

VIDEO ANALYSIS FOR EVERYONE

Session A17 Physics Teachers Conference 15th Feb 2013

In this session 4 main topics were covered.

1. Three examples of free software for PC, Mac and iPad.
2. The cameras used.
3. Experiments which the software had been used to analyse.
4. Potential pitfalls to help save our students trouble.

THE SOFTWARE

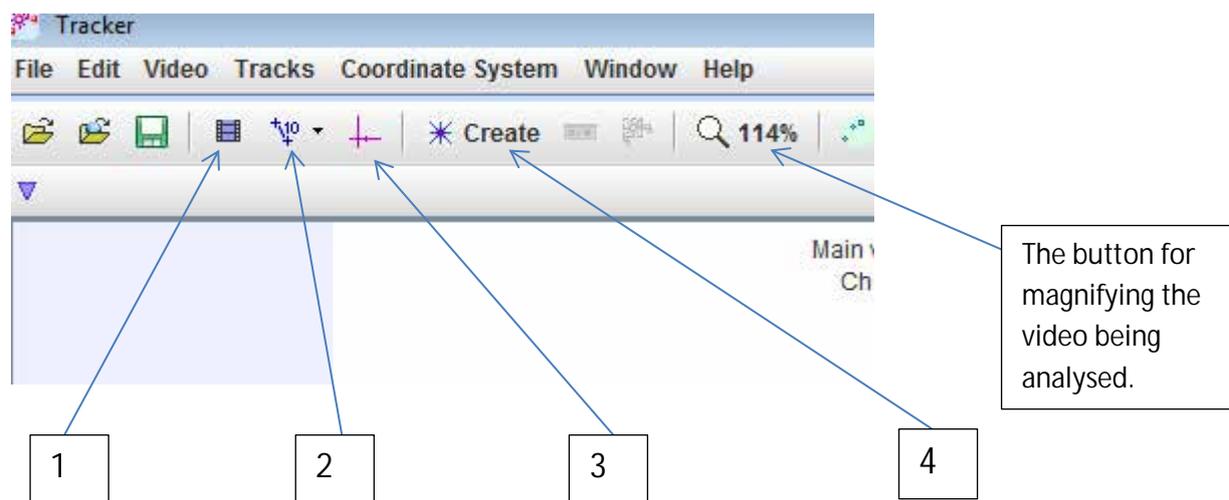
1. **TRACKER** Download from....<http://www.cabrillo.edu/~dbrown/tracker/>

This is an excellent piece of software which has been available for several years now. It is also very complex and capable of doing analysis way beyond the needs of our students. It can be made to draw graphs from the points analysed and as such can be a valuable teaching aid during motion studies.

If your video will play in Quicktime, then Tracker can be used to analyse it.

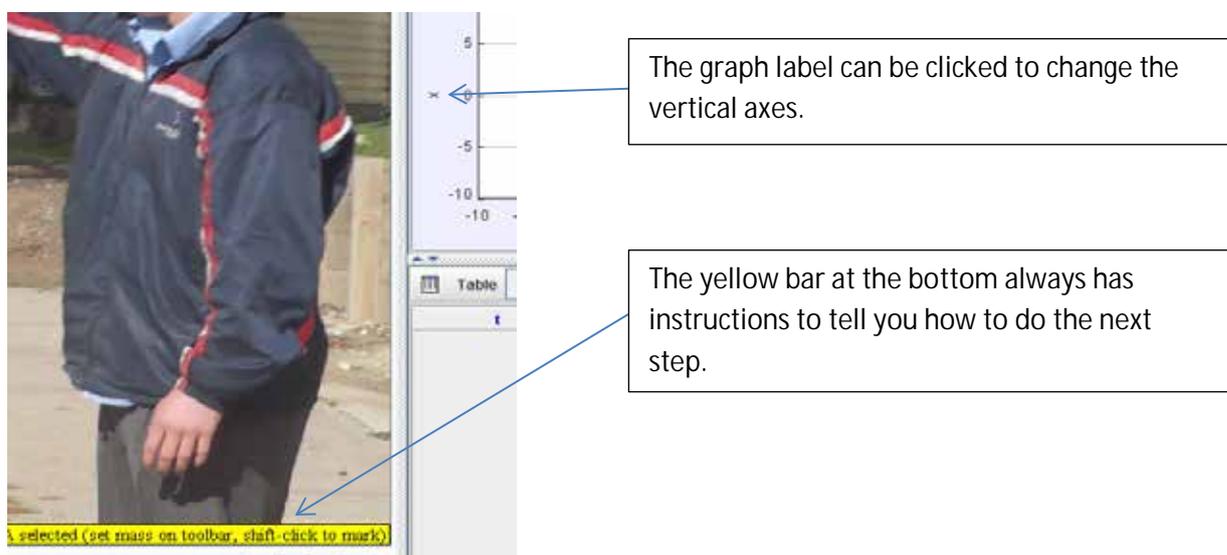
There are many buttons available on the tool bar but for basic analysis 4 are important. You should use the buttons in order. The first one can be ignored if you have not adjusted the frame rate from the normal 30fps. Some cameras are capable of filming at frame rates much higher. Unless the CLIP SETTINGS are changed the default value is 29.97fps.

After you have loaded your video for analysis then work through the other 3 buttons in order.



1. Clip settings button
2. Calibration button....choose calibration stick and drag its ends to set a distance. Then you must click on the default length shown to tell the software the actual length of your stick in your video frame.
3. Set the origin for measurements....Not really needed but may be useful.

4. Choose Point mass and then your graph will happen as you plot the points. By default the vertical axis on the graph is x position. Clicking on the label brings up a menu which allows the label to be changed. There are many choices.



Now that the setup has been done you are ready to do some analysis.

After dragging the video along to the section you wish to analyse you should hold down the shift key. The cursor will change and every time the mouse is clicked a point will be marked on the video, graph and the data from the point recorded in the table.

After that, you should spend time doing what students would do. Fiddle around with things and you will find lots.

The project can be saved in its entirety for use at a future time. The data can be cut and pasted across to other software if the students wish to set up their own analysis.

2. **Physmo2**.....Download from <http://physmo.sourceforge.net/download.html>

Like Tracker, this is also open source software and free. That is free for our use and able to be re-written if you or your students were so inclined. It is very convenient that the writer of this software is my son and access is simple. He is very keen to hear from users of the software and can explain aspects of its operation as well as take suggestions for future updates. The updates are not regular though as programming is a personal interest not his employment.

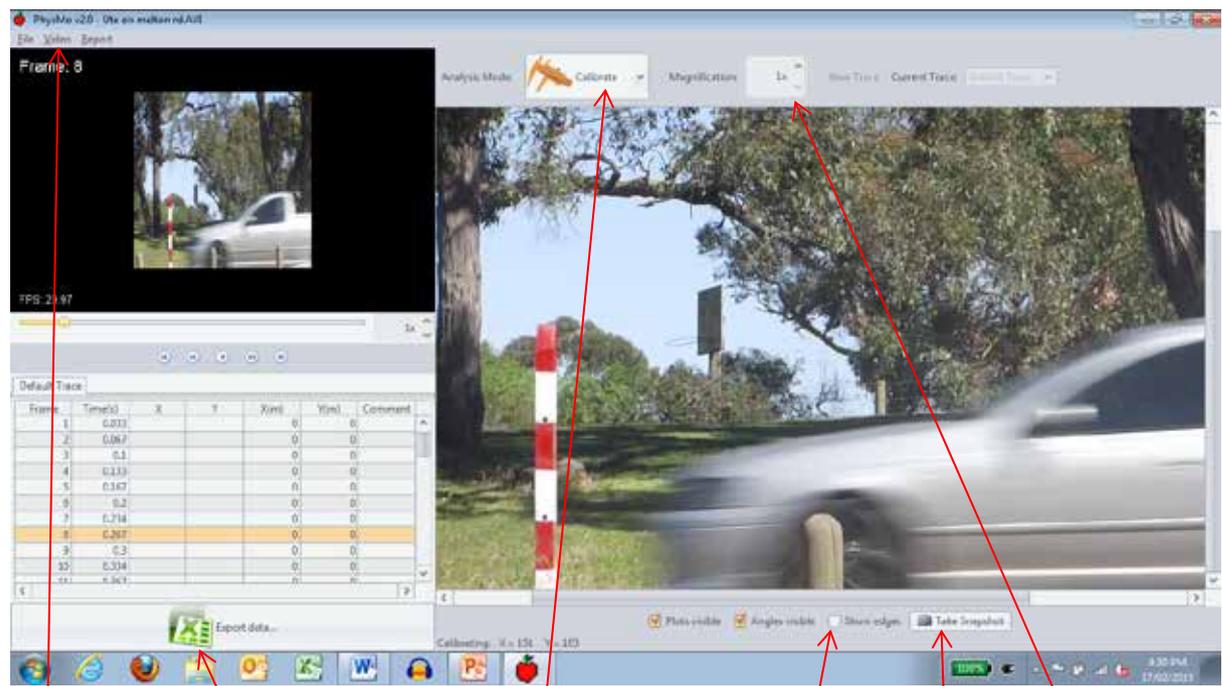
I have had students using Physmo2 for about 3 years now. On the PC it can be loaded onto a memory stick and run from that. This was great because it enabled the bypassing of computer techs and any need to have their approval to put software on the image of the schools networked computers. At last we were able to do video analysis in bulk instead of just the teacher's laptop. The only problem which came from using a memory stick was that some students had insufficient space on their stick to save the decomposed pictures. Their home network drives were not large enough either. **KEEP THE VIDEO SHORT!!!!**

When students had their own laptops we were in business even better. Even the lock down to stop students loading their own software on these computers is bypassed because it does not require any installation. You just need to save a folder of files. Students with macs were not excluded either because the program is written in java and is not platform dependant. Provided the files are put in the right place everything works well.

In Physmo2's case if VLC will play your video then it can be analysed.

Physmo decomposes the video into a massive folder of still frames in .png format and plays those for your analysis.

The user interface is not cluttered and as a result is quite intuitive.



Set frame rate

Export data to Excel

- Calibrate
- Plot
- Find angle
- Set Origin

Show edges

Magnification

Snapshot of all the analysis screen contents for use in a report.

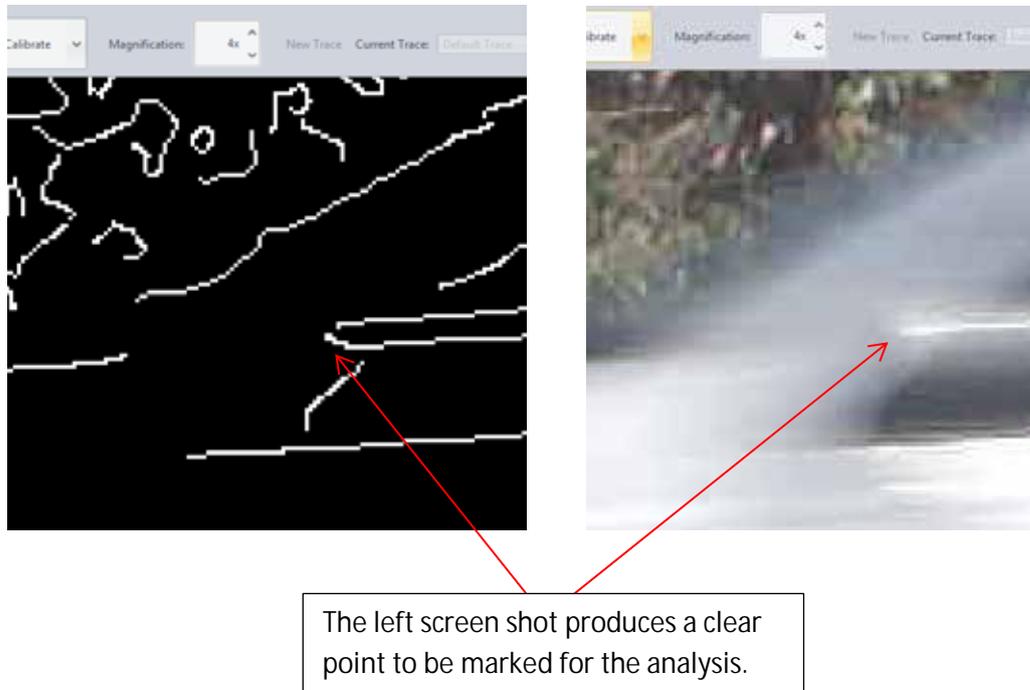
After loading the video, Calibrate the frame, set the origin if desired, then choose Plot to mark the position of the object.

Physmo is only a data gathering tool. For analysis, you will need to either save the data using the Excel button at the bottom, or cut and paste the data from the table to the software of your choice.

Personally, I like the idea of the students doing the analysis of the data as it is the learning exercise about motion that we are trying to teach them.

The 'show edges' check box at the bottom of the analysis screen can be of help in some videos to find the point to be marked in the blurred vision.

(See below example of the mirror from the car shown in the screen shot above.)



3. iTrack motion.....download at the Apple apps store.

<https://itunes.apple.com/us/app/itrackmotion/id509868368?mt=8>

This software will work on an iPhone or iPad. There are two versions. The lite version has no ads and does everything except allow you to email the data to someone for extra analysis. It is really intended to be used in the field so that a quick result can be obtained. If you want to do more than that, the full version is needed. The full version can be bought for \$1.99.

Again with this software we have good access to its writer because he is my son's friend. He too is keen to know about how the software is being put to use or any other feedback.

iTrack motion was quickly demonstrated during the session. On the day some free promo download codes were issued to the participants as per the apps store allowance.

Tutorials for all 3 software packages can be found on Youtube.

The Cameras

At Gisborne we managed to find the funds to purchase the Casio Exilim camera. It is capable of up to 1000fps filming but it comes at the expense of resolution in the picture. The cost was \$250 approx.

This Fuji HS 20 is my own personal camera. It will film up to 320fps and cost approx. \$600.

One of the participants on the day suggested the use of a DSLR from the schools photography or art faculty. Some of these cameras will video up to 60fps at full resolution and allow control of the shutter speed. The shutter speed of the camera seems to vary to control the light available on the subject. For this reason the best results on the cameras we have used have all been in bright sunlight with high contrast in the objects filmed. Some students used flood lights to assist in filming both indoors and outdoors.

Ideas for investigations

The ideas presented fall into 3 categories.

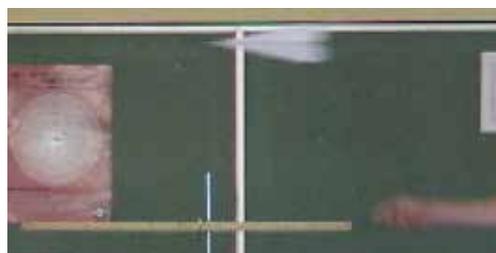
1. Student investigations
2. Researchers investigations
3. Curiosity

Student investigations

These have been done by students from year 7 through to year 12. Video analysis has been a common method used by year 12 students as a way of monitoring the movement of objects for their EPI.

Velocity measurements

- Falling ball
- Throwing ball to determine speed
- Flight speed of a paper plane
- Speed check of cars crossing the school crossing. Eg screen shots shown earlier.



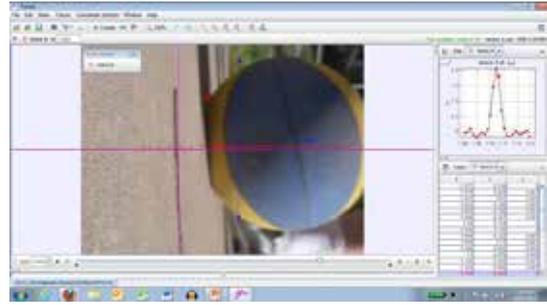
Acceleration Measurements

- Falling ball to measure 'g'
- Glider accelerated on airtrack either by falling weight or angled track



Impulse has been made possible using the high speed video camera.

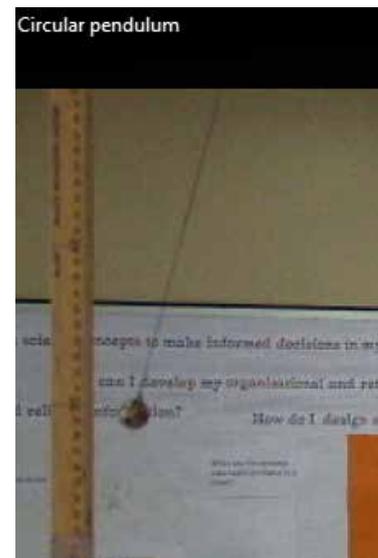
- The bounce of a basket ball to compare area under the 'a-t' graph with the change in momentum.
- Collisions of gliders on the airtrack
- Billiard balls against the table cushion.
- Comparison of impulse available from model rocket motor with change in momentum of the rocket car. Car was guided by two strings while carpark lines gave calibration for the footage. The promised impulse from the motor did not result in the change in momentum expected.



Circular Motion

Luna Park has several rides which lend themselves to video recording for analysis.

- G-Force and Enterprise rides are a circular pendulum which the angle the carriages swing to can be measured in comparison with the tangential speed of the ride.
- Scenic Railway, Pharaoh's Curse and Twin Dragon. What centripetal acceleration is experienced by its riders.
- A roller coaster in a theme park in Kuala Lumpur was filmed during a school trip for later analysis relating to the experience of its riders. Centripetal 'a' was measured through the loop.
- A circular pendulum in the classroom was investigated relating to the angle of the string, length of the pendulum and its period of rotation. This example has occurred as an exam question on several occasions and so provides an excellent example for students.



Momentum

- Billiard balls before and after collision
- Airtrack gliders of different mass colliding.
- Newton's cradle

Rocket launch

- Velocity at a point after blast off.
- Its acceleration at take off

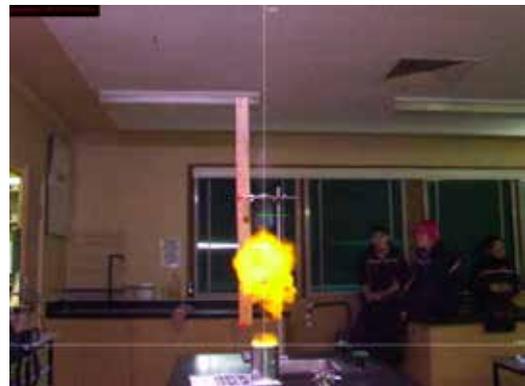


Explosion of the H₂ balloon

- How long did the explosion take?
- How fast did the flame front expand?
- How far did the flame front extend?

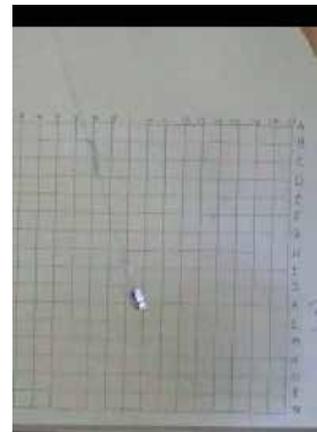
Hydrogen can explosion

- How fast was the lid travelling after the explosion?
- How high did the flame travel from the can?
- For what time after the explosion was the flame evident?
- How long did it take to hit the roof?



Conservation of energy

- Energy in the projectile from a toy nerf gun. Was the energy in loading the spring converted to Kinetic energy in the projectile?
- Does the swinging pendulum conserve the energy in its conversion from PE to KE.



Researchers investigations

- Micro rods being spun with ultrasound. Investigation of these rods has potential for use in blood vessels for distribution of appropriate drugs among other purposes.
- Investigating human response movement to create data base for other software. The Max Planck Institute in the Netherlands is manually obtaining data to teach computers how to recognise human responses to stimulus.

- Measuring the displacement of the kidney during treatment at Peter MacCallum.
- Tracking the movement of ants in a colony
- Tracking the movement of bees in flight using 2 cameras for 3D.
- Monitoring the movement of suspension in rally cars
- Gamer quantifying the movements of characters in games for realism. eg. Mario Bros. It was found that different values for 'g' applied for different jumps while the walking speed was similar to a human. Knowing the values behind the games design helped to produce a better appeal in the way the figure moved in a new game. (Great possibility for a student's EPI)

Pitfalls and problems

Lighting conditions seem to change the shutter speed of the smaller cameras. If the light is less, the blur in the moving objects image seems to be greater. Some students used flood lights to raise the light on the object being filmed. See clarity of picture at right in full sunlight. At only 30fps the ball is relatively clear.



In an effort to reduce parallax the camera is usually set some distance from the object being filmed. When the lens is zoomed in, more light is required. Blurring can be the result making image identification difficult. The picture at right resulted from the camera zoomed in from some distance away. The tape measure is clear but the ball is blurred.



Resolution of the video goes hand in hand with the frame rate. Higher the frame rate the lower the resolution of the video. The picture at right shows the ruler which can't be read due to low resolution at 1000fps. Closer inspection in the analysis software shows the high pixelation in the ball surface. Since the software pinpoints the position to the nearest pixel from the current cursor position, this can cause dramatic variations in results calculated. It always affects pairs of results.



My demonstration during the session highlighted the problem with the calculated 'g' showing wide variation and lack of consistency. The problem was caused by a high frame rate combined with very small displacements in the ball between frames. The small displacements allowed the errors made in the pinpointing of the ball position to be magnified in the results. The benefits from the extra frames per second were counteracted by the lower resolution in the pictures.

Contrast in the video can make it much easier to pinpoint the position of the moving object. The high contrast in the orange ball above was also improved by the 500W floodlamp applied at close range to ball.

Playback frame rate needs to be recorded in student's notes as the information is **NOT** in the video file. The video file assumes the frame rate is the playback rate of 30fps. When the frame rate is adjusted in the software, the time for each frame in the data table is calculated and displayed.

High definition video does not necessarily reduce the blurring of the moving object with the smaller cameras. It seems again that the shutter speed is used as the method of getting enough light for an adequate exposure. This was filmed at 30fps High Definition. There was inadequate shutter speed to stop the ball properly in the video.



I hope that you will find this document of assistance as you try this engaging method for investigating the motion of moving objects. Perhaps the ideas presented here will help your students to think of new ideas for investigations using the software.

Please feel free to contact me if you would like to ask anything about the information presented at the conference. The software writers for iTrack and Physmo can be contacted via addresses on the web sites where the programs are obtained from.

Please enjoy your investigations and the benefits to be gained from using video analysis.

Kelvin Barraclough..... barraclough.kelvin.k@edumail.vic.gov.au