Rose-Hulman Institute of Technology
Integrated curriculum encourages students to become problem solvers

At Rose-Hulman Institute of Technology in Terre Haute, Indiana, 39 freshmen are midway through the first year of an integrated science, mathematics, and engineering curriculum. Rose-Hulman designed the curriculum to meet two goals: to show the connections among basic concepts in technical disciplines, and to promote problem-solving skills, independent learning, and the inclination to explore.

Computers provide a unifying link for the integrated curriculum
A team of five professors teach the curriculum in two classroom/computer labs equipped with 60 NeXT computers. Jeffrey Froyd, professor of electrical and computer engineering and one of the curriculum coordinators, explains that Rose-Hulman looked for a platform with a specific combination of built-in features, including networking, electronic mail, *Mathematica*, a graphical user interface, and virtual memory. Froyd says, "The user interface enables students to become familiar with the computer rapidly, and the operating system allows them to open as many applications as they need to work on a particular problem. For example, in this environment a student might simultaneously open the mail application to communicate with other members of a group, *Mathematica,* to look at data, and FrameMaker to prepare a project report."

Custom applications help students visualize important concepts
More than 30 custom applications have been developed to help students understand various topics and concepts covered in their coursework. For two months during the summer of 1990, eight Rose-Hulman studentsÐtwo graduating seniors, two juniors, two sophomores, and two freshmenÐused Interface Builder to develop the applications, including the following:

· *Physics World* allows students to put particles in gravitational fields, electrostatic fields, and magnetic fields, and watch their motion. Says Froyd, "The students can adjust the parameters of the particle in terms of mass and charge, they can adjust the field, they can assume the particle would be moving with some type of air resistance, and they can get a visual feel for the particle behavior."

· *Taylor Series* provides an interface to *Mathematica* that makes it easier for students to find the Taylor series of a given function. Explains Froyd, "Students can, for example, enter a function and say 'Let's look at the Taylor series of such an order about such a point. What does the Taylor series polynomial look like? What do the graphs (of the function itself and of the Taylor series approximation) look like? How far off are they at a certain point?' They can play with that more readily than they could in *Mathematica*. And this kind of playing around can lead to the kind of insights we're hoping they'll have."

· *Function and Sons* displays graphs of a function and its first and second derivatives, in random order, and asks students to identify which is which.

· *Skiing* forces students to do an inverse problem, says Froyd. "Instead of giving them a slope showing a skier going down it, and asking them to find the skier's horizontal position, velocity, and acceleration, we give them graphs of these three things and say 'Now construct the slope.' So instead of doing analysis, they have to do synthesis. They have to do some qualitative reasoning, with some quantitative backup."

· *Slope* plots a graph and allows the student to estimate the slope of a tangent line, which can then be plotted on a separate curve simply by clicking a point. "The computer shows what the derivative really looks like, giving the student visual feedback," says Winkel.

· *Area* finds the area beneath a curve. Explains Winkel, "We're trying to get the students to understand that just as the notion of 'derivative' has many interpretationsĐvelocity, rate, slopeĐthe integral has a number of interpretations, too, and one of them is a geometric one that they can see."

· *Gas Law* shows the relationship of the variables in the ideal gas law. For example, the student can hold certain variables fixed and vary othersĐand generate real-time graphs that would be difficult to produce another way.

· *Rate Law* allows a student to set up a simulated chemical reaction that can proceed from reactants to products and in the reverse direction. The student can set the rate at which the process occurs. Edward Mottel, associate professor of chemistry, says this gives students a better feeling for something that often cannot be observed directly. "To be able to change variables and see what the results are will give students a much better understanding of cause and effect," he says. "Immediate feedbackÐseeing what happens when you manipulate variables in an emulation of a physical processÐis extremely helpful."

· *Field Simulator* performs electric field simulations, drawing electric field lines and equipotential lines. Says Michael Moloney, professor of physics and applied optics, "The application gives students a visual sense of where the electric field is very large, and which way it's pointing throughout the region they're looking atÐthey can look at electric fields and potentials *visually*."

The applications have helped explain difficult concepts and show the interrelatedness of concepts from various disciplines within the curriculum. "Anything we can give the students in the way of experienceÐvisual feedbackÐwe think is valuable," says Winkel. "A comment we've heard frequently from students working with these applications is 'I took this in high school, but never really understood it.'"

Creative computer use facilitates learning

The NeXT computers have also been used as the basis of several innovative assignments. In one of these projects, students were asked to listen to a recording of a golf ball bouncing (they weren't told what it was) and calculate from what height the object was dropped. As Jerry Fine, associate professor of mechanical engineering, explains, "The golf-ball design project would have been difficult or impossible to do with any other computer. Students were able to run a spreadsheet, *Mathematica*, a digitized sound recording that could be played over and over, and a graphic representation of the waveforms associated with the soundÐand all of these things integrated nicely into a desktop computer and made it easy to solve a difficult problem."

Along with using NeXT computers for assignments and "exploration" in the computer lab, students often use the computers during class, at the professor's request, to try new applications or plot graphs, for example. And at the end of each class, students are asked to send comments, anonymously, to a "Comments" fileÐproviding what the faculty considers to be extremely valuable feedback. Students also use WingZ or *Mathematica*, to analyze data they've collected in the school's chemistry lab and new physics lab. Finally, they use the computers for their exams.

In addition, spending time with the computers actually increases student interaction. "They feel a sense of collegiality and closeness here," says Winkel. "They spend a great deal of time in the computer labs, and they interact a lot: if you don't know how to do something, you turn to the guy next to you, and if he doesn't know, somebody else does. A lot of learning goes on."

Good results alreadyÐand more on the way
"The students are becoming better self-learners," says Froyd, summarizing the results of the curriculum so far. "They're moving toward concentrating on concepts and many of the students are enjoying the approach. They're becoming more comfortable with the environment and the applications we ask them to use because they're working on a machine where you don't ask 'can it do it?,' but rather, 'how long will it take?' "

All of the faculty are looking forward to fine-tuning the curriculum. Making a point echoed in slightly different form by the other faculty members, Froyd says "One of the things that the integrated curriculum lets me do is work more closely with the students who will be studying electrical engineeringÐgiving them a firm foundation on which to build. That way, they'll be that much more prepared for the sophomore year."

For more information, contact:
Professor Jeff Froyd
froyd@sem.rose-hulman.edu

[Sidebar]

Outside funding provides support for curriculum

In planning and establishing the integrated curriculum, Rose-Hulman received financial assistance from four organizations:

· The National Science Foundation provided funding for the NeXT computers in the classroom labs; for the new physics lab; and for support of faculty and students involved in course development, application development, and instruction.

· Lilly Endowment, Inc., provided seed money for faculty during the summer of 1988 and additional funding for the development of the final curriculum syllabus in 1990.

· The Westinghouse Foundation provided support for the students who developed applications during the summer of 1990.

· The General Electric Educational Foundation is providing funding for a thorough evaluation of the curriculum by consultants as well as by faculty from other institutions.

Jeff Froyd believes that Rose-Hulman has been successful in obtaining this funding because the philosophy embodied by the integrated curriculum meshes with a growing national awareness of the need for changes in engineering education to keep up with rapidly changing technology.