At the front of a classroom, a classical ballet dancer performs leaps, arabesques, and pirouettes. Students then try the movements, recording their own motions on video.

LEAPING INTO PHYSICS

A dance class? No, it's Continuum Mechanics 270, where future engineers study the mechanics of motion.

"It's a way of making them realize that engineering is everywhere," Professor Glen Ellis explains. "In this session, we introduce students to the concepts of the 'dynamics of deformable bodies.' " (When a dancer moves her arms and legs, she "deforms" her body's shape.) The problems involved are the same as those in most classes on motion and gravity. But where other engineering classes typically study the movement of projectiles, these students examine the physics of dance.

Why study dance? And why should these young women try the moves themselves?

Ellis, a civil engineer and Ford Visiting Professor of Engineering Education, answers that the human body in motion poses one of the more complex engineering problems. A graduate of Princeton University's doctoral program, he's taught in several settings, from the United States Air Force Academy to Japan's Kajima Corporation, and is convinced that, "Humans are more interesting subjects than the typical examples of blocks on an inclined plane."

There are several reasons why engineering students should look at a ballerina's plié or fouette. Drawing on his experiences teaching physics at Smith's Summer Science and Engineering Program, Ellis says female students appreciate problems that feature female examples. In an era when only 20 percent of engineering graduates are women, Ellis maintains, such factors must be recognized if engineering education is to be improved.

Dance also conveys the tactile sense of the physics involved. "Dance is a natural for a learner-centered teaching environment. By trying the moves themselves, students actually feel the forces acting upon them; they're not passive observers. We try to make the problem interesting and fun while still involving high-level academics."

Once they've got the feel of it, students tackle the classroom assignment, which addresses one of dance's most difficult questions: How does a dancer appear to hover in space during a grand jeté?

Ellis demonstrates the problem using a videotape of a ballerina performing a grand jeté, a giant leap across the stage with arms and legs extended. Her head rises, then moves on a steady horizontal for many frames before coming back down. Her motion appears to defy the laws of gravity, which say that she should rise and fall in one continuous arc with no more "hang time" than a cannonball shot out of a gun.

Students analyze this videotape with the aid of computational software. They freeze each frame, making red marks that denote the rise and fall of different reference points on the dancer's body, such as her ear and waist. Frame by frame, they plot information about changes in the dancer's velocity, acceleration, vertical height and horizontal travel from one fraction of a second to the next. When the dots are made into a series of graphs and run through successive equations—much like crunching numbers on an elaborate pocket calculator—students can solve the puzzle.

The answer? While the audience is focused on watching the height of the ballerina's head above the floor, the dancer is repositioning her legs and shifting her center of mass upwards, from her abdomen to her chest. In other words, by extending her appendages at just the right moment during her leap, she contorts her shape so her head stays the same height above the floor while her body goes up and down, as the theory says it should.

"Mystery solved," said Ellis. Then he examines homework on the explanations for the movement of a rower's power stroke on the crew team and the effect of topspin on a volleyball.

"Engineering is

GLENN ELLIS

Glenn Ellis, Ph.D.
Ford Motor Visiting Professor
of Engineering Education

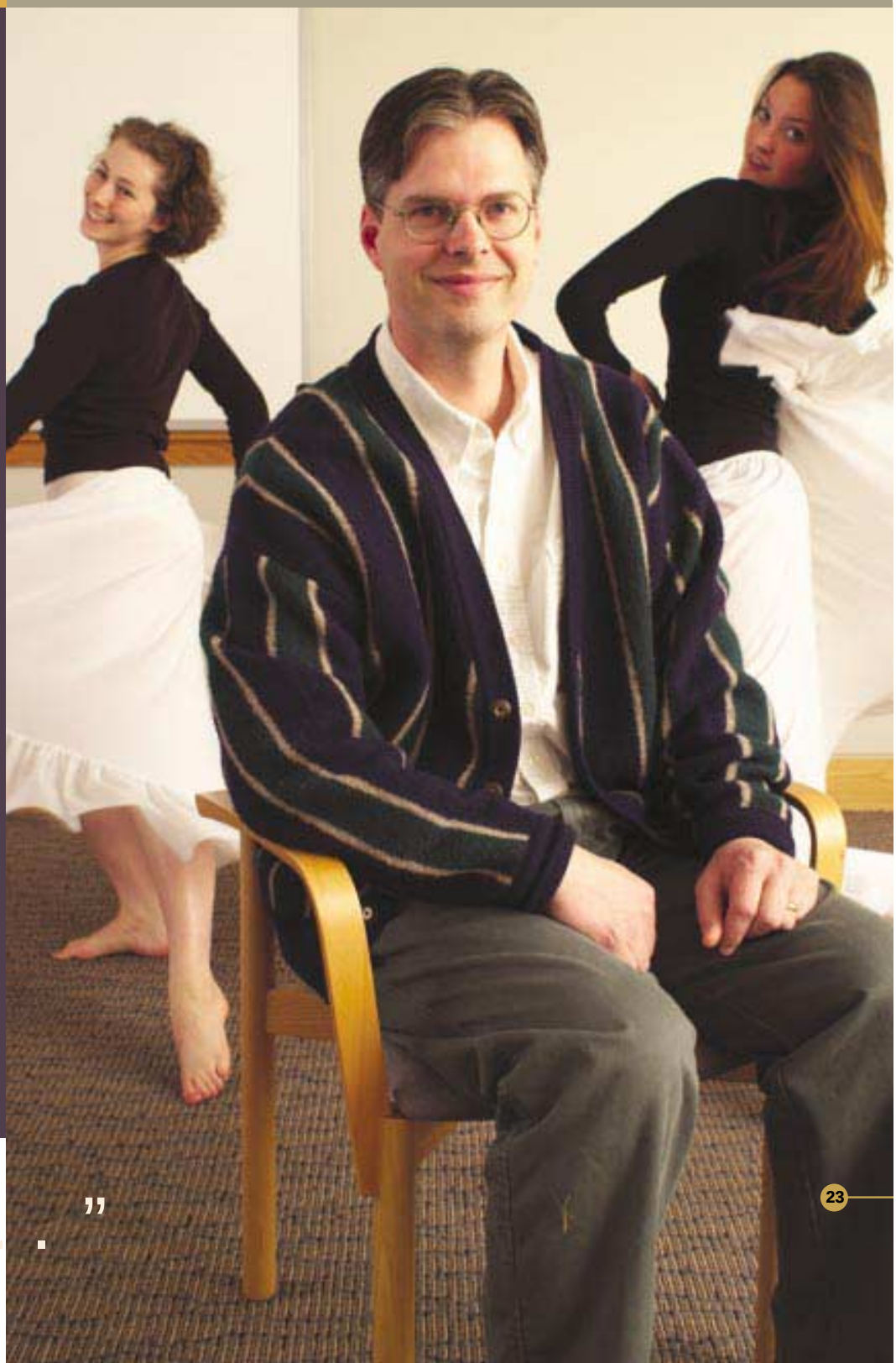
Area of Expertise
Civil engineering and engineering education

Education
Ph.D., Princeton University, 1987

Professional Experience
- Visiting Professor, Civil and Environmental Engineering, United States Air Force Academy
- Assistant Professor, Civil and Environmental Engineering, Clarkson University

Selected Recent Publications
- "Getting the 'big picture' in engineering: using narratives and conceptual maps" (with B. Mikic and A. Rudnitsky), Proceedings of the American Society for Engineering Education Annual Conference and Exposition, Nashville, Tennessee, June 22-25, 2003.
- "Modeling the effectiveness of ozone as a water disinfectant using an artificial neural network" (with S. Heck and V. Hoermann), Environmental Engineering Science, 18 (3), 2001.
- "Improving the conceptual understanding of kinematics through graphical analysis" (with Warren A. Turner), Proceedings of the American Society for Engineering Education Annual Conference and Exposition, Montreal, Canada, June 15-19, 2002
- "Helping students organize and retrieve their understanding of dynamics" (with Warren A. Turner), accepted for publica tion in the Proceedings of the American Society for Engineering Education Annual Conference and Exposition, Nashville,

Selected Honors and Awards
- Outstanding New Teacher Award, Clarkson University
- Tau Beta Pi Faculty Award, Clarkson University



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