

# 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
  - Dr. Jeremy Huber



# Download the PDF here

A PDF of this document can be found at <http://physics.thomasmore.edu/PHY121Lab/TMC-lab-setup.pdf>. (288 kB)



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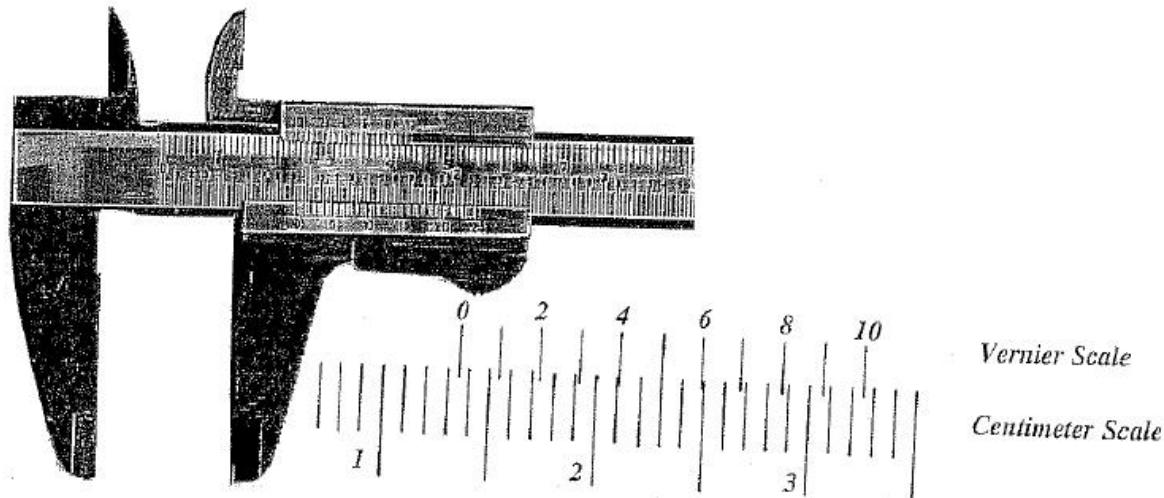
# Class 1

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

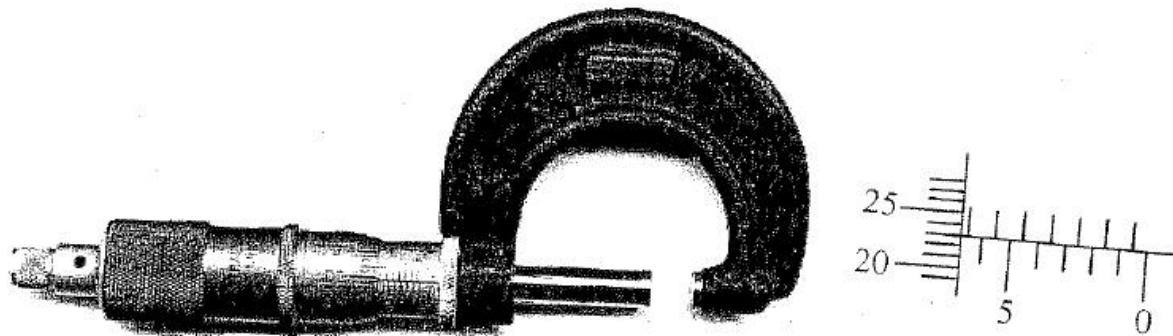
### 1.1 Meaningful Measurements

Location	Equipment	Notes
<i>For Each Lab Station</i>		
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)
<i>At the front for students to share</i>		
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/PHY121Lab/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/PHY121Lab/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)

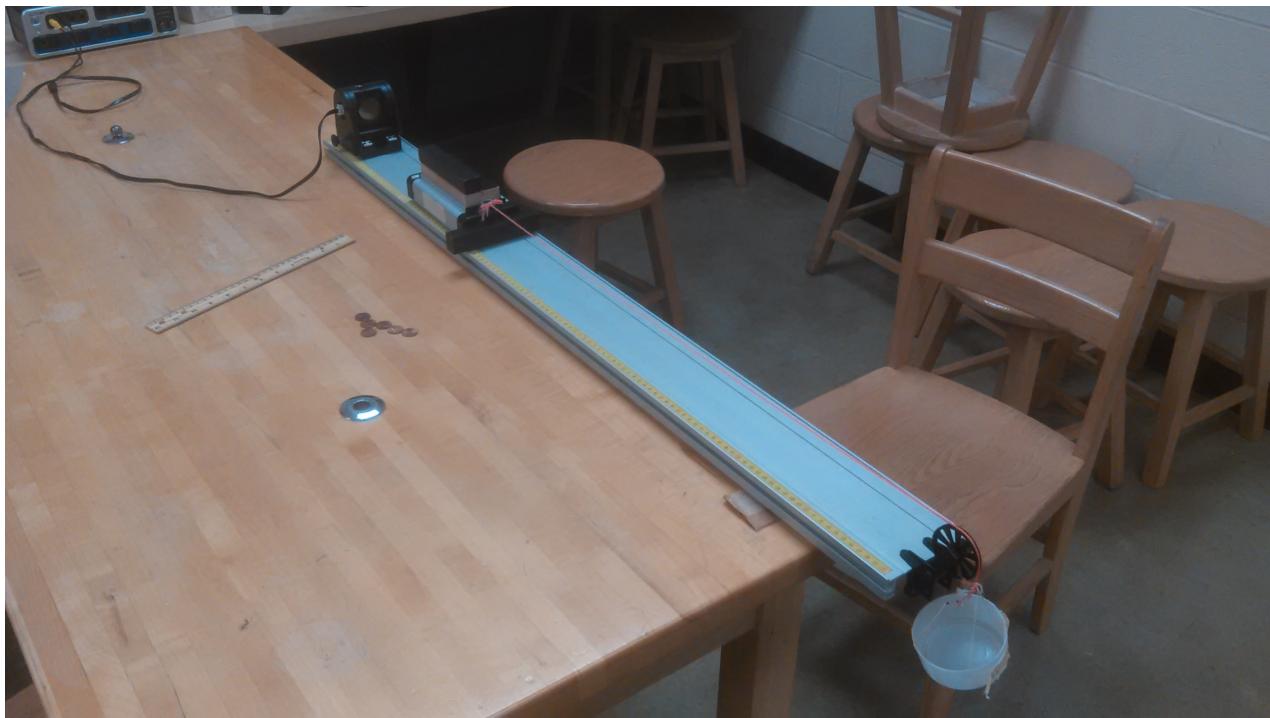
A digital version of the lab should be found at <http://physics.thomasmore.edu/PHY121Lab/c-acceleration.html>

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/PHY121Lab/c-Newton.html>

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

## 1.5 Dry Sliding Friction

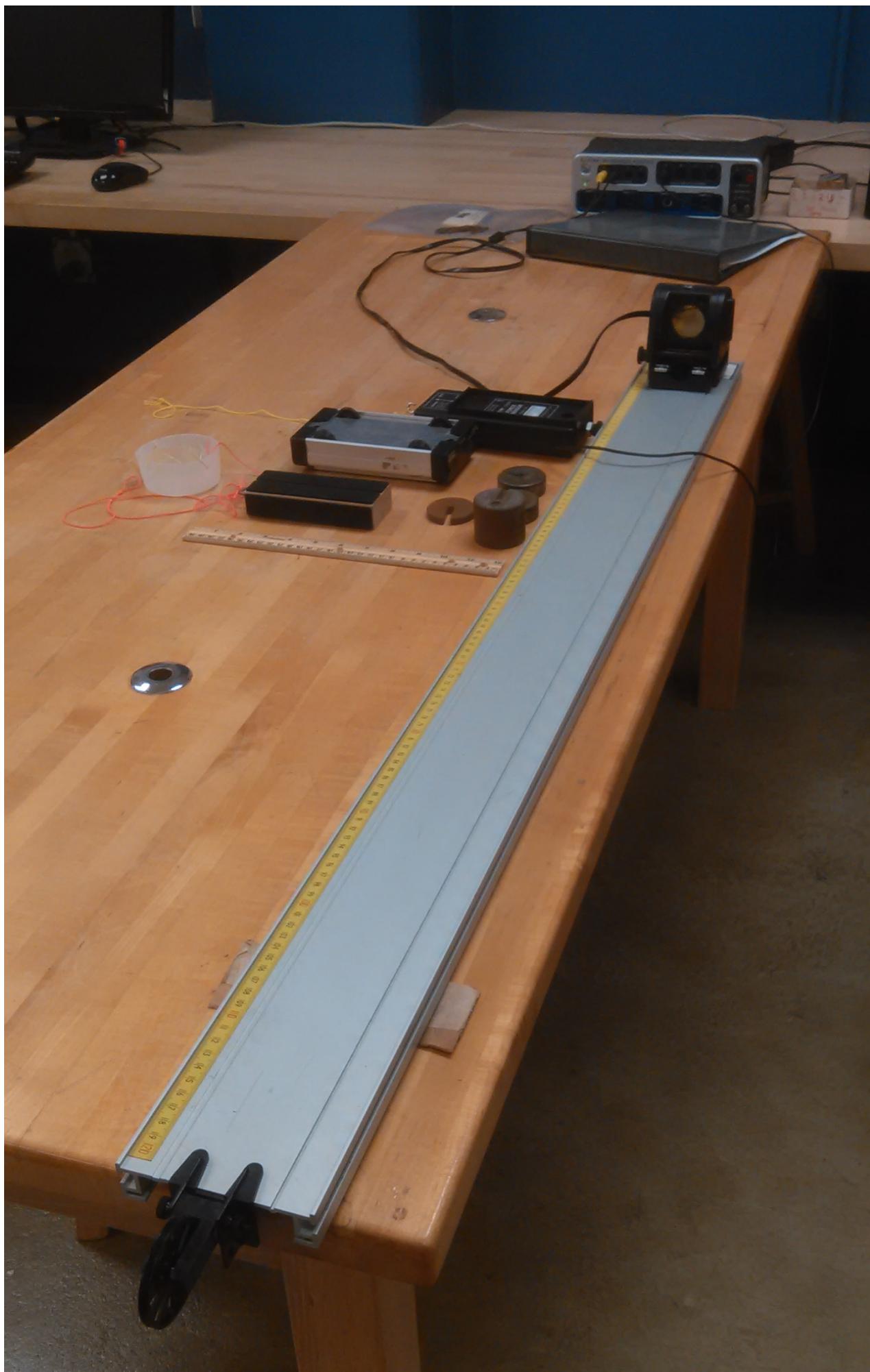
Most of this equipment is the same as [Newton's 2<sup>nd</sup> Law on a Linear Track with the Sonic Ranger](#), but it is not exactly the same.

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.



(Updated: October 12, 2017)

A digital version of the lab should be found at <http://physics.thomasmore.edu/PHY121Lab/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/PHY121Lab/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 1.7.4:** 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/PHY121Lab/c-springs.html>

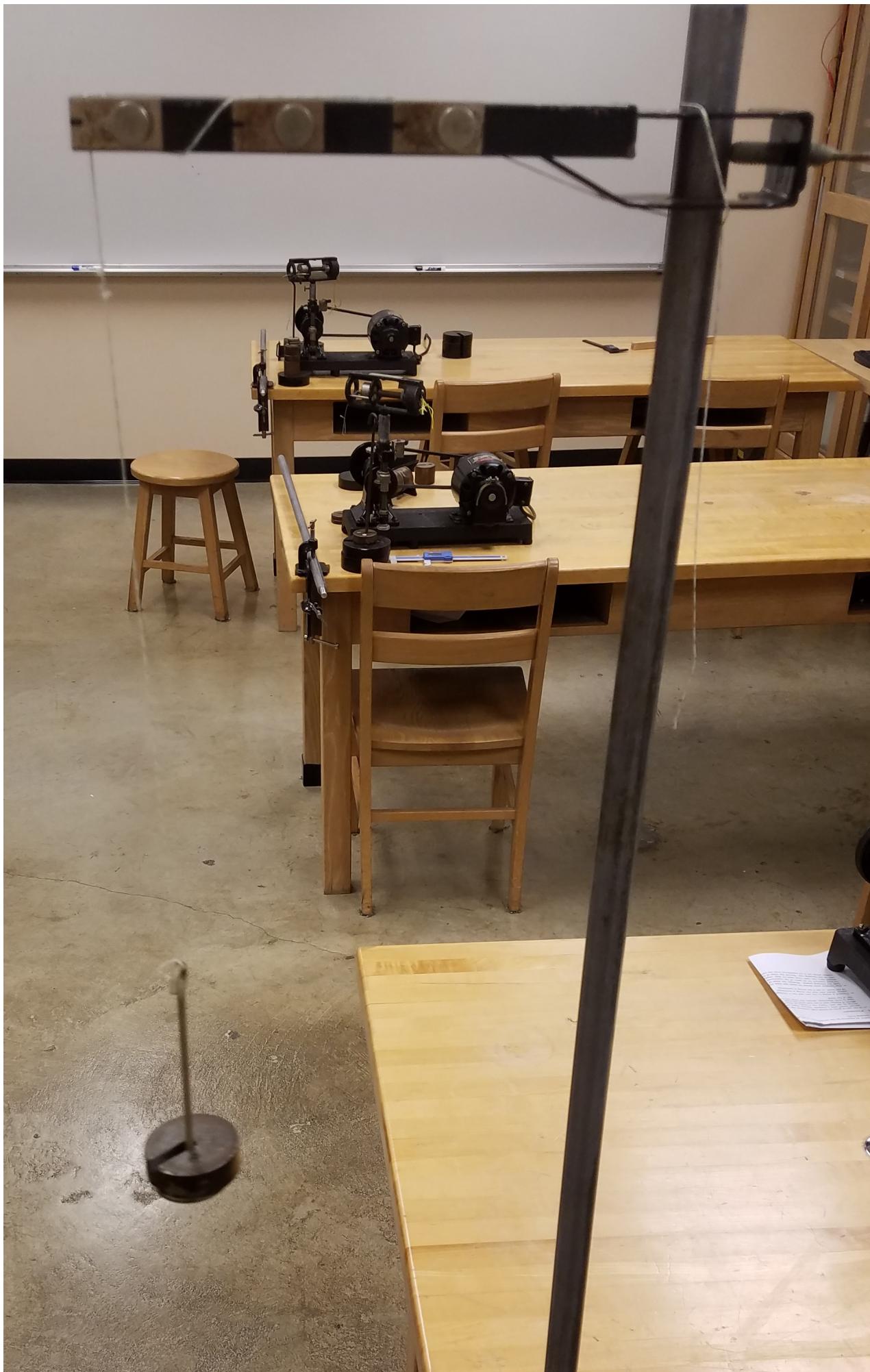
A PDF version might be found at [springs.pdf](#)

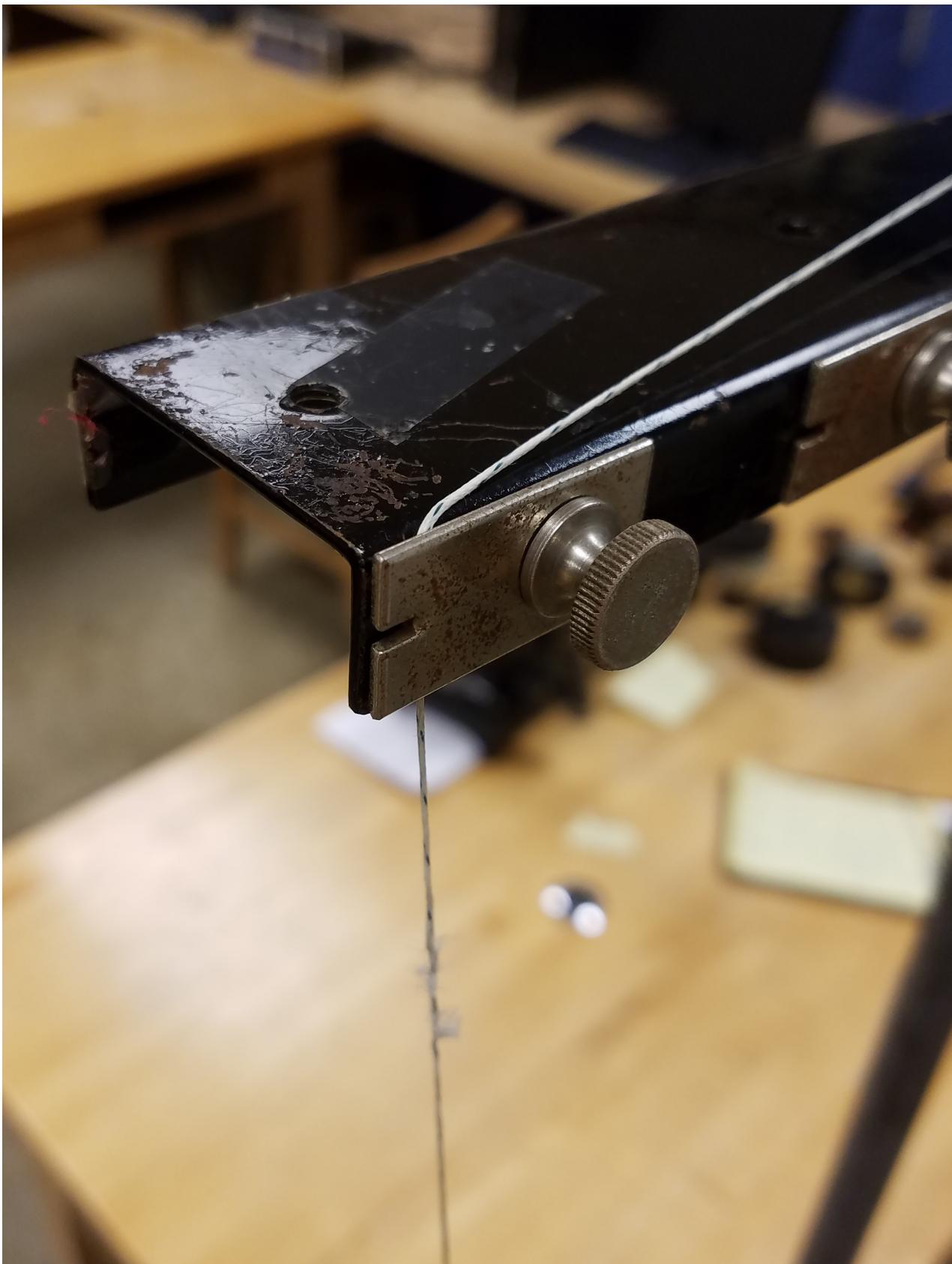
## 1.8 Pendulum / Peer Review

**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 1.8.4:** The equipment setup.

(Updated: October 12, 2017)

A digital version of the lab should be found at <http://physics.thomasmore.edu/PHY121Lab/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><i>This is only needed in the second week</i></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/PHY121Lab/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/PHY121Lab/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.
    - 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>Do not wait until the last minute to set this lab up!</b>
AD91	1 1-meter stick, 1 2-meter stick	Note they will need two metersticks
AD <sup>72</sup> <del>AD43</del>	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

(Updated: November 9, 2017)

A digital version of the lab should be found at <http://physics.thomasmore.edu/PHY121Lab/c-ballistic.html>A PDF version might be found at [ballistic.pdf](#)

## 1.11 Next Lab

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

**Table 1.11.1:** Equipment Needed: Next Lab

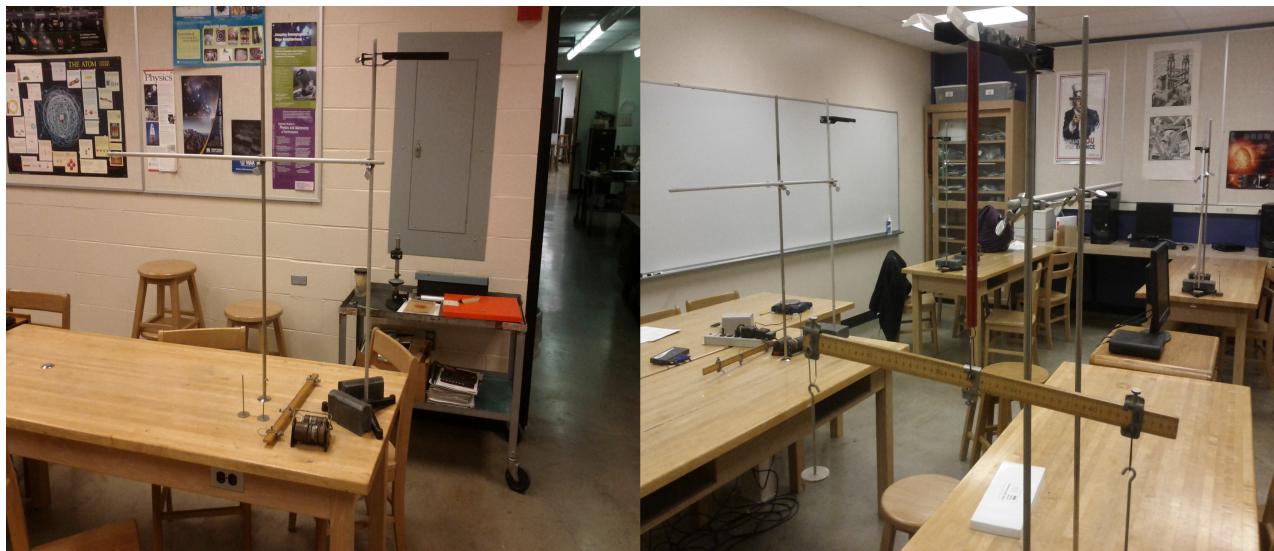
(Updated: October 12, 2017)

A digital version of the lab should be found at <http://physics.thomasmore.edu/PHY121Lab/c-labname.html>A PDF version might be found at [labname.pdf](#)

## 1.12 Human Forearm

Location	Equipment	Notes
<b>For Each Lab Station</b>		
AD??	2 rod clamps (size depends on the rods you picked)	These connect the vertical rods to the horizontal rod
AE??	clamps for the meter-sticks	These are the little black things that slide onto a meter-stick and have a metal piece that a mass-hanger can hang off of.
End of AD	3 rods (2 long, 1 short)	Note that one rod goes in the table, so you need to notice if each table has a hole or a screw for this rod. The short rod is for stability.
End of AF	1 2-meter stick	.
AF42	1 spring	(any color)
AF44	hangers and various masses	.
AF34	1 meter stick	(might need a 1/2-meter stick)

**Table 1.12.1:** Equipment Needed: [Human Forearm](#)



**Figure 1.12.2:** The equipment setup.

(Updated: February 27, 2013)

A digital version of the lab should be found at <http://physics.thomasmore.edu/PHY121Lab/c-equilibrium.html>  
A PDF version might be found at [equilibrium.pdf](#)

## Class 2

**PHY122L: General Physics  
(algebra-based, spring)**