**Simple Statistics**

With the inclusion of statistics in the curriculum, the TI-83 is a good choice for teachers. The TI-83’s powerful statistical features allow you to concentrate on ideas and concepts rather than mechanical computations. Some of the built in distribution functions are shown on the calculator opposite.

“**There are few computer packages to match it for price and functionality as well as classroom convenience.**”

To simulate the tossing of a coin the TI-83 has a built in random integer function: [MATH] PRB 5. With the construct shown here, we are generating random integers between 0 and 1, 100 times. Here 1 represents a head, 0 a tail. Store the results in list L1.

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**TI-TIME**

Technology in Maths Education

**For the UK & Ireland**

**Issue 10**

Spring 1998
Simple Statistics

Should you be interested in interrogating this sample, there are many built in functions that allow you to do so. If, for example, we wished to find the mean of this sample such a function exists: [2nd],[LIST],MATH,3.

\[
\text{mean}(L_1) = 0.58
\]

By combining functions we are able to do many types of simulation. The example shown calculates a sequence: [2nd],[LIST],OPS,5 of the mean of 5 random integers between 0 and 1 (e.g. 0,1,0,0,1) 100 times and stores the result in list L1.

Such a simple line of statements can be used to demonstrate quite complex ideas, in this case the central limit theorem.

As sample sizes from a population increase, the distribution of the means of these samples becomes more normally distributed, with the mean of all possible samples the same as the population mean.

This complex idea can be simply demonstrated by using the sequence previously shown and a stat plot set up as shown followed by zoomstat.

First run the line with the sample size set at 5. Then examine the plot of these sample means.

By using the 2nd function entry facility on the calculator you are able to recall and edit the statement with a new sample size each time. Try 10, 20 then 30.

The plots shown are for the given sample sizes and give a reasonable graphic demonstration of the principle involved.

Sample size 5

Sample size 10

Sample size 20

Sample size 30

Contributed by T3 Scotland
TI-TIME
Spring ’98

Advanced Mathematics, More Memory & Flash Technology

TI continues to improve the TI-92 in such a way that your original investment in the calculator is preserved! How? We have created the TI-92 Plus Module with Advanced Mathematics Software. A small, easy-to-use snap-in cartridge, transforms your TI-92 into one of the most advanced tools for maths.

The TI-92 is a symbolic calculator, a tool for experimentation and visualisation, and an educational tool that can aid more effective teaching and learning.

With the TI-92 Plus Module you can upgrade your TI-92 as easily as you upgrade your computer software. Upgrading to the TI-92 Plus Module with Advanced Mathematics Software provides you with the following additional features:

- Advanced maths algorithms (symbolic, numeric, and graphic) including differential equations and advanced algebra.
- Flash technology, allowing you to upgrade software or acquire future software applications simply by downloading them from our web site (Graph Link™ is needed to connect your calculator to your computer).
- More memory (almost 3 times the user-available RAM of the classic TI-92 plus 384 KB of archive memory).

For more information on the TI-92 Plus Module please contact the TI Customer Support Team on: 0181 230 3184

How the new plug-in TI-92 Plus Module can handle one of Euler’s problems!

Leonhard Euler studied the dynamic behaviour of the terms of a simple iteration $u(n)$:

1. Choose a starting value: e.g. $u(1)=1$
2. Think of a number $k$: e.g. $k = 1.2$
3. Form the sequence of values given by the recurrence: $u(n+1)=k^{u(n)}$

For each value of $k$ does this (a) diverge, (b) converge, or (c) do something different?

You can easily investigate this iteration numerically on a TI-92 (or graphic calculator) for different values of $k$ by using the SEQ graph mode. For example, with $k=2$ we get a sequence $\{1, 2, 4, 16, ...\}$ which quickly diverges, and with $k=1$ we get the sequence $\{1, 1, 1, 1, ...\}$ which certainly converges! Euler wondered whether there would be a critical value of $k$ between 1 and 2. So we shall now try to find this value.

The sequence may have one or more fixed points $x$ which are solutions of the equation $k^x=x$. Unfortunately we cannot manipulate this expression to get $x$ as an explicit function of $k$. By graphing $y=k^x$ and $y=x$ we see that there are values of $k$, such as 1.6, for which the graphs have no intersections, hence no fixed points, and where the sequence inevitably diverges. Similarly there are also values, such as 1.2, for which the graphs have 2 points of intersection, and hence two fixed points. The theory of iterations tells us that such a fixed point will only be an attractor when the slope of the curve $y=k^x$ at the fixed point $x$ is between -1 and 1. We can easily obtain approximate values for the slopes at each such fixed point. In the case of $k=1.2$ we find that the smaller fixed point ($x=1.258$) is an attractor (with slope $= 0.229$), and the larger fixed point ($x=14.77$) is a repellor (with slope $= 2.694$). The largest value of $k$ for which convergence is possible will be that for which the two fixed points coincide, and the line $y=x$ is tangent to the curve $y=k^x$ with a slope of 1. Hence we need to solve two non-linear equations:

$$k^x = x \quad \text{and} \quad \frac{dk^x}{dx} = 1$$

The derivative

$$\frac{d}{dx} k^x = \ln(k) k^x$$

and it is then possible to manipulate the equations $k^x=x$ and $\ln(k) k^x=1$ first to eliminate $k$, and then to find $x$.

"With the new TI-92 Plus Module we can solve this set of simultaneous non-linear equations directly!"

Of course it may not always be possible to find explicit symbolic solutions. But it is possible to ‘break’ the search with the ON key to include numerical approximations to the solutions as initial guesses which the algorithm will refine numerically.

Using approximate solutions $k=1.5$ and $x=1.5$ we have stumbled across Euler’s result: that the largest value of $k$ for which convergence is possible is when $x=e$, and hence $k=e^x=1.444...$ But that isn’t the end of the story. Try using a very small value of $k$, such as $k=0.02$. This time there seems to be a repeating pattern, oscillating between the two fixed points, and we have a period two attractor. Euler also answered the question: “what is the smallest value of $k$ for which convergence to single fixed point is possible?”. Can you? (Hint: What will the slope of the curve be at the fixed point in the critical case?) See David Wells’ Penguin Book of Curious and Interesting Numbers for more detail.

Adrian Oldknow
University College Chichester.
Winner 1: Over 16yrs group - Gannet Rock

The table below shows measurements of the height of the tide on one day at Gannet Rock, Canada.

<table>
<thead>
<tr>
<th>Time (in hours after midnight)</th>
<th>Height of water (in feet)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>9.0</td>
</tr>
<tr>
<td>1</td>
<td>13.4</td>
</tr>
<tr>
<td>2</td>
<td>16.9</td>
</tr>
<tr>
<td>3</td>
<td>18.4</td>
</tr>
<tr>
<td>4</td>
<td>17.5</td>
</tr>
<tr>
<td>5</td>
<td>14.8</td>
</tr>
<tr>
<td>6</td>
<td>11.1</td>
</tr>
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<td>7</td>
<td>7.2</td>
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<td>8</td>
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<td>9</td>
<td>2.1</td>
</tr>
<tr>
<td>10</td>
<td>2.4</td>
</tr>
<tr>
<td>11</td>
<td>4.8</td>
</tr>
</tbody>
</table>

Comments:
Students should be able to enter the data as a scatterplot then fit a graph over this. An important modelling skill is tested. Students are unlikely to succeed with an uninformed trial and error approach, (which can be a problem with some assessments based on calculator use). A student with a systematic approach based on
TI-TIME

Spring '98

Winner 2: 11-16yrs group - Plot

How long have you been using technology for teaching?

“I have been using graphing calculators and computers for 7 Years.”

What turned you onto using the Graphing Calculator?

“I was fed up drawing graphs on the board! Really, I wanted to see the calculation and the solution at the same time. On a normal calculator, you lose your calculation. The big screen of a graphic calculator lets you see both.”

Why has it been helpful for your teaching?

“Doing iterations with 6th year pupils is much easier now, so are the Newton Raphson algorithms. My entire Numerical Analysis course is taught on the Graphing Calculator.”

How does the rest of your school use the technology?

“Three others in the school are using them now. We start the students with them at 3rd year (age 12-15).”

Using Pythagoras:

\[ d_1 = (x^2 + 16)^{1/2} \]

\[ d_2 = (64 + (10-x)^2)^{1/2} \]

and \[ t_1 = d_1 / 4 \] and \[ t_2 = d_2 / 2 \]

Using the TI-80 enter the functions as follows:

\[ \Delta TBL = 1 \]

Set Tblset to TBLMIN = 0 and \( \Delta TBL = 1 \)

Press 2nd TABLE to generate the tables.

Alter the Tblset values as required to home in on the solution

Plot the Route (1) Solution

A group of people wish to walk from A to B in the fastest possible time. They can walk at 4km per hour over flat land and 2km per hour over hilly country. Investigate which route they should take and how long it will take them.
The “Owndice” Program

I am a secondary mathematics teacher in a Southampton school. Since buying my TI-82 graphic calculator some years ago I have been fascinated by the potential for using this technology in the classroom. I’ve recently been introduced to the overhead ViewScreen™ and the TI-Graph Link™ which I am using with a PC. I am very much looking forward to getting hold of the CBR which impressed me greatly when I had an opportunity to use one on a recent ATM course.

The first thing I wanted to say was “Thank you” for the effort Texas Instruments have put into providing schools with useful technology in recent years. I am convinced that hand-held technology, like the TI-82, will be a major way in which technology is incorporated into mathematics lessons in the future. Secondly, I have written some programs for the TI-82 which may be of interest to TI-Time readers. I’ve not written to you before, but I do read each issue with great interest.

I was delighted recently to find, the “protection” facility, so programs cannot be changed either by accident or deliberately. I have started writing programs, because I enjoy doing it and I have not found much of this type of software. However, they do take (me at least) an enormous amount of time to design, write, debug and modify and I would value the opportunity to share my ideas with others and vice-versa.

If you have any information about published books or booklets of programs I would be interested to hear about them, or perhaps your readers could send in programs they have used to be made into a booklet.

One of the programs I have written, “Owndice”, allows the user (pupil) to make up their own experiments using larger numbers of dice. I enclose a listing of Owndice for the interest of your readers.

David Payne
Southampton

Many useful items of information, including programs and programming hints can be located at our web page:

www.ti.com/calc

The protection facility is an update to the GraphLink™ software and has been a great help to many teachers.

We are always pleased to receive correspondence from users of our graphing calculators and if you would like to contribute an article you feel may be of interest to others please send it to us at the address shown on page 2.
Mathematics and Technology Down Under

Australia may not be a major user of technology by global standards, but per head of population there are few nations which can boast as rapid an uptake of new technologies: from VCRs to CD-ROM, from optic fibre cable to the world wide web, this nation has for some years now led the way in taking and using what the information revolution has to offer.

This is no less true in mathematics teaching and learning than in other areas: while in many parts of Australia, the same battles against conservatism and resistance to change are waged as elsewhere, large and influential sections of the educational community lead the way in introducing teachers and students to the many advantages that technology may bring to classrooms at all levels. More importantly, decision makers and curriculum developers have responded to this invitation, and several Australian states are at the forefront of developments in the effective use of a range of innovative technologies for teaching and learning. Two Australian states (Victoria and Western Australia) have now permitted the use of graphic calculators in the major external examinations which mark the end of secondary schooling; others are poised to follow.

In 1996, the Australian Association of Mathematics Teachers captured the spirit of the time with their Statement on the Use of Calculators and Computers for Mathematics in Australian Schools. This timely document provided a framework from which all those with a stake in the educational process might make informed decisions regarding the uptake and use of technologies for learning. Principal recommendations made clear reference to the critical issues of pedagogy, research, assessment and professional development, in addition to recognising the role of calculators and computers as “natural media for mathematics learning” to which ALL students should have ready access in order to both support and extend their learning experiences.

What is teaching with the TI-92 really like?

Calculator technology has been an integral part of teaching within the Mathematics Department at Napier University, Edinburgh for several years.

The TI-92 pilot project co-ordinated through the NUMERIC (Napier University Mathematical Education Research and Innovations Centre) has completed its first year in the autumn of 1997. Here the TI-92 is used as an integral part of the 1st year Mathematics course for a combined class of Energy with Environmental and Energy with Management Engineers. This has been made possible by a subsidy from the Mathematics and Mechanical, Manufacturing, and Systems Engineering Departments, allowing all the students to purchase the TI-92.

It is intended that the machine be used extensively by all students for all three years of mathematics they are required to study.

A set of articles is available to anyone who would like to find out about more information about the project aims, teaching experiences and learning experiences.

For a copy of these details, please contact: Dr. Les Short, Maths Dept, Rm208, Napier University, Edinburgh, or telephone: 0131 455 4380.
Calculators for A-level Calculus

During this academic year, I have been working with some A-level mathematics students from local secondary schools. We have been exploring the support that different levels of calculator technology give to students when they meet calculus for the first time.

This project arose from discussions with a trainee teacher who had been working with A-level students using DERIVE. The students appeared to be supported by the use of the technology, but find more support in relating functions and graphs than in algebraic manipulation. Does this mean that the TI-92 is only of limited value to a student taking a British A-level in mathematics? Would any graphing calculator support the students equally well?

I am exploring whether, having the support of symbolic manipulation ready to hand rather than for limited times in the computer room, will give A-level students more confidence in developing the skills of algebraic manipulation demanded by a typical British A-level course.

Texas Instruments are supporting this investigation by arranging a loan, for several weeks, of a number of TI-92 units to a group of local sixth form students.

I wonder if there are teachers or researchers reading this who have information to add to this debate. If so, please contact me.

Steve Feller
Edge Hill University College
Ormskirk
Fellerst@staff.ehche.ac.uk

Teachers Teaching with Technology (T³) Update

<table>
<thead>
<tr>
<th>Dates</th>
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<th>Course Leader</th>
<th>Course</th>
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<tr>
<td>30 Jan - 20 March</td>
<td>Sheffield</td>
<td>Harry Grinton</td>
<td>Understanding Statistics</td>
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<tr>
<td>11 Feb - 25 March</td>
<td>Edinburgh</td>
<td>Adrian Oldknow</td>
<td>Visual Imagery &amp; Geometry</td>
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<td>26 Feb - 15 March</td>
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<td>Enhancing maths with graphic</td>
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<td>6/7 March</td>
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<td>John Berry</td>
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<td>8/20 May</td>
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<td>Sonia Jones</td>
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<td>22/24 June</td>
<td>Jordantown</td>
<td>Ken Houston</td>
<td>Teaching &amp; learning Advanced</td>
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<td>maths with a graphic calculator</td>
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<td>Barnstaple</td>
<td>Kevin Pankhurst</td>
<td>Enhancing maths with graphic</td>
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<tr>
<td>16/18 July</td>
<td>University of Plymouth</td>
<td>John Berry</td>
<td>calculators</td>
</tr>
<tr>
<td>3/5 Aug</td>
<td>Scotland (Venue TBA)</td>
<td>John Sealf</td>
<td>Summer school</td>
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</tbody>
</table>

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http://www.tech.plym.ac.uk/maths/ctmhome/t3.html

TI-CARES
This is the sister publication to TI-TIME, intended to help you when contacting TI and to provide a wide variety of information which is specifically calculator related, including new products, supplier contact details, resource materials and more.

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