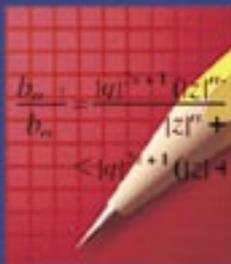


# Mathematics Speakers Bureau



Mathematics & NSA: A Long Term Partnership

## Catalog of Topics 2005-2006





## **National Security Agency Mathematics Speakers Bureau**

The National Security Agency (NSA) is the largest employer of mathematicians in the nation and therefore is critically dependent on the continuing development of first-class American mathematicians. In response to concerns about a decline in the health of mathematics education in the United States, NSA has initiated several programs to support the mathematics education reform effort at the local, state, and national levels. One of these programs is the Mathematics Speakers Bureau, the objective of which is to increase students' interest in mathematics while presenting instruction that models the recommendations of the National Council for Teachers of Mathematics (NCTM) Standards.

The Mathematics Speakers Bureau offers a large variety of fun and fascinating mathematics and science talks given by NSA volunteers to elementary, middle or high school students. In-service talks for teachers are also available. NSA hopes that the speakers' knowledge of and excitement about mathematics will inspire students to be more enthusiastic about their future encounters with mathematics.



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## *Requesting a Speaker*

If you are interested in requesting a speaker, please fill out the **NSA Mathematics Speakers Bureau Request Form** found in the middle of this catalog. Feel free to reproduce it as often as needed. When complete, **fax (preferred)** or mail it to:

**National Security Agency  
Mathematics Speakers Bureau  
ATTN: E / MEPP  
Ft. Meade, MD 20755-6637  
Fax: 443-479-1193  
Phone: 301-688-6214**

Requests may also be submitted by e-mail to [mepp@nsa.gov](mailto:mepp@nsa.gov). Please use “Math Speakers Bureau Request” in the subject line of the e-mail. Please include all of the requested information from the NSA Mathematics Speakers Bureau Request Form in the text of the e-mail. Please do not send attachments.

Requests cannot be taken over the telephone. However, if you have any questions, please feel free to call us on the number listed above.

Many of the talks are interactive and therefore work better if the audience is small. Note that “appropriate grade levels” and “minimum time needed” are specified for each talk. Please pay attention to those levels and times when you request a talk.

To better meet the needs of all schools, we limit each class at any school to one speaker per academic year. Please provide first, second and third choice topics for each class to improve our ability to serve you. The speakers are limited to three presentations per day. Accommodations for additional classes can be arranged with your speaker.

The teacher may request a special topic for his/her class; every attempt will be made to find a speaker on that topic. Please be as specific as possible when making a special request.

For special events such as Math Day, please give two months notice prior to the scheduled date. The Mathematics Speakers Bureau will make every attempt

to satisfy such requests as fully as possible.

The Speakers Bureau program manager will contact you when a speaker has been assigned. That speaker will then contact you to arrange a date and time that works well for both of you. To assist in this process, please be sure to include complete contact information. The more flexible you are, the better we can serve your needs! We will honor requests as our resources permit.

The talk must be scheduled during a time that the regular teacher, and not a substitute, will be present in the classroom and the teacher must remain in the classroom during the entire presentation.

There is a speaker evaluation form on the back of the Mathematics Speakers Bureau Request Form. We would greatly appreciate you making a copy of this form, filling it out and sending it back to us with your comments.

**THERE IS NO CHARGE FOR THESE TALKS.**



## Section I: Talks for Elementary School

### **Adventures in Countable County**

*(Appropriate for grades K-4; minimum time needed is 45 minutes.)*

This adventure is geared toward familiarizing students with mathematical terminology, fostering logical thinking, and demonstrating the usefulness of mathematics. This includes working with the names of numbers, basic geometric shapes, telling time, counting, modular or clock arithmetic and measuring.

### **Bubble Sorting**

*(Appropriate for grades K-3; minimum time needed is 30 minutes.)*

In this talk the students simulate a simple sorting algorithm by acting as components of a computer.  $N+6$  children are needed, where  $N$  is the number of children to be sorted. ( $N=4$  or  $5$  is a good sort length.) The  $N$  children to be sorted sit in memory and the remaining  $6$  children residing in the CPU are assigned jobs such as fetch, store and swap. Concepts covered include computer architecture, algorithm, order, bubble sort, address, pointer and compare. Additional topics that could be discussed are other sorting algorithms, sort fields, complexity, efficiency, ties, time/memory trade-off, factorial, other computer algorithms and class development of an algorithm.

### **Buried Treasure**

*(Appropriate for grades 3-5; minimum time needed is 45 minutes.)*

This is a wonderful introduction to cryptology! Students will be asked to follow a buried treasure map and decode directions in order to find a valuable treasure.

### **“But Who’s Counting?”**

*(Appropriate for grades 2-5; minimum time needed is 60 minutes.)*

“But Who’s Counting?” is a number game shown on the PBS mathematics program Square One. To play, a digit between  $0$  and  $9$  is randomly chosen, and each player puts the digit into a place in a blank five-digit number. Once a digit is placed, it cannot be moved. Then another digit is chosen and placed, and so on, until the number is complete. The player with the highest number wins. In the earliest grades, this game can be used to practice the concepts of greater than and less than as applied to multi-digit integers. Other versions of this game can be used to practice addition or multiplication of multiple-digit numbers. For older children this game can serve as an introduction to probability, and the strategy of the game can be discussed.

## Cryptoball

*(Appropriate for grades 3-10; minimum time needed is 60 minutes.)*

Students are first introduced to various encryption methods, such as Caesar substitution, by encoding and decoding select messages. The students then play an indoor football-like game in which the offensive team creates a secret code to designate which player will receive the pass. The defense tries to break the code to intercept the ball.

## Elementary Cryptanalysis

*(Appropriate for grades 4-10; minimum time needed is 45 minutes.)*

This presentation defines the basic terminology used in code breaking. It then introduces a variety of elementary ciphers. Students are led through the deciphering of several messages using various substitution and transposition ciphers. The letter frequencies of letters in English are discussed. For more advanced classes, a message in English is deciphered by using frequency counts. Background material and additional problems are given as handouts.

## Exclamation Explanation!

*(Appropriate for grades 4-6; minimum time needed is 45 minutes.)*

What does it mean to be smart in mathematics? That's not a simple question because being smart in math can mean several, different things. Most of us, at one time or another, have needed to adjust our thinking from "I can't do this" to "Hmmm... now here's a problem I just haven't solved yet." The real trick is believing that math makes sense (or CAN make sense if you put your mind to it). This talk is designed to take your students through the process of developing (and understanding) a mathematical concept one step at a time, by recognizing patterns, extending their thinking, and just having some fun. The actual concept developed is factorial numbers, but that really doesn't matter – it's the journey not the destination that counts here. It is best if the students have never seen factorial numbers before.

## Experimenting With Chance

*(Appropriate for grades 4-8; minimum time needed is 45 minutes.)*

In this talk students are introduced to the concept of probability by exploring the scientific method. The ideas of testing hypotheses, collecting data by simulation, and empirical probability will be emphasized. As time permits, pairs of students will perform statistical experiments to test their hypotheses regarding the results of: (1) tossing a coin, (2) rolling a single die, or (3) rolling a pair of dice and taking the sum of the two faces. Other experiments can be substituted depending on the level of the class. Relevant worksheets and charts will be provided to all students. If time permits, students will draw the bar graphs or histograms that depict the probability distributions of the outcomes of these experiments.

## Fossils and Miocene Shark Teeth of Maryland

*(Appropriate for grades 2-5; minimum time needed is 60 minutes.)*

Do you want to find out how a fossil is formed, where you can find fossils, and how to identify various kinds of fossil shells, bones and teeth? In this talk students are given a hands-on opportunity to examine and identify Miocene-age fossils found in the Calvert Cliffs area of Maryland. Students will be introduced to the various types of fossil bones, shells and teeth that can be found in this area. After a discussion on how to identify fossils, each student (or group of students) will be given a bag of fossils to identify. All papers and materials will be provided.

## Fun With Geometry

*(Appropriate for grades 3-7; minimum time needed is 45 minutes.)*

Students learn, by participating at their desks, how to quickly construct triangles, squares, hexagons (or stars) and octagons using only a compass and a straight edge. If time permits, the exercise can be extended to dividing a circle into twelve parts and drawing chords inside it with colored pencils, thus creating a kaleidoscopic effect.

## Gold Bug

*(Appropriate for grades 3-8; minimum time needed is 60 minutes.)*

Edgar Allen Poe's "The Gold Bug" is a fascinating story of pirates and buried treasure. Poe tells about a slightly eccentric man who deciphers a secret message to find some of Captain Kidd's hidden treasure. The children will hear a summary of "The Gold Bug" story and will learn the problem-solving skills needed to break the code. By working together and with the instructor, the students solve this puzzle with a logical, step-by-step attack using simple statistics.

## Graph Theory Every Day

*(Appropriate for grades 3-5; minimum time needed is 45 minutes.)*

This talk introduces basic concepts of graph theory and optimization through examples that might include placing police officers on the grid of a neighborhood or finding the shortest path between two points. Emphasis will be placed on ways that we already use these concepts in everyday life.

## Likenesses and Differences

*(Appropriate for K-1 only; minimum time needed is 30 minutes.)*

A domino-like game is played using large cards. Cards may be placed next to one another only if the pictures differ in exactly  $N$  ways (size, shape, color). We begin with  $N=1$ .

## **M&M's Guessing Game**

*(Appropriate for grades 1-4; minimum time needed is 50 minutes.)*

In this talk students are introduced to the important concept of estimation by exploring the scientific method. Every student is given a fun-size bag of M&M's candies (data) from which they are asked to estimate: (1) the total number of candies in the bag; (2) the most commonly occurring color in the bag; (3) the numbers of each of the six colors occurring in the bag. After each student has made his/her "guesses," the real fun begins. Every student is asked to open his/her bag of M&M's to gather and analyze the data, then form conclusions. All necessary worksheets and candies will be provided to the students.

*\*Note: Plain M&M's candies carry a peanut warning. Please be aware of peanut allergies in your class before requesting this presentation. You may request that Skittles be used in place of M&M's.*

## **M-A-T-H...It's Not Just Another Four-Letter Word!**

*(Appropriate for grades 4-10; minimum time needed is 45 minutes.)*

This talk is aimed at lower-level math students and students who think that math is not fun. The students participate in activities involving television and solving a murder mystery. The focus is not on arithmetic but on problem solving and decision-making.

## **Mathematical Ways of Thinking**

*(Appropriate for grades 3-8; minimum time needed is 45 minutes.)*

Through a variety of puzzles and games, students are introduced to the idea that mathematics can be an enjoyable and rewarding experience. They will be asked to find and extend patterns in numbers. They will also be introduced to limitations of inductive reasoning through simple examples from number sequences. The beauty of deductive reasoning will be shown using a board game of pennies and paper clips, various number tricks and logical puzzles. This informal approach to inductive and deductive reasoning concludes with a brief discussion on how these ways of thinking are used by a mathematician to solve problems on the job.

## **Mathematics – Creativity, Not Computation**

*(Appropriate for grades 4-6; minimum time needed is 45 minutes.)*

What is mathematics really about? How do mathematicians spend their time? This talk conveys by example and anecdote several important facts about real mathematics. Facts conveyed are: that mathematics involves much more than numbers and arithmetic, that new mathematics is always being created by inventive mathematicians, and that mathematical problems in the real world do not come with a guarantee of single right answers (or even any answer at all!). A brief presentation of the famous four-color problem and Fermat's Last Theorem are given.

## Mission Possible

*(Appropriate for grades 4-6; minimum time needed is 45 minutes.)*

Your mission, should you choose to accept it, is to recover the secret code which holds the key to this briefcase. During this session your class will join “the Agency,” an elite group of cryptanalysts and problem solvers. They will be trained on two basic types of cryptography and the elementary statistical properties demonstrated by those systems. They will then be divided into teams which will each have a message to identify and solve. The success of “the Agency” depends upon all teams solving their messages and then working together on one final problem. This interactive session presents some basic cryptanalytic concepts and focuses on problem solving techniques with a lot of teamwork.

## New Planets

*(Appropriate for grades K-5; minimum time needed is 45 minutes.)*

Recently, planets have been confirmed in orbit around “suns” other than our own. After it is determined what the students actually know/don’t know, the presenter goes into such topics as how these planets actually were discovered.

## One Dollar Shirt

*(Appropriate for grades 2-3; minimum time needed is 45 minutes.)*

The lesson provides a general review of geometric shapes: point, line, rectangle, triangle, circle and oval. After describing these basic geometric shapes, a fun exercise is presented to show students how these shapes can be used in paper folding (Origami) using a dollar bill to create a small shirt. The students can bring in their own crisp one dollar bills, or we will supply play money.

## Pascal’s Triangle

*(Appropriate for grades 2-8; minimum time needed is 50 minutes.)*

Blaise Pascal was a renowned 17th Century French scientist and mathematician. One of his most important discoveries was a collection of integers arranged in a triangular fashion which can easily be computed using only simple addition. Today, we call this construction Pascal’s Triangle. During the class, the instructor will help students generate Pascal’s Triangle on their own and then investigate some of the marvelous mathematical properties of Pascal’s Triangle. Applications covered in class can vary according to the level and ability of the class and include: elementary probability, binary arithmetic, sequences and patterns.

## Patterns and Number Sequences

*(Appropriate for grades 4-8; minimum time needed is 45 minutes.)*

Students will be introduced to sequences of numbers by examining various geometric and arithmetic sequences, and then determining the continuation of the sequences. The students will also determine the “rule” for generating each sequence. Students will then look at the expected letter frequencies for samples of

English text. They will then find patterns in the frequency counts for the sample text. Finally, they will use the expected frequency patterns to decrypt a message that was encrypted with a slide code.

## Polls, Probability and You

*(Appropriate for grades 4-8; minimum time needed is 45 minutes.)*

In this talk students are introduced to the concept of probability through the vehicle of a statistical survey. Appealing to the natural curiosities that students have about themselves, the speaker will conduct a poll to determine prominent attributes and marked preferences of the class. Students are then given the opportunity to reveal their class profile by using worksheets to answer pertinent probability questions. Venn diagrams will be used to assist students in their assessment of both conditional and unconditional probabilities. At least two examples of Venn diagrams will be done with two sets of student characteristics, such as the set of all left-handed students and the set of all girls in the class. Depending on the level of the class, a Venn diagram with three sets will be constructed and analyzed. It illustrates the data from a student opinion poll, e.g., those students who like/dislike math, music or sports.

## Science Fair Projects – A Judge’s Perspective

*(Appropriate for grades 4-12; minimum time needed is 45 minutes.)*

Over the past years, many NSA volunteers have served as judges for Kindergarten through 12th grade science fairs throughout the Maryland/DC/Virginia area. This talk is based on a compilation of our observations and is intended for both the student and teacher alike. It covers the major steps in the scientific method (problem statement, hypothesis, materials, testing/procedure, analysis, conclusion), and focuses on experiment versus demonstration, repeated trials/stratified testing, presentation and the interview.

## Science of Voice

*(Appropriate for grades K-12; minimum time needed is 45 minutes.)*

Students will be introduced to the science of their own voices. The guest lecturer will record, modify, play and display the students’ own voices with the assistance of a laptop computer and a microphone. Students will be able to interact with the equipment and actually view how their own voices appear. The lecturer will solicit volunteer students and record a sample of his or her speech onto the laptop computer. This speech sample can then be modified to play out at different rates (slower, faster, different pitch), to echo, to play with the sound reversed, and other interesting modifications. A discussion of what the computer is doing and why one might be interested will be interwoven into the talk. Computer experience is not needed to appreciate and enjoy this talk.

## Space Travel

*(Appropriate for grades 1-5; minimum time needed is 35 minutes.)*

The students and instructor will prepare for a space flight. Preparations include determining how much food they'll need to bring along and how to dress for space. They'll learn why it is hard to work in a space suit, and it's not because the suits are heavy! They'll talk about what it is like to live in space – eating, sleeping, working, exercising and playing.

## Strega Nona

*(Appropriate for grades 1-4; minimum time needed is 45 minutes.)*

“Strega Nona,” a children’s book written by Tomie de Paola, tells the story of Strega Nona, or “grandmother witch,” and Big Anthony, her hired hand. When Big Anthony doesn’t pay attention and interferes with Strega Nona’s magic pasta pot, he learns a very big lesson. Three different mathematical activities are available to students for this presentation with the areas of emphasis being patterns, time and money.

## Taking Polls and Making Faces

*(Appropriate for grades K-early 1; minimum time needed is 30 minutes.)*

Students will answer age-appropriate questions based on their likes and will match their answers to geometric shapes. The students then draw the geometric shapes on paper plates to create faces, and compare faces to see how much they are alike and different from each other.

## Total Integer Workout

*(Appropriate for grades 3-4; minimum time needed is 45 minutes.)*

This presentation reinforces addition, subtraction, multiplication and division skills. It will also show their associative and commutative properties while encouraging independent, creative problem solving. Given a set of numbers between 1 and 9, the students will be asked to “build” another specified number between 1 and 9.

## Vignettes

*(Appropriate for grades K-5; minimum time needed is 50 minutes.)*

These presentations allow students to “experience” mathematics. Mathematical ideas are illustrated by having the students play roles within the class, acting out short literary sketches designed to be fun while demonstrating mathematical reasoning. The vignettes can be customized to fit the students’ level and abilities. Available stories are:

### K-1st Grade

- \* The Pee Little Thrigs (Counting, Reasoning)
- \* Three Little Girls Who Wanted to Be Just Alike (Similarity, Size)

### 2nd-5th Grade

- \* Sherlock Holmes and the Strange Case of the Mixed-Up Markers (Inductive/ Deductive Reasoning)
- \* Riddle of the Vanishing Leprechaun (Geometry, Number Theory)

### 3rd-5th Grade

- \* The Lady or the Tiger (Mathematical Logic)
- \* To Be or Knot to Be (Knot Theory)
- \* Pandora's Box (Connectedness, Parity)
- \* Barefoot in Boogieville (Arithmetic, Number Theory)
- \*The Devil's Disciple (Mathematical Reasoning, Mathematical Induction)

### 5th Grade

- \* The Prisoner's Dilemma (Game Theory)
- \* Indiana Jones and the Haunted Castle (Cryptography/Cryptanalysis)

## Winning Games: Luck or Logic?

*(Appropriate for grades 4-10; minimum time needed is 45 minutes.)*

This presentation introduces students to some of the basic concepts of game theory. By first discussing a simple game and then playing the game in pairs, some fundamentals of picking strategies are demonstrated. After each game is played, the group discusses the strategies available and which ones worked best.



## Section II: Talks for Middle School

### **Coding Theory in your Mailbox**

*(Appropriate for grades 6-12; minimum time needed is 45 minutes.)*

Do you ever wonder what those lines are for on the bottom of business reply mail postcards? This talk lets students answer this question in a hands-on manner, and, time permitting, shows other applications of “check digits” in the modern world. In more advanced classes, students can investigate questions such as, what types of errors will such checking catch? What percentage of errors will be caught?

### **Cryptoball**

*(Appropriate for grades 3-10; minimum time needed is 60 minutes.)*

Students are first introduced to various encryption methods, such as Caesar substitution, by encoding and decoding select messages. The students then play an indoor football-like game in which the offensive team creates a secret code to designate which player will receive the pass. The defense tries to break the code to intercept the ball.

### **Cryptology Past and Present**

*(Appropriate for grades 6-12; minimum time needed is 50 minutes.)*

This talk will cover the basics of cryptography. Basic terminology, historical information and current topics will be discussed and illustrated with slides, including:

- \* simple substitution – Caesar cipher, cipher disk  
(Italy 1470, Civil War, WWI), Vigenere square (1586);
- \* simple transposition;
- \* combination of substitution and transposition;
- \* the Enigma (WWII German cipher device);
- \* Data Encryption Standard;
- \* public key cryptography;
- \* bibliography handout.

### **Curve of the Earth**

*(Appropriate for grades 6-8; minimum time needed is 45 minutes.)*

Did you ever stand on a beach and wonder how far out you can see over the ocean? This talk discusses how to calculate this distance. Emphasizing basic problem setup skills, it presents some facts about the earth’s size and shape. Mathematics used: basic geometry, trigonometry and algebra, along with

some estimation and simplification techniques. One equation is presented (the Pythagorean theorem).

## Elementary Cryptanalysis

*(Appropriate for grades 4-10; minimum time needed is 45 minutes.)*

This presentation defines the basic terminology used in code breaking. It then introduces a variety of elementary ciphers. Students are led through the deciphering of several messages using various substitution and transposition ciphers. The letter frequencies of letters in English are discussed. For more advanced classes, a message in English is deciphered by using the frequency counts. Background material and additional problems are given as handouts.

## Ethical Use of Computers

*(Appropriate for grades 6-12; minimum time needed is 45 minutes.)*

Are the ethical issues surrounding computers really new? Are they unique? Or are the issues the same old ethical issues confronting society for centuries? The information presented will help students understand the ethical issues as related to computers. Terms will be introduced and cases will be presented to help the students understand the material. Topics that will be presented include: 1) Computers and Privacy; 2) Crime, Abuse, and Hacker ethics; 3) Responsibility; and 4) Social Implications and Consequences. The students will leave with simple guidelines on how to make an ethical decision and the Ten Commandments of Computer Ethics.

## Exclamation Explanation!

*(Appropriate for grades 4-6; minimum time needed is 45 minutes.)*

What does it mean to be smart in mathematics? That's not a simple question because being smart in math can mean several, different things. Most of us, at one time or another, have needed to adjust our thinking from "I can't do this" to "Hmmm... now here's a problem I just haven't solved yet." The real trick is believing that math makes sense (or CAN make sense if you put your mind to it). This talk is designed to take your students through the process of developing (and understanding) a mathematical concept one step at a time, by recognizing patterns, extending their thinking, and just having some fun. The actual concept developed is factorial numbers, but that really doesn't matter – it's the journey not the destination that counts here. It is best if the students have never seen factorial numbers before.

## Experimenting With Chance

*(Appropriate for grades 4-8; minimum time needed is 45 minutes.)*

In this talk students are introduced to the concept of probability by exploring the scientific method. The ideas of testing hypotheses, collecting data by simulation, and empirical probability will be emphasized. As time permits, pairs of students will perform statistical experiments to test their hypotheses regarding

the results of: (1) tossing a coin, (2) rolling a single die, or (3) rolling a pair of dice and taking the sum of the two faces. Other experiments can be substituted depending on the level of the class. Relevant worksheets and charts will be provided to all students. If time permits, students will draw the bar graphs or histograms that depict the probability distributions of the outcomes of these experiments.

## Fun with Algebra – Gauss Was Just the Beginning

*(Appropriate for grades 7-12; minimum time needed is 45 minutes.)*

Many students, by this time, have heard about Gauss' famous trick about "bending" the numbers from 1 to  $n$  in half to come up with an expression for the sum of the integers from 1 to  $n$ . How might we make use of this expression in coming up with expressions for the sums of the powers of integers? And what good are these anyway? Students should have some algebra experience.

## Fun With Geometry

*(Appropriate for grades 3-7; minimum time needed is 45 minutes.)*

Students will learn, by participating at their desks, how to quickly construct triangles, squares, hexagons (or stars), and octagons using only a compass and a straight edge. Then the exercise will be extended to dividing a circle into twelve parts and drawing chords inside it with colored pencils, thus creating a kaleidoscopic effect.

## Gold Bug

*(Appropriate for grades 3-8; minimum time needed is 60 minutes.)*

Edgar Allen Poe's "The Gold Bug" is a fascinating story of pirates and buried treasure. Poe tells about a slightly eccentric man who deciphers a secret message to find some of Captain Kidd's hidden treasure. The students will hear a summary of the story of "The Gold Bug" and will learn the problem-solving skills needed to break the code. By working together with the instructor, the students solve this puzzle with a logical, step-by-step attack using simple statistics.

## How Many Dinosaurs Are There?

*(Appropriate for grades 6-8; minimum time needed is 50 minutes.)*

In this talk, students are introduced to the basic notions of nonparametric statistics by learning how to statistically estimate the sizes of various populations, e.g., the number of fish in a lake, the number of deer in a forest, or the number of marbles in a jar. The "capture-recapture" method of estimation will be addressed. Through the use of manipulatives, students will become familiar with the process of capturing, tagging, and recapturing toy dinosaurs in order to estimate the total number of dinosaurs in a given "population." This process will be repeated in the class at least twice to obtain two distinct estimates of the dinosaur population. Other examples of this capture-recapture model and its assumptions may be

discussed if time allows.

## How To Lie With Statistics

*(Appropriate for grades 6-12; minimum time needed is 45 minutes.)*

The study of statistics is mathematically rigorous, but the statistics themselves can be used, often incorrectly, in non-mathematical ways. TV advertisers do not usually falsify statistics – they can be sued or fined for that. However, they still mislead us with statistics that are taken out of context, that are based on too small a sample size or on a biased sample, or that are based on biased questions or words with no generally agreed upon meaning. For example, Bayer Aspirin asked 100 doctors, if they were stranded on a desert island, would they rather have aspirin or Tylenol? More doctors chose aspirin. But why? Aspirin is also an anti-inflammatory drug, not just a pain reliever. Doctors know this and therefore choose the aspirin, but that does not mean it would be their drug of choice for a headache at work. The statistic might well be true, but the question on which it is based is misleading. Consumers must be aware of how to lie with statistics in order to avoid being taken in by others' lies, and this talk will illustrate how this is done.

## Logic

*(Appropriate for grades 6-12; minimum time needed is 45 minutes.)*

This talk presents an introduction to logic and mathematical reasoning. All students participate in solving logic puzzles and in identifying unstated yet mathematically true statements. Venn diagrams, syllogisms, and advertisements from current magazines are used to reinforce the principles discussed.

## M-A-T-H...It's Not Just Another Four-Letter Word!

*(Appropriate for grades 4-10; minimum time needed is 45 minutes.)*

This talk is aimed at lower-level math students and students who think that math is not fun. Students participate in activities involving television and solving a murder mystery. The focus is not on arithmetic, but on problem solving and decision-making.

## Mathematical Ways of Thinking

*(Appropriate for grades 3-8; minimum time needed is 45 minutes.)*

By being offered a variety of puzzles and games, students are introduced to the idea that mathematics can be an enjoyable and rewarding experience. They will be asked to find and extend patterns in numbers. The limitations of inductive reasoning will be introduced using simple examples from number theory. The beauty of deductive reasoning will be shown using a board game of pennies and paper clips, various number tricks and logical puzzles. This informal approach to inductive and deductive reasoning concludes with a brief discussion on how these ways of thinking are used by a mathematician to solve problems on the job.

## Mathematics – Creativity, Not Computation

*(Appropriate for grades 4-6; minimum time needed is 45 minutes.)*

What is mathematics really about? How do mathematicians spend their time? This talk conveys by example and anecdote several important facts about real mathematics. Facts conveyed are: that mathematics involves much more than numbers and arithmetic, that new mathematics is always being created by inventive mathematicians, and that mathematical problems in the real world do not come with a guarantee of a single right answer (or even any answer at all!). A brief presentation of the famous four-color problem and Fermat's Last Theorem are given.

## Mission Possible

*(Appropriate for grades 4-6; minimum time needed is 45 minutes.)*

Your mission, should you choose to accept it, is to recover the secret code which holds the key to this briefcase. During this session your class will join "the Agency," an elite group of cryptanalysts and problem solvers. They will be trained on two basic types of cryptography and the elementary statistical properties demonstrated by those systems. They will then be divided into teams which will each have a message to identify and solve. The success of "the Agency" depends upon all teams solving their messages and then working together on one final problem. This interactive session presents some basic cryptanalytic concepts and focuses on problem solving techniques with a lot of teamwork.

## Pascal's Triangle

*(Appropriate for grades 2-8; minimum time needed is 45 minutes.)*

Blaise Pascal was a renowned 17th century French scientist and mathematician. One of his most important discoveries was a collection of integers arranged in a triangular fashion which can easily be computed using only simple addition. Today, we call this construction Pascal's Triangle. During class, the instructor will help students generate Pascal's Triangle on their own and then investigate some of the marvelous mathematical properties of Pascal's Triangle. Applications covered in class can vary according to the level and ability of the class and include: polynomials, probability and statistics, the binomial theorem, counting methods, binary arithmetic, sequences, patterns and combinations.

## Patterns and Number Sequences

*(Appropriate for grades 4-8; minimum time needed is 45 minutes.)*

Students will be introduced to sequences of numbers by examining various geometric and arithmetic sequences, then determining the continuation of the sequences. The students will also determine the "rule" for generating each sequence. Students will look at the expected letter frequencies for samples of English text. They will then find patterns in frequency counts for the sample text.

Finally, looking at the expected frequency patterns and using a slide code, they will decrypt an encrypted message.

## Polls, Probability and You

*(Appropriate for grades 4-8; minimum time needed is 45 minutes.)*

In this talk students are introduced to the concept of probability through the vehicle of a statistical survey. Appealing to the natural curiosities that students have about themselves, the speaker will conduct a poll to determine prominent attributes and marked preferences of the class. Students are then given the opportunity to reveal their class profile by using worksheets to answer pertinent probability questions. Venn diagrams will be used to assist students in their assessment of both conditional and unconditional probabilities. At least two examples of Venn diagrams will be done with two sets of student characteristics, such as the set of all left-handed students and the set of all girls in the class. A Venn diagram with three sets will be constructed and analyzed. It illustrates the data from a student opinion poll, e.g., those students who like/dislike math, music or sports.

## Power of Reason

*(Appropriate for grades 6-9; minimum time needed is 50 minutes.)*

This presentation makes the point that analytical thinking and planning are critical to success and achievement of goals. This is done by having the students play the game of Skunk and discussing various game strategies. Skunk is a game of chance. It is a game that is easy for the students to understand and they invariably enjoy playing it, thus they are involved in the activity. The students must make choices based on their goal and their understanding of the chances of different game results occurring – just like when making basic life decisions. The students will understand that the strategy can be different if the goal is different.

## Prime Numbers

*(Appropriate for grades 6-8; minimum time needed is 45 minutes.)*

This talk defines what a prime number is and then discusses why primes are interesting mathematically. Topics to be covered include large primes, the infinitude of primes, twin primes, the Fundamental Theorem of Arithmetic, the Sieve of Eratosthenes, and the Goldbach Conjecture. This is an interactive talk at a level where students can participate by answering some simple questions. There is also a brief discussion of how primes can be used to encrypt a message after which students are given a sample of cipher which they can decrypt themselves by using a prime factorization.

## Science Fair Projects – A Judge’s Perspective

*(Appropriate for grades 4-12; minimum time needed is 45 minutes.)*

Over the past years, many NSA volunteers have served as judges for

Kindergarten through 12th grade science fairs throughout the Maryland/DC/Virginia area. This talk is based on a compilation of our observations and is intended for both the student and teacher alike. It covers the major steps in the scientific method (problem statement, hypothesis, materials, testing/procedure, analysis, conclusion), and focuses on experiment versus demonstration, repeated trials/stratified testing, presentation and the interview.

## Science of Voice

*(Appropriate for grades K-12; minimum time needed is 45 minutes.)*

Students will be introduced to the science of their own voices. The guest lecturer will record, modify, play and display the students' own voices with the assistance of a laptop computer and a microphone. Students will be able to interact with the equipment and actually view how their own voices appear. The lecturer will solicit volunteer students and record a sample of his or her speech onto the laptop computer. This speech sample can then be modified to play out at different rates (slower, faster, different pitch), to echo, to play with the sound reversed, and other interesting modifications. A discussion of what the computer is doing and why one might be interested will be interwoven into the talk. Computer experience is not needed to appreciate and enjoy this talk.

## Tessellations

*(Appropriate for grades 6-8; minimum time is 45 minutes.)*

From architecture to textiles, tessellations are all around us. In this fun geometry talk, students discover how repeating patterns have been used around the world throughout history. There's plenty of room for creativity as students learn the basic features of pattern design and create their own tessellations.

## Turbo Codes

*(Appropriate for grades 8-12; minimum time is 45 minutes.)*

Turbo codes are being seen more and more in state-of-the-art communications. What are these codes and why are they so important? This talk will present the history of turbo codes and will introduce students to Hamming codes and to the Hamming code within the turbo code. This talk would be appropriate for any math class above algebra II. The amount of math presented can be adjusted according to the level of the students.

## Vignettes

*(Appropriate for grades 6-8; minimum time needed is 50 minutes.)*

These presentations allow students to "experience" mathematics. Mathematical ideas are illustrated by having the students play roles within the class, acting out short literary sketches designed to be fun while demonstrating mathematical reasoning. The vignettes can be customized to fit the students' level and abilities. Available stories are:

- \* Sherlock Holmes and the Strange Case of the Mixed-Up Markers (Inductive/ Deductive Reasoning)
- \* Riddle of the Vanishing Leprechaun (Geometry, Number Theory)
- \* The Lady or the Tiger (Mathematical Logic)
- \* To Be or Knot to Be (Knot Theory)
- \* Pandora's Box (Connectedness, Parity)
- \* Barefoot in Boogieville (Arithmetic, Number Theory)
- \* The Devil's Disciple  
(Mathematical Reasoning, Mathematical Induction)
- \* The Prisoner's Dilemma (Game Theory)
- \* Indiana Jones and the Haunted Castle (Cryptography/Cryptanalysis)

## Why Math?

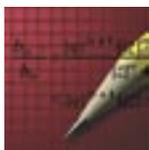
*(Appropriate for grades 6-8; minimum time needed is 30 minutes.)*

The practicality of math in real-life situations is illustrated by the functional math test that every student must pass in order to graduate. Many careers, however, require more math than people realize and more than would be listed in a job description. This talk will give students some insight into the usefulness and necessity of math competence in their future.

## Winning Games: Luck or Logic?

*(Appropriate for grades 4-10; minimum time needed is 45 minutes.)*

This presentation introduces students to some of the basic concepts of game theory. By first discussing a simple game and then playing the game in pairs, some fundamentals of picking strategies are demonstrated. After each game is played, the group discusses the strategies available and which ones worked best. Some of the concepts touched on in the discussions will include probability, matrices, and trees. If additional time is available, another game can be added which will introduce more probability, matrices, and trees and can also illustrate a use for solving simultaneous equations. Simple matrix game exercises are also available for discussion.



## Section III: Talks for High School

### **Boolean Algebra and Digital Circuits**

*(Appropriate for grades 9-12; minimum time needed is 50 minutes.)*

All functions of a digital computer can be modeled mathematically via Boolean algebra. This talk will describe the most commonly used binary/Boolean algebra functions and their truth tables, and show how parts of a digital computer can be represented by these functions. The computer functions/topics covered include (as time permits) half adders, full adders, carry ripple adders, subtractors, multipliers, and dividers – the essence of the arithmetic logic unit (ALU).

### **Coding Theory in Your Mailbox**

*(Appropriate for grades 6-12; minimum time needed is 45 minutes.)*

Do you ever wonder what those lines are for on the bottom of business reply mail postcards? This talk lets students answer this question in a hands-on manner and, time permitting, shows other applications of “check digits” in the modern world. Students can investigate questions such as, what types of errors will such checking catch? What percentage of errors will be caught?

### **Cryptoball**

*(Appropriate for grades 3-10; minimum time needed is 60 minutes.)*

Students are first introduced to various encryption methods, such as Caesar substitution, by encoding and decoding select messages. The students then play an indoor football-like game in which the offensive team creates a secret code to designate which player will receive the pass. The defense tries to break the code to intercept the ball.

### **Cryptography and Cryptanalysis**

*(Appropriate for grades 9-12; minimum time needed is 60 minutes.)*

Cryptography and Cryptanalysis will introduce the students to the art of making and breaking codes/ciphers. For the cryptography portion of the talk, symmetric vs. asymmetric (traditional vs. public key) cryptography, keys and basic security services (confidentiality, integrity, authentication, nonrepudiation, availability) will be discussed. Applications and use of cryptography for the government and private sector will also be discussed. Students will have an opportunity to decipher a symmetric message and also participate in a game to demonstrate one of the security services. For the cryptanalysis portion of the talk, codes vs. ciphers will be discussed; examples of public codes (UPC, Morse, sign language) will be shown. The students will be introduced to transposition and substitution encipherment/decipherment through brief examples and will have an opportunity to decipher a cryptogram.

## Cryptology Past and Present

*(Appropriate for grades 6-12; minimum time needed is 50 minutes.)*

This talk will cover the basics of cryptography. Basic terminology, historical information and current topics will be discussed and illustrated with slides, including:

- \* simple substitution – Caesar cipher, cipher disk (Italy 1470, Civil War, WWI), Vigenere square (1586);
- \* simple transposition;
- \* combination of substitution and transposition;
- \* the Enigma (WWII German cipher device);
- \* Data Encryption Standard;
- \* public key cryptography;
- \* bibliography handout.

## Does the Better Team Win the World Series?

*(Appropriate for grades 9-12; minimum time needed is 45 minutes.)*

Many people have “pet” explanations for the outcomes of sporting events, particularly the World Series. The “better team” theory, home advantage, momentum, and the “back-to-the-wall” theories are among the most common. Using actual results since 1924 (when the modern best-of-seven, 2-3-2 format began), this talk helps students develop statistical models for these theories, and compares the results of these theories to what has actually happened and how well they predict the expected length of the Series. A modest familiarity with elementary probability would be helpful (but not essential); there is some polynomial manipulation in the talk; using calculators to do some of the arithmetic involved is encouraged.

## Elementary Cryptanalysis

*(Appropriate for grades 4-10; minimum time needed is 45 minutes.)*

This presentation defines the basic terminology used in code breaking. It then introduces a variety of elementary ciphers. Students are led through the deciphering of several messages using various substitution and transposition ciphers. The letter frequencies of letters in English are discussed. A message in English is deciphered by using frequency counts. Background material and additional problems are given as handouts.

## Ethical Use of Computers

*(Appropriate for grades 6-12; minimum time needed is 45 minutes.)*

Are the ethical issues surrounding computers really new? Are they unique? Or are they the same old ethical issues confronting society for centuries? The

information presented will help students understand the ethical issues as related to computers. Terms will be introduced and cases will be presented to help the students understand the material. Topics that will be presented include: 1) Computers and Privacy; 2) Crime, Abuse, and Hacker ethics; 3) Responsibility; and 4) Social Implications and Consequences. The students will leave with simple guidelines on how to make an ethical decision and the Ten Commandments of Computer Ethics.

## Fourier Series – Making Waves

*(Appropriate for grades 11-12; minimum time needed is 45 minutes.)*

This talk will show how to use the orthogonality relations for the trigonometric functions  $\sin(nx)$  and  $\cos(nx)$  to represent a periodic function which is integrable on  $[-\pi, \pi]$  as an infinite series of such functions. This technique allows one to decompose non-sinusoidal waveforms into a series of sinusoids, and to synthesize approximations to non-sinusoidal waveforms using sinusoids. The talk will compute Fourier series for square waves and sawtooth waves, and students will be able to compute and plot sinusoidal approximations to these waves on their graphing calculators. (Prerequisites: computation of definite integrals; integration by parts.)

## Fun with Algebra – Gauss Was Just the Beginning

*(Appropriate for grades 7-12; minimum time needed is 45 minutes.)*

Many students, by this time, have heard about Gauss' famous trick about "bending" the numbers from 1 to  $n$  in half to come up with an expression for the sum of the integers from 1 to  $n$ . How might we make use of this expression in coming up with expressions for the sums of the powers of integers? And what good are these anyway?

## Geometrical Paradoxes

*(Appropriate for grades 9-12; minimum time needed is 45 minutes.)*

Mathematician George Polya said, "Geometry is the art of correct reasoning on incorrect figures." This talk presents and proves a few funny "theorems" of geometry, such as "right angles are sometimes obtuse" (a favorite of Lewis Carroll) and "all triangles are isosceles." The proofs are, of course, wrong, but it is a challenge to find out exactly why. In all cases, the problem resides in making assumptions from the drawing that goes with the proof. The lesson learned is an important one for mathematicians. The class should be familiar with geometric proofs, e.g., proving that two triangles are similar.

## Geometry of the Nth Dimension

*(Appropriate for grades 9-12; minimum time needed is 45 minutes.)*

What does a hypercube look like? Are there any regular solids in higher dimensions? This talk provides a fascinating look at the 4th and higher dimensions. Students will learn how to visually construct 4th-dimensional objects, how a higher dimensional object behaves and how Euler's formula generalizes. This talk is especially interesting to students experimenting with three-dimensional geometry.

## How To Lie With Statistics

*(Appropriate for grades 6-12; minimum time needed is 45 minutes.)*

The study of statistics is mathematically rigorous, but the statistics themselves can be used, often incorrectly, in non-mathematical ways. TV advertisers do not usually falsify statistics – they can be sued or fined for that. However, they still mislead us with statistics that are taken out of context, that are based on too small a sample size or on a biased sample, or that are based on biased questions or words with no generally agreed upon meaning. For example, Bayer Aspirin asked 100 doctors, if they were stranded on a desert island, would they rather have aspirin or Tylenol? More doctors chose aspirin. But why? Aspirin is also an anti-inflammatory drug, not just a pain reliever. Doctors know this and therefore choose the aspirin, but that does not mean it would be their drug of choice for a headache at work. The statistic might well be true, but the question on which it is based is misleading. Consumers must be aware of how to lie with statistics in order to avoid being taken in by others' lies, and this talk will illustrate how this is done.

## Irrational and Transcendental Numbers

*(Appropriate for grades 11-12; minimum time needed is 45 minutes.)*

Students have long been told that pi and e are irrational numbers, and with calculus, it is actually possible to prove these statements. This talk will give the easy proof that e (defined by its Maclaurin series evaluated at  $x=1$ ) is irrational, and the much harder proof that pi is irrational. In addition, a similar technique will be used to prove that e is actually transcendental. (Prerequisites: knowledge of derivatives and definite integrals.)

## Königsberg Bridges Problem

*(Appropriate for grades 9-12; minimum time needed is 45 minutes.)*

On Sunday afternoons, the nobility in Königsberg, Germany often visited the park to stroll. One of them noticed that whenever he crossed each of the bridges once, he always finished at a place that was different from his starting point. So he posed the question: "Is it possible to cross each bridge exactly once and end up where you started?" This problem remained unanswered for many years

and was finally solved by Euler. Emphasizing class participation, the speaker will use logic and some very simple graph theory to derive the solution to this problem. This will introduce the logical thinking behind many mathematical proofs and give the students some insight into how to solve other problems they may encounter. In identifying the general solution and demonstrating it to be correct, we will also apply this solution to the Königsberg bridges to show that it is impossible to cross all of the Königsberg bridges exactly once. This general solution and its application emphasizes the concept that not all problems can be solved, and that it is often important to know when you are dealing with such a problem.

### Let's Solve Some Cipher!

*(Appropriate for grades 9-12; minimum time needed is 45 minutes.)*

This talk will guide the class through a step-by-step diagnosis and solution of an unknown (and challenging) cryptogram. The speaker will make use of several statistical tests and mathematical techniques as well as logical thinking and intuition to arrive at a solution. Student participation is encouraged.

### Logic

*(Appropriate for grades 6-12; minimum time needed is 45 minutes.)*

This talk presents an introduction to logic and mathematical reasoning. All students participate in solving logic puzzles and in identifying unstated yet mathematically true statements. Venn diagrams, syllogisms, and advertisements from current magazines are used to reinforce the principles discussed.

### M-A-T-H...It's Not Just Another Four-Letter Word!

*(Appropriate for grades 4-10; minimum time needed is 30 minutes.)*

This talk is aimed at lower-level math students and students who think that math is not fun. The students participate in activities involving television and solving a murder mystery. The focus is not on arithmetic, but on problem solving and decision-making.

### Nowhere Differentiable Function

*(Appropriate for grades 11-12; minimum time needed is 45 minutes.)*

For many students, calculus is just a collection of formulas to be mechanically applied to compute derivatives and integrals. This talk will examine some of the more subtle aspects of continuity and differentiability, and look at examples of functions which are nowhere continuous, continuous at only the irrational numbers, and continuous everywhere but differentiable nowhere. (Prerequisites: definitions of continuity, differentiability, and convergence of an infinite series.)

## Power of Reason

*(Appropriate for grades 6-9; minimum time needed is 50 minutes.)*

This presentation makes the point that analytical thinking and planning are critical to success and achievement of goals. This is done by having the students play the game of Skunk and discussing various game strategies. Skunk is a game of chance. It is a game that is easy for the students to understand and they invariably enjoy playing it, thus they are involved in the activity. The students must make choices based on their goal and their understanding of the chances of different game results occurring – just like when making basic life decisions. The students will understand that the strategy can be different if the goal is different.

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## Symbolic Logic

*(Appropriate for grades 9-12; minimum time needed is 45 minutes.)*

This talk presents an introduction to logic and mathematical reasoning. Students will learn how to state and prove theorems using symbolic logic. The students will learn about implication, assumptions, conclusions, proof by contradiction, proof by cases, proof by induction, and of course plain old direct derivation.

## Taxicab Trigonometry

*(Appropriate for grades 9-12; minimum time needed is 45 minutes.)*

This talk describes the changes necessary to define the standard trigonometric functions, sine and cosine, using the taxicab distance function – the function which measures distance as would a taxicab driving through a town with only north-south and east-west streets. This new distance function allows us to redefine the unit circle and, therefore, the trigonometric functions. We describe how to obtain the new trigonometric functions in terms of the old, and explore the reworking of familiar trig identities. Students should be taking or have completed trigonometry.

## Turbo Codes

*(Appropriate for grades 8-12; minimum time needed is 45 minutes.)*

Turbo codes are being seen more and more in state-of-the-art communications. What are these codes and why are they so important? This talk will present the history of turbo codes and will introduce students to Hamming codes and to the Hamming code within the turbo code. This talk would be appropriate for any math class above algebra II. The amount of math presented can be adjusted according to the level of the students.

## Vectors and Matrices in Error-Correcting Codes

*(Appropriate for grades 11-12; minimum time needed is 45 minutes.)*

When bits of information are sent via communication links, the receiver needs to be able to detect and correct errors that occurred during transmission. Coding theory is the area of mathematics that deals with this problem. This talk will teach students about Hamming codes, their applications, and their error detection and correction capabilities. It is helpful if the students have a basic understanding of vectors and matrices.

## What Is the Square Root of -1?

*(Appropriate for grades 9-12; minimum time needed is 45 minutes.)*

Is  $i$  a “real” number? Many students find the concept of imaginary and complex numbers difficult to grasp. This talk goes over the evolution of the concept of “number,” starting with the counting numbers and building to fractions, reals, negatives and finally complex numbers. If time permits, the speaker may address even further extensions of the complex numbers. Along the way, the speaker will discuss why the various extensions may seem unnatural, and how they increase the range of problems people can solve.

## Winning Games: Luck or Logic?

*(Appropriate for grades 4-10; minimum time needed is 45 minutes.)*

This presentation introduces students to some of the basic concepts of game theory. By first discussing a simple game and then playing the game in pairs, we demonstrate some fundamentals of picking strategies. After each game is played, the group discusses the strategies available and which ones worked best. Some of the concepts touched on in the discussions will include probability, matrices, and trees. If additional time is available, another game can be added which will introduce more probability, matrices, and trees and can also illustrate a use for solving simultaneous equations. Simple matrix game exercises are also available for discussion.

## Wythoff's Nim – Fun with Number Theory

*(Appropriate for grades 9-12; minimum time needed is 60 minutes.)*

The winning strategy for Wythoff's Nim, a variation of the well-known two-player game Nim, is shown to be based on the properties of the golden ratio and Fibonacci sequences.

## **Section IV: In-Service Talks**

This section of the catalog contains talks specifically for classroom teachers. NSA mathematicians will try to be as flexible as possible, speaking to a gathering of teachers on an in-service day or after school. The talks in this section are designed to meet the needs of the classroom teacher and may involve more time or days than the typical Speakers Bureau talks. Please see included talks for specific details.

### **Alternatives to the Lecture Method**

This interactive presentation is designed for a group of up to 30 teachers. Its goal is to explore alternatives to the traditional lecture method in teaching mathematics. Topics to be covered can include learning in small groups, tools for teaching, how math rules can be learned other than by rote, bringing practical problems into the classroom to get students interested, and making a plan to incorporate some of these changes. This talk can be modified to fit the needs of elementary, middle, and high school teachers.

### **Speak For Yourself**

Your favorite talks from this catalog are available for you to learn to give by yourself. Give us a prioritized list of up to five talks from the catalog, and we will do our best to

## Section V: Other Resources

### Visit the MEPP Web Site!

Are you looking for some fresh ideas on lesson plans? Visit the MEPP web site at <http://www.nsa.gov/mepp/index.htm> for the collection of learning units which were developed during our summer teacher institutes. While you're there, check out the other programs MEPP offers for enriching math and science education.

### Visit the NSA.gov Kids' Page for Cryptologic Fun!

This excellent online resource introduces students to the world of Cryptology in a fun, interactive and educational way. Students can become familiar with codes and ciphers by mastering games, encrypting and decrypting messages, solving puzzles and learning how to apply math and logic to solve problems.

Other added features of the site include coloring pages for younger students, information about the National Security Agency/Central Security Service (NSA/CSS), a historical timeline highlighting cryptologic achievements at NSA, and information about visiting the National Cryptologic Museum.

For a new and exciting way to learn about Cryptology, students and teachers can visit the NSA/CSS's newly designed Kids' Page at <http://www.nsa.gov/kids/intro.htm>.



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