

Check out Those Legs!

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Fort Defiance HS, Ft. Defiance, VA

Time: One 90 minute class

Grade Level: 8 – 10

Subject: Math

Learning Objectives:

On completion of this lesson students will be able to use the Pythagorean Theorem to solve problems involving right triangles. Prerequisites: Students should be familiar with triangles classified by the lengths of their sides: scalene, isosceles, and equilateral, and by their angles: acute, obtuse and right.

Standards:

This lesson addresses Va. SOLs

8.10 The student will

- a) verify the Pythagorean Theorem, using diagrams, concrete materials, and measurement; and
- b) apply the Pythagorean Theorem to find the missing length of a side of a right triangle when given the lengths of the other two sides.

G.7 The student will solve practical problems involving right triangles by using the Pythagorean Theorem, properties of special right triangles, and right triangle trigonometry. Solutions will be expressed in radical form or as decimal approximations.

Media Components/Technology:

Video:

- *Project Mathematics*: “The Theorem of Pythagoras: Three Questions from Real life.” (2:52) This is available from United Streaming.
<http://www.unitedstreaming.com/search/assetDetail.cfm?guidAssetID=7C2A099D-66F4-482F-82C9-A8920B569882>
- *Math Vantage* , #8, “Trusting Triangles” available from Blue Ridge PBS
- <http://www.pbs.org/wgbh/nova/proof/puzzle/theorem.html>

Smart Board

Geometer’s Sketchpad Software

Materials:

For the Teacher:

- You may use the Smart Board to demonstrate the Geometer's Sketchpad Activity or students can go to the computer lab to do the Geometer's Sketchpad Activity individually or in pairs.

For the Student:

- Paper, pencil, and straight edge or ruler.
- Glue stick for each pair of students
- Scissors for each student
- Two copies of the attached worksheet, copied in color.
- A copy of the directions from the Culminating Activity, using Geometer's Sketchpad

Prep for Teachers

- Familiarize yourself with the lesson format.
- Prior to teaching, have all Internet sites bookmarked
- Preview the video clips and fast forward *Math Vantage* #8 "Trusting Triangles" for 2:15 minutes until you see Ellen, wearing yellow rain gear, standing under a ladder. You will start the video at this point.
- Download *Project Mathematics: "The Theorem of Pythagoras: Three Questions from Real Life"* from United Streaming and have it ready to access for the lesson.
- Set up the Personal Response System and have Power Point Quiz ready for Assessment.
- Make copies of the directions found in the Culminating Activity, using Geometer's Sketchpad.

Introductory Activity

(You will begin with the first video segment: *Math Vantage*, #8 "Trusting Triangles". Start at end of Ch. 18: 1:12:32 or 2:15 minutes into the program after the Math Vantage logo appears. You will see Ellen Withrow, wearing yellow rain gear, and standing underneath a ladder.)

Provide a Focus for media Interaction by saying: "Today we are going to be learning about the Pythagorean Theorem. We'll be watching two different video clips to learn what the Pythagorean Theorem is, and then what questions can be answered by using this theorem."

Focus: "I want you to listen to the hostess, Ellen Withrow, as she tells us what kind of triangles we are going to be studying today."

Play *Math Vantage*, #8 "Trusting Triangles". **Pause** after you hear her say, "But never an equilateral triangle."

Ask: "What kind of triangle are we discussing today and how did they get that name?" (It's a right triangle, because it has a 90 degree angle or a right angle.)

Say: "Ellen says that a right triangle can be isosceles or scalene but never equilateral. I want you to draw an example of an isosceles right triangle and a scalene right triangle. Can

you draw an equilateral right triangle? Why or why not?" (An equilateral triangle must have three 60° angles.)

Focus: "Next I want you give me the names of the sides of a right triangle. "

Resume and **Pause** when you see the ladder labeled "Hypotenuse".

(The two sides forming the right angle are called legs and the longest is the hypotenuse.)

Focus: "Now listen for the name and formula of the theorem that Ellen discusses and be able to describe how the theorem works."

Resume and **Pause** after the demonstration showing the two smaller squares fitting into the square on the hypotenuse.

Ask: "What's the name of the theorem?" (The Pythagorean Theorem) "And what is the formula for the Pythagorean Theorem?" ($\text{Leg}^2 + \text{Leg}^2 = \text{Hypotenuse}^2$) "And how does the theorem work?" (The squares of the smaller two sides fit into the square on the hypotenuse.)

Focus: "How is the Pythagorean Theorem used?" (If we know two sides of a right triangle, then we can find the length of the third side.)

Resume and **Stop** when Ellen exits and a black triangular shape appears with Ellen sitting on it.

Second Viewing Activity:

Focus: "Now we are going to look at another video clip to see if we can learn about some questions that can be answered by using the Pythagorean Theorem.

Listen to the clip from Project Mathematics and tell me what the first question is that can be answered by using the Pythagorean Theorem."

Play: *Project Mathematics*: "The Theorem of Pythagoras: Three Questions from Real Life." Pause at 00:53 after seeing the triangle being pulled apart and the narrator says "but how much smaller is it?"

Say: "Describe the first situation and tell me what question can be answered by using the Pythagorean Theorem?" (How much shorter is it to run along the diagonal of a rectangle than to run around the edges of the rectangle?)

Focus: "Listen and watch the second situation so that you can tell me how else the Pythagorean Theorem is used."

Resume and **Pause** at 1:29 when you hear the narrator say "How long should the ladder be to reach the top of the wall?"

Ask: "What is the second question and what information do we know? (If we know the height of the wall and the width of the moat, how long should the ladder be to reach the top of the wall?)

Focus: Now I want you to describe the third situation posed by this video.

Resume and **Stop** at the end of the video clip.

Ask: "What was the third situation in which we can use the Pythagorean Theorem?"

(Knowing the height of the tower and the length of the guy wire, where should the guy wire be fastened on the ground so that the tower will be vertical when lifted into place?)

Ask: "So if the altitude is 10 yds. and the guy wire is 12 yds., how long is the other side?" ($2\sqrt{11}$ yds. or approximately 6.63 yds.)

Focus: "Can you state the Pythagorean Theorem for me, and tell me why is it used?" (Leg squared plus leg squared equals the hypotenuse squared. The Pythagorean Theorem is used to find the third side of a right triangle when you are given the other two sides.)

Say: “Ok, let’s try doing the geometric experiment that Ellen showed us! We are going to try it in two different ways, one online and one with paper and scissors.”

Learning Activities:

NOVA online <http://www.pbs.org/wgbh/nova/proof/puzzle/theorem.html> Click on this website and follow the directions for the activity.

1. Try dragging the squares of the sides to the square on the hypotenuse. Did it work for you?

Say: “Now it is your turn to see if you can get the two smaller squares to fit into the largest one.”

2. Hand out two copies of the attached worksheet and scissors to each student and glue sticks to each pair of students.

3. Students should cut out smaller squares and glue them on top of the largest square on the second worksheet.

4. Discuss why this works.

Ask: “What were the lengths of the sides? What was the length of the hypotenuse? Most of the examples we have seen were 3-4-5 triangles! But will the Pythagorean Theorem work for any right triangle? Let’s see!”

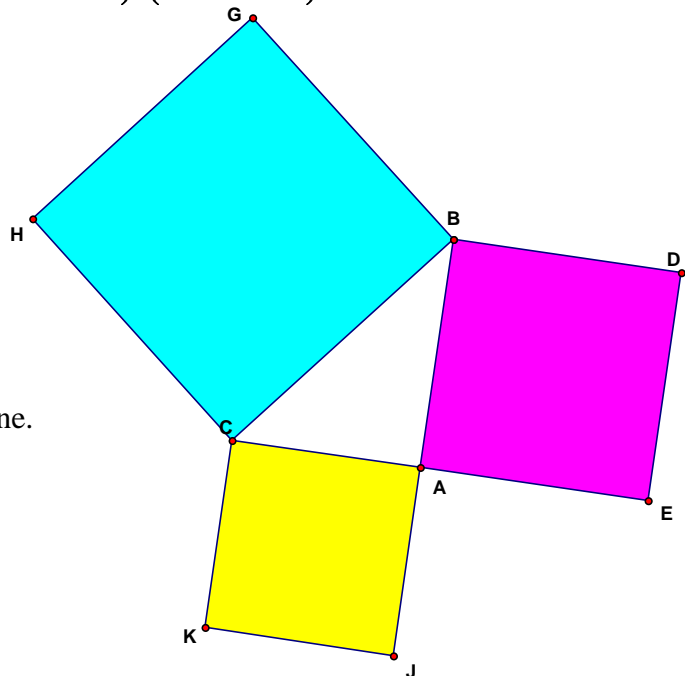
Culminating Activities:

Proving the Pythagorean Theorem Works for All Right Triangles

Say: “We’re going to find out if the Pythagorean Theorem works for any right triangle by creating a tool to make right triangles and the squares on each of the sides of the triangle. Then we’ll find the area of each square, add the 2 squares on the legs and see if it equals the area of the square of the hypotenuse.”

Geometer’s Sketchpad Activity:

Area AJKC = 17.85 cm²	AC = 4.23 cm
Area EABD = 26.36 cm²	BA = 5.13 cm
Area CHGB = 44.21 cm²	BC = 6.65 cm
(Area AJKC)+(Area EABD) = 44.21 cm²	



1. Open a new sketch. Using the segment tool, draw a segment.
2. Label the segment AB.
3. Select the segment AB and point A and go to the Construct Menu and Construct a Perpendicular Line.
4. Put a point on the perpendicular line

with the point tool. Label that point C.

5. With the arrow tool, select points A, B, and C and go to the Construct Menu and construct segments.

6. Once the triangle is drawn, click outside the triangle then select the perpendicular line. Go to the Display menu and click Hide Perpendicular Line so that only the right triangle ABC shows.

7. Drag the triangle to see if it holds together.

8. Measure each side of the triangle by selecting the sides and then going to the Measure Menu and clicking on Length.

9. Double Click on point A so that it flashes. Select point B and segment AB. Go to the Transform menu and click on Rotate and change the angle measure to 90° . If the segment does not go in the correct direction, make the angle of rotation -90°

10. Double click on point B, then select point A and segment AB then go to the Transform Menu and click on Rotate and if the resulting segment looks like it is going the wrong direction then change the sign of the 90° angle of rotation. You will see the location where the segment will be rotated.

11. Select the new endpoints that you have created and construct a segment, thus creating a square with one side AB.

12. Repeat this for sides BC and AC. You have now constructed squares on the sides of each leg and hypotenuse of the triangle.

13. Select the vertices (do not select the sides) of the smallest square and go to Construct then to Quadrilateral Interior. Repeat this for the other two squares. Students might want to change the color of the squares by going to Display then to Color and choosing a different color while the polygon interior is selected.

Now it is time to see if the sum of the squares of the legs of the right triangle equals the square of the hypotenuse.

14. Select the area of each of the squares and go to the Measure Menu and select area. All three areas will show up.

15. Go to the Measure Menu and select Calculate. Click on the smallest square's area, type +, then click on the middle size square's area and click ok. Check to see if the sum of those equals the area of the third square.

16. Drag one vertex of the triangle and see if this is always true for any right triangle. Now let's create a Pythagorean Theorem Tool.

17. Select the entire figure, go to the double arrows on the tool bar and hold it down for a couple of seconds. The Create New Tool Menu should show up.

18. Click on it then name the tool Pythagorean Theorem. Hold the double arrows down again and you will see your new tool that has been created.

19. Click on Pythagorean Theorem and notice that the selection arrow now has a red dot on the end of it. Click and drag in the sketch and a new set of squares on the sides of a right triangle will be created.

Some students might think that the Pythagorean Theorem works for every triangle. Have students repeat the process but use any triangle instead of constructing a right triangle.

They can then determine if the Pythagorean Theorem works for any triangle.

What conclusions can you draw from this activity? (The Pythagorean Theorem only works for right triangles.)

Assessment:

Students will use the Personal Response System to determine if the Pythagorean Theorem should be used to solve these questions. Sample questions have been taken from the SOL released tests. Due to the various lengths of time it takes students to solve individual problems, I do not recommend using the PRS to find the solutions, you could print out the questions or they can go online to take practice SOL questions.

<http://www.pen.k12.va.us/VDOE/Assessment/releasedtests.html>

Go back to <http://www.pbs.org/wgbh/nova/proof/puzzle/theorem.html> and click on “How can I use the Pythagorean Theorem to solve real problems?”. Have students solve the two problems shown on this website. They may also try the more challenging pyramid problem.

Cross-Curricular Extensions

- Physical Education-Have one student pace off the diagonal from home to second base and the other pace off the distance from home to second, going around the base line. Compare the two numbers.
- Art. Have students create artwork using right triangles.
- Social Studies: Students can find the length of the face of the pyramids if they know the height and the length of one of the bases (cut it in half.)

Community Connections

- Sports: Have a baseball recruiter visit class to discuss what they are looking for in a baseball player. Why is it important to know how fast someone can throw the ball to the bases vs. how fast the player can run the bases?
- A tile mason or carpenter could be invited to come to class to discuss how the Pythagorean Theorem is used in the building trades.

Name _____

Date _____

SOL 8.10 and G.7

Cut out the two smaller squares. On the second worksheet glue those pieces within the boundaries of the largest square. What relationship do you notice?

