

## Enhancing Physics Teaching with Technology

### Demonstration i) 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 relating to and
- ii) projectile motion.

These experiments are discussed below

#### Exercise 1: Impulse

The figure at right shows an air track glider colliding on end 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.

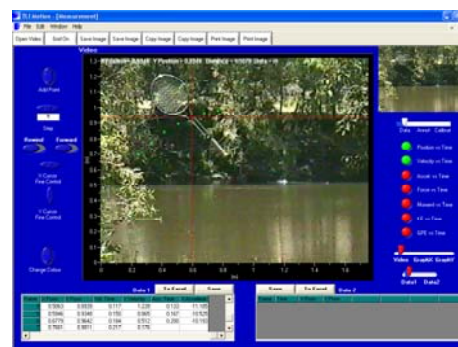
Verify that momentum was conserved in this collision by determining the total momentum before and after the collision.

#### 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.



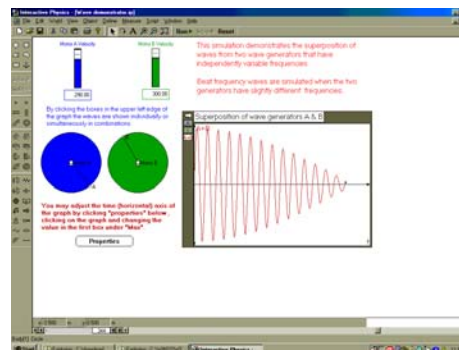
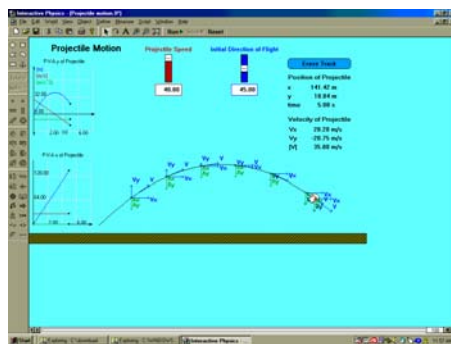
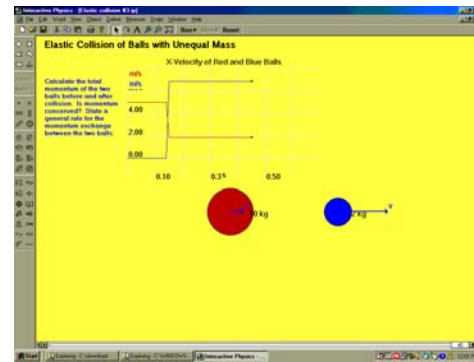
## Demonstration 2: Simulations you Create Yourself: Interactive Physics

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.



### 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).

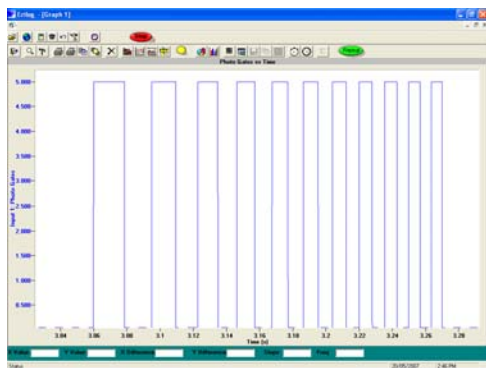
In this demonstration we look at three experiments using your data logger

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.

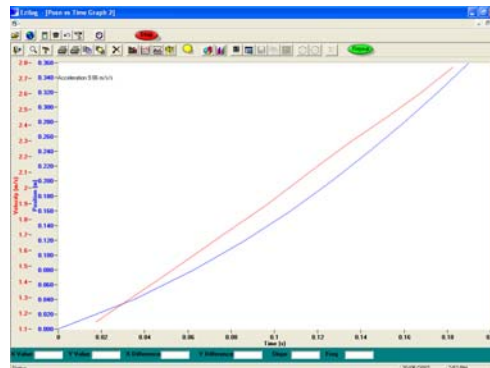
#### Using your data logger as an electronic ticker timer

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.

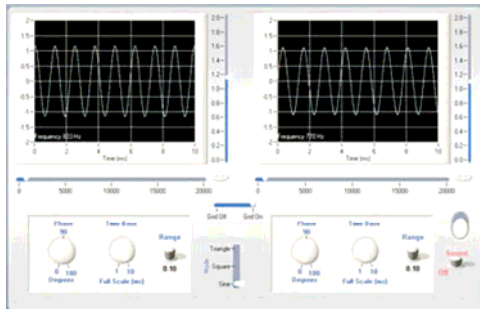


b) Position vs time and velocity vs time graphs generated from graph a) using the Ezilog USB.

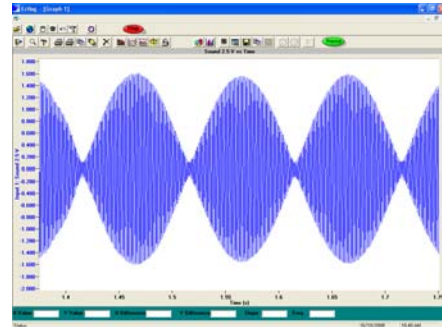
**The importance of sampling rate for physics experiments - examination of sound waves from a speaker.**

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.

**Apparent Mass**

This activity 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.



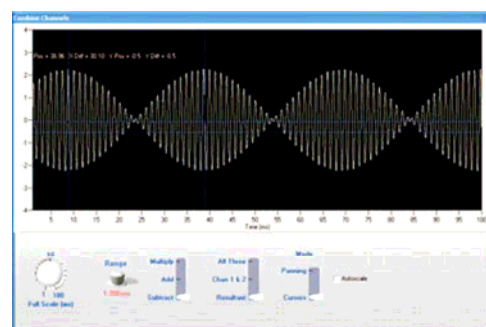
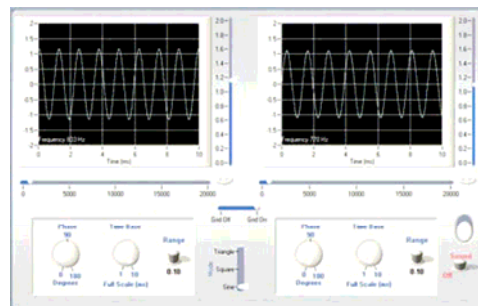
### Demonstration 4: Simulation vs Direct Data Acquisition with a Computer

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.

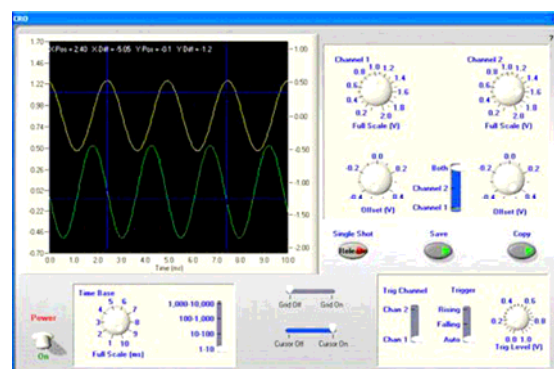
By opening up the Virtual CRO in the TLI WaveGen we can see clearly the two waves and the resultant wave generated by them. We have not actually acquired the data, but simply created simulated data in this Virtual CRO. This technique is great for looking at wave interference and showing our students 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 playing



#### 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.