

# IMPROVING THE PHYSICS LAB MULTIMEDIA CONTENTS.

AN INTERACTIVE QUALIFYING PROJECT

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## ABSTRACT

This Project is an attempt to enhance and improve the physics lab experience, by integrating multimedia materials in the instruction pages of each lab. Data was collected from both students and faculty in order to understand which points needed improvement. Later on videos and animations were created that covered the observed deficiencies and improved the experimenting process.

## EXECUTIVE SUMMARY

This paper is a review of the procedures we followed while trying to enhance the multimedia contents of the physics laboratory experiments. After having gone through several of the undergraduate physics courses offered at WPI, we had noticed that a fair amount of students were arriving to lab sessions unprepared. This gave me the motivation, to spend my Interactive Qualifying Project trying to improve the situation. This project has much to offer to the community, since it is directly addressed to students, trying to help them improve their knowledge, skills and grades through the use of media, such as videos or animations. In the following pages you will find the methodology we used to “measure” the problem and identify its roots. Later on we discuss the procedure we followed in order to create interesting and comprehensive videos that the students could use prior, during, or even after their experiment, as instructions or reference. Finally, we provide the methods by which we evaluated our product as well as the results.

Overall this was a successful project according to our evaluation since we managed to create plenty of videos that would help students overcome their lab difficulties. Furthermore the feedback we got from the users was very encouraging and might lead to future expansion.

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# 1. INTRODUCTION

When I was still a physics student, the most challenging part of the courses I had to take, were the labs. While performing the labs, many times I came across partners that came to lab sessions unprepared or others that had difficulties understanding the procedures like myself.

Once I started looking for an IQP, I came across a representative from the physics department that was offering projects to students that wanted to enhance the freshman physics lab experience. There I found myself thinking whether I was able to help solve the problem that [tormented](#) me when I was a student. After conversing with the Lab Manager, Mr. Hutson, several times, we took a look at a previous IQP where students had created animated videos in order to assist students with their lab procedures.

Using that idea, I set forth to create a set of instructional and demonstrational videos that would be inserted into the instruction pages of each lab and would offer students a different point of view to the instructions provided. This was no easy task, since I had to [make sure](#) to give the information that would be useful, but on the other hand, give them food for thought and not something “ready made” that they could copy or mimic.

## 1.1 PROBLEM STATEMENT

[At this point the problem was clear.](#) Students [were not paying as much attention as they should to the instructions.](#) This was the main reason as to why students spent so many frustrating hours trying to figure out how to do something, as well the reason for many lost points in their lab reports.

## 1.2 MOTIVATION

After conversing several times with various people from the physics department, I had decided that the lab set that could use the most this multimedia enhancement was in fact that of Physics 1140. I could testify to that my self, since I had taken this course previously. Being one of the most technical and demanding introductory courses, I was lucky enough to have a background as to what were the “hard” parts of each lab. But this was not enough since each professor uses different lab sets according to the way they teach the class.

In order to overcome this differentiation problem I decided to observe the lab session of a class that Professor Frank Dick was lecturing in addition to a lab set being lectured by Professor Phillies. During this observation period I gathered information as to what students are having trouble with during the labs. Fortunately, one of the classes had two lab sections giving me the ability observe

both and increase my sample size. By using different approaches with each section I was able to collect different types of feedback.

The two ways I was observing students were a passive and a more active [method](#). During the former I was attending the lab sessions, sitting quietly at one corner of the room listening and watching the questions being raised to the TA and judging whether these questions were solvable through the use of multimedia. The latter option required more involvement from my part. I was closer to the students observing and receiving questions myself and trying to help them out, just like a TA would.

The questions were mostly of similar context, half of them were concerned about the procedure they need to follow and what result they should be getting, and the rest were concerned with the implementation of the experiment (for example questions asked during lab, see appendix). But it seemed that this was not enough.

After the data collection, students seemed to have problems with the write up and sometimes even relating the lab to what was taught in class at that given period. Therefore, I set of to create a set of surveys for each lab session. The data I collected from those was surprising, some of the students had problems with the write-ups, but that was just in one of the sections. This was a critical point in the project because I decided not to assist students with the write up via multimedia materials, as this would require minimum effort from the students to generate a lab report and this was not the goal.

## 2. DESIGN AND IMPLEMENTATION

The design and implementation decisions I had to take were complicated, but with the help of a previous IQP done on a similar topic by Meshal Alasfour, Brian Grabowski, Brendan Harris (B/C/D 2010) it was easier.

I chose to make each video about 30 seconds long, so that students would be able to view it prior to conducting the experiment or during the lab time. This way, they would have the option to access help on how to attempt the experiment at any time they chose.

Each video contained a brief segment on how to conduct the experiment the right way as well as some notes on what they should pay attention to when experimenting. The last part of the video was a view of what the experiment will look like if conducted the wrong way.

A tool that I used to decide which parts of each lab were important, were surveys. These surveys addressed questions that would give me an idea whether I should emphasize the theory or the procedure for each experiment. I provided them at the end of a couple of lab sessions, and the students were asked to complete them after they completed the write up of the assignment. Surveys are located in Appendix 6.3.

Finally, I had to decide how the completed product would be displayed to the students. This wasn't hard, because I had decided that in contrast to the previous IQP I wanted the video to be embedded to the page instead of having to leave the page to watch it. In my opinion this was a critical point as to whether the students would use the videos. Having the video instantly viewable instead of forcing them to leave the page would save both time and give an extra incentive to watch it.

This is the reason I chose to upload them on a YouTube account that offers free storage space in high definition as well as coding in order to embed the videos directly to the instructions page of the lab.

### 3. METHODOLOGY

#### 3.1 STORYBOARD

Storyboarding was a crucial first step to the success of the project. In order to make the videos easy to follow throughout the course a certain style had to be conserved when creating each one of the videos. Therefore we created the following template for each of the demonstrations.



By having a familiar sequence of events in the videos the student can focus on the procedure after having watched a couple of them, rather than try to understand how videos are structured.

The second video type were animations. In this category, the theory is going to be displayed in an animated maner. This way we could couple any experimental video along with its theory. The reason we chose to create two different videos for each of these tasks, is so that students have the choice of what to watch, and possibly revisit the theory videos several times without having to watch through the experimental part. The layout of an animation would be similar to Figure 1.

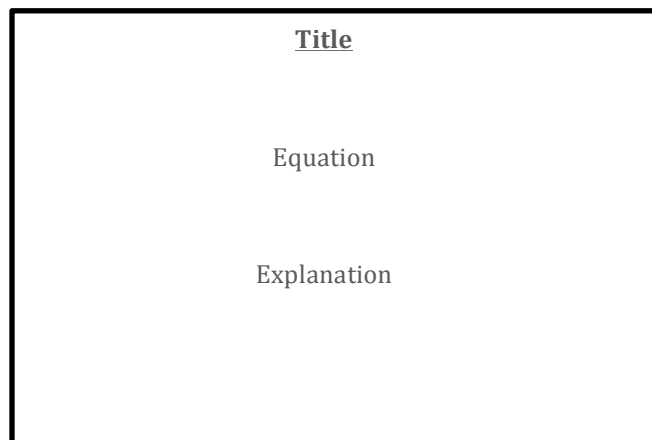


Figure 1: Slide layout

### 3.2 SCRIPT WRITING (FOR SCRIPTS, SEE APPENDIX 6.2.1 & 6.2.2)

At this point everything had been planned out; the one thing that was left to be done before shooting, was to mock up a script for each of the videos and animations, in order to gather all the information and supplies needed to start the shooting process. Script writing turned out to be one of the most useful parts of the preparation, since we were able to figure out the exact information we wanted to convey to the students.

### 3.3 VIDEO SHOOTING

In order to start the video shooting procedure, the physics department ordered the equipment, which consisted of a Sony High Definition camera and a tripod. The tripod was used to keep the camera steady in a locked position during filming.

We made the decision of filming each experiment in a first person point of view, so that the viewers could relate easier to what they would be watching. Light was of the essence, so we had to account for extra lighting, since the videos were shot in the university labs, which tend to be dark. This was achieved by using additional lighting fixtures, and a monochromatic background for a clearer result.

Another clarity problem that arose was that of scaling, since most of the videos were done for oscillations and waves the experiments tend to be of greater scale than others (i.e. electric circuits). Therefore the camera had to move further back (Figure 2) in order to be able and accommodate the scenery, thus sacrificing clarity.

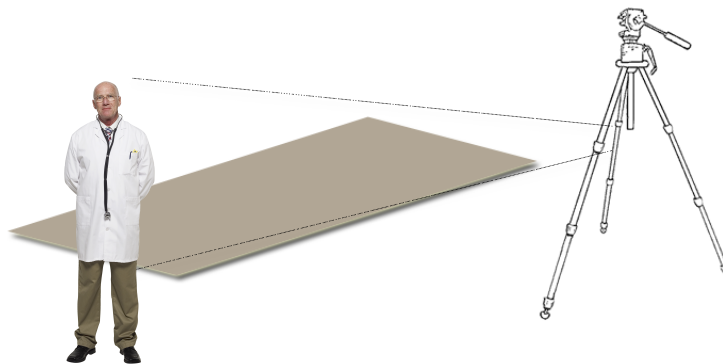



Figure 2: Recording apparatus set-up.



### 3.4 ANIMATION

What came next was setting up the layout for the animations. The tool used to create the slide layouts was Apple's Keynote 2009(  , Figure 3). There, we created a slide for each animation that contained the information necessary for each video. After adding the transitional effects, the slides were ready to get animated.

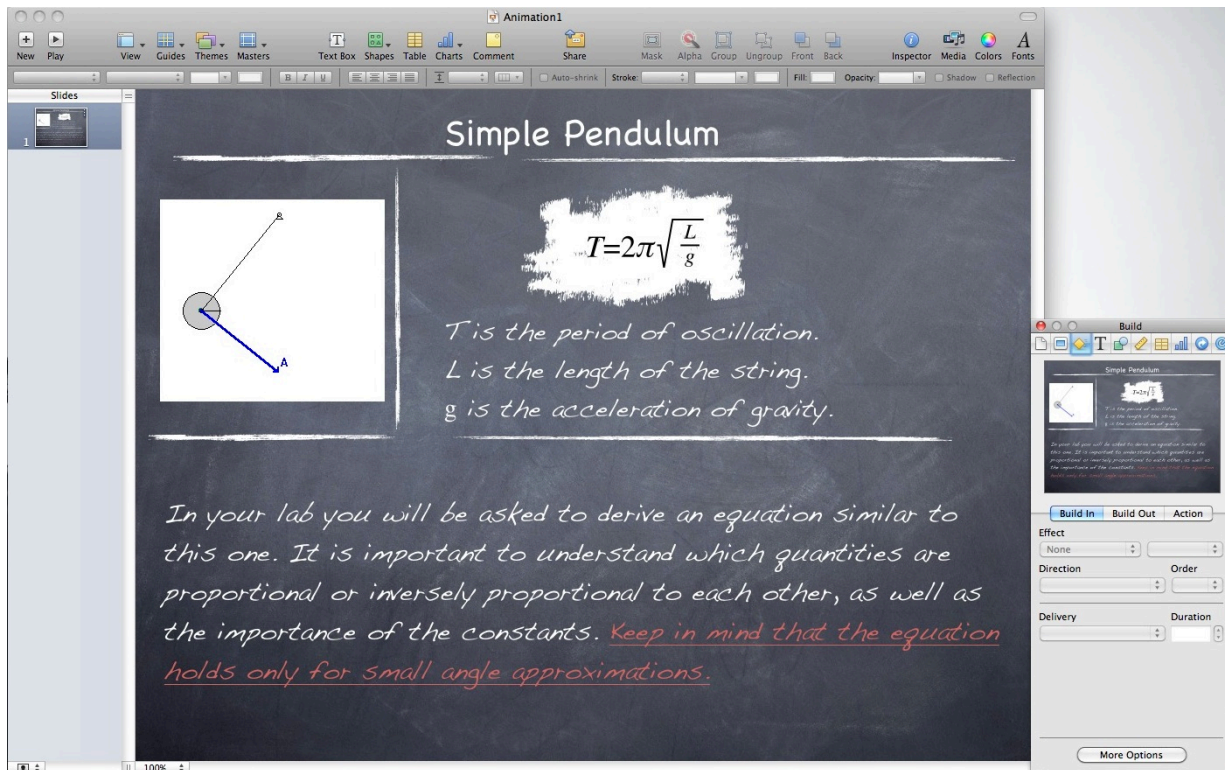

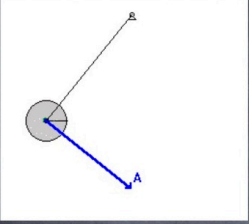


Figure 3: Keynote 2009, slide preparation and transition effect addition.



In order to create a video out of the slides, the Screenflow 2 (  , Figure 4) program was used. This allowed us to record what was viewed on the screen and export it as a video format.

**Simple Pendulum**


$$T = 2\pi\sqrt{\frac{L}{g}}$$

*T is the period of oscillation.  
L is the length of the string.  
g is the acceleration of gravity.*

*In your lab you will be asked to derive an equation similar to this one. It is important to understand which quantities are*

Video Properties

Scale: 100%

X Rotation: 0°

Y Rotation: 0°

Z Rotation: 0°

Opacity: 100%

Reflection: 30%

Shadow

Angle: -45°

Color: [Black]

Offset: 40

75% Opacity Blur Size

Saturation: 100%

Brightness: 100%

Contrast: 100%

Add Video Action

Screen Recording 2/9/11

Duration: 35 seconds

Figure 4: Screenflow, animation captures.

### 3.5 VIDEO EDITING AND EXPORTING

The editing that took place for the videos that were shot with the High Definition camera was done with Apple's iMovie program (Figure 5a & 5b). This program allowed us to import all of the videos shot with the camera to a computer, and create libraries (Figure 5a) with experiments tagged for each of the events. This procedure helped a lot with organizing the videos and especially when looking for the appropriate footage during the montaging stage.



Figure 5a: iMovie, Library containing the raw footage. The projects are at the top left and all the raw footage at the lower half of the image.

After the videos were inserted, we selected the ones we needed and began editing. All unnecessary shots were removed and we synthesized 30-second clips, with the specifications described in the storyboard section. Then, we proceeded by adding the voiceover (Figure 5b), to each of the videos. We first had to cancel out any sounds coming from the recorded videos and then narrate the script while recording.

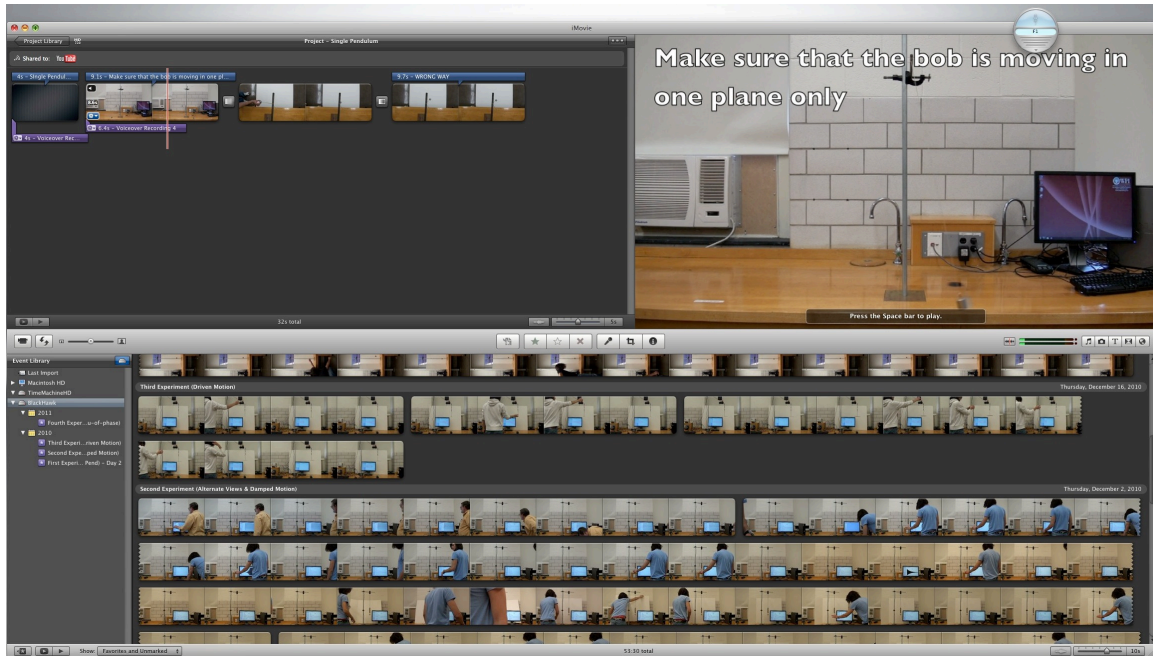
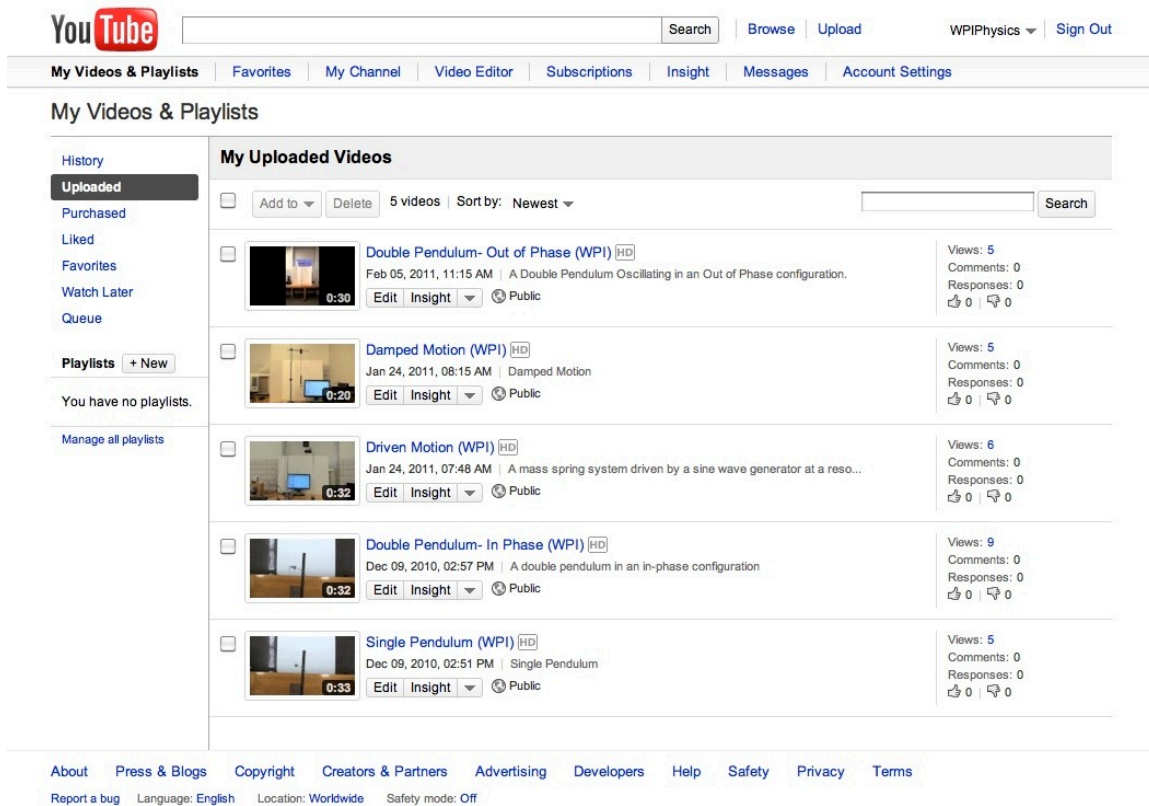


Figure 5b: iMovie, Montage and Voiceover procedures take place at the upper half of the image.

### 3.6 YOUTUBE SET-UP

In order to be able to deliver the final product as decided (embedded rather than linked) a YouTube account, with its own channel (Figure 6, <http://www.youtube.com/wpiphysics>), was created. There the videos could be hosted free of charge and in any format or resolution we pleased. YouTube provides a code that anyone can insert to their site and embed the videos; permissions are easily manageable as well, so it made up for the perfect candidate. More detailed instructions are located in appendix 6.4.



The screenshot shows the YouTube channel page for 'WPIPhysics'. The page is titled 'My Videos & Playlists' and features a navigation menu on the left with options like 'History', 'Uploaded', 'Purchased', 'Liked', 'Favorites', 'Watch Later', 'Queue', 'Playlists', and 'Manage all playlists'. The main content area is titled 'My Uploaded Videos' and displays a list of five videos. Each video entry includes a thumbnail, a title, a description, a timestamp, and statistics for views, comments, and responses. The videos are:

- Double Pendulum- Out of Phase (WPI) [HD]**: Feb 05, 2011, 11:15 AM | A Double Pendulum Oscillating in an Out of Phase configuration. Views: 5, Comments: 0, Responses: 0.
- Damped Motion (WPI) [HD]**: Jan 24, 2011, 08:15 AM | Damped Motion. Views: 5, Comments: 0, Responses: 0.
- Driven Motion (WPI) [HD]**: Jan 24, 2011, 07:48 AM | A mass spring system driven by a sine wave generator at a reso... Views: 6, Comments: 0, Responses: 0.
- Double Pendulum- In Phase (WPI) [HD]**: Dec 09, 2010, 02:57 PM | A double pendulum in an in-phase configuration. Views: 9, Comments: 0, Responses: 0.
- Single Pendulum (WPI) [HD]**: Dec 09, 2010, 02:51 PM | Single Pendulum. Views: 5, Comments: 0, Responses: 0.

The footer of the page contains links for 'About', 'Press & Blogs', 'Copyright', 'Creators & Partners', 'Advertising', 'Developers', 'Help', 'Safety', 'Privacy', and 'Terms'. It also includes a 'Report a bug' link and information about the language (English), location (Worldwide), and safety mode (Off).

Figure 6: YouTube, Uploaded videos. <http://www.youtube.com/wpiphysics>

## 4. SURVEY AND RESULTS

In order to be able to assess the work done on this project, it was decided that a survey should be set up. The students would complete this survey after each lab. The questions were all aimed towards helping us understand what student like or dislike, and what can be done to improve the material in the videos.

Unfortunately for the 1140 Physics course, each professor has their own set of labs that go along with their lecture. That meant that we would not be able to evaluate all of the videos since not all of the labs corresponding to them were repeated during the period this IQP was done. Although, we were lucky enough to have some overlaps and create a small sample size.

The feedback we got back was very exciting and helpful. Most of the students found the videos to be helpful, particularly the ones that went over the experiment instructions. Questions as to when the videos were viewed did not have much to do with the videos per se, but more with the behavior of the students towards preparing for lab and during the course of the lab.

But let's take a look at the numbers:

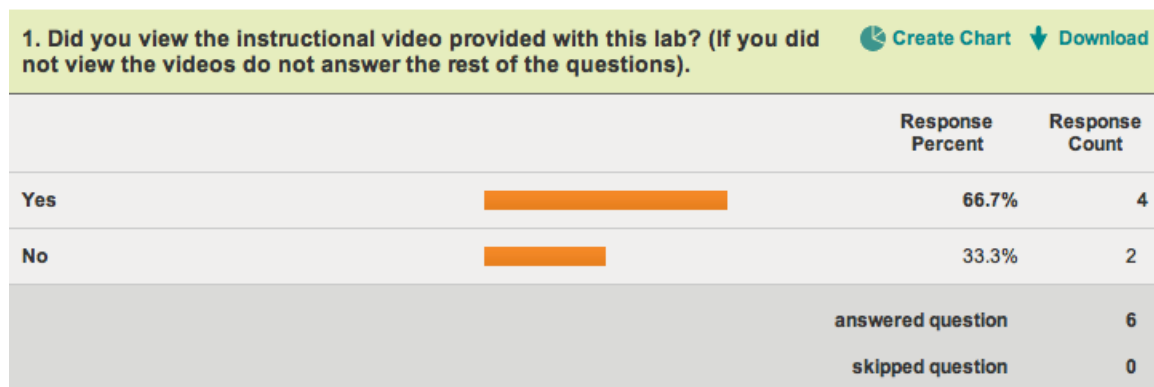


Figure 7: Viewing Percentage. This question was aimed at examining the percentage of students that gave the videos a try for the first time after their introduction

The first question asked (Figure 7), was aimed at examining the amount of students that viewed the new material that was posted in the lab instruction page. This would give us an idea of how many students actually gave the videos a try.

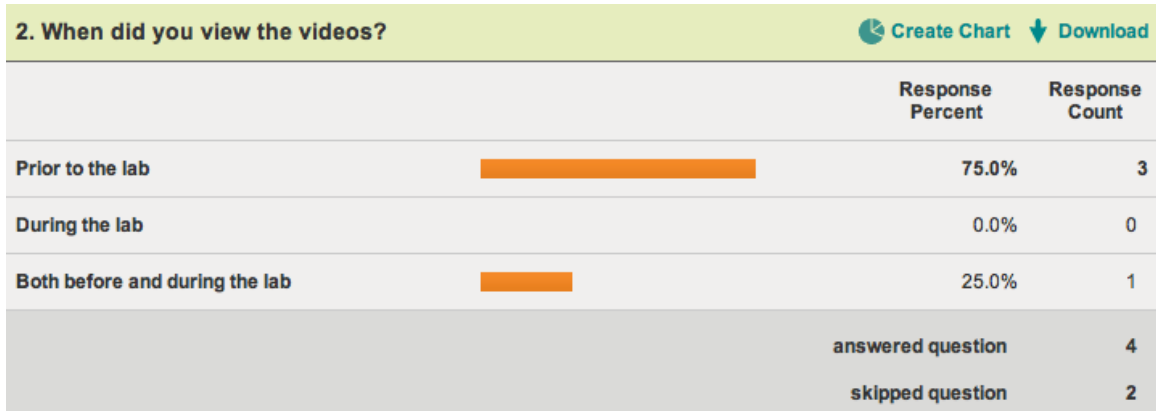


Figure 8: Time of Viewing. This helped us understand how the students prepare for the lab and if they include the material when doing so.

The next question (Figure 8), was addressing the students that answered yes during the previous question. This time their answers would inform us when the students decided to view the media. Most of them answered prior to the lab, which is very encouraging, since we are trying to increase the amount of people that come prepared to lab [sessions](#).

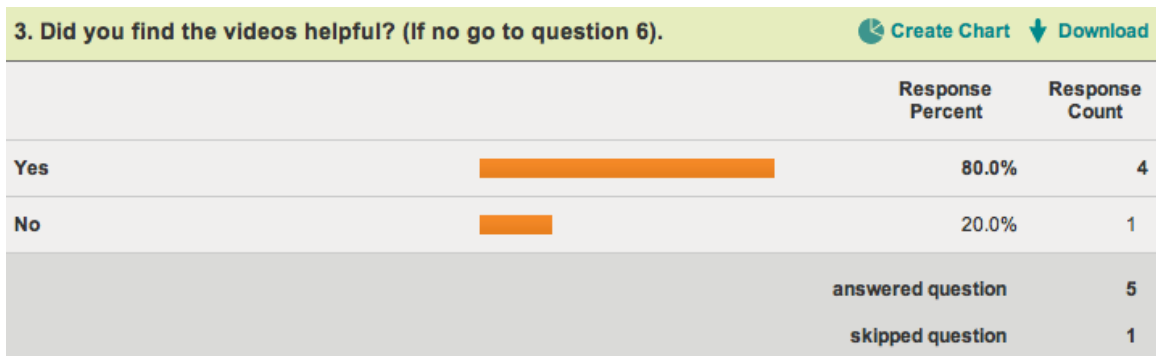


Figure 9: Video effectiveness. Whether the material helped them during the process.

The third question (Figure 9), is concerned with the students opinion on the helpfulness of the media we provided them with. Once again the results were encouraging since the majority of the students seemed to have used the videos to help themselves through out this lab session.

4. Which of the two videos did you find more helpful?		<a href="#">Create Chart</a>	<a href="#">Download</a>
		Response Percent	Response Count
The experiment instructions	<div style="width: 100%; height: 10px; background-color: orange;"></div>	100.0%	4
The theory overview		0.0%	0
They were both equally helpful		0.0%	0
		answered question	4
		skipped question	2

Figure 10: Effectiveness classification. Since there were two videos we wanted to clarify if there was a difference in their effectiveness.

The fourth question (Figure 10), was aiming to categorize the help we provided the students with. That would helpful information because we now can work on those videos that performed poorly and improve them

Following the previous question, we asked for the ways that the students felt the new material helped them. Now we knew the specific reasons they liked our new idea, giving us the option to emphasize it in later work.

**5. How did the videos help you with your work?** [Download](#)

	Response Count
	3

[Hide Responses](#)

Responses (3)
Text Analysis
My Categories (0)

**GOLD FEATURE:** Text Analysis allows you to view frequently used words and phrases, categorize responses and turn open-ended text into data you can really use. To use Text Analysis, upgrade to a GOLD or PLATINUM plan. [Learn More](#) [Upgrade »](#)

Showing 3 text responses No responses selected

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good visual of how things are supposed to be set up and work  
3/30/11 2:01AM [View Responses](#)

---

Provided an example of the lab setup  
3/30/11 9:57PM [View Responses](#)

---

It demonstrated what we were supposed to do in the lab...how to set it up and perform it. A visual example is very simple, but it makes a significant difference in our understanding of lab instructions.  
3/31/11 12:25AM [View Responses](#)

---

answered question	3
skipped question	3

Figure 11: Reasons the videos were effective.



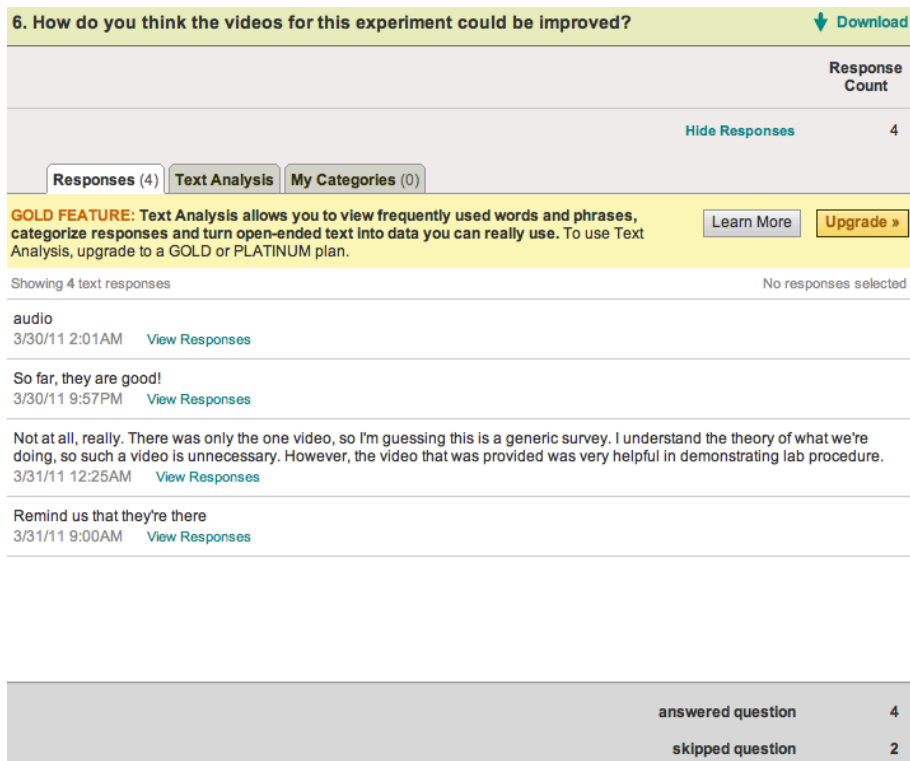


Figure 12: Improvement Suggestions. The students provided us with ways to improve our work.

In our sixth and last question (Figure 12) we asked the participants for suggestions of how to improve the material. This kind of information will be very useful to future developers.

## 5. CONCLUSION

Over the four terms this Interactive Qualifying Project lasted, our goal stayed consistent to the school's motto "Lehr und Kunst" (German for "Theory and Practice"). During this time we tried our best to make the combination and transition of theory and practice as intuitive as possible. Our method of combining the two and stimulating students' interest was through the utilization of modern technology and media. Therefore, we created digital videos and animations of the laboratory experiments for one of the physics courses offered for freshmen students. In order to conduct such a procedure successfully, we had to study the behavior of the students prior to lab time, as well as during the lab. From personal experience we had found out that the key point as to whether a student could perform satisfactorily in a laboratory assignment, was preparation. Those who lacked preparation or did so poorly seemed to be lost and confused during the experiment or the write up. We tried to give this group of students an alternative option. We used our multimedia creations to stimulate their interest and make information that already existed even more accessible to them.

Finally after all our hard work, we had to evaluate our results. We did so by conducting surveys, and the results were astonishing. The students seemed to have embraced this new way of displaying information and all gave very positive feedback including the following "A visual example is very simple, but it makes a significant difference in our understanding of the lab instructions". This was all the information we needed in order to come to the realization that we had succeeded in our goal. As long as we were able to provide help to even a single student we had succeeded. But there was a hidden lesson for us as well, and that was that students will produce and output outstanding material as long as the right buttons are pushed.

## 6. APPENDICES

### 6.1 QUESTIONS ASKED DURING THE LABS.

Should I be varying the mass on the pendulum?

Should I be varying the length of the string?

Does the initial displacement of the pendulum matter?

How many times should the experiment be repeated?

How to position the magnets on the masses for the damped motion?

How do I get the out of phase double pendulum to work?

How do I get the in phase double pendulum to work?

### 6.2.1 VIDEO SCRIPTS

#### Single Pendulum Experiment

This is a demonstration of the simple pendulum. When the pendulum oscillates, make sure it only does so in one plain.

#### Double Pendulum Experiment (In-Phase)

This is a demonstration a double pendulum, in of phase. When the pendulum oscillates make sure it only does so in one plane.

#### Double Pendulum Experiment (Out-of-Phase)

This is a demonstration of a double pendulum in an out of phase configuration. When conducting this experiment, make sure that the masses oscillate only in one plane just like any other pendulum. In order to get the timing right you will need some calculations to set the initial distance of each mass from the vertical position. Make sure that when the upper mass has reached it's furthest right position the lower mass has reached it's furthest left, and vice versa.

#### Driven Motion

Driven motion and Resonance. When a system resonates, it's amplitude keeps increasing with time, just like in the graph shown. On the other hand, when a system is oscillating at a frequency, different from the resonant it's amplitude fluctuates with time.

## 6.2.2 ANIMATION SCRIPTS

Title: Simple Pendulum

$$\text{Equation: } T \cong 2\pi \sqrt{\frac{L}{g}}$$

Explanation: T- Period of Oscillation

L- Length of string

g- gravitational acceleration

Relationship to the experiment: You have to derive an equation similar to this.

Title: Double Pendulum In-phase & Out of Phase

Equation:

$$\ddot{\Theta}_1 = -\frac{g}{L}(2\Theta_1 - \Theta_2)$$

$$\ddot{\Theta}_2 = -\frac{g}{L}(\Theta_1 - \Theta_2)$$

$$\Theta_1 = C_1 \cos(\omega t + \phi)$$

$$\Theta_2 = C_2 \cos(\omega t + \phi)$$

$$\left(2\frac{g}{L} - \omega^2\right)\Theta_1 - \frac{g}{L}\Theta_2 = 0$$

$$2\frac{g}{L}\Theta_1 - \left(2\frac{g}{L} - \omega^2\right)\Theta_2 = 0$$

$$-\left(2\frac{g}{L} - \omega^2\right)\left(2\frac{g}{L} - \omega^2\right) + 2\frac{g^2}{L^2} = 0$$

$$\omega_{\pm} = \sqrt{\frac{g}{L}(2 \pm \sqrt{2})}$$

$$\frac{C_{1+}}{C_{2+}} = -\frac{1}{\sqrt{2}}$$

$$\frac{C_{1-}}{C_{2-}} = \frac{1}{\sqrt{2}}$$

$$\Theta_{1+} = C_+ \cos(\omega_+ t + \phi_+)$$

$$\Theta_{2-} = \sqrt{2} C_- \cos(\omega_- t + \phi_-)$$

$$\Theta_{1-} = C_- \cos(\omega_- t + \phi_-)$$

$$\Theta_{2+} = -\sqrt{2} C_+ \cos(\omega_+ t + \phi_+)$$

Explanation: We use the equations of motion of the system to derive, the amount that we need to displace the masses of the double pendulum in order to get it to oscillate in and out of phase.

The answer we get is in terms of theta, but with simple calculations it can be converted to a displacement on the x-axis.

Relationship to the experiment: During this 2 part experiment the students are asked to measure the period of a double pendulum that oscillates in and out of phase. In Order to make the pendulum oscillate correctly and not a random motion, students have to calculate the initial displacement of the masses from equilibrium.

These Equations help them do that.

---

Title: Driven motion

Equation:  $\exp(-\gamma t/2)[A \exp(t(\gamma^2/4 - \omega_0^2))^{1/2} + B \exp(-t(\gamma^2/4 - \omega_0^2))]$

Explanation: Explain the three possible cases that Damped motions can get into.

- Under Damped
- Over Damped
- Critically Damped

Why we get these cases, and what's the difference between them.

Relationship to the experiment: During the Damped motion experiment, students have to experiment with a system that oscillates, and we introduce damping by attaching magnets and running it through a copper tube.

## 6.3 PRELIMINARY SURVEY

### Response Summary

Total Started Survey: 9  
Total Completed Survey: 9 (100%)

PAGE: 1

**1. Which part of today's lab assignment did you find hard?** [Create Chart](#) [Download](#)

	Response Percent	Response Count
Experiment	44.4%	4
Calculations	33.3%	3
Write Up	66.7%	6
Other	22.2%	2
Other (please specify) <a href="#">Show Responses</a>		2
answered question		9
skipped question		0

**2. Do you recognize the relation of the experiment to what is done in class?** [Create Chart](#) [Download](#)

	Response Percent	Response Count
Yes	55.6%	5
Yes but not completely	44.4%	4
No	0.0%	0
answered question		9
skipped question		0

**3. What do you think would improve this lab for future students?** [Download](#)

	Response Count
<a href="#">Show Responses</a>	7
answered question	7
skipped question	2

**4. Were the instructions clear enough in order to proceed with the experiment, if no what do you think was missing.** [Download](#)

	Response Count
<a href="#">Show Responses</a>	7
answered question	7
skipped question	2

**5. Did you come across any unexpected questions during the write up?** [Create Chart](#) [Download](#)

	Response Percent	Response Count
Yes	55.6%	5
No	44.4%	4
No (Which were they) <a href="#">Show Responses</a>		2
answered question		9
skipped question		0

Figure 13: Survey for experiment number 4.

## Response Summary

Total Started Survey: 3  
Total Completed Survey: 3 (100%)

PAGE: 1

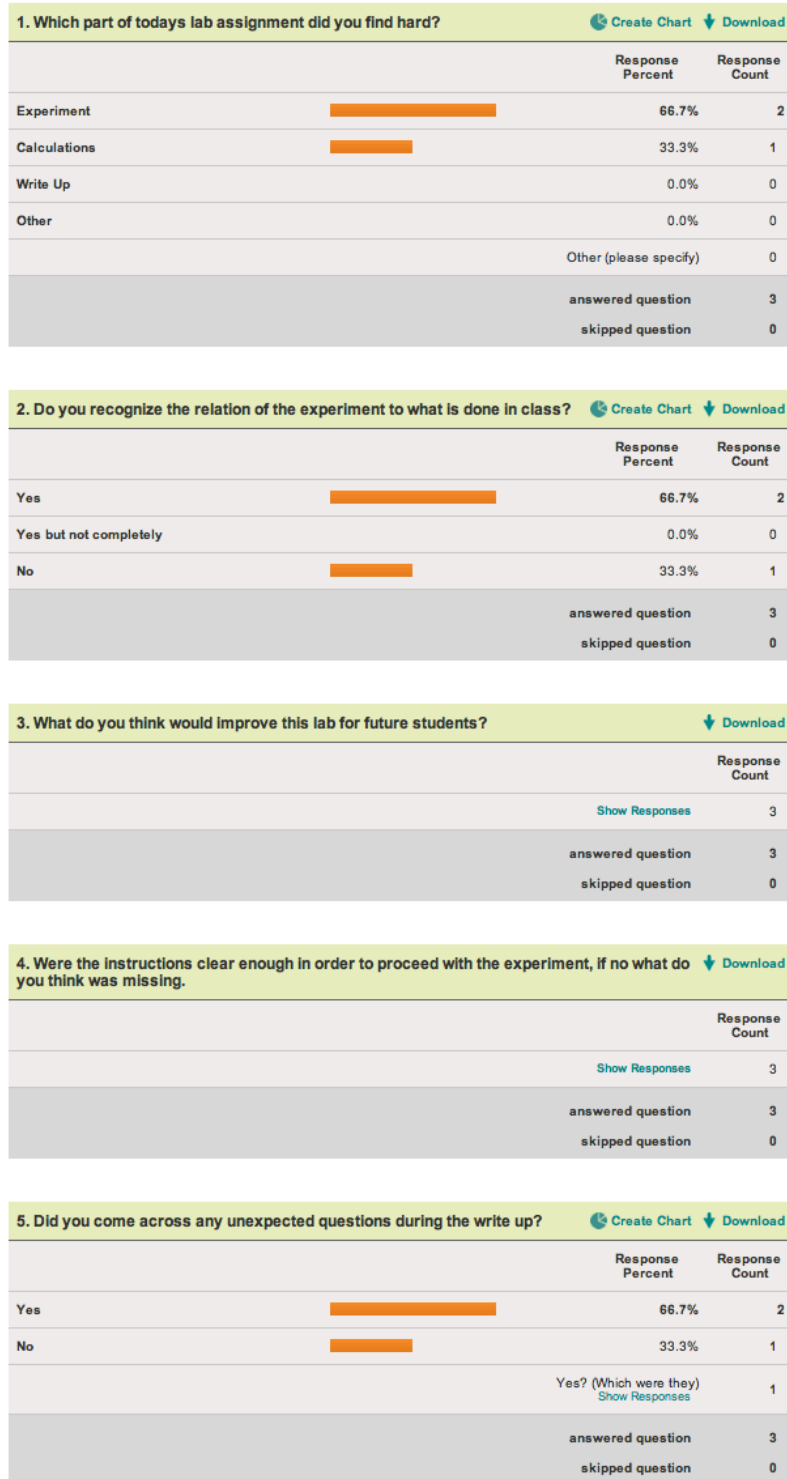


Figure 14: Survey for experiment number 6.

## 6.4 VIDEO EMBEDDING INSTRUCTIONS

Due to the fact that we wanted to embed the videos to the instruction page of each lab the process of linking the labs to the videos, has become slightly more complicated. Following, are the steps one needs to make in order to successfully embed a video to a SharePoint page.

1. Log in to YouTube, using the WPI Physics account details.
2. Upload the video (make sure it is the high definition version, and not a reduced one), by visiting the following link, [http://upload.youtube.com/my\\_videos\\_upload](http://upload.youtube.com/my_videos_upload).
3. After the video has been uploaded, update all of the information, such as Name (please follow existing format), Tags, Location etc.
4. Locate the video and copy the code named "<Embed>".
5. Log in to SharePoint, at <https://student.sharepoint.wpi.edu/courses/physicslabs/Wiki%20Pages/Home.aspx>.
6. Locate the page that needs updating.
7. Click on Site Actions (located at the top right corner of the page)
8. After a box appears at the bottom of the page named "Add a web part", click on the "Add a web part" banner.
9. Search the list and add a content editor.
10. Follow the instructions on the sidebar that appear to at the right part of the window, and click on "Source Editor".
11. Paste the code that was copied from YouTube in the box that come up.
12. Click on save.
13. When done adding Content editors click OK on the sidebar.



## 7 REFERENCES

- WPI Sharepoint ,  
<https://student.sharepoint.wpi.edu/courses/physicslabs/Wiki%20Pages/Home.aspx>
- Class notes
- Young, Hugh D., Roger A. Freedman, A. Lewis Ford, and Francis Weston Sears. *Sears and Zemansky's University Physics: with Modern Physics*. San Francisco: Pearson Addison Wesley, 2008. Print.
- Giancoli, Douglas C. *Physics for Scientists and Engineers with Modern Physics*. Upper Saddle River, NJ: Pearson Education, 2008. Print.