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Physics Instructional Toolbox IQP

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Physics Instructional Toolbox IQP

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Acknowledgements

I would like to thank my adviser, Professor Germano Iannacchione, for his direction and guidance throughout the course of this IQP.

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Abstract

This project is a yearly endeavor by the Physics Department to continually improve the labs for the 1100-level physics courses. For this year, my project consisted of using data to find problems with labs, choosing a lab to change, altering the lab in order to improve upon the problems, and lastly, testing out how well these changes improved the lab. The project used two methods of determining the effect of the lab on the students: using a survey to get subjective opinions from the students and analysis of the grades to see how well the students were performing in the labs.

Lab 6 of PH 1120: General Physics – Electricity and Magnetism was the lab chosen to be changed. The result of this experiment into an attempted improvement resulted in virtually no change of how well students performed during in the lab. While a large effort was put into making the instructions clearer, a blunder was counteractive toward this goal, and it ended up tainting the results. I was not able to determine how well I was able to improve the instructions. Furthermore, the average grade for this lab did not vary by much. This was mostly due to the fact that the change in the lab procedure that was made seemed to be too small of a change to make a difference. Overall, this IQP was not a failure, because there were certainly lessons learned for future work. However, it was certainly not a success either, because the changes that were made to the lab yielded virtually no difference in how the students performed.

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1 Introduction

The goal of this IQP is improve one 1100-level Physics lab. I took several introductory level Physics courses, and I can recall that there were labs that I found to be more difficult than others. This was either due to directions that were not easily understandable, data that took a great deal of either effort or time to record, or the overall length of the experiment was too long to be completed during the lab period. I set out to choose one of these labs, isolate the problems that contributed to one or more of those difficulties, and try to improve the experiment by altering it in order to reduce those difficulties. I determined how well my changes improved the lab by analyzing and comparing survey responses and the students' grades.

1.1 Background

This IQP is part of an ongoing effort by the Physics Department in conjunction with the Academic Technology Center at WPI to continually improve the quality of the labs for introductory physics courses. This IQP is hosted by the Physics Department on a yearly basis. In the past, previous projects have included rewriting the instructions to labs; making multimedia, such as Java applets, for specific labs; and improving the procedure for one or multiple labs.

Unlike most of the previous IQPs, the scope for my IQP was, initially, not determined. I was set to work on a single lab rather than multiple labs, but I wanted to use research to determine upon what I could improve in the lab. I had set no limits for myself as to what I could change in a lab; it could include lab instructions, pictures or diagrams used, other multimedia sources used, or even designing a better-suited lab for the course material. My plan for this IQP was to first find a lab that was the source of difficulty for students, determine what was causing problems or what could improve the lab, change the lab to try to improve it, and lastly, determine how successful my attempt at improving the lab was.

1.2 Strategy

In order to accomplish this, I needed to collect whatever initial data I required in B term. In C term, I needed to analyze that data, to choose which lab on which to focus my efforts, and to alter that lab. Finally, in D term, I needed to collect data for the changed lab and compare it to the data of the original lab.

I restricted the physics courses on which to focus to PH 1120: General Physics – Electricity and Magnetism, PH 1121: Principles of Physics – Electricity and Magnetism, and PH 1140: Oscillations and Waves. These three courses were the three introductory level (1100-level) courses offered in both B- and D terms. Due to the time constraints, I restricted my choice of labs to three in the middle of the term for each course. This means that for PH 1120, I collected data for Labs 4, 5, and 6; for PH 1121, I collected data for

Labs 3, 4, and 5; and for PH 1140, I collected data from Labs 4, 5, and 6. All in all, I had nine labs from which to draw information and choose to try to improve.

1.2.1 B Term: Data Collection and Analysis

In order to gain information about each lab, I had to collect and analyze data. I decided that this would be in two parts. The first was from a survey; I would be able to see subjective opinions directly from the students on which labs caused difficulty or were confusing.

Secondly, I would be able to gain information from the grades of the students. I planned to look at the average grades for each of the labs, to look at the standard deviation for each lab, and to compare lab grades with exam grades. These would give me a good idea of which labs had the lowest grades, which exams had the largest range of grades, and which labs had the strongest effect on other aspects of the course.

1.2.2 C Term: Choosing a Lab

Once I had all the data scrutinized, I could then make an informed decision as to which lab I would like to work on. I planned to use the grades I collected to choose which lab to work on and to use the survey results as a gauge as to what were the main issues students had with the lab. Because of this, I needed to make sure that the survey questions were specifically aimed to determine what problems students encountered while performing the lab.

Once I had the lab decided, I could use the students' responses on the surveys to pinpoint what issues and difficulties they were having. Depending on what the issues were, I could either alter the lab in some way or redesign it completely.

1.2.3 D Term: Data Analysis and Results

D Term is when I would see how well my changes improved the lab. The courses from which I originally got the data in B Term were going to be repeated in D Term. By collecting the survey data and grades again, I could compare them to B Term results and analyze what worked and what did not. I also planned on splitting up the course in order to have a control group. For this, I would try to split up the course as evenly as possible, with one half performing the original, unaltered lab, and the other half performing my rebuilt lab. That way, not only would I be able to compare the results in D Term to the results in B Term, but I would also be able to compare them to results from the same term, learning the exact same material at the same time.

2 Data Collection

For the first portion of data collection, I needed to design a survey for the students in the labs to fill out. I needed to design this survey to highlight any problems the students were having. I asked the students to rate the difficulty of various aspects of the labs. I also included a portion where they could write out anything with which they specifically had difficulty. The full survey can be found in Appendix A.

For the second portion of my data collection, I needed the grades of the students currently taking the physics labs. I was able to receive the grades from Fred Hutson, the Physics Department Lab Coordinator. He sent me the grades of every student taking one of the three current 1100-level physics courses, separated by course instructor. By separating the grades by course instructor, I could take into account if a professor graded especially harder than another. He also sent me the exam grades and the conference grades associated with each of the students. In order to keep the grades confidential, Fred Hutson made sure to send me the grades without either the students' names or ID numbers. Instead, I was simply given the section to which the student belonged. By doing this, I could account for any lab instructors that were especially tough or especially lenient for the labs, just like I did for the professors.

2.1 Analytic Tools

In order to analyze the data, I used Microsoft Excel. There were a few main ways I looked at the data. The first is histograms. I used them to visually represent how many people answered what in the surveys, as well as I used it show how many people got what grade on the labs. I also used Excel to find the arithmetic mean of the lab grades and their standard deviation. This is important, because that can help me find which labs averaged lower than others and which labs had the highest variance.

When trying to find a lab to work on for this IQP, I looked for labs with low averages and high deviations. To visually represent this, I overlaid a plot of the Gaussian distribution, which I found using Excel's Normal Distribution function. Lastly, I compared the lab grades to the exam which directly succeeded that lab. I used a linear regression to determine how much there existed of a correlation between that lab and its corresponding exam.

2.2 Failure with Surveys

The first problem I encountered was the uninterested the students were in filling out and returning surveys. When I was trying to determine whether I should post a survey online or hand out hard copy versions, I opted for the hard copies. It was my thought that it is much easier for a student to pass up a survey online than in person. I had figured the fact that I was in the lab, taking to the students face-to-face would produce better results than an online version. I figured the direct interaction would pressure or at least guilt more students into returning their surveys.

That notion was very wrong. Out of close to 400 surveys handed out, only nine were filled out and returned, all of which were filled out during class and handed to me right after I had passed the surveys out. I did not receive a single survey that was taken home, filled out, and then turned in during the next lab. I think now that, although direct interaction may provide more motivation to return the surveys, the convenience of filling out a survey online provides much better results.

2.2.1 Results of Surveys

Despite receiving only nine completed surveys, we can still try to extrapolate some information from these data. Because there was so little information, all I could really do is provide histograms of the data in order to visualize it. You can find the results of the surveys in Appendix B.

The subjectively most difficult lab of the three I was able to collect data on was the LCR Circuit from PH 1140. People also had a fairly difficult time understanding the instructions. While the LC Circuit lab had comparable difficulty when it came to understanding the instructions, the students seemed to think they were doing better. Of course this is all based off of what only nine subjective surveys had to say about three different labs. No hard conclusions could be drawn from these results. Instead, I had to rely solely on the grades of the labs.

2.3 Analysis of Grades

The full visual analysis of the grades can be found in Appendix C. Like I stated before, I used Excel to provide histograms, normal distributions, and comparisons of the labs and the exams. Before I chose which lab to work on, I wanted to eliminate the obvious labs that would not benefit from alterations. I used the lab grades averages, standard deviations, and correlation factors with exams to determine which labs had the highest potentials for improvement.

For PH 1120, the only lab we can really eliminate is Lab 5. For all three instructors, Lab 5 has both the highest mean and the lowest standard deviation. Lab 4 and Lab 6, however, both have their benefits and drawbacks. In Professor Frank Dick's course, Lab 6 had both the lowest average and the highest standard deviation. Additionally, it had the highest correlation factor between itself and its corresponding exam. This means, potentially, that in Professor Dick's course, Lab 6 has a higher effect on its corresponding exam than the other two labs. However, in Professor Hektor Kashuri's course, Lab 6 has the lowest correlation factor, and its standard deviation and class average are both typical compared to the other two labs. I only really felt safe eliminating Lab 5 from potential labs to work on for PH 1120.

In PH 1121, Lab 4 is the only one of the three that does not have fairly good numbers for both professors. In both cases, Lab 4 has both the lowest average and the highest standard deviation. It also has the highest correlation factor in Professor Izabela Stroe's course.

The PH 1140 course had a similar scenario as PH 1121. Lab 5 had both a lower grade average and a higher standard deviation. With that, I knew I had narrowed my choices down to Labs 4 and 6 from PH 1120, Lab 4 from PH 1121, and Lab 5 from PH 1140. They all exhibited much higher potential for improvement than the other labs.

3 Choosing a Lab

Now that I had four labs from which to choose, I had to figure out exactly on what I could make improvements. Had I had enough surveys, this might have been less work. However, without them, I had to examine the labs myself to try and find what might be causing difficulties.

3.1 Eliminated Courses

My choices were narrowed down even further at the start of D Term. The professors of both PH 1121 and PH 1140 had chosen different labs than the ones I had been studying from B Term. At this point, I realized it would be more appropriate to simply choose either Lab 4 or Lab 6 from PH 1120. If the professors had specifically chosen the labs with which to work, trying to force in an altered lab from B Term would surely be counterproductive toward the goal of this IQP.

3.2 Analysis of PH 1120 Labs

In order to choose between Lab 4 and Lab 6, I had to read through them and see if I could find anything I wanted to improve upon. Lab 4 was the lab, Electrical Potential and RC Discharge. It was a fairly simple lab of measuring the discharge of a capacitor in parallel with a resistor over time. Lab 6 was Linear vs Nonlinear Circuits and Magnetic Field Measurements. This was a two part lab in which the two parts had not much to do with each other. While Part 1, Linear vs Nonlinear Circuits, was the last lab dealing with circuit elements, Part 2, Magnetic Field Measurements, was an introductory lesson into measuring magnetic fields. I decided that Lab 4 was fairly simple, and I did not think I could improve upon it. There were also a few things about Part 2 of Lab 6 that I thought I could make easier and more informative.

3.3 Lab 6

Part 1 dealt with comparing the resistance across a resistor and the resistance across a light bulb at different voltages. Just like Lab 4, I thought the experiment was fairly simple. Part 2, however, I thought I could make better. The experiment was just to use a Vernier LoggerPro magnetic field probe to map and understand the magnetic field created by a permanent bar magnet. An image of the probe can be seen in Figure 1. Figure 1 is courtesy of Bryan Bergeron's Physics Toolbox IQP from last year (Bergeron, 2013).

Figure 1: Bar magnet (left) with Magnetic field probe (right).

The experiment had the students move the magnet in different positions with respect to the probe and monitor the results on the computer. Next, they had to place a paper clip in between the magnet and the probe to see how that affects the magnetic field of the permanent magnet. The full, original lab instructions for Lab 6 Part 2 are located in Appendix D.

3.3.1 Instructions

The first thing I wanted to change about this lab was the lab instructions. The instructions, I noticed, were a little confusing. I thought there were a few sentences that were either run-ons and difficult to follow, or just worded badly. This area I thought could be enhanced by simply making the directions much more clear.

3.3.2 Lack of Recording Data

The one other thing that bothered me was the lack of recording any data or measurements in Part 2. For this portion of Lab 6, all they had to do was watch the computer as they moved the magnet as directed and take mental note of what was happening. It was always my impression that the purpose of a lab is to connect concepts learned in class to hands-on activities. By using the concepts learned in class in a very direct manner, one can physically see the effects. I think this is lost to a substantial extent when students do not collect data or measurements.

It seemed to me that there's not much difference between learning a concept in class and then simply watching it happen in the lab. If you do not have numbers or data to analyze properly, then all you can comment on in the lab report is how it was generally functioning. I determined that I could make the lab more substantial and more helpful in learning concepts discussed in the courses if I found a way to have the students collect measurements and report on their findings.

4 Changing Lab 6, Part 2

I had chosen a lab that had considerable room for improvements, and I had pinpointed two specific areas that I wanted to change. I spent time with Fred Hutson discussing what changes I should and could make. He is the Lab Coordinator so I very much valued his opinion as well as I needed him to agree to the changes I wanted to make.

4.1 Instructions

There was one specific passage at the beginning of Part 2 that I found particularly confusing. The students were supposed to translate the magnet from where it was in the first set up until it was pointed at the probe and facing perpendicular to the direction the probe was facing. See Figures 2 and 3 for simple images of the two positions. I found that not only was it worded badly, but it was fairly difficult to describe exactly what needed to be done.

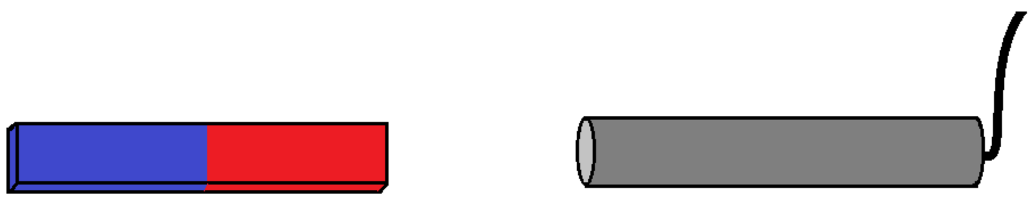


Figure 2: First position of magnet (left) and probe (right)

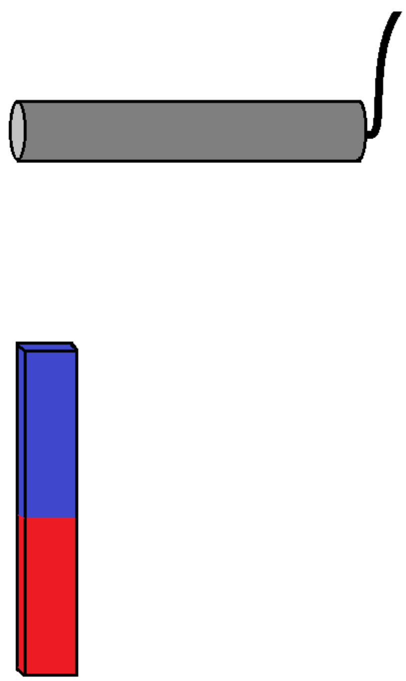


Figure 3: Second position of magnet (bottom) and probe (top)

4.1.1 Adding a Diagram or Picture

My solution to this was to add some pictures or diagrams to the instructions, such as Figures 2 and 3. My reasoning was that if we had photographs or diagrams depicting the positions of the magnet and the probe at different points during the lab, then the wording that I found to be confusing would have less of an effect. I discussed this idea with Fred Hutson, but he was not keen on the idea of adding pictures.

He was worried that if pictures were used, it would take away from the thinking that was required for this portion of the lab. The main objective of Lab 6 Part 2 was to understand how the magnetic fields emanate from the magnet and to understand how the probe works. In that respect, the students were supposed to learn, through moving the magnet around at different locations with respect to the probe, that the probe can measure field lines that run along the probe's long axis, but not perpendicular to it. In other words, the probe measures the component of the magnetic field that runs parallel to the long axis of the probe.

Fred Hutson explained that in order to properly understand this fact, it was necessary for the students to read what was written, picture how the experiment should be performed, and then use the probe to see how it reacted. By showing them an image of the setup, one would effectively eliminate the thinking the students needed to do in order to understand how the probe measures magnetic fields. He agreed to allow a very bare image to be put into the lab. It needed to be minimal enough that the students were still required to think about how the setup needed to look. I decided that putting an image in that simple would really not accomplish anything. I, instead, decided to clear up the instructions.

4.1.2 Rewriting the Instructions

The first part of the instructions that I wanted to change was the portion describing moving the magnet to a perpendicular location with respect to the probe. It describes moving the magnet in one sentence. I thought that if the student knew they had to both translate the magnet to the side of the probe and rotate it 90 degrees so that it was facing the probe, it would be easier to visualize what needed to be done.

The next thing I thought to do in order to clear up the instructions was to number the steps in the lab instructions. However, Fred Hutson did not want the steps numbered. He wanted the students to be able to read the lab instructions in paragraph form, rather than step-by-step directions. I removed the numbers and reorganized the instructions in paragraph form. The last thing I did was clean up the language in a few other places. I found that sometimes, the language was either too verbose or too bare. You can see the differences between the original instructions and my altered instructions in the appendices. The original version is in Appendix D, and my revised instructions are in Appendix E.

4.2 Lack of Recording Data

The second revision to the instructions I intended was to somehow find a way of having the students record and analyze some data from the experiment. I thought that since this was an introductory course into new material, I could use a different experiment to replace the portion of the lab the involved using a paper clip to change the magnetic field.

4.2.1 Measuring the Magnetic Moment of the Permanent Magnet

The lab that I wanted to use I found on the Vernier webpage. It was called, *The Magnetic Field of a Permanent Magnet* (Vernier Software & Technology). This lab was designed for high school students. The experiment is about using the magnetic field probe to calculate the magnet moment of a permanent magnet. The students were to use LoggerPro software to record both the magnetic field being sensed by the probe and the distance that the magnet was from the probe. Once the students had enough data points, they were to use the LoggerPro software to match the points with a best fit, variable power line, with the power set to -3. This would fit a line of form,

$$y = Ax^{-3}$$

to the points collected. They could use the constant, A, to determine what the strength of the permanent magnet was.

This seemed to me like a simple lab that demonstrated how to use the magnetic field probe. I was careful to use a lab that did not measure the magnetic field created by a current running through a coil of wire. This was because Lab 6 was meant to be a simple introduction into field lines and how to use the magnetic field sensor. Lab 7 covered the electrical and magnetic fields created by current going through a coil of wire, and I wanted to make sure that I did not intrude on topics that were yet to be discussed in class.

4.2.2 Recording the Probe Readings While Moving the Paperclip

Fred Hutson was against the idea of getting rid of the paperclip portion of the experiment. I knew that if we kept that in, we would not be able to put in the lab I wanted to put in; this would have caused the lab to become much too long. This meant that I had to alter something in the current lab, either the part with the paper clip, or the part without the paper clip. I knew that because of the nature of the former, it would be a bad idea to collect data there.

Fred Hutson was keen on the idea of changing the portion of the lab when the instructions direct the students to move the paper clip back and forth between the magnet and the probe. He felt this would be an excellent place to collect data. We decided that we could change it such that students were required to slide the paperclip in between the magnet and the probe three times, each with the paperclip in a different orientation; once parallel to the probe and magnet, once perpendicular to the probe and magnet, and once diagonally with respect to both the probe and magnet. Figures 4 through 6 show the three different orientations of the paper clip.

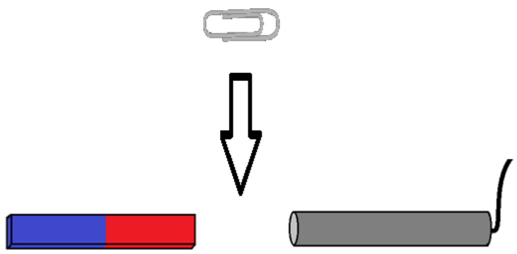


Figure 4: Sliding the parallel paperclip

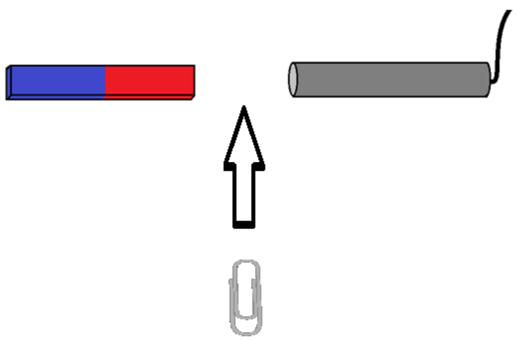


Figure 5: Sliding the perpendicular paperclip back

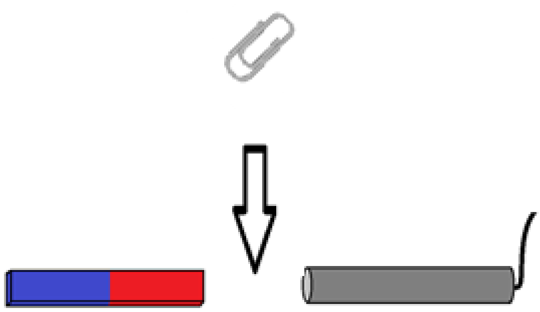


Figure 6: Sliding the diagonal paperclip

We wanted the students to record the entire process and record the peaks of that the probe sensed. The LoggerPro file was already set up to record magnetic field over a time span. We also wanted them to discuss what their graph of magnetic field over time looked like. This would effectively fulfill my desire to have something in this lab where students recorded data and then analyze them. Again, to see the changes that were made, you can refer to Appendix D for the original instructions and Appendix E for the revised instructions.

4.3 Alterations to the Data Sheet

I needed to adjust the data sheet so that it accurately represented what the students had done in class. The original questions pertaining to Part 2 of Lab 6 from the datasheet are located in Appendix F. My revised questions can be found in Appendix G. The only thing I really changed is I put a place for the students to record the three peaks that the probe sensed when the paper clip was slid past it. I also asked them to discuss what those results meant. This little bit of data collection and asking them to discuss the numbers, I felt, would help them think more about the effect of the paper clip on the magnetic field created by the permanent magnet.

5 Data Collection

This portion, just like the data collection that occurred in B Term, had two parts. The first consisted of the survey completed by willing students, and the second consisted of the students' grades. I wanted to compare how well students did on this lab to both B Term and to other students taking it this term. That would provide two benefits. Firstly, I would be able to have a more accurate gauge of how the lab went; I would be taking people from the same course and splitting them up, so they would absolutely be learning the same material at exactly the same time. Secondly, because I do not have an extensive collection of surveys from B Term, I would be able to issue a survey this term and receive information back from both version of the lab.

So I needed to choose a way to split up the students. The lab was being offered on a Tuesday and on a Wednesday to PH1120 students. Both had approximately the same amount of students. I figured it would be best to post the revised instructions and data sheet Tuesday evening after everyone had finished the lab.

5.1 Survey

The survey was very similar to B Term's survey. I want to know certain things such as how easy the lab was and how clear the instructions were. However, having learned from my mistakes in B Term, I provided a survey online that the students could take. I created the survey using Google Drive's form format. A screen capture of the survey can be found in Appendix H. In order to determine who came from which lab period, I simply asked which day they had their lab period. When I went to analyze the results, I could simply separate the students that answered, "Tuesday" from those that answered, "Wednesday."

5.2 Grades

The grades were collected in a similar manner as B Term. Fred Hutson was able to provide the lab grades from all the labs up through Lab 6. I planned to separate the grades, like the surveys, by the sections that took the lab on Tuesday from those that took it on Wednesday.

Unlike B Term, all I wanted was the lab grades. I was not concerned as much with the exam grades anymore. That was used simply to determine if there were certain labs that demonstrated more prudent to the students' understanding of the material covered. This time, because I was simply examining how well the students did and I was not looking for what effect the lab grade could have on other grades, this information was not necessary.

6 Results

Just like B Term data, I used Microsoft Excel to perform my numerical analysis on my collected data. For the survey, I found it easiest to visually represent the information as histograms. For the grades, I wanted to examine not only how well the students performed, but also how well they did in comparison to previous grades. That's where the previous lab grades came in. I wanted to compare how well they did in this lab to what the average grade in previous labs was. I also wanted to see if there was any sort of pattern with the lab grades. For example, maybe the average lab grades got better at a steady rate. Or perhaps because it is the last term of the year, students are getting more nonchalant about their work, and the grades are steadily decreasing. I wanted to examine these aspects in order to successfully rate how well students did on this lab.

Because the subset of students who took the lab on Tuesday did the original lab, they were the students to whom I was comparing the changes I was testing out. I will hereafter refer to that group of students as the "control group," while I will refer to the students who took the lab on Wednesday and performed my revised lab as the "test group."

6.1 Survey Analysis

Just like B Term, I used histograms to visually represent the data I collected from the surveys. I also overlaid a normal distribution line over the bar graphs. The histograms give me a very good understanding of how many people answered what to which questions; however, I found that the normal distribution did not entirely or accurately represent how people voted. I think there were too few people who answered the survey (a total of 27 students), for the normal distribution to be worth anything. For that reason, I did not record the mean or the standard deviation of the votes. For the complete visual representations of the survey questions from both the control and test groups, refer to Appendix I.

6.1.1 Lab Difficulty

Compared to the control group, the test group subjectively determined that my revised lab was somewhat easier than the original lab. Seven students in the test group rated the difficulty as a three or less, while only five students in the control group voted it as a three and none voted it as a one or two. While that seems like good news, the average grade for the test group was only half a point lower than the control group. Because this survey was subjective and less than 15 students answered either survey, it's safe to say that half a point is well within range of the margin of error. I do not think the data here supports the notion that the changes I made caused the lab to become easier.

6.1.2 Understandability of Lab Instructions

How clear the instructions were was one of the main things I was looking to improve upon when I decided on this lab. However, as shown in Figures 7 and 8, my changes seem to have caused the lab instructions to be even more confusing. While the difference of the two averages is less than half a point, the vast majority of students in the test group voted either a one or two, indicating that the lab instructions were very confusing. The control group, on the other hand, proved to have a much more evenly-spread spectrum of votes.

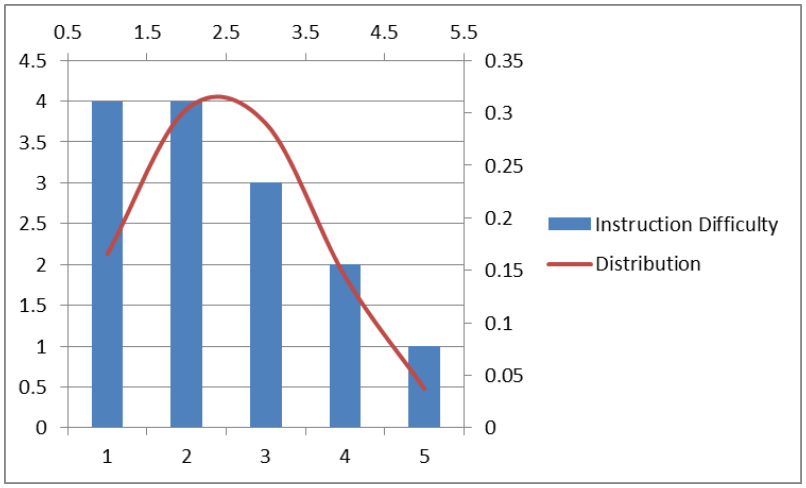


Figure 7: Clarity of instructions from control group

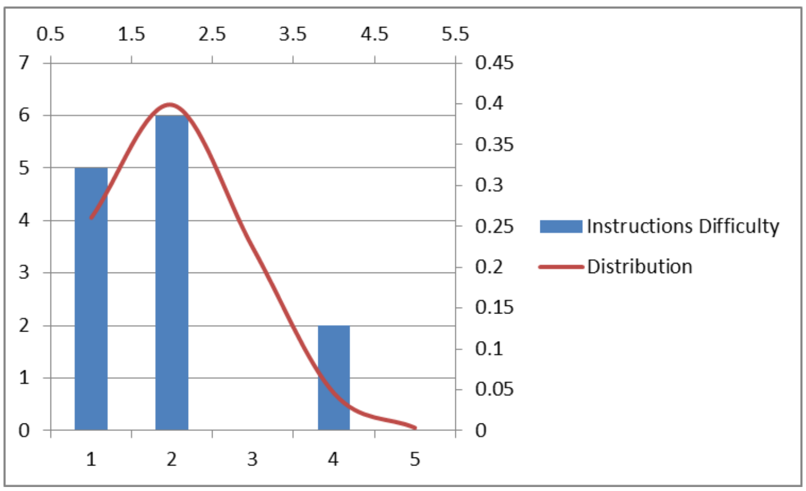


Figure 8: Clarity of instructions from test group

I found this particularly intriguing. Why would my directions, which were specifically designed to be less confusing, come out as more confusing? I looked back at my revised instructions in Appendix E, and found a likely explanation. I had originally written the lab instructions to be numbered, step-by-step directions. However, like I said in a previous section, Fred Hutson did not like that, so I promptly removed the numbered system. I, apparently, had not been comprehensive enough in my proofreading, because there are a few references to step numbers (e.g., "Repeat steps 6 and 7") in my instructions. This was a costly mistake, and it tainted my results. I wanted to see if I could improve this lab by making the lab instructions more explicit without taking away from the thought required. However, because of my mistake, I was not able to determine if I in fact succeeded at that.

6.1.3 Concepts Learned in Class, Expected Grade, and Time Management

For the test group, all three of the last categories were comparable to the answers received from the control group. While students in the test group subjectively felt that this lab helped them with concepts learned in class less than in the control group, the difference between the two groups was small. The difference is too small to say with certainty that it is not due to the small size of the groups. Also, the spread of votes between the control group and the test group for this question is very similar.

Almost half the students in the test group (six out of 13) felt that they were going to receive an “A” on this lab. On the other hand, just as many students in the test group thought they were going to receive an “A” as students that thought they were going to receive a “C.” Although the results are fairly comparable, this still demonstrates a slightly higher confidence with respect to this lab in students in the test group than the students in the control group. This may be indicative of the fact that this lab helped the students understand the concepts better than the control group.

In both cases, only about 15% of the students were able to complete the lab in the allotted time. Out of 14 students in the control group, only two finished; while in the test group, out of 13 students, again, only two finished in time. This was a problem with this lab that I could have recognized and addressed had I used an electronic survey in B Term rather than hard copies.

6.2 Grades

A big problem came with the grades. Talking to Fred Hutson, I found that the labs reports were due at midnight the same day as the lab was performed in class. I thought this meant that the grades for the labs would have been by that time next week. After all, they students had to do another lab the same time the next week. I had prepared to analyze the Lab 6 grades in comparison with the previous lab grades. I wanted to look for any trends in the grades, and see how that compared to grades of Lab 6. Unfortunately, I was not able to do this because the grades for Lab 6 were not ready by the time I had report my findings. Any conclusions to this IQP I had to draw off of the survey results, and the information that could be inferred from those results.

7. Conclusions

This IQP was not as successful as I had hoped. I was not able to evaluate grades in order to determine how well this helped students understand the material. The survey results were ambiguous as to the effect of this lab. I think I did a fairly good job on the IQP, I just was not able to evaluate the success of the lab due to the time constraints I was under. I was not aware that it would take the time that it did to grade the reports.

The survey provided some insight into how the students' perceived the lab. Unfortunately, even with an online survey, very few of the students took part. Out of over 200 students who took the lab, only 27 decided to answer the survey. This causes fairly large inaccuracies when trying to analyze those data. From the little information we got, though, we can draw a few conclusions.

Firstly, in an effort to make the lab instructions more clear, I ended up making them even more convoluted. Students tended to agree with my subjective opinion that the lab instructions were not as understandable as they possibly could be. We can see from the control group that very few of the students voted a "3" or higher for the level of clarity of the lab instructions. In trying to make the lab instructions clearer, I made a fairly large blunder that tainted the results of this experiment. By leaving in references to step numbers after I had removed the numbering from the lab instructions, I caused the students even more confusion. I may have been able to clear up the portion of the lab I had difficulty understanding, but because of my mistake, it is impossible to know that.

We also know that while generally speaking, students felt that my revised lab was nominally more difficult, we can also see that they felt more confident about their grades after having completed the lab. A big similarity between the control group and the test group was the percentage of students that finished the lab in the allotted time. This was an issue that was well within the scope of this IQP to address. However, because of the lack of replies from the hard copy surveys in B Term, we were not able to recognize this problem.

One of the things that we will not be able to know about this lab revision is how it affected the students' understanding of the material. The B Term grade analysis was able to see if any lab grades had higher correlation to the upcoming exams. This was a decent gauge into how much a lab affected a students' understanding of the material. Because of when this particular lab took place and the time constraints associated with this IQP, it was impossible to be able to tell if exam grades improved due to the revised lab. A lab that occurred earlier in the term would have been a more appropriate choice.

8. Recommendations

The first major improvement of this IQP for future work that could be made would to improve the surveys. In both B Term and D Term, very little information could be extrapolated from the survey results. In both terms, this was for the same reason: lack of responses. Offering an incentive for the surveys may yield more responses. A previous IQP used this idea and had positive results (Faucher, Spitz, Vilk, & Wunschel, 2010).

In regards to getting more students to answer surveys, a strong recommendation can be made not use hard copies. It was my thought that interacting with students face-to-face would make them more likely to turn in surveys. This thought was wrong. The convenience of online surveys trumps any sort of friendly interaction or even guilt trip. Had the surveys been poster online originally, the mistake of Lab 6 being too long for about 85% of students could have been rectified.

Finally, the last recommendation that could be made for the surveys is to ask more thorough questions. I avoided asking very particular questions, because I found from the first survey that students are usually less likely to provide a text response than simply giving something a numerical rating or selecting from multiple choices. More information could be extrapolated from the surveys if the survey had more in-depth questions without requiring full text responses from the students taking the survey. In this IQP, I only changed the second part of a two-part lab. The survey responses, however, reflected the entire lab. I could have used the questions to ask specifically about the things I changed in the lab. This sort of more specific questions would have led to better data.

As for the actual changes made, the biggest advice I could give is to make more substantial changes. It is tough to see if improvements were made (especially with only 27 students responding to the survey) if the only major change in the lab was adding a place to record data. While I stand by my thought that collecting data in labs helps students understand the material in a hands-on manner, this lab was barely changed at all from the data collection.

The last piece of advice I can give to future IQP teams is to make sure you choose an earlier lab. When I choose this lab, I was focused on the lab; I did not take into account my own time constraints. Choosing an earlier lab would probably have led to better data.

Works Cited

Bergeron, B. (2013, September 13). *Title page for E-project-091313-123410.* Retrieved April 2014, from WPI Electronic Projects Collection: http://www.wpi.edu/Pubs/E-project/Available/E-project-091313-123410/unrestricted/IQP.pdf

Faucher, J., Spitz, D., Vilk, J., & Wunschel, J. (2010). *Physics Lab Toolbox 0907 Collisions Lab IQP.* Worcester Polythechnic Institute, Department of Physics.

Vernier Software & Technology. (n.d.). *The Magnetic Field of a Permanent Magnet.* Retrieved April 2014, from Vernier website: http://www2.vernier.com/sample_labs/PWV-31-COMP-magnetic_field_permanent_magnet.pdf

Appendix A: B Term Survey

Lab Name : ___________________________________

Course & Section : ___________________________________

Rate the Difficulty of this Lab: (1-easiest to 5-most difficult)

___1 ___2 ___3 ___4 ___5

Rate the Difficulty of the Lab Write-Up: (1-easiest to 5-most difficult)

___1 ___2 ___3 ___4 ___5

How well did this Lab help you understand the concepts discussed in class? (1-not at all to 5-helped completely)

___1 ___2 ___3 ___4 ___5

How clear and understandable were the Lab Instructions? (1-not at all to 5-very clear)

___1 ___2 ___3 ___4 ___5

Were you able to complete the lab in the allotted time?

___Yes ___No

Did you have any difficulties or encounter any inconveniences while using the Lab Equipment?

___Yes ___No If so, explain:

____

____

____

____

____

Did you have any difficulty or encounter any inconveniences while using any software needed for the lab?

___Yes ___No ____N/A (No software used) If so, explain:

____

____

____

____

____

What grade do you expect to receive for this Lab?

___A ___B ___C ___<C

Any other feedback or suggestions?

____

____

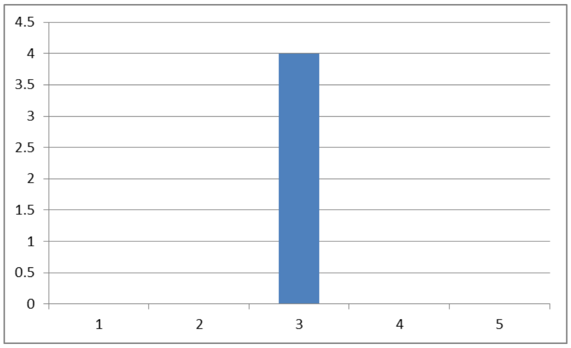
____

____

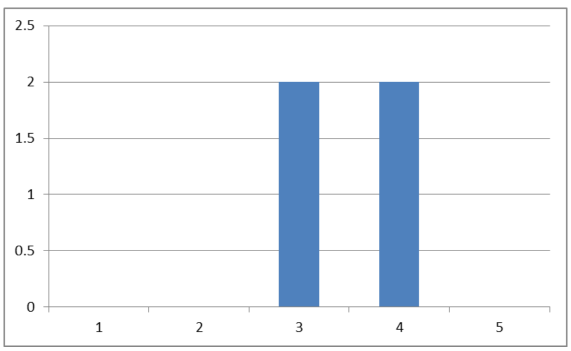
Appendix B: Results of B Term Survey

PH 1120: Electric Potential & RC Discharge

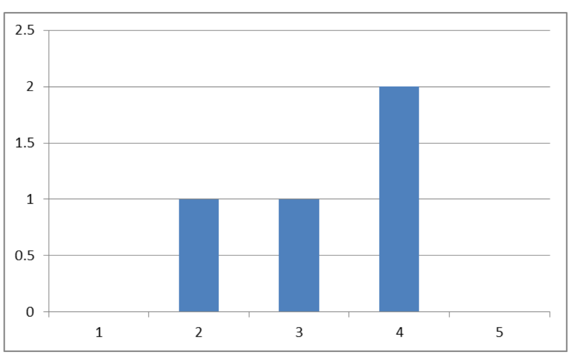
Rate the Difficulty of this Lab: (1-easiest to 5-most difficult):



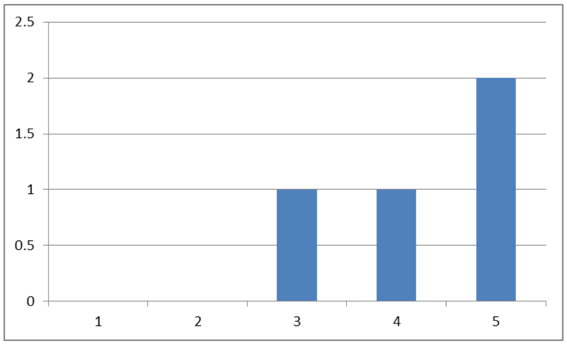
Rate the Difficulty of the Lab Write-Up: (1-easiest to 5-most difficult):



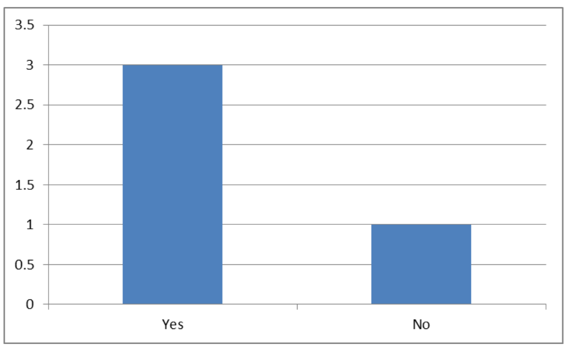
How well did this Lab help you understand the concepts discussed in class? (1-not at all to 5-helped completely):



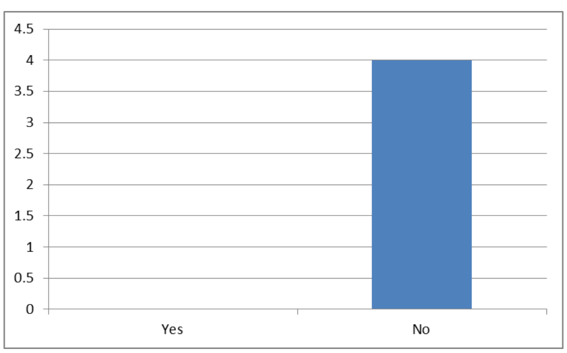
How clear and understandable were the Lab Instructions? (1-not at all to 5-very clear):



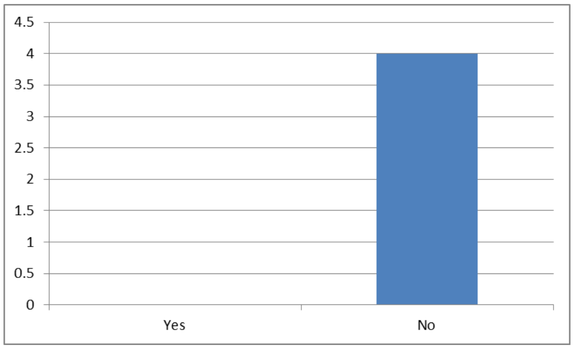
Were you able to complete the lab in the allotted time?:



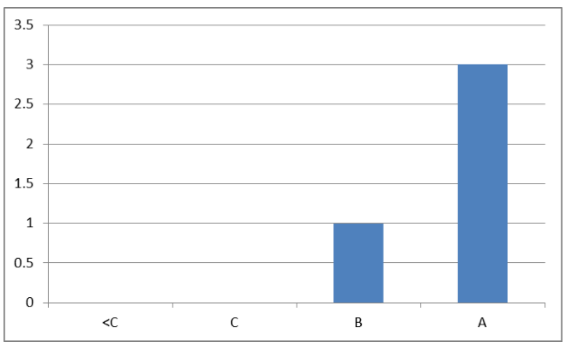
Did you have any difficulties or encounter any inconveniences while using the Lab Equipment?:



Did you have any difficulty or encounter any inconveniences while using any software needed for the lab?:



What grade do you expect to receive for this Lab?:



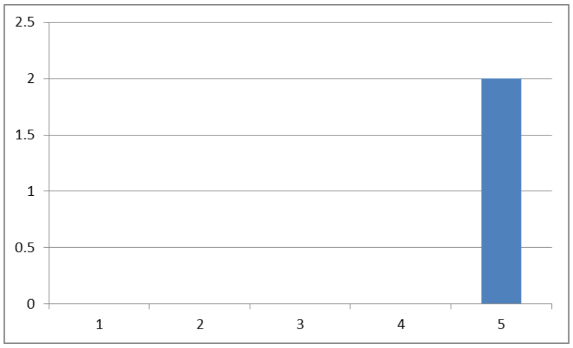
Any other feedback or suggestions?:

One student wrote:

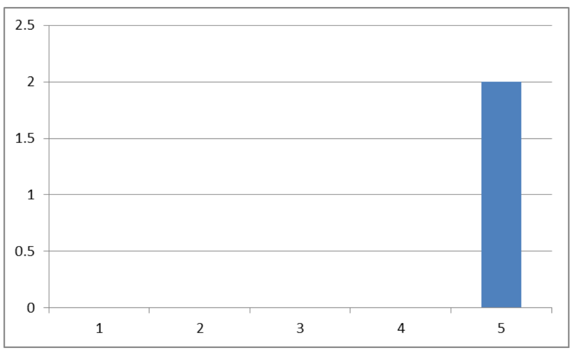
> *"This lab was very relevant to the topic, however, usually the labs are not very helpful."*

PH 1140: LCR Circuit

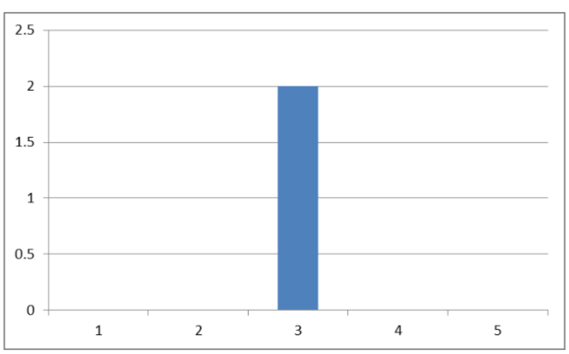
Rate the Difficulty of this Lab: (1-easiest to 5-most difficult):



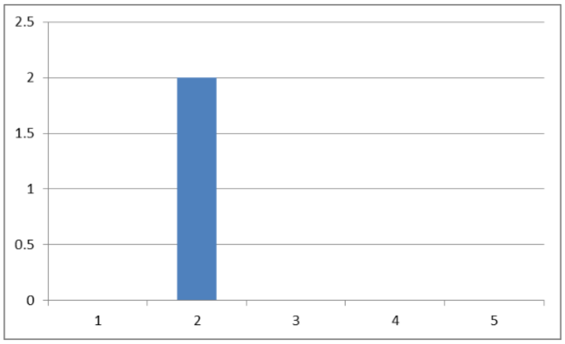
Rate the Difficulty of the Lab Write-Up: (1-easiest to 5-most difficult):



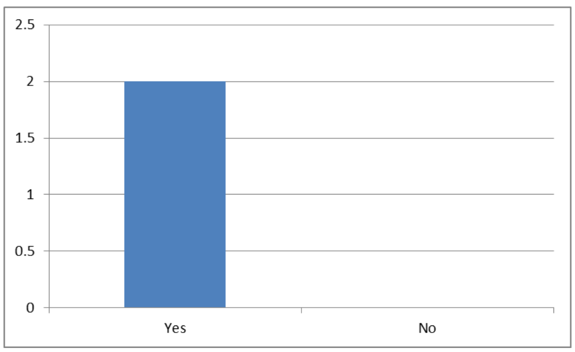
How well did this Lab help you understand the concepts discussed in class? (1-not at all to 5-helped completely):



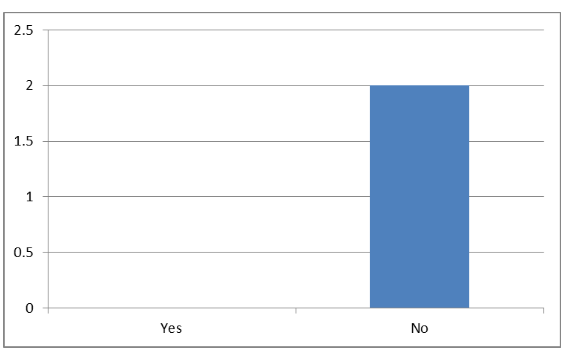
How clear and understandable were the Lab Instructions? (1-not at all to 5-very clear):



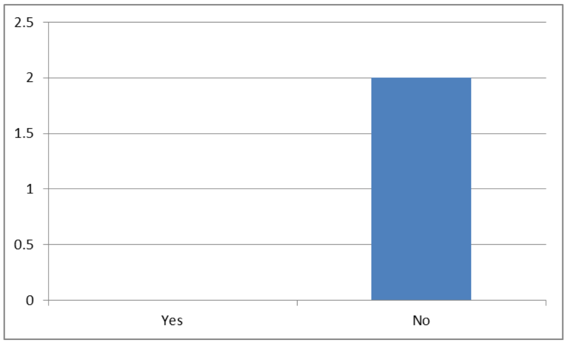
Were you able to complete the lab in the allotted time?:



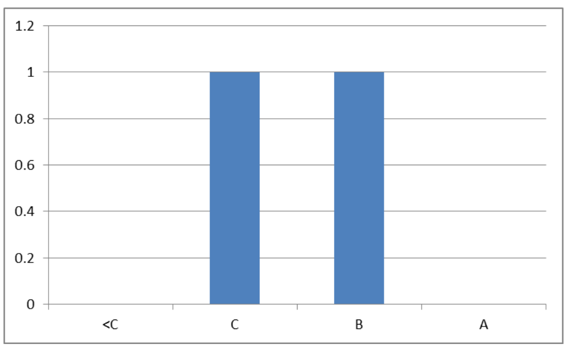
Did you have any difficulties or encounter any inconveniences while using the Lab Equipment?:



Did you have any difficulty or encounter any inconveniences while using any software needed for the lab?:



What grade do you expect to receive for this Lab?:

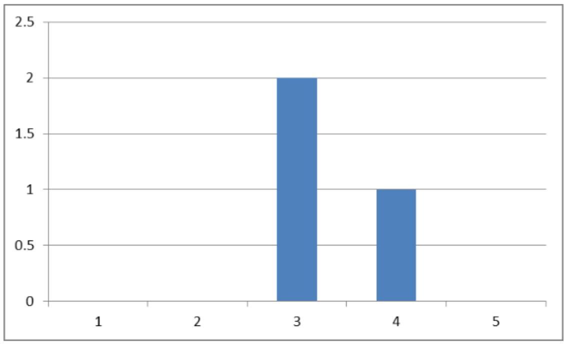


Any other feedback or suggestions?:

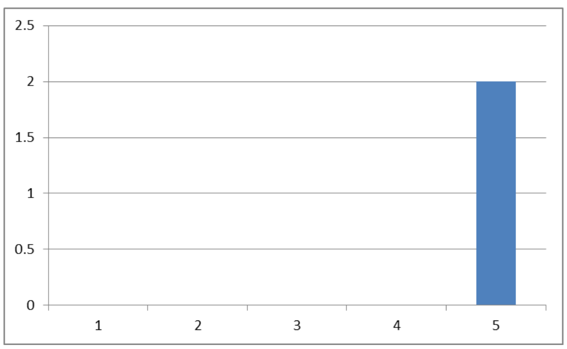
None.

PH 1140: LC Circuit

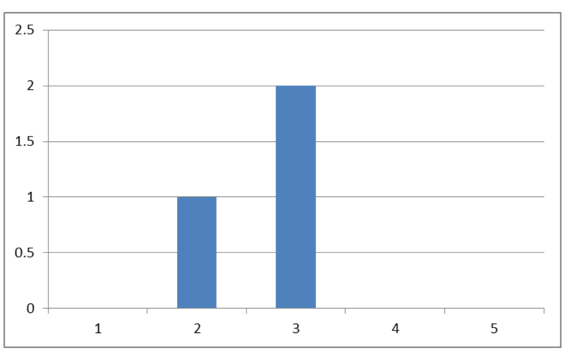
Rate the Difficulty of this Lab: (1-easiest to 5-most difficult):



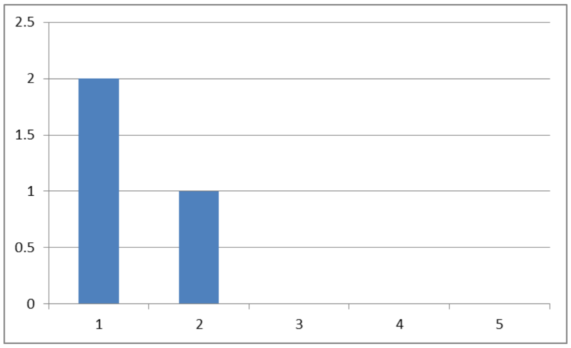
Rate the Difficulty of the Lab Write-Up: (1-easiest to 5-most difficult):



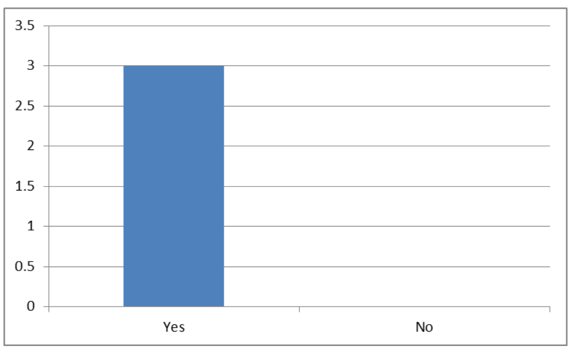
How well did this Lab help you understand the concepts discussed in class? (1-not at all to 5-helped completely):



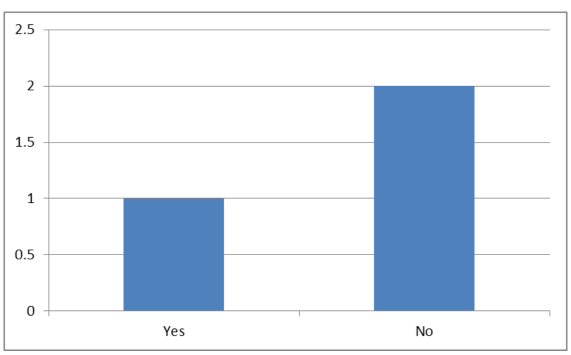
How clear and understandable were the Lab Instructions? (1-not at all to 5-very clear):



Were you able to complete the lab in the allotted time?:



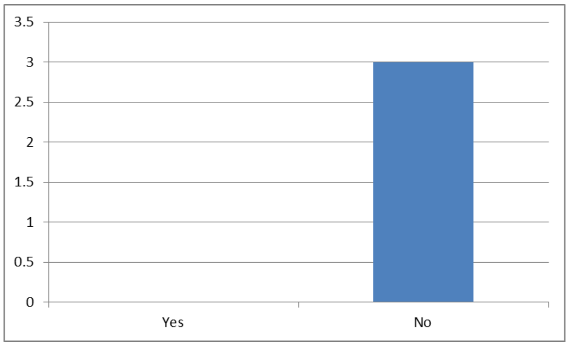
Did you have any difficulties or encounter any inconveniences while using the Lab Equipment?:



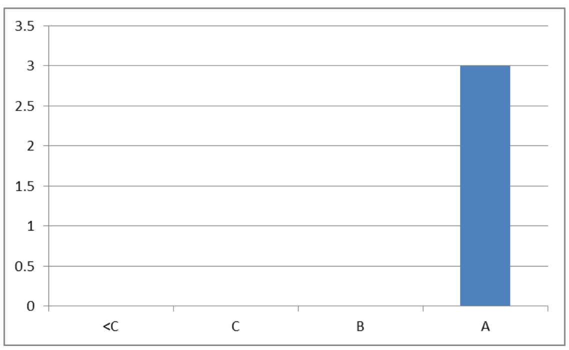
The one student that answered “Yes” to that question also wrote in:

“The Instructions are lieing![sic]”

Did you have any difficulty or encounter any inconveniences while using any software needed for the lab?:



What grade do you expect to receive for this Lab?:



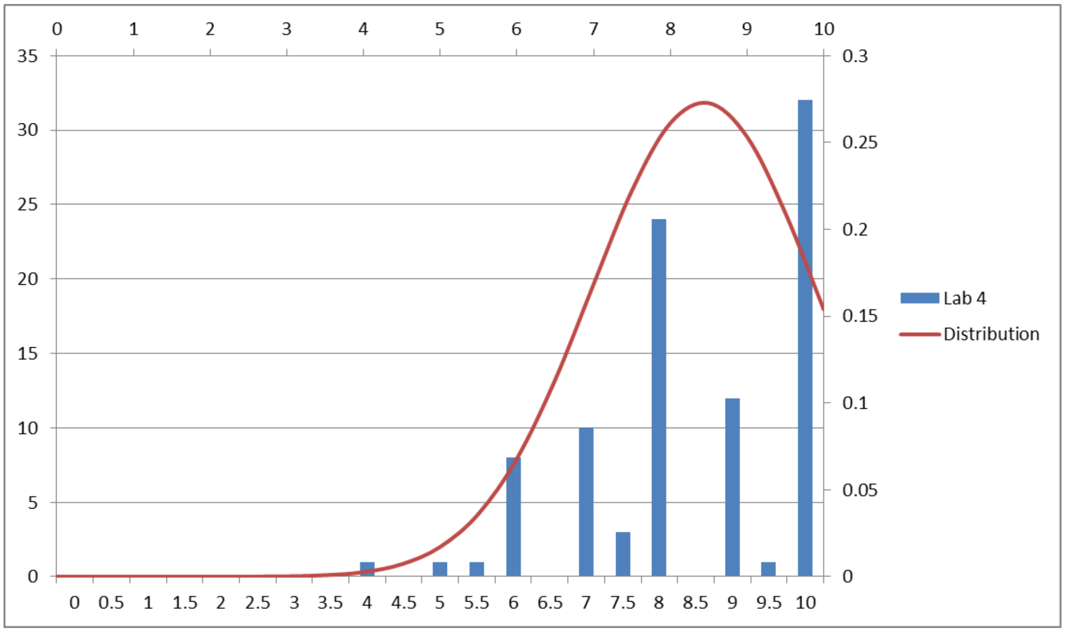
Any other feedback or suggestions?:

None.

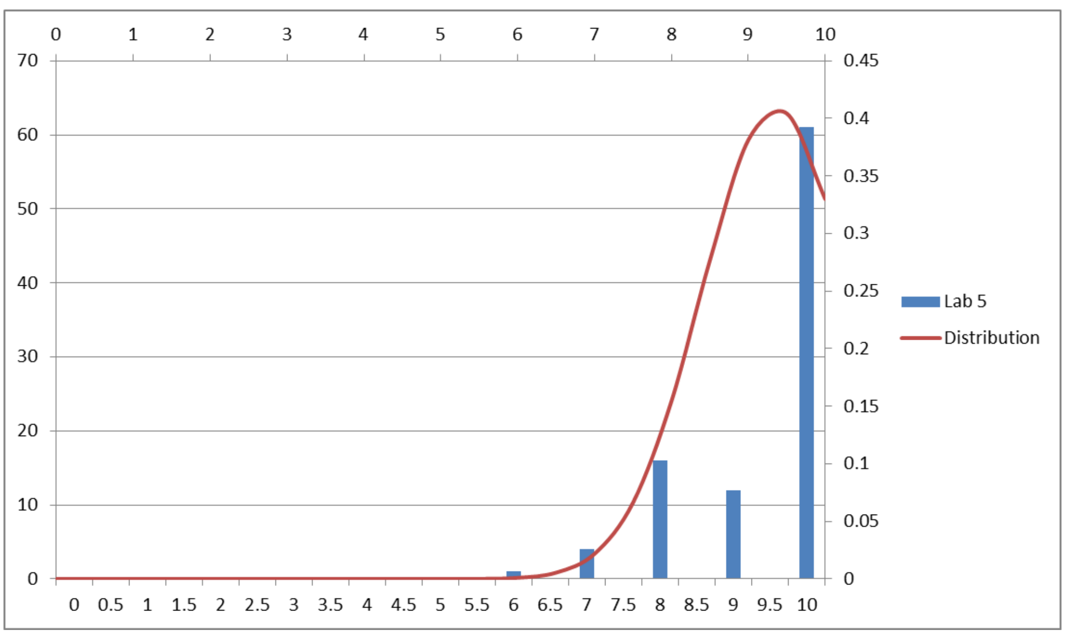
Appendix C: B Term Grade Analyses

PH 1120: Professor Frank Dick

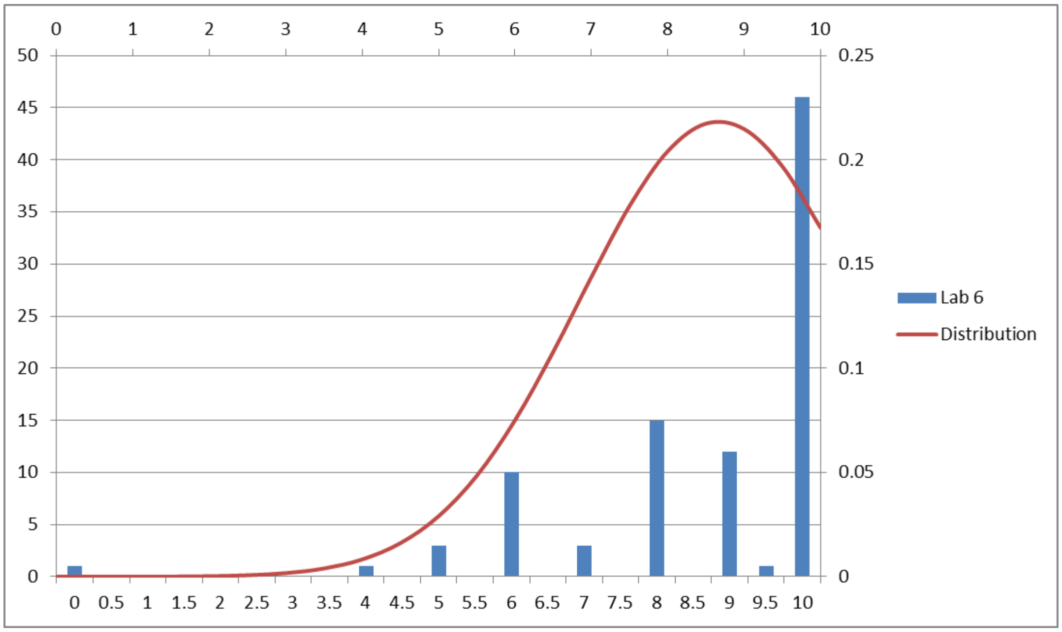
Lab Grades with Normal Distribution:



Mean: 8.435483871 Standard Deviation: 1.461376959

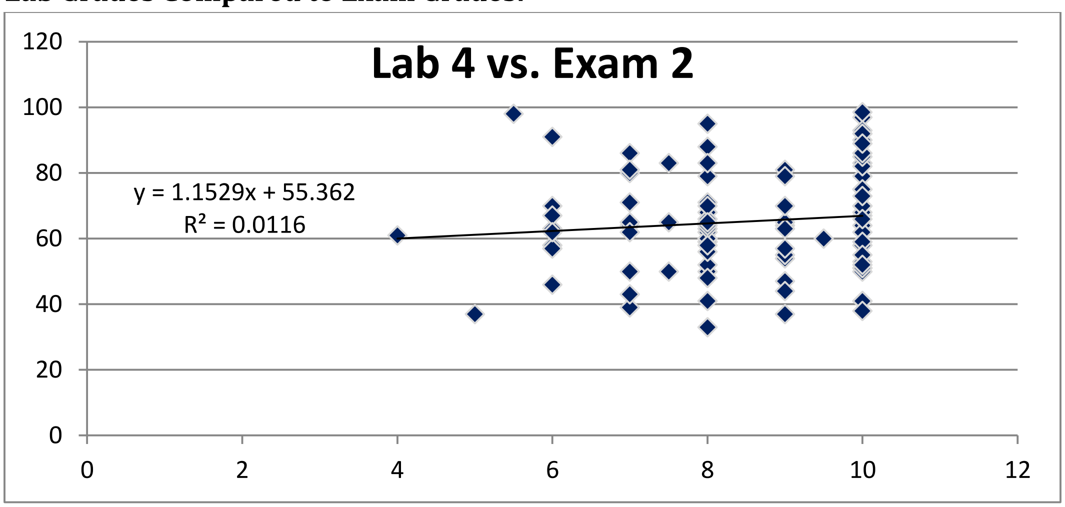


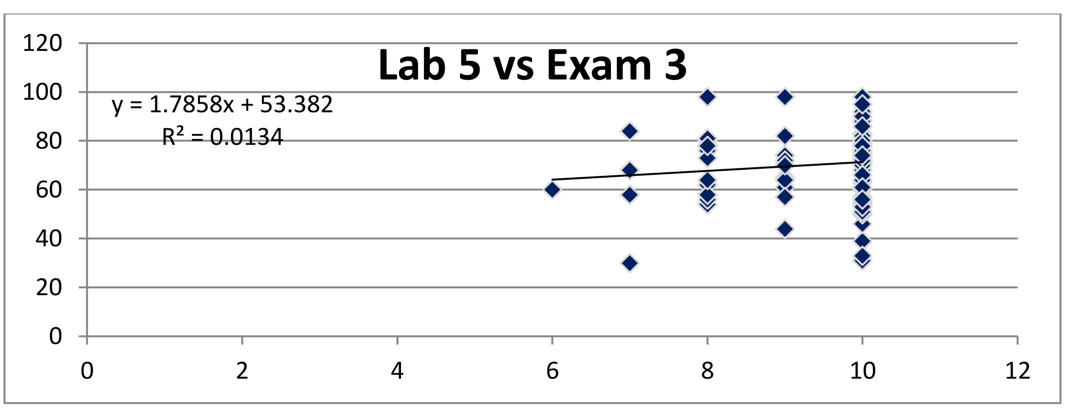
Mean: 9.361702128 Standard Deviation: 0.976871513

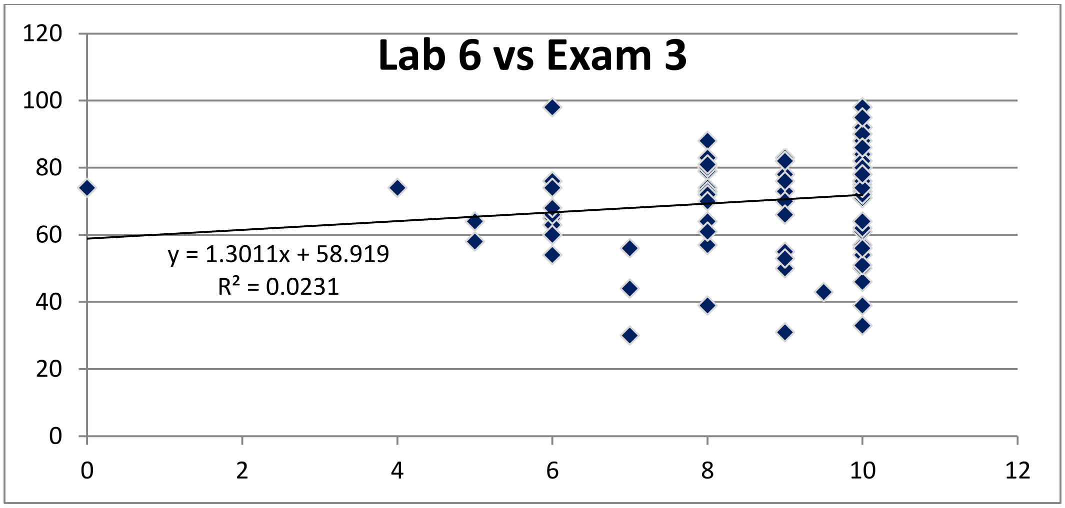


Mean: 8.668478261 Standard Deviation: 1.827146108

Lab Grades Compared to Exam Grades:

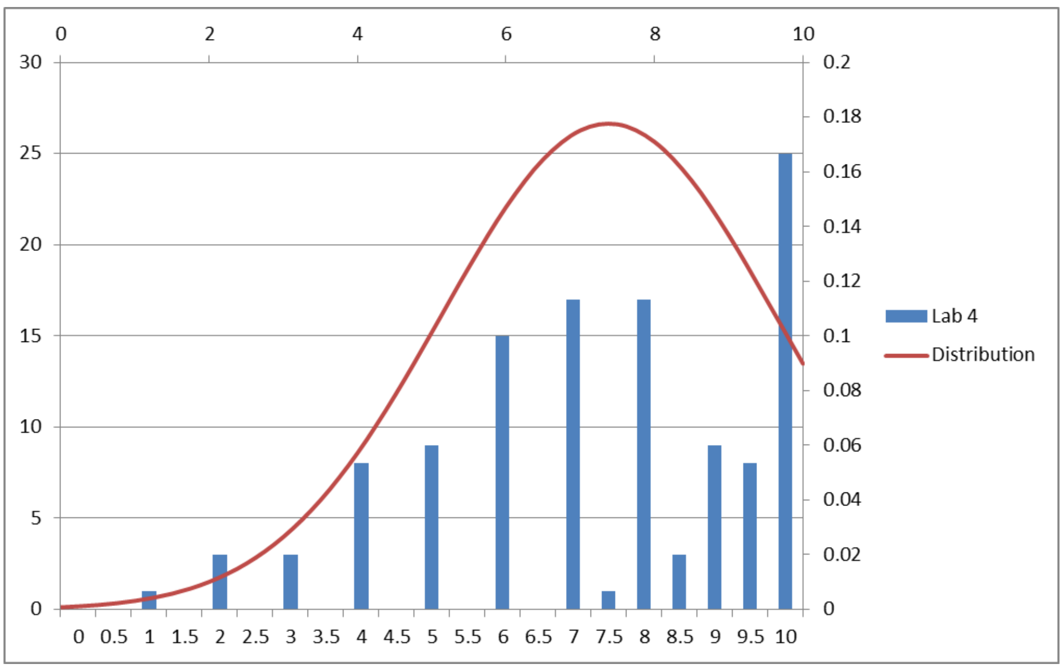




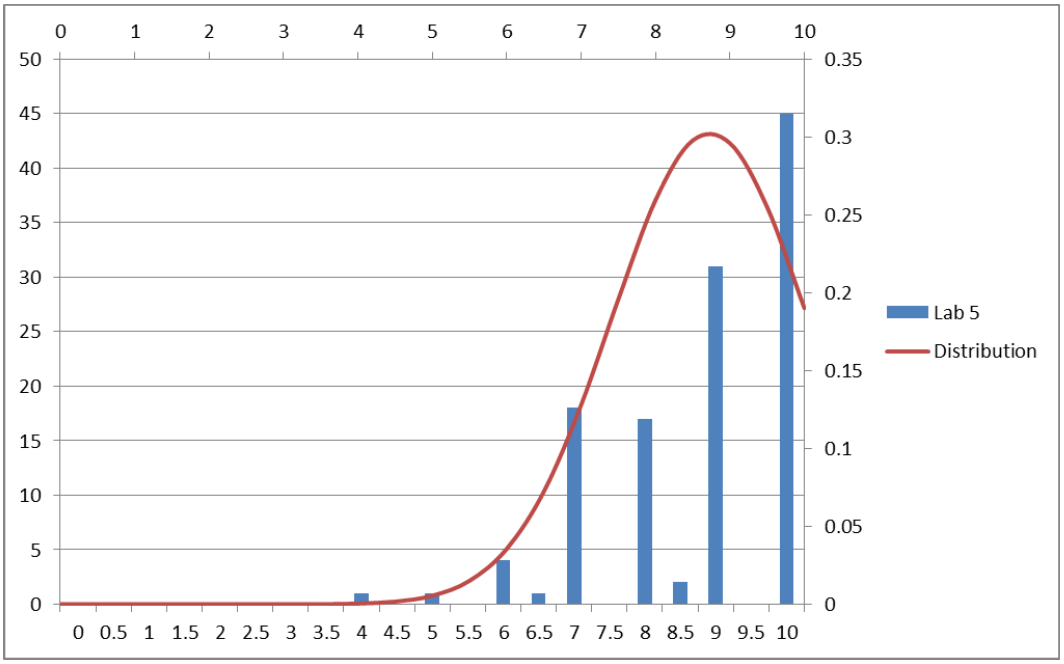


PH 1120: Professor Hektor Kashuri

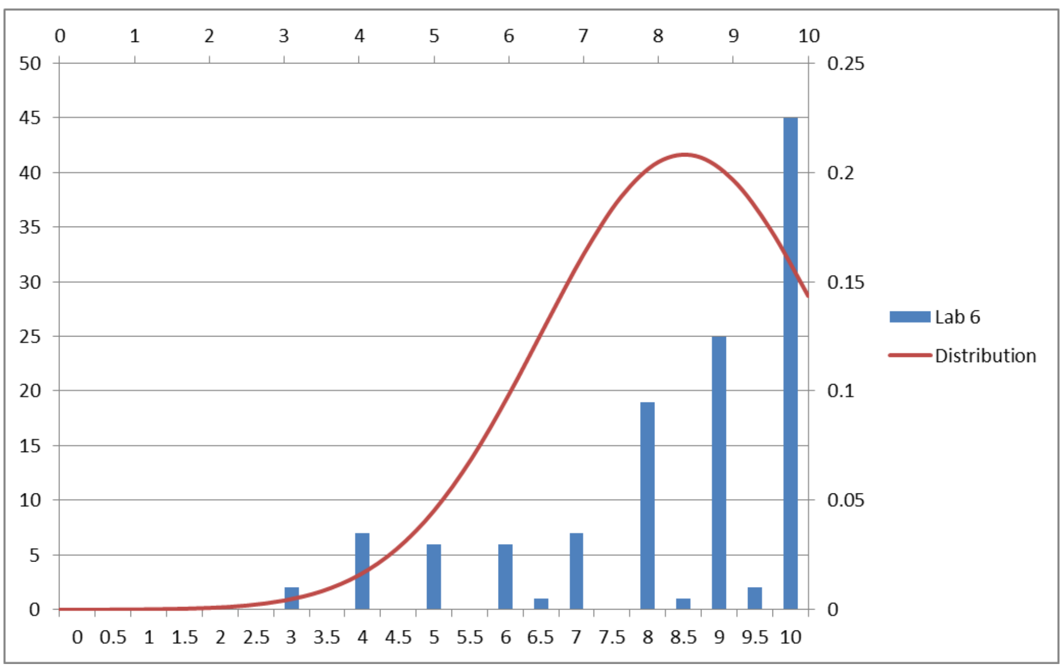
Lab Grades with Normal Distribution:



Mean: 7.378151261 Standard Deviation: 2.245412117

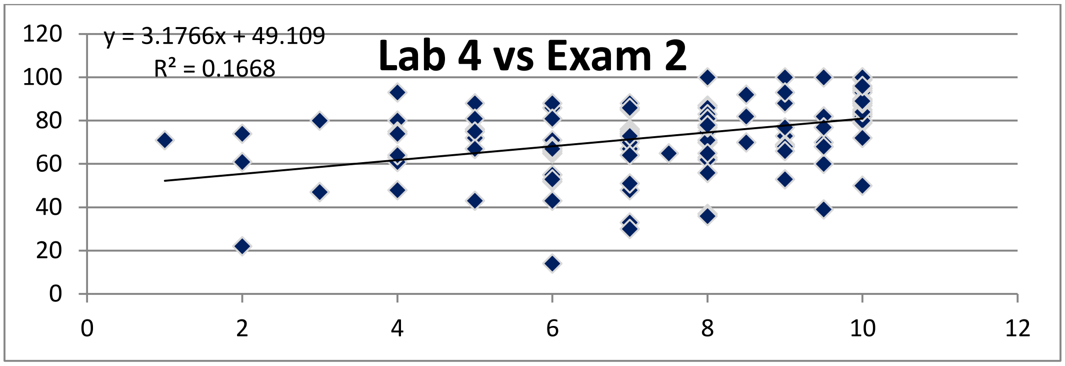


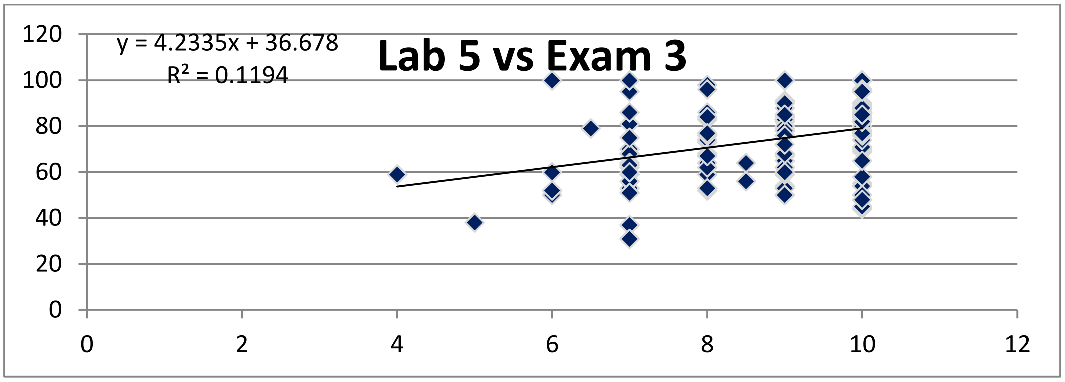
Mean: 8.729166667 Standard Deviation: 1.319557744

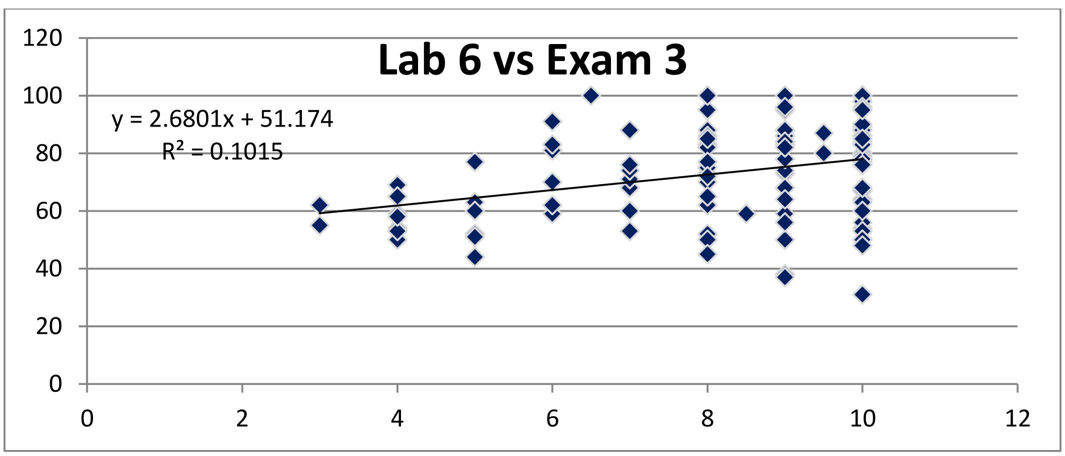


Mean: 8.347107438 Standard Deviation: 1.916482417

Lab Grades Compared to Exam Grades:

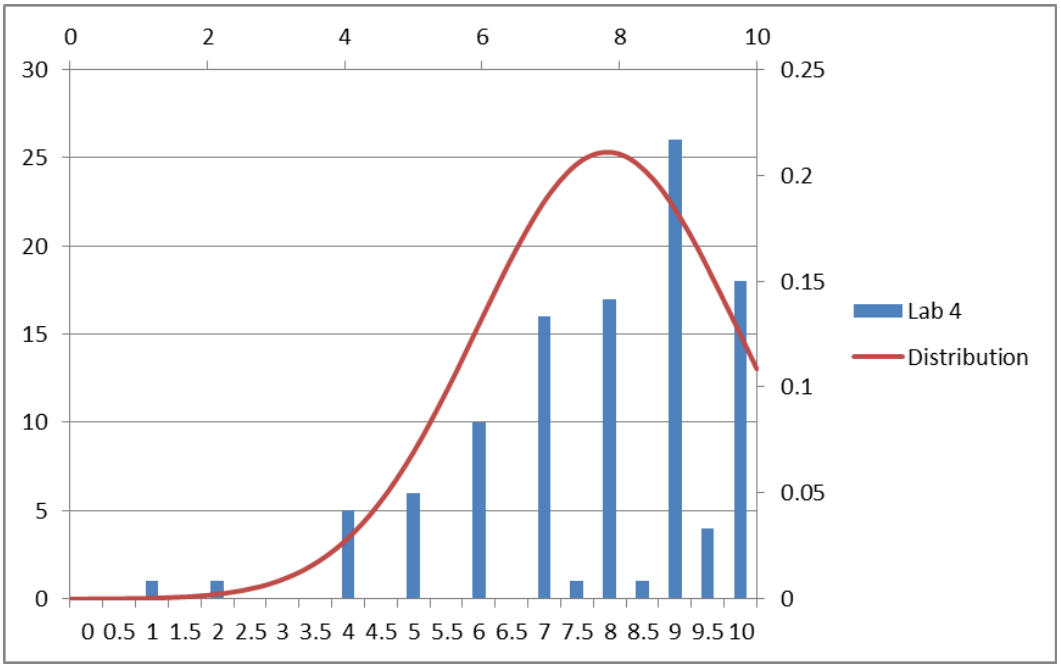




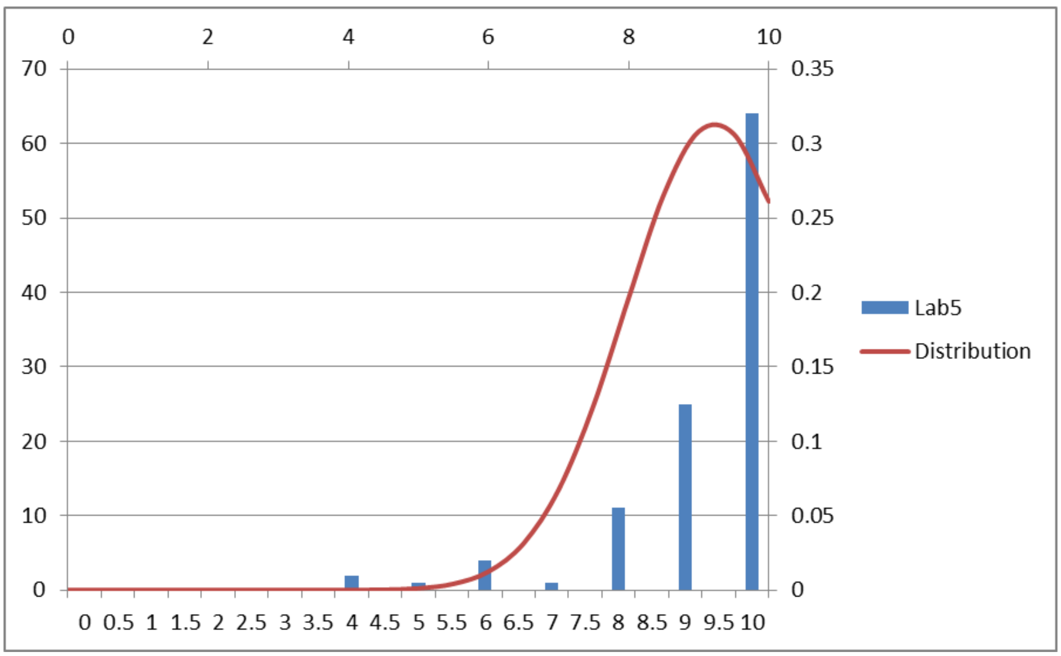


PH 1120: Professor PK Aravind

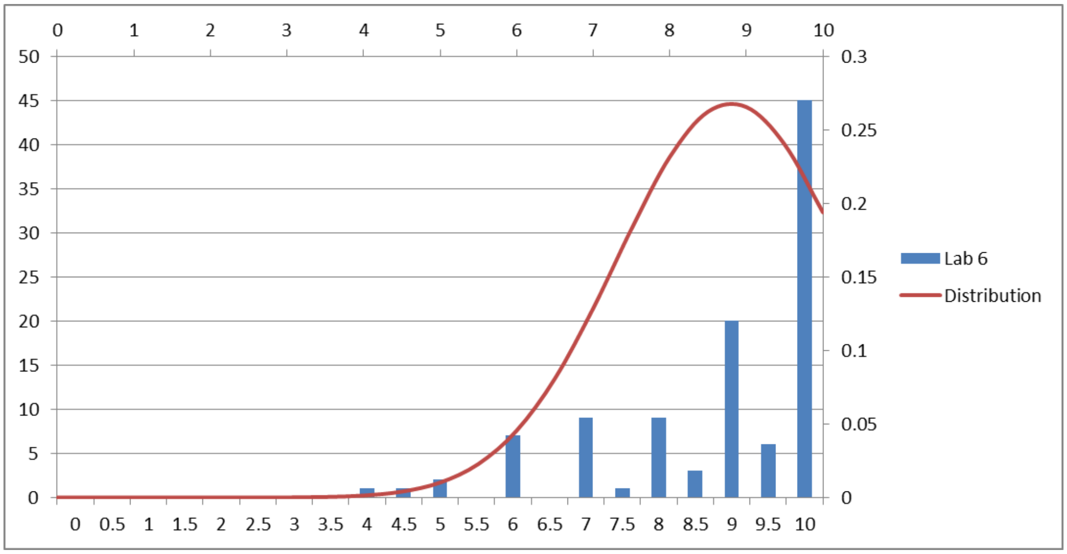
Lab Grades with Normal Distribution:



Mean: 7.820754717 Standard Deviation: 1.891127096

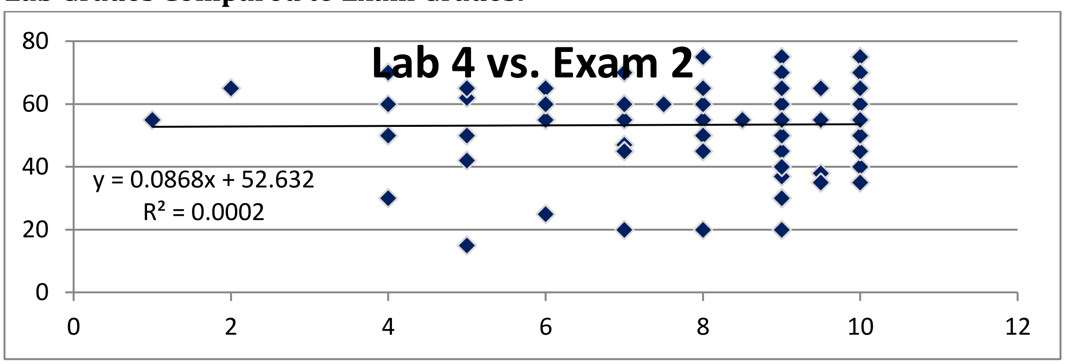


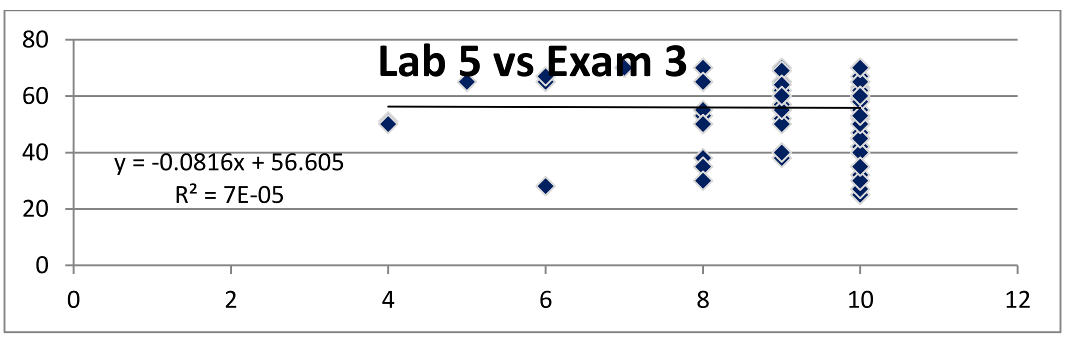
Mean: 9.231481481 Standard Deviation: 1.273711996

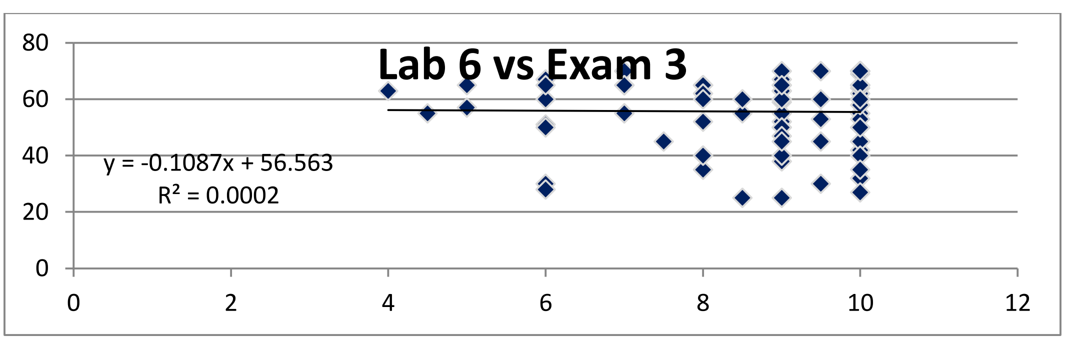


Mean: 8.802884615 Standard Deviation: 1.489415007

Lab Grades Compared to Exam Grades:

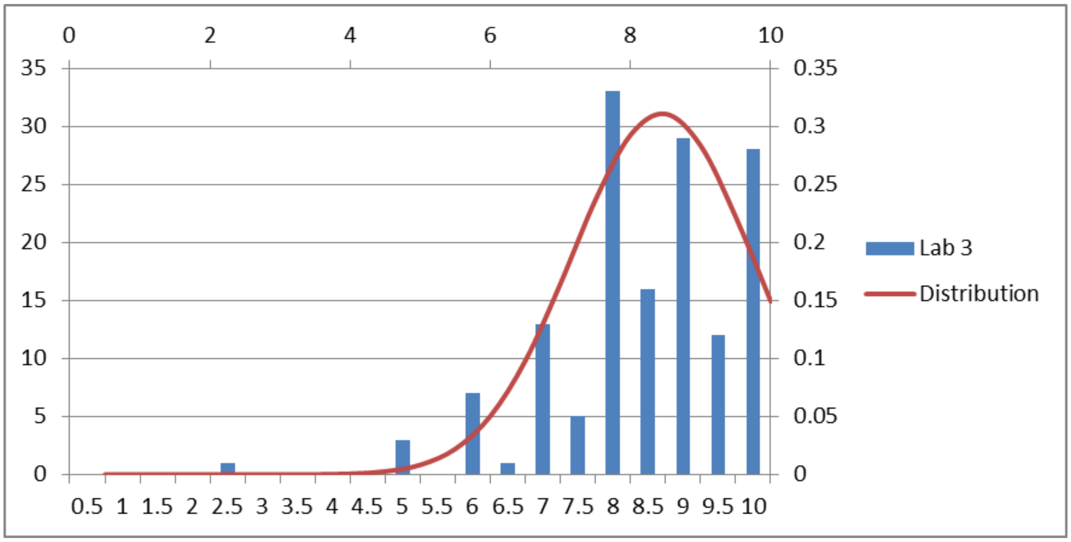




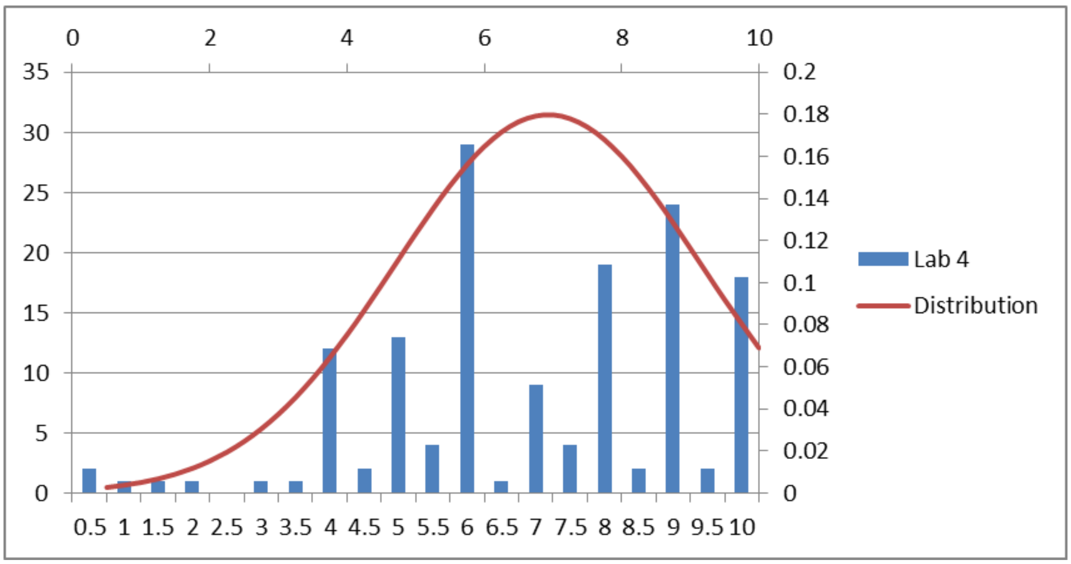


PH 1121: Professor Izabela Stroe

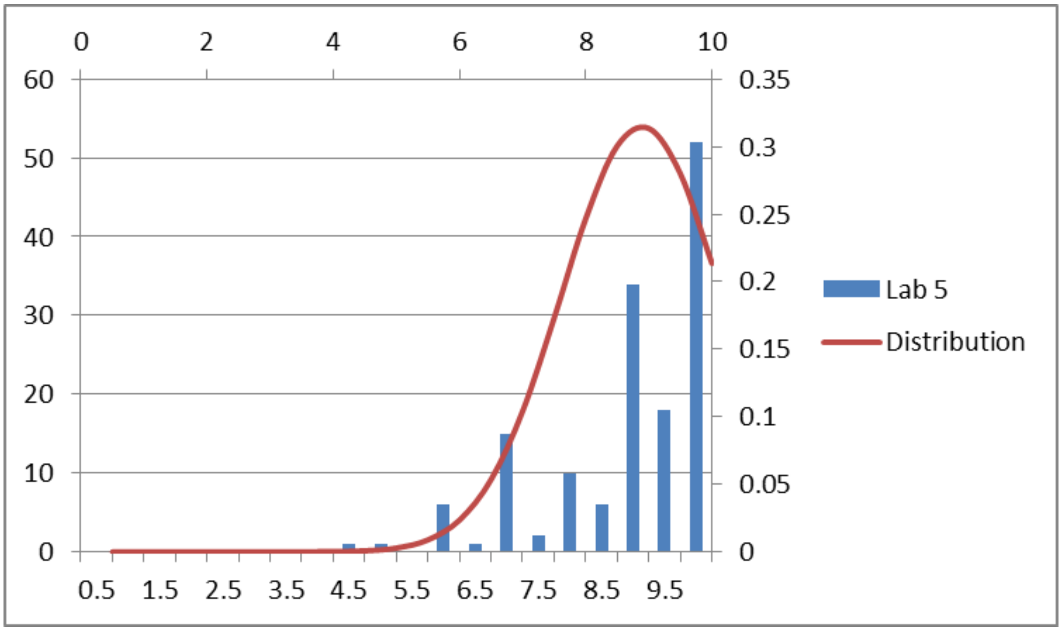
Lab Grades with Normal Distribution:



Mean: 8.446308725 Standard Deviation: 1.282485187

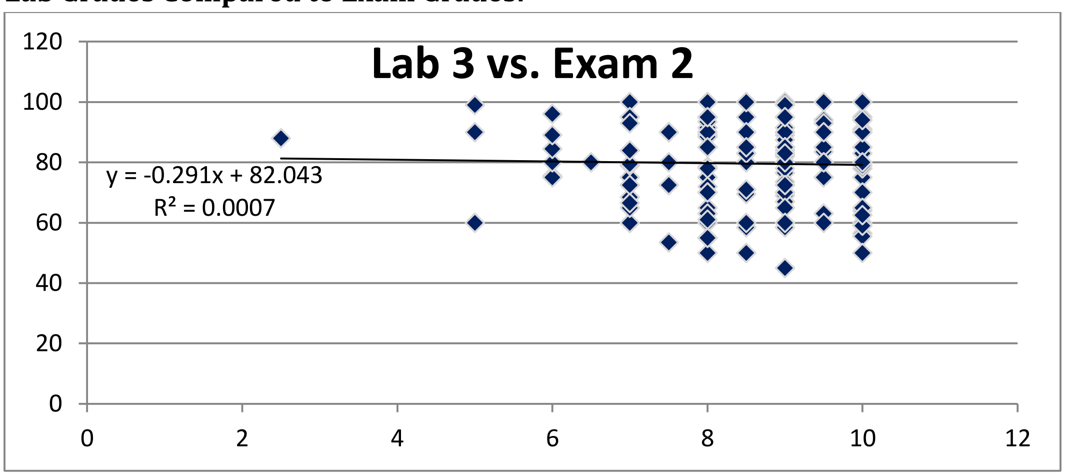


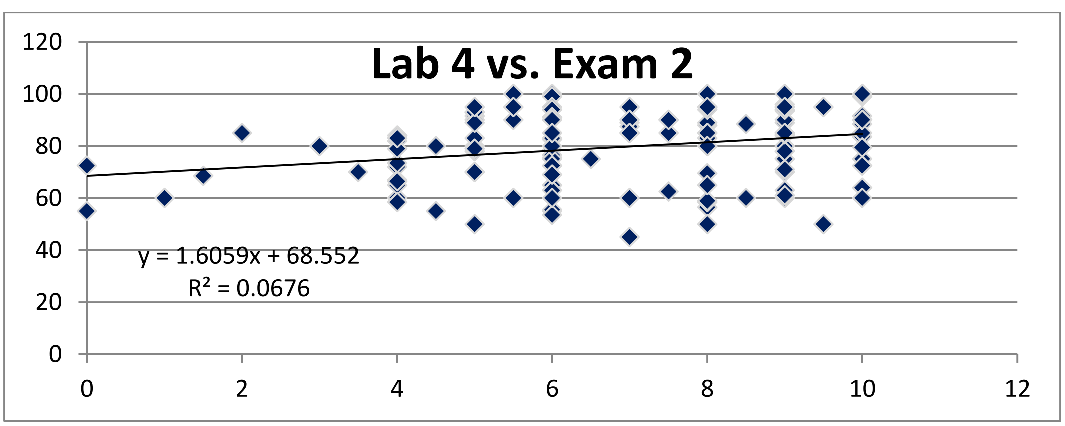
Mean: 6.928571429 Standard Deviation: 2.218505963

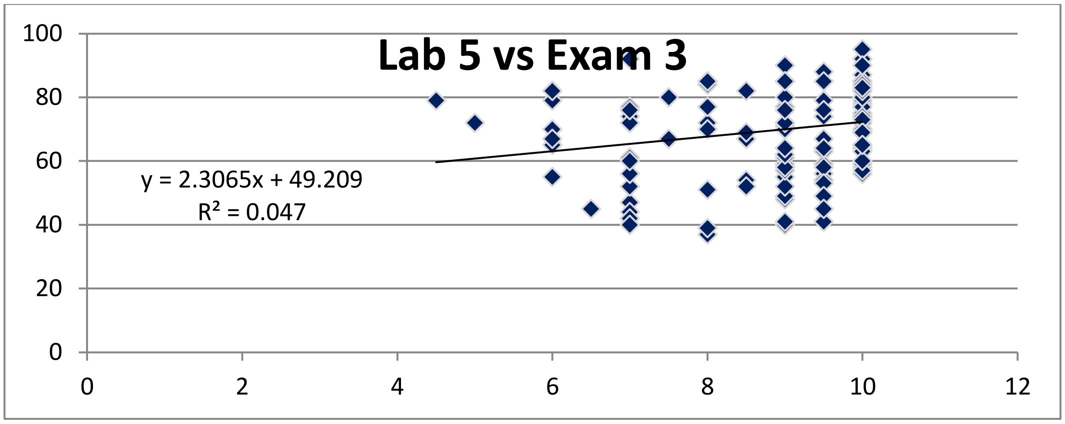


Mean: 8.884353741   Standard Deviation: 1.267151752

Lab Grades Compared to Exam Grades:

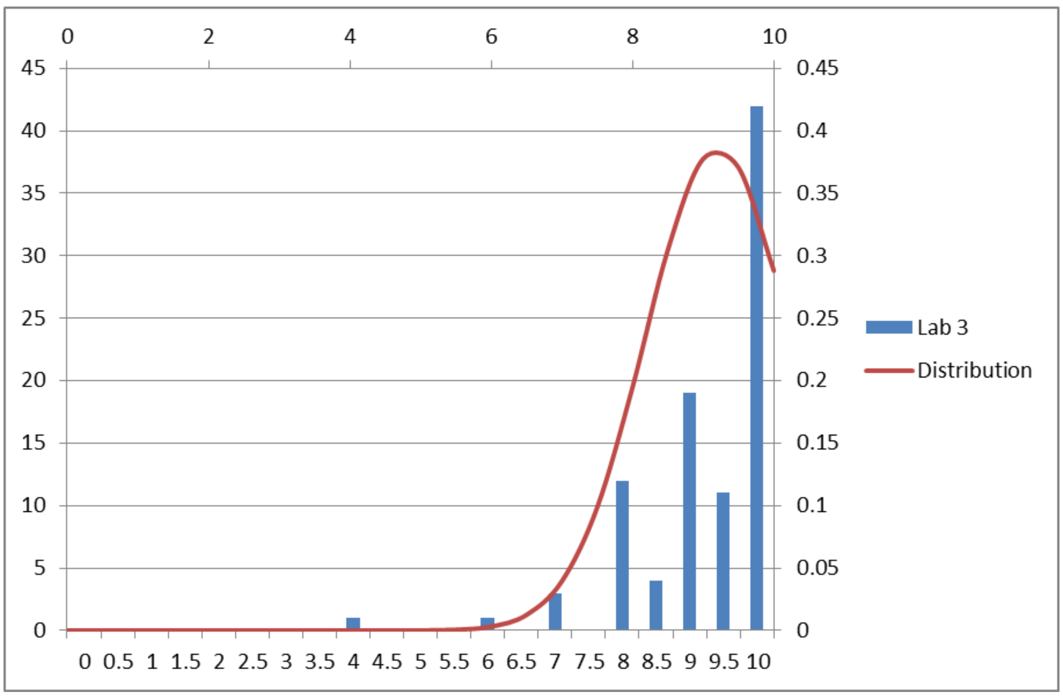




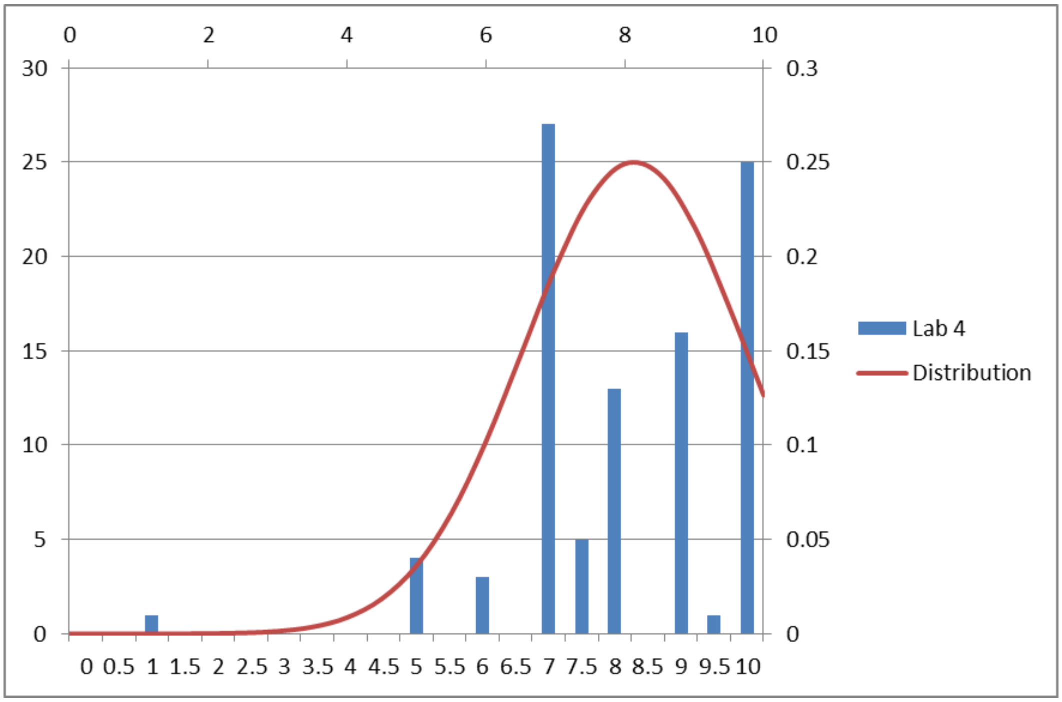


PH 1121: Professor Qi Wen

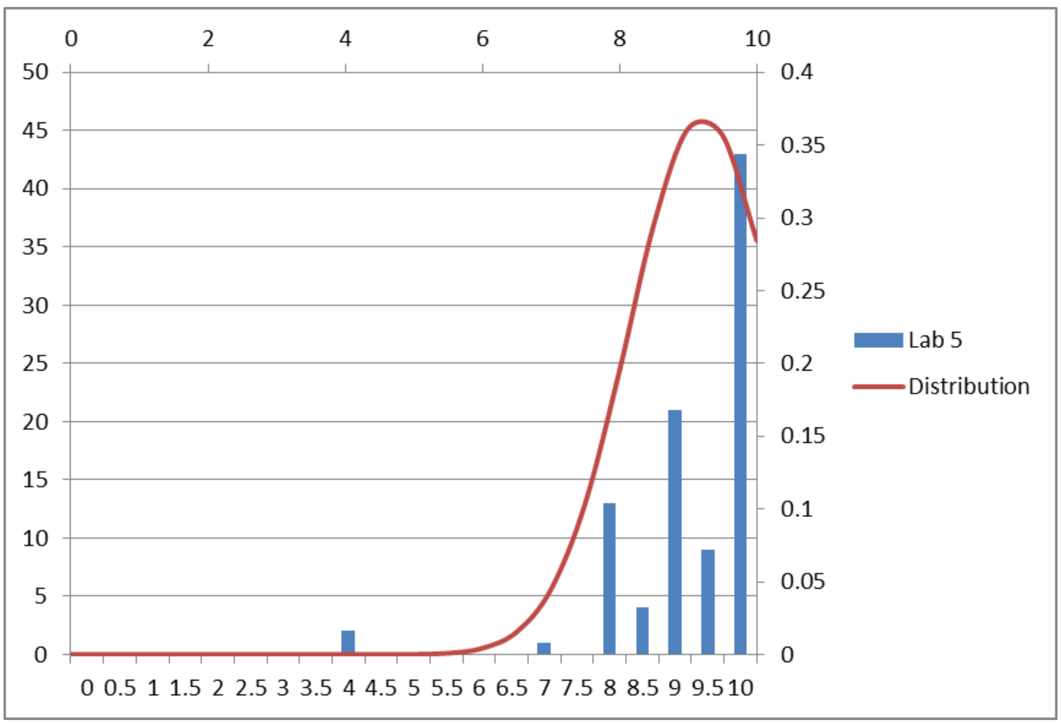
Lab Grades with Normal Distribution:



Mean: 9.21 Standard Deviation: 1.04

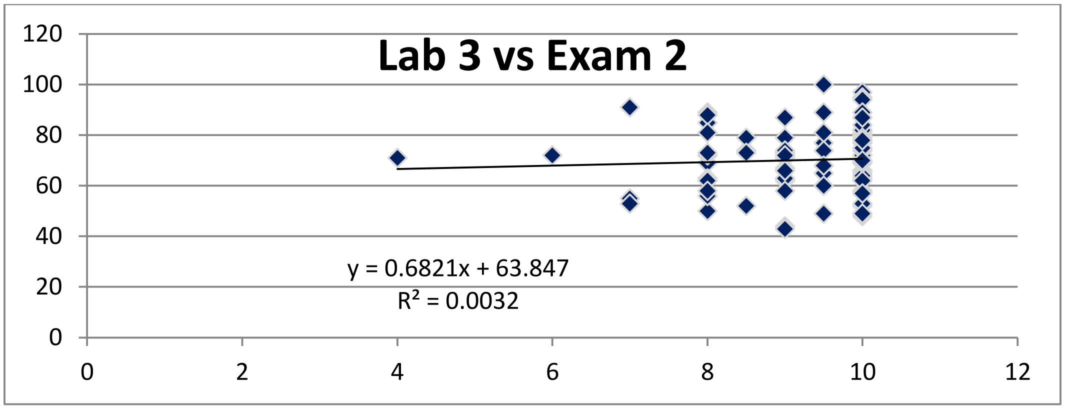


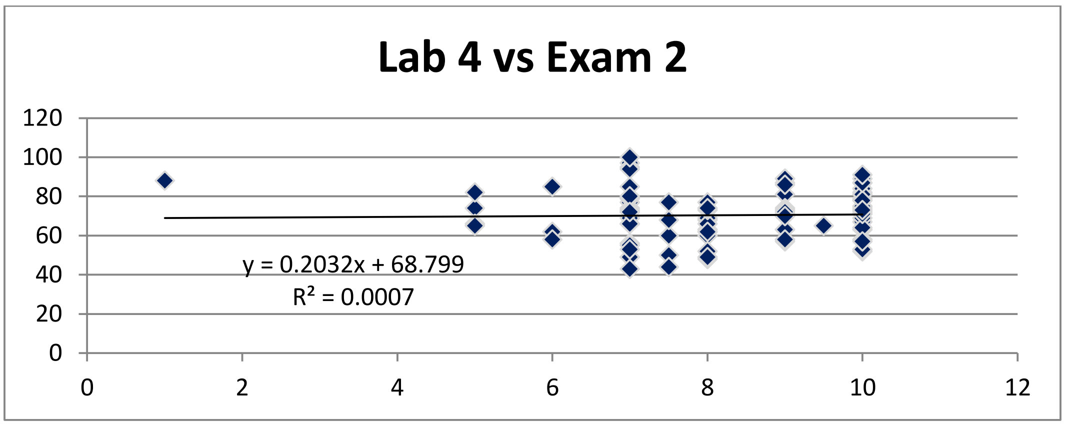
Mean: 8.14 Standard Deviation: 1.60

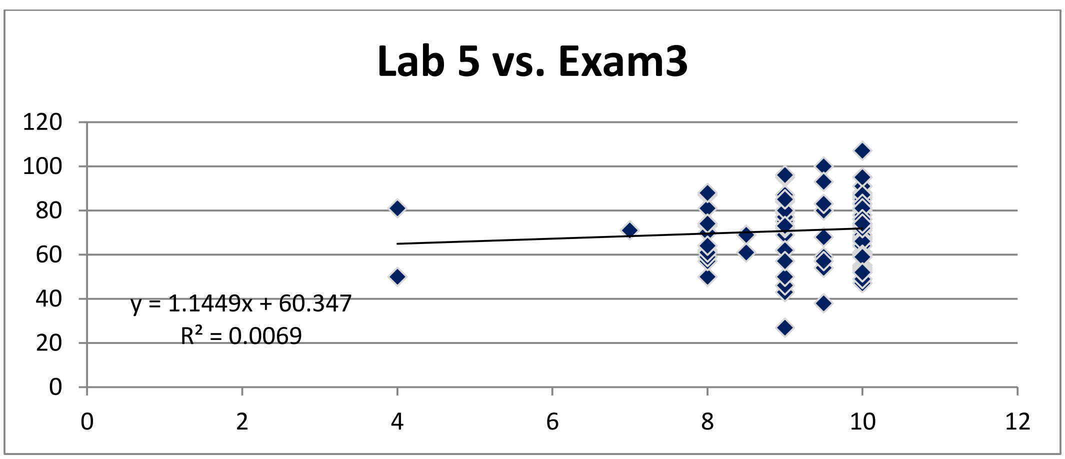


Mean: 9.22 Standard Deviation: 1.08

Lab Grades Compared to Exam Grades:

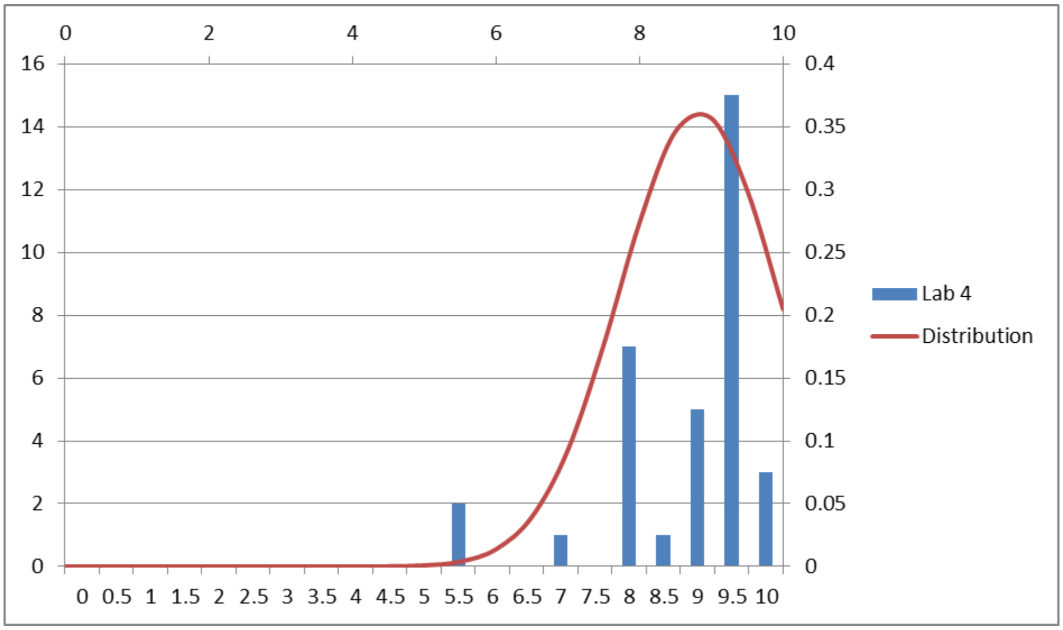




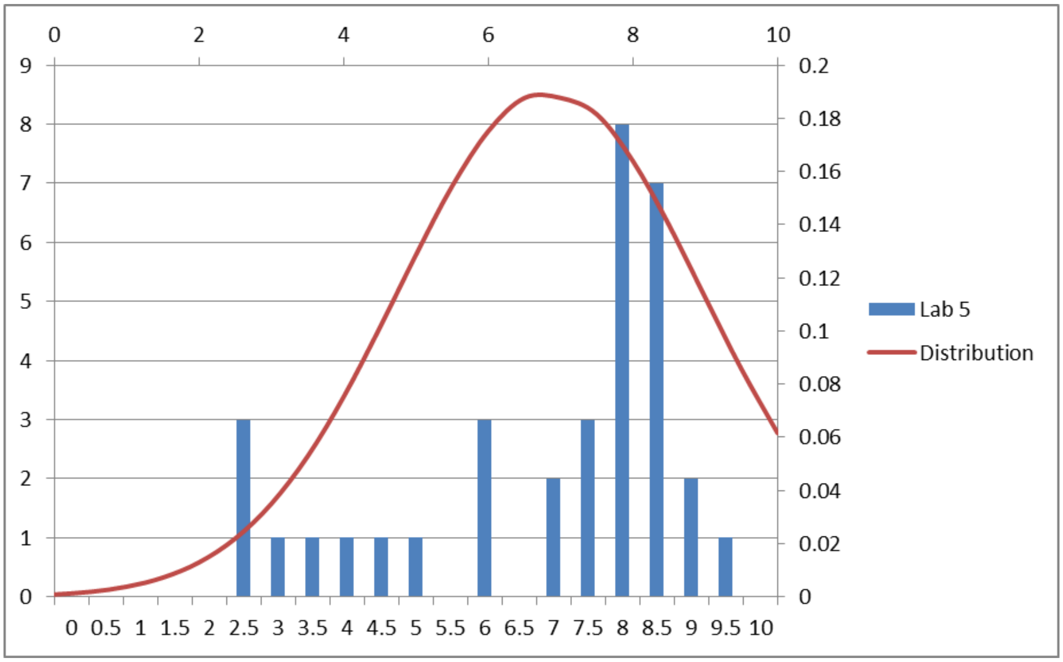


PH 1140: Professor Sabyasachi Sarkar

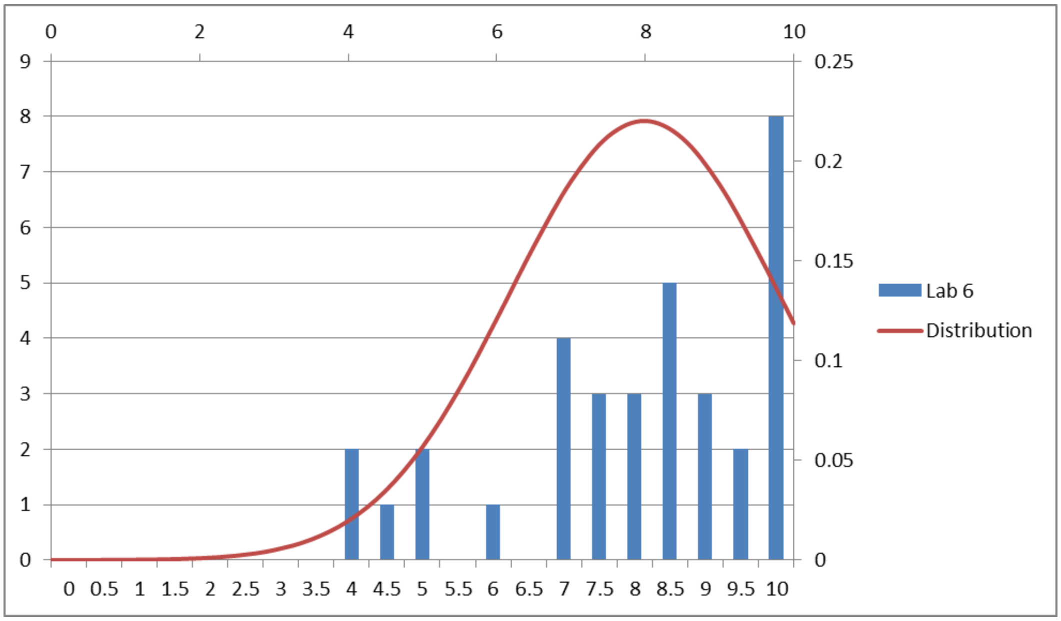
Lab Grades with Normal Distribution:



Mean: 8.82 Standard Deviation: 1.10

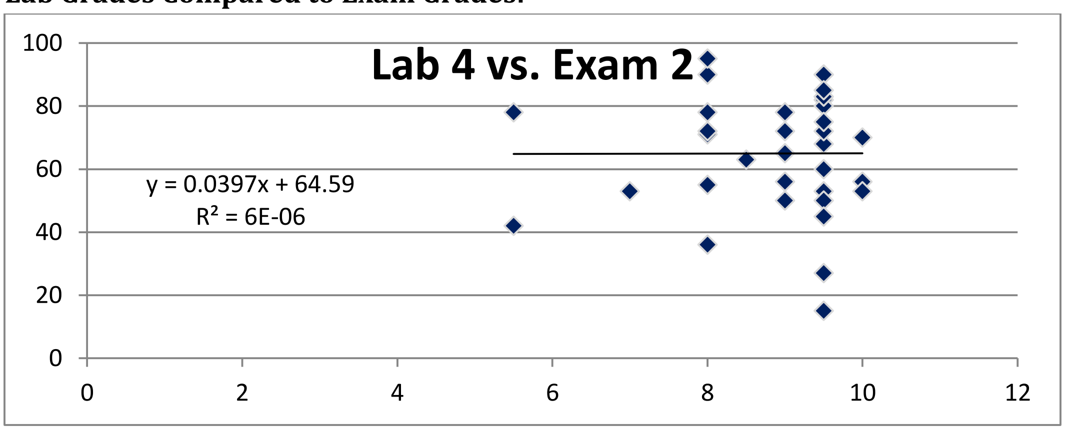


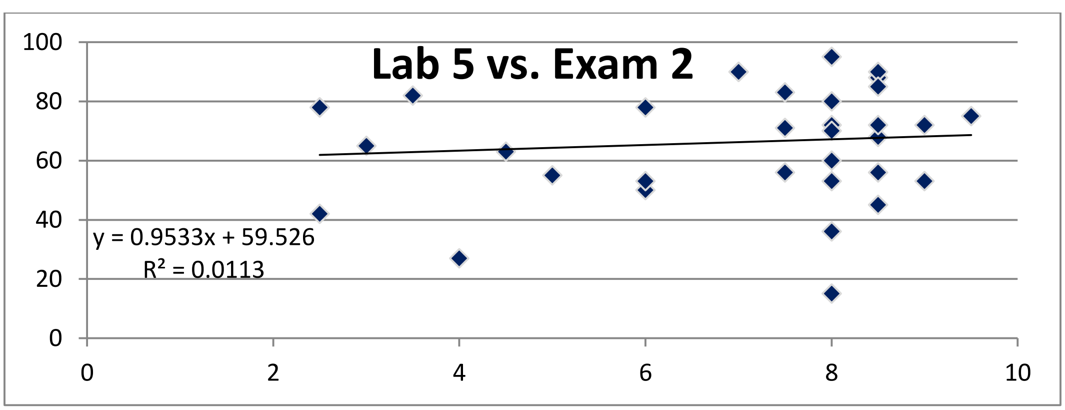
Mean: 6.85 Standard Deviation: 2.10

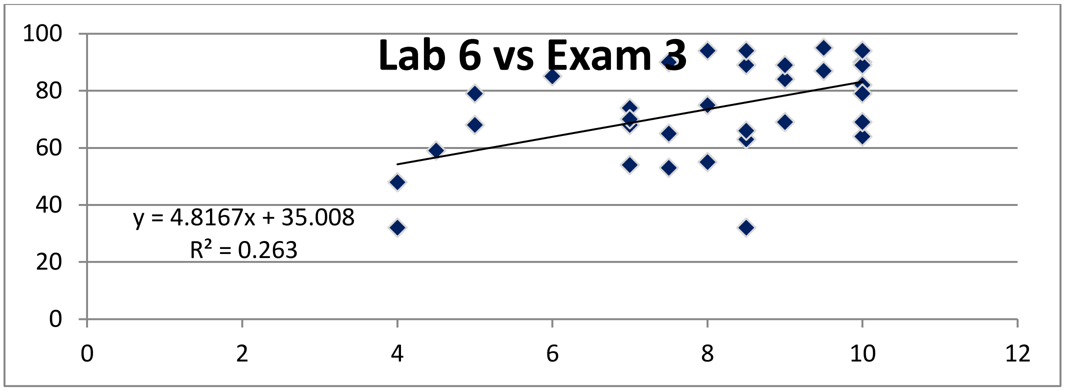


Mean: 7.99 Standard Deviation: 1.81

Lab Grades Compared to Exam Grades:






Lab 6 vs Exam 3
y = 4.8167x + 35.008
R² = 0.263
100
80
60
40
20
0
0
2
4
6
8
10
12

Appendix D: PH 1120 Lab 6, Part 2 Original Instructions

Now you will use Vernier equipment to measure values of actual magnetic fields, such as those created by permanent bar magnets.

Open the MagField1.cmbl template. Set the range switch on the magnetic field probe to the 6.4 mT setting. With the magnetic field probe held in place on the surface of the lab bench, zero the reading, and then begin collecting data.

Keeping the magnetic field probe motionless on the bench top, slide the bar magnet along the table top toward the probe along an extension of the long axis of the probe. Watch the probe meter reading, and be careful NOT to exceed a magnetic field magnitude of 5 mT (which is just below the upper-reading limit of the magnetic field probe).

Move the bar magnet some distance away, turn it end-for-end, and slide it in directly toward the probe again. When at a reading of approximately 5 mT magnitude, don't bring the magnet any closer but rotate it around its center slowly while watching the magnetic field reading carefully. Rotate through at least 360°.

Now, rotate the magnet so its long axis is perpendicular to the long axis of the probe. Then translate the position of the magnet so it is pointed at the probe about 1 cm behind the tip of the probe and far away from the probe. Now, move the magnet in a line toward the probe, and, as you do so, adjust the distance of its line of travel either closer or further from the tip in order to make the probe reading close to zero. Because the magnetic field lines diverge from one another after leaving the tip of the bar magnet, the magnetic field in the vicinity of the Hall Effect wafer (inside the probe) will have a small component along the axis of the probe unless the center of the bar magnet is aimed exactly at the wafer, and by slight adjustment of the bar magnet's line of travel, you can aim the center of the bar magnet end directly at the (hidden) wafer, so that the measured field strength is zero.

At this point you have established that the probe is most sensitive to fields parallel (or antiparallel) to the probe's long axis and oblivious to fields that are perpendicular to the long axis of the probe. (Actually, this field sensitivity varies as the cosine of the angular difference between the probe axis and the direction of the magnetic field at the wafer.)

Take a paper clip and bring it up to the tip of the probe. Turn the paper clip end-for-end, and determine from this test that the paper clip is not magnetized. If it does cause a small reading as you turn it end-for-end, throw the paper clip vigorously to the floor or against the wall a few times, and that should remove most of any residual magnetism. (Related admonition: Do NOT drop the permanent magnets on the floor or on the lab bench. With abuse, even a permanent magnet can lose a bit of its magnetization.)

Move the magnet so it is a distance away from the probe and facing the probe, with its long axis aligned with the long axis of the probe. Slide the bar magnet back to a point a large distance away from the probe, and place a paper clip near one end of the bar magnet (near enough that the clip leaps to that near end of the magnet). Because the paper clip is made of a magnetic material (soft iron), the paper clip is attracted to the magnet and can be made to cling to one end. Holding the paper clip so that it touches the magnet and sticks straight out along the long axis of the magnet, slide this arrangement toward the probe along the probe's long axis with the paper clip between the magnet and probe. As the clip+magnet arrangement approaches the probe, a nonzero field value should begin to register, and, as long as the reading never exceeds 5 mT, you can bring the free end of the paper clip right up the flat end of the probe.

With the paper clip held firmly in place against the probe, take the magnet out of contact with the paper clip, bring the magnet back again, and repeat this cycle several times while watching the probe reading.

Reverse the direction of the bar magnet, and repeat steps 6 and 7.

With the clip+magnet touching the end of the probe, leave the magnet in place, and this time, remove the paper clip. Reinsert and remove the paper clip through a few cycles, noting the behavior of the probe reading as you do that.

Then, reverse the direction of the clip+magnet arrangement, and again remove and reinsert the paper clip from between the magnet and the probe through a few cycles.

Now, slide the magnet back until it is at least three times as far away from the probe as it was in the previous steps. Place the paperclip in between the magnet and the probe, with its long axis aligned with both the long axis of the probe and the magnet. Now, slide the paperclip in a direction perpendicular to the direction of the probe until it is offset by a few inches. This will be the starting position for the paperclip. Start collecting data. Slide the paperclip along a line perpendicular to the direction the probe is facing. Keep sliding it along this path until it has passed between the magnet and the probe and is a few inches offset on the opposite side. Continue to collect data through the next two steps.

Rotate the paperclip 90 degrees so it is facing a direction perpendicular to the direction the probe is facing. Again, slide it past the magnet, to its original starting position.

Now rotate the paperclip 45 degrees, so that it is facing a diagonal direction compared to the direction the probe is facing. Again, pass the paperclip between the magnet and the probe until it is again on the opposite side. You can stop collecting data. Record in your worksheet what the peaks were for each of the three orientations of the paperclip: in line with the probe, perpendicular to the probe, and diagonal to the probe.

Take away the magnet and place it at some distance. Place the paper clip against the probe tip and observe the probe-reading change as you rotate the clip end-for-end. You should observe that the paper clip retains some residual magnetization, and you will be asked to describe your observations on your Lab Report. Now throw the paper clip down on the floor at least two or three times and repeat the end-for-end measurements as above. What do you observe now?

Here's the point. In all magnetic materials there are lots of little magnetic domains where all atoms in a given domain have their microscopic magnetic moments – their tiny bar magnet equivalents – all lined up in the same direction. In a permanent magnet, all these little domains can be more or less lined up, giving a large resulting magnetic field, AND these domains tend to stay lined up for a LONG time unless the temperature of the magnet is raised to a high-enough level to cause the domains to disalign OR unless the"permanent" magnet suffers enough dropped-to-the-floor type abuse. We call such material a "hard" magnetic material (a "hard" magnetic material requires a LOT of abuse to lose any of its magnetism, but we don't want our magnets to lose even 1% – so treat them CAREFULLY). A paper clip, of the other hand, is "soft". Although it has domains containing atoms that tend to be all magnetized in the same direction, these domains only line up cooperatively when an external magnetic field is applied, and this alignment largely disappears when the field is removed. But "largely" does not mean"completely". You'll no doubt be interested to learn that any residual alignment of domains in soft iron (like a paper clip) can usually be completely disrupted by a few sharp impacts (like throwing the paper clip to the floor a few times).

Appendix E: PH 1120 Lab 6, Part 2 Revised Instructions

Now you will use Vernier equipment to measure values of actual magnetic fields, such as those created by permanent bar magnets.

Open the MagField1.cmbl template. Set the range switch on the magnetic field probe to the 6.4 mT setting. With the magnetic field probe held in place on the surface of the lab bench, zero the reading, and then begin collecting data.

Keeping the magnetic field probe motionless on the bench top, slide the bar magnet along the table top toward the probe along an extension of the long axis of the probe. Watch the probe meter reading, and **be careful NOT to exceed a magnetic field magnitude of 5 mT** (which is just below the upper-reading limit of the magnetic field probe).

Move the bar magnet some distance away, turn it end-for-end, and slide it in directly toward the probe again. When at a reading of approximately 5 mT magnitude, do not bring the magnet any closer but rotate it around its center slowly while watching the magnetic field reading carefully. Rotate through at least 360°.

Now, rotate the magnet so its long axis is perpendicular to the long axis of the probe. Then translate the position of the magnet so it is pointed at the probe about 1 cm behind the tip of the probe and far away from the probe. Now, move the magnet in a line toward the probe, and, as you do so, adjust the distance of its line of travel either closer or further from the tip in order to make the probe reading close to zero. Because the magnetic field lines diverge from one another after leaving the tip of the bar magnet, the magnetic field in the vicinity of the Hall Effect wafer (inside the probe) will have a small component along the axis of the probe unless the center of the bar magnet is aimed exactly at the wafer, and by slight adjustment of the bar magnet's line of travel, you can aim the center of the bar magnet end directly at the (hidden) wafer, so that the measured field strength is zero.

At this point you have established that the probe is most sensitive to fields parallel (or antiparallel) to the probe's long axis and oblivious to fields that are perpendicular to the long axis of the probe. (Actually, this field sensitivity varies as the cosine of the angular difference between the probe axis and the direction of the magnetic field at the wafer.)

Take a paper clip and bring it up to the tip of the probe. Turn the paper clip end-for-end, and determine from this test that the paper clip is not magnetized. If it does cause a small reading as you turn it end-for-end, throw the paper clip vigorously to the floor or against the wall a few times, and that should remove most of any residual magnetism. (Related admonition: Do NOT drop the permanent magnets on the floor or on the lab bench. With abuse, even a permanent magnet can lose a bit of its magnetization.)

Move the magnet so it is a distance away from the probe and facing the probe, with its long axis aligned with the long axis of the probe. Slide the bar magnet back to a point a large distance away from the probe, and place a paper clip near one end of the bar magnet (near enough that the clip leaps to that near end of the magnet). Because the paper clip is made of a magnetic material (soft iron), the paper clip is attracted to the magnet and can be made to cling to one end. Holding the paper clip so that it touches the magnet and sticks straight out along the long axis of the magnet, slide this arrangement toward the probe along the probe's long axis with the paper clip between the magnet and probe. As the clip+magnet arrangement approaches the probe, a nonzero field value should begin to register, and, as long as the reading never exceeds 5 mT, you can bring the free end of the paper clip right up the flat end of the probe.

With the paper clip held firmly in place against the probe, take the magnet out of contact with the paper clip, bring the magnet back again, and repeat this cycle several times while watching the probe reading.

Reverse the direction of the bar magnet, and repeat steps 6 and 7.

With the clip+magnet touching the end of the probe, leave the magnet in place, and this time, remove the paper clip. Reinsert and remove the paper clip through a few cycles, noting the behavior of the probe reading as you do that.

Then, reverse the direction of the clip+magnet arrangement, and again remove and reinsert the paper clip from between the magnet and the probe through a few cycles.

Now, slide the magnet back until it is at least three times as far away from the probe as it was in the previous steps. Place the paperclip in between the magnet and the probe, with its long axis aligned with both the long axis of the probe and the magnet. Now, slide the paperclip in a direction perpendicular to the direction of the probe until it is offset by a few inches. This will be the starting position for the paperclip. Start collecting data. Slide the paperclip along a line perpendicular to the direction the probe is facing. Keep sliding it along this path until it has passed between the magnet and the probe and is a few inches offset on the opposite side. Continue to collect data through the next two steps.

Rotate the paperclip 90 degrees so it is facing a direction perpendicular to the direction the probe is facing. Again, slide it past the magnet, to its original starting position.

Now rotate the paperclip 45 degrees, so that it is facing a diagonal direction compared to the direction the probe is facing. Again, pass the paperclip between the magnet and the probe until it is again on the opposite side. You can stop collecting data. Record in your worksheet what the peaks were for each of the three orientations of the paperclip: in line with the probe, perpendicular to the probe, and diagonal to the probe.

Take away the magnet and place it at some distance. Place the paper clip against the probe tip and observe the probe-reading change as you rotate the clip end-for-end. You should observe that the paper clip retains some residual magnetization, and you will be asked to describe your observations on your Lab Report. Now throw the paper clip down on the floor at least two or three times and repeat the end-for-end measurements as above. What do you observe now?

Here's the point. In all magnetic materials there are lots of little magnetic domains where all atoms in a given domain have their microscopic magnetic moments – their tiny bar magnet equivalents – all lined up in the same direction. In a permanent magnet, all these little domains can be more or less lined up, giving a large resulting magnetic field, AND these domains tend to stay lined up for a LONG time unless the temperature of the magnet is raised to a high-enough level to cause the domains to disalign OR unless the "permanent" magnet suffers enough dropped-to-the-floor type abuse. We call such material a "hard" magnetic material (a "hard" magnetic material requires a LOT of abuse to lose any of its magnetism, but we do not want our magnets to lose even 1% – so treat them CAREFULLY). A paper clip, of the other hand, is "soft". Although it has domains containing atoms that tend to be all magnetized in the same direction, these domains only line up cooperatively when an external magnetic field is applied, and this alignment largely disappears when the field is removed. But "largely" does not mean "completely". You'll no doubt be interested to learn that any residual alignment of domains in soft iron (like a paper clip) can usually be completely disrupted by a few sharp impacts (like throwing the paper clip to the floor a few times).

Appendix F: PH 1120 Lab 6 Part 2 Original Data Sheet

This represents only the questions from the data sheet that pertain to Part 2 of Lab 6.

4. Explain briefly what must be going on with the magnetic field measurement when the magnet is in a fixed location relative to the Hall Effect probe and a paper clip is slipped in between the magnet and probe (touching both at either end) and then removed. In other words, explain briefly your view of why the probe reading changes as the paper clip is slipped in and out.

5. Explain briefly what must be going on with the paper clip when it registers a magnetic field with the probe when the bar magnet is first taken away, but then shows very little magnetic field after being thrown vigorously to the floor a few times.

Appendix G: PH 1120 Lab 6 Part 2 Revised Data Sheet

This represents only the questions from the data sheet that pertain to Part 2 of Lab 6.

4. Record the peaks of the three orientations of the paperclip:

   In-line with the probe and magnet: _______________

   Perpendicular to the probe and magnet: _______________

   Diagonal to the probe and magnet: _______________

   Discuss these results.

5. Explain briefly what must be going on with the magnetic field measurement when the magnet is in a fixed location relative to the Hall Effect probe and a paper clip is slipped in between the magnet and probe (touching both at either end) and then removed. In other words, explain briefly your view of why the probe reading changes as the paper clip is slipped in and out.

6. Explain briefly what must be going on with the paper clip when it registers a magnetic field with the probe when the bar magnet is first taken away, but then shows very little magnetic field after being thrown vigorously to the floor a few times.

Appendix H: D Term Survey

This survey was made online using Google Drive. The URL of the survey is:

https://docs.google.com/forms/d/18mUTlULEkoiEb2iuTISLHA7wK1HwHalD4WQLu-mc0vQ/viewform?usp=send_form

PH 1120 Lab 6

Rate the difficulty of this lab.

	1	2	3	4	5	
Very Easy	○	○	○	○	○	Very Difficult

How clear and understandable were the lab instructions?

	1	2	3	4	5	
Not Clear At All	○	○	○	○	○	Very Clear

How well did this lab help you to understand the concepts discussed in class?

	1	2	3	4	5	
Not At All	○	○	○	○	○	Helped Very Much

Were you able to complete this lab in the alloted time?

- ○ Yes
- ○ No

What grade do you expect to receive for this lab?

- ○ A
- ○ B
- ○ C
- ○ Lower than a C

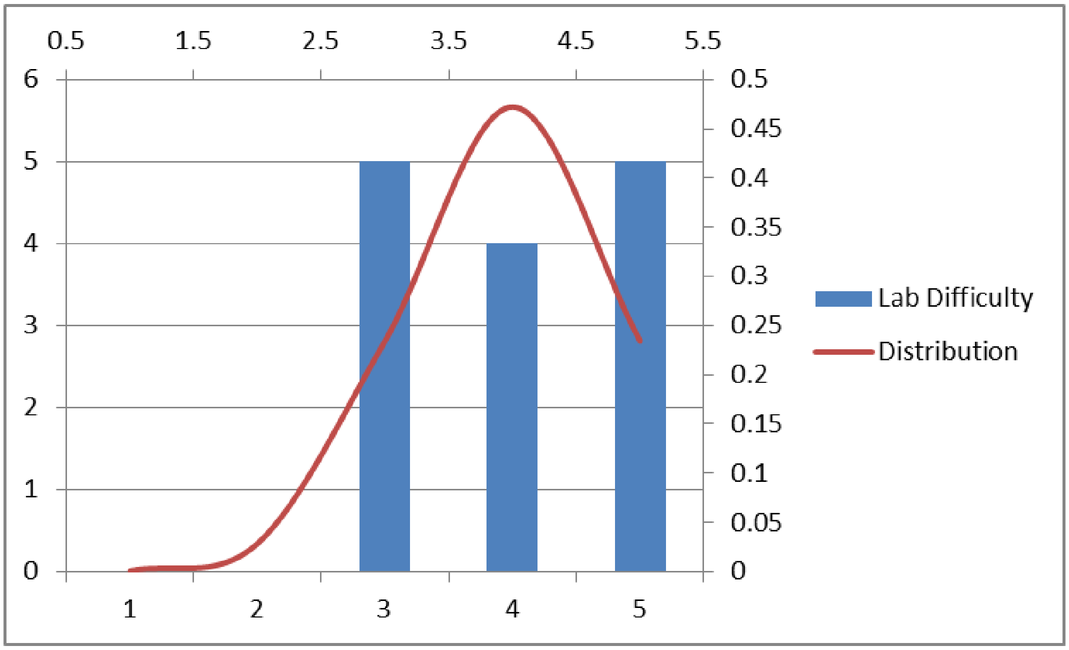
When did you have this lab?

- ○ Tuesday
- ○ Wednesday

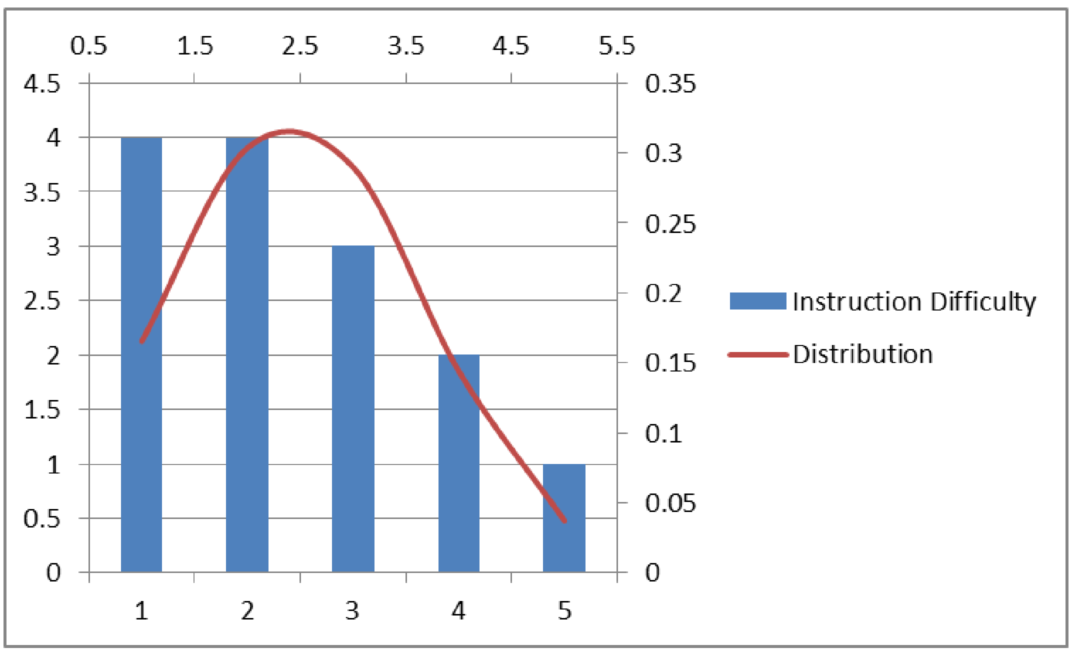
Appendix I: Results of D Term Survey

Tuesday Lab Surveys:

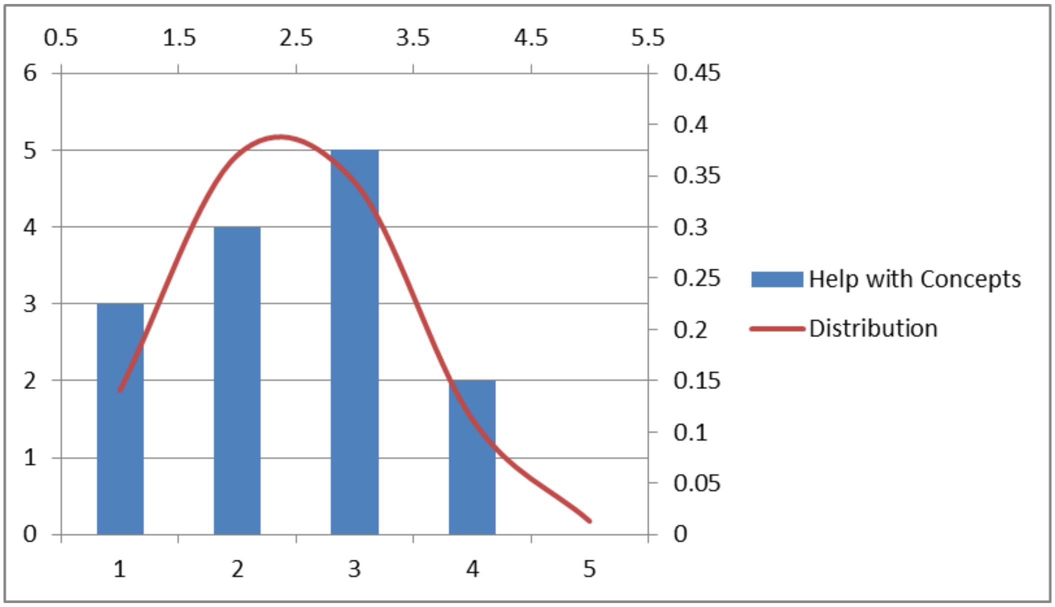
Rate the difficulty of this lab (1-Very Easy to 5-Very Difficult):



How clear and understandable were the instructions? (1-Not Clear At All to 5-Very Clear):



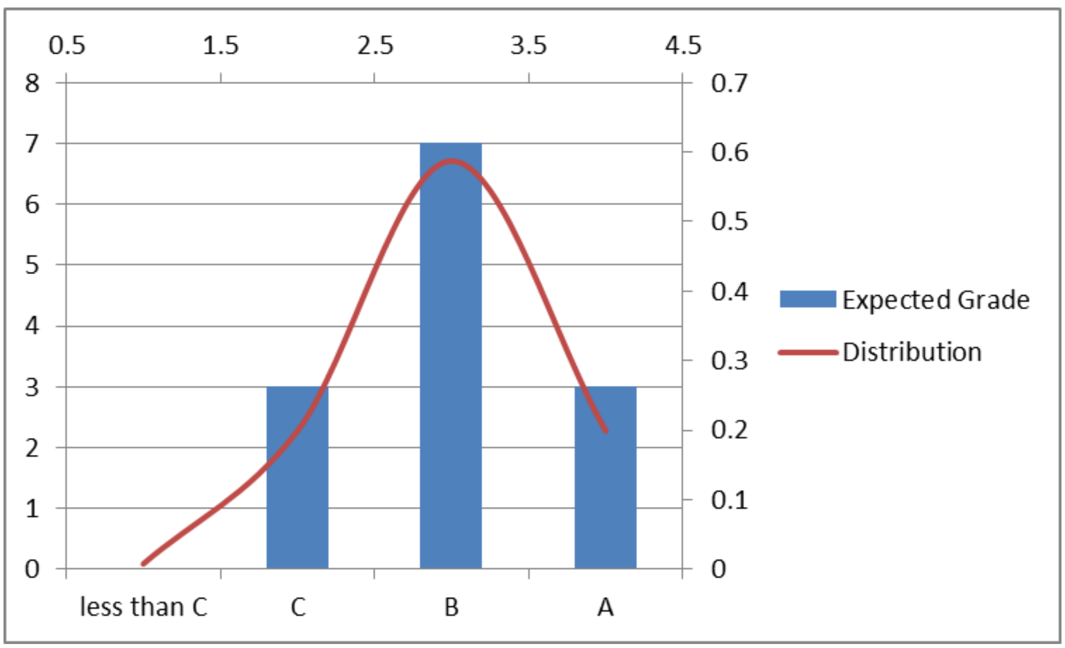
How well did this lab help you to understand the concepts discussed in class? (1-Not At All to 5-Helped Very Much):



Were you able to complete the lab in the allotted time?

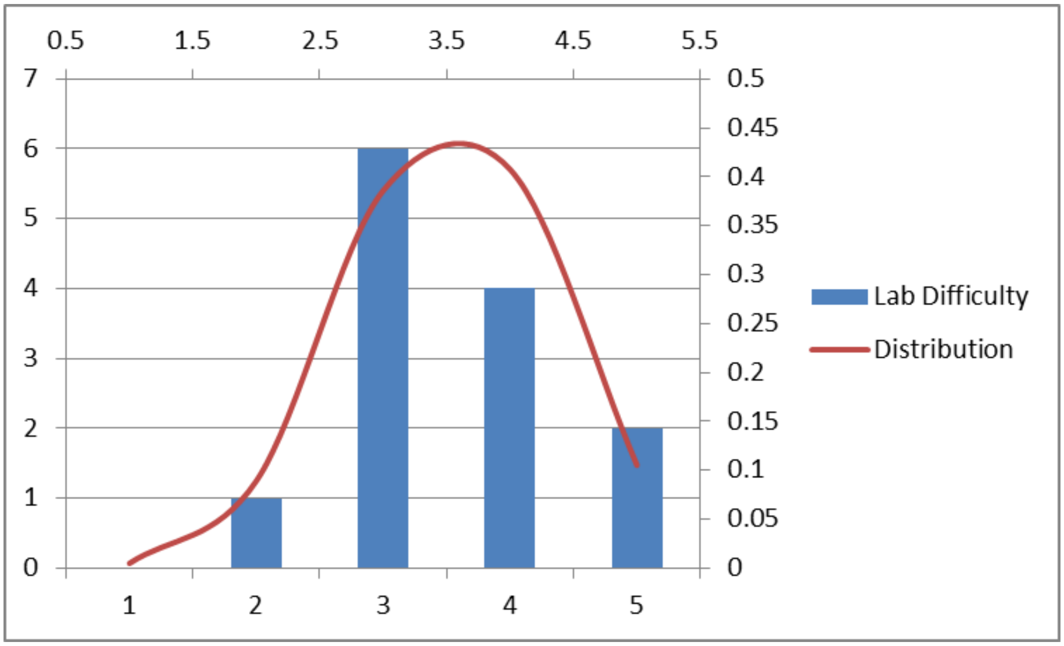
Percent that answered, "Yes": 14.28571429% (2 out of 14)

What grade do you expect to receive on this lab?

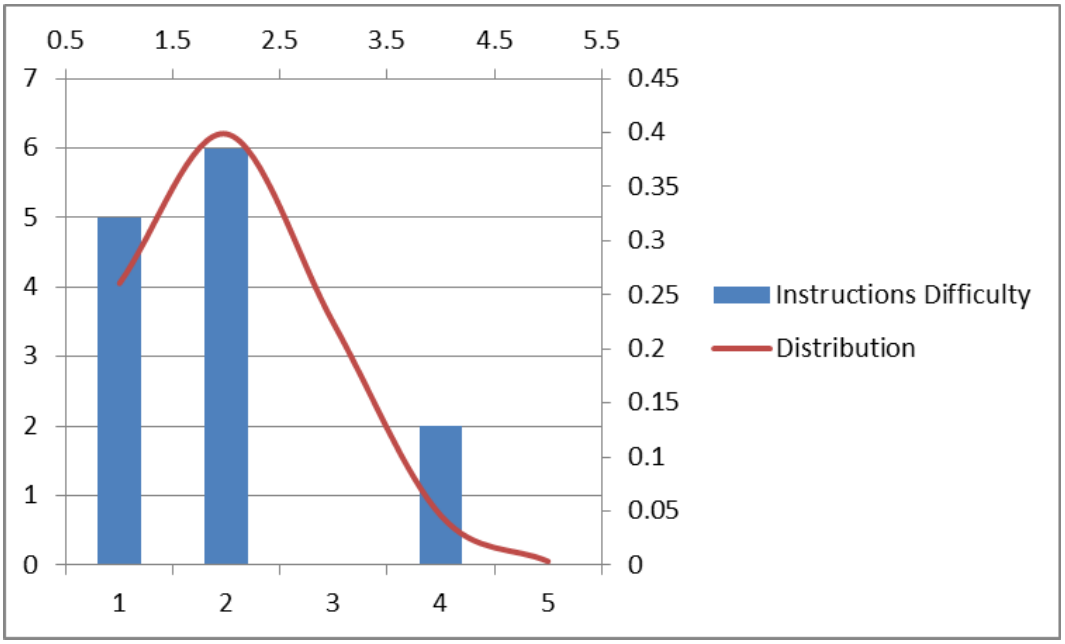


Wednesday Lab Surveys:

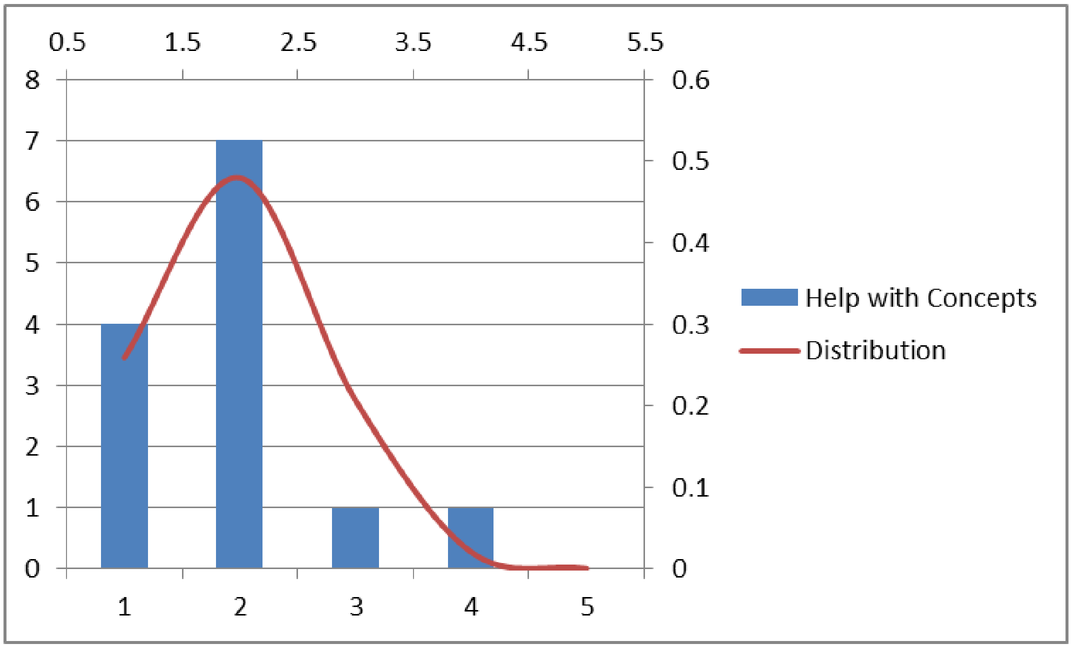
Rate the difficulty of this lab (1-Very Easy to 5-Very Difficult):



How clear and understandable were the instructions? (1-Not Clear At All to 5-Very Clear):



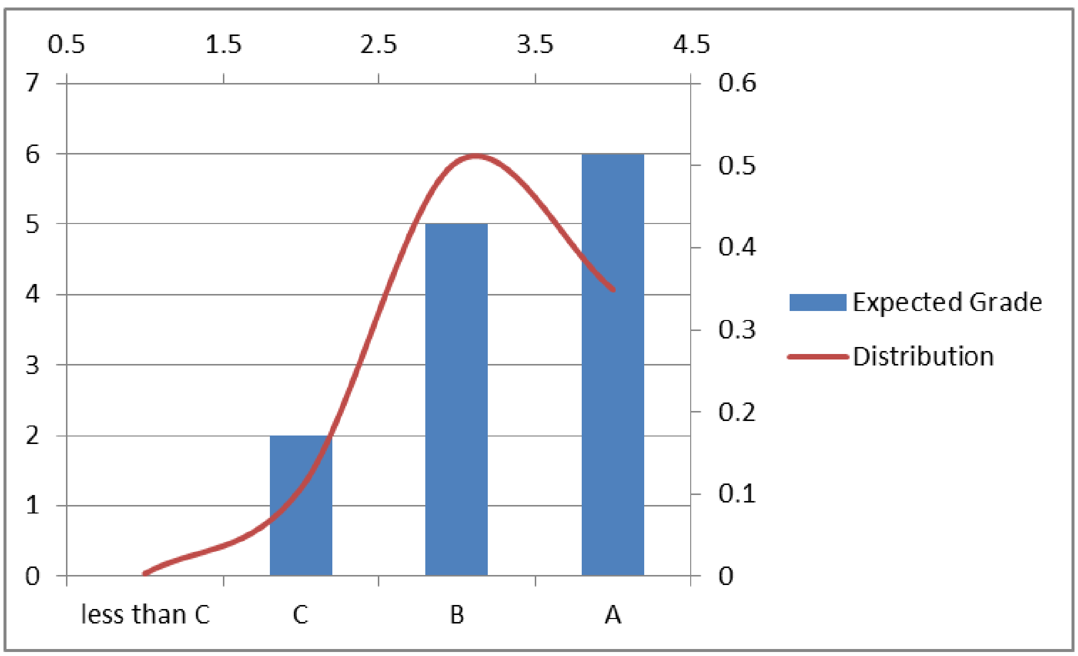
How well did this lab help you to understand the concepts discussed in class? (1-Not At All to 5-Helped Very Much):



Were you able to complete the lab in the allotted time?

Percent that answered, “Yes”: 15.38461538% (2 out of 13)

What grade do you expect to receive on this lab?



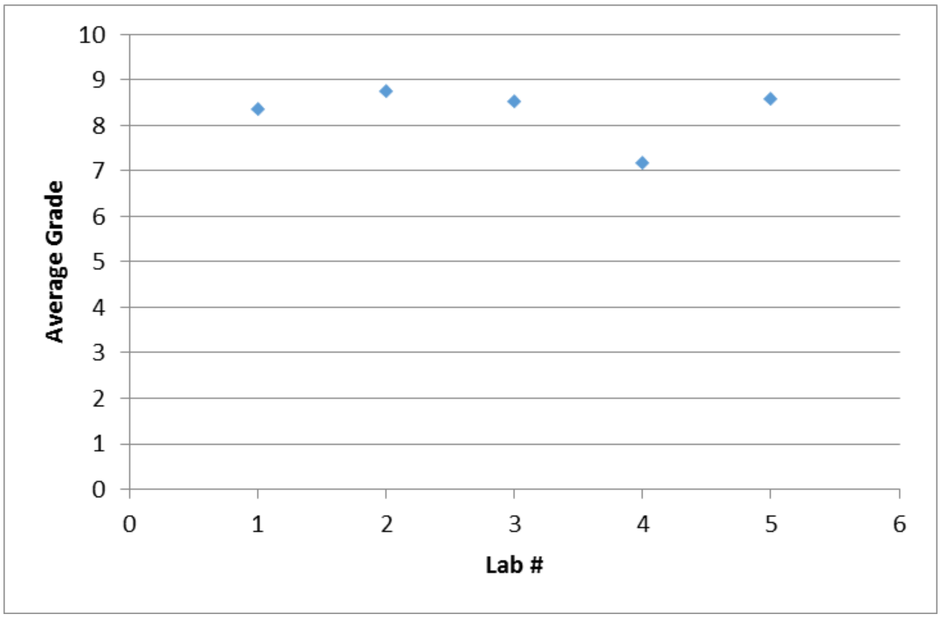
Appendix J: D Term Grade Analyses

Previous Labs (PH 1120 Labs 1-5)

Average of all students' grades from all labs:

8.297866205

Graph of average grades, separated by lab number:



Lab 6