Grading Two Example Student Laboratory Reports

Introductory physics courses at the University of Minnesota are *Writing Intensive (W-I).* This means that a course grade is directly tied to the quality of the student's writing as well as to knowledge of the subject matter, so that *students cannot pass the course who do not meet minimal standards* of writing competence.

In physics laboratory reports, students are provided the opportunity to learn about physics through written assignments that involve problem solving, language use, and organizational skills. Writing factors to consider in your grading include the following:

Content	Has the student included technical or scientific *Content* accurately & thoroughly? Does the student address accurate information such as definitions, formulas, theorems, explanations, or data?
Context	Has the student communicated in a way appropriate for the situation or *Context* in which the document / presentation / visual will be received? Have the requirements of the assignment been met?
Audience	Has the student addressed the *Audience* with appropriate language & technical content, vocabulary, level of knowledge, & register (informal or formal)?
Purpose	Has the student identified the *Purpose* of their communication, such as to inform, persuade, instruct, or demonstrate?
Support	Has the student included appropriate *Support* in the form of documentation, facts, statistics, formulas, illustration, or evidence?
Design	Does the student use effective *Design*, both for page design & for the integration of verbal explanation & visual illustration? Does the student display neatness & cross-references at appropriate points?
Organization	Has the student *Organized* the communication into logical sections, paragraphs, topic sentences, & headings?
Expression	Has the student *Expressed* written work clearly, efficiently, & effectively? Has the student used correct grammar & mechanics?

INDIVIDUAL TASKS:

1. *Individually* read through the 2 example student laboratory reports. Mark down any and all comments on the example student laboratory reports as you do so.
2. Assign points for each student laboratory report on the grading rubric, according to your teaching team's grading policy. Group discussion about the grading will take place at the next seminar session.
3. Record the *time* it took you to grade each student report. (How much time do you expect to spend grading an entire class of lab reports? How can you improve your grading efficiency?)

Campus Resources for Writing Support

Writing Support Network. The Writing Support Network is a web page that lists support services for students in writing classes. All writing centers home pages are listed.

See: http://www.writinghelp.umn.edu/

Center for the Interdisciplinary Studies of Writing. CISW offers workshops for TAs and faculty teaching writing-intensive courses. You can also find on their website sources for sample courses, syllabi, and assignments that are writing-intensive.

See: http://CISW.cla.umn.edu/

Writing-Intensive Resources for Scientific and Technical Disciplines. This web site provides information for faculty and students in scientific and technical disciplines. Faculty information includes suggestions for evaluating written reports, integrating writing in assignments, and incorporating revision and peer review. Student information provides a number of online handouts on writing topics such as writing and revising, editing, oral presentations, and student collaboration. Student can also find helpful links to other resources about writing such as other writing centers and sources for documentation.

See: http://www.agricola.umn.edu/writingintensive/

PHYSICS 1301 LABORATORY REPORT

Laboratory I

Name and ID#: ______________________________

Date performed: ______________ Day/Time section meets: ______________________

Lab Partners' Names: ______________________________

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Problem # and Title: ______________________________

Lab Instructor's Initials: __________

Grading Checklist	Points*
LABORATORY JOURNAL:	
PREDICTIONS (individual predictions and warm-up completed in journal before each lab session)	
LAB PROCEDURE (measurement plan recorded in journal, tables and graphs made in journal as data is collected, observations written in journal)	
PROBLEM REPORT:	
ORGANIZATION (clear and readable; logical progression from problem statement through conclusions; pictures provided where necessary; correct grammar and spelling; section headings provided; physics stated correctly)	
DATA AND DATA TABLES (clear and readable; units and assigned uncertainties clearly stated)	
RESULTS (results clearly indicated; correct, logical, and well-organized calculations with uncertainties indicated; scales, labels and uncertainties on graphs; physics stated correctly)	
CONCLUSIONS (comparison to prediction & theory discussed with physics stated correctly ; possible sources of uncertainties identified; attention called to experimental problems)	
TOTAL(incorrect or missing statement of physics will result in a maximum of 60% of the total points achieved; incorrect grammar or spelling will result in a maximum of 70% of the total points achieved)	
BONUS POINTS FOR TEAMWORK (as specified by course policy)	

* An "R" in the points column means to rewrite that section only and return it to your lab instructor within two days of the return of the report to you.

Example #1

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Lab Report 2 – Lab 3, Problem 1

Statement of the problem:

I am a volunteer in the city's children's summer program. One suggested activity is for the children to build and race model cars along a level surface. To ensure that each car has a fair start, my co-worker recommends a special launcher be built. The launcher uses a string attached to the car at one end and, after passing over a pulley, the other end of the string is tied to a block hanging straight down. The car starts from rest and the block is allowed to fall, launching the car along the track. After the block hits the ground, the string no longer exerts a force on the car and the car continues moving along the track. I want to know how the launch speed of the car depends on the parameters of the system that you can adjust. I decide to calculate how the launch velocity of the car depends on the mass of the car, the mass of the block, and the distance the block falls. My ultimate goal was to find the answer to the question – "What is the velocity of the car after being pulled for a known distance?"

Prediction:

I predicted that, using the equation $V=\sqrt{(2M_agh)/(M_a+M_c)}$

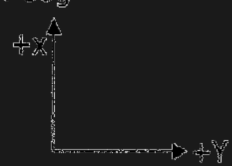
and with the data collected during setup, that the velocity at the time the block hit the floor would be 60.5cm/s.
(Prediction graphs are attached.)

Procedure:

First, we gathered supplies. We used a cart, a flat track with a pulley attached, a mass hanger with a mass set to simulate the wooden block, string, and a video camera attached to a computer with video analysis software. We massed the cart and the block, and began to set up the experiment. We placed the cart on the track, and ran the string through the pulley. We hooked our mass onto the end of the string, and held it to a height that we measured and marked. We began recording video and let the mass go. We made 3 runs like this to obtain the best video. When we were satisfied we analyzed the video and came up with a good measurement of the cart's velocity. We printed our graphs and made conclusions based on our data.

Data and Results:

Mass of Cart (Mc): 753.8g
Mass of Block (Ma): 50g
Height (H): 30cm
Coordinate Axis:



(Graphs of data analysis are attached)

Discussion:

The results from the lab were pretty close to the prediction made by plugging the masses of the cart and block and the height of the drop into the equation I wrote in my lab journal.

In the lab, there were a few sources of obvious error. The first major source was the method of getting data. The computer software is a bit inaccurate in measuring the velocity with the method of selecting points in the video frames. The camera we used has a curved lens, which distorts the video. This all leads to data that is off from the expected return. Another possible source of error is the equipment. The set-up we used was not entirely perfect in the fact that we were not taking friction into account, yet there was most likely friction in the cart's wheels. This would matter most during the time after the block has hit the ground, which is the situation we are modeling.

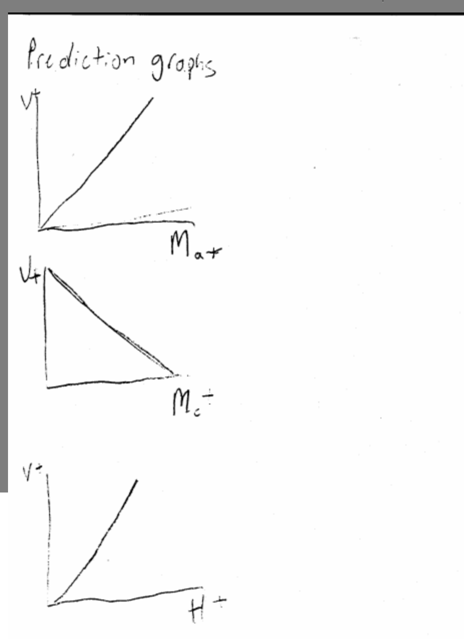
We could have made a few improvements. The main improvement would be to more accurately analyze the data within the computer software to compensate for any distortion in the video. We also could have made sure the cart was properly lubricated before performing the experiment.

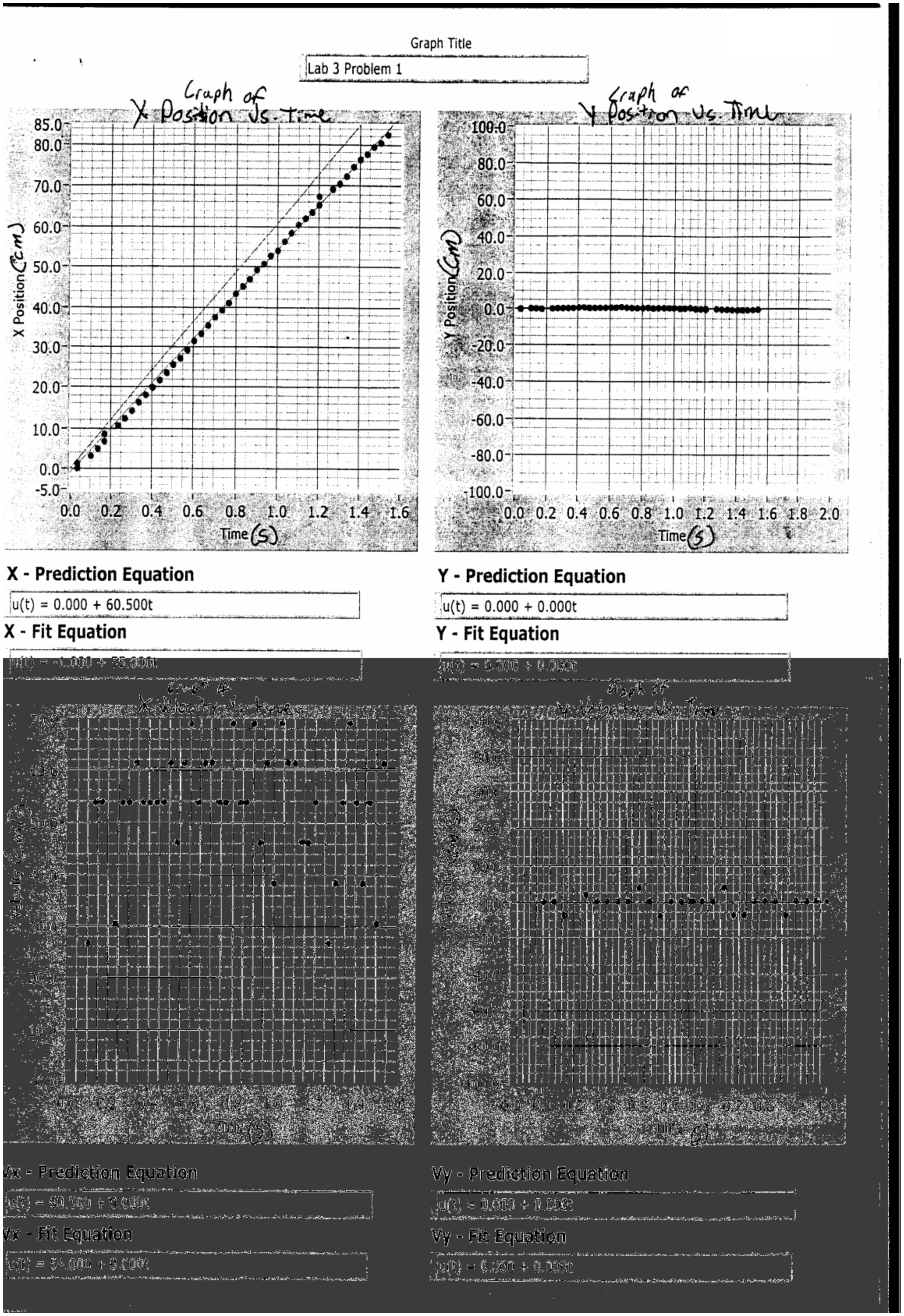
Conclusions:

In our lab, we discovered the velocity of the car after being pulled a known distance was around 55cm/s. This was close to our initial prediction, so we were satisfied with our results.

The launch velocity of the car does depend on its mass, as well as the mass of the block and the distance the block falls. This is due to the fact that they all affect the forces acting on the car. There are some instances where the mass would not really affect the launch velocity. If the distance dropped were very close to zero, the launch velocity would be near zero no matter what the mass of the block was.

If the same block falls the same distance, the force exerted by the block on the cart would not change, no matter the mass of the cart. The force of the block on the cart is always equal to the block's weight.




Graph Title
Lab 3 Problem 1
Graph of X Position Vs. Time
X Position (cm)
Time (s)
Graph of Y Position Vs. Time
Y Position (cm)
Time (s)
X - Prediction Equation
u(t) = 0.000 + 60.500t
X - Fit Equation
Y - Prediction Equation
u(t) = 0.000 + 0.000t
Y - Fit Equation
Vx - Prediction Equation
Vx - Fit Equation
Vy - Prediction Equation
Vy - Fit Equation

PHYSICS 1301 LABORATORY REPORT

Laboratory I

Name and ID#: ____________________

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Example #2

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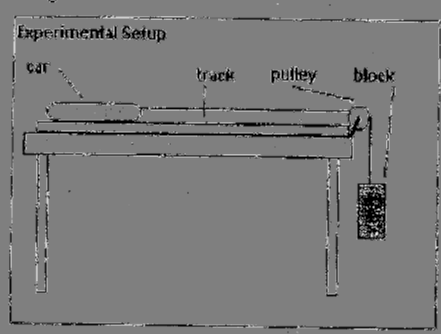
Lab III Problem 1: Force and Motion

1. Statement of the Problem -- According to the lab manual, my group members and I were asked to test the velocity of a toy car launched down a track. The car is attached to a string at the end of the track, which goes over a pulley and is then attached to a block. When the block is released, the string pulls the car down the track. After the block hits the ground, the car is no longer pulled but keeps going. We were asked to find how the cars speed after the block hits the ground depends on the mass of the car, the mass of the block, and the distance the block falls before hitting the ground. The question we answered in this lab is:

What is the velocity of the car after being pulled a known distance?

We used a toy car with a string attached to it, a block, a pulley, and a track to conduct our experiment. We recorded the motion of the car and the block using a video analysis application written in LabVIEW™, then analyzed the video to find the position, velocity and acceleration of the car while it was being pulled by the falling block and after the black reached the ground.

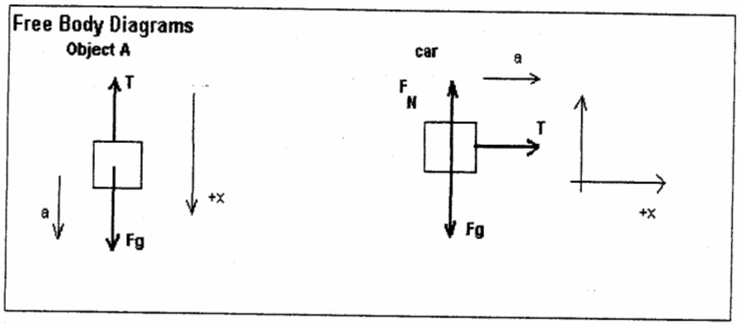
The block (called object A) has a significantly shorter distance to fall than the car has to travel along its track. In this experiment, we ignored the friction between the car and the track and between the pulley and the string. We also ignored the mass of the string.



2. Prediction --

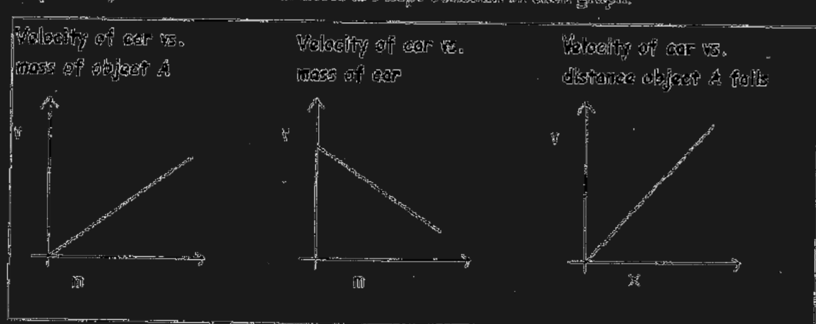
The first question asked me to calculate the cart's velocity after the block had hit the ground. I predicted that $\mathbf{v_c} = \sqrt{\mathbf{2xg[m_a/(m_c + m_a)]}}$. I solved the first kinematics equation, $\mathbf{x_c = x_{0c} + v_{0c}t + 1/2at^2}$ **for t**, assuming that x_0 =O, v_0 =0 and $a_c = a_A$, and that the magnitude of the car's displacement was the same as the magnitude of the block's, (since the string did not stretch), yielding $\mathbf{t = 2x/a}$. Since v= at, $\mathbf{v = a\sqrt{(2x/a)}}$ and v^2 =2ax. Solving for a gives $\mathbf{a = v^2/2x}$.

Variables	
x	position
xo	initial position
v	velocity
vo	initial velocity
a	acceleration
t	time
m	mass of object A
m	mass of car
F	Force
g	gravity
N	Normal Force
T	tension force



Since the objects are attached to the same string, the tension forces acting upon them are equal to each other. The sum of the forces acting on Object A in the x direction is ΣF_A= Fg-T. The sum of the forces acting on the car in the x direction is ΣF_c= T. Since F= ma, $M_A a = M_A g$-T and $M_c a$=T. Using $a = v^2/2x$, $M_A(v^2/2x) = M_A g$-T, and $M_c(v^2/2x)$=T. Combining these equations gives $M_A(v^2/2x) = M_A g - M_c(v^2/2x)$, and solving for v gives $v_c = \sqrt{2xg[m_a/(m_c + m_a)]}$.

The next three prediction problems asked us to draw a graph of the car's velocity vs. time as a function of the mass of object A, mass of the car, and distance object A falls, respectively. The other two variables are kept constant in each graph.



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The velocity would increase as the mass of object A or the distance object A falls increased, and would decrease as the mass of the car increased. The velocity would increase at a greater rate with the increase in distance than it would with the increase in mass of object A. Another way this could be said is that the graph of velocity vs. distance would have a greater slope than the graph of velocity vs. mass of object A.

3. Procedure – We set up the experiment according to the experimental setup picture above. The mass of the car we used was 252 g, and the mass of object A was 50 g. The distance form object A to the ground was 0.41m and the total distance the car was able to travel was 1m. There was 0.59m for the car to travel after object A hit the ground.

We placed the camera about 1.5m away from the table holding the track so that the entire length of the track could be seen as well as object A. We recorded the car's motion and then analyze it in LabVIEW™. We divided the motion of the car into two parts -- motion before object A hit the ground and motion after object A hit the ground -- and analyzed each part separately. We predicted the equations for the position vs. time graphs, plotted data points of both the horizontal and vertical motion of the graphs, and then found the best-fit equations for them. We did the same for the car's velocities.

4. Data and Results – SEE ATTACHED GRAPHS

We predicted that there would be no motion, and hence no velocity, in the y direction for any of the graphs, and our prediction was correct.

Before object A hit the ground --When we predicted the equation for the x position vs. time of the car before object A hit the ground, we didn't really know what we were doing. We should have used the equation $x = x_0 + v_0t + 1/2at^2$ to make our prediction. The values for x_0 and v_0t would both have been equal to zero and we could have predicted the acceleration using $a = v^2/2x$: $(\sqrt{2xg[m_a/(m_c + m_a)]})^2/2x = [m_a/(m_c + m_a)]g = a$. This would have given us an acceleration of 1.49 m/s*s, and a predicted equation of $x = 0 + 0(t) + 0.75\text{m/s*s}(t^2)$. The value of 0.897 m/s*s in the best-fit equation is reasonably close to this. Since the slope of a velocity vs. time graph is equal to the acceleration and since 0.897 m/s*s was equal to ½ a, we predicted that the slope of the acceleration vs. time graph would be equal to 1.80 m/s*s, and our prediction fit the actual value of 1.70 m/s*s well.

After object A hit the ground—We predicted that the car would have zero acceleration during this portion of its motion and that its velocity would be equal to its final velocity, just as object A hit the ground. Again, we used the equation $x = x_0 + v_0t +$

$1/2at^2$ to describe the predicted motion, with x_0 and a both equal to zero. We predicted the velocity to be $v= \sqrt{2xg[m_a/(m_c+m_a)]}$, or 1.167m/s. This prediction was very close to the actual value. We predicted that for the velocity vs. time graph, the velocity would stay constant at 0.167m/s, and our prediction was very close to the actual best-fit line equation.

5. Discussion--

Results- The acceleration of the car in the experiment is dependant on the block falling. Before the block hits the ground, the car accelerates because of the falling block. The acceleration of the block and the car is the same because the same tension force acts them upon. Their accelerations are equal to $[m_a/(m_c+m_a)]g$, where m_a is the mass of object a (the block), m_c is the mass of the car, and g is the acceleration due to gravity, 9.8m/s*s. The velocity of the car and of object a at the time when object a hits the ground is equal to $\sqrt{2xg[m_a/(m_c+m_a)]}$.

After the block hit the ground there would no longer be any tension in the string and the sum of the forces on the car would be equal, (since T=0 and F_g =-F_N). Because F=ma, the car would have no acceleration. Its velocity would continue to be equal to $\sqrt{2xg[m_a/(m_c+m_a)]}$.

Error- Error resulted from our collection of data points again. It is difficult to click on exactly the same point of the car each time and to click on the same y value along the track each time as well. This results in distortion of the position measurements and velocities calculated. There is not much that can be done about this, except that we should try to be very precise in future collection of data points. Also, the camera could have caused a slight distortion of the collected data values. In this experiment, we neglected the friction between the car and the track and between the pulley and the string. This made the calculations a lot easier, but it caused our predicted value for the acceleration of the car and the block to be different than the actual value.

Improvements- It would be optimal to do many trials of this experiment, using different values for m_c, m_a and x, to check that the equations really fit, but time is an issue. With more precise data collection, we could have eliminated some of the movement and velocity seen along the y-axis.

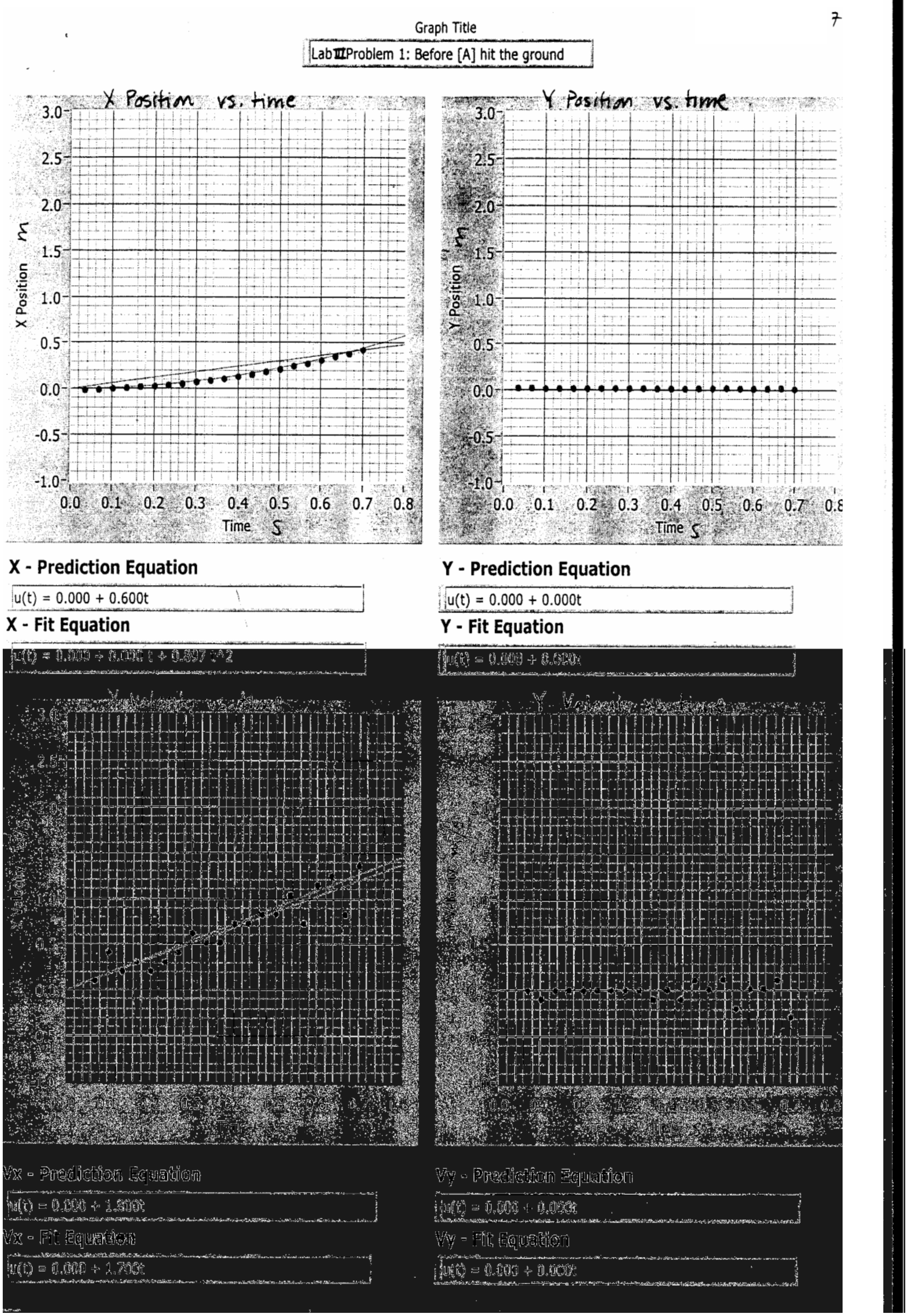
6. Conclusions-- Using physics principles and equations, we predicted that the velocity of car pulled a known distance by a falling object would be equal to $\sqrt{2xg[m_a/(m_c+m_a)]}$.

where x is equal to the distance the object falls, g is equal to gravity (9.8m/s*s), m_a is the mass of the object falling and m_c is equal to the mass of the car being pulled. Since the tension forces on each object are the same, they have the same acceleration and this can be predicted using Newton's second law and kinematics equations. The results of our experiment confirmed this.

In each case but one, the predicted values for the components of the equations of the graphs were the same or close to the actual ones. When we predicted the value for acceleration of the car before the block hit the ground, we didn't figure any friction into the calculations. We based all of our future predictions off of the actual values we got for this graph's equation and they all matched the actual values well.

The launch velocity of the car does depend on the mass of the car, the mass of the block and the distance the block falls, according to $v = \sqrt{2xg[m_a/(m_c + m_a)]}$. For values of m_a that are much larger than m_c, m_c does not affect v very much, since $[m_a/(m_c + m_a)]$ becomes very close to 1.

The tension force upon the car and the block is dependent on the masses of both objects. Changing the mass of either one will change the tension force exerted on both. The tension force on the block is equal to its weight if the block has no net acceleration; in other words, when $T = F_g$. This would happen if the mass of the block was zero, and since it could never have zero mass, it would never happen in a frictionless system. It may come close to zero though, and would reach zero in a system with friction. We could test this experimentally by using a car with a very large mass and using blocks of decreasing masses. The acceleration of the car should go toward zero as the mass of the blocks decrease.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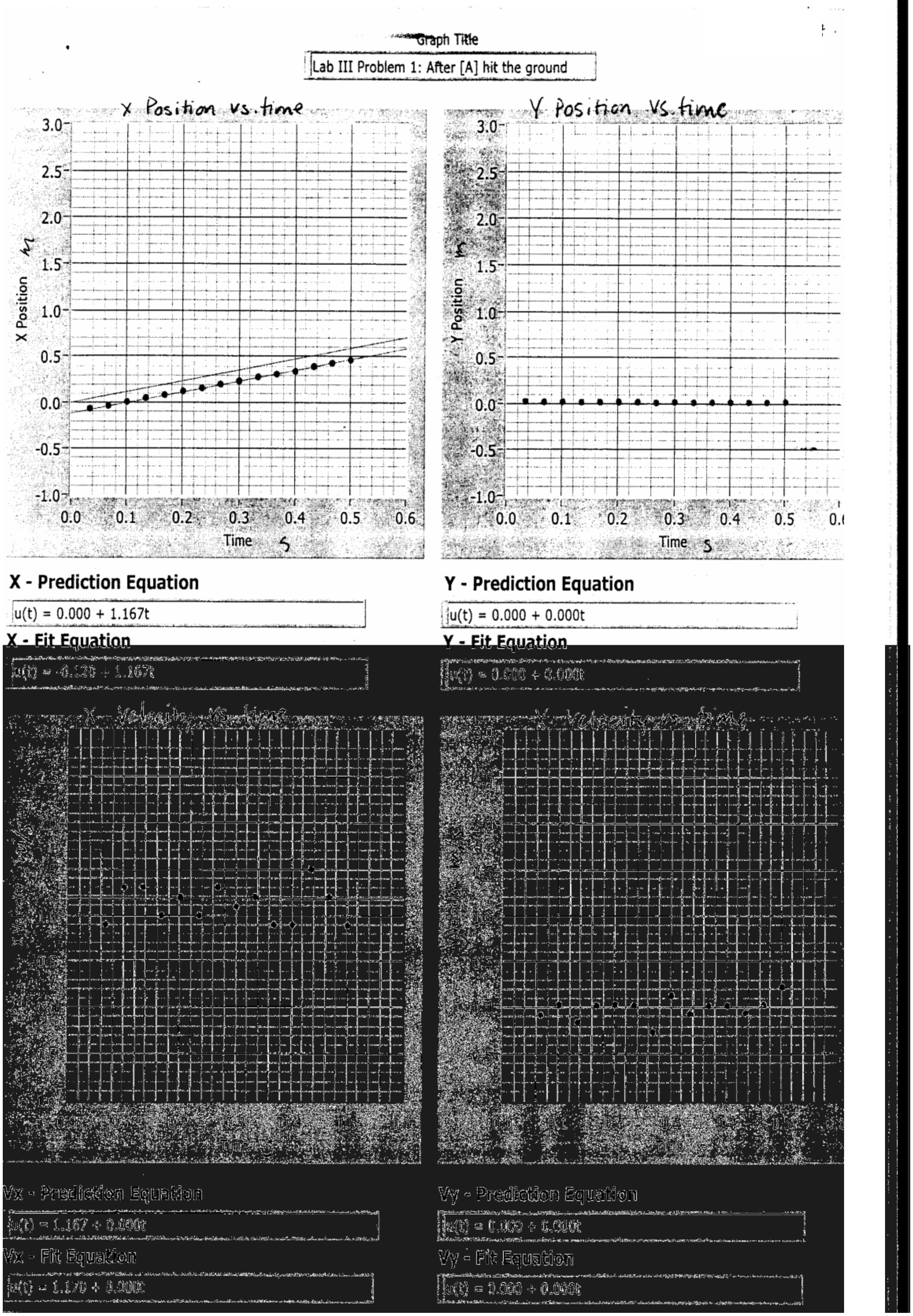
Graph Title
LabIIIProblem 1: Before [A] hit the ground
X Position vs. time
Y Position vs. time
X - Prediction Equation
u(t) = 0.000 + 0.600t
X - Fit Equation
Y - Prediction Equation
u(t) = 0.000 + 0.000t
Y - Fit Equation
Vx - Prediction Equation
Vx - Fit Equation
Vy - Prediction Equation
Vy - Fit Equation


Graph Title
Lab III Problem 1: After [A] hit the ground
X Position vs. time
X Position m
Time s
Y Position vs. time
Y Position m
Time s
X - Prediction Equation
u(t) = 0.000 + 1.167t
Y - Prediction Equation
u(t) = 0.000 + 0.000t
X - Fit Equation
u(t) = -0.120 + 1.167t
Y - Fit Equation
u(t) = 0.000 + 0.000t
X Velocity vs. time
Y Velocity vs. time
Vx - Prediction Equation
u(t) = 1.167 + 0.000t
Vy - Prediction Equation
Vx - Fit Equation
u(t) = 1.170 + 0.000t
Vy - Fit Equation