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Collaborators:

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Soil Testing

When testing soil these are the common tests
-permeability testing
-sieve analysis
-hydrometer testing
-triaxial shear testing

We focused on the first two during our four weeks of research.

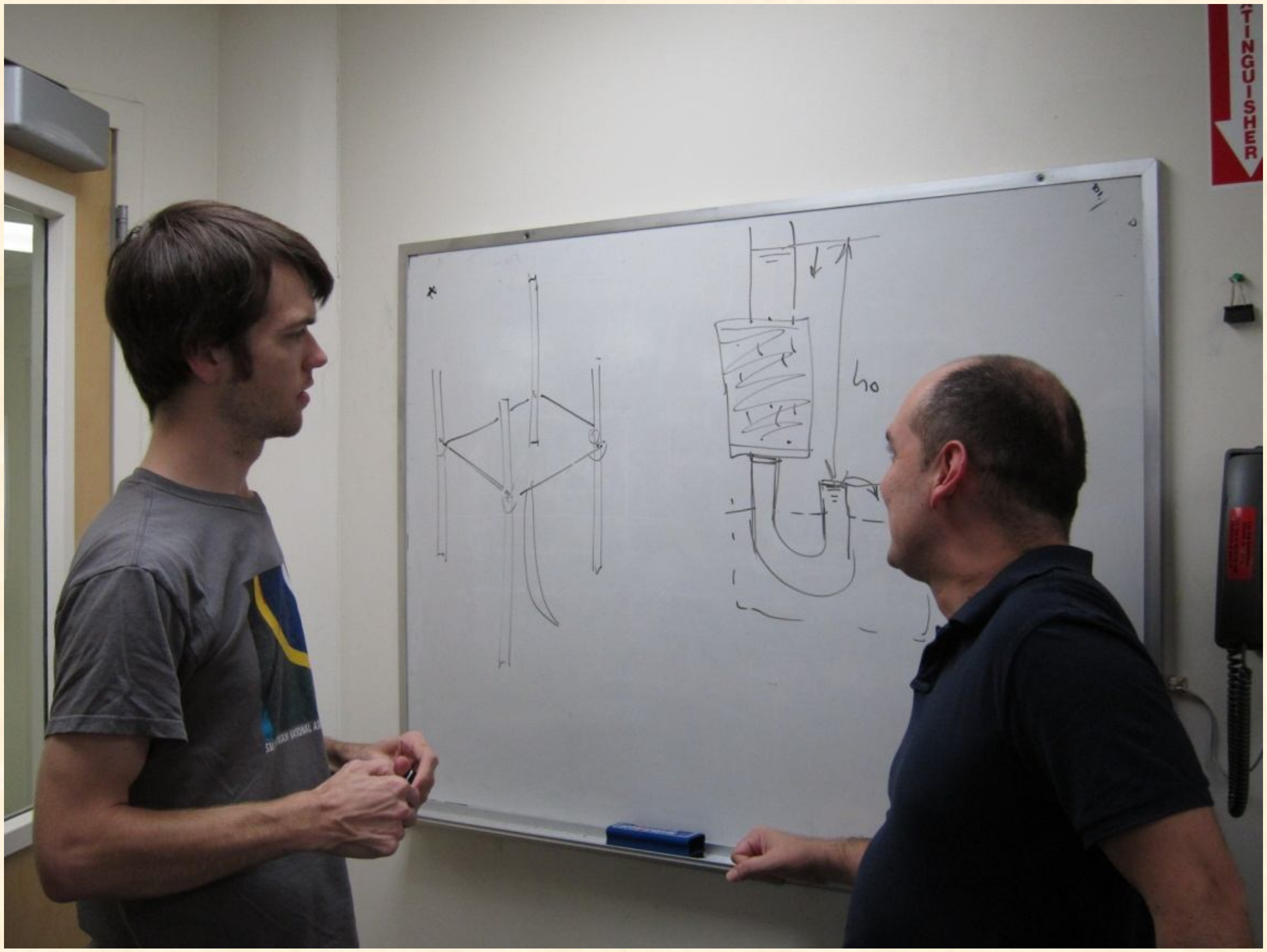
Permeability Testing

Our first test was to run a permeability test on a sand mixture. We used the ELE permeameter to determine how fast water could flow through the sample. This device was cumbersome, messy, and expensive.

Permeability Testing

We set out to redesign the permeameter in a way to make it neater, more affordable, and K-12 friendly. Water flow in soil has a direct connection to the NYC Science Scope and Sequence

Preliminary Designing

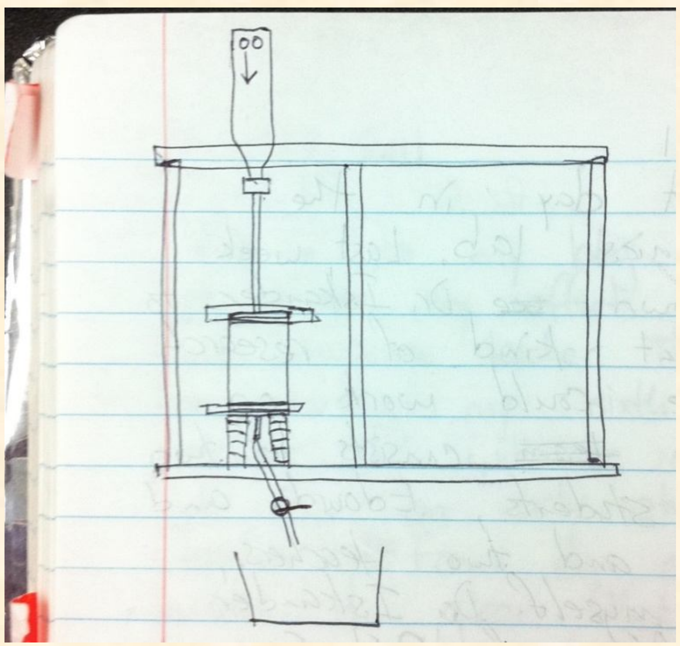


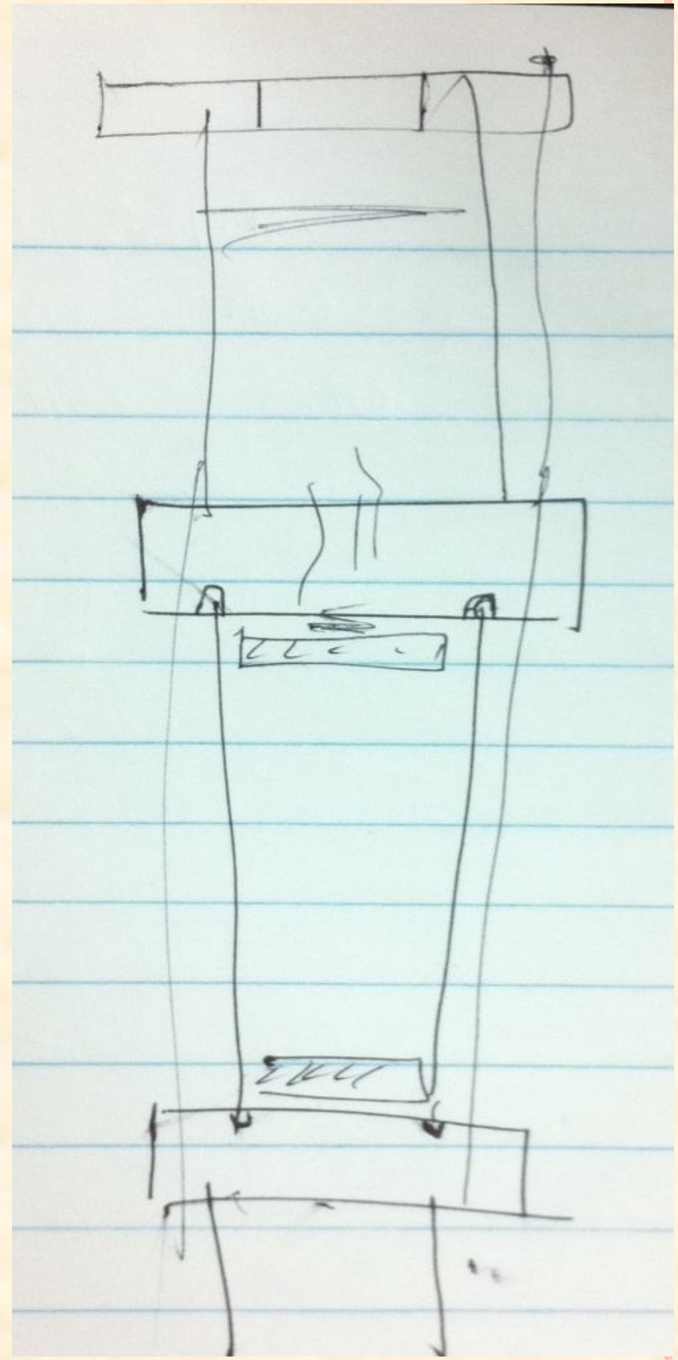
Andrew Cave and Eduardo Seuscún are graduate students working for Dr. Iskander. They consulted and guided us in the design process.

We reviewed the design several times. Each time we met as a team to discus its strengths and weaknesses.

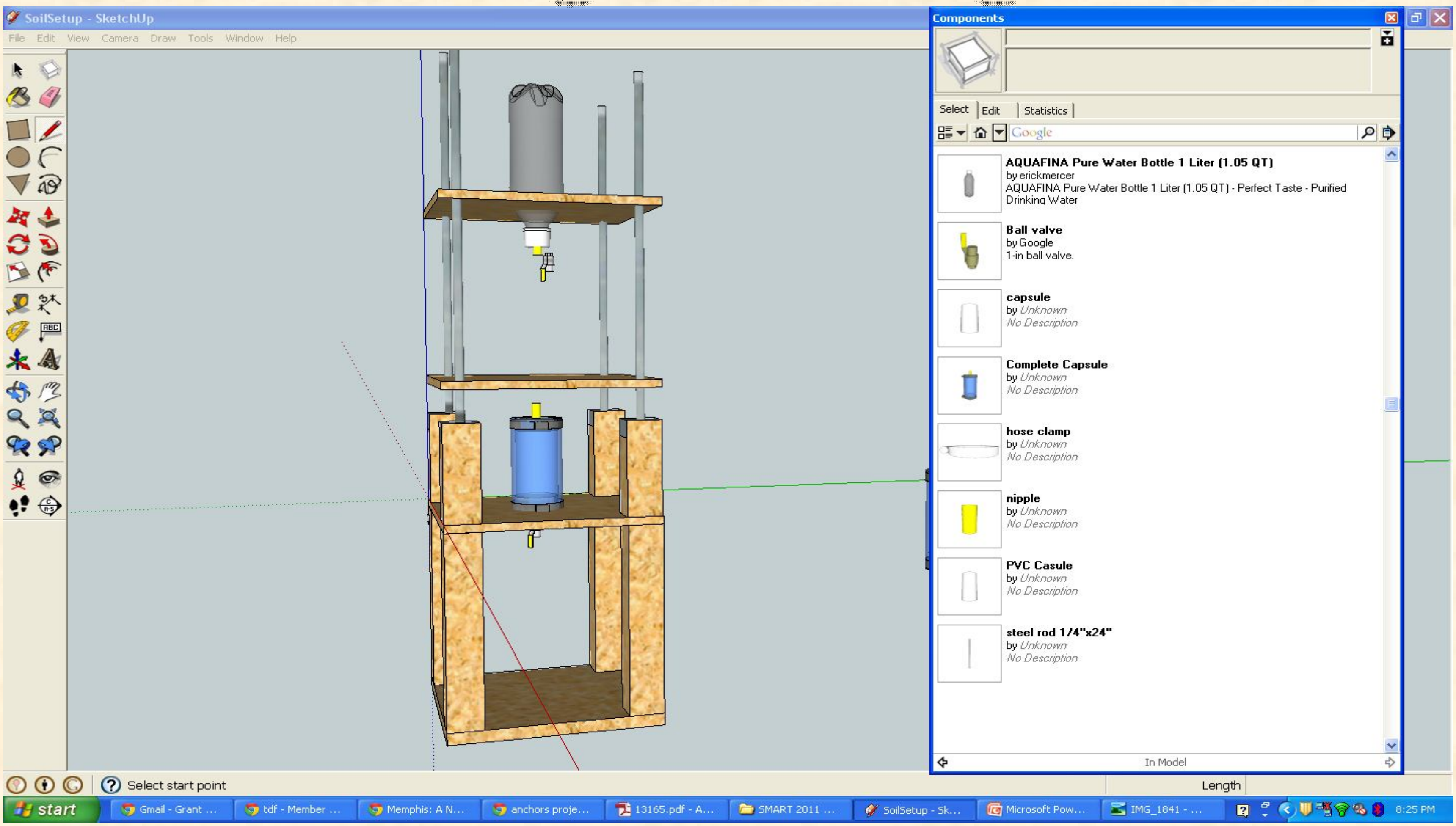
Early Sketches

We started with some rough drawings to flesh out our ideas. We also decided to automate the timing of the test. We made sure the BS2 and the ultrasonic sensor could read the surface of the water.



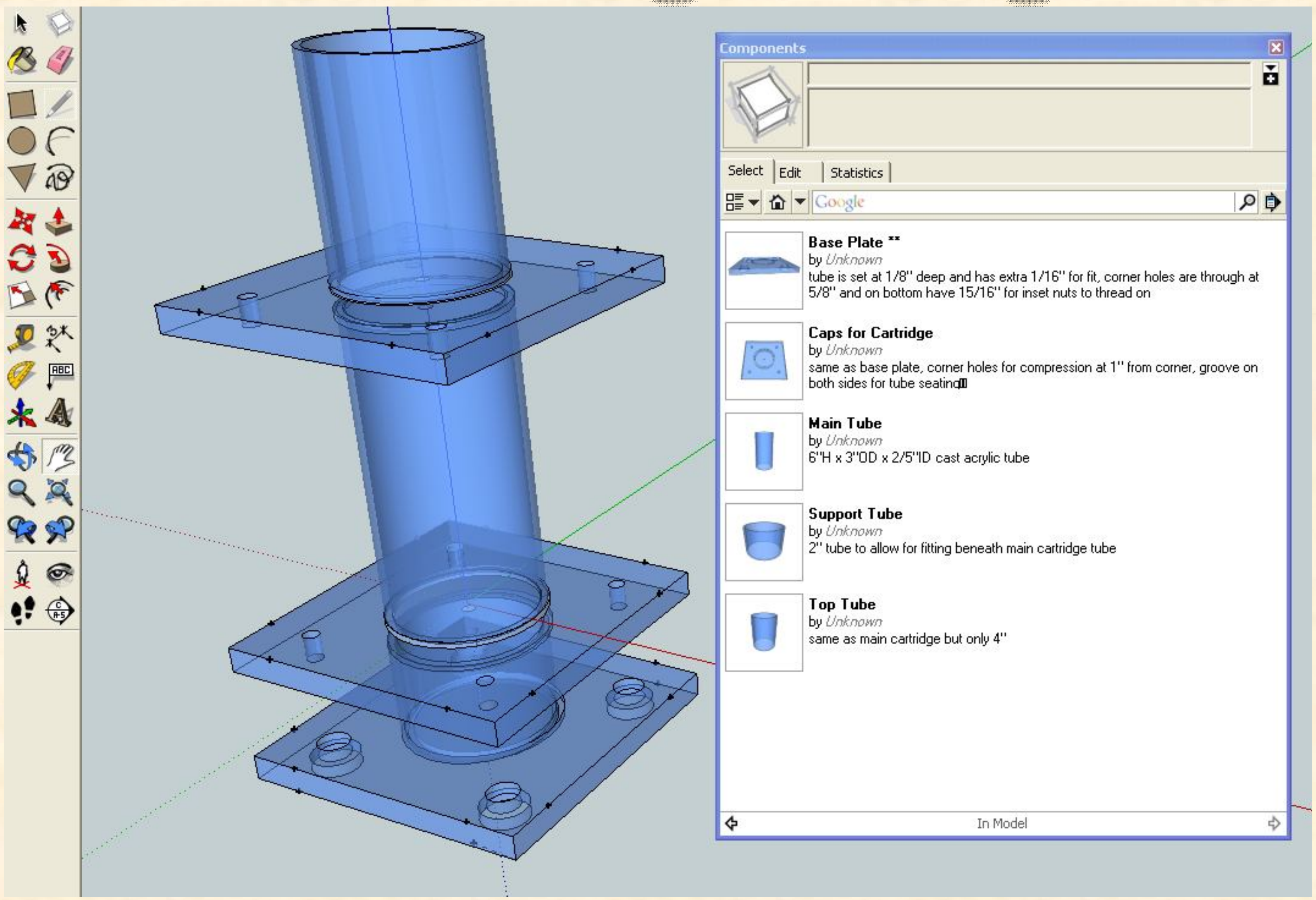


Our first design in Google Sketchup



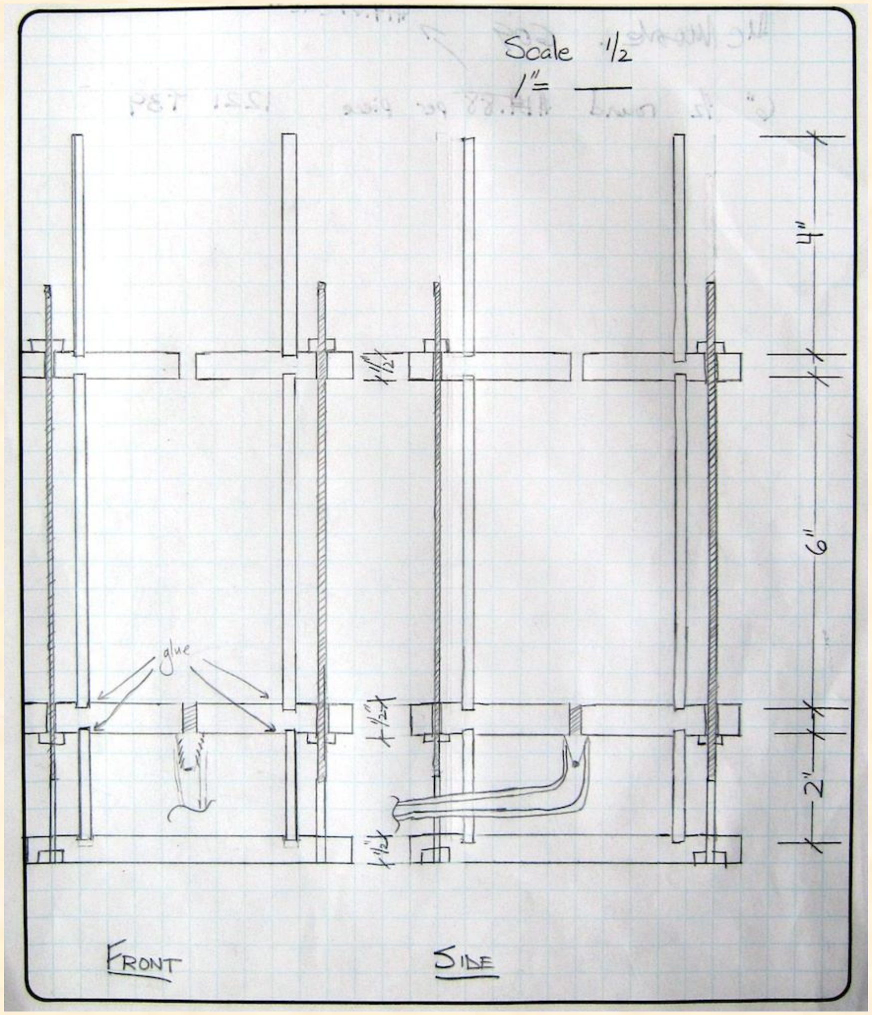
This design would work but became a bit too heavy. We redesigned a more portable version on attempt #2.

Streamlining: Design #2

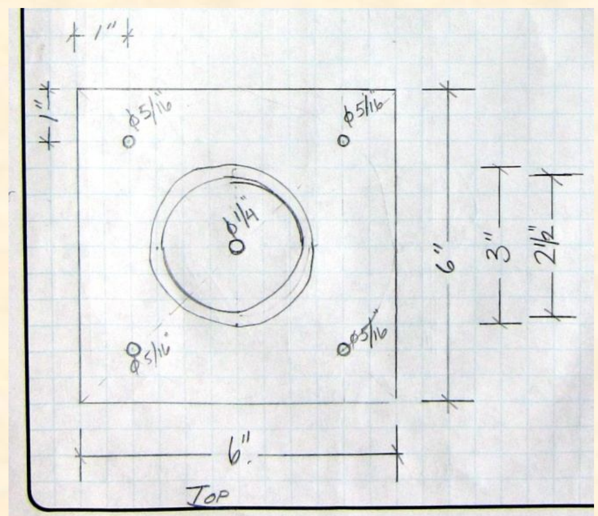


By using lighter materials and adjusting some of the measurements we developed a viable design that could easily be used in schools.

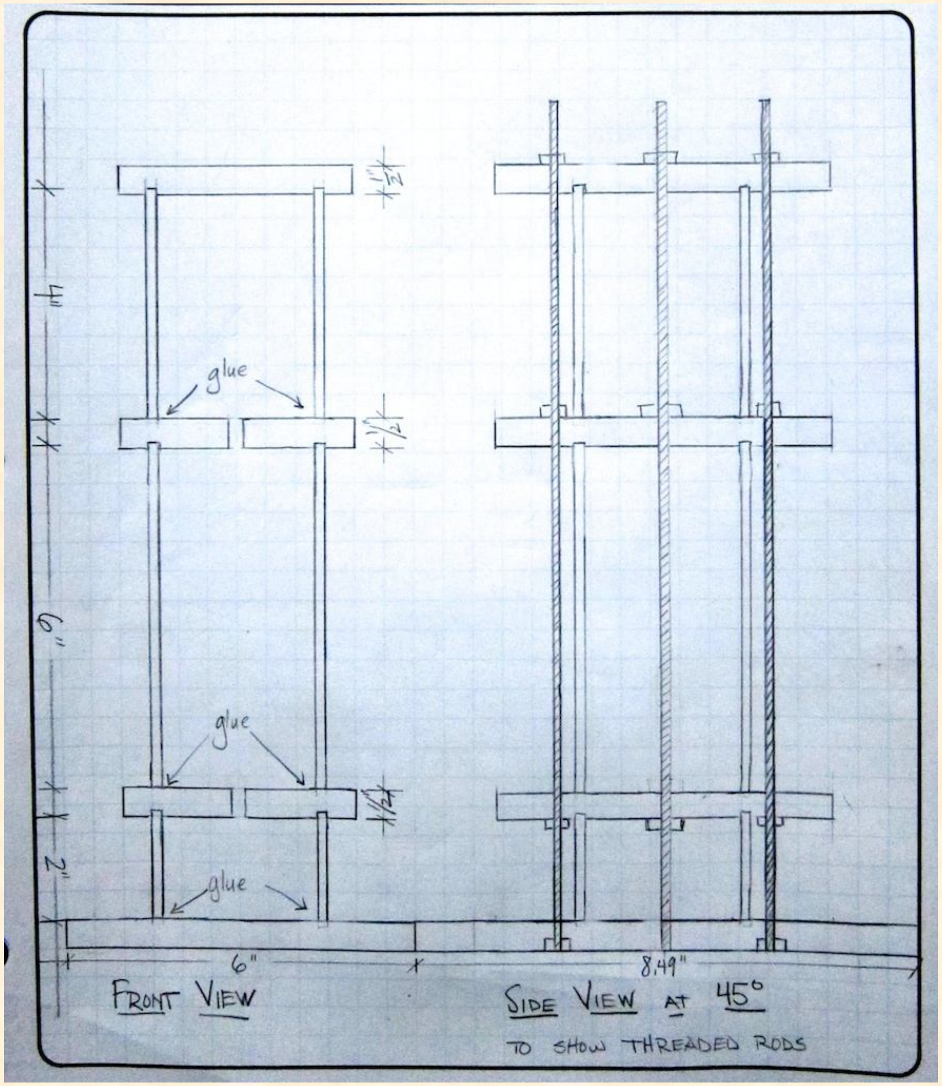
Prep for the Machinist



To get efficient, effective design, accurate drawings need to be supplied to the machinist to construct appropriate components.



Final Design, Almost



We prepared for machining by updating our measurements on our design and preparing for the actual production phase of our creation. We realized there was a mistake in one of the measurements. "Measure twice, cut once."

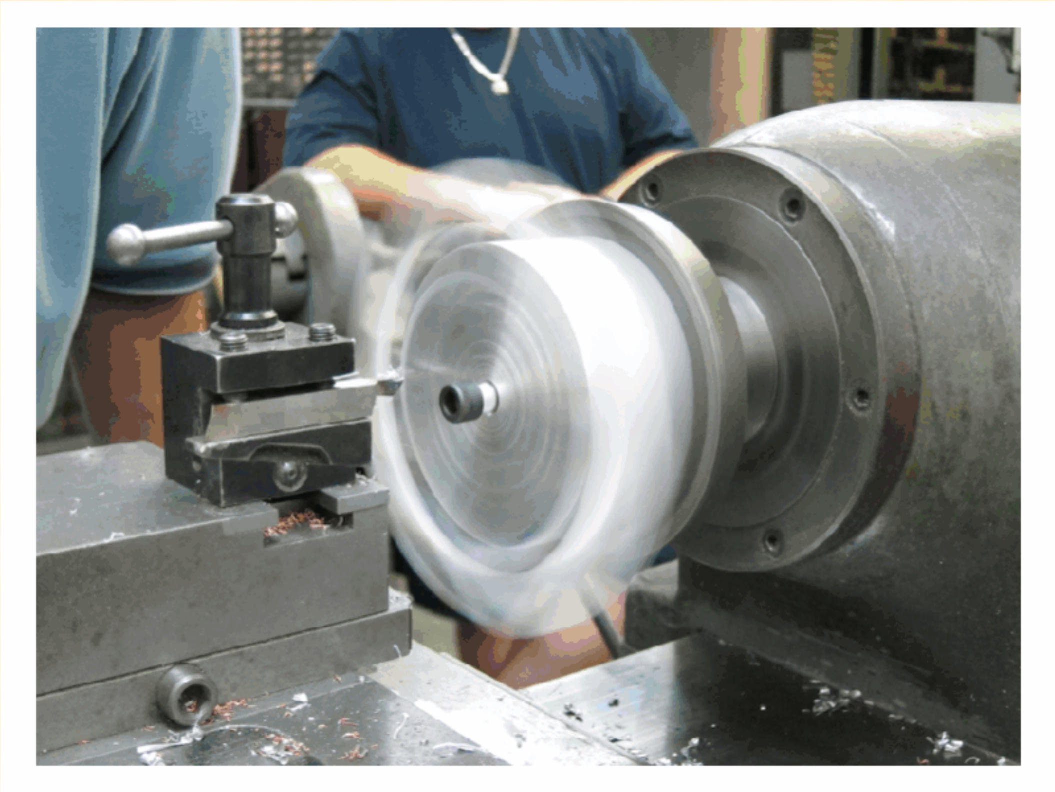
Production Phase

Allesandro Betti, the machinist, assisted and advised us on how best to fabricate our design with the most appropriate tools. He performed the more complex aspects of the process.

Production Phase

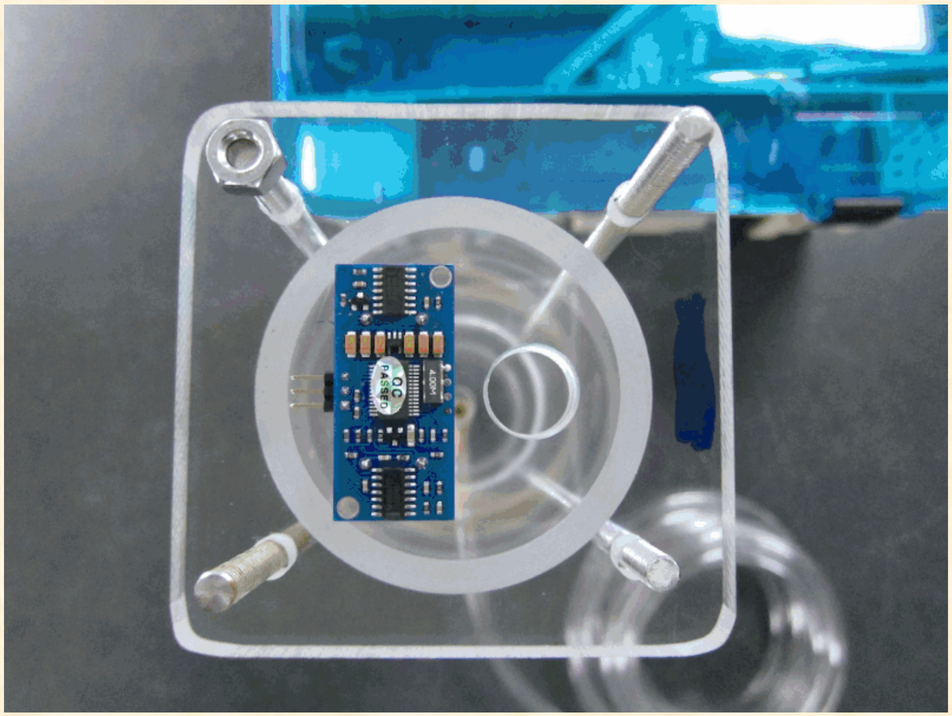
It is imperative to use the correct tools on certain materials so as not to damage them or hurt yourself.
It was an oversight that we did not factor in the blade width into our measurements. This caused us to come up short on one of the materials.

Production Phase



Allesandro cut the channels in the plates to allow for the insertion of a gasket to provide a watertight seal.

Installing Mechatronics



One final touch we needed was to provide a cover for the installation of our mechatronic components that allows us to automate the process of data collection in a falling head permeability test.

Testing the Design

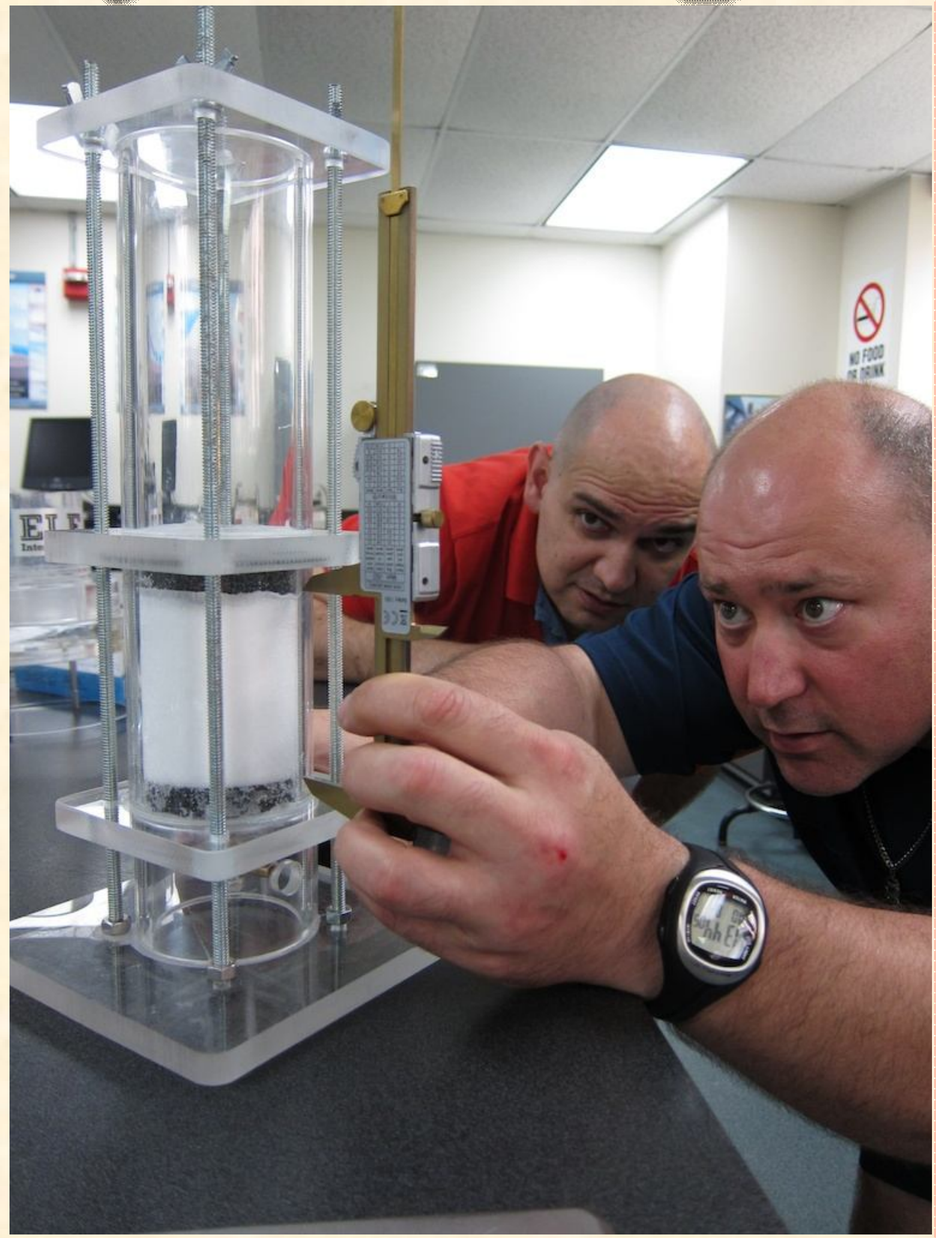
We then began to test our apparatus to ensure it was fully watertight. Thereafter we finished the remaining five cartridges and continued compiling permeability data.

Permeabilty Testing

We built five more permeameters after being satisfied with the prototype. We now have two sets of three permeameters. This will allow us to run three concurrent tests in our respective classrooms.

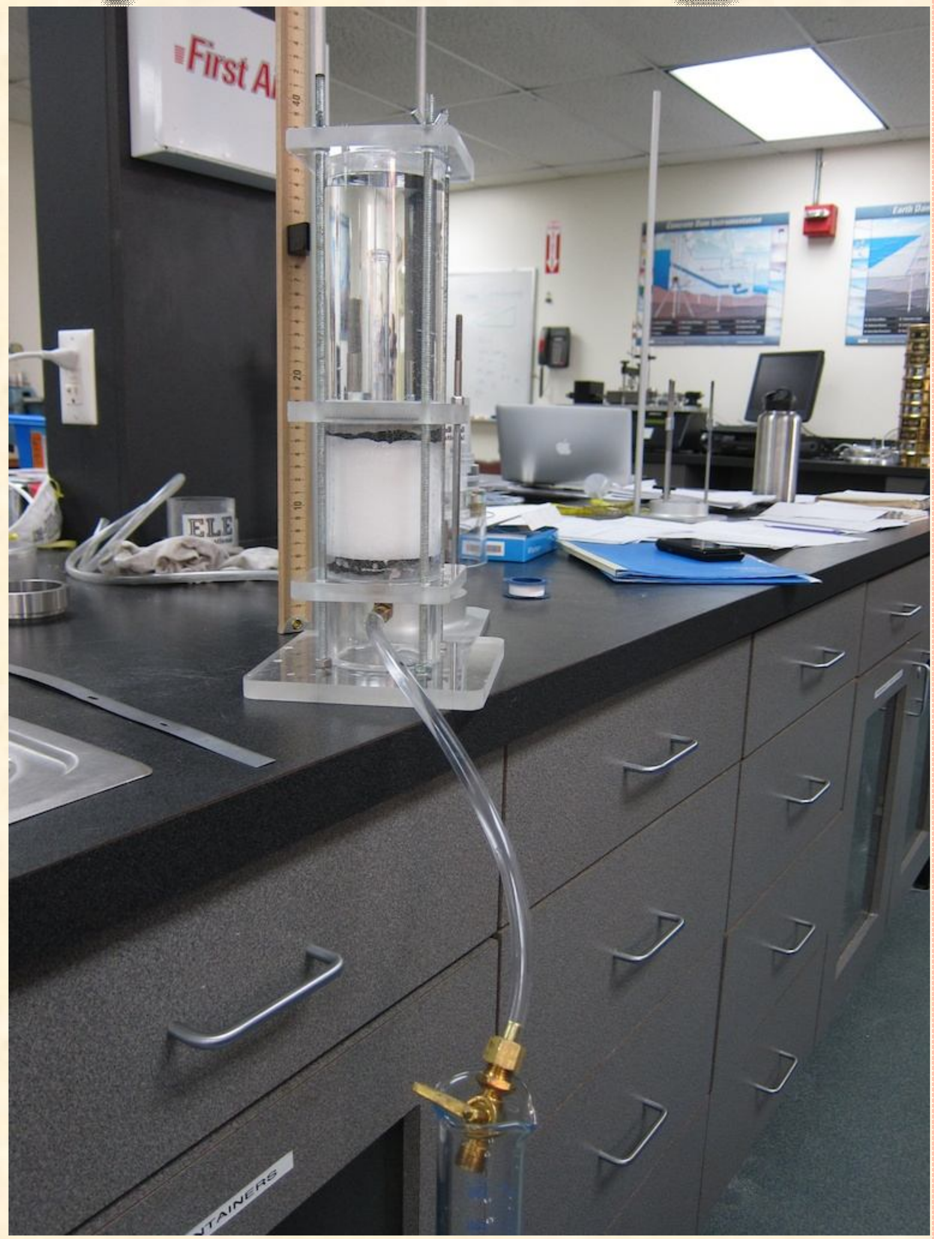
Permeabilty Testing

We ran permeability tests on a natural sand mix that was in the lab, sand from Fire Island, fused quartz, aqaubeads, plastic pellets and glass marbles. Factors that control flow rate are particle shape and particle size distribution (known as gradation). These two characteristics result in more or less void space in the sample.



Permeabilty Testing

We began each test by measuring the mass and volume of the sample. We then timed the duration for the sample to pass 205mL of water. We also noted the difference between the starting head height and the ending head height.



Permeabilty Testing

For each soil specimen, we recorded measurements to calculate the void ratio. Additionally, we conducted sieve analyses for two separate soil samples. Running the permeability test allowed us to measure the actual coefficient of permeability for each type of soil.

Appendix B

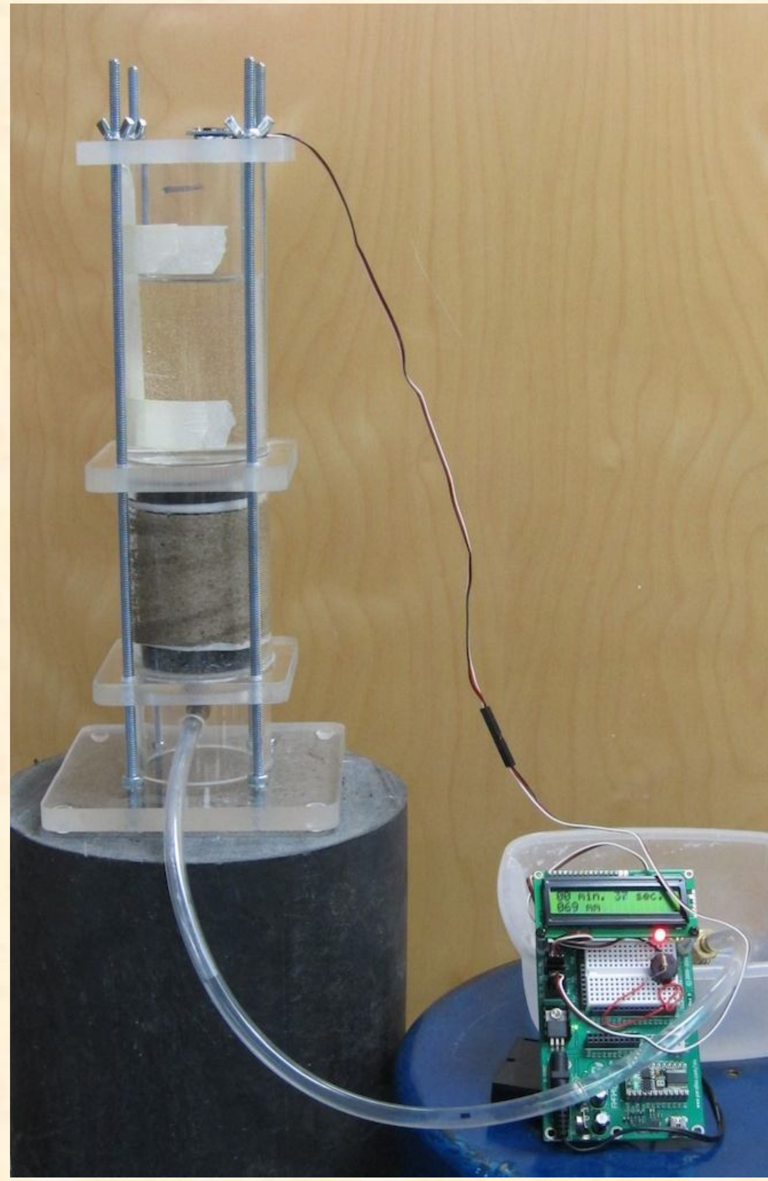
Fused quartz 50/50 fine/extra-fine mixture description of specimen

Determination of void ratio

Description of soil	50% fine – 50% extra-fine mixture fused quartz
Location of Test	Soil Mechanics Laboratory, RH415
Length of specimen, L 7.57 cm	Diameter of specimen, D 6.35 cm
Tested by Eduardo Seuscún, Ryan Cain, and Russ Holstein	Date August 1, 2011
Volume of specimen, $\mathbf{V} = \frac{\pi}{4}\mathbf{D}^2\mathbf{L}(cm^3)$	239.74 cm^3
Specific gravity of soil solids, G_s	2.24
Mass of specimen tube with fittings, W_1 (g)	1,697 g
Mass of tube with fittings and specimen, W_2 (g)	1,996 g
Dry density of specimen, $\rho_d = \frac{W_2 - W_1}{V}(g/cm^3)$	1.25 g/cm^3
Void ratio of specimen, $e = \frac{G_s \rho_w}{\rho_d} - 1$ (*Note:* $\rho_w = 1 g/cm^3$)	1.8 g/cm^3

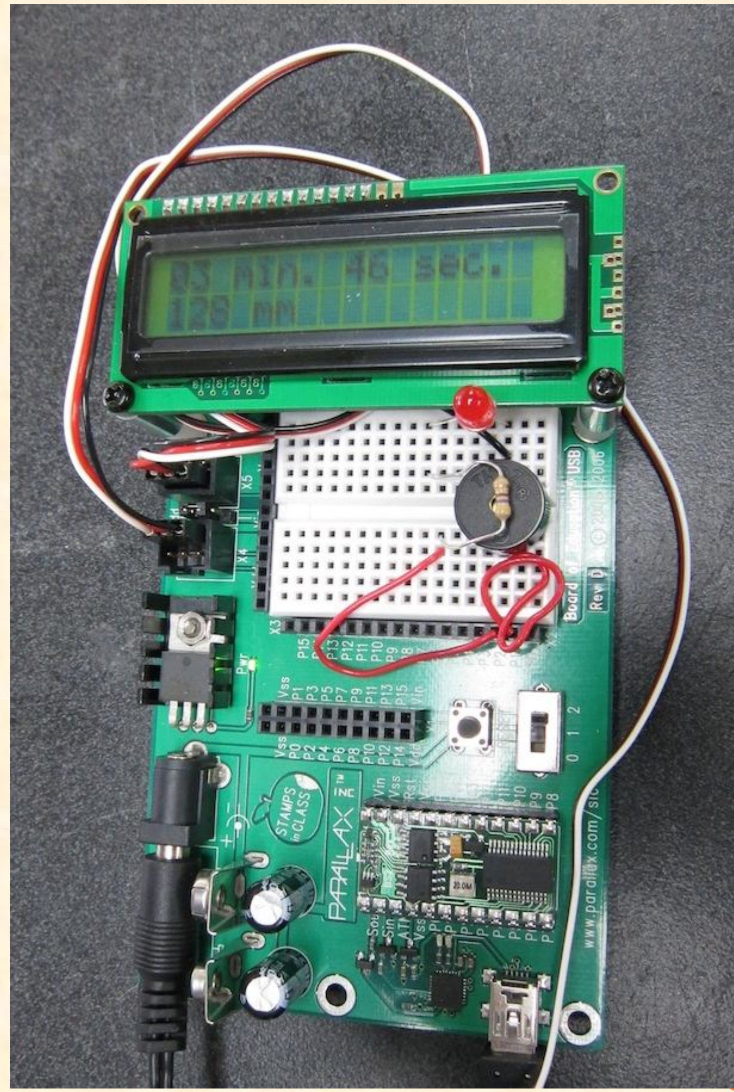
Automated Data Collection

We mounted an ultrasonic sensor to the top plate of the permeameter. The BS 2 measures time when the distance from the surface of the water is greater than 65mm and less than 128mm. This gives us the amount of time for a flow of 205mL.



Automated Data Collection

Children will use the permeameter with and without the automation. We will also run simultaneous flow tests as a race. We are developing this lesson with Eduardo Suescún for an AMPS activity. We will also be submitting this lesson to the ASCE. The ASCE has put out a call for activities for their new pre-college outreach program.



Sieve Analysis

The sieve analysis allows us to quantify mass distribution by particles size. It does not distinguish between clay and silt. Soil hydrometer testing is used to measure quantities of silt and clay. We were unable to run this test.

Sieve Analysis

First we had to weigh the sample to find the total mass.

Sieve Analysis

Next we poured the soil into the sieve stack. The openings get smaller and smaller each level down. The machine on the bottom shakes the stack to sort out the particles by size.

Sieve Analysis

We weighed and recorded the contents of each layer.

Sieve Analysis

Appendix F

Sieve Analysis, natural sand from Fire Island, Robert Moses State Park,

Mass of sample, W = 1884g, 8/8/2011

Sieve No.	Sieve opening (mm)	Mass of soil retained on each sieve, W_n (g)	Percent of mass retained on each sieve, R_n	Cumulative percent retained, $\sum R_n$	Percent finer, $100 - \sum R_n$
3/8	9.51 mm	0 g	0.0	0.0	100
#4	4.76 mm	2 g	0.1	0.1	99.9
#10	2 mm	6 g	0.3	0.4	99.6
#20	.85 mm	178 g	9.4	9.8	90.2
#25	.707 mm	132 g	7.0	16.8	83.2
#40	.425 mm	1064 g	56.5	73.3	26.7
#60	.25 mm	432 g	22.9	96.2	3.8
#80	.177 mm	68 g	3.6	99.8	0.2
#140	.105 mm	2 g	0.1	99.9	0.1
#200	.075 mm	0 g	0.0	99.9	0.1
Pan		0 g	0.0	99.9	0.1

Σ = 1884 g = W_1

Mass loss during sieve analysis = $\frac{W - W_1}{W} \times 100 = 0.0$ % (OK if less than 2 %)

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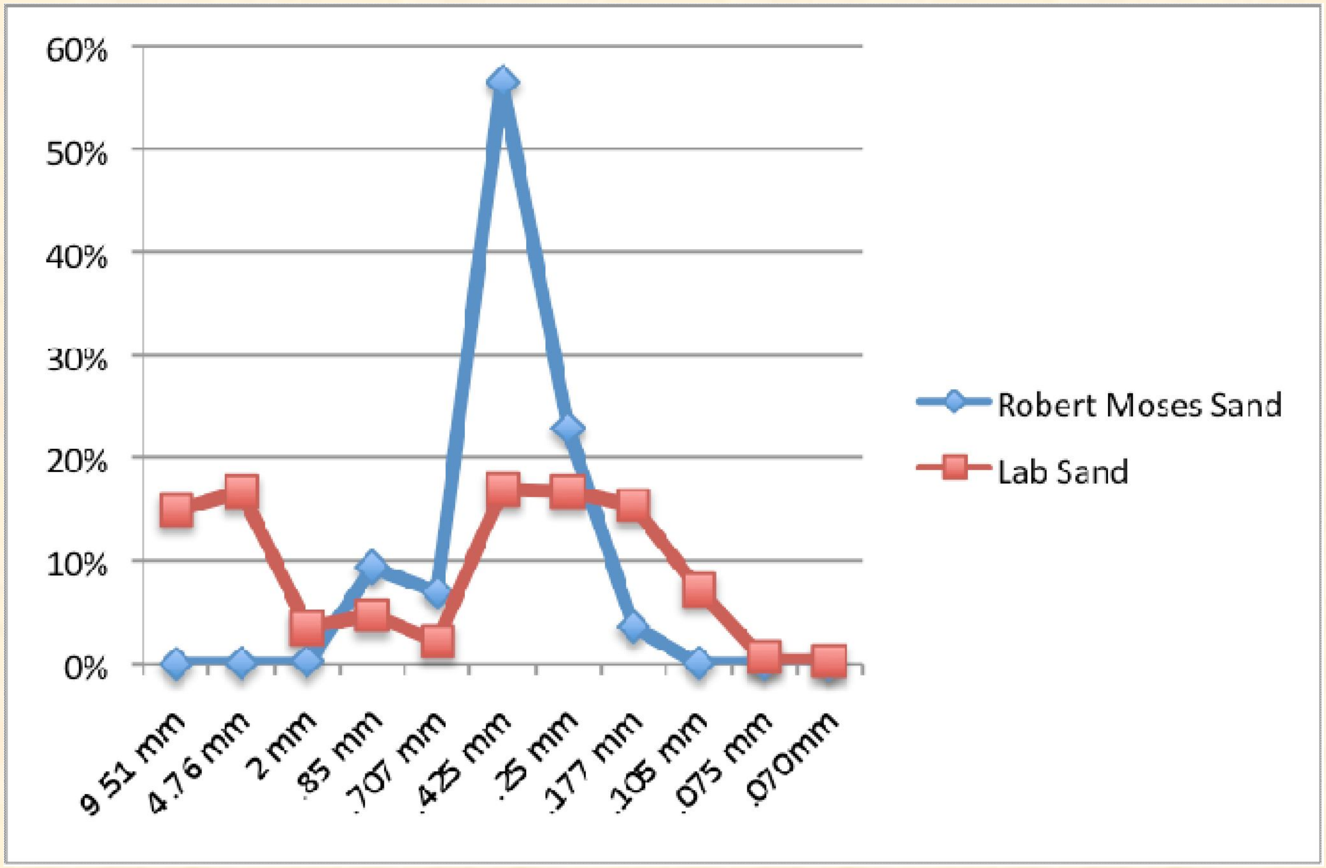
The results we obtained from the analysis of the Fire Island sand indicated that it was a poorly graded sand and therefore had a greater porosity which caused it to be much more permeable.

Sieve Analysis

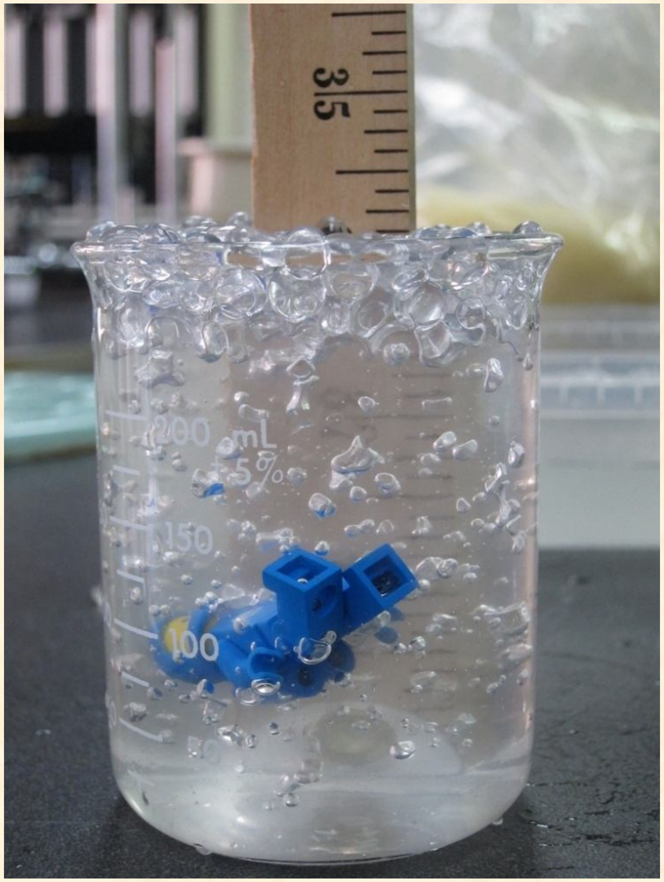


Neither of the sand samples were well graded, where particle size would be evenly distributed. A well graded soil will have less void space, lower permeability, and greater structural integrity.

Transparent Soils

The Soil Mechanics Lab focuses their research on transparent soils. Transparent soils allow us to see what is happening inside the soil, This could be helpful to monitor what happens inside the soil when a force is applied or how a contaminant travels through soil. The LEGO man disappears over time because we added Aquabeads to the water. Aquabeads are a a water absorbing polymeric gel. They grow 200x their original size.

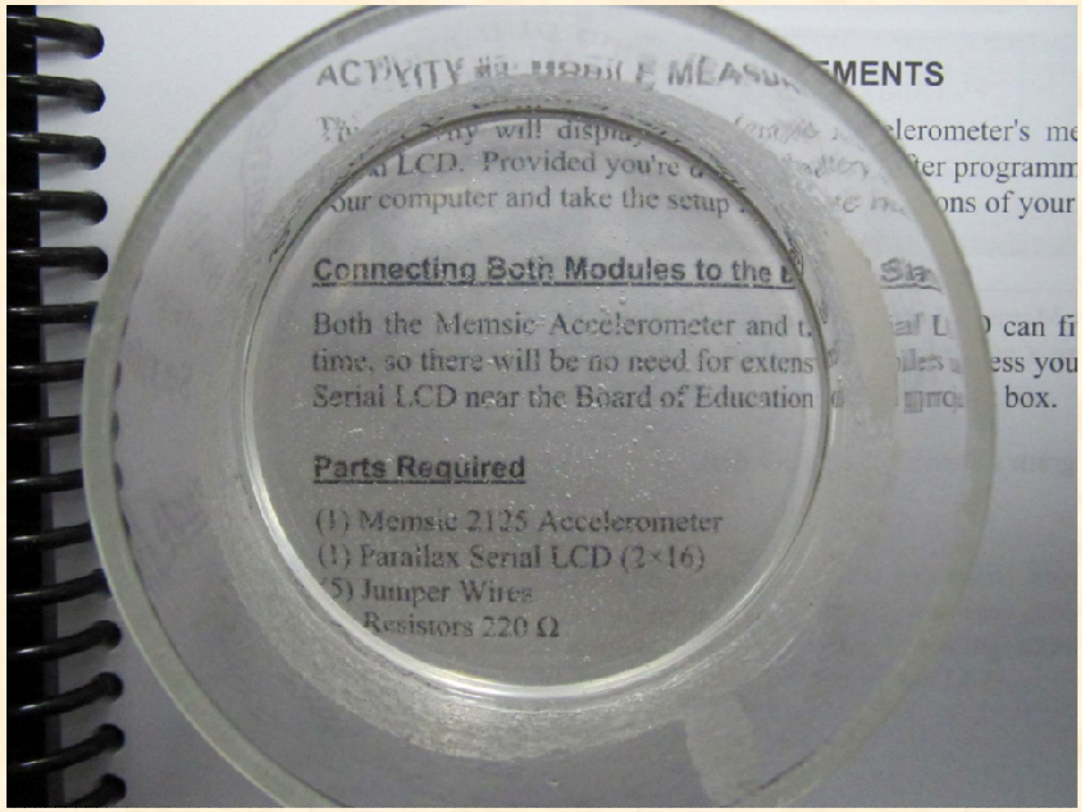
Transparent Soils



Transparent soils become transparent when we fill the void space with a liquid with a matching index of refraction. Aquabeads have the same index of refraction as water.

Transparent Soils

Aquabeads can be useful for some tests, but they are easily crushed under a small force. Fused quartz behaves like a real soil under load. Here is a transparent sample of fused quartz. The liquid is not water.



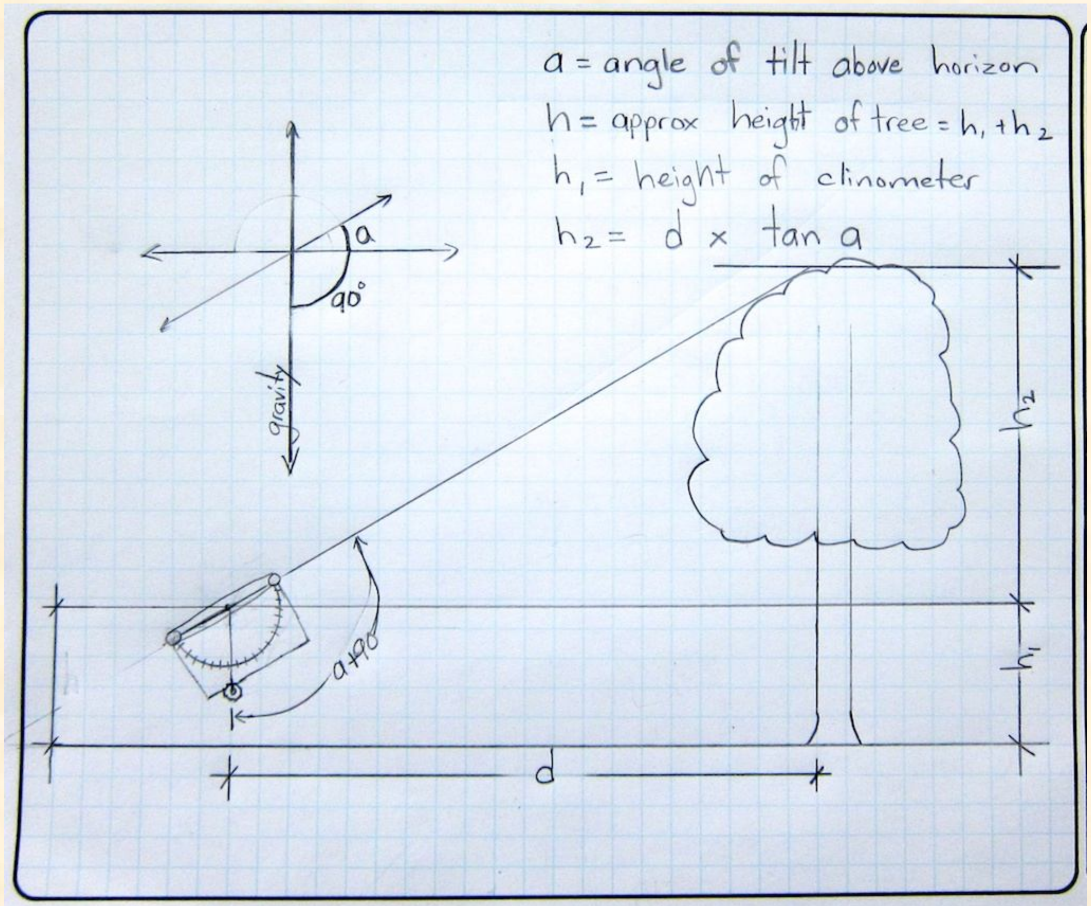
Transparent Soils

We ran permeability tests on the fused quartz and found results consistent with the literature. We observed Iván Guzmán conduct triaxial shear tests on the fused quartz. This test simulates a soil's behavior at a specified depth.

Transparent Soils

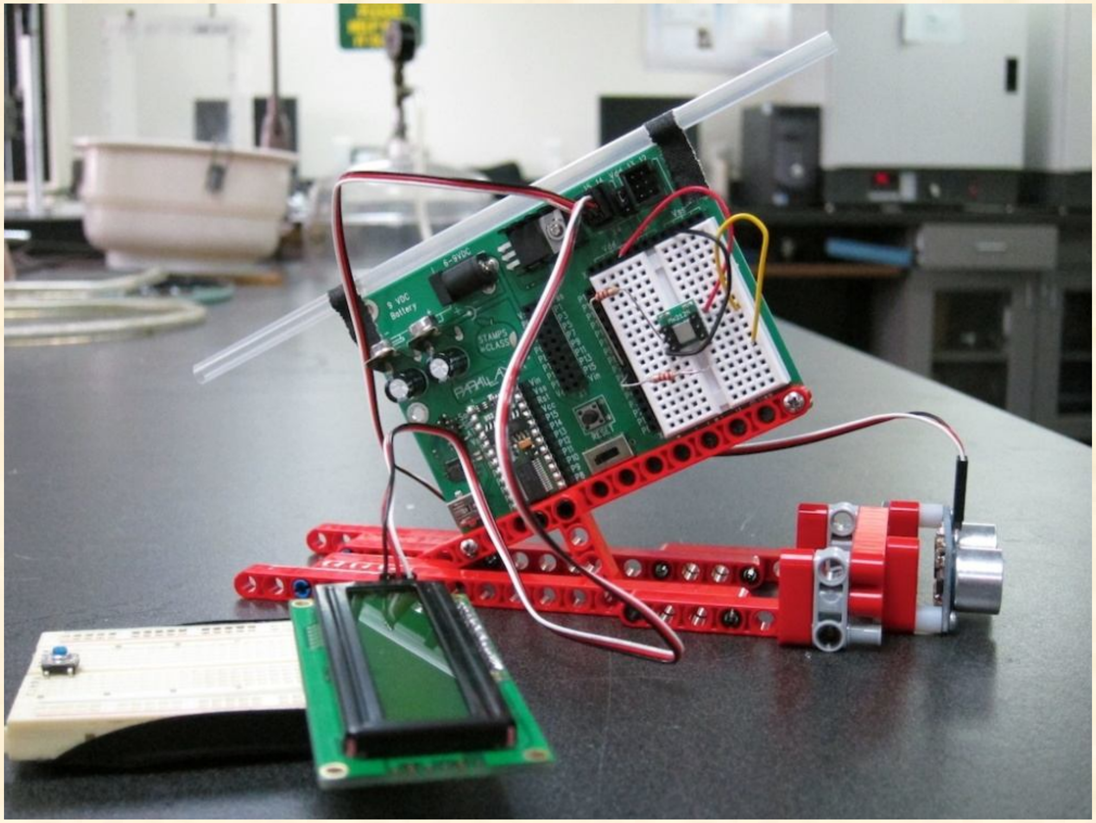
Once all the characteristics of the fused quartz are identified, the soil can be used to simulate a non transparent soil with similar characteristics.

Lesson Plan



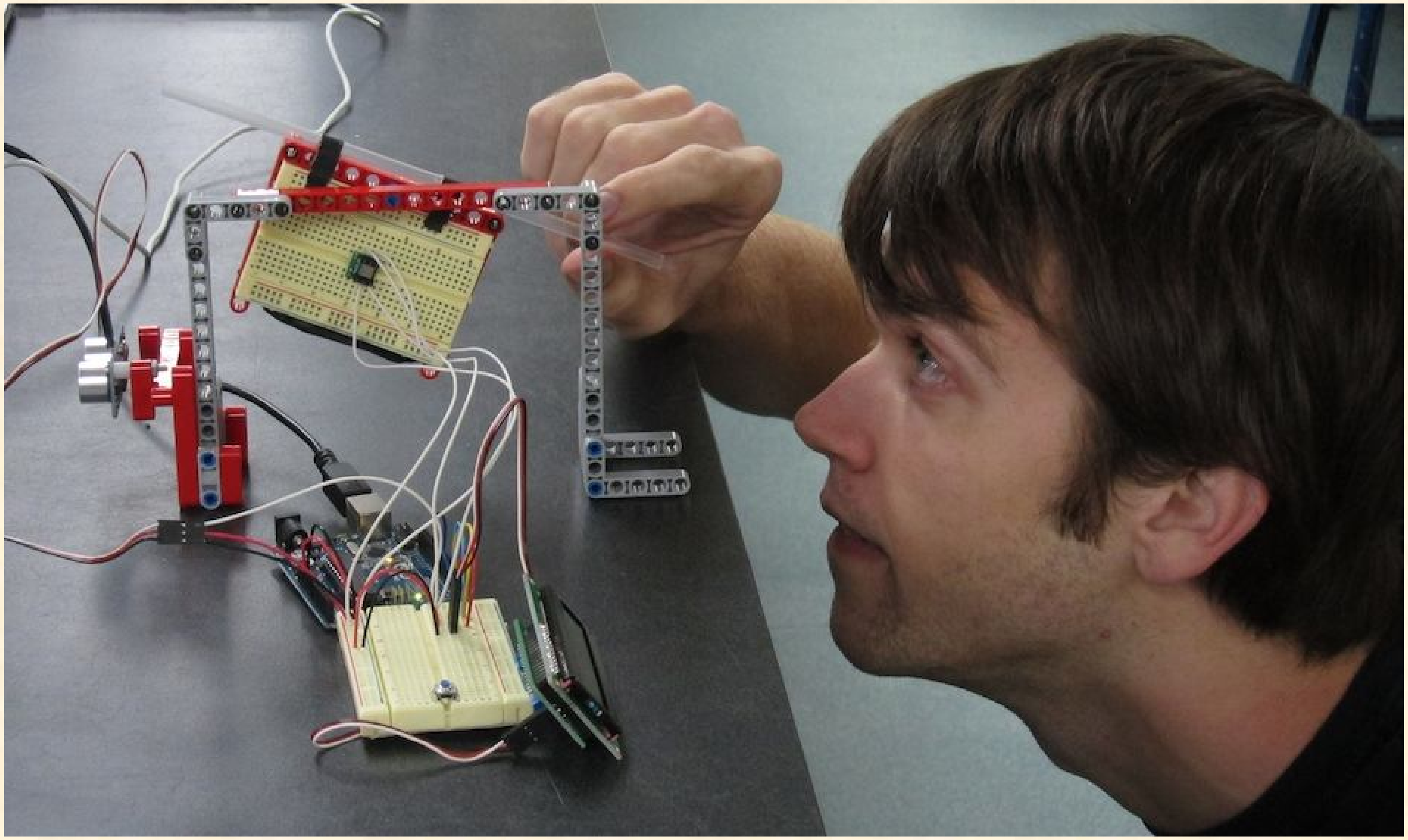
The Clinometer activity in the Smart Sensor book connected perfectly with our civil engineering placement. The lesson integrates math, science, and the surveying aspect of civil engineering.

Lesson Plan



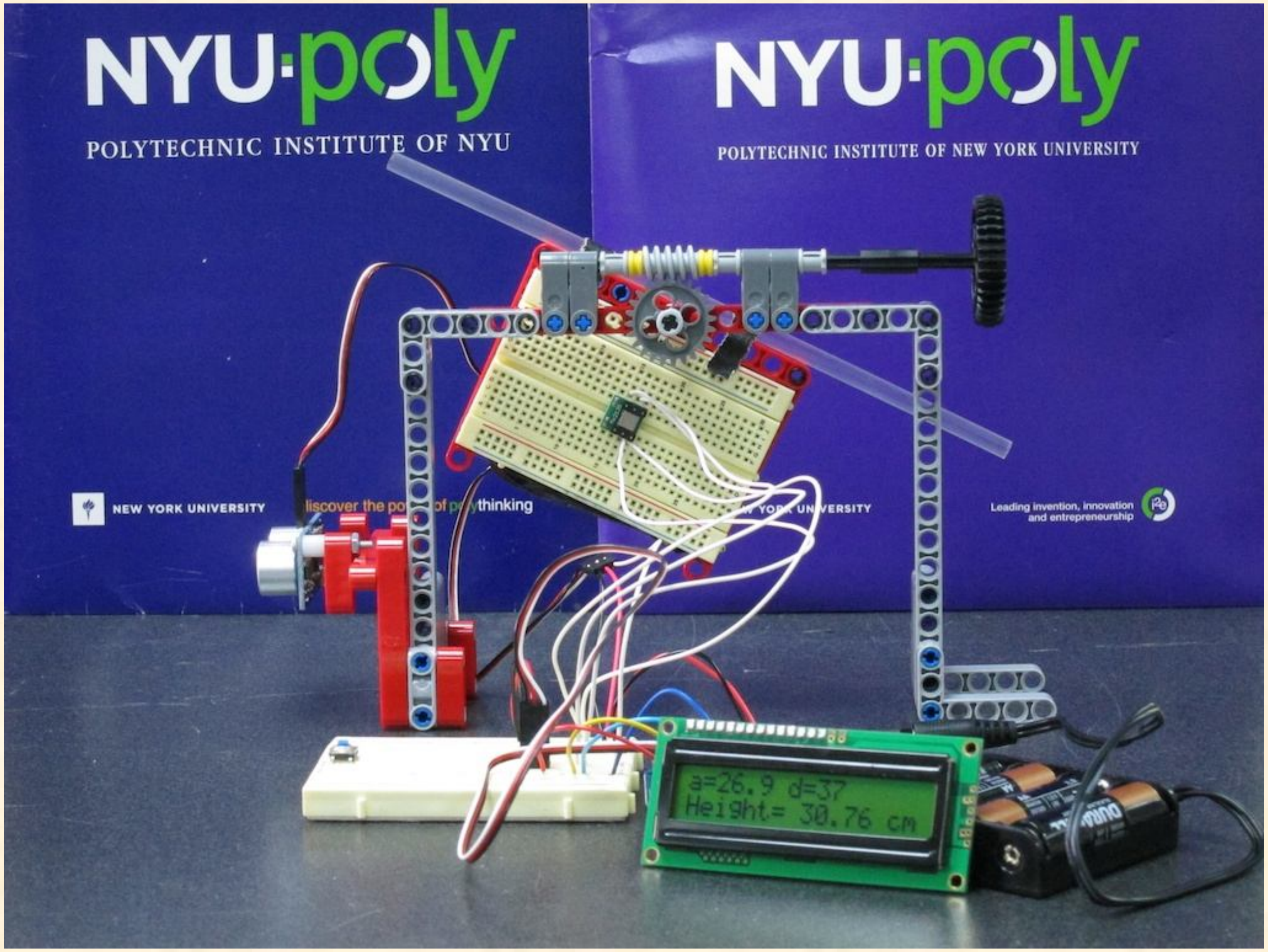
We decided to make a mechatronic clinometer. This was a first prototype, but the math was flawed. The height of the pivot point for the straw was not constant.

Lesson Plan



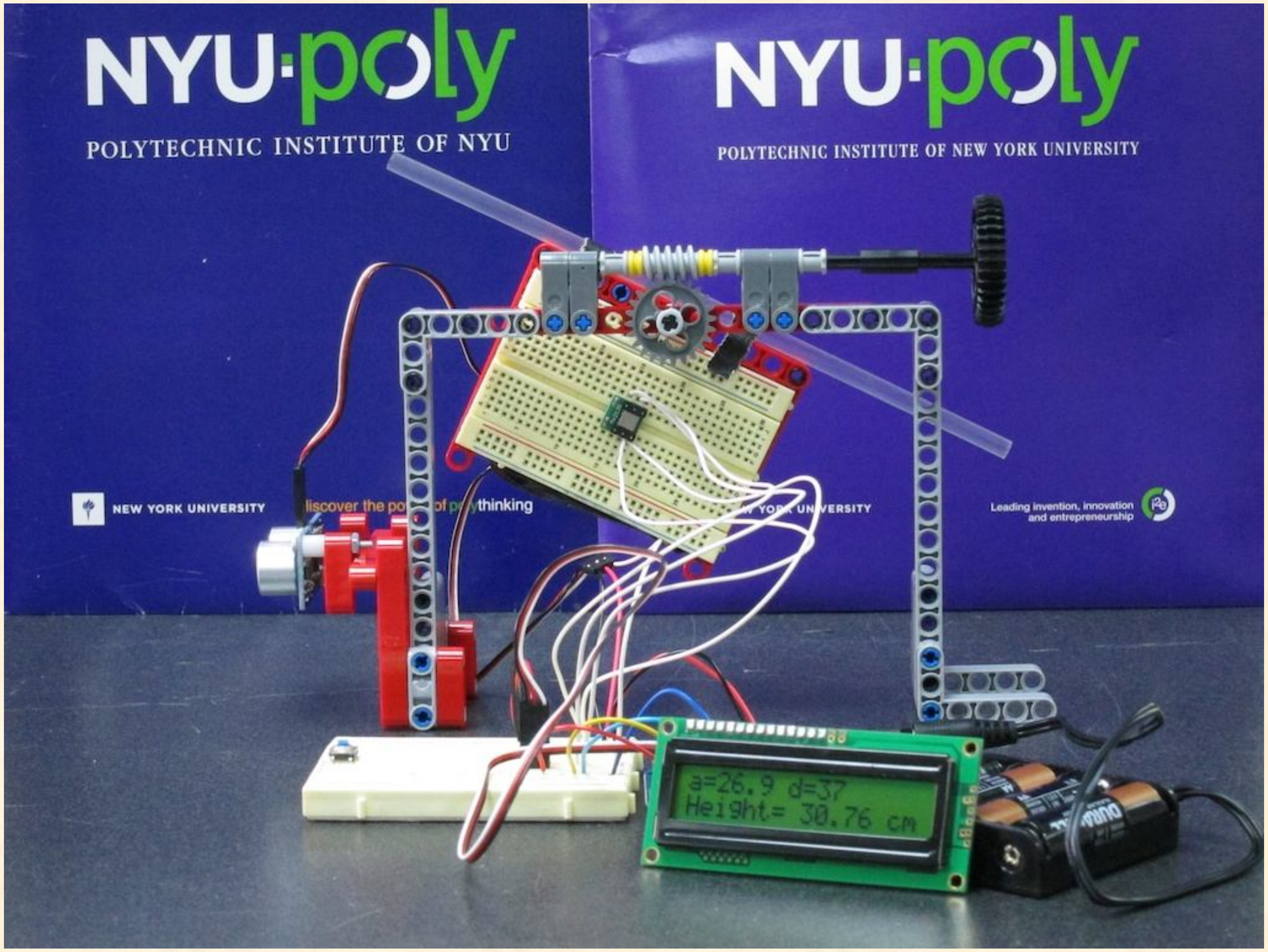
We relocated the pivot point so the center of the straw was right on top of it.

Lesson Plan



Andrew gave us a great idea by developing a lesson on worm gears. The worm gear does a great job of locking the straw's position.

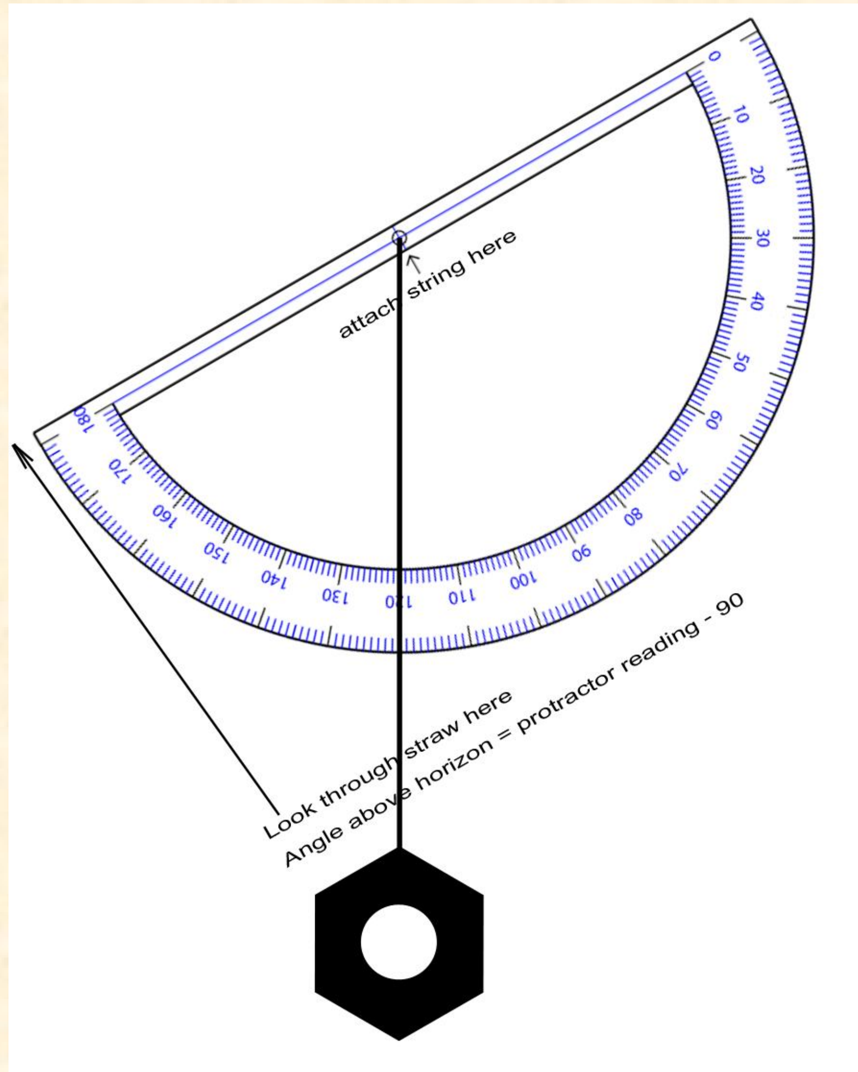
Lesson Plan



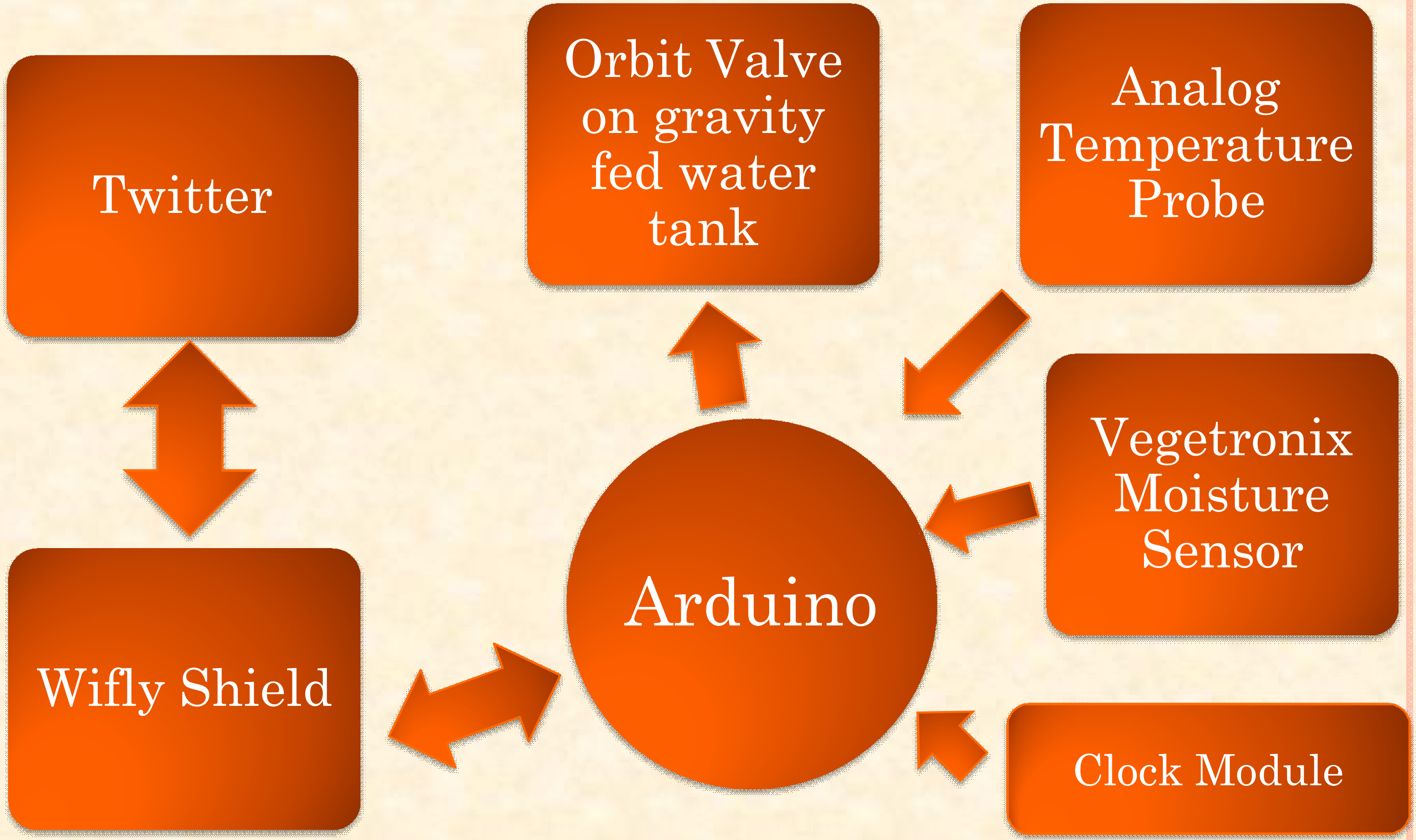
Andrew gave us a great idea by developing a lesson on worm gears. The worm gear does a great job of locking the straw's position.

Lesson Plan

Students will use the mechatronic clinometer only after learning how to use a manual one first. We have included a pdf file for teachers to create this simple clinometer. The children will use the protractor to measure the angle and a measuring tape to measure distance.



Twitter Enabled Garden



Acknowledgements

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This work was conducted in summer 2011 in the Soil Mechanics Lab at Polytechnic Institute of New York University and we fondly acknowledge the hospitality and support of the lab personnel.

Acknowledgements

This research could not have been accomplished without the assistance of several individuals. First and foremost, we would like to express our deepest appreciation to our advisor, Professor M. Iskander, for his support, guidance, and advice. Second, we would like to thank Andrew Cave, Eduardo Suescún, Iván Guzmán, and Sina Kashuk for all their technical assistance, guidance, and collaboration throughout this entire project. Also, we are grateful to Jared Alan Frank, David Lopez, and Ryan Caeti, who played an integral role in our quest to master programming our Basic Stamp and Arduino. Finally, without the support of Allesandro Betti, the machinist for the mechanical engineering department, and Sebastian Bellantuono , the machinist for the civil engineering department, our actual creation of a new permeameter could never have been fully realized.