02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Craig A Ogilvie

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☐ Not Hispanic or Latino

Race:
(Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status:
(Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☐ None

Citizenship: (Choose one) ☐ U.S. Citizen ☒ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☒

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: David Atwood

Gender: ☒ Male ☐ Female

Ethnicity: (Choose one response) ☐ Hispanic or Latino ☒ Not Hispanic or Latino

Race:
(Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status:
(Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☒ None

Citizenship: (Choose one) ☐ U.S. Citizen ☒ Permanent Resident ☐ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☐

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☐

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization’s eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

02 INFORMATION ABOUT PRINCIPAL INVESTIGATORS/PROJECT DIRECTORS(PI/PD) and co-PRINCIPAL INVESTIGATORS/co-PROJECT DIRECTORS

Submit only ONE copy of this form **for each PI/PD and co-PI/PD** identified on the proposal. The form(s) should be attached to the original proposal as specified in GPG Section II.B. Submission of this information is voluntary and is not a precondition of award. This information will not be disclosed to external peer reviewers. ***DO NOT INCLUDE THIS FORM WITH ANY OF THE OTHER COPIES OF YOUR PROPOSAL AS THIS MAY COMPROMISE THE CONFIDENTIALITY OF THE INFORMATION.***

PI/PD Name: Paula Herrera-Siklody

Gender: ☐ Male ☒ Female

Ethnicity: (Choose one response) ☒ Hispanic or Latino ☐ Not Hispanic or Latino

Race:
(Select one or more)
- ☐ American Indian or Alaska Native
- ☐ Asian
- ☐ Black or African American
- ☐ Native Hawaiian or Other Pacific Islander
- ☒ White

Disability Status:
(Select one or more)
- ☐ Hearing Impairment
- ☐ Visual Impairment
- ☐ Mobility/Orthopedic Impairment
- ☐ Other
- ☐ None

Citizenship: (Choose one) ☐ U.S. Citizen ☐ Permanent Resident ☒ Other non-U.S. Citizen

Check here if you do not wish to provide any or all of the above information (excluding PI/PD name): ☒

REQUIRED: Check here if you are currently serving (or have previously served) as a PI, co-PI or PD on any federally funded project ☐

Ethnicity Definition:
Hispanic or Latino. A person of Mexican, Puerto Rican, Cuban, South or Central American, or other Spanish culture or origin, regardless of race.
Race Definitions:
American Indian or Alaska Native. A person having origins in any of the original peoples of North and South America (including Central America), and who maintains tribal affiliation or community attachment.
Asian. A person having origins in any of the original peoples of the Far East, Southeast Asia, or the Indian subcontinent including, for example, Cambodia, China, India, Japan, Korea, Malaysia, Pakistan, the Philippine Islands, Thailand, and Vietnam.
Black or African American. A person having origins in any of the black racial groups of Africa.
Native Hawaiian or Other Pacific Islander. A person having origins in any of the original peoples of Hawaii, Guam, Samoa, or other Pacific Islands.
White. A person having origins in any of the original peoples of Europe, the Middle East, or North Africa.

WHY THIS INFORMATION IS BEING REQUESTED:

The Federal Government has a continuing commitment to monitor the operation of its review and award processes to identify and address any inequities based on gender, race, ethnicity, or disability of its proposed PIs/PDs. To gather information needed for this important task, the proposer should submit a single copy of this form for each identified PI/PD with each proposal. Submission of the requested information is voluntary and will not affect the organization's eligibility for an award. However, information not submitted will seriously undermine the statistical validity, and therefore the usefulness, of information recieved from others. Any individual not wishing to submit some or all the information should check the box provided for this purpose. (The exceptions are the PI/PD name and the information about prior Federal support, the last question above.)

Collection of this information is authorized by the NSF Act of 1950, as amended, 42 U.S.C. 1861, et seq. Demographic data allows NSF to gauge whether our programs and other opportunities in science and technology are fairly reaching and benefiting everyone regardless of demographic category; to ensure that those in under-represented groups have the same knowledge of and access to programs and other research and educational oppurtunities; and to assess involvement of international investigators in work supported by NSF. The information may be disclosed to government contractors, experts, volunteers and researchers to complete assigned work; and to other government agencies in order to coordinate and assess programs. The information may be added to the Reviewer file and used to select potential candidates to serve as peer reviewers or advisory committee members. See Systems of Records, NSF-50, "Principal Investigator/Proposal File and Associated Records", 63 Federal Register 267 (January 5, 1998), and NSF-51, "Reviewer/Proposal File and Associated Records", 63 Federal Register 268 (January 5, 1998).

List of Suggested Reviewers or Reviewers Not To Include (optional)

SUGGESTED REVIEWERS:

Not Listed

REVIEWERS NOT TO INCLUDE:

Not Listed

COVER SHEET FOR PROPOSAL TO THE NATIONAL SCIENCE FOUNDATION

PROGRAM ANNOUNCEMENT/SOLICITATION NO./CLOSING DATE/if not in response to a program announcement/solicitation enter NSF 04-23

NSF 04-565 **12/02/04**

FOR CONSIDERATION BY NSF ORGANIZATION UNIT(S) (Indicate the most specific unit known, i.e. program, division, etc.)

DUE - CCLI-Adaptation and Implementation

FOR NSF USE ONLY

NSF PROPOSAL NUMBER

DATE RECEIVED	NUMBER OF COPIES	DIVISION ASSIGNED	FUND CODE	DUNS# (Data Universal Numbering System)	FILE LOCATION
				005309844	

EMPLOYER IDENTIFICATION NUMBER (EIN) OR TAXPAYER IDENTIFICATION NUMBER (TIN)

426004224

SHOW PREVIOUS AWARD NO. IF THIS IS
☐ A RENEWAL
☐ AN ACCOMPLISHMENT-BASED RENEWAL

IS THIS PROPOSAL BEING SUBMITTED TO ANOTHER FEDERAL AGENCY? YES ☐ NO ☒ IF YES, LIST ACRONYM(S)

NAME OF ORGANIZATION TO WHICH AWARD SHOULD BE MADE

Iowa State University

AWARDEE ORGANIZATION CODE (IF KNOWN)

0018697000

ADDRESS OF AWARDEE ORGANIZATION, INCLUDING 9 DIGIT ZIP CODE

Iowa State University
2207 Pearson Hall, Room 15
Ames, IA. 500112207

NAME OF PERFORMING ORGANIZATION, IF DIFFERENT FROM ABOVE

PERFORMING ORGANIZATION CODE (IF KNOWN)

ADDRESS OF PERFORMING ORGANIZATION, IF DIFFERENT, INCLUDING 9 DIGIT ZIP CODE

IS AWARDEE ORGANIZATION (Check All That Apply) (See GPG II.C For Definitions)
☐ SMALL BUSINESS ☐ MINORITY BUSINESS
☐ FOR-PROFIT ORGANIZATION ☐ WOMAN-OWNED BUSINESS
☐ IF THIS IS A PRELIMINARY PROPOSAL THEN CHECK HERE

TITLE OF PROPOSED PROJECT **Tracking Student Solution-Pathways In Complex, Context-Rich Physics Problems**

REQUESTED AMOUNT	PROPOSED DURATION (1-60 MONTHS)	REQUESTED STARTING DATE	SHOW RELATED PRELIMINARY PROPOSAL NO. IF APPLICABLE
$ 99,815	24 months	10/01/05	

CHECK APPROPRIATE BOX(ES) IF THIS PROPOSAL INCLUDES ANY OF THE ITEMS LISTED BELOW

☐ BEGINNING INVESTIGATOR (GPG I.A)
☐ DISCLOSURE OF LOBBYING ACTIVITIES (GPG II.C)
☐ PROPRIETARY & PRIVILEGED INFORMATION (GPG I.B, II.C.1.d)
☐ HISTORIC PLACES (GPG II.C.2.j)
☐ SMALL GRANT FOR EXPLOR. RESEARCH (SGER) (GPG II.D.1)
☐ VERTEBRATE ANIMALS (GPG II.D.5) IACUC App. Date ________
☐ HUMAN SUBJECTS (GPG II.D.6)
Exemption Subsection ________ or IRB App. Date ________
☐ INTERNATIONAL COOPERATIVE ACTIVITIES: COUNTRY/COUNTRIES INVOLVED (GPG II.C.2.g.(iv).(c))
____
☐ HIGH RESOLUTION GRAPHICS/OTHER GRAPHICS WHERE EXACT COLOR REPRESENTATION IS REQUIRED FOR PROPER INTERPRETATION (GPG I.E.1)

PI/PD DEPARTMENT
Department of Physics and Astronomy

PI/PD FAX NUMBER
515-294-6027

PI/PD POSTAL ADDRESS

Ames, IA 50011
United States

NAMES (TYPED)	High Degree	Yr of Degree	Telephone Number	Electronic Mail Address
PI/PD NAME **Craig A Ogilvie**	**PhD**	**1987**	**515-294-2219**	**cogilvie@iastate.edu**
CO-PI/PD **David Atwood**	**PhD**	**1989**	**515-294-5225**	**atwood@iastate.edu**
CO-PI/PD **Paula Herrera-Siklody**	**PhD**	**1999**	**515-294-2607**	**siklody@iastate.edu**
CO-PI/PD				
CO-PI/PD				

CERTIFICATION PAGE

Certification for Authorized Organizational Representative or Individual Applicant:

By signing and submitting this proposal, the individual applicant or the authorized official of the applicant institution is: (1) certifying that statements made herein are true and complete to the best of his/her knowledge; and (2) agreeing to accept the obligation to comply with NSF award terms and conditions if an award is made as a result of this application. Further, the applicant is hereby providing certifications regarding debarment and suspension, drug-free workplace, and lobbying activities (see below), as set forth in Grant Proposal Guide (GPG), NSF 04-23. Willful provision of false information in this application and its supporting documents or in reports required under an ensuing award is a criminal offense (U. S. Code, Title 18, Section 1001).

In addition, if the applicant institution employs more than fifty persons, the authorized official of the applicant institution is certifying that the institution has implemented a written and enforced conflict of interest policy that is consistent with the provisions of Grant Policy Manual Section 510; that to the best of his/her knowledge, all financial disclosures required by that conflict of interest policy have been made; and that all identified conflicts of interest will have been satisfactorily managed, reduced or eliminated prior to the institution’s expenditure of any funds under the award, in accordance with the institution’s conflict of interest policy. Conflicts which cannot be satisfactorily managed, reduced or eliminated must be disclosed to NSF.

Drug Free Work Place Certification

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Drug Free Work Place Certification contained in Appendix C of the Grant Proposal Guide.

Debarment and Suspension Certification

(If answer "yes", please provide explanation.)

Is the organization or its principals presently debarred, suspended, proposed for debarment, declared ineligible, or voluntarily excluded from covered transactions by any Federal department or agency? Yes ☐ No ☒

By electronically signing the NSF Proposal Cover Sheet, the Authorized Organizational Representative or Individual Applicant is providing the Debarment and Suspension Certification contained in Appendix D of the Grant Proposal Guide.

Certification Regarding Lobbying

This certification is required for an award of a Federal contract, grant, or cooperative agreement exceeding $100,000 and for an award of a Federal loan or a commitment providing for the United States to insure or guarantee a loan exceeding $150,000.

Certification for Contracts, Grants, Loans and Cooperative Agreements

The undersigned certifies, to the best of his or her knowledge and belief, that:

(1) No federal appropriated funds have been paid or will be paid, by or on behalf of the undersigned, to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with the awarding of any federal contract, the making of any Federal grant, the making of any Federal loan, the entering into of any cooperative agreement, and the extension, continuation, renewal, amendment, or modification of any Federal contract, grant, loan, or cooperative agreement.

(2) If any funds other than Federal appropriated funds have been paid or will be paid to any person for influencing or attempting to influence an officer or employee of any agency, a Member of Congress, an officer or employee of Congress, or an employee of a Member of Congress in connection with this Federal contract, grant, loan, or cooperative agreement, the undersigned shall complete and submit Standard Form-LLL, ‘‘Disclosure of Lobbying Activities,’’ in accordance with its instructions.

(3) The undersigned shall require that the language of this certification be included in the award documents for all subawards at all tiers including subcontracts, subgrants, and contracts under grants, loans, and cooperative agreements and that all subrecipients shall certify and disclose accordingly.

This certification is a material representation of fact upon which reliance was placed when this transaction was made or entered into. Submission of this certification is a prerequisite for making or entering into this transaction imposed by section 1352, Title 31, U.S. Code. Any person who fails to file the required certification shall be subject to a civil penalty of not less than $10,000 and not more than $100,000 for each such failure.

AUTHORIZED ORGANIZATIONAL REPRESENTATIVE	SIGNATURE	DATE
NAME		

TELEPHONE NUMBER	ELECTRONIC MAIL ADDRESS	FAX NUMBER

*SUBMISSION OF SOCIAL SECURITY NUMBERS IS VOLUNTARY AND WILL NOT AFFECT THE ORGANIZATION’S ELIGIBILITY FOR AN AWARD. HOWEVER, THEY ARE AN INTEGRAL PART OF THE INFORMATION SYSTEM AND ASSIST IN PROCESSING THE PROPOSAL. SSN SOLICITED UNDER NSF ACT OF 1950, AS AMENDED.

NATIONAL SCIENCE FOUNDATION
Division of Undergraduate Education

NSF FORM 1295: PROJECT DATA FORM

The instructions and codes to be used in completing this form are provided in Appendix II.

1. **Program-track** to which the Proposal is submitted: **CCLI-Adaptation and Implementation**
2. Name of **Principal Investigator/Project Director** (as shown on the Cover Sheet):
   Ogilvie, Craig
3. Name of submitting **Institution** (as shown on Cover Sheet):
   Iowa State University
4. **Other Institutions** involved in the project's operation:
   UCLA

Project Data:

A. Major Discipline Code: **13**
B. Academic Focus Level of Project: **LO**
C. Highest Degree Code: **D**
D. Category Code: **X**
E. Business/Industry Participation Code: **NA**
F. Audience Code: __ __ __ __ __ __ __ __
G. Institution Code: **PUBL**
H. Strategic Area Code: _____
I. Project Features: **1** **3** __ __ __

Estimated number in each of the following categories to be directly affected by the activities of the project during its operation:

J. Undergraduate Students: **500**
K. Pre-college Students: **0**
L. College Faculty: **5**
M. Pre-college Teachers: **0**
N. Graduate Students: **0**

Many science and engineering students attempt to solve problems by searching for the "right" equation, an approach that fails for complex problems. Research on the differences between novices and experts has led to teaching innovations that model the steps of strong problem-solving strategies, then students practice these techniques. We propose to use an online tool to support, develop, and track what students do when solving problems and to use this tracking to determine the extent to which pedagogical reforms have improved problem-solving processes. We propose to use the web-based problem-solving environment (IMMEX) that has been used in K-12 education, and in biology and chemistry courses at the university-level, but there are few problems in physics. We will convert our existing complex, context-rich, physics problems into the IMMEX-structure, and track which strategies or pathways students use to solve these problems. Students will be presented with a realistic, multifaceted problem, and can request different information by clicking on links to, e.g. numerical data, advice from experts, sketches, or scientific principles. Not all the options are useful, and each comes with an associated "cost." Students solving IMMEX problems must make decisions as to what information they need. The main intellectual merit in this proposal, beyond extending the database of problems, is to adapt IMMEX by asking student to justify their decision and reflect on the problem-solving process. Since requesting information comes at a time or dollar "cost" to the student within an IMMEX problem, we will add justification steps to problems that provide students with a time or financial "bonus," The broad impact of our work will come from the analysis of the solution-pathways used by students and how they change with instruction. Persistent weak points in student strategies can be used to focus problem-solving instruction to improve a critical aspect of the education of our future scientists and engineers.

TABLE OF CONTENTS

For font size and page formatting specifications, see GPG section II.C.

Appendix Items:

*Proposers may select any numbering mechanism for the proposal. The entire proposal however, must be paginated. Complete both columns only if the proposal is numbered consecutively.

Progress in our technological society absolutely requires that young scientists and engineers have strong quantitative problem-solving skills. Yet most science and engineering students struggle when faced with complex and unfamiliar problems because they usually approach problem-solving tasks with a relatively limited strategy of searching for ready-made formulae to apply to the problem. In contrast, experts have learned to approach complex problem-solving challenges by qualitatively analyzing the problem, identifying the fundamental principles, and use this analysis to break the problem down into manageable sub-tasks. These and other differences in strategy between novices and experts are well-established, and have led to the development of several teaching innovations designed specifically to move students away from the novice equation-based 'plug-and-chug' technique. The fundamental pedagogy is to teach students the multiple steps of strong problem-solving strategies, model these steps via example, and students then practice these techniques. To evaluate the success of such reforms, faculty have used interviews with a small number of students to yield qualitatively rich data on the process of learning and problem-solving. However, such interviews are very labor-intensive and cannot be implemented widely. What is critically needed, therefore, are methods to support, develop, and track the processes students use when solving problems and to use this tracking to determine the extent to which pedagogical reforms have improved problem-solving processes. The lack of these evaluation tools means that we do not have readily usable guideposts to use to improve a critical aspect of the education of our future scientists and engineers.

The *long-term goal* of our program is to understand how to develop students' problem-solving skills in a wide range of quantitative disciplines and course-levels. The *objective of this proposal* is to use a web-based problem-solving environment to track the pathways that students follow when solving complex physics problems, and to determine changes in student solution strategies as students participate in explicit problem-solving instruction. The web-based problem-solving environment (IMMEX) has been used in K-12 education, and in biology and chemistry courses at the university-level. Students are presented with a realistic, multifaceted problem, and can request different information by clicking on links to, e.g. numerical data, advice from experts, sketches, or scientific principles. Not all the options are useful, and each comes with an associated "cost." We propose converting existing complex, context-rich, university-level physics problems into the IMMEX-structure, and tracking which strategies or pathways students use to solve these problems.

Our *rationale* for the studies outlined in this proposal is that analyzing the solution pathways and processes will provide rich information about how students solve quantitative problems. Our specific aims for this proposal are:

Objective #1: ***To convert existing complex context-rich problems into the IMMEX environment for online delivery.*** We will convert existing problems into the IMMEX web-format and have students in sophomore physics classes solve these problems. We will track which information students request and in which order, and categorize the types of solution-strategies.

Objective #2: ***Add rewards to online complex problems to encourage regulatory problem-solving steps such as problem categorization, checking-strategies, justification, and reflection.*** Currently students solving IMMEX problems must make decisions as to what information they need. Significant learning can occur if students are asked to justify their decision and reflect on the problem-solving process. Since requesting information comes at a time or dollar "cost" to the student within an IMMEX problem, we will add justification steps to problems that provide students with a time or financial "bonus,"

Objective #3: ***To analyze the solution-pathways that students use when solving complex, context-rich problems and to determine changes in student solution strategies as they participate in explicit problem-solving instruction.*** We will evaluate the extent to which solution-strategies change during participation in academic coursework designed to improve problem-solving skills. We will also examine persistent weak points in student strategies and use this information to focus instruction.

Our group brings multiple perspectives to these tasks, including Craig Ogilvie's and Dave Atwood's experience in teaching problem-solving during physics courses, in particular using the nationally-recognized University of Minnesota Physics Department instructional format. Craig Ogilvie, David Atwood, and Paula Herrara have extensive experience in developing online problem-sets for large enrollment courses with over 1,000 questions authored and categorized in a searchable database. David Meltzer and Mack Shelley will lead the evaluation work: David has successfully developed diagnostic instruments in technical subjects ranging from vectors to thermodynamics, and Mack Shelley is Director of the Research Institute for Studies in Education at Iowa State University.

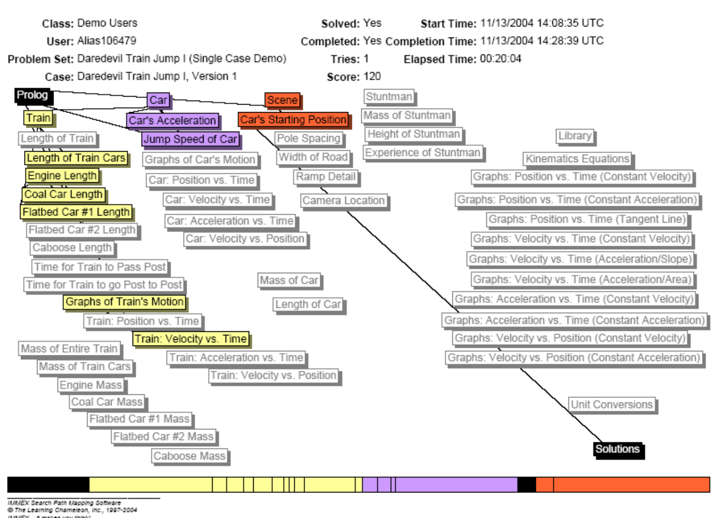
The main innovation in this proposal is obtaining rich information on how students solve physics problems and analyzing solution pathways to inform our teaching practice. At the completion of this project, we expect to have at least ten IMMEX-based problems in Physics that other instructors can use. The quantitative information we will obtain is critical to guide faculty on how to improve the problem-solving skills of students that are so essential to their future success as engineers and scientists.

Review of Literature that is Relevant to this Application. Extensive research on problem-solving has established three main categories of interwoven knowledge that are required to solve quantitative problems (Anderson, 1985; Maloney 1994; Bransford, 2000): (1) declarative knowledge or strong content understanding that is well-organized, (2) procedural knowledge or competence in a variety of problem-solving strategies and heuristics, and (3) regulatory knowledge, e.g., planning the solution before embarking on the details and monitoring progress for technical and strategy errors as the solution develops. Developing strong problem-solving skills in students is a major challenge because these three areas of knowledge need to be developed simultaneously.

Assessment of student problem-solving has been predominantly of two types (Royer, 1993): (a) interviews or (b) asking students to solve a complex problem and grading the solution. Interviews designed to evaluate problem-solving were pioneered by Reif (1976) and Schoenfeld (1985). Other researchers have relied on scoring completed problems worked by students (Heller, 1992; Heuvelen, 1991; Bagno, 1997; Beichner, 1999; Sutherland, 2002). However, since only the final solution is available, it is difficult to learn what steps the student went through in formulating the solution: Did the student struggle with analyzing the problem at the start, or did drawing the diagram enable the student to make progress?

In recent years several online problem-solving environments (Stevens, 2003; Chung, 2004; Ryan, 2004, VanLehn, 2002) have been developed. These tools fall into two classes: 1) online tutors such as ANDES (VanLehn, 2002) that provide some structure to guide students through different stages together with tutoring when students get stuck, or 2) unstructured environments where students are presented with a general description of the task at hand, a menu of items that contain information and are required to make many decisions about how to solve the problem. Stevens has shown (Stevens 2003) that students start with a scattershot approach in such unstructured environments, but with experience they develop more effective strategies. There are several open-ended environments with slightly different focuses; Chung's tool is for design-problems in which students are asked to construct a virtual device that must satisfy given constraints. The Engineering Learning Portal developed by Ryan presents students with an industrial business case of, for example, whether to upgrade existing manufacturing lines or outsource production. Students can select spreadsheets containing pertinent costs, or projections of demands. The online environment that seems most closely matched to complex, multifaceted physics problems is the IMMEX environment developed by Stevens and collaborators (Stevens).

Here is one example from the IMMEX database: the "Daredevil Train Jump," in which a stunt driver has to calculate when s/he must start a car to jump over a moving train. Here is the solution pathway of one of the PIs on this proposal.



The colored boxes represent the information that the PI requested with links showing the sequence of requests. The grey items were not requested. The IMMEX tools track the pathways the students follow as they solve the problem, and these pathways can be categorized offline into several classes. Stevens and co-workers (Stevens et al., 2004, Stevens & Palacio-Cayetano, 2003) used a neural-net to group the solution for high-school students solving chemistry and biology problems into a few characteristic approaches: (1) the Prolific strategy, whereby a student requests a broad range of relevant and irrelevant information, (2) the Redundant strategy, in which a student requests information that s/he already has, or, in the case of a diagnosis-case, the student orders a test that provides information on only an already eliminated diagnosis, (3) the Efficient strategy whereby a student requests the pertinent information, and (4) the Limited strategy, in which a student makes a guess at the solution without having requested sufficient information.

Preliminary Studies. At ISU we have considerable experience in using pen-and-paper complex problems in active-learning recitations to improve students' problem-solving skills. Of the several innovative pedagogies to improve student problem-solving skills, e.g., Overview Case Studies (Heuvelen, 1991), and SCALE-UP (Beichner, 1999), we have adapted the technique first introduced by the Physics Department at University of Minnesota (Heller, 1992). The crucial step is for students to practice on multifaceted, realistic problems. Weekly problem-solving/recitation sessions are held in which approximately 20 students meet with their Teaching Assistant. For the past three years, ISU students have worked in groups of three to four in these sessions on multifaceted problems differing from "normal" textbook problems by involving more than one scientific principle; hence the groups cannot readily solve it by "searching" for a formula. Rather, they must analyze the problem qualitatively, identify the principles involved, and then build a solution. These problems are a natural match to be delivered in the online IMMEX environment, where students would still work in groups and have to make joint decisions about what information they need to solve the problem and what physics the solution requires.

We have written and used 36 pen-and-paper context-rich problems, primarily in areas of thermal physics, electricity/magnetism, and optics. These problems and their solutions are available to all physics instructors at http://owl.physics.iastate.edu. This database complements the Minnesota database of problems that focus primarily on kinematics and dynamics. The main differences between a written context-rich, complex problem and a problem written for IMMEX delivery are:

1. The prolog or description of the problem contains no quantitative information characterizing the physical situation. This information has to be requested explicitly by the student, at some cost.
2. The statement of the problem not only makes the student the central figure, but also imposes some boundary condition (e.g., the director wants a solution in under 4 hours), and the "cost" for obtaining information is then listed as taking a certain amount of time.

3. The information available to the student is categorized into several types—e.g., data, diagrams, physical principles, advice from experts. Not all the information is relevant or useful.

We have started converting the pen-paper context-rich problems into the IMMEX structure. We have made a first cut of the categories of information students request and have designed links for one problem in 2-dimensional dynamics: the "Ski-Jump" problem in the Minnesota database (see Appendix A). The objective of the work in this proposal is to produce at least ten such questions, analyze the solution pathways, track whether these change over time, and use this information to inform instruction on problem-solving. The research required to accomplish these objectives is described in the next section.

Research Design

Objective #1: ***To convert existing complex context-rich problems into the IMMEX environment for online delivery.***

1.1. **Introduction:** There are no more than two or three problems in the current IMMEX database that are suitable for use in college-level physics courses. Hence the first objective of this proposal is to convert existing complex problems that we have into the IMMEX structure.

1.2. **Specific Tasks Required to Accomplish this Research Aim:**

- Decide on common categories of types of information. Our current list is: data, physical principles, diagrams, estimation of result, and ask the experts for advice.
- Select problems for conversion. We will choose problems that require at least two physics principles for their solution as well as those that offer multiple paths for correct solutions.
- Design the information items a student can request, and assign costs to these.
- Write the problems using the IMMEX authoring tool.
- Use a focus group of paid student volunteers to test-drive the problems and provide feedback. Implement changes to the problems based on the feedback.

1.3. **Expected Outcomes** At the completion of the studies outlined in this aim we expect to have a set of 10 questions written and tested for delivery in the IMMEX environment.

Objective #2: ***Add rewards to online complex problems to encourage regulatory problem-solving steps such as problem categorization, checking-strategies, justification, and reflection.***

2.1. **Introduction** Strong problem-solving depends on a wide-range of skills, e.g., using different representations of the problem, categorizing the problem by identifying the principles involved, rather than surface features. We can encourage and support such skills by offering rewards in the IMMEX environment for these new tasks, e.g., the addition of more "time" to solve the problem.

2.2. **Specific Tasks Required to Accomplish this Research Aim:**

- In the second year of this proposal we will add four new categories of regulatory tasks to IMMEX: categorizing the problem (Jonassen, 2004), choice of checking strategies, justification statements (Ryan, 2004), and reflection statements. These tasks can be implemented via pull-down menus and text-entry forms. As a first step it will not be possible to assign a score based on what the student writes, but the responses can be examined offline.

- Track the usage of these incentives, when are they chosen, and what actions follow their use. Establish the extent to which the use increases the percentage of correct solutions.

2.3. **Expected Outcomes** At the completion of the studies outlined in this aim we expect to have regulatory tasks and positive incentives for the 10 IMMEX complex physics problems and to have evaluated the extent these impact student problem-solving strategies.

Objective #3: ***To analyze the solution-pathways that students use when solving complex, context-rich problems, and to determine changes in student solution strategies as they participate in explicit problem-solving instruction.***

3.1. **Introduction** The IMMEX environment collects the pathways students use as they solve the problems. This information can be analyzed to provide information to the instructor and the student about what types of strategies the student is using and how these change over time.

3.2. **Specific Tasks Required to Accomplish this Research Aim:**

- Use the IMMEX complex problems in recitations in our sophomore calculus-based ISU physics course where approximately 500 students are enrolled per semester. We plan to divide these into an experimental group of approximately 100 students who would use the IMMEX environment during their recitations and a comparison group that would solve the same problems in the traditional pen-paper format. Stevens, 2003 reports that groups working in the IMMEX environment engage in intense discussions on the decisions to be made to solve the problem.
- Track the pathways used by the experimental group as they solve IMMEX problems, and mine this information to address questions such as: Are students more likely to get the question correct if they spend more time at the start of the problem on links that help qualitatively analyze the problem? If students start off by requesting a series of quantitative data, what do they do next? Establish the extent to which these characteristics change during the semester.
- Categorize the solution pathways using neural-net tools developed at IMMEX to find clusters of strategy types. Track how the frequency of these strategies changes during the semester.
- Compare how well the experimental group does with respect to the comparison group on several measures: performance on the same exams, weekly problem-sets, and learning gain measured via standard conceptual diagnostics (e.g., Force Concept Inventory).

3.3. **Expected Outcomes** At the completion of these studies we expect to have analyzed solution pathways for 100 students on at least seven different problems and to have evaluated the extent to which the problem-solving strategies of these students change over the semester.

Evaluation The evaluation will be headed by Mack Shelley and David Meltzer, and the results will be shared with the IMMEX Project team. An evaluation report will be written each year of the project compiled by Shelley: the first year evaluation will be used to guide the rest of the project. We will use the a-e-I-o-u approach (Kemis, 2000) which organizes evaluation questions into five areas:

(a)ccountability, i.e. did the project team do what it said it was going to do?

(e)ffectiveness, i.e. how well did the activities meet the objectives of the project?

(I)mpact, i.e. what changes occurred as a result of the project? Did the students in the experimental group (those using IMMEX) perform better on exams, problem sets, and physics diagnostic instruments (e.g. FCI) compared to the comparison group? Although the two groups should be comparable, we will correlate these measures with institutional records (ACT and math diagnostic scores). Surveys and focus groups will be used to obtain qualitative information on impact.

(o)rganizational context, i.e. which structures, or events affected the project, based on data collected from interviews with key personnel, focus groups made up of those most affected by the project, or analysis of documents? In particular, what helped to achieve the goals and objectives of the project and what made it difficult?

(u)nanticipated outcomes, i.e. what happened that was not planned for or expected?

Dissemination Once a problem is approved by the IMMEX project-team it is available to be used by any instructor at any institution. Currently there are over 400 K-12 schools and universities registered to use IMMEX problems. This has the additional benefit of a larger and broader pool of students who solve any one IMMEX problem so that problem-solving strategies can be analyzed in a larger data set. In addition to this automatic dissemination, we plan to present our work at national meetings of the APS and AAPT, as well as submit our findings to peer-reviewed literature.

Future directions At the end of this project we expect to have 10 well-tested, complex, context-rich physics problems in the IMMEX database, along with information on how students solve these problems and how these strategies change with time. One area for future work is for students to be able to add their own diagrams, planning or mathematics to the solution. Currently students request the information from IMMEX, but setup their algebra and numerical solution on a piece of paper. There are potential benefits to providing a link to a graphics, text, and mathematics workspace, e.g., a webMathematica window that a student could use to add diagrams, text, or execute and store the mathematical side of their work.

Anderson 85, John R. Anderson , Cognitive psychology and its implications. W.H. Freeman, c1985.
Maloney 94,D. P. Maloney, Research on Problem Solving: Physics, Handbook of Research on Science Teaching and Learning, MacMillan Publishers 1994.
Bransford 00,J. Bransford, A. Brown, R. Cocking eds, How People Learn, National Academy Press, 2000
Royer 93 , J.M. Royer, C.A. Cisero, M.S. Carlo, Techniques and procedures for Assessing Cognitive Skills, Rev. of Educational Research, 63, 201 (1993)
Reif 76, F. Reif, J.H. Larkin, and G.S. Brackett, Teaching General Learning and Problem-Solving Skills, Am. J. Physics, 44, 212 (1976)
Schoenfeld 85, A.H. Schoenfeld, Mathematical Problem Solving (Academic, San Diego CA) 1985
Heller 92 , P. Heller, R. Keith, S. Anderson, Teaching Problem Solving Through Cooperative Grouping, Am. J. Phys 60, 627 (1992)
Bagno 97, E. Bagno, B-S. Eylon, From Problem-Solving to a Knowledge Structure, Am. J. Phys 65, 726 (1997)
Beichner 99, R. Beichner et al., Case study of the physics component of an integrated curriculum, S16 Phys. Educ. Res., Am. J. Phys. Suppl. 67, (1999)
Sutherland 02, L. Sutherland, Developing Problem solving expertise: the impact of instruction in a question analysis strategy, Learning and Instruction 12, 155 (2002)
Stevens 03, Ron Stevens and Joycelin Palacio-Cayetano, Design and Performance Frameworks for Constructing Problem-Solving Simulations Cell Biology Education Vol. 2, 162–179, Fall 2003
Chung 04, G.K.W.K. Chung, E.L. Baker, An Exploratory Study to Examine the Feasibility of Measuring Problem-Solving Processes Using a Click-Through Process, J. Tech. Learn. and Assess 2(2) 2003
Ryan 04, Ryan, S., J. Jackman, F. Peters, S. Olafsson, M. Huba (2004). The Engineering Learning Portal for Problem Solving: Experience in a Large Engineering Economy Class. *The Engineering Economist* **49**(1), 1-20
VanLehn 2002, Kurt VanLehn, Collin Lynch, Linwood Taylor, Anders Weinstein, Robert Shelby, Kay Schulze, Don Treacy, and Mary Wintersgill. Minimally Invasive Tutoring of Complex Physics Problem Solving. In: Cerri, Gouarderes, Paraguacu (eds) Intelligent Tutoring Systems, 2002, pages 367-376.
Stevens 04 Stevens, R., Soller, A., Cooper, M., and Sprang, M, Modeling the Development of Problem Solving Skills in Chemistry with a Web-Based Tutor, Computer Science Editorial III. Springer-Verlag, Heidelberg Germany, 2004
Heuvelen A. van Heuvelen, Overview, Case Study Physics, Am. J. Phys 59, 898 (1991)
Jonassen 04, D. H. Jonassen, Learning How to Solve Problems, Pfeiffer Publishing, 2004
Kemis 00, Kemis, M., & Walker, D. (2000). The a-e-I-o-u approach to program evaluation. *Journal of College Student Development, 41*(1), 119-122.

CRAIG ANDREW OGILVIE

Professional Preparation

University of Canterbury, New Zealand	Physics	B.Sc. (Honors, First Class), 1983
University of Birmingham, England	Physics	PhD 1987

Appointments

Associate Professor, Iowa State University, IA	2003 - present
Assistant Professor of Physics, Iowa State University, IA	2000 - 2003
Assistant Professor of Physics, Massachusetts Institute of Technology, MA	1992 - 2000
Consultant, Unica Technologies, Lincoln, MA	2000
Research Scientist, GSI, Darmstadt, Germany	1990 - 1992
Research Scientist, Michigan State University, East Lansing, MI	1987 – 1990

Selected Publications (114 articles published in refereed journals)

1. **Formation of Dense Partonic Matter in Relativistic Nucleus-Nucleus Collisions at RHIC: Experimental Evaluation by the PHENIX Collaboration.** By PHENIX Collaboration (K. Adcox *et al.*). Oct 2004. 127pp. Submitted to Nucl.Phys.A e-Print Archive: nucl-ex/0410003
2. **Transverse Mass Dependence of Two Pion Correlations in Au+Au Collisions at S(NN)**(1/2) = 130-GeV**. By PHENIX Collaboration (K. Adcox et al.). Phys.Rev.Lett.88:192302,2002
3. **Review of Nuclear Reactions at the AGS.** C.A. Ogilvie Nucl.Phys.A698:3-12,2002
4. **Suppression of Hadrons with Large Transverse Momentum in Central Au+Au Collisions at S(NN)**(1/2) = 130-GeV**. By PHENIX Collaboration (K. Adcox et al.). Phys.Rev.Lett.88:022301,2002
5. **An Excitation Function of K- and K+ Production in Au+Au Reactions at the AGS**, L. Ahle et al., Phys.Lett.B490, 53, 2000
6. **The Rise and Fall of Multi-fragment Emission.** C.A. Ogilvie, et al., Phys. Rev. Lett 67 1214, 1991.

Synergistic Activities

1. Educational initiatives;
    a. Redesigned physics recitations in Phys 222 (Iowa State) and 8.01 (MIT) to increase student problem-solving skills by having students work cooperatively on complex, realistic problems. Funded by internal seed grant (Miller Fellowship)
    b. Implemented on-line assignments for Phys 222 (Iowa State) that provided detailed and specific feedback tailored to the student.
    c. Awarded HP Technology for Teaching Grant, "Increasing Feedback to Students During Discussion Sections" $65,000 4/1/2004
    d. Added active learning exercises to lectures of Phys 222 (Iowa State) to improve student learning.

e. Extended an introductory physics course (8.01x MIT) to have "take-home" experiments where students worked in pairs to construct experiments from small inexpensive parts.
f. Developed and taught a distance-learning graduate level course at MIT (8.712) on Relativistic Heavy-Ion Physics. Students at several universities across the country participated in the lectures via live videoconference.

2. Education Honors
   a. 2002 Miller Faculty Fellow, ISU
   b. 1997 James H. Ferry, Jr. Fund for Innovation in Research Education, MIT
   c. 1996 Buechner Prize for Teaching, Department of Physics, MIT
3. Outreach and Service
   a. Aug 2004, University Teaching Seminar, ISU, "*Effective Lectures*", "*Leading Labs and Recitations in Math and Science*"
   b. Oct 2003, presented at ISU Faculty Forum "Developing Problem-solving Skills in Students"
   c. Invited talk, 2002, Wakonse Conference on Higher Education, *Active Learning in Large Lectures*
   d. Member of school board's Technology Advisory Committee, Wayland, MA.
   e. Science Judge for DOE Science Bowl
   f. Faculty Panel for APEX Academic Success Seminar, Iowa State's minority retention program
   g. Member of Provost Task Force on Scholarship of Teaching and Learning (Iowa State)
   h. Member of LEARN Teaching Network (ISU)

<u>Collaborators & Other Affiliations</u>

Collaborators during past 48 months

PHENIX collaboration, approximately 500 coauthors
STAR collaboration, approximately 500 coauthors
E917 and E866 collaboration, approximately 100 coauthors

Graduate and Postdoctoral Advisors

John Nelson, University of Birmingham, Gary Westfall Michigan State, Uli Lynen GSI

Thesis Advisor and Postgraduate Scholar Sponsor

PhD students Hua Pei, Nathan Grau, James Dunlop, MIT (Ph.D. awarded 2000), George Heintzelman, MIT (Ph.D. awarded 1999), Larry Ahle, MIT (Ph.D. awarded 1998)
Post-docs Jan Rak, Gunther Roland, Eleanor Judd, Mark Baker

DAVID MALCOLM ATWOOD

Professional Preparation

University of Toronto	Physics and Math	B.Sc. 1984
McGill University	Theoretical High Energy Physics	MSc 1986
McGill University	Theoretical High Energy Physics	PhD 1989

Brookhaven National Laboratory	Theoretical High Energy Physics	1989-1992
Stanford Linear Accelerator Facility	Theoretical High Energy Physics	1992-1995
Thomas Jefferson National Accelerator Facility	Theoretical High Energy Physics	1995-1997

Appointments

Adjunct Research Assistant Prof., Iowa State University, IA	1997-present
Research Associate, Thomas Jefferson National Accelerator Facility	1995-1997
Research Associate, Stanford Linear Accelerator Center	1992-1995
Research Associate, Brookhaven National Laboratory	1989-1992

Publications

1. D. Atwood , T. Gershon, M. Hazumi, A. Soni, **Mixing Induced CP Violation in B to P1 P2 gamma…**, hep-ph/0410036.
2. D. Atwood, S. Bar-Shalom, G. Eilam and A. Soni, **Three Heavy Jet Events at Hadron Colliders**, Phys. Rev D69, 033006 (2004).
3. D. Atwood and Y. Wang, **Rate difference between b to s$\mu\mu$ and b to see in SUSY with large tan(β),**Phys.Rev.D68 094016 (2003).
4. D. Atwood, A. Soni, **The Role of charm factories in extracting CKM phase information via B$\to$DK**. Phys. Rev. D68 033003 (2003).
   Dependent CP Violation in B0 Decays to Rho(Omega) + Pseudoscalar, Phys. Lett B516, 29 (2001).

Synergistic Activities

1. Educational initiatives;
   a. Redesigned physics recitations in Phys 222 (Iowa State) to increase student problem-solving skills by having students work cooperatively on complex, realistic problems.
   b. Introduced complex problem solving into Phys 221 (Iowa State) recitations.
2. Education Honors
   a. 2002 Miller Faculty Fellow, ISU

Collaborators & Other Affiliations

Collaborators during past 48 months

S. Bar-Shalom (Technion), C.P. Burgess, (McGill U.), I. Dunietz (Fermilab), G. Eilam (Technion), E. Filotas (McGill U.), F. Leblond (McGill U.), D. London (Montreal U.), I. Maksymyk (Maryland U.) A. Petrov (Wayne State University), A. Soni (Brookhaven)

Graduate and Postdoctoral Advisors

- Prof. A. Contogouris, McGill University and Athens University; Prof. W. Marciano, Brookhaven National Laboratory;Prof. S. Broadsky Stanford Linear Accelerator Center; Prof. N. Isgur Thomas Jefferson National Accelerator Facility.

PAULA HERRERA-SIKLÓDY

Professional Preparation

University of Barcelona, Spain	Physics	B.Sc., 1993
University of Barcelona, Spain	Physics	PhD, 1999

Appointments

Lecturer, Iowa State University, IA	2002- present
Visiting Instructor, University of Illinois at Urbana-Champaign, IL	2000-2002
Visiting Instructor, Syracuse University, NY	1999-2000

Synergistic Activities

At Iowa State University:

- Redesigned and authored physics recitations in Phys 221 to transform them into active sessions where students work in groups on assigned worksheets. Introduced the use of the Tutorials from the University of Washington in recitations.
- Implemented and authored the online assignments for Phys 221 using WebCT. Currently working on an improved version that includes interactive help links, with financial support of an internal grant for the development of computer tools in teaching.
- Authored interactive segments to lectures in Phys 221 that allow students to test their understanding and provide feedback of this understanding to instructor.

At the University of Illinois:

- Implemented the use of an archival database to allow TAs to access comments and experience from previous semesters.
- Participation in the TA observation and evaluation program.
- Preparation of class material.

At Syracuse University:

- Training of TAs.
- Collaboration with the Physics Education team (preparation of class material., data analysis)

BIOGRAPHICAL SKETCH
DAVID ELLIOTT MELTZER

Professional Preparation

Columbia University	Physics	B.A., 1974
S.U.N.Y. at Stony Brook	Physics	M.A., 1980
S.U.N.Y. at Stony Brook	Physics	Ph.D., 1985
Oak Ridge National Laboratory	Condensed Matter Theory	1985-1987
University of Tennessee, Knoxville	Condensed Matter Theory	1985-1987
University of Florida, Gainesville (Quantum Theory Project)	Condensed Matter Theory	1987-1991

Appointments

Assistant Professor of Physics	Iowa State University	1998-present
Assistant Professor of Physics	Southeastern Louisiana University	1994-1998
Visiting Assistant Professor of Physics	Southeastern Louisiana University	1991-1994
Adjunct Instructor in Physics	University of Florida, Gainesville	1991
Adjunct Instructor in Physical Science	Santa Fe Community College, Gainesville, Florida	1990
Adjunct Instructor in Physical Science	Lake City Community College, Lake City, Florida	1990
Instructor, State Civil Service Courses in Elementary Mathematics	Downstate Medical Center, Brooklyn, New York	1974-1975
Teaching Assistant in Mathematics	Borough of Manhattan Community College, New York	1974

Selected Publications

1. Kevin S. Bedell and David E. Meltzer, ***Spin waves and spin diffusion in Fermi liquids: Bounds on effective diffusion coefficients***, Physical Review B **33**, 4543-4556 (1986).
2. D. E. Meltzer, J. R. Sabin, and S. B. Trickey, ***Calculation of mean excitation energy and stopping cross section in the Orbital Local Plasma Approximation*****,** Physical Review A **41**, 220-232 (1990).
3. George A. Cowan, David Pines, and David Meltzer, editors, ***Complexity: Metaphors, Models, and Reality: Proceedings Volume XIX, Santa Fe Institute Studies in the Sciences of Complexity.*** Addison-Wesley, Reading, Massachusetts, 1994.
4. Zachary Fisk, Lev Gor'kov, David Meltzer, and Robert Schrieffer, editors, ***Proceedings of Physical Phenomena at High Magnetic Fields – II.*** World Scientific, Singapore, 1996.
5. David E. Meltzer and Kandiah Manivannan, ***Promoting interactivity in physics lecture classes*****,** The Physics Teacher **34,** 72-76 (1996).
6. David E. Meltzer and Amy Woodland Espinoza, ***Guided inquiry: Let students "discover" the laws of physics for themselves***, Science Scope **21 (2)**, 28-31 (October 1997).
7. David E. Meltzer and Kandiah Manivannan, ***Transforming the lecture-hall environment: The fully interactive physics lecture***, American Journal of Physics **70**, 639-654 (2002).

8. David E. Meltzer, ***The relationship between mathematics preparation and conceptual learning gains in physics: a possible "hidden variable" in diagnostic pretest scores,*** American Journal of Physics **70**, 1259-1268 (2002).
9. Ngoc-Loan Nguyen and David E. Meltzer*,* ***Initial understanding of vector concepts among students in introductory physics courses,*** American Journal of Physics*,* **71**, 630-639 (2003).
10. David E. Meltzer***, Investigation of students' reasoning regarding heat, work, and the first law of thermodynamics in an introductory calculus-based general physics course***, American Journal of Physics **72**, 1432-1446 (2004).

Synergistic Activities

1. Principal Investigator, National Science Foundation projects: DUE-#9354595, ***"Introductory physics: A pilot project for an elementary course based on guided inquiry, with the theme of 'energy',"*** CCD program, $37,233 12 months, 1994; DUE-#9650754, ***"Microcomputer-based curricular enhancements for elementary physics,"*** ILI-IP program, $10,396, 24 months, 1996 [Co-PI: K. Manivannan]; DUE-#9653079, ***"Elementary physics course based on guided inquiry,"*** CCD program, $80,153, 24 months, 1997 [Co-PI: K. Manivannan]; DUE-#9981140, ***"Development of Active-Learning Curricular Materials in Thermodynamics,"*** CCLI-EMD program, $149,479, 35 months, June 2000 [Co-PI: Thomas J. Greenbowe]; REC-#0206683, "***Investigation of Diverse Representational Modes in the Learning of Physics and Chemistry,"*** Research on Learning and Education Program, $99,949, 18 months, July 2002 [Co-PI: T. J. Greenbowe]; DUE-#0243258, "***Formative Assessment Materials for Large-Enrollment Physics Lecture Classes***,"ASA program, $104,914, 24 months, July 2003; DUE-#0311450, "***Active-Learning Curricular Materials for Fully Interactive Physics Lectures***," CCLI-A&I program, $59,926, 24 months, September 2003; PHY-#0406724, "***Collaborative Research: Research on the learning and teaching of thermal physics***," EIR program, $267,615 (expected), 36 months (estimated), July 2004.
2. Workshop leader (with Kandiah Manivannan), American Association of Physics Teachers Workshops on **"*Interactive Methods for Large Classes*,"** January 1998, August 1998, August 1999, August 2000.
3. Iowa State University faculty awards: Miller Faculty Fellowship [with T. Greenbowe], 1999-2000; Center for Teaching Excellence Teaching Scholar for 2002-2003.
4. Member of Review Panel for NSF, Division of Undergraduate Education: July 1997, February 1999, July 2000, July 2003.
5. Member, Committee on Research in Physics Education of the American Association of Physics Teachers, (appointed for period 2000-2003).

Collaborators and Other Affiliations

Collaborators during past 48 months: R. S. Lindell Adrian, Kansas State University (KSU); L. Allen (Ohio State U.); M. K. Ballay, Denham Springs High School; M. S. Bean, KSU; R. J. Beichner, N. C. State U.; J. Dostal, Iowa State University (ISU); Warren Christensen, ISU; T. J. Greenbowe, ISU; B. I. Grimberg, ISU; P. R. L. Heron, U. Washington; K. Manivannan, Southwest Missouri State University (SMSU); L. McCullough, University of Wisconsin-Stout; L. C. McDermott, U. Washington; N.-L. Nguyen, ISU; E. F. Redish, U. Maryland; C. P. Schaefer, SMSU; J. R. Thompson, U. Maine.

Graduate and Post-doctoral Advisors: K. S. Bedell, Boston College; G. E. Brown, S.U.N.Y. (Stony Brook); G. D. Mahan, Penn State University; J. R. Sabin and S. B. Trickey, Univ. of Florida.

Thesis Students: Warren Christensen, ISU**;** Jack Dostal, ISU; Tina Fanetti, ISU [Total graduate students: 4]

Postgraduate Scholar Sponsored: Bruna Irene Grimberg, Iowa State University [Total: 1]

Biographical Sketch
Mack Clayton Shelley, II

Professional Preparation

American University	International Studies and Economics	B.A., 1972
University of Wisconsin-Madison	Economics	M.S., 1973
University of Wisconsin-Madison	Political Science	Ph.D., 1977

Appointments

Iowa State University:

Director, Research Institute for Studies in Education, 2003-present
Coordinator of Research, Research Institute for Studies in Education, 1999-2003
Professor, Departments of Statistics and Educational Leadership and Policy Studies, with courtesy appointment in Department of Political Science, 2000-present
Professor, Departments of Statistics and Political Science, and (rank only) Educational Leadership and Policy Studies, 1999-2000
Vice Chair, Department of Political Science, 1/1/93-6/30/94
Professor, Departments of Statistics and Political Science, 1990-1999
Assistant Professor, 1979-83; Associate Professor, 1983-90;

Mississippi State University

Assistant Professor, Department of Political Science, 1977-1979

Publications:

(i) Publications most closely related to the proposed project

John H. Schuh and Mack C. Shelley, II, "A Longitudinal Analysis of Funding for Student Affairs in Public Institutions," *Journal of College Student Development, 42*(5), 456-464 (2001).

Kari A. Hensen and Mack Shelley, "The Impact of Supplemental Instruction: Results from a large, public, Midwestern university," *Journal of College Student Development, 44*(2), 250-259 (2003).

Ana Arboleda, Yongyi Wang, Mack C. Shelley, II, and Donald F. Whalen, "Predictors of Residence Hall Involvement," *Journal of College Student Development, 44*(4), 517-531 (2003).

Florence A. Hamrick, John H. Schuh, and Mack C. Shelley, II, "Institutional Characteristics and Resource Allocation: Predictors of Graduation Rates," *Education Policy Analysis Archives, 12*(19) (2004) [On-line] Available: **http://epaa.asu.edu/epaa/v12n19/**

Mack Shelley, Lisa Thrane, Stuart Shulman, Evette Lang, Sally Beisser, Teresa Larson, and James Mutiti, "Digital Citizenship: Parameters of the Digital Divide," *Social Science Computer Review, 22*(2), 256-269 (2004).

(ii) other significant publications

Donald G. Hackmann and Mack C. Shelley, II, "Instructional Practices and Curricular Integration in an Interdisciplinary Secondary School Teaming Approach," *Planning and Changing, 33*(3&4), 223-247 (2002).

John Shertzer, Kevin P. Saunders, J. Lily Zheng, Mack C. Shelley, II, and Donald F. Whalen, "Influences on Residence Hall Undergraduates' Perceptions of Student Leadership," *Journal of College and University Student Housing, 31*(2), 12-21 (2003).

J. Lily Zheng, Kevin P. Saunders, Mack C. Shelley, II, and Donald F. Whalen, "Predictors of Academic Success for Freshmen Residence Hall Students," *The Journal of College Student Development, 43*(2), 267-283 (2002).

Yongyi Wang, Ana Arboleda, Mack C. Shelley, II, and Donald F. Whalen, "The Influence of Residence Hall Community on Academic Success of Male and Female Undergraduate Students," *Journal of College and University Student Housing, 32*(3), 16-22 (2004).

Ana Arboleda, JingJing Chen, Mack C. Shelley, II, and Donald F. Whalen, "Earning and Learning: Reasons Students Attend College," *Journal of the First-year Experience and Students in Transition, 16*(1) (2004)—forthcoming.

Synergistic Activities

Professor Shelley has served at Iowa State University for over 20 years with a joint faculty appointment, from 1979-99 between Political Science and Statistics and since August 1999 between Statistics and Educational Leadership and Policy Studies. As Director, and previously Coordinator of Research, of the

Research Institute for Studies in Education, in the College of Education, a primary role has been to stimulate multidisciplinary research efforts. Much of his research has been conducted jointly with faculty and graduate students in Sociology, Human Development and Family Studies, Economics, Civil Engineering, Textiles and Clothing, Political Science, Health and Human Performance, and other Education departments. Research topics span areas such as higher education, special education, early Head Start, environmental contamination, voting behavior and elections, transportation, biotechnology, public health, gerontology, and student affairs. He has consulted with several state and national agencies, primarily on statistical issues related to public policy, has been principal investigator, co-principal investigator, or consultant on a variety of externally funded grants from agencies including the National Science Foundation, and has provided expert witness testimony in federal district court. He has served on multidisciplinary research groups and administrative teams on such topics as university residence facilities, communication across the curriculum, learning communities, instructional technology, teacher education, strategic planning, and student discipline. From 1993-2002, he was co-editor of the *Policy Studies Journal,* an international multidisciplinary refereed journal addressing public policy issues. He has served as major professor for about 75 Ph.D. and master's graduate students, and over 550 other doctoral and master's dissertation and thesis committees for students in many departments. He has been mentor to several junior faculty members and external evaluator for many promotion and tenure decisions.

Collaborators & Other Affiliations:

(a) Collaborators and Co-Editors

Barbara A. Bardes—U. of Cincinnati
Sally Beisser—Drake U.
Sedahlia J. Crase—Iowa State U.
Michael R. Crum—Iowa State U.
Paula W. Dail—Iowa State U. (retired)
Uday Desai—Southern Illinois U.
Larry H. Ebbers—Iowa State U.
David Feldman—U. of Tennessee-Knoxville
Warren D. Franke—Iowa State U.
Steve Garasky—Iowa State U.
Shirley A. Gilmore—Iowa State U.
Walter H. Gmelch—Iowa State U.
Donald G. Hackmann—Iowa State U.
Florence A. Hamrick—Iowa State U.
Junehee Kwon—unknown
Paul Lasley—Iowa State U.
Freeman Moser, III—Iowa State U.
Paula C. Morrow—Iowa State U.
James Mutiti—Ohio U.
Mary Jane Oakland—Iowa State U.
Barbara Ohlund—U. of Nebraska-Lincoln
Carla A Peterson—Iowa State U.
Sandra L. Ramey—Marquette U.
Robert D. Reason—Pennsylvania State U.
Stephen Sapp—Iowa State U.
Steffen W. Schmidt—Iowa State U.
John H. Schuh—Iowa State U.
Stuart Shulman—Drake U.
Harvey M. Stahr—Iowa State U.
Montgomery Van Wart—Texas Tech U.
Gregory Welk—Iowa State U.
Donald F. Whalen—Iowa State U.
William Woodman—Iowa State U.

(b) Graduate and Postdoctoral Advisors

Graduate Advisor: Barbara Hinckley (deceased)

(c) Thesis Advisor and Postgraduate-Scholar Sponsor (85 total—last 4 years listed)

Robin Leigh Maas-Galloway—Iowa State U.
Jeffrey G. Berger—Iowa Dept. of Education
Robert Lee McNair—Boone, IA (retired)
Susan Marie Collins—U. of Northern Colorado
Harold Eddie Lee—Marshalltown, IA
Ellis Ott—Iowa State U.
Yalem Teshome—Iowa State U.
Christopher C. Pierson—Iowa State U.
Wenyu Su—Iowa State U.
Dong Yan—unknown
Xinpeng Wang—unknown
Jing (Lily) Zheng—Capital One (Virginia)
Jing-Jing Chen—unknown
Yufang Wu—unknown
Xiaojin Chen—unknown
Yumei Sun—Iowa Department of Public Health
Xiaoxia Lou—unknown
Yangyang Luo—unknown
Xiao-lan Li—unknown
Zhenya Hu—unkown
Yongyi Wang—National Opinion Research Center
Mary Elizabeth Manion—Ames, IA
Minguan Wang
Yan Guo—Iowa State U.
Bin Zhang
Linghong Zhang—graduated in 2004
Lanying Qi—graduated in 2004
Yan Li
Brian Hayes—graduated in 2004
Jun Yan
Peng Fan
David Walker—U. of Northern Illinois
Ching-Chun Shih—Taiwan
Robert Reason—Pennsylvania State U.
William Nelson—U. of Iowa
Lisa Thrane—Iowa State U.
Kay Ann Taylor—Iowa State U.
Shari Ellertson—Iowa State U.
Kevin Saunders—Iowa State U.

Ron Stevens, Ph.D.
Professor, UCLA School of Medicine
Director, IMMEX Project

5601 W. Slauson Blvd. #255
Culver City, CA 90230
(310) 649-6589 voice
(310) 649-6591 fax
immex_ron@hotmail.com

Dr. Ron Stevens is Professor of Microbiology and Immunology, UCLA School of Medicine and the director of the technology-based IMMEX problem-authoring and solving project. As a basic science researcher he has published over 100 peer-reviewed articles in the area of cellular and molecular immunology. He has also published articles on technology and professional development topics spanning elementary school through medical school. He is/has been the principal investigator on multiple science education grants (National Science Foundation and Howard Hughes Medical Institute) to foster the integration of technology and problem solving into the classrooms of Los Angeles and through the Department of Education's PT3 program has extended these technologies to preservice teacher instruction.

<u>Professional Preparation</u>
Ohio Wesleyan University, B.A. 1968. Major: Bacteriology
Harvard University, Ph.D. 1971. Major: Microbiology and Molecular Genetics
<u>Appointments</u>
1974- Professor of Microbiology and Immunology, UCLA

<u>Synergistic Activities</u>
The educational software tools developed by the IMMEX project have received multiple research and corporate awards including the New Researcher Award from the Association of American Medical Colleges (1992), a Masters of Innovation award from Zenith Corporation (1992), a nomination from the Computerworld-Smithsonian Institute's "A Search For New Hero's" competition (1994) and an award of excellence from the 2001 Minnesota Learning Software Design Competition.

Dr. Stevens has served on multiple national committees/panels related to the use of technology for education and assessment, is a member of the Center for Research, Evaluation Students Standards and Testing (CRESST), and a member of the board of Bioquest Inc. He also serves as a member of the University of California, Office of the President's Committee on Outreach and Technology and also a member of the education committee of the American Association of Immunologists. In September 2000 IMMEX was one of twelve educational technology projects invited to participate in Secretary Riley's Conference on Educational Technology in Washington D.C.

<u>Collaborators:</u>
Collaborators include Dr. Eva Baker, UCLA/CRESST, Drs. Doug Harris and David Gibson from VISMT, Dr. Sara Dexter from the University of Minnesota and Dr. Eric Klopfer from MIT.

<u>Ph.D. Mentor :</u> Harold Amos, Ph.D., Harvard University

Most Closely Related Publications

Stevens, R.H., and Najafi K. (1993). Artificial Neural Networks as Adjuncts for Assessing Medical Students' Problem-Solving Performances on Computer-Based Simulations. *Computers and Biomedical Research* 26(2), 172-187.

Stevens, R., Wang, P., Lopo, A. (1996). Artificial Neural Networks Can Distinguish Novice and Expert Strategies During Complex Problem-Solving. *Journal of the American Medical Informatics Association* vol. 3 Number 2 p 131-138.

Stevens, R.H., Ikeda, J., Casillas, A., Palacio-Cayetano, J., and S. Clyman (1999). Artificial Neural Network-based Performance Assessments. *Computers in Human Behavior*, 15: 295-314.

Underdahl, J., Palacio-Cayetano, J., and Stevens, R., (2001). Practice Makes Perfect: Assessing and Enhancing Knowledge and Problem-solving Skills with IMMEX Software. *Learning and Leading with Technology*. 28: 26-31.

Vendlinski, T. and Stevens R. (2002) "A Markov model analysis of problem-solving progress and transfer." The Journal of Technology, Learning and Assessment. **1**(1).

Stevens, R. H. and Palacio-Cayetano, J., (2003). Design and Performance Frameworks for Constructing Problem-Solving Simulations. Cell Biology Education 2, 162-179.

Stevens, R. H., Soller, A., Cooper, M., and Sprang, M. (2004). Modeling the Development of Problem-Solving Skills in Chemistry with a Web-Based Tutor. Lecture Notes in Computer Science, 3220, 580-591, 2004.

Other Relevant Publications

Hurst, K. C., Casillas, A. C., & Stevens, R. (1998). Exploring the dynamics of complex problem-solving with artificial neural network-based assessment systems. (Tech Rep. 446). Los Angeles, California: *University of California, Center of Research on Evaluation, Standards and Student Testing.*

Kanowith-Klein, Carolyn Burch & R. Stevens. (1998) Sleuthing for Science. *National Staff Development Council Journal of Staff Development* vol. 19, No. 3 p.48-53.

Palacio-Cayetano, J., Allen, R. D., & Stevens, R. H. (1999). Computer assisted evaluation--The next generation. *The American Biology Teacher* vol. 61, No. 7, p 514-522.

Palacio-Cayetano, J., Kanowith-Klein, S., and Stevens, R., (1999). UCLA's Outreach Program of Science Education in the Los Angeles Schools. Academic Medicine 7(4): 348-351.

Casillas, A.M., Clyman, S.G., Fan, Y.V., and Stevens, R.H. (1999). Exploring Alternative Models of Complex Patient Management with Artificial Neural Networks. Advances in Health Sciences Education 1: 1-19, 1999.

Kanowith-Klein, S., Stave, M., Stevens, R., and Casillas, A., (2001). Problem-solving Skills Among Pre-College Students in Clinical Immunology and Microbiology: Classifying Strategies with a Rubric and Artificial Neural Network Technology. *Microbiology Education,* 2: 25-33. 2001.

Publications/Evaluations of The IMMEX Project

Lawton, M., (1998). Making the Most of Assessments. Education Week on the Web, October 1998. http://www.edweek.org/sreports/tc98/cs/cs9.htm

Chen, E., Chung, G., Klein, D., deVries, L., Burnham, B. (2000). How Teachers Use IMMEX In The Classroom. 2000 CRESST Evaluation Report. http://www.immex.ucla.edu/Topmenu/WhatsNew/EvaluationForTeachers.PDF

SUMMARY PROPOSAL BUDGET

YEAR 1

ORGANIZATION: Iowa State University				FOR NSF USE ONLY — PROPOSAL NO.	DURATION (months): Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: Craig A Ogilvie				AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Craig A Ogilvie - PI	0.00	0.00	0.75	$ 5,875	$
2. David Atwood - Co-PI	0.00	0.00	1.00	6,469	
3. Paula Herrera-Siklody - Co-PI	0.00	0.00	1.00	6,383	
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (3) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	2.75	18,727	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (0) UNDERGRADUATE STUDENTS				0	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				18,727	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				4,906	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				23,633	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				1,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				500	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				8,000	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				8,500	
H. TOTAL DIRECT COSTS (A THROUGH G)				33,133	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) H at (Rate: 47.0000, Base: 33133)					
TOTAL INDIRECT COSTS (F&A)				15,573	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				48,706	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 48,706	$
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME: Craig A Ogilvie	FOR NSF USE ONLY — INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET YEAR 2

ORGANIZATION: Iowa State University				FOR NSF USE ONLY	
				PROPOSAL NO.	DURATION (months): Proposed / Granted
PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: Craig A Ogilvie				AWARD NO.	

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Craig A Ogilvie - PI	0.00	0.00	0.75	$ 6,051	$
2. David Atwood - Co-PI	0.00	0.00	1.00	6,663	
3. Paula Herrera-Siklody - Co-PI	0.00	0.00	0.75	4,931	
4.					
5.					
6. (0) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (3) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	2.50	17,645	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (2) UNDERGRADUATE STUDENTS				2,000	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				19,645	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				4,623	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				24,268	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				2,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS					
1. STIPENDS $ 0					
2. TRAVEL 0					
3. SUBSISTENCE 0					
4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				500	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				8,000	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				8,500	
H. TOTAL DIRECT COSTS (A THROUGH G)				34,768	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE) H at (Rate: 47.0000, Base: 34768)					
TOTAL INDIRECT COSTS (F&A)				16,341	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				51,109	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 51,109	$
M. COST SHARING PROPOSED LEVEL $ 0	AGREED LEVEL IF DIFFERENT $				

PI/PD NAME: Craig A Ogilvie	FOR NSF USE ONLY		
	INDIRECT COST RATE VERIFICATION		
ORG. REP. NAME*	Date Checked	Date Of Rate Sheet	Initials - ORG

 *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

SUMMARY PROPOSAL BUDGET — Cumulative

FOR NSF USE ONLY		
PROPOSAL NO.	DURATION (months) Proposed	Granted
AWARD NO.		

ORGANIZATION: **Iowa State University**

PRINCIPAL INVESTIGATOR / PROJECT DIRECTOR: **Craig A Ogilvie**

A. SENIOR PERSONNEL: PI/PD, Co-PI's, Faculty and Other Senior Associates (List each separately with title, A.7. show number in brackets)	NSF Funded Person-months CAL	ACAD	SUMR	Funds Requested By proposer	Funds granted by NSF (if different)
1. Craig A Ogilvie - PI	0.00	0.00	1.50	$ 11,926	$
2. David Atwood - Co-PI	0.00	0.00	2.00	13,132	
3. Paula Herrera-Siklody - Co-PI	0.00	0.00	1.75	11,314	
4.					
5.					
6. ( ) OTHERS (LIST INDIVIDUALLY ON BUDGET JUSTIFICATION PAGE)	0.00	0.00	0.00	0	
7. (3) TOTAL SENIOR PERSONNEL (1 - 6)	0.00	0.00	5.25	36,372	
B. OTHER PERSONNEL (SHOW NUMBERS IN BRACKETS)					
1. (0) POST DOCTORAL ASSOCIATES	0.00	0.00	0.00	0	
2. (0) OTHER PROFESSIONALS (TECHNICIAN, PROGRAMMER, ETC.)	0.00	0.00	0.00	0	
3. (0) GRADUATE STUDENTS				0	
4. (2) UNDERGRADUATE STUDENTS				2,000	
5. (0) SECRETARIAL - CLERICAL (IF CHARGED DIRECTLY)				0	
6. (0) OTHER				0	
TOTAL SALARIES AND WAGES (A + B)				38,372	
C. FRINGE BENEFITS (IF CHARGED AS DIRECT COSTS)				9,529	
TOTAL SALARIES, WAGES AND FRINGE BENEFITS (A + B + C)				47,901	
D. EQUIPMENT (LIST ITEM AND DOLLAR AMOUNT FOR EACH ITEM EXCEEDING $5,000.)					
TOTAL EQUIPMENT				0	
E. TRAVEL 1. DOMESTIC (INCL. CANADA, MEXICO AND U.S. POSSESSIONS)				3,000	
2. FOREIGN				0	
F. PARTICIPANT SUPPORT COSTS 1. STIPENDS $ 0 2. TRAVEL 0 3. SUBSISTENCE 0 4. OTHER 0					
TOTAL NUMBER OF PARTICIPANTS (0) TOTAL PARTICIPANT COSTS				0	
G. OTHER DIRECT COSTS					
1. MATERIALS AND SUPPLIES				1,000	
2. PUBLICATION COSTS/DOCUMENTATION/DISSEMINATION				0	
3. CONSULTANT SERVICES				16,000	
4. COMPUTER SERVICES				0	
5. SUBAWARDS				0	
6. OTHER				0	
TOTAL OTHER DIRECT COSTS				17,000	
H. TOTAL DIRECT COSTS (A THROUGH G)				67,901	
I. INDIRECT COSTS (F&A)(SPECIFY RATE AND BASE)					
TOTAL INDIRECT COSTS (F&A)				31,914	
J. TOTAL DIRECT AND INDIRECT COSTS (H + I)				99,815	
K. RESIDUAL FUNDS (IF FOR FURTHER SUPPORT OF CURRENT PROJECTS SEE GPG II.C.6.j.)				0	
L. AMOUNT OF THIS REQUEST (J) OR (J MINUS K)				$ 99,815	$

M. COST SHARING PROPOSED LEVEL $ 0 AGREED LEVEL IF DIFFERENT $

PI/PD NAME: **Craig A Ogilvie**

ORG. REP. NAME*

FOR NSF USE ONLY		
INDIRECT COST RATE VERIFICATION		
Date Checked	Date Of Rate Sheet	Initials - ORG

C *ELECTRONIC SIGNATURES REQUIRED FOR REVISED BUDGET

The senior personnel have the following major responsibilities in this proposal;

Year 1**, Objective #1:** ***To convert existing complex context-rich problems into the IMMEX environment for online delivery.***

Atwood, Ogilvie, Herrera: iterate with IMMEX team on the conversion of the first few complex problems. After testing these with a focus group of students, convert at least ten problems into IMMEX environment.

Meltzer: Run first test of IMMEX problems with a focus group of students.

Stevens: Consult and review problems as they are converted into IMMEX.

Shelley: Collect evaluation information from project during first year.

Year 1 and 2, **Objective #2:** ***Add rewards to online complex problems to encourage proactive problem-solving steps such as problem categorization, checking-strategies, justification, and reflection.***

Herrera: write links where students enter justifications and reflections. Track usage of these rewards.

Year 2, **Objective #3:** ***To analyze the solution-pathways that students use when solving complex, context-rich problems and to determine changes in student solution strategies as they participate in explicit problem-solving instruction.***

Atwood, Ogilvie, Stevens: Perform first trial of 100 students in one full-semester. Analyze student solution-pathways, categorize these with e.g. IMMEX neural-net tool. Examine whether these strategies change over time.

Herrera: Make changes to IMMEX problems based on first trial feedback.

Meltzer: Compare experimental group of 100 students with comparison group of 400 students on various measures; conceptual diagnostic tests, problem-set scores, exam scores.

Shelley: Complete evaluation of project. Use multiple-sources of information including the above comparison between experimental group, interviews, other data about the student groups.

One note; David Meltzer's appointment at ISU is due to end in mid-2005, so he is listed on this project as a consultant rather than a co-PI. Other items requested are

a) Travel to UCLA for collaboration with IMMEX team for one person per year (Ogilvie/Atwood will alternate) ($400 airfare, $500 hotel, $150 meals = $1000 per trip)
b) In the second year there is an additional travel request of $1000 to an AAPT meeting to present our results.
c) Undergraduate research assistants for analysis of problem-solution pathways @ $10/hour

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **Craig Ogilvie**

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **Relativistic Heavy Ion Collisions**

Source of Support: **DOE**

Total Award Amount: $ **1,710,000** Total Award Period Covered: **11/15/03 - 11/14/06**

Location of Project: **Iowa State University**

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Sumr: **1.25**

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

---

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **David Atwood**

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **Investigation in Experimental and Theoretical High Energy Physics**

Source of Support: **Department of Energy**

Total Award Amount: $ **3,360,000** Total Award Period Covered: **11/01/03 - 10/31/06**

Location of Project: **Iowa State University**

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Sumr: **1.00**

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

 USE ADDITIONAL SHEETS AS NECESSARY

Current and Pending Support

(See GPG Section II.C.2.h for guidance on information to include on this form.)

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: **Paula Herrera-Siklody**

Other agencies (including NSF) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title: **No Other Support**

Source of Support:

Total Award Amount: $ **0** Total Award Period Covered: **01/01/00 - 01/01/00**

Location of Project:

Person-Months Per Year Committed to the Project. Cal: **0.00** Acad: **0.00** Sumr: **0.00**

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Sumr:

Support: ☐ Current ☐ Pending ☐ Submission Planned in Near Future ☐ *Transfer of Support

Project/Proposal Title:

Source of Support:

Total Award Amount: $ Total Award Period Covered:

Location of Project:

Person-Months Per Year Committed to the Project. Cal: Acad: Summ:

*If this project has previously been funded by another agency, please list and furnish information for immediately preceding funding period.

Ski Jump

You have landed a summer job with a company that has been given the contract to design the ski jump for the next Winter Olympics. The track is coated with snow which slopes downwards at an angle of 20^o from the horizontal. A skier zips down the ski jump ramp so that he/she leaves it at high speed. The winner is the person who jumps the farthest after leaving the end of the ramp. Your boss tells you to determine the maximum safe height of the starting gate above the end of the ramp which will determine the mechanical structure of the ski jump facility. You have 24 hours to tell him the height so that the group can proceed with the rest of the design.

Information Links

1) Data
   a) Static coefficient of friction between skis and snow [2 hour]
      - The coefficient of static friction is in the range $0.0500 \leq \mu \leq 0.1000$.

   b) Kinetic Coefficient of friction between skis and snow [2 hour]
      - The coefficient of kinetic friction is in the range $0.0200 \leq \mu \leq 0.0300$.

   c) Acceleration of gravity at the resort to 6 figures [2 hour]
      - $g=9.79609$ m/s^2 at the resort.

   d) Speed at which skiers leave starting gate [2 hour]
      - The speed at which the skier leaves the starting gate is 2m/s.

   e) Safety standards for ski jumps [2 hour]
      - The velocity component of the skier perpendicular to the landing surface should not exceed 7m/s.

   f) Mass of Skiers [2 hour]
      - You should assume that skiers can have a mass in the range 60kg≤M≤120kg

   g) Temperature range for resort [2 hour]
      - The temperature range at the ski resort is –10°C≤T≤-1°C

   h) Ask your boss about air resistance [2 hour]
      - Your boss suggests that the cautious assumption would be to suppose that air resistance is negligible.

2) Physical Laws
   a) Constant Acceleration Formulae [3 hour]

$$\vec{r} = \vec{r}_0 + \vec{v}_0 t + \tfrac{1}{2}\vec{a}t^2$$
$$\vec{v} = \vec{v}_0 + \vec{a}t$$
$$v^2 = v_0^2 + 2\vec{a}\cdot(\vec{r} - \vec{r}_0)$$
$$v_x^2 = v_{0x}^2 + 2a_x \cdot (x - x_0)$$

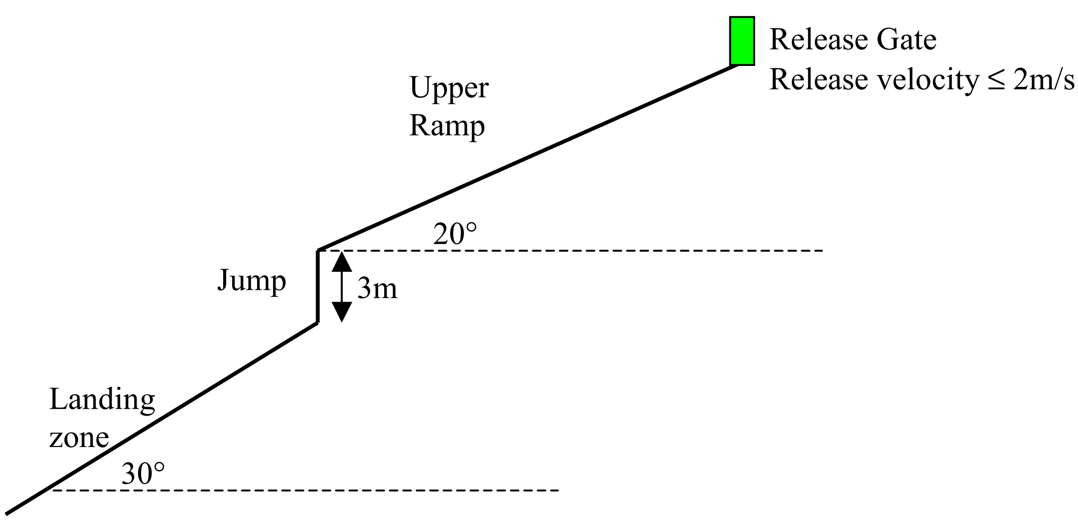
b) Conservation of Energy [3 hour]
- The total energy of a closed system does not change during any physical process. Friction converts mechanical energy into heat.

c) Work Energy Theorem [3 hour]
- The change in kinetic energy of a system is equal to the work done on that system. The work done by a constant force is $W = \vec{F}\cdot\Delta\vec{r}$.

d) Newton's Three Laws [3 hour]
- An object moves at a constant velocity unless acted on by a force
- The force acting on an object is mass times acceleration: $\vec{F} = m\vec{a}$.
- If object A exerts a force on object B then object B exerts an equal and opposite force on object A.

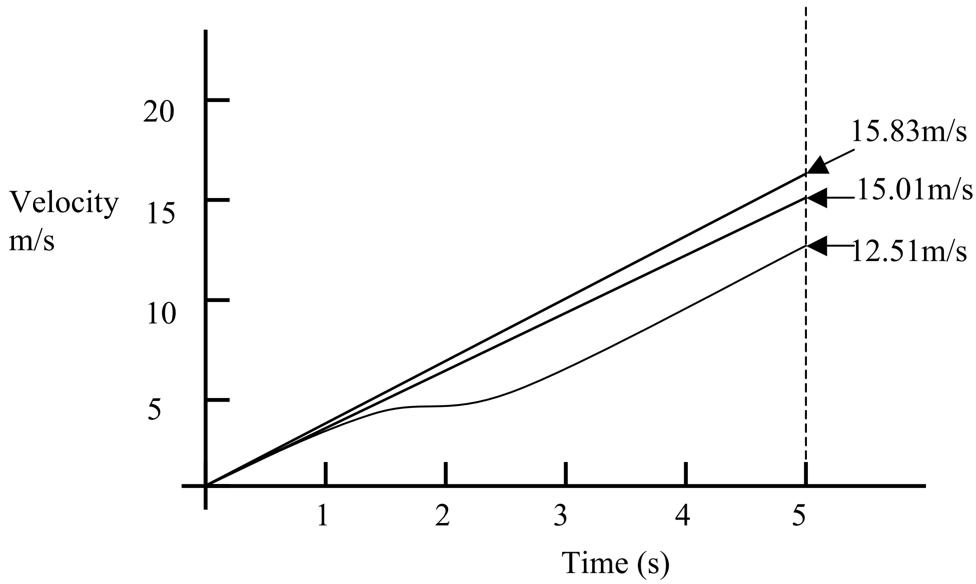
3) Diagrams

a) Sketch of the ski jump [4 hours]

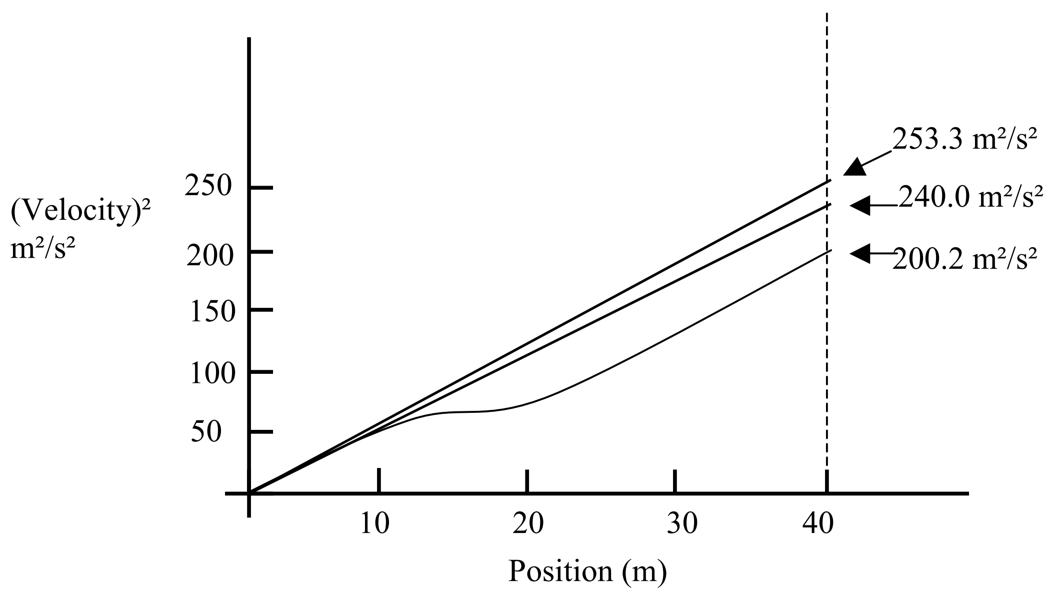


b) Empirical velocity versus time curves for skiers on ramp [4 hours]

- Three professional skiers were clocked going down a snow ram similar to the one above the ski jump. Below is are the velocity versus time curves for these runs. The best of these skiers should be about as good as Olympic class ski jumpers.



c) Empirical velocity squared versus position curves for skiers on ramp [4 hours]

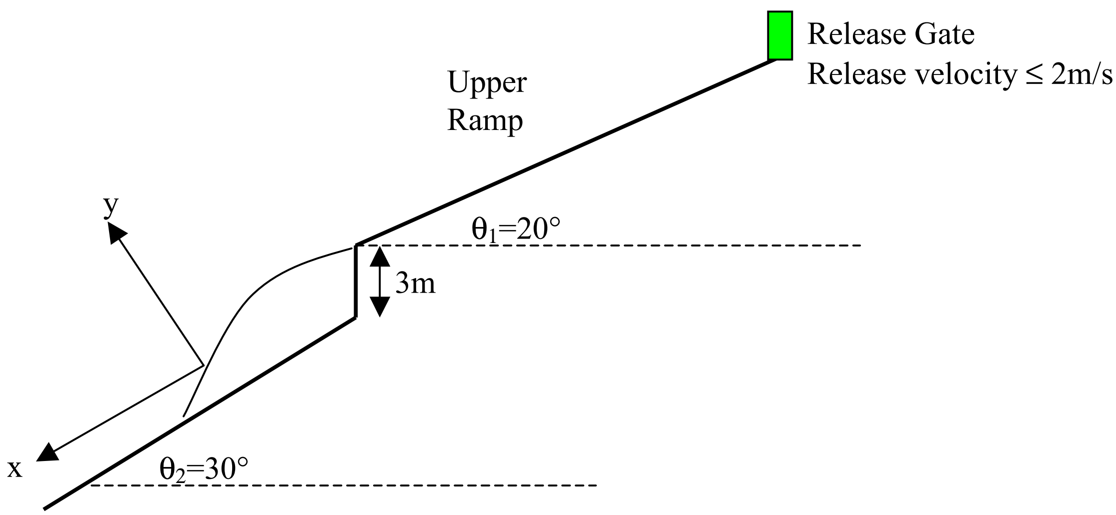


4) Hints
   a) Suggested setup [5 hours]
      - First determine the maximum velocity at which the skier can leave the ramp and then determine how high above the ramp he must be released to reach that velocity.

   b) Suggested Coordinate Systems [5 hours]
      - For analyzing the trajectory after the jump, use a coordinate system with the x-axis parallel to the slope in the landing zone. For the motion on the upper ramp, use a coordinate system with the x-axis parallel to the upper ramp.

Solution

First, let us determine the maximum velocity which the jumper can leave the gate without violating the safety condition. To do this, let us adopt a coordinate system with the x-axis parallel to the slope below the jump.



According to the safety specifications, $v_y \le v_{y\,\max} = 10m/s$. In the critical case where $v_y = v_{y\,\max}$, since we are assuming air resistance can be neglected, we can use constant velocity formalism.

Setting this up as a constant acceleration problem, the acceleration in the y direction is $a_y = -g\cos\theta_2$ while the displacement of the jump point above the landing slope is $\Delta y = h\cos\theta_2$. The vertical component of the skier at the jump in the critical case is given by:

$$
\begin{aligned}
v_{y\ jump}^2 &= v_{y\,\max}^2 - 2\Delta y\ a_y \\
&= v_{y\,\max}^2 - 2gh\cos^2\theta_2 \\
v_{y\ jump} &= \sqrt{v_{y\,\max}^2 - 2gh\cos^2\theta_2}
\end{aligned}
$$

The initial vertical component must be positive since $\theta_1 < \theta_2$.

When the skier leaves the jump, he/she is moving at an angle of $\theta_2 - \theta_1$ and will have a vertical component in our coordinate system of

$$v_{jump} = v_{y\ jump} / \sin(\theta_2 - \theta_1)$$
$$= \frac{\sqrt{v_{y\max}^2 - 2gh\cos^2\theta_2}}{\sin(\theta_2 - \theta_1)}$$

To determine the release point, let us now use a coordinate system for the upper ramp which is parallel to that ramp. At the point of the jump, the kinetic energy of the skier is

$$K_{jump} = \frac{1}{2} m v_{jump}^2 = \frac{1}{2} m \frac{v_{y\max}^2 - 2gh\cos^2\theta_2}{\sin^2(\theta_2 - \theta_1)}$$

if L is the length of the ramp above the jump then

$$K_{jump} = K_{gate} + F_x L$$

Where F_x is the force parallel to the ramp. The length of the ramp is thus given by

$$L = \frac{K_{jump} - K_{gate}}{F_x}$$

where $F_x = mg(\sin\theta_1 - \mu_k \cos\theta_1)$. Thus,

$$L = \frac{v_{jump}^2 - v_{gate}^2}{2g(\sin\theta_1 - \mu_k \cos\theta_1)}$$

Substituting in the numbers, we find

$$v_{jump} = \frac{\sqrt{v_{y\max}^2 - 2gh\cos^2\theta_2}}{\sin(\theta_2 - \theta_1)} = \frac{\sqrt{(7m/s)^2 - 2(9.796m/s^2)(3m)\cos^2 30^O}}{\sin(10^O)}$$
$$= 12.77m/s$$

From this we get the maximum length of the ramp above the jump where we take the coefficient of kinetic friction at its lower range to be cautious:

$$L = \frac{v_{jump}^2 - v_{gate}^2}{2g(\sin\theta_1 - \mu_k \cos\theta_1)} = \frac{(12.77m/s)^2 - (2m/s)^2}{2(9.795m/s^2)(\sin 20^O - (0.0200)\cos 20^O)} = 25.1m$$

UNIVERSITY OF CALIFORNIA, LOS ANGELES **UCLA**

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO SANTA BARBARA • SANTA CRUZ

IMMEX Software Development Labs
5601 W. SLAUSON AVENUE
SUITE 255
CULVER CITY, CALIFORNIA 90230
PHONE: 310-649-6568 FAX: 310-649-6591

November 27, 2004

To Whom It May Concern:

I am pleased to be an external consultant on Dr. Ogilvie's CCLI proposal to incorporate his library of existing complex, context-rich, university-level physics problems into the IMMEX problem-solving software environment, and to begin to model the strategies students use to solve these problems.

Dr. Ogilvie and I have discussed the design formats and technical requirements of both the existing problem sets and the IMMEX software and it would appear that there is a natural synergy of the projects here. I do not foresee any major difficulties in converting the problems into a web-based format and integrating them into the IMMEX data system. The proposed number of students participating in his courses should be sufficient to ensure the generation and revision of valid performance models.

Our existing web-based training materials should allow the local generation of sample problem sets that can then be pre-tested by our staff at IMMEX. During this period it may be useful for Dr. Ogilvie and a member of his team to visit IMMEX to learning the details of the problem packaging, staging and the mechanics of accessing the student performance data. Later in the project when sufficient performances have been collected and the data analysis begins we can use Net Meeting or similar software to discuss and refine the general performance models.

I look forward to establishing this collaboration.

Sincerely,

Ronald H. Stevens, Ph.D.
Professor of Microbiology, UCLA
Director of The IMMEX Project (http://www.immex.ucla.edu)