

# Physics Lab Set-up

Thomas More College



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- Physics faculty who designed and contributed to the design of the lab experiments
  - Jack Wells
  - Dr. Wes Ryle
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# Download the PDF here

A large PDF of this document can be found at <http://physics.thomasmore.edu/labs/TMC-lab-setup.pdf>.



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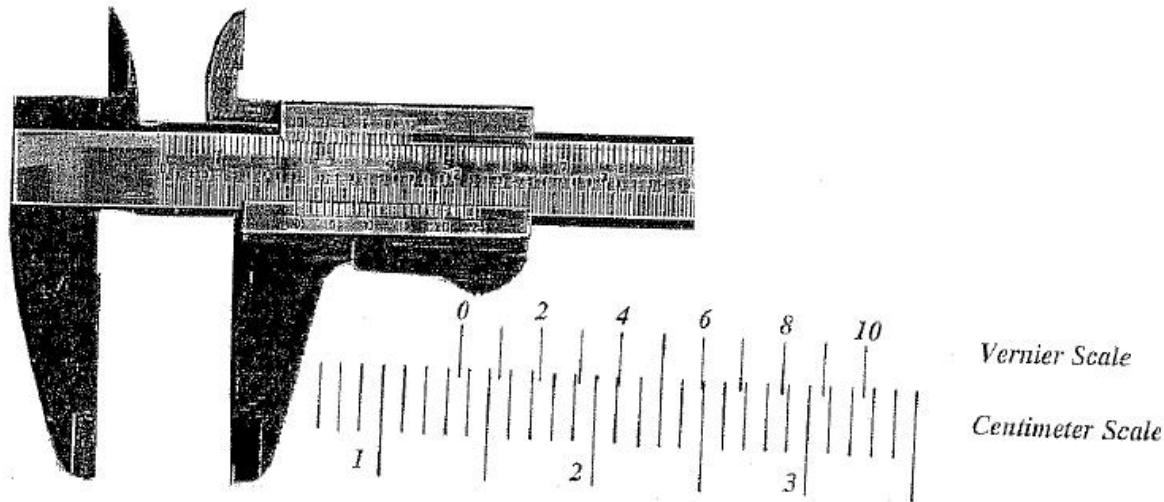
# Class 1

## PHY 121L: Elements of Physics (algebra-based, fall)

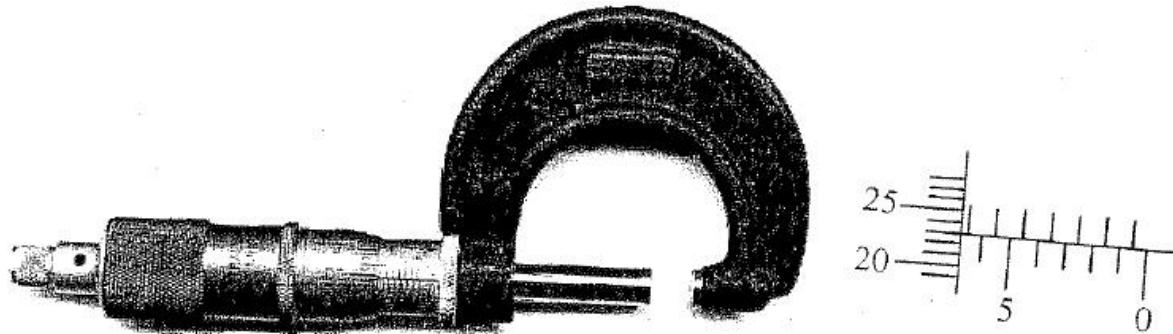
### 1.1 Meaningful Measurements

Location	Equipment	Notes
<b><i>For Each Lab Station</i></b>		
AA13	1 Vernier caliper ( <a href="#">Figure 1.1.2</a> )	Ask faculty if they want digit or analog before and after lab, verify digital calipers are turned off
AA14	1 micrometer ( <a href="#">Figure 1.1.2</a> )	before and after lab verify jaws are not tight
AF34-14	1 metric ruler	could be a 1-foot ruler or a 0.25-meter stick
AF55-19	1 tall, skinny, graduated cylinder	at least 2 of the 3 objects should fit inside the graduated cylinder
AE21	string	sufficient string to tie onto the objects in order to immerse them in the cylinder and retrieve them
AE82	3 objects to measure	Ask faculty which objects they want (smooth sphere, rough sphere, cube, block of metal, irregular shape, etc) <b><i>These objects should fit inside the graduated cylinder.</i></b>
<b><i>At the front for students to share</i></b>		
S224	at least 1 digital scale	the available scale(s) should be able to weigh the chosen objects
AF36-4		

**Table 1.1.1:** Equipment Needed: Meaningful Measurements



**Figure 1.1.2:** The Vernier Caliper



**Figure 1.1.3:** The Micrometer Caliper

(Updated: October 12, 2017)

A digital version of the lab should be found at <http://physics.thomasmore.edu/Labs/121/c-meaningful-measurements.html>

A PDF version of the write-up might be found at [Measurement.pdf \(291 kB\)](#)

## 1.2 Standard Deviation

Location	Equipment	Notes
<i>At the front for students to share</i>		
AL32-5	several boxes/bags of pennies	in sufficient number for each student to have up to 50 pennies

**Table 1.2.1:** Equipment Needed: Standard Deviation

(Updated: September 6, 2017)

A digital version of the lab should be found at <http://physics.thomasmore.edu/Labs/121/c-standard-deviation.html>

A PDF version of the write-up might be found at [StDev.pdf \(232 kB\)](#)

## 1.3 Constant Acceleration

Location	Equipment	Notes
<b>For Each Lab Station</b>		
S224	1 motion sensor (same as “sonic ranger”)	Should have a black-yellow plug
AF12 (tube)	1 track	.
AF15	Wood Squares	probably 2-3, used to prop up one end of track
AF22-2-13	1 cart with “sail”	these are in a large box labelled “DYNAMIC CARTS AF22-2-13”
AF34-14	ruler	used to level the track
either		
AF35 (shelf) or AE82 (drawer)	1 metal ball (any size)	used to level the track
-	Pasco	Computer
<b>At the front for students to share</b>		
AA41 or AA42 (drawers)	1 gravity protractor	This is the large yellow protractor
AF44	Pendulum bob to hang with the gravity-protractor	Used to level the track. (There are enough protractors to give these to everybody, but it is not clear if there are enough pendula strings and bobs for everybody.) <i>This really only needs to be a short string with a washer or other small mass tied to it.</i>

**Table 1.3.1:** Equipment Needed: [Constant Acceleration](#)

(Updated: October 12, 2017)

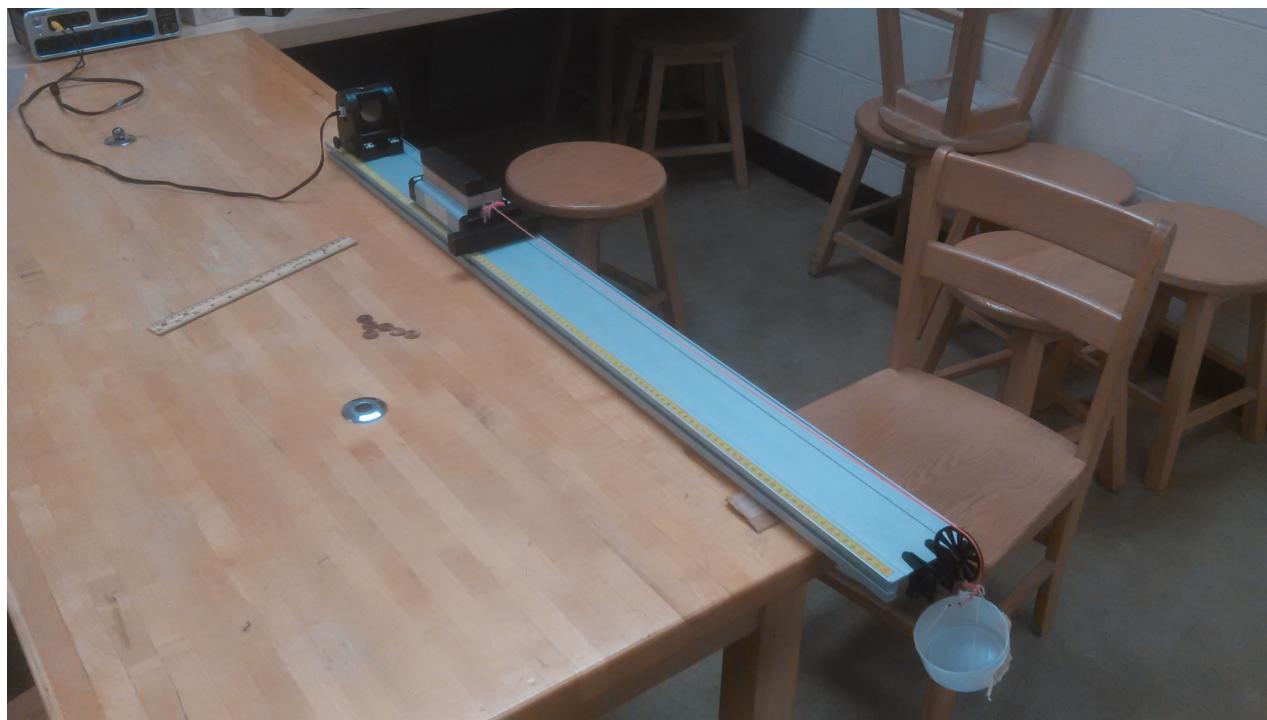
A digital version of the lab should be found at <http://physics.thomasmore.edu/Labs/121/c-acceleration.html>

A PDF version might be found at [Acceleration.pdf](#)

## 1.4 Newton's 2<sup>nd</sup> Law on a Linear Track with the Sonic Ranger

Location	Equipment	Notes
<b>For Each Lab Station</b>		
S224	1 motion sensor (AKA "sonic ranger")	Should have a black-yellow plug
AF12 (tube)	1 track	.
AF15	2-3 small wooden squares	used to level the track
AF22-2-13	1 cart	these are in a large box labelled "DYNAMIC CARTS AF22-2-13"
AF22-2-13	1 wooden cart-block	these are in a large box labelled "DYNAMIC CARTS AF22-2-13"
AF22-2-13	light plastic bucket	These might already be attached to the string in a large box labelled "DYNAMIC CARTS AF22-2-13"
(attached to plastic bucket?)	string	There should be pre-cut string that is long enough to reach from the cart, over the pulley and to a hanging mass. About one meter long. This is likely in a large box labelled "DYNAMIC CARTS AF22-2-13"
AF22-2-13	1 pulley	these are in a large box labelled "DYNAMIC CARTS AF22-2-13"
AF34-14	ruler	used to level the string
either AF35 (shelf) or AE82 (drawer)	1 metal ball (any size)	used to check the level of the track
AF44	larger weights	These are to ride the cart. <b>Check with instructor: EITHER</b> an assortment of 100-500 gram, cylindrical masses <b>OR</b> 2 black rectangular masses that fit into the cart (like the 1-wooden block above).
AF44 or AL32-5	tiny weights	These are to transfer between the cart and the basket. <b>Check with instructor: EITHER</b> an assortment of 7-10 very small masses (2-5 grams) <b>OR</b> 10 pennies.
-	Pasco	Computer
<b>At the front for students to share</b>		
S224	functioning digital scales	(please verify that these function and are set to metric)
AA41, AA42	Gravity Protractor	Used to level the track. (There are enough to give these to everybody, but it is not clear if there are enough pendulua strings and bobs for everybody.)
AF44	Pendulum bob to hang with the gravity-protractor	Used to level the track. (There are enough protractors to give these to everybody, but it is not clear if there are enough pendulua strings and bobs for everybody.) <i>This really only needs to be a short string with a washer or other small mass tied to it.</i>

**Table 1.4.1:** Equipment Needed: Newton's 2<sup>nd</sup> Law on a Linear Track with the Sonic Ranger



**Figure 1.4.2:** The equipment setup.

(Updated: October 12, 2017)

A digital version of the lab should be found at <http://physics.thomasmore.edu/Labs/121/c-Newton.html>

A PDF version might be found at [Newton.pdf](#)

## 1.5 Dry Sliding Friction

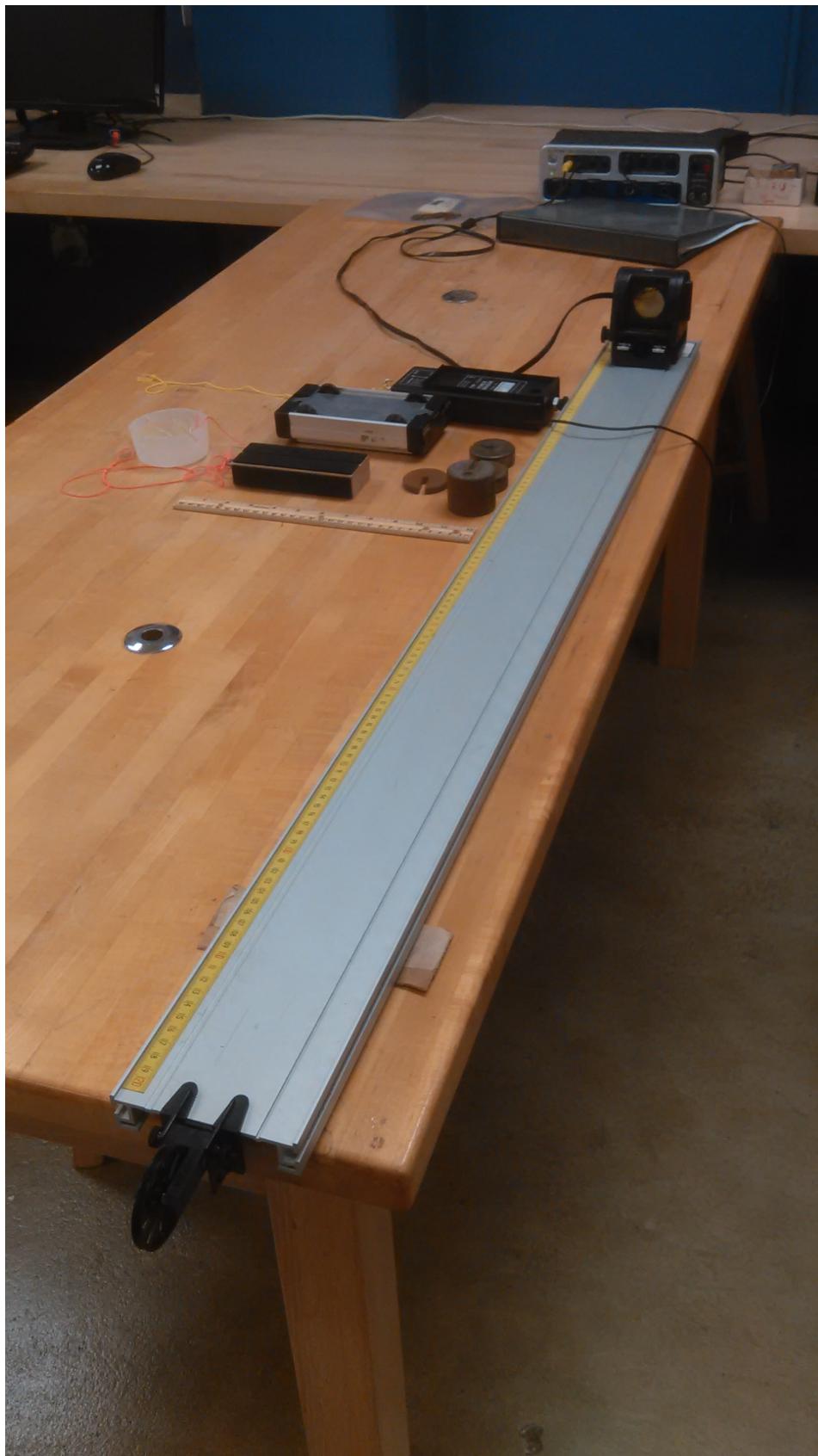
Most of this equipment is the same as [Newton's 2<sup>nd</sup> Law on a Linear Track with the Sonic Ranger](#), but it is not exactly the same.

Location	Equipment	Notes
<b>For Each Lab Station</b>		
S224	1 motion sensor (AKA “sonic ranger”)	Should have a black-yellow plug
S224	1 force transducer	Should be the thing shaped to sit on top of the wooden cart-block and it has a loop-screw at one side to tie a string to
AF12 (tube)	1 track	.
AF22-2-13	1 cart	these are in a large box labelled “DYNAMIC CARTS AF22-2-13”
AF22-2-13	1 wooden cart-block	these are in a large box labelled “DYNAMIC CARTS AF22-2-13”
AF22-2-13	light plastic bucket	These might already be attached to the string in a large box labelled “DYNAMIC CARTS AF22-2-13”
(attached to plastic bucket?)	string	There should be pre-cut string that is long enough to reach from the cart, over the pulley and to a hanging mass. About one meter long. This is likely in a large box labelled “DYNAMIC CARTS AF22-2-13”
AF22-2-13	1 pulley	these are in a large box labelled “DYNAMIC CARTS AF22-2-13”
AF34-14	ruler	used to level the string
either AF35 (shelf) or AE82 (drawer)	1 metal ball (any size)	used to check the level of the track
AF15	2-3 small wooden squares	used to level the track
AF44	larger weights	These are to ride the cart. <b>Check with instructor: EITHER</b> cylindrical masses (2 500-g, 4 200-g, 2 100-g) <b>OR</b> 2 black rectangular masses that fit into the cart (like the 1-wooden block above).
AF44 or AL32-5	tiny weights	These are to transfer between the cart and the basket. <b>Check with instructor: EITHER</b> an assortment of 7-10 very small masses (2-5 grams) <b>OR</b> 10 pennies.
AE21	string	This string is for pulling the force transducer, not the same as the string that is attached to the plastic bucket
AG15	1 thermal glove	<b>Check with the instructor.</b> This is only used as a soft glove to catch the cart in case it accelerates too quickly. Not all instructors want this.
-	Pasco	Computer
<b>At the front for students to share</b>		
S224	functioning digital scales	(please verify that these function and are set to metric)
AA41, AA42	Gravity Protractor	Used to level the track. (There are enough to give these to everybody, but it is not clear if there are enough pendulua strings and bobs for everybody.)
AF44	Pendulum bob to hang with the gravity-protractor	Used to level the track. (There are enough protractors to give these to everybody, but it is not clear if there are enough pendulua strings and bobs for everybody.)  <i>This really only needs to be a short string with a washer or other small mass tied to it.</i>

Table 1.5.1: Equipment Needed: Dry Sliding Friction



**Figure 1.5.2:** The equipment set up.



**Figure 1.5.3:** The equipment setup.

(Updated: October 12, 2017)

A digital version of the lab should be found at <http://physics.thomasmore.edu/Labs/121/c-friction.html>

A PDF version might be found at [friction.pdf](#)

## 1.6 Centripetal Force

This describes the old equipment. New equipment (that plugs into the PASCO interface) has been purchased, but that equipment list has not been itemized yet.

Location	Equipment	Notes
<b>For Each Lab Station</b>		
AA13	1 caliper	<b>Ask instructor</b> if they want digital or analog (they might not care)
AA12	1 stop watch	Verify that they work and have good batteries. <b>You might need to purchase new batteries for department!!</b>
AD71	1 C-clamp	<b>Important:</b> There are small pieces of cardboard available to place between the clamp and the lab table so that you do not add dents to the table!
end of AD	1 thick metal rod	Mount horizontally off the table to hang the (spinning) carriage
AF14-1-6	1 centripetal force apparatus	(with card?)
AF46	1 0.5-kg hanger	.
AF46	Large cylindrical masses: 1 2-kg, 2 1-kg, 1 0.5-kg	.
AF44	Additional small cylindrical masses of various sizes	include at least one of each: 200-g, 100-g, 50-g, 20-g

**Table 1.6.1:** Equipment Needed: Centripetal Force



Figure 1.6.2: The equipment setup.

(Updated: October 12, 2017)

A digital version of the lab should be found at <http://physics.thomasmore.edu/Labs/121/c-centripetal.html>

A PDF version might be found at [centripetal.pdf](#)

## 1.7 Hooke's Law / Springs / Peer Review

**Warning 1.7.1.** This lab might be set-up by itself or it might be paired with [Pendulum / Peer Review](#). **Check with your instructor** to see if this is part of the “Peer Review” setup. If so, then discuss the setup. The instructor might want both Springs and Pendulum in both the morning and afternoon labs (in which case you need to verify how many setups of each lab and which tables), or the instructor might want one lab setup in the morning and a different lab setup in the afternoon.

Location	Equipment	Notes
<b>For Each Lab Station</b>		
AD41	1 2-slot-perpendicular clamp	This is used to connect the vertical thick rod to the horizontal small rod
AD71	1 C-clamp	<b>Important:</b> There are small pieces of cardboard available to place between the clamp and the lab table so that you do not add dents to the table!
AD82	1 clamp	This is used to hold the track in place. Note the size of rod that fits through the hole on this clamp. <b>CAUTION:</b> Do not over-tighten this clamp. <i>The track should not be bent by the clamp!</i>
end of AD	1 thick metal rod	Mount vertically off the table
end of AD	1 small rod	This is used to connect the clamp to the thick rod
AF12	1 track	This is used to measure the elongation of the spring.
AF44	hangers and various masses	each table should have a similar distribution of large and small mass sizes ( <b>Check with instructor:</b> Your instructor might prefer to use the AF34 box of black hanging cylinders.)
<b>At the front for students to share</b>		
AF43	2 boxes of colored springs	Students will be allowed to select their spring. <b>Check with instructor:</b> Your instructor might want specific springs distributed to the tables

**Table 1.7.2:** Equipment Needed: [Hooke's Law / Springs / Peer Review](#)



**Figure 1.7.3:** The equipment setup version “A”. Your instructor might want the track setup in a different way.



**Figure 1.7.4:** The equipment setup version “A”. Your instructor might want the track setup in a different way.

(Updated: October 12, 2017)

A digital version of the lab should be found at <http://physics.thomasmore.edu/Labs/121/c-springs.html>

A PDF version might be found at [springs.pdf](#)

## 1.8 Pendulum / Peer Review

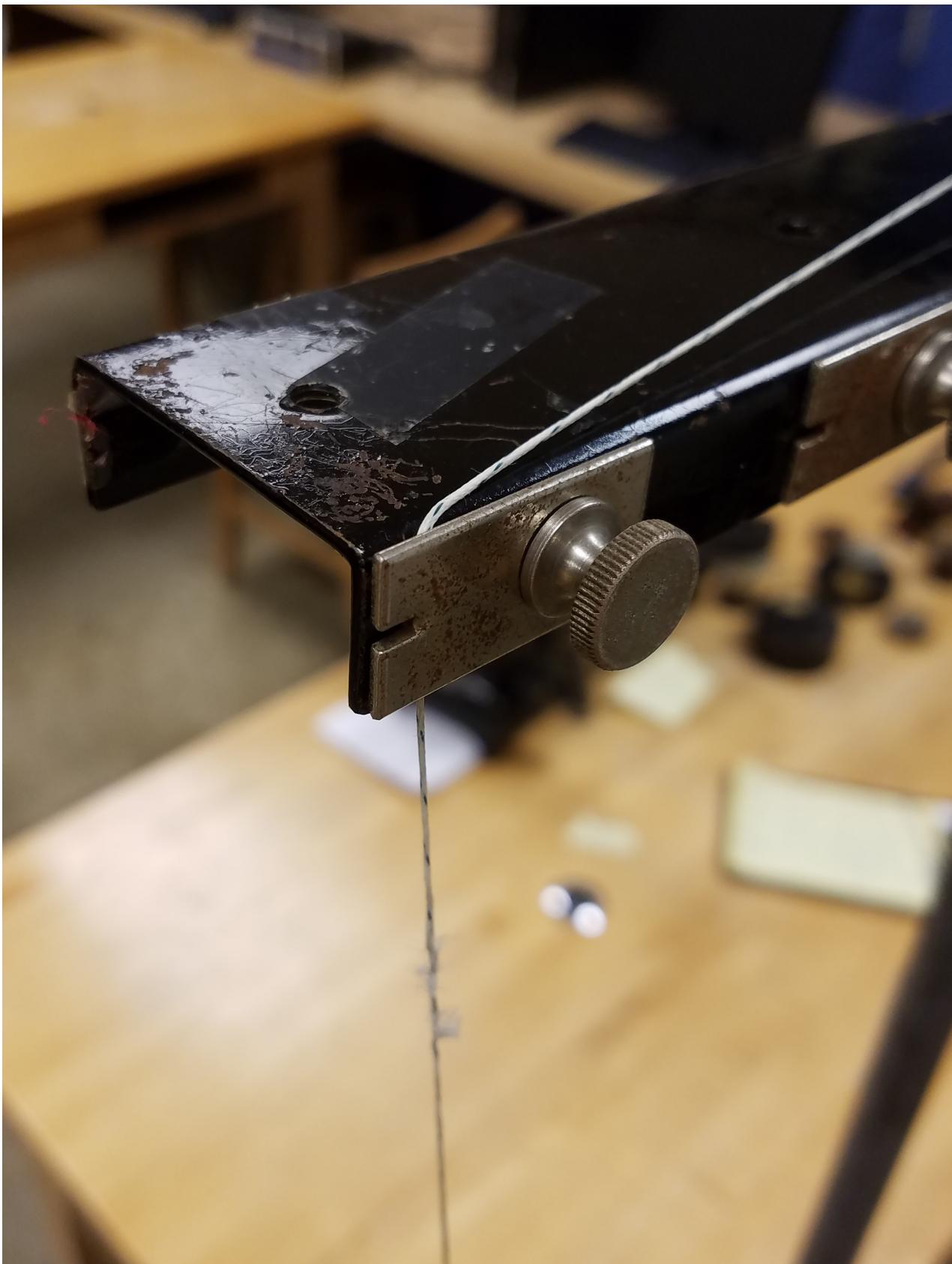
**Warning 1.8.1.** This lab might be set-up by itself or it might be paired with [Hooke’s Law / Springs / Peer Review](#). **Check with your instructor** to see if this is part of the “Peer Review” setup. If so, then discuss the setup. The instructor might want both Springs and Pendulum in both the morning and afternoon labs (in which case you need to verify how many setups of each lab and which tables), or the instructor might want one lab setup in the morning and a different lab setup in the afternoon.

Location	Equipment	Notes
<b>For Each Lab Station</b>		
AA??, maybe AA41?	1 plastic protractor	To measure the amplitude of the pendulum swing.
AA12	1 stop watch	Verify that they work and have good batteries.  <i>You might need to purchase new batteries for department!!</i>
AD21	1 3-notch black “arm” support	See picture below for how to mount the string inside the clamp. Do not just wrap it around the screw; clamp it inside the metal piece, which you should note has a nub holding it in place. (Take the metal square off, you’ll see what I mean.)
AD71	1 C-clamp	<b>Important:</b> There are small pieces of cardboard available to place between the clamp and the lab table so that you do not add dents to the table!
end of AD	1 thick metal rod	Mount vertically off the table
AF44	hangers and various masses	each table should have a similar distribution of large and small mass sizes ( <b>Check with instructor:</b> Your instructor might prefer to use the AF34 box of black hanging cylinders.)

**Table 1.8.2:** Equipment Needed: [Pendulum / Peer Review](#)



**Figure 1.8.3:** The equipment setup.



**Figure 1.8.4:** The equipment setup.

(Updated: October 12, 2017)

A digital version of the lab should be found at <http://physics.thomasmore.edu/Labs/121/c-pendulum.html>

A PDF version might be found at [pendulum.pdf](#)

## 1.9 Conservation of Energy

**Check with the instructor:** There are two versions of this lab. One is designed for a single week; the other is designed to do over two-weeks. All of the equipment used in the first week would also be used in the second week, but if you are doing the 2-week version, there are two additional items needed during the second week.

**Check with the instructor:** This lab is written with the intention of having students decide how to measure certain variables. This arrangement of equipment assumes that some equipment will be at the front of the room available for students to select; however, your instructor might prefer to have all of it at each lab station. Please confirm with your specific instructor.

Location	Equipment	Notes
<b>For Each Lab Station</b>		
AF12 (tube)	1 track	.
AF22-2-13	1 cart	these are in a large box labelled "DYNAMIC CARTS AF22-2-13"
AF22-2-13	light plastic bucket	These might already be attached to the string in a large box labelled "DYNAMIC CARTS AF22-2-13"
(attached to plastic bucket?)	string	There should be pre-cut string that is long enough to reach from the cart, over the pulley and to a hanging mass. About one meter long. This is likely in a large box labelled "DYNAMIC CARTS AF22-2-13"
AF22-2-13	1 pulley	these are in a large box labelled "DYNAMIC CARTS AF22-2-13"
AF22 either AF35 (shelf) or AE82 (drawer)	C-shaped magnetic for the track	used in the second part of the lab (it will replace the pulley)
AF15	2-3 small wooden squares	used to level the track
-	Pasco	Computer
<b>At the front for students to share</b>		
S224	functioning digital scales	(please verify that these function and are set to metric)
S224	1 motion sensor (AKA "sonic ranger")	Should have a black-yellow plug
S224	1 force transducer	<b>This is only needed in the second week</b> (if you are doing a second week)
AD91	meterstick	used to measure the height of the hanging basket
AF34-14	ruler	used to level the string
AA41, AA42	Gravity Protractor	Used to level the track. (There are enough to give these to everybody, but it is not clear if there are enough pendulua strings and bobs for everybody.)
AF44	Pendulum bob to hang with the gravity-protractor	Used to level the track. (There are enough protractors to give these to everybody, but it is not clear if there are enough pendulua strings and bobs for everybody.)  <i>This really only needs to be a short string with a washer or other small mass tied to it.</i>
AF44	larger weights	These are to ride the cart. A few cylindrical masses in the 200-g to 500-g range.
AF44	larger weights	These are to ride the cart. Two black rectangular masses that fit into the cart.
AF44 or AL32-5	tiny weights	They will only need one or two to accelerate the basket. Provide an assortment of 7-10 very small masses (2-5 grams). (Pennies would work, too.)

**Table 1.9.1:** Equipment Needed: [Conservation of Energy](#)



**Figure 1.9.2:** The equipment setup.

(Updated: October 25, 2017)

A digital version of the 1-week version of the lab should be found at <http://physics.thomasmore.edu/Labs/121/c-energy-1.html>

A PDF version might be found at [energy-1.pdf](#)

A digital version of the 2-week version of the lab should be found at <http://physics.thomasmore.edu/Labs/121/c-energy-2.html>

A PDF version might be found at [energy-2.pdf](#)

## 1.10 Ballistic Pendulum

There is **additional work** for you to do beyond simply setting out the equipment this week.

- You will need to adjust the screws at the top of the pendulum arm.
  - While making this adjustment, you should remove the pendulum arm and verify the mass that is written on the masking tape. If that number is wrong, please update the tape and date it.
  - When you are making the adjustments, you will need to shoot the gun multiple times. Please note the following tips for cocking and shooting the gun.
    - Put the ball on the gun tip to cushion your hand when cocking the gun.
    - Brace your “other” hand on the back of the trigger-handle while cocking the gun.
    - The gun, when shot, has enough kick to bump the whole apparatus back a little, which can cause the pendulum arm to swing before the ball is caught, which might cause the ball to not be caught. Clamping the apparatus to the table will minimize this.
    - If you clamp the apparatus to the table, the clamp needs to be out of the path of the gun – this affects the way the tables are arranged in the room.
    - Be aware of what the gun might hit if it misses the pendulum bob. Do not shoot it towards people or expensive equipment!
  - Your goal while adjusting these screws is to simultaneously allow

1. the gun to shoot *straight* into the pendulum bob AND
  2. the pendulum to swing back and catch on the notches of the angled platform.
- You *might* need to trade the arms between the apparatuses. The steel machines are interchangeable and the red machines are interchangeable, but you cannot interchange the arms between red and steel.
- You will need to rearrange the lab tables so that students can shoot the gun giving the ball a 2-dimensional trajectory off the end and onto the floor. Please consider the following: (Assuming the lab room door is on the ***north*** side of the room)
    - The northside tables can shoot northwards. Be sure that the middle table is not aimed at the glass doors. You might have to move it slightly to the east (front of the room). The apparatuses should be clamped to the north east corner of the table. They do not need to be ALL the way north on the table, but if they are too far back from the edge, they might hit the table.
    - The three south tables will need to be moved. You have some options. In each case, you have to remember to leave room for the lab students to move around without crossing paths and access both their gun and the box that catches the ball being shot.
      - The south east and south west tables might be aligned long-ways east-west (rather than long-ways north-south as they are now). In this case, the south west table (apparatus clamped on the NW corner) shoots west (back of the room) and the south east table (apparatus clamped on the SE corner) shoots east (towards the white board). These should be pulled to the north-south middle of the room so that the south middle table can be aligned long-ways east-west to the south of these tables and can shoot either east (apparatus clamped on the SE corner) or west (apparatus clamped on the NW corner).
      - The south east and south west tables might be aligned long-ways north-south (as they are now); but they should be squeezed to abut the south middle table. In this case, the tables should be slightly off-set in order to allow students to access their guns and the location their gun fires to, without interfering with their neighbor. In this case, the south west table (apparatus clamped on the NW corner) shoots west (back of the room) and the south east table (apparatus clamped on the SE corner) shoots east (towards the white board). The south-west and south-east tables should be moved slightly towards the north-south middle of the room so that the south middle table can stick out a bit to the south of these tables. The south middle table should shoot east (towards the white board) specifically so that it can be clamped to the south-east corner of the table.
      - It is possible to arrange the room so that the southern table shoot to the south, but then the students have to crawl under the counter and they are shooting towards the computers along the south wall. I recommend against this option.
      - When you move the tables, ***be aware*** that the tables have electrical outlets in them and ***all have plugs*** that are in the floor or in the wall. ***Be careful not to pull the plugs out of the floor*** when moving the tables. If you get a small screw driver, then you can unwind some extra cable and relocate the stopper that keeps the cable from being re-wound. (See [Figure 3](#) below.)
    - All tables will need to be adjusted so that there is sufficient room to shoot and land far enough from the wall that a box can be placed between the landing spot and the wall. If the landing spot is too close to the box, then the ball *could* bounce off the wall and back onto the carbon paper, which makes the lab more difficult than necessary. Please leave enough room between the landing spot and the box that protects the wall that the ball does not immediately drop back onto the carbon paper that will be positioned at the landing site.

Location	Equipment	Notes
<b>For Each Lab Station</b>		
AF26	Ballistic Pendulum apparatus	One is missing a foot and uses a black rubber cork as a stabilizer. Several have difficulty with keeping the pendulum portion fixed in place. You are expected to check the maintenance of this equipment early enough before lab that you (or possibly the instructor) can fix any flaws in the equipment before the lab. <b><i>Do not wait until the last minute to set this lab up!</i></b>
AD91, AF34	1 1/2-meter stick, 1 1-meter stick, 1 2-meter stick	Note they might want more metersticks.
AD72 <b>AD43</b>	1 C-clamp	The AD72 clamps will work for the red ballistic pendulums, because they are short. The steel ones, though, are too tall and need the AD43 C-clamps. (I might be wrong about the AD43 bin number; please correct me so I can update this file.)
		<b>Important:</b> There are small pieces of cardboard available to place between the clamp and the lab table so that you do not add dents to the table!
?	pendulum bob	When you find this, tell Dr. Christensen the bin-number so he can update this page.
?	carbon paper	When you find this, tell Dr. Christensen the bin-number so he can update this page.
take from the printer in S224A	5 sheets of printer paper	
<b>At the front for students to share</b>		
?	bubble level	When you find this, tell Dr. Christensen the bin-number so he can update this page.
?	2 rolls of masking tape	When you find this, tell Dr. Christensen the bin-number so he can update this page.

**Table 1.10.1:** Equipment Needed: Ballistic Pendulum



Figure 1.10.2: The equipment setup.



Figure 1.10.3: When rearranging the tables, but aware that under each table, there is a cord plugged into the floor or the wall. These can be unwound and, with a screwdriver, the stopper can be moved so that a longer stretch of cord is extended.

(Updated: November 15, 2017)

A digital version of the lab should be found at <http://physics.thomasmore.edu/Labs/121/c-ballistic.html>  
A PDF version might be found at [ballistic.pdf](#)

## 1.11 Human Forearm

For the instructor: We do **not** have permission to reproduce this image, but it might be useful for you to have in your head when explaining the lab.

Location	Equipment	Notes
<b>For Each Lab Station</b>		
AD21	3 clamps for the meter-sticks	These are the little aluminum things that slide onto a meter-stick and have a metal piece that a mass-hanger can hang off of. If the instructor wants you (instead of the students to put these on, notice that two hang down and one hangs up – see image below.)
AD41	1 2-slot-perpendicular clamp	This is used to connect the vertical thick rod to the horizontal small rod
AD71	1 C-clamp	<b>Important:</b> There are small pieces of cardboard available to place between the clamp and the lab table so that you do not add dents to the table!
AD82	1 clamp	This is used to hold the track in place. Note the size of rod that fits through the hole on this clamp. <b>CAUTION:</b> Do not over-tighten this clamp. <i>The track should not be bent by the clamp!</i>
AD91	1 1-meter stick	.
end of AD	1 thick metal rod	Mount vertically off the table
end of AD	1 small rod	This is used to connect the clamp to the thick rod
AF12	1 track	This is used to measure the elongation of the spring.
AF22-2-13	light plastic bucket	These likely have string attached and are in a large box labelled "DYNAMIC CARTS AF22-2-13"
AF34	1 1/2-meter stick	(might need a 1/2-meter stick)
AF43	1 spring	(any color)
AF43	1 small rectangular mirror	These are for minimizing parallax.
AF44	hangers and various masses	The hangers might be in AF43, but their home is AF44.
<b>At the front for instructor to use</b>		
AK32	Model of Human Forearm	This is in a white cardboard box. The label might or might not be facing outwards.

**Table 1.11.1:** Equipment Needed: Human Forearm

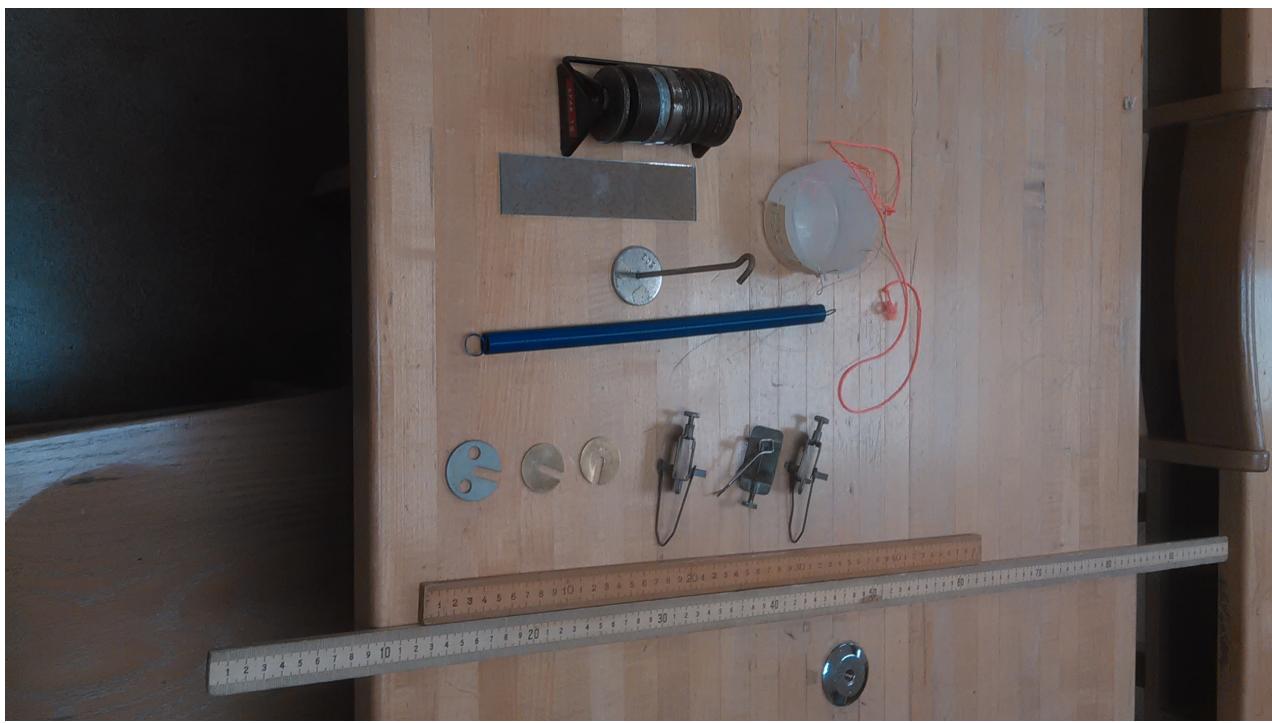


Figure 1.11.2: The necessary equipment laid out.



**Figure 1.11.3:** *If* your instructor wants you to set up the “arm”, then this is how it is connected. Notice that the two clamps on the outer edges hang down and the clamp connected to the spring “hangs” up.



**Figure 1.11.4:** How to set up the support. Recall also [Figure 1.7.3](#) and [Figure 1.7.4](#).

(Updated: November 15, 2017)

A digital version of the lab should be found at <http://physics.thomasmore.edu/Labs/121/c-equilibrium.html>

A PDF version might be found at [equilibrium.pdf](#)

## 1.12 Next Lab

Location	Equipment	Notes
<i>For Each Lab Station</i>		
AF12	1 track	.
<i>At the front for students to share</i>		
.		

**Table 1.12.1:** Equipment Needed: [Next Lab](#)

(Updated: October 12, 2017)

A digital version of the lab should be found at <http://physics.thomasmore.edu/Labs/121/c-labname.html>

A PDF version might be found at [labname.pdf](#)



# Class 2

## PHY122L: Elements of Physics (algebra-based, spring)

### 2.1 Skills Review

There is no lab equipment to be set up for this lab. The instructor will provide the students with a worksheet.

(Updated: Jan 8, 2018)

A digital version of the lab should be found at <http://physics.thomasmore.edu/Labs/122/c-122skills.html>

A PDF version might be found at <122skills.pdf>

### 2.2 Archimedes' Principle

You might also review [Archimedes' Principle](#) for another version with less advice for setting up the lab.

Location	Equipment	Notes
<b>For Each Lab Station</b>		
AA13	Vernier Caliper	
AC11-12	<i>precise</i> graduated cylinder	You will probably need the tall, skinny ones, but the important thing is to get the cylinders with the finest gradation in their measurement.
AE82	One brass cylinder <b>NOTE:</b> your instructor might want a variety of shapes of objects.	These are in a box in the AE82 drawer, but you can use other cylinders from a different drawer or other shapes if indicated by the instructor.
AF35	Balance scale	The porcelain scales are fragile. Please be careful when handling these balances. These will be placed on the short rods. You should ask your instructor if they want you to do this. There is a picture below.
AF44	A tray of masses.	(I suggest using the cylindrical masses even though they do not need a hanger.) These will be used on the second scale of the scale-balance and should be at least as heavy as the cylinder placed at the table.
end of AF	short rod that screws into the table-top.	Shorter is better. The balance scale will be placed on top of this and short rods will wobble less.
AG14	Lab Jack	These need to be tall enough to place the spill container high enough under the balance, which is on the pole, so that the string from the balance reaches into the container. You might need to tie a new string to attach the metal cylinder to the balance.
AG44	Spill container	These are the aluminum "cups" that have a small spout projecting from the side near the top.
<b>At the front for students to share</b>		
either AC11 or AG35	EITHER the drinking glass (with the slight bulge 3/4 of the way up, in AC11) OR the small beaker (with a pour-spout, in AC11) OR the black and silver cups (in AG35)	This will be used as the "boat" that will carry the pennies. The point is to see how many pennies it takes to sink; the glass makes it difficult to measure volume, but the beaker has a thick lip and a lowered pour-spout. The instructor may want a different boat, such as the aluminum cup in the calorimeter (AG44?) from the <a href="#">specific heat lab</a> ; but that has a very large lip. <b>NOTE:</b> The instructor might want one boat at the front for everybody to use, or the instructor might want each table to have their own boat.
either AH18 or AF63	a tank for holding several gallons of water	There are two cylindrical tanks at AH18; You should only need the smaller tank, but the instructor might want a larger one. There is a fish tank at AF63 that should also work. Your instructor might want you to fill the tank with water. It should be deep enough that the "boat" can sink below the depth of water.
AL32	pennies	You need enough to sink the boat, but each sinking gets the pennies wet. Since the pennies are annoying to dry off, there should be enough pennies to sink at least one (maybe two) boats per group. Before putting the pennies away, you should make sure to dry them off so they don't get moldy. You can use a towel for the most part, but they might have to sit out overnight. <b>NOTE:</b> The instructor might want the pennies distributed among the tables.

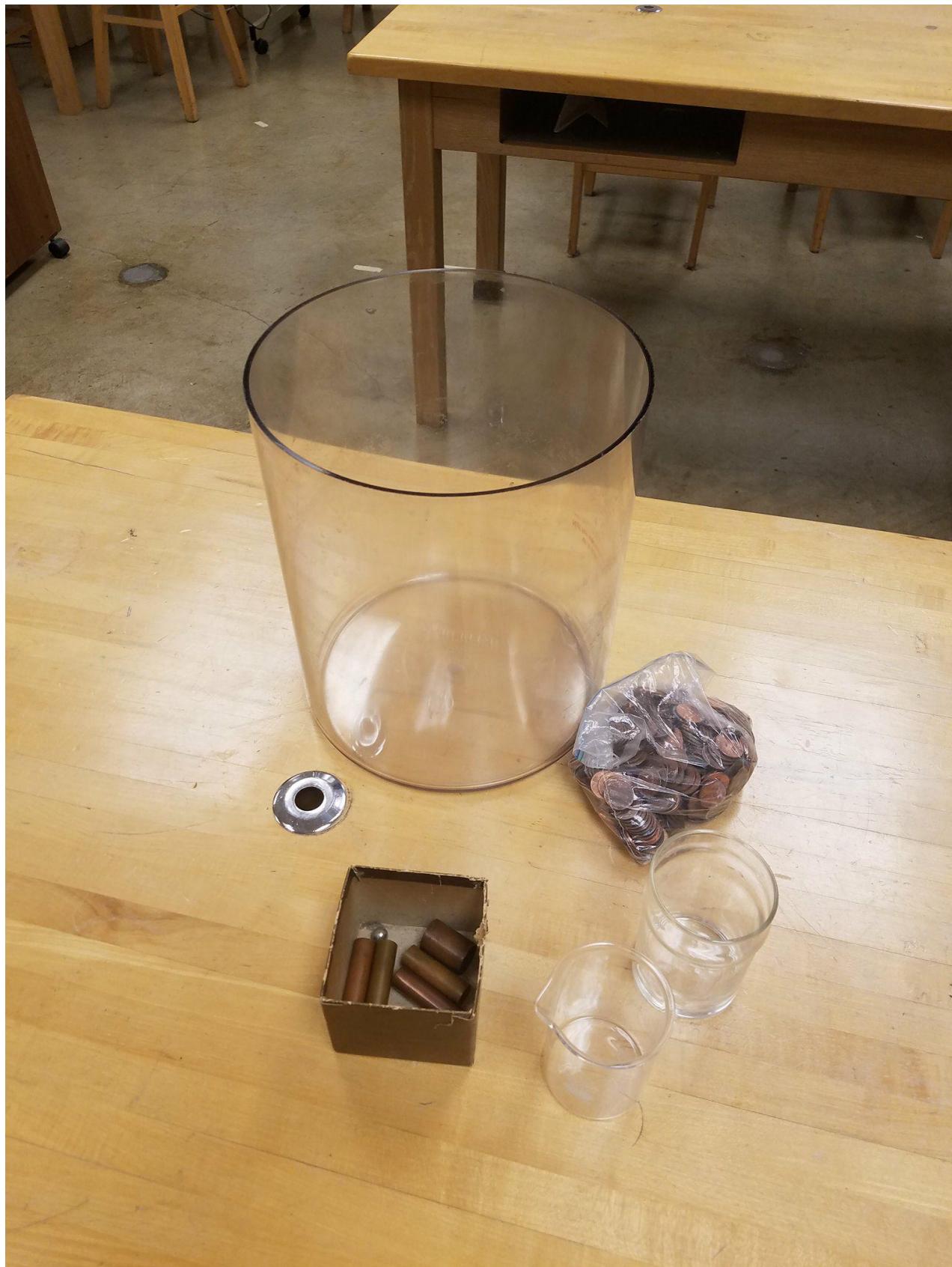
**Table 2.2.1:** Equipment Needed: [Archimedes' Principle](#)



**Figure 2.2.2:** The equipment setup for each group. (Caliper not shown, but needed)



**Figure 2.2.3:** The equipment setup showing the balance on the pole.



**Figure 2.2.4:** The equipment setup for the front of the room.

(Updated: Jan 9, 2018)

A digital version of the lab should be found at <http://physics.thomasmore.edu/labs/122/c-Archimedes.html>  
A PDF version might be found at [Archimedes.pdf](#)

## 2.3 Properties of a Battery

*2013 version by Matthew: May need updating..*

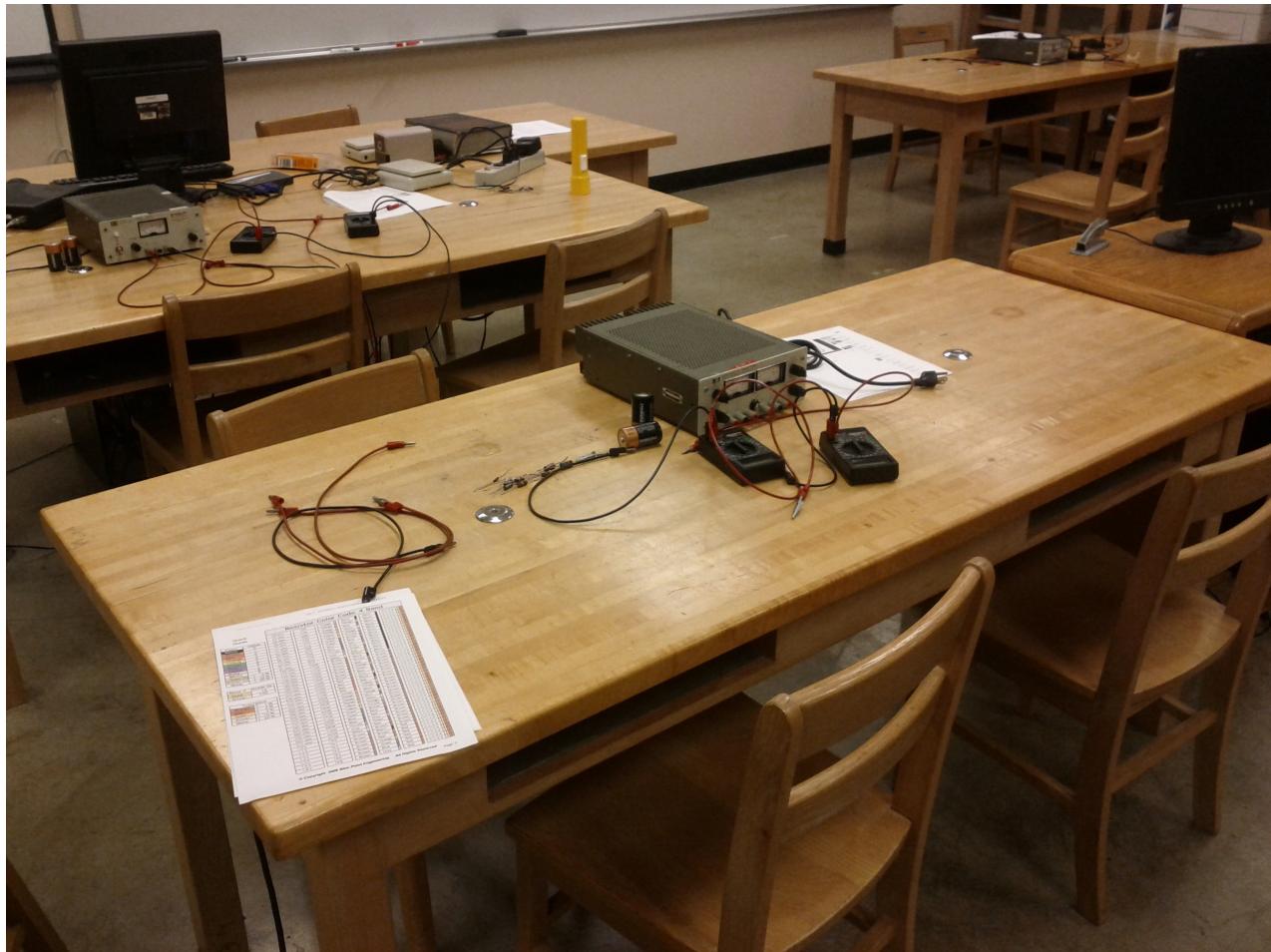
Location	Equipment	Notes
<b>For Each Lab Station</b>		
AK55	Power Supply	Ensure that the non-major equipment is used
AN22	Multimeter	
Electronics Lab	Resistors	
AL12	Batteries	
End Cap of J & K	Wires and Wire attachments	

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*At the front for students to share*

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**Table 2.3.1:** Equipment Needed: Properties of a Battery



**Figure 2.3.2:** The equipment setup.

(Updated: 2013)



# Class 3

## NSC 220L: Anything Physics

### 3.1 Meaningful Measurements

Please set this up according to the [Meaningful Measurements](#) from the [PHY 121L: Elements of Physics \(algebra-based, fall\)](#).

### 3.2 Measuring Motion

Location	Equipment	Notes
<b>For Each Lab Station</b>		
AD91	1 1-meter stick	-
end of AF	2-meter stick	-
AA41 or AA42 (drawers)	1 gravity protractor	This is the large yellow protractor
<b>At the front for students to share</b>		
AL32-5	several boxes/bags of pennies	in sufficient number for each student to have up to 6 pennies
?	2 rolls of masking tape	When you find this, tell Dr. Christensen the bin-number so he can update this page.
<b>set at two tables only</b>		
S224	1 motion sensor (same as “sonic ranger”)	Should have a black-yellow plug; please connect this to the PASCO interface

**Table 3.2.1:** Equipment Needed: [Measuring Motion](#)

(Updated: January 15, 2018)

A digital version of the lab should be found at <http://physics.thomasmore.edu/Labs/220/c-motion.html>

A PDF version of the write-up might be found at [motion.pdf \(128 kB\)](#)

### 3.3 Constant Acceleration

Please set this up according to the [Constant Acceleration](#) from the [PHY 121L: Elements of Physics \(algebra-based, fall\)](#).

### 3.4 Newton's 2<sup>nd</sup> Law on a Linear Track with the Sonic Ranger

Please set this up according to the [Newton's 2<sup>nd</sup> Law on a Linear Track with the Sonic Ranger](#) from the [PHY 121L: Elements of Physics \(algebra-based, fall\)](#).

### 3.5 Dry Sliding Friction

Please set this up according to the [Dry Sliding Friction](#) from the [PHY 121L: Elements of Physics \(algebra-based, fall\)](#).

### 3.6 Hooke's Law

I have not written this yet. Tentatively, please set this up according to the [Hooke's Law / Springs / Peer Review](#) from the [PHY 121L: Elements of Physics \(algebra-based, fall\)](#).

### 3.7 Pendulum / Peer Review

Please set this up according to the [Pendulum / Peer Review](#) from the [PHY 121L: Elements of Physics \(algebra-based, fall\)](#).

### 3.8 Conservation of Energy

Please set this up according to the [Conservation of Energy](#) from the [PHY 121L: Elements of Physics \(algebra-based, fall\)](#).

### 3.9 Bouncing Springs

I have not written this yet. Tentatively, please set this up according to the [Hooke's Law / Springs / Peer Review](#) from the [PHY 121L: Elements of Physics \(algebra-based, fall\)](#).

## Class 4

# PHY141L: General Physics I (calculus-based, spring)

See also [PHY 121L: Elements of Physics \(algebra-based, fall\)](#)



# Class 5

## PHY142L: General Physics II (calculus-based, spring)

See also [PHY122L: Elements of Physics \(algebra-based, spring\)](#)

### 5.1 Ohm's Law (Ohmic material)

*2013 version by Matthew: May need updating..*

Location	Equipment	Notes
<b><i>For Each Lab Station</i></b>		
AK55	Power Supply	(JS listed a function generator AK23)
End Cap of J & K	Wires and Wire attachments	
AN22	Multimeter	Requires 4
AI25	Ammeter	Around 3 to 10 amps
Electronics Room	Resisters and Diodes	

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*At the front for students to share*

**Table 5.1.1:** Equipment Needed: [Ohm's Law \(Ohmic material\)](#)



**Figure 5.1.2:** The equipment setup.

(Updated: 2013)

## 5.2 Ohm's Law (non-Ohmic material)

*2013 version by Matthew: May need updating..*

Location	Equipment	Notes
<b>For Each Lab Station</b>		
AK23	Function Generator	
End Cap of J & K	Wires and Wire attachments	
AN22	Multimeter	Requires 4
Electronics Room	Resisters and Diodes	
<b>At the front for students to share</b>		

**Table 5.2.1:** Equipment Needed: [Ohm's Law \(non-Ohmic material\)](#)



**Figure 5.2.2:** The equipment setup.

(Updated: 2013)

### 5.3 Mapping the Electric Field

*2013 version by Matthew: May need updating..*

Location	Equipment	Notes
<b>For Each Lab Station</b>		
AK55	Power Supply	
End cap of J & K	Wire and Wire Supplies	
AN22	Multimeter	JS also lists AJ43 and AJ25: Small Black ones & Large Blue ones; AJ24: Small Blue ones & Boxed ones; AI15: Ones with three buttons
AG24	Field Plate Apparatus and Field Plates	

*At the front for students to share*

**Table 5.3.1:** Equipment Needed: [Mapping the Electric Field](#)



**Figure 5.3.2:** The equipment setup.

(Updated: 2013)

## 5.4 Resistor Bridge

*2013 version by Matthew: May need updating..*

Location	Equipment	Notes
<i>For Each Lab Station</i>		
AJ43	Bridge Apparatus	
AJ24	Resistor Coil Set	
AJ23	Resistor Box	
AK23	Power Supply	
End of Isle J & K	Wires & Supplies	
AI15	Galvanometer	
<i>At the front for students to share</i>		

**Table 5.4.1:** Equipment Needed: [Resistor Bridge](#)



**Figure 5.4.2:** The equipment setup.

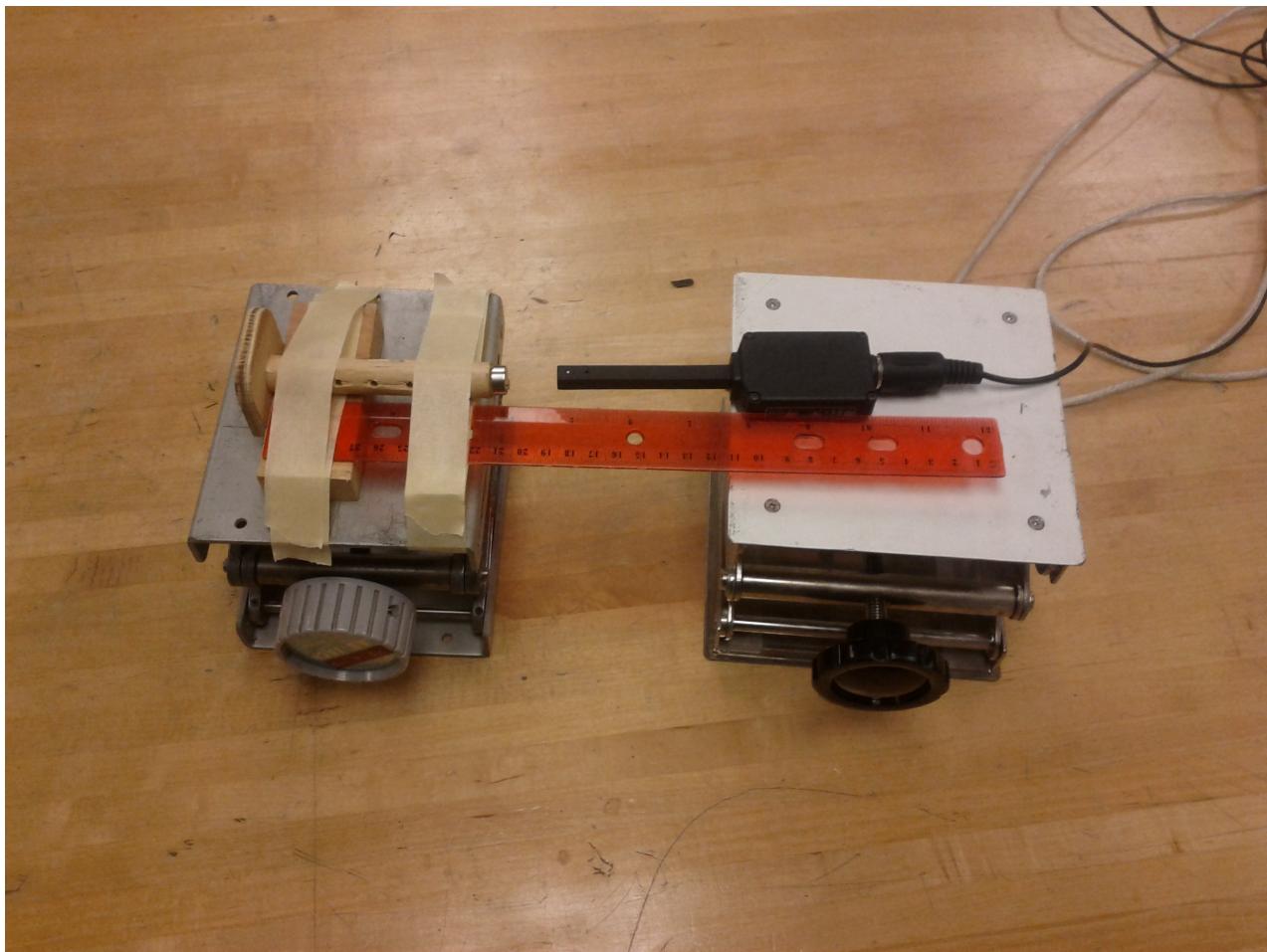
(Updated: 2013)

## 5.5 Magnetic Field Strength

*2013 version by Matthew: May need updating..*

Location	Equipment	Notes
<i>For Each Lab Station</i>		
AM36	Magnet	
AG14	2 Lab Jacks	
AF34	Ruler	
AF15	2 Blocks of Wood	
Room S224 Closet	Magnetic Sensor	
<i>At the front for students to share</i>		

**Table 5.5.1:** Equipment Needed: [Magnetic Field Strength](#)



**Figure 5.5.2:** The equipment setup.

(Updated: 2013)

## 5.6 High Current Force

*2013 version by Matthew: May need updating..*

Location	Equipment	Notes
<i>For Each Lab Station</i>		
AG14	Lab Jack	
AH12	Laser	
BA14	Current apparatus	
AE61	Double-throw Switch	
AF34	Ruler	
End of Isle J &K	Wire and Supplies	
AK12	High Current Power Supply	
AN22	Multimeter	
AA13	Caliper	(inconsistent listing)
AF43	Small mass set	(inconsistent listing)

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*At the front for students to share*

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**Table 5.6.1:** Equipment Needed: [High Current Force](#)



**Figure 5.6.2:** The equipment setup.

(Updated: 2013)

## 5.7 Magnet in a Tube

*2013 version by Matthew: May need updating..*

Location	Equipment	Notes
<b><i>For Each Lab Station</i></b>		
AH63	Magnetic pipe apparatus	
white box	Magnet and non-magnet	
-	Foam Pads	
S224 Closet	Force Sensor	
<b><i>At the front for students to share</i></b>		

**Table 5.7.1:** Equipment Needed: [Magnet in a Tube](#)

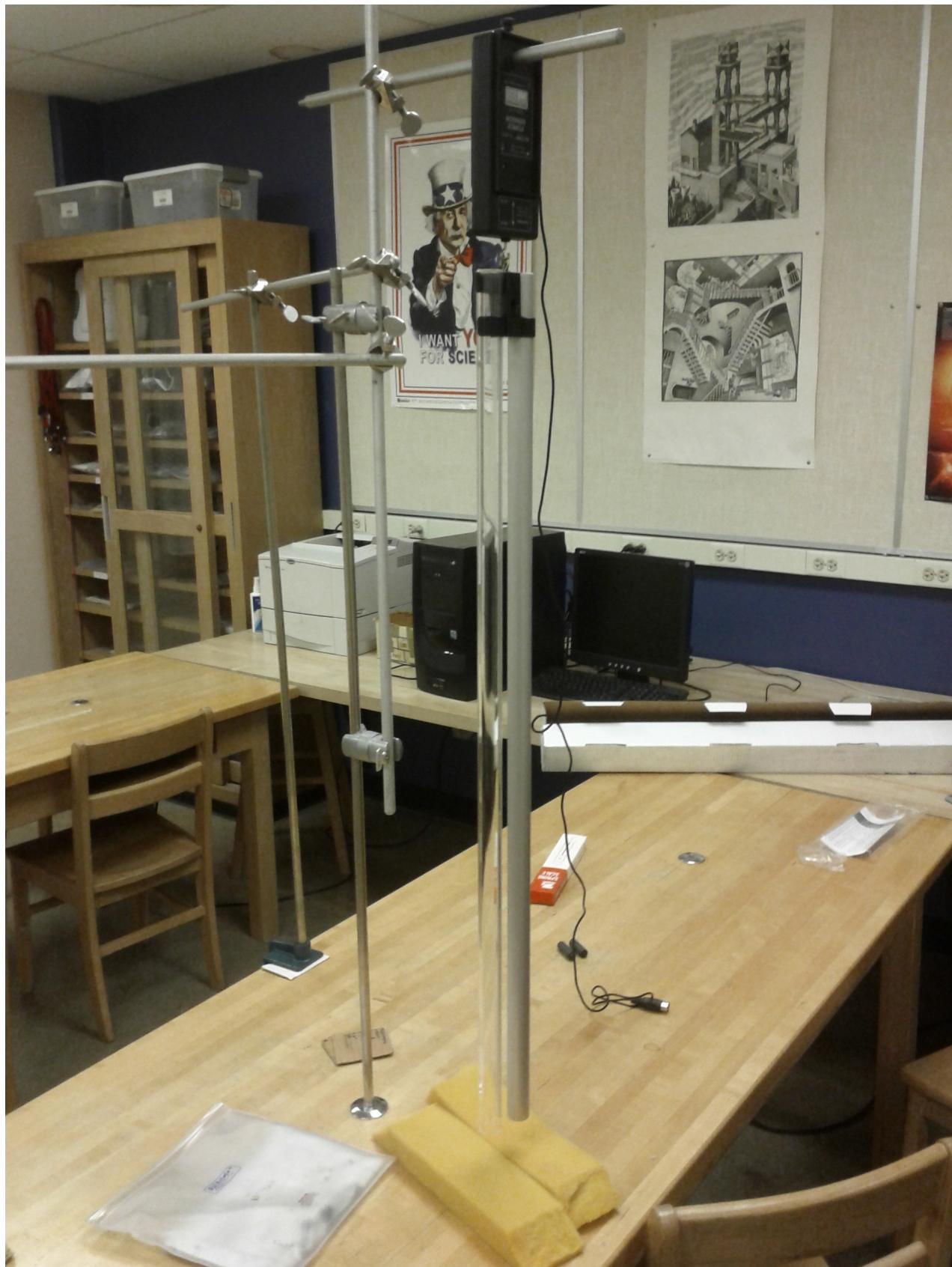


Figure 5.7.2: The equipment set up.

(Updated: 2013)

## 5.8 Capacitor and Variable Resistor

*2013 version by Matthew: May need updating..*

Location	Equipment	Notes
<b>For Each Lab Station</b>		
AK23	Function Generator	
End of Isle J & K	Wire and Supplies	
AN22	Multimeter	
AJ13	Resistor Apparatus	
AJ26	Varying Resistor Board	
<i>At the front for students to share</i>		

Table 5.8.1: Equipment Needed: Capacitor and Variable Resistor



Figure 5.8.2: The equipment setup.

(Updated: 2013)

# Class 6

## PHY241L: General Physics III (calculus-based, spring)

See also [PHY122L: Elements of Physics \(algebra-based, spring\)](#)

### 6.1 Archimedes' Principle

*2013 version by Matthew: May need updating..* Please also review [Archimedes' Principle](#) for another version with additional advice for setting up the lab.

Location	Equipment	Notes
<i>For Each Lab Station</i>		
AA13	Vernier Caliper	
AC11 (aisle E)	Beaker	
AE82	Objects	
AG44	Overflow Cup	
AF35	Scales	
AG14	Lab Jack	
AG35	Black and silver cups	"Boats"
AL32	Pennies	
<i>At the front for students to share</i>		
AF63	Fish Tank	

**Table 6.1.1:** Equipment Needed: [Archimedes' Principle](#)



Figure 6.1.2: The equipment setup.



Figure 6.1.3: The equipment set up.

(Updated: 2013)

## 6.2 Standing Waves

*2013 version by Matthew: May need updating..*

Location	Equipment	Notes
<i>For Each Lab Station</i>		
AK23	Function generator	
End of isle F	two-meter stick	
AG14	Lab jack	
AG16	Lead Brick	
AD72 & AE81	Pulley system	
AF13	Vibrator	
Inside of the vibrator box	String	
AF44	Masses and Hooks	
End cap of isle J & K	Wires	
<i>At the front for students to share</i>		
AN24	Strobe light	

**Table 6.2.1:** Equipment Needed: [Standing Waves](#)



**Figure 6.2.2:** The equipment setup.

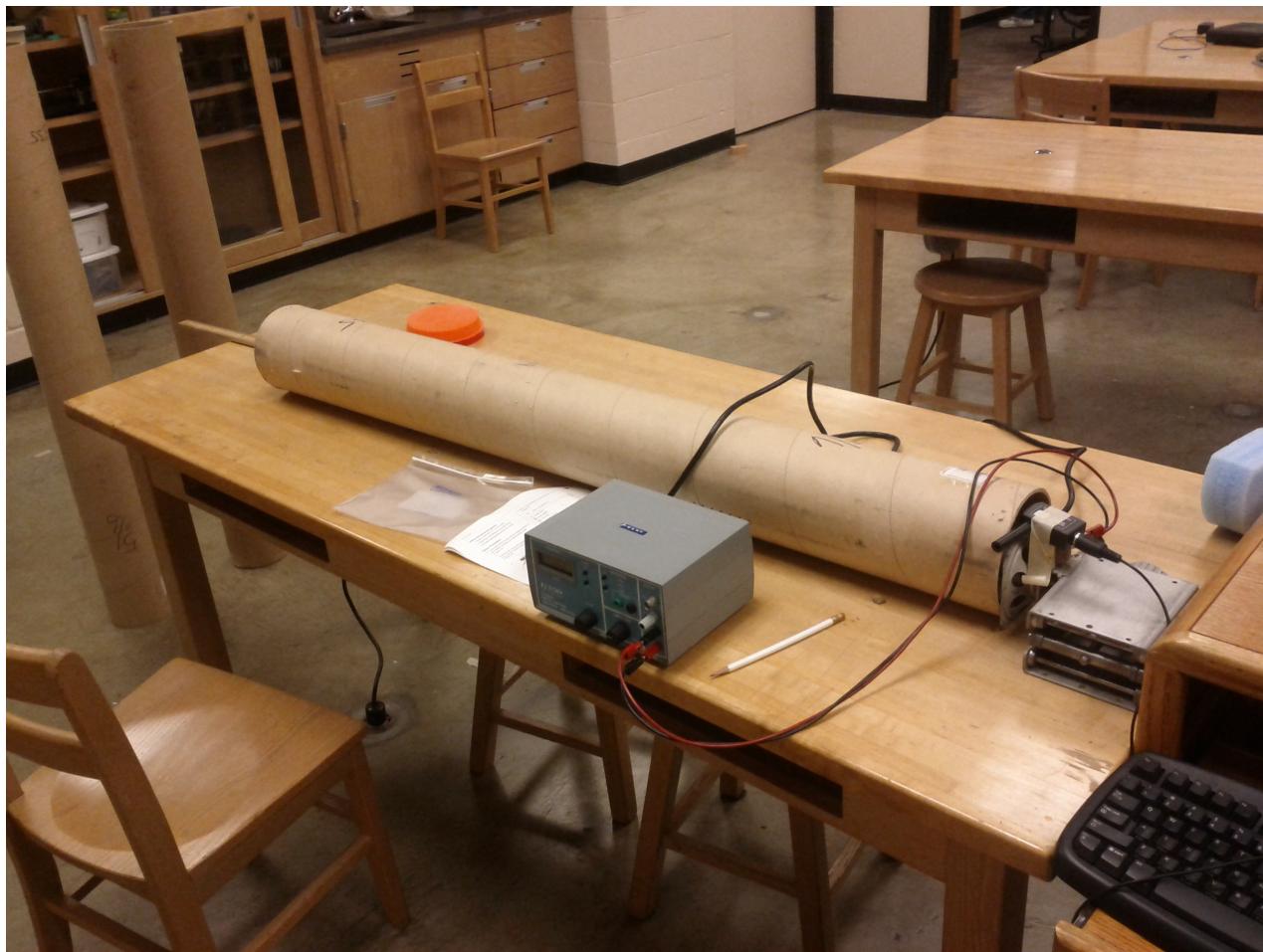
(Updated: 2013)

### 6.3 Speed of Sound in a Tube

*2013 version by Matthew: May need updating..*

Location	Equipment	Notes
<b>For Each Lab Station</b>		
AK63	Speaker	
Room S224 Closet	Sound Sensor	
AF12	Cardboard Tube	Use the cardboard tubes used to hold the aluminum tracks
End of isle F	two-meter stick	
AK23	Function Generator	
<b>At the front for students to share</b>		

**Table 6.3.1:** Equipment Needed: [Speed of Sound in a Tube](#)



**Figure 6.3.2:** The equipment setup.

(Updated: 2013)

## 6.4 Thermal Expansion

*2013 version by Matthew: May need updating..*

Location	Equipment	Notes
<b>For Each Lab Station</b>		
AH12	Laser	
S224 closet	Mirror	
AG14	Lab jack	
AG45	Hot plate	Only have 5
AG15	Gloves	
AF31	Jar and Lid	
AG55 & AG56	Apparatus: Pipe, tubing, and pan	Pan can be found at AG45
AG56	Expansion rods	
AE41	Stoppers	
End of isle F	Meter stick	
Room S224	Thermometer	
<i>At the front for students to share</i>		

**Table 6.4.1:** Equipment Needed: [Thermal Expansion](#)



**Figure 6.4.2:** The equipment set up.

(Updated: 2013)

## 6.5 Boyle's Law

*2013 version by Matthew: May need updating..*

Location	Equipment	Notes
<b><i>For Each Lab Station</i></b>		
End of isle G & H	Boyle's law apparatus	
Faucet	water	(fill the apparatus to the appropriate height)
<b><i>At the front for students to share</i></b>		

**Table 6.5.1:** Equipment Needed: [Boyle's Law](#)



Figure 6.5.2: The equipment setup.

(Updated: 2013)

## 6.6 Specific Heat Capacity

*2013 version by Matthew: May need updating..*

Location	Equipment	Notes
<b>For Each Lab Station</b>		
AC11	Beaker	
AG44	Calorimeter	the insulated cup
AG45	Hot Plate	only have 5
Room S224, BB21	2 Thermometers	
End of isle F	Rods	
AG37	Objects	
AF15 (AG15?)	Gloves	
AE21	string	
<b>At the front for students to share</b>		

**Table 6.6.1:** Equipment Needed: [Specific Heat Capacity](#)



**Figure 6.6.2:** The equipment setup (revised).



**Figure 6.6.3:** The equipment setup (old version, but better view of most equipment).

(Updated: 2013)

## 6.7 Newton's Law of Cooling

*2013 version by Matthew: May need updating..*

Location	Equipment	Notes
<i>For Each Lab Station</i>		
AG45	Hot Plate	
AG11	Large and Small Beaker	
End of isle F	Stand to hold objects and Wires	
Room S224, BB21	Thermometer	
AF15	Gloves	
Either in lab room or room S224	Computer with Pasco	
AG58	Bottles	
<i>At the front for students to share</i>		

**Table 6.7.1:** Equipment Needed: [Newton's Law of Cooling](#)



**Figure 6.7.2:** The equipment setup.

(Updated: 2013)

## 6.8 Snell's Law of Refraction

*2013 version by Matthew: May need updating..*

Location	Equipment	Notes
<b><i>For Each Lab Station</i></b>		
AH34	Refraction Plates	
AH45	Card bored Plates	
AAAA	Laser	
AG14	Lab Jack	
AA43	Pins	
AA42	Protractor	
<b><i>At the front for students to share</i></b>		

**Table 6.8.1:** Equipment Needed: [Snell's Law of Refraction](#)

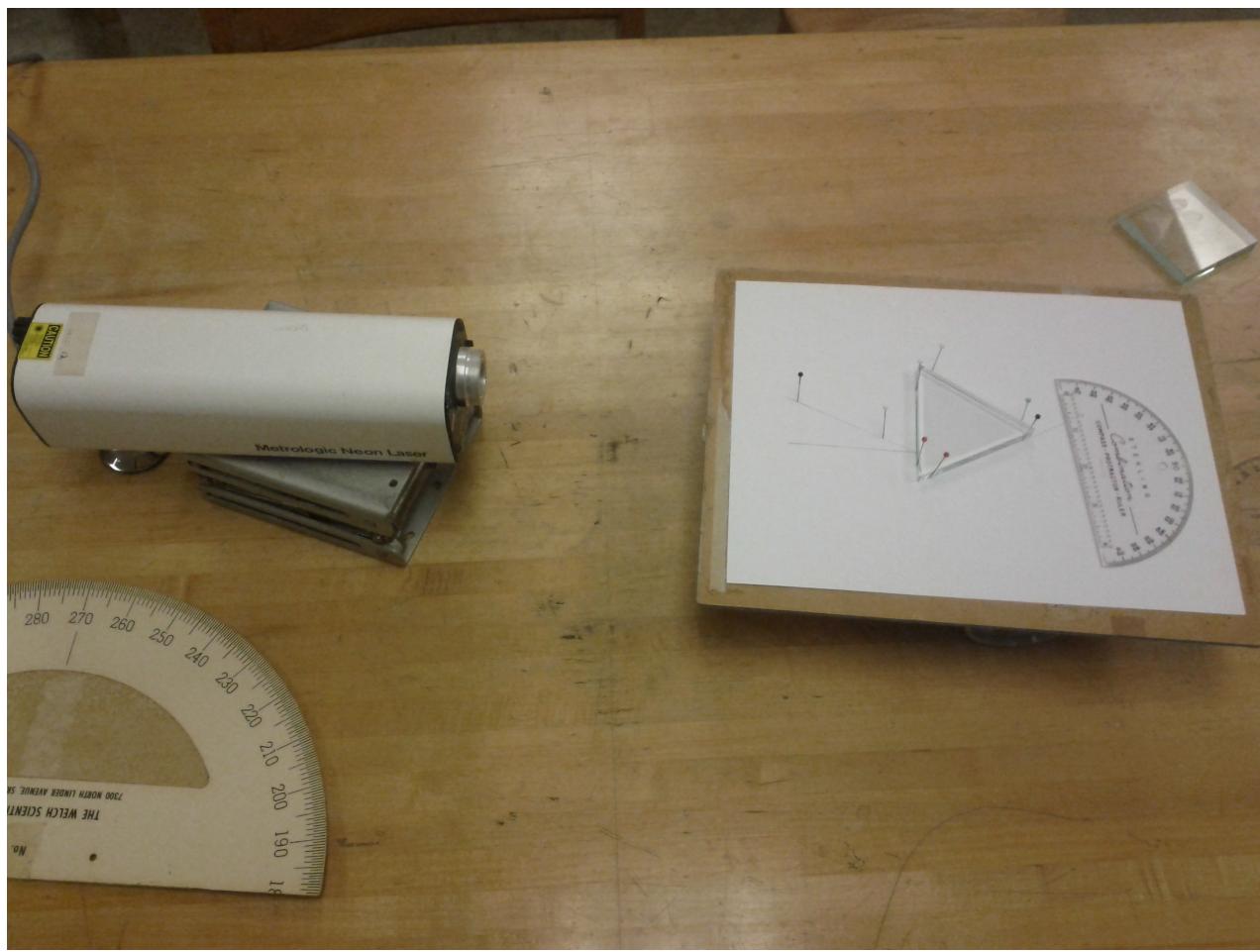


Figure 6.8.2: The equipment setup.

(Updated: 2013)

## 6.9 Reflection and Refraction

*2013 version by Matthew: May need updating..*

Location	Equipment	Notes
<b>For Each Lab Station</b>		
AH34	Refraction Plates	
AH45	Cardboard Plates	
AH45	Red Plastic Lens	
AH12	Lamps	
AG14	Lab Jack	
AA21	Hinged Mirror	
AA43	Pins	
AA42	Protractor	
AG12	Light Pipe	

*At the front for students to share*

**Table 6.9.1:** Equipment Needed: [Reflection and Refraction](#)



**Figure 6.9.2:** The equipment setup.

(Updated: 2013)

## 6.10 Radiation

*2013 version by Matthew: May need updating..*

Location	Equipment	Notes
<b><i>For Each Lab Station</i></b>		
(ASK)	Radioactive Samples	
AG16	Lead Bricks	
-	Stop Watch	
AM53	Geiger counter	
AM43	Shields	
<b><i>At the front for students to share</i></b>		

Table 6.10.1: Equipment Needed: [Radiation](#)

(Updated: 2013)

## 6.11 Interferometer

*2013 version by Matthew: May need updating..*

Location	Equipment	Notes
<b><i>For Each Lab Station</i></b>		
AN32	Interferometer	
AH12	Laser	
AK4	Screen	
AG14	Lab Jacks	
AG12	Hand Pump	
<b><i>At the front for students to share</i></b>		

Table 6.11.1: Equipment Needed: [Interferometer](#)



**Figure 6.11.2:** The equipment setup.

(Updated: 2013)