DISCRETE MATHEMATICS WITH THE TI-89

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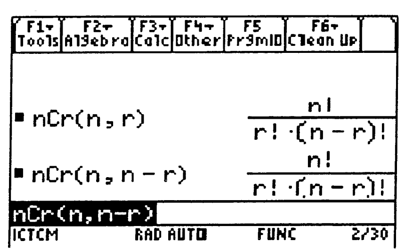
Discrete mathematics is a course which can be enhanced by use of the symbolic capabilities of TI-89 calculator. At the Woodbridge Campus of Northern Virginia Community College discrete mathematics is taught as a post-calculus course for both mathematics and computer science majors. Typical students come to the first class with their TI-89 in hand, both wanting and expecting to be able to use it. In response to their expectations we have developed a series of calculator worksheets which can be used to supplement some of the topics of discrete mathematics.

The symbolic capabilities of the TI-89 allow the instructor to ask students questions like the following:

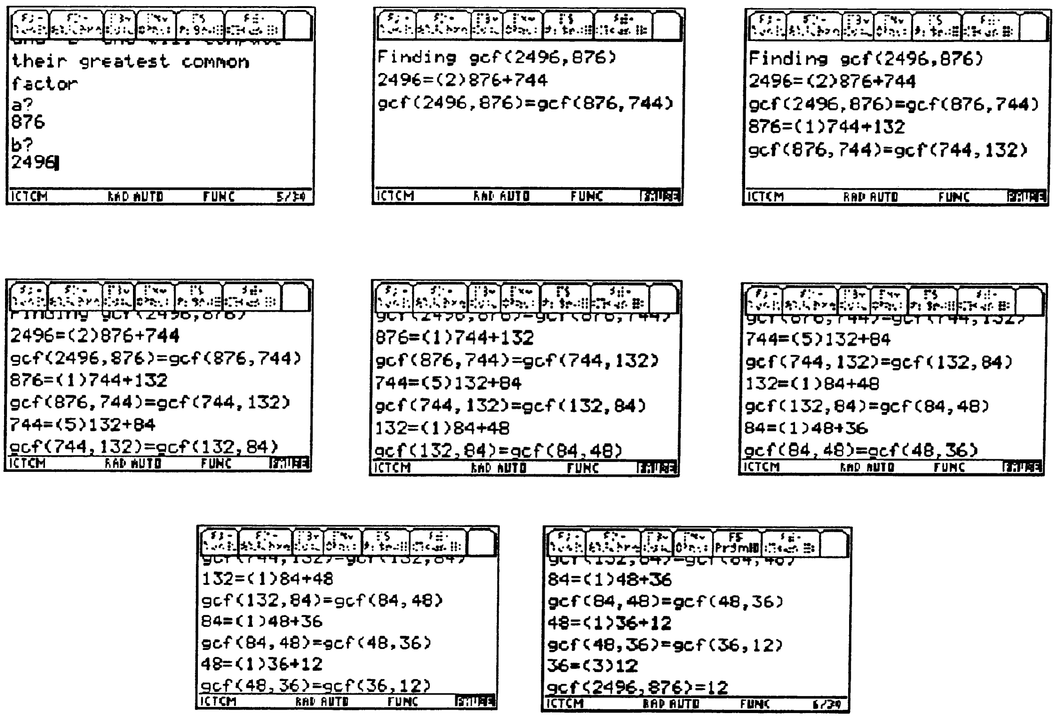
> Your calculator can help you conjecture that $\binom{n}{r} = \binom{n}{n-r}$. Can you prove this conjecture on your calculator? Show, by hand, that $\binom{n}{r} = \binom{n}{n-r}$ is indeed true. Be sure to record your verification below and explain the logic you used to reach your conclusion.

When the student puts $\binom{n}{r}$ and $\binom{n}{n-r}$ into his TI-89 he obtains the following screen:

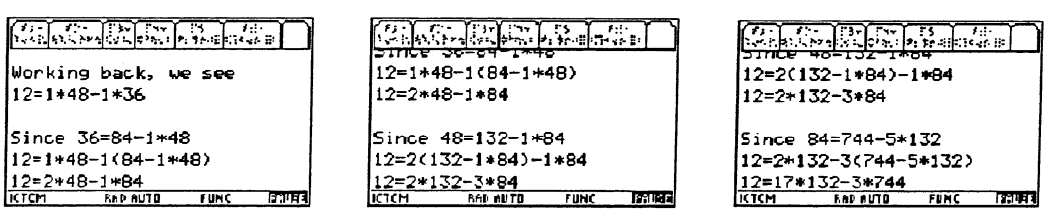


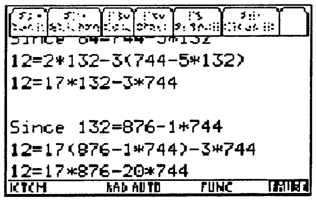
The student is now faced with a dilemma that the calculator cannot settle. To answer the questions posed, the student must make a value judgement about whether or not this constitutes proof that the expressions are equal. The calculator has provided the algebraic groundwork allowing the student to infer that $\binom{n}{r} = \binom{n}{n-r}$.

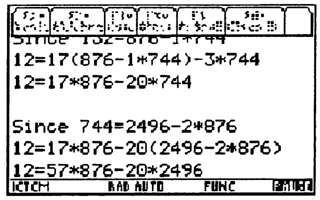
The TI-89 can be readily used to take the drudgery out of calculations through the use of programs. For example, the programs *euclid* and *rewrite* take care of the calculations connected with the Euclidean Algorithm. The program, *euclid*, allows the student to enter two integers and returns a step by step solution for finding the greatest common factor of the two numbers. For example, if he wants to calculate the $gcf(876, 2496)$ he can run *euclid* by typing euclid() on the TI-89's home screen and pressing ENTER. The student will need to enter the numbers 876 and 2496 at the prompts. The following sequence of screens will appear on the calculator screen:



Once this program has been run, the student can access the program *rewrite* which allows him to express the greatest common factor of two numbers as a linear combination without having to do extensive arithmetic calculations. This program asks the student to input both the numbers and their greatest common factor at the appropriate prompts. It then returns, in a step by step fashion, the equations necessary to rewrite the greatest common factor as a linear combination of the two numbers.







The linear combination of $12 = 57 * 876 - 20 * 2496$ is obtained with relatively ease.

Many students gain a first exposure to proof in their discrete mathematics course. When trying to prove or disprove a statement they frequently complain that they do not know whether they are working with a true or a false statement. While their calculator will not prove a statement for them, it can be used as an aid to discover the 'suspected' truth of a given statement. It has also been beneficial for finding counterexamples.

On one of the worksheets we ask the students to use their TI-89 to conjecture the following:

> You are asked to show that if x and y are odd show that $x^2 + y^2$ is even but is not divisible by 4. Here, because of the two variables, you will need to switch the mode to 3D (MODE, graph, $\rightarrow$ to submenu, 3D). You can then enter the three dimensional function as $z1 = x^2 + y^2$. You can then enter any odd number for x and a list for y to try this formula for a number of values. After entering the above expression and returning to the home screen, evaluate it at $(1,3),(1,7),(1,25),(1,101),(1,57321)$ by entering $z1(1,\{3,7,25,101,57321\})$. Are all of the entries in this list even? Are they divisible by 4? How can you tell if they are divisible by 4 using the calculator? Without using the calculator? Try this with some other values of your choosing. Based on this work, do you think you will be trying to prove a true or a false statement?

Many of today's students want the calculator to give them all of the answers. Their first experiences with the calculator reinforce this idea. As they advance through the curriculum they begin to experience situations in which the calculator does not return the anticipated result. Our task is to take students from the level of dependency to the place where they can use the calculator as an analytical tool. As instructors, one way in which we can accomplish this purpose is by providing calculator worksheets which ask questions that require interpretation of the result. The calculator cannot answer why, nor does it flag an erroneous answer.

Developing calculator skills is a direct way to improve analytical thinking. The calculator allows the student to gain a sense of what is happening in a problem. It allows them to ask how their calculators can be used to help investigate problems and formulate solutions in a more concrete fashion. The guidance which an instructor can provide through worksheets will help the student polish these skills while simultaneously reinforcing the concepts of discrete mathematics.

At the Woodbridge Campus of Northern Virginia Community College we have developed a number of worksheets and programs which can be used in discrete mathematics classes. Our worksheets provide an environment in which unusual situations occur. The worksheets encourage the students to reread class notes and the text and to spend time thinking about the concepts of the section. The complete set of worksheets: Combinations, Euclidean Algorithm, Floor and Ceiling, Help with Proofs, Modular Arithmetic, Permutations, and Truth Tables along with the accompanying TI-89 programs is available at www.nvcc.edu/home/jhorn/mth286/calculator.

References:

J. A. Anderson. Discrete Mathematics with Combinatorics. Prentice Hall, Inc, 2001.

S. S. Epp. Discrete Mathematic with Applications, Second Edition. Brooks/Cole Publishing Company, 1995.

R. Johnsonbaugh. Discrete Mathematics, Fifth Edition. Prentice Hall, Inc., 2001.

Cormen, Leiserson, Riviest and Stein. Introduction to Algorithms, 2nd Edition. The MIT Press/McGraw-Hill 2001.

K.H. Rosen. Discrete Mathematics and its Applications, fourth edition. McGraw-Hill, 1999.

TI-89 Guidebook, Texas Instruments, 1998.