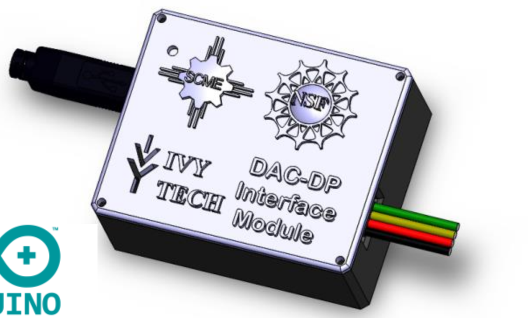
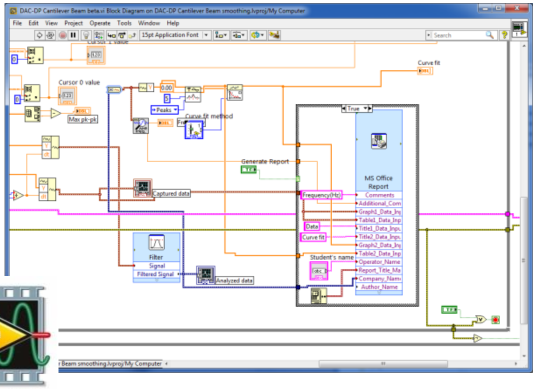
Using Arduino & LabView for Teaching MEMS Devices

Andrew G. Bell



ARDUINO



NATIONAL INSTRUMENTS LabVIEW

June 28, 2016

IVY TECH COMMUNITY COLLEGE

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Ivy Tech Community College is Indiana's largest public postsecondary institution and the nation's largest singly accredited statewide community college system. Ivy Tech serves nearly 200,000 students annually and has campuses throughout Indiana.

We offer Associates of Science degrees in:

Electrical Engineering Technology
Mechanical Engineering Technology
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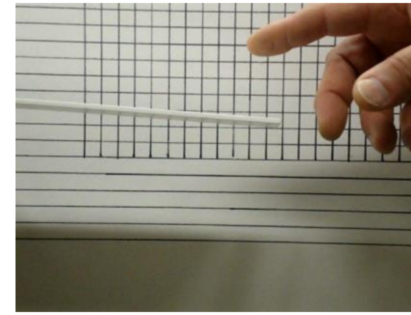
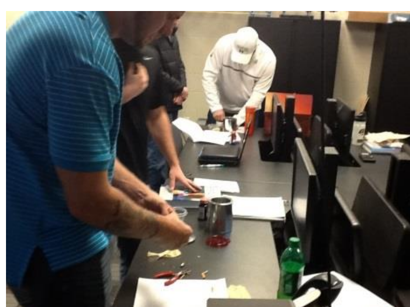
over 40 degree programs

Ivy Tech started its associating with SCME in the Fall of 2012 and has been a Co-PI on Southwest Center for Microsystem Education (SCME) NSF ATE Grant. We also have a NSF ATE small project grant for Microsystems Certification



MEMS Kits Implementation Plan IVY TECH (Fort Wayne & Valparaiso)								
	MEMS Kit	**ENGT 120**	**METC 111**	**METC 143**	**EECT 111**	**EECT 112**	**ENGR 251**	**ENGT 279**
1	MEMS: Making Micro Machines Kit	X						
2	Dynamic Cantilever Kit		X	X			X	
3	Crystallography Kit			X				
4	Pressure Sensor Model Kit	X			X	X	X	
5	GeneChip Model Kit	X						
6	MEMS Innovators Kit							X
7	Lift-off Kit			X	X			
8	Pressure Sensor Process Kit				X			
9	LIGA Micromachining Simulation Kit			X				
10	Anisotropic Etch Kit			X	X			
11	Rainbow Wafer Kit	X						



MEMS are sensors that measure something that can be interfaced to electronics.

MEMS are device be used to translate mechanical motion into electrical signals.

MEMS are devices operate using the same laws of physics that describe much larger systems.

MEMS are devices can be made very small

Since MEMS devices are smaller it takes less physical space to use them in an educational setting.

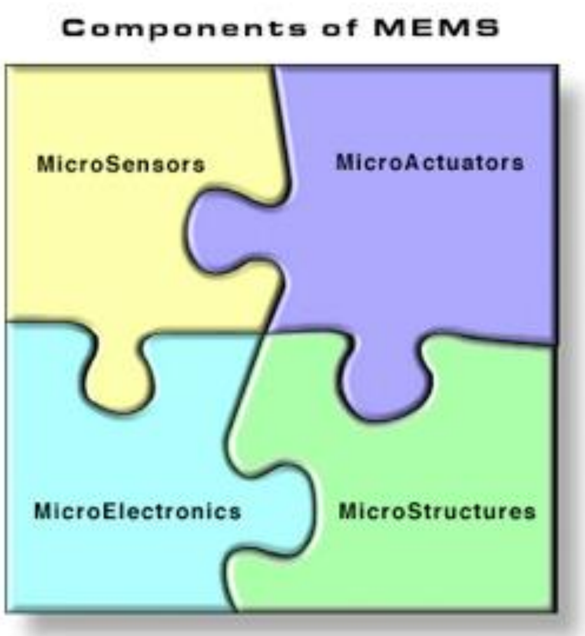
There are numerous engineering analogies that can be taught using MEMS devices and since they are small there the is a lower cost.

Some MEMS devices are based on variations on resistance, capacitance or inductance.

Learning how to interface sensors to electronics is an essential element in learning how to use MEMS devices.

Micro-Electro-Mechanical Systems, or MEMS, is a technology that in its most general form can be defined as miniaturized mechanical and electro-mechanical elements (i.e., devices and structures) that are made using the techniques of microfabrication.[1]

The critical physical dimensions of MEMS devices can vary from well below one micron on the lower end of the dimensional spectrum, all the way to several millimeters.[1]



In our case we will focus only on sensors and how to use MEMS devices with electronics.

1 - http://www.memsnet.org/mems/what_is.html

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The Arduino is a small inexpensive microcontroller board that allows for easy and popular (electronic) project development.

A microcontroller typically includes, I/O, memory and a microprocessor. It is sort of a mini microprocessor board.

The Arduino is built to accept daughter boards called Shields and there exists many commercially available shield that you can stack onto your Arduino boards.

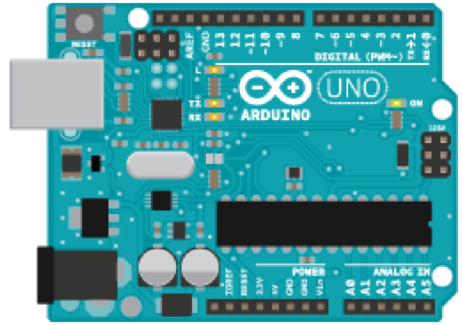
One of the most common shields is called a prototype shield and it allow the user to develop their own electronics.

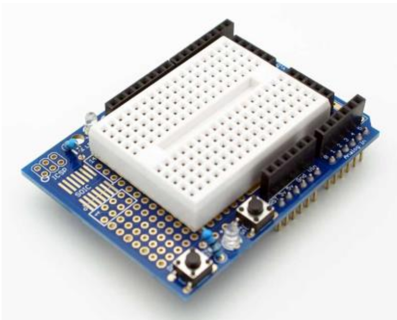
The Arduino can be programmed with simple free open source code or even high level or graphically based languages like LabView.

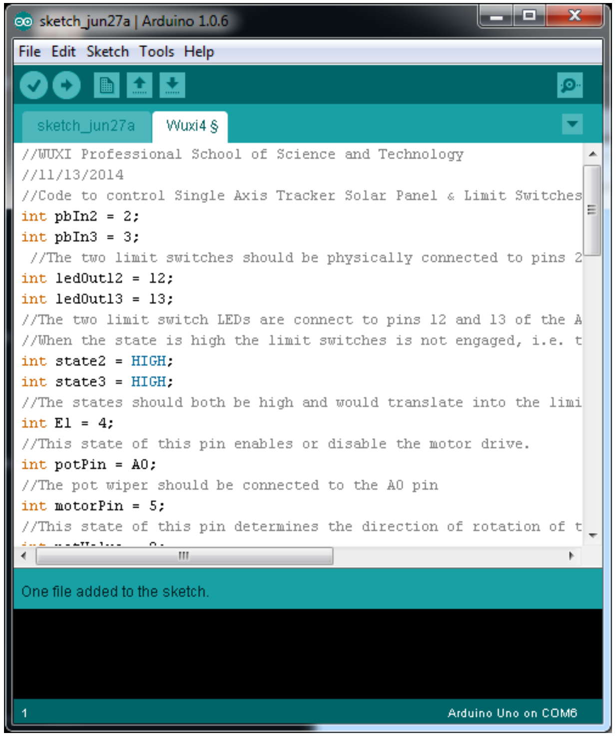
2 - https://www.arduino.cc/

What is an Arduino?

Microcontroller	[ATmega328P]
Operating Voltage	5V
Input Voltage (recommended)	7-12V
Input Voltage (limit)	6-20V
Digital I/O Pins	14 (of which 6 provide PWM output)
PWM Digital I/O Pins	6
Analog Input Pins	6
DC Current per I/O Pin	20 mA
DC Current for 3.3V Pin	50 mA
Flash Memory	32 KB (ATmega328P) of which 0.5 KB used by bootloader
SRAM	2 KB (ATmega328P)
EEPROM	1 KB (ATmega328P)
Clock Speed	16 MHz
Length	68.6 mm
Width	53.4 mm
Weight	25 g







2 - https://www.arduino.cc/

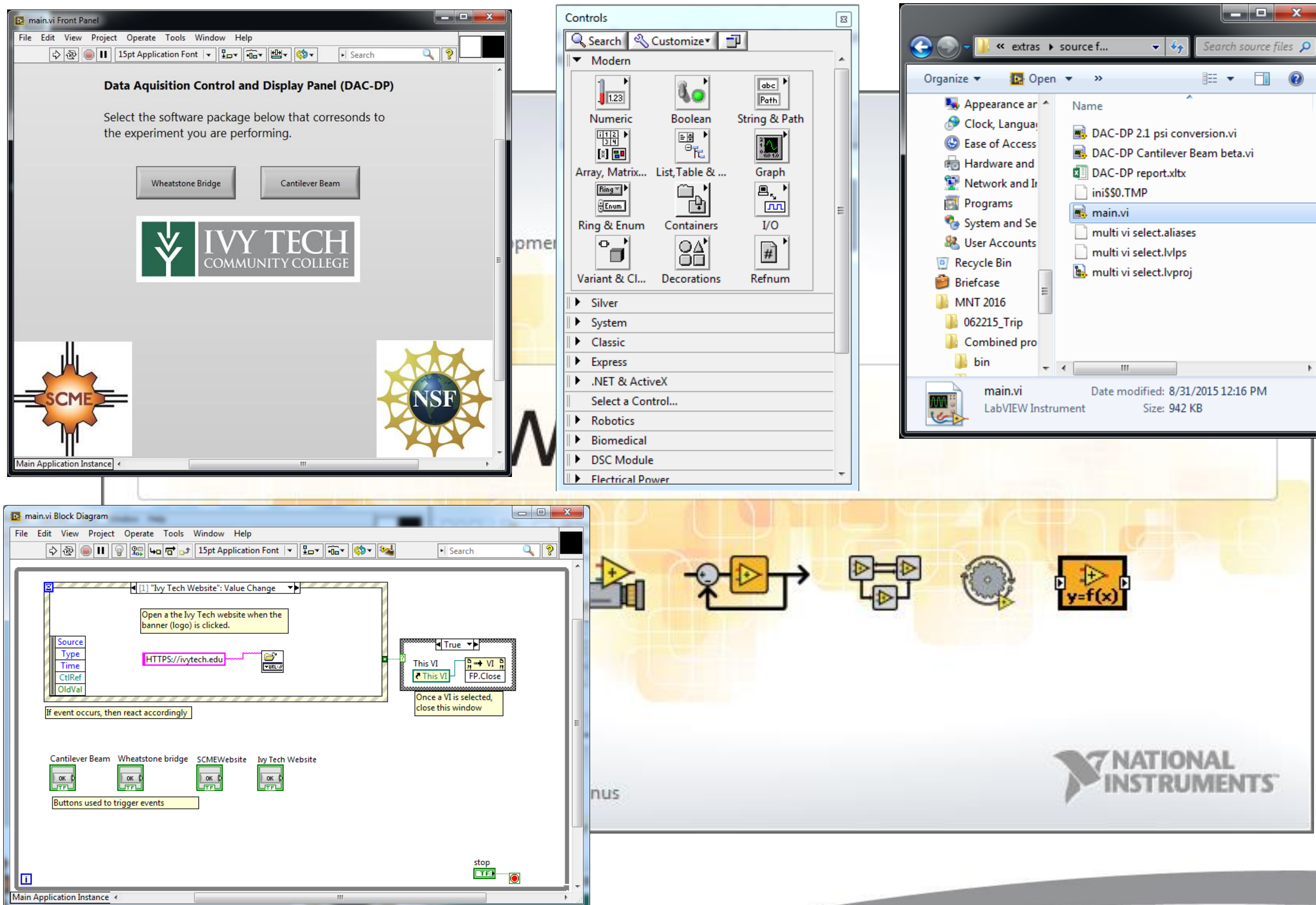
LabView is graphical based programming language developed by National Instruments and used extensively in industry.

LabView program are called "vi" programs and typically include a block diagram type of program that is programmed via block interconnections of various functional blocks.

LabView program also have a gui interface window that can be designed to allow users to view the data and control the programs.

LabView programs can be executed on computers with LabView installed or compiled and run as standalone programs. To create an executable program you must have a compiler.

What is LabView?



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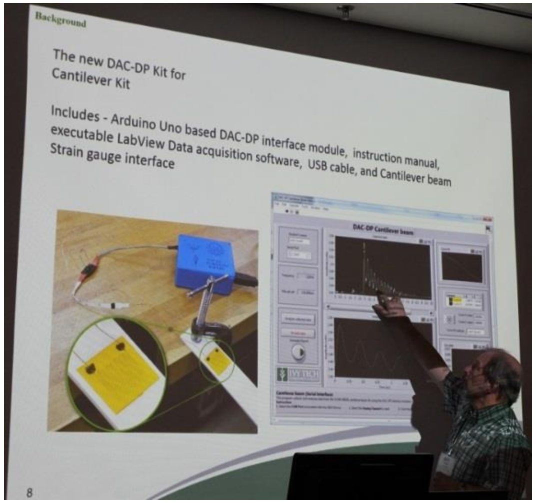
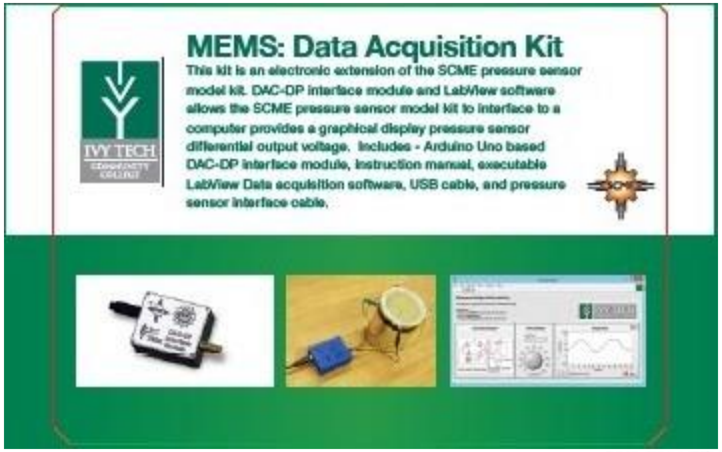
Design and build electronic kits that could be used in tandem with the SCME[3] kits.

These new kits should focus on cost and maximize student learning

New kits should be developed by student workers

Should be based on Arduino UNO, LabView and SCME kits





3 - http://scme-nm.org/

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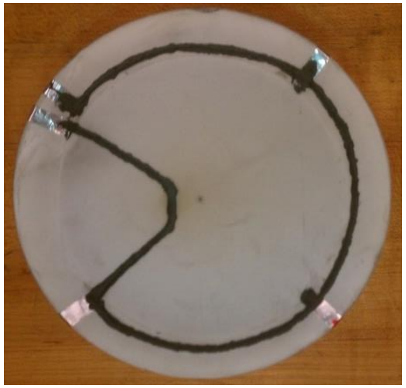
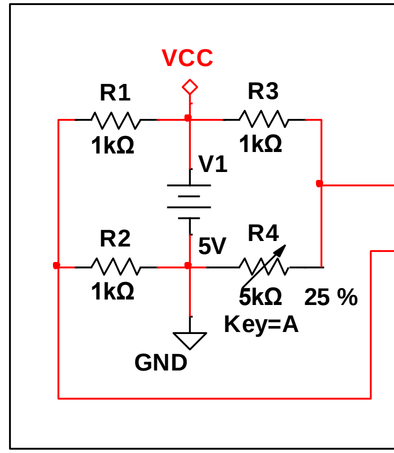
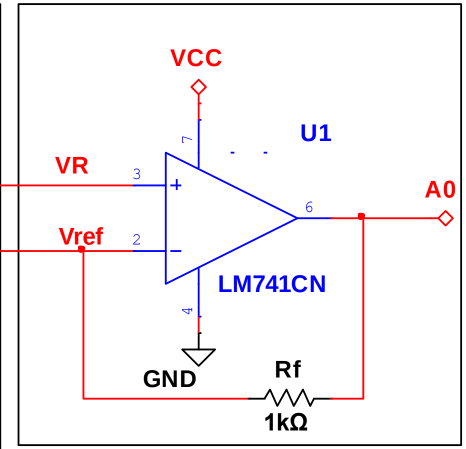
Our Projects?

First up the Pressure Sensor kit => ***Modeling a Micro Pressure Sensor Kit***

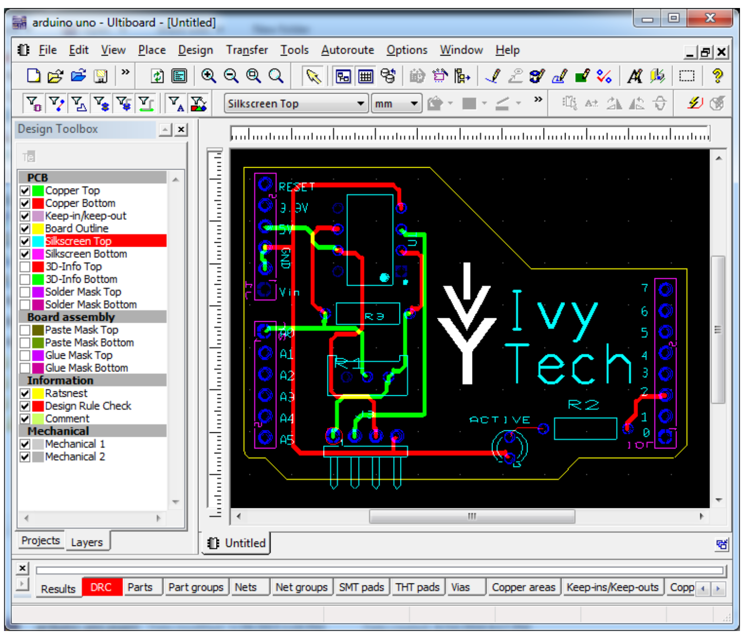


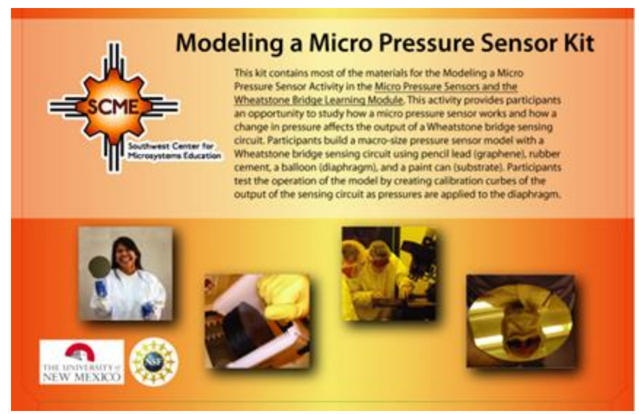


A simulated wheatstone bridge



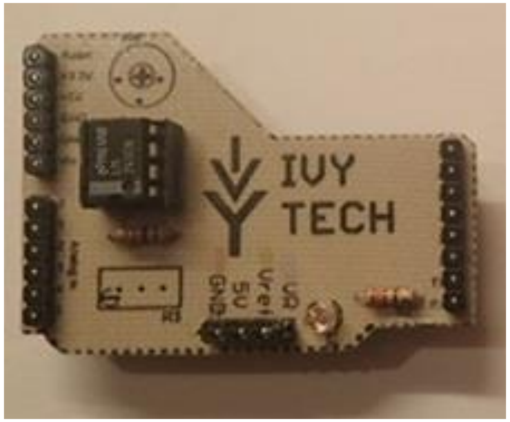
The basic form of the DAC-DP shield

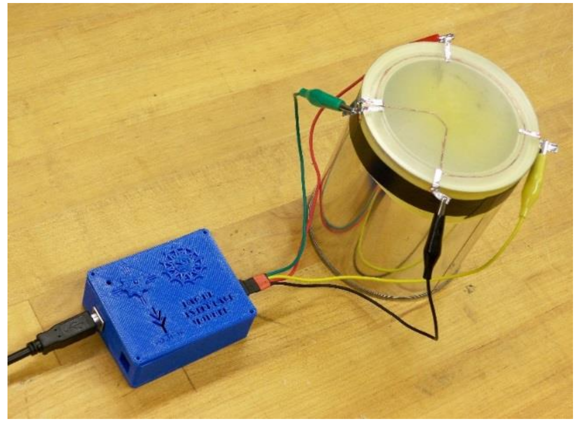


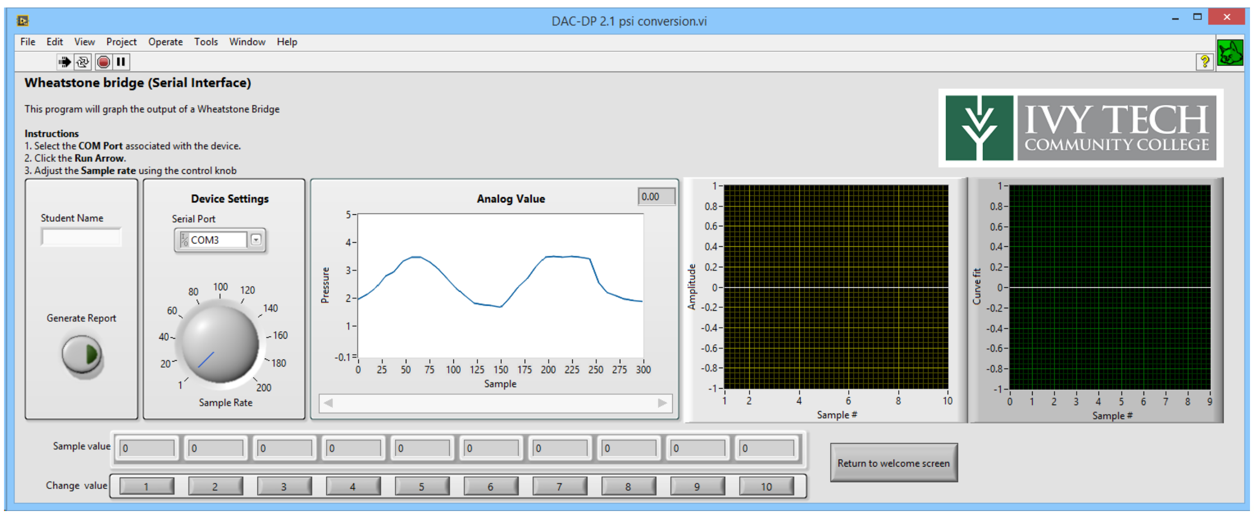


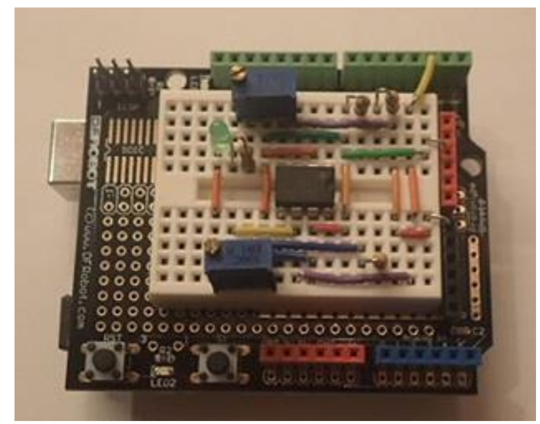
Our Projects?

After many months …









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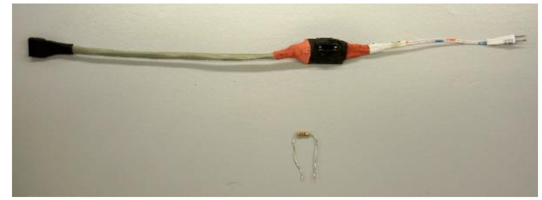
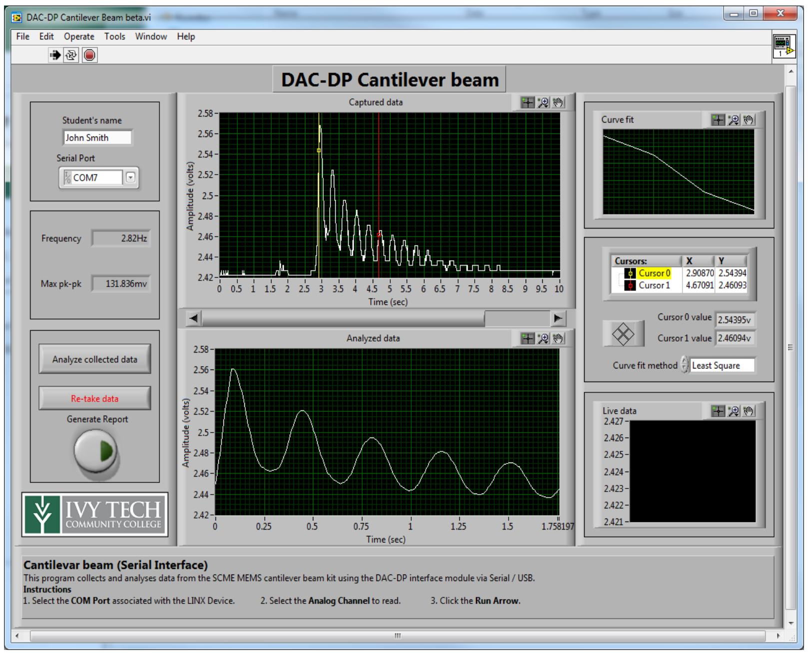
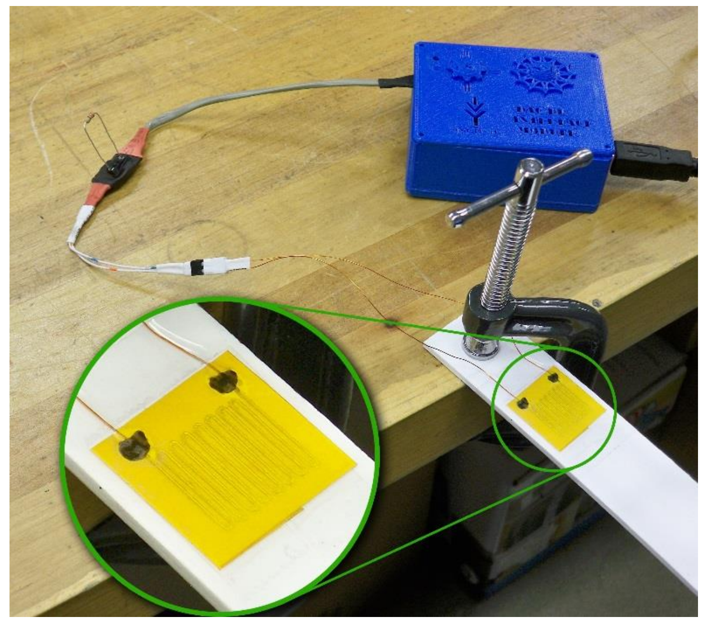
Second up the Cantilever Beam kit => ***Microcantilever Model Kit***







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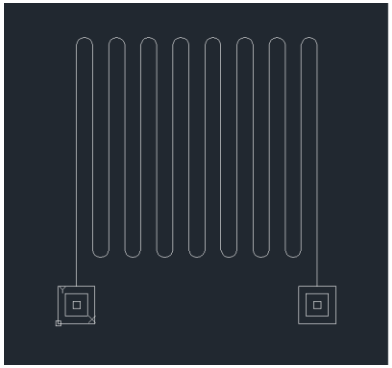
And we had to build our own strain gauges …

How to make a strain gauge

What you will need

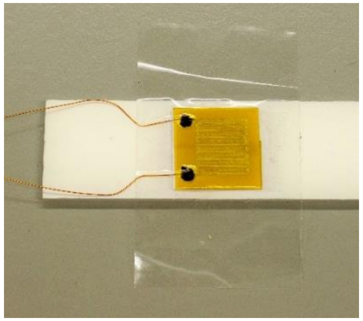
1. Silhouette cameo
2. Computer with Silhouette studio
3. Silhouette pen holder
4. Electroninks Circuitscribe conductive ink pen
5. Common white printer paper
6. Kapton tape 1’’ wide
7. 30ga Magnet wire
8. 2x1 Female pin header/terminals
9. Conductive Wire glue
10. Strain gauge silhouette file
11. Silhouette grid cut file

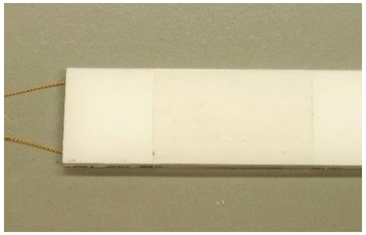


More details …

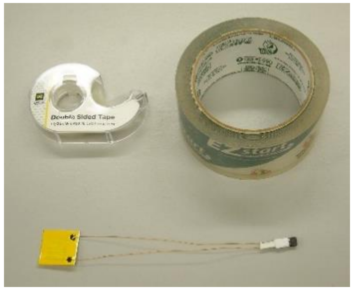
Make the sensor

1. Plugin the silhouette cameo
2. Place the white printer paper onto the cutting mat aligning the top left corner of the paper with the top left corner of the cutting mat.
3. Load the cutting mat into the cameo
4. Set the blade height to "1"
5. Load the blade into the cameo and secure in place
6. Open the grid cutting file on the computer in silhouette studio
7. Click "send to silhouette"
8. The cameo will now cut out the strain gauge backing pieces
9. Remove the blade from the cameo
10. Place the pen in the pen holder and tighten the screws to secure the pen in place
11. Place the pen/pen holder into the cameo and secure
12. Open the "strain gauge" file on the computer in silhouette studio
13. Click "send to silhouette"
14. The cameo will now draw the strain gauges
15. Remove the pen holder and clean any residue that it has collected on the pen tip
16. Repeat steps 10-13 to draw a second layer onto the strain gauges. This will ensure that the ink is properly connected along the trace of the strain gauge.
17. Once it is done, tap the unload button on the cameo.
18. Set the cutting mat and strain gauges off to the side and let the ink dry for at least 30 minutes.
19. Remove the strain gauges - DO NOT try to peel the strain gauges off of the cutting mat, the more that the strain gauge is bent or curled, the more variation or unreliable the strain gauge will be. Instead, Slide a long flat blade (pocket knife or razor blade) under each strain gauge to remove them from the adhesive, keeping the strain gauge as flat as possible



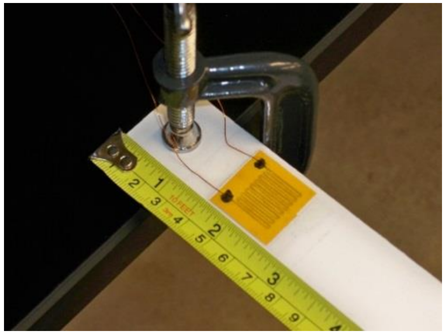


More details …



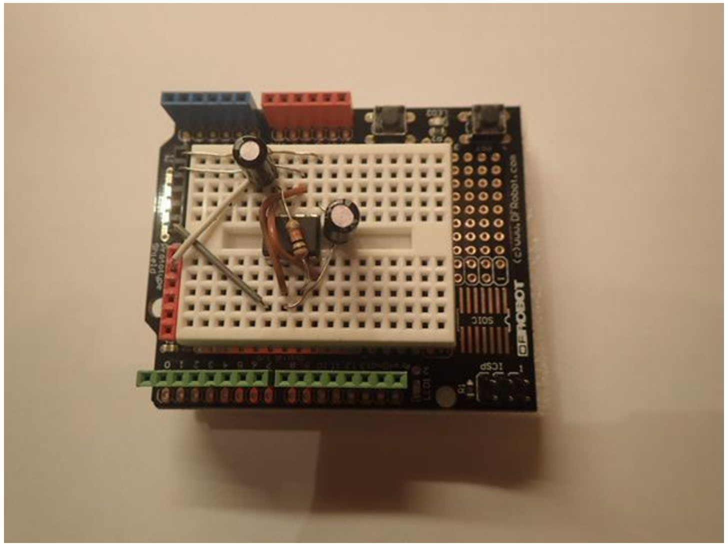
Prepare the wires

1. Cut two lengths of at least 6” of 30ga magnet wire
2. Use a knife to scrape the enamel off of both ends for ¼”
3. Use a crimp tool or pliers to connect a terminal to one end of each wire
4. Place the terminals into the 2 pin connector
5. Place an inch of heatshrink tubing over the pin header/wires
6. Use a heat source to shrink the tubing
7. Flatten the end of the tubing by the wire, this will allow for some flexibility and prevent the wires from breaking from too sharp of a bend.
8. Use a dab of wire glue to adhere the bare end of each wire to each pad of the strain gauge.
9. Wait at least an hour for the glue to cure
10. Cut a length of kapton tape 1.5” long
11. Place the tape centered over the strain gauge and perpendicular to the direction of the wires, being certain to align the top and bottom of the strain gauge with the edges of the tape.
12. Wrap the tape around the back of the strain gauge
13. You are done!



The process to develop a kit based on discovery based learning

1. Provide limits to the project with minimum design rules and objectives
2. Suggest student research the topic via the web
3. Suggest student conduct experiments to see what does and doesn't work
4. When student ask question only provide minimum suggestion unless they really need additional help. Also encourage group collaboration.
5. Provide feedback and remember the goal is learning.
6. Give the credit for the success and de-emphasis the failures



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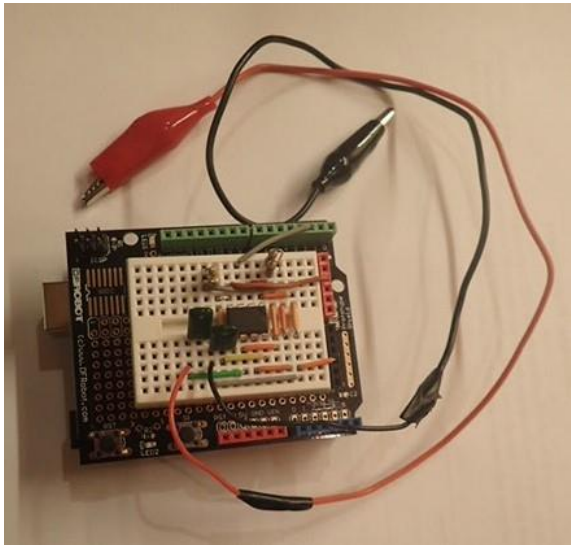
All kits developed to support collaboration class use for physics, electronics and engineering courses.

New kits developed using same type of LabView code but new shields. The variable capacitor shield is based on the 555 timer and can be adapted to use the unused lid in the pressure kit. A prototype has been built for this new shield.



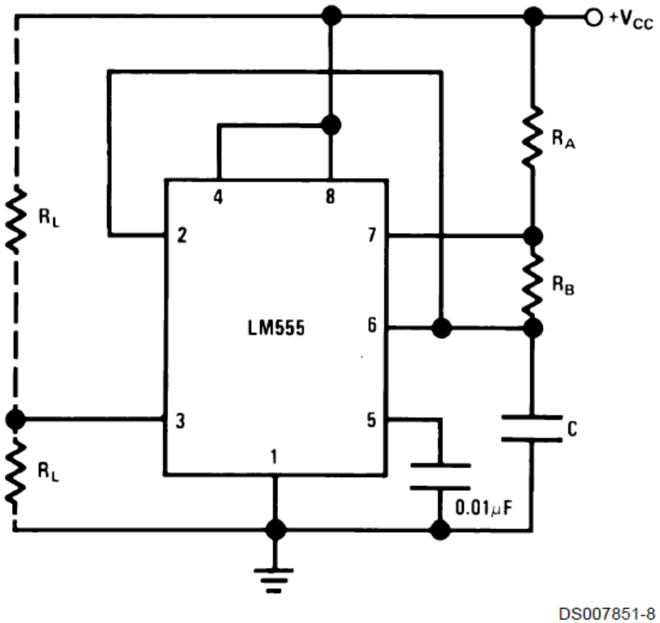


FIGURE 4. Astable

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The variable inductor shield will use an multi-turn inductor wound around a cylinder either a another wound inductor or ferrite core will be placed inside the plastic cylinder and the center core will be displaced based on a fixed or moving mass. Current thinking is to use a simple buck converter topology to convert mass displacement into a unregulated DC which and be measured using the Arduino. The input AC could be generated using a 555 timer.

Getting started with LabView and Arduino code
https://www.labviewmakerhub.com/

More on SCME Kits
http://scme-nm.org/

More on Ivy Tech MEMS
http://www.ivytech-mems.org

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