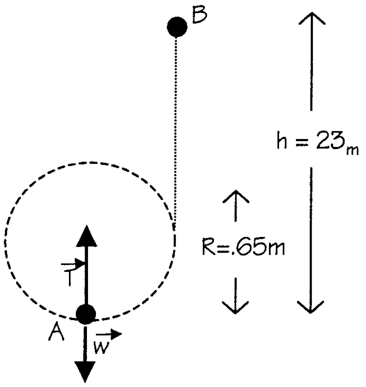
APPENDICES

Appendix A: Interview Artifacts

Set I: 3 Instructor Solutions

Instructor Solution I



The tension does no work

Conservation of energy between point A and B

$Mv_A^2/2 = mgh$

$V_A^2 = 2gh$

At point A, Newton's 2nd Law gives us:

$\vec{T} - \vec{w} = m\vec{a}$

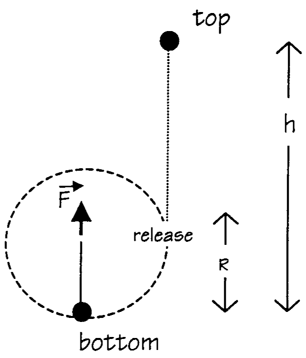
$T - w = mv_A^2/R$

$T = 18_N + 2 \cdot 18_N \cdot 23_m / .65_m = \boxed{1292N}$

Instructor Solution II

Known
- w =18N = weight of stone
- R= 0.65m
- h= 23m
- v_t= 0 = velocity at top

Unknown
- v_r= ? = velocity at release
- v_b= ? = velocity at bottom
- force my hand exerts = F=?



Step 1) Find v_r needed to reach h

$$E_i = E_f$$

$$E_{release} = E_{top}$$

$$PE_{release} + KE_{release} = PE_{top} + KE_{top}$$

$$\cancel{m}gR + \cancel{m}v_r^2/2 = \cancel{m}gh + \cancelto{0}{\cancel{m}v_t^2}/2$$

$$v_r^2 = 2g(h - R)$$

Conservation of energy for the stone earth system, since no external forces.

Note: you could also choose other systems.

KE of earth estimated to be 0

You could also use kinematics to find v_r.

Step 2) Find v_b needed to have v_r at release

$$E_{bottom} = E_{release}$$

$$PE_{bottom} + KE_{bottom} = PE_{release} + KE_{release}$$

$$mg0 + \cancel{m}v_b^2/2 = \cancel{m}gR + \cancel{m}v_r^2/2$$

Using v_r from above:

$$V_b = [2gh]^{1/2}$$

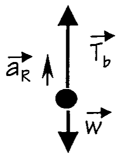
Conservation of energy for the stone earth system. Since $T \perp v$ in circular path, T does no work.

Step 3) Find T_b , tension at bottom, needed for stone to have v_b at bottom

$$\sum \vec{F} = m\vec{a}$$

$$\sum F_R = ma_R$$

$$T_b - w = m\, v_b^2/R$$



Free body diagram

To relate the forces to velocity we can look at the radial component, and use $a_R = v^2/R$.

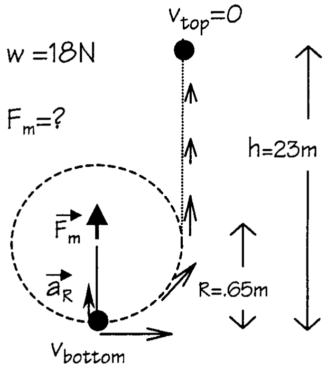
Using v_b from above:

$$T_b - w = 2\,mgh/R$$

$$T_b = w + 2\,w\,h/R = 18 + 2\;18\;23/.65 = \boxed{1292N}$$

T_b equals F, the force my hand exerts, for a massless string

Instructor Solution III



Approach:

I need to find F_m, force exerted by me. I know the path, h (height at top) and v_t (velocity at top)

A) For a massless string $F_m = T_b$ (T_b-Tension at bottom)

B) I can relate T_b to v_b (velocity at bottom) using the radial component of $\sum \vec{F}=m\vec{a}$, and radial acceleration $a_R=v^2/R$, since stone is in circular path

C) I can relate v_b to v_t using either i) energy ii) Dynamics and kinematics

ii) Messy since forces/accelerations change through the circular path

i) I can apply work-energy theorm for stone. Path has 2 parts:

first - circular, earth and rope interact with stone,

second - vertical, earth interacts with stone

In both parts the only force that does work is weight, since in first part hand is not moving $\Rightarrow \vec{T}\perp\vec{v} \Rightarrow \vec{T}$ does no work.

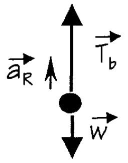
Execution:

B) Relate T_b to v_b

$\sum \vec{F}= m\vec{a}$

$\sum F_R= ma_R$

$T_b - w = m\, v_b^2/R$



C) Relate v_b to v_t

Work = ΔKE

For constant force

$\vec{F}\cdot\vec{d} = KE_f - KE_I$

$F_y d_y = KE_{top} - KE_{bottom}$

Substituting C) into B)

$T_b - w = 2\,w\,h/R$

$F_m = T_b = w + 2\,w\,h/R$

$= 18 + 2\;18\;23/.65$

$= \boxed{1292N}$

N=N m/m
units O.K.

Large compared to weight, but stone needs to travel up large distance

Check limits: $T_b\uparrow$ as R $\downarrow$, for smaller circle I'll need bigger force, reasonable

Set II: 5 Student Solutions

Student Solution A

$$\frac{V^2}{R} = a = \frac{F}{m} \qquad \frac{2\pi R}{T} = V$$

$$a = \frac{\left(\frac{2\pi R}{t}\right)^2}{R} = \frac{4\pi^2 R}{T^2}$$

$$V = \sqrt{Ra}$$

$$y = y_0 + vt + \frac{at^2}{2}$$

$$= 0.65 + \sqrt{Ra}\,t + \frac{at^2}{2}$$

$$\overset{\to 0}{\cancel{V^2}} - V_0^2 = -2g\Delta y$$

$$V_0 = \sqrt{2g\Delta y} = \sqrt{Ra}$$

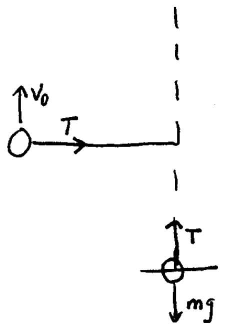
$$\frac{2g\Delta y}{R} = a = \frac{F}{m}$$

uses $V_{release}$ instead of V_{bottom}

Does not sum forces

$$F = \frac{2mg\Delta y}{R} = \frac{2\cdot 18\cdot(23-0.65)}{0.65} = 1237.846N$$

Student Solution B



This is a centripetal force problem $\Rightarrow F = m\frac{v^2}{R}$

Free fall:

$$\overset{=0 \text{ at max. height}}{V_y} = V_0 - gt$$

$$gt = \frac{V_0}{g}$$

$$t = \frac{V_0}{g}$$

$$\Delta y = y_0 + V_0 t - \tfrac{1}{2} g t^2$$

uses Δy instead of y

$$\Delta y = y_0 + V_0\left(\frac{V_0}{g}\right) - \frac{1}{2} g\left(\frac{V_0}{g}\right)^2$$

$$\Delta y = y_0 + \frac{V_0^2}{g} - \frac{1}{2}\frac{V_0^2}{g}$$

makes math error

$$\Delta y = \frac{(y_0 - 1/2)\, V_0^2}{g}$$

$$\frac{\Delta y g}{(y_0 - \frac{1}{2})} = V_0^2$$

Does not sum Forces

$$T = F = ma = \frac{m V_0^2}{R}$$

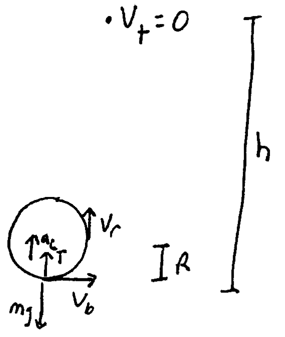
Force Exerted by me

uses $V_{release}$ instead of V_{bottom}

$$= \frac{mg\,\Delta y}{(y_0 - 1/2)R}$$

$$= \frac{18 \cdot 22.65}{(.65 - 1/2)(.65)} = 4182N$$

Student Solution C



$V_t = 0$
$V_r = ?$
$V_b = ?$
$T = ?$
$mg = 18N$
$h = 23m$
$R = 0.65m$

Find velocity to reach height (free Fall)

$$V^2 - V_0^2 = 2a(y-y_0)$$

~~$0 - V_0^2 = 2(-g)(h)$~~

$$0 - V_r^2 = 2(-g)(h-R)$$

$$V_r = \sqrt{2g(h-R)}$$

$$= \sqrt{2\cdot 9.8\,m/s^2 \cdot (23-0.65)m} \qquad \sqrt{m/s^2 \cdot m} = m/s$$

$$= 20.9\,m/s$$

It can't be that $V_r = V_b$ but I don't know how to relate them. If $V_r = V_b$, then:

uses $V_{release}$ instead of V_{bottom}

Find Force

$$\Sigma \bar{F} = m\bar{a}$$

$$T - mg = ma_c$$

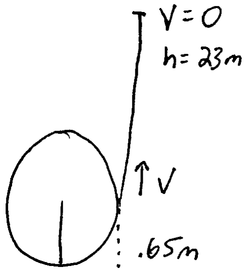
$$N + \frac{N}{m/s^2} \cdot \frac{m^2/s^2}{m} = N$$

$$T = mg + \frac{mv_r^2}{R} = 18N + \frac{\frac{18N}{9.8\,m/s^2}(20.9\,m/s^2)^2}{0.65m}$$

Force exerted by me $= 1256N$

Looks large, but stone needs to go up far

Student Solution D



Energy conservation between top and release

$\frac{1}{2}mv^2 = mg\,\Delta h$

$v^2 = 2gh$

$V = \sqrt{2(-9.8)23}$

$V = 21.2$

uses h instead of h-R

makes sign error

changes sign

Between release and bottom $T \perp V$ so no work done

∴ Energy is conserved and velocity is the same

$\Sigma \bar{F} = m\bar{a}$

$T - mg = \frac{mv^2}{R}$

$T = 18 + \frac{\frac{18}{9.8} \cdot 21.2^2}{.65}$

$= 1292N$

uses $V_{release}$ instead of V_{bottom}

Student Solution E

$$V^2 = 2gh$$

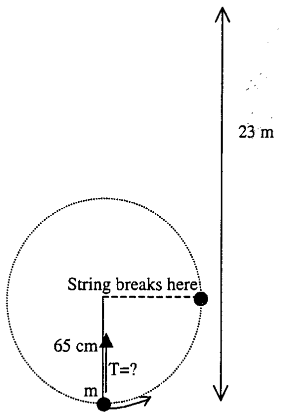
$$F - mg = \frac{m2gh}{R}$$

$$F = 18 + \frac{2 \cdot 18 \cdot 23}{.65} = 1292\,N$$

Set III: 4 Problem Types

Problem A

A 1.8 kg mass is attached to a frictionless pivot point and is moving in a circle at the end of a 65 cm string. The string breaks when the mass is moving directly upward and the mass rises to a maximum height of 23.0 m. What is the tension in the string one-quarter turn before the string breaks? Assume that air resistance can be neglected.



A) What velocity, v_1, must the stone have when released in order to rise to 23 meters above the lowest point in the circle?

B) What velocity, v_o, must the stone have when it is at its lowest point in order to have a velocity v_1 when released?

C) What force will you have to exert on the string at its lowest point in order for the stone to have a velocity v_o?

Problem B

You are whirling a stone tied to the end of a string around in a vertical circle having a radius of 65 cm. You wish to whirl the stone fast enough so that when it is released at the point where the stone is moving directly upward it will rise to a maximum height of 23 meters above the lowest point in the circle. In order to do this, what force will you have to exert on the string when the stone passes through its lowest point one-quarter turn before release? Assume that by the time that you have gotten the stone going and it makes its final turn around the circle, you are holding the end of the string at a fixed position. Assume also that air resistance can be neglected. The stone weighs 18 N.

A) 1292 N
B) 1258 N
C) 1248 N
D) 1210 N
E) None of the Above

Note: The choices are based on common student problems.

Problem C

You are working at a construction site and need to get a 3 lb. bag of nails to your co-worker standing on the top of the building (60 ft. from the ground). You don't want to climb all the way up and then back down again, so you try to throw the bag of nails up. Unfortunately, you're not strong enough to throw the bag of nails all the way up so you try another method. You tie the bag of nails to the end of a 2 ft. string and whirl the string around in a vertical circle. You try this, and after a little while of moving your hand back and forth to get the bag going in a circle you notice that you no longer have to move your hand to keep the bag moving in a circle. You think that if you release the bag of nails when the string is horizontal to the ground that the bag will go up to your co-worker. As you whirl the bag of nails around, however, you begin to worry that the string might break, so you stop and attempt to decide before continuing. According to the string manufacturer, the string is designed to hold up to 100 lbs. You know from experience that the string is most likely to break when the bag of nails is at its lowest point.

Problem D

You are whirling a stone tied to the end of a string around in a vertical circle of radius R. You wish to whirl the stone fast enough so that when it is released at the point where the stone is moving directly upward it will rise to a maximum height, H, above the lowest point in the circle. In order to do this, what force will you have to exert on the string when the stone passes through its lowest point one-quarter turn before release? Assume that by the time that you have gotten the stone going and it makes its final turn around the circle, you are holding the end of the string at a fixed position. Assume also that air resistance can be neglected.

A) For each point labeled in the diagram, circle the symbol(s) that describe how the speed of the stone is changing.

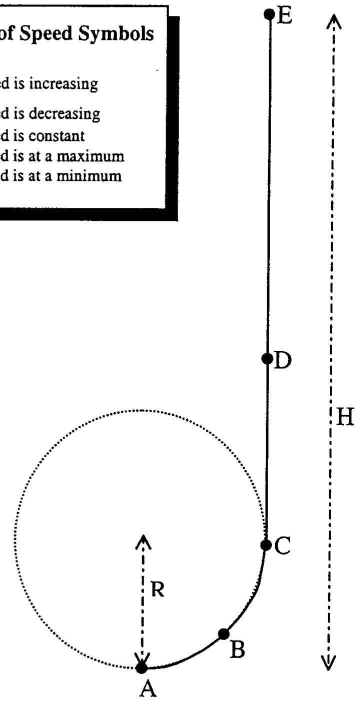
Point	Change in Speed
A	↑ ↓ = max min
B	↑ ↓ = max min
C	↑ ↓ = max min
D	↑ ↓ = max min
E	↑ ↓ = max min

Change of Speed Symbols

↑	Speed is increasing
↓	Speed is decreasing
=	Speed is constant
max	Speed is at a maximum
min	Speed is at a minimum

B) At each point on the diagram, draw and label a vector representing the acceleration of the stone.

C) At each point, draw and label vectors to represent all of the forces acting on the stone.



Appendix B: Interview Protocol

Introduction

"This interview is divided into 4 situations, the first focuses on solutions that instructors give students, the second on solutions students give instructors, the third on possible ways of posing problems, and the final situation will be a combination of the things we've talked about in the first three situations. Throughout the interview we will refer back to the "homework problem" that you solved."

"Please think about your experience teaching introductory calculus-based physics as you answer the interview questions. I'll start with examples of solved problems."

Situation #1 (Example Problem Solutions)

Q1: "In what situations are students provided with examples of solved problems in your class. For example, during lecture, after homework or a test, etc."

Probing question, if necessary: "How does this work? Do you hand out the solutions, or is there something else that happens?"

"What is your purpose in providing solved examples in these different situations?"

Q2: "How would you like your students to use the solved examples you give them in these different situations? Why?"

"What do you think most of them actually do?"

Q3: "Here are several instructor solutions for the problem you solved that were designed to be posted or distributed for students to see. They are based on actual instructor solutions."

"Take a look at each of these instructor solutions and describe how they are similar or different to your solutions. Please explain your reasons for writing solutions the way you do."

"I want to look now from a slightly different Perspective: Some instructors' solutions represent aspects/components of what instructors consider important in problem solving. This may include things that a student needs to know or be able to do, or explicit representation of thought processes he has to go through while solving a problem. Now, I'd like to have you consider how these things are represented in the worked examples."

"Looking at the instructor solutions, what aspects/components that you consider important in problem solving are represented in these instructor solutions, and what aspects are not represented?"

Write each thing on an individual index card (Label card IS and solution #).

Situation #2 (Student Solutions)

Q4: "This situation will deal with written student solutions. We will first focus on grading of student solutions. I imagine you grade students on the final exam and quizzes. What is your purpose in grading the students?

"What would you like your students to do with the graded solutions you return to them?"

Probing question, if necessary: "Why?"

"What do you think most of them actually do?"

"Are there other situations besides the final exam and quizzes in which your students are graded? Do you have the same purposes for these situations?"

Q5: "Here are student solutions to the problem that we have been looking at. These solutions are based on actual student solutions from an introductory calculus-based physics class at the University of Minnesota. To save time, we have indicated errors in each solution in the boxes on the page."

"Please put the solutions in order of the grade they would receive for this solution on a quiz if they were in your class. Then I'll ask you to grade them and explain your grading. Assume the students were told by you about how they will be graded.

Probing question, if necessary: "What are the features you considered when assigning this grade?"

Record the grades and ranking.

Probing question, if necessary: "Please explain what these numbers mean – what is your grading scale?"

"Would you grade them differently if they were graded in the other situations (other than a quiz)? How?"

Q6: "Now I would like to use these student solutions to expand the discussion of aspects or components of problem solving that we started in the 1st situation. Here I'd like to focus on what students actually think or do while solving a problem."

"Imagine you gave this problem to your students for homework near the end of your course and you got the following solutions. I know that it is not possible to infer with certainty from a written solution what a student went through while he was solving the problem. However, in this situation I will ask you to do just that."

"Try to put yourself in the students' shoes: go through the solution from beginning to end, following what you think was on the students mind when he did what he did, and speculate about things that are suggested by these solutions".

"What other aspects/components of problem solving that we havn't already talked about are suggested by these solutions. By aspects/components of problem solving we mean thought processes that the student might have gone through, things he might have known or done."

Write each thing on a card, in a positive manner (Label card SS and solution letter).

Probing question, if necessary (make sure this is answered for all student solutions): "What is your overall impression of each of these students approaches? What are the most important differences between them?"

"Are there other things that you have noticed in the way students solve problems that we haven't talked about already?"

Write each thing on a card, in a positive manner (Label card SS).

Situation #3 (Problems)

Q7: "In the first two situations we dealt with one problem and talked a lot about what sorts of things a student might need to know or be able to do to solve it. In this situation, we will expand our view somewhat by looking at other ways of asking problems around the same physical situation. There are four new problems."

"Please describe how these problems are similar or different to problems you give to your students. Please explain why you use the problems that you use."

Probing question, if necessary: "Do the problems you give students look different in different situations (lecture, homework, test, Beginning or end of course…)? How and Why?"

Q8: "Different ways of asking problems require different things from students. We would like to use these problems to capture aspects of problem solving that we might not have talked about yet."

"Comparing these problems to the problem that we have been using so far (the Homework Problem), are there things a student needs to know or be able to do when solving these problems that are not required in solving the homework problem? Do you see any things that the homework problem requires that you haven't yet mentioned?"

Write each thing on a card (Label card P and problem letter).

Situation #4 (Grand finale)

Q9: "Now I would like to combine the things that we've talked about in the last 3 situations. I've written each of the things you thought students might go through when solving a problem on an individual card. I would like to have us talk about these in more detail, but to make it simpler I would first like you to categorize them."

"Please put these cards into categories of your choosing?"

Probing question, if necessary: "Tell me about each category … Why do these go together? How would you name this category?"

Write each category on a big index card, clip it on top of the cards in the category.

Write the name of each category on recording sheet.

Q10: "For students who had troubles with each of these categories at the beginning of the course, what do you think they could do to overcome them?"

Q11: "For a student who had trouble with each of these categories, what could you do to help him/her overcome it?"

Probing questions, if necessary: "In particular what type of solved examples or problems could you give? What would you ask students to do with them? How would you grade to help this type of student?"

Q12: "I would like to focus on how hard it is for students to improve in the things in each of these categories if they had trouble with them in the beginning of the course? Please put the cards in order from easiest to hardest for students to improve. Please explain your ordering."

Write ordering on recording sheet.

Q13: "Which of these things is it reasonable to expect most students to be able to do by the end of the introductory calculus-based physics course? Why?"

Q14: "Next, I'd like to find out where your students are regarding the things you mentioned. Think about a typical calculus based physics course at your school. For each category check the appropriate box that represents roughly what portion of the class can do these sorts of things at the beginning of the course and what portion of your class can do them at the end of the course?"

Allow Interviewee to fill in appropriate section on recording sheet.

Q15: "I want you to focus on two kinds of students: those who improved things they had trouble with at the beginning, and those who did not. What makes these 2 kinds of students different?"

Probing questions, if necessary: "What things did each kind of student do during class? What qualities did each kind of student bring to class?"

Q16: "Looking down the list of changes of your students during the course, are you happy with your course outcomes? What would need to be different in order for you to be happier?"

Probing questions, if necessary: "How should your institution treat the Introductory physics course? What can you as an instructor do? Should students be required to bring certain qualities to class?"

Probing questions, if the instructor indicates that he is interested in changing something about himself or his teaching (if necessary): "What could help you in doing things differently? What could help you to find out how you could do things differently?"

Recording Sheet (For Situation 4)

Categories of things	**Difficulty of Improvement** (1 for hardest)	Beginning				End				Satisfaction	
		0 - 25%	25 - 50%	50 - 75%	75 - 100%	0 - 25%	25 - 50%	50 - 75%	75 - 100%	**Yes**	What needs to change?
1.	○										
2.	○										
3.	○										
4.	○										
5.	○										
6.	○										
7.	○										
8.	○										
9.	○										

Appendix C: Packet Mailed to Interviewee Prior to Interview

Cover Letter

Physics Education Research Group
April XX, 2000

Dr. Research Participant
Department of Physics
Whatever University
123 Street Address
City, State, ZIP

Dear Dr. Participant;

Thank you for agreeing to participate in our NSF-sponsored study "Problem Solving in Introductory Physics". Your interview is scheduled for Tuesday, April XX, 2000 at 1:00 PM. We will meet you at your office. The interview will be videotaped and take approximately 1½ hours to complete.

Enclosed is a background questionnaire that we would like you to complete – it should take about 5 minutes. Also enclosed is an introductory physics problem labeled "Homework Problem". Many parts of the interview will be based around this problem and its solution so we'd like you to solve it before coming to the interview.

We appreciate your participation in this project and hope that you will find the interview thought provoking.

Please contact us if you have any questions.

Sincerely;

Charles Henderson
612-625-9323
hend0007@tc.umn.edu

Edit Yerushalmi
612-624-7578
Idit@physics.umn.edu

Homework Problem

Homework Problem

You are whirling a stone tied to the end of a string around in a vertical circle having a radius of 65 cm. You wish to whirl the stone fast enough so that when it is released at the point where the stone is moving directly upward it will rise to a maximum height of 23 meters above the lowest point in the circle. In order to do this, what force will you have to exert on the string when the stone passes through its lowest point one-quarter turn before release? Assume that by the time that you have gotten the stone going and it makes its final turn around the circle, you are holding the end of the string at a fixed position. Assume also that air resistance can be neglected. The stone weighs 18 N.

The correct answer is 1292 N

Background Questionnaire

BACKGROUND INFORMATION

Your answers to the following questions will help us understand the interview results.

Name ____

Where do you teach? ____

Sex: ☐ Male
☐ Female

How many years have you taught physics at the college level? _______

	Introductory Calculus-Based Physics	Introductory Algebra-Based Physics	Introductory Honors Physics
Is this class offered at your school?	☐ Yes ☐ No	☐ Yes ☐ No	☐ Yes ☐ No
How many times have you taught this course?			
What was the last year that you taught this course?			

COURSE INFORMATION:

Please answer the following questions as they apply to the introductory calculus-based course at your school when you are the course instructor.

How many students are in a typical introductory calculus-based course: ___________

What is the gender distribution of a typical introductory calculus-based course:

_____% Male

_____% Female

Lecture / Whole Class Meetings

Who is in charge: ☐ I am
☐ Someone else
(Another Professor, Staff Member, Teaching Assistant, etc.)

Contact hours/week: __________

Special Session

What type(s) of special sessions do you have?

☐ No Special Session
☐ Recitation / Discussion Session
☐ Tutorial Session
☐ Problem-Solving Session
☐ Other: ____________________

Who is in charge? ☐ I am
☐ Someone else
(Another Professor, Staff Member, Teaching Assistant, etc.)

Contact hours/week: __________

Please check the appropriate box to indicate ***how often*** *the following activities occur in each portion of your introductory calculus-based physics course. Each activity is broken down into two categories – one involving problem solving and the* ***other*** *involving other types of activities.*

A = HARDLY EVER   B = NOT VERY OFTEN   C = SOMETIMES   D = QUITE OFTEN   E = ALMOST ALWAYS

	Lecture					**Special Session**				
	A	**B**	**C**	**D**	**E**	**A**	**B**	**C**	**D**	**E**
Instructor solves example problem	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other Instructor presentation (e.g. lecture, demo)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Whole-class discussion leading to a problem solution	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other whole-class discussion (e.g. exploring new concept)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Student presents problem solution	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other student presentation (e.g. project report)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Students work in small groups to solve a problem	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other student small group work (e.g. discussing new concept)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Students work alone to solve a problem	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Other individual student work (e.g. read textbook)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Laboratory

Who is in charge? ☐ I am
☐ Someone else (Another Professor, Staff Member, Teaching Assistant, etc.)

Contact hours/week: __________

Please check the appropriate box to indicate ***the importance*** *of the following goals in the* ***Laboratory*** *portion of your introductory calculus-based physics course.*

A = UNIMPORTANT
B = SLIGHTLY IMPORTANT
C = SOMEWHAT IMPORTANT
D = IMPORTANT
E = VERY IMPORTANT

The purpose(s)/goal(s) of ***our lab*** *is for students to:*	**A**	**B**	**C**	**D**	**E**
Verify physical principles	☐	☐	☐	☐	☐
Learn to use experimental tools	☐	☐	☐	☐	☐
Build conceptual knowledge	☐	☐	☐	☐	☐
Develop scientific reasoning skills	☐	☐	☐	☐	☐
Improve problem solving skills	☐	☐	☐	☐	☐
Other: ____________________	☐	☐	☐	☐	☐

Office Hours

Contact hours/week: __________

Grading

Who is in charge? ☐ I am
☐ Someone else (Another professor, Staff Member, Teaching Assistant, etc.)

How much time do **you** spend grading (hours/week)? __________

Goals for the Introductory Physics Course:

Many different goals could be addressed through a calculus-based introductory physics course. Please rate each of the following possible goals in relation to its importance.

A = Unimportant
C = Somewhat important
E = Very Important
B = Slightly important
D = important

	A	B	C	D	E
Know the basic principles behind all physics (e.g. forces, conservation of energy,...).	☐	☐	☐	☐	☐
Know the range of applicability of the principles of physics (e.g. conservation of energy applied to fluid flow, heat transfer, plasmas,...).	☐	☐	☐	☐	☐
Be familiar with a wide range of physics topics (e.g. specific heat, AC circuits, rotational motion, geometric optics,...).	☐	☐	☐	☐	☐
Solve problems using general quantitative problem solving skills within the context of physics.	☐	☐	☐	☐	☐
Solve problems using general qualitative logical reasoning within the context of physics.	☐	☐	☐	☐	☐
Formulate and carry out experiments.	☐	☐	☐	☐	☐
Analyze data from physical measurements.	☐	☐	☐	☐	☐
Use modern measurement tools for physical measurements (e.g. oscilloscopes, computer data acquisition, timing techniques,...).	☐	☐	☐	☐	☐
Program computers to solve problems within the context of physics.	☐	☐	☐	☐	☐
Overcome misconceptions about the behavior of the physical world.	☐	☐	☐	☐	☐
Understand and appreciate "modern physics" (e.g. solid state, quantum optics, cosmology, quantum mechanics, nuclei, particles,...).	☐	☐	☐	☐	☐
Understand and appreciate the historical development and intellectual organization of physics.	☐	☐	☐	☐	☐
Express, verbally and in writing, logical, qualitative thought in the context of physics	☐	☐	☐	☐	☐
Learn to work in teams to solve problems within the context of physics.	☐	☐	☐	☐	☐
Use with confidence the physics topics covered.	☐	☐	☐	☐	☐
Apply the physics topics covered to new situations not explicitly taught by the course.	☐	☐	☐	☐	☐
Other Goal: ________________________	☐	☐	☐	☐	☐

Please place a star (*) next to the two goals listed above that you consider to be most important.

Appendix D: Consent Form

CONSENT FORM
Problem Solving in Introductory Physics

You are invited to be in a research study of physics problem solving. We have selected you because you have taught introductory calculus-based physics in the Twin Cities area in the last five years. We ask that you read this form and ask any questions you may have before agreeing to be in the study.

This study is being conducted by: Pat Heller, Ken Heller, Charles Henderson, and Idit Yerushalmi from the University of Minnesota.

Background Information:

We are conducting a study, funded by the National Science Foundation, to determine what physics faculty value in the learning and teaching of problem solving. We will use this information to improve the design of curricular materials.

Procedures:

If you agree to be in this study, you will be asked to complete four tasks that are based on physics problems and solutions taken from introductory calculus-based physics courses. The entire interview should take approximately 1½ hours. The interview will be videotaped, however the video will be focused on the activity you are performing. Your face or other identifying features will not be videotaped.

Risks and Benefits of Being in the Study:

There are no risks to participation in this study.

We hope that you will find the interview questions interesting and that they allow you to think about aspects of physics instruction that you might not frequently have the time to consider.

Confidentiality:

The records of this study will be kept private. In any sort of report we might publish, we will not include any information that will make it possible to identify you. Research records will be kept in a locked file; only researchers will have access to the records. The videotapes will only be accessible by the researchers. They will be kept for three years after the completion of the study and then destroyed.

Voluntary Nature of the Study:

Your decision whether or not to participate will not affect your current or future relations with the University of Minnesota. If you decide to participate, you are free to withdraw at any time without affecting those relationships.

Contacts and Questions:

The researchers conducting this study are Pat Heller, Ken Heller, Charles Henderson, and Idit Yerushalmi. You may ask any questions you have now. If you have questions later, you may contact them at Physics Building, room #161; Phone: (612) 625-9323.

If you have any questions or concerns regarding the study and would like to talk to someone other than the researcher(s), contact Research Subjects' Advocate line, D528 Mayo, 420 Delaware Street S.E., Minneapolis, Minnesota 55455; telephone (612) 625-1650.

You will be given a copy of this form to keep for your records.

Statement of Consent:

I have read the above information. I have asked questions and have received answers. I consent to participate in the study.

Signature ____ Date ________________

Signature of Investigator ___________________________ Date ________________