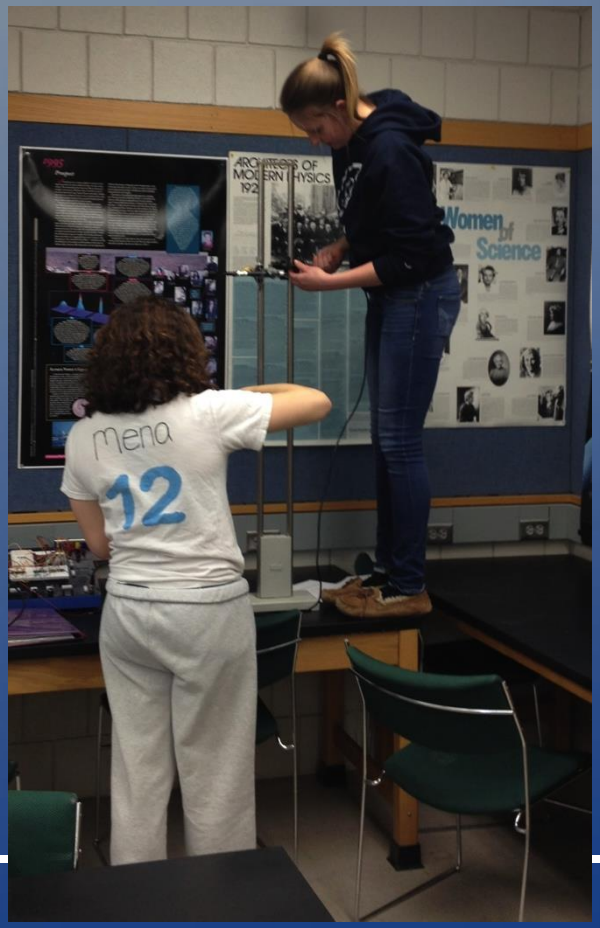
ITHACA COLLEGE

A Dissociated, Progressive Introductory Physics Laboratory



Physics 120
Intro Applied Physics Lab

Bruce Thompson

31 July 2014

AAPT Summer 2014

Department of Physics and Astronomy

Acknowledgements

Physics 120 Lab

Original Inception and Implementation circa 1985:

Peter Seligmann, Ithaca College 1971-2002
Charles Spencer, Ithaca College 1973-2003

Caretaker 2004-2010:

Michael Rogers

Caretaker 2011-Present:

Bruce Thompson

Photo: Ithaca Physics

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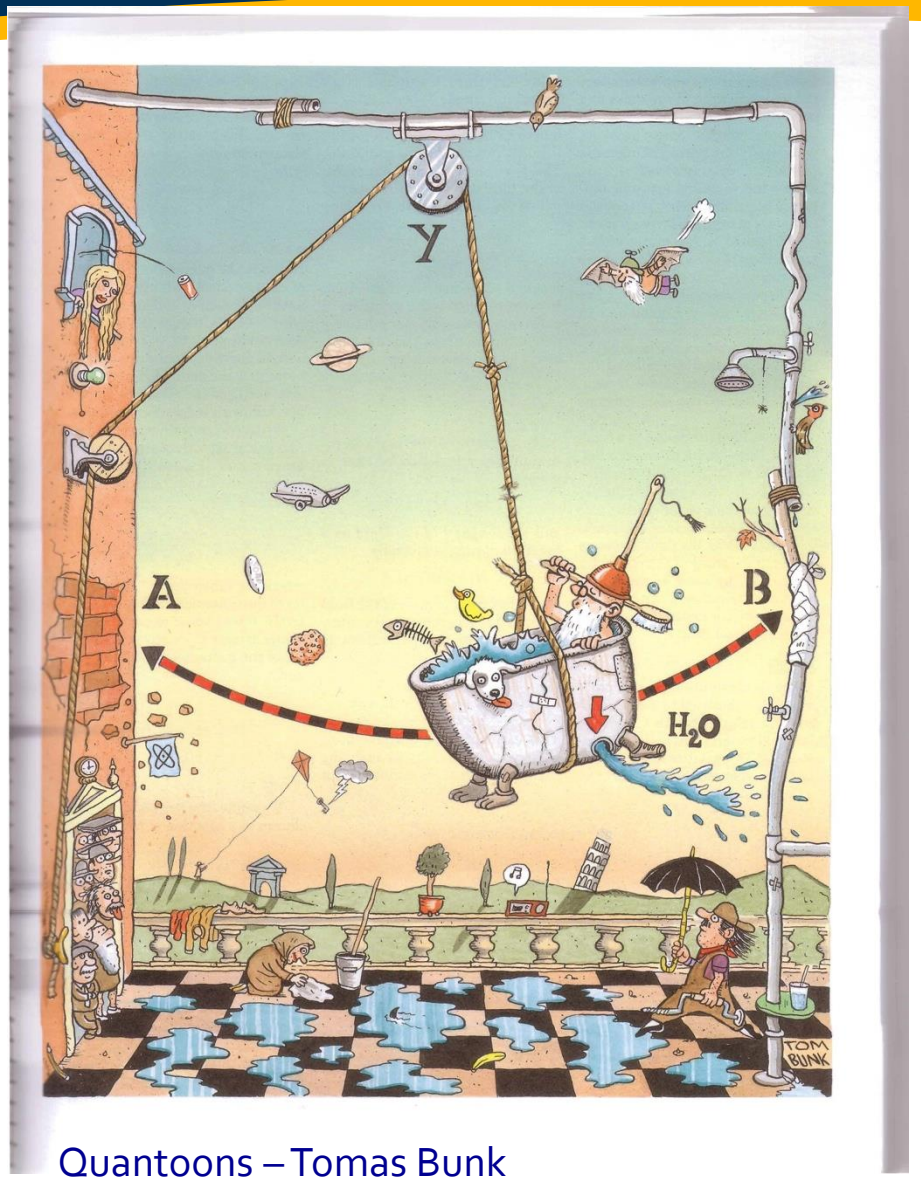
Philosophies

Physics 120 Lab

- Go on a journey.
- Dive deep.
- Look under the hood.
- Reinvent the wheel.
- No more spherical cow.
- Get your hands dirty.
- Develop a bull&%# detector.
- Grind a pound of data.
- Tell the tale of your journey.



Quantoons – Tomas Bunk

Course is Dissociated

Physics 120 Lab

Fall First Year
- Mechanics (SCALE-UP)
- Calc 1

Spring First Year
- E&M (SCALE-UP)
- Calc 2
- “Mechanics” Lab – Ph120

Fall Second Year
- Waves, Optics, Thermo
- Calc 3
- “E&M” Lab

Spring Second Year
- Modern Physics
- CompSci 1 (Python)
- Linear Algebra or Calc 4

Course is Dissociated

E&M Lab

Fall First Year
- Mechanics (SCALE-UP)
- Calc 1

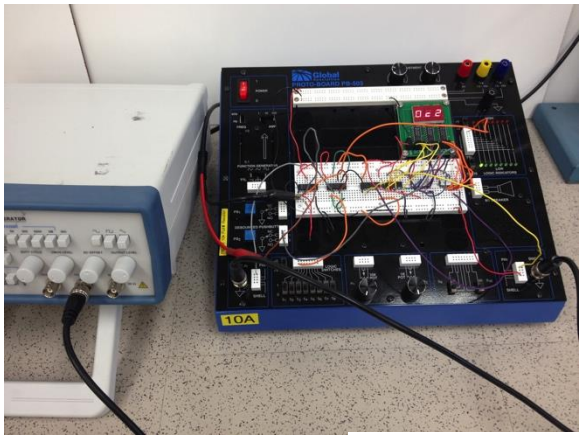
Spring First Year
- E&M (SCALE-UP)
- Calc 2
- “Mechanics” Lab – Ph120

Fall Second Year
- Waves, Optics, Thermo
- Calc 3
- “E&M” Lab

Spring Second Year
- Modern Physics
- CompSci 1 (Python)
- Linear Algebra or Calc 4

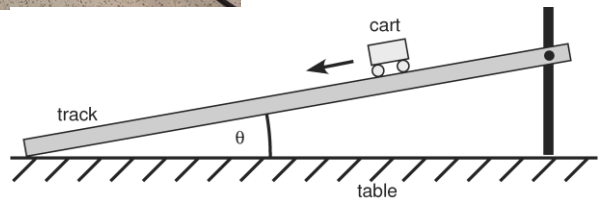
What the students do:

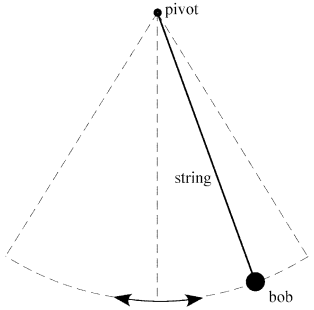
Build a photogate timer from scratch (1/3 semester)

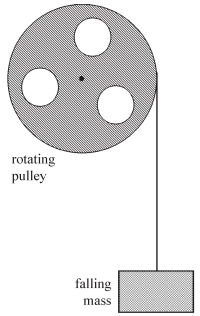


Use the timer for measurements in 3 mechanical systems (2/3 semester)

1. Linear Accelerated Motion
2. Simple Pendulum
3. Rotational Accelerated Motion with Rotational Inertia





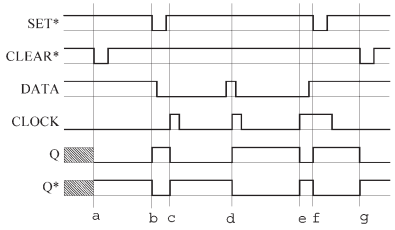


Course is Progressive

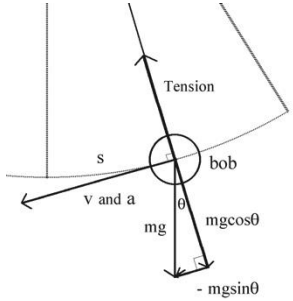
Physics 120 Lab

Skills are developed and themes are maintained throughout the semester.

Logical thinking



Mechanics redux

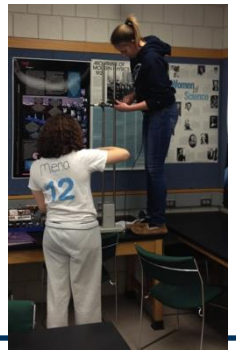


Modelling

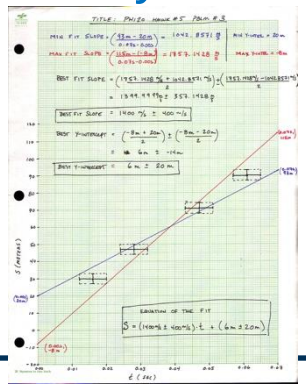
$$T = 2p\sqrt{L/g}$$

$$\left(T^2\right) = \frac{4p^2}{g}\left(L\right) + 0$$

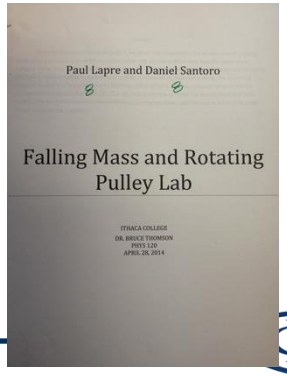
Dexterity



Analysis



Communication



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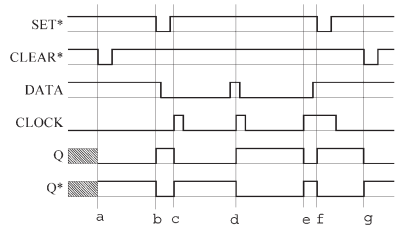
Course is Progressive

Physics 120 Lab

Skills developed and themes maintained throughout the semester

Logical thinking



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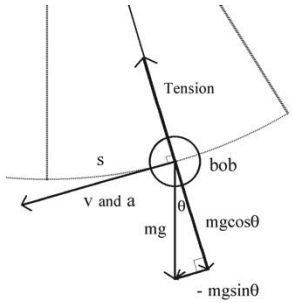

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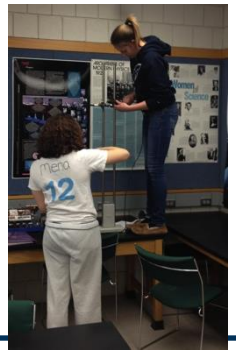

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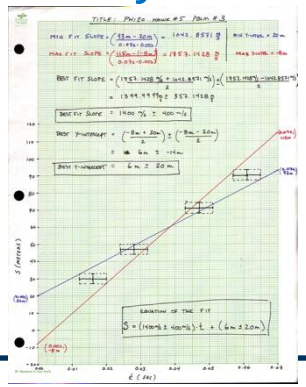

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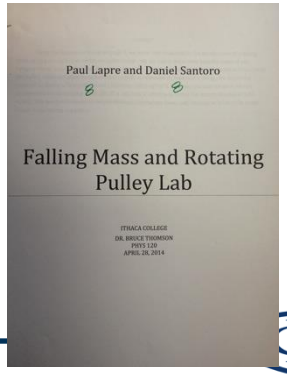

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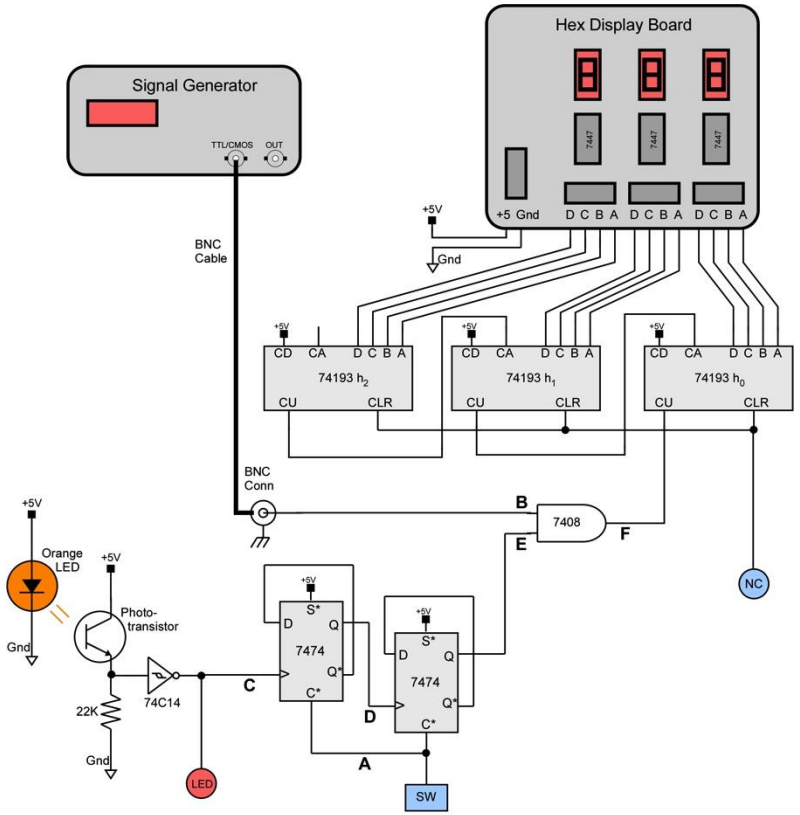
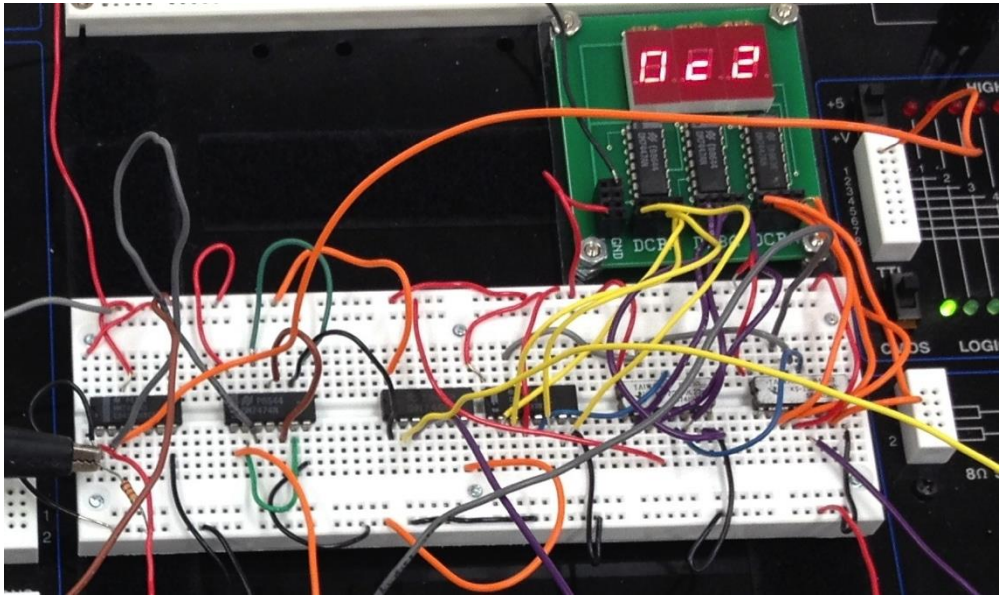
Logical Thinking 1

Digital circuit analysis

Ph120 Pendulum Timer



Circuit troubleshooting



Logical Thinking 2

Experimental procedure design

Student generated procedure

Description of the steps needed to obtain the counts

1) We first set the signal generator to about 100000 Hz and made sure that it maintained the frequency and didn't fluctuate by a lot. We recorded the data on an EXCEL spreadsheet.
2) Then, we wrapped the string we used around the pulley.
3) Next, we added the mass to the end of the string and made sure that the phototransistor was in place. We recorded the measurement of the mass and its uncertainty in our EXCEL spreadsheet.
4) If necessary, we adjusted the phototransistor and made sure the light was either blocked or unblocked, depending on the respective angular position of the pulley.
5) Then we made sure that our circuit was wired correctly and checked whether any of the wires were loose.
6) We then started the program on a computer ("Get120TimerData") in order to start recording data and counts, which we copied to an EXCEL spreadsheet if the measurements seemed reasonable.
7) By taking the counts and the frequency, we were able to figure out the change in time.
8) Then we used the change in time and θ in order to calculate the angular velocity ω.
9) Then we calculated ω^2 and recorded the value in our EXCEL spreadsheet.
10) Next, we took the acquired data and drew the graph ω^2 vs. θ.
11) In order to have a more accurate value for the slope, intercept and their uncertainties of our graph, we used the LINEST function in EXCEL.
12) Lastly, we calculated the linear acceleration of the mass and recorded the data.
13) Then, we repeated this process for the other five masses we were using in order to figure out how different masses would affect the outcome of the experiment.

11

Raw data evaluation

Falling mass
Raw Count
21
464
348
294
263
233
215
198
190
175
171
188
195
204
217

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Logical Thinking 2

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Falling mass
Raw Count

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348
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171 (?)
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195
204
217

Student data choice

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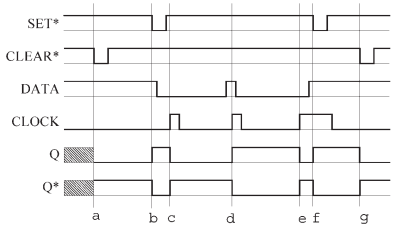
Course is Progressive

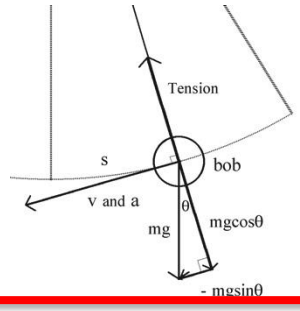
Physics 120 Lab

Skills developed and themes maintained throughout the semester

Logical thinking



Mechanics redux



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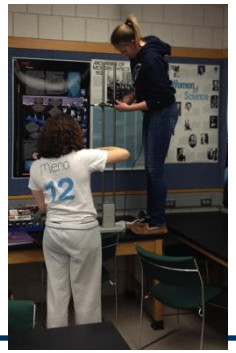
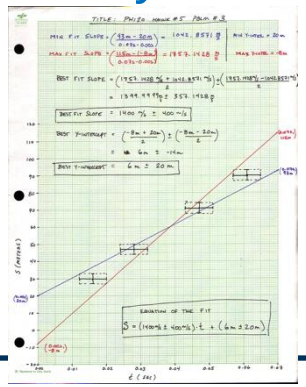
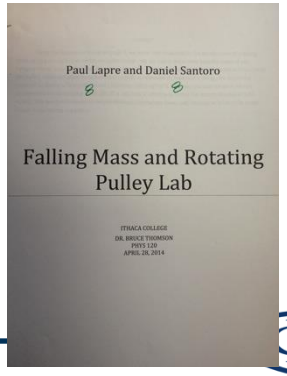
Dexterity



Analysis



Communication



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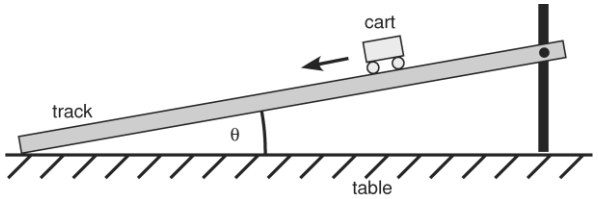
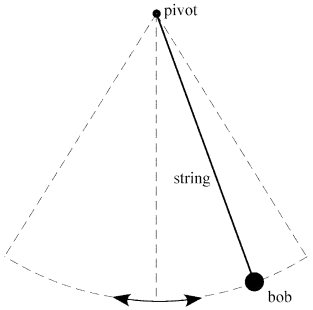
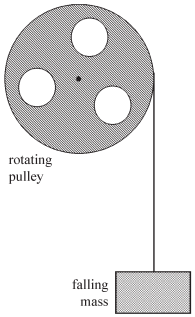
Mechanics Redux



Linear kinematics and dynamics



Pendulum simple harmonic motion and all angle energy solution



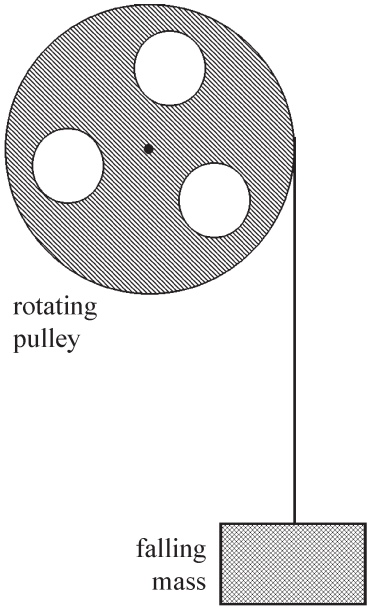
Rotational dynamics

Mechanics Redux

Assessment of "ALL" the forces

$$\sum_i \vec{F}_i$$

$$\sum_i \vec{t}_i$$

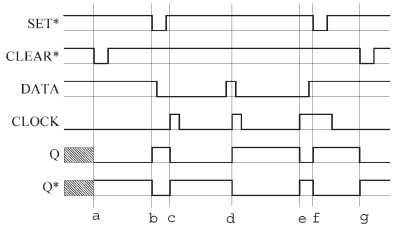


Course is Progressive

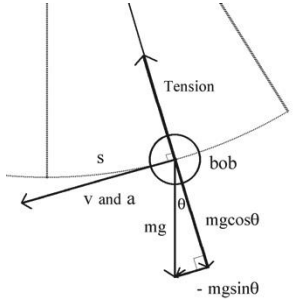
Physics 120 Lab

Skills developed and themes maintained throughout the semester

Logical thinking



Mechanics redux



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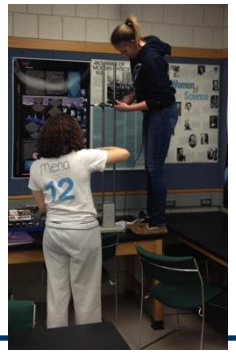
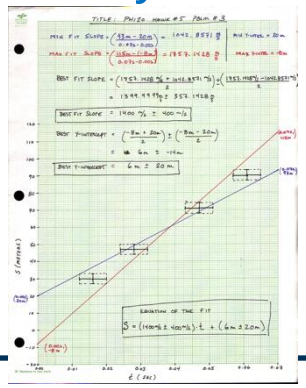
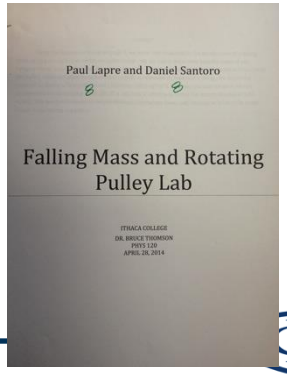
Dexterity



Analysis



Communication



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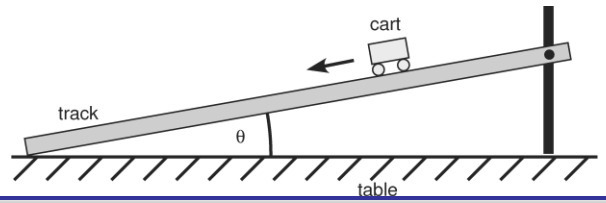
Modeling

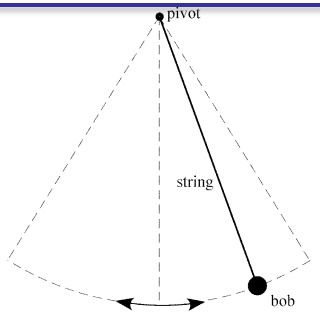
Linearized modeling and model verification $y = Ax + B$



Linear accelerated motion

$$a = g\sin q$$

$$(a) = [g](\sin q) + [0]$$

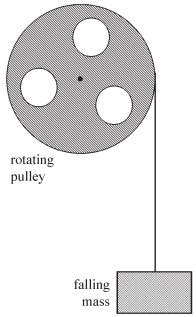


Pendulum small angle approximation and Pendulum all angle

$$T = 2p\sqrt{L/g}$$

$$(T^2) = \left[\frac{4p^2}{g}\right](L) + [0]$$

$$T = \sqrt{\frac{8L}{g}}\,INT(q_0)$$



Falling mass - rotating a pulley

$$a = \frac{mg + F_D + t_f / r}{m + \frac{I}{r^2}}$$

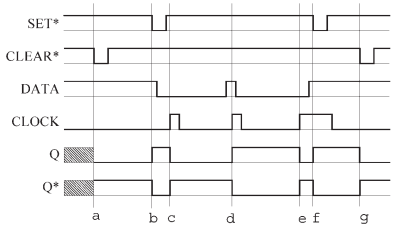
$$\left(\frac{1}{a}\right) = [A]\left(\frac{1}{m}\right) + [B]$$

Course is Progressive

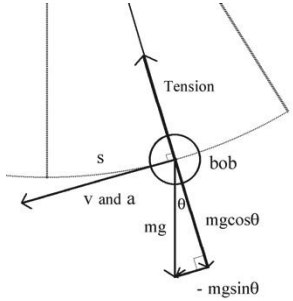
Physics 120 Lab

Skills developed and themes maintained throughout the semester

Logical thinking



Mechanics redux



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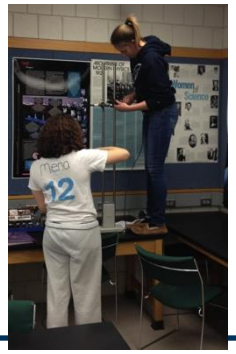

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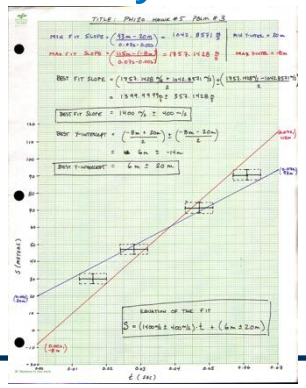
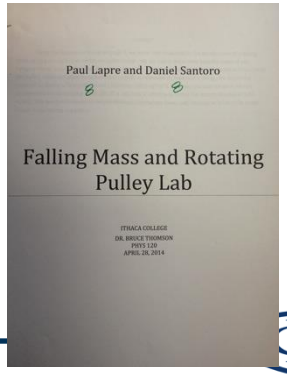


Communication



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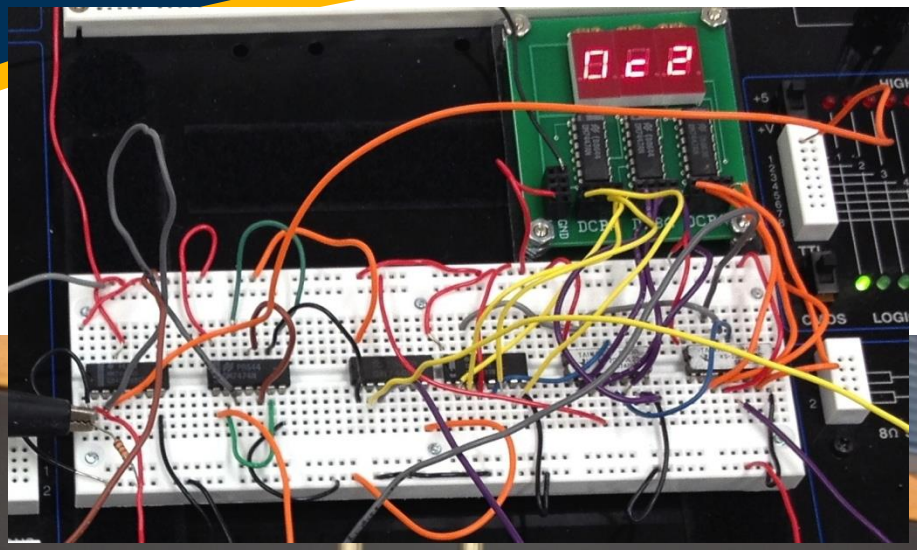
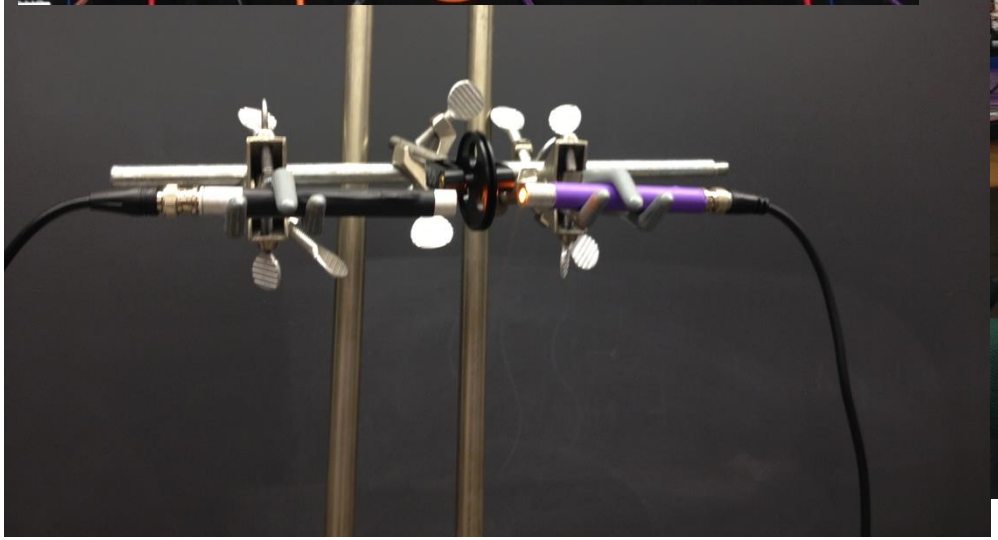
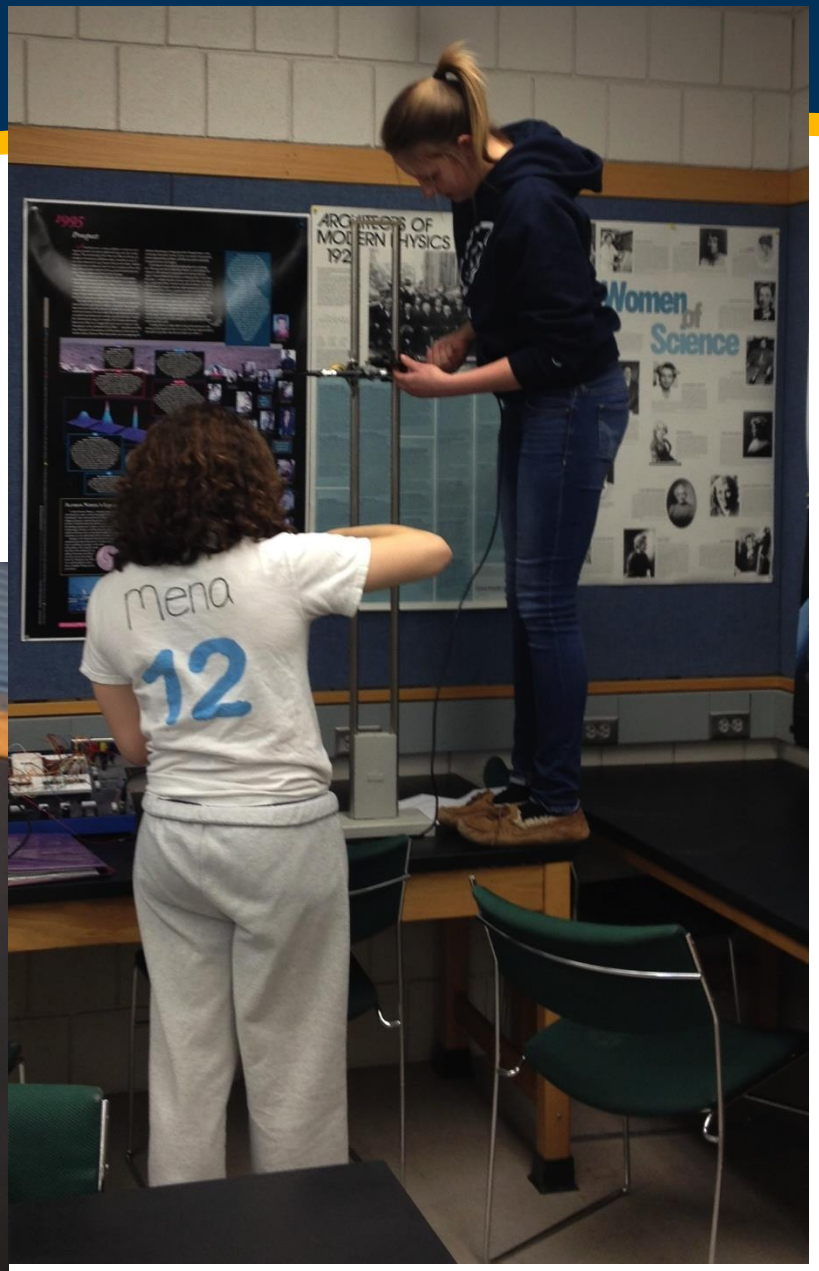
Dexterity







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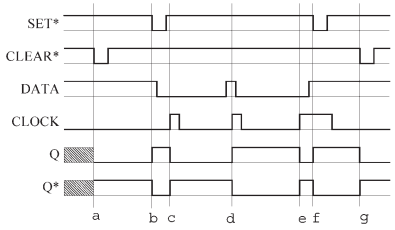
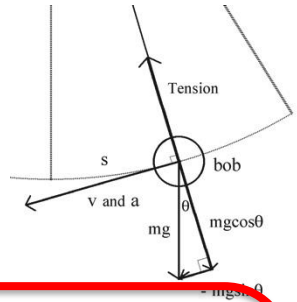


Mechanics redux

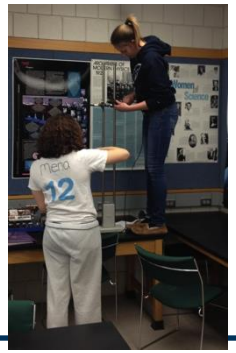


Modelling

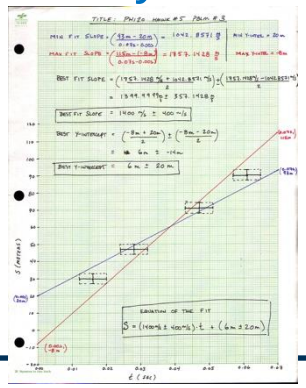
$$T = 2p\sqrt{L/g}$$

$$\left(T^2\right) = \frac{4p^2}{g}\left(L\right) + 0$$

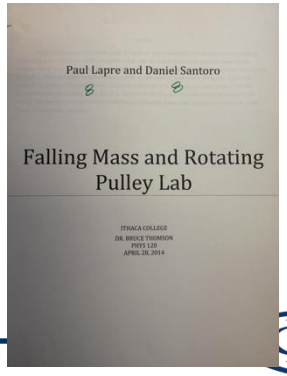
Dexterity



Analysis



Communication



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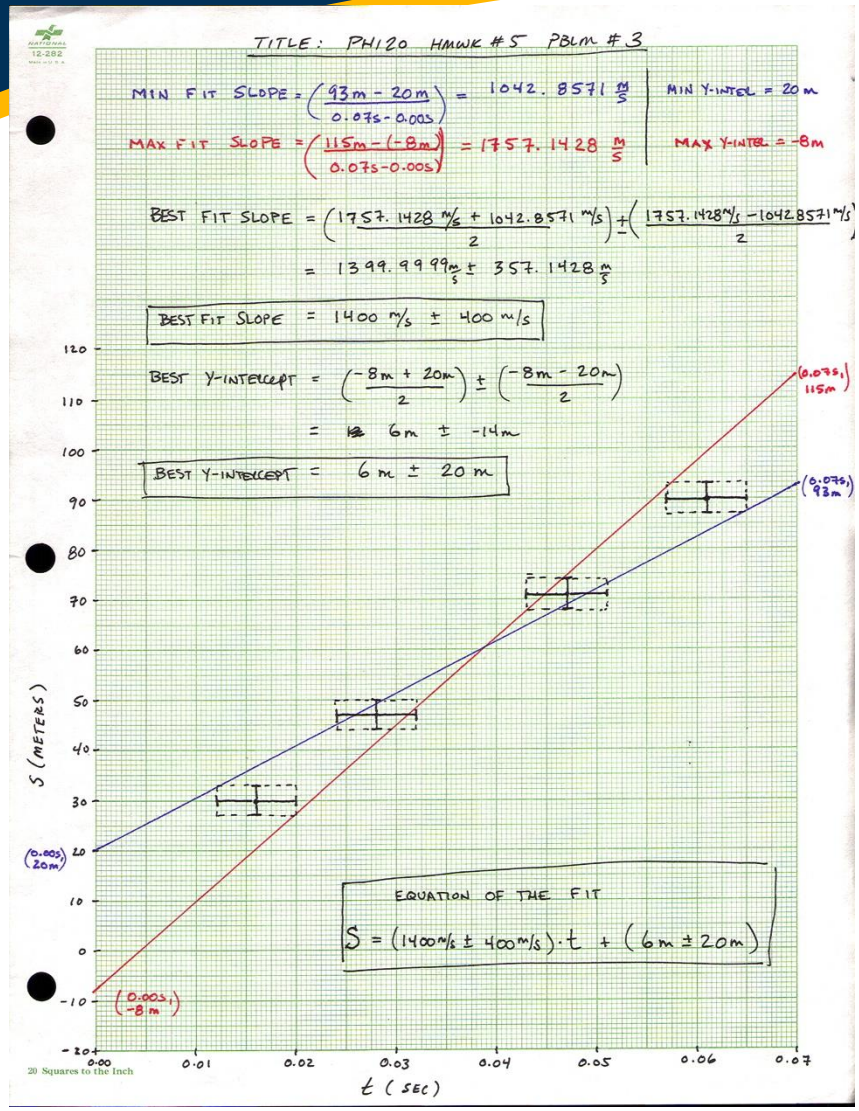
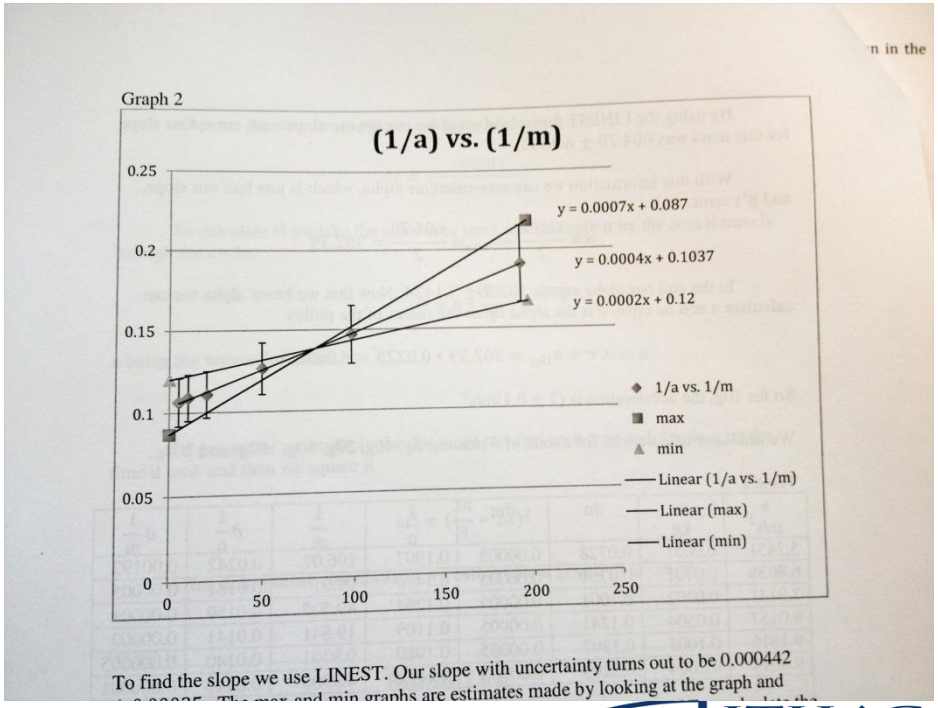
Analysis



From hand drawing …

To

… Spreadsheet analysis

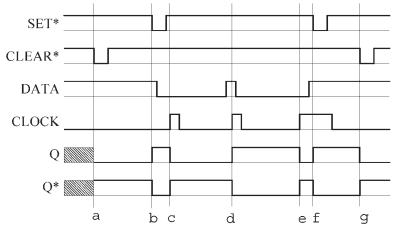


Course is Progressive

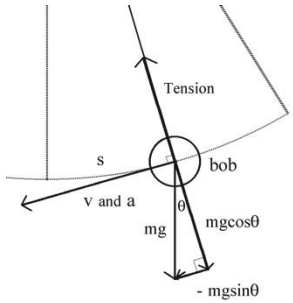
Physics 120 Lab

Skills developed and themes maintained throughout the semester

Logical thinking



Mechanics redux



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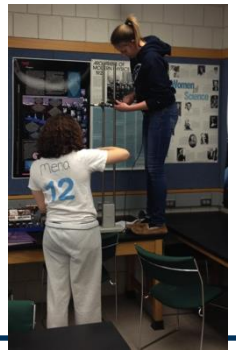
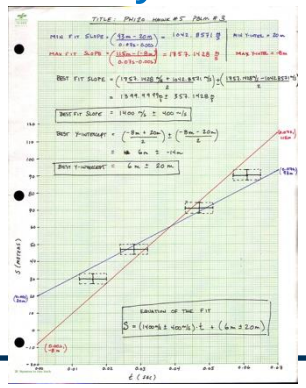
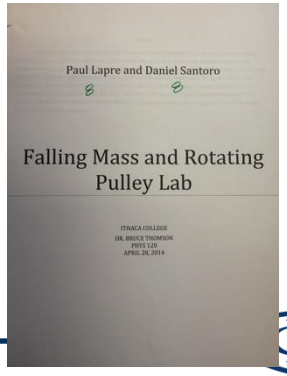
Dexterity



Analysis



Communication



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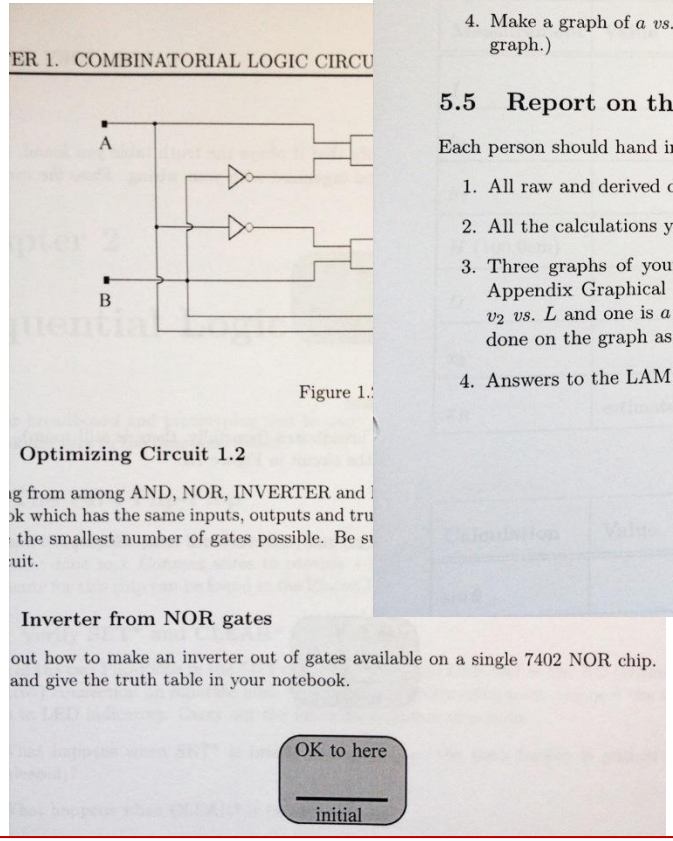
Communication


ER 1. COMBINATORIAL LOGIC CIRCU

A

B

Figure 1.

Optimizing Circuit 1.2

g from among AND, NOR, INVERTER and
k which has the same inputs, outputs and tru
the smallest number of gates possible. Be su
uit.

Inverter from NOR gates

out how to make an inverter out of gates available on a single 7402 NOR chip.
and give the truth table in your notebook.

OK to here

initial

3. Combine your two data points $a_1 \pm \delta a_1$ and $a_2 \pm \delta a_2$ with those of your partner(s). Enter them into the table of Section 5.6.4. Also enter your determinations of $\sin\theta \pm \delta(\sin\theta)$ into the table.
4. Make a graph of a *vs.* $\sin\theta$ of the combined data. (Each group member should do a separate graph.)

5.5 Report on the Experiment

Each person should hand in the following by the due date.

1. All raw and derived data (*i.e.* the tables from the lab manual).
2. All the calculations you did (on separate sheets of paper).
3. Three graphs of your data that adhere to the graphing guidelines of the course (see the Appendix Graphical and Linear Fitting in the Background Manual). Two of them are the v_2 *vs.* L and one is a *vs.* $\sin\theta$. Each graph should have slope calculations and results neatly done on the graph as described in the data analysis section.
4. Answers to the LAM homework questions.

Summary reports

Paul Lapre and Daniel Santoro

Falling Mass and Rotating Pulley Lab

ITHACA COLLEGE
DR. BRUCE THOMSON
PHYS 120
APRIL 28, 2014

Extensive report

Binary reporting (“It worked!”)

ITHACA COLLEGE

Student Reaction

"I learned to think effectively on how to assess data and models."

"I really liked how this class helps you grow as a scientist."

"I don't like estimating."

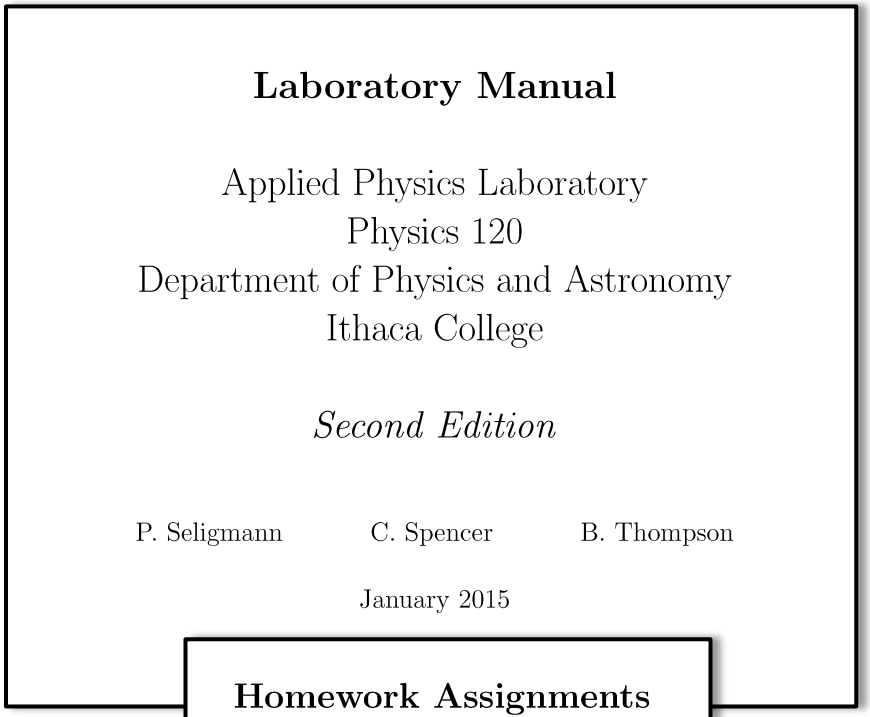
"I learned how to use physical formulas in real life."

"I learned methods to approach problems in a more thoughtful manner."

"I learned so much about logic circuits."
"I've become better at using calculus for physics."
"I learned how to problem-solve better than I was able to before."

Thank you for your interest

Course materials available by writing to me:
bthompso@ithaca.edu



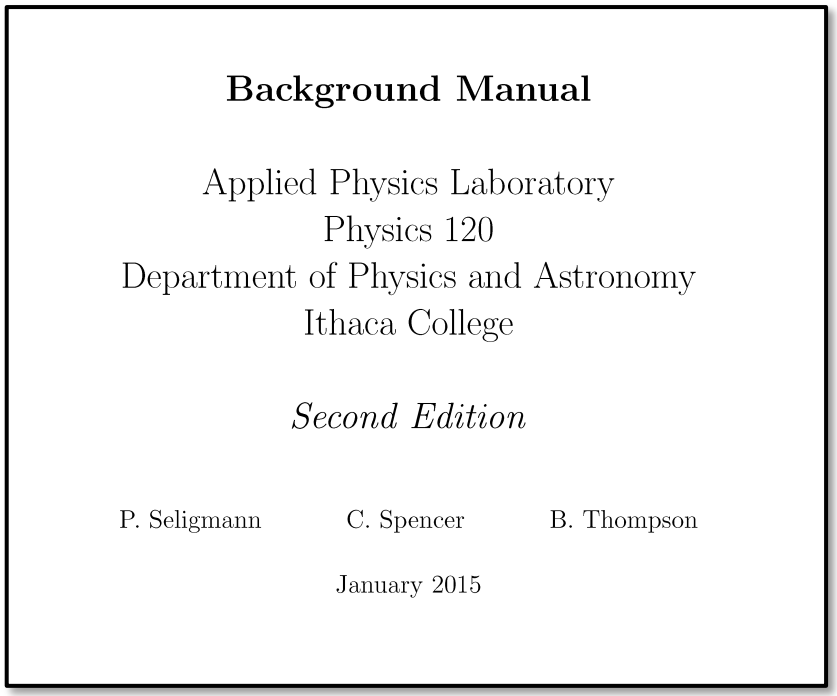
Laboratory Manual

Applied Physics Laboratory
Physics 120
Department of Physics and Astronomy
Ithaca College

Second Edition

P. Seligmann C. Spencer B. Thompson

January 2015



Background Manual

Applied Physics Laboratory
Physics 120
Department of Physics and Astronomy
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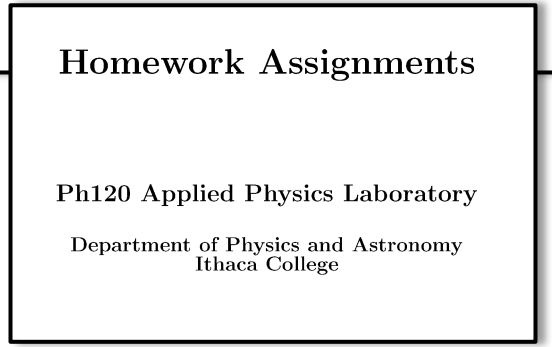
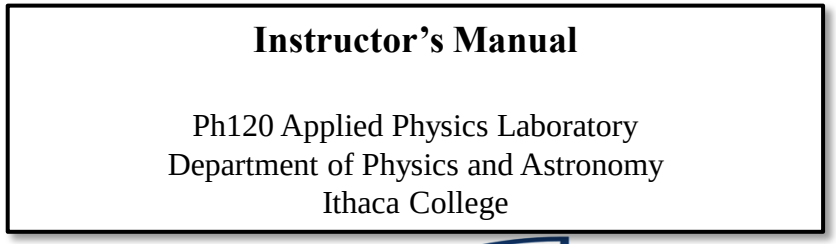


Homework Assignments

Ph120 Applied Physics Laboratory

Department of Physics and Astronomy
Ithaca College



Instructor's Manual

Ph120 Applied Physics Laboratory
Department of Physics and Astronomy
Ithaca College

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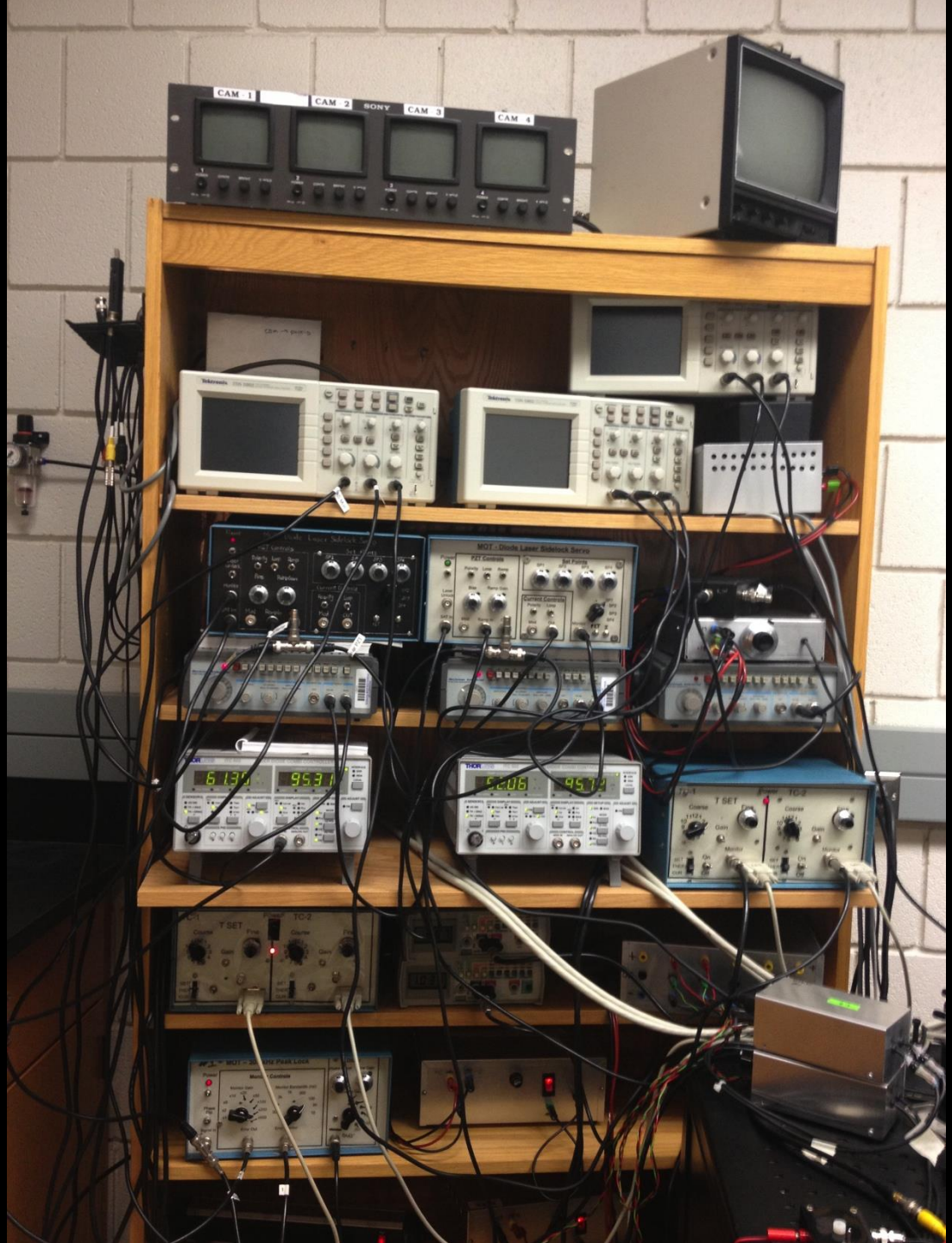
Stop!

Questions?

Next Steps

Video tape lectures
Better notebook skill development


CAM 1
CAM 2
SONY
CAM 3
CAM 4
MOT - Diode Laser Sidelock Servo

Our Newborn Baby MOT!

DOB 2011-09-02