Brief Introduction to Video-Based Motion Analysis

BCAPT Annual Conference UBC-O (May 7, 2011)

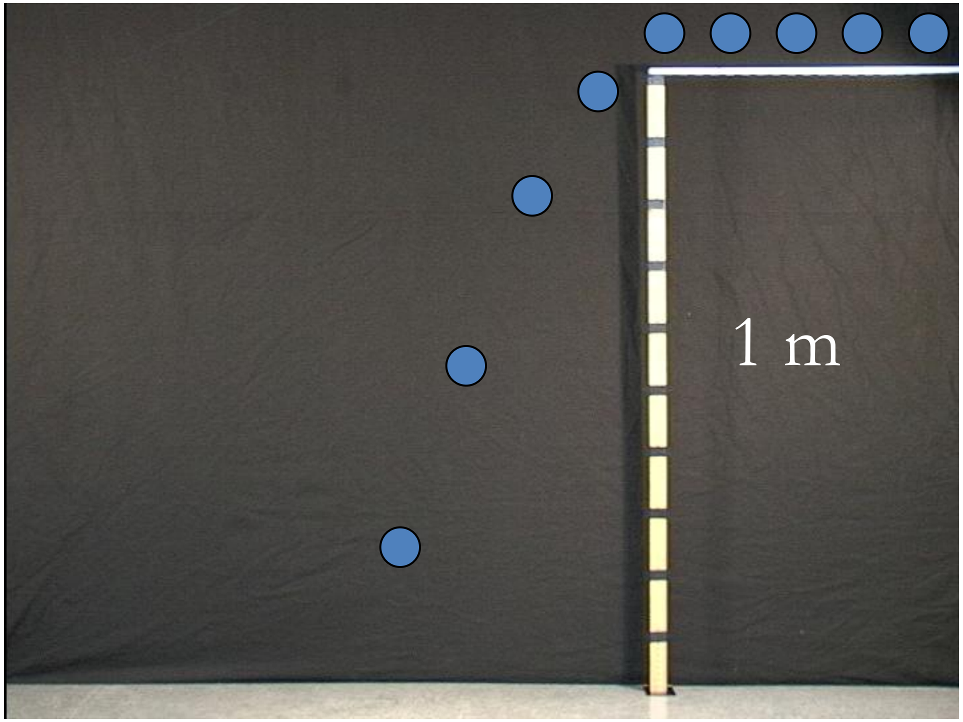
Dr. Marina Milner-Bolotin
(Contributions from T. Antimirova)

Department of Curriculum and Pedagogy
University of British Columbia, Vancouver, Canada

Why Might Physics Teachers Want to Use Video-Analysis?

- Real life events versus idealized textbook problems
- Easy data collection for analysis or modeling
- Scientific "disputes"' resolution by experimenting
- Feasible cost effective alternative or addition to live experiments
- Promotes higher order critical thinking skills
- Can be used in lectures, labs, homework, exams

What is Video-Based Motion Analysis?



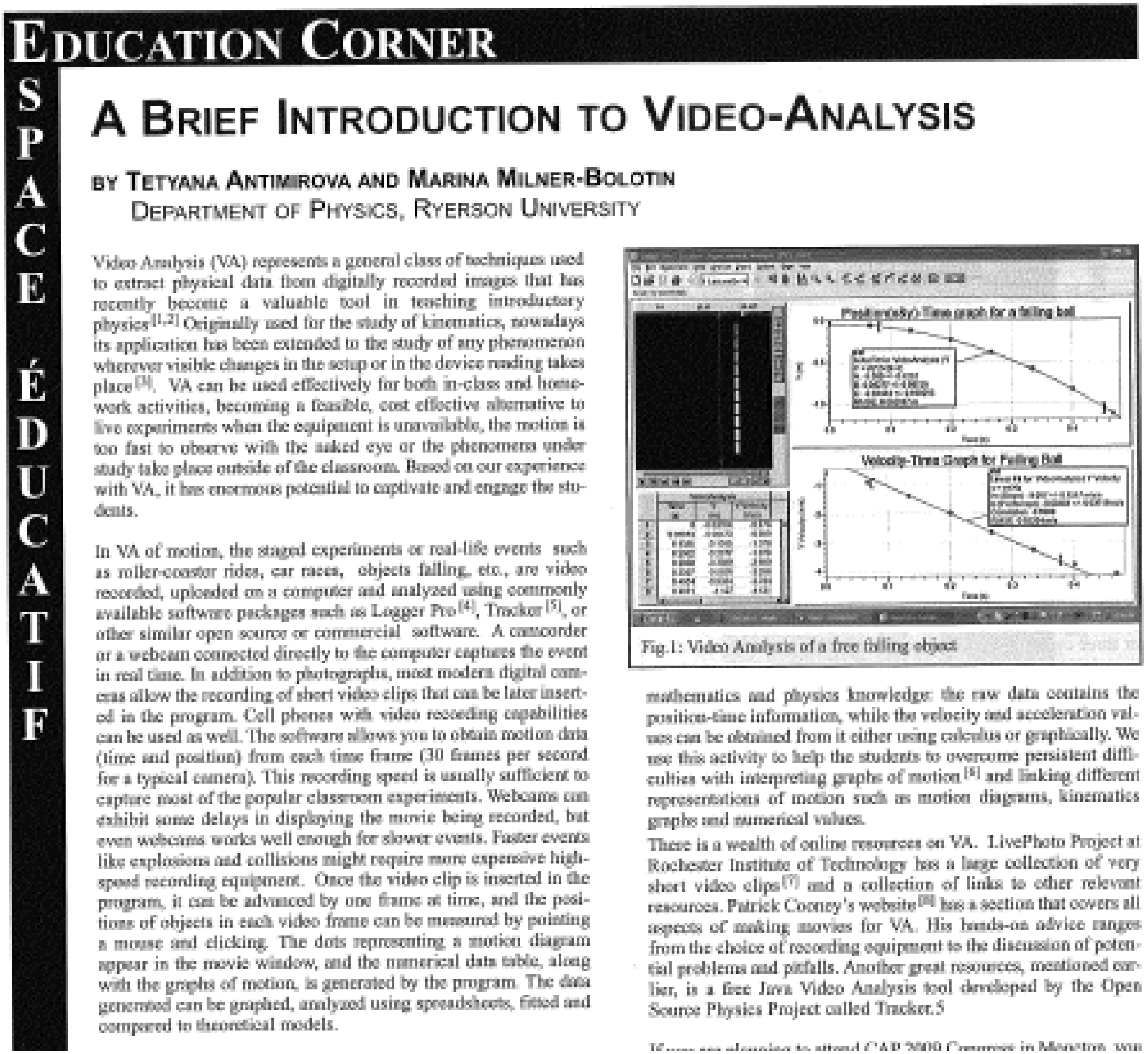
Frame by frame video-recorded motion analysis.

Position data points are collected for each frame.

Generated data is graphed, analyzed in spreadsheets, compared to theoretical models.

Equipment: Simple video camera and software (Vernier Logger *Pro*, Tracker, etc…)

Physics in Canada: Education Corner



EDUCATION CORNER

SPACE ÉDUCATIF

A BRIEF INTRODUCTION TO VIDEO-ANALYSIS

BY TETYANA ANTIMIROVA AND MARINA MILNER-BOLOTIN
DEPARTMENT OF PHYSICS, RYERSON UNIVERSITY

Video Analysis (VA) represents a general class of techniques used to extract physical data from digitally recorded images that has recently become a valuable tool in teaching introductory physics[1,2] Originally used for the study of kinematics, nowadays its application has been extended to the study of any phenomenon wherever visible changes in the setup or in the device reading takes place[3]. VA can be used effectively for both in-class and home-work activities, becoming a feasible, cost effective alternative to live experiments when the equipment is unavailable, the motion is too fast to observe with the naked eye or the phenomena under study take place outside of the classroom. Based on our experience with VA, it has enormous potential to captivate and engage the students.

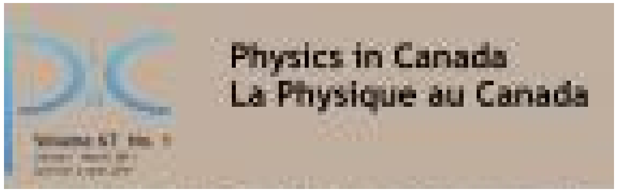
In VA of motion, the staged experiments or real-life events such as roller-coaster rides, car races, objects falling, etc., are video recorded, uploaded on a computer and analyzed using commonly available software packages such as Logger Pro[4], Tracker[5], or other similar open source or commercial software. A camcorder or a webcam connected directly to the computer captures the event in real time. In addition to photographs, most modern digital cameras allow the recording of short video clips that can be later inserted in the program. Cell phones with video recording capabilities can be used as well. The software allows you to obtain motion data (time and position) from each time frame (30 frames per second for a typical camera). This recording speed is usually sufficient to capture most of the popular classroom experiments. Webcams can exhibit some delays in displaying the movie being recorded, but even webcams works well enough for slower events. Faster events like explosions and collisions might require more expensive high-speed recording equipment. Once the video clip is inserted in the program, it can be advanced by one frame at time, and the positions of objects in each video frame can be measured by pointing a mouse and clicking. The dots representing a motion diagram appear in the movie window, and the numerical data table, along with the graphs of motion, is generated by the program. The data generated can be graphed, analyzed using spreadsheets, fitted and compared to theoretical models.

Fig.1: Video Analysis of a free falling object

mathematics and physics knowledge: the raw data contains the position-time information, while the velocity and acceleration values can be obtained from it either using calculus or graphically. We use this activity to help the students to overcome persistent difficulties with interpreting graphs of motion[6] and linking different representations of motion such as motion diagrams, kinematics graphs and numerical values.

There is a wealth of online resources on VA. LivePhoto Project at Rochester Institute of Technology has a large collection of very short video clips[7] and a collection of links to other relevant resources. Patrick Cooney's website[8] has a section that covers all aspects of making movies for VA. His hands-on advice ranges from the choice of recording equipment to the discussion of potential problems and pitfalls. Another great resources, mentioned earlier, is a free Java Video Analysis tool developed by the Open Source Physics Project called Tracker.5

Antimirova, T., & Milner-Bolotin, M. (2009). A Brief Introduction to Video Analysis. *Physics in Canada, 65* (April-May), 74.



Data Acquisition and Analysis Software from Vernier (Logger *Pro*)

Vernier

CELEBRATING 30 YEARS

David Vernier

www.vernier.com

Getting Started: Resources for Video-Based Motion Analysis

American Association of Physics Teachers
Enhancing the understanding and appreciation of physics through teaching

Motion Video-Based Analysis Resources:

comPADRE
Resources for Physics & Astronomy Education

Live Photo Project:

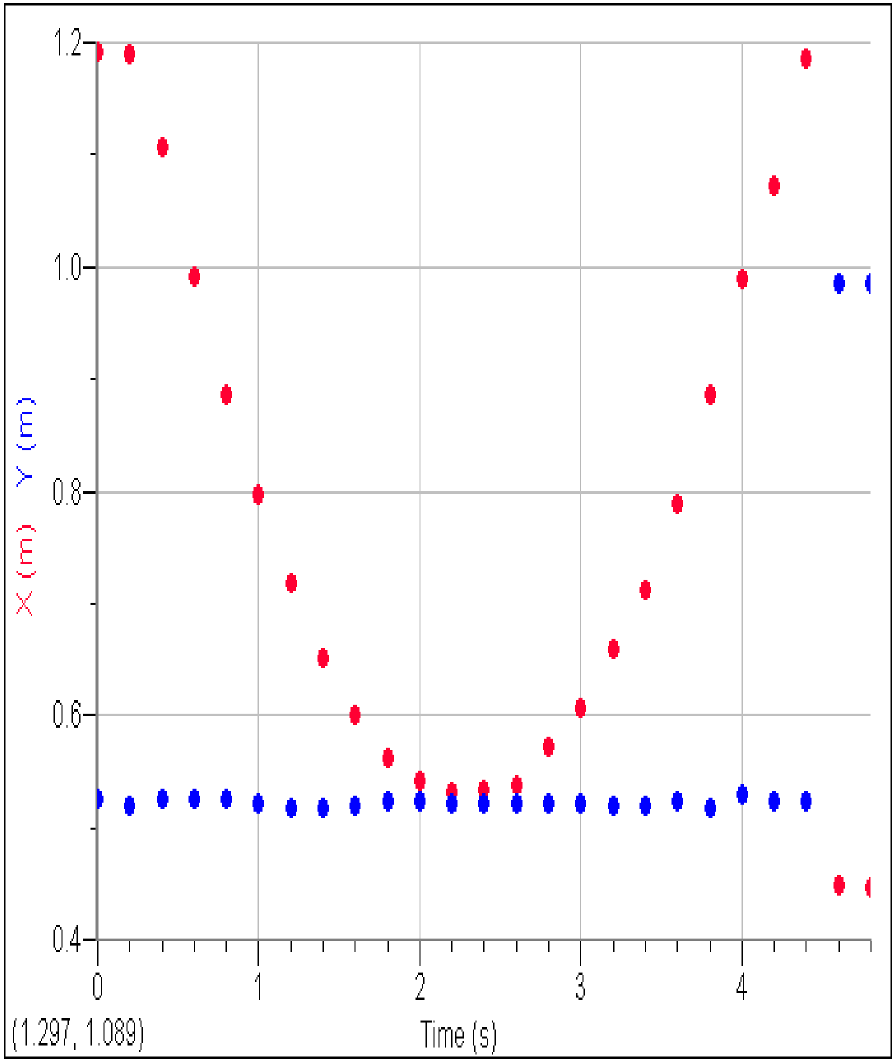
http://livephoto.rit.edu/
http://livephoto.rit.edu/wiki/

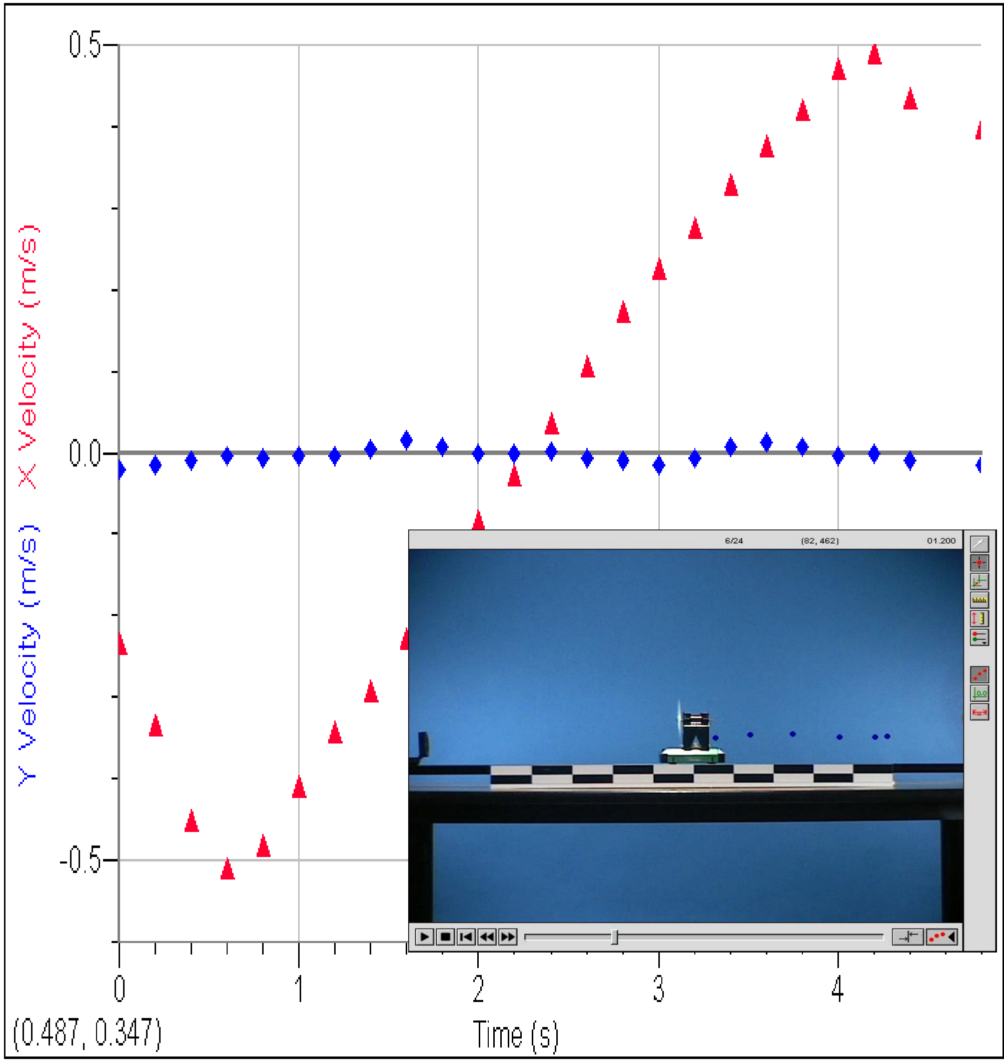
Patrick Cooney's website:

http://www.millersville.edu/~pjcooney
http://muweb.millersville.edu/~pjcooney/making-movies/

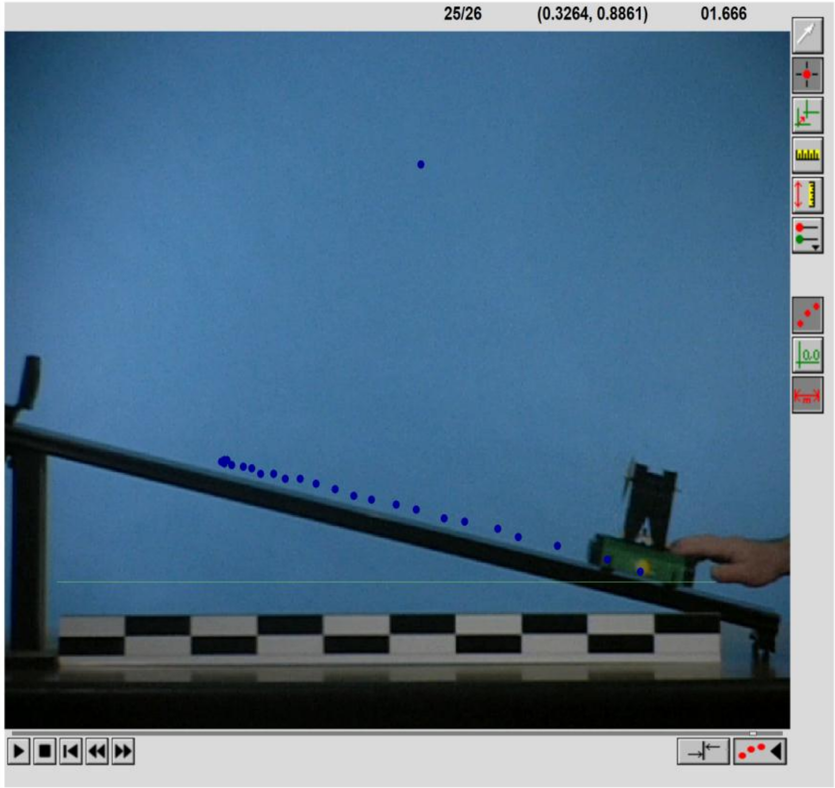
EXAMPLES

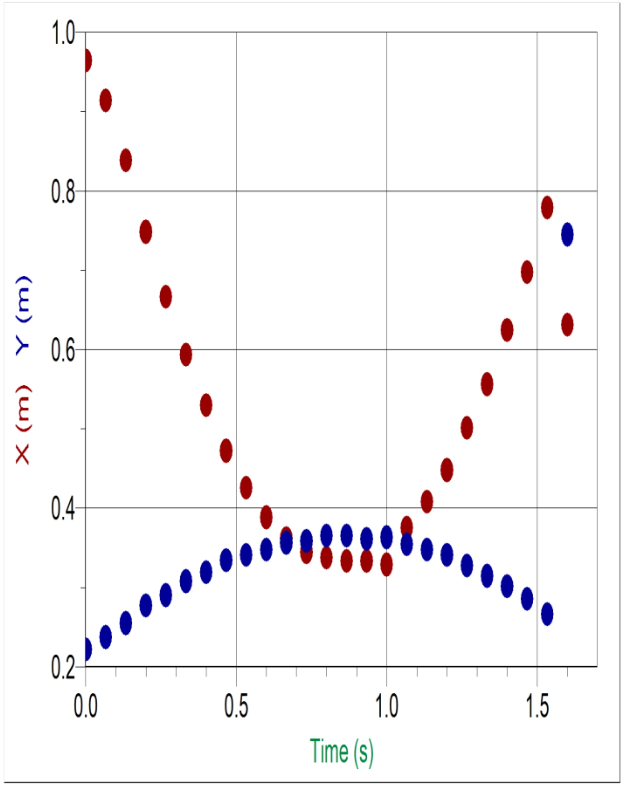
Cart Moving Forth and Back



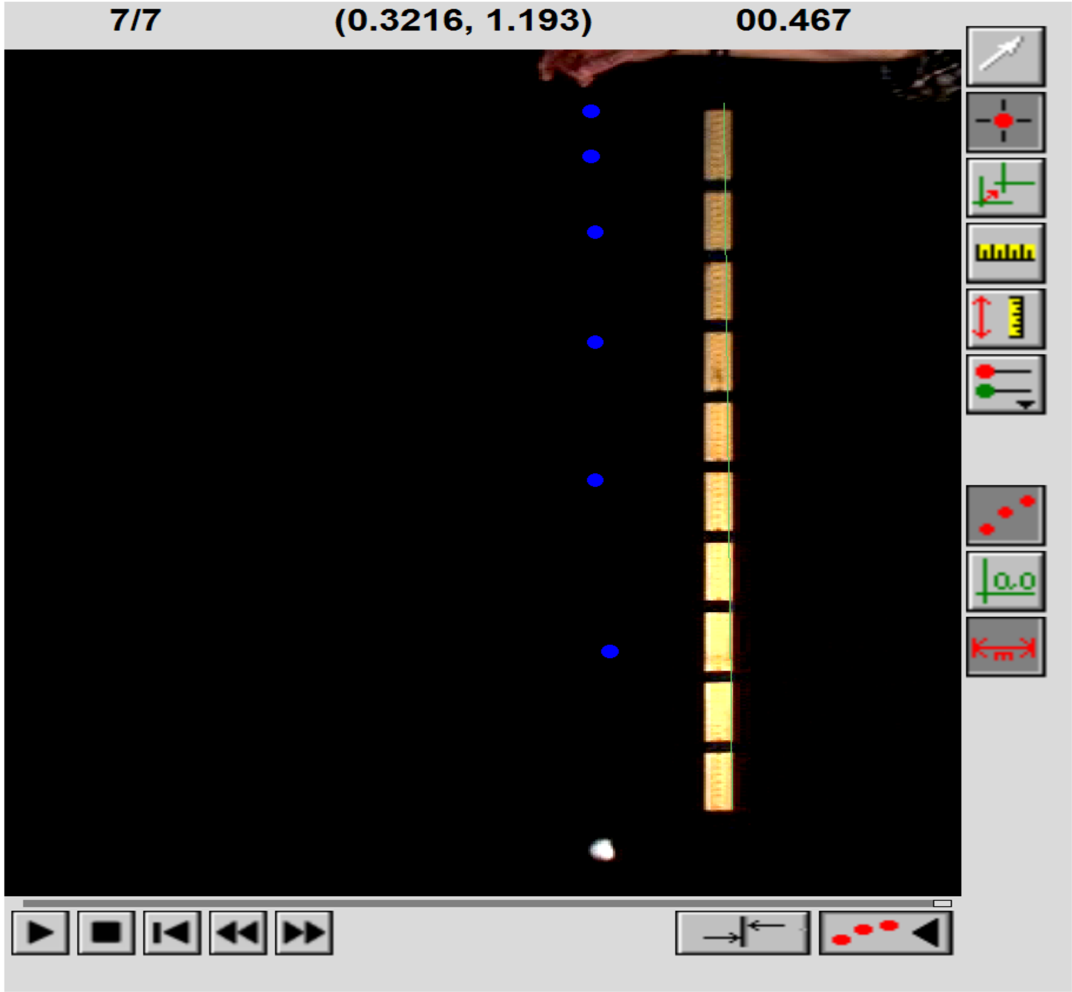


An Object Moving Along the Incline Plane





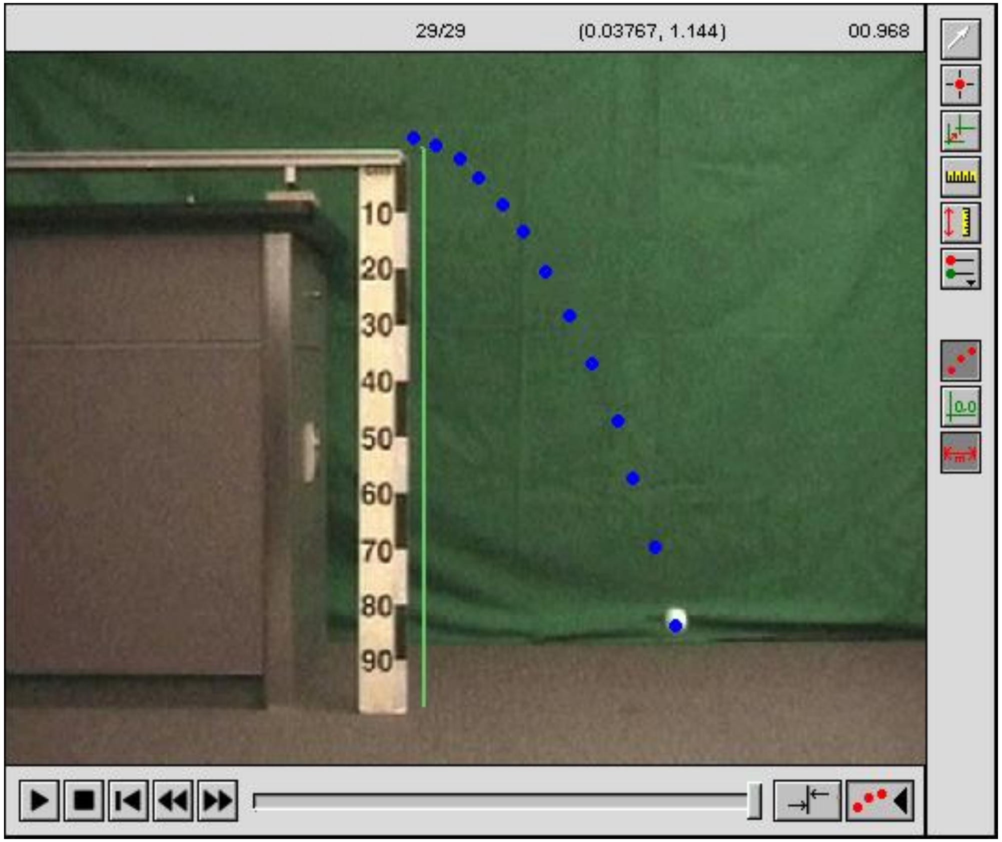
Free Fall



- Frame-by-frame traced
- Trajectory of a free falling ball
- Used in first year labs and lecture experiments at UBC

VIDEO FROM "CONTEMPORARY GALILEO'S PROJECTILE"

(Courtesy of Activity Based Physics Group)



Frame-by-frame traced trajectory

TWO-TRACKS DEMO FROM ONTARIO SCIENCE CENTRE

Two metal balls are released from the the top point simultaneously. Which one will finish first? Explain.

Some Video-Analysis Applications

- Homework
- Labs
- Exams
- Lectures
- Projects
- Combination with sensors
- ?

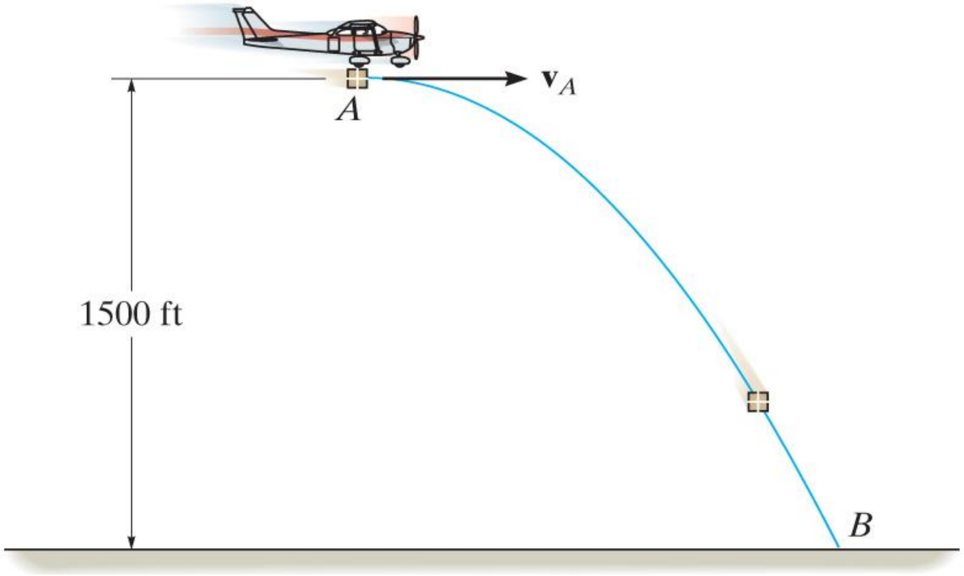
Video-Analysis as Homework

- Some of the traditional end-of-chapter problems can be converted into motion video-analysis problems

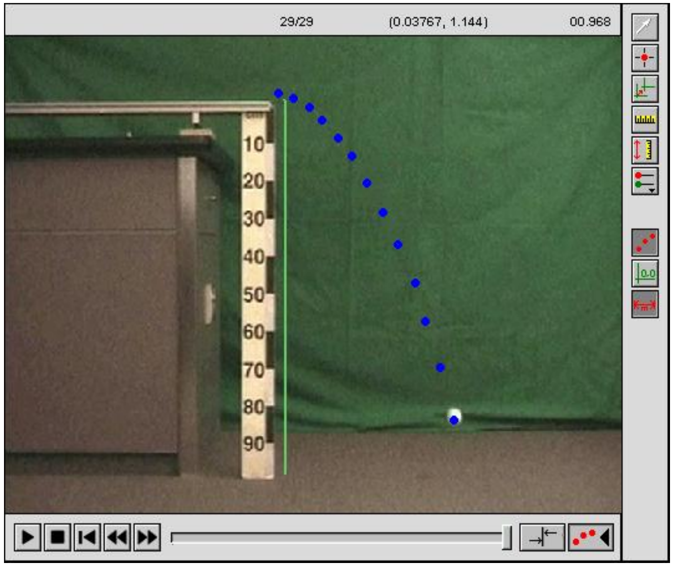
- **Additional benefit:** comparison of analytical and numerical solutions and modeling using real data

Traditional End-of-Chapter Problem

A package is dropped from the plane which is flying with a constant horizontal velocity of $Va = 150\ ft/s$. Determine the normal and tangential components of acceleration, and the radius of curvature of the path of motion just before the package strikes the ground (R.C Hibbeler, (2006), "Engineering Mechanics", Pearson)



Video-Analysis Problem Example ("CONTEMPORARY GALILEO'S PROJECTILE" , Activity Based Physics Group)



Frame-by-frame traced trajectory

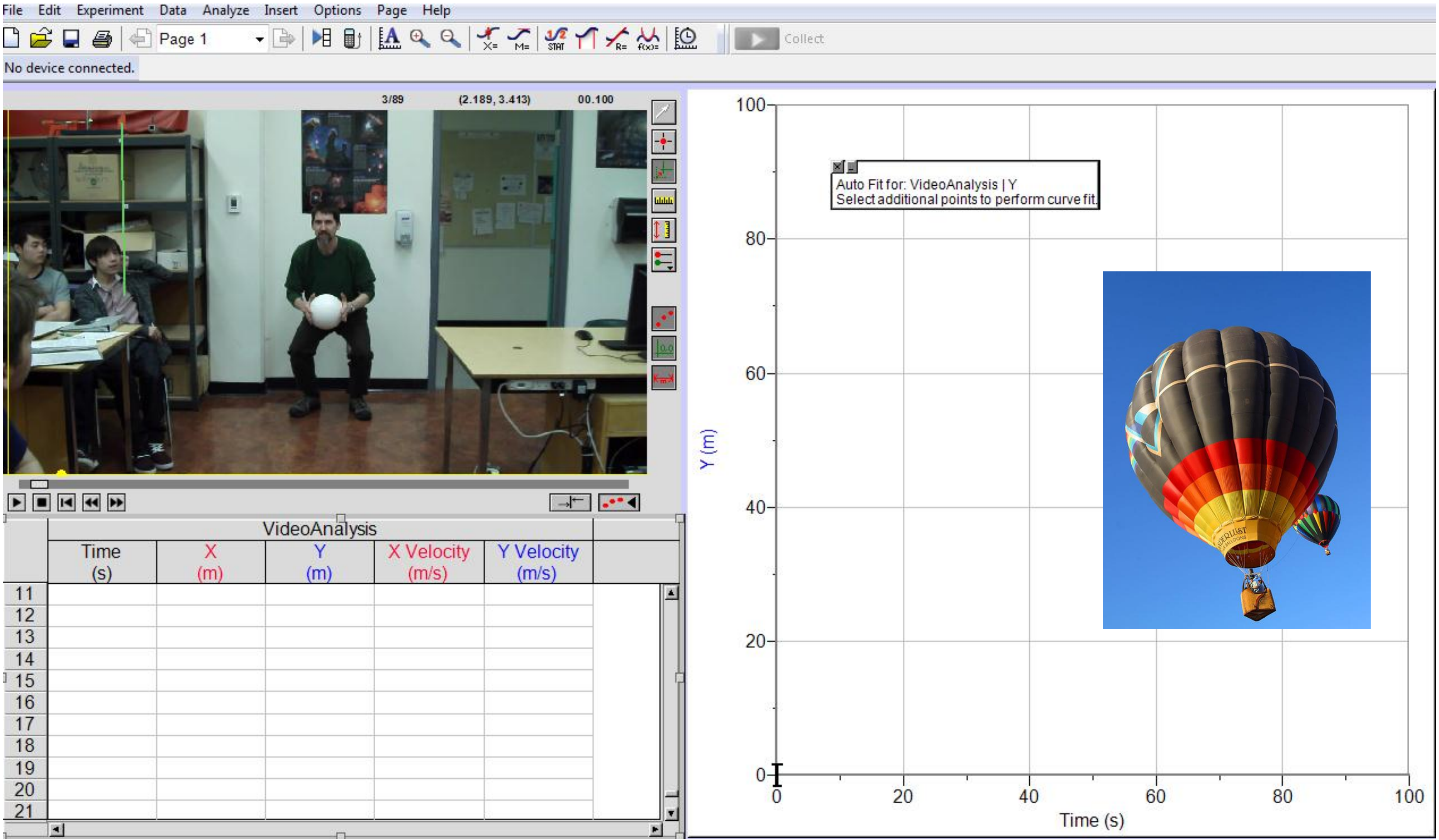
Based on what you know about curvilinear motion, calculate the rate of increase of speed for the third last point of the trajectory (t=0.917 s). Whenever possible, use real data from the movie.

(Was offered as a supplement to the ABP's "Galileo's Projectile II: Using Contemporary Techniques" assignment)

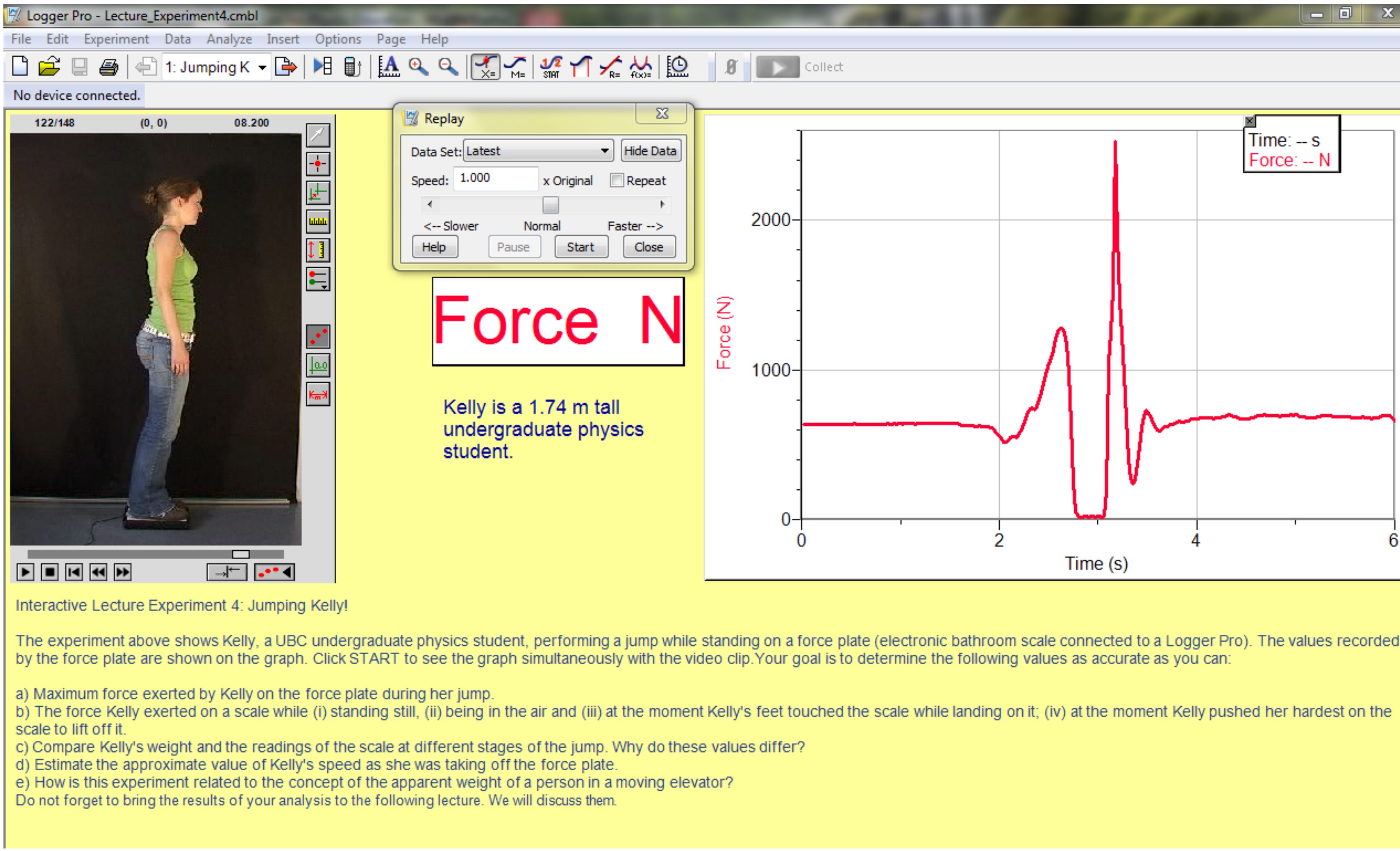
Vide- Analysis as a Group Problem Solving Activity

A hot air balloon is travelling upwards at a constant speed of 8 m/s. A passenger drops a small sandbag over the side of the balloon. Your group has 10 minutes to produce the ***y(t), v(t)*** and ***a(t)*** graphs for the sandbag. Assume the positive *y* axis is directed upward and *y=0* at the ground.

Science Dispute Resolution Example



Video-Based Motion Analysis and Sensors!



TRACKER: Free Video-Analysis Software

Tracker
Video Analysis and Modeling Tool

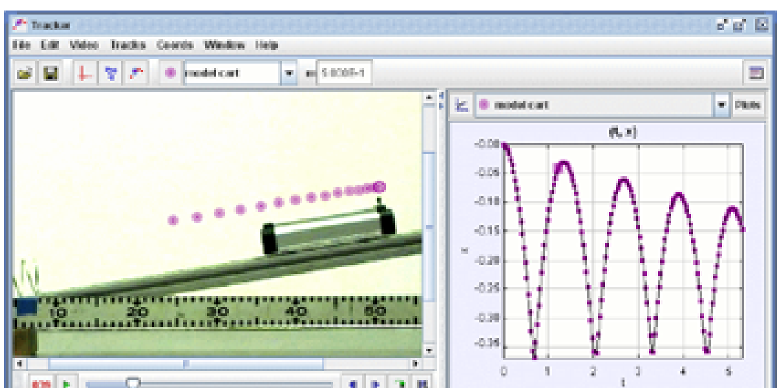
Webstart Tracker 4.0 Download Tracker 4.0 jar

Download Tracker 4.0 Windows installer

What is Tracker?

Tracker is a free video analysis and modeling tool built on the Open Source Physics (OSP) Java framework. It is designed to be used in physics education.

Tracker **video modeling** is a powerful new way to combine videos with computer modeling. For more information see Particle Model Help or my AAPT Summer Meeting posters Video Modeling (2008) and Video Modeling with Tracker (2009).



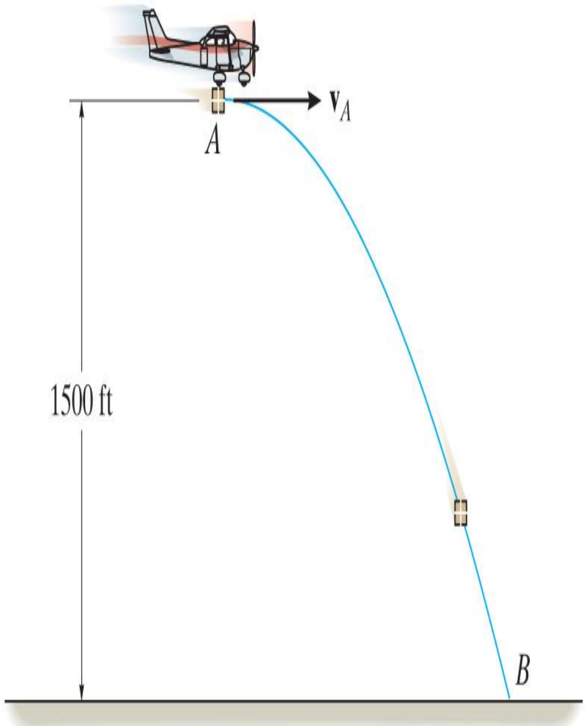
What's n

Quantum leap! Tracker 4.0 now use
greatly expands the number of reada
supported but not required). Xuggle i
installer, available now for Windows

Other new features include:

1. **Export Video wizard** enables
2. **New installer** installs Tracker,
   and videos.
3. Robust autotracker now **evolv**
4. Autotrack in both **1D and 2D**.
5. Multiple **video calibration** opti
6. New **protractor** and read-only
7. New **page view** displays html
8. **Expanded preferences**: set
9. Particle models have **start and**

What Do These Problems Have in Common?



© 2007 by R. C. Hibbeler. To be published by Pearson Prentice Hall, Pearson Education, Inc., Upper Saddle River, New Jersey. All rights reserved.