The Indestructibility of Hardtack:
Radiation, Flames and Fire Arms

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Introduction

Hardtack has been a staple in soldier diets because of its cheap preparation cost, light load and long shelf life. Rumored to stop bullets, hardtack has great potential for self defense and survival. This project includes three experiments that test the defensive properties of hardtack compared to plywood. The experiments include its ability to block radiation, its ability to withstand fire and its ability to stop a bullet.

Hardtack- How is it made?

Hardtack is a military meal of the American Civil War made of baked flower and water. For this experiment the hardtack was made using two parts of flour combined with one part water. This was kneaded until it would not stick to itself or the table. The resulting dough was spread out at approximately one half inch thick, and 10cm squares cut out. These squares were baked for one half hour at 375 degrees Fahrenheit, flipped, and baked for another half hour at the same temperature.

Radiation

Hardtack and plywood were tested for the use of blocking radiation for comparable effectiveness. To test the use of blocking radiation, a radioactive source and Geiger counter were obtained. The source used was a piece of Uranium purchased online. The Geiger counter to be used was Dutch military surplus also purchased online. After taking the Dutch Geiger counter to the Nuclear Engineering Department for calibration, it was determined that the Geiger counter could not produce the accuracy or precision needed for the experiment. A TA PUG-7 Geiger counter was borrowed for the experiment. The PUG-7 had recently been calibrated in March 2010 and is not due for another calibration for a full year. To make sure the calibration was correct, the known Uranium source was checked and proved to be at similar radiation levels as predicted.

To collect data, the Uranium source was constantly measured from the top of the tin where the source was stored. The average source reading was obtained and recorded. Next, six different samples of hardtack and six samples of wood were placed individually on top of the source and measured by the Geiger counter directly above them. The resulting data and averages can be seen in Table 1.

It can be concluded that the hardtack appears to be better at filtering the radiation than the wood but the hardtack had a slight width advantage that should have only effected the alpha radiation. As for the Geiger counter, it only took spontaneous readings rather than an average or total reading so there was a bit of fluctuation in the readings. For more accurate results, longer amounts of continuous readings should be taken to find a better average. The Geiger counter was the most appropriate transducer for this experiment but, for the relatively low source, a better more accurate Geiger counter should have been used.

Table 1: Radiation Filtration Experimental data.

Shielding Material	Measurement (CPM)	Averages:
Hard Tack 1	85	40.83333
Hard Tack 2	20	
Hard Tack 3	40	
Hard Tack 4	50	
Hard Tack 5	35	
Hard Tack 6	15	
Wood 1	100	74.66667
Wood 2	8	
Wood 3	65	
Wood 4	100	
Wood 5	100	
Wood 6	75	
Nothing	425	425

Fire arms

For the shooting portion of the experiment the group decided to use self made sensors that took advantage of the property of capacitance being a function of the physical properties of a capacitor and the simplicity of capacitor construction. The actual construction consisted of gluing Saran Wrap onto of aluminum foil, and then aluminum foil on top of the Saran Wrap. These were then cut into 10cm squares, and it was verified that after creation the squares were not electrically shorted to each other. Normal rubber cement was found, with a few failed attempts, to be too thick to flow well enough for this purpose. The rubber cement was mixed with acetone to make it flow better, though this may have been a contributing factor in their failure later on when they were used after having time for the components to react and dry.

The capacitive transducers were calibrated using half of an Airsoft Pellet hot glued to a board. This half pellet was used to induce a half-sphere deformation into the capacitor, of known radius. The same Fluke 12 multimeter was used for all of the measurements taken throughout the project, such that the group has assumed that any degree of error caused by the Fluke would be accounted for in the overall standard deviation and linearity calculations. The results of these calibrations can be seen in the Figures 1-3 below. The group observed that the data is fairly linear whenever average values are used. The standard deviations were surprisingly low for the mediocre construction of the transducers, though it was observed that the deviation increased greatly as the number of deformations increased. It is believed that may be the product of the transducers being vulnerable to deformation along their edges and an increase in such deformation as the number of divots that were to be induced increased.

Figure 1: Averaged Difference Capacitance vs. Percentage Change in Surface Area

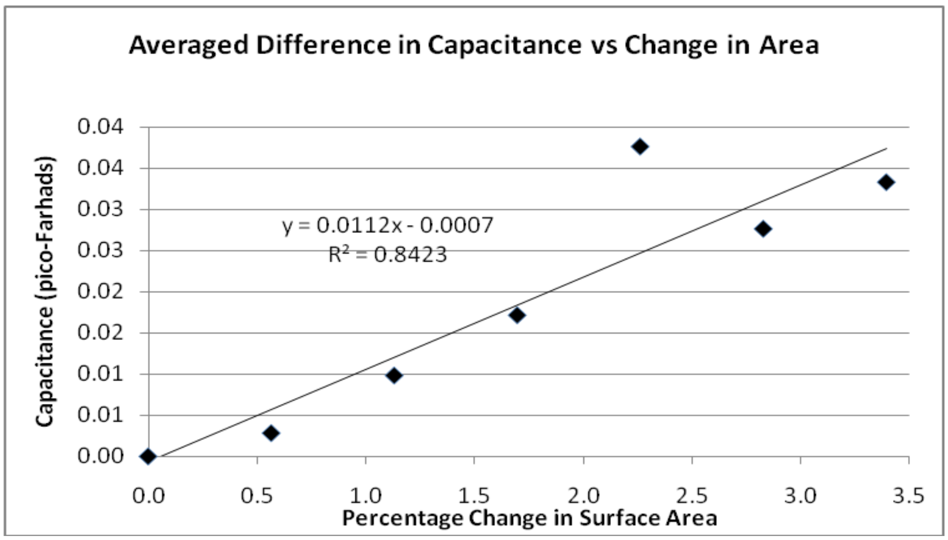


Figure 2: Standard Deviations vs. Percentage Change in Surface Area

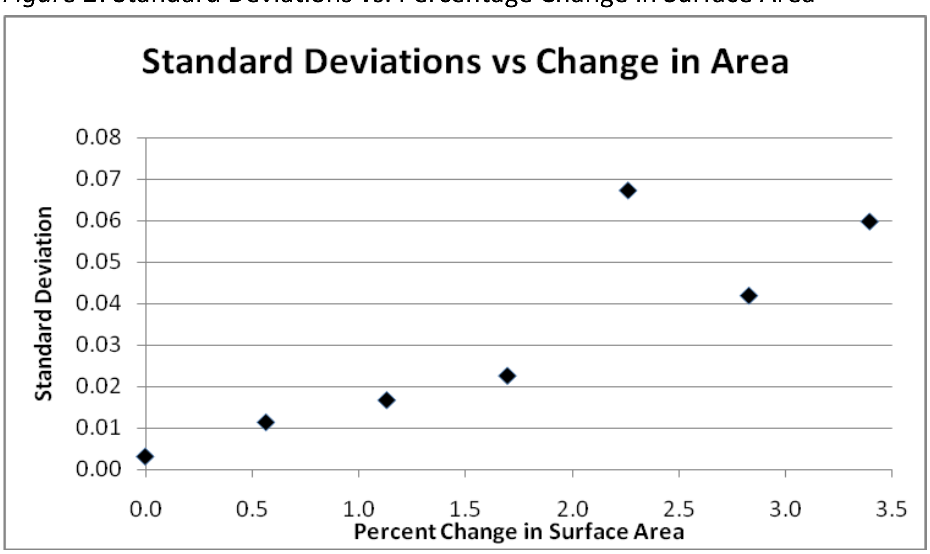
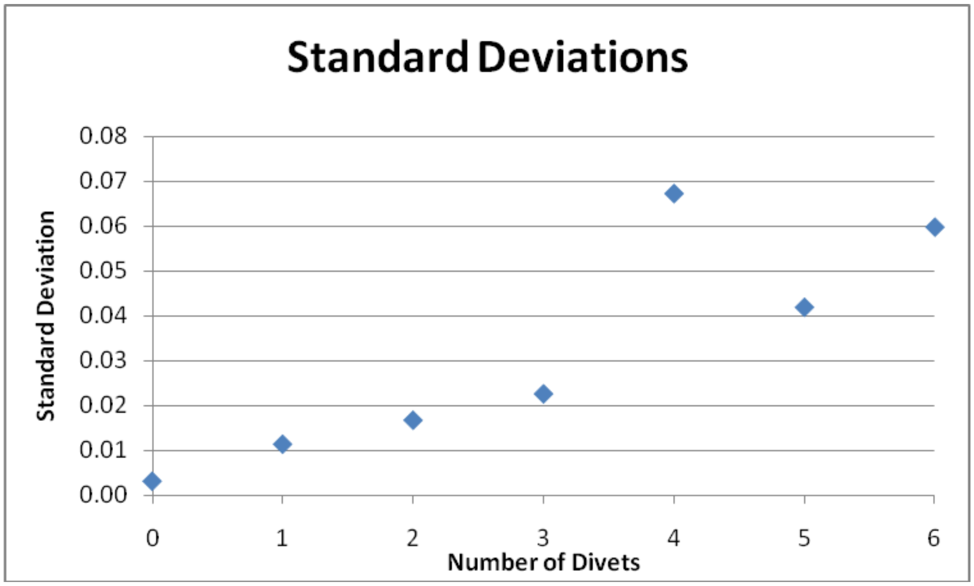


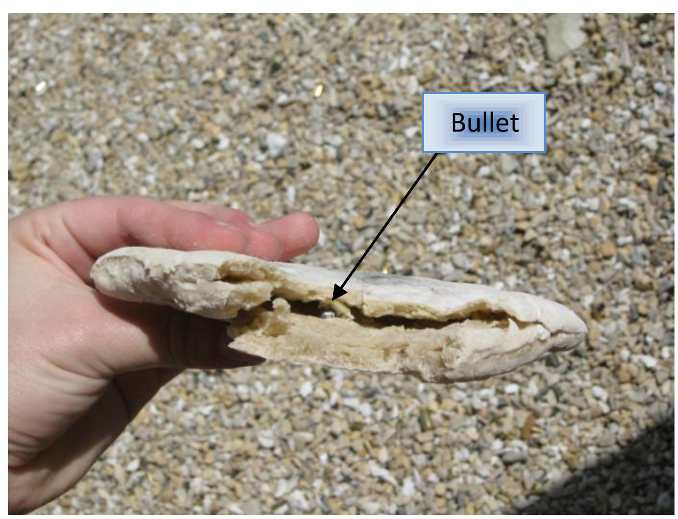
Figure 3: Standard Deviations vs. Number of Divets



For the second portion of the experiment, the group intended to use the capacitor based deformation sensors previously mentioned to quantify the ability of the hard tack and the oak squares to act as armor against bullets. After having determined that lunch bags of cat litter were capable of stopping .22 Short CB rounds, the group used rubber cement to attach capacitive deformation sensors to the back of bag of cat litter and fired into hard tack placed in front of the bags with an RG Model 10 revolver. The setup can be seen in Figure 4. The Model 10 was selected for its short barrel and lose tolerances, with the hopes of minimizing the velocity of the rounds for fear of completely penetrating the entire setup.

Figure 4 Left: The setup for the hardtack shooting experiment.

Figure 5 Below: the bullet inside the hardtack.



To the group's surprise, the hard tack was capable of entirely stopping the .22 Short CB rounds as can be seen in Figure 5. Upon testing, it was verified that the oak squares could not. From this, the group was able to determine that the hard tack was a better armor than the oak squares by simple observation. In order to quantify the difference, the group switched to using .22 Short High Velocity rounds, which were able to penetrate the hard tack and not the entire apparatus.

One critical issue that the group encountered was the failure of the majority of the sensors. Most of the sensors were shorted out, and it is the opinion of the group that as the sensors aged the acetone used in their construction dissolved the Saran Wrap which was used as an insulator between the sheets of aluminum foil. Due to this, the sample size was reduced from six each of oak and hard tack from six samples to three. This was greatly sub-optimal, but the group was not confident of being able to get more range time at a later date and decided to proceed with the limited data. The data that was collected can be seen in Table 2

Table 2: Data from Shooting

	Capacitance (Micro-farads)	Capacitance (Micro-farads)	
Material	Before	After	% Change in Surface Area
Hard Tack 1	0.003	0.003	-0.063
Hard Tack 2	0.003	0.003	-0.063
Hard Tack 3	0.029	0.029	-0.063
Wood 1	0.004	0.015	0.920
Wood 2	0.003	0.005	0.116
Wood 3	0.021	0.09	6.098

Using the trendline from the transducer calibration curve, the above Table 2’s column of percentage change in surface area was calculated. The mild amount of error that is made obvious by a predicted change in surface area when there is no change in capacitance is the result of the trendline not being a perfect representation of what occurred. For the wood, the calculated change in surface area was plausible when subjectively compared to our firsthand observation of the deformation of the sensors following the shootings.

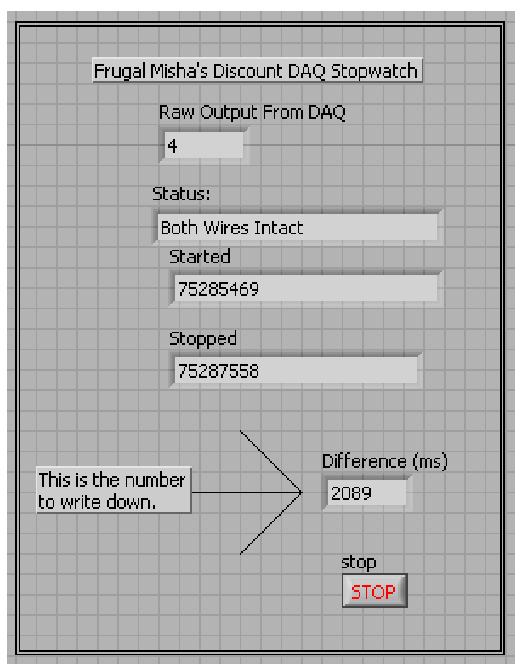
It is felt by the group that this specific implementation of the capacitive transducers is in no way a suitable transducer for this kind of project. This is mostly due to the extremely poor reliability of the sensors, given that most of them failed after being aged for approximately one week. Their suitable performance shortly after creation during the calibration portion could be viewed as evidence that capacitive transducers could be used for this sort of experiment if their reliability issues were to be resolved.

Fire

For the fire portion of the experiment, an apparatus was constructed which would allow the specimen to be held in place by bailing wire with replaceable thin copper wires above and below the specimen. A torch was planned to be applied to the top of the surface, though the torch could not be kept alight in this configuration the final configuration is shown in Figure 6. To correct this, the wiring on the breadboard was adjusted and the torch applied to the bottom surface. The torch would melt through one wire, then burn through the material, then finally melt through the second wire. A DAQ board and Labview program would be used to observe the time delay between first and second wire being cut. The program would essentially run in a loop of polling the DAQ board. If both wires were open, the program would display the difference between the starting and stopping box. When both wires were closed, the starting box would be set to the value of the system clock, in milliseconds. When the top wire was open and the bottom wire closed, then the stop box would be set to the system clock, in milliseconds. In this manner, a very simple Labview program was created which required no input from the user during operation. It was felt that it would be safest for pencil and paper to be used for the recording of data and no input required by the computer. This was so that the data recorder could help focus their attention on the fire while the experiment was in progress. An example of the program in progress is shown in Figure 7 and the program attachments can be seen in Attachment A.

Figure 6: The Fire testing setup

Figure 7: Screenshot of a Trial Run



The fire portion of the experiment proved difficult, due to the arrival of heavy winds. A wind screen was constructed, and the testing continued. It was observed that the propane torch was insufficient to cut through either the hard tack or the oak squares. The group decided that there was insufficient justification to purchase a more expensive torch of approximately $50 for this portion of the experiment, and chose to substitute two different types of aluminum foil for the materials. The apparatus functioned in a fairly straight forward manner from this point, with very few complications. As seen in Table 3 below, the name brand aluminum foil resisted the fire for longer than the store brand, though this data is of no direct utility. The group had no difficulties with executing the Labview program that was written, nor did the DAQ board provide any complications when hooked up to the apparatus.

Table 3: Data collected from the Aluminum Foil

	Test 1 (ms)	Test 2 (ms)	Test 3 (ms)
Great Value	16631	6399	4130
Reynolds wrap	17344	24379	45832

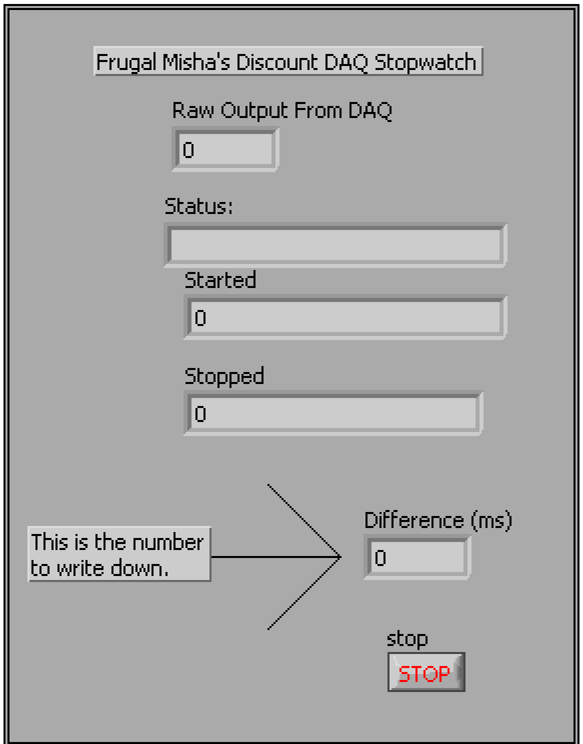
Conclusion and Review

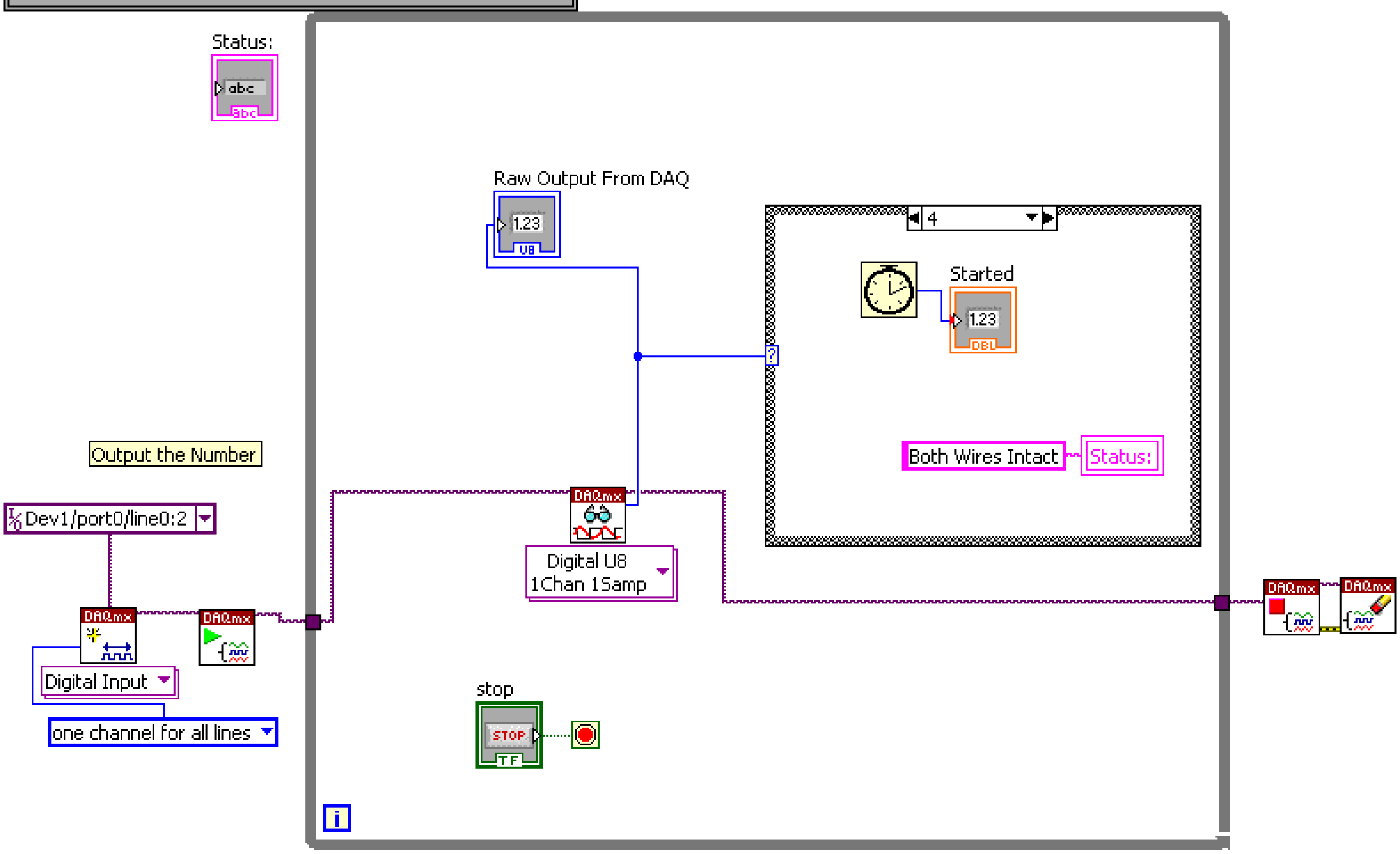
The group modified one procedure from Deliverable 2, and decided to not engage in three of the activities listed therein. Balls for the Colt 1858 were difficult to locate, given the mildly obscure caliber that it fired. Accordingly, the group decided to switch to the weakest breach loading firearm that was available amongst the group. This was an RG Model 10 loaded with .22 Short CB, which was later switched to .22 Short High Velocity when the hard tack proved to be too durable for testing with the low velocity rounds. The three point bending and hammering portion of the experiment were determined to be likely to require too much time, effort, and supplies to be worthwhile given the availability of other tests to be performed. The water penetration test was predicted to require too much time. The two remaining experiments were performed about as described in the Deliverable 2, and only required mild modification to their procedures as described in earlier sections of this report.

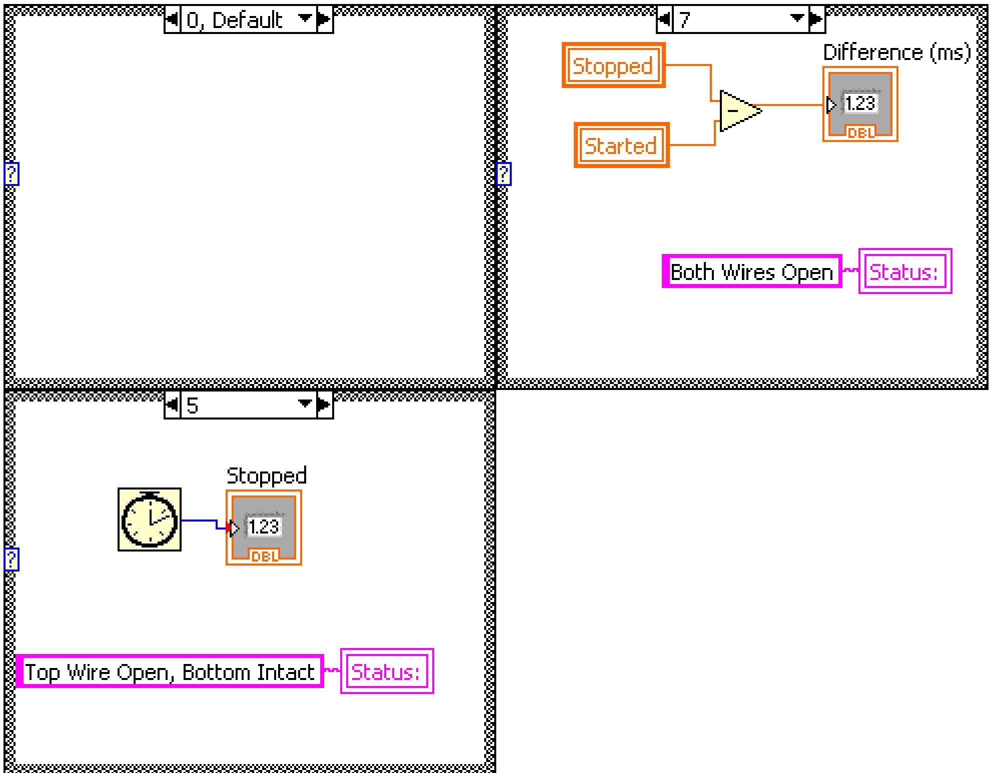
In the end, the project didn't exactly go as planned. Issues arose for every part of the experiment, form insufficient equipment to bad ideas. The radiation experiment either needed a stronger source or better Geiger counter. The shooting experiment needed better capacitors i.e. ones that didn't short 90% of the time or materials that destroyed each other. The fire experiment could not be accomplished with the desired materials so others were substituted. More data points on all experiments were needed but couldn't be obtained. Overall, it was learned that the DAQ was a reliable and accurate stopwatch, shooting things is fun, and hardtack is surprisingly durable. Different transducers not learned in class were experimented with and it was concluded that people learn more from failure than from success.

Appendix A: Documentation of the Labview Program

hardtack.vi







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DAQmx Read.vi
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DAQmx Create Channel (DI-Digital Input).vi
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DAQmx Create Virtual Channel.vi
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DAQmx Start Task.vi
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DAQmx Clear Task.vi
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