

NUMB3RS Activity: Now You See It, Now You Don't Episode: "In Plain Sight"

Topic: Steganography

Grade Level: 7 - 12

Objective: Give students hands-on experience with hidden writing, connecting an ancient art with its modern applications.

Time: 20 minutes

Materials: graphing calculator

Introduction

"Steganography" comes from the Greek word for "hidden writing". It is an ancient art that has been updated and has become much more sophisticated with the use of modern computers. During, "In Plain Sight", Charlie uses it to see hidden pictures. Generally, a message is written in plain text and then in some way it is disguised by "writing over it." The form of visual cryptography used in this activity was invented by Adi Shamir in 1994 and is an example of the beauty that can be found in simplicity.

The steganographs used here may be difficult for some students to see in some circumstances. If possible, make transparencies of the two rectangles on the following page and overlap them on a projector for the class to see. For best results, print using the highest resolution possible.

Discuss with Students

Communicating in secret uses very sophisticated mathematics through the study of cryptography—or writing codes. Another way to insure secrecy in communication is to hide the message so that someone else does not even know it is there. Tell students steganography is the practice of hiding a message or image.

NUMB3RS Example In the episode "In Plain Sight", Charlie gains access to a hidden message because he understands steganography. This activity demonstrates a simple example of how this works and gives students the chance to create and view hidden writing.

Student page answers:



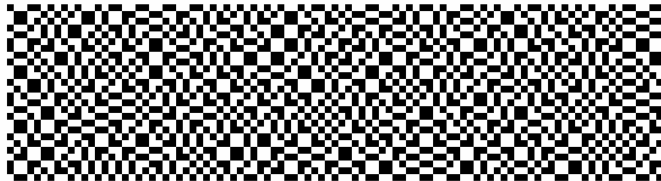
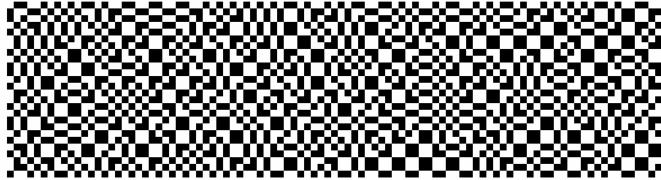
1. NUMB3RS 2. Not necessarily in this order: 3. There are 4 choices for the first box to color black and after that choice is made, there are 3 for the second one. $4(3) = 12$. But, each combination was selected twice (Box A first and then Box C is identical to Box C first and then Box A) so divide by 2: $12/2 = 6$. 4. Answers will vary; student's initial should appear. 5. Reverse the squares that do NOT have a part of the initial and leave the others alone.

Name: _____

Date: _____

NUMB3RS Activity: Now You See It, Now You Don't

1. Cut one of these rectangles out and carefully place it exactly over the other while keeping the same orientation (i.e. the top left remains at the top left, etc.). Hold the overlapped rectangles up to a light source. What hidden message do you see? _____



The process used is called "steganography" and consists of hiding a message in such a way that no one can read it and there is no evidence that there even is a message. This particular message is made by taking a piece of grid paper and breaking each square grid into 4 smaller congruent squares. In each of these squares, two of the smaller squares are chosen randomly and colored black. Here are two possible shadings:



2. Find all the possible ways to shade two squares out of the four. Shade a different pair of small squares by coloring them black in each of the following diagrams.



1



2



3



4



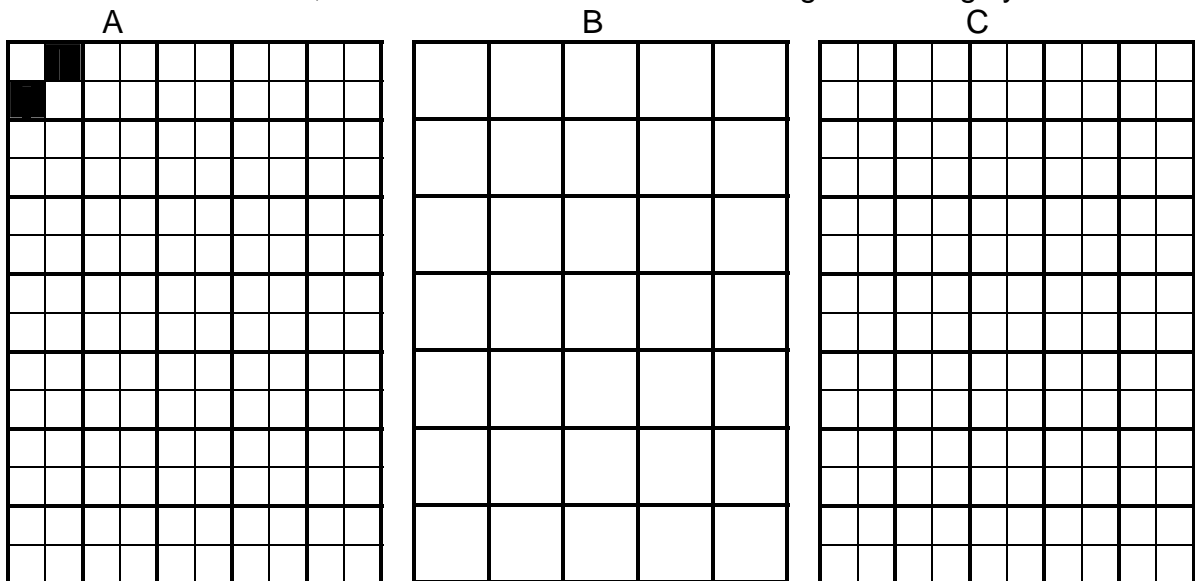
5



6

3. How can we show that there are only 6 ways to do this? _____

4. Now you are going to create your own secret message using the grids below, and a random number generator to create the hidden message.
 - a. Use a TI-84 Plus calculator to generate a series of 35 random integers from 1 to 6 using `RandInt(1,6)` (or roll a six-sided die 35 times and record the number each time).
 - b. Use the corresponding pattern from exercise 2 to shade in the 2 X 2 squares in grid A below. Suppose the first number is a 2. Shade in the first square as shown. Continue shading the other 34 squares using the random numbers generated, working left to right, row by row. For best results, use black ink and shade in the region thoroughly.



- c. On grid B, shade in the first letter of your first name. You must fill the entire square or leave it blank. For example, if your first initial is "L", then you should shade in the first column and last row, shading 11 squares and leaving 24 squares blank.
 - d. On grid C, copy the 2 X 2 squares exactly from grid A except for the squares that you use in grid B. For each of the 2 X 2 squares colored in grid B, reverse the black and white when you fill in grid C.
 - e. Cut out grids A and C, put them together (taping them might help hold them steady) and hold them to a bright light. You will see your first initial, with the initial in black against a lighter background (the opposite of what happened in exercise 1).
5. How would you alter the directions above to make your initial appear as light on black as in the original? _____

The goal of this activity is to give your students a short and simple snapshot into a very extensive math topic. TI and NCTM encourage you and your students to learn more about this topic using the extensions provided below and through your own independent research.

Extensions

Activity: More on Steganography

Introduction

The examples on the previous pages are elementary and not at the level that Charlie deals with in "In Plain Sight". The idea of hidden pictures can be made much more complex by adding color. In addition, there are schemes for sharing knowledge where by certain combinations of the transparencies will produce a result but others will not. For example, a group of four people might each have a transparency such that any two of them appear random, but any three would yield the message. This would ensure a majority could act on it, but no two people could. Some of the resources below illustrate these and other concepts.

Additional Resources

To see a more detailed explanation as well as the masters for a Canadian flag, π , and a happy face, see: <http://www.cacr.math.uwaterloo.ca/~dstinson/visual.html>

Some work with color can be seen at:

<http://homes.esat.kuleuven.be/~rijmen/vc/whatisvc.html>

An example that is closer to what Charlie encounters in the episode is included in a discussion of steganography at: <http://en.wikipedia.org/wiki/Steganography>

For the Student

- Now that you have made a simple message by hand and understand how this system works, visit: <http://www.leemon.com/crypto/VisualCrypto.html> and try your hand at making a longer message.
- Teach a friend to do this and send this person a message. A readable reply will indicate that you have both mastered the technique. Explain why this process works and why it is secure.
- Adi Shamir and Moni Naor first presented this at EUROCRYPT 94. Do an Internet search to learn more about the many interesting creations of Adi Shamir and Moni Naor. The creations vary from the serious to the whimsical and make for interesting research.

Related Topic: Cryptography in general

The Internet is a rich source for both the history and techniques of sending secure messages. The National Security Agency (<http://www.nsa.gov/>) provides college scholarships for students interested in the field.