DOCUMENT RESUME

ED 325 373 SE 051 709

AUTHOR Redish, Edward F., Ed.; Risley, John S., Ed.
TITLE Computers in Physics Instruction. Proceedings of a Conference (Raleigh, North Carolina, August 1-5, 1988).
REPORT NO ISBN-0-201-16306-3
PUB DATE 90
NOTE 594p.
AVAILABLE FROM Addison Wesley Publishing Company, 350 Bridge Parkway, Suite 209, Redwood City, CA 94065-1522 ($50.50).
PUB TYPE Collected Works - Conference Proceedings (021) -- Books (010)

EDRS PRICE MF03/PC24 Plus Postage.
DESCRIPTORS *College Science; Computer Simulation; Computer Software; *Computer Uses in Education; Demonstrations (Educational); *Educational Technology; *Educational Trends; Higher Education; Laboratory Procedures; Networks; *Physics; Programing Languages; Research and Development; Science Instruction; Science Materials; *Secondary School Science; Spreadsheets; Teaching Methods; Videodisks; Workshops

ABSTRACT

Computers are revolutionizing activities in all areas of life. Physics researchers, accustomed to being at the forefront of technology, have been deeply affected by the computer revolution. This effect has serious implications for what is taught and how it is taught in the physics classroom. This conference was organized to allow physics teachers and software developers in physics education to come together and see the state of the art in using computers to teach physics. The conference included 39 invited lectures and 122 contributed presentations. It introduced a number of innovations in the hope of increasing interactions and stimulating future contacts. This document contains the text of the invited and contributed papers organized as follows: (1) "The Computer's Impact on the Physics Curriculum"; (2) "Physics Computer Simulations"; (3) "Computers in the Physics Laboratory"; (4) "Physics Education Research and Computers"; (5) "Computational Physics and Spreadsheets"; (6) "Computer Tutorials in Physics"; (7) "Physics Lecture Demonstrations Using Computers"; (8) "Authoring Tools and Programming Languages"; (9) "Computer Utilities for Teaching Physics"; (10) "Computer Networking Workshops"; (11) "Publishing Physics Software"; and (12) "Videodiscs and Visualization for Physics." Appended are author and general indexes, a list of the contents of distributed software, and a software order form. (CW)

COMPUTERS IN PHYSICS INSTRUCTION: Proceedings

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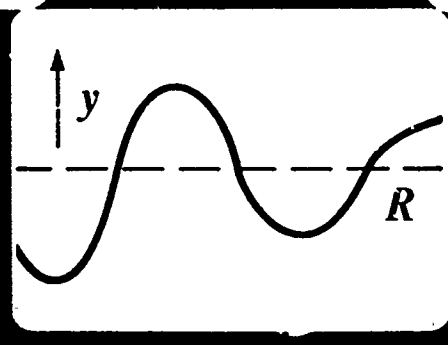
THE CONFERENCE ON

# COMPUTERS IN PHYSICS INSTRUCTION

PROCEEDINGS

Edward F. Redish and John S. Risley, Editors





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**ADDISON-WESLEY PUBLISHING COMPANY, INC.**
**THE ADVANCED BOOK PROGRAM**
Redwood City, California • Menlo Park, California • Reading, Massachusetts
New York • Amsterdam • Don Mills, Ontario • Sydney • Bonn • Madrid
Singapore • Tokyo • San Juan • Wokingham, United Kingdom

Publisher: *Allan M. Wylde*
Production Manager: *Jan V. Benes*
Electronic Production Consultant: *Mona Zeftel*
Promotions Manager: *Laura Likely*
Cover Design: *Michael A. Rogondino*

**Library of Congress Cataloging-in-Publication Data**
Conference on Computers in Physics Instruction (1988 : North Carolina State Universi.y)
The Conference on Computers in Physics Instruction : proceedings / [edited by] Edward F. Redish, John S. Risley.
p. cm.
Conference held at North Carolina State University, Aug. 1988.
Includes index.
1. Physics--Study and teaching--Data processing--Congresses. 2. Physics--Computer-assisted instruction--Congresses. I. Redish, Edward F. II. Risley, John S. III. Title.
QC30.C636 1990 530'.07'8--dc19 90-364
ISBN 0-201-16306-3

A complete list of trademarks appears on page 542.

This book was typeset in Quark Xpress™ using a Macintosh computer. Camera-ready output is from an Apple LaserWriter II NTX Printer.



ABCDEFGHIJ-MA-89

# VideoGraph: A New Way to Study Kinematics

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The *VideoGraph* software package provides students with a new way of taking data on the motion of objects.[1] Targeted for any introductory high school or college-level physics course, this software not only makes it easier and faster to collect motion data, but also helps students make the cognitive link between the physical event and the mathematical graph representing it.

Students begin by videotaping an interesting motion. This motion could be something like the collision of air-track carts or the oscillation of a mass on a spring. It could also be a "real-world" landing of a jet airplane or the acceleration of an automobile. Students use a tripod-mounted videocamera to record the motion of the object as it moves across the field of view. These images are played back one at a time on a single-frame–advancing videocassette recorder. As the images are displayed by the VCR, they are digitized and sent into a Macintosh microcomputer and stored as "MacPaint" documents. We use Pixelogic's *MacViz* interface to do this, although others will work.

To run the *VideoGraph* software, the students select the "Open" choice under the "File" menu and load the video frames into the computer. By making the proper selections from the "Set-up" menu, they select an origin of coordinates, calibrate the image (by selecting an object of known size from a frame and then entering its size and units of measure), and mark a point of interest on each frame. This last task is usually very time consuming during traditional labs, because it involves measuring extremely small dots on a photograph.

The *VideoGraph* software presents each frame individually. The student moves a mouse-controlled cursor until it is on a readily discernible part of the moving object. Clicking the mouse button records the position of that point and automatically advances to the next frame. This process continues until all frames have been marked. It generally takes fewer than two seconds per frame.

Now the student selects a graph from the "Windows" menu. For example, if the student selects the "X-Position" graph, the software opens a new window and draws appropriate axes. Selecting "Animate" under the "View" menu then produces a movie showing the object as it goes across the screen. At the same time, the software generates a graph of the object's position along the $x$ direction. It can also produce graphs of position, speed, and acceleration for both $x$ and $y$ directions or can display a list of coordinates for the graph.

We are currently conducting a thorough evaluation of the effectiveness of the software.[2] The research design permits us to compare the *VideoGraph* technique with the more traditional stroboscopic method of gathering motion data. We will also be able to see if viewing an object moving on the screen reduces the need for students actually to produce the motion. We certainly do not want to imply that using the software will completely remove the requirement for hands-on experimentation. But if students need not be involved in producing every motion, they could be assigned a series of previously produced motions for thorough analysis. This could be done as homework assignments or as part of laboratory exercises. Using *VideoGraph* will thus allow students to examine a broader variety of motions, both those they produce and those produced by others.

Since this technique of gathering data will work for a wide range of motions, we are developing an entire series of laboratory exercises using the *VideoGraph* package.[3] We are also designing supplementary software to allow students to "build" motion graphs by selecting line segments from a palette of choices. Distance, speed, and acceleration graphs will be linked so that adding a segment to one graph will automatically update the other two. Student creation of a simple object that moves according to the kinematics graphs will lead students from graph to motion. We hope this will complement the current *VideoGraph* software, which goes from motion to graph.

The*VideoGraph* project was partially supported by the National Science Foundation (grant no. CSI8750443). Mainstay, Inc. donated their software development environment, V.I.P.

1. The *VideoGraph* software is available from the Center for Learning and Technology The current version requires at least two megabytes of memory in order to work with a reasonable number of images. The animation is smoothest on a Macintosh II.
2. The development and evaluation of the *VideoGraph* software is being done as part of Mr. Beichner's Ph.D. dissertation in science education at SUNY Buffalo. Statistical results of the research will be available at the conference.
3. This curriculum package will be made available by the department of physics at the SUNY College at Buffalo. Titles of the labs include: "Measurement and Error," "Vectors," "Acceleration," "Free Fall," "Projectiles," "Harmonic Motion," "Work," "Linear Collisions," "Two-Dimensional Collisions," and "Angular Momentum."

# Computer Analysis of Physics Lab Data

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Computerized data-acquisition devices can now record more data in a few seconds than students can analyze in a semester using standard techniques. Fortunately, the computer also provides students with the power and speed to discover patterns and