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| **Lesson Title : Cryptography and Ethics** | **Unit #:**  **1** | **Lesson #:**  **2** | **Activity #:**  **3** |
| **Activity Title: Ethical Considerations and Review** |

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| **Estimated Lesson Duration:** | **7 Days** |
| **Estimated Activity Duration:** | **2 Days** |

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| **Setting:** | **Classroom** |

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| **Activity Objectives:**   1. **Students will brainstorm the criteria for evaluating ethical dilemmas** 2. **Students will apply their criteria to evaluate ethical dilemmas** 3. **Students will suggest possible resolutions to a variety of ethical dilemmas** 4. **Students will practice encryption, decryption, and cipher breaking with the cryptographic systems studied throughout the unit** |

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| **Activity Guiding Questions:**   1. **What are the ethics surrounding the usage of cryptography and cyber security?** 2. **When throughout history have ethics intersected with cryptography?** 3. **What criteria should we use to evaluate the ethics of cryptography and cyber security?** |

| **Next Generation Science Standards (NGSS)** | |
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| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| ☐ Asking questions (for science) and defining problems (for engineering) | ☒ Patterns |
| ☐ Developing and using models | ☒ Cause and effect |
| ☐ Planning and carrying out investigations | ☐ Scale, proportion, and quantity |
| ☐ Analyzing and interpreting data | ☐ Systems and system models |
| ☐ Using mathematics and computational thinking | ☐ Energy and matter: Flows, cycles, and conservation |
| ☐ Constructing explanations (for science) and designing solutions (for engineering) | ☐ Structure and function. |
| ☐ Engaging in argument from evidence | ☐ Stability and change. |
| ☐ Obtaining, evaluating, and communicating information |  |

| **Ohio’s New Learning Standards for Science (ONLS)** |
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| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| ☐ Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| ☐ Demonstrating Science Knowledge **(D)** |
| ☐ Interpreting and Communicating Science Concepts **(C)** |
| ☐ Recalling Accurate Science **(R)** |

| **Common Core State Standards -- Mathematics (CCSS)** | |
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| **Standards for Mathematical Practice (Check all that apply)** | |
| ☐ Make sense of problems and persevere in solving them | ☐ Useappropriate tools strategically |
| ☐ Reason abstractly and quantitatively | ☐ Attendto precision |
| ☒ Construct viable arguments and critique the reasoning of others | ☐ Look for and make use of structure |
| ☐ Model with mathematics | ☐ Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, ONLS and/or CCSS):** |

HS.A.SSE.2 - Use the structure of an expression to identify ways to rewrite it.

HS.A.CED.2 - Create equations in two or more variables to represent relationships between quantities; graph equations on coordinate axes with labels and scales.

HS.A.REI.10 - Understand that the graph of an equation in two variables is the set of all its solutions plotted in the coordinate plane, often forming a curve (which could be a line).

HS.F.IF.1 - Understand that a function from one set (called the domain) to another set (called the range) assigns to each element of the domain exactly one element of the range. If f is a function and x is an element of its domain, then f(x) denotes the output of f corresponding to the input x. The graph of f is the graph of the equation y = f(x).

HS.F.BF.1.a.b.c - Write a function that describes a relationship between two quantities.

HS.F.BF.4.b.c - Find inverse functions.

HS.F.LE.5 - Interpret the parameters in a linear or exponential function in terms of a context.

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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

Handouts with a variety of ethical dilemmas related to cryptography and cyber security listed.

A guided notes sheet for the recorder on Day 1.

Practice codes and messages for students to encrypt, decrypt, and break on Day 2.

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| **Teacher Advance Preparation:** |

Printout enough handouts for every student.

Divide students into groups of 3-4.

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| **Activity Procedures:** |

Day 1: Ethical Considerations

1. Give every student a handout with a variety of ethical dilemmas related to cryptography and cyber security.
2. Assign one dilemma per group. Explain that each group will have 5 minutes to discuss their dilemma and come up with a resolution, which will be shared with the class.
3. Each group should assign a recorder to takes notes on their group discussion, to be turned in at the end of class (see “Group Notes Sheet”).
4. After the 5 minutes are up, have groups present their dilemma, resolution, and criteria along with any special considerations (3-4 minutes each). After each presentation, give other students opportunities to add any additional thoughts.
5. After all groups have presented, have a class discussion about the criteria, and use consensus to build a list of shared criteria for determining the ethics of a situation.
6. Introduce the “Coventry Dilemma” to the whole class, tell each group that they are the Prime Minister of England, during World War II, and that they have received intelligence from the broken Engima code that the Germans plan to bomb Coventry tonight. They have 5 minutes to decide whether to alert Coventry to the attack and try to evacuate or to safeguard the broken code.
7. At the end of the 5 minutes, take a tally on the board to see how many would let the Germans bomb Coventry, and how many would try to save it.
8. (Optional if time): Change the scenario from Coventry to Pearl Harbor or the World Trade Center Towers on 9/11, to see if students’ responses change when it’s their own country.

Day 2: Review Cryptographic Systems and Protocols

1. Divide students into groups of 3 (sender, receiver, and attacker); switch roles throughout exercise
2. Have students practice Diffie-Hellman Key Exchange and Man-in-the-Middle attacks
3. Have students practice Caesar ciphers
4. Have students practice RSA algorithm
5. Have students practice Chinese Remainder Theorem

**Formative Assessments:** Link the items in the Activities that will be used as formative assessments.

Use student presentations on the ethical dilemmas from Day 1 as a formative assessment to see where students are with understanding the ethical dilemmas related to cryptography and cyber security. Use Q&A where needed to bring them along.

**Summative Assessments:** These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

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| **Differentiation:** Describe how you modified parts of the Lesson to support the needs of different learners.  Refer to Activity Template for details. |

For the ethical portion of the activity, students will be in groups, and so some students might talk less during the presentation based on their comfort level.

For the review portion of the activity, students will be allowed to use notes, a calculator, and be provided handouts for the various cryptographic systems we’ll be reviewing.

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| **Reflection:** Reflect upon the successes and shortcomings of the lesson. |

This lesson went very well. Students were really into the ethical dilemmas. One interesting aspect was that most students are used to scenarios with clear right and wrong solutions, and the ethical dilemmas in this lesson (based on historical scenarios) all involved a complex “grey area”. Students had to wrestle with seeing the scenarios from multiple perspectives, and really push themselves to weigh various pros and cons. They got very into the activity, and there was a lot of discussion within groups, and as groups presented.

There are two things I would change the next time I did this: 1) I would make the group presentations more formal. I kept them relatively informal because of our small class size and the fact that I was trying not to take more than one class period; but in the future, I would schedule 2-3 days for the activity and presentations, and make students give a more formal presentation. 2) I would do a little more pre-work with students on identifying the values and ideals that underpinned their decisions. They had more difficulty than I expected identifying and articulating the values that impelled them to choose one side of a dilemma over the other. I think a pre-activity that got them warmed up with this would help things move along.

I would also add an extra day for the “review” portion. We didn’t get as much review in as I had expected.