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Grade 9-12 STEM Challenge

Can you hack it?

Inspired by Barry, an Information Assurance Analyst in the Indiana Uplands.

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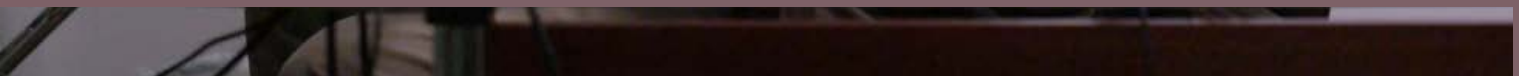
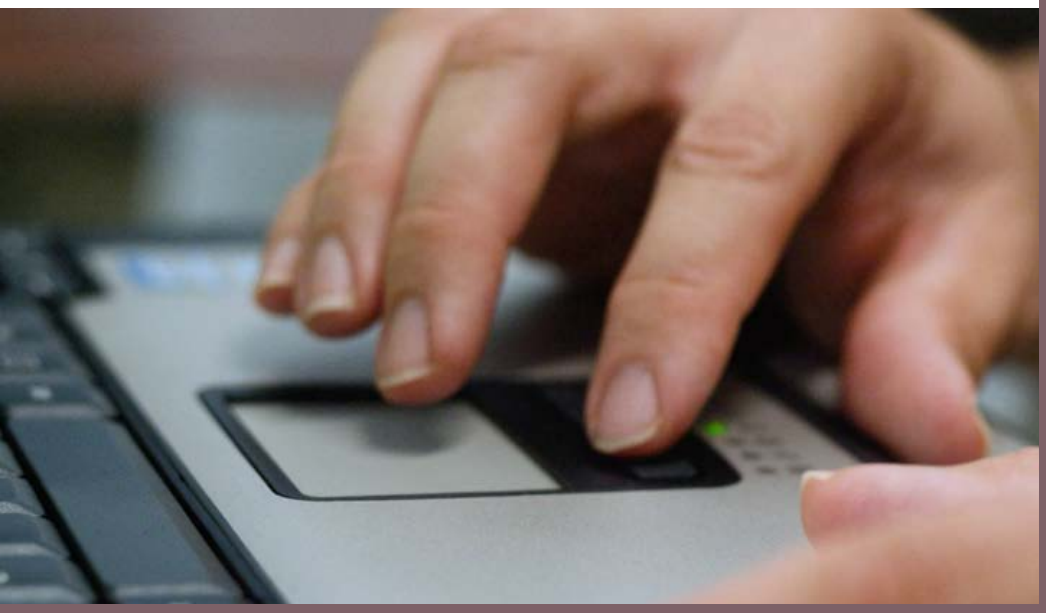


GRADE 9-12 STEM CHALLENGE

Can You Hack It?

Inspired by Barry, an Information Assurance Analyst in the Indiana Uplands.

Students will make (and break) their own secret codes.



LESSON TIMELINE

DAY 1

- Show the job shadow video, "Barry - Information Assurance Analyst" (5 minutes)
- Introduce the challenge and connect the "Hack the Code" game to how hackers work to break passwords. (10 minutes)
- Student game and worksheet (25 minutes)
- Discussion and reflection (10 minutes)

Recommended Supplies

For the class:

- Pen or pencil
- Hack the Code sheets (printed)
- Code Sheets (printed, one per student)
- Optional: computer and projector to show web-based option

CAREER CONNECTION AND LESSON OVERVIEW

Barry is an information assurance analyst for TriStar Engineering, a defense contractor in southern Indiana. Information security and cybersecurity professionals like Barry work to protect many different kinds of data, including banking information, health records, and people's personal information. This requires an in-depth knowledge of not only computer systems and programming but also encryption strategies. Many cybersecurity experts also try to hack their way into systems (with permission!) to find their vulnerabilities and fix weaknesses. They also help train ordinary people on best information security practices such as identifying suspicious links in emails as well as creating strong passwords and PINs and keeping computer credentials private.

In this activity, a modification of the game Mastermind will be used to teach students how simple passwords can be cracked. Personal identification numbers (PINs) are used to secure access to a variety of private information. But how secure are they? Students will practice cracking four-digit PINs through both brute-force approaches and by leveraging what they know about their classmates.

IN THIS CHALLENGE, STUDENTS WILL:

- Develop simple algorithms to determine the correct order of numbers in four-digit password in the fewest number of steps.
- Learn about the role that algorithms and combinatorics play in computing and cybersecurity.

Standards

Science & Engineering Process Standards

SEPS.1 Posing Questions (for science) and defining problems (for engineering)
SEPS.2 Developing and using models and tools
SEPS.4 Analyzing and interpreting data
SEPS.6 Constructing explanations (for science) and designing solutions (for engineering)
SEPS.8 Obtaining, evaluating, and communicating information

Preparing for College and Careers

PCC-2.1 Determine roles, functions, education, and training requirements of various career options within one or more career clusters and pathways
PCC-2.2 Analyze career trends, options and opportunities for employment and entrepreneurial endeavors for selected career clusters and pathways
PCC-2.3 Evaluate selected careers and pathways for education requirements, working conditions, benefits, and opportunities for growth and change

Computer Science

ICS-2.5 Formulate algorithms using programming structures to decompose a complex problem.
ICS-6.3 Evaluate the social and emotional implications of privacy in the context of safety, law, and ethics.
CSI-3.1 Develop algorithms to determine a solution.
CSI-3.2 Assess the use of algorithms to provide a solution.
CSI-3.5 Explain how the algorithm can be used to solve a problem.
CSII-3.10 Integrate classic algorithms (sorting and searching) to solve computational problems.

Grade 9-10 Employability Skills

9-10.M.1 Seek and participate in challenging learning activities related to career goals.
9-10.M.2 Able to view feedback as data' that helps the learning process.
9-10.LS.7 Predict outcomes to problems based on data and evidence.
9-10.LS.10 Able to approach problems with reasoning and logic to hypothesize results.
9-10.LS.11 Able to combine concepts in different ways to create new ideas and innovative solutions.

Planning and Implementation

CAN YOU HACK IT?

Essential Vocabulary

- ALGORITHM: A process or set of rules to be followed to solve a problem or calculation. It is a set of guidelines that describe how to perform a task.
- ENCRYPTION: The process of converting information or data into a code to prevent unauthorized access.
- TROUBLESHOOTING: A systematic approach to problem solving that is used to find and correct errors or problems in processes, machines, robots, or computer software.
- BRUTE-FORCE ATTACK: A hacking strategy where the attacker submits many passwords as fast as possible in the hope of guessing correctly.

In this challenge, students will:

- Develop simple algorithms to determine the correct order of numbers in four-digit password in the fewest number of steps.
- Learn about the role that algorithms and combinatorics play in computing and cybersecurity.

Before Class:

- Read the activity outline sheet and leader notes to become familiar with the activity.
- Gather necessary materials. Be sure that you have enough copies of the Hack the Code instructions and play sheets for students to work in groups of 2. Groups of 3 can also work if you have an odd number of students. Each pair will take turns creating a four-digit password for their partner to crack.

Guiding Questions

1. What does it mean for data to be “secure?”
2. How do we keep sensitive data both accessible to the people who need it and safe from people who shouldn’t have access?
3. What types of attacks might an information assurance or cybersecurity expert protect data from?

Introduction

Can You Hack It?

"Treat your password like your toothbrush: Don't let anybody else use it, and get a new one every six months."

- Clifford Stoll

Show students Barry's career shadow video and discuss what cybersecurity professionals do. Barry is an information assurance analyst—his job is to make sure that the data he works with is readily accessible for the people who need to use it but is also protected from those who don't have permission to see it. Here, students will be playing a modified version of the game Mastermind. In Mastermind, a player creates a password or code out of colored marbles. In our version, students will create a personal identification number, similar to the PINs used to secure things like bank cards. Their partner will then try to crack this code.

Unlike a real numerical password, students will only be able to create their PIN out of the digits 1 through 6. Repeats are allowed and order matters! Some students will have played the game Mastermind at home (or on a computer) and will already have strategies (algorithms!) to crack the codes faster.

The Rules of the Game

Each student will play one of two roles in each round:

- The ANALYST will come up with a four-digit code comprised of numbers between 1 and 6. The codes may use a number more than once but the order of the numbers matters. 1234, 4554, 6541, 4222, etc are all valid codes.
- The HACKER will attempt to break this code by suggesting possible solutions. After each submitted solution, the Analyst will provide feedback on whether or not the Hacker is correct.

For example: If the Analyst's PIN is 2344 and the Hacker guesses 2143 the feedback would be "2-1": two correct digits in the correct place (2143) and one correct digit in the wrong place (2143). The Hacker has 10 attempts to break the PIN. If the response is 4-0, all numbers are correct and in the correct location) the Hacker wins. If it takes more than 10 guesses to break the PIN, the Hacker loses.

Extension

Computer scientists have written programs to solve puzzles like this and there is already a basic algorithm for solving Mastermind. The codebreaker at http://csunplugged.mines.edu/codebreaker/game.cgi is an example of a simple program written to break a user's chosen code. Here, students can select a code (in this case, like the physical Mastermind game, the code is colors instead of numbers) and the artificial intelligence algorithm will try to guess the solution.

Humans also use algorithms to break these codes but the strategy is a little different—nobody is going to write down 1296 possible combinations and start crossing things off! What humans do to crack the PIN is more like troubleshooting. The key to efficient troubleshooting is to change one thing at a time to determine what is wrong with programs or equipment.

Students may also engage in "social hacking," that is, using information they gather to help unlock a system. Four-digit PINs are notorious for being easily hacked because many people set them to important dates. Your birthday, anniversaries, and other important dates are often readily available through a simple search. As students work through several rounds of the game, encourage them to think about what does (and does not) make a strong PIN or password.

Discuss and Report

After all students have had an opportunity to play as both HACKER and ANALYST, guide them back to a discussion of the activity and how it relates to cybersecurity and computer science.

1. When you played the Analyst what kinds of PIN codes did you pick? Were some codes harder to guess than others? Mathematically all PIN combinations should be equally hard to guess but some combinations tend to be harder for people and computers to break than others.
2. When you played the Hacker, did knowing more information about your partner make it easier to crack their PIN? What might be a bad choice for a PIN? Knowing things like the Analyst's birth date, important dates, etc might make it easier for the Hacker to guess the PIN.
3. How many possible codes are there? There are 4 digits in the code and 6 possibilities for each one. 6 X 6 X 6 X6 = 1296.

Discuss and Report - Continued

4. What strategies (algorithms!) did you come up with to help you break the Analyst's PIN faster? Answers here will vary. Some people choose to guess the same number in all spots to eliminate choices or know if there are duplicates. Others pick two numbers at a time (1122 or 2233, etc). Ask students to think through and discuss why they built the algorithms they did and examine whether or not they make sense.
5. Say your school decided everyone's grades would be protected by a 4 digit password.
    a. How secure would that be? What does it mean to be "secure"?
    b. How easy would it be able for someone else to crack your password?
    c. How easy would it be for a computer to crack the password?
    d. What do you think companies do to guard against brute-force attacks on people's PINs and passwords?

Career Exploration and Extension

Prompt students to think about and research what a career as an Information Assurance Analyst might entail.

- What does an information assurance analyst do all day? What does Barry do?
- What kind of training would a student need to become an information assurance analyst? What about a cybersecurity expert in general? What other jobs are like this?
- Are jobs like Barry's in demand? Will more people be hired for cybersecurity and information assurance jobs in the future?
- What kind of education is needed for these types of jobs? Where could a student be trained locally for a career in information assurance or cybersecurity?

Name: _____

CAN YOU HACK IT?

Student Instruction Sheet

Today you and your partner will play the roles of Hacker and Analyst. Analysts will be responsible for devising a 4 digit personal identification number (PIN). Hackers will then try to crack this secret code! Each of you will take turns being the Hacker and Analyst.

You are developing or breaking a secret code that contains four digits. Each of the four digits can be the numbers 1, 2, 3, 4, 5, and 6. Numbers may be repeated.

The **ANALYST** will make up a PIN and write it on the code slip, without showing their partner. Make it harder to guess by avoiding things like important dates!

The **HACKER** will write each guess, one at a time, on the worksheet and hand it to the Analyst. The Analyst will fill out the Feedback column corresponding to the guess. Here, the Analyst will write down two numbers:

1. The first number will be how many digits are both CORRECT and in the RIGHT LOCATION.
2. The second number will be how many digits are CORRECT but in the WRONG LOCATION.

For example: If the Analyst picked 1234 and the Hacker guessed 4322 the Analyst would write 0-3 in the feedback column since zero numbers are in the correct location but the guess DOES include 3 correct numbers.

The HACKER will continue to guess and get feedback from the ANALYST until either:

- The HACKER gets a 4-0 response (all digits are in the correct place). HACKER wins!
- HACKER has used up all 10 guesses without cracking the PIN. ANALYST wins!

CAN YOU HACK IT?

Code Slips

Analyst Name:

Secret Code:

Digit A	Digit B	Digit C	Digit D

Analyst Name:

Secret Code:

Digit A	Digit B	Digit C	Digit D

Analyst Name:

Secret Code:

Digit A	Digit B	Digit C	Digit D

Analyst Name:

Secret Code:

Digit A	Digit B	Digit C	Digit D

Name: _____

CAN YOU HACK IT?

Hacker Sheet

Attempt #	Digit A	Digit B	Digit C	Digit D	Feedback
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
Winner:					

ACKNOWLEDGEMENTS

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IMAGE AND CONTENT CREDITS

Images

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Content

Lesson adapted and modified from Colorado School of Mines, retrieved from website: http://csunplugged.mines.edu/activity-codebreaker.html

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