LESSON PLAN – Sabbath Middle School		
Grade Level:	8	**Title**: Construction with the Pythagorean Theorem **Author**: Kyle Linford
Enduring Understanding:		The students will develop an understanding of the Pythagorean theorem and how to utilize square roots and fractions by creating 3D models.
Overview:		Students will explore and develop their understanding of the Pythagorean theorem, square roots, and fractions. After exploring architecture that utilizes these concepts, students will practice their understanding by creating their own physical and virtual 3D models of structures and then calculating the dimensions of this design. After the students have finished this activity, they will analyze their creation for design and correctness.
Objectives:		SWBAT: Utilize the Pythagorean Theorem to determine unknown side lengths. Calculate square roots of real numbers with a calculator Measure distances using measuring tools Graph 3D designs in GeoGebra Convert mixed numbers into improper fractions and vice versa Multiply fractions

Content Standard(s):

CCSS.MATH.CONTENT.8.G.B.7—Apply the Pythagorean theorem to determine unknown side lengths in right triangles in real-world and mathematical problems in two and three dimensions.

CCSS.MATH.CONTENT.HSG.SRT.C.8—Use trigonometric ratios and the Pythagorean Theorem to solve right triangles in applied problems.

CCSS.MATH.CONTENT.6.G.A.1—Use square root and cube root symbols to represent solutions to equations of the form $x^2 = p$ and $x^3 = p$, where p is a positive rational number. Evaluate square roots of small perfect squares and cube roots of small perfect cubes. Know that is $\sqrt{2}$ irrational.

CCSS.MATH.CONTENT.7.NS.A.2—Apply and extend previous understandings of multiplication and division and of fractions to multiply and divide rational numbers.

CCSS.MATH.CONTENT.7.NS.A.2.C—Apply properties of operations as strategies to multiply and divide rational numbers.

CCSS.MATH.CONTENT.5.NF.B.6—Solve real world problems involving multiplication of fractions and mixed numbers, e.g., by using visual fraction models or equations to represent the problem.

Art Standard(s):

VA:Cr1.1.4a—Brainstorm multiple approaches to a creative art or design problem.

VA:Cr1.1.6a—Combine concepts collaboratively to generate innovative ideas for creating art.

VA:Cr1.1.8a—Document early stages of the creative process visually and/or verbally in traditional or new media.

VA:Cr1.2.7a—Develop criteria to guide making a work of art or design to meet an identified goal.

VA:Cr2.1.8a—Demonstrate willingness to experiment, innovate, and take risks to pursue ideas, forms, and meanings that emerge in the process of art-making or designing.

VA:Cr2.3.8a—Select, organize, and design images and words to make visually clear and compelling presentations.

VA:Cr3.1.7a—Reflect on and explain important information about personal artwork in an artist statement or another format.

VA:Pr4.1.6a—Analyze similarities and differences associated with preserving and presenting two-dimensional, three-dimensional, and digital artwork.

VA:Pr5.1.8a—Collaboratively prepare and present selected theme-based artwork for display, and formulate exhibition narratives for the viewer.

Materials: Spaghetti Mini Marshmallows Pencils Tablets with GeoGebra	**Other Resources**: http://www.interestingamerica.com/2011-01-03_Flatiron_Building_New_York_by_R_Grigonis.html http://www.aviewoncities.com/nyc/flatiron.htm https://stephenbeck777.wordpress.com/2010/06/02/using-the-pythagorean-theorem-in-the-real-world/ https://www.pinterest.com/alsubait/0-greek-period/
Vocabulary: Pythagorean Theorem Legs of a Triangle Hypotenuse 3D Model	**FROM THE NATIONAL ARTS STANDARDS**-- **Create**: Students create their own design by utilizing right triangles. **Present**: Students share their designs and calculations with the class. **Respond**: Students check for correctness and analyze their use of triangles to develop an affective structure. **Connect**: Students connect and compare their art works to that of Wassily Kandinsky and Piet Mondrain, while reflecting on how they can further develop the piece.
Assessment Strategies **FORMATIVE**: Class discussion on the parts of a triangle and how to use the Pythagorean Theorem. **SUMMATIVE**: Completion of the construction activity.	
Instructional Activities & Strategies	
ENGAGE: (5 minutes) Students will be presented with architecture and visual mathematical representations that utilize right triangles for designs. They will be asked to identify what they see, what they think of the art pieces, and what questions they have because of them. The class will be guided into discussing the use of triangles to construct these pieces, particularly right triangles. The instructor will check for the understanding of and clarify the Pythagorean theorem and identify the different components of a right triangle.	
BUILD: (5 minutes) Students will then be asked to hypothesis why architects and builders utilize these shapes in their designs and how the Pythagorean Theorem helps aid them. The instructor should guide the discussion to the strength of triangular shapes and properly understanding the dimensions of their creation. Once students have had time to respond, the class will discuss how understanding benefits of different shapes allows individuals to better understand how structures are created. The instructor should connect this idea back to the use of tensegrity structures.	
APPLY: (35 minutes) Students will apply their knowledge of the Pythagorean Theorem, square roots, and fractions by creating physical and virtual models of original structures that utilize right triangles. To do this activity, students will be organized into groups of 4 or 5 with individual roles for each of the group members. Roles for the activity include Head Drawer, Head Builder, Head Recorder, Head Measurer, and Head Grapher. Each group will be given the responsibility of creating a freestanding structure out of their materials that utilizes right triangles. To begin the activity, the groups will define their individual roles and begin planning their design; this planning stage should include sketches of different possible designs. Then, groups will begin to create a physical representation of the structure they determined to design. Each group will then be required to measure and record the dimensions of their structure; using the Pythagorean Theorem, students will verify their design as incorporating right triangles. The groups will then calculate the actual size of their structure by multiplying their dimensions by a given scale factor and recording these new dimensions. When completed with the physical structure, the group will then create a virtual representation using the 3D graphing feature on the app GeoGebra. The breakdown for this activity should be organized in a way that provides students individual, smaller	

tasks to be completed rather than doing everything at once. The suggested breakdown is as follows: define group roles, plan design and sketch, construct design, measure the dimensions, verify with the Pythagorean Theorem, graph on GeoGebra. See the attached activity handouts for each of the specific requirements. Before students begin the activity, the instructor will inform students about the creation, how to use the materials effectively, and how to utilize the GeoGebra app on the tablets. The exploration of the app should also discuss the individual responsibilities students have with the technology and how to properly operate and treat the technology. The instructor should also present the class with the required rubric for the activity.

REFLECT: (7 minutes) The students will review their final product and determine their correctness. Each group will then be asked to present their structures and the methodology they used to create the design. One member from each group will be asked to present the design (physical and virtual) and describe why this design should be selected for a potential building. Their explanation should describe how right triangles were utilized and how they help the design of the structure. Students will then analyze and critique the different designs to determine effectiveness.

RUBRIC: See attachment.

ANY ADDITIONAL INFORMATION

The last 3 minutes of class will be spent cleaning up and reorganizing the classroom.

Name: _____

Activity – Construction with the Pythagorean Theorem

Task: For this project, you will be working in groups to create a structure out of your materials that uses triangles. The structure is to be a model for a potential building. You will have the class period to create your structure, find its dimensions, and describe the dimensions of the actual building. Each person in your group is to help create this structure, so every group member will select a role for the group. When everyone has a job, your group can begin working through each of the steps. Make sure to show all of your work.

Jobs

Head Drawer: _____ Head Builder: _____

Head Recorder: _____ Head Measurer: _____

Head Grapher: _____

Preliminary Sketch

Sketch 3 different designs for potential structures and circle the one you will use.

Dimensions
Fill out the below measurements in inches.

- Structure Height:
- Base Shape:
- Base Dimensions:

Verify
Find the right triangles you used in your design. Measure their dimensions and record them below. Then, using the Pythagorean Theorem, verify that the measurements form a right triangle; that is, show that $a^2 + b^2 = c^2$. If this does not work for your measurements, you might not have a right triangle.

- Length of Triangle Leg (a):
- Length of Triangle Leg (b):
- Length of Hypotenuse (c):
- Verify:

Calculation
Your structure is just a model for a potential building. If we have it so that $1in. = 5\frac{1}{2}\ ft.$, what are the actual dimensions of your building? To do this, look back to the dimensions you wrote down in the **Dimensions** section.

- Building Height:
- Building Base Dimensions:

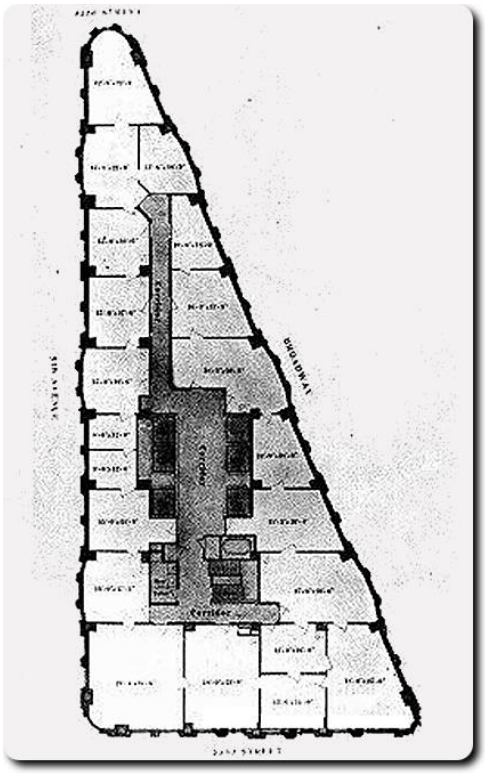
Virtual Graph

Graph your structure in the 3D Graphics feature on GeoGebra. To do this, construct a polygon base for your structure by selecting the "Polygon" option. When you have made your base, select the extrude option for the structure you want. Draw your graph below and draw what the individual sides look like. Use the angle measure feature to verify that you have a right triangle.

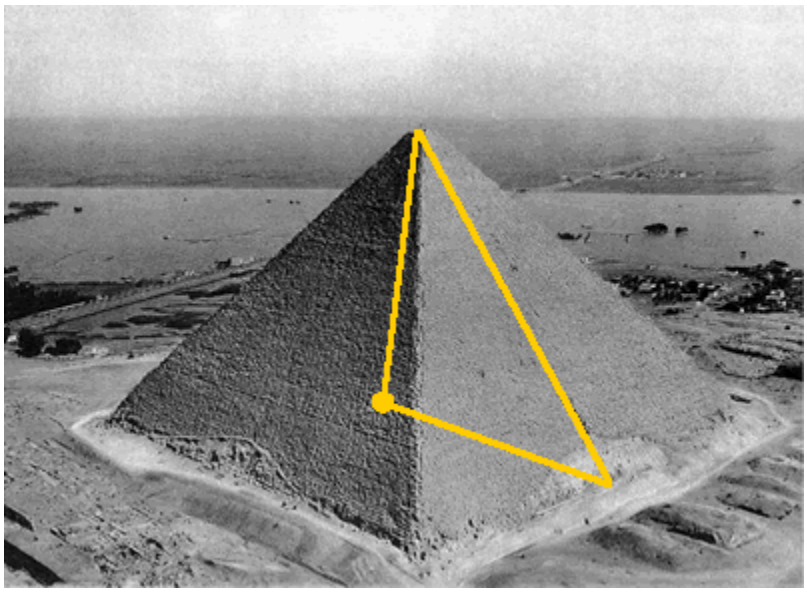
Math Goals – Pythagorean Theorem

We should be able to meet all of these statements for the different activities when we are finished. If we can, then we know that we have made great artwork that depicts math!

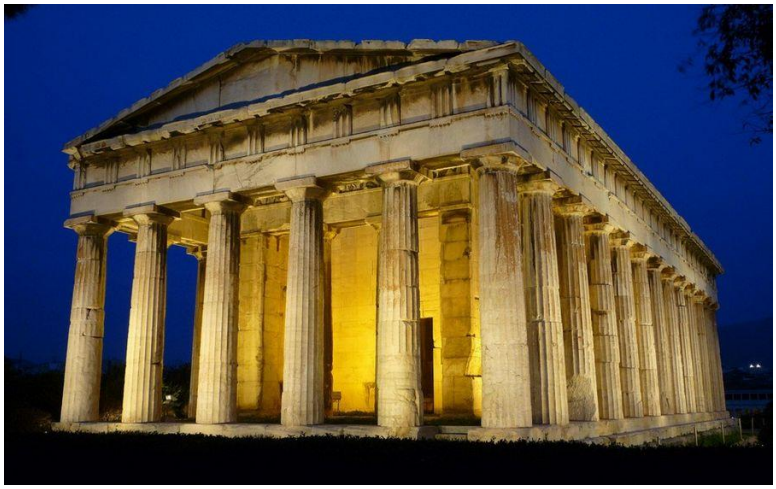
Category	4	3	2	1
Neatness and Attractiveness	Exceptionally well designed, neat, and attractive.	Neat and relatively attractive.	Design is properly utilized but the design appears quite plan.	Appears messy and "thrown together" in a hurry. Overly simple design.
Triangles	The structure utilizes right triangles			The structure does not utilize right triangles
Measurements	All measurements are found accurately and with proper units	All measurements are found accurately	All but 2 of the measurements are found accurately	More than 3 of the measurements are found inaccurately
Calculations	All calculations for the Pythagorean Theorem are correct and work was shown.	All calculations for the Pythagorean Theorem are correct.	Calculations for the Pythagorean Theorem are incorrect because of computation error.	Calculations for the Pythagorean Theorem are incorrect because of error with the theorem.



Name: Flatiron Building (1903)
Location: New York, New York
Designer: Daniel Burnham
Height: 21 Stories or 307 ft.



Name: Great Pyramid of Giza (2560 BC)
Location: El Giza, Egypt
Designers: Khufu, Imhotep, and Hemiunu
Height: 455 ft.



Name: Temple of Hephaestus (415 BC)
Location: Athens, Greece
Designer: Ictinus