Enhancing Physics Teaching with Technology.

Presenter Profile Phil Jones has a BSc(HONS) (Sydney), MSc(HONS) (Macquarie), DipEd. He has taught science, physics and IT subjects in Australia and Europe and has been a lecturer in the DipEd program at Sydney Institute of Education, Sydney Uni. He has written a number of software programs and developed a range of interfaces and sensors for science. He regularly presents workshops for NSW DET, STANSW, STAV, Universities and TAFE NSW. He is currently manager of The Logical Interface.

Abstract

Sophisticated technology, once only the domain of forensic and research laboratories, is now within the reach of every science teacher passionate about incubating our scientists of the future. Such technologies excite both teachers and students and bring a sense of relevance to learning science. In this workshop I examine a number of such technologies for teaching physics, including

- Video Analysis of Motion. This technology is an excellent application of the computer to data acquisition and analysis. TLI Motion video analysis software is ideal for analysing motion in one and two dimensions to produce a range of graphs of motion.
- Interactive Physics (IP). IP is physics modelling software. With TLI Motion we have software for data collection data and analysis. With IP we have a tool to extend this process to do modelling and what if analysis. It is also a superb tool for creating simulations in physics - from Kepler's Laws through to Electromagnetic simulations.
- Simulation software - Krucible is revolutionary software for creating simulations and demonstrating experiments that are impractical in the secondary science lab. With Krucible you can even convert your PC into a fully functional Ripple Tank!
- PC Based Signal Generator and Oscilloscope. TLI WaveGen and TLI CRO exploit the power of the sound card in your PC and convert your PC into a powerful Signal Generator and Oscilloscope.
- Data Logging Technology. Data loggers are an extremely powerful data acquisition and analysis tool, which support a wide range of experiments from elementary to more advanced experiments such as force on current carrying wire, electromagnetic induction, apparent mass and electronic ticker timer.

Demonstration 1) Video analysis and TLI Motion video analysis software

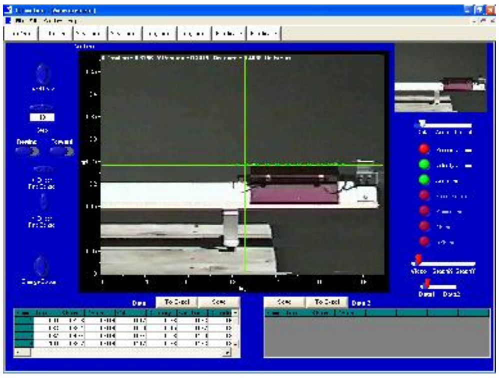
TLI Motion is a program designed to analyse video footage and produce a range of graphs from position vs time to momentum vs time. A large number of videos are included on the CD, which illustrate both one and two dimensional motion. They range from objects rolling along horizontal and inclined planes to projectile motion and collisions. In addition you can analyse your own video, if you have a video camera and a video capture card.

In this workshop we use this software to perform two experiments -

i) a collision and
ii) projectile motion.

These experiments are discussed below

Exercise 1: Impulse

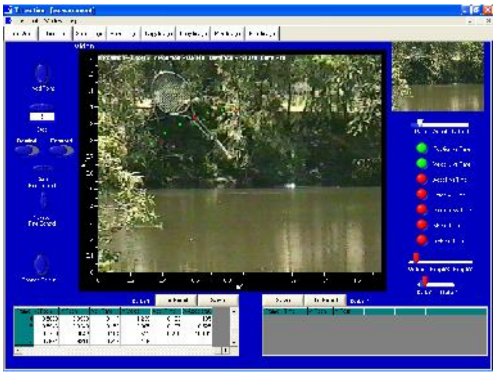


The figure at right shows an air track glider colliding with the end of an air track. An air track provides a cushion of air and reduces friction. In this example we step through the video marking the position of the glider and then view the position vs time, velocity vs time and momentum vs time.

Optional: Place a clear overlay on your screen and mark the dots for the motion. Measure distances from the start dot to successive dots and record this data along with the time between each dot. Using this data plot position vs time, velocity vs time and momentum vs time graphs for the motion before and after the collision. From these graphs determine the velocities before and after the collision. Compare your graphs with that produced by the software.

Verify that momentum was conserved in this collision by determining the total momentum before and after the collision.

Exercise 2: Projectile Motion



The figure below shows a picture of a tennis racket traveling across the video. As it travels, it also rotates. In this example we can show that the centre of mass of the racket undergoes projectile motion. A black tape indicates the centre of mass.

By stepping through the video and placing dots on the centre of mass for each frame produce position vs time graphs for this motion in the horizontal and vertical directions. Compare your graphs with those generated by the computer.

Optional: Produce velocity vs time graphs for both directions.

Demonstration 2: Questioning and Predicting - Simulations you and your students create.

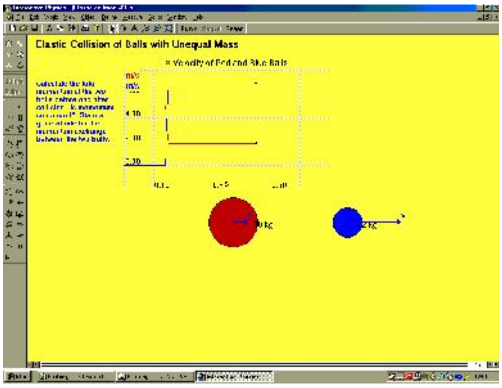
Simulation software is traditionally directed at demonstrating a particular experiment, or activity. Such software can be excellent for performing experiments that are difficult or impossible to do in school laboratories.

However the two products in this demonstration go far beyond this type of simulation to provide a platform for both teachers and students to create their own simulations. This approach to interactive software exploits students' creativity in a way that has been difficult to achieve in the past. They are ideal for open ended activities and What If analysis. I have found my students benefit enormously from this approach.

Interactive Physics

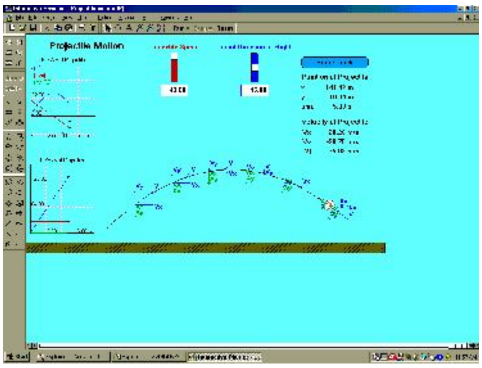
Interactive Physics makes it easy to integrate modelling and simulation into your physics classes.

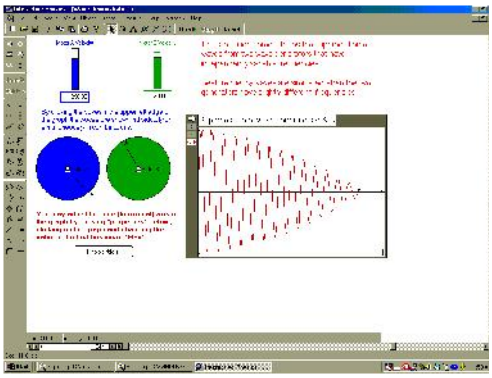
It contains a range of predefined solutions including dynamics, mechanics, electrostatics and magnetism, or alternatively you can create and save your own by drawing onscreen with a powerful and easy-to-use graphic interface.



You can add objects such as springs, dampers, ropes, and joints. Measure attributes of your objects like velocity, acceleration, momentum, and energy. You can also display these measurements as numbers, graphs, or animated vector displays. Then interact with your model in real time by changing parameters as the simulation runs.

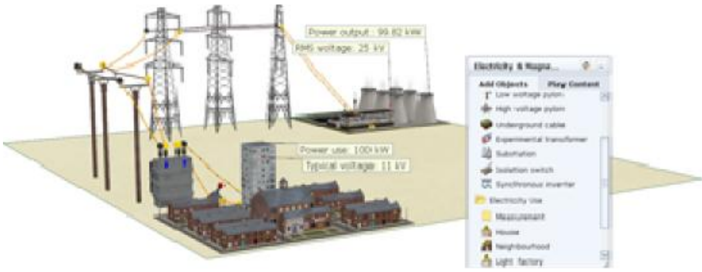
In this part of the workshop we examine a number of predefined solutions and create a simple one reproducing the projectile motion exercise of Demo 1.





Yenka

Yenka Physics is a powerful but easy-to-use simulator, which lets you learn by experimenting in a colourful, accurate environment.



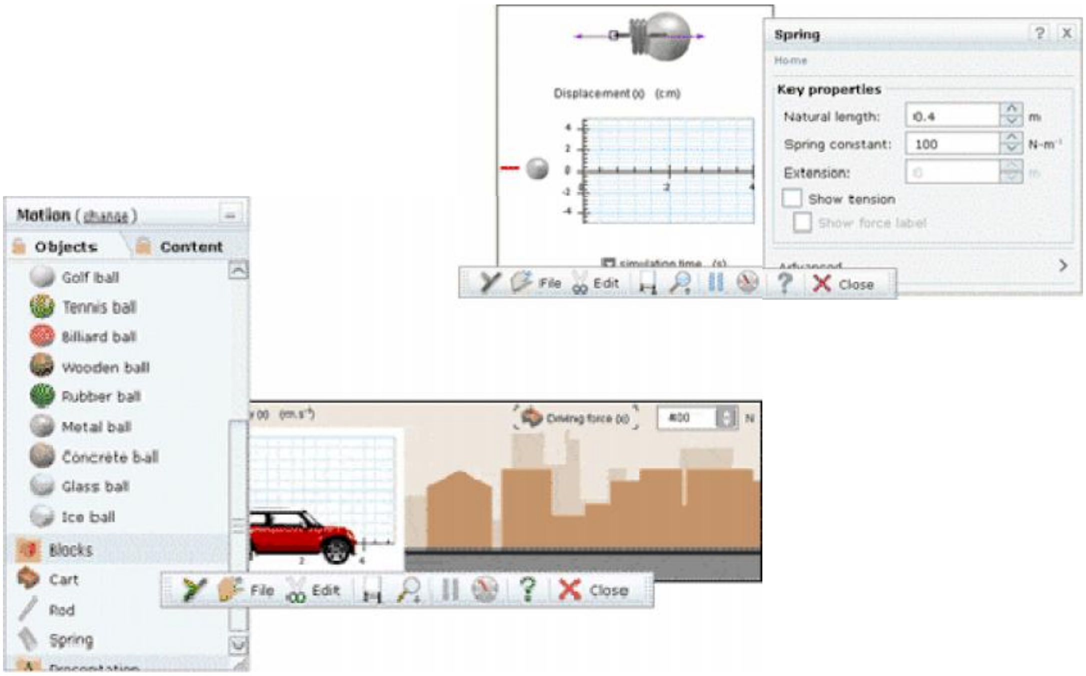
Simulate however you wish, from designing circuits and optical systems, through modeling wave propagation, to accelerating masses and graphing their motion.

There's a wide range of lessons and activities, and a set of training videos, to help you get started.

It can be used as a flexible demonstration tool - for example, on a whiteboard. Alternatively, students can use Yenka themselves, to investigate concepts in Yenka's safe, accurate world.

And teachers and students can all use the full version of Yenka Physics at home, free of charge.

One of the great features is that students get a free student licence so that they can continue their work at home, or independently at school. It's an ideal platform for BYOD.



Krucible

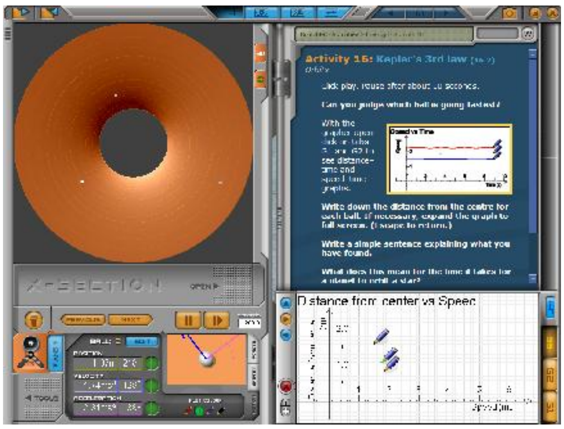
Krucible is a remarkable program and one of my favourites. It has to be seen to fully appreciate its features and functionality.

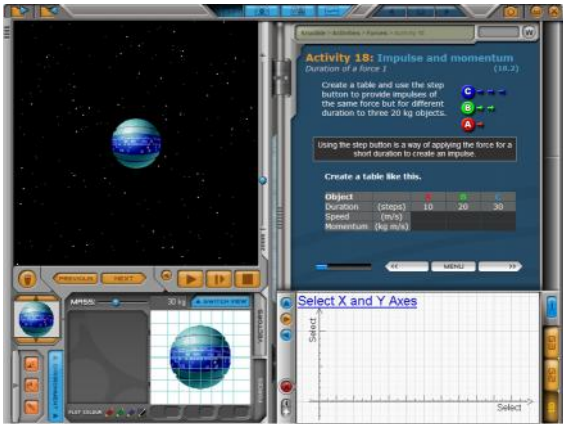
Krucible provides three experimental platforms to examine

1. Waves – all properties – virtually all aspects of wave motion
2. Dynamics and Energy
3. Forces and Momentum

Its approach is different to Interactive Physics in that it has a large number of predefined activities to guide students through the concepts with a more structured approach. You can easily leave your students to work through the activities with a minimal amount of guidance.

However it also provides a platform for creating simulations which can be saved and reloaded when needed. In this sense it is an open ended program for constructing simulations.





In Summary students can:

- plot experiment simulation data with a dynamic graph plotter
- use a notepad to record observations
- save and share experimental outcomes
- complete over 150 activities and apply knowledge to more than 150 real life challenges.

Features

- Demonstrates difficult physical concepts clearly.
- Encourages students to question and explore.
- Teaches experimental method and observational skills.
- Ideal for whole class or individual learning.
- Allows pupils to apply theory to real life challenges.
- Extends learning experience to exploit your student's creativity.

Demonstration 3: Using data loggers in Physics

Data loggers have many applications in physics. There are many examples of motion experiments using photo gates and distance sensors (sonic ranges).

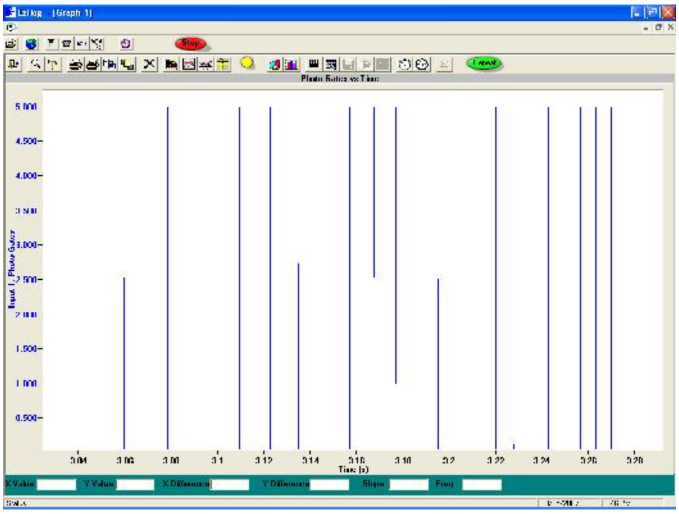
In this demonstration we look at three experiments using your data logger

1. as an electronic ticker timer
2. to illustrate the importance of sampling rate for physics experiments and
3. to demonstrate apparent mass of an object when placed in an accelerating container such as a lift, or rocket.

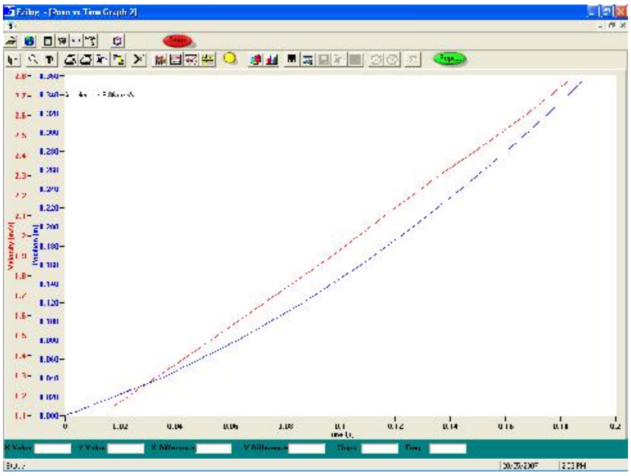
Using your data logger as an electronic ticker timer

In this demonstration we connect a photo gate to the Ezilog USB data logger. Some data logger brands allow your photo gate to work as an analogue sensor, most however simply work as a digital sensor and return time only.

By attaching a picket fence to an air track glider, or trolley and placing a photo gate over the track so the picket fence will break the beam we can achieve the same effect as a ticker timer only with much more ease and accuracy. The graphs below illustrate the type of results achieved. The picket fence produces a series of rectangles, which are then used to measure time intervals in much the same way as we measure distance intervals in a ticker timer pattern. The students use this data and the picket fence distances to create position vs time and velocity vs time graphs.



a) Graph produced from dropping a picket fence through a photo gate using the Ezilog USB.

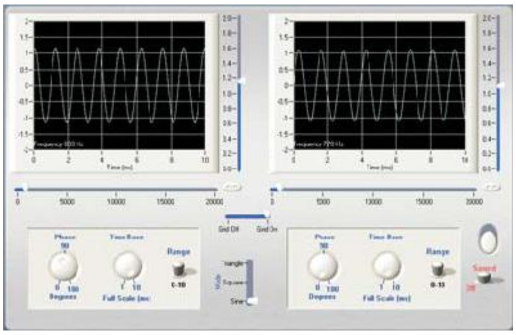


b) Position vs time and velocity vs time graphs generated from graph a using the Ezilog USB.

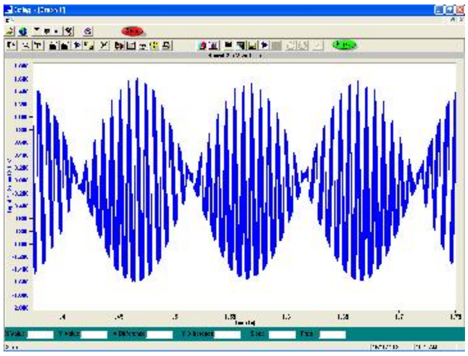
The importance of sampling rate for physics experiments - examination of sound waves from a speaker.

In this demonstration we use a computer based dual channel signal generator (the TLI WaveGen) to generate beats.

A sound sensor (microphone) is placed close to the computer speakers to record the sound. Various sampling rates are used to record beats and beat frequency and wave frequency are determined. The effect of sampling rate on the quantitative and qualitative results is examined.



TLI WavGen used to generate beats.



The beat envelope recorded with the Ezilog USB at 20,000 samples per second.

Demonstrating Apparent Mass

This activitiy demonstrates how we can use a data logger to

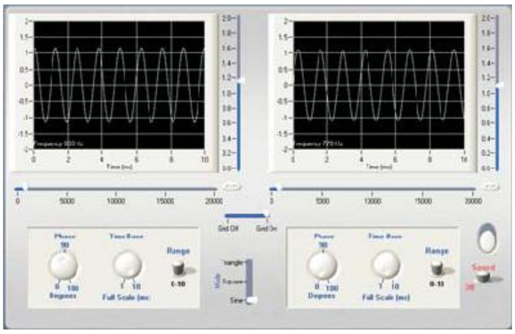
i) examine the apparent change in mass and weight of an object while in an accelerating lift and
ii) determine the acceleration of a lift when leaving and arriving at a floor.

By using a mass balance (TLI Mass-Balance Sensor) attached to a data logger we can examine directly the effect of acceleration on the apparent mass of an object. To perform this experiment you need to place your data logger and mass balance in a lift. Place a mass (around 200g) on the balance and record the mass as the lift accelerates upward and downward. This is an example of an experiment that was very difficult if not impossible to do without the use of a data logger.

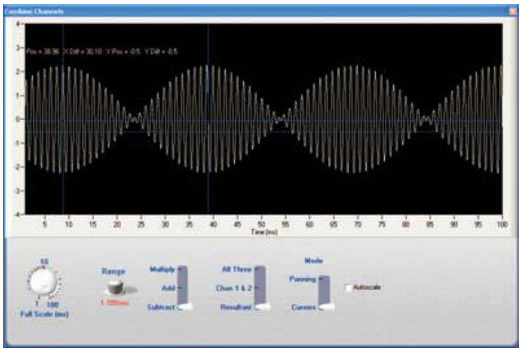
Demonstration 4: Simulation vs Direct Data Acquisition with a Computer

Using the TLI WaveLab system we examine two ways of looking at interference of waves.
TLI WaveLab consists of a computer based C.R.O. (TLI CRO) and Signal Generator (TLI WaveGen). In addition TLI WaveGen has a Virtual CRO for examining the output from the generated signals.

1. Interference of Waves



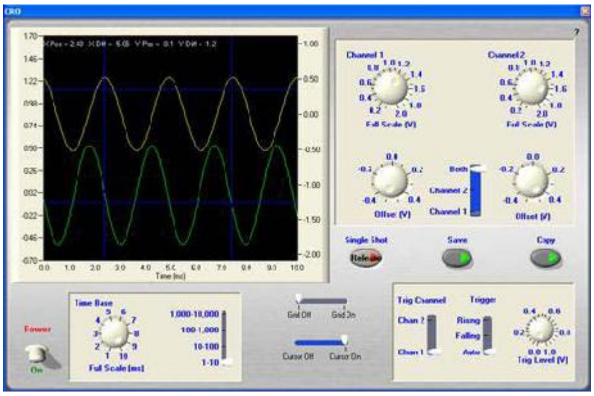
In this demonstration we examine beats by creating a wave with frequency of 820 Hz in Channel 1 of the TLI WaveGen and 830 Hz in Channel 2. We keep the phase difference the same.



By opening up the Virtual CRO in the TLI WaveGen we can see clearly the two waves and the resultant wave generated by them. We have not actually acquired the data, but simply created simulated data in this Virtual CRO. This technique is great for looking at wave interference and showing our students any variation of interference pattern, but does not teach them about oscilloscopes, or how to acquire real data using an oscilloscope. The students can hear the sound created by outputting the waves to the computers speakers.

2. Using a Computer Based CRO to collect data

The TLI CRO uses the computers sound card and the Line In and Microphone Inputs to actually collect, display and record data.



In this demonstration we examine beats by creating a wave with frequency of 820 Hz in Channel 1 of the TLI WaveGen and 830 Hz in Channel 2. We keep the phase difference the same. We record the generated waves using the TLI CRO software

We can view the waves in two ways -

i) by taking the generated waves from the computer's speaker output and putting it directly into the computer's Line In input (see figure at right).
ii) Playing the signal through the computers speakers and using a microphone to record the generated waves.

Both examples illustrate the actual collection of data and then analysis of data (measurement of frequency, period etc) by the TLI CRO software and so the students have the experience of using a signal generator and CRO to create, record and analyse data.