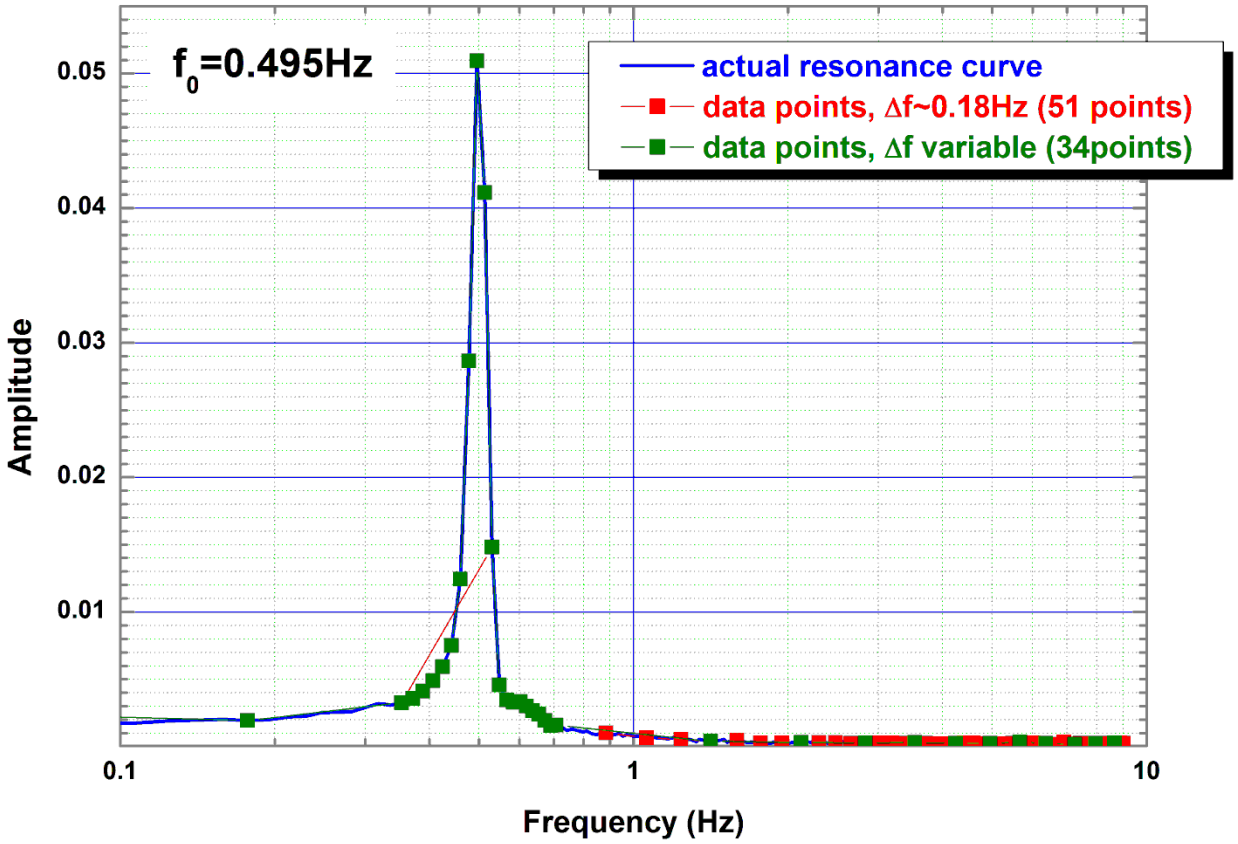
Course Objective. *Lab section.*

…carry out preliminary data analysis…



Course Objective. *Lab section.*

…carry out preliminary data analysis…



Course Objective. *Lab notebook*

Laboratory notebook:

You should have two notebooks. Both are identical. One will be submitted with report and the second will be with you to work on next experiment.

Course Objective. *Lab notebook*

Your laboratory notebook is the scientific record of your experiment. It needs to contain in brief all information required to solidly connect the experimental data with physics observables in the data analysis:

- ✓ drawing of the setup,
- ✓ environment conditions (as needed)
- ✓ dimensions or other characteristics of experimental equipment relevant to later analysis
- ✓ results from calibration procedures
- ✓ data and error estimate
- ✓ some preliminary results and graphs

Course Objective. *Lab report*

The main goal of the Lab report is to show the main results and findings of the experiment and how these results were obtained. The main components of the report:

Laboratory report:

Report should be submitted to your TA not later than a week after the Lab was done. Despite you doing experiments in team of two each student should write a *personal report*

Course Objective. *Lab report*

The main goal of the Lab report is to show the main results and findings of the experiment and how these results were obtained.

The main components of the report:

1. Title, name, affiliation, date

Second Sound in Liquid He^4 II

Name
Department of Physics, University of Illinois at Urbana-Champaign
August 30th, 2011

Course Objective. *Lab report*

The main goal of the Lab report is to show the main results and findings of the experiment and how these results were obtained.

The main components of the report:

2. Abstract

Abstract

Second sound waves in superfluid liquid helium were created and observed. The second sound speeds were measured for different temperatures, which matched the expected values well. Corrections were made to account for the contraction of the Lucite cylinder when cooled to liquid Helium temperatures. The location of resonance frequencies for higher geometries were predicted, and found to match the observed frequencies. The responses of the receivers for different receiver and transmitter geometries were also compared.

Course Objective. *Lab report*

The main goal of the Lab report is to show the main results and findings of the experiment and how these results were obtained. The main components of the report:

3. Introduction (Theory, motivation)

Introduction

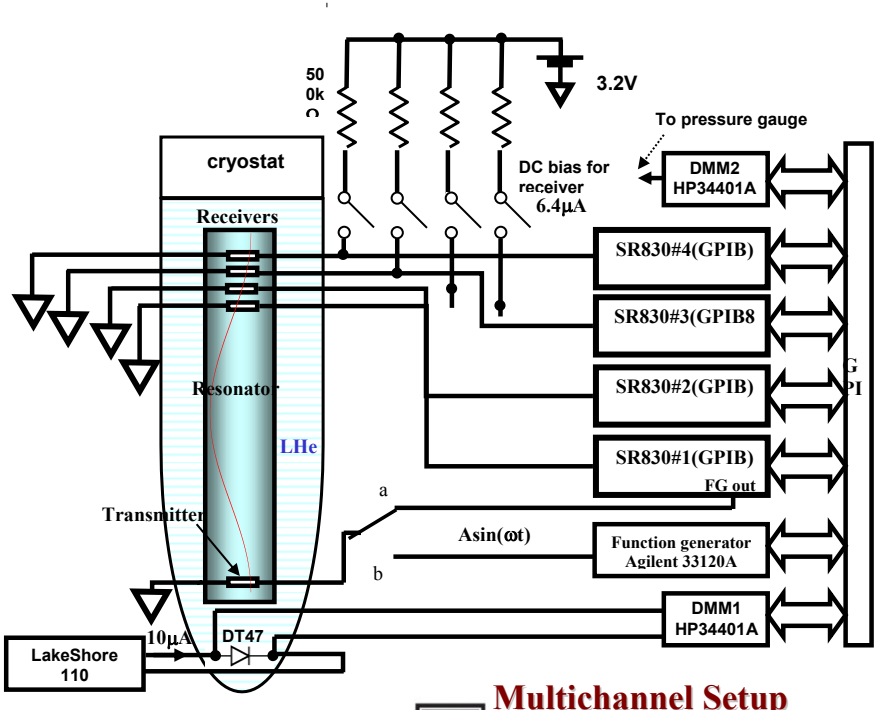
Liquid Helium has very unique properties when cooled to temperatures below 2.17K and the pressure is lowered below 37.77 torr, which is known as the lambda point. It changes to a new phase of matter called He II. He II has several unique properties that distinguish it form normal liquid Helium or He I. These properties include zero viscosity while flowing through very small tubes, flowing without friction up containers walls and a thermal resistivity that goes to zero as the temperature goes to zero. All of this results in heat traveling in high speed waves, in contrast to ordinary heat travel through diffusion. The speed of these waves is called second sound, the name will become more apparent shortly. It also exhibits He I properties as a torsion pendulum with slowly decay showing the viscosity is about one-tenth of air. This viscosity paradox would be explained by Lazlo Tisza in 1938 with the formation of the two-fluid model. This model explains the properties of He II by letting the He II be a mixture of both normal liquid helium and superfluid helium.

Course Objective. *Lab report*

The main goal of the Lab report is to show the main results and findings of the experiment and how these results were obtained. The main components of the report:

4. Procedure (Setup, Measuring technique, Object of study)

Experimental Setup



Multichannel Setup

Course Objective. *Lab report*

The main goal of the Lab report is to show the main results and findings of the experiment and how these results were obtained. The main components of the report:

5. Results (main finding, analysis, errors)

Results and Analysis

The results obtained were for the most part successful. For a few of the runs, there was too much temperature drift to be able to obtain reliable results. An example of the data obtained for the Day 2 Run 1 is shown in Figure 6 below.

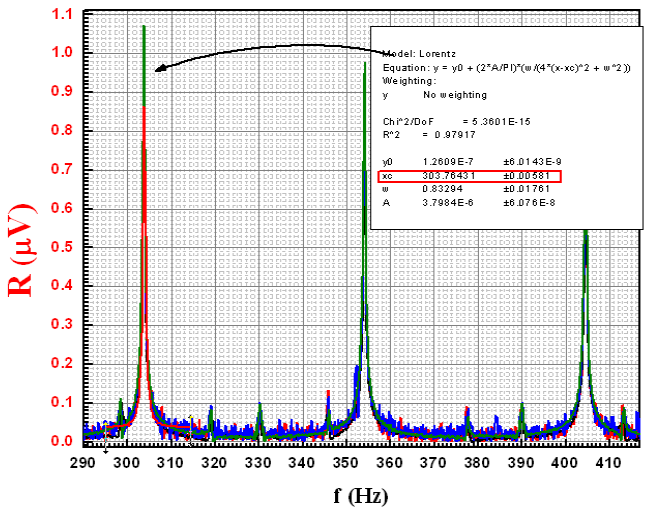


Figure 6: Sample data taken during a run for which T = 1.85 K and the applied voltage is 5 V. Different 1-D resonance peaks can be seen as well as peaks that result from the power line

Course Objective. *Lab report*

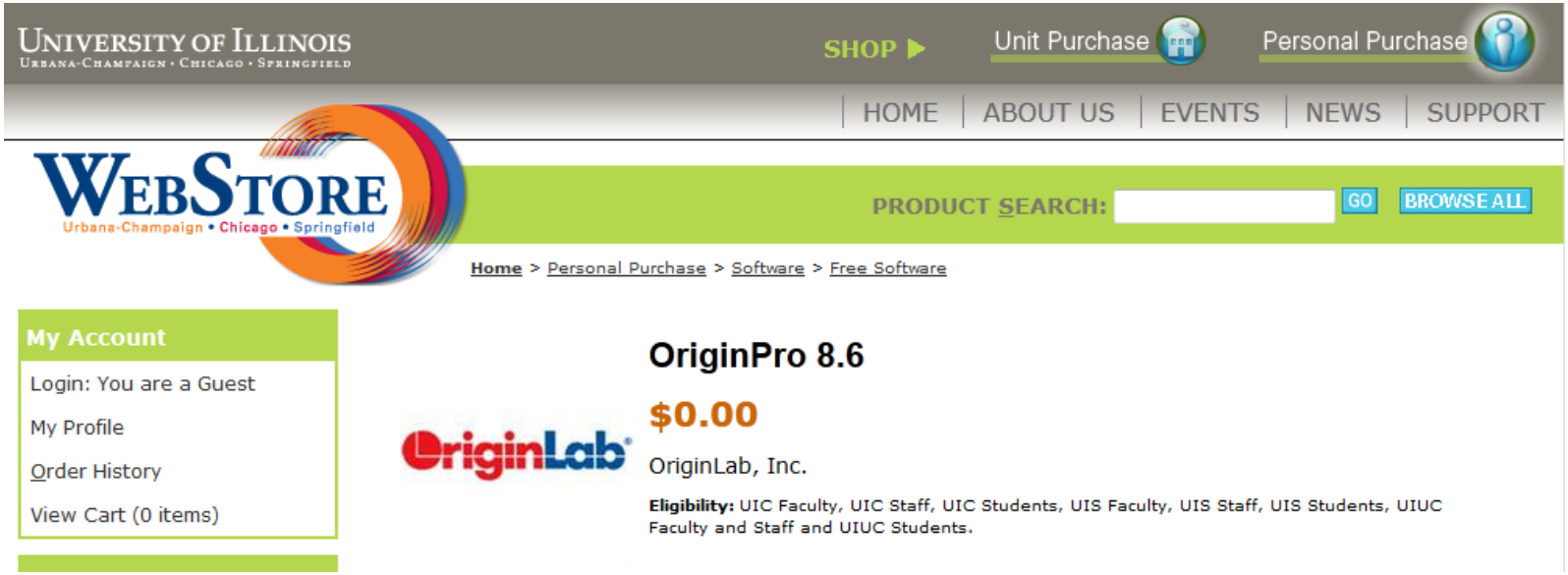
The main goal of the Lab report is to show the main results and findings of the experiment and how these results were obtained. The main components of the report:

6. Conclusions

Course Objective. *Lab report*

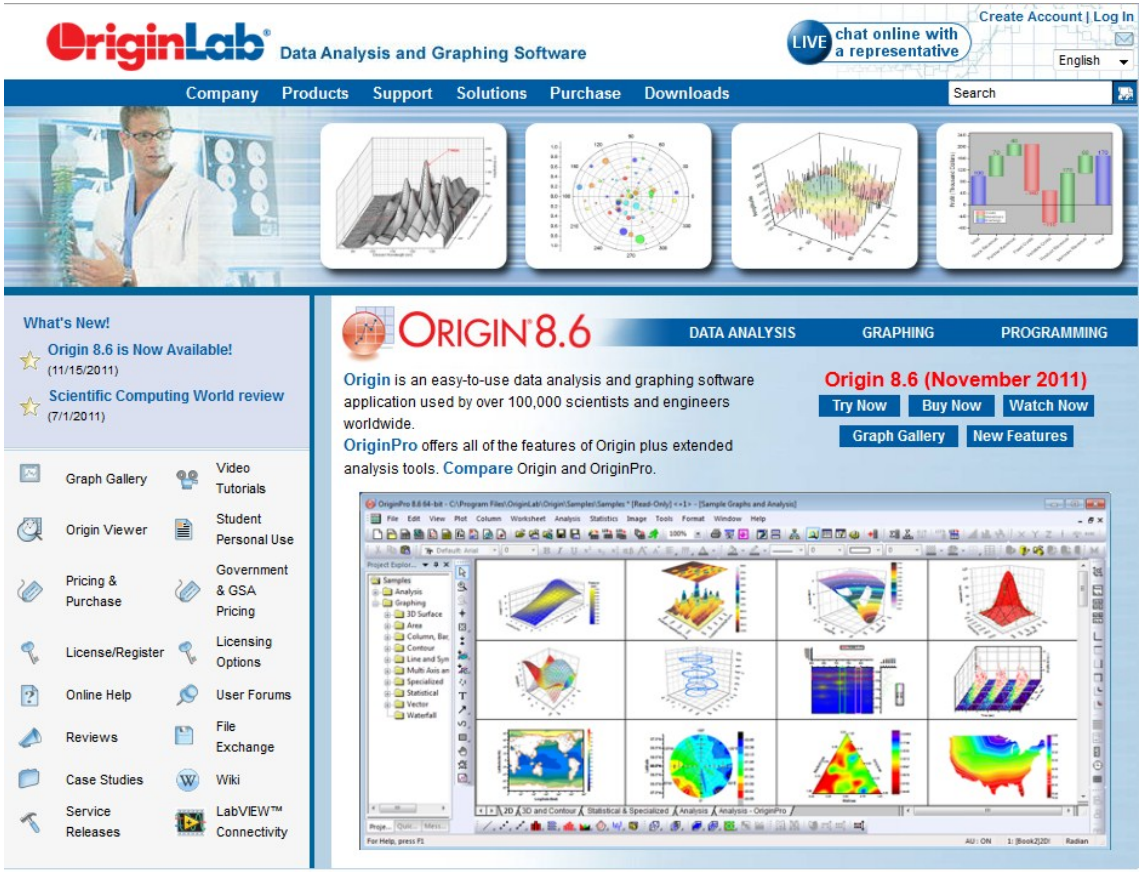
Graphs, graphical software

Origin can be used for data analysis and data presentation. There is 8.6 version available on all Lab computers



Course Objective. *Lab report*

Graphs, graphical software

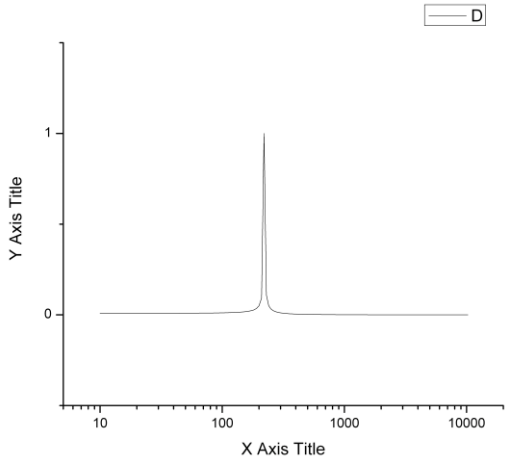


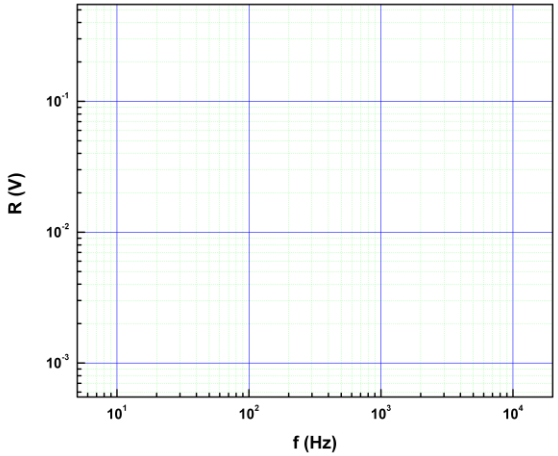
http://www.originlab.com/

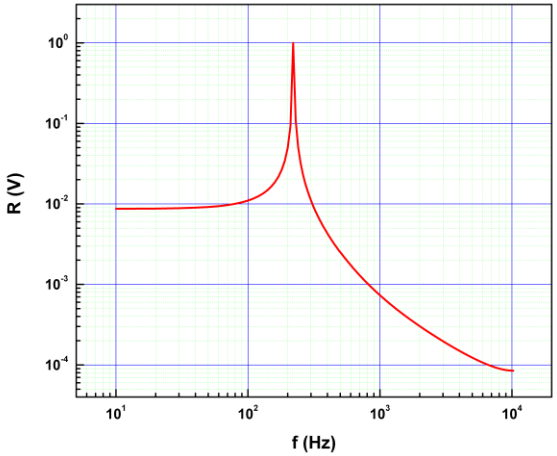
Course Objective. *Lab report*

Graphs, graphical software

Working with Origin you can use the templates

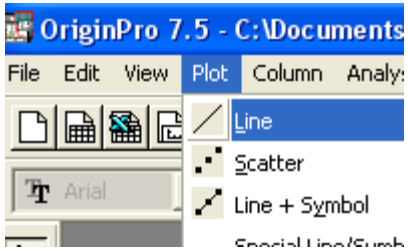




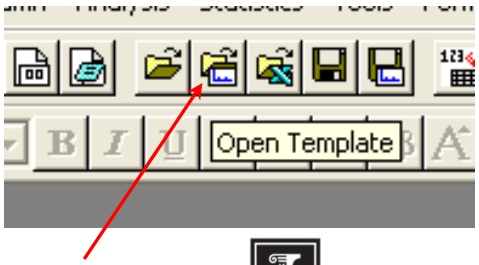


PhyaplportaI\PHYCS401\Common\Origin templates

Simply plotting the data



Open the template



Course Objective. *Lab report. Submission*

The reports should be uploaded to the server:

https://my.physics.illinois.edu/courses/upload/

All assignments have the names close to the Lab Title

Frequency Domain Analysis Report_L1

Your Lab section

The acceptable file formats are: doc, docx, pdf

Be careful with assignment name and your Lab section selection!

Course Objective. *Lab report*

Deadline for notebook and lab-reports is the day (up to midnight) of each lab-section one week later. You have ***two vouchers*** to return the report by one week later. In the case if you will not use vouchers you will get ***5 points*** credit per voucher.

Voucher I to turn in notebook + report one week late.

Date:
Experiment No.:
Student Name:
Signature:

void after December 10 2012

Voucher I to turn in notebook + report one week late.

Date:
Experiment No.:
Student Name:
Signature:

void after December 10 2012

Course Objective. *Lab report*

All experiments will be performed in team of two, but the report should be written by each student *personally* using results of *personal analysis* of data and *personal graphs*.

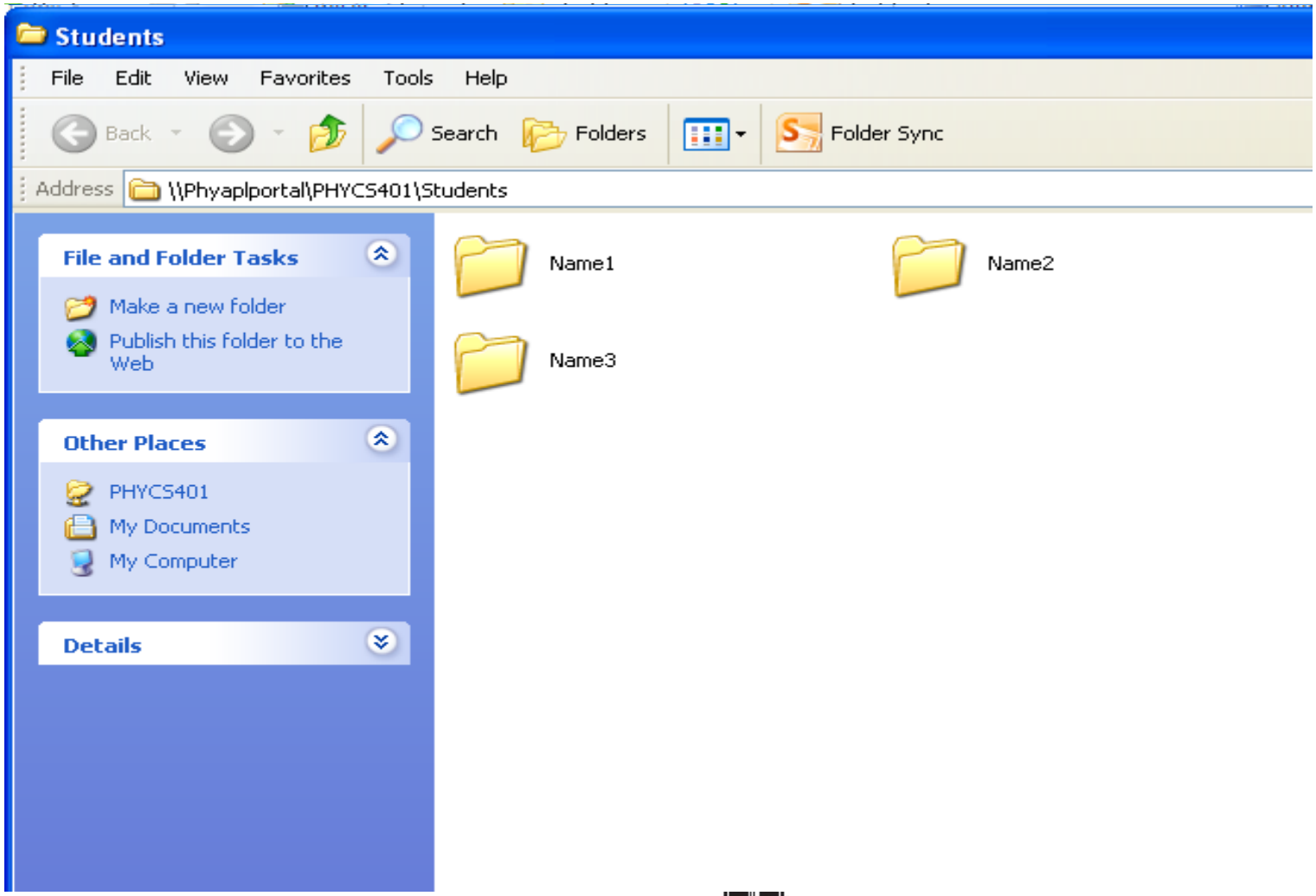
Course Objective.
Absences/Late reports

In the case if you have acceptable reason for absence of the Lab section you have to contact Eugene Colla and we will try to figure out how to make up the Lab.

The rules for late reports:

- **5% of total score for report for up to 1 week late.**
- **10% - for up to 2 weeks late.**
- **After that, it's too late.**
- **May 5th is the final deadline for everything**

Computer Access in P401



Typical Lab Routine

1. Reading the wright up (better before the Lab session)
2. Assembling the experimental setup. Drawing the diagram if it is necessary.
3. Taking data. Saving data using DAQ or writing manually the numbers in the notebook. In the case if data was obtained automatically you have to write in logbook the filename and its location.
4. Preliminary analyzing the data. Correcting the experiment settings if it is necessary.
5. Writing the report.

Times and Locations

Section	Type	Times	Days	Location
A	Lecture	03:00 PM - 03:50 PM	Monday	144 Loomis Laboratory
L1	Lab	01:00 PM - 04:50 PM	Tuesday	6103 ESB
L3	Lab	01:00 PM - 04:50 PM	Wednesday	6103 ESB
L4	Lab	08:00 AM - 11:50 AM	Thursday	6103 ESB
L5	Lab	01:00 PM - 04:50 PM	Thursday	6103 ESB

Physics 401 staff

	Name	Office	Phone	e-mail
Lecturer	Eugene V. Colla	4137 ESB	333-5772	kolla@illinois.edu
Lab Instructor	Matthew C Stupca	494 Loomis	333-0509	stupca@illinois.edu
Lab Instructor	Longxiang Zhang		333-2751	lzhang24@illinois.edu
Lab Instructor	Jaseung Ku		244-2804	jku2@illinois.edu
Lab Instructor	Robert Halliday		847-217-3644	hallida2@illinois.edu
Lab Technician	Jack Boparai	6101 ESB	333-2208	jboparai@illinois.edu

Semester Schedule

Week of	*Week #*	*Lab Title*
January 14	1	Introduction to Scope/Function Generator/DMM
January 21	2	Transients and Oscillations in RLC Circuits *No lecture on Monday (MLK Holiday)*
January 28	3	Frequency Domain Analysis of Linear Circuits Using Synchronous Detection
February 4	4	Pulses in Transmission Lines
February 11,18	5,6	Millikan Oïl Drop week 1,2
February 25, March 4	7,8	Torsion Oscillator week 1,2
March 11	9	Hall Probe Measurement of Magnetic Fields
March 25	11	Qualitative Studies with Microwaves / week 1
April 1	12	Microwave Cavities / week 2
April 8,15,22	13,14,15	Final Project Weeks 1,2,3 – AC Measurement of Magnetic Susceptibility

Grading

Total Points(max) =

1000(reports) +

10(unused vouchers) +

50(Lectures attendance)

Letter grading scale is approximately: 97% = A+, 93% = A, 90% = A-,

87% = B+, 83% = B, 80% = B-, 77%=C+, 73%=C, 70%=C-.67%=D+,

63%=D, 60%=D-

P401 and Upper level Undergraduate Physics Labs

PHYS 401 Classical Physics Lab

PHYS 402 Light

PHYS 404: Electronic Circuits

I

PHYS 403 Modern Experimental Physics

II

This week: "Introduction to Oscilloscope, Function Generator, DMM"

Function Generator: Wavetek model 81

Waveforms:

- *Sine wave*
- *Triangular wave*
- *Rectangular wave*
- *Positive pulses*
- *Negative pulses*
- *Positive ramp*

Frequency range: *10mHz ÷50MHz*

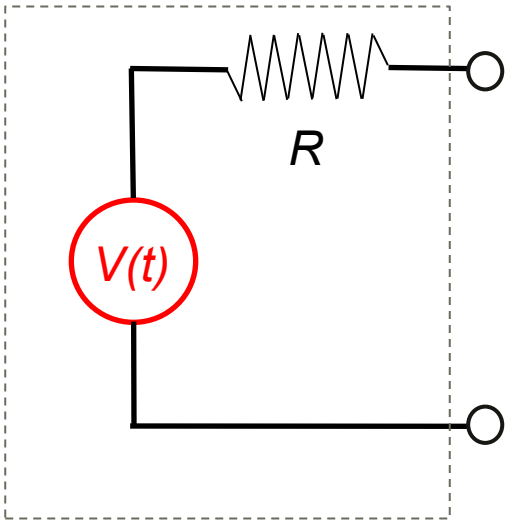
Output voltage: *up to 16V (amplitude)*

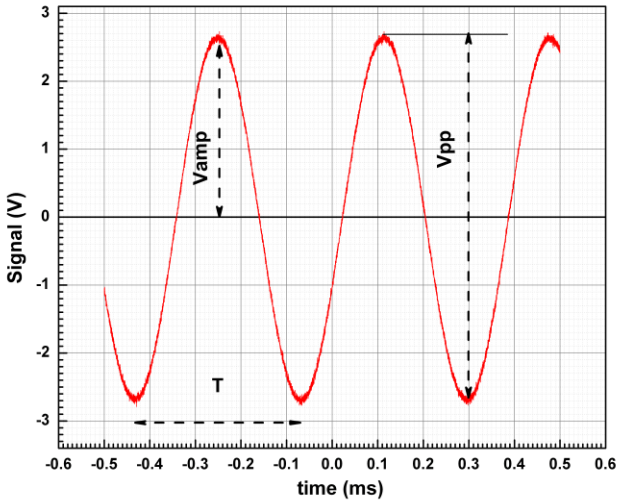
This week: "Introduction to Oscilloscope, Function Generator, DMM"

The goal of the Lab is to get familiar with the these laboratory tools.

Function Generator

Wave Function Generator; generates time dependent voltages *V(t)* as input for the study of electrical circuits electrical circuits or can be used as signal source in scientific experiment.



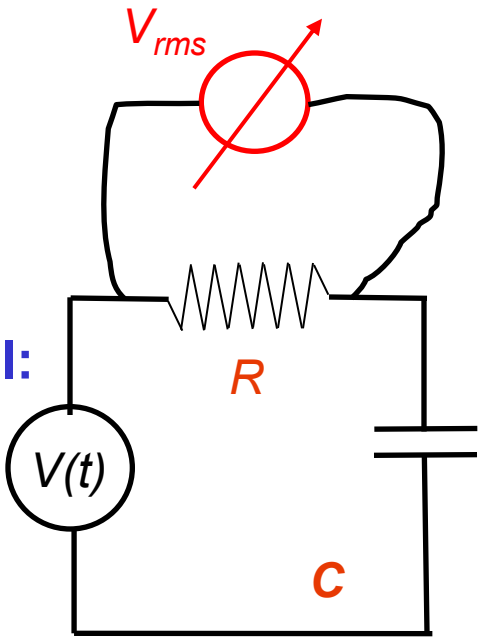


This week: "Introduction to Oscilloscope, Function Generator, DMM"

DMM – digital multimeter. (Agilent 34401A)

You can use DMM to measure:

- AC/DC voltage
- AC/DC current
- Resistance
- Frequency
- Period



All DMM's measure AC signals (voltage or current) in rms (root mean square) units. For periodic signal:

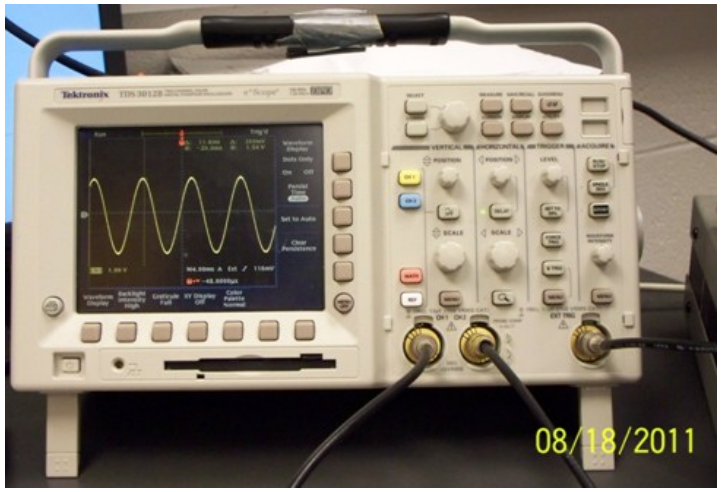
$$V_{rms} = \sqrt{\frac{1}{T}\int_0^T [V(t)]^2 dt}$$

In case of sine wave

$$V_{rms} = \frac{V_{amp}}{\sqrt{2}} \approx 0.707 V_{amp}$$

This week: "Introduction to Oscilloscope, Function Generator, DMM"

Digital Oscilloscope Tektronix TDS3012b



Higher Speeds Demand Greater Bandwidth

The TDS3000B DPOs offer bandwidths from 100 to 500 MHz to best suit the needs of your most demanding projects, so you can complete your tasks efficiently and confidently.

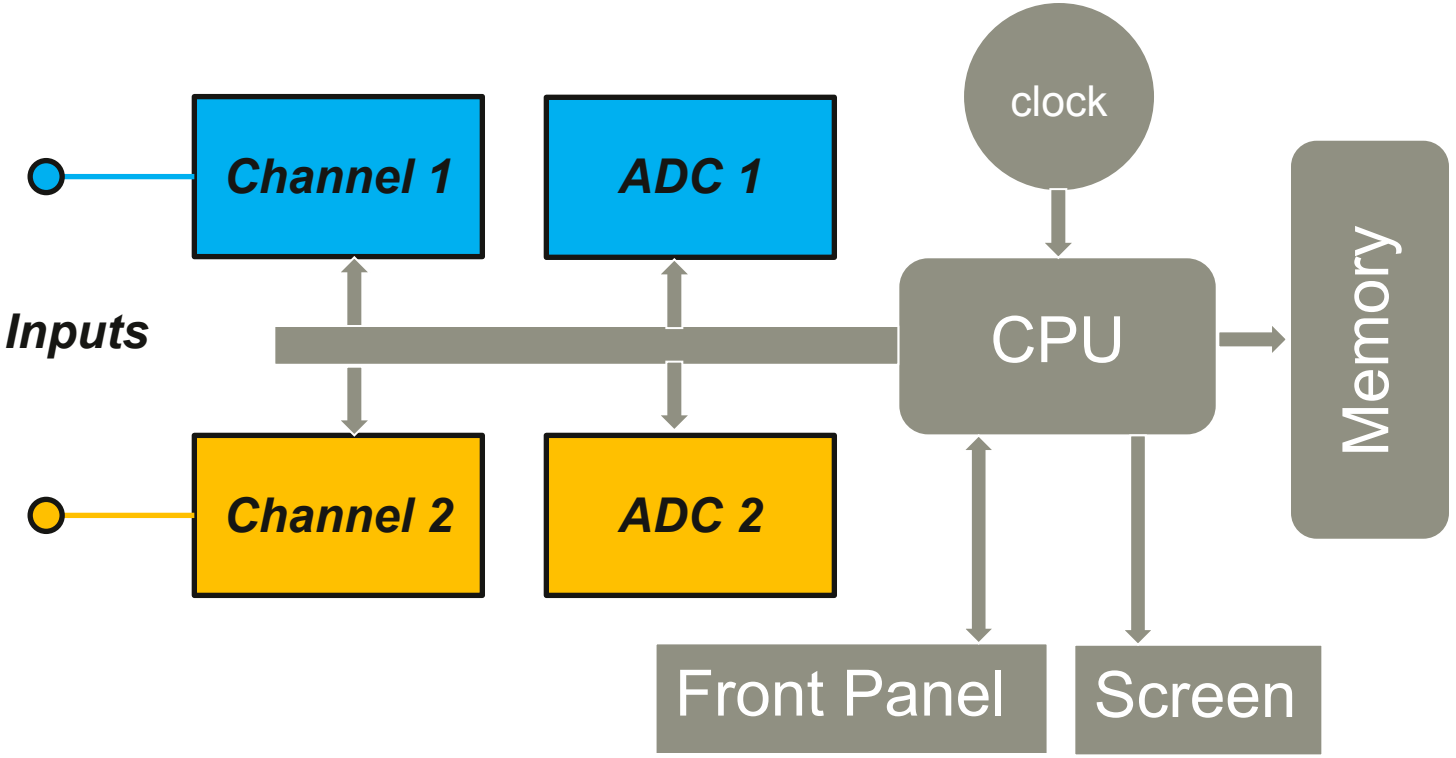
Model	Bandwidth	Channels	Sample Rate
TDS3054B	500 MHz	4 Ch	5 GS/s
TDS3052B	500 MHz	2 Ch	5 GS/s
TDS3044B	400 MHz	4 Ch	5 GS/s
TDS3034B	300 MHz	4 Ch	2.5 GS/s
TDS3032B	300 MHz	2 Ch	2.5 GS/s
TDS3024B	200 MHz	4 Ch	2.5 GS/s
TDS3014B	100 MHz	4 Ch	1.25 GS/s
TDS3012B	100 MHz	2 Ch	1.25 GS/s

The things you have learn and know about the scope:

- *Inputs characteristics of the channels (input resistance, gain, bandwidth)*
- *Time base range*
- *Triggering*
- *Measurements of signal parameters*
- *Using cursors*
- *Averaging*
- *Using Math options*
- *Computer access to the image and data*
- *And much more ….*

This week: "Introduction to Oscilloscope, Function Generator, DMM"

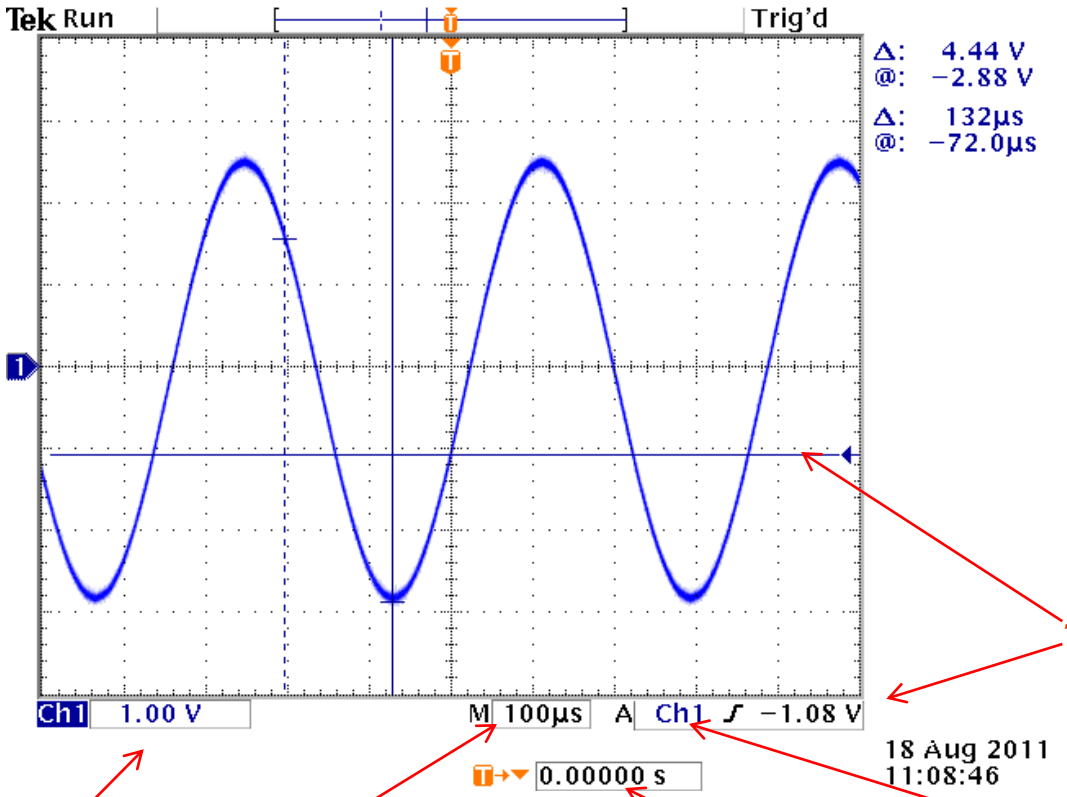
Digital Oscilloscope Tektronix TDS3012b



Simplified block diagram of two channels digital oscilloscope

This week: "Introduction to Oscilloscope, Function Generator, DMM"

Digital Oscilloscope Tektronix TDS3012b - Triggering



Triggering level

Triggering source

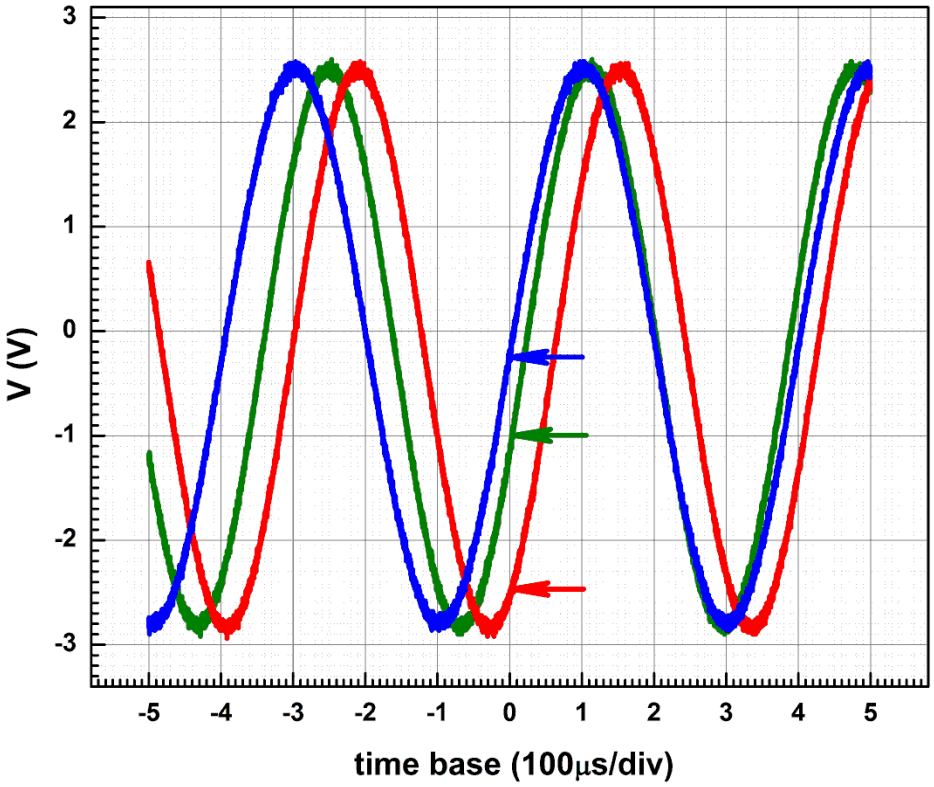
Horizontal scale(s/div)

Vertical scale(V/div)

Triggering delay

This week: "Introduction to Oscilloscope, Function Generator, DMM"

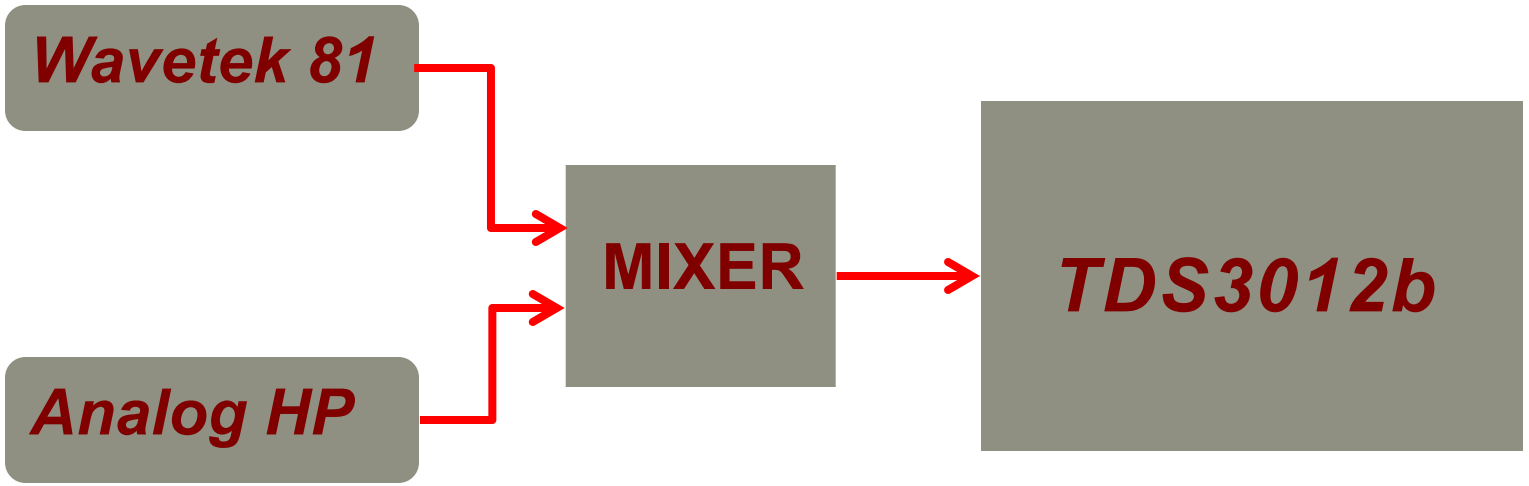
Digital Oscilloscope Tektronix TDS3012b - Triggering



This data was taken from scope in ASCII format and plotted using Origin. Color arrows indicate the triggering levels for each trace

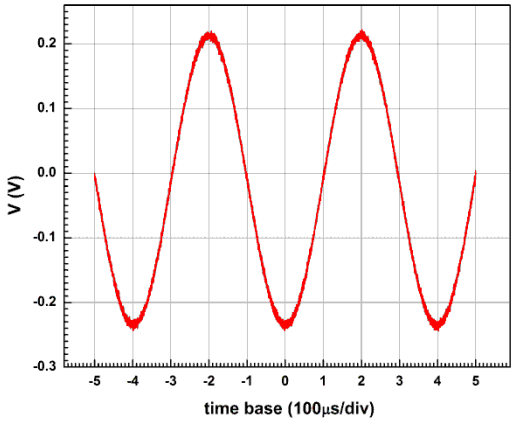
This week: "Introduction to Oscilloscope, Function Generator, DMM"

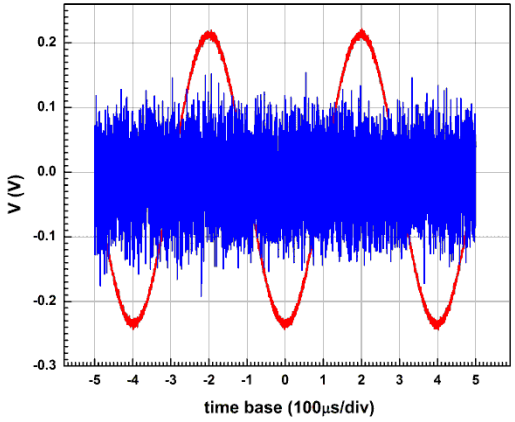
Digital Oscilloscope Tektronix TDS3012b – Averaging

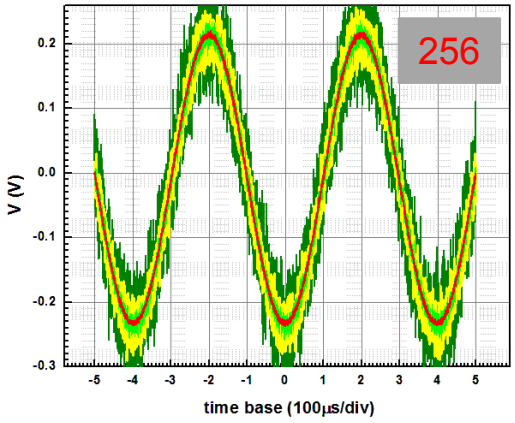


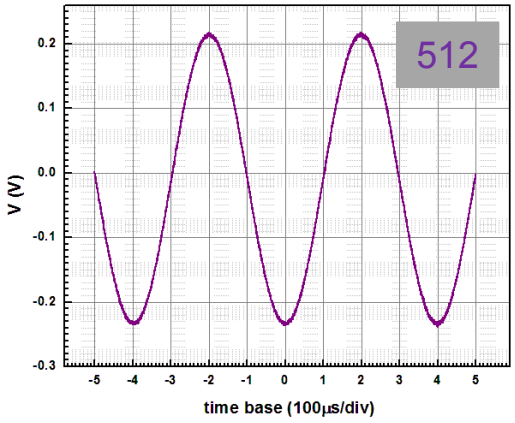
This week: "Introduction to Oscilloscope, Function Generator, DMM"

Digital Oscilloscope Tektronix TDS3012b – Averaging



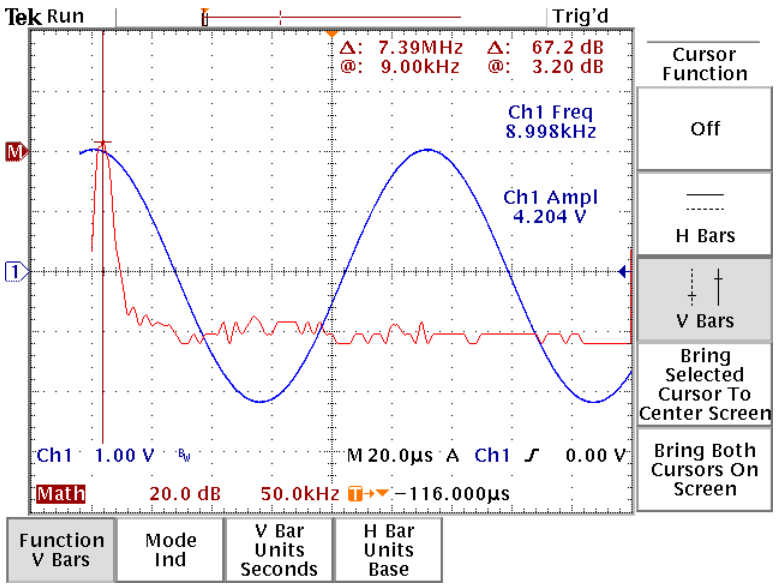


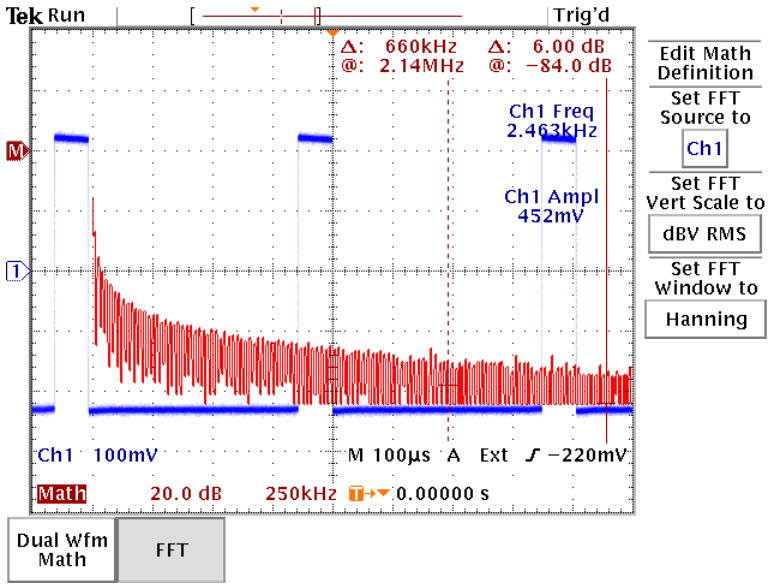




This week: "Introduction to Oscilloscope, Function Generator, DMM"

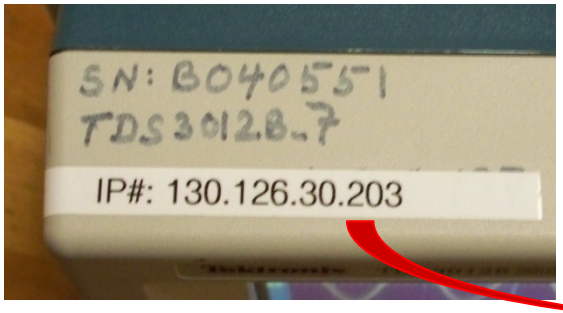
Digital Oscilloscope Tektronix TDS3012b – Math



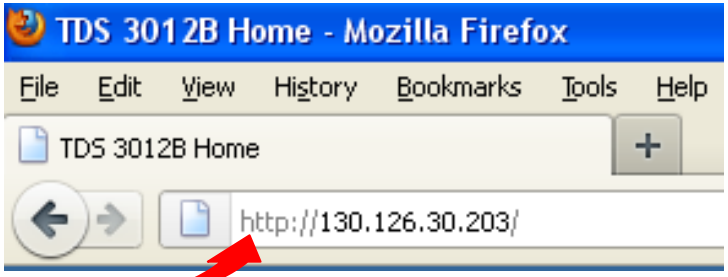


This week: "Introduction to Oscilloscope, Function Generator, DMM"

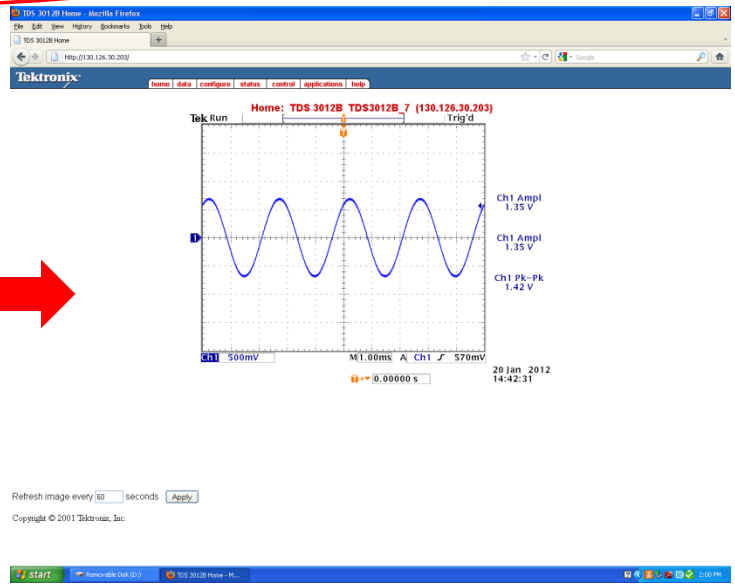
Retrieving the data from scope. All scopes in the Lab are connected to network



Find IP address of the scope on the top of its case and type it in the browser window

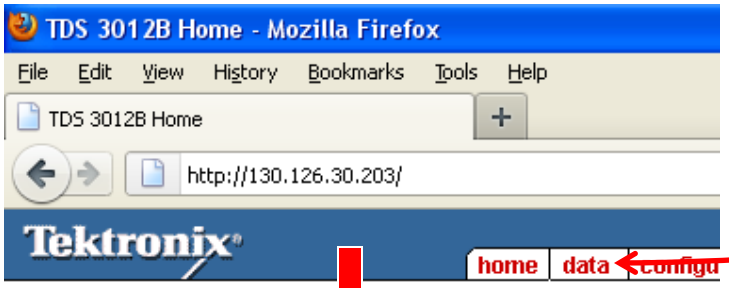


You will have access to the scope screen image and data stored in scope memory from computer



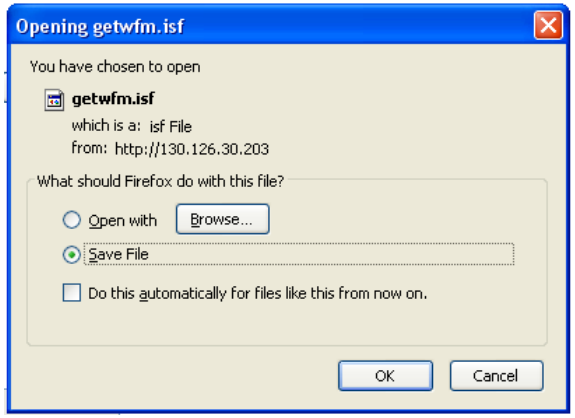
This week: "*Introduction to Oscilloscope, Function Generator, DMM*"

Retrieving the data from scope.



To get the data from scope – click on *data* button in Tektronix window

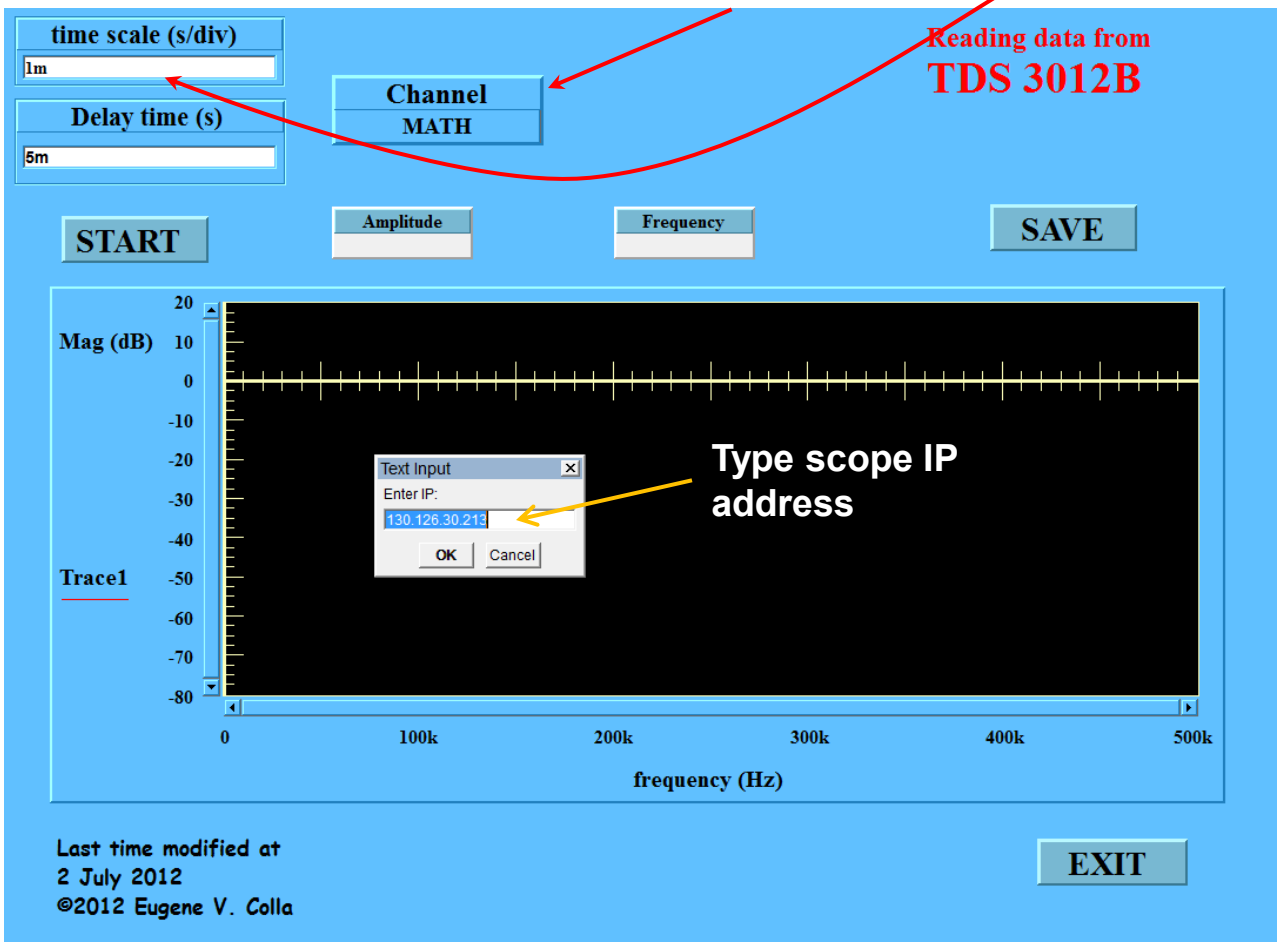
In data window choose the proper channel and format and click "*Get*". *Spreadsheet* format corresponds to ASCII



Downloading the data

This week: "Introduction to Oscilloscope, Function Generator, DMM"

Choose the scope channel and time scale



This program will help you to take data much faster than using Tektronix site.

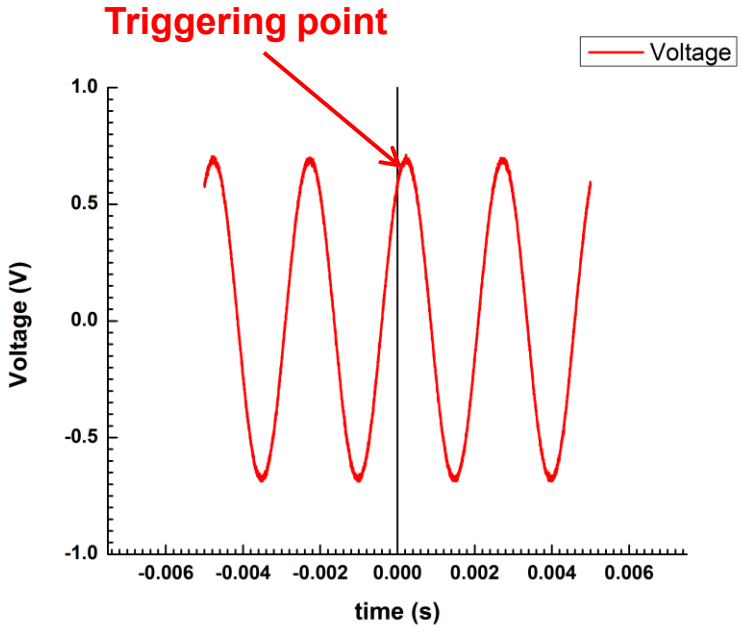
This week: "Introduction to Oscilloscope, Function Generator, DMM"

Retrieving the data from scope.

Now we import the data in Origin, Excel

sine1 - sine1.dat

	A(X)	B(Y)
Long Name	time	Voltage
Units	s	V
Comments		
Sparklines		
1	-0.005	0.59
2	-0.005	0.58
3	-0.005	0.58
4	-0.005	0.59
5	-0.005	0.59
6	-0.005	0.57
7	-0.00499	0.58
8	-0.00499	0.58
9	-0.00499	0.59
10	-0.00499	0.6
11	-0.00499	0.58



The first column represent time in sec accounted from triggering event. The second – voltage applied to corresponding channel

This week: "Introduction to Oscilloscope, Function Generator, DMM"

The most important things which you have learn from Lab1:

- **Function generator.** Manipulating with wave form, frequency, amplitude of the signal. What is the output resistance of the generator.
- **DMM.** Input resistance of DMM. Measuring AC signals. What is rms and how to calculate it.
- **Oscilloscope.** Triggering. Time base. Input sensitivity. Input resistance. Averaging. Simple math operations. Using computer for downloading the images and data from scope. Plotting this data on computer (Origin).
- **General.** Access to the Lab portal. Create a personal folder in "Students" area.