Activity Book

TA Orientation
School of Physics and Astronomy, University of Minnesota

Fall, 2004

TABLE OF CONTENTS
FOR CLASS ACTIVITIES

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What is a TA?

What is your image of a teaching assistant (TA)? What would you see a TA doing? Who does a TA work with? etc.

Formulate **an answer individually.**

Share **your answer with a partner.**

Listen **carefully to your partner's answer.**

Create **a new answer through discussion.**

2

Notes: ____

University of Minnesota Model for Teaching Introductory Physics

Research-based Models for Teaching Introductory Courses

Teaching Physics with the Physics Suite by E. Redish

Recitations

- Tutorials in Introductory Physics (University of Washington PER Group) page 146
- Activity Based Tutorials (University of Maryland PER Group) page 152
- Cooperative Problem Solving (University of Minnesota PER Group) page 158

Labs

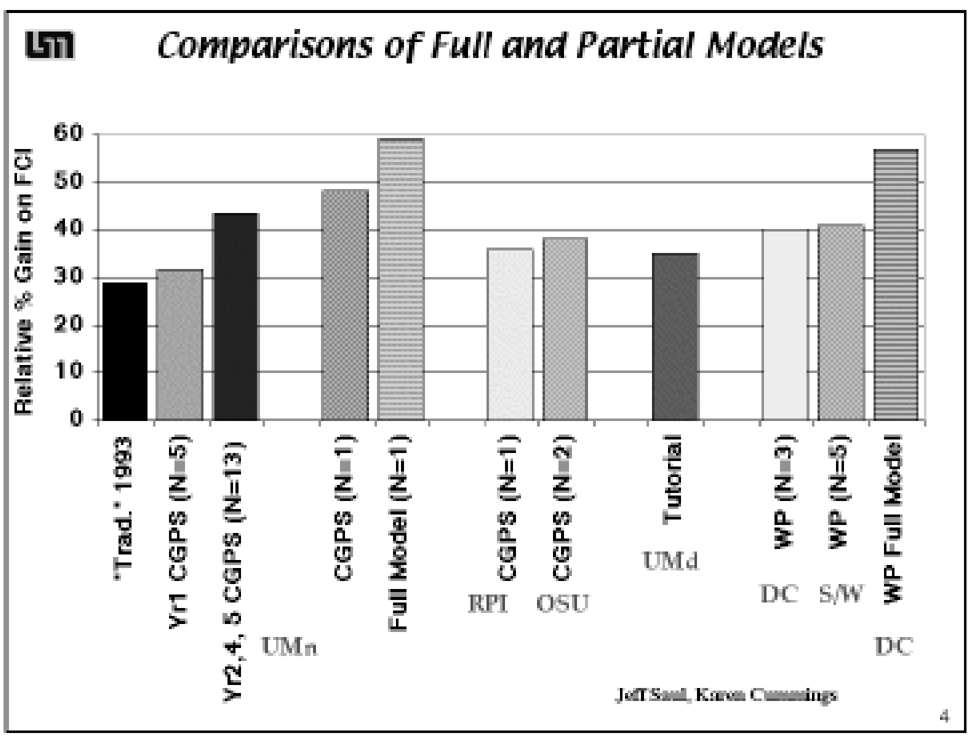
- RealTime Physics (Tuffs University) page 164
- Cooperative Problem Solving Labs

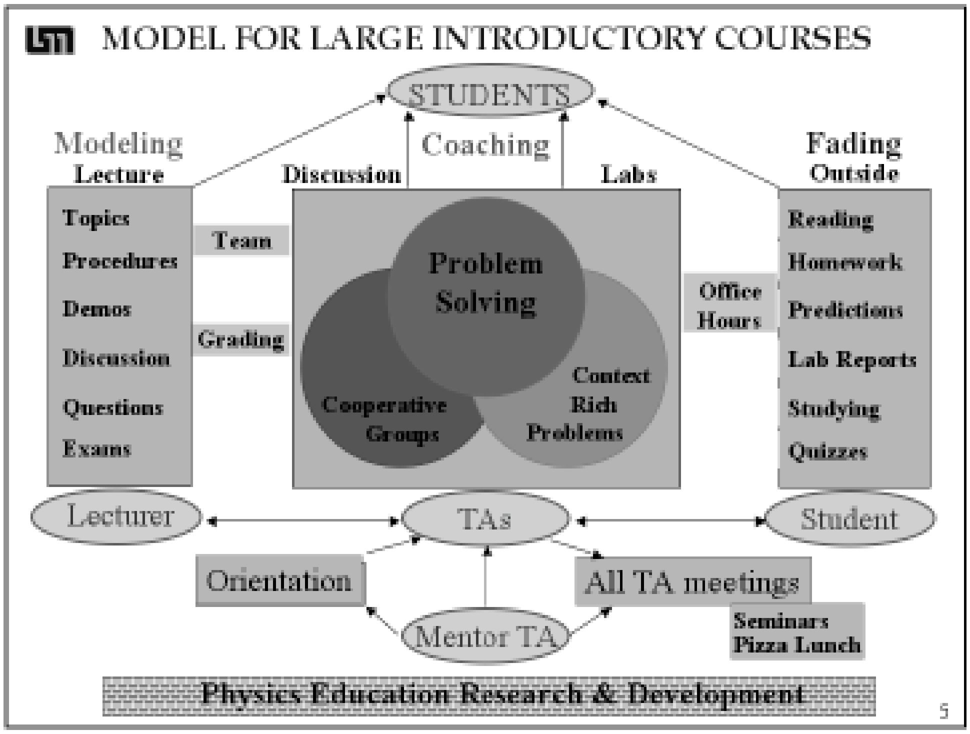
Workshop and Studio Methods

- Workshop Physics (Dickinson College) page 176

All models are effective in improving students' understanding of physics

3





Introductory Physics Courses

LECTURES	Three hours each week (Monday, Tuesday, Wednesday), sometimes with informal cooperative groups.
DISCUSSION SECTION	One hour each Thursday -- groups practice using a logical problem-solving framework to solve problems.
LABORATORY SECTION	Two hours each week -- *same* groups practice using problem-solving framework to solve experimental problems.
TESTS	Friday -- usually a problem-solving quiz every three weeks with some multiple-choice conceptual questions.

6

Algebra Based Physics Students
300 students/term

Pre-majors

Architecture	45%
Paramedical	26%
Physical therapy	
dentistry	
pharmacy	
chiropractic	
medical tech	
veterinary	
Agriculture / ecology	9%



equal female / male
50 % had calculus
40 % had chemistry
50% had high school physics

30% freshman
30% sophomore
30% junior
10% senior

7

Calculus Based Physics
1200 students/term

Majors

Engineering	75%
Physics/Astro	5%
Chemistry	6%
Mathematics	5%
Biology	9%



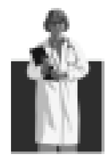
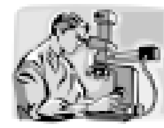
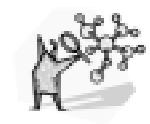
Male	79%
Had Calculus	80%
Had HS Physics	87%

Freshman	64%
Sophomores	22%
Juniors	10%

Expect A	61%
Work	53%
Work more than 10 hrs/wk	25%

8

Physics for Biology Majors
500 students/term

Majors

Biological Science	49%
Pre-Med	37%
Allied Health	19%
Social Science	7%
Architecture	3%
Engineering	2%
Other	16%

Freshman	7%
Sophomore	38%
Junior	19%
Senior	17%

Male	39%
Female	61%

Had U. Calculus	71%
(Had HS Calculus)	50%
Had HS Physics	71%

Expect A	48%
Work	74%
Work more than 10 hrs/wk	50%

9

Learning Modes in UMn Model

Component	hours/week	Mode
Lecture	3	Individual
Discussion/Labs	3	Collaborative groups
Study/Homework	7 - 8	Individual

23% of course time spent in cooperative groups with TA

10

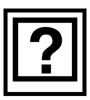
TA Orientation Course (about 2 Education Credits)

	Hours in Class
1. Course structure, students & TA duties	3
2. Alternative Conceptions of Students	3
3. Teaching the Problem-solving Labs	
Demonstration Lab	3
Peer Teaching of Labs	11
Writing Intensive Requirement	3
4. Teaching the Discussion Sessions	
Demonstration Discussion Session	4
Student Difficulties with Problem Solving	4
Peer Teaching of Discussion Sessions	4
Characteristics of Good Problems	1
5. Professionalism and Diversity Issues	3
6. First Week Lesson Plans	3
	42

11

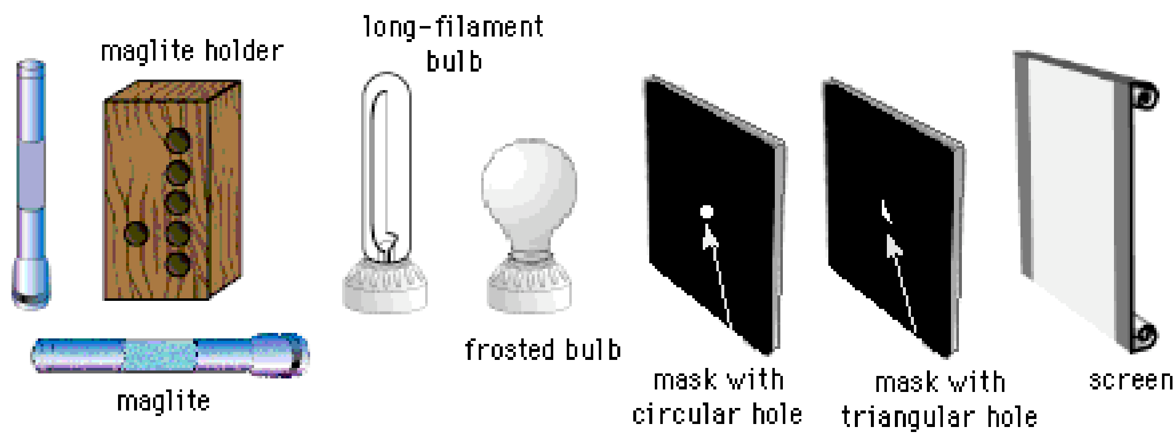
EXPLORATORY PROBLEM #1:
Light Patterns

Because of your physics background, you have been asked to consult for the FBI on an industrial espionage investigation. A new invention has been stolen from a workroom, and the FBI is trying to determine the time of the crime. They have found several witnesses who were walking outside the building that evening, but their only recollections are of unusual light patterns on the side of the building opposite the workroom. These patterns were caused by light from the workroom coming through two holes in the window shade, a circular hole and a triangular hole. The room has several lights in it, including two long workbench bulbs. During the theft, the burglar hit one of the workbench lamps and broke the supporting wire, leaving it hanging straight down. Together with the other bulb, it forms a large "L" shape. Going outside, you see that the lamps do leave interesting patterns on the sidewalk. Your job is to determine, based on the light patterns the witnesses recall seeing, when the theft took place. You decide to model the crime scene in your lab using the equipment shown below.



What patterns of light are produced with different shaped holes and light sources?

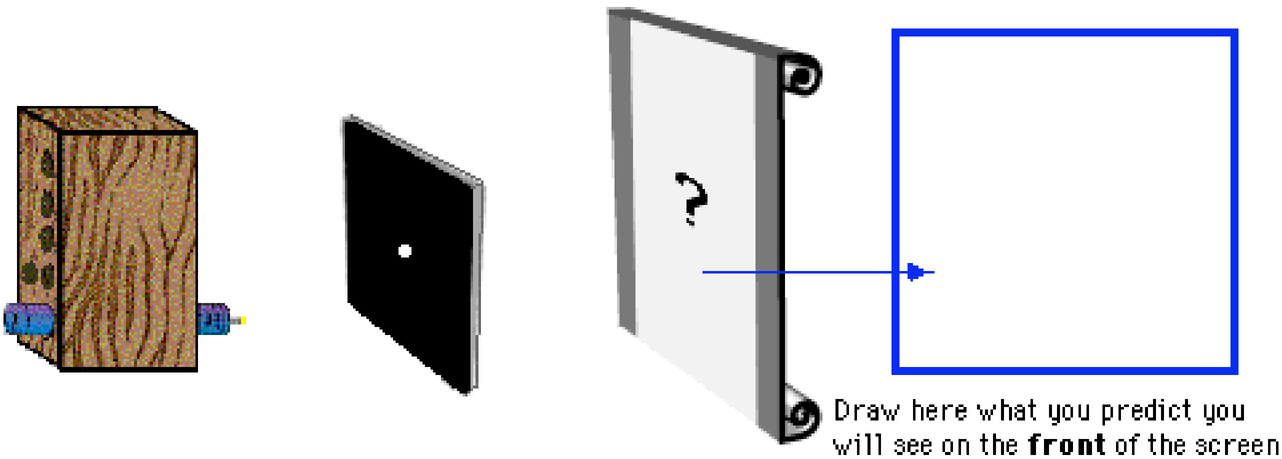
EQUIPMENT



You will have: a maglite holder; two mini maglites; a clear tubular bulb with a straight filament mounted in a socket (representing a long workbench bulb); two cardboard masks, one with a circular hole and one with a triangular hole (representing the holes in the window shade); and a large white cardboard screen (representing the side of the building).

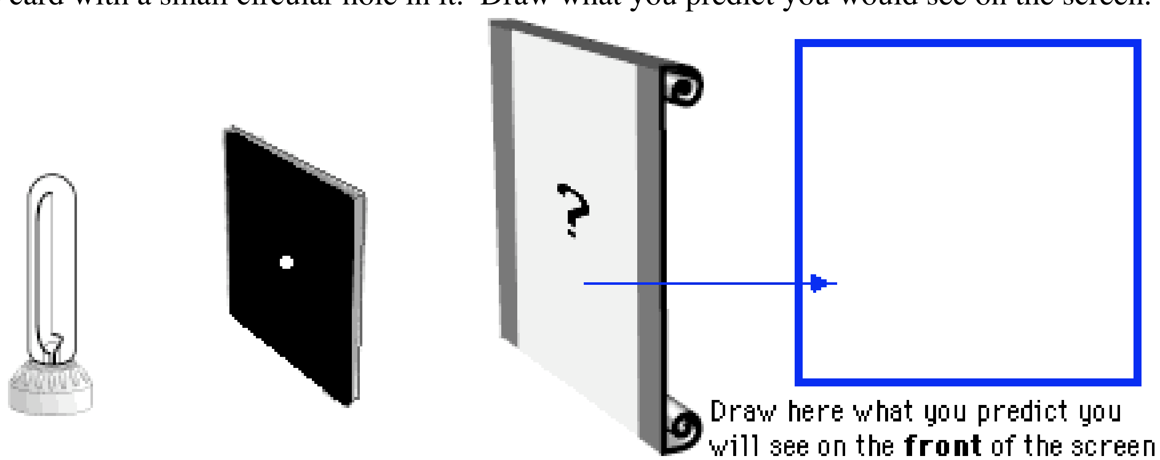
PREDICTIONS

1. Suppose you took a Maglite flashlight, took the cover off, and held it close to a card with a small circular hole in it. What would you see on the screen behind the card? Draw what you think you would see on the screen.



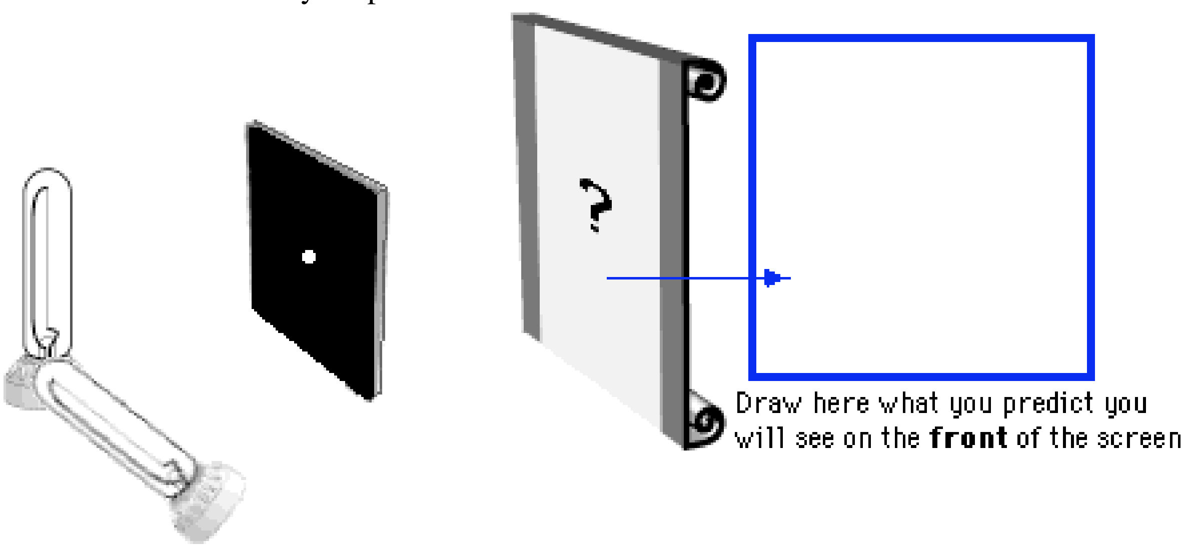
Explain your reasoning. Why do you think this is what you will see?

2. Now suppose you had a bulb with a long filament inside. Imagine you were to hold this near the card with a small circular hole in it. Draw what you predict you would see on the screen.



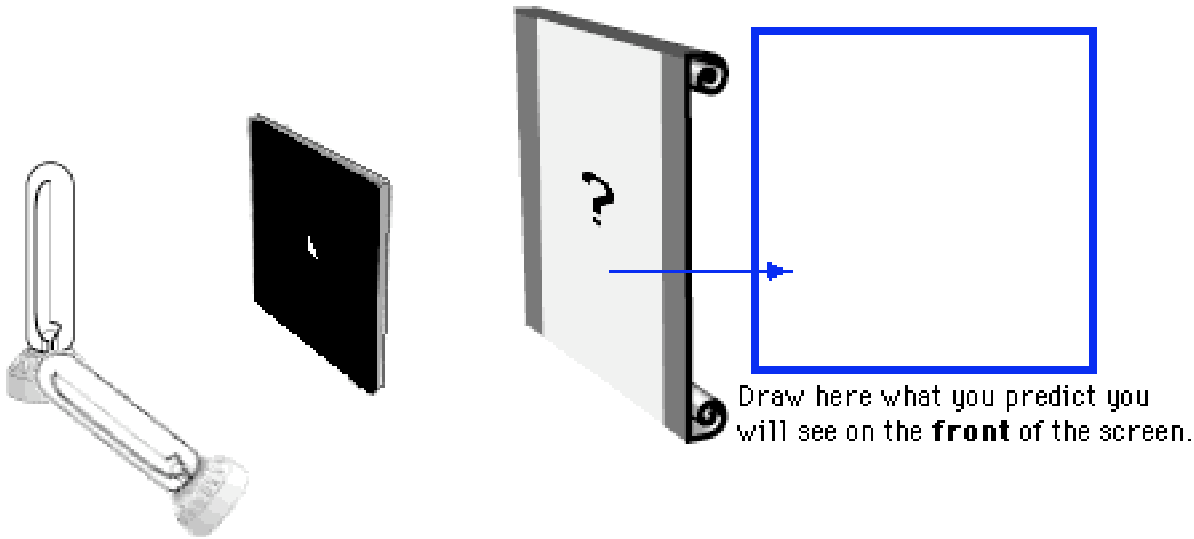
Why did you draw what you drew? Explain your reasoning.

3. Suppose you took two of the long filament bulbs and held them together to form an "L" shaped filament, and held this setup near a card with a small circular hole in it. What would you see on the screen? Draw your prediction.



What was your reasoning?

4. Now imagine you kept the bulbs in the shape of an "L", but now replace the hole in the card with a triangle instead of a circle. Predict what you would see on the screen, and draw your prediction.

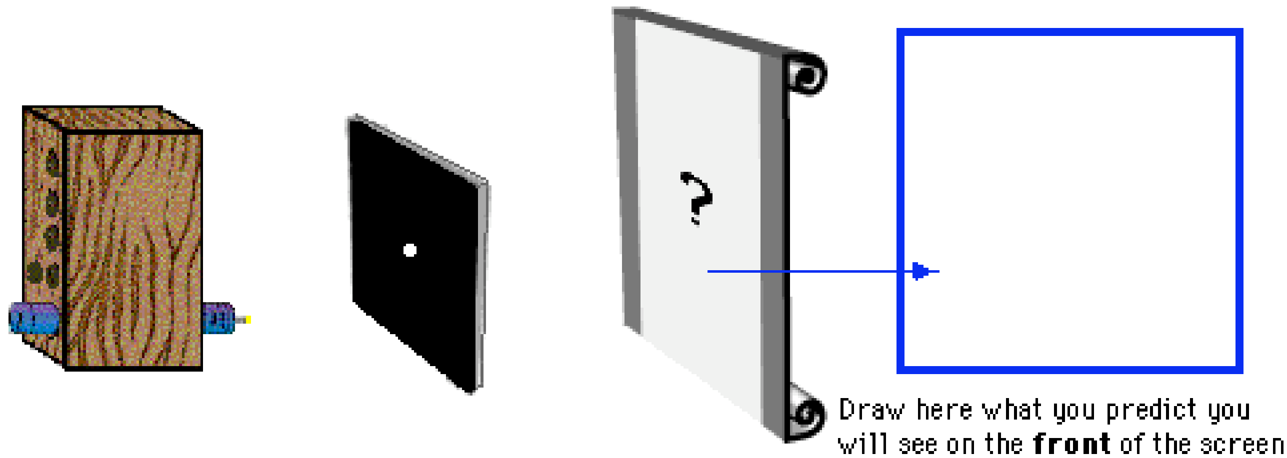


Explain your reasoning.

EXPLORATION

Before you tackle the complex problem, you decide to explore the different light patterns you can get on a screen when light from different kinds of sources shine through holes with different shapes.

1. Suppose you had a maglite, arranged as shown below, close to a card with a small circular hole. **Predict** what you would see on the screen with a lit maglite in a darkened room.



Explain your reasoning.

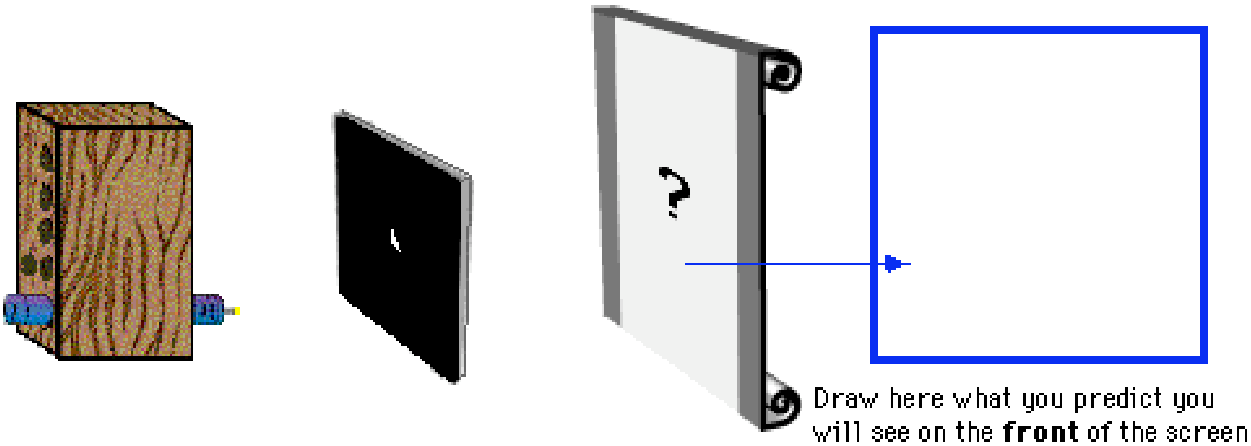
Predict how moving the maglite upward would effect what you see on the screen. Explain.

Test your predictions. Ask an instructor for a maglite. Unscrew the top of a maglite, and mount the maglite in the lowest hole of the maglite holder, as shown above. Place the card with the circular hole between the maglite and the screen.

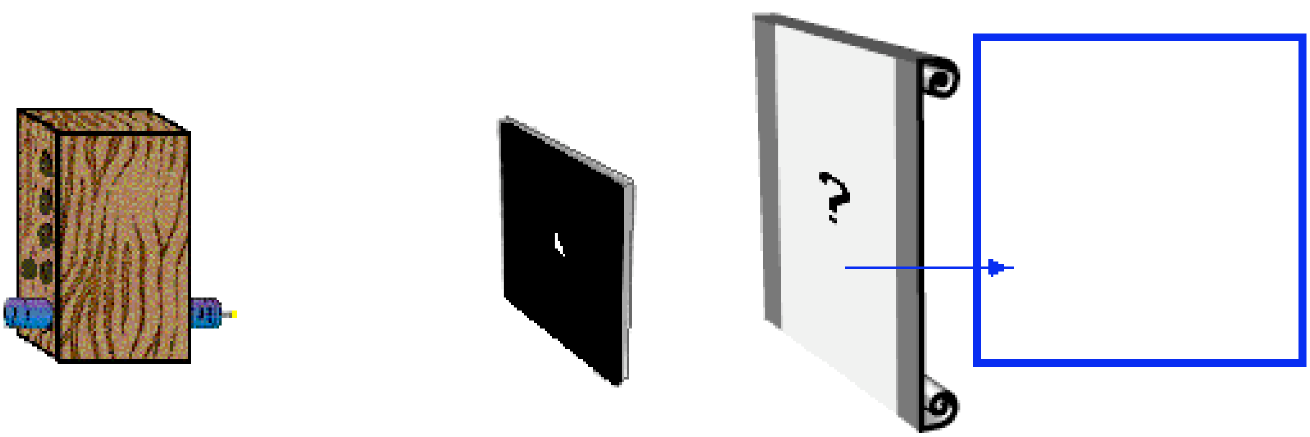
If any of your predictions were incorrect, resolve the inconsistency.

2. **Predict** how each of the following changes would affect what you see on the screen. Explain your reasoning and include sketches that support your reasoning.

A. The mask is replaced by a mask with a triangular hole.

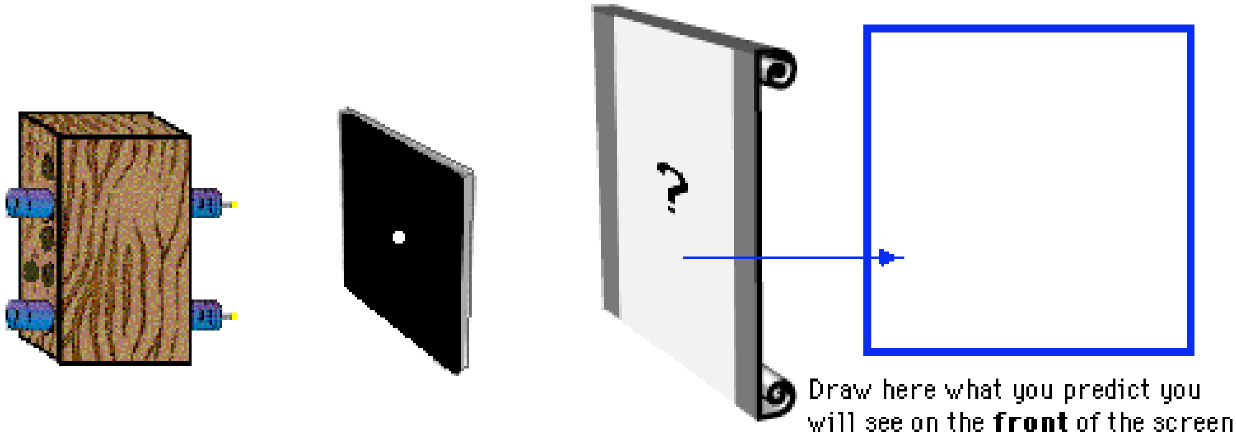


B. The bulb is moved further from the mask.



C. **Test your predictions.** Ask your instructor for a card with a triangular hole, and perform the experiments. If any of your predictions were incorrect, resolve the inconsistency.

3. Predict how placing a second maglite above the first would affect what you see on the screen.

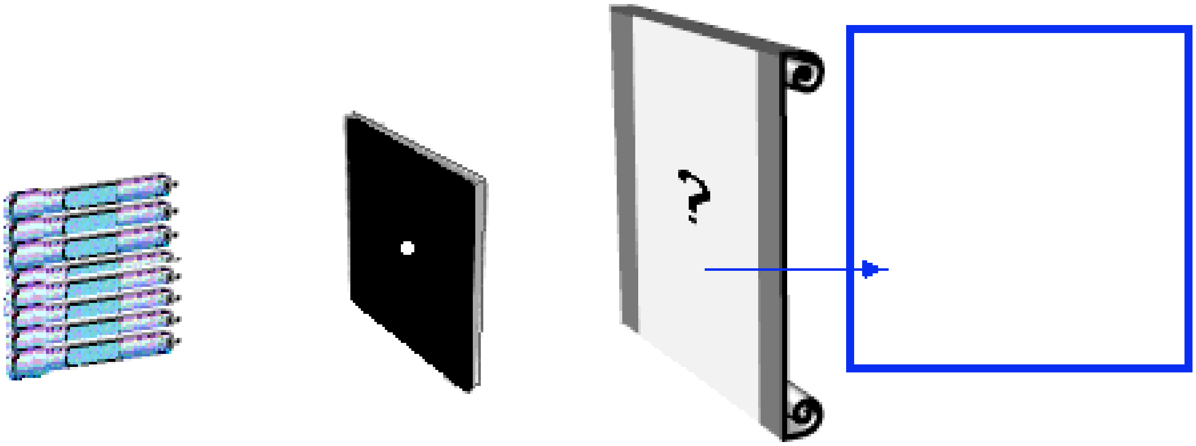


Explain your reasoning.

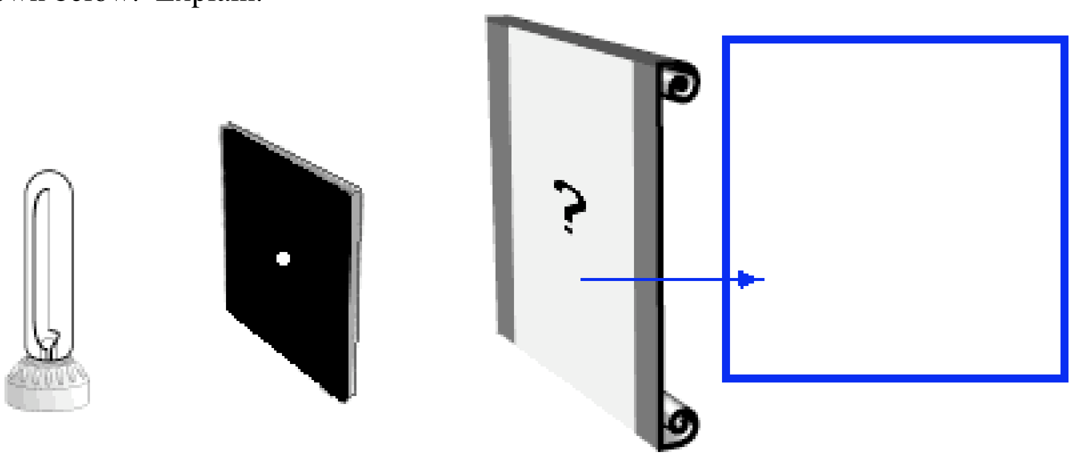
Test your predictions. Ask an instructor for a second maglite, and perform the experiments. If any of your predictions were incorrect, resolve the inconsistency.

4. What do your observations suggest about the **path** taken by the light from the maglite to the screen?

5. Imagine that you had several maglites held close together, as shown below. **Predict** what you would see son the screen. Explain.

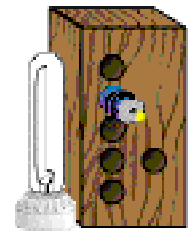


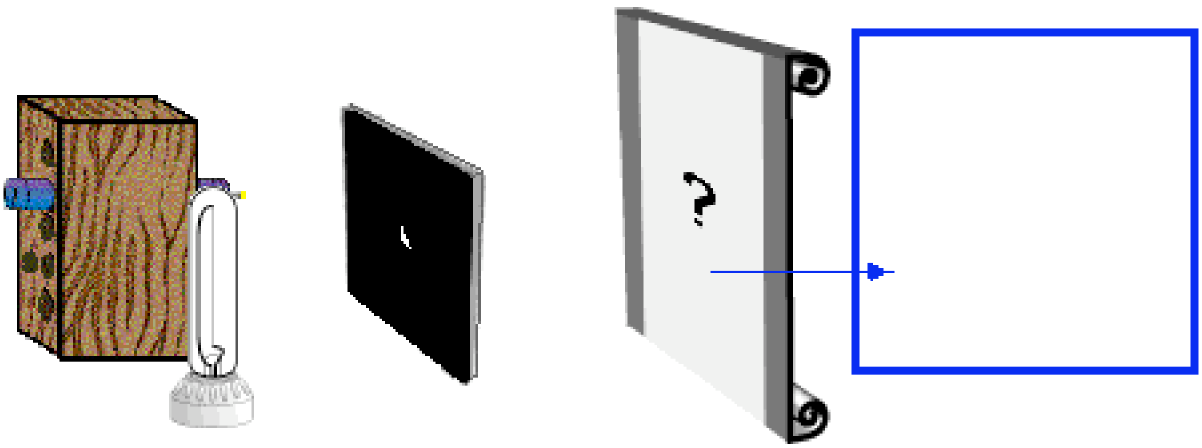
Predict what you would see on the screen if you used a bulb with a long filament instead, as shown below. Explain.



Test your predictions. Ask an instructor for a long filament bulb, and perform the experiments. If any of your predictions were incorrect, resolve the inconsistency.

6. **Individually predict** what you would see on the screen if you had both a maglite and a long filament bulb arranged side by side, as shown at right and below.





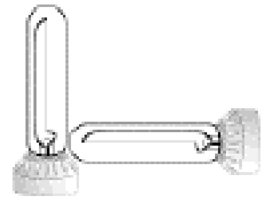
Explain your reasoning.

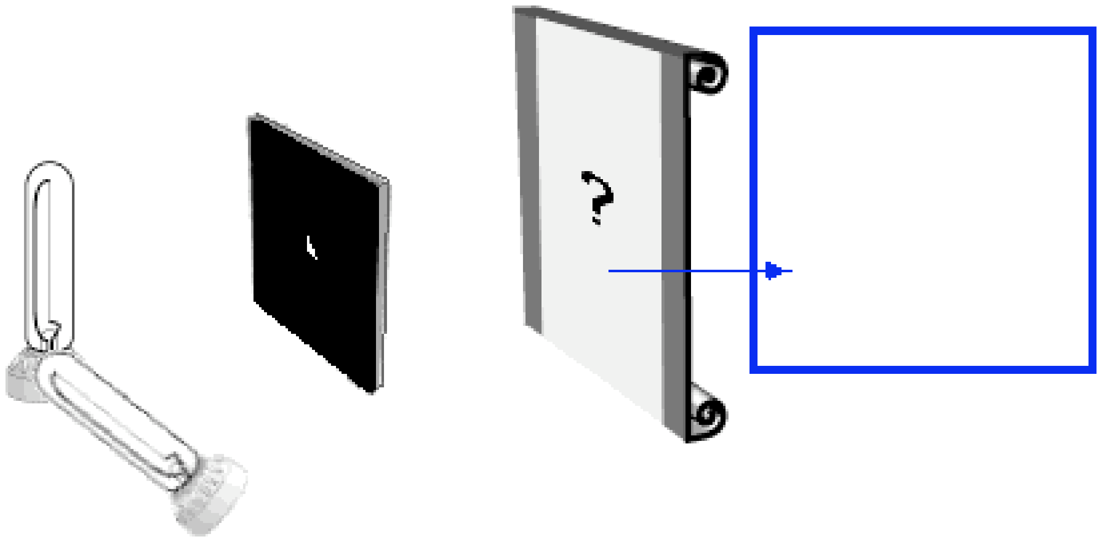
Compare your prediction with those of your partners. After you and your partners have come to an agreement, **test your prediction** by performing the experiment. Resolve any inconsistencies.

MEASUREMENT & ANALYSIS

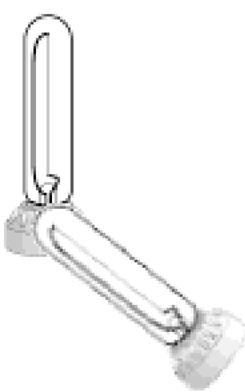
You are now ready to investigate the light patterns that would be seen by the witnesses who passed the crime scene.

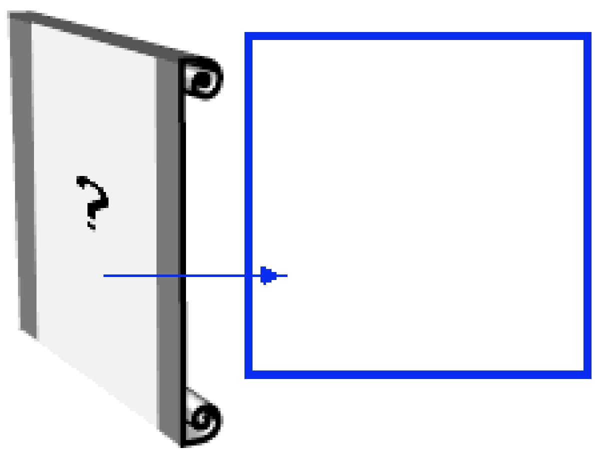
1. **Predict** what you would see on the screen if you had two long filament bulbs arranged as shown at right and below.





Predict what you would see on the screen if the mask were *removed*.





Test your predictions. Ask your instructor for a second long-filament bulb, and perform the experiments. If any predictions were incorrect, resolve the inconsistency.

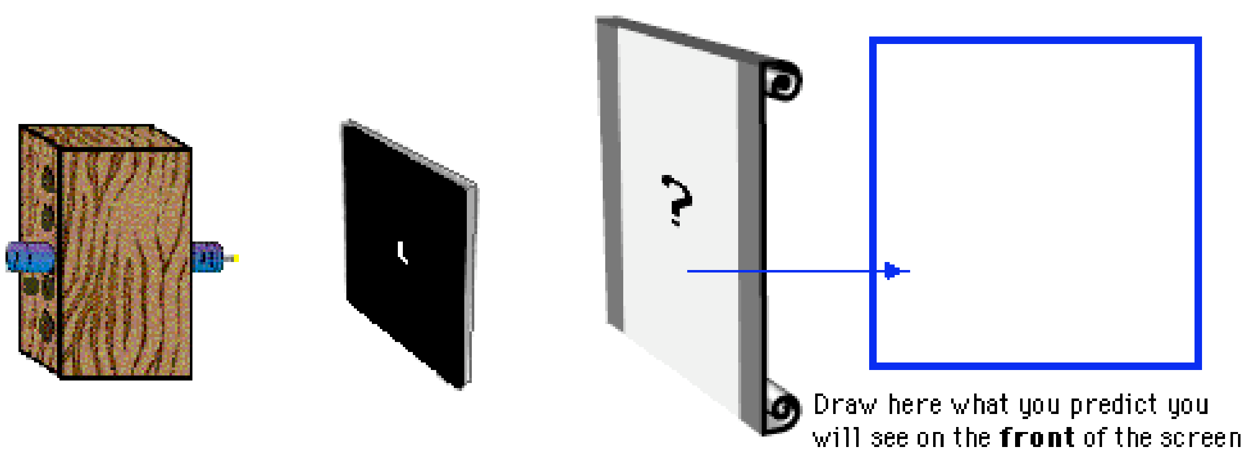
CONCLUSION

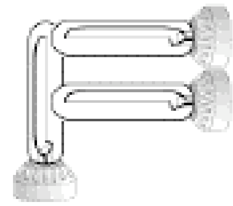
What pattern would a witness see on the building wall from two horizontal lit bulbs through a circular hole and a triangular hole in the window shade? What would a witness see when one bulb was horizontal but the other bulb was vertical? How would you determine the approximate time of the crime?

☑ CHECK YOUR UNDERSTANDING

A mask containing a hole in the shape of the letter **L** is placed between the screen and a very small bulb of a maglite as shown below.

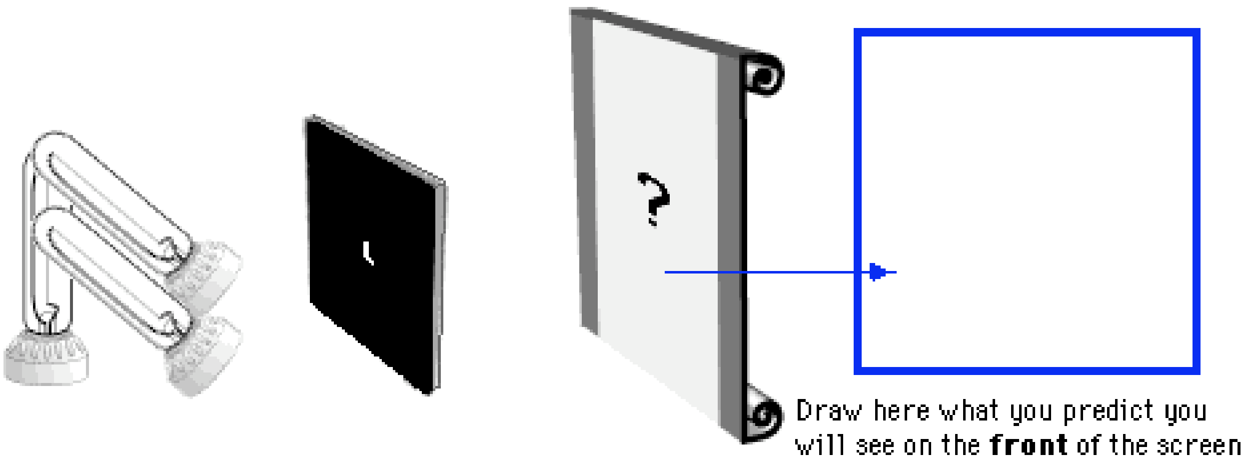
1. On the diagram below, sketch what you would see on the screen when the maglite is turned on.



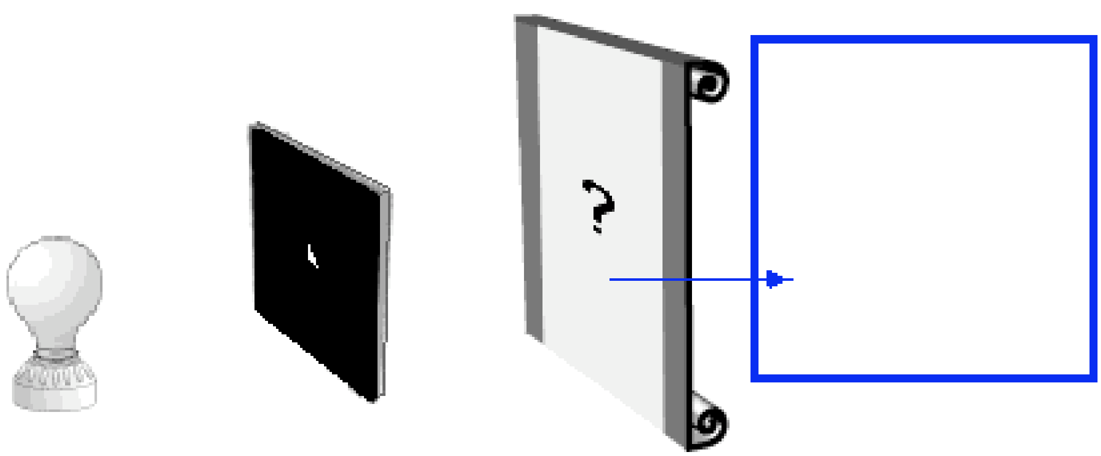


2. The maglite is replaced by three long filament light bulbs that are arranged in the shape of the letter **F**, as shown at right a below.

   On the diagram, sketch what you would see on the screen when the bulbs are turned on. ***Explain how you determined your answer.***



3 **Predict** what you would see on the screen when an ordinary frosted bulb is held in front of the mask with the triangular hole, as pictured below. Explain your reasoning.



TA Orientation 2004 Name: ______________________________.
Activity #2b (2 points)

Alternative Conceptions -- Light Patterns

James Wandersee, Joel Mintzes, and Joe Novak (1994) describe several "knowledge claims" that have emerged from the research on students' alternative conceptions in the past 20 years. As you reflect on the activity, *Light Patterns*, describe briefly any examples you experienced of these claims.

Knowledge Claims	Examples from *Your Experience*
Claim 1: Learners come to formal science instruction with a diverse set of alternative conceptions concerning natural objects and events.	
Claim 2: The alternative conceptions that learners bring to formal science instruction cut across age, ability, gender, and cultural boundaries.	
Claim 3: Alternative conceptions are tenacious and resistant to extinction by conventional teaching strategies.	
Claim 4: Alternative conceptions often parallel explanations of natural phenomena offered by previous generations of scientists and philosophers.	
Claim 5: Alternative conceptions have their origins in a diverse set of personal experiences including direct observation and perception, peer culture, and language, as well as in teachers' explanations and instructional materials.	
Claim 6: Teachers often subscribe to the same alternative conceptions as their students.	
Claim 7: Learners' prior knowledge interacts with knowledge presented in formal instruction, resulting in a diverse set of unintended learning outcomes.	
Claim 8: Instructional approaches that facilitate conceptual change can be effective classroom tools.	

NOTES

What are Alternative Conceptions?

All learners come to instruction with their own common-sense ideas about how the world works.

These ideas have been gained through their attempts to make sense of the world by describing, explaining, predicting and designing the world around them.

Sometimes learners' ideas match the scientific view of the world. But most often they do not match. When students' ideas do not match the scientific conceptions, students are said to have "alternative conceptions" or "misconceptions."

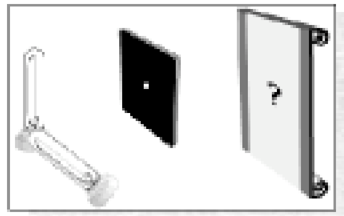
2

Reconstruction of Knowledge

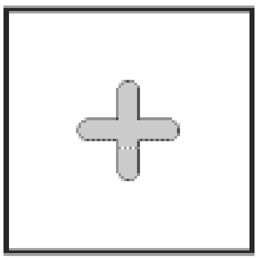
Problem (disequilibrium)	"My explanation didn't work." or "My explanation is not the same as my friends' explanations."
Intelligible	"I can at least understand the scientific concept, even if it doesn't make sense."
Plausible	"I see how the scientific concept solves the problem. It is also consistent with other things I know."
Fruitful	"The scientific concept is useful because it solves a lot of other related and seemingly unrelated problems."

3

What do students learn from traditional physics instruction?



1. **Undisturbed Outcome:** Students' views remain substantially unchanged.
2. **Reinforced Outcome:** Students incorporate the new ideas in ways that reinforce their alternative conceptions.



"It's like the first photographic machine, the camera obscura."

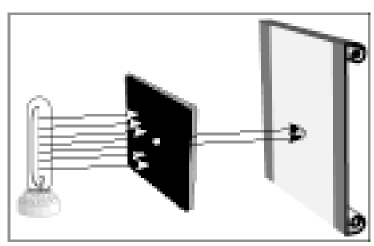
REINFORCES

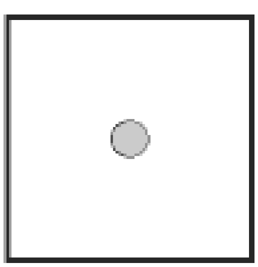
student's idea that a symmetrical hole produces a symmetrical light pattern on the screen.

4

3. Two Perspectives Outcome

Students retain two, opposing perspectives:
- (a) their own, used in everyday situations, and
- (b) the scientific view, applied only in school situations (like tests).

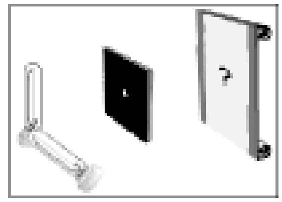


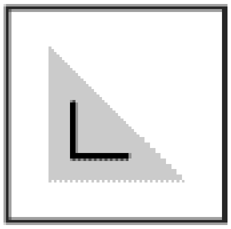


For example, a student who can state correctly that "an extended light source acts like an infinite number of point sources," but still believes that light travels from the source in parallel rays.

5

4. Mixed Outcome: Students lose confidence in their earlier ideas, but better ideas are not constructed. Students end up with confused or incoherent ideas.





"The form (L shape of bulb filaments) will affect the picture, but there will be a triangle corresponding to the shape of the hole."

5. Hypothetical "Unified Scientific Outcome:" Students restructure their ideas and build up a coherent, scientific view.

6

Passage

The procedure is actually quite simple. First you arrange them into different groups. Of course, one pile may be sufficient depending on how much there is to do. If you have to go somewhere else due to lack of facilities that is the next step; otherwise, you are pretty well set.

It is important not to overdo things. That is, it is better to do too few things than too many. In the short run this may not seem important, but complications can easily arise. A mistake can be expensive as well. At first, the whole procedure will seem complicated. Soon, however, it will become just another fact of life. It is difficult to foresee any end of the necessity of the task in the immediate future, but then, one can never tell.

After the procedure is completed, one arranges the materials into different groups again. Then they can be put into their appropriate places. Eventually they will be used once more and the whole cycle will then have to be repeated. However, that is a part of life.

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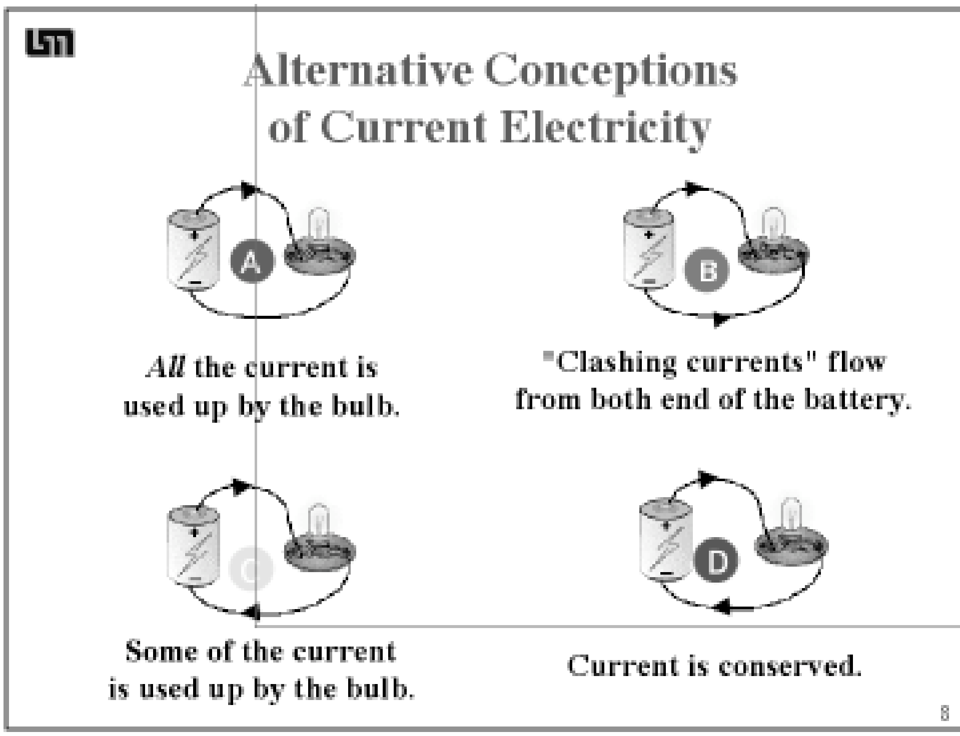
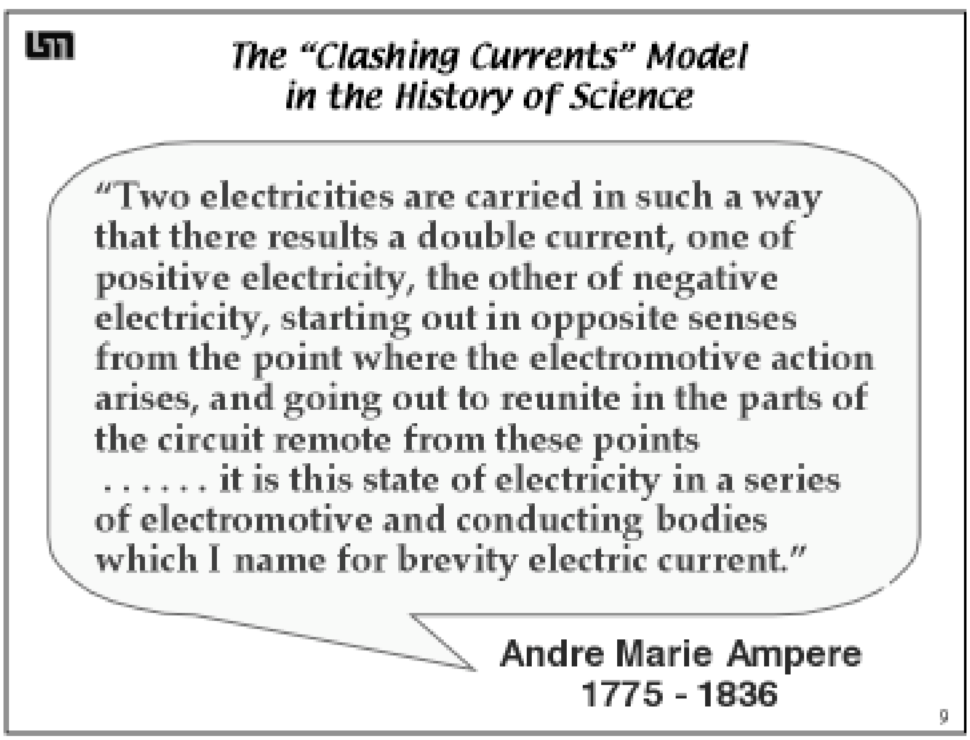

Alternative Conceptions
of Current Electricity
A
All the current is
used up by the bulb.
B
"Clashing currents" flow
from both end of the battery.
Some of the current
is used up by the bulb.
D
Current is conserved.
8


The "Clashing Currents" Model
in the History of Science
"Two electricities are carried in such a way that there results a double current, one of positive electricity, the other of negative electricity, starting out in opposite senses from the point where the electromotive action arises, and going out to reunite in the parts of the circuit remote from these points . . . . . . it is this state of electricity in a series of electromotive and conducting bodies which I name for brevity electric current."
Andre Marie Ampere
1775 - 1836
9

:

Activity 3a (2 points)

Manager: ______________________

Recorder: ______________________

Skeptic: ______________________

Summarizer: ______________________

Analyzing Force Concept Inventory Questions

Group Task:

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).

1. Individually read all the questions.
2. For each question assigned to your group:
   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?
3. For one question assigned to your group, imagine you were tutoring a student with the indicated alternative conception. Discuss what example situation, reference to a common experience the student is likely to have, or set of questions that you think might help move this student away from their alternative conception. Write your answer on the back of this page.

Group Roles

Skeptic: Ask what other possibilities there are, keep the group from superficial analysis by not allowing the group to agree too quickly; ask questions that lead to a deeper analysis; agree when satisfied that the group has explored all possibilities. (earliest birthday in year)

Manager: Suggest a plan for answering the questions; make sure everyone participates and stays on task; watch the time. (next later birthday in year)

Checker/Recorder: Ask others to explain their reasoning process so it is clear to all that their suggestions can be discussed; paraphrase, write down, and edit your group's answers to the questions. (next later birthday in year)

TIME: 25 minutes.

One member from each group will be randomly called on to contribute answers to the questions.

Group Product:

Activity #2 Answer Sheets.

2.

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.

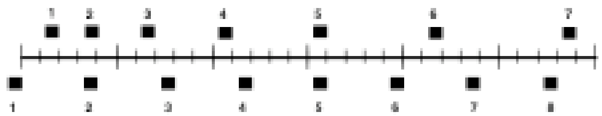
Which following force(s) is (are) acting on the tennis ball after it has left contact with the racquet and before it touches the ground?

	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?

Question 19



Do the blocks ever have the same speed?

	Pre	Post
(A) No.1	6	8
(B) Yes, at instant 2.	4	2
(C) Yes, at instant 5.	9	6
(D) Yes at instant 2 and 5.	20	20
(E) Yes at some time during interval 3 to 4.	51	65

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?

Question 13

A boy throws a steel ball straight up. Consider the motion of the ball only after it has left the boy's hand but before it touches the ground, and assume that forces exerted by the air are negligible. For these conditions, the force(s) acting on the ball is (are):

		Pre	Post
(A)	a downward force of gravity along with a steadily decreasing upward force.	1	2
(B)	a steadily decreasing upward force from the moment it leaves the boy's hand until it reaches its highest point; on the way down there is a steadily increasing downward force of gravity as the object gets closer to the earth.	17	3
(C)	an almost constant downward force of gravity along with an upward force that steadily decreases until the ball reaches its highest point on the way down after there is only the constant downward force of gravity.	65	38
(D)	an almost constant downward force of gravity only.	17	57
(E)	none of the above -- the ball falls back to ground because of its natural tendency to rest on the surface of the earth.	0	1

3

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?

Question 11

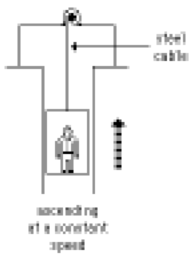
The main force(s) acting on the puck after the "kick" is (are):

	Pre	Post
(A) a downward force of gravity	9	3
(B) a downward force of gravity and a horizontal force in the direction of motion.	3	34
(C) a downward force of gravity, an upward force exerted by the surface, and a horizontal force in the direction of motion.	44	34
(D) the downward force of gravity and an upward force exerted by the surface.	13	59
(E) None. (No forces act on puck.)	0	0

4

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?



Question 17

An elevator is being lifted up an elevator shaft at a constant speed by a steel cable, as shown in the figure. All frictional effects are negligible. In this situation, forces on the elevator are such that:

		Pre	Post
(A)	the upward force by the cable is greater than the downward force of gravity.	64	36
(B)	the upward force by the cable is equal to the downward force of gravity.	18	60
(C)	the upward force by the cable is smaller than the down ward force of gravity.	2	0
(D)	the upward force by the cable is greater than the sum of the downward force of gravity and a downward force due to the air.	11	2
(E)	None of the above. (The elevator goes up because the cable is shortened, not because an upward force is exerted on the elevator by the cable).	5	1

5

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?

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?

While the car, still pushing the truck, is *speeding up* to get up to cruising speed;

Question 15

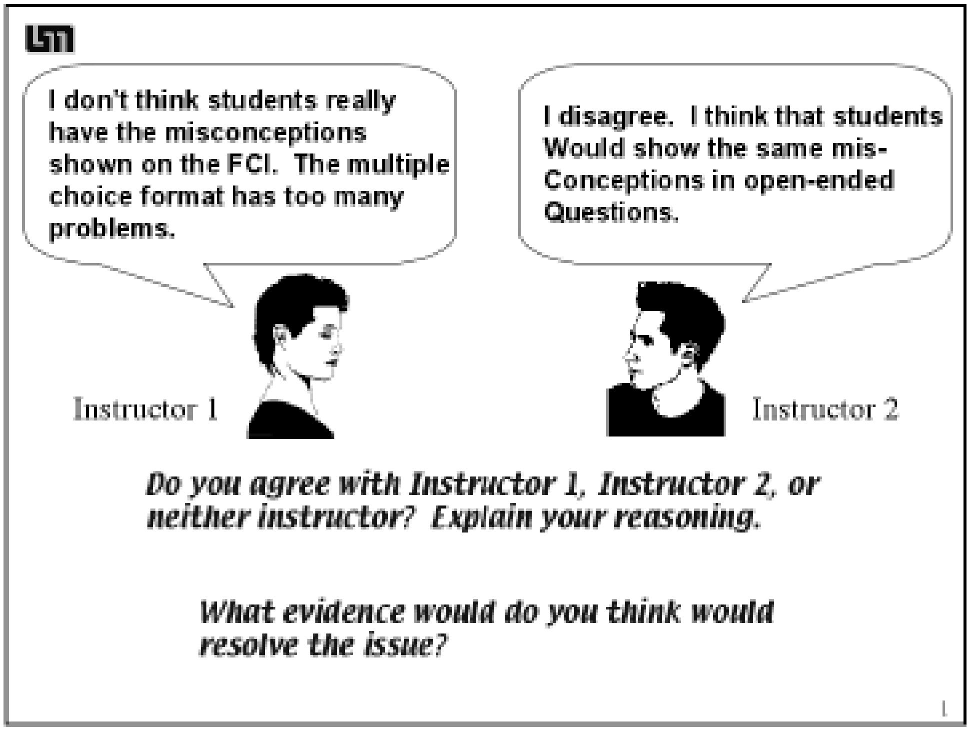
	Pre	Post
(A) the amount of force of the car pushing against the truck is equal to that of the truck pushing back against the car.	19	25
(B) the amount of force of the car pushing against the truck is less than that of the truck pushing back against the car.	9	5
(C) the amount of force of the car pushing against the truck is greater than that of the truck pushing against the car.	68	69
(D) the car's engine is running so it applies a force as it pushes against the truck, but the truck's engine is not running so it can't push back against the car -- the truck is pushed forward. simply because it is in the way of the car.	3	1
(E) neither the car nor the truck exert any force on the other, the truck is pushed forward simply because it is in the way of the car.	0	0

7

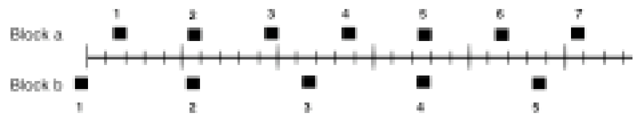
a. Describe briefly how a student might be thinking who gives each incorrect answer.

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

3. Imagine you are tutoring a student who has an "alternative conception" similar to that of Question # ______. What example situation, reference to a common experience the student is likely to have, or set of questions do you think might help move this student away from their alternative conception?


I don't think students really have the misconceptions shown on the FCI. The multiple choice format has too many problems.
I disagree. I think that students Would show the same mis-Conceptions in open-ended Questions.
Instructor 1
Instructor 2
Do you agree with Instructor 1, Instructor 2, or neither instructor? Explain your reasoning.
What evidence would do you think would resolve the issue?
1

Question 21

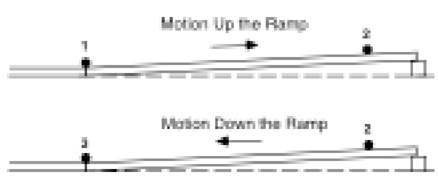


~35% "Confuse v and a" on FCI Pretest

21. The acceleration of the blocks are related as follows:	Pre	Post
(A) acceleration of "a" > acceleration of "b"	16	7
(B) acceleration of "a" = acceleration "b" > 0	6	1
(C) acceleration of "b" > acceleration "a"	29	16
(D) acceleration of "a" = acceleration of "b" = 0	*41*	*73*
(E) not enough information to answer.	8	2

2

Ramp Problem
(1993)



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.

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

3

How Does the Acceleration Compare Up and Down a Ramp?

~74% "Confuse v and a" on Open-ended Question

Type of Response	Algebra-based (n = 112) pre (%)	Algebra-based (n = 112) post (%)	Calculus-based (n = 100) pre (%)	Calculus-based (n = 100) post (%)
1. Includes accepted idea	6	79	19	40
2. Includes alternative conception				
a. confuse v and a, but believe motion up and down is the same	58	16	57	51
b. confuse v and a, but believe motion up and down is different	35	2	17	6
3. Uncodeable	1	3	7	3

4

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.

~80% Non-Newtonian Force of "hit" on FCI Pretest

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	1	1
(E) 1, 2, and 3	75	36

5

Question 11

~77% Non-Newtonian "horizontal force" on FCI Pretest

The main force(s) acting on the puck after the "kick" is (are):

	Pre	Post
(A) a downward force of gravity	9	3
(B) a downward force of gravity and a horizontal force in the direction of motion.	33	34
(C) a downward force of gravity, an upward force exerted by the surface, and a horizontal force in the direction of motion.	44	34
(D) the downward force of gravity and an upward force exerted by the surface.	*13*	59
(E) None. (No forces act on puck.)	0	0

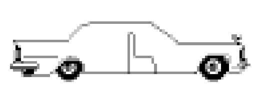
6

Two Open-Response Questions

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

(a) On the picture below, draw and label arrows (vectors) representing all the forces acting on the car while it is accelerating. . . Beside the Picture, describe in words each force shown.

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



7

What is the Nature of the Forces on the Car?

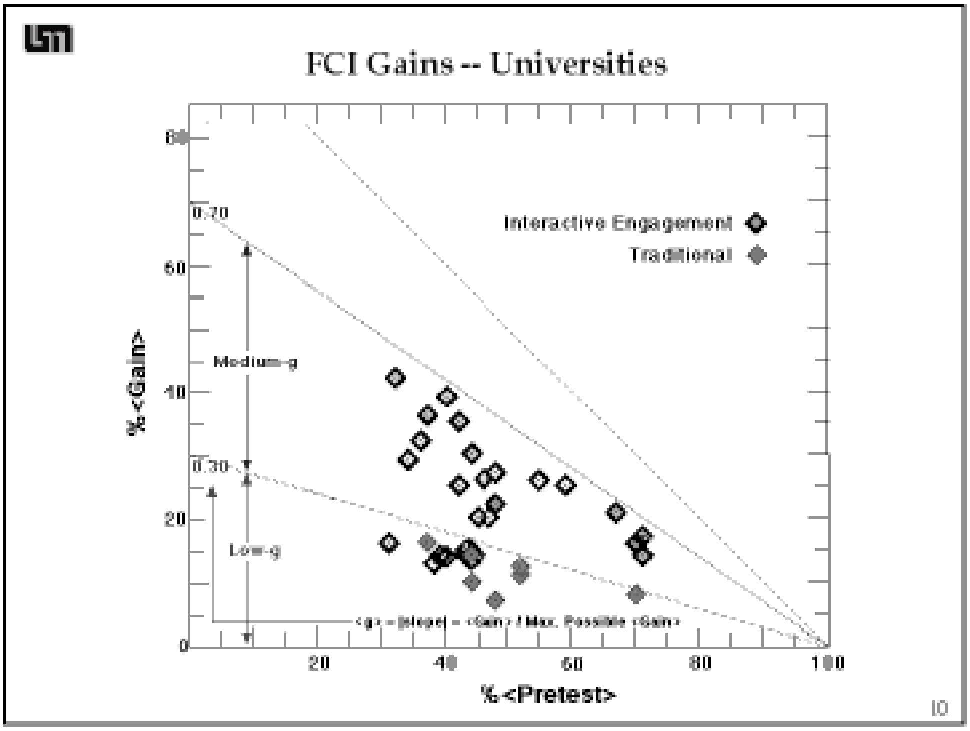
Type of Response	FCI post 68% 1993 Baseline (n = 100) pre (%)	post (%)	FCI 72% 1996 Coop. Group (n=85) post (%)	FCI 82% 1996 Full Model (n=71) post (%)
1. Only Newtonian forces	*10*	*39*	*58*	*73*
2. Newtonian forces, but some are 3rd Law pair on wrong object	4	15	4	2
3. Include non-Newtonian forces (e.g., acceleration of car, engine, inertia, etc.)	73	39	38	25
4. Uncodeable	8	1	0	0

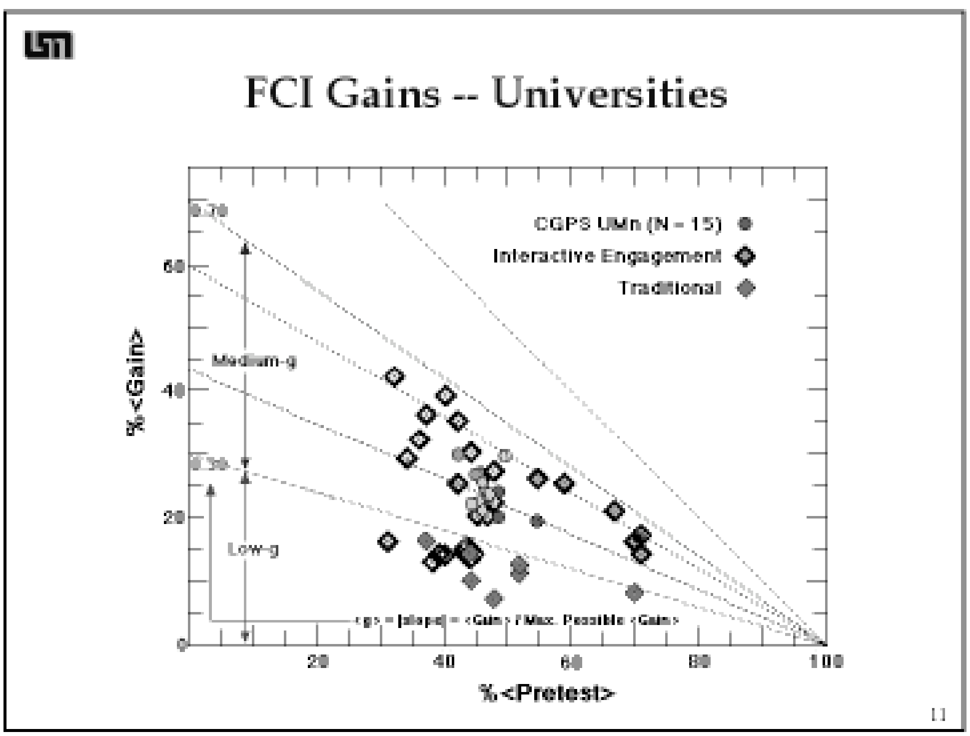
8

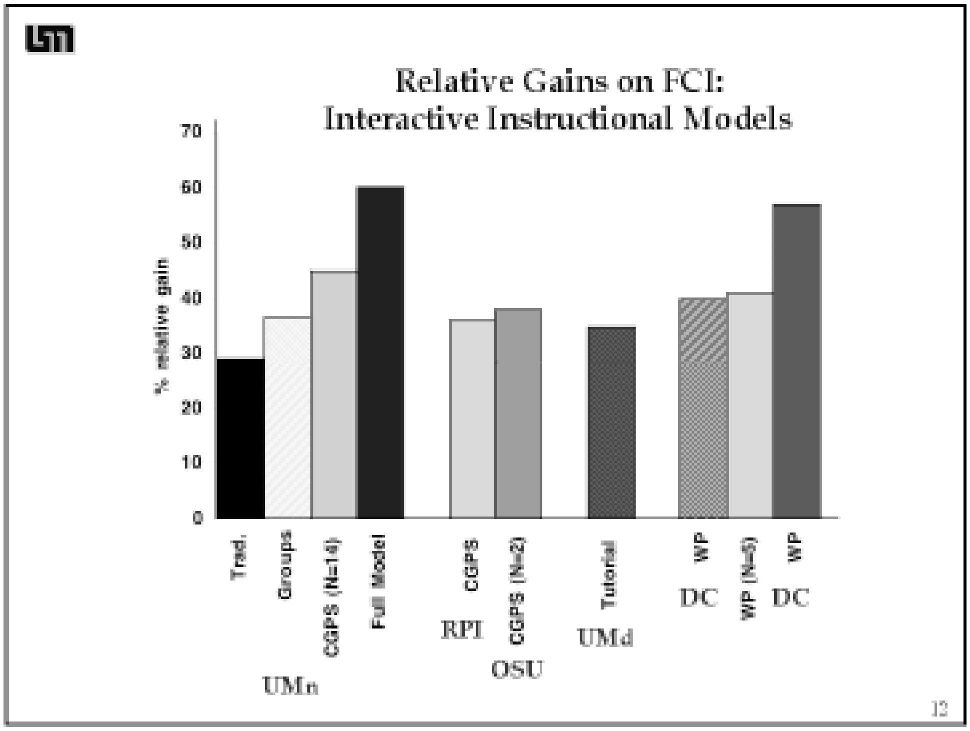
Why Does the Car Accelerate?

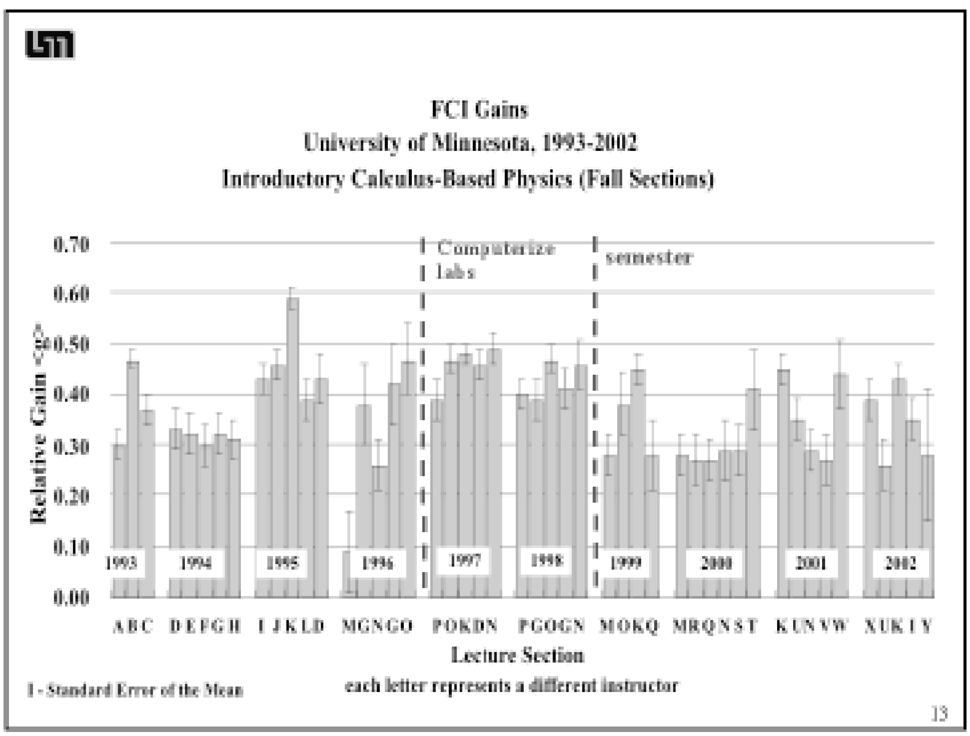
Type of Response	FCI post 68% 1993 Baseline (n = 100) pre (%)	post (%)	FCI 72% 1996 Coop Group (n=85) post (%)	FCI 82% 1996 Full Model (n=71) post (%)
1. Includes correct ideas about summing real forces	7	20	42	58
2. Vague or incorrect summing	25	29	24	21
3. Includes alternative ideas				
a. accel. due to one force	4	23	21	19
b. accel. not due to real force on the car	48	23	7	0
4. Uncodeable	16	7	6	4

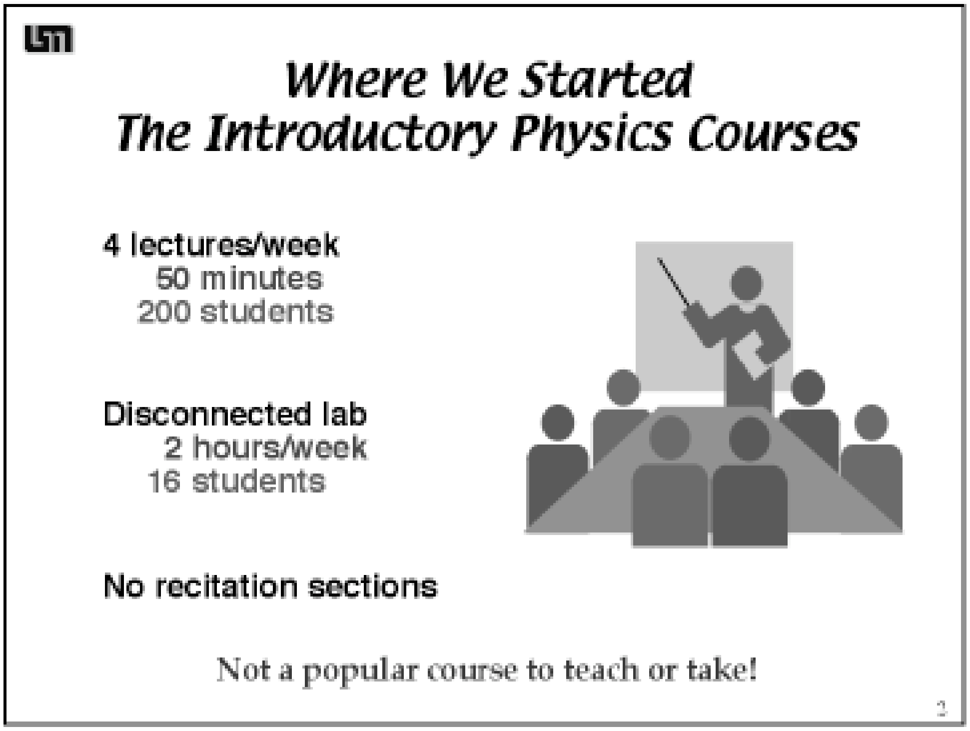
9

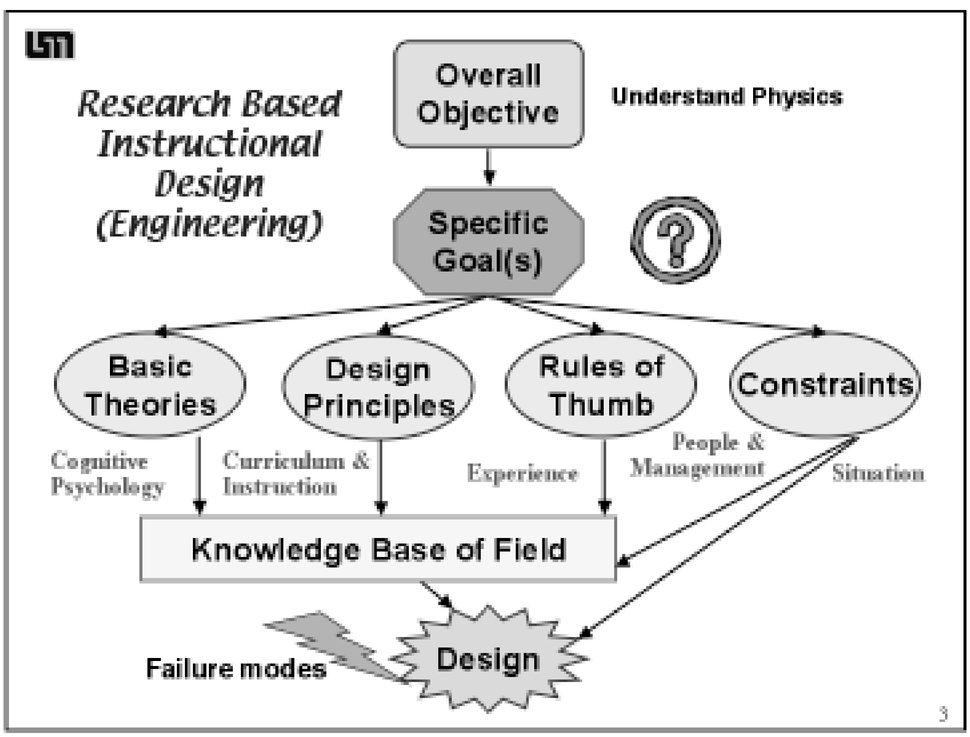

FCI Gains -- Universities
Interactive Engagement
Traditional
0.70
0.30
Medium-g
Low-g
<g> = |slope| = <Gain> / Max. Possible <Gain>
%<Gain>
%<Pretest>
0
20
40
60
80
100
10


FCI Gains -- Universities
CGPS UMn (N = 15)
Interactive Engagement
Traditional
0.70
0.30
Medium-g
Low-g
<g> = |slope| = <Gain> / Max. Possible <Gain>
%<Gain>
%<Pretest>
0
20
40
60
80
100
11


Relative Gains on FCI:
Interactive Instructional Models
% relative gain
0
10
20
30
40
50
60
70
Trad.
Groups
CGPS (N=14)
Full Model
UMn
CGPS
RPI
CGPS (N=2)
OSU
Tutorial
UMd
WP
DC
WP (N=5)
WP
DC
12


FCI Gains
University of Minnesota, 1993-2002
Introductory Calculus-Based Physics (Fall Sections)
Relative Gain <g>
0.00
0.10
0.20
0.30
0.40
0.50
0.60
0.70
Computerize labs
semester
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
ABC
DEFGH
IJKLD
MGNGO
POKDN
PGOGN
MOKQ
MRQNST
KUNVW
XUKIY
Lecture Section
I - Standard Error of the Mean
each letter represents a different instructor
13


Where We Started
The Introductory Physics Courses
4 lectures/week
50 minutes
200 students
Disconnected lab
2 hours/week
16 students
No recitation sections
Not a popular course to teach or take!
2


Research Based Instructional Design (Engineering)
Overall Objective
Understand Physics
Specific Goal(s)
Basic Theories
Design Principles
Rules of Thumb
Constraints
Cognitive Psychology
Curriculum & Instruction
Experience
People & Management
Situation
Knowledge Base of Field
Failure modes
Design
3

What Do Other Faculty Want?

Goals: Calculus-based Course (88% engineering majors) 1993

- 4.5 Basic principles behind all physics
- 4.5 General qualitative problem solving skills
- 4.4 General quantitative problem solving skills
- 4.2 Apply physics topics covered to new situations
- 4.2 *Use with confidence*

Goals: Algebra-based Course (24 different majors) 1987

- 4.7 Basic principles behind all physics (e.g., Newton's Laws)
- 4.2 General qualitative problem solving skills
- 4.2 *Overcome misconceptions about physical world*
- 4.0 General quantitative problem solving skills
- 4.0 Apply physics topics covered to new situations

Goals: Biology Majors Course 2003

- 4.8 Basic principles behind all physics
- 4.3 General qualitative problem solving skills
- 4.2 *Use biological examples of physical principles*
- 4.1 General quantitative problem solving skills
- 4.0 *Overcome misconceptions about physical world*
- 4.0 *Apply physics topics covered to real world situations*
- 4.0 *Know range of applicability of physics principles*
- 3.9 *Analyze data from physical measurements*

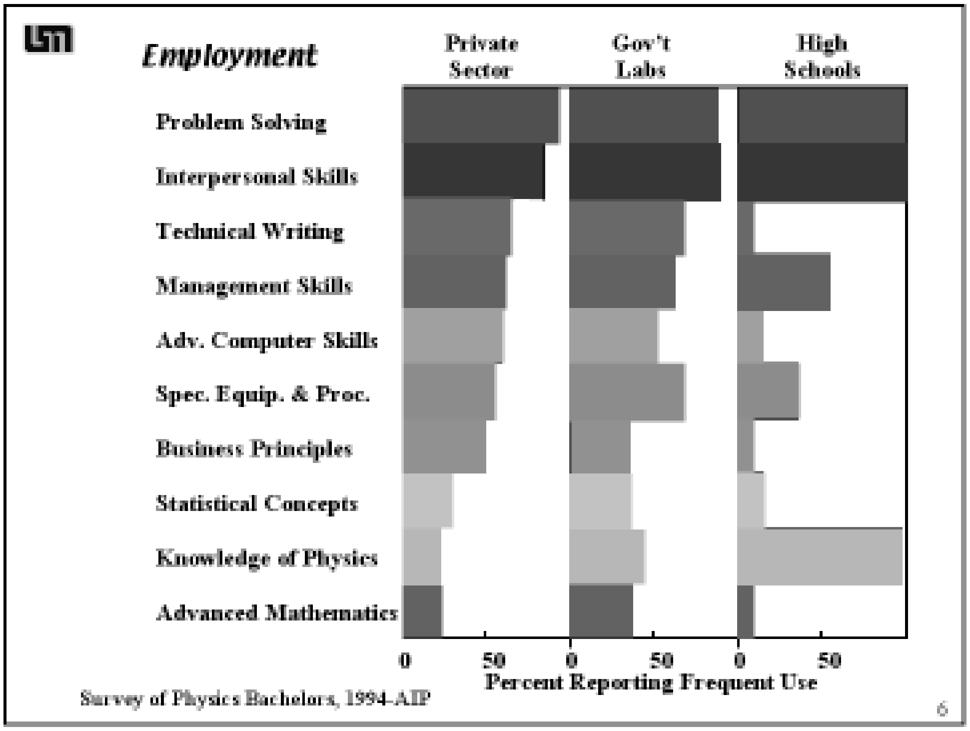
Modified survey in response to CBS Curriculum Committee

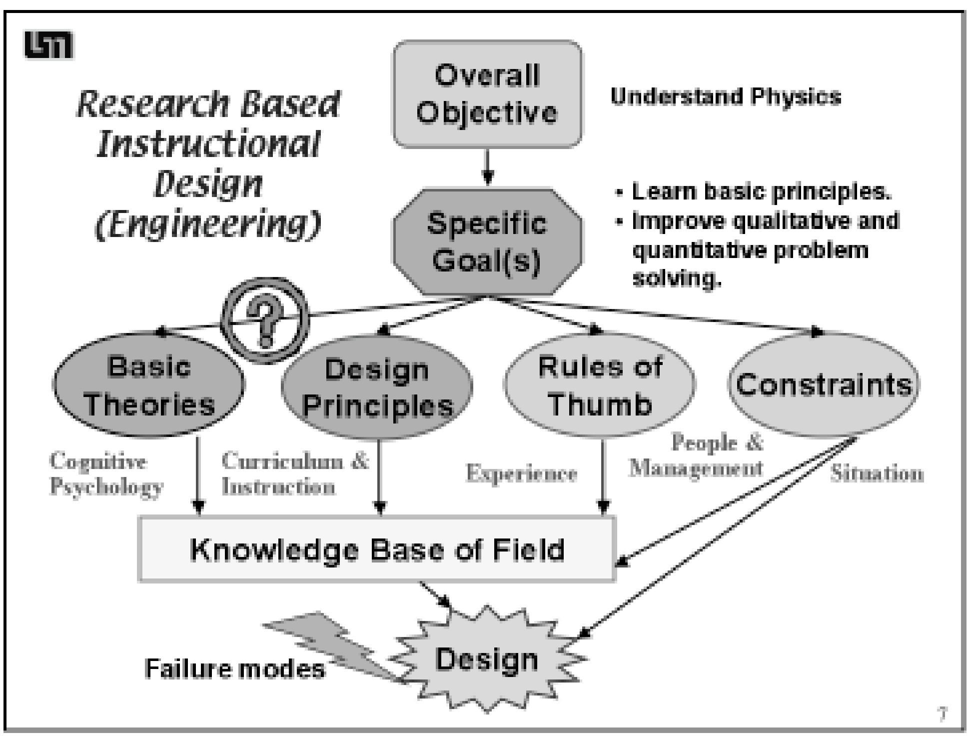
4

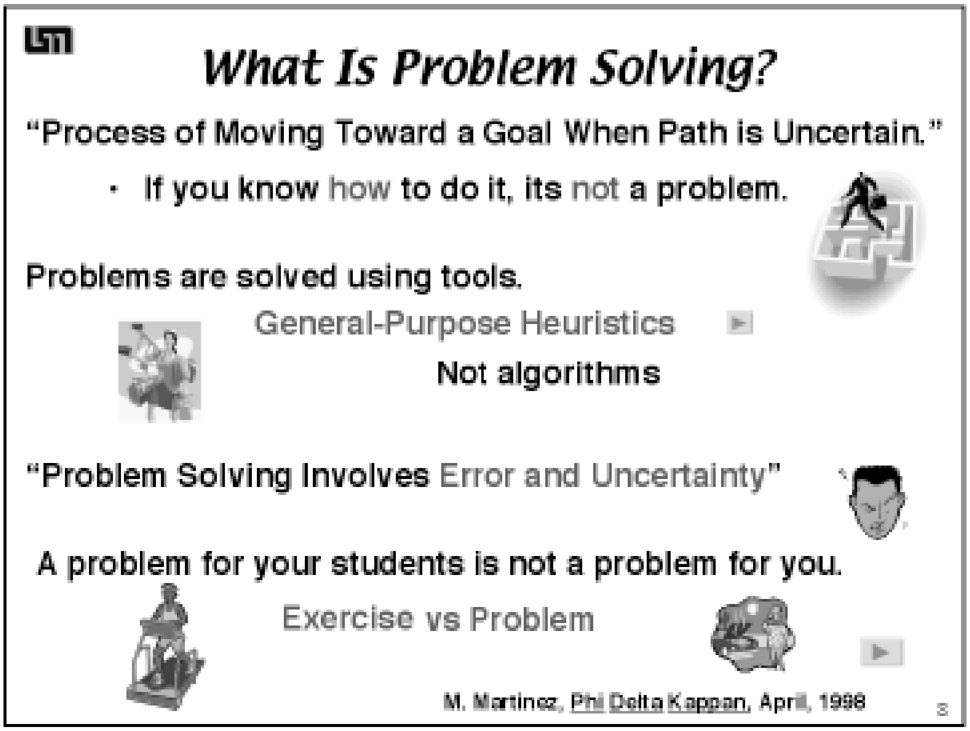
Goals Not Chosen

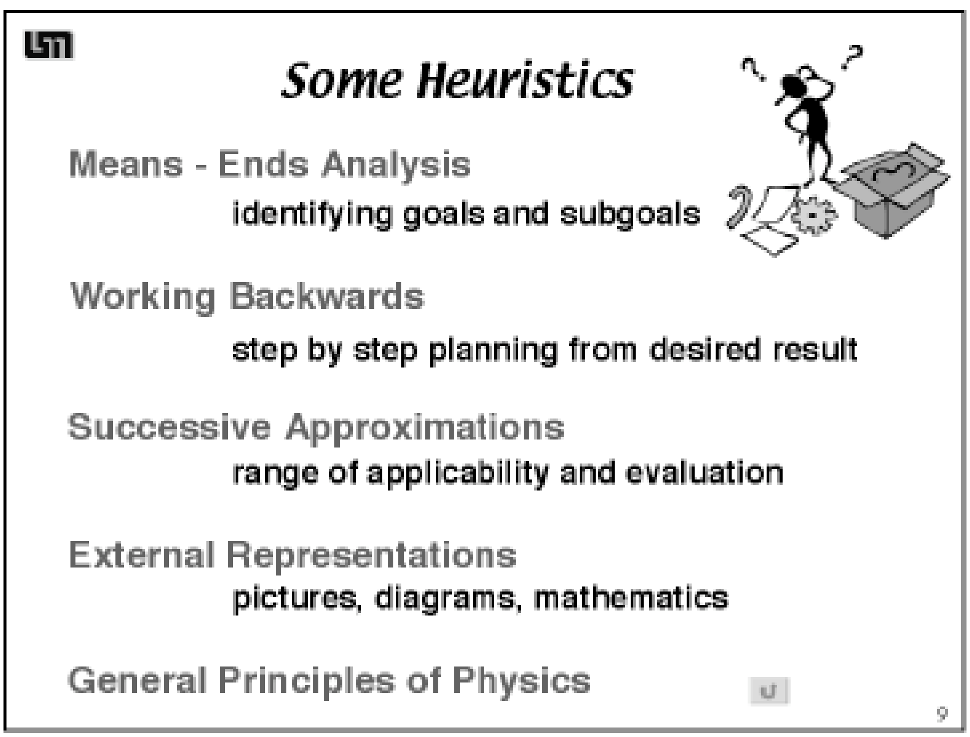
- Be familiar with a wide range of physics topics.
- Formulate and carry out experiments.
- Use modern measurement tools for physical measurements (e.g., oscilloscopes, etc.).
- Analyze data from physical measurements.
- Program computers to solve physics problems.
- Understand and appreciate "modern physics" (e.g., solid state, quantum mechanics, nuclei, etc.).
- Understand and appreciate the historical development and intellectual organization of physics.

5


Employment
Private Sector
Gov't Labs
High Schools
Problem Solving
Interpersonal Skills
Technical Writing
Management Skills
Adv. Computer Skills
Spec. Equip. & Proc.
Business Principles
Statistical Concepts
Knowledge of Physics
Advanced Mathematics
0
50
0
50
0
50
Percent Reporting Frequent Use
Survey of Physics Bachelors, 1994-AIP
6


Research Based Instructional Design (Engineering)
Overall Objective
Understand Physics
Specific Goal(s)
• Learn basic principles.
• Improve qualitative and quantitative problem solving.
Basic Theories
Design Principles
Rules of Thumb
Constraints
Cognitive Psychology
Curriculum & Instruction
Experience
People & Management
Situation
Knowledge Base of Field
Failure modes
Design
7


What Is Problem Solving?
"Process of Moving Toward a Goal When Path is Uncertain."
• If you know how to do it, its not a problem.
Problems are solved using tools.
General-Purpose Heuristics
Not algorithms
"Problem Solving Involves Error and Uncertainty"
A problem for your students is not a problem for you.
Exercise vs Problem
M. Martinez, Phi Delta Kappan, April, 1998
8

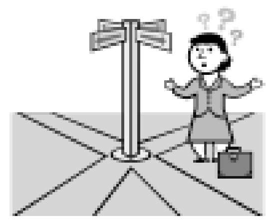

Some Heuristics
Means - Ends Analysis
identifying goals and subgoals
Working Backwards
step by step planning from desired result
Successive Approximations
range of applicability and evaluation
External Representations
pictures, diagrams, mathematics
General Principles of Physics
9

Solving Problems Requires

Conceptual Knowledge:

From Situations to Decisions

- Visualize situation
- Determine problem-solving goal(s)
- Choose applicable principles
- Choose relevant information
- Construct a plan
- Arrive at an answer
- Evaluate the solution



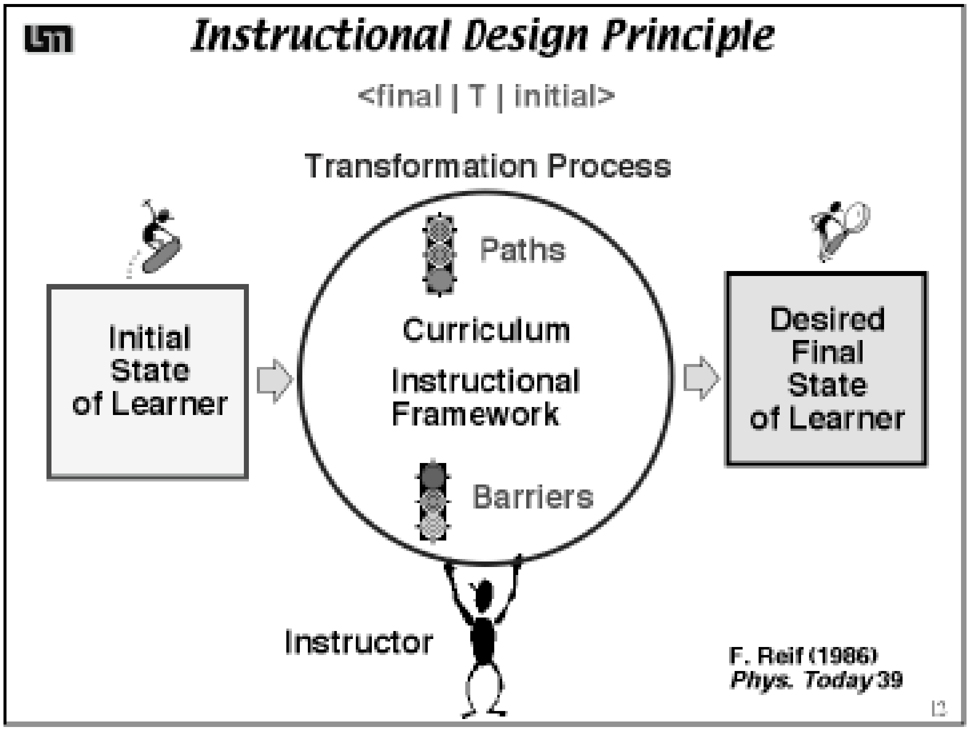
10

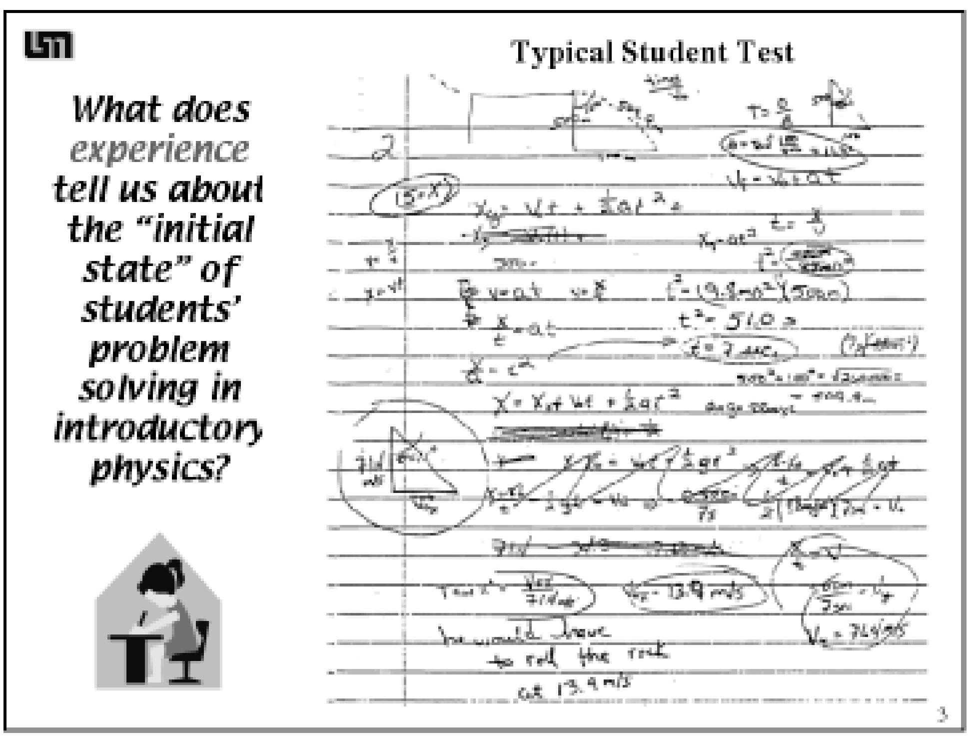
Solving Problems Requires

Metacognative Skills:

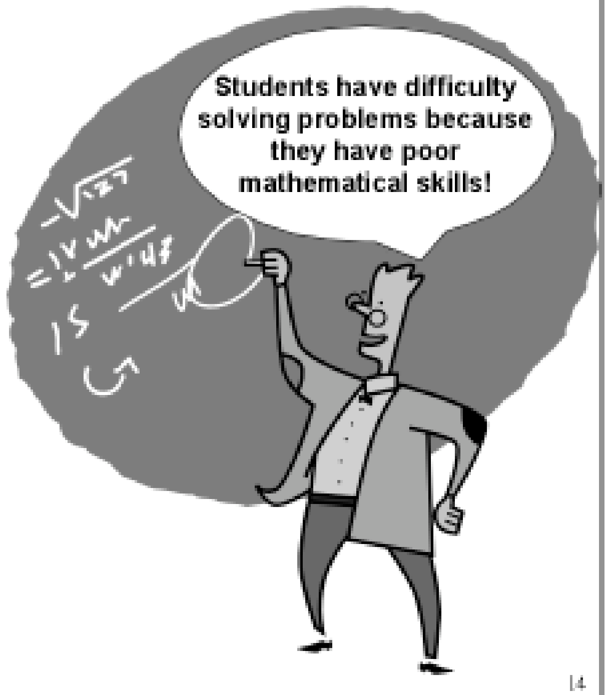
- Managing time and direction
- Determining next step
- Monitoring understanding
- Asking skeptical questions
- Reflecting on own learning process

11


Instructional Design Principle
<final | T | initial>
Transformation Process
Paths
Curriculum
Instructional Framework
Barriers
Initial State of Learner
Desired Final State of Learner
Instructor
F. Reif (1986)
Phys. Today 39
12


Typical Student Test
What does experience tell us about the "initial state" of students' problem solving in introductory physics?
he would have to roll the rock at 13.9 m/s
3

What is the Initial State of a Physics Learner?

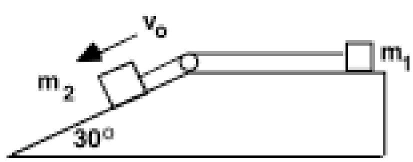


Do you agree with this professor? Why or why not?

14

Modified Atwood Machine Problem

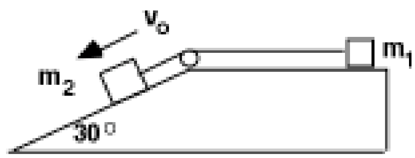
On Final Exam for calculus-based course, 1993



In the diagram shown above, block 1 of mass 1.5 kg and block 2 of mass 4 kg are connected by a light taut rope that passes over a frictionless pulley. Block 2 is just over the edge of the ramp inclined at an angel of 30°, and the blocks have a coefficient of sliding friction of 0.21 with the surface. At time t = 0, the system is given an initial speed of 11 m/s that starts block 2 down the ramp. Find the tension in the rope.

15

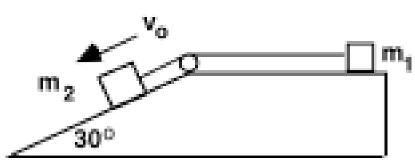
Atwood Solutions (N = 174)



Type of Solution	%
1. Correct or minor errors	29
2. Careless; many omissions; no sense of order	9
3. Incorrect Physics Approaches	52
4. Mathematics Problems	
a. Can't solve simultaneous equations	6
b. Trigonometry or algebra errors	3

16

Incorrect Physics Approaches: Atwood Machine



	%
a. $F_{unknown} = \sum F_{known}$ $T = F_{net} = f_1 + f_2 - m_2 g \sin\theta$	22
b. $\sum F = 0$ $\sum F = T - f_1 - f_2 = 0$	13
c. $F_{unknown} = ma$ $F = T = ma = m_2 g \sin\theta$	6
d. Incomplete, can't tell	11

17

Initial State of the Learner

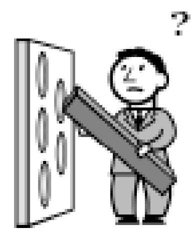
Students have Misconceptions about

The Field of Physics

Learning Physics

Nature

Problem-solving



All combine to make it difficult for students to solve problems.

Not the same as "getting a problem right".

18

Some References in Problem Solving

1916 - A. Binet & T. Simon, *Development of Intelligence in Children,* trans. E. S. Kite, Baltimore, Williams, and Witkins

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19

1979 - J. Larkin, & F. Reif, Understanding and teaching problem solving in physics, European Journal of Science Education, 1(2): 191-203

1985 - A. Schoenfeld, Mathematical problem solving. Orlando, FL: Academic Press.

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1993 - J. Mestre, R. Dufresne, W. Gerace, P. Hardiman, & J. Touger, Promoting skilled problem-solving behavior among beginning physics students. Journal of Research in Science Teaching, 30(3), 303-317.

1994 - D. Maloney, Research on problem solving: Physics, in D. Gabel (Ed), Handbook of Research on Science Teaching and Learning (pp. 327-356). New York: Macmillan.

20

Misconceptions About Learning Physics

Professor explains what is required for that topic

Clear explanations which follow the textbook.

"I understand the concepts,
I just can't do the problems"

The test is exactly what the professor clearly explained.

Test problems follow
exactly worked examples.

"I can do the homework
but your test problems
are too different."

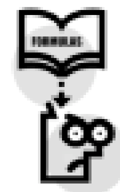
21

Students' Misconceptions About Problem Solving

You need to know the right formula to solve a problem:

- Memorize formulas;
  - Bring in "crib" sheets.
- Manipulate the equations as quickly as possible.

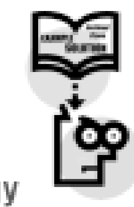
Novice "Plug-and-chug" Strategy



It's all in the sequence of mathematics:

- Memorize example solutions.
- Numbers are easier to deal with;
  - Plug in numbers as soon as possible.

Novice "Pattern Matching" Strategy

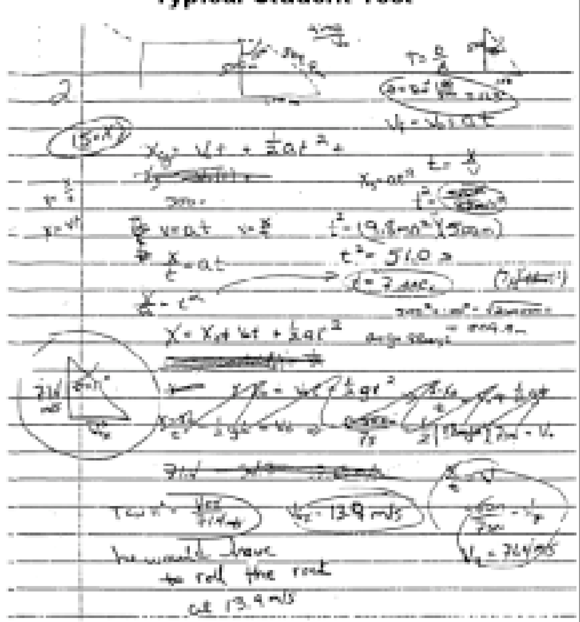


22

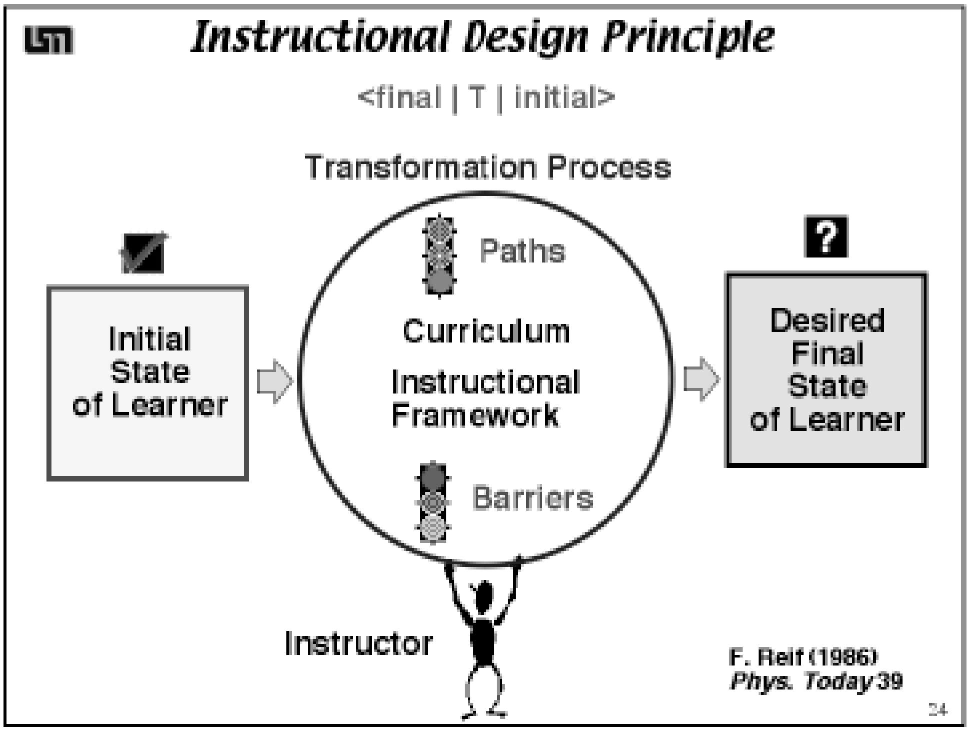
Initial State of the Learner

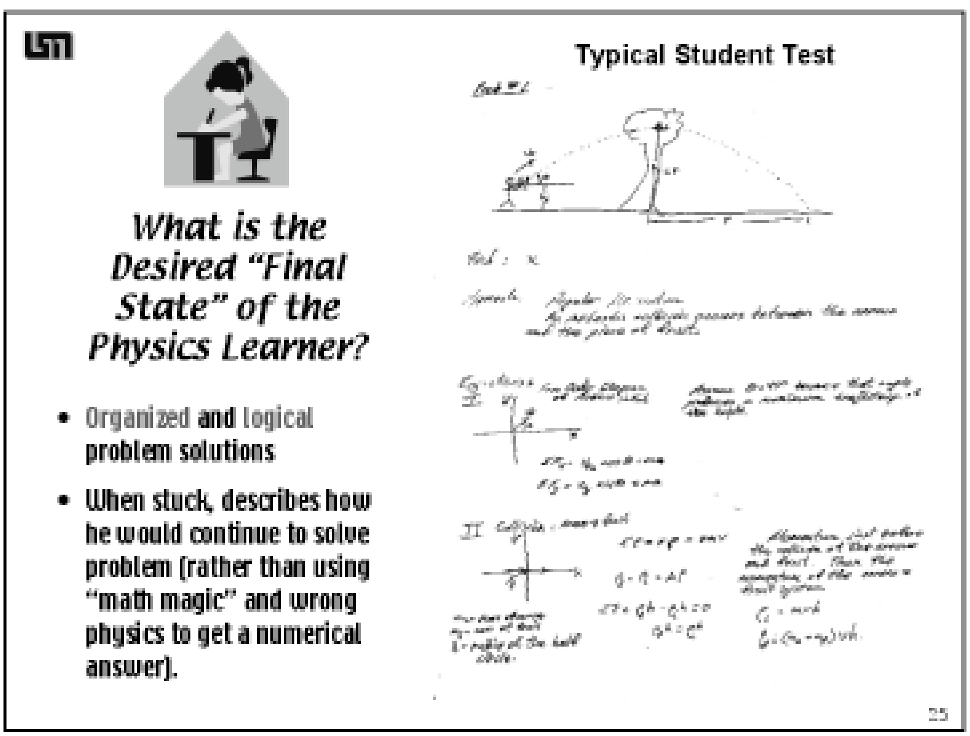
- Misconceptions about physics, learning physics, and problem solving
- Lack of metacognitive skills
- No problem-solving heuristics

Typical Student Test



23


Instructional Design Principle
<final | T | initial>
Transformation Process
Initial State of Learner
Paths
Curriculum
Instructional Framework
Barriers
Desired Final State of Learner
?
Instructor
F. Reif (1986)
Phys. Today 39
24


What is the Desired "Final State" of the Physics Learner?
• Organized and logical problem solutions
• When stuck, describes how he would continue to solve problem (rather than using "math magic" and wrong physics to get a numerical answer).
Typical Student Test
25

From Novice to Expert Problem Solver

7 - 10 Years

Novice -- context-bound facts, features, rules
Every case is unique (plug-and-chug)

Advanced Beginner -- adds situational elements to rules
Patterns based on context (pattern matching)

Competent -- context-free rules applied to unique situations
Patterns based on rules

Proficient -- context-free rules applied to patterns of situations
Patterns based on situations

Expert -- context-free rules modified by situation pattern

26

We can NOT expect students to become expert problem solvers in one year!

GOAL: Help student move along the continuum from novice or advanced beginners towards Competent problem solvers (patterns based on rules).

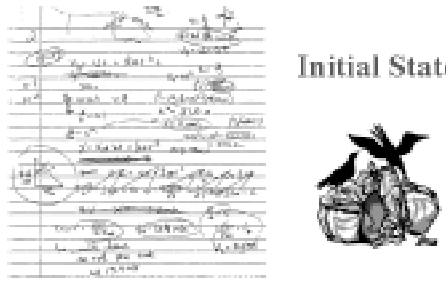
Students can learn a "competent" problem-solving framework that directs their efforts toward making connections both among physics concepts and between those concepts and the rest of their knowledge.

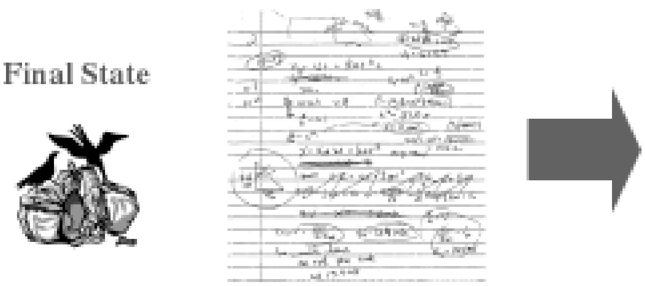
The framework should be a logical and organized guide to arrive at a problem solution. It gets students started, guides them to what to consider next, organizes their mathematics, and helps them determine if their answer is correct.

27

Experiment 1:
Show (model) how to use "competent" problem solving framework in lecture

Initial State



Final State

No Change!

Why do you think this experiment failed?

28

Practice Makes Perfect *BUT*

Traditional Textbook and Exam "Problems"

- Can often be solved by manipulating equations
- Little visualization necessary
- Few decisions necessary
- Disconnected from student's reality
- Can often be solved without knowing physics

What is being practiced?

29

This Textbook Problem Does NOT Reinforce Problem Solving

A block starts from rest and accelerates for 3.0 seconds. It then goes 30 ft. in 5.0 seconds at a constant velocity.

a. What was the final velocity of the block?

b. What was the acceleration of the block?

Why?

31

Appropriate Problems for Problem Solving

The problems must be challenging enough so there is a *real* advantage to using some problem solving heuristics.

1. **The problem must be complex enough so the best student in the class is not certain how to solve it.**

   The problem must be simple enough so that the solution, once arrived at, can be understood and appreciated.

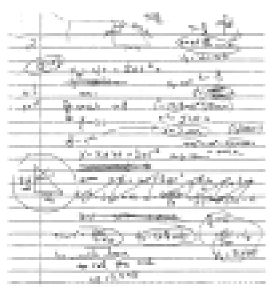
32

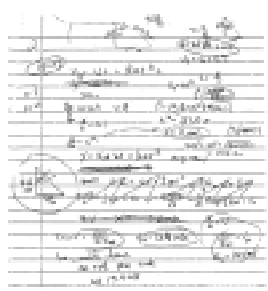
Context-Rich Problem

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.

33

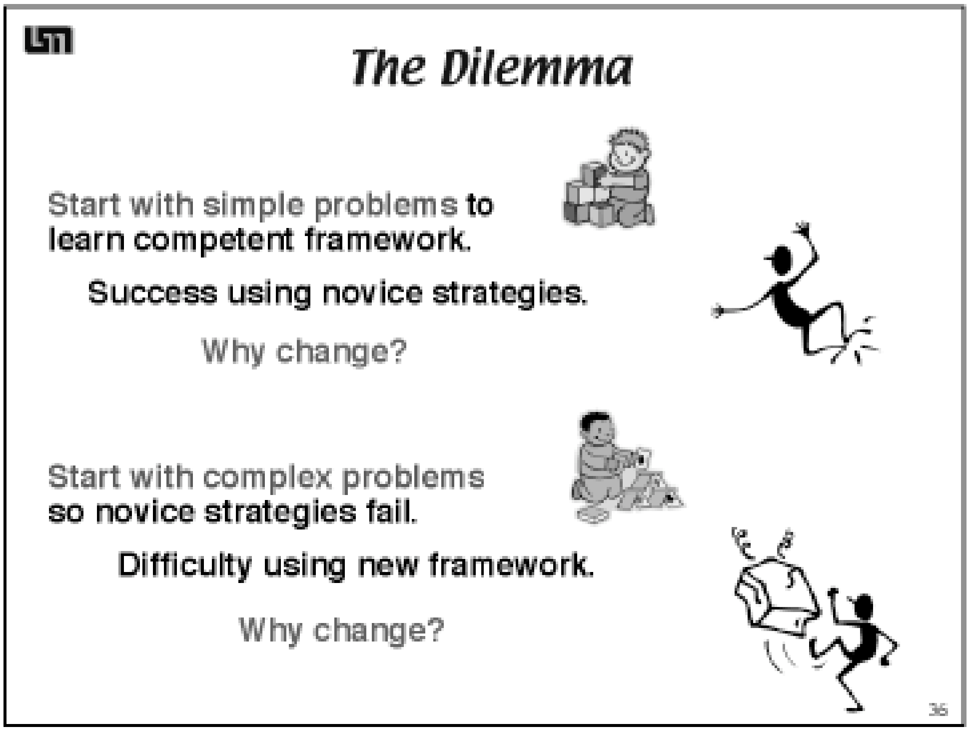
Experiment 2:

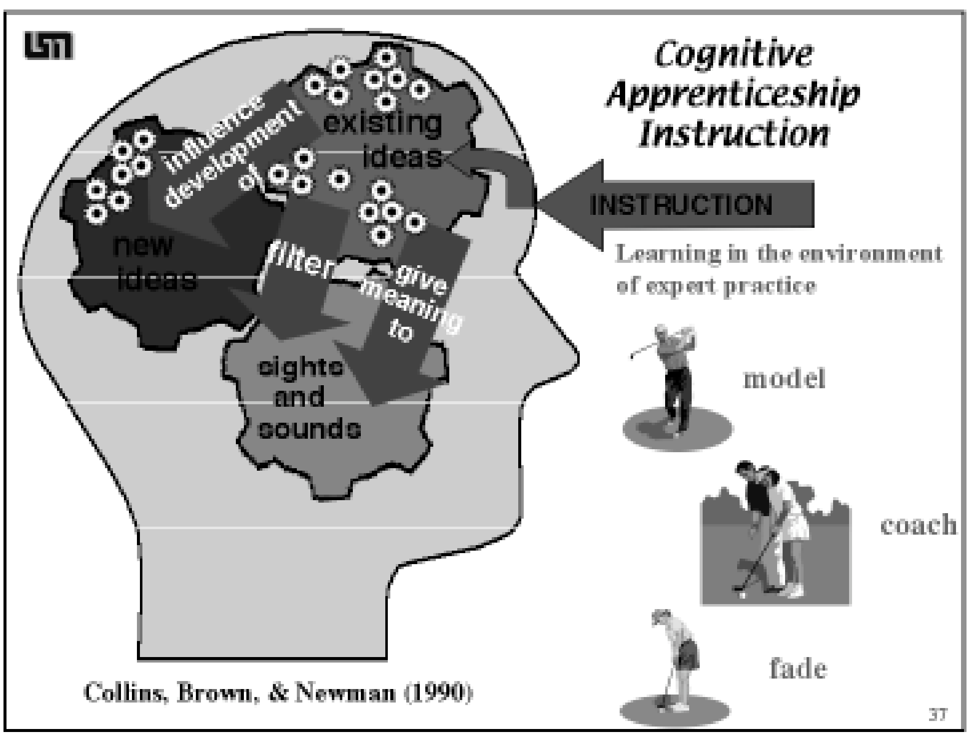
Show (model) "competent" problem solving framework in lecture and use context-rich problems.

Initial State

Final State

No Change!

Why do you think this experiment failed?

35


The Dilemma
Start with simple problems to learn competent framework.
Success using novice strategies.
Why change?
Start with complex problems so novice strategies fail.
Difficulty using new framework.
Why change?
36


Cognitive Apprenticeship Instruction
influence development of
existing ideas
new ideas
filter
give meaning to
sights and sounds
INSTRUCTION
Learning in the environment of expert practice
model
coach
fade
Collins, Brown, & Newman (1990)
37

Cooperative Problem Solving "Full Model"

Emphasis: Fundamental Physics Principles & Problem Solving

Problem Design and Problem-solving Framework
based on expert-novice research

Coaching based on collaborative learning research

Constraints: Lecture, Recitation and Laboratory

- **Lectures: MODEL concept construction in problem context and competent problem solving**
- **Recitation and Laboratory: COACH problem solving**

Scaffolding

- **Context-rich problems that require physics decisions**
- **Explicit problem-solving framework**
- **Structured cooperative groups**

- **Remove scaffolding: FADE support**

38

Recitation Sections

Traditional Recitation Sections Do Not Work

- Instructor chooses problems to solve for students
- Students choose problems for instructor to solve
- Instructor gives review of professor's lecture

→ Less efficient lectures

Use Recitation Section for Coaching

Students work on an appropriate task
- In small groups (peer coaching)
- Intervention by instructor (expert coaching)

Need

- Appropriate task
- Group structure
- Intervention tactics

→ Cooperative Group Problem Solving

41

Activity 5 (2 points). Teaching Discussion Sessions at UMn

The purpose of this activity is to introduce you to your role as instructors in the discussion section.

Part A: Demonstration of a Discussion Session (~ 50 minutes)

A Mentor TA will demonstrate how to teach a typical discussion session, with you as the students! To make your experience similar to what undergraduate students experience, your group will solve an old problem from the Graduate Written Exam (GWE). Focus on the *process* of collaborative problem solving.

Group Task:

Follow the directions of the Mentor TA.

Group Product:

Your group's problem solution.

Grading Rubric

The solution will **not** be graded for a correct answer. Instead, the solution will be graded for organization and logical progression.

Part B: Class Discussion About Teaching Discussion Sessions

(1) On the following pages is the revised *Outline for Teaching a Discussion Session*. Read through this outline and think about the experience you had solving the GWE problem in a group. Write down questions and comments

(2) The Mentor TA will lead a class discussion about your questions. Write important answers/notes in the space provided.

Preparation Checklist

- ❑ New Group/Role assignments (if necessary, on overhead or written on board)
- ❑ Photocopies of Problem & Useful Information *(one per person)* OR list of useful information to put on board
- ❑ Photocopies of Answer Sheet (optional) or blank sheets of paper *(one per group)*
- ❑ Photocopies of problem solution *(one per person)*
- ❑ Group Evaluation forms (optional one per group) and extra photocopies of Group Roles Sheet

	Instructor Actions	What the Students Do
Opening Moves ~3-5 min.	⓪ Be at the classroom early ① Introduce the problem by telling students: a) what they should learn from solving problem; b) the part of the solution you want groups to put on board ② Prepare students for group work by: a) showing group/role assignments and classroom seating map; b) passing out Problem & Useful Information and Answer Sheet.	• Students sitting and listening • Students move into their groups, and begin to read problem. • Checker/Recorder puts names on answer sheet.

QUESTIONS/NOTES:

	Instructor Actions	What the Students Do
Middle Game ~35 min.	③ Coach groups in problem solving by: a) monitoring (diagnosing) progress of all groups b) helping groups with the most need. ④ Prepare students for class discussion by: a) giving students a "five-minute warning" b) selecting one person from each group to put specified part of solution on the board. c) passing out Group Evaluation Sheet (optional)	• Solve the problem: - participate in group discussion, - work cooperatively, - check each other's ideas. • Finish work on problem • Write part of solution on board • Discuss their group effectiveness
End Game ~10 min.	⑤ Lead a class discussion focusing on what you wanted students to learn from solving the problem ⑥ Discuss group functioning (optional) ⑦ Pass out the problem solution as students walk out the door.	• Participate in class discussion

QUESTIONS/NOTES:

Activity 6a (1 point). The Cowboy Bob Problem

Below is a problem from an exam in Physics 1101 (algebra-based introductory course). Solve this problem as quickly as you can.

Cowboy Bob Problem: Because parents are concerned that children are taught incorrect science in cartoon shows, you have been hired as a technical advisor for the Cowboy Bob show. In this episode, Cowboy Bob, hero of the Old West, happens to be camped on the top of Table Rock in the Badlands. Table Rock has a flat horizontal top, vertical sides, and is 500 meters high. Cowboy Bob sees a band of outlaws at the base of Table Rock 100 meters from the side wall. The nasty outlaws are waiting to rob the Dodge City stagecoach. Cowboy Bob decides to roll a large boulder over the edge and onto the outlaws. Your boss asks you if it is possible to hit the outlaws with the boulder. Determine how fast Bob will have to roll the boulder to reach the outlaws.

Notes:

Activity #**6b** (2 points)

Differences in Expert-Novice Problem Solving

GROUP TASKS:

1. Make a list or flow chart of all the steps (major decision points and/or actions) that you took to solve a "real problem" (the Graduate Written Exam Problem).
2. Make a list or flow chart of all the steps (major decision points and/or actions) that you took to solve an "exercise" (the Cowboy Bob Problem).
3. Make a list of all the ways an expert problem solver (e.g., you, a professor) solves a "real problem" *differently* than an "exercise."
4. What does Larkin recommend be done to help students become better problem solvers? How should this be done? What do you think of this idea?

COOPERATIVE GROUP ROLES:

Skeptic: Ask what other possibilities there are, keep the group from superficial analysis by not allowing the group to agree too quickly; ask questions that lead to a deeper analysis; agree when satisfied that the group has explored all possibilities.

Manager: Suggest a plan for answering the questions; make sure everyone participates and stays on task; watch the time.

Checker/Recorder: Ask others to explain their reasoning process so it is clear to all that their suggestions can be discussed; paraphrase, write down, and edit your group's answers to the questions.

TIME: 25 minutes.

One member from your group will be randomly selected to present your group's answers to Questions #1 and #2.

PRODUCT:

Activity #6b Answer Sheet.

Activity 6b (2 points)

Manager: ________________________

Recorder: ________________________

Skeptic: ________________________

Summarizer: ________________________

Answer Sheet for Activity 6b

1. Examine your group solution to the Graduate Written Exam Problem. Make a flow chart of the major steps (decisions and/or actions) you took to solve the problem.

2. Now compare and contrast your group solution to the Graduate Written Exam (GWE) Problem and your individual solutions to the Cowboy Bob Problem. For you, as expert problem solvers, the GWE problem was a "real problem" -- one you did not know how to solve immediately -- and the Cowboy Bob Problem was probably more like an "exercise" -- a type of problem you have solved so many times before that you immediately knew how to approach the problem.

   (a) Make a flow chart of the steps (major decisions and/or actions) you took to solve the Cowboy Bob Problem.

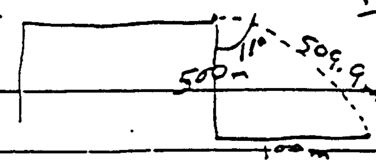
   (b) How were your solution steps different for the real problem and the exercise?

3. For students in an introductory physics class (novice problem solvers), the Cowboy Bob Problem **IS A REAL PROBLEM**. Compare and contrast the attached novice solution to the Cowboy Bob Problem with your group solution to the GWE Problem.

   Based on (a) your comparison of the solutions, and (b) the reading of Larkin (1979), make a list of all the ways that experts solve real problems (e.g., the GWE problem) ***differently*** than novices solve what is, for them, a real problem (e.g., the Cowboy Bob Problem).

Expert Solving Real Problem	Novice Solving a Real Problem

"Novice" Solution to Cowboy Bob Problem



find V_o

$t = \frac{0}{A}$

2.

$\theta = \tan^{-1}\frac{100}{500} = 11.3°$

$V_f = V_o + at$

(5 = x)

$X_y = V_o t + \frac{1}{2}at^2 \div$

~~$X_y = V_o(t) +$~~

$t = \frac{x}{v}$

$v = \frac{x}{t}$

$X_y = at^2$

$500 =$

$t^2 = \left(\frac{500m}{9.8m/s^2}\right)$

$x = vt$

$v = at \quad v = \frac{x}{t}$

$t^2 = (9.8m/s^2)^{-1}(500m)$

$\frac{x}{t} = at$

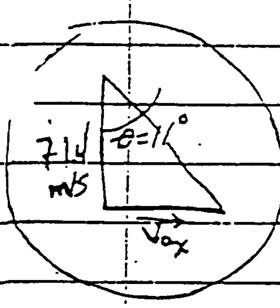
$t^2 = 51.0\ s$

$t = 7\ sec.$

$\frac{x}{a} = t^2$

$500^2 + 100^2 = \sqrt{260000} =$
$= 509.9m$

$X = X_o + V_o t + \frac{1}{2}at^2 \quad a = g = 9.8m/s^2$



~~$X - X_o = V_o t + \frac{1}{2}gt^2 \rightarrow \frac{X - X_o}{t} = V_o + \frac{1}{2}gt$~~

$\frac{X - X_o}{t} - \frac{1}{2}gt = V_o \Rightarrow \frac{0 - 500m}{7s} - \frac{1}{2}(9.8m/s^2)(7sec) = V_o$

~~71.4 − 34.5 =~~

$\frac{x}{t} = V$

$\tan 11° = \frac{V_{ox}}{71.4m/s} \quad V_{ox} = 13.9\ m/s$

$\frac{500m}{7sec} = V_y$

$V_y = 71.4\ m/s$

he would have to roll the rock at 13.9 m/s

4. Optional: Shown below is a standard textbook solution to the Cowboy Bob problem. Discuss why this solution promotes continued use of a novice strategy (i.e., discourages the use of a more expert-like strategy).

"Choose a coordinate system with its origin at the point where the boulder goes off the cliff, with the x axis pointing horizontally to the right and the y axis vertically downward. The horizontal component of the initial velocity is:

$$v_{0x} = \frac{D}{t} = \frac{D}{\sqrt{2h/g}} = \frac{100\,\text{m}}{\sqrt{2(500\text{ m})/9.8\text{ m/s}^2}} = 10\text{ m/s}$$

Since the fastest athletes run at about this speed, it is unlikely that Cowboy Bob would be able to push a big boulder this fast."

TA Orientation 2004
Activity #**7** (2 points)

Solving Problems With Methods Questions

INDIVIDUAL TASK:

Solve your *assigned* problem (one of the two problems shown below).

Please include detailed diagram(s), define all variables, and show all steps in your solution. You can pick up and use a series of *Methods Questions* for the problem. These questions are a guide or framework for a logical, organized approach for solving the problem.

TIME: 20 minutes

PRODUCT:
Your problem solution. Your solution will **not** be graded for a correct answer. Instead, the solution will be graded for organization and logical progression.

QUANTUM MECHANICS PROBLEM. You are investigating the properties of very thin materials to study the behavior of quantum systems as their dimensionality goes from three to two. Your system is a surface held at liquid helium temperatures with dislocations in which electrons can be trapped. To predict the equipment needed to detect these trapped electrons, you first decide to calculate the first three energy levels assuming that the potential energy can be approximated as a two dimensional harmonic oscillator with a very small first order coupling between the two orthogonal dimensions. You decide to take the effect of that coupling as a perturbation to the pure harmonic oscillator potential energy. That perturbation is proportional to product of the distance of the electron from its equilibrium position in each dimension. You will work in units in which the mass of the electron is 1 and $\hbar = 1$.

Useful Mathematical Relationships:

$$\int_0^\infty dx\, e^{-\alpha x} = \frac{1}{\alpha} \qquad \int_0^\infty dx\, e^{-\alpha x^2} = \frac{1}{2}\sqrt{\frac{\pi}{\alpha}} \qquad \int_0^\infty dx\, x^n e^{-\alpha x} = \frac{\Gamma[n+1]}{\alpha^{n+1}}$$

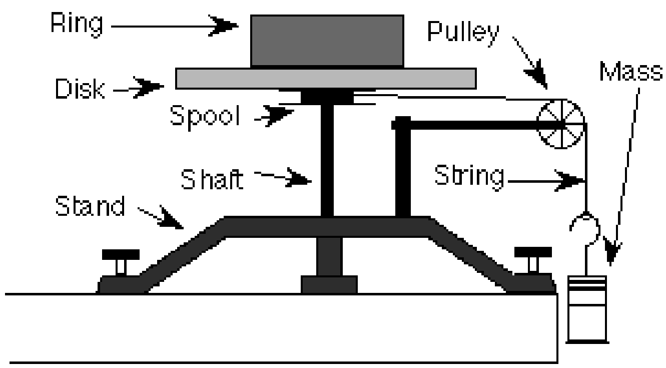
$$\int_0^\infty dx\, x^m e^{-\alpha x^2} = \frac{\Gamma\left(\frac{m+1}{2}\right)}{2\alpha^{\frac{m+1}{2}}} \qquad \Gamma(n) = \frac{\Gamma(n+1)}{n} \qquad \Gamma\left(\frac{1}{2}\right) = \sqrt{\pi}$$

Fundamental Concepts and Principles:

$$-\frac{\hbar^2}{2m}\nabla^2\Psi = i\hbar\frac{\partial}{\partial t}\Psi \qquad \int \Psi^* \Psi\, d\tau = 1 \qquad \Delta x \Delta p \geq \frac{\hbar}{2}$$

$$\int \Psi^* \hat{H} \Psi\, d\tau = E$$

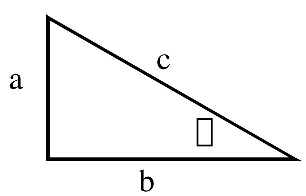
MOMENT OF INERTIA PROBLEM. While examining the engine of your friend's snow blower, you notice that the starter cord wraps around a cylindrical ring of metal. This ring is fastened to the top of a heavy, solid disk, "a flywheel", and that disk is attached to a shaft. You are intrigued by this configuration and wonder how to determine its moment of inertia. Your friend thinks that you just add up all of the individual moments of inertia of the parts to get the moment of inertia of the system. To test this idea you decide to build a laboratory model described below to determine the moment of inertia of a similar system from its motion. You think you can do it by just measuring the acceleration of the hanging weight, as shown in the diagram below.



A disk that is mounted on a sturdy stand by a metal shaft. Below the disk on the shaft is a metal spool to wind string around. A metal ring sits on the disk so both ring and disk share the same rotational axis. A length of string is wrapped around the spool and then passes over a pulley lined up with the edge of the spool. A weight is hung from the other end of the string so that the weight can fall past the edge of the table.

Calculate that the moment of inertia of the ring/disk/shaft/spool system as a function of the acceleration of the hanging weight and the radius of the spool.

Useful Mathematical Relationships:



For a right triangle: $\sin\theta = \frac{a}{c}$, $\cos\theta = \frac{b}{c}$, $\tan\theta = \frac{a}{b}$,
$a^2 + b^2 = c^2$, $\sin^2\theta + \cos^2\theta = 1$

Small angles: $\sin\theta \approx \theta$, $\cos\theta \approx 1 - \frac{\theta^2}{2}$

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 $x = \frac{-B \pm \sqrt{B^2 - 4AC}}{2A}$

$\frac{d}{dz}\left(z^n\right) = nz^{n-1}$, $\frac{d}{dz}(\cos z) = -\sin z$, $\frac{d}{dz}(\sin z) = \cos z$, $\frac{df(z)}{dt} = \frac{df(z)}{dz}\frac{dz}{dt}$, $\int\left(\frac{dw}{dz}\right)dz = w$,

$\frac{d}{dz}\int w\,dz = w$, $\int z^n dz = \frac{z^{n+1}}{n+1} (n \neq -1)$

Fundamental Concepts and Principles:

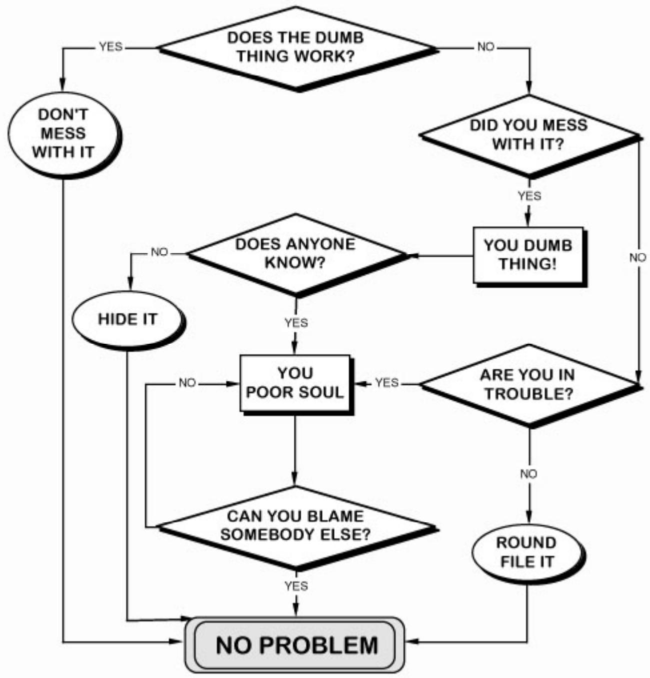
$v_{x\,av} = \frac{\Delta x}{\Delta t}$	$s_{av} = \frac{dist}{\Delta t}$	$a_{x\,av} = \frac{\Delta v_x}{\Delta t}$	$\theta = \frac{\Delta C}{r}$	$\omega_{av} = \frac{\Delta \theta}{\Delta t}$	$\alpha_{av} = \frac{\Delta \omega}{\Delta t}$
$v_x = \frac{dx}{dt}$	$s = \frac{dr}{dt}$	$a_x = \frac{dv_x}{dt}$	$\omega = \frac{d\theta}{dt} = \frac{v_t}{r}$	$\alpha = \frac{d\omega}{dt} = \frac{a_t}{r}$	$\sum \vec{F} = m\vec{a}$
$\tau = rF_t$	$\sum \vec{\tau} = I\vec{\alpha}$	$W = \int_{path} \vec{F} \bullet d\vec{\ell}$	$KE = \frac{1}{2}mv^2$	$E_f - E_i = \Delta E_{transfer}$	$\vec{p} = m\vec{v}$
$\vec{p}_f - \vec{p}_i = \Delta \vec{p}_{transfer}$	$\vec{p}_{transfer} = \int \vec{F} dt$	$\vec{r}_{com} = \frac{\sum m_i \vec{r}_i}{\sum m_i} = \frac{\int \vec{r} dm}{\int dm}$		$I = \sum m_i r_i^2 = \int r^2 dm$	$\vec{L} = I\vec{\omega}$
$\vec{L}_f - \vec{L}_i = \Delta \vec{L}_{transfer}$	$\vec{L} = \vec{r} \times \vec{p}$	$\vec{L}_{transfer} = \int \vec{\tau} dt$		$f = \frac{1}{T}$	

Under Certain Conditions:

$x_f = \frac{1}{2}a(\Delta t)^2 + v_{ox}\Delta t + x_o$	$F = \mu_k F_N$	$F \le \mu_s F_N$	$F = k\Delta x$	$KE = \frac{1}{2}I\omega^2$	$PE = mgy$	$PE = \frac{1}{2}kx^2$
$\theta_f = \frac{1}{2}\alpha(\Delta t)^2 + \omega_o\Delta t + \theta_o$	$a = \frac{v^2}{r}$	$I = I_{cm} + Md^2$	$v_{cm} = r\omega$	$x = A\cos(2\pi f t + \phi)$		

$I_{cm} = fI_{ring}$: f (hollow sphere)=2/3; f (disk)=1/2; f(solid sphere)=2/5; f (solid rod, perpendicular to length)=1/3

Useful constants: 1 mile = 5280 ft, 1km = 5/8 mile, g = 9.8 m/s^2 = 32 ft/s^2, R_E = 4x10^3 miles, G = 6.7x10^{-11} Nm^2/kg^2



Solving Problems with Methods Questions

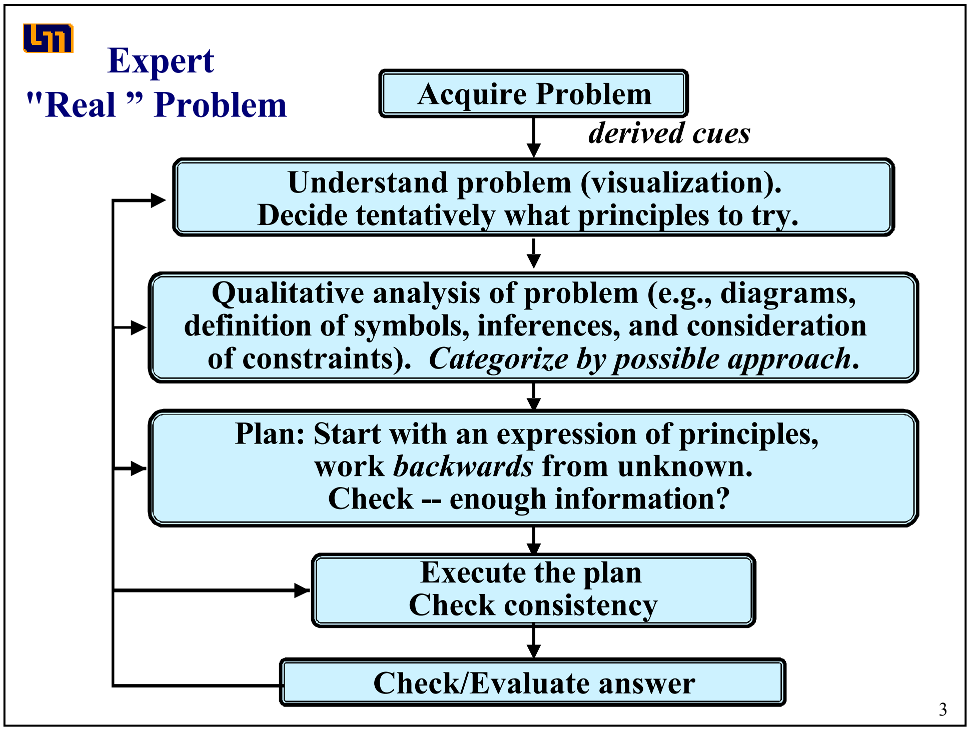
1

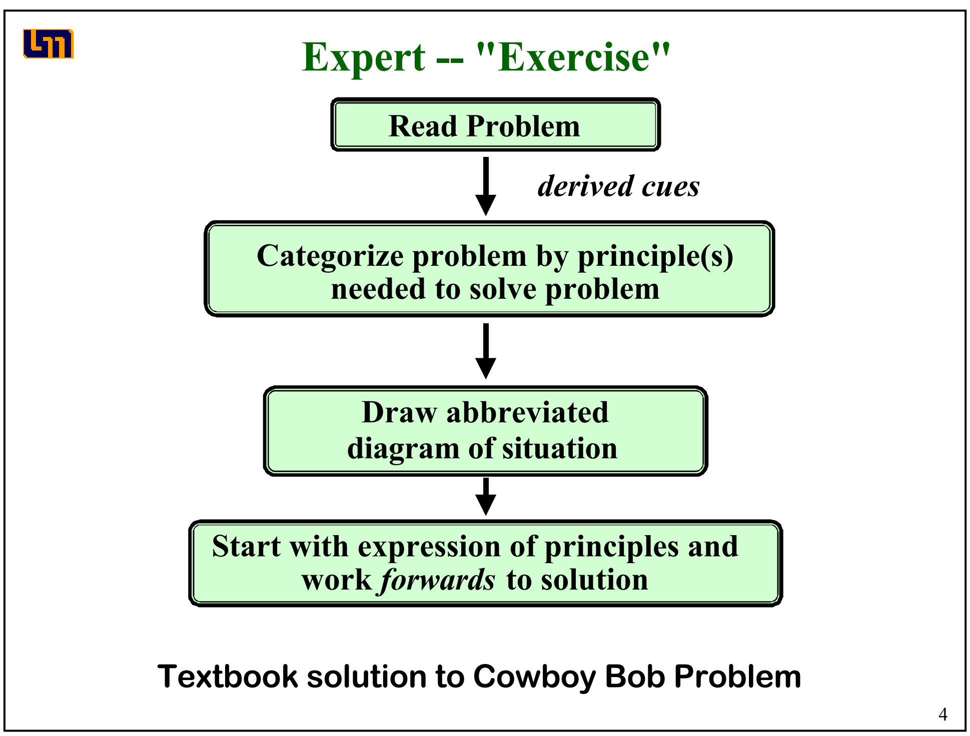
Problem solving is a process similar to working your way through a maze.

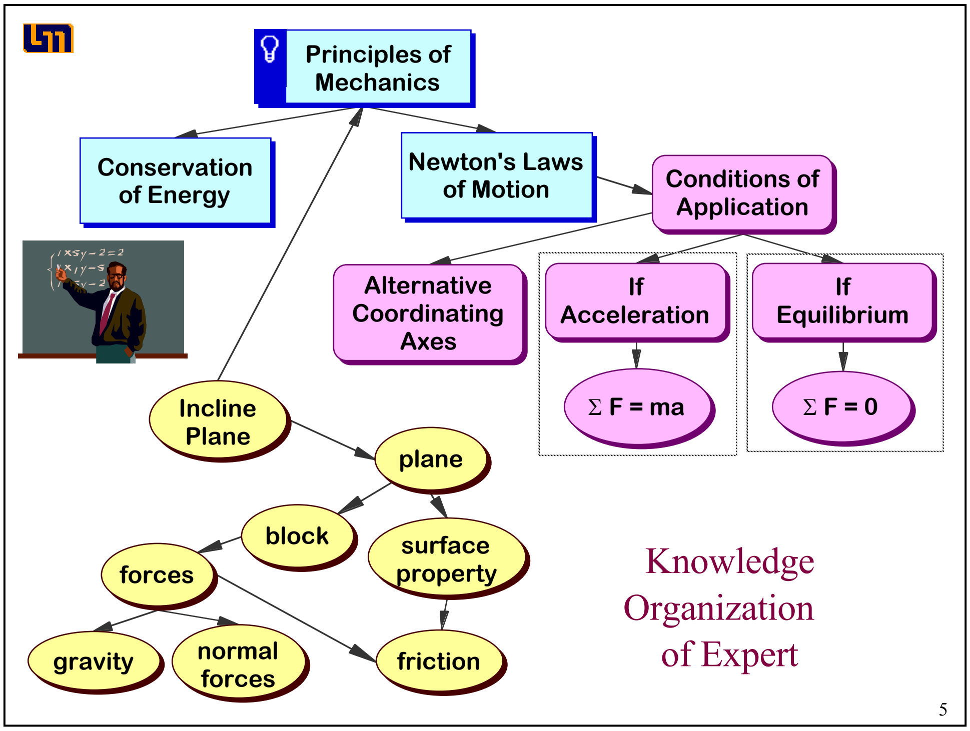
You navigate your way through a maze toward your goal (solution) *step by step*, making some false moves but gradually moving closer toward the goal.

But what are these "steps" and what guides your decisions?

2


Expert
"Real " Problem
Acquire Problem
derived cues
Understand problem (visualization).
Decide tentatively what principles to try.
Qualitative analysis of problem (e.g., diagrams, definition of symbols, inferences, and consideration of constraints). *Categorize by possible approach*.
Plan: Start with an expression of principles, work *backwards* from unknown.
Check -- enough information?
Execute the plan
Check consistency
Check/Evaluate answer
3


Expert -- "Exercise"
Read Problem
derived cues
Categorize problem by principle(s) needed to solve problem
Draw abbreviated diagram of situation
Start with expression of principles and work *forwards* to solution
Textbook solution to Cowboy Bob Problem
4



Novice *Pattern Matching*

Read Problem

↓ *literal cues*

Categorize problem by surface features

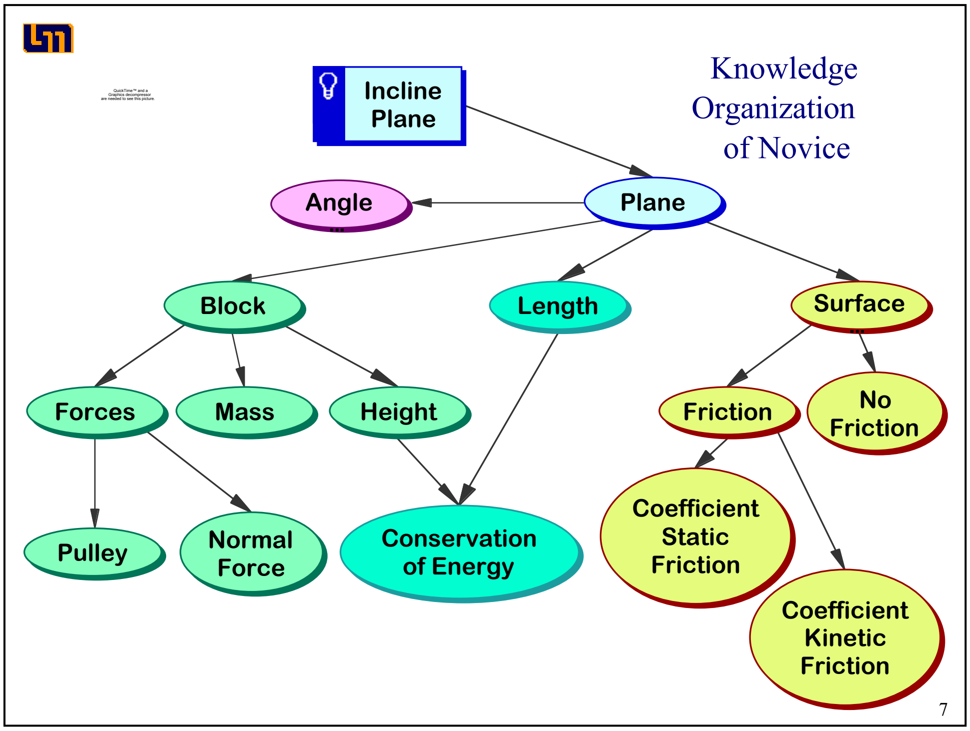
↓

Recall memorized pattern of actions and specific formulas for solving problem type

↓

Manipulate a procedure until solution obtained

6



For freshmen, many physics problems are **real problems**, not exercises.

So how can students be coached in using a logical, organized process for solving real problems?

1. **Discussion Section:** Focus of final discussion is on the *qualitative analysis of the problem*, not on the mathematics.

2. **Laboratory Section:**

(a) Students answer *Methods Questions* (before lab) that provide a guide or framework for how to solve each laboratory problem in a logical, organized fashion.

(b) Focus of discussion is on **Methods Questions that are part of the qualitative analysis of the problem**.

8

Activity #8b (2 points)

Using Methods Questions for Coaching

INDIVIDUAL AND GROUP TASKS:

1. **Individually** read the passage below. Participate in a class discussion about this passage

   The procedure is actually quite simple. First, you arrange them into different groups. Of course, one pile may be sufficient depending on how much there is to do. If you have to go somewhere else due to lack of facilities that is the next step; otherwise, you are pretty well set.

   It is important not to overdo things. That is, it is better to do too few things than too many. In the short run, this may not seem important, but complications can easily arise. A mistake can be expensive as well. At first, the whole procedure will seem complicated. Soon, however, it will become just another fact of life. It is difficult to foresee any end of the necessity of the task in the immediate future, but then, one can never tell.

   After the procedure is completed, one arranges the materials into different groups again. Then they can be put into their appropriate places. Eventually they will be used once more and the whole cycle will then have to be repeated. However, that is a part of life.

2. You will be given directions for a group discussion with specific questions about using Methods Questions for coaching.

COOPERATIVE GROUP ROLES:

Skeptic: Ask what other possibilities there are, keep the group from superficial analysis by not allowing the group to agree too quickly; ask questions that lead to a deeper analysis; agree when satisfied that the group has explored all possibilities.

Manager: Suggest a plan for answering the questions; make sure everyone participates and stays on task; watch the time.

Checker/Recorder: Ask others to explain their reasoning process so it is clear to all that their suggestions can be discussed; paraphrase, write down, and edit your group's answers to the questions.

TIME: 20 minutes.

One member from your group will be randomly selected to present your group's answers.

PRODUCT:

Overhead of group answers. One member from your group will be randomly selected to present your group's answers.

Activity 9 (2 points)

Teaching Lab Sessions at UMn

Today, a mentor TA will demonstrate how to teach a problem-solving laboratory session at the University of Minnesota. The goals of this activity are for you to learn:

- the structure of the problem-solving labs you will be teaching;
- the rationale for each teaching action in the lab sessions.

During the demonstration, another mentor TA will observe the teacher. At the end of the demonstration, the teacher will be mentored by the observer. Compare your impressions with those of the mentor.

INDIVIDUAL AND GROUP TASKS:

1. Participate in the laboratory demonstration as undergraduates might.
2. Periodically, we will stop the demonstration. Discuss the reasons for *each part* of the lesson plan with your group. Then *individually* write the reasons under "Rationale" on the attached lesson plan. These reasons will then be shared and expanded upon by the class and instructors.
3. Work on the assigned laboratory problem and be prepared to discuss your results.

COOPERATIVE GROUP ROLES:

Skeptic: Ask what other possibilities there are, keep the group from superficial analysis by not allowing the group to agree too quickly; ask questions that lead to a deeper analysis; agree when satisfied that the group has explored all possibilities.

Manager: Suggest a plan for discussing the reasons for each part of the lesson plan; make sure everyone participates and stays on task; watch the time.

Checker/Recorder: Ask others to explain their reasoning process so it is clear to all that their suggestions can be discussed; paraphrase, your group's rationale.

TIME: 2 hours.

PRODUCT:

We will randomly collect the answer sheet of one group member to grade. Every group member will receive this grade.

Activity 9 Answer Sheet Name: ______________________________

Time	**Opening Moves**	Rationale
	0 Get there early and lock door. - Collect one piece of equipment needed for lab problems - Write new groups/roles on board (when appropriate) - Write which methods questions groups should write on board - Open Door	
10 min.	**1.** Prepare students for group work by showing group/role assignments.	
	2. Prepare students for lab.	
~1 min.	**a)** <u>Focus on what students should learn</u>. Tell students which Methods Question(s) they should discuss and put on the board.	
5 min	**b)** <u>Diagnose student difficulties</u>. While groups discuss *Methods Questions*, circulate around the class, ***observe/listen to*** each group, and diagnose difficulties.	
2 min	**c)** <u>Post Group Answers</u>. Select (randomly) one person from each group to write/draw on board answers to the *Methods Questions*.	
5-10 min	**d)** <u>Lead a class discussion</u>. Give students a few minutes to read all the answers on the board. Ask the representatives of each group to give their reasons for each of their answers.	
1 min	**e)** <u>How much time</u>. Tell class time they need to stop (usually about 30 – 40 minutes) and remind Managers to keep track of the time.	

NOTES:

<table>
<tr><th>Time</th><th>Middle Game</th><th>Rationale</th></tr>
<tr><td>5 min

~5 min.

variable</td><td>3. Coach groups in problem solving (making decisions) by:
a) <u>Diagnose initial difficulties with the problem or group functioning</u>.
- Return equipment to groups
- Watch class from front of room:
Don't answer questions.
Is class able to proceed?
Stop class and discuss difficulty if everyone is off task.

b) <u>Monitor groups and intervene to coach when necessary</u>.
Monitor and diagnose :
- Establish a circulation pattern around room. Listen to each group (without them knowing) at least one before answering questions.
Diagnose difficulties with physics;
Diagnose difficulties with group functioning.
Prioritize who needs the most help.
Is entire class confused on the same thing? If so, stop the class and discuss the difficulty.

Coach Groups with the Most Need.
- coach first with the group that needs the most help, and so on
- Always join a group at eye level.
- If you spend a long time with group, circulate around class again, listening briefly to each group and diagnose difficulties, before intervening again.
- Be sure groups are completing all parts of the problem
- If a group finishes early, have them start the next problem.</td><td></td></tr>
</table>

Time	**Middle Game (continued)**	Rationale
	4. <u>Start grading lab procedures (journals)</u>.	
10 min	**5.** Prepare Students for class discussion by **a)** <u>Ten-Minute Warning</u>. Ten minutes before you want the groups to stop, tell them to find a good stopping place and clean up their area. (Make sure you are done grading journals). (If groups are new, you may want to pass out the group functioning forms.)	
5 min	**b)** <u>Posting Corrected Methods Questions and/or Results</u>. Tell one person in each group, who is *not* the Recorder/Checker, to write their corrected answers (if necessary) to the methods questions on the board (and/or their results).	

NOTES:

Time	End Game	Rationale
~10 min	**6.** Lead a class discussion. Usually, focus the discussion on the qualitative analysis of problem.	
5 -10 minutes	**7.** Optional: Discuss group functioning. Call on one group for "good" response, another group for a "problem," and a third group for a "specific action." Repeat until every group has spoken twice.	
5 min	**8.** Start next problem. If there is time, have students start the next assigned lab problem. Repeat Steps 1 through 7.	
	9. End of Lab Session. **a)** Tell students what lab problem(s) to do Methods Questions for next week. **b)** Assign students problems to write up (if last session of lab). In each group, randomly assign each student in the group a different problem for a lab report. **c)** Leaving the Lab. Leave a neat lab room for the next class.	

NOTES:

Activity #10 (9 points)

Preparation for Peer Teaching of Labs and Discussion Session

INDIVIDUAL AND TEAM TASKS:

1. **Individually** read through the next four pages. These pages describe how the four afternoon peer-teaching sessions are structured and graded. Be prepared to ask questions in a class discussion.

2. **Lab Preparation:** It is assumed that each team member has already done the *Method Questions* for your assigned lab problems.
   (a) Discuss with your team the answers to the Methods Questions.
   (b) Work through the assigned lab problems (as a team), collect data, and analyze your results (3 points). What is the conclusion for this lab problem? Your team will be the "expert" on this lab, and should be able to answer questions from other TAs. If you need help with anything, ask the mentor TA working with you.
   (c) When you have finished (b), ask your mentor TA for the *Lab Instructor's Guide* for these problems. This manual was written by former TAs to help you prepare for and teach each lab problem.
   (d) Discuss the following questions with your team. How does the data you collected and analyzed compare with the example data in the Instructor's Guide? What other information is included in the Instructor's Guide? How will this information help you prepare to teach these lab problems?
   (e) Photocopy your results and analysis for each lab problem (one per "student"). These will be handed out to your "students" at the end of each lab practice teaching session.

3. **Discussion Session Preparation:** It is assumed that each team member has already solved the assigned group problem in a logical, organized manner.
   (a) Discuss with your team your individual solutions to the discussion problem.
   (b) As a team, write a ***good solution*** for this problem. A good solution must be helpful to undergraduate students who do not know how to solve the problem. A good solution includes:
   - Detailed diagram(s)
   - Definition of all variables
   - Logical progression and complete steps in the solution (working backwards from target variable).
   - Symbolic representation of all equations (both fundamental principles and relationships that apply in certain situations) should be written before substitution of defined variables.
   - Solve the problem mathematically **before** the substitution of quantities (numbers) into the final equation for the target variable.

   (c) Photocopy your solution (one per "student"). This will be handed out to your "students" at the end of the discussion practice teaching session.

Structure of Peer Teaching

As a way of preparing to teach the University of Minnesota's problem-solving labs and discussions sessions, you will have the opportunity to practice-teach either one lab problem or one discussion session to your peers. ***You have already been assigned to a 3-member team, and your team has been assigned two lab problems and one discussion session to prepare***. For four afternoons in the next week, the mentor TAs will supervise the practice teaching of the labs and discussion sessions.

There are two goals for this peer teaching. One is for you to get practice "running through" a lab problem or discussion session, so that you have a sense of what it feels like to keep track of time, supervise a room full of people solving a problem, and lead a discussion. The other goal is for you to become familiar and comfortable with the equipment and typical results for the problem-solving labs.

Each afternoon will be structured as follows:

- The mentor TAs may need to make some brief announcements.
- The "practice teachers" for one afternoon will teach, and the practice teachers for the other three afternoons will act like undergraduate students. This means that you must come to morning class with the *Methods Questions* completed, and be ready to participate in discussions and take data in the afternoon (see Homework #4, #5, #7 and #9 in the Syllabus).
- On the day your team practice teaches:
  - Your team will receive your “students” (peers acting as undergraduates) answers to the Methods Questions during the morning. This will allow you to look over the answers and decide which Method Question(s) you will have your “students” discuss put on the board.
  - Just before lunch, your Mentor TA will tell each team member whether they will teach the assigned discussion session or a lab problem (and which assigned lab problem). So each team member has to be prepared to teach all three.
- Each practice teacher will have about 60 minutes to teach one lab problem, or about 30 minutes to teach a discussion session. The practice teachers for lab will then pass out the data and results that THEY had previously prepared for their lab problem (3 points). The practice teachers for discussion will hand out the solution to the problem (3 points).
- The "students" for this lab or discussion session will give each practice teacher written feedback.
- After all the TAs have practice-taught on a day, they will stay and be mentored by the mentor TA.

These afternoon sessions should run between 3 and 4 hours for the first three days, and about 2 hours for the fourth day.

Each TA will select one free afternoon!

Grading When You Are a Student

2 Labs:

Methods Questions	6 points	Homework #4.#5, #7, and #8
Journals	1 point	
Written feedback to Practice Teachers	1 points	

1 Discussion:

Group Solution	2 points
Written feedback to Practice Teacher	0. 5 points

Grading When You Are a Teacher

Labs:

Data Analysis and Results for 2 problems	6 points (team)
Teaching (see following pages)	3 points

Discussion:

Written Group Solution	3 points (team)
Teaching (see following pages)	3 points
Total:	21 points

Grading Sheet for Homework #4, #5, #7 or #9
When You Are the Practice Teacher: LAB

What the TA Does	TA Initials:				
Opening Moves:	⓪ Be at the classroom early				
	① Prepare students for group work by showing group/role assignments.				
	② Prepare students for lab by: a) diagnosing difficulties while groups discuss and come to consensus on *Methods Questions*.				
	b) selecting one person from each group to write/draw on board answers to the *Methods Questions*.				
	c) leading a class discussion about the group answers.				
	d) telling students how much time they have to check their predictions; reminding Manager to keep track of time				
Middle Game	③ Coach groups in problem solving (making decisions) by: a) monitoring (diagnosing) progress of all groups				
	b) helping (coaching) groups with the most need, using group roles.				
	④ Grade Lab Procedure (journal).				
	⑤ Prepare students for class discussion by: a) giving students a "10-minute warning." Pass out Group Evaluation Form (if necessary)				
	b) selecting one person from each group to put corrected methods questions and results on board.				
End Game	⑥ Lead a class discussion focusing on what you wanted students to learn from solving the problem.				
	⑦ Discuss group functioning (optional)	*na*	*na*	*na*	*na*
	⑧ Start next lab problem (repeat Steps 1 – 7) if time	*na*	*na*	*na*	*na*
	⑨ End of Lab a) Tell students what lab problems to do Methods Question for next week; if last session, assign students problems for lab report.				
	b) Leave a neat lab room for the next class. Do NOT let the next group of students into the classroom. Write down the comments about equipment that did not work on the lab-room sheet .				
	Total:				
	Grade:				

Total Steps Performed	Grade	Total Steps Performed	Grade
13 - 14	3 points	9 - 10	1 points
11 -12	2points	0 - 8	0 points

Grading Sheet for Homework #4, #5, #7 or #9
When You Are the Practice Teacher: DISCUSSION SESSION

What the TA Does	TA Initials:				
Opening Moves:	⓪ Be at the classroom early				
	① Introduce the problem by telling students: a) what they should learn from solving problem;				
	b) the part(s) of the solution you want groups to put on board				
	② Prepare students for group work by: a) showing group/role assignments and classroom seating map (if necessary);				
	b) passing out Problem (& Useful Information) and one Answer Sheet.				
	c) Tell class the time they need to stop and remind Managers to keep track of the time.				
Middle Game	③ Coach groups in problem solving by: a) Monitoring (diagnosing) progress of all groups. Establish a circulation pattern for periodically listening to groups and *diagnosing difficulties*.				
	b) helping (coaching) groups with the most need. Using group roles.				
	④ Prepare students for class discussion by: a) giving students a "five-minute warning"				
	b) selecting one person from each group to put specified part of solution on the board.				
	c) passing out Group Evaluation Sheet (optional)	*na*	*na*	*na*	*na*
End Game	⑤ Lead a class discussion focusing on what you wanted students to learn from solving the problem.				
	⑥ Discuss group functioning (optional)	*na*	*na*	*na*	*na*
	⑦ Pass out the problem solution as students walk out the door.				
	Total:				
	Grade:				

Total Steps Performed	Grade	Total Steps Performed	Grade
11-12	3 points	7-8	1 points
9-10	2 points	0 - 6	0 points

All problem-solving guides or frameworks *in any field* are:

- **based on expert-novice research;**
- **similar to on George Polya 's (1957) framework for mathematics problem solving.**

Physics problem-solving frameworks by different authors:

- **divide the framework into a different number of steps;**
- **Have different ways to say essentially the same thing;**
- **Emphasize different heuristics depending on the backgrounds of the students.**

9

Polya (1957) Framework

1. Understand the Problem

Describe the problem:

- **Translate the situation and goals into the fundamental concepts of your field.**
- **Decide on the reasonable idealizations and approximations you need to make.**

2. Devise a Plan

Apply the specialized techniques (heuristics) of your field to develop a plan, *using the concepts of your field to connect the situation with the goal.*

Re-examine the description of the problem if a solution does not appear possible.

3. Carry Out the Plan

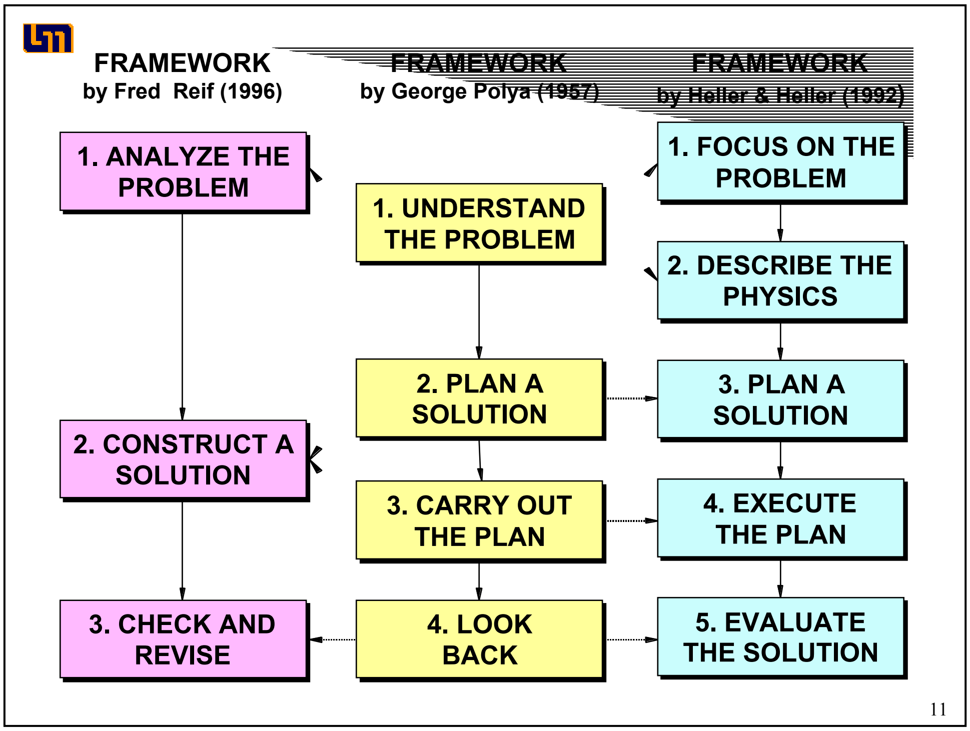
Follow your plan to the desired result.

Re-examine your plan if you cannot obtain the desired result.

4. Look Back

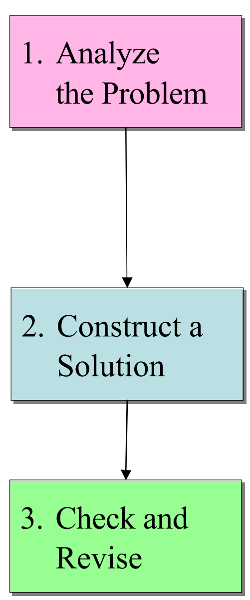
Determine how well your result agrees with your knowledge of similar behavior, within limits that you understand.

10



11

Framework by Reif



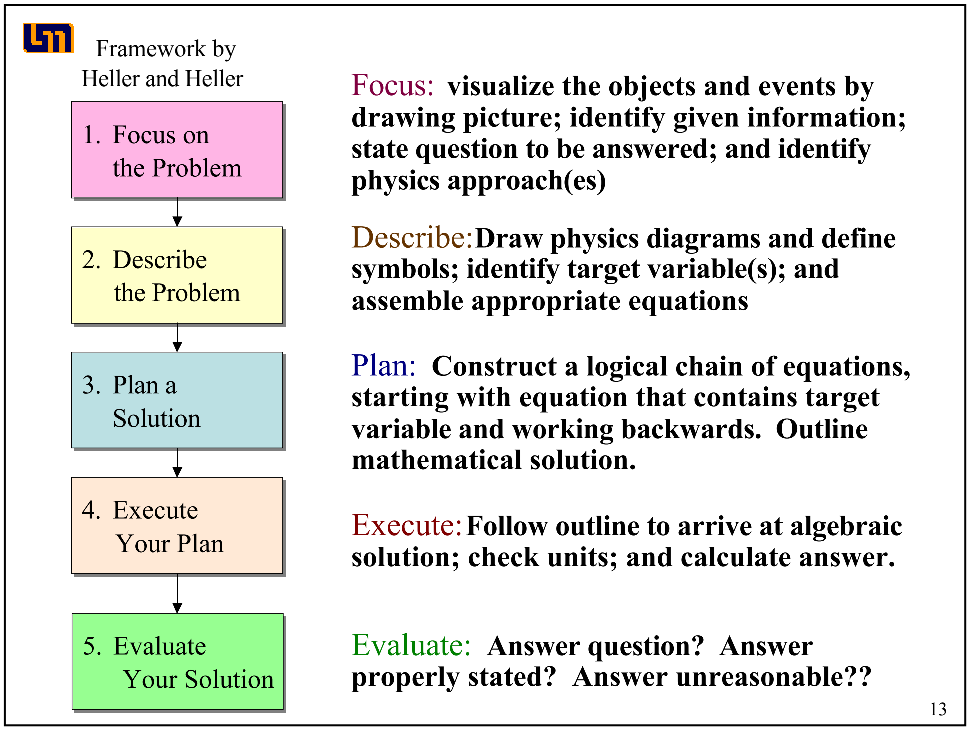
Basic Description: **draw diagram(s) to summarize situation; specify knowns and wanted (target) unknown(s) both symbolically and numerically.**

Refined Description: **Specify time sequence of events and identify time intervals where situation is different; use physics concepts to describe situation (e.g., velocity, acceleration, forces, etc.)**

Solve simplersubproblems *repeatedly*:
Examine status of problem for obstacle;
Select suitable sub-problem to overcome obstacle (e.g., apply basic relation)
Eliminate unwanted quantity

Check for Errors and Revise:
Goals attained? Well Specified? Self-consistent? Consistent with other known information? Optimal?

12


Framework by
Heller and Heller
1. Focus on the Problem
2. Describe the Problem
3. Plan a Solution
4. Execute Your Plan
5. Evaluate Your Solution
Focus: visualize the objects and events by drawing picture; identify given information; state question to be answered; and identify physics approach(es)
Describe: Draw physics diagrams and define symbols; identify target variable(s); and assemble appropriate equations
Plan: Construct a logical chain of equations, starting with equation that contains target variable and working backwards. Outline mathematical solution.
Execute: Follow outline to arrive at algebraic solution; check units; and calculate answer.
Evaluate: Answer question? Answer properly stated? Answer unreasonable??
13

Activity #11b (1 point)

Lab Methods Questions and Problem Solving

GROUP TASKS:

You solved either a Quantum Mechanics Problem or a Moments of Inertia Problem in Activity 7.

1. Get in the same group as in Activity 7. Rotate Roles

If you solved the Quantum Mechanics Problem

2. **Individually** read through the problem-solving framework by Fred Reif (on the next page).
3. Go to the Answer Sheet on page 103. For each Method Question (Questions #1 - #10), identify and briefly describe the corresponding step and substep(s) from the *Understanding Basic Mechanics Framework* (Fred Reif).

If you solved the Moments of Inertia Problem:

2. **Individually** read through the problem-solving framework by Heller and Heller (on the page 100).
3. Go to the Answer Sheet on page 101. For each Method Question (Questions #1 - #8), identify and briefly describe the corresponding step and substep(s) from the *Competent Problem Solving Framework* (Heller & Heller).

TIME: 12 minutes.

One member from your group will be randomly selected to present your group's answers.

PRODUCT:

Answer Sheet for Activity #11b (Quantum Mechanics Problem), or
Answer Sheet for Activity #11b (Quantum Mechanics Problem)

Calculus-based Problem Solving Framework by Frederick Reif
(From *Understanding Basic Mechanics*, Wiley, 1995)

1. **Analyze the Problem:** Bring the problem into a form facilitating its subsequent solution.
   a. Basic Description -- clearly specify the problem by
      - describing the *situation*, summarizing by drawing diagram(s) accompanied by some words, and by introducing useful symbols; and
      - specifying compactly the *goal(s)* of the problem (wanted unknowns, symbolically or numerically)

   b. Refined Description -- analyze the problem further by
      - specifying the *time-sequence* of events (e.g., by visualizing the motion of objects as they might be observed in successive movie frames, and identifying the *time intervals* where the description of the situation is distinctly different (e.g., where acceleration of object is different); and
      - describing the situation in terms of important *physics concepts* (e.g., by specifying information about velocity, acceleration, forces, etc.).

2. **Construct a Solution:** Solve simpler subproblems repeatedly until the original problem has been solved.
   a. Choose subproblems by
      - examining the *status* of the problem at any stage by identifying the available known and unknown information, and the obstacles hindering a solution;
      - identifying available *options* for subproblems that can help overcome the obstacles; and
      - selecting a useful subproblem among these options.

   b. If the obstacle is lack of useful information, then apply a *basic relation* (from general physics knowledge, such as $m\mathbf{a} = \mathbf{F}_{TOT}$, $f_k = \square N$, $x = (1/2)a_x t^2$) to some *object or system* at some *time* (or between some times) along some *direction*.

   c. When an available useful relation contains an unwanted unknown, eliminate the unwanted quantity by combining two (or more) relations containing this quantity.

   Note: Keep track of wanted unknowns (underlined twice) and unwanted unknowns (underlined once).

3. **Check and Revise:** A solution is rarely free of errors and should be regarded as provisional until checked and appropriately revised.
   a. Goals Attained? Has all wanted information been found?
   b. Well-specified? Are answers expressed in terms of known quantities? Are units specified? Are both magnitudes and directions of vectors specified?
   c. Self-consistent? Are units in equations consistent? Are signs (or directions) on both sides of an equation consistent?
   d. Consistent with other known information? Are values sensible (e.g., consistent with known magnitudes)? Are answers consistent with special cases (e.g., with extreme or

specially simple cases)? Are answers consistent with known dependence (e.g., with knowledge of how quantities increase or decrease)?

e. Optimal? Are answers and solution as clear and simple as possible? Is answer a general algebraic expression rather than a mere number?

Algebra-based Problem Solving Framework by P. Heller and K. Heller (From *The Competent Problem Solver.* Prentice Hall 1995)

1. Focus the Problem. Establish a clear mental image of the problem.

a. Visualize the situation and events by drawing a useful picture.
   - ♦ Show how the objects are related spatially and identify the time sequence of events, especially those times when an object experiences an abrupt change.
   - ♦ Identify the given information, in words and on the picture.

b. Precisely state the question to be answered.

c. Identify physics approach(es) that might be useful to reach a solution.
   - ♦ Which fundamental concepts of physics (e.g., kinematics, Newton's Laws, conservation of energy) might be useful for relating the physics to the problem situation.
   - ♦ List any approximations or constraints that are reasonable to apply to this situation.

2. Describe the Physics

a. Draw any necessary diagrams (e.g., motion diagrams, force diagrams, momentum diagrams) with coordinate systems that are consistent with the approach.
   - ♦ Define symbolically and consistently any quantities that are relevant to the situation.
   - ♦ Identify which of these quantities is known and which is unknown.

b. Identify the target variable(s) -- the quantity (or quantities) that will provide the answer to the question

c. Assemble the appropriate equations to quantify the physics concepts and constraints identified in your approach.

3. Plan a Solution

a. Construct a logical chain of equations, from those identified in the previous step, leading from the target quantity to quantities that are known.
   - ♦ Begin with the quantitative relationship that contains the *target variable*. Identify other unknowns in the equation.
   - ♦ Choose a new equation for one of these unknowns. Keep track of any additional unknowns.
   - ♦ Continue this process for each unknown.

b. Determine if this chain of equations is sufficient to solve for the target quantity by comparing the number of unknown quantities to the number of equations.

c. Outline the solution steps you will take to solve this chain of equations so that no algebraic loops are created. Work from the last equation to the first equation that contains the target quantity

4. Execute the Plan

Follow your solution outline

a. Arrive at an *algebraic* equation for your target quantity by following your chain of equations in reverse order (from quantities that are known to the target quantity).

b. Occasionally check the units of your process to help find mathematical errors.

c. Use numerical values to calculate the target quantity.

5. Evaluate the Answer

a. Does the mathematical result answer the question asked?

b. Is the result properly stated with appropriate units?

c. Is the result unreasonable?

TA Orientation 2004 Name: ______________________

Answer Sheet for Activity 11b (Moments of Inertia Problem)

Moment of Inertia Problem. For each Method Question below (Questions #1 - #8), identify the and briefly describe the corresponding step and sub-step(s) from the *Competent Problem Solver* (Heller & Heller) framework.

Step	Problem-solving Steps
1. Draw a side view of the equipment. Draw the velocity and acceleration vectors of the weight. Add the tangential velocity and tangential acceleration vectors of the outer edge of the spool. Also, show the angular acceleration of the spool. What is the relationship between the acceleration of the string and the acceleration of the weight if the string is taut? What is the relationship between the acceleration of the string and the tangential acceleration of the outer edge of the spool when the string is taut.	
2. Since you want to relate the moment of inertia of the system to the acceleration of the weight, you probably want to consider a dynamics approach (Newton's 2nd Law) especially using the torques exerted on the system. It is likely that the relationships between rotational and linear kinematics will also be involved.	
3. To use torques, first draw vectors representing all of the forces which could exert torques on the ring/disk/shaft/spool system. Identify the objects that exert those forces. Draw pictures of those objects as well showing the forces exerted on them.	
4. Draw a free-body diagram of the ring/disk/shaft/spool system. Show the locations of the forces acting on that systems. Label all the forces. Does this system accelerate? Is there an angular acceleration? Check to see you have all the forces on your diagram. Which of these forces can exert a torque on the system? Identify the distance from the axis of rotation to the point where each force is exerted on the system. Write down an equation which gives the torque in terms of the force that causes it. Write down Newton's second law in its rotational form for this system. Make sure that the moment of inertia includes everything in the	

Step	Problem-solving Steps
system.	
5. Use Newton's 3rd Law to relate the force of the string on the spool to the force of the spool on the string. Following the string to its other end, what force does the string exert on the weight? Make sure all the forces on the hanging weight are included in your drawing.	
6. Draw a free-body diagram of the hanging weight. Label all the forces acting on it. Does this system accelerate? Is there an angular acceleration? Check to see you have all the forces on your diagram. Write down Newton's second law for the hanging weight. How do you know that the force of the string on the hanging weight is not equal the weight of the hanging weight?	
7. Is there a relationship between the two kinematic quantities that have appeared so far: the angular acceleration of the ring/disk/shaft/spool system and the acceleration of the hanging weight? To decide, examine the accelerations that you labeled in your drawing of the equipment.	
8. Solve your equations for the moment of inertia of the ring/disk/shaft/spool system as a function of the mass of the hanging weight, the acceleration of the hanging weight, and the radius of the spool. Start with the equation containing the quantity you want to know, the moment of inertial of the ring/disk/shaft/spool system. Identify the unknowns in that equation and select equations for each of them from those you have collected. If those equations generate additional unknowns, search your collection for equations which contain them. Continue this process until all unknowns are accounted for. Now solve those equations for your target unknown.	

TA Orientation 2004 Name: ______________________________

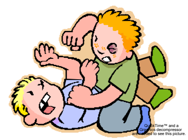
Answer Sheet for Activity 11b (Quantum Mechanics Problem)

Quantum Mechanics Problem. For each Method Question below (Questions #1 - #10), identify the and briefly describe the corresponding step and sub-step(s) from the *Understanding Basic Mechanics* (Fred Reif) framework.

Step	Problem-solving Steps
1. Write down the Hamiltonian for a one-dimensional harmonic oscillator in the x direction. What is the quantum mechanical operator that represents the kinetic energy? What quantum mechanical operator represents the potential energy?	
2. Solve the Schrodinger equation for this system. What function has the same form as its derivative? How do you determine if this equation has an eigenvalue?	
3. What is the normalized wave function for the ground state? Make sure all constants are determined. What is the eigenvalue for this wavefunction? How is the eigenvalue related to the ground state energy level?	
4. How do you construct the wave function for the first excited state from the ground state wave function? Determine the first excited state energy level.	
5. Write down the Hamiltonian for a two dimensional harmonic oscillator in the x direction and in the y direction where each dimension is independent. What is the Schrodinger equation for this system?	
6. Write down the functional form of the ground state wavefunction that is the solution to this Schrodinger equation. Why is this solution a product of a function of x only times a function of y only?	
7. Separate the two-dimensional harmonic oscillator equation into two one-dimensional equations and solve them. How do you assemble these solutions to construct the ground state solution and the ground state energy levels for the two dimensional equation?	

Step	Problem-solving Steps
8. How do you construct the wave functions for the first excited state in each dimension from the ground state wave function? Determine these energy levels. Are they the same or are they different? Why should this be true?	
9. Now add the coupling term to the two dimensional harmonic oscillator Hamiltonian as a perturbation to the potential energy. Write down the Hamiltonian of this system as the Hamiltonian to the pure two-dimensional harmonic oscillator plus a Hamiltonian that represents the perturbation of the harmonic oscillator potential energy. Calculate the effect of the perturbation Hamiltonian on the ground state energy of the pure harmonic oscillator in terms of the small parameter that gives the strength of the perturbation. In this calculation, you will encounter an integral over all space. Determine whether the integral is over an even function, an odd function, or a mixed function. In which of these cases is the value of the integral trivial?	
10. Calculate the effect of the perturbation Hamiltonian on the first exited state wavefunctions of the pure two-dimensional harmonic oscillator. How many different expectation values do you need to calculate? Use symmetry to determine which are non-zero. How do you use these perturbation energies to calculate the energy levels that you wish to determine?	

Why Group
Problem Solving
May
Not Work



1. **Poor structure and management of Groups**
2. **Inappropriate Grading**
3. ***Inappropriate Tasks***

2

Appropriate Group Problems

The problems must be challenging enough so there is a *real* advantage to solving the problem in a group .

1. The problem must be complex enough so the best student in the group is not certain how to solve it.

   The problem must besimple enough so that the solution, once arrived at, can be understood and appreciated by all group members.

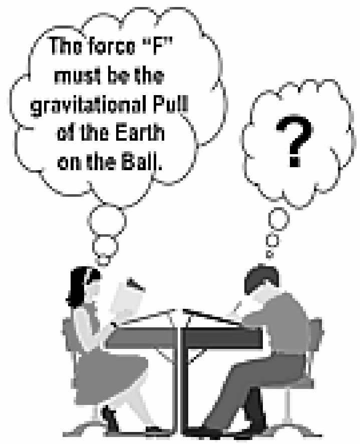
3

Appropriate Group Problems

The problems must be challenging enough so there is a *real* advantage to solving the problem in a group .

1. The problem must be complex enough so the best student in the group is not certain how to solve it.

   The problem must be simple enough so that the solution, once arrived at, can be understood and appreciated by all group members.



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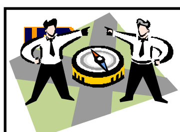
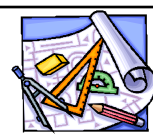
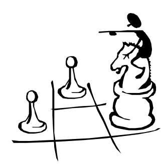




2. The task must be designed so that

   - the major problem solving heuristics are required (e.g. physics understood, a situation requiring an external representation);
   - there are several decisions to make in order to do the task (e.g. several different quantities that could be calculated to answer the question; several ways to approach the problem);
   - the task cannot be resolved in a few steps by copying a pattern.



4

3. The task problem must connect to each student's mental processes
   - the situation is real to the student so other information is connected;
   - there is a reasonable goal on which to base decision making.

5

What Characteristics of Textbook Exercises Promote the Plug-and-Chug Strategy?

Cart A, which is moving with a constant velocity of 3 m/s, has an inelastic collision with cart B, which is initially at rest as shown in Figure 8.3. After the collision, the carts move together up an inclined plane. Neglecting friction, determine the vertical height *h* of the carts before they reverse direction.

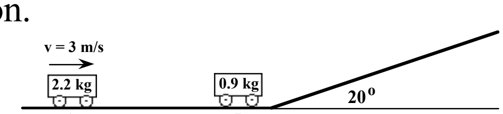


Figure 8.3

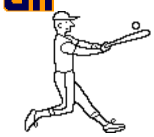
6

Context-rich Problem

You are helping a friend prepare for the next skate board exhibition. The plan for the program is to take a running start and then jump onto a heavy duty 8-lb stationary skateboard. Your friend and the skateboard will glide in a straight line along a short, level section of track, then up a sloped concrete wall. The plan is to reach a height of at least 10 feet above the starting point before turning to come back down the slope. The fastest your friend can run to safely jump on the skateboard is 7 feet/second. Knowing that you have taken physics, your friend wants you to determine if the plan can be carried out. When you ask, you find out that your friend's weight is 130 lbs.

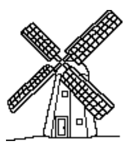
7

Context-rich Problems




1. Each problem is a short story in which the major character is the student. That is, each problem statement uses the personal pronoun "you."
2. The problem statement includes a plausible motivation or reason for "you" to calculate something.
3. The objects in the problems are real (or can be imagined) -- the idealization process occurs explicitly.
4. No pictures or diagrams are given with the problems. Students must visualize the situation by using their own experiences.
5. The problem cannot be solved in one step by plugging numbers into a formula.






8

Context-rich Problems

In addition, more difficult context-rich problems can have one or more of the following characteristics:

- The unknown variable is not explicitly specified in the problem statement (e.g., Will this design work?).
- More information may be given in the problem statement than is required to solve the problems, or relevant information may be missing.
- The solution requires using geometry/trigonometry of physical situation to eliminate an unknown. .
- The problem may require more than one fundamental principle for a solution (e.g., Newton's Laws and the Conservation of Energy).
- The problem consist of more than 2 subparts (e.g., more than 2 interacting objects, time intervals, or different types of events.

9

Why is this not a context-rich problem?

A 44-kg mass is suspended by two ropes, as shown in Figure 4-3. Find the tension in each rope.

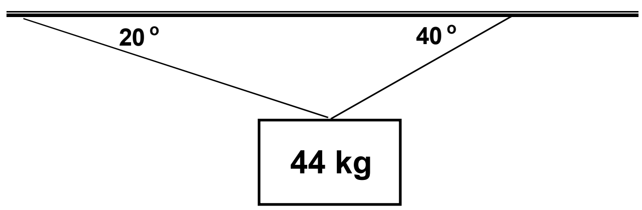


Figure 4-3

10

Context-rich Problem

You are part of a team to help design the atrium of a new building. Your boss, the manager of the project, wants to suspend a 20-lb sculpture high over the room by hanging it from the ceiling using thin, clear fishing line (string) so that it will be difficult to see how the sculpture is held up. The only place to fasten the fishing line is to a wooden beam which runs around the edge of the room at the ceiling. The fishing line that she wants to use will hold 20 lbs (20-lb test) so she suggests attaching two lines to the sculpture to be safe. Each line would come from the opposite side of the ceiling to attach to the hanging sculpture. Her initial design has one line making an angle of 20° with the ceiling and the other line making an angle of 40° with the ceiling. She knows you took physics, so she asks you if her design can work.

11

Why is this <u>not</u> a context-rich problem?

If an aircraft is properly banked during a turn in level flight at constant speed, the force F_a exerted by the air on the aircraft is directed perpendicular to a plane which contains the aircraft's wings and fuselage (Fig. 6-25). Draw a free-body diagram for such an aircraft.

(*Hint:* Note the similarity to the conical pendulum in Example 6-7.) An aircraft traveling at a speed v = 75 m/s makes a properly banked turn at a banking angle of 28°. What is the radius of curvature of the turn?

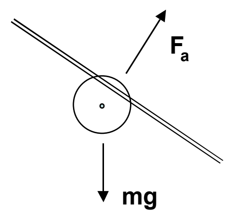


Figure 6-25

12

Context-rich Problem

You are flying to a job interview when the pilot announces that there are airport delays so the plane will have to circle the airport. The announcement also says that the plane will maintain a speed of 400 mph at an altitude of 20,000 feet. To pass the time, you decide to figure out how far you are from the airport. You notice that to circle, the pilot "banks" the plane so that the wings are oriented about 10^o to the horizontal. An article in your in-flight magazine explains that an airplane can fly because the air exerts a force, called "lift," on the wings. The lift is always perpendicular to the wing surface. The magazine article gives the weight your type of plane as 100×10^3 pounds and the length of each wing as 150 feet. It gives no information on the thrust from the engines or the drag on the airframe.

13

Why is this not a context-rich problem?

As you are driving to school one day, you pass a construction site for a new building and stop to watch for a few minutes. A crane is lifting a batch of bricks on a pallet to an upper floor of the building. Suddenly a brick falls off the rising pallet. You clock the time it takes for the brick to hit the ground at 2.5 seconds. The crane, fortunately, has height markings and you see the brick fell off the pallet at a height of 72 feet above the ground. Your friend in the car with you asks, "I wonder how fast the pallet was rising before the brick fell off?" Since you are taking physics, you quickly calculate the answer for him.

14

Context-rich Problem

As you are driving to school one day, you pass a construction site for a new building and stop to watch for a few minutes. A crane is lifting a batch of bricks on a pallet to an upper floor of the building. Suddenly a brick falls off the rising pallet. You clock the time it takes for the brick to hit the ground at 2.5 seconds. The crane, fortunately, has height markings and you see the brick fell off the pallet at a height of 72 feet above the ground. A falling brick can be dangerous, and you wonder how fast the brick was going when it hit the ground. Since you are taking physics, you quickly calculate the answer.

15

Activity #13 (2 points)

What Questions Would You Ask?

Last year, students in a discussion session (calculus-based course for engineers) were given the following group practice problem to solve.

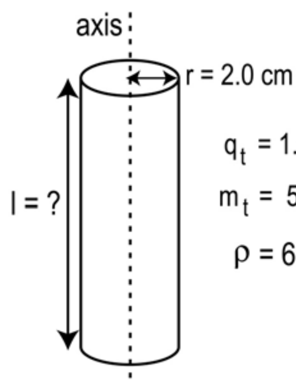
> You have a great summer job in a research laboratory with a group investigating the possibility of producing power from fusion. The device being designed confines a hot gas of positively charged ions, called plasma, in a very long cylinder with a radius of 2.0 cm. The charge density of the plasma in the cylinder is 6.0 x 10^{-5} C/m^3. Positively charged Tritium ions are to be injected into the plasma perpendicular to the axis of the cylinder in a direction toward the center of the cylinder. Your job is to determine the speed that a Tritium ion should have when it enters the plasma cylinder so that its velocity is zero when it reaches the axis of the cylinder. Tritium is an isotope of Hydrogen with one proton and two neutrons. You look up the charge of a proton and mass of the tritium in your trusty Physics text to be 1.6 x 10^{-19} C and 5.0 x 10^{-27} Kg.

The TA asked groups to:

- draw and label a diagram; and
- write and number the equations they used to solve the problem.

Three groups put the following diagrams and equations on the board.

Group #1



$q_t = 1.6 \times 10^{-19}$ C

$m_t = 5.0 \times 10^{-27}$ Kg

$\rho = 6.0 \times 10^{-3}$ C/m^3

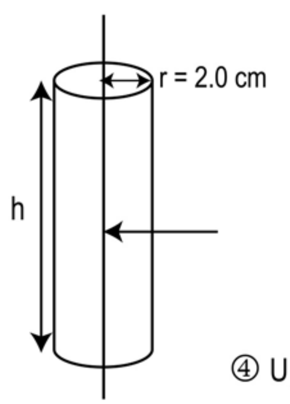
① $W = \Delta KE = \frac{1}{2} mv^2 = F\,r$

② $F = E\,q$

③ $\oint E \cdot dA = \frac{q}{\varepsilon_o}$

④ $q = V\rho$

Group 2



tritium charge $= 1.6 \times 10^{-19}$ C

tritium mass $= 5.0 \times 10^{-27}$ Kg

charge density $\rho = \frac{Q}{V} = 6.0 \times 10^{-3}$ C/m^3

① $A = 2\pi rh$

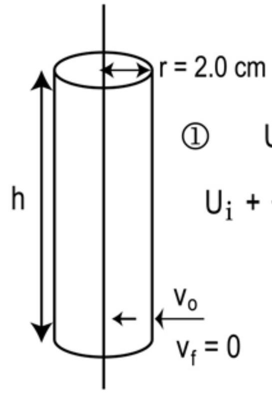
② $V = \pi r^2 h$

③ $W = F\,r$

④ $U_f - U_i = F\,r$

⑤ $\oint E \cdot dA = \frac{q}{\varepsilon_o}$

Group 3



① $U_i + K_i = U + K_f$

$U_i + \frac{1}{2}mv^2 = U_f + 0$

② $W = Fr = U_f - U_i$

③ $F = \frac{kq}{r^2}$

GROUP TASK

1. Individually, examine what each group put on the board.

2. As a group, discuss how you would lead the class discussion.

    a) What questions would you ask about the diagrams?

    b) What questions would you ask about the conservation of energy for this problem?

    c) What questions would you ask about the electricity concept needed to solve this problem?

    d) What, if anything, would you write on the board during or at the end of the discussion?

TIME: 20 minutes

PRODUCT

Answer sheet for this activity. One answer sheet will be randomly collected from each group for grading.

Activity 13 (2 points)

Manager: ________________________

Recorder: ________________________

Skeptic: ________________________

Summarizer: ________________________

Answer Sheet for Activity 13

a) What questions would you ask about the diagrams?

b) What questions would you ask about the conservation of energy for this problem?

c) What questions would you ask about the electricity concept needed to solve this problem?

d) What, if anything, would you write on the board during or at the end of the discussion?

Evaluating Laboratory Reports for Communication

- **Writing Across the Curriculum**
- **Defining "Good" & "Bad" Writing**
  - ***Homew*** #6: ***k #: Initial evaluation of example laboratory reports from 2 students***
- **Expanding Our Vocabulary for Evaluating Writing – Writing Factors**
- **Redefining Quality of Writing: moving away from "Good" & "Bad"**
- **Ways that Writing Factors Apply to Physics Laboratory Reports**
  - ***Act*** 17b: ***16: Evaluating sample laboratory report from laboratory manual***
  - ***Act*** 18a: ***17a: How to grade student laboratory reports***
  - ***Act*** 18b: ***17b: Grading of example laboratory reports from 2 students***
- **Campus Resources for Writing Support**
- **Formal Requirements for Writing-Intensive Course Work**

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Writing Across the Curriculum

The national movement called "Writing Across the Curriculum," or WAC, advocates the instruction of writing *across* & *within* disciplines, as it holds the belief that writing is important to all subject areas & can be effectively instructed in specific disciplinary contexts.

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WAC

Some basic assumptions:

- **Writing is a learning activity that involves problem solving & communication skills**
- **Writing is a social activity, shaped by contextual factors such as a community of peers**
- **Writing is not separable from content**
- **Forms of writing vary from context to context**
- **Certain factors of writing are central to all writing acts, such as audience, purpose, context, organization, support, design, & expression**

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Teaching with Writing

At the University of Minnesota, instructors from across the disciplines are *incorporating writing* into their courses. Doing so has *affirmed the enhancing role* that writing activities can play in *student learning*. It has also allowed faculty & students alike to *recognize* that *language use* & *text production* take place *within disciplinary language communities*

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Mission of the Writing Requirements

- **Learning to write is a *life-long task* … *refined* through an individual's personal, social, & professional *experiences***
- **Principal means by which all scholars … *make inquiries* & *communicate* their learning**
- **Learning to write effectively can be one of the most *intellectually empowering* components of an university education**
- **University regards the teaching of writing as a *responsibility shared by all departments***

Writing-Intensive (W-I) Courses

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WAC: *complementary objectives*

Good writers:

- **practice on a continuing basis, so one of the goals of W-I courses is to offer *ongoing writing practice***
- **are able to write for a variety of audiences; they understand that effective writing depends on context. For this reason, students should *write in many different kinds of courses, to audiences ranging from their peers to senior scholars & scientists***
- **are able to produce a range of different kinds of writing. So the *nature of the writing* done in W-I courses should *vary considerably***
- **Because no one course can meet all these goals, the *collective goal* of all these W-I courses is to *prepare students to communicate effectively in a variety of situations* at the University, in their future employment, & in their roles as citizens**

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W-I Courses

Address the idea that *writing is important to learning technical content*. It is important to acknowledge that writing involves more than simply mastering grammar, spelling, & mechanics

W-I courses in Physics provide students the *opportunity to learn about physics* through written assignments *(laboratory reports)* that involve problem solving, language use, & organizational skills

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W-I Courses: *requirements*

1) 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
2) Courses requiring a significant amount of writing – *minimally 10 to 15 finished pages* beyond informal writing & any in-class examinations. Note that the page guidelines may be met with an assortment of short assignments that add up to the total
3) Courses in which *students are given instruction on the writing aspect of the assignments*
4) Courses in which *assignments include at least one for which students are required to revise a draft & resubmit* after receiving feedback from the course instructor or graduate teaching assistant. Otherwise, writing assignments may be of various kinds & have various purposes, as appropriate to the discipline

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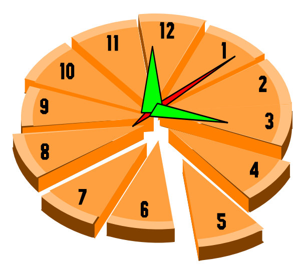
Defining "Good" & "Bad"

Your task:

- Take 5 minutes to compare the characteristics that you came up with for Homework with your nearest neighbor
- Take 5 minutes to discuss your grading of the 2 examples for Homework with your nearest neighbor



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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?

Discussion of Homework: ***Initial Evaluating of 2 Examples***

Example #1	***Example #2***
Good:	**Good:**
Bad:	**Bad:**

Expanding Our Vocabulary for Evaluating Writing - Writing Factors

Although different situations require that writing take different forms (i.e., resume versus laboratory report), certain factors are important to ALL writing situations. These factors, while general, can be adapted or explained in terms that are specific to each writing situation. Below is a list of eight communication factors that apply to writing situations. I encourage you to begin using this vocabulary to describe writing.

Expanding Vocabulary: *Writing Factors*

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?**

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Expanding Vocabulary: *Writing Factors*

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?

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Redefining Quality of Writing:

Moving away from "good" & "bad"

Content	Satisfactory	Adequate	Poor
Addresses *content* accurately and thoroughly	Accurate and complete technical information, including formulas, explanations, theory, and data.	Accurate technical information, but has missed some important information.	Does not include accurate or complete information.

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Redefining Quality of Writing:

Moving away from "good" & "bad"

Context	Satisfactory	Adequate	Poor
Writes to the appropriate *context* or situation of assignment – format suitable for a short technical document	Meets the requirements of the assignment; includes proper format & sections that assignment requires.	Adequately meets requirements of the assignment; does not always display proper format.	Does not meet the requirements of the assignment as specified.

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Redefining Quality of Writing:
Moving away from "good" & "bad"

Audience	Satisfactory	Adequate	Poor
Addresses *audience* appropriately – can be understood by classmates in this physics class	Writes appropriately for classmates, including proper terms, explanations of concepts, formal register.	Does not always include proper terms, concepts, or register (perhaps is too informal).	Does not include proper terms, concepts, or register to effectively address audience.

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Redefining Quality of Writing:
Moving away from "good" & "bad"

Purpose	Satisfactory	Adequate	Poor
Indicates clear *purpose* for writing	Indicates purpose of the report (to solve a problem, to instruct, to explain, to demonstrate, etc.) in the beginning of the report.	Purpose of the report is not clearly indicated by the writer, or is indicated incorrectly.	Purpose of the report is not indicated at all. No effort has been made to indicate purpose of writing.

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Redefining Quality of Writing:

Moving away from "good" & "bad"

Organization	Satisfactory	Adequate	Poor
Paper is logically *organized*	Has complete, concise, paragraphs; includes strong topic sentences that indicate focus of paragraph; includes strong forecasting statements; includes appropriate headings & subheadings; demonstrates coherence throughout report.	Adequate overall format; does not display concise paragraph or topic sentences; does not have all appropriate headings; paragraphs are not clearly coherent.	Does not use appropriate headings or subheading; paragraphs do not logically connect nor are they concise; topic sentences are not effective.

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Redefining Quality of Writing:

Moving away from "good" & "bad"

Support	Satisfactory	Adequate	Poor
Includes adequate *support* (documentation & illustrations)	Has necessary illustrations or figures. Refers to appropriate readings, theories, & relevant background information; includes relevant graphs & tables; with proper labeling & cross-references figures, tables, & graphs.	Has appropriate readings & background information, but does not use clear logic; has tables & graphs but they are not always labeled or cross-referenced.	Does not include necessary support in the form of logic, background information, tables, or graphs. No labeling, & cross-references.

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Redefining Quality of Writing:

Moving away from "good" & "bad"

Design	Satisfactory	Adequate	Poor
Applies an appealing *design*	Report & figures are clear & legible. Visuals are balanced on the page with appropriate verbal explanation nearby. Report is neat; headings & titles have similar font & style to indicate hierarchy of information. Easy to read.	Report & figures are legible, but some areas are difficult to read. Figures & illustrations are not as neat as they could be. Do not demonstrate hierarchy of information.	Reports & figures are messy & difficult to read. Visuals & explanations are not convenient to read.

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Redefining Quality of Writing:

Moving away from "good" & "bad"

Expression	Satisfactory	Adequate	Poor
Uses clear *expression*	Uses complete sentences & proper subject-verb construction. No spelling errors. Uses commas, periods, & other punctuations correctly. Uses correct abbreviations & capitalization. Uses appropriate vocabulary & writes in a tone that clearly conveys ideas or concepts. Uses consistent voice.	Uses readable tone, but is not clear all the time. Includes occasional spelling errors. May occasionally misuse punctuation. Does not include consistent voice.	Includes multiple spelling, grammar, or punctuation errors. Is difficult to read due to misuses of language.

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Ways that Writing Factors Apply to Physics Laboratory Reports

Although evaluating sheets for laboratory reports may not exclusively address the eight factors mentioned in pervious pages, many are implicitly included. For example, the grading rubric used by Physics to assess laboratory reports includes words such as "clear and readable," "stated correctly," "section headings provided," "correct grammar and spelling," and "use of labels on graphs." I would consider each of these criteria that address communication.

(See sample grading rubric on the next page)

SAMPLE COVER SHEET

PHYSICS ____ LABORATORY REPORT
LABORATORY I

Name and ID#: ____

Date performed: ____________ Day/Time section meets: ___________

Lab Partners' Names: ____________________________________

____

____

Problem # and Title: ____________________________________

Lab Instructor Initials: _________

Writing Factors

Grading Checklist	Points
LABORATORY JOURNAL:	
PREDICTIONS (individual predictions completed in journal before each lab session)	
LAB PROCEDURES (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; 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)	

Expression

Expressi

Organization

Content

Expression & design

Support

Support

Content

* 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.

Evaluating Sample Laboratory Report from Laboratory Manual

We've redefined the quality of writing based on the general writing factors, and how these factors relate to the rubric used to grade physics laboratory reports. The laboratory manual for the students includes, at the beginning, information about what is to be expected of their laboratory reports. There is also a sample report that further model what is expected. In this activity you will evaluate this sample laboratory report for its quality based on the grading rubric, all the while keeping in mind the qualities as described and defined by the general writing factors.

Individual Tasks:

1. *Individually* read through the sample laboratory report (the double-barred sections are descriptions and explanations on what is expected in each section of the report).

2. *Individually* evaluate the sample laboratory report – mark down any and all comments about the quality of the paper, both good and bad.

Whole Group Discussion:

Follow along with the overhead presentation as it points out certain segments that related to the writing factors. Participate in discussing various aspects of the quality of the sample laboratory report.

Time: 45 minutes.

SAMPLE COVER SHEET

PHYSICS ____ LABORATORY REPORT
LABORATORY I

Name and ID#: ______________________________________

Date performed: _____________ Day/Time section meets: ____________

Lab Partners' Names: __________________________________

____

____

Problem # and Title: __________________________________

Lab Instructor Initials: __________

Grading Checklist	Points
LABORATORY JOURNAL:	
PREDICTIONS (individual predictions completed in journal before each lab session)	
LAB PROCEDURES (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; 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 <u>rewrite that section only</u> and return it to your lab instructor within two days of the return of the report to you.

Appendix E: Sample Laboratory Report

There is no set length for a problem report but experience shows the good reports are typically three pages long. Graphs and photocopies of your lab journal make up additional pages. Complete reports will include the terminology and the mathematics relevant to the problem at hand. Your report should be a clear, concise, logical, and honest interpretation of your experience. You will be graded based on how well you demonstrate your understanding of the physics. Because technical communication is so important, neatness, and correct grammar and spelling are required and will be reflected on your grade.

Note: As with Problem 1 of Lab 1, the double vertical bars indicate an explanation of that part of the report. These comments are not part of the actual report.

Statement of the problem

In a complete sentence or two, state the problem you are trying to solve. List the equipment you will use and the reasons for selecting such equipment.

The problem was to determine the dependence of the time of flight of a projectile on its initial horizontal velocity. We rolled an aluminum ball down a ramp and off the edge of a table starting from rest at two different positions along the ramp. Starting from the greater height up the ramp meant the ball had a larger horizontal velocity when it rolled along the table. Since the table was horizontal, that was the horizontal velocity when it entered the air. See Figure 1 from my lab journal for a picture of the set-up.

We made two movies with the video equipment provided, one for a fast rolling ball and one for a slower one. These movies were analyzed with LabVIEW™ to study the projectile's motion in the horizontal and vertical directions.

Prediction

Next comes your prediction. Notice that the physical reason for choosing the prediction is given. In this case there is a theoretical relationship between Δt and v_o. There is a reference to real life experience: the example of the bullets. Also, **note that this prediction is wrong**. That is all right. The prediction does not need to be correct, it needs to be what you really thought before doing the lab; that is why it is called a prediction. The prediction is supposed to be a complete and reasonable attempt by your group to determine the outcome of the problem.

Our group predicted that the time the ball took to hit the ground once it left the table would be greater if the horizontal velocity were greater. We have observed that the faster a projectile goes initially, the longer its trajectory. Since the gravitational acceleration is constant, we reasoned that the ball would take more time to travel a larger distance.

Mathematically, we start from the definition of acceleration:

$$a = \frac{d}{dt}\left(\frac{dy}{dt}\right)$$

and integrate twice with respect to time to see how a change in time might be related to initial velocity. We found that:

$$y - y_o = v_o\Delta t + 0.5a\Delta t^2 \qquad (1)$$

With the y-axis vertical and the positive direction up, we know the acceleration is -g. We also know that v_o is the initial velocity, and $y_o - y$ is h, the height of the table. Solving for Δt one finds:

$$\Delta t = \frac{vo \pm \sqrt{(vo^2 + 2hg)}}{g} \qquad (2)$$

Faced with a choice in sign, our group chose the solution with the positive sign, deciding that a possible negative value for elapsed time does not correspond with our physical situation. From equation (2), we deduced that if v_o increased, then the time of fall also increases. This coincided with our prediction that a projectile with fastest horizontal velocity would take the most time to fall to the ground. For a graph of our predicted time of flight versus initial horizontal velocity, see Graph A from the lab journal.

LabVIEW™ generated graphs of x and y positions as functions of time. Our prediction for the vertical direction was equation (1). Since the ball only has one acceleration, we predicted that equation (1) would also be true for the horizontal motion:

$$x - x_o = v_o\Delta t + 0.5a\Delta t^2$$

The dotted lines on the printed graphs represent these predictions.

The Example of Two Bullets

Our TA asked us to compare a bullet fired horizontally from a gun to a bullet dropped vertically. Our group decided the bullet that is fired horizontally will take longer to hit the ground than the one that is simply dropped from the same height.

Data and results

This section describes your experimental method, the data that you collected, any problems in gathering the data, and any crucial decisions you made. Your actual results should show you if your prediction was correct or not.

To ensure the ball's velocity was completely horizontal, we attached a flat plank at the end of the ramp. The ball rolls down the ramp and then goes onto the horizontal plank. After going a distance (75 cm) along the plank, the ball leaves the edge of the table and enters projectile motion.

We measured the time of flight by simply counting the number of video frames that the ball was in the air. The time between frames is 1/30 of a second since this is the rate a video camera takes data. This also corresponds to the time scale on the LabVIEW™ graphs. We decided to compare the times of flight between a ball with a fast initial velocity and one with a slow initial velocity. To get a fast velocity we started the ball at the top of the ramp. A slower velocity was achieved by starting the ball almost at the bottom of the ramp.

During the time the ball was in the air, the horizontal velocity was a constant, as shown by the velocity in the x-direction graphs for slow and fast rolling balls. From these graphs, the slowest velocity we used was 1.30 m/s, and the fastest was 2.51 m/s.

After making four measurements of the time of flight for these two situations, we could not see any correspondence between time of flight and initial horizontal velocity (see table 1 from lab journal). As a final check, we measured the time of flight for a ball that was started approximately halfway up the ramp and found it was similar to the times of flight for both the fast and the slow horizontal velocities (see table 2 from lab journal).

A discussion of uncertainty should follow all measurements. No measurement is exact. Uncertainty must be included to indicate the reliability of your data.

Most of the uncertainty in recording time of flight came from deciding the time for the first data point when the ball is in the air and the last data point before it hit the ground. We estimated that we could be off by one frame, which is 1/30 of a second. To get a better estimate of this uncertainty, we repeated each measurement four times. The average deviation served as our experimental uncertainty (see Table 1 from lab journal). This uncertainty matched our estimate of how well we could determine the first and the last frame of the projectile trajectory.

Conclusions

This section summarizes your results. In the most concise manner possible, it answers the original question of the lab.

Our graph indicates that the time of flight is independent of the ball's initial horizontal velocity (see lab journal, Graph A). We conclude that there is no relationship between these two quantities.

A good conclusion will always compare actual results with the predictions. If your prediction was incorrect, then you must discuss where your reasoning went wrong. If your prediction was correct, then you should review your reasoning and discuss how this lab served to confirm your knowledge of the basic physical concepts.

Our prediction is contradicted by the apparent independence of the time of flight and initial horizontal velocity. We thought that the ball would take longer to fall to the floor if it had a greater initial horizontal velocity. After some discussion, we determined the error in our prediction. We did not understand that the vertical motion is completely independent of the horizontal motion. Thus, in the vertical direction the equation

$$y - y_o = v_o\Delta t + 0.5a\Delta t^2$$

means that the v_o is the only the y-component of initial velocity. Since the ball rolls horizontally at the start of its flight, v_o in this equation always equals zero.

The correct equation for the time of flight, with no initial vertical component of velocity, is actually:

$$y - y_o = 0.5a\Delta t^2$$

In this equation, there is no relationship between time of flight and initial horizontal velocity.

Furthermore, the graphs we generated with LabVIEW™ showed us that velocity in the y-direction did not change when the initial horizontal velocity changed. Velocity in the y-direction is always approximately zero at the beginning of the trajectory. It is not exactly zero because of the difficulty our camera had determining the position when the projectile motion begins. We observed that the y-velocity changed at the same rate (slope of v_y plots, graphs 1 and 2) regardless of the horizontal velocity. In other words, the acceleration in the y-direction is constant, a fact that confirms the independence of vertical and horizontal motion.

After you have compared your predictions to your measured results, it is helpful to use an alternative measurement to check your theory with the actual data. This should be a short exercise demonstrating to yourself and to your TA that you understand the basic physics behind the problem. Most of the problems in lab are written to include alternative measurements. In this case, using the time of fall and the gravitational constant, you can calculate the height of the table.

The correct equation for the horizontal motion is

$$x - x_o = v_o \Delta t$$

The horizontal acceleration is always zero, but the horizontal distance that the ball covers before striking the ground does depend on initial velocity.

Alternative Analysis

Since $y_o - y = h$ and $a = -g$ we can check to see if our measured time of flight gives us the height of the table. From our graph, we see that the data overlaps in a region of about 0.41 sec. With this as our time of flight, the height of the table is calculated to be 82.3 cm. Using a meter stick, we found the height of the table to be 80.25 cm. This helped convince us that our final reasoning was correct.

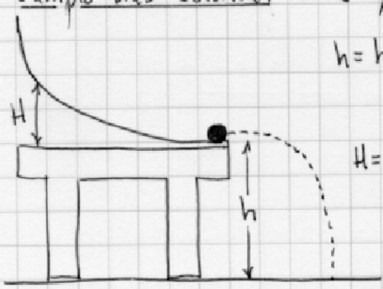
The example of the two bullets discussed in the Prediction section was interpreted incorrectly by our group. Actually, both bullets hit the ground at the same time. One bullet travels at a greater speed, but both have the same time of flight. Although this seems to violate "common sense" it is an example of the independence of the horizontal and vertical components of motion.

APPENDIX E: SAMPLE LAB REPORT

The following are pages photocopied from my lab journal:

Sample Lab Journal July 13th, 1998

h = height of table



H = ball's starting height

Equipment: ramp, aluminum ball, video camera, computer, meterstick

Purpose: Determine if Time of flight depends on initial horizontal velocity

Method: One person releases ball, another operates video camera. Count frames with ball in the air to find time of flight.

Exploration: Larger H results in larger horizontal $\vec{v}$.

Table 1

Fast Ball, $H \simeq 35\,cm$, $v_0 = 2.51\ m/s$

Trial	Frames with ball in air	Deviation from ave.
1	13	0.25
2	13	0.25
3	12	0.75
4	13	0.25
Average	12.75	0.4

Time of flight:
$12.75\,\text{frames} \times \frac{1}{30} \frac{\text{sec}}{\text{frame}} =$

0.42 sec

Uncertainty:
$\pm 0.4\,\text{frames} \times \frac{1}{30} \frac{\text{sec}}{\text{frame}} =$

± 0.014 sec

Slow Ball, $H \simeq 10\,cm$, $v_0 = 1.3\ m/s$

1	12	0.5
2	13	0.5
3	13	0.5
4	12	0.5
Average	12.5	0.5

Time of flight:
$12.5\,\text{frames} \times \frac{1}{30} \frac{\text{sec}}{\text{frame}} =$

0.41 sec

Uncertainty
$\pm 0.5 \times \frac{1}{30} \frac{\text{sec}}{\text{frame}} =$

± 0.018 sec

Table 2

Medium Ball, $H \simeq 20$, $v_0 = 1.8\ m/s$

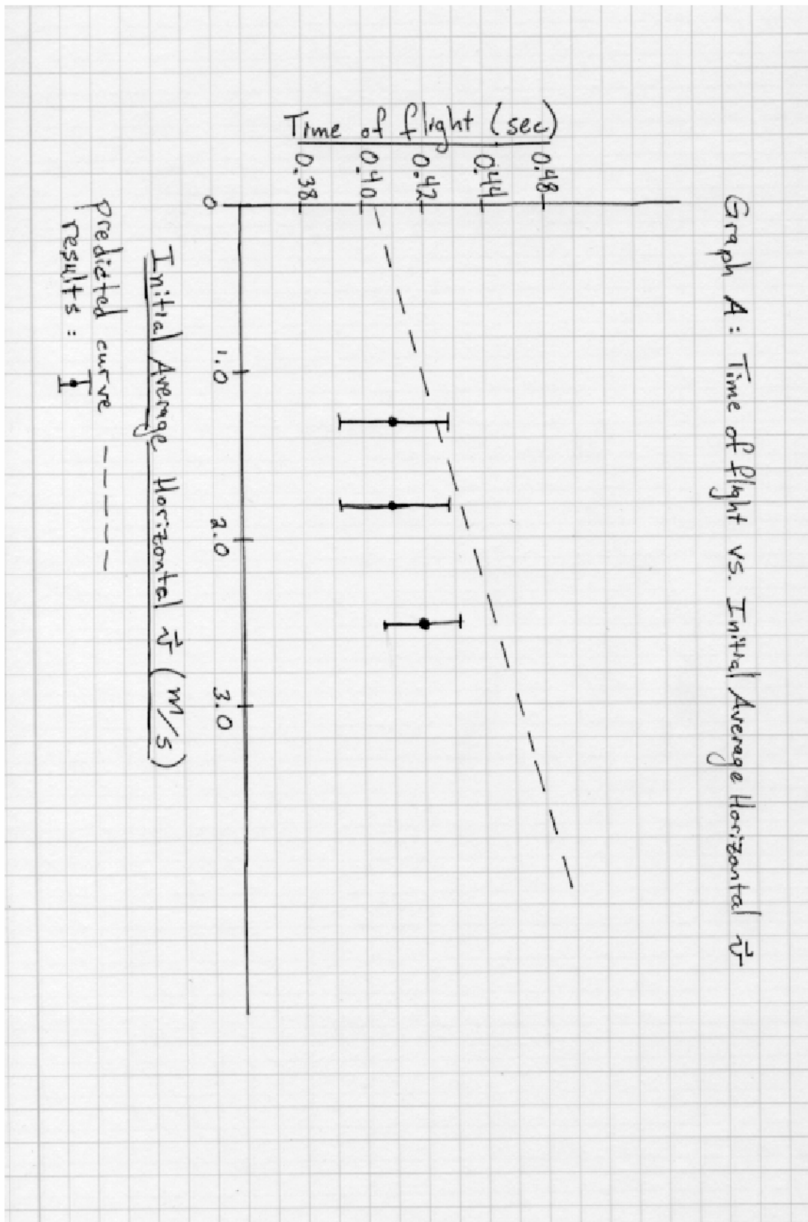
Trial	# frames	Deviation
1	12	0.5
2	12	0.5
3	13	0.5
4	13	0.5
Average	12.5	0.5

Time of flight:
$12.5\,\text{frames} \times \frac{1}{30} \frac{\text{sec}}{\text{frames}} =$

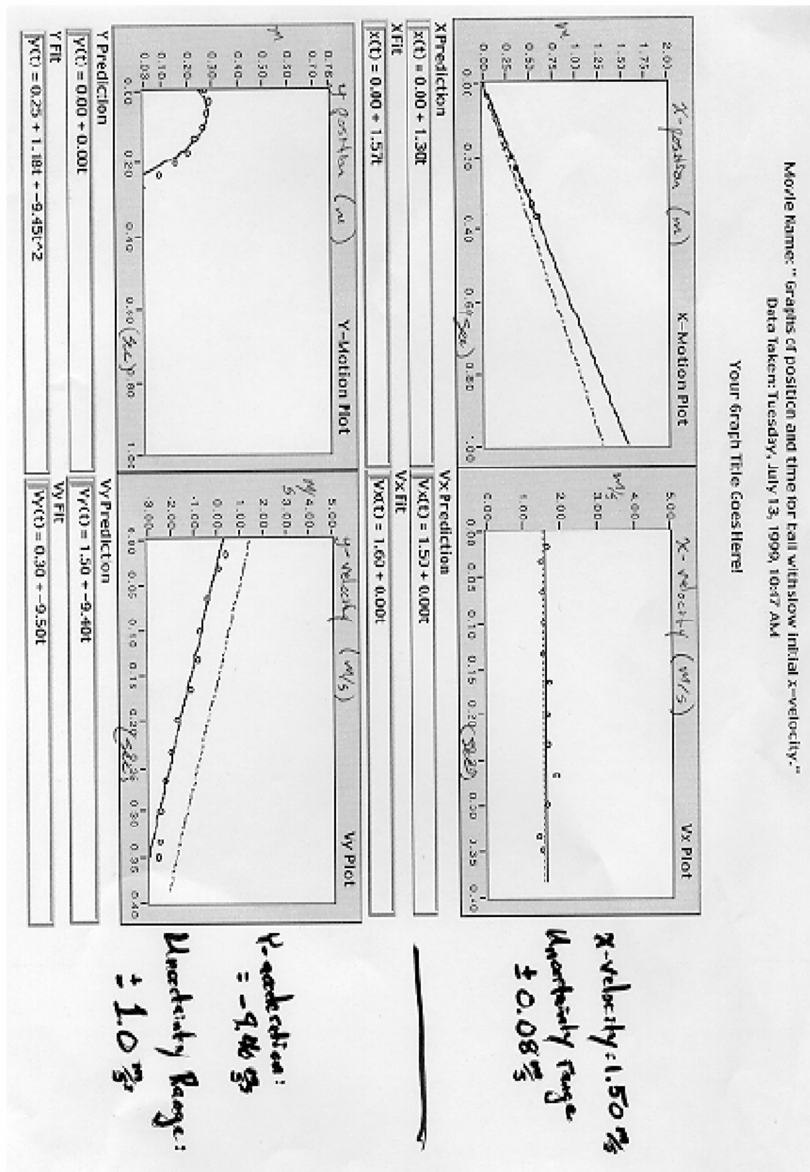
0.41 sec

Uncertainty: $\pm 0.5 \times \frac{1}{30} \frac{\text{sec}}{\text{frame}} =$

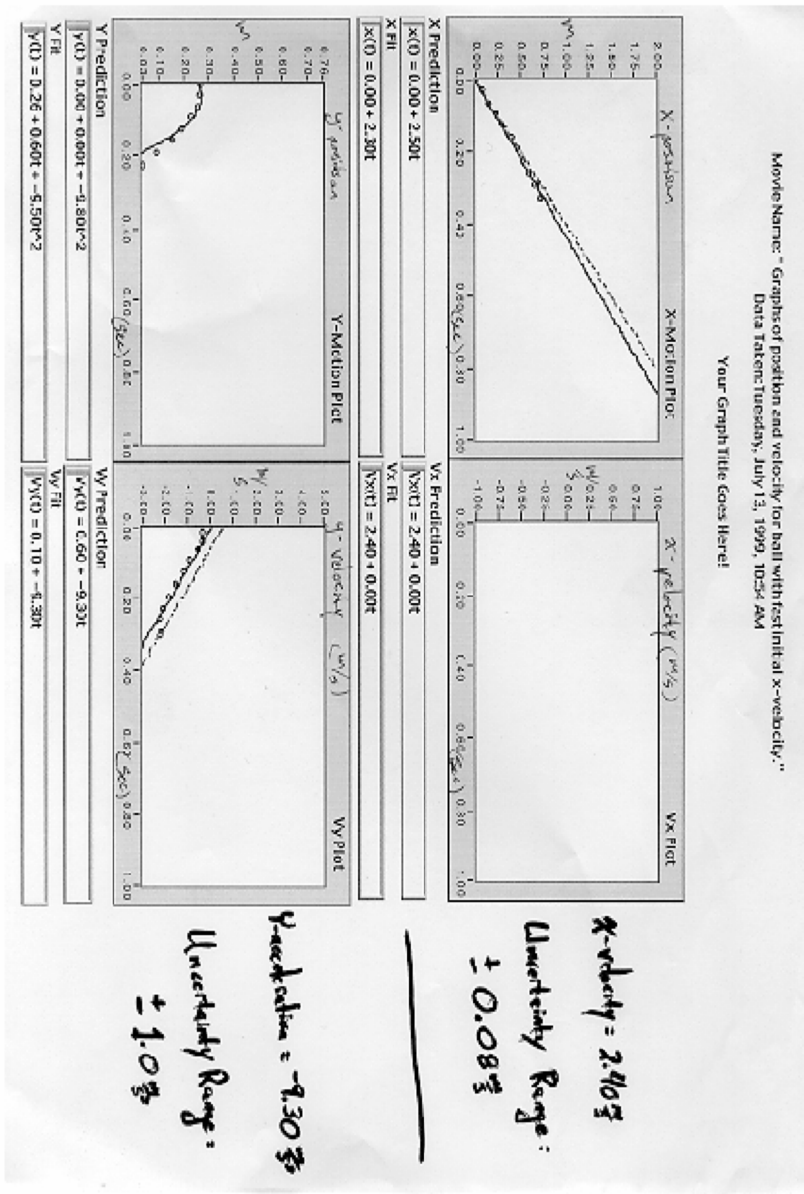
± 0.018 sec


Graph A: Time of flight vs. Initial Average Horizontal $\vec{v}$
Time of flight (sec)
0.38
0.40
0.42
0.44
0.48
0
1.0
2.0
3.0
Initial Average Horizontal $\vec{v}$ (m/s)
predicted curve - - - -
results :

APPENDIX E: SAMPLE LAB REPORT



APPENDIX E: SAMPLE LAB REPORT



E - 10

Discussion of Sample Laboratory Report with Annotations Regarding Communication – Writing Factors

What characteristics of writing does the report display well?

What characteristics are not displayed well?

How to Grade a Student Laboratory Report

We've redefined the quality of writing based on the general writing factors, and how these factors relate to the rubric used to grade physics laboratory reports. We've also evaluated the sample laboratory report from the laboratory manual. Now we will go through an example of how to grade a student laboratory report.

Individual Tasks:

3. *Individually* read through the example student laboratory report.

4. Follow closely as we go over the grading of the example student laboratory report.

5. Mark down any and all comments made during the presentation on the example student laboratory report.

Time: 30 minutes

Note: This activity is to show you how to grade student laboratory reports, so follow along closely.

SAMPLE COVER SHEET

PHYSICS ____ LABORATORY REPORT
LABORATORY I

Name and ID#: ____

Date performed: ______________ Day/Time section meets: ____________

Lab Partners' Names: ____________________________________

____

____

Problem # and Title: ____________________________________

Lab Instructor Initials: __________

Grading Checklist	Points
LABORATORY JOURNAL:	
PREDICTIONS (individual predictions completed in journal before each lab session)	
LAB PROCEDURES (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; 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 <u>rewrite that section only</u> and return it to your lab instructor within two days of the return of the report to you.

88\

Lab report of lab 2 problem #1

312

MASS AND THE ACCELERATION OF A FALLING BALL

The purpose of this lab is to determine if the acceleration of an object depend on its mass. We use a baseball and a plastic orange ball (1/3 mass of baseball). These two objects have different mass but almost the same size. They are use to be dropped so we can calculate the acceleration for each of them. A camcorder is used to record the different intervals of the balls. From the information received, we can determine the change of distance and the change of time of each interval. The software program "Lab View" guides us in our analysis of the change of velocity of each interval as it goes down the screen.

Prediction

It is understand that any object regardless of its mass will be pull towards the earth at a constant acceleration of 9.8 m/s2. This is only true in a vacuum room. We predicted that the acceleration of an object would have a factor from its mass. The free-fall acceleration of an object will increase as the mass of the object increase. This change of acceleration is depending on the air acting on the ball. If the object has more mass then the object is able to reduce the pressure acting upon it but if the object is light, air will be a factor and it will not accelerate as fast.

Data and Results

We use a meter stick to ensure a vertical path for the ball to follow. The ball is being dropped from the top of the meter stick to the floor (bottom). We use the video camera to record a movie of the free-fall. The movie capture individual intervals of the fall, each time frame if capture every 1/30 sec. We then use the intervals to determine the change of distance over change of time.

The starting time for the baseball was 0.80sec and ended at 1.02 sec. The total time is 0.22 seconds to travel 100 cm. The average velocity is 454 cm/sec. The weight of this ball (baseball) is 140 grams and 7cm in diameter.

The starting time for the orange ball is at 0.6 seconds and ends at 0.9 seconds. The total time is 0.3 seconds over a distance of 100 cm. The average velocity of the free-fall is 333.33 m/s. The weight of the ball is 47.7 grams and a diameter of 6.5 cm.

From the data above, we can see that the velocity of the baseball is higher then the Orange ball.

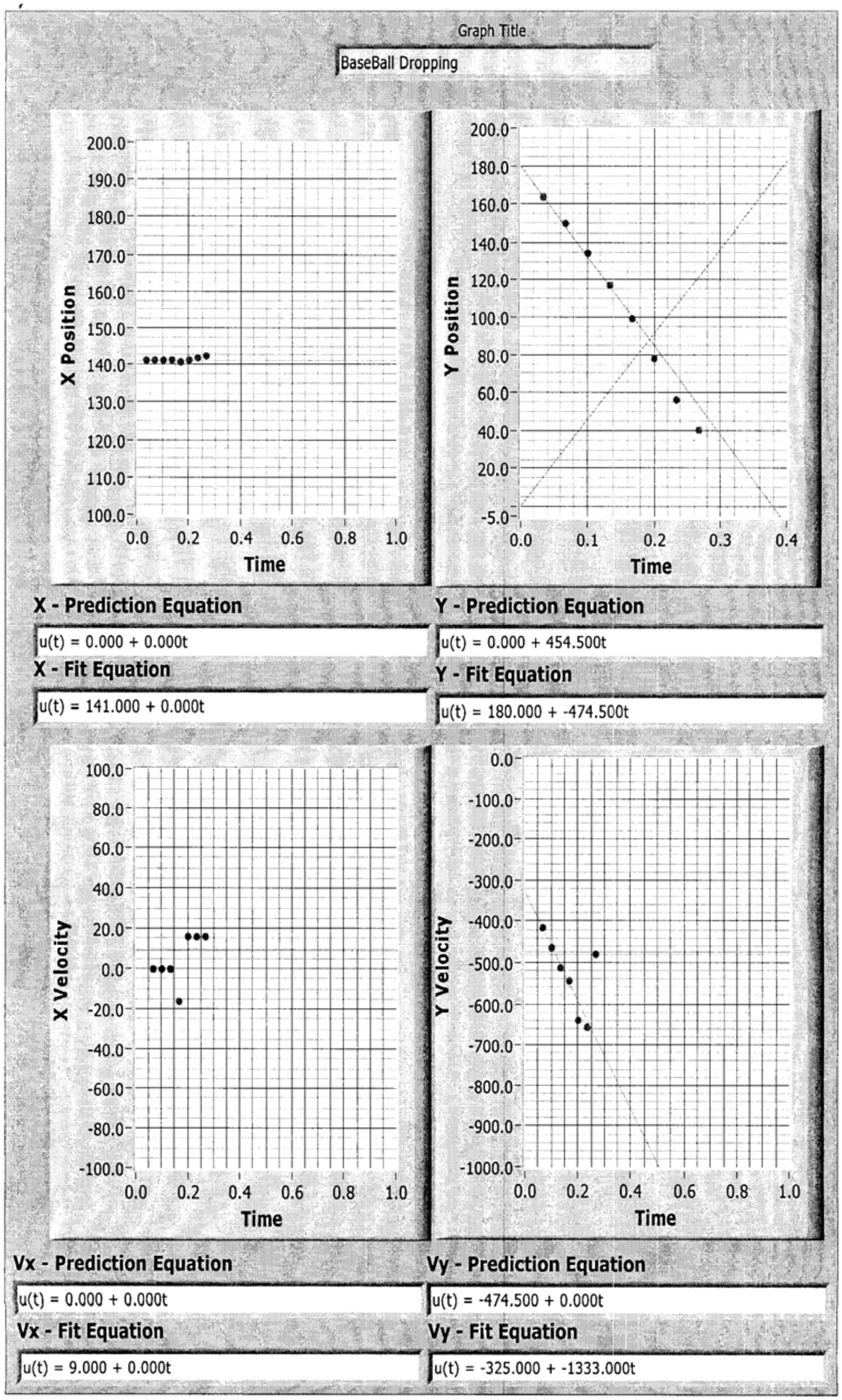
Baseball:
(Interval 2) 140cm/ 0.26sec = 538 m/s
(Interval 1) 125cm/ 0.24sec = 520 m/s
18.46 m/s / 0.02 sec = 923 cm/s = **9.23 m/s2**

Orange Ball:
(Interval 2) 330cm/ 0.22sec = 1500m/s
(Interval 1) 140cm/ 0.10sec = 1400m/s
100m/s / 0.12 sec = 833.33 cm/s = **8.33m/s2**

Difference of acceleration:
9.23 m/sec2 – 8.33 m/sec2 = 1.10 m/sec2

Conclusion

In conclusion, it took 0.08seconds longer for the orange ball to reach the ground then the baseball and baseball is acceleration 1.10 m/sec2 faster then the orange ball. We predict that if the balls were being evaluated in a vacuum room, the acceleration would be the same even if they have different mass.


Graph Title
BaseBall Dropping
X Position
Time
Y Position
Time
X - Prediction Equation
u(t) = 0.000 + 0.000t
X - Fit Equation
u(t) = 141.000 + 0.000t
Y - Prediction Equation
u(t) = 0.000 + 454.500t
Y - Fit Equation
u(t) = 180.000 + -474.500t
X Velocity
Time
Y Velocity
Time
Vx - Prediction Equation
u(t) = 0.000 + 0.000t
Vx - Fit Equation
u(t) = 9.000 + 0.000t
Vy - Prediction Equation
u(t) = -474.500 + 0.000t
Vy - Fit Equation
u(t) = -325.000 + -1333.000t

Grading Two Example Student Laboratory Reports

Now it's your chance to grade student laboratory reports. Please keep in mind the information from Activities **17** & **#18a** as you go through the following 2 student laboratory reports.

INDIVIDUAL TASKS:

1. *Individually* read through the 2 example student laboratory reports and grade them using the grading rubric for physics laboratory reports.

2. Mark down any and all comments on the example student laboratory reports as you grade them.

3. Assign points for each student laboratory report on the grading rubric.

GROUP DISCUSSION

TIME: 30 minutes

PRODUCT

Grading rubric; comments and feedback on each student laboratory report.

Activity 18b. Grading Two Example Lab Reports

SAMPLE COVER SHEET

PHYSICS ____ LABORATORY REPORT
LABORATORY I

Name and ID#: ____

Date performed: _____________ Day/Time section meets: ____________

Lab Partners' Names: ____

____

____

Problem # and Title: ____

Lab Instructor Initials: __________

Grading Checklist	Points
LABORATORY JOURNAL:	
PREDICTIONS (individual predictions completed in journal before each lab session)	
LAB PROCEDURES (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; correct grammar and spelling; section headings provided; physics stated correctly)	
DATA AND DATA TABLES (clear and readable; units and assigned uncertainties clearly stated)	
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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

n

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.

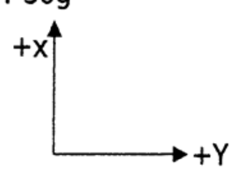
Data and Results:

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.

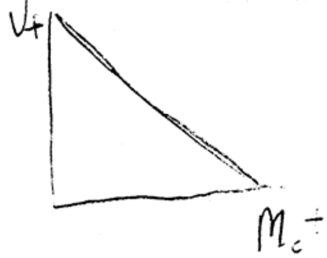
Conclusions:

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.

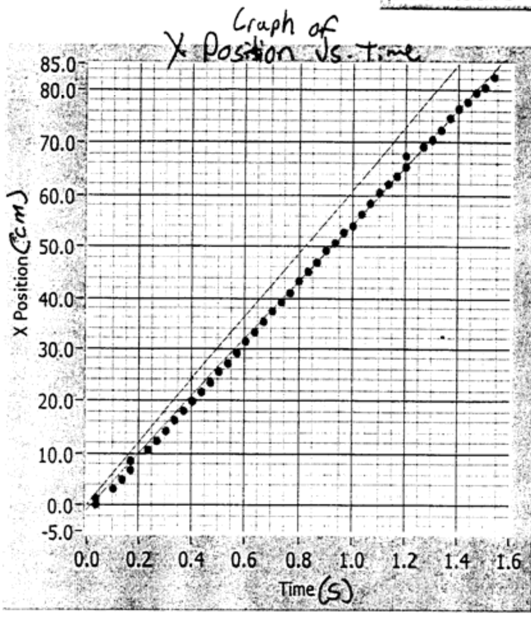
If the same block falls the same distance, the force exerted by the block on the cart would not change, no matter the mass of the cart. The force of the block on the cart is always equal to the block's weight.

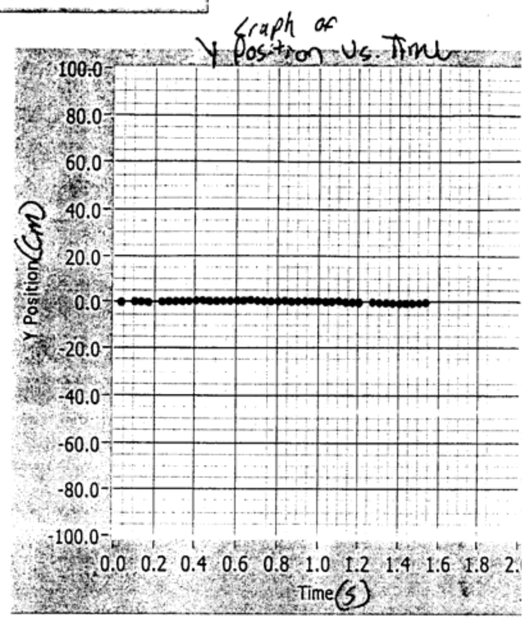
Prediction graphs



Graph Title 7

Lab 3 Problem 1





X - Prediction Equation

u(t) = 0.000 + 60.500t

X - Fit Equation

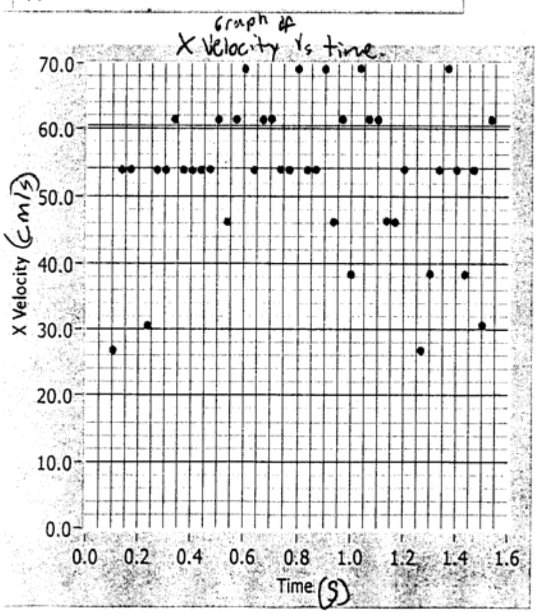
u(t) = -1.000 + 55.000t

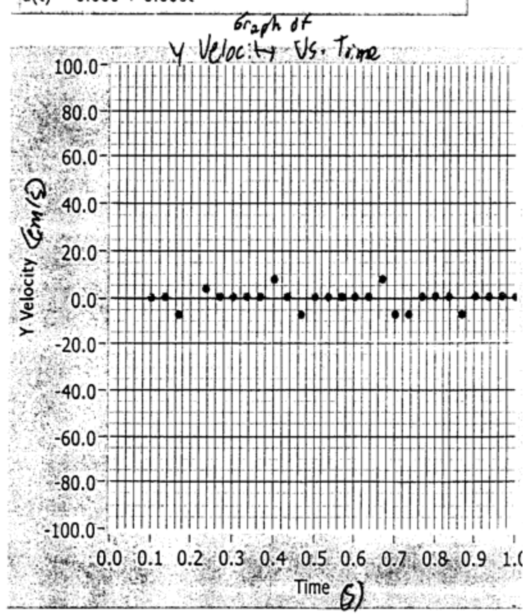
Y - Prediction Equation

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

SAMPLE COVER SHEET

PHYSICS ____ LABORATORY REPORT
LABORATORY I

Name and ID#: ____

Date performed: ____________ Day/Time section meets: ____________

Lab Partners' Names: ____________________________________

____

____

Problem # and Title: ____________________________________

Lab Instructor Initials: __________

Grading Checklist	Points
LABORATORY JOURNAL:	
PREDICTIONS (individual predictions completed in journal before each lab session)	
LAB PROCEDURES (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; 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 <u>rewrite that section only</u> and return it to your lab instructor within two days of the return of the report to you.

Example #2

uist

109

002

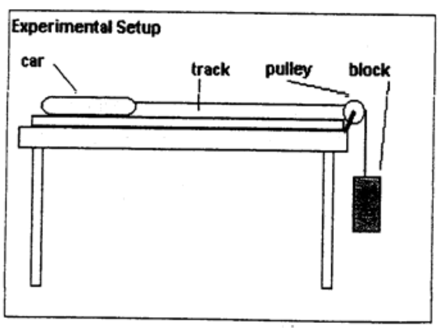
Lab III Problem 1: Force and Motion

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.

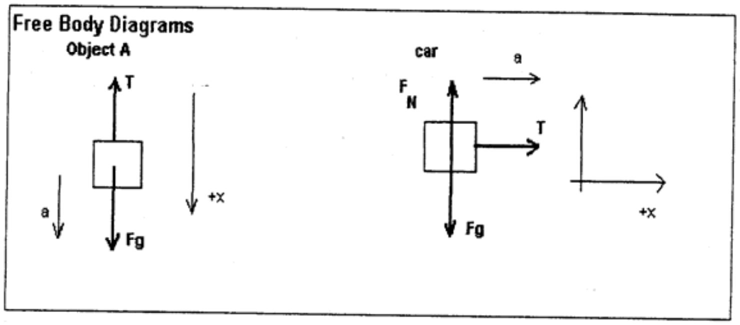
The block (called object A) has a significantly shorter distance to fall than the car has to travel along its track. In this experiment, we ignored the friction between the car and the track and between the pulley and the string. We also ignored the mass of the string.



2. Prediction --

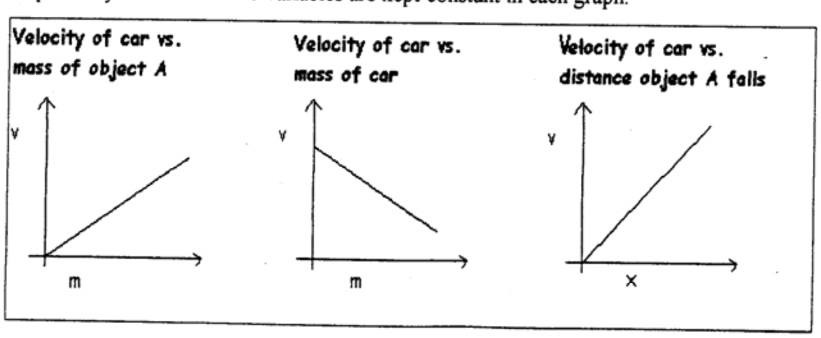
The first question asked me to calculate the cart's velocity after the block had hit the ground. I predicted that $\mathbf{v_c} = \sqrt{\mathbf{2xg[m_a/(m_c + m_a)]}}$. I solved the first kinematics equation, $\mathbf{x_c = x_{0c} + v_{0c}t + 1/2at^2}$ **for t**, assuming that x_0 =O, v_0 =0 and $a_c = a_A$, 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 $\mathbf{\Sigma F_A = Fg - T}$. 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.



Sonah 4

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.

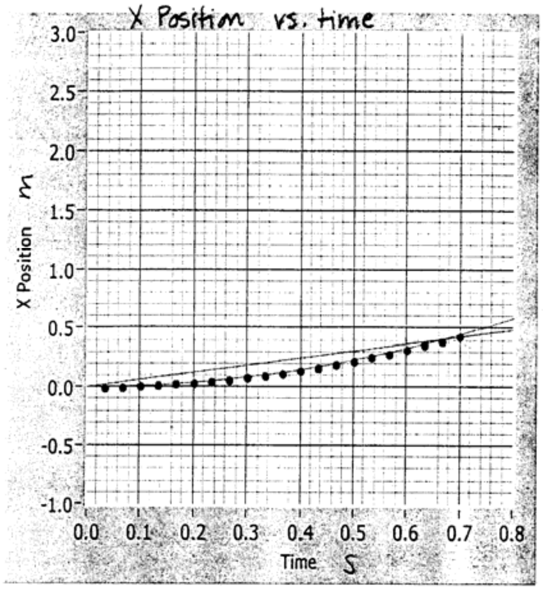
The launch velocity of the car does depend on the mass of the car, the mass of the block and the distance the block falls, according to $v = \sqrt{2xg[m_a/(m_c + m_a)]}$. For values of m_a that are much larger than m_c, m_c does not affect v very much, since $[m_a/(m_c + m_a)]$ becomes very close to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

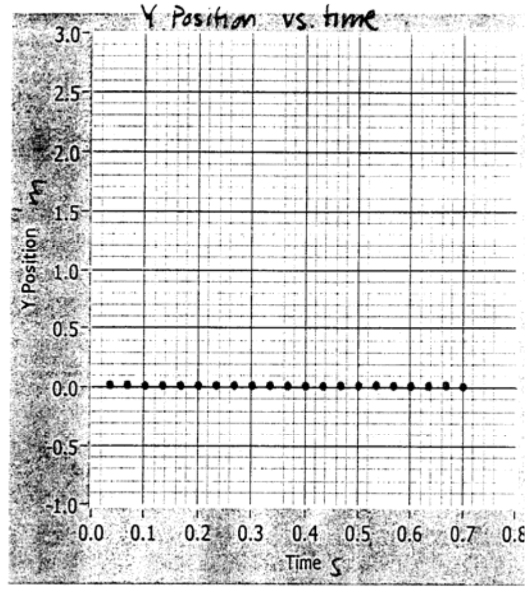
The tension force upon the car and the block is dependent on the masses of both objects. Changing the mass of either one will change the tension force exerted on both. The tension force on the block is equal to its weight if the block has no net acceleration; in other words, when $T = F_g$. This would 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.

7

Graph Title

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





X - Prediction Equation

u(t) = 0.000 + 0.600t

X - Fit Equation

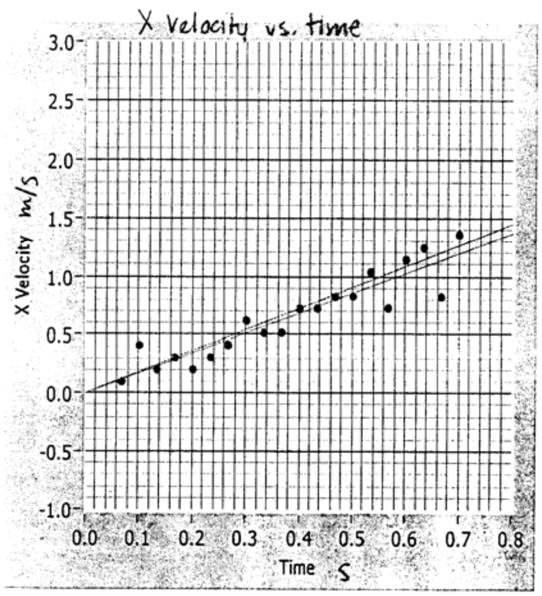
u(t) = 0.000 + 0.000 t + 0.897 t^2

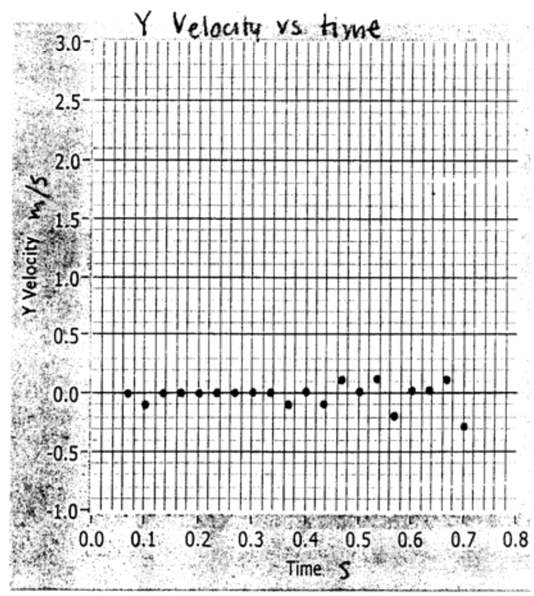
Y - Prediction Equation

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

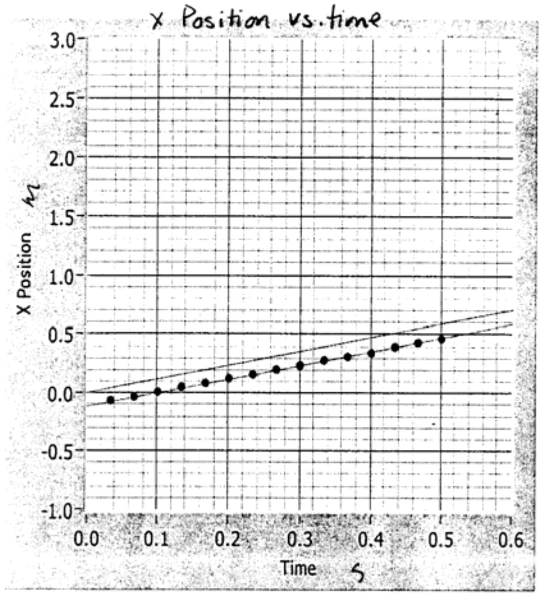
u(t) = 0.000 + 0.000t

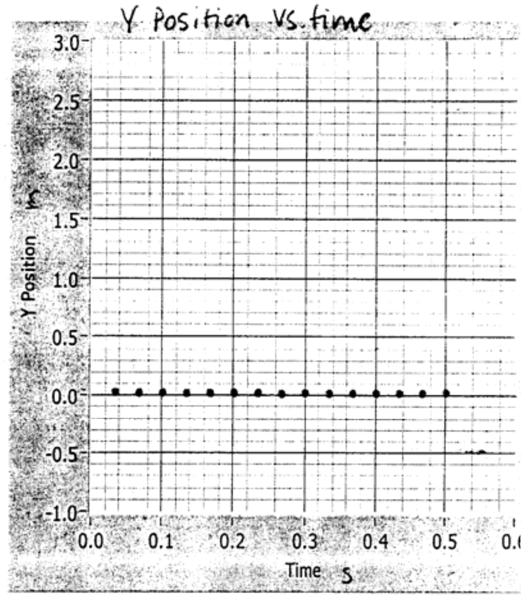
Vy - Fit Equation

u(t) = 0.000 + 0.000t

Graph Title

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





X - Prediction Equation

u(t) = 0.000 + 1.167t

X - Fit Equation

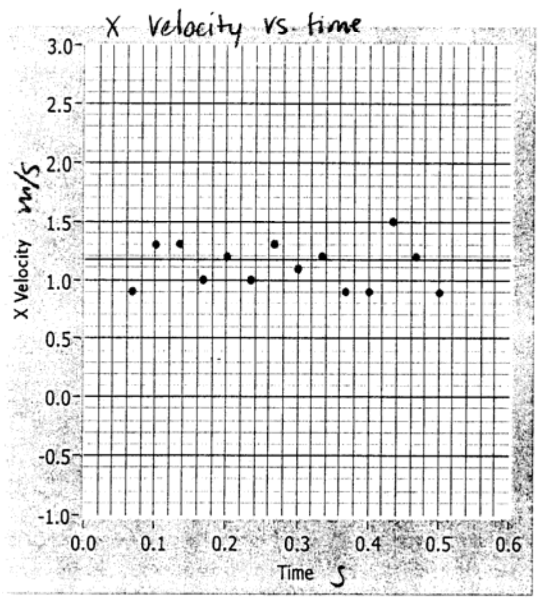
u(t) = -0.120 + 1.167t

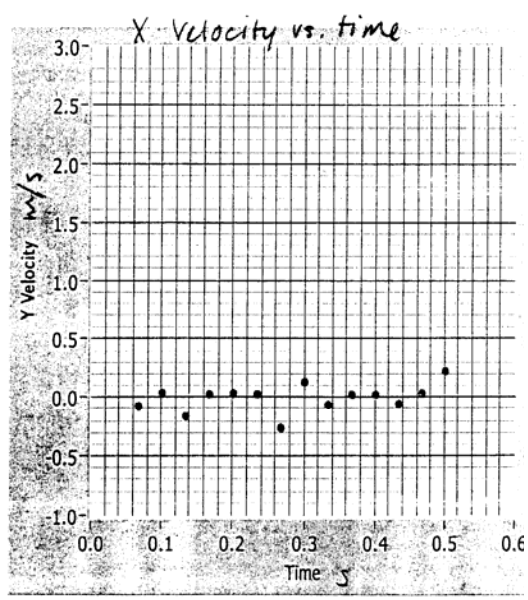
Y - Prediction Equation

u(t) = 0.000 + 0.000t

Y - Fit Equation

u(t) = 0.000 + 0.000t





Vx - Prediction Equation

u(t) = 1.167 + 0.000t

Vx - Fit Equation

u(t) = 1.170 + 0.000t

Vy - Prediction Equation

u(t) = 0.000 + 0.000t

Vy - Fit Equation

u(t) = 0.000 + 0.000t

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/

Writing Support Network

Example – http://cisw.cla.umn.edu/wsn.html

Welcome to the Writing Support Network! Do you need help with your writing? The Centers listed below are rich sources of information for you. You can take your assignment to a walk-in center, submit a question to an online center, or explore handouts on everything from how to organize a paper to how to document sources.

Writing Centers provide help for all students: writers at *all* levels of ability and experience, those who would like help with English as a second language, and those who want assistance because of learning or physical disabilities.

Student Writing Center

This center provides walk-in assistance with all aspects of writing. Consultants can help students with writing assignments and writing process skills. Located in the English Department, 306B Lind Hall, hours are generally Monday through Thursday 9:00 a.m. to 4:00 p.m. and Friday 9:00 a.m. to 2:00 p.m. Check the Web site or call 612-625-1893 for updated hours of operation. Students can either make appointments or just walk in and can request help once or twice or request an ongoing weekly appointment. Instructor referrals are also accepted.

Online Writing Center

This online resource provides personalized online writing service for both undergraduate and graduate students, including consulting, interactive skills exercises, and specialized help for students in the sciences or technology. Since this service is online, student can submit their questions at any time and receive answers within several days. It is especially useful for students who cannot be on campus for face-to-face tutoring. This service is provided by the Rhetoric Department.

Center for Interdisciplinary Studies of Writing

The Center primarily encourages faculty research into writing across the curriculum. Though it does not have tutors for undergraduates, it does have a variety of useful writing handouts and resources. The Web site is especially designed to help students, faculty, and researchers enhance their writing. The site contains hundreds of useful links to other writing resources around the country and information on the University's writing-intensive courses. Click on "Resources for Undergraduates" for this information.

Composition Program

Composition is a program of the Department of English. Through its various courses, Composition teaches students to use language effectively and creatively, to construct compelling arguments, and recognize that writing is empowering. Most Composition courses satisfy the Freshman Writing Requirement. Composition also gives students an introduction to life at the university, good study skills, the library and its resources, and the ways knowledge is created. The Composition Web has information, resources, and links for students, instructors, and visitors.

General College Writing Center

This is a walk –in center with undergraduate consultants who can work with students at any stage of the writing process. The center also accepts writing questions through email. Instructors may also refer students to the Center for one or two visits or for ongoing help. Located in the Academic Resource Center in 11 Appleby Hall, hours are 9:00 a.m. to 4:00 p.m. Monday through Thursday and 9:00 a.m. to 3:00 p.m. on Friday.

Minnesota English Center

The Minnesota English Center (MEC) provides noncredit composition and reading/composition classes for nonnative speakers of English who want to improve their English for academic, business, or personal reasons. The MEC also offers classes in other skills and provides referrals to qualified tutors who charge by the hour for short-term or long-term tutoring. For information on course offering and fees, call 612-624-1503. e-mail mec@tc.umn.edu, or visit the MEC website, http://www1.umn.edu/mec/

Writing Intensive Coursework Requirements

1. 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***

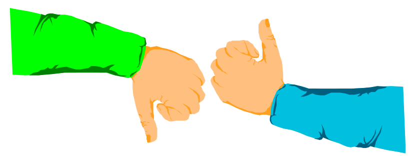
2. Courses requiring a significant amount of writing – ***minimally ten to fifteen finished pages*** beyond informal writing and any in-class examinations. Note that the page guidelines may be met with an assortment of short assignments that add up to the total

3. Curses in which ***students are given instruction on the writing*** aspect of the assignments

4. Courses in which ***assignments include at least one for which students are required to revise a draft and resubmit*** after receiving feedback from the course instructor or graduate teaching assistant. Otherwise, writing assignments may be of various kinds and have various purposes, as appropriate to the discipline

Classroom Climate

A positive Classroom Climate can play an important role in determining academic misconduct and sexual harassment.



In your groups:

1. **Recall examples of positive/negative classroom climates.**
2. **Brainstorm factors that contributed to the positive/negative classroom climate**

Scholastic Dishonesty is ...

Directions: Circle **T** if the statement accurately completes the above sentence; Circle **F** if the statement does not accurately complete the above sentence.

T / F 1. The act of passing off someone else's work as your own.

T / F 2. Extensive assistance from other people on an assignment without recognition.

T / F 3. Using sections of someone else's homework assignment.

T / F 4. Looking at another student's examination during a testing situation.

T / F 5. Conferring with fellow students during an examination period.

T / F 6. Allowing another student to copy from your examination.

T / F 7. Using notes stored on a calculator during a closed-book examination.

T / F 8. Using another person's idea without acknowledging that person.

T / F 9. Allowing another student to copy sections of your paper.

T / F 10. Signing another student's name on an attendance sheet.

T / F 11. Permitting another student to sign your name on an attendance sheet.

T / F 12. Collaborating with a fellow student on a take home exam.

T / F 13. Copying an answer to a problem line-for-line from a textbook or solution manual without identifying where it came from.

T / F 14. An act that can result in expulsion from the University.

Adapted with permission from the Teaching Enrichment Program at the University of Minnesota.

Activity #16b (3 points)

Case Studies: Diversity and Gender Issues

GROUP TASK

This exercise uses "critical incidents" derived from encounters among and between teachers and students at the University of Minnesota. The critical incidents are, as the name implies, incidents or situations that are of importance in understanding the behavior, values, and cultural differences of those described in the incident. Case Studies #1 through #6 deal with incidents you might encounter as a graduate teaching assistant. Case Studies #7 and #8 describe encounters between people from the U.S. and international scholars. Case Studies #9 through #11 deal with incidents with fellow graduate students.

The incidents are open-ended, with no absolute right answer to be guessed or learned. In our discussion of the incidents, several explanations, alternatives, or solutions could be proposed depending on the personality, style, or culture of the individuals.

Discuss the four critical incidents assigned to your group. Use the guidelines listed under each critical incident to begin the discussion. There is no need to limit your discussion to just the questions provided.

GROUP ROLES

Skeptic: Ask what other possibilities there are, keep the group from superficial analysis by not allowing the group to agree too quickly; ask questions that lead to a deeper analysis; agree when satisfied that the group has explored all possibilities.

Manager: Suggest a plan for discussing each incident and answering the questions; make sure everyone participates and stays on task; watch the time.

Checker/Recorder: Ask others to explain their reasoning process so it is clear to all that their suggestions can be discussed; paraphrase, write down, and edit your group's response to each incident.

TIME: 25 minutes

The *Checker/Recorder* will be asked to make the opening comments about **one** of the assigned case studies when we return to the larger group.

GROUP PRODUCT

Answer Sheets for assigned Case Studies.

 Name : ____________________

Case Study #1*

One of your physics students is a highly achieving undergraduate who is very bright, personable, and attractive. You enjoy working with this student, but are not otherwise interested in a relationship. Unexpectedly, the student leaves you a note, professing an interest in establishing a close relationship, along with a bouquet of flowers.

*Adapted from University-wide sexual harassment training

1. What are your responsibilities in this situation?
2. How can you maintain the kind of teaching relationship you want?

NOTES:

Name : ___________________________________

Case Study #2*

One day, as you are waiting for students to come in and settle down for your discussion session, you notice that one of the students enters wearing a T-shirt which is emblazoned with a sexually obscene and violent slogan. The student sits down as the bell rings for the class to begin. Just as you are about to begin your opening game, another student states loudly that he cannot sit in the class and attempt to learn if that T-shirt is allowed to stay there. The two students then engage in a shouting match.

*Taken from University-wide sexual harassment training

1. What are your responsibilities in this situation?
2. What are some possible solutions?

NOTES:

Name : ____________________________________

Case Study #3

You are discussing with your class the physics of sound, specifically why longer musical instruments make deeper sounds. To provide a quick demonstration, you have one male student and then one female student stand up and say "oooh." After the session, the female student goes to the professor and says that she felt singled out since she is the only woman in the class. Further, she was upset and embarrassed since saying "oooh" loudly in a room full of men seemed to her to be too sexual a thing to do.

1. What could you have done to prevent the situation?
2. What could you do to resolve the situation?
3. What could your professor have done to prevent the situation?
4. What could the professor do to resolve the situation?

NOTES:

Name : ___________________________________

Case Study #4

Jose, a student in your section, is in a wheelchair. His brother Pedro is in the same section, and is very protective of Jose. (Pedro registered for all the same classes as Jose on purpose so that he can help him out.) The brothers want to be in the same group, but you want to have diverse groups so that students can get to know one another. However, because of Jose's disability you give in to the brothers and put them in a group with two other people. When there is a group test problem, the brothers surprise you by speaking Spanish to one another. You ask them to speak English so that everyone in the group can understand. They tell you that they don't think they read English as well as other people in the class and are just talking to each other in Spanish to be sure that they understand the quiz problem.

1. What could you have done to prevent the situation?
2. What can you do to resolve the situation?

NOTES:

Name : ____________________________________

Case Study #5

You are a relaxed TA, often chatting and laughing with students in your section before you start class. One day before lab, you discover that you share an interest in racquetball with one of your students and you make an appointment to play. Soon you are meeting every Wednesday at lunch for a racquetball game with this student and becoming friends. The other students in your section know about this and are upset about it. You think it's no big deal, since it's not as though you are romantically involved with your student.

1. What are your responsibilities in this situation?
2. What can you do to resolve the situation?

NOTES:

Name : ____________________________________

Case Study #6

Early in the spring semester, one of your fellow team members stops by your lab section and starts chatting and visiting with one of your students during the lab. It is soon obvious that the two are in a relationship. After lab, you find out that this student was in the TA's lab last term.

1. What are your responsibilities in this situation?
2. What can you do to resolve the situation?

NOTES:

 Name : ____________________________________
Activity 16b

Case Study #7*

Abdelkader, Mohammed and Naji, students from the same country, are close to completing their first semester at the University. When they first met at the new student orientation program and discovered they were all in the same engineering department, they arranged their schedules so they could take most of their classes together. Every day before their physics class they met to study each other's notes and to discuss the assigned reading and homework they had done the night before.

Their physics professor noticed that the three students made nearly the same errors in the first exam of the semester. At the time, he assumed it was because they were from the same educational background. However, when he noticed that all three students had exactly the same problems incorrect on their second test, he decided they had to be cheating. The professor called the students into his office and explained that this type of behavior was unacceptable. He told them that he was going to call the foreign-student advisor to see what action could be taken because of their cheating.

*Adapted from Florence A. Funk's "Intercultural Critical Incidents"

1. What happened? (Describe the situation.)
2. Why? (Give causes/interpretation of the situation.)
3. Alternatives/Solutions:
   a. What could have been done to prevent the situation?
   b. What can be done to resolve the situation?

NOTES:

Case Study #8*

Chong, a new international student at the University of Minnesota, arrived on campus two weeks before classes began so he could find housing, register for classes and become familiar with the St. Paul-Minneapolis area. During this two week period everything went well. He found an apartment to share with a U.S. student from his department, was able to register for all the classes he needed, and made the acquaintance of a few other students. Once classes began Chong discovered that he was thrilled with the discussion that took place between the students and professors in his classes, he enjoyed the company of his roommate's friends and he enjoyed the easy access to movies, shopping, and fast food establishments.

About three weeks into the term, Chong began to find the endless classroom discussions a waste of time. He was frustrated with the ridiculous antics of his roommate's friends and it seemed that everything he needed cost too much. He found that he was now seeking the company of his countrymen and that their discussions most often centered on how "screwed-up" everything was in the States. He ate lunch in a local ethnic restaurant and avoided contact with students from the U.S. unless it was required to fulfill classroom assignments.

*Taken from Florence A. Funk's "Intercultural Critical Incidents"

1. What happened? (Describe the situation.)
2. Why? (Give causes/interpretation of the situation.)
3. Alternatives/Solutions:
   a. What could have been done to prevent the situation?
   b. What can be done to resolve the situation?

NOTES:

 Name : ___________________________________

Case Study #9

Boris is a first year physics graduate student from Russia. Although he speaks English with a heavy accent, he is fluent and is given his own discussion and lab sections to teach. After a few weeks he becomes puzzled by his students' behavior. Even though he can tell from their test scores that they are confused about physics, they never ask questions or come to his office hours. They come to class late and have to be asked two or three times before they will respond when he asks them to go to the board. Boris comes to you and asks what he should do.

1. What happened? (Describe the situation.)
2. Why? (Give causes/interpretation of the situation.)
3. Alternatives/Solutions:
   a. What could have been done to prevent the situation?
   b. What can you do to help resolve the situation?

NOTES:

 Name : ___________________________________
Activity 16b

Case Study #10

Mary was having some difficulty in one of her 5000-level physics classes.
She had trouble with the homework assignments and then scored below the median on the first two exams. About halfway through the term, Mary went to see the professor to ask him for help. He told Mary that she should really be ashamed at her performance in the class and that she would probably fail. He refused to help her and told her that she should drop out of school, since it was unlikely that she would ever be a physicist. After meeting with him, the student was so upset that she went to the top of a tall building and considered killing herself.

1. What happened? (Describe the situation.)
2. Why? (Give causes/interpretation of the situation.)
3. Alternatives/Solutions:
   a. What could Mary have done to prevent the situation?
   b. What can Mary do to resolve the situation?
   c. What could the professor have done to prevent the situation?
   d. What could you (as one of Mary's classmates) do to prevent or resolve the situation?

NOTES:

Name : ___________________________________

Case Study #11

In one of her sections Susan had a male student, Joe, who was very self-assured. During her office hours, he often sat very close to her and put his arm around the back of her chair. One day in lab, as Susan helped a group at the next table, Joe reached behind him and stroked her leg. She said, "Don't do that," and asked to speak to him after class. When the other students had gone, Susan said, "I don't know what you thought you were doing when you touched my leg in class." Joe said that it had been an accident, and Susan ended the conversation. Immediately after that, she went to see the lecturer for Joe's class and told him the whole story. The professor laughed.

1. What happened? (Describe the situation.)
2. Why? (Give causes/interpretation of the situation.)
3. Alternatives/Solutions
   a. What could the TA (Susan) have done to prevent the situation?
   b. What could Susan do to resolve the situation?
   c. What could the professor have done to prevent the situation?
   d. What could the professor do to resolve the situation?

Name : ___________________________________

Homework

 Name: ______________________

Homework #3: Solving Problems

Solve the following problems like you, as an instructor, would like see freshman solutions. That is, draw diagrams with a clear definition of symbols, clearly represent the symbolic forms of the fundamental concepts and principles you use, and show a logical, organized progression of steps in your solution.

1. **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 you can only use the fundamental concepts listed below.)

Fundamental Concepts: $\vec{v}_{av} = \dfrac{\Delta \vec{r}}{\Delta t}$, $\vec{a}_{av} = \dfrac{\Delta \vec{v}}{\Delta t}$

Under Certain Conditions: $r_f = \dfrac{1}{2} a_r t^2 + v_{ro} t + r_o$,

2. **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 about the force on the children's arms which 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 you can only use the fundamental concepts listed below.)

Fundamental Concepts: $\vec{v}_{av} = \frac{\Delta \vec{r}}{\Delta t}$, $\vec{a}_{av} = \frac{\Delta \vec{v}}{\Delta t}$, $\vec{v} = \frac{d\vec{r}}{dt}$, $\vec{a} = \frac{d\vec{v}}{dt}$, $\Sigma \vec{F} = m\vec{a}$, $F_{12} = F_{21}$

Under Certain Conditions: $r_f = \frac{1}{2} a_r t^2 + v_{ro} t + r_o$, $F = \mu_{sliding} N$, $F \leq \mu_{static} N$

3. **Safe Ride Problem:** A neighbor's child wants to go to a neighborhood carnival to experience the wild rides. The neighbor is worried about safety because one of the rides looks dangerous. She knows that you have taken physics and so asks your advice. The ride in question has a 10-lb. chair which hangs freely from a 30-ft long chain attached to a pivot on the top of a tall tower. When a child enters the ride, the chain is hanging straight down. The child is then attached to the chair with a seat belt and shoulder harness. When the ride starts up the chain rotates about the tower. Soon the chain reaches its maximum speed and remains rotating at that speed. It rotates about the tower once every 3.0 seconds. When you ask the operator, he says that the ride is perfectly safe. He demonstrates this by sitting in the stationary chair. The chain creaks but holds and he weighs 200 lbs. Has the operator shown that this ride safe for a 50-lb. child? (Remember you can only use the fundamental concepts listed below.)

Fundamental Concepts: $\vec{v}_{av} = \frac{\Delta\vec{r}}{\Delta t}$, $\vec{a}_{av} = \frac{\Delta\vec{v}}{\Delta t}$, $\vec{v} = \frac{d\vec{r}}{dt}$, $\vec{a} = \frac{d\vec{v}}{dt}$, $\Sigma\vec{F} = m\vec{a}$, $F_{12} = F_{21}$

Under Certain Conditions: $r_f = \frac{1}{2}a_r t^2 + v_{ro}t + r_o$, $a = \frac{v^2}{r}$, $F = \mu_{sliding}N$, $F \leq \mu_{static}N$, $F = -k_s x$

4. **Fusion Problem:** You have a great summer job in a research laboratory with a group investigating the possibility of producing power from fusion. The device being designed confines a hot gas of positively charged ions, called plasma, in a very long cylinder with a radius of 2.0 cm. The charge density of the plasma in the cylinder is 6.0 x 10^{-5} C/m^3. Positively charged Tritium ions are to be injected into the plasma perpendicular to the axis of the cylinder in a direction toward the center of the cylinder. Your job is to determine the speed that a Tritium ion should have when it enters the plasma cylinder so that its velocity is zero when it reaches the axis of the cylinder. Tritium is an isotope of Hydrogen with one proton and two neutrons. You look up the charge of a proton and mass of the tritium in your trusty Physics text to be 1.6 x 10^{-19} C and 5.0 x 10^{-27} Kg.

Fundamental Concepts:

$\vec{v}_{av} = \dfrac{\Delta \vec{r}}{\Delta t}$	$\vec{a}_{av} = \dfrac{\Delta \vec{v}}{\Delta t}$	$\vec{v} = \dfrac{d\vec{r}}{dt}$	$\vec{a} = \dfrac{d\vec{v}}{dt}$	$\sum \vec{F} = m\vec{a}$
$F_{12} = F_{21}$	$W = \int_{path} \vec{F} \bullet d\vec{\ell}$	$KE = \dfrac{1}{2}mv^2$	$E_f - E_i = \Delta E_{transfer}$	$\vec{E} = \dfrac{F_e}{q}$
$\oiint \vec{E} \bullet dA = \dfrac{Q}{\varepsilon_o}$	$\iint_{surface} \vec{E} \bullet dA = \Phi$			

Under Certain Conditions:

$F = k_e \dfrac{q_1 q_2}{r^2}$	$\vec{E} = k_e \dfrac{q}{r^2}$	$U = k_e \dfrac{q_1 q_2}{r}$	$\Delta V = \dfrac{\Delta U}{q}$	$\Delta V = IR$

 Name: ______________________________
Homework #6

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

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.

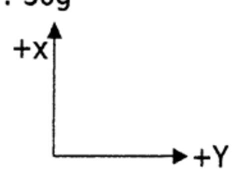
Data and Results:

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:

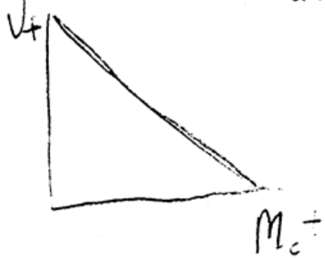
In our lab, we discovered the velocity of the car after being pulled a known distance was around 55cm/s. This was close to our initial prediction, so we were satisfied with our results.

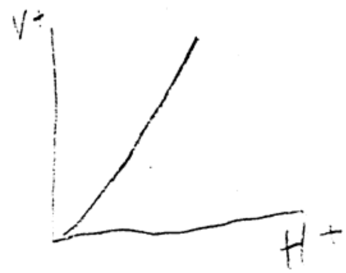
The launch velocity of the car does depend on its mass, as well as the mass of the block and the distance the block falls. This is due to the fact that they all affect the forces acting on the car. There are some instances where the mass would not really affect the launch velocity. If the distance dropped 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.

Prediction graphs

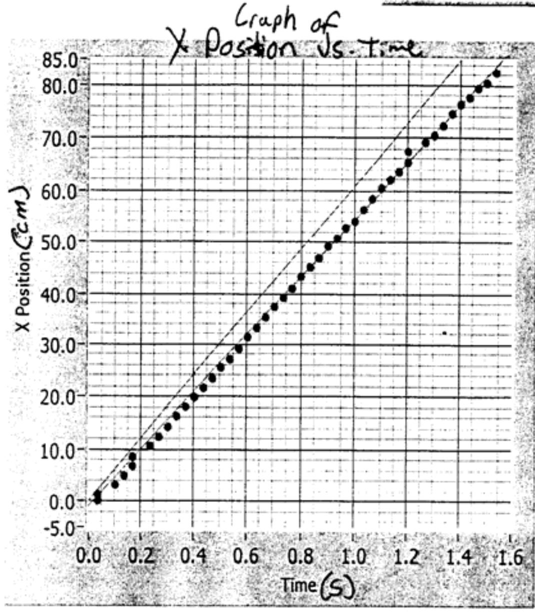
Cary 6

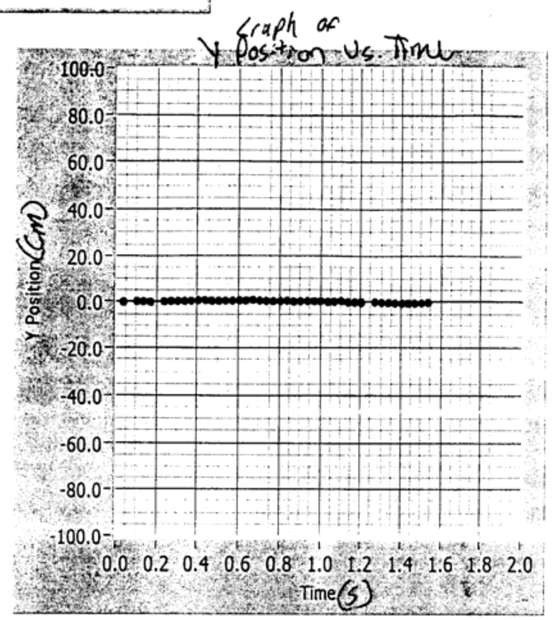




Graph Title 7

Lab 3 Problem 1





X - Prediction Equation

u(t) = 0.000 + 60.500t

X - Fit Equation

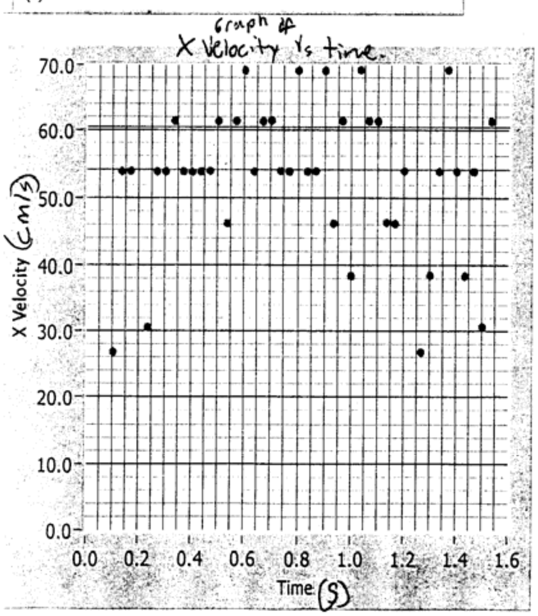
u(t) = -1.000 + 55.000t

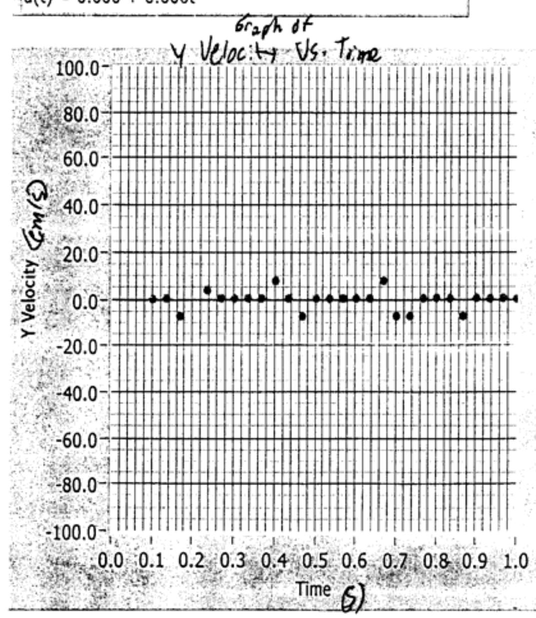
Y - Prediction Equation

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

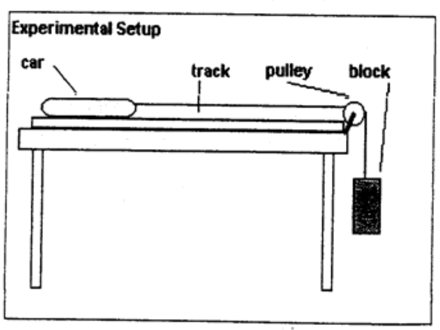
Lab III Problem 1: Force and Motion

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.

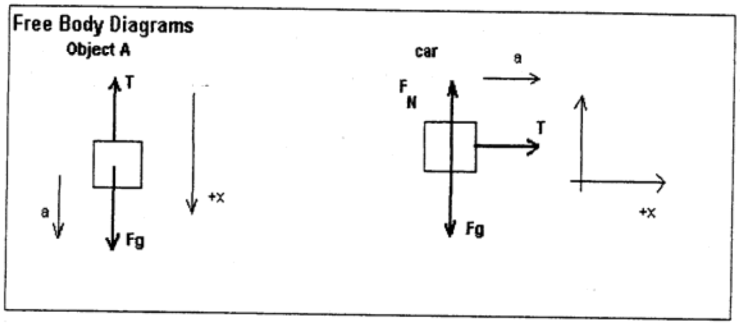
The block (called object A) has a significantly shorter distance to fall than the car has to travel along its track. In this experiment, we ignored the friction between the car and the track and between the pulley and the string. We also ignored the mass of the string.



2. Prediction --

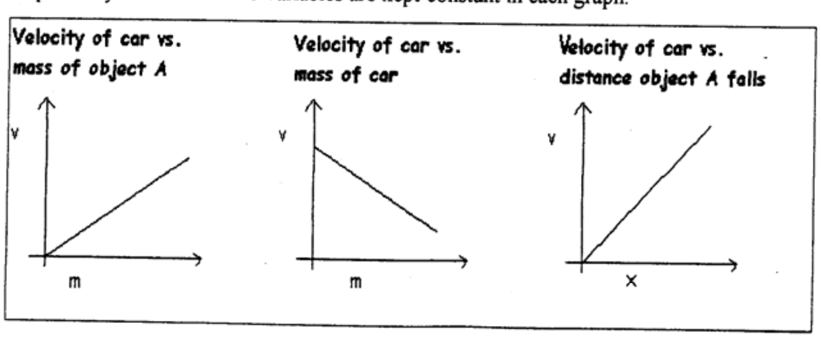
The first question asked me to calculate the cart's velocity after the block had hit the ground. I predicted that $\mathbf{v_c = \sqrt{2xg[m_a/(m_c + m_a)]}}$. I solved the first kinematics equation, $\mathbf{x_c = x_{0c} + v_{0c}t + 1/2at^2}$ **for t**, assuming that x_0 =O, v_0 =0 and $a_c = a_A$, 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 $\mathbf{\Sigma F_A = Fg - T}$. 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 $\mathbf{v_c = \sqrt{2xg[m_a/(m_c + m_a)]}}$.

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.

<u>Before object A hit the ground</u> --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.

<u>After object A hit the ground</u>—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.

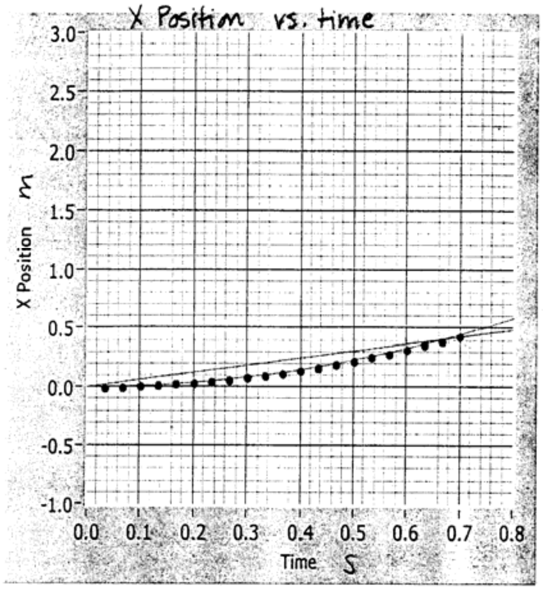
The launch velocity of the car does depend on the mass of the car, the mass of the block and the distance the block falls, according to $v = \sqrt{2xg[m_a/(m_c + m_a)]}$. For values of m_a that are much larger than m_c, m_c does not affect v very much, since $[m_a/(m_c + m_a)]$ becomes very close to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

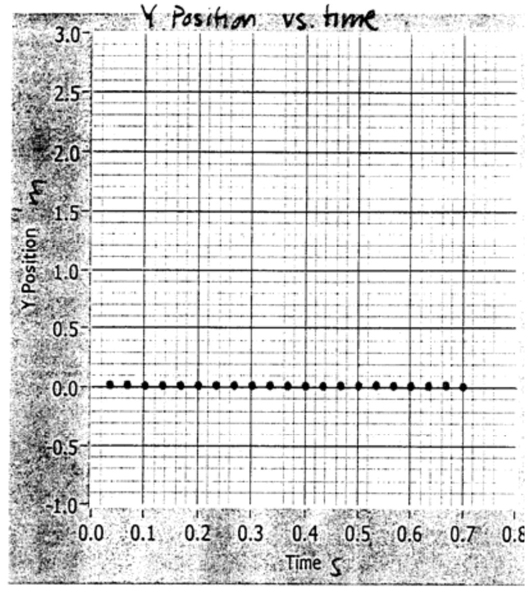
The tension force upon the car and the block is dependent on the masses of both objects. Changing the mass of either one will change the tension force exerted on both. The tension force on the block is equal to its weight if the block has no net acceleration; in other words, when $T = F_g$. This would 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.

7

Graph Title

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





X - Prediction Equation

u(t) = 0.000 + 0.600t

X - Fit Equation

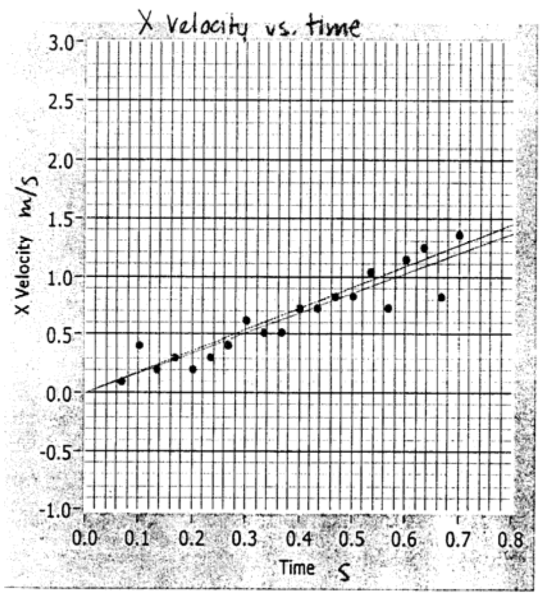
u(t) = 0.000 + 0.000 t + 0.897 t^2

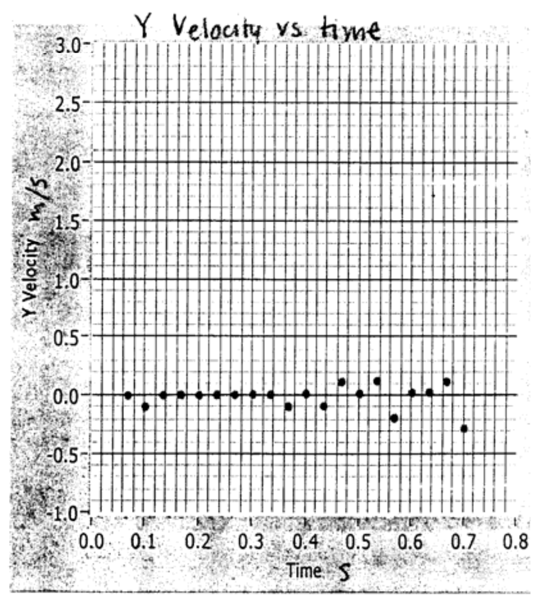
Y - Prediction Equation

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

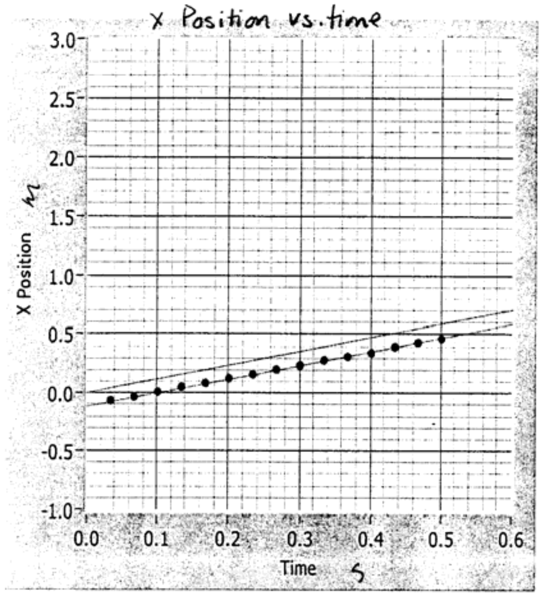
u(t) = 0.000 + 0.000t

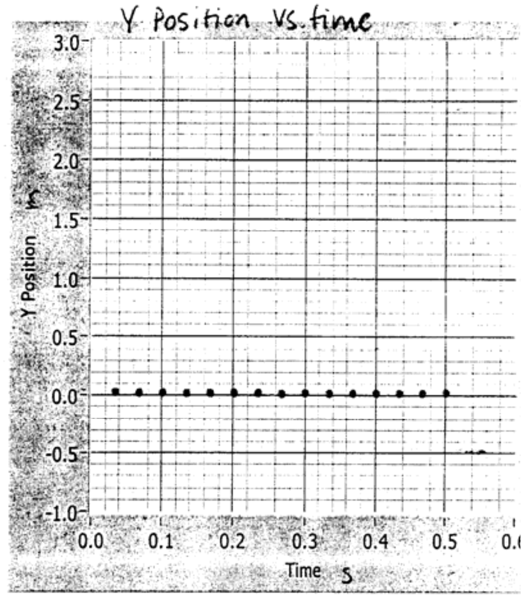
Vy - Fit Equation

u(t) = 0.000 + 0.000t

Graph Title

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





X - Prediction Equation

u(t) = 0.000 + 1.167t

X - Fit Equation

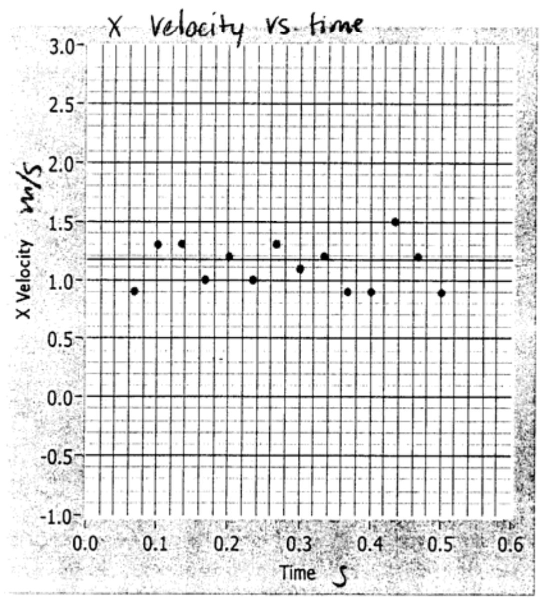
u(t) = -0.120 + 1.167t

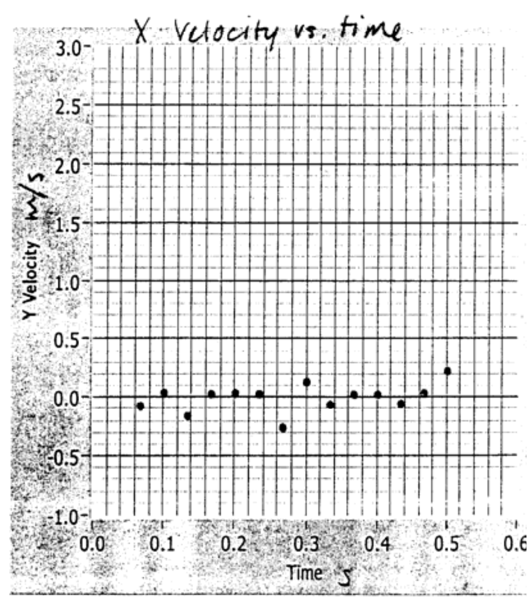
Y - Prediction Equation

u(t) = 0.000 + 0.000t

Y - Fit Equation

u(t) = 0.000 + 0.000t





Vx - Prediction Equation

u(t) = 1.167 + 0.000t

Vx - Fit Equation

u(t) = 1.170 + 0.000t

Vy - Prediction Equation

u(t) = 0.000 + 0.000t

Vy - Fit Equation

u(t) = 0.000 + 0.000t

TA Orientation 2004 Name: ____________________
Homework #8

Judging Problems

1. Read/Review the criteria for judging whether a problem would be a good group practice problem (20 - 25 minutes), a good graded group problem (45 - 50 minutes), and/or a good (easy, medium, difficult) individual problem (see pages 39 to59 in the *Instructor's Handbook*). There is considerable overlap in the criteria, so most problems can be judged to be **both** a good group practice or graded problem *and* a good easy, medium-difficult, or difficult individual problem.

2. Check the items in the right column that apply to each problem you solved in Homework #3. Then use the decision strategy to decide whether you think each problem is a good individual problem, group practice problem, or graded group problem [check your decision(s) in the right column]. Finally, explain your reasoning for each decision.

1. **Oil Tanker Problem:** Assume students have *just started* their study of linear kinematics (i.e., they only have the definition of average velocity and average acceleration).

Reject if:
___ one-step problem
___ tedious math, little physics
___ problem needs "trick"

Decision:
___ group practice problem (20 - 25 minutes);
___ group test problem (45 - 50 minutes); and/or
___ easy medium difficult individual problem (circle one)

Reasons:

Approach	Analysis	Mathematical Solution

1. Cues Lacking ___ A. No target variable ___ B. Unfamiliar context 2. Agility with Principles ___ A. Choice of principle ___ B. Two principles ___ C. Abstract principle 3. Non-Standard Application ___ A. Atypical situation ___ B. Unusual target	4. Excess or Missing Info. ___ A. Excess data ___ B. Numbers required ___ C. Assumptions 5. Seemingly Missing Info. ___ A. Vague statement ___ B. Special constraints ___ C. Diagrams 6. Additional Complexity ___ A. >2 subparts ___ B. 5+ terms ___ C. Vectors	7. Algebra required ___ A. No numbers ___ B. Unknown(s) cancel ___ C. Simultaneous eqns. 8. Targets Math Difficulty ___ A. Calc/vector algebra ___ B. Lengthy algebra

2. **Ice Skating Problem:** Assume students have *just finished* their study of the application of Newton's Laws of Motion.

Reject if:
___ one-step problem
___ tedious math, little physics
___ problem needs "trick"_

Decision:
___ group practice problem (20 - 25 minutes);
___ group test problem (45 - 50 minutes); and/or
___ easy medium difficult individual problem (circle one)

Reasons:

Approach	Analysis	Mathematical Solution

1. Cues Lacking ___ A. No target variable ___ B. Unfamiliar context 2. Agility with Principles ___ A. Choice of principle ___ B. Two principles ___ C. Abstract principle 3. Non-Standard Application ___ A. Atypical situation ___ B. Unusual target	4. Excess or Missing Info. ___ A. Excess data ___ B. Numbers required ___ C. Assumptions 5. Seemingly Missing Info. ___ A. Vague statement ___ B. Special constraints ___ C. Diagrams 6. Additional Complexity ___ A. >2 subparts ___ B. 5+ terms ___ C. Vectors	7. Algebra required ___ A. No numbers ___ B. Unknown(s) cancel ___ C. Simultaneous eqns. 8. Targets Math Difficulty ___ A. Calc/vector algebra ___ B. Lengthy algebra

3. Safe Ride Problem: Assume that students have *just finished* their study of forces and uniform circular motion.

Reject if:

___ one-step problem
___ tedious math, little physics
___ problem needs "trick"

Reasons:

Decision:

___ group practice problem (20 - 25 minutes);
___ group test problem (45 - 50 minutes); and/or
___ easy medium difficult individual problem (circle one)

Approach	Analysis	Mathematical Solution
1. Cues Lacking ___ A. No target variable ___ B. Unfamiliar context 2. Agility with Principles ___ A. Choice of principle ___ B. Two principles ___ C. Abstract principle 3. Non-Standard Application ___ A. Atypical situation ___ B. Unusual target	4. Excess or Missing Info. ___ A. Excess data ___ B. Numbers required ___ C. Assumptions 5. Seemingly Missing Info. ___ A. Vague statement ___ B. Special constraints ___ C. Diagrams 6. Additional Complexity ___ A. >2 subparts ___ B. 5+ terms ___ C. Vectors	7. Algebra required ___ A. No numbers ___ B. Unknown(s) cancel ___ C. Simultaneous eqns. 8. Targets Math Difficulty ___ A. Calc/vector algebra ___ B. Lengthy algebra

4. **Fusion Problem:** Assume students have *just finished* their study of the electricity.

Reject if:
___ one-step problem
___ tedious math, little physics
___ problem needs "trick"

Reasons:

Decision:
___ group practice problem (20 - 25 minutes);
___ group test problem (45 - 50 minutes); and/or
___ easy medium difficult individual problem (circle one)

Approach	Analysis	Mathematical Solution
B. Cues Lacking ___ A. No target variable ___ B. Unfamiliar context C. Agility with Principles ___ A. Choice of principle ___ B. Two principles ___ C. Abstract principle D. Non-Standard Application ___ A. Atypical situation ___ B. Unusual target	E. Excess or Missing Info. ___ A. Excess data ___ B. Numbers required ___ C. Assumptions F. Seemingly Missing Info. ___ A. Vague statement ___ B. Special constraints ___ C. Diagrams G. Additional Complexity ___ A. >2 subparts ___ B. 5+ terms ___ C. Vectors	H. Algebra required ___ A. No numbers ___ B. Unknown(s) cancel ___ C. Simultaneous eqns. I. Targets Math Difficulty ___ A. Calc/vector algebra ___ B. Lengthy algebra

Name: ____