The Pythagorean Theorem in Crime Scene Investigation

I   UNIT OVERVIEW & PURPOSE:
Students are asked to solve a series of crimes using critical thinking, science and math skills. As they move through the coursework and complete exploration tasks and activities, they investigate and gradually discover who, what, when, where and how of this plotted series of crimes. Ultimately the students solve the case to see how it's happening and who is involved.

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III   COURSE:
Mathematical Modeling: Capstone Course

IV   CONTENT STRAND:
Geometry

V   OBJECTIVES:
Students will be able to:
- Recognize a right triangle, using the Pythagorean Theorem.
- Use the Pythagorean Theorem to calculate the length of the third side when they know the length of two of the sides.
- Apply the converse of the Pythagorean Theorem to verify right triangles.

VI   MATHEMATICS PERFORMANCE EXPECTATION(s):

MPE.5 Solve real world problems involving right triangles by using the Pythagorean Theorem and its converse, properties of special right triangles, and right triangle trigonometry.

VII CONTENT:
This unit will provide opportunities for students to use their skills and reasoning to solve real world problems. Through this experience they may gain a deeper understanding and appreciation for the application of mathematical properties modeling real-world situations that allow for strong student connections. Students will learn how to analyze data, recognize and figure out patterns and create a model for the data by using a graphing calculator and spreadsheet software. In addition to mathematics, students will be exposed to the concepts

and terminology in fields such as Criminology, Architecture, and Engineering.

VIII   REFERENCE/RESOURCE MATERIALS:
- ○ Geogebra – create constructions, measure, calculate, mathematical modeling
- ○ Graphing Calculator – TI 83 or similar, number crunching and calculating
- ○ Microsoft Excel – use spreadsheets to collect, analyze and display data
- ○ Microsoft Word – Word processing and reports
- ○ Smartboard (if not available, images may be projected on a whiteboard with an LCD or similar projector) - use the apps and tools to view, plan, model and sketch (coordinate plane, maps & math measuring tools)
- ○ Scenarios of associated crimes will be presented in detail to the students in each lesson plan.

IX   PRIMARY ASSESSMENT STRATEGIES:
Informal observations of cooperative groups, journal responses, and conclusions. Students will be assessed on their work demonstrating the steps in the process of completing the lesson tasks. Students will earn scores according to rubrics based on effort and accuracy of the mathematical computations. Students will also be assessed on their ability to discuss and describe the significance and the meaning of the problems they solve. Students will be assessed on a summative review of the unit and their preparation and presentation of the problems solved as well as the calculations and their significance.

X   EVALUATION CRITERIA:
The plan for this unit is designed to be flexible and open-ended. Students will be challenged to work through the stages of the case, reviewing the details provided to gather information and solve problems. The teacher will need to evaluate evidence of students' learning and performance. The mathematical functions integrated into the unit are basic geometry, number sense, and mathematical reasoning to interpret and assist in making decisions. Basic grading rubrics will be developed and refined as this unit is put in practice and modified according to student's needs.

A special focus is placed on learning the Pythagorean theorem in this unit. As an extension to this unit a pre-assessment may be designed to gauge the students' prior knowledge and skills involving right triangles and the Pythagorean Theorem. Baseline data may help measure performance expectations and learning objectives. A post-test would need to be designed to get the feedback

needed to measure growth and progress.

XI INSTRUCTIONAL TIME:

One week with 60 minute class periods (five days of learning activities, presentations and reflections).

Lesson 1: C.S.I. – Student Crime Solvers

Strand
Geometry

Mathematical Objective(s)
Identifying right triangles, Pythagorean Theorem
In this lesson students will use the Pythagorean Theorem to find distance between two points on a map. Students will also use the converse of the Pythagorean Theorem to determine if points on a map form a right triangle. Students will use provided information in the story to map out the story. Students will use their knowledge of right triangles to determine the distance traveled. Students will locate three points on a map that form a right triangle. Students will also use deductive reasoning to reach logical conclusions.

Mathematics Performance Expectation(s)
MPE.5 Solve real-world problems involving right triangles by using the Pythagorean Theorem and its converse, properties of special right triangles, and right triangle trigonometry.

Related SOL
G.5 The student, given information concerning the lengths of sides and/or measures of angles in triangles, will:
   c) determine whether a triangle exists; and
   d) determine the range in which the length of the third side must lie.
   These concepts will be considered in the context of real-world situations.

NCTM Standards
- Apply and adapt a variety of appropriate strategies to solve problems
- Communicate mathematical thinking coherently and clearly to peers, teachers, and others
- Use visualization, spatial reasoning, and geometric modeling to solve problems
- Specify locations and describe spatial relationships using coordinate geometry and other representational systems

Materials/Resources
- The teacher will need access to a Smartboard to display the MAP1
- Each group will have a copy of the MAP1
- Ruler

Assumption of Prior Knowledge
- Students need to know the Pythagorean Theorem and its converse.
- Students need to have mastered basic arithmetic without use of a calculator.
- Students need to be on Level 3 of the Van Hiele scale, with respect to triangles, angles, and finding areas.
- Student need to be able to identify and draw triangles on a map.

Introduction: Setting Up the Mathematical Task
For the first 10 minutes prior to students beginning work, the teacher will review the Pythagorean Theorem with the entire class to ensure that all students have the same knowledge going into group work. Other information about the map will be discussed, such as the length of each city block being 0.10 miles.

Student Exploration:
Story 1 will be read to the class, and then distributed to each student:

It is Monday morning and you and your partner have been selected by the local police force to assist on a case while the police force is short staffed due to the flu. A janitor at the local art museum arrived to work this morning only to discover the door was unlocked, valuable artifacts were missing and the curator nowhere to be seen and cannot be reached.

This is the information you are given:
1. *The curator is not at the museum or at home, and hasn't been seen or heard from since Friday.*
2. *The curator walks to and from work every day (see Map1), stopping to get coffee every morning at the Coffee House, and stopping for dinner every night at the Cafe.*
3. *Every day, the curator has lunch at the Deli.*
4. *The curator's keys are also missing.*

For 20 minutes:
- Students will work in groups of two.
- Each group will have their own map, scenario, and an investigation sheet.
- The investigation sheet will contain questions to guide students towards finding the area of right triangles, and the length of the hypotenuse. The final question on the investigation sheet will ask students to determine to the total area to be searched, if a search for a missing person were conducted using the map and story provided.

For 20 minutes:

- As a class, student groups will take turns presenting their answers to the questions on the investigation sheet, drawing their triangles on the smartboard.
- The class should discuss reasons for differences between groups.
- The class should discuss why someone might choose to not travel by foot along the hypotenuse of a triangle on the map.

For 10 minutes:
- The students will take time to complete their journal entries, with the writing prompt.

Student/Teacher Actions:

- While students are solving the problems, the teacher will move around the room listening to the discussion but avoiding answering questions directly. The goal is for the students to discover the math on their own, so be careful not to tell students whether they are right or wrong and be very careful with hints. Qualifying questions are okay but be careful not to lead the students too much.

- Students will be working independently to solve the first task. Then they should work constructively together in pairs to analyze the deeper aspects of the scenario.

- To facilitate learning, teachers should encourage the students to draw a picture to work through problem solving steps. They should write down ideas and the facts they are sure of and consider what they do not know but need to find out.

- During the second twenty minute segment, student groups will each present their map and reasoning to the rest of the class. We will then wrap up the lesson with a whole group discussion with inquiry and reflection prompts offered by the teacher.

Assessment
- See Student Investigation Sheet 1

Journal/writing prompts
- Students should consider why the curator didn't walk on the hypotenuse of the triangles when traveling around town, or why he may have.

Monitoring Student Responses:

- Students will communicate their thinking by formulating their own thoughts in the journal about the curator and the museum break in.

- Students will communicate with each other in their small groups; students will discuss the storyline, and speculate about possible outcomes.

- The main ideas the teacher and students should focus on in this lesson are identifying types of right triangles (isosceles, scalene, etc.).

- Students might have misconceptions with calculating the distance between the museum and the curator's house; they may be too focused on the route the curator walked to the museum instead of finding the hypotenuse of the triangle formed by his path.

Extensions and Connections (for all students)

- Students will use the Pythagorean Theorem and algebra to solve higher level combined variation problems with circles and areas.
- Students will be encouraged to participate in a mini independent research project on how math is used to solve crimes and real world problems.
- Connect and extend into trigonometry concepts
- Connections to content in other subject areas: Science, Technology & Engineering

Strategies for Differentiation

- Allow students who have difficulty with understanding the word problems to have extra copies of the map, to draw the actions in the scenario.
- Allow ELL students additional time to complete the investigation sheet.
- Present the map and scenario at the same time.
- Before having all groups come together at once, combine three small groups together to form medium size groups for discussion.

Student Scenario 1

It is Monday morning and you and your partner have been selected by the local police force to assist on a case while the police force is short staffed due to the flu. A janitor at the local art museum arrived to work this morning only to discover the door was unlocked, valuable artifacts were missing, and the curator is nowhere to be seen and cannot be reached.

This is the information you are given:
- The curator is not at the museum or at home, and hasn't been seen or heard from since Friday.
- The curator walks to and from work every day (see Map1), stopping to get coffee every morning at the Coffee House, and stopping for dinner every night at the Cafe.
- Every day, the curator has lunch at the Deli.
- The curator's keys are also missing.

Student Map 1

On the map below, each square is one block; each block is equal to 0.10 miles.
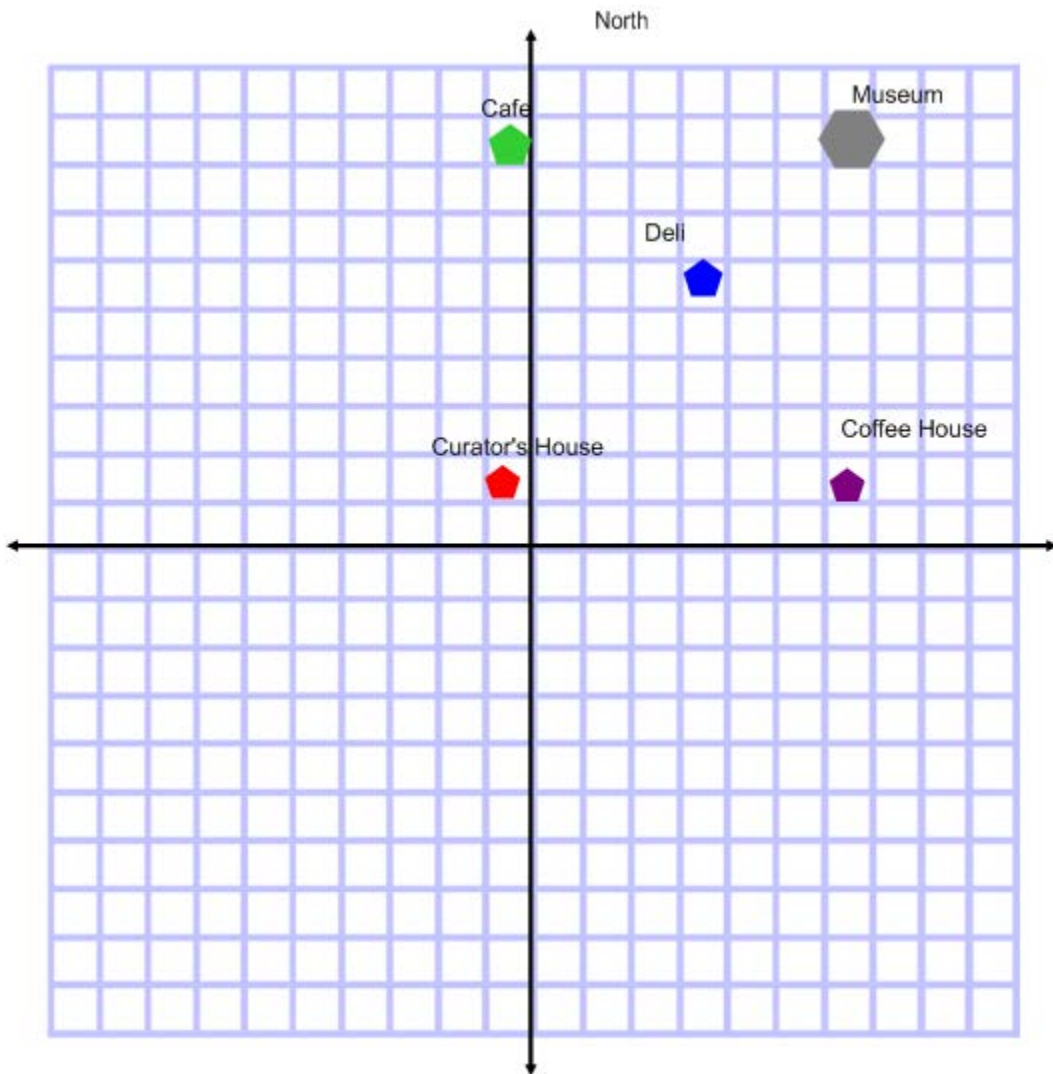
Student Investigation 1

Name: _____   Date: _____

- How many blocks did he walk from his house, to the coffee shop, and then to museum? _____

- If the curator walked directly from home to the coffee shop, then to the museum, and the police want to search the area enclosed by his path, what would the area of that triangle be? Remember, each block is 0.10 miles.
  _____ square miles

- What is the total distance between the curator's house and the museum?
  _____ miles

- How were you able to find the total distance?
  _____
  _____

- Using the paths the curator walks each day, how many right triangles were you able to draw considering each stop he makes? _____
  _____

- Are there different types of right triangles formed? _____
  _____

- What types of right triangles are formed? _____
  _____

Lesson 1 Rubric

Student Name: _____

Assignment	0	1	2	3	Teacher Score & Comments
Investigation Sheet	Answer is completely incorrect.	Answer is partially correct, no convincing reasoning.	Mathematical concepts are correct, but lacking convincing reasoning.	Mathematical concepts are correct, demonstrates full understanding with sound mathematical reasoning.	
Journal Entry	Answer is completely incorrect.	Answer is partially correct, no convincing reasoning.	Mathematical concepts are correct, but lacking convincing reasoning.	Mathematical concepts are correct, demonstrates full understanding with sound mathematical reasoning.	
Group Presentation	Answer is completely incorrect.	Answer is partially correct, no convincing reasoning.	Mathematical concepts are correct, but lacking convincing reasoning.	Mathematical concepts are correct, demonstrates full understanding with sound mathematical reasoning.	

Overall Score for Lesson 1: _____

Questions on Student Investigation 1, answers in blue, wording may vary.

- How many blocks did he walk from his house, to the coffee shop, and then to museum?

  14 total, 7 to the coffee shop, then 7 more to the museum

- If the curator walked directly from home to the coffee shop, then to the museum, and the police want to search the area enclosed by his path, what would the area of that triangle be? Remember, each block is 0.10 miles.

  __24.5___ square miles

  What is the total distance between the curator's house and the museum?

  __9.89__ miles

- How were you able to find the total distance?

  _You are able to calculate the total distance by finding the area of the triangle formed by the curator's route to the museum. He walks 7 blocks to the coffee shop, then 7 more to the museum. We calculate the total distance with the formula to find the hypotenuse, $a^2 + b^2 = c^2$. Since a and b both equal 7, we are able to calculate that c^2 equals 98, which means c equals (approximately) 9.89.

- Using the paths the curator walks each day, how many right triangles were you able to draw considering each stop he makes?

  Three (minimum answer).

- Are there different types of right triangles formed?

  Yes.

- What types of right triangles are formed?

  Isosceles and scalene.

Lesson 2:   C.S.I. – Student Crime Solvers

Strand
Geometry

Mathematical Objective(s)
Students use the Pythagorean Theorem to find missing lengths of objects to draw conclusions make decisions and solve problems.
Students will use presentation and other communication technology to develop, refine, and share developed solutions, ideas, and problems.

The goal of this lesson is for the students to experience math in a real problem solving scenario and apply the Pythagorean Theorem and algebra involved. Students will also learn about details involved in the case and objects associated with right triangles. The conclusions derived will help to confirm suspicions and establish evidence involved in a case.

Mathematics Performance Expectation(s)
MPE.5 Solve real-world problems involving right triangles by using the Pythagorean Theorem and its converse, properties of special right triangles, and right triangle trigonometry.

Related SOL
G.8 The student will solve real-world problems involving right triangles by using the Pythagorean Theorem and its converse, properties of special right triangles, and right triangle trigonometry.

NCTM Standards
- Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships
- Use visualization, spatial reasoning, and geometric modeling to solve problems
- Specify locations and describe spatial relationships using coordinate geometry and other representational systems
- Recognize and use connections among mathematical ideas
- Understand how mathematical ideas interconnect and build on one another to produce a coherent whole
- Recognize and apply mathematics in contexts outside of mathematics

- Create and use representations to organize, record, and communicate mathematical ideas
- Apply and adapt a variety of appropriate strategies to solve problems
- Use the language of mathematics to express mathematical ideas precisely
- Communicate mathematical thinking coherently and clearly to peers, teacher, and others

Additional Objectives for Student Learning:
For extension activities, students will apply knowledge and skills in algebraic expressions and operations:
A.1 The student will represent verbal quantitative situations algebraically and evaluate these expressions for given replacement values of the variables.

A.2 The student will perform operations on polynomials, including
   a) applying the laws of exponents to perform operations on expressions;
   b) adding, subtracting, multiplying, and dividing polynomials; and
   c) factoring completely first- and second-degree binomials and trinomials in one or two variables. Graphing calculators will be used as a tool for factoring and for confirming algebraic factorizations.

Materials/Resources
- Smart Board - use this device and tools to demonstrate, view student work in planning, modeling and sketching (applications, coordinate plane , other math measuring tools)
- Smart Board software installed on Laptop/PC
- Smart Notebook file needs to be created to demonstrate examples and present the task to the students
- Classroom set of TI-83 (or similar) graphing calculators
- Traditional graph paper, pencils and straight edges can be used to assist students with sketching concepts and to provide visualizations

Assumption of Prior Knowledge
- Students need to know the Pythagorean Theorem and its converse.
- Students will need to realize and affirm that the Pythagorean Theorem only applies to right triangles.
- Students need to have mastered basic arithmetic and be proficient with the use of a TI-83 or similar graphing calculator.
- To be successful with these tasks, students should be operating on a level 3 of the Van Hiele scale. Students should have a solid understanding of properties with respect to triangles and angles.
- Students should have a workable understanding of basic math terminology.

- ○ Some students may struggle with the instructions and may need require assistance interpreting the instructions and breaking down the tasks into small steps
- Students will need to analyze and apply their mathematical skills to solve problems in the context of crime scene investigation.

Introduction: Setting Up the Mathematical Task

- Students will use the Pythagorean Theorem to find missing lengths of right triangles. Students will also use deductive and inductive reasoning to reach logical conclusions.
- This lesson is expected to be completed in one 60 minute block. (possibly broken down into 3 twenty-minute segments)
- In this lesson, students will investigate a situation and use mathematical skills and properties to identify evidence in a crime scene. Students will begin by applying the Pythagorean Theorem to find missing lengths of objects that form right triangles involved with the case.
- Students will begin this lesson by thinking about the task and how math may be used in various ways to piece together information and possibly solve a crime. A challenge will be presented to them to learn about the crime on their own and with a partner.
- **Experiential learning will be the primary instructional technique used for this lesson. The instructional goals for our students include:**
  - ○ Experiencing the learner-centered activities involved in the C.S.I. theme.
  - ○ Analyzing and processing clues and information which leads to learning about the numbers and details involved in the case.
  - ○ Deriving and applying the math in the activities and tasks in this unit. This theme revolves around the principles of the Pythagorean Theorem and C.S.I. and leads to an understanding and appreciation of how geometry and algebra are applied in the real world.
  - ○ Reflection about the experience and articulation of the math students used in this theme and how they could apply to other aspects of problem solving and decision making in life.
- Students will work individually at first to draw on prior knowledge and skills to solve problems independently. The idea is for each student to get invested in the case, focus in on the details, and come to conclusions without help from a partner.
- Students will then be carefully partnered and work in pairs that complement personalities, learning styles and abilities. The idea is for students to collaborate and help each other understand the details of the task and discover the math and details involved.

- Student pairs will then share ideas, observations and findings to the entire class. The idea is that the students will share multiple strategies and learn from a variety of perspectives involved with the tasks in the case.
- Students will be encouraged to be well-prepared and have their facts straight. The context of sharing their findings will be linked back to C.S.I. as if they were sharing their observations as a forensics expert testifying in a criminal case.
- The teacher will close the activity by focusing on the learning involved and the application to a real world scenario. The main idea is to demonstrate how we observe details and apply math and science to learn about situations and make decisions in life.

Student Exploration:
Introduction (5-10 minutes)
The teacher will read the following scenario to engage the students and elicit initial responses and ideas (which they would write down and keep to themselves for the sake of preserving other students' self-discovery)

There has been a break-in at the local museum. Valuable artifacts have been stolen. Two windows have been breached and it is suspected that the perpetrator used a very tall ladder to enter or leave the museum through these windows. The authorities are hoping that learning more about this unusual ladder will provide clues to identify a suspect.
Near the first window, two indentations were found on the ground 16 feet away from the base of the building. It is suspected that the feet of a ladder created these indentations. The first breached window is 30 feet high off of the ground. Investigators need to determine approximately how tall the ladder was.

Solicit responses before the first task is presented: "Has anyone ever seen a ladder that tall? Are they common? What else may be involved with this scenario? Are there other ideas or things to consider? Jot down your possible answers to these and other questions you may have."

Individual Work (10-15 minutes)
Students will be provided a written copy of the scenario with appropriate space to guide their work and responses. Students will be directed to interpret the situation and begin to work through it on their own:

Task #1: *Use this information to sketch and label a diagram of the crime scene and find the length of the suspected ladder used.*
Assumption #1: *It is assumed that the wall of the building is "plumb" and rises perpendicular to the ground.*

Why do you think this assumption is given? State what makes it relevant to the scenario.

Small Group Work (20 minutes)
In groups of 2, students will collaborate to shares notes and results and verify solutions. Partners will then collaborate to work through the next step of this case.

Investigators have determined that the second window breached at the museum was 33 feet off of the ground. No obvious indentations were found on the ground near the second window and we are not quite sure yet where the foot of the ladder was located.

Task #2: Use this information to sketch and label a diagram of the crime scene and consider the length of the suspected ladder used. Please show your work off to the side and demonstrate any formulas or mathematical properties that come into play.

Task #3: Based on the same assumption as before, discuss the circumstances with your partner, then individually answer the following questions on your paper:
- *Is it possible that the same ladder was used to breach the second window?*
- *If not, explain your reasoning.*
- *If so, approximately where on the ground could we look for evidence of the where the ladder was based? (Your answer should be expressed in feet and inches.)*
- *How could this information possibly lead us to conclusions about the suspect entering and exiting the museum?*

Whole Class Sharing/Discussion (20 minutes)
Student presentations, class discussion, inquiry and reflection

Student/Teacher Actions:
- While students are solving the problems, the teacher will move around the room listening to the discussion but avoiding answering questions directly. The goal is for the students to discover the math on their own, so be careful not to tell students whether they are right or wrong and be very careful with hints. Qualifying questions are okay but be careful not to lead the students too much. Let the students wrestle with the challenge of the unknown.
- Teachers should refrain from bringing direct attention to the Pythagorean Theorem, but subtly bring attention to the fact that it is a right triangle if needed.

- Students will be working independently to solve the first task. Then they will constructively working together in pairs to analyze the deeper aspects of the scenario.
- To facilitate learning, teachers should encourage the students to draw a picture to work through problem solving steps. They should write down ideas and facts they know to really identify what they do not know but need to find out.
- For the last 20 minutes of class, student pairs will take a few minutes each to sketch their crime scene on the Smartboard and demonstrate how they solved their tasks and discuss their findings of the case so far. We will then wrap up the lesson with a whole group discussion with inquiry and reflection prompts offered by the teacher.
- **Possible solutions to the exploration:**
  Assumption #1: This assumption is given because the ladder represents the hypotenuse of a right triangle. The wall would need to be plumb and perpendicular with the ground to form a right angle and be able to apply the Pythagorean Theorem.
  Task #1: Diagram of a ladder forming a right triangle with the ground and the wall at the first window.
  Task #2: Diagram of a ladder forming a right triangle with the ground and the wall at the second window.
  Task #3: Yes, it is possible; N/A; approximately 8'2" from the building; a variety of theories and conclusions can be drawn from the last question, the intention is to get the students to think. Possible answers include: the criminal may have entered through one window and exited through another carrying their loot, while adding more weight and leaving a deeper depression in the ground at the base of the ladder.

Possible misconceptions or errors:
- Students may get confused with the replacement values of legs as "a" & "b" and the hypotenuse of right triangles as "c."
- Students may try to multiply the dimensions by 2 versus squaring them.
- Students may add the dimensions together before squaring them.
- These misconceptions must be carefully addressed by asking qualifying questions, referring students back to their prior knowledge with similar examples and prompts without "giving away the learning."

Assessment

Please see the Rubric and Student Investigation 2 as students are tasked to use details provided to constructing diagrams, apply mathematical procedures, develop and communicate mathematical reasoning.

Presentation of findings and reflection

Some partners will share their findings in a brief presentation at the end of this lesson. By the end of the unit, everyone will be expected to have presented their findings from at least one of the unit lessons. Students will be expected to clearly explain their conclusions and how they came to them. Students will be encouraged to share ideas about other applications where the Pythagorean Theorem could be used in real life.

Provide special accommodations for individual students as required and needed.
- Assist students with interpreting instructions
- Read aloud items for students
- Flexible schedule (allow breaks, break large tasks into small tasks, allow extended time to complete tasks, etc.)

Extensions and Connections (for all students)
- Students will use the Pythagorean Theorem and algebra to solve higher level combined variation problems:
- Students will be encouraged to participate in a mini independent research project on how math is used to solve crimes and real world problems.
- Connect and extend mathematics into trigonometry concepts
- Connections to content in other subject areas: Science, Technology, Engineering

Strategies for Differentiation
- Students will be offered grid/graphing paper, rulers and related manipulatives to assist with sketches and constructions and address the needs of kinesthetic and visual learners.
- Teachers should promote individual discussions and assist with instructions for students with special auditory, processing, and memory needs.
- Provide assistance and special dictionaries for English language learners (ELLs);
- Provide challenging extension problems for high-ability students who breeze through the tasks and offer more depth to the level of math and thinking required.
- Provide special seating arrangements for any student with special needs.

Student Investigation Sheet 2

Name: _____   Date: _____

Introduction (5-10 minutes)

There has been a break-in at the local museum. Valuable artifacts have been stolen. Two windows have been breached and it is suspected that the perpetrator used a very tall ladder to enter or leave the museum through these windows. The authorities are hoping that learning more about this unusual ladder will provide clues to identify a suspect.
Near the first window, two indentations were found on the ground 16 feet away from the base of the building. It is suspected that the feet of a ladder created these indentations. The first breached window is 30 feet high off of the ground. Investigators need to determine approximately how tall the ladder was.

Individual Work (10-15 minutes)

Task #1: *Use the information provided to sketch and label a diagram of the crime scene and find the length of the suspected ladder used. Use your ruler, straightedge and tools available to create a quality sketch with accurate labels. Draw your sketch in the space below in the time allotted.*

Assumption #1: *It is assumed that the wall of the building is "plumb" and rises perpendicular to the ground.*

Why do you think this assumption is given? State what makes it relevant to the scenario.

_____

_____

Student Investigation Sheet 2

Name: _____   Date: _____

Small Group Work (20 minutes)

Investigators have determined that a second window breached at the museum was 33 feet off of the ground. No obvious indentations were found on the ground near the second window and we are not sure where the foot of the ladder was located.

Task #2: *Use this information to sketch and label a diagram of the crime scene and consider the length of the suspected ladder used. Please show your work on the side and demonstrate any formulas or mathematical properties that come into play.*

Task #3: *Based on the same assumption as before, discuss the circumstances with your partner, then individually answer the following questions on your paper:*

1. **Is it possible that the same ladder was used to breach the second window?**

2. **If not, explain your reasoning.**

3. **If so, approximately where on the ground could we look for evidence of where the ladder was based? (Your answer should be expressed in feet and inches.)**

4. **How could this information possibly lead us to conclusions about the suspect entering and exiting the museum?**

Student Investigation Sheet 2 Grading Rubric

Student :_____

Objective	Superior 10 points	Good 6-9 points	Fair 3-5 points	Poor 0-2 points
Individual Work **Task #1**	Student's diagram is to scale with accurate labels on all features. A right angle symbol is included. Diagram reflects that students took their time and used appropriate tools. Student found the correct height of the ladder and clearly demonstrated their steps. Student's response to Assumption #1 is clear, accurate and demonstrated a solid understanding.	Student's diagram features accurate labels on most features. Diagram reflects that students took some time & attempted to use appropriate tools. Student found the correct height of the ladder and demonstrated their steps fairly. Student's response to Assumption #1 is mostly clear, accurate and demonstrated relevancy to the scenario.	Student's diagram features some labels. Diagram demonstrates an attempt to use straight edge. Student almost found the correct height of the ladder, but may have missed a step or two. Student did attempt to show their work. Student's response to Assumption #1 is a fair attempt, but lacking clarity and accuracy.	Student's diagram is sloppy with little to no labels or measurements. Diagram does not or poorly indicates wall, ladder, and base. Student did not find the height of the ladder and did not demonstrate steps clearly. Student did not respond to Assumption #1.
Small Group Work **Task #2**	Student's diagram is to scale with accurate labels on all features. A right angle symbol is included. Diagram reflects that students took their time and used appropriate tools. Student clearly demonstrated their mathematical process and used appropriate formulas accurately.	Student's diagram features accurate labels on most features. Diagram reflects that students took some time & attempted to use appropriate tools. Student demonstrated their mathematical process within reason and used appropriate formulas with good accuracy.	Student's diagram features some labels. Diagram demonstrates an attempt to use straight edge. Student fairly demonstrated their mathematical process, with some errors and attempted to use appropriate formulas.	Student's diagram is sloppy with little to no labels or measurements. Diagram does not or poorly indicates wall, ladder, and base. Student demonstrated their mathematical process poorly with many errors. Students did not use appropriate formulas.
Small Group Work **Task #3**	Student demonstrated accurate reasoning to approximate the height of the ladder and where it was located on the ground. Student offered justified conclusions regarding the scenario.	Student demonstrated reasoning to approximate the height of the ladder and its location. Student offered a conclusion regarding the scenario.	Student demonstrated mistakes in their reasoning to find height of the ladder and its location. Student offered a weak conclusion regarding the scenario.	Student demonstrated a poor attempt to reason and find the missing information. Student offered no conclusion regarding the scenario.

Lesson 3 C.S.I. – Student Crime Solvers

Strand
Geometry

Mathematical Objective(s)
Identifying right triangles, Pythagorean Theorem.

In this lesson students will use the Pythagorean Theorem, as well as distance traveled over time, to find possible locations on a map. Students will also use the converse of the Pythagorean Theorem to determine if points on a map form a right triangle, and a circle. Students will use provided information to determine where an action originated, based on where it landed. Students will use their knowledge of right triangles to determine the distance traveled. Students will locate three points on a map that form a right triangle. Students will also use deductive reasoning to reach logical conclusions.

Mathematics Performance Expectation(s)
MPE.34 Given information in the form of a figure or statement, prove two triangles are similar, using algebraic and coordinate methods as well as deductive proofs.

MPE.5 Solve real-world problems involving right triangles by using the Pythagorean Theorem and its converse, properties of special right triangles, and right triangle trigonometry.

Related SOL
G.5 The student, given information concerning the lengths of sides and/or measures of angles in triangles, will:
    c) determine whether a triangle exists; and
    d) determine the range in which the length of the third side must lie.
    These concepts will be considered in the context of real-world situations.

G.8 The student will solve real-world problems involving right triangles by using the Pythagorean Theorem and its converse, properties of special right triangles, and right triangle trigonometry.

NCTM Standards
- Apply and adapt a variety of appropriate strategies to solve problems.
- Communicate mathematical thinking coherently and clearly to peers, teachers, and others.

Materials/Resources

- The teacher will need access to a Smartboard to display the map 2.
- Each group will have a copy of the map 2.
- Ruler
- Compass
- Classroom set of computers

Assumption of Prior Knowledge
- Students need to know the Pythagorean Theorem and its converse.
- Students need to have mastered basic arithmetic without use of a calculator.
- Students need to be on Level 3 of the Van Hiele scale, with respect to triangles, angles, and finding areas.
- Student need to be able to identify and draw triangles on a map.

Introduction: Setting Up the Mathematical Task

The teacher will also review the previous lessons with the class to refresh everyone about the details of the case. Other information about the map will be discussed, such as the length of each city block being 0.10 miles. The formula for finding the area of a circle will be displayed for students for reference.

For 15 minutes:
- Students will use map 2 and the details of the next segment of the scenario to determine possible locations for where the curator is being held.
- Each group will have their own map, scenario with set of clues, and an investigation sheet.
- The investigation sheet will contain questions to guide students towards finding the area of right triangles, and the length of the hypotenuse. The final question on the investigation sheet will ask students to determine to the total area to be searched, if a search for a missing person were conducted using the map and scenario provided.

For 15 minutes:
- Students will work in small groups of three, using map 2 and the scenario to complete investigation sheet 3.

For 20 minutes:
- Student presentations, class discussion, inquiry, and reflection on individual and group discoveries.

Student Exploration:

Scenario 3 will be read to the class:
The authorities have received an anonymous phone call. The caller left the following information:
The curator was seen getting into a vehicle immediately after leaving the coffee shop where he got his morning coffee, but before he got to the museum.

After being picked up, the vehicle drove three blocks, turned left, drove another four blocks, and then stopped. The curator is still alive. The caller refused to give any further detail and hung up immediately after relaying this information. The authorities want you to remember that the curator has not been seen since disappearing.

Instructions:
Looking at the map, locate possible places as to where this holding place might be located. Also, using the coffee shop as a starting point, determine the area in which this location could be. Answer the questions on the investigation sheet.

For 20 minutes:
  ● Students will use Map 2 and the details in the scenario to determine possible locations for the holding place.

Student/Teacher Actions:

  ● While students are solving the problems, the teacher will move around the room listening to the discussion but avoiding answering questions directly. The goal is for the students to discover the math on their own, so be careful not to tell students whether they are right or wrong and be very careful with hints. Qualifying questions are okay but be careful not to lead the students too much. Let the students wrestle with the challenge of the unknown.

  ● Students will be working independently to solve the first task. They will constructively work together in pairs to analyze the deeper aspects of the scenario.

  ● To facilitate learning, teachers should encourage the students to draw a picture to work through problem solving steps. Encourage students to write down ideas and facts they know to really identify what they do not know but need to find out.

  ● During the last twenty minute segment, student groups will each present their map and reasoning to the rest of the class. We will then wrap up the lesson with a whole group discussion with inquiry and reflection prompts offered by the teacher.

Assessment
  • Questions on Student Investigation Sheet 3

Monitoring Student Responses:
  ● Students will communicate their thinking with their sketches on the map. They will answer the questions on the investigation sheet.

- Students will communicate with each other and discuss reasons for eliminating possible locations where the curator might have been seen. They will discuss reasons for being able to eliminate certain locations.

- Students and teachers will discuss the relationship between triangles and circles, in particular the relationship between the hypotenuse of the triangle and the radius of the circle, and how the students know those lengths are the same.

- Students might have misconceptions when determining the possible locations for where the curator was seen in the window, as relayed in the scenario. It is possible that some of the weaker students will not understand that they need to use the details provided to find the hypotenuse of the triangle, and the area of the circle from that information.

Extensions and Connections (for all students)

- Students will use the Pythagorean Theorem and Algebra to solve higher level combined variation problems:
- Students will be encouraged to participate in a mini independent research project on how math is used to solve crimes and real world problems.
- Connect and extend mathematics into trigonometry concepts
- Connections to content in other subject areas: Science, Technology, Engineering

Strategies for Differentiation

- Allow students who have difficulty with understanding the word problems to have extra copies of the map, to draw the actions in the scenario.
- Allow ELL students additional time to complete the investigation sheet.
- Present the map and scenario at the same time.
- Before having all groups come together at once, combine three small groups together to form medium size groups for discussion.

Student Scenario 3

The authorities have received an anonymous phone call. The caller left the following information:

The curator was seen getting into a vehicle immediately after leaving the coffee shop where he got his morning coffee, but before he got to the museum.
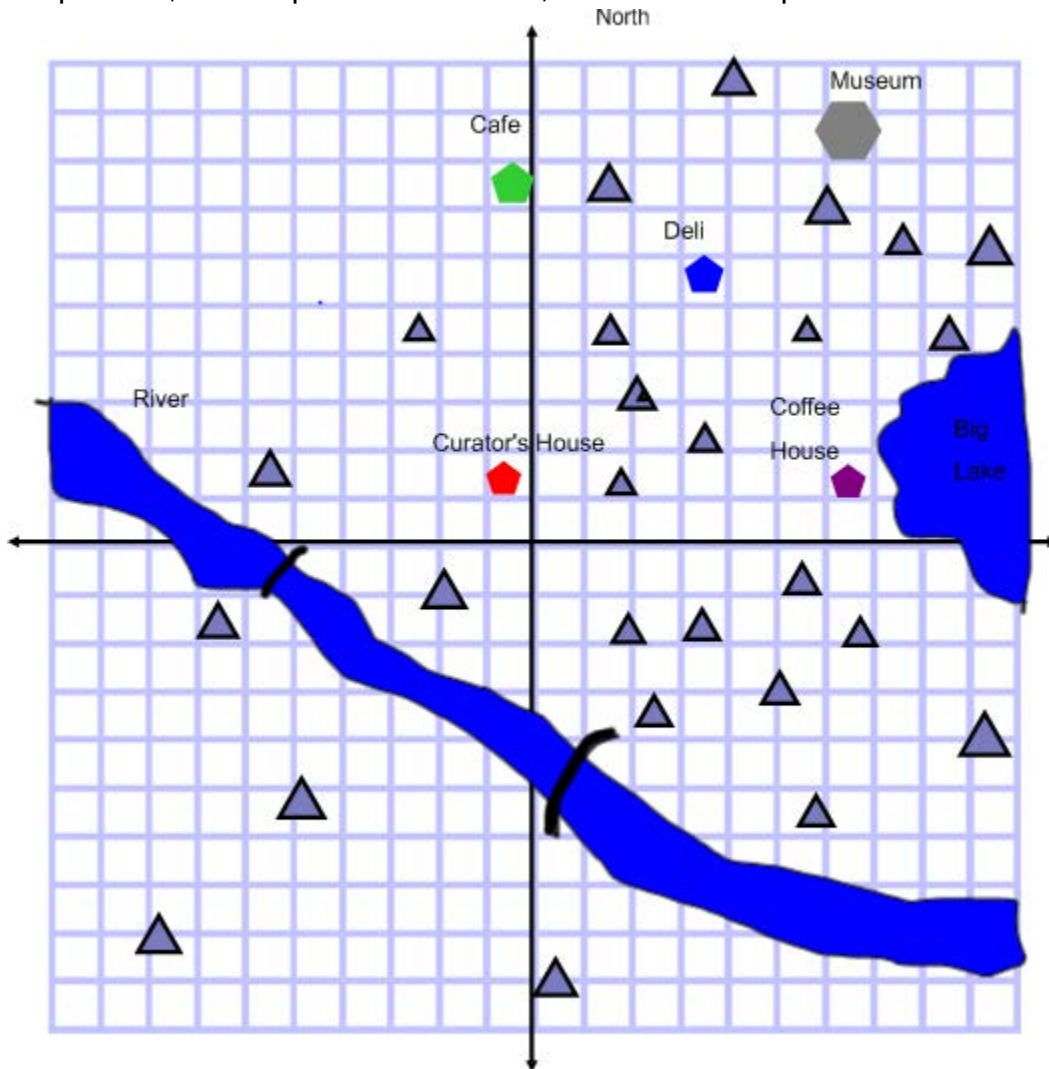
After being picked up, the vehicle drove three blocks, turned left, drove another four blocks, and then stopped. The curator is still alive. The caller refused to give any further detail and hung up immediately after relaying this information. The authorities want you to remember that the curator has not been seen since disappearing.

Student Map Lesson 3

Name: _____   Date: _____

On the map below, each square is one block; each block is equal to 0.10 miles.

Student Scenario 3

The authorities have received an anonymous phone call. The caller left the following information:

- The curator was seen getting into a vehicle immediately after leaving the coffee shop where he got his morning coffee, but before he got to the museum.
- After being picked up, the vehicle drove three blocks, turned left, drove another four blocks, and then stopped. The curator is still alive. The caller refused to give any further detail and hung up immediately after relaying this information. The authorities want you to remember that the curator has not been seen since disappearing.

Student Investigation Sheet 3

Name: _____   Date: _____

- What is the radius of the circle created? _____

- What is the diameter of the circle created? _____

- How did you determine the length of the diameter of the circle?

  _____

  _____

- What is the area of the circle created? _____ square miles

- Using a compass, draw a circle on your own map.

- Compare circles. Are there any differences among the maps in the group?

  _____

- What might account for some of the differences? _____

  _____

- As a group, are you able to eliminate possible locations? _____

- Why were you able to eliminate some of the locations? _____

  _____

Lesson 3 Rubric

Student Name: _____

Assignment	0	1	2	3	Teacher Score & Comments
Investigation Sheet	Answer is completely incorrect.	Answer is partially correct, no convincing reasoning.	Mathematical concepts are correct, but lacking convincing reasoning.	Mathematical concepts are correct, demonstrates full understanding with sound mathematical reasoning.	
Journal Entry	Answer is completely incorrect.	Answer is partially correct, no convincing reasoning.	Mathematical concepts are correct, but lacking convincing reasoning.	Mathematical concepts are correct, demonstrates full understanding with sound mathematical reasoning.	
Group Presentation	Answer is completely incorrect.	Answer is partially correct, no convincing reasoning.	Mathematical concepts are correct, but lacking convincing reasoning.	Mathematical concepts are correct, demonstrates full understanding with sound mathematical reasoning.	

Overall Score for Lesson 3: _____

Questions on Student Investigation 3, answers in blue, wording may vary.

- What is the radius of the circle created? 5 blocks

- What is the diameter of the circle created? 10 blocks (part of this is in the lake)

- How did you determine the length of the diameter of the circle?

  Once you have determined the hypotenuse of the triangle formed by the path of the

  car with the curator using the Pythagorean Theorem (which is the radius), you

  double it to find the diameter.

- What is the area of the circle created? __78.5 or 25pi_ square miles

- Using a compass, draw a circle on your own map.

- Compare circles. Are there any differences among the maps in the group?

  ___ Answers will vary _____

- What might account for some of the differences?

  _____Answers will vary___

- As a group, are you able to eliminate possible locations?

  _____Answers will vary___

- Why were you able to eliminate some of the locations?

  __Answers will vary___

Lesson 4:   C.S.I. – Student Crime Solvers

Strand
Geometry

Mathematical Objective(s)
Students use the Pythagorean Theorem to solve problems.
Students will use presentation and other communication technology to develop, refine, and share developed solutions, ideas, and problems.

The goal of this lesson is for the students to experience math in a real problem solving scenario and apply the Pythagorean Theorem and algebra involved. Students will also learn about details involved in the case and objects that form right triangles. The conclusions derived will help to confirm suspicions and establish evidence involved in a case.

Mathematics Performance Expectation(s)
MPE.5 Solve real-world problems involving right triangles by using the Pythagorean Theorem and its converse, properties of special right triangles, and right triangle trigonometry.

Related SOL
G.8 The student will solve real-world problems involving right triangles by using the Pythagorean Theorem and its converse, properties of special right triangles, and right triangle trigonometry.

NCTM Standards
● Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships
● Use visualization, spatial reasoning, and geometric modeling to solve problems
● Specify locations and describe spatial relationships using coordinate geometry and other representational systems
● Develop and evaluate mathematical arguments and proofs
● Recognize and use connections among mathematical ideas
● Understand how mathematical ideas interconnect and build on one another to produce a coherent whole
● Recognize and apply mathematics in contexts outside of mathematics
● Create and use representations to organize, record, and communicate mathematical ideas

- Apply and adapt a variety of appropriate strategies to solve problems
- Use the language of mathematics to express mathematical ideas precisely
- Communicate mathematical thinking coherently and clearly to peers, teacher, and others

Materials/Resources

- SmartBoard - use this device and tools to demonstrate, view student work in planning, modeling and sketching (coordinate plane, maps & measuring tools)
- SmartBoard software installed on Laptop/PC
- Smart Notebook file needs to be created to demonstrate examples and printed to present the task to the students
- Classroom set of TI-83 or other graphing calculators
- Traditional graph paper, pencils and straight edges can be used to assist students with sketching concepts and to provide visualizations

Assumption of Prior Knowledge

- Students need to know the Pythagorean Theorem.
- Students will need to realize and affirm that the Pythagorean Theorem only applies to right triangles.
- Students need to have mastered basic arithmetic and be proficient with the use of a TI-83 or similar graphing calculator.
- To be successful with these tasks, students should be operating on a level 3 of the Van Hiele scale. Students should have a solid understanding of properties with respect to triangles and angles.
- Students should have a workable understanding of basic math terminology.
- Some students may struggle with the instructions and may require assistance interpreting the instructions and breaking down the tasks into smaller steps
- Students will need to analyze details and apply basic problem solving skills.

Introduction: Setting Up the Mathematical Task

- Students will use the Pythagorean Theorem to find missing lengths of right triangles. Students will also use deductive and inductive reasoning to reach logical conclusions.
- This lesson is expected to be completed in one 60 minute block. (possibly broken down into 3 twenty-minute segments)
- Students will begin this lesson by thinking about the task and how math may be used in various ways to connect information and possibly solve a crime. A challenge will be presented to them to learn about the crime on their own and with a partner.

Experiential learning will be the primary instructional technique used for this lesson. The instructional goals for our students include:

- ○ Experiencing the learner-centered activities involved in the C.S.I. theme.
- ○ Analyzing and processing clues and information which lead to learning about the numbers and details involved in the case.
- ○ Deriving and applying the math in the activities and tasks in this unit. This theme revolves around the principles of the Pythagorean Theorem and C.S.I. and lead to an understanding and appreciation of how geometry and algebra are applied in the real world.
- ○ Reflection about the experience and articulation of the math students used in this theme and how they could apply to other aspects of problem solving and decision making in life.
- ● Students will work individually at first to draw on prior knowledge and skills to solve problems independently. The idea is for each student to get invested in the case, focus in on the details, and come to conclusions without help or distractions from a partner.
- ● Students will then be carefully partnered to work in pairs that complement personalities, learning styles and abilities. The idea is for students to collaborate and help each other understand the details of the task and discover the math and details involved.
- ● Student pairs will then share ideas, observations and findings to the entire class. The idea is that the students will share multiple strategies and learn from a variety of perspectives involved with the tasks in the case.
- ● Students will be encouraged to be well-prepared and have their facts straight. The context of sharing their findings will be linked back to C.S.I. as if they were sharing their observations as a forensics expert testifying in a criminal case.
- ● The teacher will close the activity by focusing on the learning involved and the application to a real world scenario. The main idea is to demonstrate how we observe details and apply math and science to learn about situations and make decisions in life.

Student Exploration:

Introduction (5 minutes)

The teacher will read the following scenario to engage the students and elicit initial responses and ideas (which they would write down and keep to themselves for the sake of preserving other students' self-discovery)

The authorities have video evidence of a possible suspect in the museum break in. The suspect was seen carrying a briefcase measuring 20" long by 16" high by 3" wide. One of the artifacts stolen was 24" long and 2" wide. Investigators are trying

to determine if this artifact was possibly smuggled out of the museum in this suspect's briefcase.

Prompt students to write down their initial ideas and possibilities for this scenario. Advise the students not to share any information with their peers at this point.

Individual Work (15 minutes)
Students will be provided a written copy of the scenario which would provide appropriate space to guide their work and responses. Students will be directed to interpret the situation and begin to work through it on their own:

Task #1: *Use this information to sketch and label a diagram of the briefcase and the artifact that was stolen.*

Task #2: *Individually, students will use the dimensions provided to determine mathematically if the investigators' suspicions are possible. Students should show all work and provide relevant properties and formulas.*

Small Group Work (20 minutes)
In groups of 2, students will collaborate to share notes and results and verify solutions. Partners will then collaborate to work through the next step of this case.

Investigators have discovered that a large painting was stolen from the museum. Use your math skills to determine if the painting was smuggled out of one of the museum windows or not. The museum windows were all intact and are all the same measurement 24" wide by 24" tall. The large painting that was stolen was 35"wide by 36" tall.

Task #3: *Based on the information given, perform the mathematical steps necessary to determine if this painting would have fit through the window. This information will help lead to a suspect and may also be used in court as evidence - so make it look official!*

Would the painting fit through the window? _____
Why or why not? (provide a written summary of your mathematical findings)

_____

_____

_____

Whole Class Sharing/Discussion (20 minutes)
Student presentations, class discussion, inquiry and reflection

Student/Teacher Actions:
o   While students are solving the problems, the teacher will move around the room listening to the discussion but avoiding answering questions directly. The goal is for the students to discover the math on their own, so be careful not to tell students whether they are right or wrong and be very careful with hints. Qualifying questions are okay but be careful not to lead the students too much. Let the students wrestle with the challenge of the unknown.
o   Teachers should refrain from bringing direct attention to the Pythagorean Theorem, but subtly bring attention to the fact that it is a right triangle if needed.
o   Students will be working independently to solve the first task. , then constructively working together in pairs to analyze the deeper aspects of the scenario.
o   To facilitate learning, teachers should encourage the students to draw a picture to work through problem solving steps. They should write down ideas and facts they know to really identify what they do not know but need to find out.
o   For the last 20 minutes of class, student pairs will take a few minutes each to sketch their crime scene on the SmartBoard and demonstrate how they solved their tasks and discuss their findings of the case so far. Students will then wrap up the lesson with a whole group discussion with reflection and inquiry prompts offered by the teacher.

Possible solutions to the exploration:
Task 1: Diagram sketched with dimensions of the briefcase and the artifact labeled appropriately.

Task 2: Yes, it is possible that the artifact would fit in the briefcase. Even though it is longer than the briefcase, if it was placed diagonally it would fit inside. This can be proven by finding the widest opening (diagonal) of the briefcase. The diagonal of the rectangular briefcase would represent the hypotenuse of a right triangle. The Pythagorean Theorem can be applied to the dimensions of the briefcase: $20^2+16^2 =656$; the square root of 656 would be approximately 25.6". This length represents the widest space of the briefcase. Since it is greater than the length of the artifact (24"), it is conceivable that the artifact was smuggled out of the museum in the briefcase.

Task 3: No, the painting will not fit through the window, considering the widest opening of the window (the diagonal). The diagonal of the rectangular window would represent the hypotenuse of a right triangle. The Pythagorean Theorem can be applied to the dimensions of the window: $24^2 + 24^2 = 1,152$; the square root of 1,152 would be approximately 33.94. This number represents the widest opening of the window and since it is less than the width or the height of the painting, it can be concluded that the thief did not smuggle the painting out of the museum windows.

Possible misconceptions or errors:
- Students may get confused with the replacement values of legs as "a" & "b" and the hypotenuse of right triangles as "c."
- Students may try to multiply the dimensions by 2 versus squaring them.
- Students may add the dimensions together before squaring them.
- Students may realize that the artifact is longer than the briefcase and bypass checking the diagonal using the Pythagorean Theorem.
- Students may realize that the painting is wider than the window and bypass checking the diagonal using the Pythagorean Theorem.
- These misconceptions must be carefully addressed by asking qualifying questions, referring students back to their prior knowledge with similar examples and prompts without "giving away the learning."

Assessment

Please see the Rubric and Student Investigation 4 as students are tasked to use details provided to constructing diagrams, apply mathematical procedures, develop and communicate mathematical reasoning.

Presentation of findings and reflection

Some partners will share their findings in a brief presentation at the end of this lesson. By the end of the unit, everyone will be expected to have presented their findings from at least one of the unit lessons. Students will be expected to clearly explain their conclusions and how they came to them. Students will be encouraged to share ideas about other applications where the Pythagorean Theorem could be used in real life.

Extensions and Connections (for all students)
- If time permits, students can construct 3-D models of the briefcase and artifact using cardboard, tape, measure, scissors and tape.
- Students will be encouraged to participate in a mini independent research project on how math is used to solve crimes and real world problems.
- Connect and extend mathematics into trigonometry concepts
- Connections to content in other subject areas: Science, Technology, Engineering

Strategies for Differentiation

o　　Students will be offered grid/graphing paper, rulers and related manipulatives to assist with sketches and constructions and address the needs of kinesthetic and visual learners.

o　　Teachers should promote individual discussions and assist with instructions for students with special auditory, processing, and memory needs.

o　　Provide assistance and special dictionaries for English language learners (ELLs);

o　　Provide challenging extension problems for high-ability students who breeze through the tasks and offer more depth to the level of math and thinking required.

o　　Provide special seating arrangements for any student with special needs.

Student Investigation Sheet 4

Name: _____   Date:_____

Introduction (5 minutes)

The authorities have video evidence of a possible suspect in the museum break in. The suspect was seen carrying a briefcase measuring 20" long by 16" high by 3" wide. One of the artifacts stolen was 24" long and 2" wide. Investigators are trying to determine if this artifact was possibly smuggled out of the museum in this suspect's briefcase.

Individual Work (15 minutes)

Task #1: *Use this information to sketch and label a diagram of the briefcase and the artifact that was stolen.*

Task #2: *Individually, students will use the dimensions provided to determine mathematically if the investigators' suspicions are possible. Students should show all work and provide relevant properties and formulas.*

Small Group Work (20 minutes)

Partners will collaborate to share notes and verify solutions to work through the next step of this case.

Investigators have discovered that a large painting was stolen from the museum. Use your math skills to determine if the painting was smuggled out of one of the museum windows or not. The museum windows were all intact and are all the same measurement 24" wide by 24" tall. The large painting that was stolen was 35"wide by 36" tall.

Task #3: *Based on the information given, perform the mathematical steps necessary to determine if this painting would have fit through the window. This information will help lead to a suspect and may also be used in court as evidence - so make it look official!*

Would the painting fit through the window? _____

Why or why not? (provide a written summary of your mathematical findings)

_____

_____

_____

_____

_____

Whole Class Sharing/Discussion (20 minutes)

Student presentations, class discussion, inquiry and reflection

Lesson 4 Rubric

Student Name: _____

Objective	Superior 10 points	Good 6-9 points	Fair 3-5 points	Poor 0-2 points
Individual Work **Task #1**	Student's diagram is to scale with accurate labels on all features. A right angle symbol is included. Diagram reflects that students took their time used appropriate tools.	Student's diagram features accurate labels on most features. Diagram reflects that students took some time & attempted to use appropriate tools.	Student's diagram features some labels. Diagram demonstrates an attempt to use straight edge.	Student's diagram is sloppy with little to no labels or measurements. Diagram does not or poorly indicates dimensions of the briefcase and artifact.
Individual Work **Task #2**	Student clearly demonstrated their mathematical process and used appropriate formulas accurately. Student clearly reasoned that the artifact would fit in the briefcase if placed diagonally, like a hypotenuse. Student accurately use math appropriately to back up their conclusion.	Student demonstrated their mathematical process within reason and used appropriate formulas with good accuracy. Student found that the artifact would fit in the briefcase if placed diagonally, like a hypotenuse. Student use math appropriately to back up their conclusion with minor errors.	Student fairly demonstrated their mathematical process, with some errors and attempted to use appropriate formulas. Student attempted the problem with reasonable effort and accuracy. Student use math fairly to back up their conclusion with some errors.	Student demonstrated their mathematical process poorly with many errors. Students did not use appropriate formulas. Student did not give a reasonable effort to attempt the problem and apply the math. The work was poorly organized and had many errors.
Small Group Work #3	Student demonstrated accurate reasoning to determine that the painting would not fit. Student offered clear justification, free of errors, to support their decision.	Student demonstrated good reasoning to determine that the painting would not fit. Student offered adequate justification to support their decision, with minor errors.	Student demonstrated fair reasoning to determine that the painting would not fit. Student attempted to offer justification to support their decision, with some errors.	Student no or poor reasoning to determine that the painting would not fit. Student offered a poor attempt to justify any math and support their decision.

Lesson 5: C.S.I. – Student Crime Solvers

Strand
Geometry

Mathematical Objective(s)
Students will use the Pythagorean Theorem and its converse to solve problems.
Students will identify and verify right triangles using the Pythagorean Theorem and its converse.
Students will use presentation and other communication technology to develop, refine, and share developed solutions, ideas, and problems.

The goal of this lesson is for the students to use all of the information from the unit to present the best case possible. The details of the math involved throughout are designed to confirm suspicions and establish solid evidence which will be used to finally solve this crime and close the case.

Mathematics Performance Expectation(s)
MPE.5 Solve real-world problems involving right triangles by using the Pythagorean Theorem and its converse, properties of special right triangles, and right triangle trigonometry.

Related SOL
G.8 The student will solve real-world problems involving right triangles by using the Pythagorean Theorem and its converse, properties of special right triangles, and right triangle trigonometry.

NCTM Standards
- Analyze characteristics and properties of two- and three-dimensional geometric shapes and develop mathematical arguments about geometric relationships
- Use visualization, spatial reasoning, and geometric modeling to solve problems
- Specify locations and describe spatial relationships using coordinate geometry and other representational systems
- Develop and evaluate mathematical arguments and proofs
- Recognize and use connections among mathematical ideas
- Understand how mathematical ideas interconnect and build on one another to produce a coherent whole
- Recognize and apply mathematics in contexts outside of mathematics

- Create and use representations to organize, record, and communicate mathematical ideas
- Apply and adapt a variety of appropriate strategies to solve problems
- Use the language of mathematics to express mathematical ideas precisely
- Communicate mathematical thinking coherently and clearly to peers, teacher, and others

Materials/Resources
- SmartBoard - use this device and tools to demonstrate, view student work in planning, modeling and sketching (apps, coordinate plane , other math measuring tools)
- SmartBoard software installed on Laptop/PC
- Smart Notebook file needs to be created to demonstrate examples and present the task to the students
- Classroom set of TI-83 or similar graphing calculators
- Traditional graph paper, pencils, compasses, and straight edges can be used to assist students with sketching concepts and to provide visualizations

Assumption of Prior Knowledge
- Students need to know the Pythagorean Theorem and its converse.
- Students will need to realize and affirm that the Pythagorean Theorem only applies to right triangles.
- Students need to have mastered basic arithmetic and be proficient with the use of a TI-83 graphing calculator.
- To be successful with these tasks, students should be operating on at least level 2 of the Van Hiele scale – abstraction. Students should have a solid understanding of properties with respect to triangles and angles.
- Students should have a workable understanding of basic math terminology, such as angle.
- Some students may struggle with the instructions and may need require assistance interpreting the instructions and breaking down the tasks into small steps
- Students will need to analyze and apply problem solving skills to solve a mystery in the context of crime scene investigation.

Introduction: Setting Up the Mathematical Task

The teacher will pull up conclusions reached in the previous four lessons, including the maps, and information about artifacts that are missing. The teacher will then present the final piece of information from the authorities.

Experiential learning will be the primary instructional technique used for this lesson. The instructional goals for our students include:

- Experiencing the learner-centered activities involved in the C.S.I. theme.
- Analyzing and processing clues and information which lead to learning about the numbers and details involved in the case.
- Deriving and applying the math in the activities and tasks in this unit. This theme revolves around the principles of the Pythagorean Theorem and C.S.I. and lead to an understanding and appreciation of how geometry and algebra are applied in the real world.
- Reflection about the experience and articulation of the math students used in this theme and how they could apply to other aspects of problem solving and decision making in life.

Student Exploration:

Scenario 5 will be read to the class:

> ***The authorities have found a laptop connected to the case. Unfortunately it's password protected. The password hint is "Pythagorean triples".***

Task #1: *Students will be a given an investigation sheet consisting of 7 triangles (#1 is an example). Students will apply the dimensions of the triangles to the converse of the Pythagorean Theorem to verify which are right triangles. Students will show their steps and demonstrate the algebra involved.*

Task #2: *Students will complete the "Cracking the Code: Pythagorean Triples" Excel spreadsheet.*

Task #3: *Students will input the Pythagorean triples from the highlighted fields in the previous task into the password field. The correct sequence of the Pythagorean triples will unlock the laptop.*

Congratulations on cracking the code! This is the information that popped up:
- ***The curator was seen in a window that was 15 feet above the sidewalk, making it a second story window. All buildings in the third quadrant are only one story high.***
- ***From the window, the river can be seen.***
- ***If you were to draw a line from river to the window, the length of the line would be exactly one half of a mile.***

For about 20 minutes:
- Students will work in groups of two.
- Each group will have their own map, scenario, and an investigation sheet.
- Students will answer the questions on the investigation sheet and determine which building is in question.

For 10 minutes:

- Each group of students will present their discovery, and explain why it is that particular building.

For 15 minutes:
- The teacher will present the final segment in the investigation.

Using the information provided by you (i.e. the students), the police surrounded the building and there they discovered the former and now disgruntled curator was responsible for the entire situation. Arrests were made, and the artifacts were returned to the museum. The authorities send their thanks, and want you to know they couldn't have done it without your geometric expertise.

For 15 minutes:
- Students will complete their final journal entry and reflect on the case and the math involved. Students will be encouraged to think of alternative scenarios that would involve math and could be used for crime scene investigation.

Assessment
- **Pythagorean triples investigation sheet and Crack the Code**
- **Questions on investigation sheet 5**
  - Remember that a mile is 5280 feet. Each block in the town is 0.10 miles. How far is the building where the curator was seen from the coffee shop?
    - How do you know?
    - Looking at your map, which building would this be?
- **Journal/writing prompts**
  - Did you enjoy this investigation?
  - Are there other mathematical principles you could have applied to assist your investigation?

Extensions and Connections (for all students)
- Students will be encouraged to participate in a mini independent research project on how math is used to solve crimes and real world problems.
- Connect and extend mathematics into trigonometry concepts
- Connections to content in other subject areas: Science, Technology, Engineering

Strategies for Differentiation
- Students will be offered grid/graphing paper, rulers and related manipulatives to assist with sketches and constructions and address the needs of kinesthetic and visual learners.

- Teachers should promote individual discussions and assist with instructions for students with special auditory, processing, and memory needs.
- Provide assistance and special dictionaries for English language learners (ELLs);
- Provide challenging extension problems for high-ability students who breeze through the tasks and offer more depth to the level of math and thinking required.
- Provide special seating arrangements for any student with special needs. Assist students with interpreting instructions
- Read aloud items for students
- Flexible schedule (allow breaks, break large tasks into smaller tasks, allow extended time to complete tasks, etc.)

Student Investigation 5

Apply the Converse of the Pythagorean Theorem

Name_____

ID: 1

Date_____

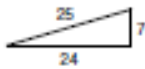**Do the following lengths form a right triangle?**
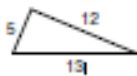
1)

2)

3)

4)

5)

6)

7)

Student Investigation 5

Apply the Converse of the Pythagorean Theorem
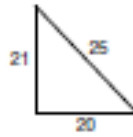
ID: 1

Name_____

Date_____

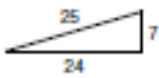**Do the following lengths form a right triangle?**

1)

4 5
3

Yes

2)

21 25
20

No

3)

25 7
24

Yes

4)

15 16
8

No

5)

12 14
9

No

6)

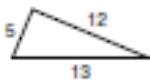

30 34
16

Yes

7)

5 12
13

Yes

Student Investigation 5

Name: _____   **Date:_____**

Crack the Code: Pythagorean Triples

Use the accompanying diagrams to record the data for triangles #2 - #7.

Verify the sequence of numbers that are Pythagorean triples and highlight the rows that represent right triangles.

Look for patterns in the data. The highlighted fields will produce a sequence of three Pythagorean triples which will be used to crack the code.

The first one is provided as an example only and is not part of the password.

Length of Leg a (units) a	Length of Leg b (units) b	Length of Hypotenuse c (units) c	Area of square with Length a (square units) a^2	Area of square with Length b (square units) b^2	Area of square with Length c (square units) c^2	$a^2 + b^2$
3	4	5	9	16	25	25

Password: __ __ __ __ __ __ __ __ __

Crack the Code: Pythagorean Triples

Record the data for the triangles you discovered.

Verify the sequence of numbers that are Pythagorean triples and highlight the rows that represent right triangles.

Look for patterns in the data. The highlighted fields will produce a sequence of three Pythagorean triples which will be used to crack the code.

The first one is provided as an example only and is not part of the password.

Length of Leg a (units) a	Length of Leg b (units) b	Length of Hypotenuse c (units) c	Area of square with Length a (square units) a^2	Area of square with Length b (square units) b^2	Area of square with Length c (square units) c^2	$a^2 + b^2$
3	4	5	9	16	25	25
20	21	25	400	441	625	841
24	7	25	576	49	625	625
8	15	16	64	225	256	289
9	12	14	81	144	196	225
16	30	34	256	900	1156	1156
5	12	13	25	144	169	169

Password: <u>24</u> <u>7</u> <u>25</u>   <u>16</u> <u>30</u> <u>34</u>   <u>5</u> <u>12</u> <u>13</u>

Lesson 5 Rubric

Student Name: _____

Assignment	0	1	2	3	Teacher Score & Comments
Investigation Sheet	Answer is completely incorrect.	Answer is partially correct, no convincing reasoning.	Mathematical concepts are correct, but lacking convincing reasoning.	Mathematical concepts are correct, demonstrates full understanding with sound mathematical reasoning.	
Journal Entry	Answer is completely incorrect.	Answer is partially correct, no convincing reasoning.	Mathematical concepts are correct, but lacking convincing reasoning.	Mathematical concepts are correct, demonstrates full understanding with sound mathematical reasoning.	
Group Presentation	Answer is completely incorrect.	Answer is partially correct, no convincing reasoning.	Mathematical concepts are correct, but lacking convincing reasoning.	Mathematical concepts are correct, demonstrates full understanding with sound mathematical reasoning.	

Overall Score for Lesson 5: _____