ED 460 001   SE 065 492

AUTHOR   Abraham, Paul
TITLE   Using the TI-92+ Calculator as a Tool for Illustrating
                  Programming Concepts.
PUB DATE   1999-11-00
NOTE   6p.; Paper presented at the Annual International Conference
                  on Technology in Collegiate Mathematics (12th, San
                  Francisco, CA, November 4-7, 1999).
AVAILABLE FROM   For full text:
                  http://archives.math.utk.edu/ICTCM/EP-12/C15/pdf/paper.pdf.
PUB TYPE   Guides - Classroom - Teacher (052) -- Opinion Papers (120)
                  -- Speeches/Meeting Papers (150)
EDRS PRICE   MF01/PC01 Plus Postage.
DESCRIPTORS   College Curriculum; *Computer Science Education; *Computer
                  Uses in Education; Educational Strategies; *Graphing
                  Calculators; Higher Education; *Programming Languages;
                  Science Education
IDENTIFIERS   *MAPLE Computer Algebra System

ABSTRACT
        This paper describes how the TI-92+ calculator can be
valuable in illustrating basic and advanced programming concepts in
introductory computer science courses. Descriptions of the scope of the
curricula for the courses in which the TI-92+ is used are provided. The
TI-92+ programming language is particularly useful in demonstrating the
progression in program development from pseudocode to code. Examples using
MAPLE code are employed. Programming examples using TI-92+ are also included.
(DDR)

Using the TI-92+ Calculator as a Tool for Illustrating Programming Concepts

By Paul Abraham
Kent State University Stark Campus

Introduction

As a mathematics professor who occasionally teaches introductory computer science courses, I have found the TI-92+ calculator to be valuable in illustrating basic and advanced programming concepts, especially when mathematics is an important underlying issue. The computer science courses I teach are an Introduction to Computer Science (CS 10051) and an Introduction to Object-Oriented Programming (CS 23021) at Kent State University Stark Campus.

CS 10051 surveys major areas of computer science like development of pseudocode and elementary structured (C++) programs, analysis of algorithms, data representation, basic computer architecture and assembly language and programming paradigms. The course lays the foundation for entry into many other computer science courses and is also the required computer science class for mathematics majors. Since the TI-92+ programming language is so natural it was particularly useful in demonstrating the progression in program development from pseudocode to code. A small segment of the course allows for a discussion of symbolic programming. As with the adopted text [1] for the course I presented a few examples of *Maple* code, but I also continued with TI-92+ examples to give students an idea of the current power of hand-held technology.

CS 23021 follows CS 10051 and is the first programming-directed course in the computer science major. As the title suggests, course discussions and student assignments progress to involve critical and varied use of objects. In particular string objects, vector objects (which behave much like TI-92+ lists), rational number objects and geometrical window objects like RectangleShape objects play a major role in the course and in the adopted text [2]. In this course a gave a few TI-92+ demonstrations which incorporated lists into symbolic programming to show how lists could be used to solve substantial mathematical problems. The function rsolve() (discussed in detail below) which determines the regions on the number line that pass/fail a given rational inequality was such an example. With College Algebra (Math 11011) as a prerequisite for CS 23021, students could certainly appreciate the significance of rsolve(). Since TI-92+ fractions and imaginary numbers are represented in standard form, I also used the TI-92+ to motivate the development of C++ rational and complex number objects.

Example Functions: rsolve(), mysort(), ispos() and gsolve()

1

2

In this section the functions rsolve(), mysort() and ispos() are presented in entirety and a fourth function gsolve() is discussed. The code for all of these functions is available from the author and perhaps the Calculator Program Archive [4].

The function rsolve() solves any given rational inequality. The solution returned by rsolve() is only partial in the sense that it determines the regions on the number line that pass/fail the inequality, but does not decide which endpoints should be included. The function rsolve() returns the solution as a list which mimics the bottom line of sign chart solutions commonly constructed in textbooks, e.g. see [3].

The function gsolve() solves any given rational inequality completely. It returns the final answer using standard interval notation, singleton sets or the empty set as needed. The code for gsolve() is somewhat more tedious than rsolve() and will not be presented here since it occupies several pages. Runs of both rsolve() and gsolve() follow:

	F1	F2▾	F3▾	F4▾	F5	F6▾	
		Algebra	Calc	Other	PrgmIO	Clean Up	

```
■ rsolve(x² > 4, x)
        (-∞  true  -2  false  2  true  ∞)
■ rsolve(x/(x-3) > 0, x)
        (-∞  true  0  false  3  true  ∞)
■ rsolve(x²/(x-3) > 0, x)
        (-∞  false  0  false  3  true  ∞)
rsolve(x^2/(x-3)>0,x)
PROCPAP     RAD AUTO     FUNC 3/20
```

	F1	F2▾	F3▾	F4▾	F5	F6▾	
		Algebra	Calc	Other	PrgmIO	Clean Up	

```
■ gsolve(x²/(x-3) ≥ 0, x)
                              "(0)∪(3,∞)"
■ gsolve(1/x² < 0, x)
                                      ()
■ gsolve((x-4)/(x²-2·x-3) < 0, x)
                        "(-∞,-1)∪(3,4)"
gsolve((x-4)/(x^2-2x-3)<0,x)
PAUL        RAD AUTO     FUNC 3/20
```

The comments in the rsolve() function code below explain fully how the function works. As the output of rsolve() illustrates, the solution is a list which contains different data types: extended real numbers and Boolean values. The ability for a list to contain values of different base types is extremely powerful and rare in common languages.

```
rsolve(ineq,var)
Func

"This function determines the regions on the number line that satisfy the given rational inequality ineq in
variable var.

"The result answ is returned as an ordered list of numbers with true or false between adjacent numbers. A
true between adjacent numbers indicates the corresponding region satisfies the inequality, else a false
appears.

Local oneside,combined,top,bottom

"The left and right sides of ineq will be combined with a common denominator into one side called
combined. 0 is understood to be the new right-hand side. top is the numerator of combined and bottom is
the denominator of combined.

left(ineq)-right(ineq)»oneside
comDenom(oneside,var)»combined
getNum(combined)»top
getDenom(combined)»bottom

Local s,z,endpt,answ

"These variables represent lists. s will hold the zeros of bottom, ⁹, and ,, z the zeros of top, and endpt will be
the ascending sorted list s∪z of endpoints.
```

2

```
zeros(top,var)»z
zeros(bottom,var)»s
augment(s,{ª,,})»s
z»endpt
augment(endpt,s)»endpt

mysort(endpt)»endpt
```

"The code for mysort() occurs later in this article. It was necessary to write mysort since a function can not call the built-in ascending sort program.

```
Local  a,b,i,testv
```

"These variables are used to construct answ. a represents the left endpoint for the current region, b represents the right endpoint, i maintains the current position in endpt and testv represents the test value for the current region.

"answ begins with left endpoint a -,. Looping ends when a reaches ,.

```
1»i
ª,»a
{ª,}»answ

While· a ,
 endpt[i+1]»b
```

" this block of code picks a test value appropriately.

```
 If a=ª, Then
  If b=, Then
   0»testv
  Else
   b-1»testv
  Endlf
 Else
  If b=, Then
   a+1»testv
  Else
   (a+b)/2»testv
  Endlf
 Endlf
```

" The next two lines insert true or false and the right endpoint into answ. testv is plugged into ineq to decide between true or false.

```
 augment(answ,{ineq|var=testv})»answ
 augment(answ,{b})»answ
```

" Finally, the right endpoint becomes the new left endpoint and the current position in endpt increases.

```
 b»a
 i+1»i
 EndWhile

Return  answ
EndFunc
```

As you may have noticed rsolve() requires a list to be sorted and calls the function mysort(). The function mysort() is a routine bubble sort. The code for mysort() follows:

```
mysort(l)
Func
"This function bubble sorts list l.

Local i,j,n,temp
dim(l)»n
1»i
While i<n
1»j
  While j<n-i
  If l[j]>l[j+1] Then
    l[j]»temp
    l[j+1]»l[j]
    temp»l[j+1]
  EndIf
  j+1»j
  EndWhile
i+1»i
EndWhile
Return l
EndFunc
```

We conclude with the code for the function ispos() that illustrates another nice feature of lists on the TI-92+: the ability to apply a function or operator across a list. In calculus this feature could be used for example to differentiate a list of functions in one step, e.g., $d(\{x,x^2,x^3\},x)$ produces the list $\{1,2x,3x^2\}$. Similarly, the function ispos() determines which list entries are positive without explicit looping through the list and returns a list of true/false outcomes. The call ispos($\{1,-2,0\}$) produces {true,false,false}.

```
ispos(l)
Func
Local z,n
dim(l)»n
"n is the size of l
newList(n)»z
"Created a list z of size n and by default filled it with 0's. The comparison of l and z entries is done next
coordinate-wise and the list of results is returned
Return l>z
EndFunc
```

References:

[1] J.P. Cohoon and J.W. Davidson, **C++ Program Design: An Introduction to Programming and Object-Oriented Design**, 2nd edition, McGraw-Hill Inc., 1999.

[2] G.M. Schneider and J.L. Gersting, **An Invitation to Computer Science**, 2nd edition, Brooks/Cole Publishing, 1999.

[3] M. Sullivan, **College Algebra**, 5th edition, Prentice Hall, 1999.

[4] Texas Instruments Inc., Calculator Program Archive, Texas Instruments Inc., <http://www.ti.com/calc/docs/arch.htm>, 22 December 1999.

4

Author's Postal Address:

KSU Stark Campus
6000 Frank Avenue NW
Canton OH 44720

Email Address: pabraham@stark.kent.edu

5

U.S. Department of Education
Office of Educational Research and Improvement (OERI)
National Library of Education (NLE)
Educational Resources Information Center (ERIC)

REPRODUCTION RELEASE
(Specific Document)

I. DOCUMENT IDENTIFICATION:

Title: Using the TI-92+ Calculator as a Tool for Illustrating Programming Concepts

Author(s): Paul Abraham

Corporate Source:	Publication Date: 10/2000

II. REPRODUCTION RELEASE:

In order to disseminate as widely as possible timely and significant materials of interest to the educational community, documents announced in the monthly abstract journal of the ERIC system, Resources in Education (RIE), are usually made available to users in microfiche, reproduced paper copy, and electronic media, and sold through the ERIC Document Reproduction Service (EDRS). Credit is given to the source of each document, and, if reproduction release is granted, one of the following notices is affixed to the document.

If permission is granted to reproduce and disseminate the identified document, please CHECK ONE of the following three options and sign at the bottom of the page.

The sample sticker shown below will be affixed to all Level 1 documents	The sample sticker shown below will be affixed to all Level 2A documents	The sample sticker shown below will be affixed to all Level 2B documents
PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL HAS BEEN GRANTED BY TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 1	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE, AND IN ELECTRONIC MEDIA FOR ERIC COLLECTION SUBSCRIBERS ONLY, HAS BEEN GRANTED BY TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2A	PERMISSION TO REPRODUCE AND DISSEMINATE THIS MATERIAL IN MICROFICHE ONLY HAS BEEN GRANTED BY TO THE EDUCATIONAL RESOURCES INFORMATION CENTER (ERIC) 2B
Level 1 ↑	Level 2A ↑	Level 2B ↑
Check here for Level 1 release, permitting reproduction and dissemination in microfiche or other ERIC archival media (e.g., electronic) and paper copy.	Check here for Level 2A release, permitting reproduction and dissemination in microfiche and in electronic media for ERIC archival collection subscribers only	Check here for Level 2B release, permitting reproduction and dissemination in microfiche only

Documents will be processed as indicated provided reproduction quality permits.
If permission to reproduce is granted, but no box is checked, documents will be processed at Level 1.

I hereby grant to the Educational Resources Information Center (ERIC) nonexclusive permission to reproduce and disseminate this document as indicated above. Reproduction from the ERIC microfiche or electronic media by persons other than ERIC employees and its system contractors requires permission from the copyright holder. Exception is made for non-profit reproduction by libraries and other service agencies to satisfy information needs of educators in response to discrete inquiries.

Sign here, please

Signature: *Paul Abraham*	Printed Name/Position/Title: Paul Abraham, Assistant Professor of Mathematics	
Organization/Address: Kent State University, Stark Campus 6000 Frank Ave NW Canton OH 44720	Telephone: (330) 244-3404	FAX: (330) 494-6121
	E-Mail Address: pabraham@stark.kent.edu	Date: Feb. 12, 2002