Introduction to the Lab

PHYS375

Experimental Physics Laboratory

Purpose of the Course

- How to learn physics through experimentation.

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- ✓ How to learn physics through experimentation.
- Basic Optics

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- ✓ How to learn physics through experimentation.
- ✓ Basic Optics
- How to keep a laboratory notebook

Purpose of the Course

- ✓ How to learn physics through experimentation.
- ✓ Basic Optics
- ✓ How to keep a laboratory notebook
- How to present your results

Purpose of the Course

- ✓ How to learn physics through experimentation.
- ✓ Basic Optics
- ✓ How to keep a laboratory notebook
- ✓ How to present your results
- **<u>Experimental physics is fun!</u>**

Components of Your Experiments

- Determine what you want to measure.

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- Understand your instrumentation.

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  - ✓You must play with your instruments.
  - – Take test runs of the data.

Components of Your Experiments

- ✓Determine what you want to measure.
- Understand your instrumentation.
  - ✓You must play with your instruments.
  - ✓Take test runs of the data.
  - – Determine what will work best for what you want to measure.

Components of Your Experiments

- ✓ Determine what you want to measure.
- ✓ Understand your instrumentation.
- Plan an approach – *should be based on the capability of your instrumentation and what you want to measure.*

Components of Your Experiments

- ✓Determine what you want to measure.
- ✓Understand your instrumentation.
- Plan an approach.
  - Determine the measurement order.

Components of Your Experiments

- ✓ Determine what you want to measure.
- ✓ Understand your instrumentation.
- Plan an approach.
  - ✓ Determine the measurement order.
  - – Determine how many measurements to make.

Components of Your Experiments

- ✓Determine what you want to measure.
- ✓Understand your instrumentation.
- Plan an approach.
  - ✓Determine the measurement order.
  - ✓Determine how many measurements to make.
  - – Generate templates to make data collection organized and straightforward.

Components of Your Experiments

- ✓ Determine what you want to measure.
- ✓ Understand your instrumentation.
- Plan an approach.
  - ✓ Determine the measurement order.
  - ✓ Determine how many measurements to make.
  - ✓ Generate templates to make data collection organized and straightforward.
  - – Determine what other information is needed.

Components of Your Experiments

- ✓ Determine what you want to measure.
- ✓ Understand your instrumentation.
- ✓ Plan an approach.
- Do your experiment – *make careful measurements and modify your approach*.

Components of Your Experiments

- ✓ Determine what you want to measure.
- ✓ Understand your instrumentation.
- ✓ Based on the above, plan an approach.
- ✓ Do your experiment.
- Analyze your data.

Components of Your Experiments

- ✓ Determine what you want to measure.
- ✓ Understand your instrumentation.
- ✓ Based on the above, plan an approach.
- ✓ Do your experiment.
- ✓ Analyze your data.
- Present your results.

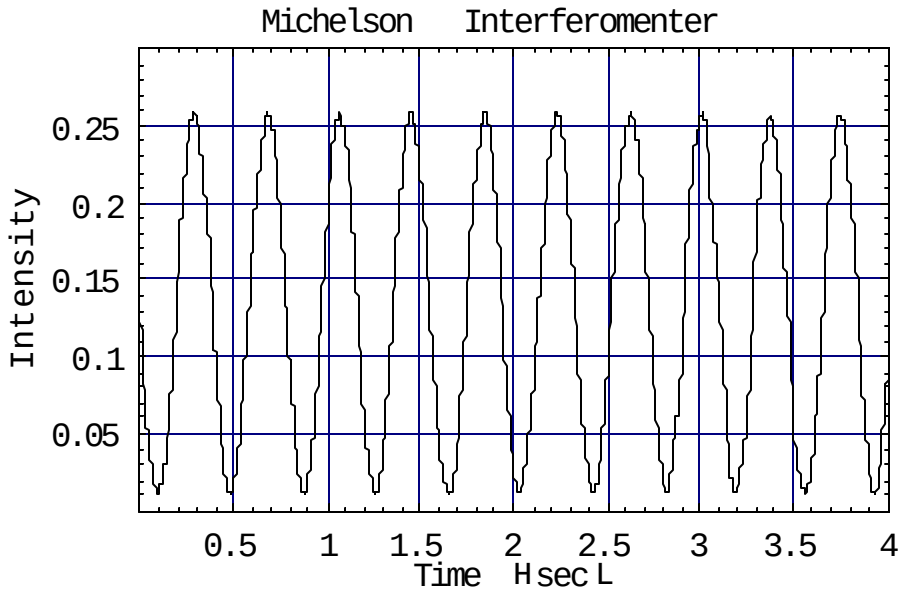
Data Analysis

Mathematica

Data Analysis

Mathematica

- Plot data



Data Analysis

- ✓ Plot data
- Analyze and fit data

```
model = a + b Cos@f + w tD^2;

fit = NonlinearFit@dat, model, t, initialvaluesD
```

	Estimate	Asymptotic SE	CI
a	0.012774	0.000538184	80.0117185, 0.0138294<
b	0.242529	0.000892566	80.240779, 0.24428<
f	0.74319	0.00368907	80.735956, 0.750425<
w	8.14337	0.00161167	88.14021, 8.14653<

$$0.012774 + 0.242529\,\mathrm{Cos@0.74319} + 8.14337\,tD^2$$

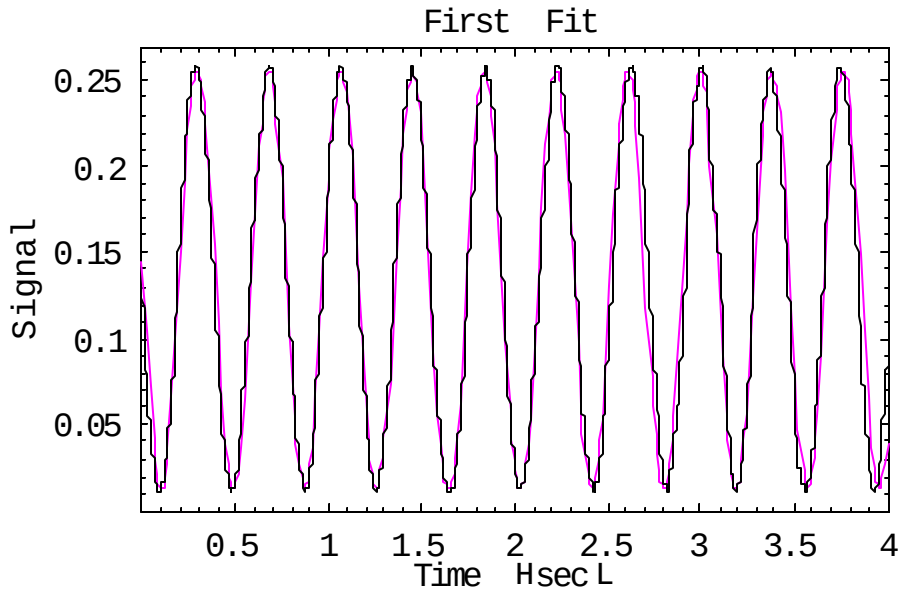
Data Analysis

Mathematica

✓ Plot data

✓ Analyze and Fit data

- Present data



Grades

• Articulation of the problem	5 pts
• Description of the instrumentation	15 pts
• Outline of the approach	10 pts
• Experimental technique	10 pts
• Data	20 pts
• Analysis	20 pts
• Presentation	20 pts

Keeping Lab Notebook

Required Entries

- Date
- Discussion of experiment

Required Entries

- ✓ Date – note the date (and sometimes the time) whenever you jot down notes.
- Give enough information that you can return to this a year from now and understand exactly what you are talking about

Overview

Setup : Laser Beam (Part I)

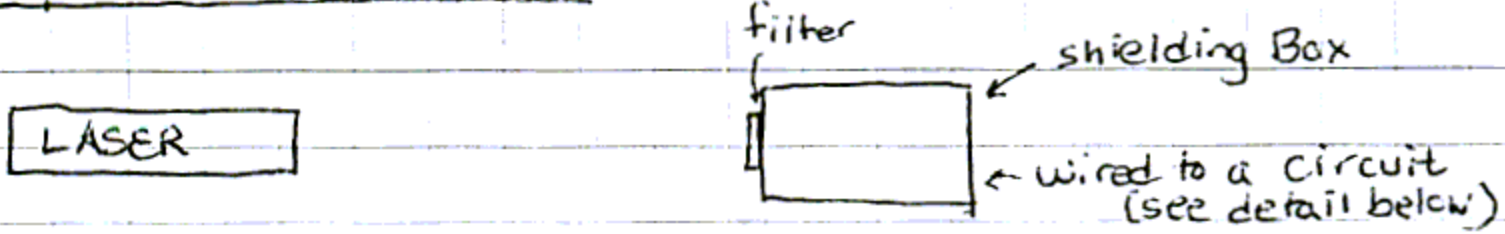


FIG 1

Setup: Mercury Lamp (Part II)

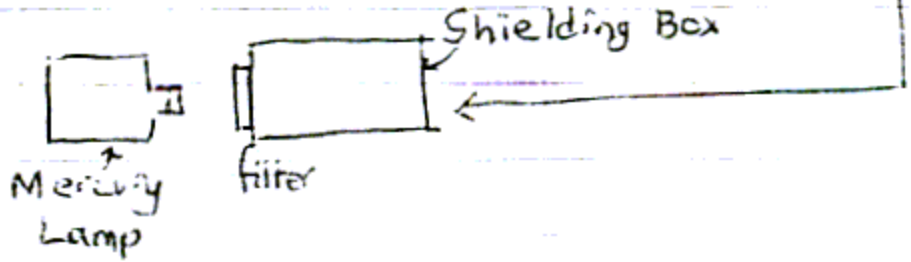


Fig 2

Detailed Circuit

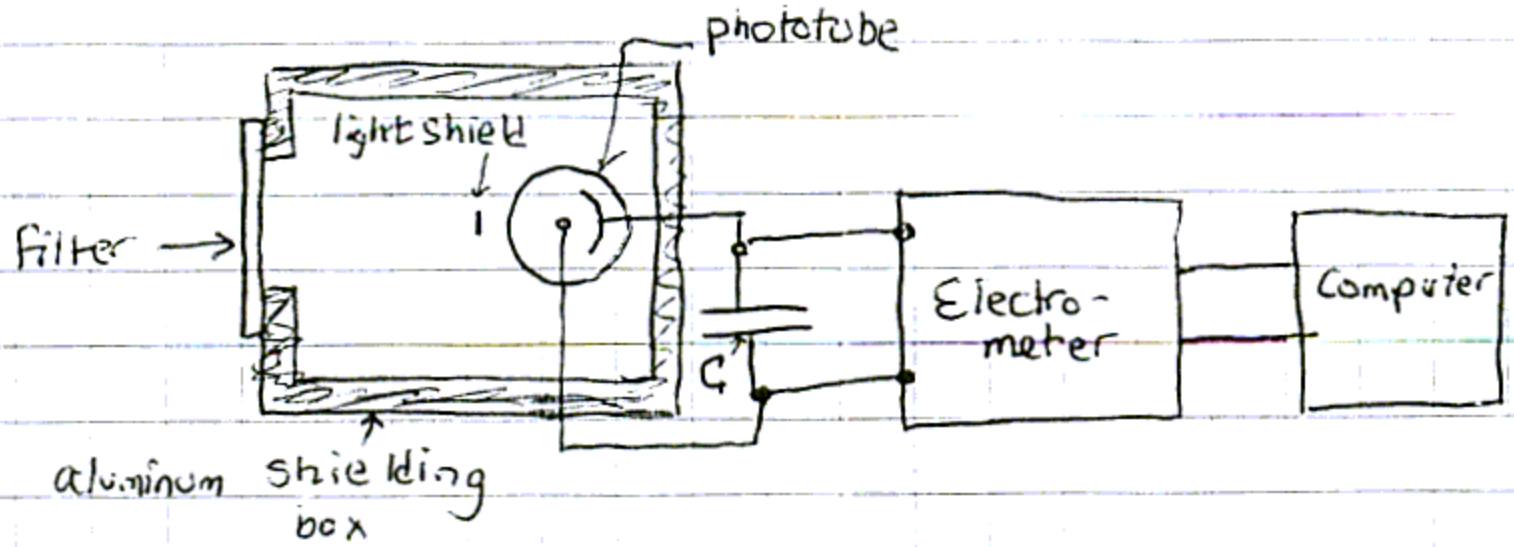


FIG 3

Instruments Used

- Electrometer
- Computer Interface Module
- Acquire.EXE
- HeNe Laser
- Mercury lamp
- Plastic Screwdriver
- Capacitor (I chose .03 μF)
- Filters (#d 0-4)

If there are any special properties of these instruments you should summarize them. You also might indicate where you can find the manuals.

Procedure

1. Project the laser beam parallel to the optical axis of mirror, + normal to it. Then translate the beam a distance a away, parallel to optical axis. Measure a + b:

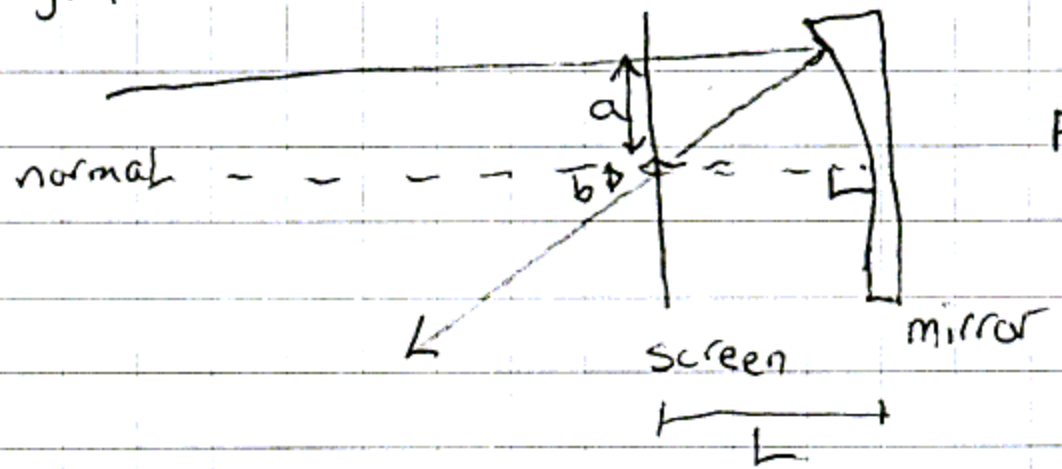


FIG B

Insert notes to direct attention to where more detail is given.

Procedure

Part I : The Laser Beam

1) Setup the apparatus as shown in FIG 1 (P. 34).
2) Referring to FIG 3 (P. 34), wire up the circuit described:
   a) Connect the photo-tube module to the CSS module w/ a BNC shielded cable.
   b) Connect the signal output from the CSS module to the input of the electrometer, again using a BNC cable.
   c) Connect output of the electrometer to the signal terminals (Channel 0) on the computer interface module.
   d) Connect the ground terminal on the electrometer to the ground terminal on the computer interface module.

value of the capacitance.

3) Direct the laser beam into the aluminum shielding box so that it hits the light shield (refer to figure 3). Once this is done, use the filter numbered with a zero in front of the shielding box and shine the light.

4) Set up ACQUIRE to take data at a reasonable sampling rate (25-50 Hz) making sure to adjust the numbers of points taken to achieve a full picture of the asymptotic behavior. Be sure to use an external trigger!!

after triggering, wait a few seconds and flip the switch on the right side of CCS module to OPEN

5) After each trial, save the data and open it in Mathematica to determine the asymptotic value, V_0. Also be sure to set the capacitor back to the SHORT position after each run.

What is missing here is the date of the subsequent entry!

Required Entries

- ✓ Date
- ✓ Discussion of experiment
- Data

Data entry table

I. Concave mirror

Position of mirror: 3.8 cm ± .3 cm

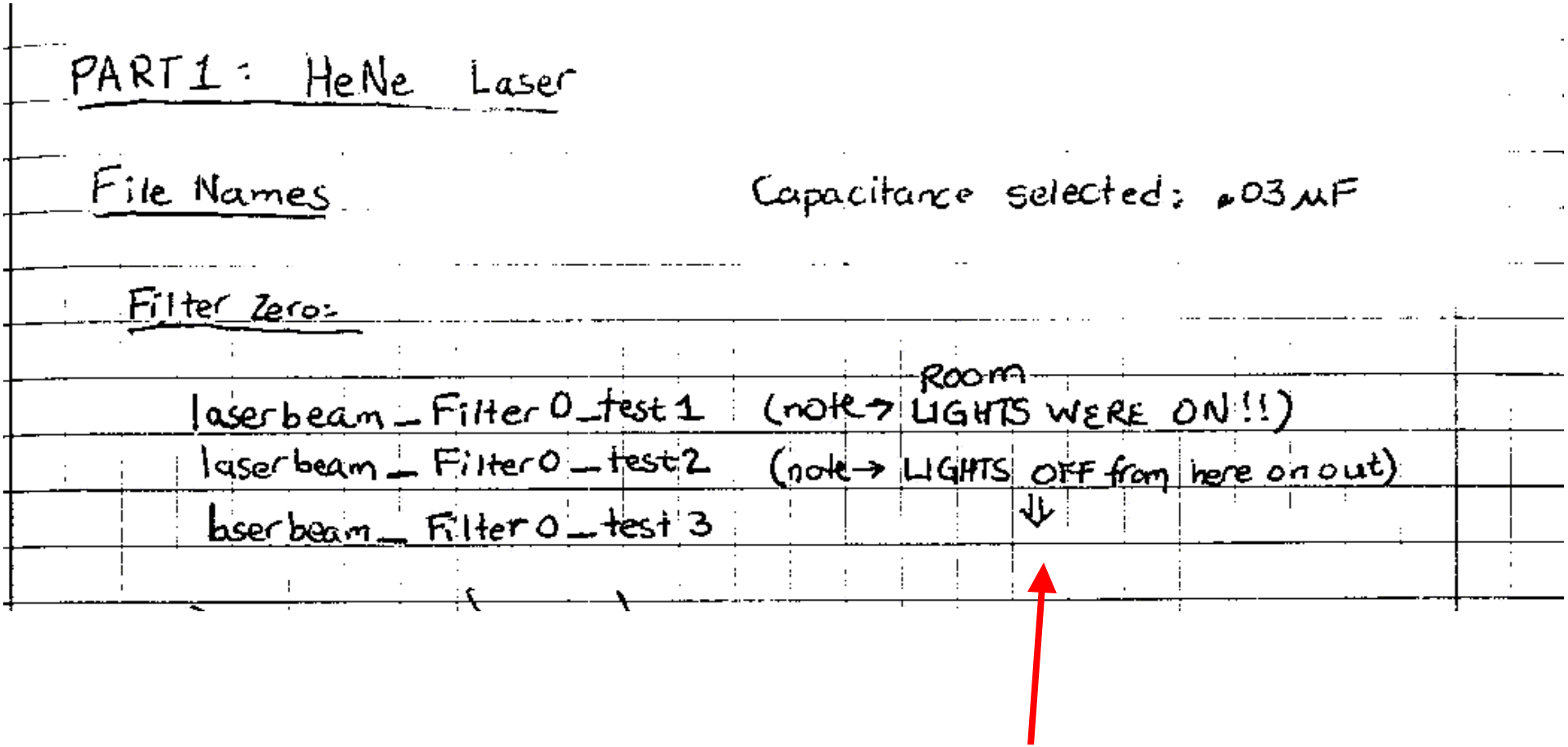
Trial	pos. of object (cm)	pos of image (cm)	So(cm)	Si(cm)	
1	69.9 cm ± .2cm	105.1 cm ± .5cm	66.1 ± .2	101.3 ± .9	REAL IMAGES TABLE 1.A
2	85.5cm ± .2cm	117.6 ± .5cm	81.7 ± .2	113.8 ± .4	
3	80.5 cm ± .2cm	114.4 ± .5cm	76.7 ± .2	110.6 ± .4	
4	74.8cm ± .2cm	103.5 ± .5cm	71.0 ± .2	99.7 ± .4	
5	81.75 ± .1	23.95 ± 1	18.05 ± .1	-31.75 ± 1	Virtual Images TABLE 1.B
6	72.2 ± .1	36.5 ± 1	8.5 ± .1	-27.2 ± 1	
7	79.5 ± .1	16.4 ± 1	15.8 ± .1	-47.3 ± 1	
8	85.5 ± .1	4.6 ± 2	21.8 ± .1	-60.0 ± 2	

Position of Mirror: 63.7 ± .1 cm

Required Entries

- ✓Date
- ✓Discussion of experiment
- ✓Data
- Analysis
- Location of additional information
- References

Raw data location



Can also add notes about conditions of experiment

Required Entries

- ✓ Date
- ✓ Discussion of experiment
- ✓ Data
- ✓ Analysis
- ✓ Location of additional information
- References

Best Fits

⇒ Filter 1 not included in fits

Fit one

m : .0000869883 $\quad \sigma_m$: .0000143652

b : −.866597 $\quad \sigma_b$: .295391

Value of $\frac{h}{e}$: $= \frac{m}{3\times10^{10}} = 2.89962\times10^{-15}\ \frac{J\cdot S}{C}$

$\sigma\left(\frac{h}{e}\right) = \frac{\sigma_m}{3\times10^{10}} = 4.7884\times10^{-16}\ \frac{J\cdot S}{C}$

Accepted value of $\frac{h}{e}$: (from Mathematica notebook) : $4.13567\times10^{-15}\ \frac{J\cdot S}{C}$

Required Entries

- Date
- Discussion of experiment
- Data
- Analysis
- Location of additional information
- References
- Conclusions

Experiment 1 Overview

Velocity of Sound Waves

Your Measurement

- Measure resonant frequencies for several columns of air using a speaker, microphone and an oscilloscope. Extract v_{sound} from your analysis
- Measure atmospheric parameters (temperature, humidity, pressure) then calculate v_{sound}.

Before You Start

- Read the manuals
- Find out where to obtain the other information required to complete the experiment.

Error (Uncertainty) Analysis

Overview