Using Graphics Calculators in the Classroom

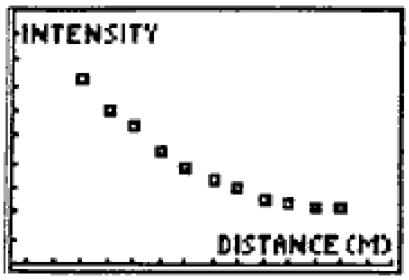
Mathematical Modelling with a CBL

Fiona Grant

The Calculator Based Laboratory System is provided with three probes for measuring light intensity, temperature and voltage. Other probes such as a microphone, ultrasonic distance detector and force sensor are also available. A wide range of mathematics and science activities are possible. In this article I will describe a few mathematics activities which I have found successful with upper secondary pupils in Edinburgh schools.

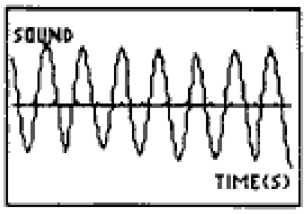
1. Light Intensity

The light probe records the light intensity of a bulb at various distances. A bicycle lamp works well! This is a practical demonstration of an inverse square law. It is fairly easy for the pupils to work out the mathematical model themselves and then consider how well the theoretical model fits the experimental data. Using the relationship $I=k/r^2$ (I is the light intensity and r is the distance from the light source), pupils find a suitable value for k.



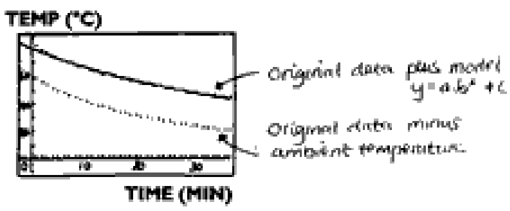
2. Musical Note

The microphone picks up the sound (pressure) from a musical instrument, human voice or tuning fork. Pupils apply their understanding of amplitude, periodicity, phase shift and radian measure to model the sound wave by a sinusoid. In the process of fitting a graph to their data, pupils develop an intuitive understanding of how the coefficients in $y=a\cos b(x-c)$ affect the graph.



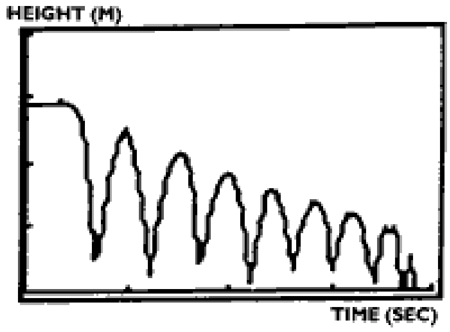
3. Water Cooling

The temperature probe is placed into hot water (or iced water). The probe is left in the water to record the temperature every minute for, say, half an hour. Alternatively, for a shorter data collection time, after being placed in the water, the probe is either held in the air or placed in a beaker of water at room temperature. Using Newton's Law of Cooling, pupils can work out values for the coefficients in $y=ab^x+c$ themselves (without using the exponential regression facility on the calculator).

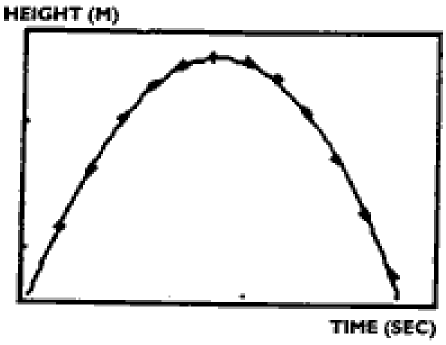


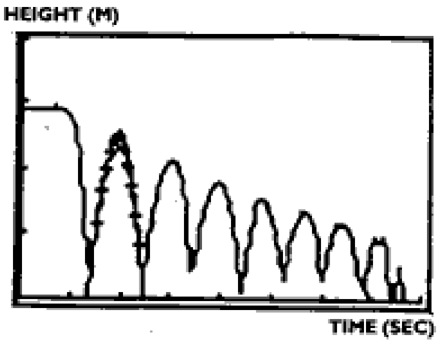
4. Bouncing Ball

A ball bounces under the ultrasonic motion detector and a distance-time graph is displayed. Pupils can analyse various aspects of the data, such as individual bounces, bounce heights, bounce times.



Plotting the data of one bounce gives a parabolic section in time. Pupils use the completed square form of the quadratic to find an equation which fits the data. The (approximate) coordinates of the turning point can be found using the TRACE button.





Pupils estimate and improve on a value for a in $y=a(x-p)^2+q$. Initially, pupils often choose a positive value for a but they quickly realise it must be negative and are able to explain why.

The TRACE button can be used to find the heights of the bounces, or a small program can be written. The heights form a geometric sequence

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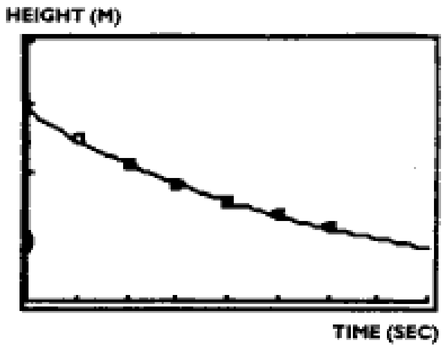
and pupils use the starting height and 'common ratio' to find an exponential equation to fit the experimental data. Pupils in S4 (15 years old) who had not formally met the terms 'geometric sequence' and 'common ratio' found a pattern in the ratios of successive bounce heights (the ratio was approximately 0.87) and were able to express what they noticed by comments such as

"if you dropped the ball from 1m it would bounce up to about 87cm",

"each bounce is about 87% of the previous one".



Is the CBL classroom friendly?

I have found the CBL equipment quite easy to set up and use. It is portable and does not need an electricity supply, unless you are using an OHP. Practical activities can be rather time consuming to set up and to do and the unexpected does sometimes happen! Swift and reliable data collection is important so that pupils have sufficient time to concentrate on the mathematics. Practical activities can enhance the teaching and learning environment when used appropriately. The CBL activities are rich in mathematics and are not just 'a bit of fun on a Friday afternoon'.

Several resource books and disks of programs are now available (some are mentioned below). Many activities have on the screen instructions which can assist the teacher or a group of pupils using the equipment. Sample sets of data are often provided, though I believe that collecting your own data is more valuable. Computer print-outs of screen graphs and data lists can be obtained via the Graph-Link cable and data can be stored on a computer for future use.

A program called SHARE enables data and screen plots to be transferred very quickly between calculators, via the link cable. If the data collection is performed only once, the data can easily be shared to each pupil or group of pupils, depending how many graphics calculators are available. Pupils quickly learn how to run the SHARE program themselves, thereby freeing the teacher.

Problem solving using real data, generated and collected by the pupils themselves provides a genuine reason for using the graphics calculators. If pupils are not already familiar with the graphics calculator, the concentration on "pressing the right button" can get in the way of the mathematics. I have found, however, that pupils quickly become familiar with the calculator's facilities.

During the data analysis and modelling there is opportunity for discussion. This can enable the teacher to gauge where the pupils are in their mathematical understandings and perhaps guide them to a deeper understanding. The teacher can tailor the activities to suit the learners, with as much guidance in the form of instructions or record sheets as the teacher considers appropriate. Pupils can see mathematics in context and be encouraged to relate their 'text book' skills to practical applications.

I would be interested to exchange views and ideas with other people using the CBL.

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References and Resources

Brueningsen C et al (1994) *Real -World Math with the CBL System*, Texas Instruments.

Explorations in PreCalculus for the TI 82 (or TI 85), (1995) Meridian Creative Group.

Explorations in Calculus for the TI 82 (or TI 85), (1995) Meridian Creative Group.

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