The Calculator Based Laboratory and Distance-Time Graphs

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The Texas Instruments Calculator Based Laboratory (CBL) is a hand-held, battery powered, data collection device. A variety of probes can be connected to the CBL to collect data such as temperature, sound, light intensity and distance. The CBL can be connected to a graphics calculator (TI-82, 83, 85, or 92) with a link cable so that the data can be sent to the calculator for analysis.

With the co-operation of several Edinburgh mathematics and science teachers, I have used a variety of CBL activities with secondary pupils from S2 to S6 (13-17 year olds). These activities are rich in mathematics.

In this first article I will describe the use of the ultrasonic motion detector to generate distance-time graphs. These activities have been successful with pupils of a wide age range.

Pupil generated distance-time graphs

The ultrasonic motion detector records the distance of an object or person, in the range 0.5m to 6m. The motion detector is placed on a desk and a pupil moves in the space in front of the sensor. The graph is produced on the calculator screen at the same time as the person moves. The use of an OHP calculator and screen allows whole class viewing and involvement. This equipment can be used for many activities, including the following.

(a) Pupils generate their own distance-time graphs by walking, running, jumping in front of the sensor. Each pupil can be asked to produce a different graph from previous ones. Pupils relate the direction and speed of their movement to the graph. Pupils can be set challenges to produce, for example, straight line graphs, discontinuous graphs, parabolas and so on. The teacher can pose questions at an appropriate level for the learners. At a higher level, for example, discussion of rate of change of speed can lead to calculus concepts. Stationary points take on real meaning! Discussion of whether or not all graphs are possible encourages pupils to verbalise their thoughts. "What if..." suggestions and predictions are also encouraged as pupils can test out their own ideas for immediate feedback and subsequent discussion. For example, what would the graph look like of someone opening the door, entering the room and then closing the door behind them? Would there be two separate lines if two people walked in front of the sensor?

The possibility or not of the following two graphs has generated lively discussion.

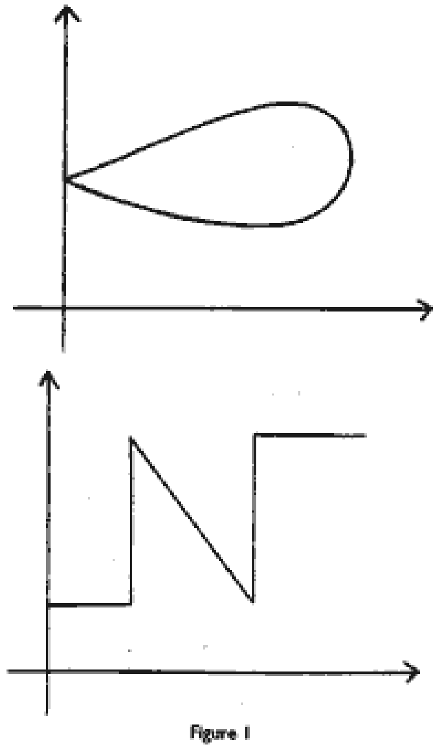


Figure 1

For the first graph, many pupils have suggested walking in a loop or using two people. Pupils have to find out for themselves that these ideas do not work. The resulting graphs help pupils to explain why this graph, which does not define a function, is impossible. Reasons given by pupils have included:

"you cannot go back in time"
"you cannot be in two places at the same time"
"the sensor only picks up the person nearest to it"

For the second graph, the horizontal lines cause no difficulty, but most pupils are initially confident about being able to produce a vertical line. Pupils see for themselves how faster movement gives a steeper line, but not a vertical one, and they give reasons such as:

"you cannot stop time when you move distance"
"you cannot be in all the places at the same time"
"you cannot move that fast"

(b) Straight line graphs are generated by the calculator for the pupil to reproduce. The pupils are personally involved in working out starting and finishing distances, speed, direction, resting places and times, etc. Real-time graphing allows the pupils to see their attempt being superimposed on the original as they walk the graph. Alternatively the screen can be hidden while the graph is being walked, and only revealed afterwards. This second method often appears to produce better graphs, perhaps because the pupil needs to have analysed the graph carefully beforehand and cannot rely on making adjustments along the way. One teacher I worked with, borrowed the CBL equipment and used this activity very successfully with primary pupils during their visit to secondary school. Teachers also seem to enjoy the challenge to 'match the graph'.

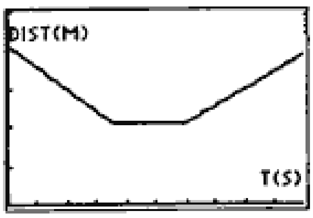
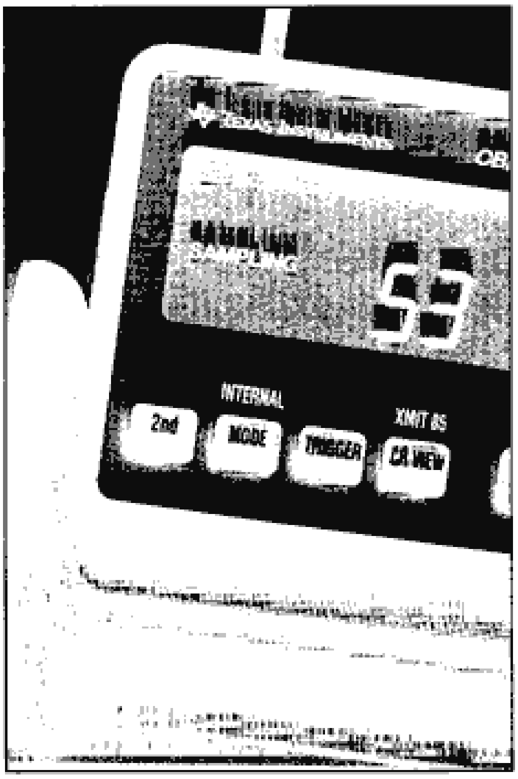


Figure 2

These activities appear not only to be fun but also give pupils of all abilities a better 'feel' for the meaning of distance-time graphs. As well as the activity and oral discussion, pupils also express their ideas in writing, which encourages them to clarify their thoughts. This written record gives the teacher insight into each pupil's thinking which is often not possible in a large class activity.

In the next article I will describe some activities suitable for mathematical modelling by upper secondary pupils. I would be interested to exchange views and ideas with other people using the CBL.



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References
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