

TI-Time: Maths

Summer 2006

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Editorial

On behalf of the Education Team at the Texas Instruments Education, I'd like to welcome you to this summer edition of TI-Time: Maths.

First a word of explanation: my name is Spencer Williams and I'm holding the fort at Melanie Horsburgh's desk while she is on maternity leave. Many of you will be delighted to know that Melanie has given birth to William, weighing in at 6lb 10oz! With her first child now 2 years old, Melanie's hands are even more full at home than when she is at work, but I'm sure you will all want to join me in wishing her and the family well.



Spencer Williams

I'm really looking forward to meeting or speaking to as many of you as possible during this year. Perhaps we'll meet up at the MEI or Handheld Learning Conferences or at BETT next year. Or perhaps we'll speak if you ring to discuss some free training at your school, or any other matters - please do feel free to contact me if you have any questions concerning TI support for your teaching.

In this edition of TI-Time you will find two articles describing the classroom use of the ultrasonic motion sensor known as the Calculator Based Ranger™ (CBR). Did you realise that the stylish new CBR 2™ is now available? With its USB connector it makes connection to the TI-84 Plus family of calculators really straightforward and reliable. Of course, as you would expect with TI, there is total compatibility between the TI-83s, TI-84s and both old and new versions of the CBR. And don't forget that any of the latest products are available through the TI loan scheme.

This issue also includes an article by Bernard Murphy of MEI that describes how advanced level students can use the calculator's parametric graphing to draw and investigate mathematically a range of very intriguing graphs.

We had a very good response to the competition in our last edition. You were challenged to produce a calculator program to simulate the card game, Snap. Encouraged by this we are running another, slightly different, competition this time and again offering some tempting equipment as prizes. Your chance to show your creativity and communication skills! Details are on page 11.

Finally, a reminder that TI-Time is available both in printed form and electronically on the TI UK website: <http://education.ti.com/uk>. If you would like extra paper copies for your departmental colleagues please do let me know.

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Do you measure up?

Roger Fentem



Roger Fentem

Just how good are you at estimating distance? Are boys worse than girls? Does expertise come with age? Is it easier along than up? ... These are a few of the investigations that can be tackled with

the data-logging activity described here by Roger Fentem, head of the Secondary Mathematics Education Department at Marjon, the College of St Mark & St John, Plymouth

All that is needed to try this activity is a TI-83 Plus or TI-84 calculator and the TI ultra-sonic motion detector known as the Calculator-Based Ranger™ (CBR or CBR 2).

This article describes how a group of Y10 students investigated the hypothesis that they could accurately estimate distances. The students and their tutor, Paul, used the application **CBL/CBR**, which comes built-in with the calculator. This APP is designed to provide quick and easy access to data-logging using either the CBR or any of the three probes that come with the CBL2 – temperature, voltage and light. It takes only a moment or two to discover how to use the APP and to configure it for your experiment.

CONFIGURING THE DATA LOGGER

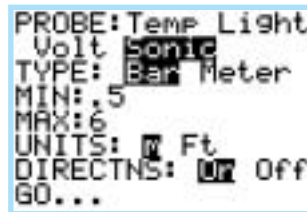
In this experiment, each student chose an object whose distance from the CBR they felt they could accurately estimate – perhaps one wall of the classroom, the door, the whiteboard, a poster etc. Paul selected the **CBL/CBR APP** by pressing the APPS button, scrolling down to the desired APP and pressing ENTER.



Then he chose the first option **1:GAUGE**.



Next, using the cursor keys he chose **Sonic** – the CBR uses sound waves. He chose to measure distances from 0.5m to 6m because this is just about the extent of the CBR's capabilities.



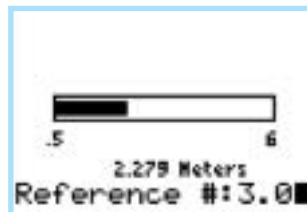
Choosing to have directions **On**, gives a check on how to connect the CBR to the calculator. Having done that, he pressed ENTER as reminded by the directions.



COLLECTING THE DATA

As soon as this was done the CBR could get to work measuring the distance to whatever object it was pointed towards with the distance displayed on the calculator.

At this stage Paul kept the screen out of the view of the students who were about to make estimates. The long lead that comes with the CBR was a great help in this respect. Paul set the CBR pointing to the first student's object and invited the estimate. On hearing the distance from the student, Paul pressed ENTER and then keyed-in the student's estimate. The screen below shows an actual distance of 2.279 metres and an estimate of 3.0 metres.



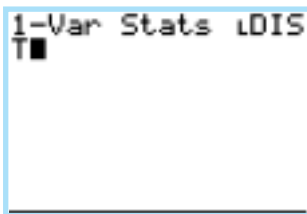
This process continued with the remaining students, their objects and their estimates. GAUGE ensured that all the accurate measurements were automatically stored in a list called **DIST** in the calculator and the corresponding estimates in another list called **DREF**.



With the data safely stored in the calculator the next step was to use the technology to analyse and interpret it and to present conclusions.

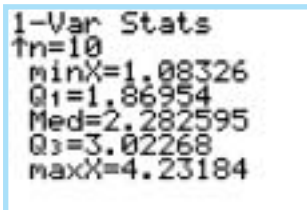
ONE STUDENT'S APPROACH TO ANALYSIS

Ayesha chose to use her calculator to assist her in analysing the data. She started by exploring the actual distances as measured by the CBR and stored in list **DIST**. The **1-Var Stats** command in the **STAT CALC** menu provides a wealth of summary statistics on any set of data stored in list form. This was entered by pressing **2ND** and then **LIST**, scrolling down to the required list name and then pressing **ENTER**.

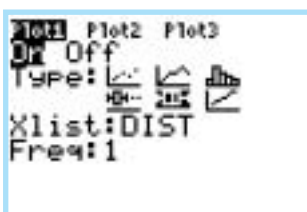


REPRESENTATIONS OF THE DATA

Among the statistics produced by **1-Var Stats** are the five that form the basis of a box plot. The range of the ten measurements in Ayesha's collection is 1.08m to 4.23m, the median is 2.28 and the inter-quartile range is 1.15m (3.02-1.87).



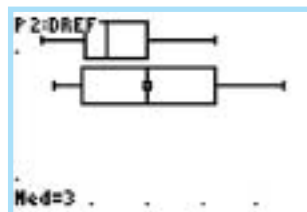
These numerical values provide information about the distribution of the set of measurements, but a graphical representation is easier to interpret. The calculator can easily display boxplots. In this case all that was needed was to press **Y=** and choose the settings for **Plot1** as shown here.



Then using **ZoomStat** (press **ZOOM**) produced the plot below.



This enabled Ayesha to understand how the actual distances were distributed. She then decided she wanted to make comparisons between the actual measurements in list **DIST** and the estimates that the students made in list **DREF**. This was done by setting **Plot2** to display a second boxplot on the same screen.



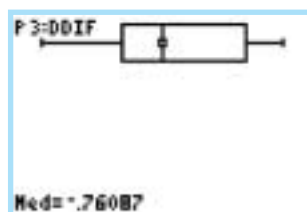
HIGHER LEVEL INTERPRETATION

The outcome produced further discussion of the data with the suggestion that each student's estimate could be compared with the corresponding actual measurement. The two data-sets can be displayed side-by-side in the data-editor making comparison very easy.

L6	DIST	DREF	#
-----	1.0833	1.3	
	1.4596	1.3	
	2.2861	1.8	
	2.2791	3.5	
	4.2318	3.5	
	4.1992	2	
	2.5961	2	

DREF = (1.3, 1.3, 1.3, ...)

Further analysis might be to calculate the differences between the corresponding values and to display the outcome as a boxplot. Alternatively the estimates and real values may be treated as bivariate data and displayed as a scatterplot.



continued overleaf ...

Do you measure up?

continued

COURSEWORK

The data-handling activity described above provides an ideal opportunity for students to engage in data collection and analysis that is appropriate for GCSE coursework, with the aims of Assessment Objective 4 readily met. Students can:

- ▶ formulate questions that can be considered using statistical methods;
- ▶ undertake purposeful enquiries based on data analysis;
- ▶ use technology as a means of data collection and as a tool for graphical representation;
- ▶ look critically at some of the ways in which representation of data can be misleading and conclusions uncertain.

This is a very versatile data-collection activity, which offers opportunities for assessment across all three tiers; foundation, intermediate, and higher. In the context of people's ability to estimate distance, the investigation might compare boys and girls, young and old, one person's estimates over time, whether estimates improve with practice, estimates of horizontal and vertical distances and so on.

Technology, in this case hand-held technology, is not only integral to the data collection but it also features in the analysis, interpretation and communication of the results.

CBR 2™

Features Summary

The CBR 2™ (Calculator-Based Ranger™) is an ultra-sonic motion detector for science and maths and directly replaces the CBR. It is designed for teachers who want an easy, affordable way to start collecting and analysing real world motion data- distance, velocity and acceleration.

- ▶ USB connectivity to the TI-84 Plus family of calculators
- ▶ Plug and collect functionality through the auto-launch of the EAsyData™ App
- ▶ Sensitivity switch for use with dynamics cart and track
- ▶ Pivoting sensor head to allow you to point the device where the action is
- ▶ Measures up to 200 samples per second
- ▶ Connect CBR 2 to CBL 2 for multi-sensor activities like motion and force
- ▶ Connects to TI-82, TI-83, TI-83 Plus, TI-83 Plus Silver Edition, TI-84 Plus, TI-84 Plus Silver Edition, TI-86, TI-89, TI-89 Titanium, TI-92, TI-92 Plus and Voyage™ 200



CBL 2™

Features Summary

The CBL 2™ is the easy-to-use, affordable and powerful data collection device for Secondary maths and science. Three probes are included: light, temperature and voltage and a wide range of other probes for maths, biology, physics and chemistry are available from your usual supplier. Additional probes are manufactured by Vernier.



Challenging Year 7 with the CBR

Nina Sparrowhawk



Nina Sparrowhawk

Nina Sparrowhawk describes some work with the Calculator Based Ranger™ that proved to be an exciting and enjoyable event for all at Thornberry Middle School in Lancing, West Sussex.

I am the KS3 coordinator at Thornberry and in 2005 we decided that we would like to experiment with the use of graphics calculators in Year 7 Maths lessons. As we had little previous experience with use of the hand-held technology, Alan Foster, maths consultant with the West Sussex Maths team, agreed to come to support us. We knew we would be able to borrow calculators and other equipment from the TI loan scheme.

We decided to focus on two areas of the National Framework for Mathematics. One group of lower-ability pupils benefit particularly from kinaesthetic learning and for them we decided to focus on graph work using the CBR. With other pupils more suited to a theoretical approach, we would use the technology to support work in algebra, functions and graphs. Below I describe only the work of the group using the TI-84 and CBR.

The team produced a pupils' work-booklet and this provided guidance for pupils. Also used were an interactive whiteboard with TI-SmartView™ emulator software to support the teaching and learning.

The TI-84 project (as the two-week topic came to be called) became such a success that the children (and staff!) could not wait for the arrival of the school's own set of calculators after having to return the borrowed calculators, CBR and ViewScreen™ Panel.

Calculator-Based Ranger

We decided to use the CBR and ViewScreen to help develop the group's understanding of distance-time graphs since this is a common area of misconception for pupils. Before starting the project, this group was certainly not able to explain what was represented by a simple distance-time graph.

The practical nature of the activity allowed for kinaesthetic, audio and visual learning without relying on recording – something that can often hinder children in low ability groups. However, not only did the children gain understanding of distance-time graphs from this work, they also practised valuable social skills such as working cooperatively, supporting and offering constructive advice to one another.

Initially, the children were set the challenge of trying to match the trace of a randomly produced distance-time graph without any prior information. First attempts to "walk the graphs" were met with great hilarity as the children worked out which way to walk to make either an upward or a downward slope.



Further development involved whole-class discussions, with one pupil matching a graph shown on the ViewScreen (and projected onto the classroom wall) by walking in front of the CBR). Other pupils helped by identifying the starting position and there were group discussions of the journey to be walked by the pupil. All pupils had a turn and this was followed by recording of the graphs, working as small groups, pairs or individuals as appropriate.

Improvements were made to the graphs following discussions about what the axes represented. This involved discussion of x- and y-axes, distinguishing between seconds and time and between metres and displacement. Support was provided by placing approximate metre markers on the floor.



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Challenging Year 7 with the CBR

continued

We found the equipment very easy to set up. All that was needed was to attach the calculator to the CBR and ViewScreen and to use the clamp to attach the CBR to the OHP. After a little instruction, the children were able to project new graphs using the calculator menu independently. For example, one pupil operated the calculator and told the other when to start walking, easily following the guidance provided on screen by the CBR software. By the end of the first hour, every child was able to give instructions of how to move in order make the real-time graph match the picture offered by the CBR, even including recognising when to walk backwards, forwards and stand still.

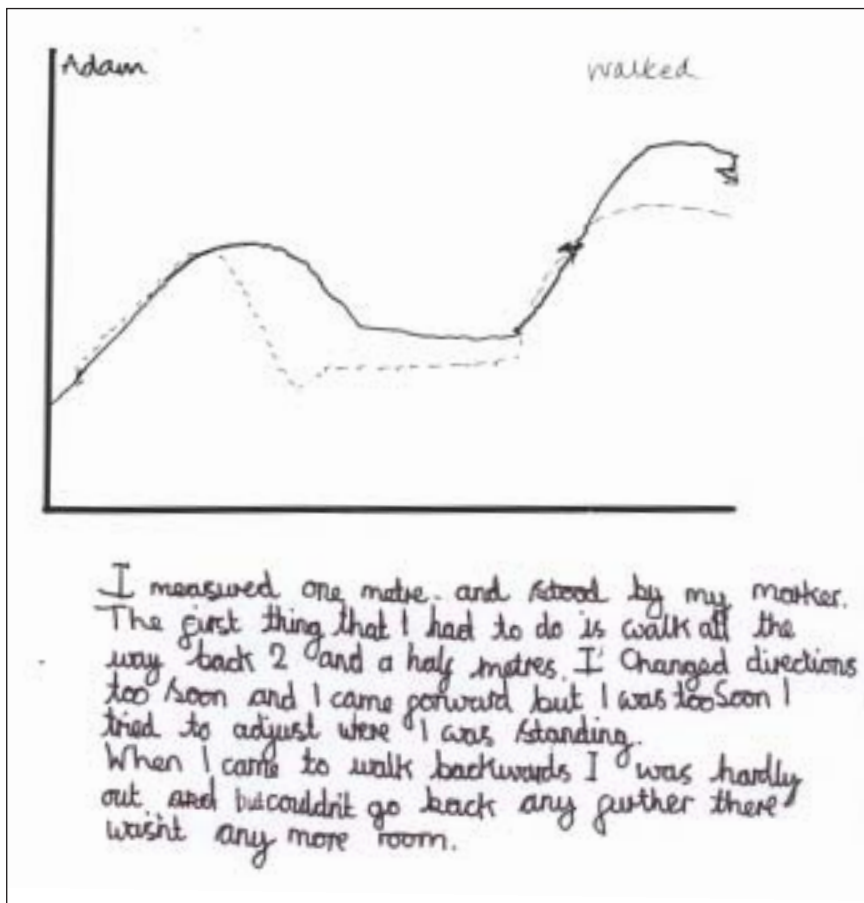
In a subsequent lesson the project continued with the children creating their own graphs on acetates placed on the ViewScreen. After trying to walk the graphs, the children's best efforts were recorded using paper and pencil (see pupils' work). As a class we discussed each graph, the children offering comments on accuracy of the match, why there were differences and what they could do to improve the match. They then had the opportunity to try to walk the graph again. Copies of the graphs were made and the children produced written accounts of their

work, explaining the relationship between the angle of slope and how quickly to walk and attempting to account for discrepancies between what they walked and their original graph.

Follow-up work included further consolidation and extension of the original ideas. Using other examples of distance-time graphs they demonstrated that they had really developed sound concepts. For example they understood:

- ▶ the representation of displacement and time by the axes;
- ▶ the use of metres and seconds;
- ▶ which way to walk according to the slope of the graph;
- ▶ when to stand still;
- ▶ when to move quickly or slowly by looking at the slope of the graph.

The final analysis was feedback from pupils. They unanimously voted it some of the most exciting maths they had ever been involved in and thoroughly enjoyed the use of this hand-held technology.



SIMULATING SNAP—the competition

In the previous edition of TI-Time we described a version of the card game, Snap:

Two players each have a pack of 52 cards. They shuffle them and then together repeatedly turn over one card at a time. A snap is when they turn cards of the same value (2 kings, 2 sevens etc.) How many snaps occur as they turn the whole pack?

We asked readers to

- ▶ find a way of simulating this on the calculator;
- ▶ write a simple snap simulation program;
- ▶ consider what would occur if there are three players.

Competition entrants were asked to write a single page of A4 describing their simulation and explaining how and why it worked.

SIMULATING SNAP – the winner



Matt Allen

We were delighted to receive so many entries of such a high standard, though all entries did seem to come from teachers. (It was quite salutary to see how many of these teachers had not read the question carefully!)

After much thought we have decided that the prize of a

TI-84 Plus Silver Edition and TI-Presenter™ should go to Matt Allen, Head of Mathematics at Woodhouse College. His solution is on the next page.

Matt's department team have been looking over the last couple of years at how best to integrate Information Technology into lessons and they recently acquired a class set of TI-84 calculators. Matt says:

We still have a lot to learn about the graphics calculators but we are enjoying the process. Following an INSET session in November, I have been playing around learning how to use the features to best effect in teaching A-level mathematics. My background is in computer science and the competition was my first look at the programming features of the calculator. I was amazed at how easy it was to implement the simulation using lists and enjoyed trying to cut the program down to the bare minimum.

I am sure the TI-Presenter and TI-84 Silver Edition calculator will be put to good use.

SIMULATING SNAP – some comments

The problem could be broken down into three steps:

Step 1:

Put some integers into a list to represent the 52 cards of a pack. One long-winded way of doing this is a command such as

```
{1,1,1,1,2,2,2,2,3,...13,13,13,13}->L1
```

However, the calculator's **seq** command offers more elegant possibilities, especially when combined with **iPart** or, as in Matt's solution, **fPart**.

Step 2:

Shuffle the numbers in the card-lists. Some entrants used loops to change places in the list but an easier method is to create another list of 52 random numbers and to sort this in conjunction with the card-list e.g. **SortA(L3, L1)**. By the way, few entrants realised that a list of random numbers can be created using an adaptation of the **rand** command: **rand(52)**. Most competition entrants (and the judge!) thought you needed to create and shuffle both card-lists. Only Matt pointed out that you really don't need to shuffle the second pack.

Step 3:

Compare the two lists of cards and count the snaps – that's where the calculator's list-handling facilities really come into their own. You can use a command such as **L1=L2** to compare the elements of two lists of equal length (Find = in the TEST menu). The result of the command is a new list containing 0s or 1s, the latter indicating when two elements are equal – a snap! So, find the sum of this list and you know how many snaps in that game: **Sum(L1=L2)** – beautiful!

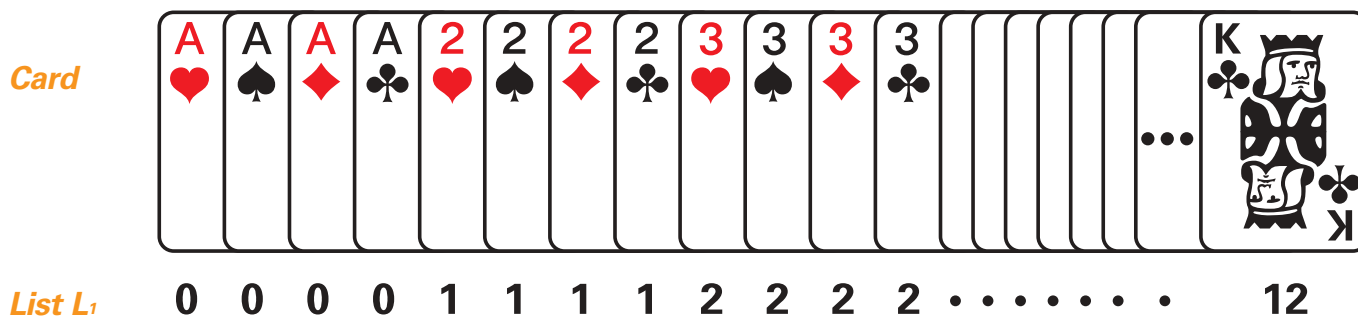
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Simulating Snap

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SIMULATING SNAP – the winning entry

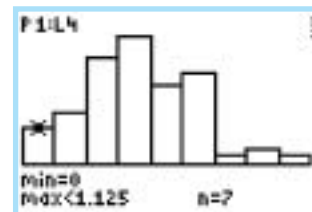
Matt Allen



In order to simulate this situation, we are only interested in the values of the cards, not their suits, so replace each card with a number to represent its value from 0, for an Ace, to 12 for a King. We can set up list L₁ with the numbers required using the sequence command (seq). If we divide the values from 0 to 51 by 4 and retain only the integer part this will do the trick.

- ▶ To set up two packs the same we copy list L₁ into list L₂.
- ▶ Let's repeat the game and count the snaps 100 times, so we'll use a **For...End** loop to count C up from 1 to 100.
- ▶ In order to shuffle the pack, we'll assign a random number to each card and then sort the pack based on the ordering of these random numbers. List L₃ is assigned the 52 random numbers and then list L₂ is sorted using these.
- ▶ Note that shuffling the other pack as well is not necessary (think about it...).
- ▶ We now need to count the number of snaps. The sum command will count how many times the corresponding values in L₁ and L₂ match. The result is displayed and stored in list L₄ at position C.
- ▶ Once all the counting is over we can draw a histogram of the results and use the Trace command to examine the distribution of the number of snaps.

```
PROGRAM: SNAP
:ClrAllLists
:seq(iPart(X/4),X,0,51)->L1
:L1->L2
:For(C,1,100)
:rand(52)->L3
:SortA(L3,L2)
:sum(L1=L2)->L4(C)
:Disp {C, L4(C)}
:End
:AxesOff
:Plot1(Histogram, L4, 1)
:ZoomStat
:Trace
```



Increasing the number of times we repeat the simulation indicates that the expected number of snaps is approximately 4.

We could increase the number of players to three by introducing another shuffled list – try this simple alteration to explore further...

Investigating Curves

Bernard Murphy



Bernard Murphy

The new Further Mathematics module, FP2, in the OCR(MEI) specification includes an optional question in which students are required to use a graphics calculator to investigate curves and

use this to inform their thinking when explaining the mathematical properties of the curve. In this article, Bernard Murphy explains the way in which graphics calculators open up a whole new area of mathematics for investigation, an area which would be impractical to study without this technology.



Imagine two 10p coins flat on the table. One coin is rolled around the other without slipping. Can you visualise the locus of a point P on the edge of the rolling coin?

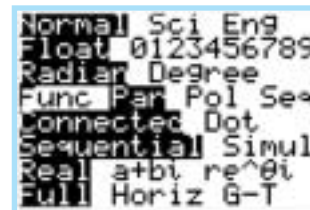
It is possible to show that the parametric equations describing the locus of the moving point, P, are

$$x = 2r\cos T - r\cos 2T \quad y = 2r\sin T - r\sin 2T$$

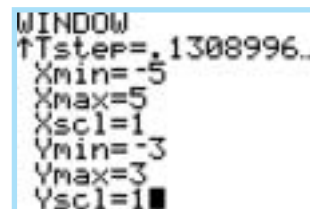
An explanation of where these come from can be found in the 'Investigation of Curves' chapter in **MEI Further Pure Mathematics 2** published by Hodder Murray: ISBN 0340889950.

These parametric equations (with $r=1$) can be entered on the graphics calculator as follows.

Press MODE and select **Par** for parametric graphing mode



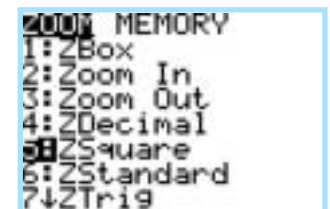
Change the WINDOW settings.



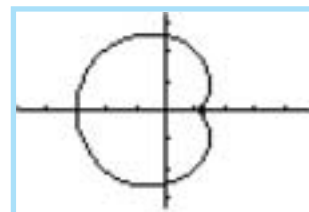
Press Y= and enter the equations. (You can use the ALPHA button for T).



Press ZOOM and choose option 5.



Finally press GRAPH.



Now, having seen the curve, a whole host of questions present themselves.

- ▶ What are the coordinates of the axes intercepts?
- ▶ What is the value of T when P is momentarily travelling parallel to the y-axis?
- ▶ What is the highest point reached by P?
- ▶ What is the area of the curve traced out by P?

Most of these require some sophisticated mathematics to solve, but pressing **r** provides some approximate numerical values for some of them.

Now let's take another look at those parametric equations:

$$x = 2r\cos T - r\cos 2T \quad y = 2r\sin T - r\sin 2T$$

If we're prepared to forget the context in which they arose and just play with the equations all sorts of interesting things arise. For example, let's change the angle $2T$ to $3T$:

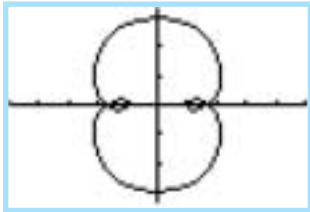
$$x = 2r\cos T - r\cos 3T \quad y = 2r\sin T - r\sin 3T$$

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Investigating Curves

continued

This is where the calculator really comes into its own. What would the curve with these parametric equations look like? To draw them by hand would be rather tedious so naturally we once again reach for the graphics calculator:

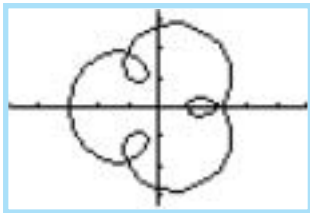


So what exactly is the role of the 3 we've just used? And more generally what is the role of n in the family of equations:

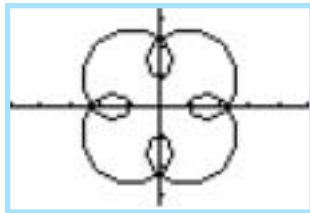
$$x = 2r\cos T - r\cos nT \quad y = 2r\sin T - r\sin nT$$

Again the graphics calculator is a good starting point:

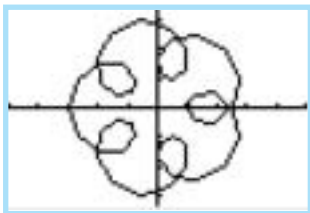
$n = 4$



$n = 5$



$n = 6$

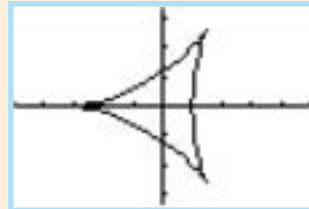


By looking at these curves, you gain insight into the role of n . You can then gain a deeper understanding by thinking about both the curve and its parametric equations together.

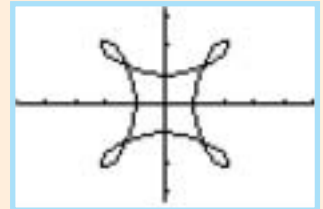
- ▶ How does the value of n affect the order of rotational symmetry of the curves? Can you prove it?
- ▶ As T increases from 0 to 2π how does the curve unfold?
- ▶ What is the closest the curve gets to the origin and at what values of T is this achieved?
- ▶ What about the points on the curve which are furthest from the origin?
- ▶ What are the coordinates of the crossover points on the curves?

But nobody said that n had to be positive...

$n = -2$



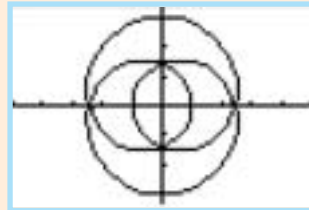
$n = -3$



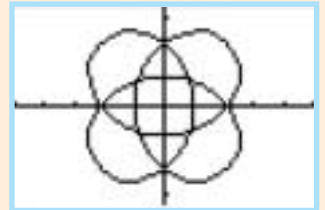
Can you extend the rotational symmetry rule you found for positive integer values of n to include negative integer values too?

... and nobody said that n had to be an integer:

$n = 1/3$



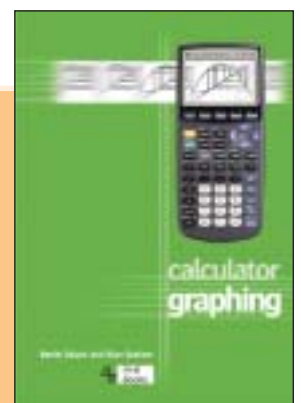
$n = -1/3$



What range of values of T is required in order to trace out the complete curve in each case? Why?

Without a graphics calculator it would not be possible to analyse families of curves at this level. In the past, graphics calculators have been used to support the mathematics being studied. In this topic the technology allows us to expand the mathematics that can be studied, thus opening up exciting areas that would otherwise be outside the experience of students.

There are further ideas for this sort of investigation in Chapter 9, Ellipses and Epicycloids, of **Calculator Graphing** (A+B Books, 2004 ISBN 0-9541020-4-5. www.AplusB.co.uk). The book also includes a gentle introduction to parametric graphing as well as polar, sequence and function graphing.



Competition Time

Three chances to win, for yourself or your school, a TI-84 Plus Silver Edition and a copy of TI-SmartView™, the graphics calculator emulator software.



The page may include anything:

- ▶ text (narrative or bullet points or lesson notes, or feedback..?);
- ▶ photos;
- ▶ examples of students' work;
- ▶ screen displays;
- ▶ data lists... whatever.

But, you have just one page to grab readers' attention and get your message across.

Please send the page together with your contact details to: Barrie Galpin, 15 Top Lodge, Fineshade, Corby, Northants, NN17 3BB or by email to barrie.galpin@zen.co.uk.

Entries should arrive by 30th September 2006 and the winning entries will be published in the next edition of TI-Time. The editor's decision is final.

Why teach with hand-held technology?

What does hand-held technology contribute in the classroom that cannot be achieved in other ways? To enter this competition you must send us a single A4 page that shows imaginatively and convincingly why your use of TI hand-held technology has improved the quality of your students' learning experience.

TI News

TI-SmartView™ 2.0 emulator software now available

The TI-SmartView™ emulator is an easy-to-use, demonstration tool for leading the classroom teaching of maths and science concepts. Based on the popular TI-84 Plus family of graphing calculators (compatible with the TI-83 Plus family), the TI-SmartView emulator complements classroom calculator use by displaying an interactive representation of the calculator, plus offers many unique teaching capabilities.

Scripts

Preloaded demonstrations (scripts) help teachers increase their familiarity and comfort with graphing calculator functionality – ideal to help those just getting started with or expanding their use of graphing calculators. Teachers can prerecord their own key press operation of the calculator for playback in class. It's easy to create, edit, play, pause, and modify delivery speed of scripts, and they can be saved on the computer for future use.

CBL 2™ / CBR 2™

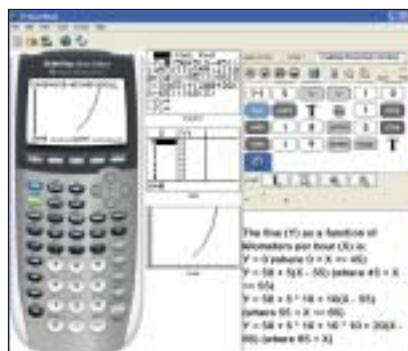
Use the TI-SmartView software connected to a CBL 2 or CBR 2 data collection device to collect real world data.

View3™ Feature

Teachers can simultaneously project up to three representations of graph, table, equation, list window and STAT plot screens – increasing student understanding of concepts and relationships.

Visual Key Pressing

Using the mouse to select keys on the TI-SmartView™ emulator (or by pressing the keys on a USB linked TI-84 Plus or TI-84 Plus Silver Edition calculator), projected keys highlight to clearly indicate selections to the class.



Key Press History

As keys are selected, key images and entire sequences can be projected to the class, helping students to follow along and stay on track.

Screen Capture

Easily create and save multiple screen captures. Screens as well as Key Press histories can be copied into commonly used document software.

TI's easiest, most effective way to lead classroom teaching of maths and science concepts.

- ▶ Highly interactive computer emulation of TI-84 Plus family graphing calculators (compatible with TI-83 Plus family)
- ▶ Helps increase student understanding by simultaneously showing multiple representations of equations
- ▶ Increases teacher familiarity and comfort with graphing calculator use through preloaded demonstrations (scripts)
- ▶ Provides a clear and easy way for students to follow along by displaying key press sequences
- ▶ Easily integrates with existing projection systems and interactive whiteboards

To request a 30-day trial CD of TI-SmartView 2.0, call 020 8230 3184

TI launches TI-Nspire™ CAS: a Computer Algebra System-based software and handheld device platform.

In August 2006, we will be launching TI-Nspire in countries where CAS is widely used within their teaching of mathematics. The concept behind TI-Nspire is that in maths, each pupil learns differently. One understands formulae better, another tables, another diagrams and so on. TI-Nspire CAS deals with these specific learning habits, by using formulae, tables, graphs, symbols, geometrical constructions and notation, separately or dynamically linked with one another. By the linking these different representations, students will gain a deeper mathematical understanding.

More details about TI-Nspire CAS will be available on our website in the coming months.



Professional Development from T³™ - Teachers Teaching with Technology

At TI, we are committed to providing excellent professional development courses. The aim is to support teachers in using TI handheld technology to encourage students' exploration and visualisation of concepts and ultimately, improve their understanding.

Free training

With a minimum of eight teachers, on-site course can be held at your school and will be free of charge. We welcome both maths and science teachers and we encourage you to invite teachers from other schools in your area or networks to take advantage of this excellent, free professional development.



Residential training

In the Autumn, we will be running two residential courses, which will start on Friday morning and finish after lunch on Saturday. The course fee is just £125 and includes:

- ▶ Accommodation at the venue (to be confirmed)
- ▶ All meals and refreshments
- ▶ A TI-84+ SE graphic calculator (worth around £75)
- ▶ Books and resources for you to use in your teaching
- ▶ Focused and relevant training given by experienced maths teachers and lecturers

To enquire about either a place on a residential course or on-site training at your school or establishment, please either email us at t3@ti.com or call the T³ Co-ordinator, Sally Pennycate on 01604 663077.

Texas Instruments Education Service

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