CaFD

Summer '97

Curriculum **a**nd **F**aculty **D**evelopment Newsletter for Two-Year College Physics Teachers

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Ranking Tasks Uses and Results

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The following article is based on my talk "Uses of a Taxonomy of Misconceptions for *A Selection of Physics Ranking Tasks*," from the 1997 AAPT Winter Meeting. In the summer of 1996, Tom O'Kuma approached me about developing an answer key and a taxonomy of misconceptions for *A Selection of Physics Ranking Tasks* book. The answer key went pretty well and was a nice review as I prepared to go back to school full-time to work on my Ph.D. in Physics Education. However, I was not prepared for the daunting task ahead of me in writing the taxonomy. With each task normally having six answers the number of combinations was overwhelming. Therefore in developing the taxonomy I tried to pick the most likely student responses. The taxonomy is not where I would like to see it, but a start has been made.

With this having been said, how might one use such resources in the classroom? To illustrate the uses I will discuss two examples, one of which does not appear in *A Selection of Physics Ranking Tasks*. Right before starting rotational motion in the Honors Calculus Physics course I work with here at ASU, I administered a ranking task on angular acceleration. The task asked students to work with disks that all have the same moment of inertia, and have a single force acting on them tangent to their surface. The forces were of varying magnitude and were acting at various distances from the axis of rotation. Of the 16 students in this class, 7 gave the same ranking. They said the ones with the forces acting closest to the axis of rotation would have the greatest angular acceleration. They used the magnitude of the force to break ties. The large percentage of students with this response intrigued me.

continued on page 8

A Modeling & Active Learning Centered Curriculum: Part 2

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Part 1 of this article briefly described a new curriculum that has been developed and tested at Columbia College (*CaFD Winter 96*). The physics education research findings that were used to guide the development of the curriculum were outlined and the impact of the new curriculum on students' understanding of basic concepts, proficiency at modeling, and success in the course were presented. This article will focus on active learning, one of four key features of the new curriculum (active learning, model-centered, collaborative learning, spiral structure).

The main goal of the curriculum is that students come to understand and become proficient at the modeling process. Concepts and principles must be learned; modeling procedures must be mastered. To this end there are seven kinds of in-class learning activities: (1) conceptual exercise, (2) qualitative reasoning exercise , (3) exploration experiment, (4) interactive demonstration, (5) collaborative modeling group work, (6) case study, (7) minilecture. All but the minilecture can be characterized as active learning activities.

continued on the next page

INSIDE...

Albers continued from page 1

alone or group ?	time (min.)	Action (* items: student is accountable for understanding the new idea)
alone	0.5	Get information and instructions
alone	1	Think it through. Write down preliminary response.
group	0.5	* Articulate reasoning/understanding to peers
group	2	* Hear and critique peer versions. Work out consensus
alone, group backed	1	* Spokesperson articulates consensus answer to class. This step is called "the debriefing"
alone	1	* Write down final response on worksheet. Hand in.

FIGURE 1. Individual and group actions during the learning tasks involved in curriculum activities (1)-(4).

Though the focus of this article will be on items (1)-(4), I will comment briefly on (5) and (6). The collaborative modeling group work is the activity in which students are coached in and get practice in the modeling procedures. This structured group work conforms to protocols similar to those developed by Heller and Hollabaugh (AJP, **60**, pp 637-644 (1992)).

Case studies are projects to be completed by collaborative modeling groups (3 students per group). In a case study the modeling group models a real physical system, designs a program of measurements and data analysis with which to judge the adequacy of the model, writes a report, and prepares a presentation. One of the more challenging and interesting case studies used at Columbia College involves the flight of a toy rocket. The collaborative group work and the case study would qualify as active learning under any definition of active learning. However, how it is that items (1)-(4) can be characterized as active learning activities requires some explication.

Suppose that the course challenge for the next few minutes is that each student come to a preliminary understanding of a new principle or concept. An *active learning* session is one for which there is a high likelihood that each student will be engaged in the following mental processes:

(a) Carrying out an internal argument to resolve a conflict between the student's preconception and the new idea.

(b) Constructing a preliminary mental model of the new idea out of the student's existing mental models.

(c) Making adjustments in the new mental model. This kind of mental activity is rare during a lecture/note-taking session. For one thing, there is no perceived immediate accountability. However, a student in an active learning session at Columbia College will find himself immediately and repeatedly held accountable for constructing a mental model of the focus concept.

At Columbia College, activities (1)-(4) use a uniform active learning protocol. An activity consists of a sequence of tasks, each task followed by a debriefing. Figure 1 is an example of the action in a 3-person informal group dealing with one task. The instructor initiates the fifth action (the debriefing) by selecting at random one or two groups and one spokesperson per group to present the group's answer/results to the class. An important ground rule is that the spokesperson cannot be preempted by groupmates or classmates during the presentation. If the instructor asks a question, the spokesperson has the option to quickly consult with groupmates, but the spokesperson must be the one to answer the question. This "no preempting" ground rule makes the presenter ultimately responsible for both presenting the group's results and understanding those results. It also eliminates zero-sum games around classroom performance competency.

There are other valuable features of this active learning protocol. Notice that every student experiences being accountable for *getting it* three times during the task and must be prepared for a fourth time, should they be chosen the spokesperson. The expectation that he/she will have to explain something about the new idea to a peer or to the class and instructor will cause a student to search for a more efficient and more effective learning strategy.

Another potent feature of this active learning task protocol is that each student finds himself explaining ideas to the two peers in his group, comparing peer explanations with his own, and resolving the differences.

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Albers continued from previous page

The motions of three objects is represented in the motion diagrams below. Place a number on the blank line to indicate the direction of the change in velocity vector.

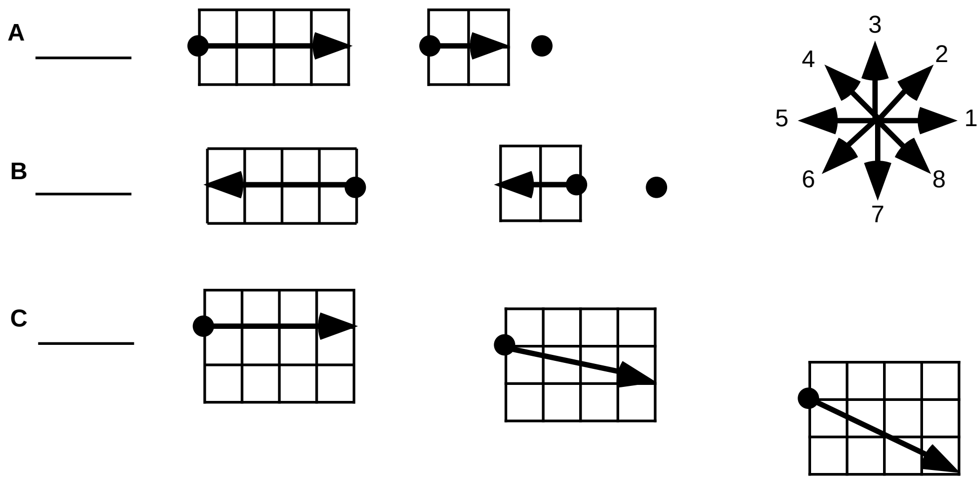

FIGURE 2. Conceptual exercise.

The debriefing should emphasize that change in v is not "something like v", it is something else entirely.

The last feature is that this structure—task, debrief, task, debrief—allows for linked sequences of tasks in which what is learned in one task is the key to the next. The debriefings reduce the possibility of a student moving on to the next task unprepared. The uniform active learning protocol applies to activities (1) through (4). Below are descriptions of each one of these four curriculum activities.

Conceptual exercises (CE) have a variety of uses. CEs can be used to help students refine their notions of a newly encountered physics concept. For example, there may be nuances of the mathematics or geometry involved in the definition of the new idea (e.g. torque, work) that are missed by many students on their first encounter. CEs can be used to check that students understand the variety of ways a new idea can manifest itself. For example, students could be asked to label 10 scenes with “static”, “kinetic”, or “neither” based on whether the key object is experiencing a friction force. CEs can help students distinguish between two ideas that seem similar. For example, in Figure 2 students find that the change of velocity vector is not necessarily in the same direction as the velocity vector.

An **exploration experiment** is a hands-on exercise whose purpose is to confront a wrong common sense belief or/and introduce a new concept or principle. For example, to introduce and scrutinize Newton’s second law in one dimension students at Columbia College are offered a numerically explicit motion diagram depicting 6 seconds of the motion of an air track glider on a horizontal track. The students perform six subtasks, consulting with each other as they go.

Subtask 1: Each student describes in everyday language every detail of the motion (represented by the offered motion diagram) to his two teammates until — in repeated trials — the teammates accept a description as complete and correct. The words “acceleration” and “rate” are disallowed forcing students to use commonly understood phrases like “going northward and slowing down.”

Subtask 2: Each student writes down his/her own description of the motion on the worksheet.

Subtask 3: Each student sketches a motion graph of the motion represented by the offered motion diagram followed by a break for *debriefing*.

Subtask 4: By trial and error, the team makes a real glider move so that its computer-detected motion graph matches the offered graph. The students are allowed to use the side of the tip of a long pine needle or a hand-held hair dryer to push lightly on the glider when needed.

Subtask 5: Each student sketches a net force vector for each of the time intervals [0, 1s], [2s, 3s], and [5s, 6s]—the vectors being of appropriate relative length based on how hard they actually pushed on the glider with the pine needle.

Subtask 6: Using the velocity vectors on the given motion diagram, each student determines the change of velocity vector for each of the same time intervals and compares there directions with the net force directions per time

continued on the next page

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Joliet Junior College (IL)

Lee College (TX)

Albers continued from previous page

Two shuttles are investigating a strange object in space. Were it not for the presence of the slab, there would be no force on either shuttle. At the instant shown one shuttle has zero velocity while the other has a velocity parallel to the slab.

1. If the shuttle on the left crashes into the slab in 2 seconds arriving with a speed of 2 m/s, how much time will be required for the shuttle on the right to crash? (a) greater than 1 s, (b) 1 s, (c) less than 1 s

2. Explain how you could estimate the direction of travel of the shuttle on the right just before it crashes.

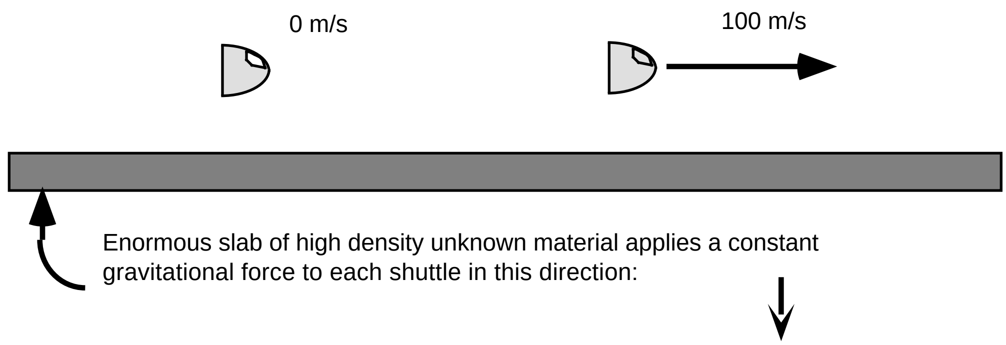

FIGURE 3. Qualitative reasoning exercise to be used after an exploration experiment

interval followed by a break for *debriefing*. The insight we seek here: During a time interval, the change of velocity (rather than the velocity) is in the same direction as the average net force. And if the average net force is zero there is no change of velocity.

Qualitative reasoning exercises ask students to carry out the initial stages of expert modeling in which a qualitative representation of the behavior of a model system is developed.

This fast-on-your-feet modeling process involves answering questions like these: Which are the key objects (those whose behavior is of interest)? With what objects do they interact? Which key object characteristics (spatial extent, elasticity, etc.) are important and which are not important? With what idealized Newtonian entities (particle, rigid bar, etc.) should the key objects be replaced to form a model system? Which change-of-state principle (2nd law, impulse-momentum, work-kinetic energy) should be applied? And often some physical representation (force diagram, momentum diagram, etc.) is visualized or sketched to help get at the qualitative behavior of the model system.

For example, after students complete an exploration experiment which utilizes an air table and puck to scrutinize Newton's second law for cases where the net force is not on line with the current velocity vector, a qualitative reasoning exercise, "Shuttles Attracted to Space Slab" (see Figure 3), checks whether students will draw on their new Newtonian principle or fall back on a wrong common sense belief, such as the belief in a velocity-dependent transverse inertia — the higher the right-hand shuttle's speed, the more difficult it will be to accelerate it sideways.

An **interactive demonstration** (ID) is just a conceptual exercise, qualitative reasoning exercise, or exploration experiment that makes use of a live or video demonstration.

When an exploration experiment is called for, why do an interactive demonstration instead? At Columbia College the course meets always in the same room — a room with laboratory tables — so exploration experiments can always be done at the time they are needed. However, sometimes an ID must be used in place of the exploration experiment because there is but one setup of the equipment needed, or the procedure is too tricky or time consuming for students to perform, or there is no such equipment or action possible in the room (a video must fill the bill). IDs adhere to the uniform active learning protocol — students work in groups of 3, they have a worksheet to fill out, they have a thinking task(s) to perform, etc. (see Figure 1).

FCI Results and Comments

Todd Leif
Cloud County Community College
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(Editors Note: This is an edited excerpt from a letter received from Todd in June 1996.)

The semester (Spring 96) is finally over and I am sitting at my desk reflecting on the past nine months of teaching. Self evaluation is one of the best things that a teacher can do every year. This year I think I actually have something that I can measure and feel really excited about.

Below are the results of my integration of your workshop information into my classroom this past semester (year). There was a remarkable change after my first semester, that is for sure. Most people wouldn't post scores like my "Traditional Scores," but I think the results point strongly to the fact that the traditional method doesn't work very well. My second set of scores are from a group of high school seniors who came to our campus for College Physics I during the second semester. The method of instruction has changed dramatically because of my integration of "Physics Simulations" and techniques from "CE/OCS." These were both very helpful and my curriculum revision for this fall is underway. I am getting some MBL II materials to include in my integration as well. You have another physics teacher sold on these techniques and teaching ideas. Here are my results from Fall '95 and Spring '96. Boy, what a difference!

FCI Results (Post) Fall Semester 1995: Trig Based College Physics — using Lecture method

# of Students	Average Score	High Score	Low Score
15	14.5/29 (50%)	26 (90%)	7 (24%)

Questions most frequently missed

Question	%missed	preferred answer	question background
#2	70%	A	Newton's 3rd
#5	70%	C	
#9	70%	C	F=MA (Force needed for speed)
#11	70%	B/D	Newton's 3rd
#13	70%	C	Newton's 3rd
#14	45%	C	Newton's 3rd
#15	45%	B	Momentum Conservation
#18	65%	A	F=MA (Force needed for speed)
#20	65%	D	Velocity at an instant?
#21	45%	C	Constant speed
#22	50%	C	Air resistance negligible??
#24	65%	C	F=MA (Force needed for speed)

These were the questions that were missed the most often and the choices that were made. Our laboratory exercises were MBL Type I where we would use the computer as a tool to record numbers for data and then would interpret graphs through slope and intercept analysis to prove some specific mathematical equation. These labs included things like: Atwood Machine, Conservation of Linear Momentum, Determining "g" (Picket Fence), and Force - Impulse measurements.

FCI Results Spring Semester 1996: Trig Based College Physics — using Simulations & CE/OCS

Student	Pre- /Post- Results	% Correct	% increase
1	09 / 15	31% / 52%	21%
2	06 / 21	21% / 73%	52%
3	12 / 19	41% / 65%	24%
4	10 / 19	35% / 65%	30%
5	15 / 24	52% / 83%	31%
6	14 / 24	48% / 83%	35%
7	06 / 17	21% / 59%	38%
Average	10 / 20	35% / 70%	35%

The questions students missed most often were 2, 11, 13, 14, 15, 18, 22, and 28.

Overall, I was pleased with the average gain. I think that if my labs become more conceptual that I will begin to see an even better increase. They still have trouble with the "bigger" means more force idea. (Newton's 3rd) MBL will definitely help this one. Also the friction force and air resistance thing could also be improved with some MBL activities.

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Summer '97

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Two Curricula In Transition*

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*This material is based upon work supported by the National Science Foundation under Grants No. DUE9651374 and DUE9651375.

Introduction

The authors of this article are the principal investigators (PIs) of two NSF ILI grants funded in the Spring of 1996. These grants are the first ILI grants awarded to the College of the Redwoods in its 31 years of existence. While the authors worked independently of each other, the simultaneous awarding of the grants has made possible the collaboration described in the remainder of this article. What we have done to date and our plans for the future may be of interest and value to *CaFD* readers who are contemplating similar projects.

The Grant Proposals

The mathematics project is entitled "Opening New Doors" and its purpose is to change the mode of instruction in multivariable calculus, linear algebra and differential equations at College of the Redwoods.

The computers and software we are purchasing under this grant will support the development and implementation of classroom demonstrations and interactive lessons that encourage students to take a more active role in their education. The currently utilized traditional lecture format will be replaced by a more collaborative and constructivist educational delivery system.

The physics project is entitled "Restructured Physics Learning Environment" and its purpose is to change the teaching and learning of physics at College of the Redwoods through the utilization of microcomputers as data acquisition, storage and analysis tools.

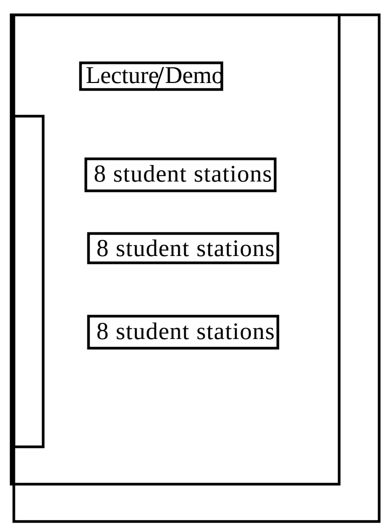
The acquisition of this technology will support the introduction of the Tools for Scientific Thinking and CE/OCS curricular materials, make possible the use of simulations, and lead to the transformation of instruction from a lecture-oriented delivery system to one that is more experiential, collaborative and constructivist.

Work In Progress

The second author (DM) had been assigned seven Macintosh LCIIs which were no longer in favor in our CIS laboratory. He already had an LCIII acquired through an NSF fund administered by Dickinson College. While his preference had been to use PCs, the availability of these LCIIs and the LCIII had been the basis and motivation for his grant proposal.

With the funding of both grants motivating consideration of classroom and laboratory utilization, it became clear to the PIs that much was to be gained from a pooling of our new resources and the sharing of our classroom/laboratory space.

Since 1967 the physics classroom/laboratory, in which all of the College's physics courses and the multivariable calculus, linear algebra and differential equations classes had been taught, had been configured as shown below. Apparatus is stored in wall and base cabinets around the perimeter of the room and in adjacent and nearby rooms. The three eight-student tables were



fixed in place and hence not conducive to small-group work. In response to proposals made by the PIs, the College's administra-

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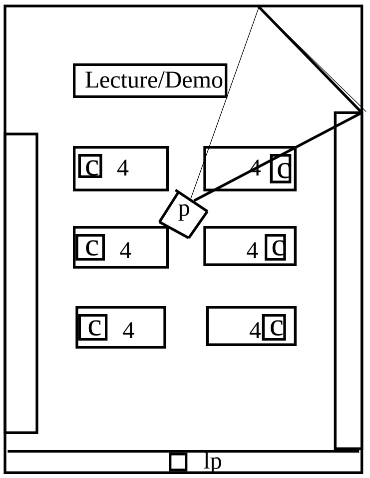
tion agreed to the remodeling of this classroom/laboratory along the lines shown below.

This work is currently in progress and will result in the creation of six four-student workstations and an instructor's demonstra-



tion station — each equipped with a mathematics grant funded Pentium-166 computer, served by a file server and interfaced to a laser printer, and a physics grant funded interface with a full complement of probes, sensors, software, inclined planes, and collision carts. The physics grant also provides for the purchase of a video projector which will be suspended from the ceiling to project the images from the instructor's monitor onto a ceiling-mounted screen in the corner of the room.

The remodeling was more complicated than one might imagine as it required the cutting of a trench through the concrete floor, the installation of under-the-floor conduits for power distribution and communication lines connecting the various system components, and the back-filling of the trench.

The laboratory tables are also being remodeled to accommodate the computers under the work surface, the keyboards and mice on pullout shelves, and the monitors on the table tops. The figure above shows the locations of the computers (c), laser printer (lp), and projector (p) in the remodeled room.

Serendipitous Side Effects

There are at least two unanticipated benefits deriving from the funding of these grants.

One is the replacement of all our 8086/88-based computers and dot-matrix printers in a nearby mathematics/science computer laboratory with Pentium-166s and a laser printer. These changes will not only support the utilization of state-of-the-art software in this laboratory but will also allow us to purchase microcomputer language compilers (e.g., Fortran90) and modernize our instruction in programming languages by eliminating our current dependence on the College's mainframe computer, a HP3000.

A second unanticipated benefit is the utilization of the LCIIs and the LCIII in a room adjacent to the physics classroom/laboratory. This room has a long history of use as a student study and conference area. We're remodeling this room to include new against-the-wall workstations for the Macintosh computers and a laser printer and adding a new conference and study table. The file server for these computers will provide wordprocessing and spreadsheet software in addition to mathematical programming. The wall and base cabinets will continue to provide storage for physics apparatus.

Conclusions

The individual successes of the grant writers has led to a sharing of facilities, computers and apparatus that neither of us had imagined would be possible. The enthusiastic participation of the College's administration in implementing the PI's remodeling proposals has brought all aspects of this project together with the end product being a vastly improved learning environment in which the results of classroom research in the learning of physics and mathematics can be utilized to the advantage of the many students we share.

Our efforts to shift our educational delivery system from one emphasizing good teaching to one focusing on the learning experiences of our students is consistent with the College's goal of becoming known as a "learning institution" rather than a "teaching institution."

RT News in Brief...

We are looking for more Ranking Tasks that you may have developed but not sent us so that we can include them in the next volume of Ranking Tasks. Also if you have modified existing RTs so they are more effective, please also send them.

In addition, if you have developed other CEs or activities such as "What's wrong, if anything?", please send us those for a future issue CaFD or a book of CEs that we may publish in the future.

A Selection of Ranking Tasks book is being reprinted so if you did not get a copy let us know and we will send you one. We have an answer key and some corrections that we will send out.

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

Summer '97

National Science Foundation

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Desbien continued from page 1

Therefore, I compared the results for the same task given in a Physical Science Class at Highland Community College (Highland, KS). The class has no pre-requisites and most of the students have very little math or science background. However, something very interesting occurred: 15 of the 37 students gave the same ranking as the students at ASU. The HCC students tended to explain their ranking based on an analogy with a bicycle wheel. The ASU students had used the same idea but tried to put it into more mathematical terms.

For the HCC students, a plan of attack to overcome the bicycle wheel analogy was developed. Hooks were evenly placed out from the hinges on a light door in the classroom. The students were given a ranking task to compare the angular acceleration of the door if a force probe was used to pull, with the same force, on each hook. The students once again used their bicycle wheel analogy to get their rankings. Then the actual experiment was performed and the students were asked to modify their explanations. Once a consensus among the class was reached they were given another ranking. They would again be using the same door, but this time the forces were allowed to vary. The students performed very well on this with 25 giving the correct ranking and explanation.

The second use of ranking tasks I would like to discuss is one I used at HCC last spring in an Algebra Based Physics course. As an introduction to DC circuits we started with two ranking tasks: One on current in a simple series circuit, and one on voltage in a similar circuit (pages 101 and 105 in *A Selection of Physics Ranking Tasks*). The students first worked individually, then in their lab groups and finally a whole class discussion. Three distinct models were developed to explain their rankings. They were: 1) fluids in tubes, 2) current is an expendable quantity, and 3) current and voltage are equivalent. The students then performed the tasks using batteries, light bulbs, and current-voltage probes for the ULI.

After the experiment, another class discussion was held to see how their model's needed to be modified. The model that matched the results became known as Shellie's model (named after the student who first had said it in the earlier class discussion). At that point the students were given two more ranking tasks this time involving current and voltage in simple parallel circuits (The circuits consisted of 2 or 3 resistors in parallel). The students were very happy to apply Shellie's model to this circuit. After a very brief class discussion, it was determined that everyone had the same rankings. They were then told to perform the experiment, and see how their results held up. Of course, Shellie's model failed miserably for the parallel circuit. After the class experiment another class discussion was held. The students together worked out a model that eventually explained both experiments and left for the day.

The next class period the students were greeted with a much more difficult ranking task. They were given pages 108 and 111 out of *A Selection of Physics Ranking Tasks*. These more complicated circuits pushed the model developed in the previous class. About 70% of the students were able to give the correct ranking and explanation. While I would hope for 100%, this was better than I had expected on these difficult tasks. It was at this point that correct names and definitions were imposed on their ideas, and a more general discussion of DC circuits occurred. However, these ranking tasks combined with lab work offered a nice introduction to DC circuits.

The answer key and taxonomy will hopefully make implementing ranking tasks, like those discussed above, a little easier. Ranking tasks have many varied and interesting uses. They allow the instructor insight into their ideas and are a good introduction to class discussions. I would appreciate hearing from anyone else who has used Ranking Tasks like I have, or in other novel ways.

CD News in Brief...

Cindy Schwarz's Interactive Journey Through Physics CD (Prentice Hall) has been released and is now shipping. The CD has both Mac and Windows versions and includes material from 1st and 2nd semester physics. They have included 20 of our Ranking Tasks from our workshops. Contact your Prentice Hall representative if you are interested in getting a copy. Cindy is spending the next academic year working in Israel.

Alan Van Heuvelen's ActivPhysics I CD and Workbook Evaluation version (Mechanics, Thermo, Waves) from Addison Wesley has been shipping for several months. The final version should be available around July 15. It includes Mac and Windows versions on the same CD and is designed to use Netscape 3.0 (included on the CD) to view the information and interact with it. We have used it with Internet Explorer a little but the plug-ins needed to be installed manually. Check the Addision Wesley web site (awi.aw.com) for updated information.

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Bar Graphs for Ideal Gas Processes

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Traditionally there have been four representations available for dealing with ideal gas processes: the word problem, diagrams of actual processes (these are rather rarely used), pV graphs and equations. I believe that using equations and pV graphs is of limited value in getting students to think conceptually since students often have difficulties with graphs and think of equations only as things to plug numbers into. In dealing with ideal gas processes I would like the students to think about what is happening to the pressure, volume and temperature, as well as thinking about what energy transformations are occurring during the process. I would like them to think about these matters qualitatively, as well as quantitatively. If we think about representations in this topic we can place them on a spectrum from concrete to abstract (Steinberg, 1997) as shown below.

Physical phenomena and systems	Diagrams	Word Problems	Equations	pV graphs
Concrete				**Abstract**

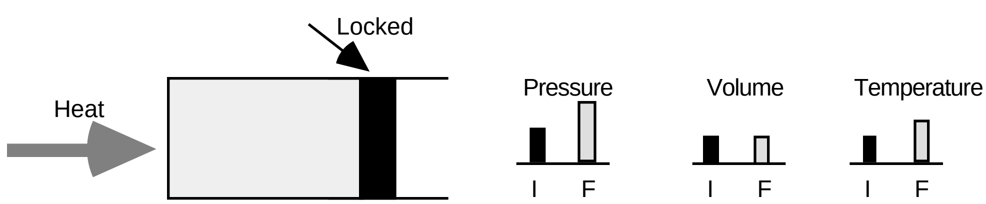
I believe it would be useful to have some representations that could serve as intermediate steps from the concrete phenomena to the abstract graphs and equations. That was the motivation for the development of the bar chart representations described below.

Alan Van Heuvelen introduced work-energy bar charts in his ALPS materials. I adapted this idea to the situation with ideal gas processes to develop two sets of bar charts, pVT bar charts and First Law bar charts. These two types of bar charts are introduced below in the manner in which I introduce them to my classes. I use diagrams of ideal gas processes with each bar chart to try to help students relate the variables and energy transformations to actual processes.

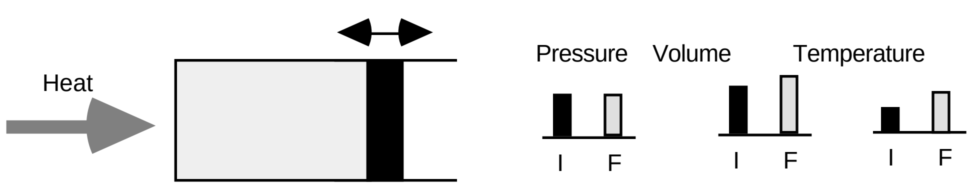
The first type of bar chart is actually a set of three separate charts for the three primary variables in the ideal gas law. (I will take the number of moles of gas as constant, although that could actually be added to the situation by incorporating a fourth chart.) It is important to emphasize that these are qualitative representations and that the scales for the three charts are different.

Shown below are figures representing containers filled with a fixed amount of an ideal gas. The containers are subjected to different processes. Beside each figure are three bar charts, one for pressure, one for volume and one for temperature. An arbitrary initial value is shown for each variable, and the heights on the different bar charts stand for different values since the quantities are different. On each bar chart students are required to indicate (by drawing a final value) how the final pressure, volume or temperature will compare to the initial value. Appropriate final values are actually shown on these bar charts, but these values would not be shown when the task is given to students. Remember that these are QUALITATIVE representations so we are not trying to get exact values.

The piston is locked in place and the container is heated.



The piston is free to move, external pressure is constant, and the container is heated.



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

Summer '97

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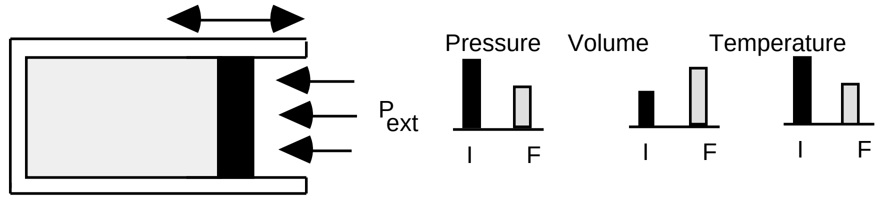
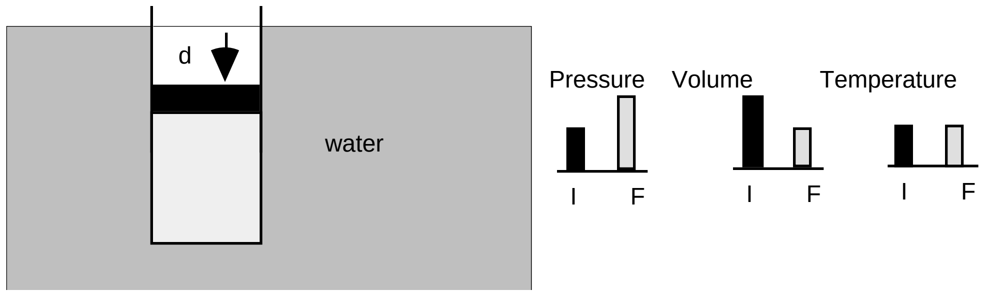
Container is completely insulated, piston is free to move and the external pressure is reduced.



The container is immersed in a very large container of water at a temperature T.
The piston is slowly pushed in a distance "d."



Once the students become familiar with these representations exercises can be designed which will require them to translate between/among the different representations. I believe translating between representations is one of the best ways to test for legitimate understanding.

The first translation process is to give them the pVT bar charts and have them draw the pV graph for the process. If one restricts the processes, at first, to the four "standard" processes — isobaric, isochoric, isothermal, and adiabatic — the students can practice associating the lines or curves on the graph with specific changes in pressure, volume and temperature. I believe having the students carry out these translations without any numerical values has a better chance of getting them to think about how these variables change in these processes.

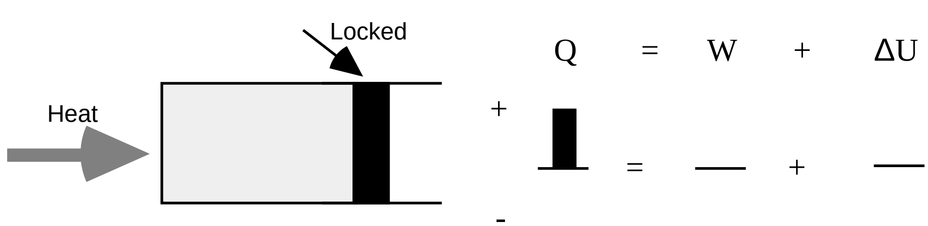
Once the students have had some practice going from the bar charts to the pV graphs it is useful to reverse the translation process. I think it is better to start with the bar chart to pV graphs because of the situation described in Steinberg's diagram. However, it is important for students also to get practice starting with the pV graphs so that they are eventually able to use them effectively.

It is also important to have the students translate between the bar charts and the ideal gas law. These translation exercises should also occur in both directions.

The other new type of bar chart is actually a closer relative to Van Heuvelen's original since it is for energy terms. A bar chart can be set up for the first law of thermodynamics. There are two ways to set this up as shown in the examples below. Once again I introduce these bar charts using diagrams of actual processes as the starting points.

Shown below are figures representing containers filled with a fixed amount of an ideal gas. The containers are subjected to different processes. Beside each figure is a bar chart describing the energy transformations during the process. The heat added, or removed, the work done, or the change in internal energy associated with the given process is shown. Draw reasonable bar values for the change in internal energy the heat added or removed, and/or the work done, taking care to shown whether they are positive or negative, that is(are) involved during the process. Remember that these are QUALITATIVE representations so we are not trying to get exact values.

The piston is locked in place and the container is heated.



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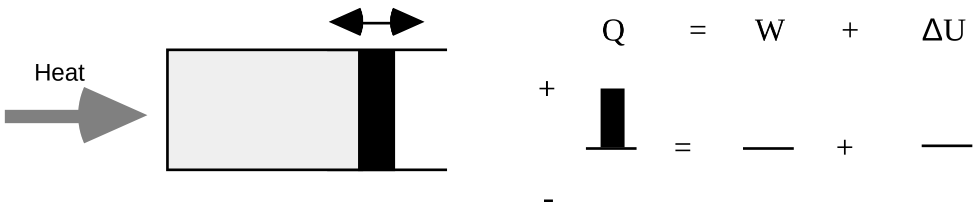
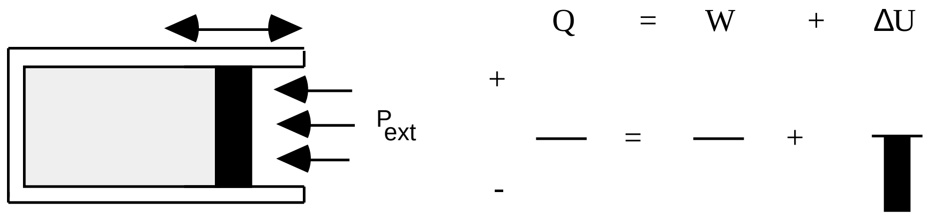
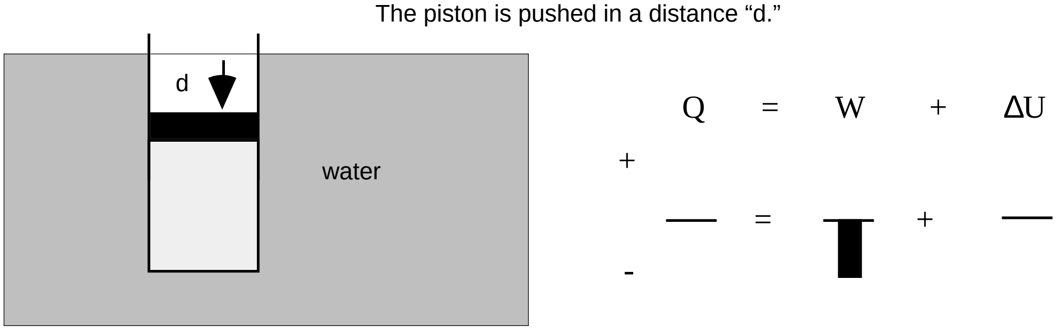
The piston is free to move, external pressure is constant, and the container is heated.



Container is completely insulated, piston is free to move and the external pressure is reduced.



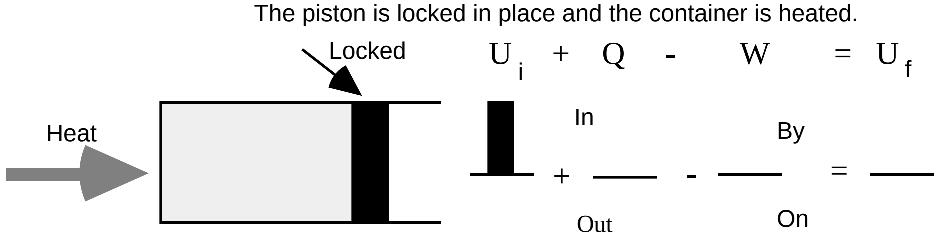
The container is immersed in a very large container of water at a temperature T.
The piston is pushed in a distance “d.”



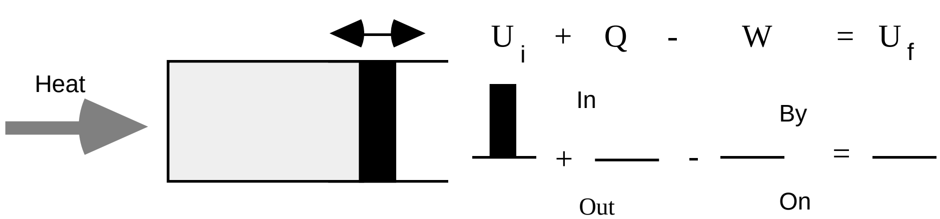
An alternative way to set up these bar charts is to indicate an arbitrary initial internal energy for the process, then provide bare lines so the heat and work can be indicated and then a line to idicate the final internal energy. This is shown in the following examples.

Shown below are figures representing containers filled with a fixed amount of an ideal gas. The containers are subjected to different processes. Beside each figure is a bar chart describing the energy transformations during the process. An arbitrary initial value is shown for the internal energy of the gas. Draw reasonable bar values for the heat and/or work, taking care to show whether they are positive or negative, that is (are) involved during the process. Then draw the bar for the final internal energy of the gas. Remember that these are QUALITATIVE representations so we are not trying to get exact values.

The piston is locked in place and the container is heated.



The piston is free to move, external pressure is constant, and the container is heated.



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

Summer '97

National Science Foundation

Joliet Junior College (IL)

Lee College (TX)

continued on the next page

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

Summer '97

National Science Foundation

Joliet Junior College (IL)

Lee College (TX)

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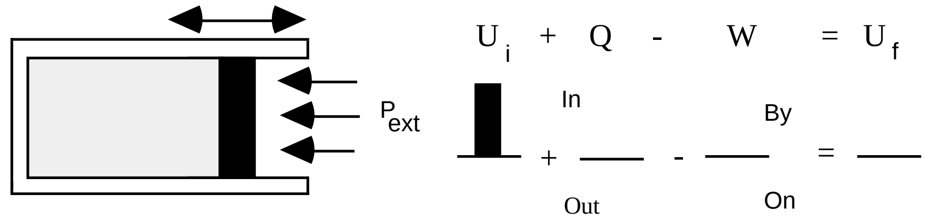
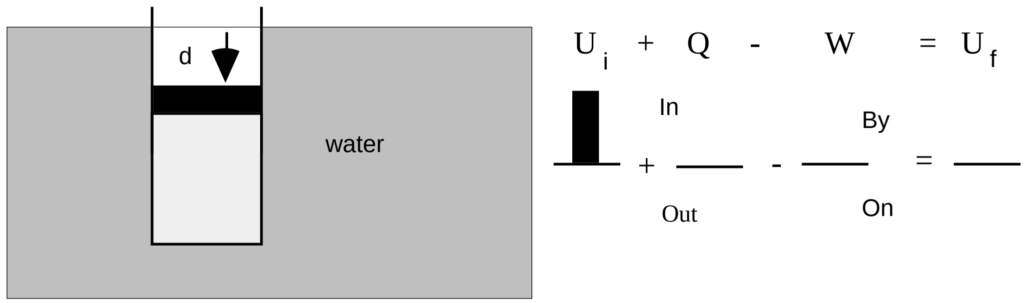
Container is completely insulated, piston is free to move and the external pressure is reduced.



The container is immersed in a very large container of water at a temperature T.
The piston is pushed in a distance "d."



With the introduction of the first law bar chart the varieties of translation exercises is increased significantly. If we assume that the bar charts are a more comfortable representation for students than graphs, then a good starting point for these new translations would be between the two types of bar charts. We can have students translate from the first law bar charts to pV graphs, initially using the four "standard" processes. Then we can reverse that process. Translations between first law bar charts and the equation are also important.

More challenging and complex tasks can be constructed with combinations of the different representations. For example, one could give the first law bar chart and the pV graph for an adiabatic process and have them construct the pVT bar charts. The goal here would be to get them to understand that they cannot predict what happens to the temperature from just the pV graph since they cannot be sure from a qualitative sketch if the process is adiabatic. To emphasize the importance of having information about both the energy transformations and two of the three variables the students could be given a pV graph and the first law bar chart for a process which is not one of the four "standards."

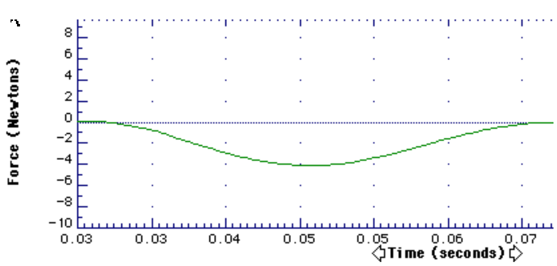
Steinberg, M. (1997) "Model Evolution Fostered by Surprising Bulb Lighting Events" AAPT Announcer 26, #4, 52.

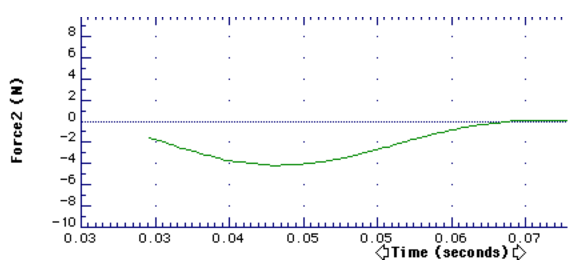
MBL News in Brief...

Vernier Software has a couple of new interesting sensors coming out. They have a new force probe that is similar to the PASCO force probe in terms of how it works but it only costs $99. It has a switch that allows a top range of either 5 N or 50 N. It does not need zeroing all the time like the old Hall effect probes. We have only been able to test the one unit that was sent to us but our early tests seem to indicate that it works fine. It started shipping this summer. See below for a screen shot of a collision between the PASCO and the new Vernier Force Probe using a ULI.

Early this fall, they will start shipping a new sonic ranger. The main difference is a new case with some nice features but it functions the same as the old one that most of us have.

We are expecting that Dave Vernier will be attending the MBL II at Green River CC so if you haven't met him this will be an excellent opportunity for it.





Impact of a TYC Workshop

Stuart Loucks
Solano Community College
Suisun, CA

(Editors Note: This is an edited excerpt from a letter received from Stuart in March 1996.)
To let you know how the workshops have been used in my teaching. . . . While in Washington (Columbia Basin College), during the '93-94 school year, I made extensive use of Alan Van Heuvelen's ALPS kits and OCS packets (in the calculus-based course). I found them very helpful, and still use ALPS quite frequently in my classes (more selectively after using them all, I have a better feel for which parts I like the most). I also began using ranking tasks quite a bit, and still do.

During the '95-95 school year, I tried to implement Workshop Physics (also in the calculus-based course) full-bore, but about 40% through the year (around the beginning of thermodynamics), I began to run out of time and energy trying to get all the equipment together (it became harder and harder to try to match the equipment needed), trying to modify each lesson, etc. So I reverted to ALPS for help in teaching the electricity and magnetism parts of the course. As you know, through the mechanics part of Workshop Physics the MBL tools and labs (Real Time Physics) were used quite a lot. I have come to the conclusion that I may try Workshop Physics, or something like it, again sometime, but only with a great deal more pre-planning. It is a good program for the most part, but is quite equipment intensive, and falls apart if the right "parts" are not available. Otherwise, I might be able to integrate parts of Workshop Physics into my courses.

Also in '94-95, I used the Tools for Scientific Thinking lab curricula in my conceptual physics course, and really liked it. I gave pre-, mid-, and post-tests (using the test from Tufts University) in all my courses (calculus-based, and conceptual) in '94-95, but have yet to compile the results. All the student answer sheets are in a box, waiting for me to get to them. I actually plan to compile them, and will let you know of the results if I do.

Now at Solano College, we are well-paid, but under-funded for equipment. We do have a few MBL type things: old XT computers, MBL interfaces, temperature probes, and I just ordered some smart pulleys with the remainder of our budget for this year. So hopefully, by next fall I can implement some of the MBL lab types. I am currently looking into writing some grant proposals for some new computers, etc. Any advice? I do have the materials given to us at the workshops on proposal writing. I am currently using some of the ALPS stuff, as well as ranking tasks, but that's about it for my first semester at Solano.

As you can tell, my teaching has really benefited from the NSF workshops. Eventually, I would like to attend the follow-up workshops, but I am not sure when. As of now, there is money available at my college to pay for conference registration fees, but no money for travel.

TYC Physics Workshop Project Update

As of July 1997, this project will have provided 30 intensive physics education workshops at 15 different community colleges in 11 states (Joliet Junior College, IL; Lee College, TX; Green River Community College, WA; Westmoreland County Community College, PA; Seminole Community College, FL; Lenoir Community College, NC; San Jose Community College, CA; Pikes Peak Community College, CO; Chaffey Community College, CA; Los Angeles Valley College, CA: South Mountain Community College, AZ; Jamestown Community College, NY; Mira Costa Community College, CA; Bainbridge College, GA; and Monroe Community College, NY).

There have been a total of 629 participants involving 318 different faculty members from 254 community colleges located in 46 states and territories. There have been 14 Microcomputer Based Labs (MBL) workshops including 4 MBL advanced or follow-up workshops and 11 Conceptual Exercises and Overview Case Studies (CE-OCS) workshops including 3 CE/OCS advanced or follow-up workshops, 3 Physics Simulations (PS) workshops and two Introductory Physics Conferences (IPC).

These workshops dealt with the development and implementation of (1) microcomputer-based laboratories in mechanics, sound, and heat; (2) digital video, modeling and microcomputer-based laboratories in electricity, magnetism and optics; (3) physics simulations; and (4) active learning problem-solving strategies using conceptual exercises and overview case studies. The fifth workshop conference provides previous workshop participants an opportunity for sharing, gaining additional experiences, and discussing new developments and technologies.

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

Summer '97

National Science Foundation

Joliet Junior College (IL)

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‘96 TYC Participant Colleges

Albuquerque Technical Vocational Institute	Albuquerque	NM
Arizona Western College	Yuma	AZ
Bainbridge College	Bainbridge	GA
Blackhawk Technical College	Janesville	WI
Brunswick College	Brunswick	GA
Casper College	Casper	WY
Central Alabama Community College	Alexander City	AL
Central Arizona College	Coolidge	AZ
Chandler-Gilbert Community College	Chandler	AZ
Chattahoochee Technical Institute	Marietta	GA
Cisco Junior College	Cisco	TX
Cloud County Community College	Concordia	KS
Coconino Community College	Flaggstaff	AZ
Colegio Regional De La Montana.UPR	Utuado	PR
College of the Mainland	Texas City	TX
College of the Redwoods	Eureka	CA
Cuyahoga Community College	Cleveland	OH
Cypress College	Cypress	CA
Don Bosco Technical Institute	Rosemead	CA
Erie Community College-City Campus	Buffalo	NY
Firelands College-Bowling Green State University	Huron	OH
Florida Community College at Jacksonville	Jacksonville	FL
Gateway Technical College	Racine	WI
Glendale Community College	Glendale	AZ
Harold Washington College	Chicago	IL
Hartnell College	Salinas	CA
Henry Ford Community College	Dearborn	MI
Highland Community College	Highland	KS
Howard Community College	Columbia	MD
Independence Community College	Independence	KS
Indian Hills Community College	Centerville	IA
Indian River Community College	Ft. Pierce	FL
Iowa Central Community College	Fort Dodge	IA
Itasca Community College	Grand Rapids	MN
Ivy Tech State College	South Bend	IN
Jamestown Community College	Jamestown	NY
Jefferson College	Hillsboro	MO
Joliet Junior College	Joliet	IL
Kent State University-Salem Campus	Salem	OH
Kent State University-Stark Campus	Canton	OH
Lake Land Community College	Mattoon	IL
Lake Sumter Community College	Leesburg	FL
Los Angeles Valley College	Van Nuys	CA
Manatee Community College	Bradenton	FL
Mesa Community College	Mesa	AZ
Miami-Dade Community College	Miami	FL
Montana Tech College of Technology	Butte	MT
Moraine Park Technical College	Fond du Lac	WI
Niagara County Community College	Sanborn	NY
Nicolet Area Technical College	Rhinelander	WI
North Harris College	Houston	TX
Northeast State Technical Comm. College	Blountville	TN
Northern Oklahoma College	Tonkawa	OK
Pensacola Junior College	Pensacola	FL
Rochester Community College	Rochester	MN
Rock Valley College	Rockford	IL
Salem Community College	Carneys Point	NJ

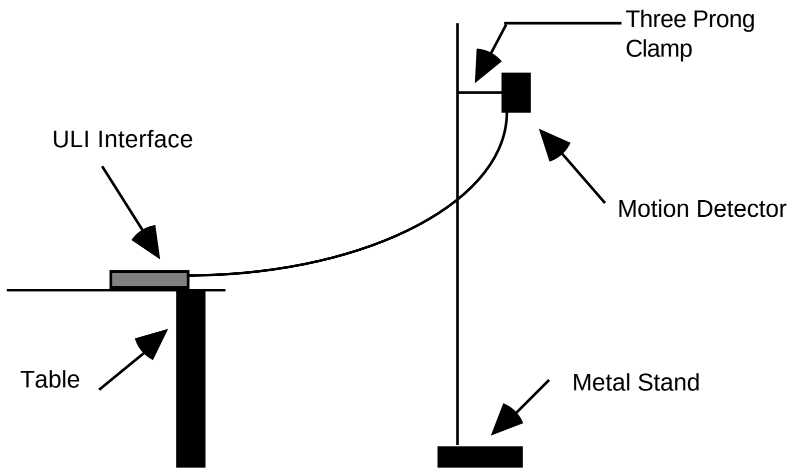
‘96 TYC Colleges continued from previous page

Salt Lake Community College	Salt Lake City	UT
San Diego Mesa College	San Diego	CA
San Jose City College	San Jose	CA
Scottsdale Community College	Scottsdale	AZ
Shelton State Community College	Tuscaloosa	AL
South Florida Community College	Avon Park	FL
South Mountain Community College	Phoenix	AZ
Southeast College, HCCS	Houston	TX
Southwestern College	Chula Vista	CA
Trinidad State Junior College	Trinidad	CO
Truckee Meadows Community College	Reno	NV
University of South Carolina at Sumter	Sumter	SC
UWC-Baraboo/Sauk County	Baraboo	WI
Vermilion Community College	Ely	MN
Vermont Technical College	Randolph Center	VT
Wayne Community College	Goldsboro	NC
Western Wisconsin Technical College	La Crosse	WI
William Rainey Harper College	Palatine	IL
Worthington Community College	Worthington	MN
Wytheville Community College	Wytheville	VA

Freedom Of Movement

Eldon Eckard
Bainbridge College
Bainbridge, Georgia

We recently renovated our physics lab at Bainbridge College and invested in six MBL lab stations. The first time we used the motion detectors we encountered some difficulty when we set the detectors on the tables. There was not sufficient room for the students to move properly to get the desired motions on the screen. To overcome this problem we set up a tall metal stand and fastened the motion detector to the stand with a large three prong clamp from the chemistry lab. This arrangement worked very well. The way our lab is now designed we could set up two of these set-ups back to back.



> **“Telling is not teaching and listening is not learning. If we truly want our students to develop sound conceptual understanding, problem-solving skills, and critical thinking, we must use course materials and course activities that provide the students with opportunities to develop those understandings, skills, and modes of thinking.”**
>
> Robert C. Hilborn, “Revitalizing Undergraduate Physics–Who Needs It?” American Journal of Physics, Vol. 65 (March 1997), p. 176

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

Summer '97

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Fall 1997 TYC Physics Workshops/Conference Schedule

Implementing Modeling, Digital Video Analysis, and Microcomputer-Based Laboratories in Electricity, Magnetism, and Optics in Introductory Physics (MBL II)
September 18-20
Green River Community College, Auburn, WA (near Seattle)

Implementing Workshop Physics and Effective Microcomputer-Based Laboratories in Mechanics, Sound, and Heat in Introductory Physics (MBL I)
October 9-11
Joliet Junior College, Joliet, IL (near Chicago)

Apply now! For applications contact:
TYC '97 Physics Workshops
Joliet Junior College
1215 Houbolt Road
Joliet, IL 60431-8938
(815) 729-9020 Ext. 2603
e-mail: tycphysics@tyc.jjc.cc.il.us
http://ac4.jjc.cc.il.us/tyc/tyc.html

CaFD is a component of the networking, follow-up, and dissemination process of a National Science Foundation supported Faculty Enhancement project (DUE 9554683). 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 Road, Joliet Junior College, Joliet, IL 60431 or e-mailed to curth@jjc.cc.il.us

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