# CaFD

Winter1994/5

Curriculum and Faculty Development Newsletter for Two-Year College Physics Teachers

*Part of a workshop project*

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## Other Workshop Curricula

**Priscilla Laws**
**Dickinson College**
**Carlisle, PA**

I am often asked by college level mathematics, chemistry and biology instructors who want to give up lecturing if there are curricula like Workshop Physics that they can use in their own teaching. Among the many new curricula under development in the sciences, several are surprisingly similar to Workshop Physics. Although I have chosen to report on these, I do so with the caveat that there may be other equally worthy projects that I don't know about.

As a result of major funding from the National Science Foundation to reform introductory calculus, many calculus courses are now using computer algebra systems such as Maple or Mathematica to augment standard lectures and as the primary tool in new weekly computer laboratory sessions.

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## SIP: Special Intensive Program

### *A New Interdisciplinary Team-Teaching Approach to Physics and Calculus for Physics and Engineering Majors*

**Oshri Karmon**
**Diablo Valley College**
**Pleasant Hill, CA**

### *Introduction*

I and David Johnson from the math department at Diablo Valley College (DVC) have created the Special Intensive Program (SIP) for physics and engineering majors at DVC. This program is supported by a three year FIPSE grant and it is currently in its third year.

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## Developing Conceptual Exercises

**David Maloney**
**Indiana-Purdue University**
**Fort Wayne, Indiana**

As an instructor for general physics one of the questions that occurs to me as I read the reports of research in physics education is: How do I use this new information to help me teach my course? One thing the results seem to be indicating strongly is that it is critical to get the students actively wrestling with the concepts, principles and relations. So I wonder what kind of tasks and exercises I might design to fit into my course. How do I go about developing exercises that have a conceptual focus and are productive for my students? How do I know if the exercises I develop are useful for the students?

These are some of the questions that I think many physics instructors are asking themselves these days. I would like to offer some ideas for how to develop conceptual exercises. Since each instructor has a unique perspective, there are probably as many conceptual exercises for any topic or issue as there are instructors teaching general physics.

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### *Inside...*



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*Digital Electronic Systems in Intro Physics..............................................*
*Problem Schemata............................*
*New ULI and 4.5 Software................*
*and much more-*

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Although there are many shared elements in our understanding of physics we have each constructed our own particular perspective. It is important to realize that our students are constructing their understanding in the context that we create. We all deal strongly with Newton's second law, but how we do so is different for each of us. There is no right way to explore this principle. So, the particular context in which the students encounter a topic in our courses is an important factor in how they learn the material. We want them to learn the concepts (I will use the term concept as a general descriptor for ideas, principles, relations, etc.) well enough that they can use it in a variety of situations, but we need to be aware that they will start to build their understanding with the context we set up in the course.

Consequently, any conceptual exercises we use have to be consistent with our understanding of the physics and the way in which we present the topic. That means it is critical that we be comfortable with any task or assignment we give the students. The implication of this realization is that we may need to modify a task or exercise that someone else has developed, or even take the basic idea and recast it in a form that is appropriate for our course. But any task we use has to fit our unique perspective and approach.

A very reasonable first question is: What is a conceptual exercise (CE)? We would all probably define this term in different ways, and there is no one correct definition. Rather than trying to come up with a specific definition let's try to identify a set of characteristics that conceptual exercises should possess. Not all CE's will have all of these characteristics, but any CE will probably have several of these characteristics. A conceptual exercise should:

- require qualitative means for its solution, i.e. it can not be solved by plugging numbers into an equation
- be of an appropriate "size" so that students believe they can productively work on the exercise
- focus on one, or two, aspects of a concept in a particular context
- elicit students' natural ideas about the concept in that context
- elicit different responses from different students comparing physics contexts and ideas to everyday contexts and ideas
- use multiple representations
- not be answerable simply by pulling something from memory

I would argue that conceptual exercises can involve numbers, BUT as indicated above the task cannot be solved by plugging the numbers into an equation and finding a numerical value. I

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BASEBALL ON THE MOON USUL II

You are stuck on Usul, an atmosphereless moon of the planet Arrakis. You knew that you would get bored with the scientific measurements so you packed a baseball and bat. With the bat you hit a fly ball. The ball is shown at four instants along part of its trajectory in the picture below. A velocity space grid for drawing velocity vectors is superimposed at each of the four ball locations. Use a straight edge to draw neat , accurate velocity vectors at 2 s, 4 s, and 5 s. Also, write in the box the value of free fall acceleration at the surface of Usul.

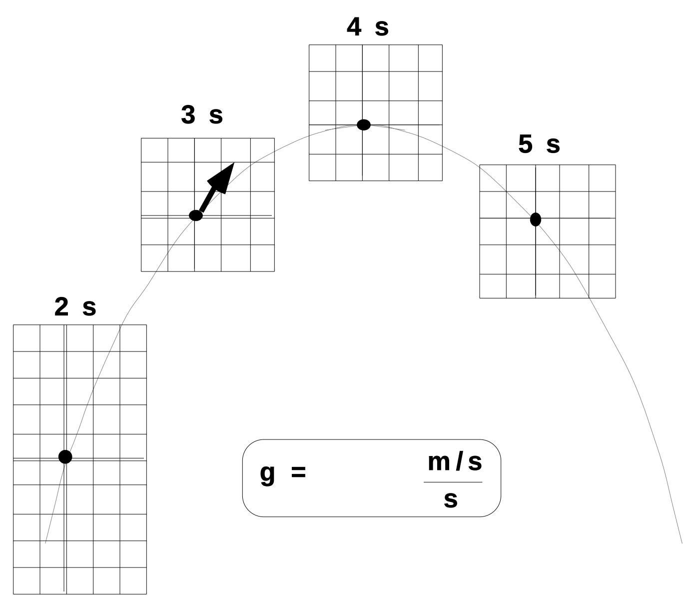


Figure 1 Conceptual Exercise developed by Dennis Albers of Columbia College

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would also argue that a specific numerical value can be the goal of a conceptual exercise, but the value must be found by some method other than an equation, I will give an example of this approach a little later.

I like to think of two categories of CE's, uniform format and unique format. Uniform format exercises all have the same basic structure. This is useful since it takes students some time to learn how to respond to an unfamiliar task format and this adjustment only has to be done once for these tasks. One disadvantage of this approach is that there is a limited number of formats that can be used in all topic domains of physics. A second disadvantage is that students can develop algorithmic, i.e. plug and chug, procedures for dealing with one format. Unique CE's have formats that fit the particular situation for that concept or topic. They have the advantage that they cannot be done in a plug and chug manner, but the corresponding disadvantage is that they can require time for the students to determine what they are to do.

Ideas for uniform format exercises include such things as: ranking tasks, what, if anything, is wrong items, meaningful/meaningless calculations, graphical tasks, trouble shooting tasks, and jeopardy problems. These formats can all be used in any topic area of physics. The items can be varied in a number of ways to make items more or less difficult. Once an instructor develops a little experience with a format it is relatively easy to generate new items. The list above is not meant to be exhaustive since there are other formats that can be used in all topic areas.

CE's which vary in format cannot be as easily identified and/or described. Rather than try, let's just look at several examples and then consider some ideas for how to develop CE's. I mentioned above that CE's could have a numerical value as the goal. A nice example of such an item comes from Dennis Albers of Columbia College, see Figure 1. This item is still a CE because the method for finding the value is conceptual. Determining the acceleration due to gravity from the given information requires the student to decompose the velocity vector into horizontal and vertical components, realize that 1 second later the ball will be at the top of its path so its vertical velocity will be zero at that point, and consequently determine the velocity change for the 1 second interval.

A second example of a unique CE format is one developed by Greg Fazzari of Walla Walla Community College, see Figure 2. Actually Greg has developed a very nice sequence of exercises on basic thermodynamics. The item selected here is well along into the sequence, and involves three different representations- verbal, diagrammatic, and graphical. In addition it involves work and internal energy. The sequence Greg has developed should enable many students to construct a strong understanding of the relevant concepts.

As a third example of a unique format exercise consider the item on the next page in Figure 3, where the students are given the emerging rays from a lens and they have to determine what kind of lens it is. To solve this task the student has to recognize the pattern of emerging rays in order to relate that pattern to a specific type of lens. If they haven't paid attention to the patterns of rays for the different lenses they would

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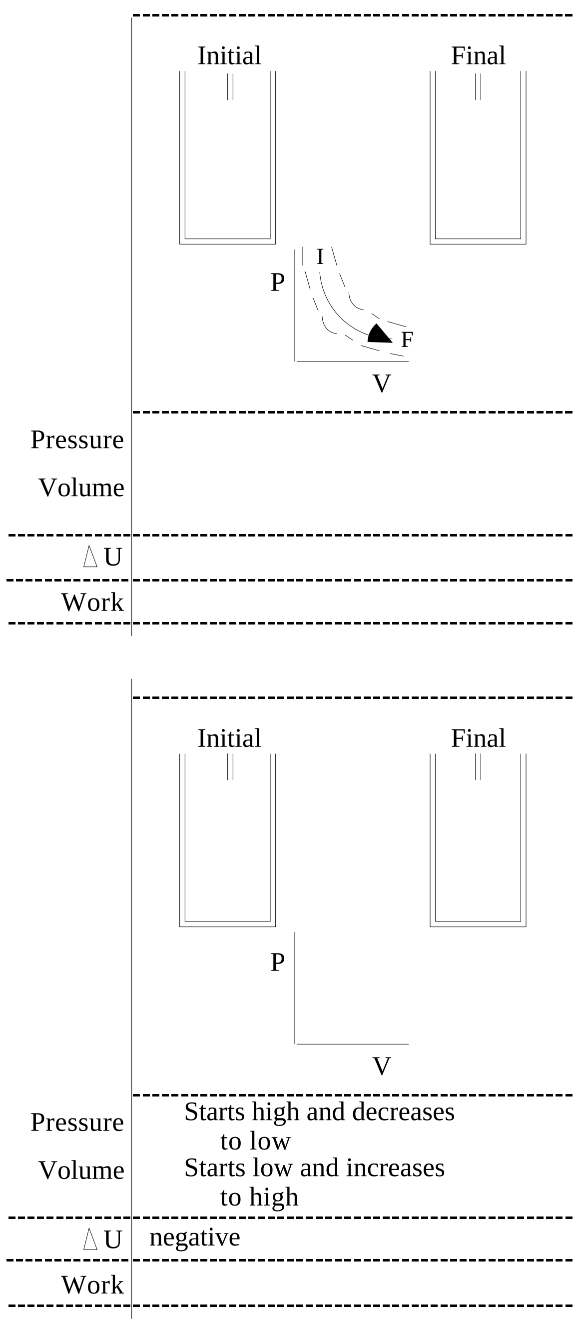


Figure 2
A series of Conceptual Exercises developed by Greg Fazzari of Walla Walla Community College. Students must draw PV graphs, and piston position and fill in blanks relating to pressure, volume, etc.

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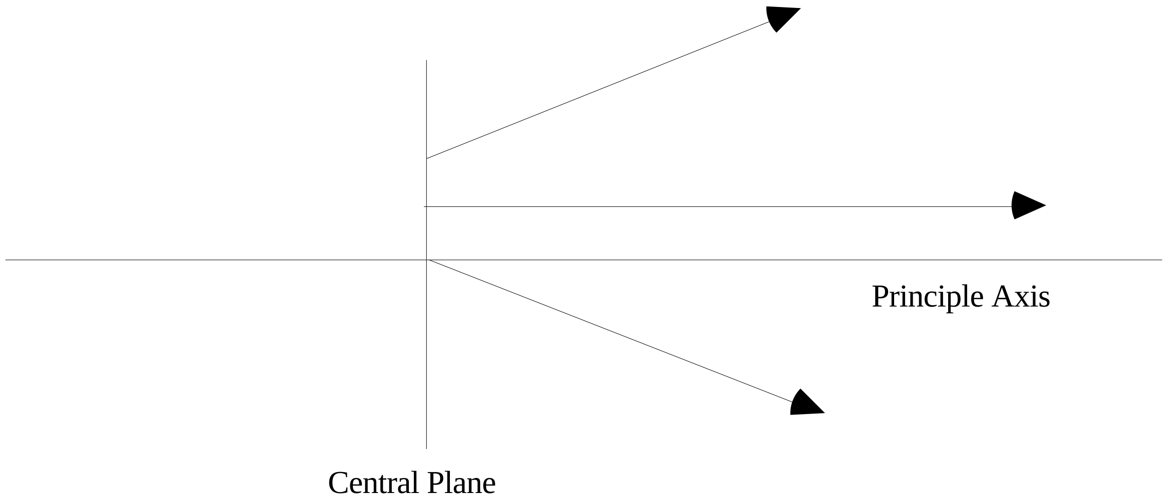


Figure 3
Conceptual Exercise using the emerging rays thru a lens to determine the type of lens

have to either go back and draw the four basic cases (converging lens - object inside and outside of the focal point, diverging lens - object inside and outside of the focal point) or realize that for a diverging lens the ray farthest from the principal axis will always be bent away from the axis. This exercise requires the student to work with the ray diagram representation in a different way. Consequently, their understanding of the representation, and hopefully the physical system, can be strengthened.

How can instructors develop conceptual exercises? There are several things that are useful for instructors to look for and think about. Representations are often productive items for developing CE's. As we have just seen the third example above uses the ray diagram representation in a different way. Translating among representations, and relating representations to other aspects of the physics are two good areas for developing exercises.

A second area that can be productive to explore is that of alternative conceptions. Research findings about conceptions students are likely to bring with them to the study of physics are frequently fruitful sources of ideas for conceptual exercises. Setting up a task in which students have to make a prediction, using their natural ideas rather than any memorized physics knowledge, about how a system behaves is often productive. Such tasks often elicit different responses from different students so the students are confronted with defending their own ideas while trying to show that the other ideas being proposed won't work.

A third area that can usually provide ideas for CE's is procedural knowledge. That is, conditions for application and limitations on application of concepts, principles and relations are frequently productive aspects to treat in CE's, especially since these aspects are often treated implicitly in our courses. An example of the condition for application aspect is the question of when do you use Newton's second law in a problem and when conservation of energy? Alan Van Heuvelen's technique of going over a variety of problems looking for cues to what principle and concepts to apply is an excellent example of an exercise in this area. Exercises dealing with the limitations on application of a concept or principle can range from straightforward questions of why can't we use one half of the initial plus final speed to find the average speed when the object's acceleration is changing to less direct tasks.

There are many other ways to develop CE's. In one sense how we develop the exercises is not all that important. The truly important thing is how effective the exercises are in helping students

**“The truly important thing is how effective the exercises are in helping students learn the physics.”**

learn the physics. From that perspective I would argue that it is critical to design your CE and then try it out with your students. Next, CAREFULLY STUDY YOUR STUDENTS’ RESPONSES, AND THEN REVISE THE TASK, IF NECESSARY TO MAKE IT MORE EFFECTIVE. This effort to monitor how the students are interpreting and working the CE is vital to producing good conceptual exercises.

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*SIP* is designed to:

- articulate curricula content between the physics and mathematics departments and develop a unified approach to physics and calculus education;
- increase the number of students, including underrepresented minority students and women, who transfer to four year universities in science and engineering, and increase the probability that such students will successfully complete their degrees; and
- be of generic design so that it can be easily adopted by other community colleges and universities.

Diablo Valley College (DVC) is a California Community College located 25 miles northeast of San Francisco in the city of Pleasant Hill. DVC is one of three colleges in the Contra Costa Community College District and serves central Contra Costa County. Approximately 23,000 students attend DVC, of which 28% are minorities and 55% are women. DVC has an excellent reputation for preparing students in the areas of science, mathematics and engineering and an outstanding record for transferring students to the University of California and the California State University system.

All physics and engineering students at DVC are required to complete sequences in physics and calculus. These sequences present a major hurdle to beginning students. The completion rate in first semester physics and calculus at DVC is approximately 60%. This rate is even lower for women and minorities. We designed a sequence of courses that interrelate the calculus and physics topics required by physics and engineering students. For one year students attend block-courses that combine calculus and physics, rather than separate courses. Physics and math instructors team-teach each course in so that the two subjects complement and reinforce each other. The sequencing of topics have been altered so that the two subjects mesh. Physics is used to illustrate concepts from calculus and calculus is used as a tool in physics. A new introductory physics course was created as part of the first semester of the block-program.

## Specific problem areas

We identified three problem areas which contribute to the high student attrition rate in physics and calculus courses at DVC:

- **Lack of Preparation for the Engineering Physics Sequence**

Community colleges have an "open door policy", which means that all willing students are accepted. This policy implies that incoming student's preparations may vary greatly. SIP concentrates on students who are considering careers in engineering and physics. These students constitute a self selected group. They have worked their way through math courses up to first semester calculus, yet many students have not had high school physics, or have a weak physics background. They need a preparatory physics course before attempting the engineering physics. This problem was recognized by Swartz who instituted a preparatory physics class for incoming science and engineering students at Stony Brook. He discovered that with the added preparatory physics course, the retention and success rate of science and engineering students is higher, especially for underrepresented minorities.

- **Lack of coordination between physics and calculus**

Traditionally, calculus and physics are taught by two separate departments in a way that de-emphasizes their inherent interconnectedness. In general there is little interaction between the math and physics departments, and most instructors are not familiar with the subject matter as taught by the other department. The result is that although engineering students must take calculus and physics, the sequencing of topics in calculus is chosen with little regard to the specific needs of those students. This problem was recognized by Hundhausen and Yeatts of the Colorado School of Mines who integrated the first semester of the engineering physics sequence with Calculus I and II. They reported improved retention and success rate for their students.

- **Lack of support networks**

Community college students are in a transitional state compared to the stable student population of the four year schools. They do not live on campus, and do not have the "campus life" experience. As a result many of them become loners. The community college transfer student is usually a loner who is unaware of the value of study groups. At the university they encounter increased competition, higher expectations and isolation. Many physics and engineering students who transfer from a community college to a four-year institution fail to make the necessary adjustments. Approximately one-third of all community college students in engineering fail to complete their major after transferring to the University of California at Berkeley. The importance and the support of study groups for science and engineering students, and particularly for underrepresented minorities, has been well documented by Triesman. He found that successful Berkeley science students tended to belong to study groups, and that unsuc-

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cessful ones did not.

### The components of SIP

Community college students are different than students at four year institutions. They are preparing to transfer and their needs depend on their transfer status. Commitment and continuity is not always possible for community college students. Any curricula change must be flexible to accommodate their variable needs yet not affect existing articulation agreements with four year institutions. To provide this flexibility we designed *SIP* in modular two semesters format which may be taken sequentially or separately. The following are the three major components of *SIP*:

**1. A new introductory physics course**

About 20% of the community college students who would like to take the engineering physics sequence did not have physics in high school. The only available option for these students is a “conceptual physics” course, which does a woefully inadequate job of preparing students for the rigors of engineering physics. *SIP* designed a new course, “Introduction to Engineering Physics” to specifically prepare students for the engineering physics program. This preparatory course addresses students who are exploring career options in engineering or physics. The only prerequisites are pre-

**“physics topics are arranged to take advantage of the essential concepts from calculus”**

calculus and little or no physics and it is taught concurrently with first semester calculus. The physics topics are arranged to take advantage of the essential concepts from calculus as soon as they are introduced. This early infusion of calculus into the physics curriculum emphasizes the inherent interconnectedness of the two subjects, and provides the students with a stronger background when they start the engineering physics sequence.

The introductory physics course is not a new invention but rather a composite of successful physics education research findings. I attended several TYC Physics Workshops where results of education theory and research have been embodied in three effective methods of physics instruction:

**MBL-** interactive micro computer based labs by Laws and Thornton

**OCS-** overview and case studies, from conceptual understanding to expert problem solving techniques by Van Huevelen

**CL-** study group collaborative learning dynamics by Heller.

The introductory course topics are: Geometrical Optics, Waves, Forces and Statics, Kinematics, Dynamics, Electricity, Atomic Structure, Fluid Statics and Heat. The course is based on collaborative and interactive learning models. The subject matter is presented in mini-lecture format (Heiggelke) at the end of which the class is divided into groups of three ( Manager, Recorder and Skeptic). The students collaborate on short context-rich problems. ALPS are used extensively with a “Spiral approach” beginning with an overview, concept building through different representations and up to advanced problem solving techniques in “case studies”. Collaborative work is submitted and graded in groups, which makes the grading task more manageable. Even quizzes are taken in groups. The course incorporates interactive computer labs (MBLs) and traditional physics labs.

Other course features are :

- Difficult concepts are visualized with the “Mechanical Universe” videos from Cal Tech which provide very effective computerized animations.
- MathCad is utilized for computerized problem solving and graphing. It is found useful for parameter changes and answering questions of “What if...”
- Students can explore the rigor of engineering physics while keeping their option of changing to another major without academic penalty.
- Assessment and evaluation are integrated into the course. Formative classroom assessment measures, such as CATS by Pat Cross and the Force Concept Inventory pretest, and summative measures such as success in grades and Force Concept Inventory post-test are employed to assess the success of the course.

- The course incorporates enrichment activities such as field trips to local research labs and speakers from local engineering firms.

**2. Team-teaching of physics and calculus**

We designed a sequence of courses that interrelates calculus and physics topics required by physics and engineering students. For one year, students attend block-courses that combine calculus and physics. Two instructors, a mathematician and a physicist, team-teach the courses in such a way that the two subjects complement and reinforce each other.

**First Semester:**

The aforementioned “Introduction to Engineering Physics” course is team taught with first semester calculus. Physics topics are co-

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ordinated with important areas from calculus as they are developed. At times, physics is used to illustrate concepts from calculus. For example, a discussion of static versus kinetic friction is used to illustrate and reinforce the concepts of the limit and continuity. At other times, calculus is used as a tool in physics. For example, the standard calculus discussion of the use of the differential in error approximation have been moved to an earlier point in the course, so that this concept can be employed in physics labs.

**Second semester:**
The third semester calculus is team taught with first semester physics (mechanics). The traditional mathematics prerequisite to first semester physics is first semester calculus, even though mechanics uses third semester calculus material. We found that Calculus II (vector calculus) and Calculus III (advanced integral calculus and Taylor series) are essentially modular courses. Each makes extensive use of Calculus I (differential and introduction to integral calculus), but neither makes significant use of the other. This rearrangement, coupled with the team-teaching approach, ensures that the necessary calculus topics are in place concurrent to their utilization in physics, yet it is not so extensive that the use of existing text books is precluded.

The block-course meets for two hours daily and four hours on Fridays. The first hour is calculus and the second is physics and Friday afternoon is a three hours physics lab. The students attend mandatory study groups which meet twice a week for two hours. The study groups are composed of five to seven students and one facilitator. The facilitator is an upper division physics or engineering student. Every other week the block-course holds an interdisciplinary workshop where interrelated topics and issues are presented and discussed.

### 3. A student support network
Mandatory collaborative study groups are at the heart of *SIP*. The study groups are led by "facilitators", upper division physics and engineering students from the University of California at Berkeley, some of whom are minority students from Berkeley's Minority Engineering Program, and others are DVC graduates. The facilitators are in the unique position of being able to relate to the DVC students what life is like at a competitive school like Berkeley and to discuss with them the study skills and survival skills that are necessary there. Thus, they served as both mentors and role models, in addition to being study group facilitators.

The collaborative study group provides the support structure necessitated by the demands of the program itself. The group facilitators are successful university students who are close in age to DVC students, and they are readily available to help the students. This creates a sense of security and belonging at a point where beginning students are questioning their abilities. The study groups create a cohesive group, a nurturing and supportive atmosphere, and a commitment to excellence. Students who graduated from our program and transferred to their universities report that they continue to participate in study groups and that they find them to be irreplaceable.

## The impact of SIP
We have been developing *SIP* for over two years. The "Force Concept Inventory" test was administered to the introductory physics level SIP students with the following results:

Pretest: 35% Post-test: 58%

The average success rates (a grade above C) for both years are given below:

| Success Rate | SIP | Traditional |
|---|---|---|
| **1st semester** | | |
| Calculus I | 65% | 55% |
| Introductory Physics | 78% | 60% |
| **2nd semester** | | |
| Calculus II | 75% | 62% |
| Physics I (mechanics) | 90% | 63% |

It is interesting to note the significant gains in physics compared with calculus. Though SIP is an interdisciplinary, team-taught project, the calculus portion is being taught in a traditional lecture mode while the physics uses collaborative learning techniques.

The project follow-up on graduating students indicates that 85% of the graduates of our programs' first year have transferred in engineering or physics to four year universities and are doing well. The graduates of our programs' second year have performed quite well: 90% of those who took the following engineering physics course (E&M) passed it compared with 76% of the traditional students.

**"85% of the graduates of our programs' first year have transferred in engineering or physics to four year universities and are doing well."**

In conclusion it was found that *SIP* positively increased both success rate of students in the lower division physics and calculus sequences at DVC and the success rate of DVC

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Although most mathematics instructors are still lecturing, there are two activity-based projects that use comprehensive computer tools to enhance student learning. These include:

***Project CALC***
**Duke University**
**David Smith and Leonard Moore**

Recently D.C. Heath has published this curriculum which replaces lectures in introductory calculus courses with computer-based activities based on real-world examples to motivate students to learn essential calculus concepts. The curriculum moves fluidly back and forth between concepts in integral and differential calculus instead of doing integral calculus after differential calculus. Computer tools include MBL tools for the measurement of motion and temperatures and computer algebra tools. (Instructors can choose either Mathematica or Maple).

***Workshop Mathematics***
**Dickinson College**
**Nancy Baxter, Allan Rossman, and P. Laws**

Instead of attending lectures Workshop Mathematics students work collaboratively on specially designed tasks using Activity Guides. Guides have been developed for four courses: Quantitative Reasoning, Statistics, and Calculus with Review I and II. Computer Tools include spreadsheets, Minitab, ISETL, and a computer algebra system (Mathematica, Maple, or Derive). Use is also being made of MBL tools to help with teaching function concepts. These materials also emphasize the use of real world applications and genuine data to enhance motivation, illuminate concepts, and enable students to use mathematics in other disciplines.

All of these courses have been designed as gateway courses to the further study of mathematics. For example a student completing calculus with Review I and II can enroll in the second semester of an introductory calculus course sequence. Springer-Verlag has arranged to publish the Activity Guides for all of the Workshop Mathematics courses. This program has been funded by the FIPSE Program, NSF, and the Knight Foundation.

In chemistry, I also want to mention two projects:

***Discovery Chemistry***
**College of the Holy Cross**
**Mauri Ditzler and Robert Ricci**

The essence of the discovery chemistry approach is to have the students discover the basic concepts of chemistry through lab work and classroom discussions.This curriculum involves a four semester sequence that includes courses entitled: atoms and molecules, Organic Chemistry I, Organic Chemistry II, and Introduction to Biophysical Chemistry.

The courses and a new laboratory environment were developed with funding from NSF, the Pew Charitable Trust, the Keck Foundation, the Kresge Foundation, and the Hewlett-Mellon Foundation. It has undergone five years of classroom testing. Large and small group discussions are held which are based on the students' experimental results and hypotheses. During the laboratory periods students often gather for group discussions involving experiment planning and data interpretation. Extensive use is made of modern instrumentation and computer-based data analysis tools.

***Bench Chemistry***
**Dickinson College**
**Nancy Devino and Cindy Samet**

This one semester course introduces students to key elements of chemistry. It is intended to start students into an entirely new chemistry curriculum in which conventional courses such as organic chemistry and physical chemistry are disbanded in favor of courses organized around chemical concepts such as reactions and energetics. Like the Workshop Physics and Workshop Mathematics courses, Bench Chem involves collaborative learning using direct experimentation enhanced by computer-based data analysis tools. Although the program is only in its second year, a laboratory guide has been written to support the program.

There are two exemplary biology programs that use activity-based instruction. These projects have also received substantial funding from a number of sources.

***Workshop Biology***
**University of Oregon**
**Daniel Udovic**

***Project Bioquest***
**Beloit College**
**John Jungck**

If someone is interested in exploring these approaches further, one should write to one of the individuals involved and request more information.

*Editor's Note:*
There are several community college projects that are developing and implementating approaches that integrate math and physics. They can be found for example in California at Diablo Valley College (see article on SIP), by Nick Nicholson at Central Alabama CC, and by Tony Zito and Wes Ostertag at Dutchess CC in New York.

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# APPLICATION OF MBL TO UNDERGRADUATE RESEARCH----NONLINEAR OSCILLATION STUDY

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**Bradenton, FL 34207**

## *MOTIVATION*

MBL has achieved great success in regular physics class and lab curriculum. The new technology feature of MBL makes the physics learning environment more attractive, which will enhance the students interest. Nevertheless, the application of MBL to undergraduate research projects still needs to be explored.

In this article, we applied MBL to studying the nonlinear oscillation of a pendulum in a calculus-based physics course. A photogate system in MBL is used to measure the period of nonlinear oscillation of the pendulum. MathCad Software is used to calculate numerical results of the oscillation period. Our study shows that the photogate system in MBL produces accurate data which matches well with the results of our numerical calculations. Additionally, students strengthen their backgrounds in calculus application, computerized laboratory techniques, and analytical thinking skills.

## *THEORY AND NUMERICAL CALCULATION*

When the angle of the oscillation of a simple pendulum is large, the period $T$ depends on initial angle. We can find the integral expression of the period from the energy conservation equation:

$$\frac{1}{2}L^2\left(\frac{d\theta}{dt}\right)^2 + mgL(1-\cos\theta) = mgL(1-\cos\theta_0) \quad (1)$$

where $g$ is the gravitational acceleration, $L$ is the length of the pendulum which is fixed at one meter for convenience in our calculation and measurement, and $\theta_0$ is the initial angle from which the pendulum is released from rest (see Fig.1). From equation (1), the period of a nonlinear pendulum $T_{non}$ can be written in an integral formula:

$$T_{non} = T_0\frac{\sqrt{2}}{\pi}\int_0^{\theta_0}\frac{d\theta}{\sqrt{\cos\theta-\cos\theta_0}} \quad (2)$$

where

$$T_0 = 2\pi\sqrt{\frac{L}{g}}$$

is the period of a linear oscillation(when $\theta$ is small).

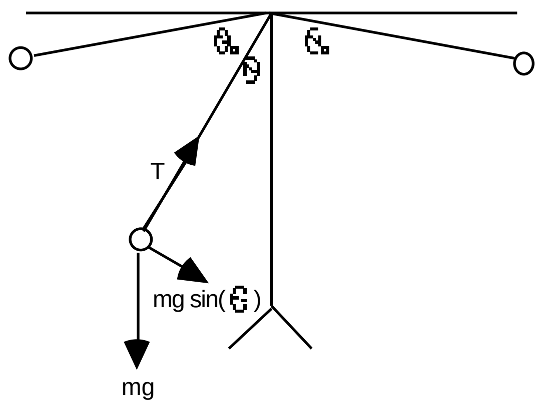


Fig. 1 Force diagram of a simple pendulum. The pendulum is released from rest at initial angle $\theta_0$.

Conventionally, an elliptical integral series representation is hired to evaluate this integral, which is defined as $T_s$ in this paper. Since Calculus I is the only prerequisite course for calculus-based physics, this evaluation is too mathematically advanced for most students. Some text books only give the first three terms of the elliptical expansion series which is copied in equation (3):

$$T_s = T_0\left(1+\frac{1}{4}Sin^2\frac{\theta_0}{2}+\frac{9}{64}\sin^4\frac{\theta_0}{2}\right) \quad (3)$$

But, the first three terms of the elliptical expansion series match well with experimental results only when angle $\theta_0 < 50°$. The discrepancy between this evaluation and the experimental result is shown in Fig. 3. An accurate evaluation at a larger angle $\theta_0$ needs more terms which are not presented in many text books used by teachers who teach in high schools and at the undergraduate level in colleges and universities.

Since there is a singularity in integral (2) at $\theta = \theta_0$, it is difficult to directly evaluate the integral with a programmable calculator. The open-ended Romberg method in MathCad can evaluate the integral with several singularities. We used MathCad software to evaluate the integral (2) with the range of $\theta_0$ from 30° to 85°. This evaluation is defined as $T_n$. $T_n$ is a function of initial angle $\theta_0$. Since the precision of the integral evaluated by MathCad can reach to $10^{-15}$, $T_n$ is considered as a standard theoretical value. $T_s$ and $T_n$

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are plotted in Fig.3. The comparison shows that $T_n$ and $T_s$ are matched quite well when the initial angle is small, but there is an obvious discrepancy in large initial angles. For example: at $\theta_0 = 85°$, $T_n = 2.3232$s and $T_s = 2.29413$s with a discrepancy of 0.0291s.

## MEASUREMENT via MBL

The experiment is conducted through our existing Microcomputer Based Laboratory (MBL). The major components of MBL in this measurement are:

1. One photogate which converts physical signals to electronic signals.
2. One Universal Laboratory Interface (ULI), which preprocesses the signals from the photogate and communicates with the host computer.
3. A Macintosh IIsi Host computer and Event Timer software made by Dickinson University.
4. DC power supply, an inductor coil, and a switch.

The setup diagram of the experiment is drawn in Fig.2. The inductor coil is connected to the power supply through a switch. When the switch is on, the inductor coil can hold the metal ball of the pendulum. When the switch is off, the ball begins to swing down. Simultaneously, the switch sends a signal to the ULI through the photogate box. The ULI starts timing.

When the metal ball passes the photogate, another signal is sent to the ULI through the photogate box. Thus, the ULI completes the measurement of one-fourth the period of a pendulum oscillation.

The angle can be measured using trigonometry. Since the length of the pendulum is fixed at one meter long, only the opposite side of the triangle needs to be changed. A threaded rod with an anti-backlash nut is used to hold the inductor coil at a precise height. This lets us closely regulate the height and angle for release.

We measured the period (actually 1/4th the period) from angles at 50˚ to 85˚ with 5˚ intervals. At each angle, twenty measurements were taken. The maximum value of the the standard deviation is less than 0.0007s. Each angle is plotted on Fig. 3 together with our numerical integral evaluation, and the evaluation by elliptical integral series representation. The average value of the period is symbolized by a square.

## DISCUSSION

Fig. 3 shows that the experimental data fits well with our own numerical integral evaluation in the range of initial angles from 50° to 85°. This gives the calculus-based students a great encouragement for applying calculus to a real scientific problem. The experience of using a Microcomputer-Based Laboratory setup in this project motivates the students to explore the expanding edge of technology. The ease of data collection, presentation, and graphing enables and encourages the students to ask and answer their own questions about physics principles by carrying out trials on computers. With the use of MathCad the students find that solving theoretical problems can be much easier.

The evaluation by an elliptical integral series representation (first three terms) is close to the experimental data when the initial angle is less 50°. When the initial angle increases, the discrepancy between the experimental data and this evaluation also increases. Higher terms in the elliptical series expansion are needed to match our experimental

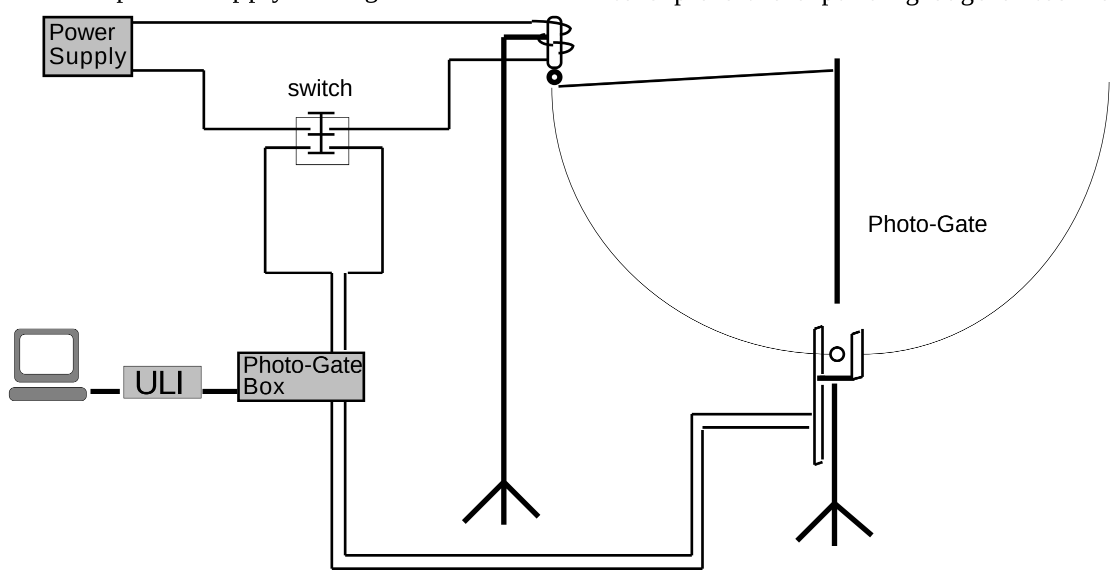


Fig. 2 The setup diagram of a MBL pendulum experiment

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# Conceptual Exercise/Overview Case Studies Workshop

**Umesh Pandy**
**T-VI**
**Albuquerque, NM**

This workshop was aimed at physics teachers from two year colleges interested in helping the students get a better conceptual understanding of the subject. Recent research has clearly shown that the problem solving ability of students can no longer be accepted as a valid criterion for the understanding of the concepts. Over 68% of students graduating out of colleges, though quite successful at problem solving, showed poor understanding of the concepts. In most cases, the lack of understanding is attributed to alternative conceptions (misconceptions) the students start with and carry with them until after they complete the course of study. These findings have led educators to a new focus on conceptual change and conceptual understanding. New methods and approaches are being designed to identify the alternative conceptions and to get the students to give up those preconceived ideas and replace them with the correct concepts. This workshop, led by David P. Maloney of Indiana/Purdue University at Fort Wayne and Alan Van Heuvelen from Ohio State University, introduced one such program to the attending physics teachers.

The workshop was held at Green River Community College at Auburn, WA from October 7 to October 9, 1993. Through an intense schedule over this three day period, the participants were introduced to the Conceptual Exercises Ranking Tasks developed by David Maloney and to his ideas on Cognitive and Perceptive Analysis. Lillian McDermott of the University of Washington described the work being done by the Physics Educator's Group at UW. Alan Van Heuvelen's "paper and pencil" ideas bring home the concepts in an effective manner. His Multiple Representation method reinforces the concepts through physical, pictorial and mathematical interpretations of problems which everyone found appealing.

The participants had received a pre-workshop materials packet including articles on the relevant research findings and on the importance of cognitive research for physics teachers and the need for the students to think like physicists. Of course, there were articles by the two workshop leaders to put the participants in the receptive frame of mind.

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data. For instance, the fourth term shows a significant correction.

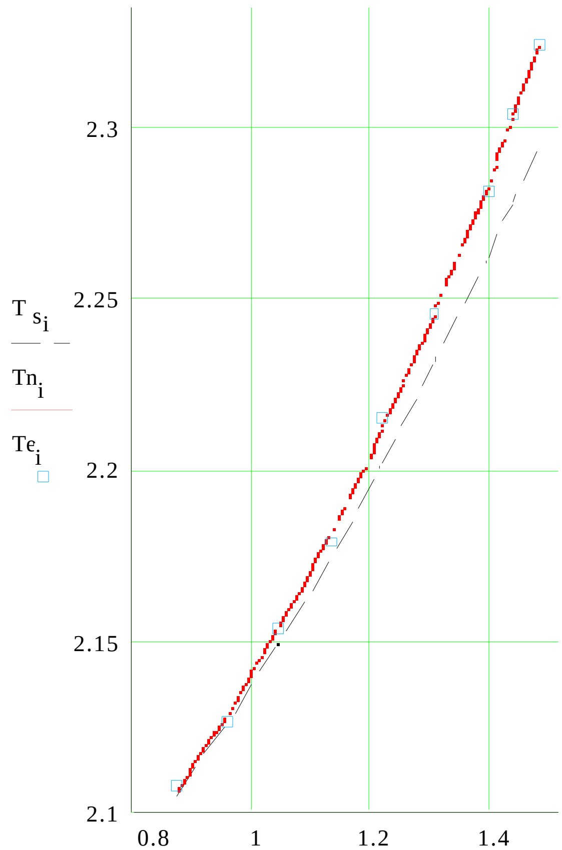


Fig. 3. Experimental Data $T_e$ vs.the initial angle. The numerical integral evaluation $T_n$ and the evaluation by the elliptical integral series representation $T_s$ are also plotted for comparison.

*Pandy continued*

The entire workshop was an intense experience for the participants, beginning each day at around 8:30 AM and going until almost 10:00 PM. In addition to all that one learned from the new pedagogy, more was achieved from the conceptual exercises the participants were asked to develop by themselves and in groups. Finally, as is always the case, the interaction with fellow teachers, and the sharing of experiences and concerns turned out to be one of the most valuable elements of the workshop.

Here at T-VI we are fortunate in getting all administrative support in working toward the objective of improved teaching of physics in our classrooms. Equipped with the microcomputer based lab materials and the training that goes with it, coupled with the CE/OCS experience, we are better prepared (we hope) to meet the challenge of effective physics teaching.

***CaFD***

*Curriculum and Faculty Development Newsletter For Two-Year College Physics Educators*

*Winter 94/95*

*National Science Foundation*

*Joliet Junior College (IL)*

*Lee College (TX)*

*National Science Foundation*

*Joliet Junior College (IL)*

*Lee College (TX)*

# Letter on Meaningful-Meaningless Calculations

**Stu Leinoff**
**Adirondack Community College**
**Queensbury, NY 12804**

March 15, 1994

Dear Editor,

I want to let you know that I appreciate the time and effort that obviously goes into the production of the CaFD newsletter. I particularly enjoy reading the diversity of opinions as to what constitutes quality physics education at the two-year college level. In that vein, I would like to offer my own "two cents" with regard to the article by David Maloney on "Meaningful-Meaningless Calculations" in the winter 93/94 edition.

I am in complete agreement with Mr. Maloney regarding the inadequacy of problem solving questions alone to assess fairly the level of understanding that our students have of somewhat substantial concepts. I think that well-constructed problems can do much to elucidate the ability of students to synthesize data and select mathematical strategies (hopefully) based on physics principles to arrive at a solution A. As such, this mode of testing should not be abandoned, but, as Mr. Maloney (and others) have pointed out, the ability to solve problems does not necessarily imply a thorough (or correct) understanding of the physical principles at play.

I like the idea of additional questions to root out hidden misconceptions, but the open-ended nature of the "meaningful-meaningless" questions approach seems to be fraught with dangers. Without significant explanation on the reasoning involved in the decision of whether or not an expression is deemed "meaningful", the answers themselves may provide a little insight into student conceptions and misconceptions.

In the position and time example, it would seem that the most desirable choices for a "meaningful" expression would be 45m/3s and 25m/2s since they represent the average velocity for the first two seconds and between the third and fourth second respectively. The other choices seem to represent some sort of fallacious reasoning where average velocity is construed to be displacement/time, or something other than (change in displacement)/(change in time).

If we look carefully at the 35m/2s choice, however, the potential "danger" to which I referred becomes apparent. If this expression is based on the fact that at t = 2 sec the displacement is 35 m the calculation may be dismissed as meaningless. If we look at the interval between t = 1 sec and t = 3 sec though, the change in displacement is indeed 35 m in the change in time of 2 sec. How should we then evaluate a student's choice of meaningful or meaningless on this expression?

It is true that an explanation of their reasoning would probably be useful, but (having read <u>many</u> a laboratory report "explaining" the concepts of an experiment) I am afraid that not all students will express their reasoning adequately enough to assess the correctness of their choice. I suspect that once their papers have been graded, students will be quite creative in demonstrating how their "explanations" do reflect the correct analysis.

The solution, for me, is to supplement the problems with <u>carefully</u> constructed multiple choice questions. There are probably many ways to test the concepts of the example cited in the multiple choice format. One question could be:

> For the position map shown, which of the following represents the average velocity in the interval given:
> a. first 2 seconds: 35 m/2 s c. the whole trip: 110 m/ 4 s
> b. t = 1 s to t = 3 s: 55 m /2 s d. the last second: 25 m/ 2 s

I am enclosing some multiple choice examples from my last kinematic test. These have already gone through some significant evolution and, as you can see, continue to do so. Well-constructed-multiple choice questions, at least for me, do not happen easily or on the first try.

On another subject, I assume that the omission of the squaring of the "r's" in Maloney's electric field example was typographical.

In any event, thank you for your attention to what became a rather lengthy note. Keep up the good work.

# Kinematics Test

**Stu Leinoff**
**Adirondack Community College**
**Queensbury, NY 12804**

Write the letter of the best choice for each question **IN CAPITALS** in the left margin.

_____1. An object moving at a constant positive velocity cannot have:
- a. a positive displacement
- b. a negative displacement
- c. zero acceleration
- d. a positive acceleration

_____2. As the time taken to travel a certain distance increases, the speed:
- a. increases
- b. decreases
- c. remains the same

_____3. Car A is going 40 m / s east, while car B is going 50 m / s east. The velocity of Car B relative to car A is:
- a. 50 m / s east
- b. 90 m / s east
- c. 90 m / s west
- d. 10 m / s east
- e. 10 m / s west

_____4. An object has an acceleration of 5 $m/s^2$. This means that:
- a. it goes 5 meters in one $sec^2$
- b. the speed increased by 5 m / s each second
- c. the speed decreases by 5 m / s each second
- d. the velocity changes by 5 m / s each second

_____5. A straight diagonal line on a displacement-time graph means:
- a. positive acceleration
- b. negative acceleration
- c. constant velocity
- d. constant distance

_____6. Constant non-zero acceleration is indicated by:
- a. a horizontal line on a s vs. t graph
- b. a diagonal line on a s vs. t graph
- c. a straight line on a v vs. t graph
- d. a curved line on a v vs. t graph

_____7. A body with a negative acceleration is:
- a. speeding up in either the + or - direction
- b. slowing down in either the + or - direction
- c. either speeding up in the + direction or slowing down in the - direction
- d. either slowing down in the + direction or speeding up in the - direction

_____8. When a golf ball is in flight, the horizontal component of its velocity
- a. increases
- b. decreases
- c. remains the same

_____9. When a golf ball is in flight, its acceleration:
- a. increases
- b. decreases
- c. is constant at zero
- d. is constant not zero

_____10. If two objects have the same velocity, they must have the same:
- a. displacement
- b. speed
- c. acceleration
- d. all of the preceding

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*Winter 94/95*

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*Joliet Junior College (IL)*

*Lee College (TX)*

# 1994 Workshop Participant Colleges

| | | |
|---|---|---|
| Bainbridge College | Bainbridge | GA |
| Blinn College | Bryan | TX |
| Blue Ridge Community College | Flat Rock | NC |
| Brevard College | Brevard | NC |
| Casper College | Casper | WY |
| Cecil Community College | North East | MD |
| Central Alabama Community College | Alexander City | AL |
| Chaffey Community College | Rancho Cucamonga | CA |
| Chandler-Gilbert Community College | Chandler | AZ |
| Chattanooga State Tech Community College | Chattanooga | TN |
| Colegio Regional De La Montana.UPR | Utuado | PR |
| College of Eastern Utah | Price | UT |
| Columbia Basin College | Pasco | WA |
| Columbia College | Columbia | CA |
| Community College of Denver | Denver | CO |
| Contra Costa College | San Pablo | CA |
| Cuyamaca College | El Cajon | CA |
| Daytona Beach Community College | Daytona Beach | FL |
| Deleware Tech and Community College | Newark | DE |
| Diablo Valley College | Pleasant Hill | CA |
| Don Bosco Technical Institute | Rosemead | CA |
| Fayetteville Technical Community College | Fayetteville | NC |
| Fireland College of Bowling Green State Univ. | Huron | OH |
| Florida Community College | Jacksonville | FL |
| Gainesville College | Gainesville | GA |
| Grossmont College | El Cajon | CA |
| Highland Community College | Highland | KS |
| Indian River Community College | Fort Pierce | FL |
| Itasca Community College | Grand Rapids | MN |
| Jamestown Community College | Olean | NY |
| Jefferson State Community College | Birmingham | AL |
| Joliet Junior College | Joliet | IL |
| Kent State University-Stark Campus | Canton | OH |
| Lake Sumter Community College | Leesburg | FL |
| Lincoln Land Community College | Springfield | IL |
| Lord Fairfax Community College | Middletown | VA |
| Los Angeles City College | Los Angeles | CA |
| Los Angeles Valley College | Van Nuys | CA |
| Manatee Community College | Bradenton | FL |
| Manatee Community College | Venice | FL |
| Miami-Dade Community College | Miama | FL |
| Mid-Plains Community College | North Platte | NE |
| MiraCosta College | Oceanside | CA |
| Monroe Community College | Rochester | NY |
| Moraine Valley Community College | Palos Hills | IL |
| New Mexico Military Institute | Roswell | NM |
| Niagara County Community College | Sanborn | NY |
| North Lake College | Irving | TX |
| Northeast State Technical Community College | Blountville | TN |
| Northeast Texas Community College | Mt. Pleasant | TX |
| Northern Oklahoma College | Tonkawa | OK |
| Orange Coast College | Costa Mesa | CA |
| Pensacola Junior College | Pensacola | FL |
| Polk Community College | Winter Haven | FL |
| Richard Bland College | Petersburg | VA |
| Rio Salado Community College | Phoeniz | AZ |
| Salem Community College | Carneys Point | NJ |
| San Jose City College | San Jose | CA |

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| | | |
|---|---|---|
| Santa Monica College | Santa Monica | CA |
| Santa Rosa Junior College | Santa Rosa | CA |
| Seminole Community College | Sanford | FL |
| Shelby State Community College | Memphis | TN |
| South Florida Community College | Avon Park | FL |
| Southwest Texas Junior College | Uvalde | TX |
| St. Louis Community College | St. Louis | MO |
| St. Petersburg Junior College | St. Petersburg | FL |
| St. Philips College | San Antonio | TX |
| T-VI Community College | Albuquerque | NM |
| UWC-Baraboo / Sauk County | Baraboo | WI |
| Ventura College | Ventura | CA |
| W.R. Harper College | Palatine | IL |
| Walla Walla Community College | Walla Walla | WA |
| Waukesha County Tech College | Pewaukee | WI |
| West Virginia No. Community College | Wheeling | WV |
| Young Harris College | Young Harris | GA |
| Yuba Community College | Marysville | CA |

# New TYC Physics Workshop

## *Constructing and Integrating Microcomputer Simulations in Introductory College-Level Physics Courses Workshop*

Traditional textbook problems, test questions, and class problem solutions teach students how to manipulate equations. Computer simulations give a visualization of the solutions to the equations of motion by presenting time graphs of quantities such as position, velocity, and acceleration while animating the motion of the object. Thus, computer simulations can expand the range and nature of student experiences — and, if properly designed and used, will extend and expand their understanding of physics. With the development of the new generation of simulation construction software and tools, physics educators are no longer limited by the available “canned” simulation software. Computer simulations, appropriately used, should supplement and enhance experiments rather than replace real labs.

This workshop will focus on the creation of useful, effective microcomputer simulations based on the results of physics education research and how to blend these simulations into an effective, active learning environment at community colleges. Participants will also gain experience and insight by being exposed to a variety of existing good physics simulations and tools. Workshop participants will work in small groups to create new simulations. These simulations will be shared and critiqued by the participants and workshop leaders.

Interactive Physics II ™ (from Knowledge Revolution) will be featured along with the HyperCard stack software from Apple Computer. Interactive Physics won the 1989 MacUser award for best educational exploration program.

Also known as Physics Simulations (PS), this workshop will be held at Joliet Junior College (near Chicago) on Oct. 5-7, 1995. It will be lead by Cindy Schwarz from Vassar College (Poughkeepsie, NY), David Winch from Kalamazoo College ( Kalamazoo, MI), Curtis Hieggelke from Joliet Junior College, and Tom O’Kuma from Lee College (Baytown, TX)

David Winch is well known in the physics education community for his work in developing software and video disk technology. The software he co-authored “Guilty or Innocent,” received the *MacWorld* Prize for best educational HyperCard stack in 1988. He recently developed a new piece of educational simulation, “An Introduction to Electrostatic Force & Coulomb’s Law,” with M.D. Squiers and R Fuller, which is being distributed by Intellimation (1992). He was recently director of software development for the “National Interactive Media Project for the Physical Sciences” (U.S. DOE) and the co-director of “A College Faculty Leadership Workshop on Transforming Physics Content Using New Technologies” project.

Cindy Schwarz is interested in integrating computers into all levels of the curriculu using Interactive Physics and other simulation software. She is the author of an article on using Interactive Physics for Campus Tech magazine and the author of a book, *An Interactive Physics Workbook* which will be published in the spring of 1995 by Prentice Hall.



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# 1995 Workshop Schedule

## *MBL: Microcomputer-Based-Labs*
## *CE/OCS: conceptual Exerises and Overview Case Studies*

| | | | |
|---|---|---|---|
| CE / OCS | | | |
| | March 9-11, 1995 | Los Angeles Valley College | Van Nuys, CA |
| MBL | | | |
| | July 20-22, 1995 | Westmoreland County CC | Youngwood, PA |
| CE / OC | | | Follow-Up |
| | June 19-24, 1995 | Lee College | Baytown, TX |
| Physics | | | Simulations |
| | October 5-7, 1995 | Joliet Junior College | Joliet, IL |

For applications and additional information write or call-

TYC ‘95
Curtis Hieggelke
Natural Science Department
Joliet Junior College

*CaFD* is a component of the networking, followup, and dissemination process of a National Science Foundation supported Faculty Enhancement project (DUE 9255466). The opinions, statements, findings, recommendations, or conclusions expressed in this newsletter are those of the author(s) and do not necessarily reflect the views of the National Science Foundation, Joliet Junior College, or Lee College. Readers are encouraged to submit responses to articles. They should be sent to Curtis Hieggelke, Natural Science Department, 1215 Houbolt, Joliet Junior College, Joliet, IL 60436 or e-mailed to cjh@aip.org.

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