LESSON TITLE: THE PYTHAGOREAN THEOREM

TOTAL TIME: ONE 60-MINUTE PERIOD

BRIEF DESCRIPTION

In this *The House That STEM Built* lesson plan, students will be introduced to the Pythagorean theorem by following along with *The House That STEM Built: The Pythagorean Theorem* video. Students will have the opportunity to prove the theorem before practising real-world examples as word problems as well as in a game.

CURRICULUM OUTCOMES

Taken from the New Brunswick Grade 10 Geometry, Measurement, and Finance curriculum.

GENERAL CURRICULUM OUTCOMES

GCO Algebra (A): Develop algebraic reasoning.

GCO Geometry (G): Develop spatial sense.

SPECIFIC CURRICULUM OUTCOMES

SCO A1: Solve problems that require the manipulation and application of formulas related to perimeter, area, volume, capacity, the Pythagorean theorem, primary trigonometric ratios, income, currency exchange, interest, and finance charges.

SCO G2: Demonstrate an understanding of the Pythagorean theorem by identifying situations that involve right triangles, verifying the formula, applying the formula, and solving problems.

NEW BRUNSWICK GLOBAL COMPETENCIES ACHIEVED[1]

- Critical Thinking and Problem-Solving
  - Learners engage in an inquiry process to solve problems, as well as acquire, process, interpret, synthesize, and critically analyze information to make informed decisions.
  - Learners construct, relate and apply knowledge to all domains of life, such as school, home, work, friends, and community.
  - Learners formulate and express questions to further their understanding, thinking, and problem-solving.
  - Learners see patterns, make connections, and transfer their learning from one situation to another, including real-world applications.
- Collaboration
  - Learners learn from and contribute to the learning of others by co-constructing knowledge, meaning, and content.

LEARNING OBJECTIVES

Learners will

- prove the equation $a^2 + b^2 = c^2$,
- apply the Pythagorean theorem to answer problems involving right-angle triangles,
- identify (3, 4, 5) triangles, and
- manipulate equations to solve questions.

---

1 https://www2.gnb.ca/content/dam/gnb/Departments/ed/pdf/K12/curric/competencies/NBCompetencies.pdf?fbclid=IwAR1ldrZs1gFgiNm8rC4oz7Fmx6mSn-6t_QJkenev0eD33rZ-foYYn6bmdmc *also available at* https://tinyurl.com/nb-competencies

MATERIALS

- Video: *The House That STEM Built: The Pythagorean Theorem*.
- Video: *When not knowing Math can cost you $15,000* (https://youtu.be/BbX44YSsQ2I).
- "Pythagorean Theorem Proof" activity (one per person).
- "Pythagorean Theorem Word Problem Practice" (to be done together or individually).
- "I Have... Who Has...?" activity (one per class).
- Writing utensils.
- Scissors.

MINDS ON: 15 MINUTES

GROUPING: ENTIRE CLASS

Today, we are going to start learning about the Pythagorean theorem. We are going to discover what it is, how to use it, where to use it, and then do some practice. To get started, watch *The House That STEM Built: The Pythagorean Theorem* video.

Included in this video are some opportunities to stop and solve practice problems together. Feel free to pause the video and ask some or all of the following questions to prompt discussions.

- 1:40 – This might seem like a basic question, but what characteristics do right-angle triangles have that other triangles do not? What is the name of the longest side?
- 2:26 – Why do you think a and b can be used interchangeably?
- 2:36 – The formula that we are working with is $a^2 + b^2 = c^2$. Why is it not $a + b = c$? Where do the square numbers come from?
- 2:42 – Correction to the definition "In a right angle triangle, the

square of the hypotenuse is equal to the sum of the squares of the other two sides."

- 3:09 – When do you think right-angle triangles are used when building a house? Can you think of any examples?

- 3:56 – Let's take a look at this example together. The equation we will always be using is $a^2 + b^2 = c^2$. If we substitute in the values we have been given for a and b, we get

$$(3\text{ m})^2 + (4\text{ m})^2 = c^2$$
$$9\text{ m}^2 + 16\text{ m}^2 = c^2$$
$$25\text{ m}^2 = c^2$$

  - Is 25 m^2 the answer to the question? Not quite, because $25\text{ m}^2 = c^2$, not c. We now need to find the square root of 25 m^2 to give us the length of the stairs in metres.

$$c = \sqrt{25\text{ m}^2}$$
$$c = 5\text{ m}$$

  - This question is a classic example of a Pythagorean triple. If we multiply all of the sides by the same number (any number) the result will be a right-angle triangle whose sides are in the ratio of (3, 4, 5). For example, (6, 8, 10), or (9, 12, 15).

- 5:35 – One more example. In this example, we are given c which is equal to 4 m. a is equal to 2.8 m. This time we are going to have to rearrange our $a^2 + b^2 = c^2$ equation to solve for b. If we subtract a^2 from both sides of the equation we can isolate b^2 by itself giving us $c^2 - a^2 = b^2$. If we substitute the values we were given, we have

$$(4\text{ m})^2 - (2.8\text{ m})^2 = b^2$$
$$16\text{ m}^2 - 7.8\text{ m}^2 = b^2$$
$$b^2 = 8.2\text{ m}^2$$
$$b = \sqrt{8.2\text{ m}^2}$$
$$b \approx 2.9\text{ m}.$$

ACTIVITY: *7* MINUTES

GROUPING: INDIVIDUAL

Hand out copies of the “Pythagorean Theorem Proof” activity to each student.

Students will follow the directions by cutting and rearranging the shapes. This will provide them with a visual representation of the theorem that they can paste into their books or hold onto for future use.

PRACTICE ACTIVITY: 15 MINUTES

GROUPING: INDIVIDUAL OR AS AN ENTIRE CLASS

The attached word problems can be tackled individually or as a class. If you want students to practice on their own, feel free to print out a copy of the questions for each student or project them onto the board. If you wish to do them as a class they can be projected.

ACTIVITY: 18 MINUTES

GROUPING: ENTIRE CLASS

Before class, print off the “I Have... Who Has...?” Pythagorean theorem game and cut out each of the statement cards.

Hold on to the starting card for yourself and hand out the rest of the cards to each of the students.

Once the slips have been handed out, start by reading your starting statement, “I have... Who has...?” Whoever has the answer to the question on your card reads their statement, continuing the chain.

Feel free to take your time to work out the solutions together or allow students a few moments before you begin to solve their respective questions. You can also split the class into two groups and reduce the length of the chain to allow for smaller group sizes.

CONCLUSION: 5 MINUTES

GROUPING: ENTIRE CLASS

Ask students to think for a moment about where it might be important to know how the Pythagorean theorem.

Play the video *When not knowing Math can cost you $15,000* and pause it after the question has been read. Ask students to vote on what answer they think is correct before watching the rest of the video.

DIFFERENTIATION

CONTENT

Use *The House That STEM Built: The Pythagorean Theorem* video to spark a conversation about careers other than construction that would require knowledge of the Pythagorean theorem (e.g., farming, fashion design, urban planning, land surveying, etc.).

Do your students take a shop/building technology class? Are there any opportunities for a cross-subject project?

Do right-angle triangles play a role in modern art? Take a look at different examples of art and identify all of the right angles.

PRACTICE

How many right-angle triangles can you find in your class? In your school? Ask students to measure two sides of a triangle (small or large) and use the Pythagorean theorem to solve for the third side. This could be done inside the classroom or outside.

Create a Kahoot quiz game (https://kahoot.com/schools-u/). Ask students in teams to find the answers to different questions asked. These questions can be in any format that you like and include anything about the Pythagorean theorem.

Task cards can be a great way for students to practice and get the

chance to move. Create 20–25 Pythagorean theorem questions on card stock, number them, and post them around the room. Ask students to list 1–20 or 25. They can start at any of the cards and do them in any order, but the goal is that students finish the questions.

PRODUCT

Ask students to explain to an alien what the Pythagorean theorem is. What is it? When do you use it? How does it work? This could be done as a writing piece, a video, or a pamphlet.

What is the Pythagorean theorem? Create a music video explaining what it is. This could be a parody or a completely original tune. There are many examples on YouTube to use as inspiration.

Doodle notes are a great way for students to take valuable class notes that allow them to use illustrations, colours, and creativity. Check out https://www.doodlenotes.org/ for tutorials and examples. Ask students to create some doodle notes about the Pythagorean theorem. They must clearly explain how it works and where it is used.

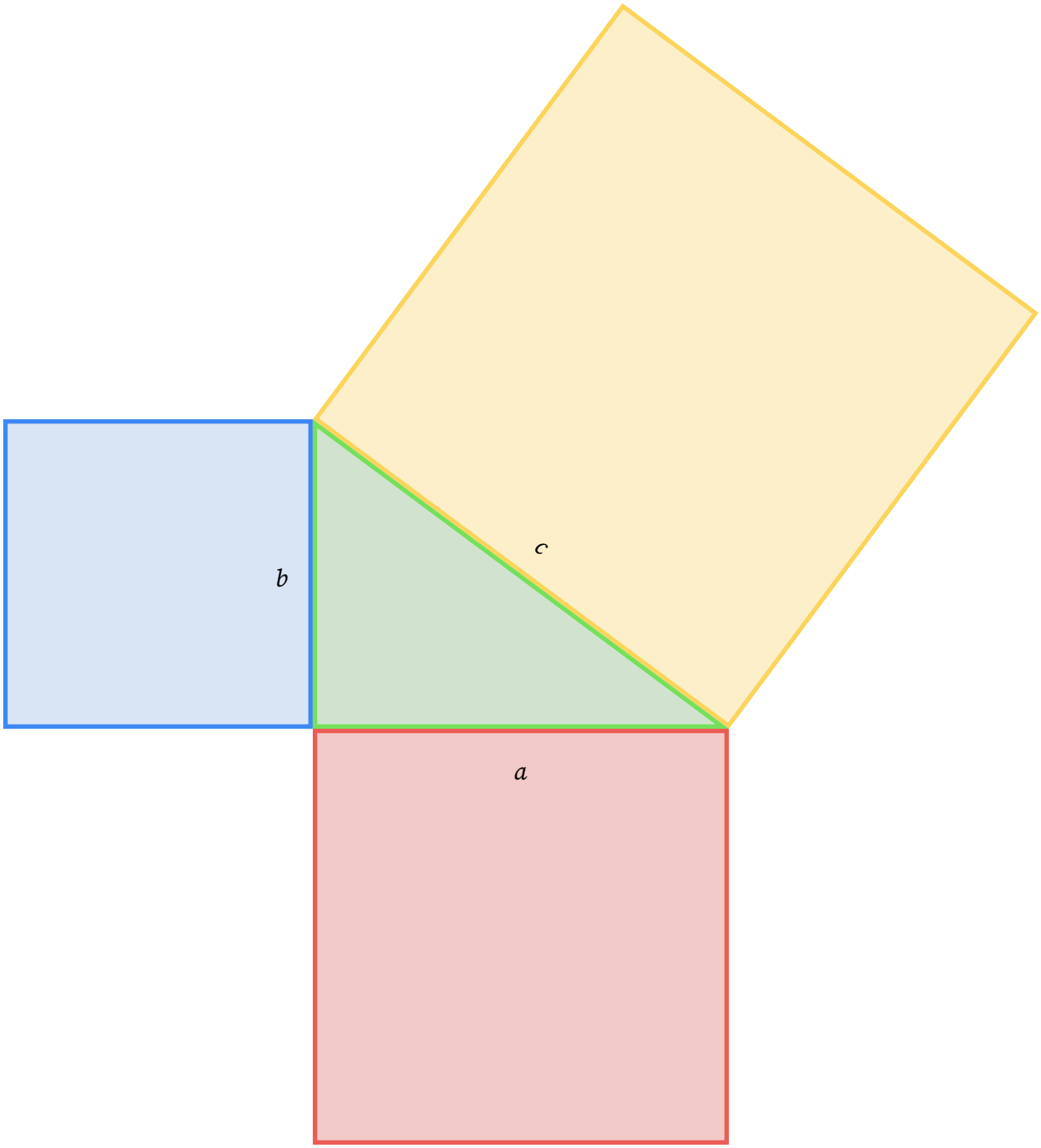
EXTENSION

Board games can be a great way to learn. In teams, students can physically or digitally create a board game that involves the Pythagorean theorem. Once teams finish, they can swap with another team. Multiple game templates can be found at https://flippity.net/. Students can create breakout rooms, bingos, board games and more by editing the template details in Google Spreadsheets.

If students are familiar with the Pythagorean theorem, they can be introduced to the trigonometric functions of sine, cosine, and tangent. Ask them to create a doodle note explaining SOHCAHTOA.

PYTHAGOREAN THEOREM PROOF

In this *The House That STEM Built* video, we were told that $a^2 + b^2 = c^2$. But how can we prove or show that that is the case? Cut out the shapes below and label all of the sides. Cut and arrange the b square and the a square so that they match or fill in the c square. Good luck!



PYTHAGOREAN THEOREM WORD PROBLEM PRACTICE

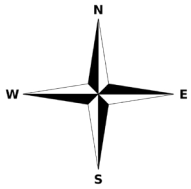
The Pythagorean theorem can be used in many different situations to calculate a side of a right-angle triangle. Give it a try with some of the following word problems. It is best to draw the situation first before solving it. Remember to show your work!

$$a^2 + b^2 = c^2$$

1. A ladder is leaning up against a wall. The base of the ladder is 1.5 m away from the wall. The top of the ladder is 3.5 m off the ground. How long is the ladder?

2. A wheelchair ramp is built at the local community centre. The piece of wood used to create the incline was 6 feet long. If the height of the ramp is 3 feet, how long is the base of the ramp?

3. Ben walks 5 blocks north and 7 blocks east to reach school every day. How far away is the school from Ben's house?



4. A robin is sitting 10 m away from the base of a telephone pole. The robin flies 14 m to reach the top of the pole. How tall is the pole?

PYTHAGOREAN THEOREM WORD PROBLEM PRACTICE ANSWER KEY

The Pythagorean theorem can be used in many different situations to calculate a side of a right-angle triangle. Give it a try with some of the following word problems. It is best to draw the situation first before solving it. Remember to show your work!

$$a^2 + b^2 = c^2$$

1. A ladder is leaning up against a wall. The base of the ladder is 1.5 m away from the wall. The top of the ladder is 3.5 m off the ground. How long is the ladder?

$a^2 + b^2 = c^2$

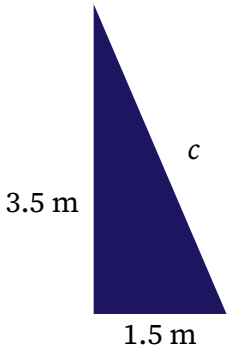
$(1.5\text{ m})^2 + (3.5\text{ m})^2 = c^2$

$2.25\text{ m}^2 + 12.25\text{ m}^2 = c^2$

$14.5\text{ m}^2 = c^2$

$c = \sqrt{14.5\text{ m}^2}$

$c = 3.81\text{ m}$



2. A wheelchair ramp is built at the local community centre. The piece of wood used to create the incline was 6 feet long. If the height of the ramp is 3 feet, how long is the base of the ramp?

$a^2 + b^2 = c^2$

$c^2 - a^2 = b^2$

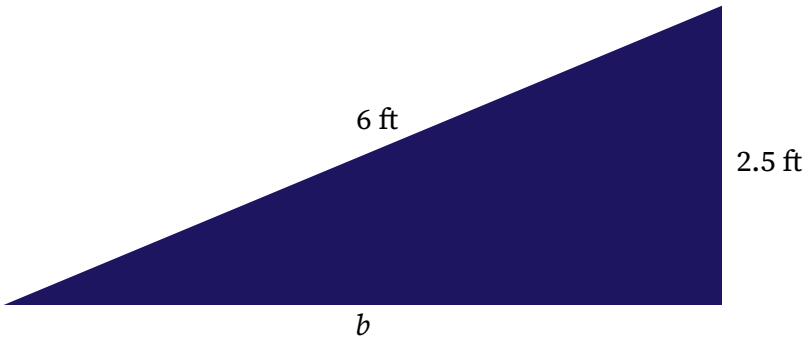
$(6\text{ ft})^2 - (2.5\text{ ft})^2 = b^2$

$36\text{ ft}^2 - 6.25\text{ ft}^2 = b^2$

$29.75\text{ ft}^2 = b^2$

$b = \sqrt{29.75\text{ ft}^2}$

$b = 5.45\text{ ft}$



3. Ben walks 5 blocks north and 7 blocks east to reach school every day. How far away is the school from Ben's house?

$a^2 + b^2 = c^2$

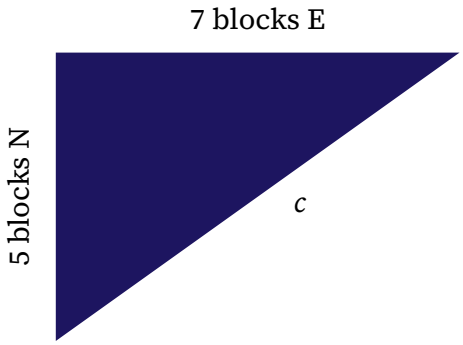
$(5 \text{ blocks})^2 + (7 \text{ blocks})^2 = c^2$

$25 \text{ blocks}^2 + 49 \text{ blocks}^2 = c^2$

$74 \text{ blocks}^2 = c^2$

$c = \sqrt{74 \text{ blocks}^2}$

$c = 8.6 \text{ blocks}$



4. A robin is sitting 10 m away from the base of a telephone pole. The robin flies 14 m to reach the top of the pole. How tall is the pole?

$a^2 + b^2 = c^2$

$c^2 - a^2 = b^2$

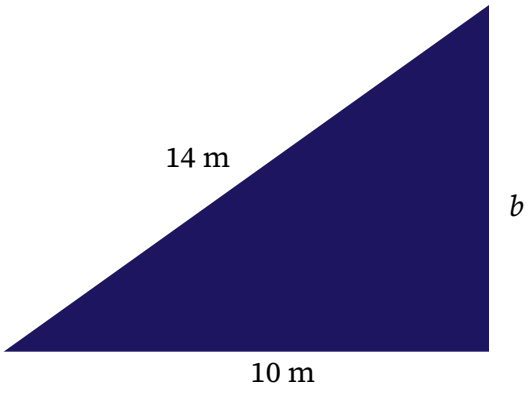
$(14 \text{ m})^2 - (10 \text{ m})^2 = b^2$

$196 \text{ m}^2 - 100 \text{ m}^2 = b^2$

$96 \text{ m}^2 = b^2$

$b = \sqrt{96 \text{ m}^2}$

$b = 9.8 \text{ m}$

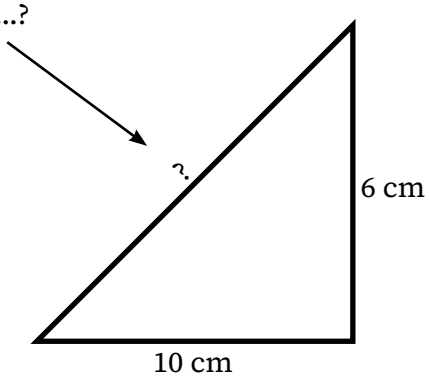


"I HAVE... WHO HAS...?" PYTHAGOREAN THEOREM GAME

To start this activity, cut out each of the cards. The facilitator holds on to the "starting card", the rest can be shuffled and handed out to the class. You can choose to give everyone a few moments to solve their respective questions or choose to do them as a class if you get stuck along the way. Start the game by reading the "I have... Who has...?" phrase. Whoever has the answer to your question continues the chain. Have fun!

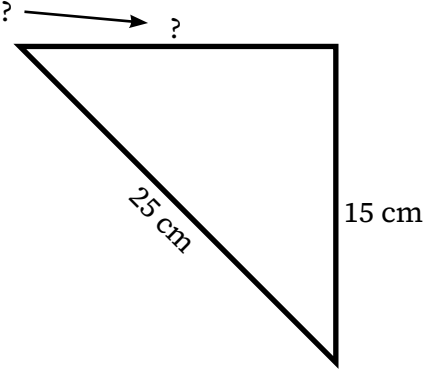
I have 5.7 cm. STARTING CARD

Who has...?



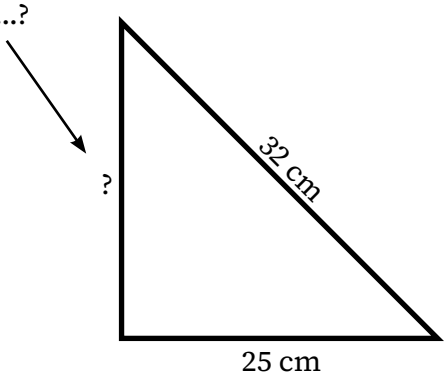
I have 11.7 cm.

Who has...?



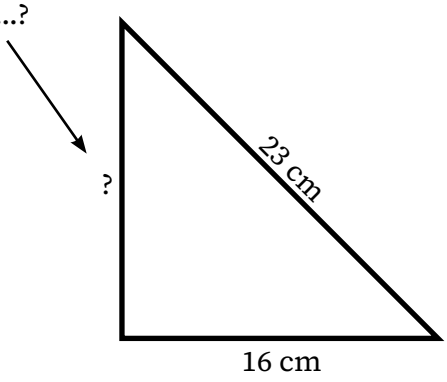
I have 20 cm.

Who has...?



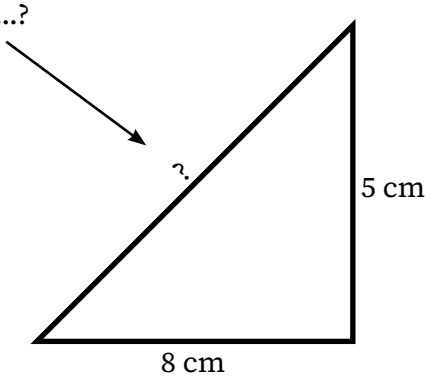
I have 19.9 cm.

Who has...?



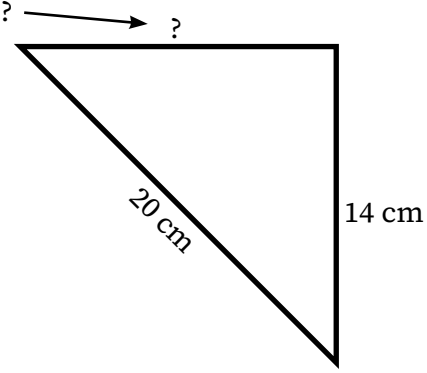
I have 16.5 cm.

Who has...?



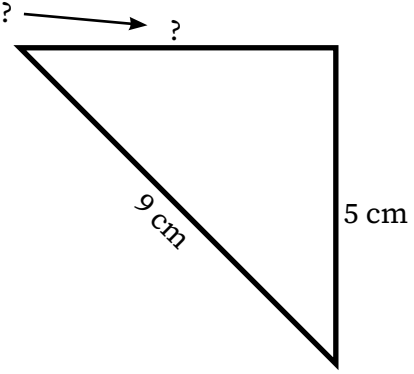
I have 9.4 cm.

Who has...?



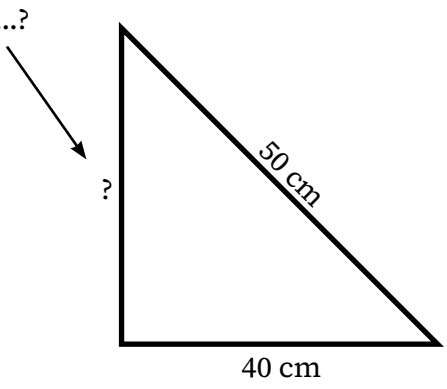
I have 14.3 cm.

Who has...?



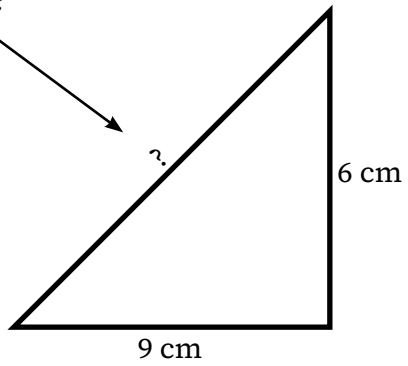
I have 7.5 cm.

Who has...?



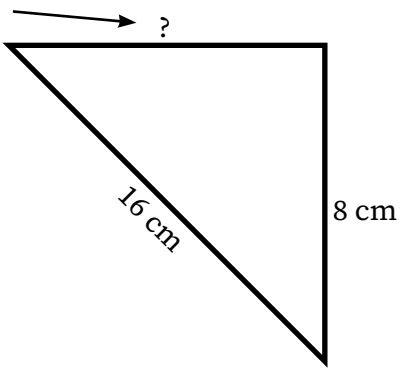
I have 30 cm.

Who has...?



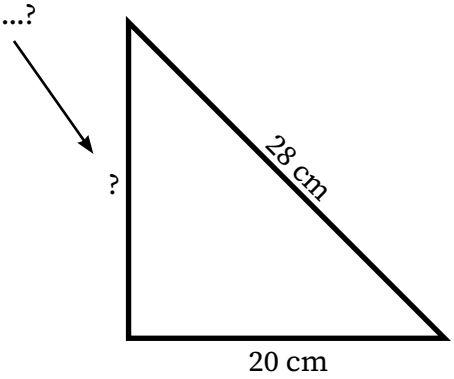
I have 10.8 cm.

Who has...?



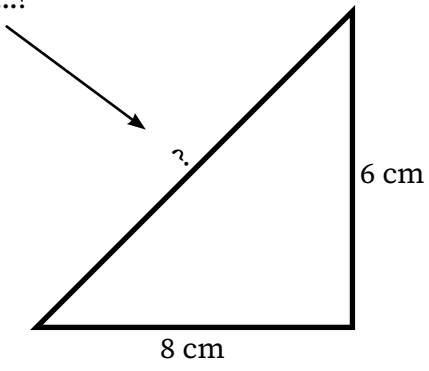
I have 13.8 cm.

Who has...?



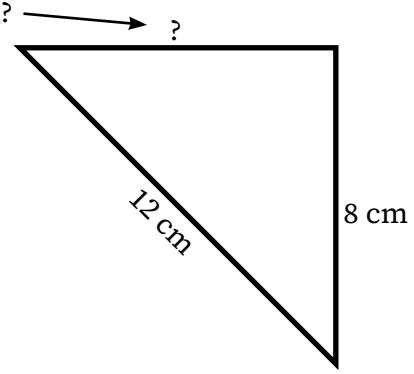
I have 19.6 cm.

Who has...?



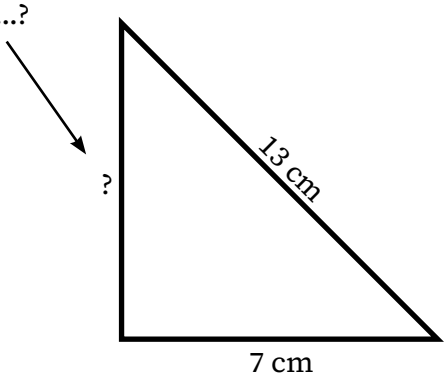
I have 10 cm.

Who has...?



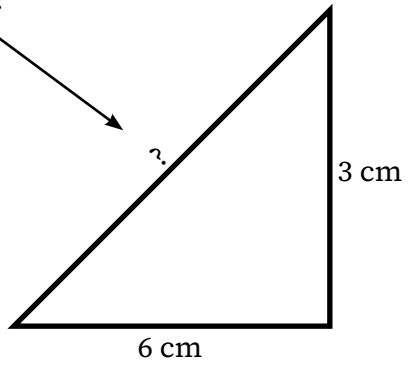
I have 8.9 cm.

Who has...?



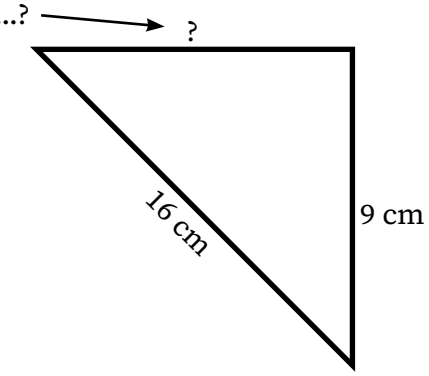
I have 10.9 cm.

Who has...?



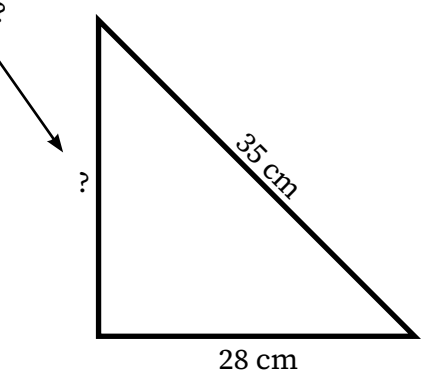
I have 6.7 cm.

Who has...?



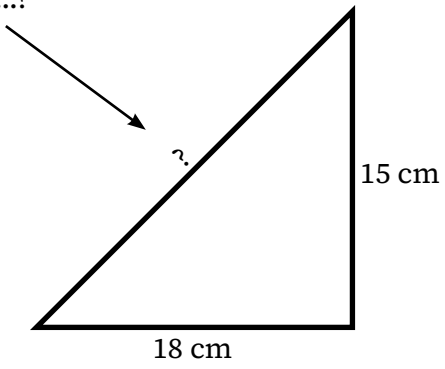
I have 13.2 cm.

Who has...?



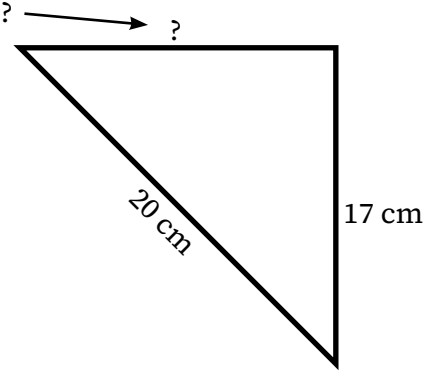
I have 21 cm.

Who has...?



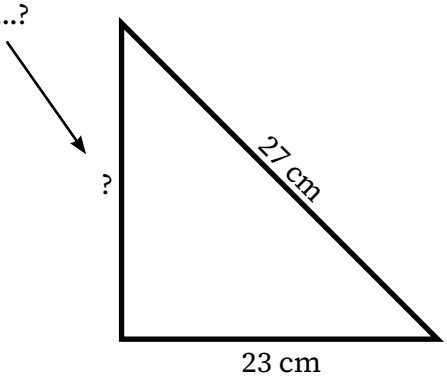
I have 9.9 cm.

Who has...?



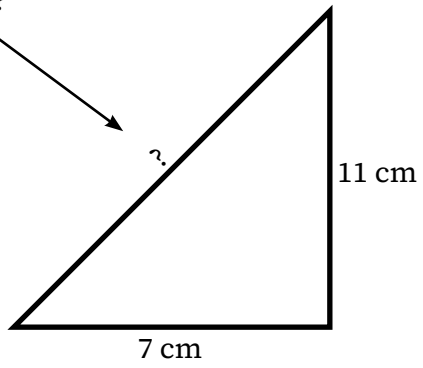
I have 10.5 cm.

Who has...?



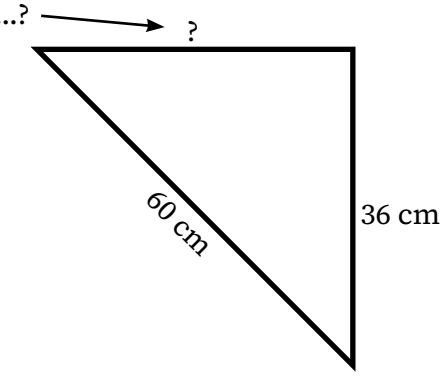
I have 14.1 cm.

Who has...?



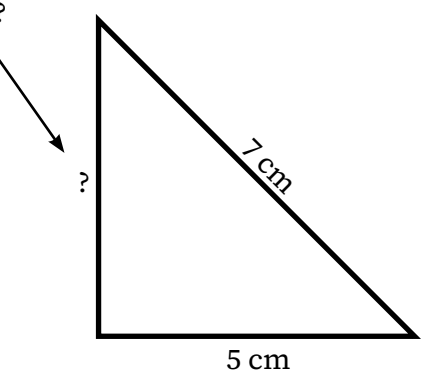
I have 13 cm.

Who has...?



I have 48 cm.

Who has...?



I have 4.9 cm.

Who has...?