Homework

Homework #1: Analyzing Students' Alternative Conceptions

Part A. Analyzing Force Concept Inventory Questions:

The top of each attached page shows a question from the Force Concept Inventory. The "Pre" and "Post" columns show the percentage of students in the calculus-based course that selected each of the possible answers on the pretest (given at the beginning of the term) and the posttest (at the end of ten weeks of instruction).

For each question:

a. Describe briefly how a student might be thinking who selected each incorrect answer. (Hint: Review the alternative conceptions from the McDermott and Wandersee et. al., articles.)
b. Which of the possible "alternative conceptions" were successfully addressed by instruction? Which were not?

1.

Question 30

Despite a very strong wind, a tennis player manages to hit a tennis ball with her racquet so that the ball passes over the net and lands on her opponent's court.
Consider the following forces:

1. **A downward force of gravity.**
2. **A force by the "hit".**
3. **A force exerted by the air.**

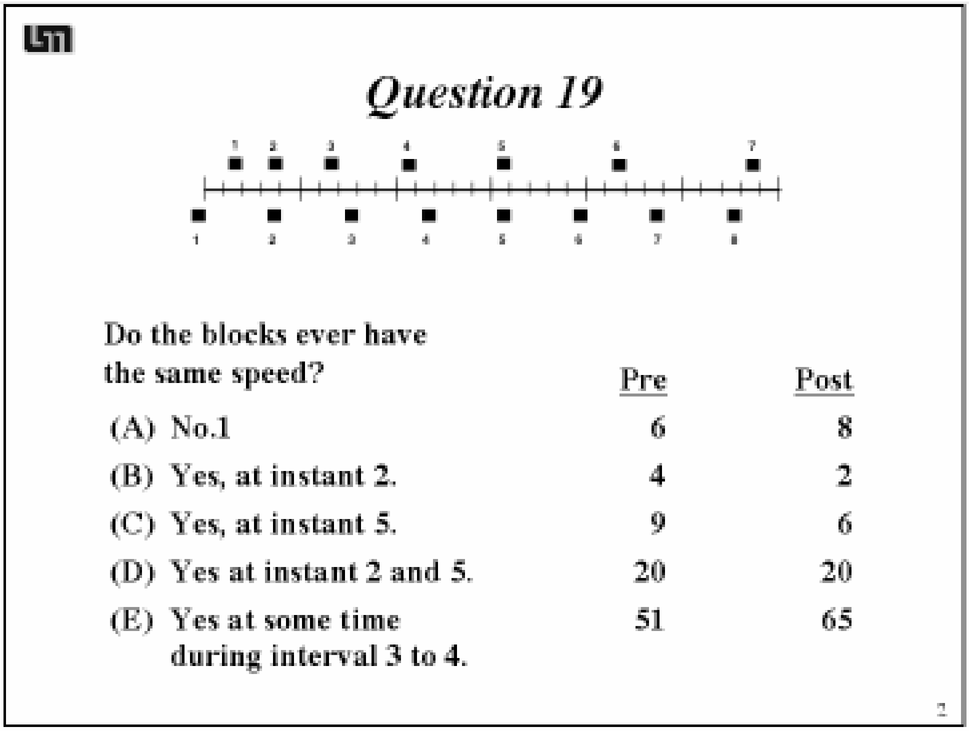
Which following force(s) is (are) acting on the tennis ball after it has left contact with the racquet and before it touches the ground?

	Pre	Post
(A) 1 only	2	10
(B) 1 and 2	4	7
(C) 1 and 3	18	46
(D) 2 and	3	11
(E) 1, 2, and 3	75	36

a. Describe briefly how a student might be thinking who gives each incorrect answer.

b. Which of these "alternative conceptions" were successfully addressed by instruction? Which were not?

2.



a. Describe briefly how a student might be thinking who gives each incorrect answer.

b. Which of these "alternative conceptions" were successfully addressed by instruction? Which were not?

3.

Question 4

A large truck collides head-on with a small compact car.
During the collision,

	Pre	Post
(A) the truck exerts a greater amount of force on the car than the car exerts on the truck	79	46
(B) the car exerts a greater amount of force on the truck than the truck exerts on the car.	2	1
(C) neither exerts a force on the other, the car gets smashed simply because it gets in the way of the truck.	0	0
(D) the truck exerts a force on the car, but the car doesn't exert a force on the truck.	0	0
(E) the truck exerts the same amount of force on the car as the car exerts on the truck.	19	53

6

a. Describe briefly how a student might be thinking who gives each incorrect answer.

b. Which of these "alternative conceptions" were successfully addressed by instruction? Which were not?

Part B. Analyzing Open-Ended Questions:

The attached sheets contain student responses to two open-ended questions given to students in the calculus-based course as a **posttest** (after ten weeks of instruction).

1. First read through the responses of Students #1, #2 and #3. These students wrote fairly good and complete answers to the questions.

2. Now read through the remainder of the student answers.
   - What is one thing that surprised you about these responses? Why?
   - What is one thing that did not surprise you? Why?

3. Read through the responses again, and answer the first three questions on the next page.

4. Imagine you were tutoring the student assigned to your group. What example situation, reference to a common experience students are likely to have, or set of questions do you think might help move the student away from their alternative conception(s)? Discuss.

Answer Sheet

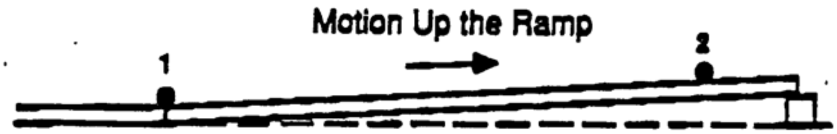
1. What conceptual difficulties do Students #4, #5 and #6 have with the concept of acceleration? (Hint: You may want to look at the McDermott article, page 27).

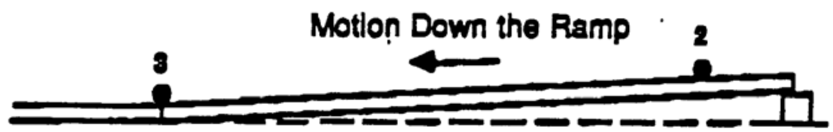
2. Which students' responses to the passenger/car questions indicate a **forward** force on the passenger or car which is a "pseudo-force" or non-Newtonian force (i.e., not caused by the interaction of the passenger or car with real objects). What might these students be thinking to indicate these non-Newtonian forces? What is your evidence?

3. Which students' responses to the passenger/car questions indicate a **backward** force on the passenger or car which is a "pseudo-force" or non-Newtonian force (i.e., not caused by the interaction of the passenger or car with real objects). What might these students be thinking to indicate these non-Newtonian forces? What is your evidence?

4. What example situation, reference to a common experience students are likely to have, or set of questions do you think might help move Student # ____ away from their alternative conception(s)?

The following questions are for course evaluation purposes only and will not be graded. They will help us evaluate how well we met your learning needs this course.





1. A steel ball is launched with some initial velocity, slows down as it travels up a gentle incline, reverses direction, and then speeds up as it returns to its starting point. Assume friction is negligible.

(a) Suppose we calculated the acceleration of the ball as it's moving *up* the ramp (from 1 to 2), and the acceleration as it's moving *down* the ramp (from 2 to 3). How would these two accelerations compare? (i.e., Are the accelerations the same size? The same direction?) Explain your reasoning.

The acceleration of the ball as it moves up the ramp would be an acceleration of the same direction as it moved down the ramp. They would also be of the same size, because the slope of the ramp is constant throughout the event.

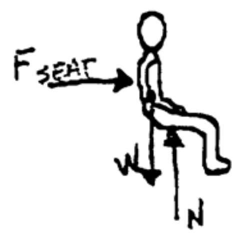
(b) Does the ball have an acceleration at it's highest point on the incline (at position 2)? Explain your reasoning.

Yes, ~~at~~ its highest point the acceleration is still the same as before, the velocity however is 0.

Student #1

3. You are a passenger in a car which is traveling on a straight road while it is increasing speed from 30 mph to 55 mph. You wonder what forces cause you and the car to accelerate. When you pull over to eat, you decide to figure it out.

(a) On the left side of the table below, draw and label arrows representing all the forces acting on *you* (passenger) while the car is accelerating. The length of the arrows should indicate the relative sizes of the forces (i.e., a larger force should be represented by a clearly longer arrow, equal forces by arrows of equal length). On the right side of the table, describe each force in words (i.e., What kind of force is it? Is the force a push or a pull? What object, if any, is exerting the force? What object is being affected by the force?).

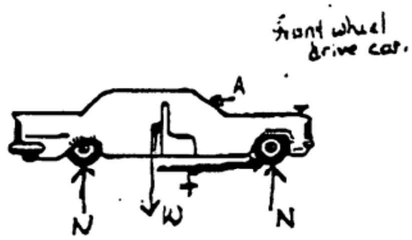
You (Passenger)	Description of Each Force
	F_{SEAT} = FORCE OF THE SEAT PUSHING YOU AS THE CAR ACCELERATES. PUSH W = GRAVITATIONAL FORCE OF EARTH ON YOU. PULL N = NORMAL FORCE OF SEAT PUSHING ON YOU.

(b) Which force(s) cause you (passenger) to accelerate? Explain your reasoning.

F_{SEAT} CAUSES YOU TO ACCELERATE BECAUSE IT IS NOT COUNTERACTED BY ANY OTHER FORCES.

Student #2

(c) On the left side of the table below, draw and label arrows representing all the forces acting on the *car* while it is accelerating. The length of the arrows should indicate the relative sizes of the forces (i.e., a larger force should be represented by a clearly longer arrow, equal forces by arrows of equal length). On the right side of the table, describe each force in words (i.e., What kind of force is it? Is the force a push or a pull? What object, if any, is exerting the force? What object is being affected by the force?).

Car	Description of Each Force
 	W = the gravitational pull of the earth on the car N = the support force of the road on the car, distributed evenly on all four tires. A = the drag force of the air on the car as it moves forward. f = the frictional force of the road on the tires causing forward motion.

(d) Which force(s) cause the car to accelerate? Explain your reasoning.

The frictional force of the road on the tires causes the car to accelerate. The tires are moving in that direction and if there where no friction, they would just spin. Since there is friction between the road and tires it acts in → this direction causing the car to move forward. This is static friction.

Student #3

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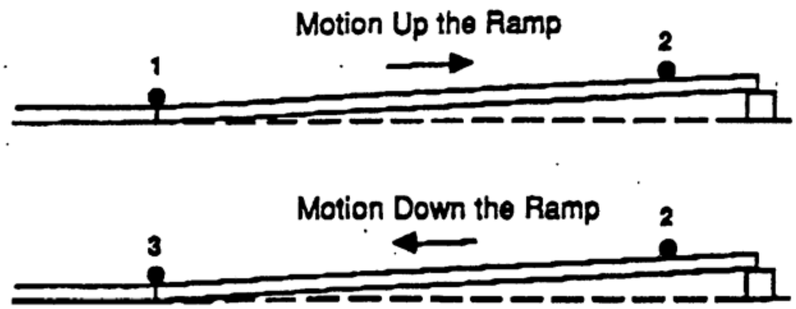


1. A steel ball is launched with some initial velocity, slows down as it travels up a gentle incline, reverses direction, and then speeds up as it returns to its starting point. Assume friction is negligible.

(a) Suppose we calculated the acceleration of the ball as it's moving *up* the ramp (from 1 to 2), and the acceleration as it's moving *down* the ramp (from 2 to 3). How would these two accelerations compare? (i.e., Are the accelerations the same size? The same direction?) Explain your reasoning.

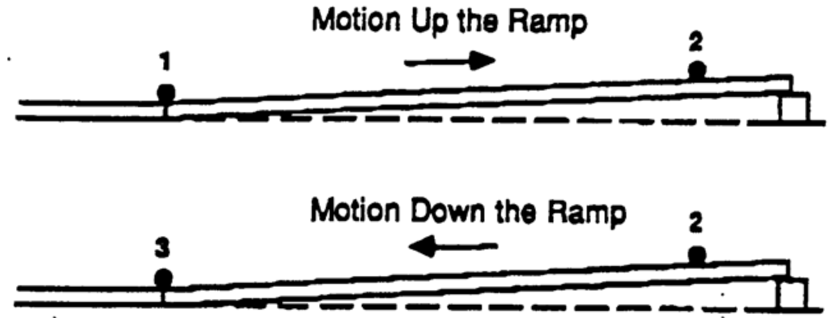
The acceleration of the ball from 2 to 3 would be larger than the acceleration of the ball from 1 to 2 because it takes more work for the ball to go up the ramp than to go down the ramp. The accelerations would be in the same direction.

(b) Does the ball have an acceleration at it's highest point on the incline (at position 2)? Explain your reasoning.

No, it does not, it must stop, at least for a second, so it can reverse its direction.

Student #4

The following questions are for course evaluation purposes only and will not be graded. They will help us evaluate how well we met your learning needs this course.



1. A steel ball is launched with some initial velocity, slows down as it travels up a gentle incline, reverses direction, and then speeds up as it returns to its starting point. Assume friction is negligible.

(a) Suppose we calculated the acceleration of the ball as it's moving *up* the ramp (from 1 to 2), and the acceleration as it's moving *down* the ramp (from 2 to 3). How would these two accelerations compare? (i.e., Are the accelerations the same size? The same direction?) Explain your reasoning.

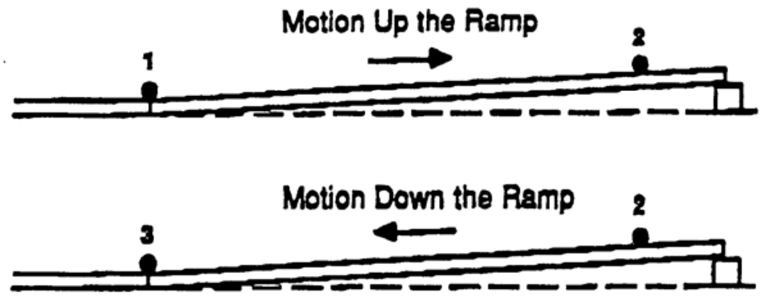
The accelerations are in opposite directions. One is positive by going down the ramp and gaining speed, but the other is negative by going up the ramp and then slowing down.

(b) Does the ball have an acceleration at it's highest point on the incline (at position 2)? Explain your reasoning.

At the point the ball turns around, there will be no acceleration since at this point $v=0$. The acceleration will start once again as the ball starts moving down the incline

Student # 5

The following questions are for course evaluation purposes only and will not be graded. They will help us evaluate how well we met your learning needs this course.



1. **A steel ball is launched with some initial velocity, slows down as it travels up a gentle incline, reverses direction, and then speeds up as it returns to its starting point. Assume friction is negligible.**

(a) Suppose we calculated the acceleration of the ball as it's moving *up* the ramp (from 1 to 2), and the acceleration as it's moving *down* the ramp (from 2 to 3). How would these two accelerations compare? (i.e., Are the accelerations the same size? The same direction?) Explain your reasoning.

To compare the two accelerations we would find the magnitudes to be approximately the same, to give the acceleration direction you must consider which way the motion is in relation to acceleration. So from one to two there is a negative acceleration because the acceleration is in the opposite direction of motion. From two to three acceleration is positive because it is the same direction as the motion.

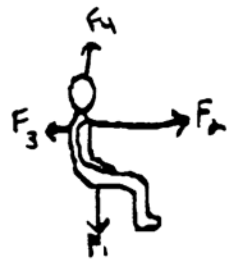
(b) Does the ball have an acceleration at it's highest point on the incline (at position 2)? Explain your reasoning.

The magnitude of the ball at point 2 is zero. With the ball at this point, the direction of motion is changing so acceleration doesn't exist at that instantaneous position.

Student # 6

3. You are a passenger in a car which is traveling on a straight road while it is increasing speed from 30 mph to 55 mph. You wonder what forces cause you and the car to accelerate. When you pull over to eat, you decide to figure it out.

(a) On the left side of the table below, draw and label arrows representing all the forces acting on *you* (passenger) while the car is accelerating. The length of the arrows should indicate the relative sizes of the forces (i.e., a larger force should be represented by a clearly longer arrow, equal forces by arrows of equal length). On the right side of the table, describe each force in words (i.e., What kind of force is it? Is the force a push or a pull? What object, if any, is exerting the force? What object is being affected by the force?).

You (Passenger)	Description of Each Force
	F_1 = force of gravity by earth (Pull) F_2 = force from acceloration of car (Pull) F_3 = force of inertia pulling back F_4 = Normal force from seat (Push)

(b) Which force(s) cause you (passenger) to accelerate? Explain your reasoning.

The force from the car causes you to accelorate, because it is longer than the inertial force

Student # 7

3. You are a passenger in a car which is traveling on a straight road while it is increasing speed from 30 mph to 55 mph. You wonder what forces cause you and the car to accelerate. When you pull over to eat, you decide to figure it out.

(a) On the left side of the table below, draw and label arrows representing all the forces acting on *you* (passenger) while the car is accelerating. The length of the arrows should indicate the relative sizes of the forces (i.e., a larger force should be represented by a clearly longer arrow, equal forces by arrows of equal length). On the right side of the table, describe each force in words (i.e., What kind of force is it? Is the force a push or a pull? What object, if any, is exerting the force? What object is being affected by the force?).

You (Passenger)	Description of Each Force
	The push force from the back of the car seat is equal to the push force from your back while the car accelerates. The the force of gravity pull is equal to the normal force of the seat bottom pushing up on you

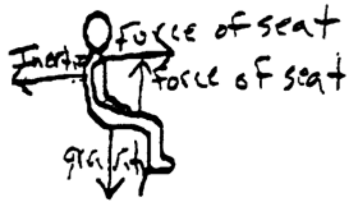
(b) Which force(s) cause you (passenger) to accelerate? Explain your reasoning.

The force of the car seat pushing you along with the car.

Student #8

3. **You are a passenger in a car which is traveling on a straight road while it is increasing speed from 30 mph to 55 mph. You wonder what forces cause you and the car to accelerate. When you pull over to eat, you decide to figure it out.**

(a) **On the left side of the table below, draw and label arrows representing all the forces acting on *you* (passenger) while the car is accelerating. The length of the arrows should indicate the relative sizes of the forces (i.e., a larger force should be represented by a clearly longer arrow, equal forces by arrows of equal length). On the right side of the table, describe each force in words (i.e., What kind of force is it? Is the force a push or a pull? What object, if any, is exerting the force? What object is being affected by the force?).**

You (Passenger)	Description of Each Force
	Inertia - the car is accelerating forward, but your body wants to stay in its original position, and you are pushed into the seat. Gravity - gravity pushes you into the seat and holds you in the car Force of seat - seat pushing back on you as you try to resist motion

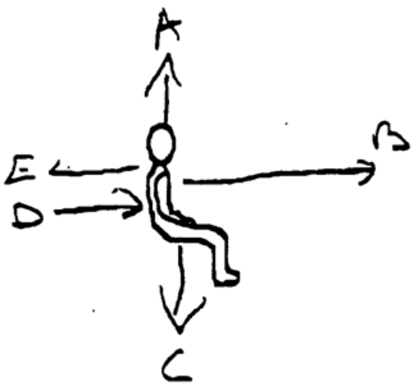
(b) **Which force(s) cause you (passenger) to accelerate? Explain your reasoning.**

The force of the seat propels you forward ~~[illegible]~~ The force of the accelerating car is transferred to the seat, which is part of the car

Student # 9

3. You are a passenger in a car which is traveling on a straight road while it is increasing speed from 30 mph to 55 mph. You wonder what forces cause you and the car to accelerate. When you pull over to eat, you decide to figure it out.

(a) On the left side of the table below, draw and label arrows representing all the forces acting on *you* (passenger) while the car is accelerating. The length of the arrows should indicate the relative sizes of the forces (i.e., a larger force should be represented by a clearly longer arrow, equal forces by arrows of equal length). On the right side of the table, describe each force in words (i.e., What kind of force is it? Is the force a push or a pull? What object, if any, is exerting the force? What object is being affected by the force?).

You (Passenger)	Description of Each Force
	A: force of earth on seat B: Force of the engine C. Force of gravity D. Force of seat E. Force you exert on seat

(b) Which force(s) cause you (passenger) to accelerate? Explain your reasoning.

E, D, A, C they keep you in the seat

Student #10

3. You are a passenger in a car which is traveling on a straight road while it is increasing speed from 30 mph to 55 mph. You wonder what forces cause you and the car to accelerate. When you pull over to eat, you decide to figure it out.

(a) On the left side of the table below, draw and label arrows representing all the forces acting on *you* (passenger) while the car is accelerating. The length of the arrows should indicate the relative sizes of the forces (i.e., a larger force should be represented by a clearly longer arrow, equal forces by arrows of equal length). On the right side of the table, describe each force in words (i.e., What kind of force is it? Is the force a push or a pull? What object, if any, is exerting the force? What object is being affected by the force?).

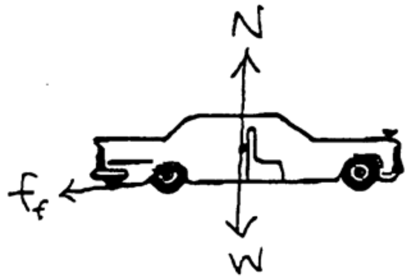
You (Passenger)	Description of Each Force
	F_g = force of gravity F_N = Normal force F_R = Force of resistance ~~[illegible]~~ (inertia) F_F = Force Forward from engine.

(b) Which force(s) cause you (passenger) to accelerate? Explain your reasoning.

F_f ⇒ the engine.
force of the, transmitted via the car.

Student #11

(c) **On the left side of the table below, draw and label arrows representing all the forces acting on the *car* while it is accelerating. The length of the arrows should indicate the relative sizes of the forces (i.e., a larger force should be represented by a clearly longer arrow, equal forces by arrows of equal length). On the right side of the table, describe each force in words (i.e., What kind of force is it? Is the force a push or a pull? What object, if any, is exerting the force? What object is being affected by the force?).**

Car	**Description of Each Force**
	N= normal force f_f= frictional force between road + tire. W= gravitational pull of earth on the car.

(d) **Which force(s) cause the car to accelerate? Explain your reasoning.**

The frictional force and gravitational pull cause the car to accelerate. The frictional force between the tires and the road allow the car to move forward and accelerate.

Student #12

(c) On the left side of the table below, draw and label arrows representing all the forces acting on the *car* while it is accelerating. The length of the arrows should indicate the relative sizes of the forces (i.e., a larger force should be represented by a clearly longer arrow, equal forces by arrows of equal length). On the right side of the table, describe each force in words (i.e., What kind of force is it? Is the force a push or a pull? What object, if any, is exerting the force? What object is being affected by the force?).

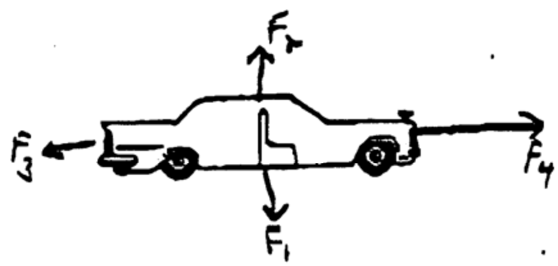
Car	Description of Each Force
	FF - the force of friction the car + the road exert. F - the force caused by the cars mass and acceleration

(d) Which force(s) cause the car to accelerate? Explain your reasoning.

The force of motion causes the car to accelerate
Because of the force of motion + the mass of the car, it accelerates.

Student #13

(c) On the left side of the table below, draw and label arrows representing all the forces acting on the *car* while it is accelerating. The length of the arrows should indicate the relative sizes of the forces (i.e., a larger force should be represented by a clearly longer arrow, equal forces by arrows of equal length). On the right side of the table, describe each force in words (i.e., What kind of force is it? Is the force a push or a pull? What object, if any, is exerting the force? What object is being affected by the force?).

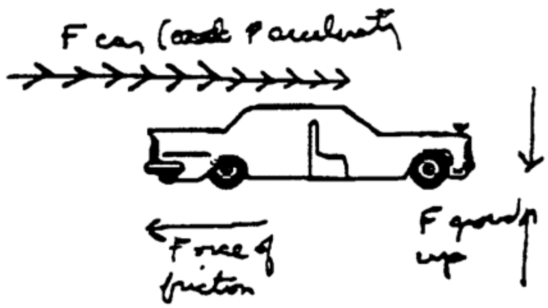
Car	Description of Each Force
	F_1 = Force of gravity from earth (Pull) F_2 = Normal force from road (Push) F_3 = Force of friction from road + tires (Pull) F_4 = accelerating force from car's motor (Pull)

(d) Which force(s) cause the car to accelerate? Explain your reasoning.

The force from the motor because it exceeds the force of friction.

Student #14

(c) On the left side of the table below, draw and label arrows representing all the forces acting on the *car* while it is accelerating. The length of the arrows should indicate the relative sizes of the forces (i.e., a larger force should be represented by a clearly longer arrow, equal forces by arrows of equal length). On the right side of the table, describe each force in words (i.e., What kind of force is it? Is the force a push or a pull? What object, if any, is exerting the force? What object is being affected by the force?).

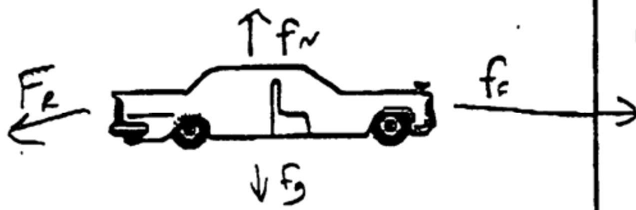
Car	Description of Each Force
	The force of car increase as the car accelerate. F car down = F ground up Force of friction = F ground up but act against F(car) accelerating.

(d) Which force(s) cause the car to accelerate? Explain your reasoning.

Force of friction + F car down + F ground up (normal force) all helps the car ~~to~~ accelerate because the F of friction act in the opposite direction which gives the car a means of accelerating.

Student #15

(c) **On the left side of the table below, draw and label arrows representing all the forces acting on the *car* while it is accelerating. The length of the arrows should indicate the relative sizes of the forces (i.e., a larger force should be represented by a clearly longer arrow, equal forces by arrows of equal length). On the right side of the table, describe each force in words (i.e., What kind of force is it? Is the force a push or a pull? What object, if any, is exerting the force? What object is being affected by the force?).**

Car	Description of Each Force
	F_N ⇒ normal, opposite to F_g F_g ⇒ force of gravity F_f ⇒ force forward from ~~a~~ engine F_R ⇒ force of resistance (air, friction)

(d) **Which force(s) cause the car to accelerate? Explain your reasoning.**

F_f, force forward no other choice.

Student #16

Homework #3: Solving Problems Using Your Problem Solving Framework

Note: Before you do this homework, complete the reading assignments:

Competent Problem Solver. Read/skim the brief descriptions and examples:

- Pictures and motion diagrams: pages 1-4 to 1-5; pages 1-8 to1-9; pages 2-4 and 2-12; pages 2-6 and 2-14; and pages 3-6 to 3-13 (17 pages)
- Free-body and force diagrams: pages 4-1 through 421 (21 pages)

Instructor's Handbook. Teaching a Discussion Session

- Overview of Teaching a Discussion Section (2 pages)
- Outline for Teaching Discussion Sessions (1 page)
- Detailed Advice for Teaching Discussion Sessions (4.5 pages)
- Some Teaching Tools

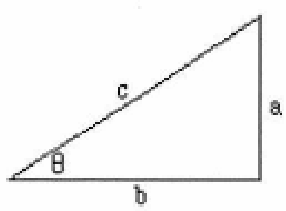
Imagine that you have been asked by your professor to write solutions for the five discussion session problems on the following pages. The solutions will be photocopied and passed out to all the students in the course at the end of each discussion session.

Solve each problem **by following the problem-solving framework** you designed in TA Orientation last Friday. Write your solutions on the answer sheets that you designed. Be sure to include motion diagrams and/or both free-body and force diagrams. Use the agent-object notation for the forces (in *Readings*, Hughes, 2002).

You can use only the fundamental concepts and equations for special conditions that your students would know at the time you give them each problem to solve. You would write these equations on the board (or they would be included with the problem) before your groups started solving the problem. Imagine also that you want to model solving problems based on *principles and concepts*, instead of the memorized plug-and-chug or pattern-matching "formulas." So you decide to limit the kinematics equations to three, independent equations.

You may find the following information useful in solving the problems.

Useful Mathematical Relationships:



For a right triangle: $\sin\theta = \frac{a}{c}$, $\cos\theta = \frac{b}{c}$, $\tan\theta = \frac{a}{b}$,

$a^2 + b^2 = c^2$, $\sin^2\theta + \cos^2\theta = 1$, $\sin 2\theta = 2\sin\theta\cos\theta$

For a circle: $C = 2\pi R$, $A = \pi R^2$

For a sphere: $A = 4\pi R^2$, $V = \frac{4}{3}\pi R^3$

If $Ax^2 + Bx + C = 0$, then $x = \dfrac{-B \pm \sqrt{B^2 - 4AC}}{2A}$

Useful constants: 1 mile = 5280 ft, 1km = 5/8 mile, $g = 9.8\ m/s^2 = 32\ ft/s^2$

1. **Runner Problem.** Chris and Alex are practicing for their next competition race. Chris runs at a constant speed of 3 meters/second down a long straight road. After 5 minutes, Alex starts from the same place and runs at a faster constant speed of 4 meters/second. How far from the starting point will the runners be when Alex catches up to Ken?

   Remember to use only the equation shown below.

   Fundamental Concept: $v_{x\ av} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_o}{t_f - t_o}$

2. **Traffic Accident Problem:** You have a summer job with an insurance company and are helping to investigate a tragic "accident." At the scene, you see a road running straight down a hill that is at 10° to the horizontal. At the bottom of the hill, the road widens into a small, level parking lot overlooking a cliff. The cliff has a vertical drop of 400 feet to the horizontal ground below where a car is wrecked 30 feet from the base of the cliff. A witness claims that the car was parked on the hill and began coasting down the road, taking about 3 seconds to get down the hill. Your boss drops a stone from the edge of the cliff and, from the sound of it hitting the ground below, determines that it takes 5.0 seconds to fall to the bottom. You are told to calculate the car's average acceleration coming down the hill based on the statement of the witness and the other facts in the case. Obviously, your boss suspects foul play.

   Remember to use only the equations shown below.

   Fundamental Concepts: $v_{x\ av} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_o}{t_f - t_o}$ $\quad a_{x\ av} = \frac{\Delta v_x}{\Delta t} = \frac{v_{xf} - v_{xo}}{t_f - t_o}$

   Under Certain Conditions: $x_f = \frac{1}{2}a_x(\Delta t)^2 + v_{xo}(\Delta t) + x_o$

3. **Ice Skating Problem:** You are taking care of two small children, Sarah and Rachel, who are twins. On a nice cold, clear day, you decide to take them ice skating on Lake of the Isles. To travel across the frozen lake you have Sarah hold your hand and Rachel's hand. The three of you form a straight line as you skate, and the two children just glide. Sarah must reach up at an angle of 60 degrees to grasp your hand, but she grabs Rachel's hand horizontally. Since the children are twins, they are the same height and the same weight, 50 lbs. To get started you accelerate at 2.0 m/s^2. You are concerned that the force on the children's arms might cause shoulder damage. So you calculate the force Sarah exerts on Rachel's arm, and the force you exert on Sarah's other arm. You assume that the frictional forces of the ice surface on the skates are negligible.

   Remember to use only the equations shown at the top of the next page.

Fundamental Concepts:

$$v_{x\ av} = \frac{\Delta x}{\Delta t} = \frac{x_f - x_o}{t_f - t_o} \qquad a_{x\ av} = \frac{\Delta v_x}{\Delta t} = \frac{v_{xf} - v_{xo}}{t_f - t_o}$$

$$\sum F_x = ma_x \qquad F_{12} = F_{21}$$

Under Certain Conditions:

$$x_f = \frac{1}{2}a_x(\Delta t)^2 + v_{xo}(\Delta t) + x_o \qquad F = mg \qquad F = \mu_{sliding}N \qquad F \le \mu_{static}N$$

4. A 20-Kg block is pulled along a horizontal table by a light cord that extends horizontally from the block over a pulley attached to the end of the table, and then down to a hanging 10-Kg block. The coefficient of static friction between the 20-Kg block and the table surface is 0.80, and the coefficient of kinetic friction is 0.40. Determine the speed of the blocks after moving 2 meters. They start at rest.

   Remember to use only the equations shown at the top of this page.

5. You have taken a summer job at a warehouse and have designed a method to help get heavy packages up a 15° ramp. A package is attached to a thin cable that runs parallel to the ramp and over a pulley at the top of the ramp. After passing over the pulley, the other end of the cable is attached to a counterweight that hangs straight down. In your design, the mass of the counterweight is always adjusted to be twice the mass of the package, so the packages will accelerate up the ramp. Your boss is worried that the thin cable will break, so she asks you to calculate the tension in the cable for the maximum mass of a package, 50 kg. You run some tests and determine that the coefficient of kinetic friction for a package on the ramp is 0.51, and the coefficient of static friction is 0.85.

   Remember to use only the equations shown at the top of this page.

Initial Evaluation of Example Student Laboratory Reports

Before you start this homework, read the article by S. Allie, A. Buffler, L. Kunda, and M. Inglis, Writing Intensive Physics Laboratory Reports: Tasks and Assessment (Selected Readings). In this homework you will you will go through 2 examples of student laboratory reports and evaluate their quality.

Homework Tasks:

1. Come up with words and characteristics that describe what you consider to be "good" and "bad" writing.

2. Using the descriptions that you came up with in step 1, evaluate the following 2 example student laboratory reports.

3. Mark down any and all comments on the example student laboratory reports, and indicate whether it is "good" or "bad" based on your description.

Note: This homework is to elicit your initial ideas on how to evaluate student laboratory reports. In class we will discuss, model, and coach grading lab reports.

Defining "Good" & "Bad" Writing

What words or characteristics come to mind when trying to define "good" writing?

What words or characteristics come to mind when trying to define "bad" writing?

Example #1

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 $V=\sqrt{(2M_a gh)/(M_a+M_c)}$

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.

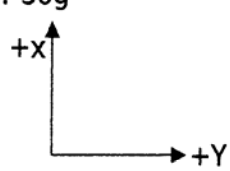
Data and Results:

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.

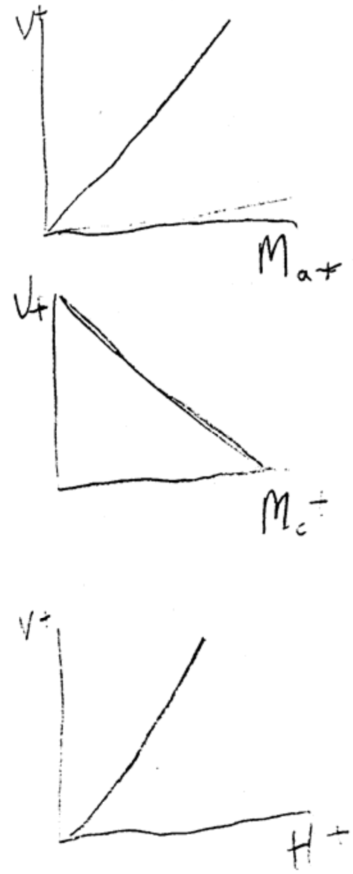
Conclusions:

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.

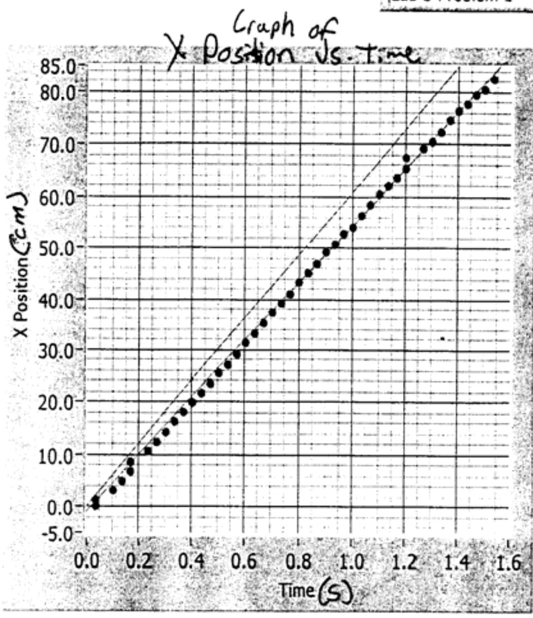
Prediction graphs

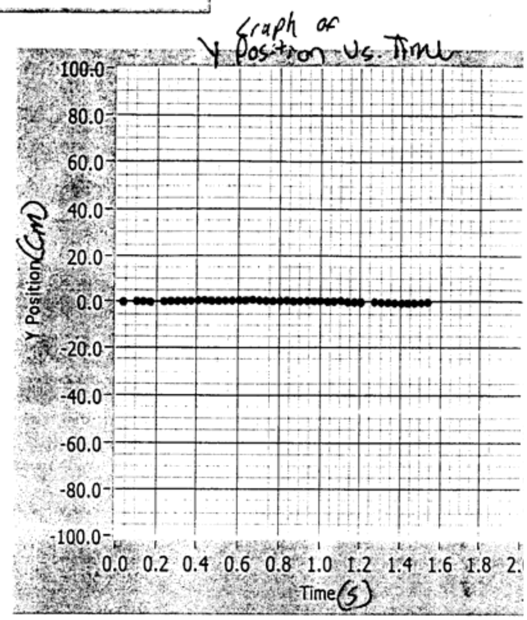


7

Graph Title

Lab 3 Problem 1





X - Prediction Equation

u(t) = 0.000 + 60.500t

X - Fit Equation

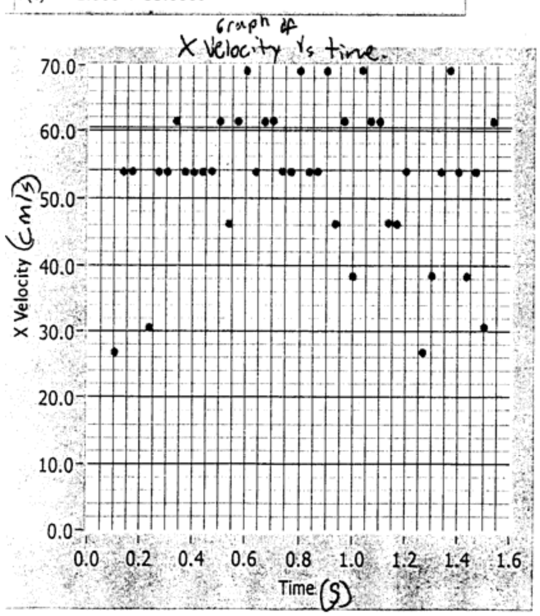
u(t) = -1.000 + 55.000t

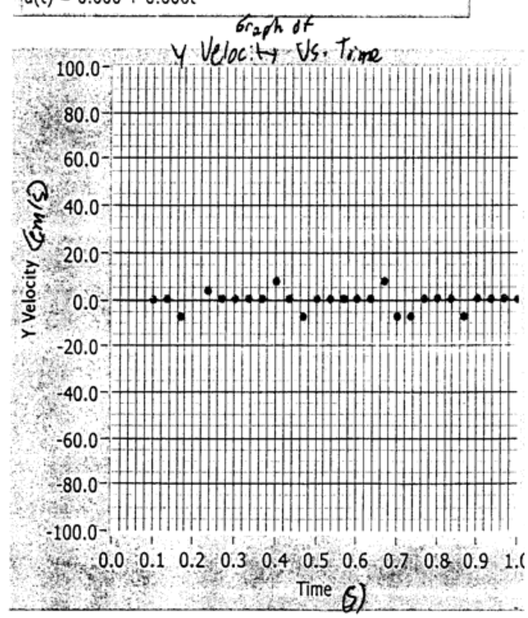
Y - Prediction Equation

u(t) = 0.000 + 0.000t

Y - Fit Equation

u(t) = 0.000 + 0.000t





Vx - Prediction Equation

u(t) = 60.500 + 0.000t

Vx - Fit Equation

u(t) = 54.000 + 0.000t

Vy - Prediction Equation

u(t) = 0.000 + 0.000t

Vy - Fit Equation

u(t) = 0.000 + 0.000t

Example #2

uist
109
002

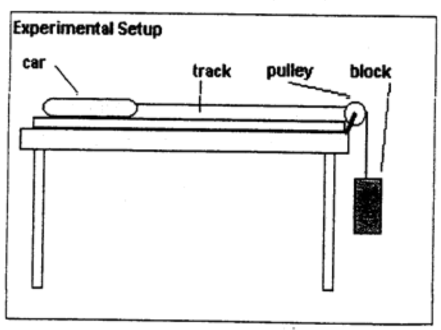
Lab III Problem 1: Force and Motion

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.

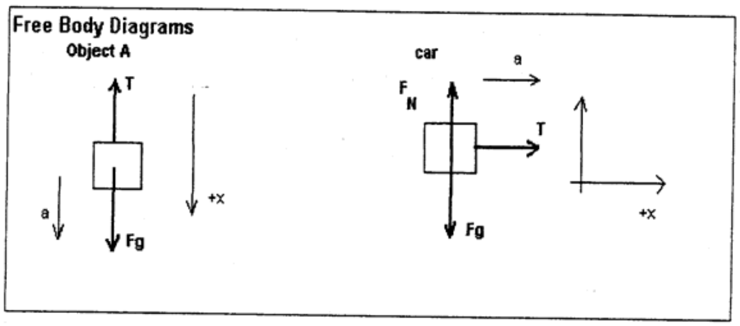
The block (called object A) has a significantly shorter distance to fall than the car has to travel along its track. In this experiment, we ignored the friction between the car and the track and between the pulley and the string. We also ignored the mass of the string.



2. Prediction --

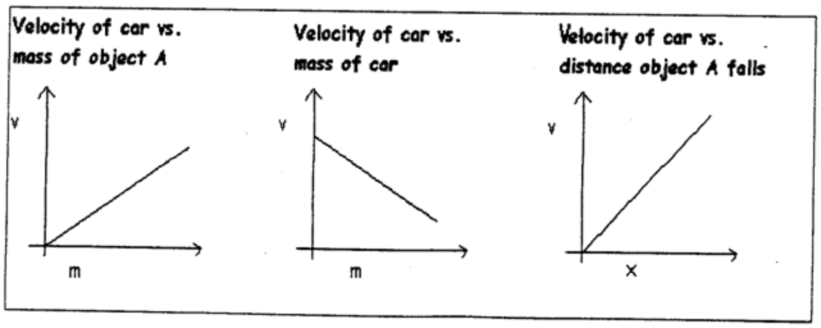
The first question asked me to calculate the cart's velocity after the block had hit the ground. I predicted that $\mathbf{v_c} = \sqrt{\mathbf{2xg[m_a/(m_c + m_a)]}}$. I solved the first kinematics equation, $\mathbf{x_c = x_{0c} + v_{0c}t + 1/2at^2}$ **for t**, assuming that x_0 =O, v_0 =0 and $a_c = a_A$, 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 $\mathbf{\Sigma F_A = Fg\text{-}T}$. The sum of the forces acting on the car in the x direction is $\mathbf{\Sigma F_c = T}$. Since F= ma, $\mathbf{M_A a = M_A g - T}$ and $\mathbf{M_c a = T}$. Using $\mathbf{a = v^2/2x}$, $\mathbf{M_A(v^2/2x) = M_A g - T}$, and $\mathbf{M_c(v^2/2x) = T}$. Combining these equations gives $\mathbf{M_A(v^2/2x) = M_A g - M_c(v^2/2x)}$, and solving for v gives $\mathbf{v_c} = \sqrt{\mathbf{2xg[m_a/(m_c + m_a)]}}$.

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.



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.

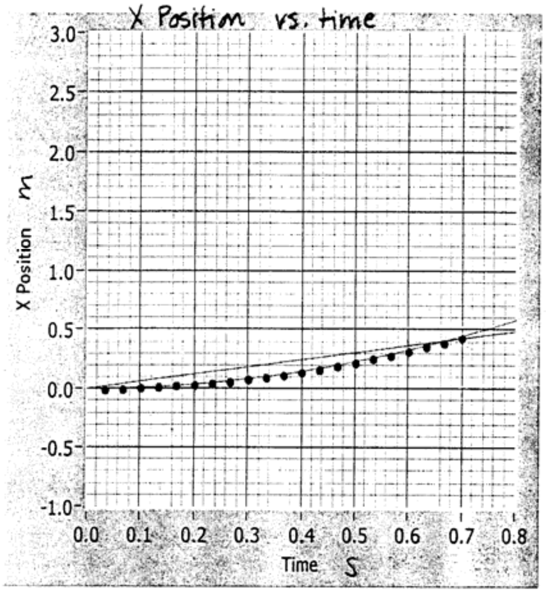
In each case but one, the predicted values for the components of the equations of the graphs were the same or close to the actual ones. When we predicted the value for acceleration of the car before the block hit the ground, we didn't figure any friction into the calculations. We based all of our future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

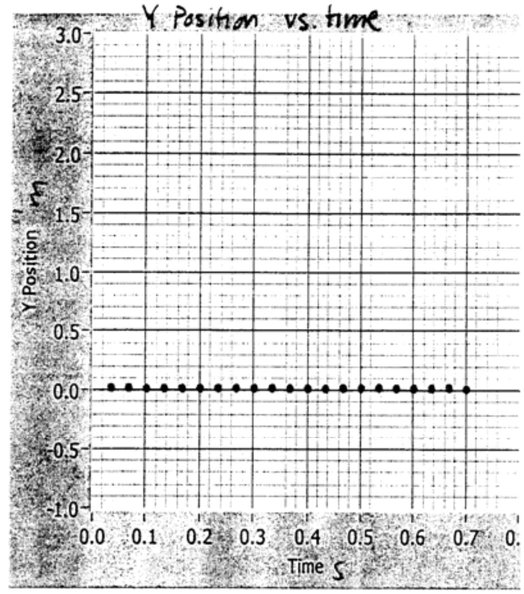
The launch velocity of the car does depend on the mass of the car, the mass of the block and the distance the block falls, according to $v = \sqrt{2xg[m_a/(m_c + m_a)]}$. For values of m_a that are much larger than m_c, m_c does not affect v very much, since $[m_a/(m_c + m_a)]$ becomes very close to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

Graph Title

Lab III Problem 1: Before [A] hit the ground





X - Prediction Equation

u(t) = 0.000 + 0.600t

X - Fit Equation

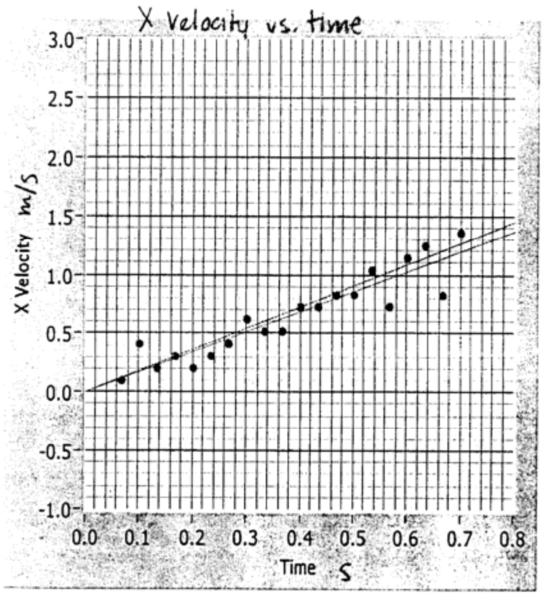
u(t) = 0.000 + 0.000 t + 0.897 t^2

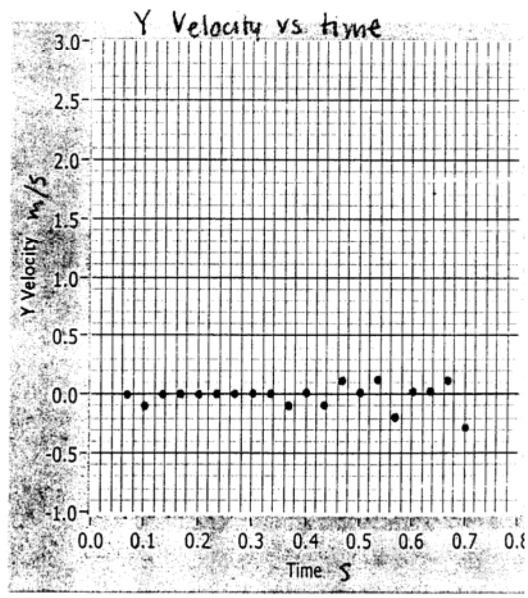
Y - Prediction Equation

u(t) = 0.000 + 0.000t

Y - Fit Equation

u(t) = 0.000 + 0.000t





Vx - Prediction Equation

u(t) = 0.000 + 1.800t

Vx - Fit Equation

u(t) = 0.000 + 1.700t

Vy - Prediction Equation

u(t) = 0.000 + 0.000t

Vy - Fit Equation

u(t) = 0.000 + 0.000t