Nine lessons from
THE LITTLE CROOKED HOUSE

This book of nine lessons is based on the work done by Miuty E. Nokar in the context of his participation in the MACIMISE[a] project. The original lessons in indigenous mathematics can be found in his paper, *A culturally based mathematics unit for grade seven students on Chuuk State,* submitted to the University of Hawaii in the context of his Master's program. In that paper, Nokar (2013) defines a major problem with the teaching of mathematics in Chuuk:

- the current approach to teaching and learning of mathematics in the classroom is inappropriate and not meaningful,
- the 'western' (sometimes called 'main land') approach to the teaching of mathematics adversely affects students' perceptions of the value of their own culture, and consequently produces mathematic knowledge that is not useful nor beneficial to the needs and practice of the Chuukese people's indigenous ways of working and interacting, and
- the transition to the learning of classroom mathematics, because of its explicit exclusions of culture, has very little effect on students' success in the learning of mathematics. (Nokar, p. 4)

The lessons follow the successive stages in the building of a traditional Chuukese house as portrayed in the storybook, *The Little Crooked House*. Each lesson presents a stage in the house construction and the mathematics embedded in each stage. Some notes on the lessons follow.

Timing of the lessons

The lessons cover a significant number of the grade seven standards and benchmarks for mathematics. The lessons can be distributed throughout the year as a particular set of topics is addressed or as an introduction to certain topics; they can be grouped together towards the end of the school year as a way of reviewing and pulling together the year's work.

Lessons vary in length but tend to require about 2 hours of class time. Each lesson is divided into 'Activities' for which the estimated time is given. Rarely do these activities exceed 45 minutes. This allows teachers to adapt lessons to the schedule for mathematics in their schools.

[a]MACIMISE, Mathematics and Culture in Micronesia: Integrating Societal Experiences, is a collaborative research and development project led by Pacific Resources for Education and Learning and the University of Hawai'i at Manoa. Founded on ethnomathematics research, the project aims to increase the mathematics learning of first-, fourth-, and seventh-grade students in ten Pacific Island states and territories.

Lesson structure

Each lesson starts with a list of the **objectives**. Where appropriate, the Chuuk benchmarks are indicated. To read these benchmarks, note that the middle number indicates the grade level. For example, MAT. 4.7.1, indicates a benchmark from Standard 4 (Patterns and Algebra) for Grade 7, and the ‘1’ indicates the first benchmark for this standard: “Find the expression for the general term in a growing pattern and use it to find the general term in the pattern.”

A list of **materials** required for the activities in the lesson to be fully implemented follows. Teachers need to prepare these materials beforehand. A few materials that are used in every lesson are listed in the early lessons but then assumed to be there. These materials are the copies of the storybook and the heavy paper and markers necessary to make the word wall cards.

The important vocabulary in each lesson is given under the title “**Word Wall**”. Each word found there should be clearly printed on cardstock 11 inches by 2 to 3 inches (cutting a letter size sheet into 3 or 4 cards). These cards are prepared ahead of time and posted to the Word Wall (an area on the board or a clear wall where the cards are visible by all students) using tape or poster putty as they arise in the lesson. A Glossary at the end of the book offers definitions of the English words. The Chuukese words are presented in a glossary at the end of the storybook.

Classroom **activitie**s follow and within each activity a number of **experiences** are described. Resources related to these experiences can be found at the end of each lesson. Although most resources are for the teacher, some are worksheets for students. When this is the case, the resource number is indicated in the materials section so the needed number of copies can be prepared ahead of time.

Scattered throughout the activities are “**Questions**” which are generally not specific questions for the students but overarching questions that guide the inquiry. They can be copied on the board as they arise and addressed from time to time as the work progresses.

Every lesson closes with a brief **plenary** that either pulls together some aspects of the lesson or anticipates the next lesson, or both.

Chuukese vocabulary

Although the lessons and related storybook are in English, the Chuukese words related to the building of a house and those used in measurements (for which there is no English equivalent) are introduced. It is important to recognize the variations in these words, and in their written form, from one region to the next. The Chuukese measurement system is primarily gestural, not written. However, a book of lessons has no choice but to offer a written form. This is why each resource dealing with units of measure contains photos of the gesture involved. In the classroom, the accent should be on the gestures, not the written words.

In this book of lessons, choices have been made not only with the spelling of Chuukese words but also with the definitions of the units of measure. Because measuring rope, as we do in house building, involves holding the rope with one hand and sliding it through the fingers of the other hand until we pinch with our thumb the appropriate place to stop, we have chosen to define measures from thumb tip to thumb tip. So, for example, an arm span is defined as the distance between the tips of the thumbs on the outstretched arms. In other contexts and regions, an arm span is often the distance between the tips of the middle fingers on the outstretched arms.

Hands-on mathematics

These lessons are based on a belief that mathematics is best learned by engaging all the senses (not just the eyes and ears). Students need to touch and manipulate significant mathematical objects and to relate them to their culture. "Most of the approaches and methods introduced and practiced in our schools today are foreign to our children.

The styles of teaching, the classroom setting, which involves rows and columns with the teacher standing or sitting in the front presenting foreign ideas and symbols hardly make good sense to the children." (Nokar, 2013, p. 4). These lessons take place outdoors as well as indoors and have students enact and model the construction of a traditional house. They work mostly in groups or teams of 2 to 6 students.

Standard units of measure

The system of length measure taught in US affiliated schools today comes from the British Imperial system (no longer used in Britain). That system of inches, feet, yards, and miles was originally based on body measurements and eventually became standardized. While the Chuukese units of measurement have not been standardized across the state, they are locally standardized when they are based on the measurements of one chosen person, in this case the *souiimw* or master builder.

By choosing a classroom souiimw, a student whose arm measures are used throughout the lessons, we avoid the problems involved in the use of non-standard units and the need to use a foreign standardized system such us the metric or the U.S. Customary System.

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MACIMISE

Lesson One

ROPE SHAPES AND MEASURING

Objectives: *Students will*

- prepare for rope work for locating corner posts
- review, in a hands-on way, definitions of lines, triangles and rectangles
- review, or be introduced to, the larger units of Chuukese length measurement
- explore standard units of measurement

Resources

1a. Finding perpendicular lines

1b. Names of triangles based on their sides

1c. Making rope triangles (4 sheets)

1d. Making rope squares (2 sheets)

1e. Identifying rectangles

1f. Chuukese length measures

Materials Needed

Measuring ropes - approximately two extended arm widths long (*ruengaf*) and 1/8 to 1/4 of an inch thick - one per student pair

Colored string or fabric strip (about 12 inches long, to tie onto ropes) - one per student pair

Copies of Resource 1a and first page of Resource 1e - one per team of four

Poster of names for triangles, or copies of Resource 1b - one per team of four.

Long strips of paper about 1.5 inches wide

Black markers

Word Wall cards and tape (or poster putty)

Vocabulary for Word Wall

straight line	quadrilateral	scalene triangle	*ngaaf*	*unungaf*
center	rectangle	isosceles triangle	*engaf*	*fengaf*
right angle	square	equilateral triangle	*ruengaf*	*(fangaf)*
measure	circle	perpendicular lines		*etineupw*

Teacher Activities

1.1. **Making Shapes with Ropes**

Experiences: Exploring straight lines with ropes
Exploring triangles with ropes
Exploring quadrilaterals with ropes

1.2. **Defining rectangles**

Experience: Rectangles as quadrilaterals

1.3. **Measuring with Ropes**

Experience: Finding standard units

Teacher Notes

Suggested total time for each lesson is 120 minutes.

Teacher notes give additional information.

Resources are in a separate folder.

The lesson ends with a plenary.

Teacher Activities

Activity 1.1. Making Shapes with Ropes

Here the students work in teams of 4. Each team has 2 ropes. The questions to be explored are either posted or given verbally by the teacher.

Experience: Exploring straight lines with ropes

Question 1: How many students are needed to make this rope into a straight line?

A straight line can be defined in many ways. It is often defined as the shortest distance between two points and that is the most useful definition here.

Direct the students to create a line:

- The two points are the two students.
- At either end of the rope, they pull until it is straight.

Students demonstrate making a straight line in pairs.

Question 2: How do you find the center or middle of a rope?

Have each pair of students find the middle of their rope.

Ask them to mark the middle by tying a colored string around it.

When all rope centers are marked, ask the teams of four to place their ropes on the ground or floor so that the two ropes are perpendicular and their centers touching.

You may have to remind them that perpendicular lines meet at right angles (90^0).

The corner of a sheet of paper can be used to check the angles.

Figure F represents the only pair of perpendicular lines, although Figure D is pretty close.

***Question 3:** How can you be sure two ropes are perpendicular?*

Students do not have a protractor to measure the angles. This forces them to think about right angles.

Have students offer their ideas on how to check for right angles.

After teams have worked on this for 5 minutes, ask a few teams of four to demonstrate.

The ropes centers should be touching and the ropes straight.

Teacher Notes

45 minutes

Answer: two students

As words are used for the first time, post them to the Word Wall.

The middle or center of a rope is the point that is the same distance from each end. By folding the rope in half (putting two ends together and finding where the rope bends), students can find the centers.

See Resource 1a: Finding perpendicular lines for an exercise in identifying perpendicular lines.

If they have done the exercise in Resource 1a, they should have some ideas. They will discover that working with lines on paper is not quite the same as working with ropes.

Note: We will return to this question of perpendicular ropes in lessons 2 and 3.

Teacher Activities

Experience: Exploring triangles with ropes

Question 4: *How many students are needed to make a triangle with one of the ropes?*

One student holds the two ends and the other two pull on the rope at two other points.

Ask each team to hold their triangles in place either on the floor or in the air and to look around at the shapes of the other triangles.

Post, or draw on the board an enlarged poster from Resource 1b.

Ask the teams to name their triangle as scalene, isosceles or equilateral.

Have a couple of teams explain why they have chosen their name.

Question 5: *Can you make your triangle into an isosceles triangle? Can you make it into an equilateral triangle?*

Students can decide on the length of one side, fold the rope and position the second student at the fold point and the third student at the point where the held end touches. The remaining rope is stretched between the first and third student.

Another strategy involves making a scalene rope triangle and then sliding the rope in the hands of one of the students until it is as tight as it will go.

To make an equilateral triangle, the first student holds the two ends of the rope and the two other students pick up the rope and slide it in their hands until they are the furthest away from each other.

Experience: Exploring quadrilaterals with ropes

Question 6: *How many students are needed to make a rectangle with a rope? What about a square?*

Have students look at each other's rope rectangles.

Ask a team to demonstrate how they made their rectangle.

If a team used a different strategy, have them demonstrate.

Discuss with the class which strategy they think is better.

Have students make a rope square in their teams.

Discuss strategies, e.g. some teams may make a rectangle as they did for Question 6, sliding the ropes through their hands to make it look square.

Guide students to try to make their angles as close to right angles as they can.

Teacher Notes

Answer: 3 students

See Resource 1b: Names of triangles based on the lengths of their sides.

A number of strategies are possible for making an isosceles triangle with a rope.

See Resource 1c: Making rope triangles for a representation of these strategies.

See Resource 1d: Making rope rectangles for two probable strategies

A better strategy would be to fold the rope in half, mark the center, fold it in half again and mark the fourths:
A holds the two ends, B holds the one fourth mark, C holds the center mark and D the other fourth mark.
Now all four sides are of equal length.

Teacher Activities

Question 7: *How many students would it take to make a circle with a rope?* (optional question)

Review the previous experiences: it took 3 students to make a rope triangle, 4 students to make a rectangle.

Ask students to generalize this to a pentagon and hexagon and beyond.

Consider: they could reflect on how many students it would take to make a 100-gon, a shape with 100 straight sides.

Would this be a circle? Not exactly, not even if it was a 1000-gon.

Teacher Notes

This kind of thinking, called generalizing, is very useful in math.

Activity 1.2. Rectangles as quadrilaterals

For this activity, students work with paper and pencil in the classroom.

Experience: Rectangles as quadrilaterals

Question 8: *How do we know a perfect rectangle or square?*

The rectangles made with the ropes are probably not "perfect."

This is the time to introduce the definition of a rectangle as a quadrilateral having four right angles.

Have students work in teams on this worksheet .

Encourage them to discuss among themselves their choices of rectangles.

At this point we are concerned only with the definition of a rectangle though some of the properties may surface in the discussion. We will look more closely at the properties of rectangles in the next lesson.

See Resource 1e: Identifying rectangles for a worksheet (first page) and some notes for a classroom discussion of the worksheet.

Activity 1.3. Measuring with Ropes

Experience: Finding standard units

Question 9: *How long are these ropes?*

The ropes used in this lesson were approximately *ruengaf* in length according to the teacher's body measurements.

Without any explanations, ask each team to measure its ropes in Chuukese measurement.

Teacher Activities

After about 5 minutes ask for their results.

Introduce *ngaaf*

Ask students to compare *engaf* among participants in their teams of four and to choose the longest (the measurement of the person with the widest arm span).

Ask them to measure off a strip of white paper for their *engaf* and write the word *engaf* and the name of their team on it with a black marker.

Post the *engaf* of each team

Invite the class to discuss which one to use for their standard *ngaaf* measure.

Introduce *etineupw.*

Ask students to verify the *etineupw* measure in their teams and how for each individual, remembering that *etineupw* is half of *engaf*.

Ask students for ideas on how to make their standard *etineupw* measure and mark a strip of white paper with the unit name. (The *etineupw* strip should be half the length of the *ngaaf* strip.)

Post both the white strips at the front of the class.

Plenary for Lesson 1

Distribute the Word Wall cards randomly among the teams.

Ask students to discuss the meaning of their words.

Have students post all the words that are for geometric shapes.

Invite discussion to ensure that the eight shapes are posted. Once there is agreement, ask those who have the words for Chuukese measure to post them.

Have the class order the measurements from the largest to the smallest.

Teacher Notes

This will provide a good opportunity to review (or introduce for some students) the units of measurement: ngaaf and etineupw and their number indicators.

See Resource 1f: Chuukese length measures.

These become the standard units of measure to be used in future lessons.

15 minutes

Answer: fengaf, unungaf, ruengaf , engaf and etineupw

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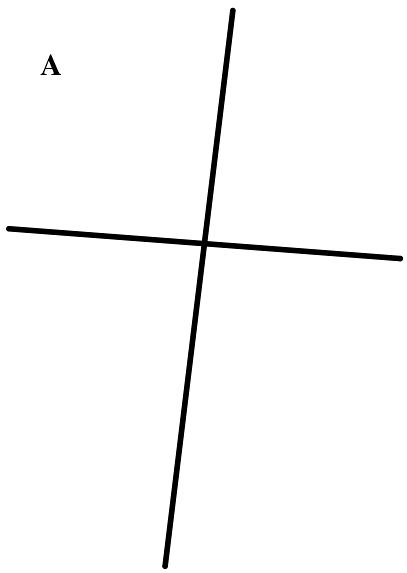
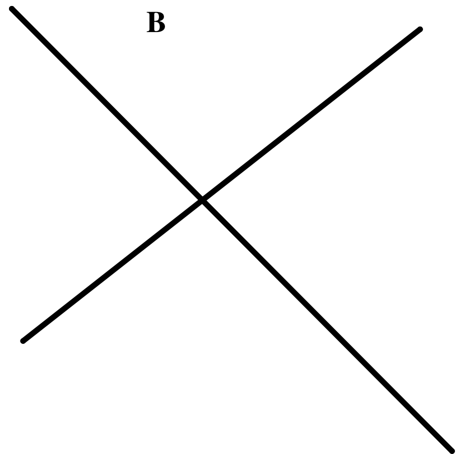
❖ Resource 1a: Finding perpendicular lines

Which of these drawings represent perpendicular lines?

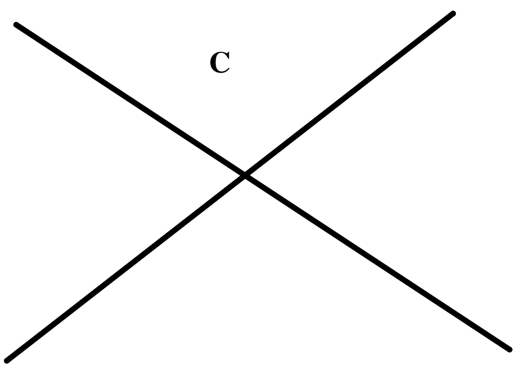
A



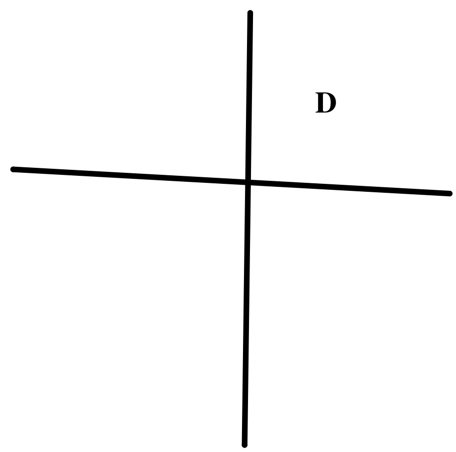
B



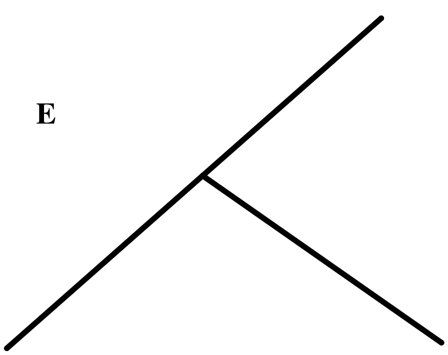
C



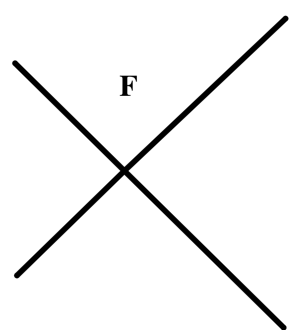
D



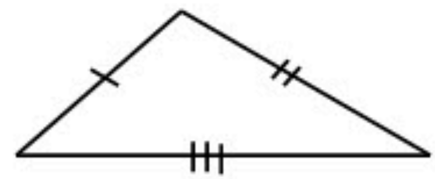
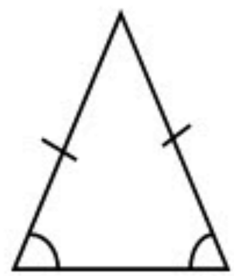
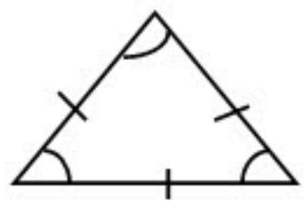
E



F



❖ Resource 1b: Names of triangles based on lengths of sides

Based on sides	
Scalene triangle All 3 sides have different lengths. Its angles are also all different.	
Isosceles Triangle 2 sides have equal lengths. 2 of its angles also measure equal.	
Equilateral Triangle All 3 sides are of same length. All three angles are equal, 60°	

❖ Resource 1c: Making rope triangles - I

Making a scalene triangle with 3 students (A, B and C):

Student A holds both ends of the rope.

Student B picks up the rope and pulls it so that it is tight between A and B (makes a straight line).

Student C picks up the remaining rope and backs up until it is tight with both A and B.

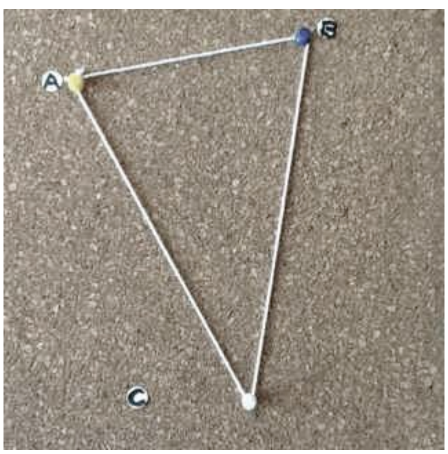
To turn the rope triangle ABC into an isosceles triangle, Students A and B can stay where they are holding the rope tight between them and C moves to the right keeping the rope tight but letting it slide through his fingers until he is as far away from both A and B as he can be.

❖ Resource 1c: Making rope triangles - II

Making an isosceles triangle with 3 students (A, B and C):

Students A, B and C start in the position of their scalene triangle. Only one student needs to move to make an isosceles triangle. We choose Student C.

Student C moves to the right letting the rope slide through his or her fingers while keeping it tight.



Student C stops when he feels he is the furthest away from A and B (and the rope between them) as he can be. At this point, ABC is in the shape of an isosceles triangle with AC equal in length to BC.

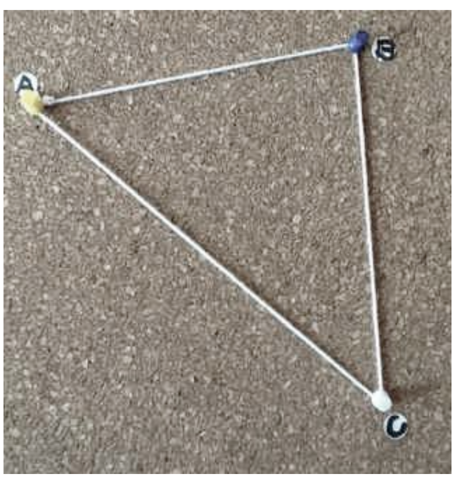
An alternative strategy for making an isosceles triangle (shown below) involves C measuring off the length of AB on the remaining loop of rope, holding the rope there (so that BC and BA are the same length) and then backing away until the rope is tight. See below for this strategy.

❖ Resource 1c: Making rope triangles - III

An alternative way to make an isosceles rope triangle with 3 students (A, B and C):

Student A holds both ends of rope and B picks up the rope and stretches it between himself or herself and A.

Student C pulls rope between B and back to A. Holding the rope at this point (length BC equals length BA), C backs up until the rope is tight with both A and B.

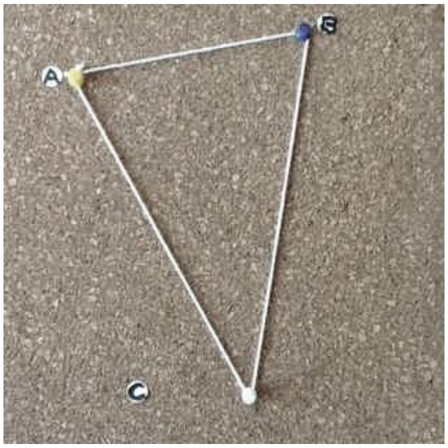


C in final position, making an isosceles triangle.

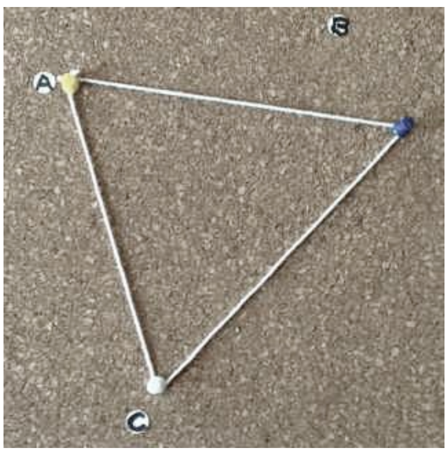
To turn an isosceles rope triangle into an equilateral triangle, two of the three students will need to move much in the same way as C did to make the isosceles triangle.

❖ Resource 1c: Making rope triangles - IV

Making an equilateral triangle with 3 students (A, B and C):



Here students start in their positions for the isosceles triangle. Student A does not move. Students B and C start rotating in a clockwise direction letting the rope slide through their hands but keeping it tight.



Students B and C stop rotating and pulling when they feel the rope is the farthest they can all three be from each other. The rope triangle ABC is in the shape of an equilateral triangle. Notice how much B has moved from his original position. C has moved back to the left and is above his original position.

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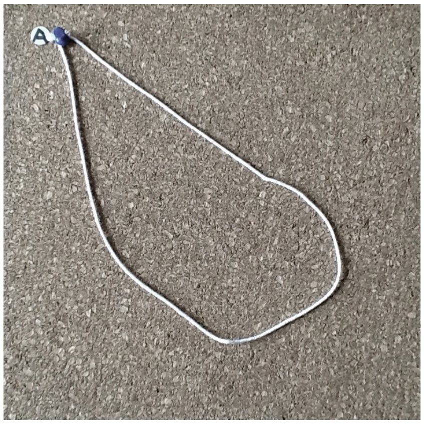
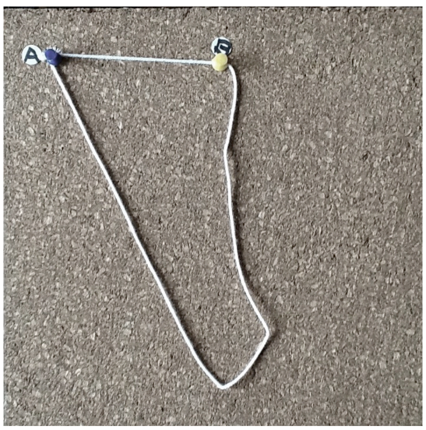
❖ Resource 1d: Making rope rectangles - I

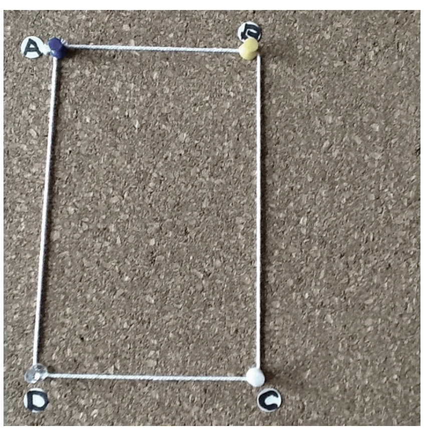
Making a rectangle with 4 students (A, B, C and D):



Student A holds both ends of the rope.



Student B picks up the rope and pulls it so that it is tight between A and B (makes a straight line).

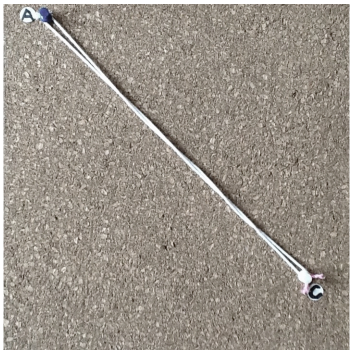


Students C and D pick up the rope and slide it through their hands until they have made a rectangular shape.

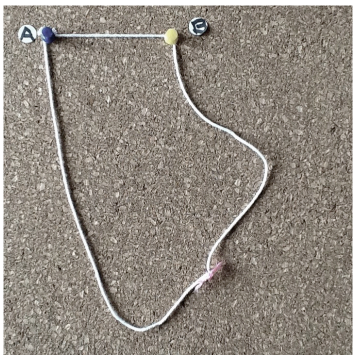
For a little more accuracy, students could fold the rope in two and have C hold the rope at the rope center. This would guarantee that the sum of the lengths of the two sides AB and BC is equal to the sum of the other two sides.

❖ Resource 1d: Making rope rectangles - II

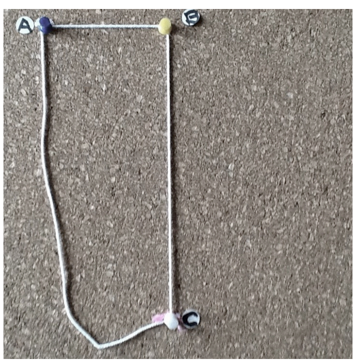
An alternative strategy for making a rope rectangle:



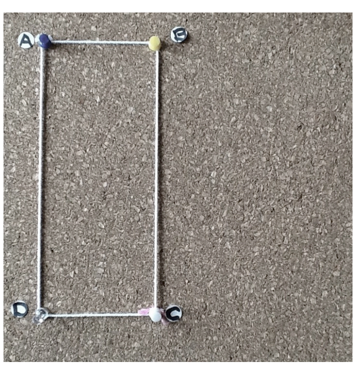
Student A holds both ends of the rope. Student C finds and marks the middle of the rope loop.



Student B picks up the rope and pulls it so that it is tight between A and B (makes a straight line).



Student C picks up the rope at the center mark and pulls it tight trying to make a right angle at B.



Student D picks up the rope and slides it through his or her hands until the rope has taken a rectangular shape.

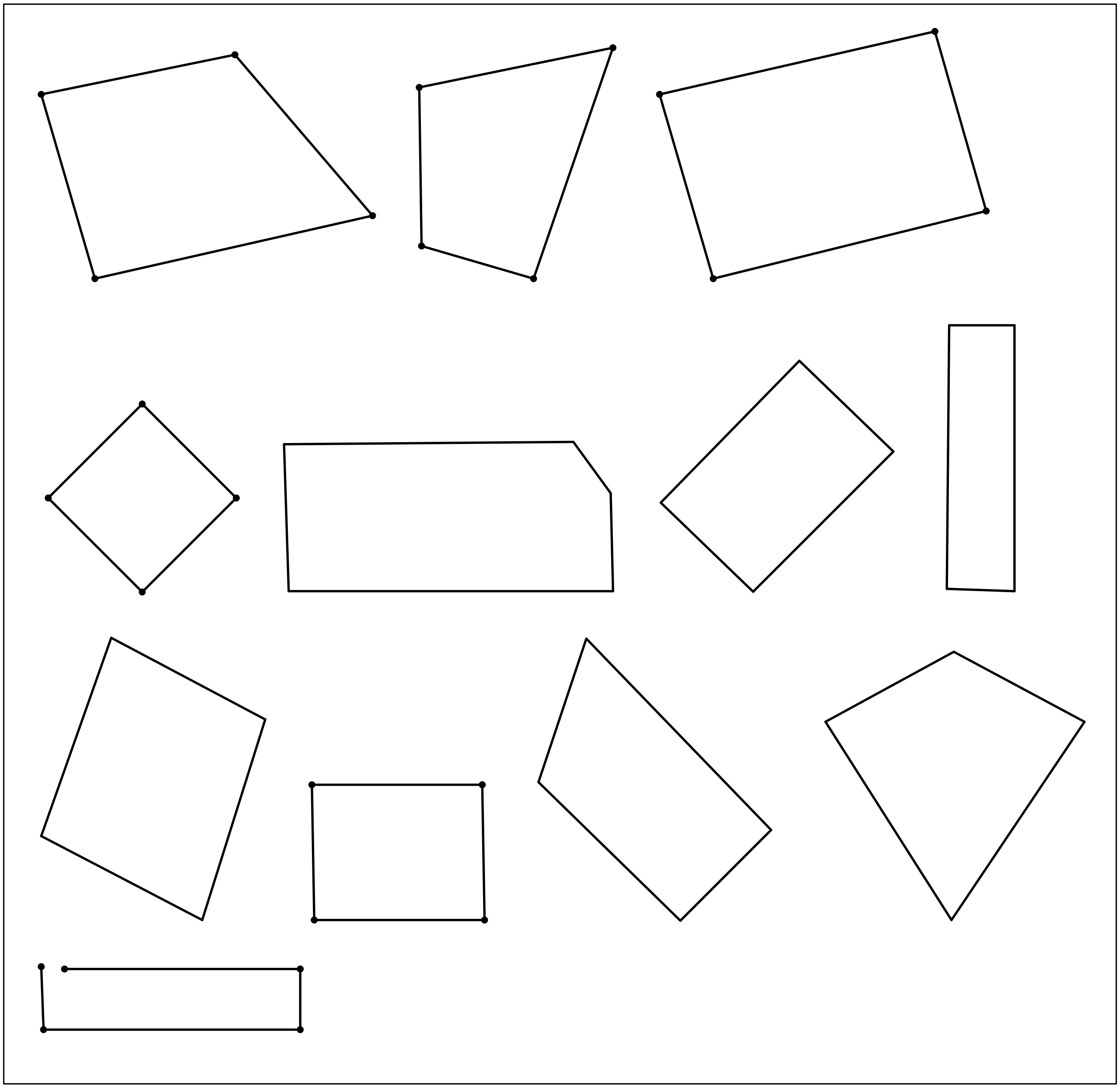
❖ Resource 1e: Identifying rectangles - I

Identifying rectangles worksheet:

Definition: a rectangle is a 4-sided plane figure (a quadrilateral) containing four right angles.

Circle the shapes below that are rectangles and say why you chose them.

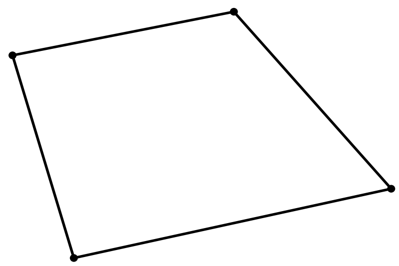
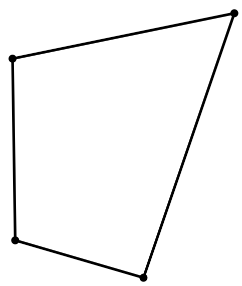
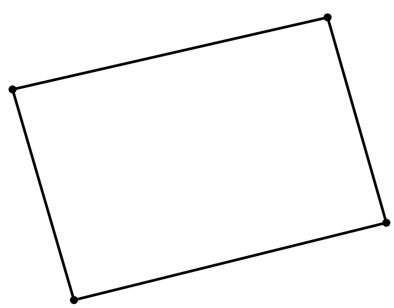
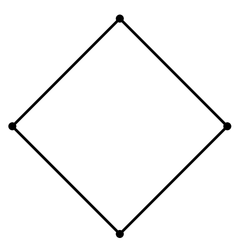
Can you name any of the shapes that are not rectangles?



Follow up with a classroom discussion (see the next three pages)

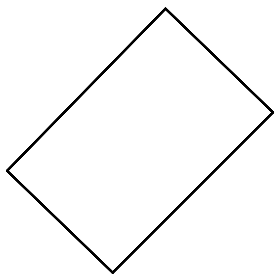
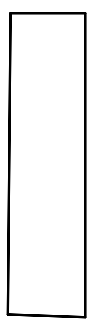
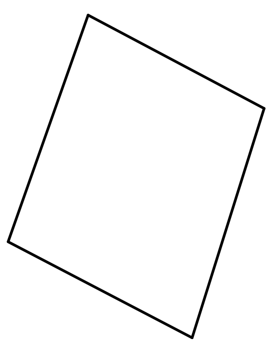
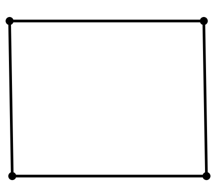
❖ Resource 1e: Identifying rectangles – II

Classroom discussion of worksheet (page 1):

	This is a 4-sided plane figure but it does not contain four right angles. It is called a quadrilateral because it has 4 sides. It has no other properties that would give it a special name. If the two sides that look parallel, turn out to be so, it would be called a trapezoid
	This is also a quadrilateral.
	This looks like it might be a rectangle but when we check the angles with the corner of a piece of paper or with a protractor we see that the angles are not quite right angles. Two angles are a bit bigger than 90^{o} and two are a bit less. Because opposite sides are of equal length and parallel, it is called a parallelogram.
	This is a rectangle. Because it has the four sides of equal length, it is a special type of rectangle called a square.
	This is a 5-sided figure, a pentagon.

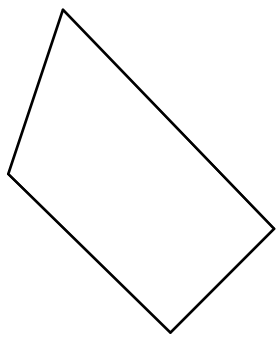
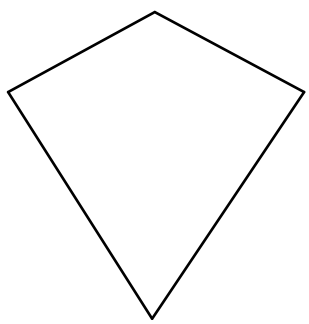
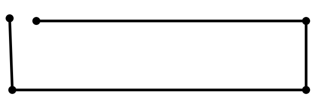
❖ Resource 1e: Identifying rectangles – II

Classroom discussion of worksheet (page 2):

	This is a <u>rectangle</u>. All four angles are right angles.
	This is also a <u>rectangle</u>. All four angles are right angles. A rectangle is a special type of parallelogram since opposite sides are equal in length.
	This is not a rectangle. But since opposite sides are of equal length and parallel, it is called a <u>parallelogram</u>.
	This is a <u>rectangle</u>.

❖ Resource 1e: Identifying rectangles – II

Classroom discussion of worksheet (page 3):

	This is a trapezoid. A trapezoid is a quadrilateral with one pair of parallel sides.
	This quadrilateral is called a kite for obvious reasons. A kite is a quadrilateral with two pairs of equal adjacent sides.
	This is not a closed figure so although it has 4 sides, it is not a quadrilateral.

❖ Resource 1f: Chuukese length measures

Unit of measurement	Number indicators	Description
NGAAF	1. engaf 2. ruengaf 3. unungaf 4. fengaf (fangaf)	Distance between thumb tips on outstretched arms
ETINEUPW	This unit is not normally used independently so no number indicators are given.	Distance from thumb tip on outstretched arm to the center of the chest

Relationship: **etineupw + etineupw = engaf**

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Lesson Two

MAKING A RECTANGULAR FLOOR

Objectives: *Students will*

- explore, in a hands-on way, the properties of rectangles
- review, or introduce, two more units of Chuukese length measurement
- build skill in measuring objects and structures in the environment
- build Chuukese and English vocabulary for the parts of a house

Resources

2a Naming rectangles

2b Shapes and properties

2c More Chuukese length measures

Materials Needed

Measuring ropes used in Lesson 1

A copy of the first page of Resource 2.b for every team of 2

Adding machine roll of paper or any long strips of paper about 1.5 inches wide

A black marker pen to write the names of the measurement units on the strips of paper

Word Wall cards and tape (or poster putty) to post them

A copy of the book "The Little Crooked House" for each student

Vocabulary for Word Wall

diagonal	congruent	corner post	*afotchuk*	*ouchamw*
crooked	parallelogram	wall beam	*emwalu*	*iimw*
vertex, vertices	trapezoid	end beam	*úúr*	*souiimw*
parallel	kite	king post	*tinéw*	*singóón*
bisect	rhombus	ridgepole		

Teacher Activities

1.1. "The Crooked House"

Experiences: Telling the story
The 'crooked' house

1.2. Fixing the Floor

Experience: Rectangles as quadrilaterals

1.3. Measuring a Rectangular Floor

Experiences: Laying down rope rectangles
Making two more standard units of measure

Teacher Notes

Suggested total time for each lesson is 120 minutes.

Teacher notes give additional information.

Resources are a separate folder.

The lesson ends with a plenary.

Teacher Activities

Teacher Notes

Activity 2.1. "The Crooked House"

45 minutes

Read pages 1 to 5 of the book to the class and then ask students to re-read these pages for themselves.

Experience: Telling the story

Question 1: Can you tell the story in your own words?

Ask for a volunteer to start telling the story in his or her own words.

Ask a second and then a third student to continue the story.

Write the main points on the blackboard as the story is told.

After each student offers a summary of part of the narrative, ask the class if they agree with the summary.

Insert any changes to summary that students seem to agree on.

Post the three Chuukese words on the Word Wall.

Make sure students understand the key Chuukese words in this part of the story (iimw, singóón, úúr) and their English equivalents (house or hut, rope, corner post).

Experience : The "crooked" house

Question 2: What is wrong with this house?

In teams of two, ask students to look very carefully at the picture of the crooked house on page 5 of the book and to make notes on things that are not right.

After students have had time to explore the problems with the house illustrated on page 5, ask students to offer their findings and write these on the board.

These might include:

- the *úúr* (corner posts) are not vertical; they are further apart at one end than at the other; they are not all the same height above the ground
- the end beam (*ouchamw*) and the wall beam (*tinéw*) are not horizontal
- the thatch does not come down far enough on the sides
- there is no thatch covering the wall beam extensions in the front and back
- the roof is longer on the far side than the near side

Point out the glossary and illustration on page 22 as a resource for vocabulary.

Post the words to the Word Wall as they come up in the students' responses.

Teacher Activities

Teacher Notes

Question 3: What shape is the floor of the crooked house?

Ask students to draw on paper what they think the shape of the floor is inside the crooked house.

Ask students to compare their drawings and come to some agreement on the shape of the floor (a quadrilateral that is not a rectangle).

Ask students to draw on paper what they think the shape of the floor of the house should be.

When students name the rectangle shape as best, continue with the next experience, which explores rectangles.

Activity 2.2: Fixing the floor

30 minutes

Here we will look at the geometry of a rectangular floor.

Experience: Recalling the properties of rectangles

Question 4: What do you know about rectangles?

In Lesson 1 we defined a rectangle as a quadrilateral with four right angles. Here we will reinforce that definition and explore the properties of rectangles. The difference between a definition and properties will be clarified.

Checking knowledge

Have students recall the definition of a rectangle and write it on the board:

A rectangle is a quadrilateral having 4 right angles.

Review the **properties of rectangles**

- *opposite sides are parallel*
- *opposite sides are congruent*
- *diagonals are congruent*
- *diagonals bisect each other*

Make sure students understand the key words ***quadrilateral*** *and* ***right angles*** *and remind them of the exercise of identifying rectangles they did in the previous lesson.*

Make sure the students understand and can use every word in the definition and properties, for example:

Congruent - *having identical size and shape*

Bisect - *to divide into two equal parts*

Diagonal - *line joining any two vertices not joined by an edge*

Teacher Activities

Post a large drawing of a rectangle or draw one on the board.

Ask students what else they know about rectangles.

Possible suggestions might be

- opposite sides are the same length.
- opposite sides are parallel.

If these are not mentioned, introduce the word diagonal.

Draw one diagonal in the rectangle.

Ask if there is another diagonal.

Have someone come and draw it.

Mark the point where the diagonals meet.

Mention that the geometric name for that point is ***centroid***. It is the center of the house, the ***nukeniféw***.

Ask where the corner posts would be placed for the floor of a house.

Question 5: Which shapes share some properties of rectangles?

Ask students to name some shapes that share some or all of the properties of rectangles.

Discuss each shape mentioned.

Distribute the first page of Resource 2b: Shapes and properties

Ask students to work with a partner on the questionnaire.

Activity 2.3: Measuring and making a rectangular floor

Experience: Making two more standard units of measure.

Review the two units of measurement from Lesson 1: *ngaaf and etineup*.

Introduce the units of measurement: *afotchuk* and *emwalu*.

Use the same person to establish the standard units to be used by the class.

Post those measures on strips of paper with the measurement name written on it (as in Lesson 1).

Have students practice gestures for each unit while saying the word.

Teacher Notes

See Resource 2a: Naming rectangles for visual aids that can be reproduced and posted.

*Also recall that **vertex** and its plural, **vertices**, are used to describe the corners of a rectangle.*

It is worth taking time to discuss properties of the 5 shapes to strengthen understanding of rectangles and differences between properties (which can be shared) and a definition (which is unique).

30 minutes

Remind students how they created the posted "standard" measures by using the measurements on one person in the class.

See Resource 2c: More Chuukese length measures.

Teacher Activities

Teacher Notes

Experience: Laying down rope rectangles

Do this experience outside and use ropes from lesson one.

Divide students into 3 teams and distribute the ropes evenly.

Ask each team to measure out a rectangle with the dimensions given and mark its center.

Suggested dimensions:

Team #1: Make a rectangle that is *ruengaf-etineup* wide and *fengaf* long (the dimensions of the house in the story).

Team #2: Make a rectangle that is *engaf-etineup* wide and *ruengaf* long (the dimensions of the house in the video).

Substitute dimensions according to the amount of space available for the activity.

Team #3: Make a rectangle that is *engaf-emwalu* wide and *engaf-afotchuk* long.

When the teams have completed their rectangles (made of ropes or lines drawn on the ground), have students rotate to another rectangle and check the measurements.

Discuss any differences.

Plenary for Lesson 2

15 minutes

Point to 3 or 4 measurement words on the Word Wall.

Have students illustrate with arm gestures how they would be measured.

Read the last two paragraphs on page 4

Ask students how they would answer Jake's question: "What is there to measure?"

Homework: Ask students (individually or with a partner) to write a paragraph with the title "How measuring can help make the house straight".

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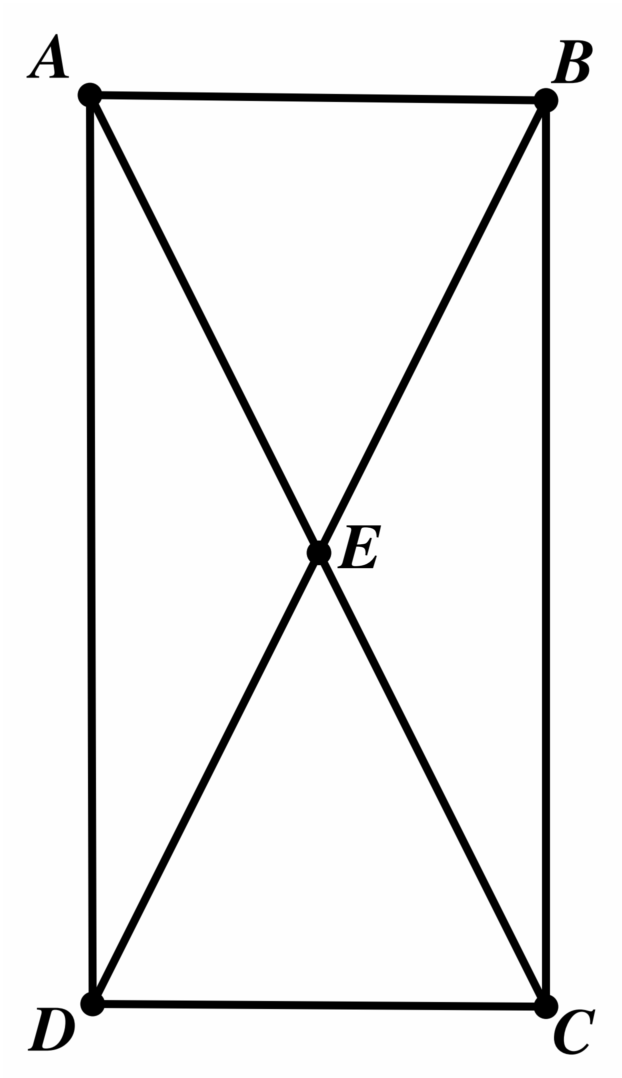
❖ Resource 2a: Naming rectangles

Rectangle ABCD



A, B, C, and D are the four vertices

E is the center or centroid of the rectangle

AC and BD are the two congruent diagonals

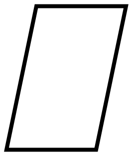
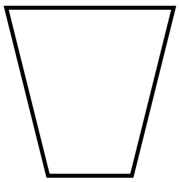
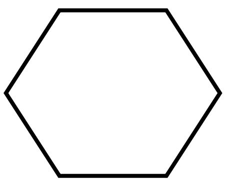
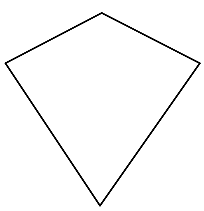
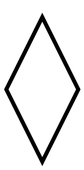
The two diagonals bisect each other at point E

AB and CD are the congruent and parallel width sides

AD and BC are the congruent and parallel length sides

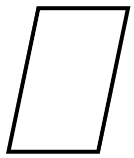
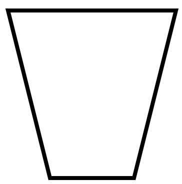
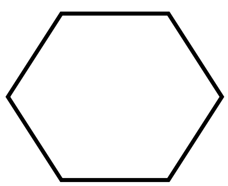
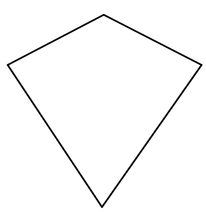
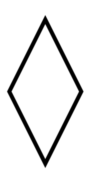
❖ Resource 2b: Shapes and properties - I

Check the properties satisfied by each of these shapes and name the shape

 Shape name: ______________________	☐ Opposite sides are parallel. ☐ Opposite sides are congruent. ☐ The diagonals are congruent. ☐ The diagonals bisect each other.
 Shape name: ______________________	☐ Opposite sides are parallel. ☐ Opposite sides are congruent. ☐ The diagonals are congruent. ☐ The diagonals bisect each other.
 Shape name: ______________________	☐ Opposite sides are parallel. ☐ Opposite sides are congruent. ☐ The diagonals are congruent. ☐ The diagonals bisect each other.
 Shape name: ______________________	☐ Opposite sides are parallel. ☐ Opposite sides are congruent. ☐ The diagonals are congruent. ☐ The diagonals bisect each other.
 Shape name: ______________________	☐ Opposite sides are parallel. ☐ Opposite sides are congruent. ☐ The diagonals are congruent. ☐ The diagonals bisect each other.

❖ Resource 2b: Shapes and properties - II

Answers for Worksheet

 Shape name: <u>parallelogram</u>	■ Opposite sides are parallel. ■ Opposite sides are congruent. ☐ The diagonals are congruent. ■ The diagonals bisect each other.
 Shape name: <u>trapezoid</u>	☐ Opposite sides are parallel. **(one pair)** ☐ Opposite sides are congruent. ☐ The diagonals are congruent. ☐ The diagonals bisect each other.
 Shape name: <u>regular hexagon</u>	■ Opposite sides are parallel. ■ Opposite sides are congruent. ☐ The diagonals are congruent.* ☐ The diagonals bisect each other. *Only the diagonals between opposite vertices are congruent and bisect each other.
 Shape name: <u>kite</u>	☐ Opposite sides are parallel. ☐ Opposite sides are congruent.* ☐ The diagonals are congruent. ☐ The diagonals bisect each other.** * Adjacent sides are congruent. ** Only the long diagonal bisects the short diagonal
 Shape name: <u>rhombus or diamond</u>	■ Opposite sides are parallel. ■ Opposite sides are congruent. ☐ The diagonals are congruent. ■ The diagonals bisect each other.

❖ Resource 2c: More Chuukese length measurements

Unit of measurement	Number indicators	Description
AFOTCHUK	1. afotchuk This unit is used to measure lengths less than ngaaf. Therefore no number indicators are presented.	Afotchuk - distance from the thumb tip on the outstretched arm to the elbow of the opposite outstretched arm
EMWALU	1. emwalu As with Afotchuk, no number indicators are used.	Emwalu - distance from the thumb tip to the elbow of the same arm

Relationship: afotchuk + emwalu = engaf

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Lesson Three

HOUSE CENTER, LENGTH AND WIDTH

Objectives: *Students will*

- explore rectangles, perpendicular bisectors in rectangles, and bisecting line segments
- review, or be introduced to two more units of Chuukese length measurement
- build skill in measuring objects and structures in the environment

Resources

Resource 3a Cross rectangle

Resource 3b Building rectangles

Resource 3c Rectangle solutions

Resource 3d Two more arm measures

Resource 3e Word wall game

Materials Needed

Measuring ropes used in Lessons 1 & 2

A copy of Resource 3b for every team of two students

A geometry compass and straight edge (ruler) for every student or every team of two

Adding machine roll of paper or any long strips of paper about 1.5 inches wide

A black marker pen to write the names of the measurement units on the strips of paper

Vocabulary for Word Wall

o'far *e'pew*	equivalent	bisector congruent	perpendicular bisector

Teacher Activities

3.1. Continuing the Story

Experience: *Measuring and laying the ropes*

3.2. Rectangles on paper

Experiences: Another look at rectangles

Everything we know about rectangles

3.3. Chuukese length measure

Experience: Two more units of arm measure

Teacher Notes

Suggested total time for each lesson is 120 minutes.

Teacher notes provide additional information

Resources for this lesson are in a separate file.

The lesson ends with a plenary.

Teacher Activities

Teacher Notes

Activity 3.1. Continuing the Story

40 minutes

Here the students work in teams of 4. Each team has 2 ropes. The questions to be explored are either posted or given verbally by the teacher.

Experience: Measuring and laying the ropes

Question 1: *How can measuring help make the house straight?*

Have students share their homework paragraphs on "How measuring can help make the house straight."

Have students move into groups of four.

Direct groups to work from the paragraphs of each to put together a paragraph that best answers the question.

Invite a representative from each group to post the group's paragraph on the board or a wall.

Give the class 10 minutes to circulate and read the posted paragraphs.

Ask students to write questions or comments on the posted papers.

Pick one or two to read aloud to the class.

Ask the group who wrote the paragraph to answer posted questions.

Points that could be included in the answers:

- measuring helps make opposite ends and sides the same length
- measuring makes sure the two king posts are the same height and the four corner posts are the same height
- measuring thatch helps us to calculate how much is needed

If students suggest measuring angles, they need to be reminded that the souiimw only mentioned bringing measuring ropes. He did not mention any tools to measure angles.

Continue reading "The Little Crooked House" with page 6.

Question 2: *Can you follow the souiimw's instructions for laying the length and width ropes on the ground?*

Direct students in their groups to move outdoors to work with ropes.

Ask students to re-read the second paragraph on page 6 and use their ropes go through all the steps:

- choose a house center and mark it
- measure a rope *fengaf* long* finding and marking its center
- place it on the ground with its center over the *nukeniféw,* making a line in the direction of the house length
- measure a rope *ruengaf-etineupw* long, finding and marking its center
- place it perpendicular to the length rope with its center over the house and length rope centers

**to make a rope fengaf long may involve tying some ropes together*

Teacher Activities

Teacher Notes

Question 3: *Are the length and width ropes perpendicular to each other?*

Remind students of the definition of perpendicular lines.

Help them recall the exercise in Resource 1a, when they were finding which pairs of lines are perpendicular.

Remind them of the still unanswered Question 3 in Lesson One, which asked them how they can be sure two ropes are perpendicular.

Have the teams circulate and look at the rope work of other teams.

If they judge the ropes are not perpendicular, they can try to fix them.

Activity 3.2: Rectangles on paper

40 minutes

Experience: Another look at rectangles

Students will work in the classroom using paper, compass, straight edge (ruler or substitute), and pencil.

Remind students that our interest in rectangles was raised by the correction we suggested for the crooked house: the floor should be in the shape of a rectangle. We wanted the four corner posts to be placed at the four vertices of a rectangle.

Review how, in Lesson One, we defined a rectangle and, in Lesson Two, we looked at some of the properties of rectangles. Here they will look at rectangles built around perpendicular line segments and vice versa.

Question 5: *How do you build a rectangle around a cross?*

Distribute Resource 3b: Building rectangles, as well as compasses and rulers (or straight edges) to students who do not have them.

Have students start with figure A, which has two perpendicular lines bisecting each other.

Ask for ideas on building a rectangle around these lines.

Discuss the suggestions of students.

A possible construction is presented in Resource 3c: Rectangle solutions.

Point out that we have constructed four congruent rectangles within the rectangle ABCD.

Ask students to complete B and C and discuss their results.

Discuss the resulting parallelogram in B and how it implies that our original lines must be perpendicular to achieve a rectangle.

Have students reflect on whether this work on paper could be any help in their work with ropes (related to the experience 3.1).

We could make a compass with a rope and a stick tied to the end. If the length and width ropes are perpendicular, we can build a rectangle, like we did on paper. If the ropes are not perpendicular, we will get a parallelogram like we did in figure B. At this point we do not know if our ropes are perpendicular.

Teacher Activities

Question 5: *How do you construct a cross within a rectangle?*

This problem involves bisecting each of the line segments that form the sides of a rectangle. If it has not already been taught, this is a good time to introduce this construction.

Experience: Everything we know about rectangles

Post a large reproduction of the rectangle ABCD as presented in Resource 3a: Cross rectangle (showing both diagonals and cross lines).

Question 6: *What do we know about rectangles?*

Put teams of two into groups of four.

Instruct each team to make a list of everything they know about this rectangle.

Ask each team in turn to offer something from their list that has not been mentioned before.

If it is correct, write it on the board.

Ask teams that had this point to put a check mark beside it to show it is correct.

Besides the points listed in Resource 3a, the definition and properties studied in Lessons 1 and 2, students may have additional responses:

- equivalent lengths (or congruency) of AF, FB, DH, HC
- equivalent lengths of AI, ID, BG, GC
- equivalent lengths of AE, BE, EC, ED
- triangles AEB and DEC are isosceles and congruent
- triangles AED and BEC are isosceles and congruent
- interior angles at A, B, C and D are right angles
- FEG, GEH, HEI, IEF are right angles
- EAB, ABE, EDC, ECD are congruent
- EAD, EDA, ECB, EBC are congruent
- triangles AEI, IED, ECG, EGB are congruent right angled triangles

Teacher Notes

See Resource 3.3: Rectangle solutions.

Note: Bisecting a line segment is one of the benchmarks for geometry in grade 7 (MAT 2.7.1).

Suggestion: the team with the longest list is winner.

Students may come up with even more options. Work together to consider if they are correct.

Teacher Activities

Teacher Notes

Activity 3.3: Chuukese length measure

20 minutes

EXPERIENCE 4: Two more units of arm measure

Question 7: *What are the four arm measures we have learned so far?*

Review the units of measure from Lessons 1 and 2.

Have students show the measures with their arms as they say the words aloud.

See Resource 3d: Two more arm measures

Question 8: *Can you name the units of measure shown?*

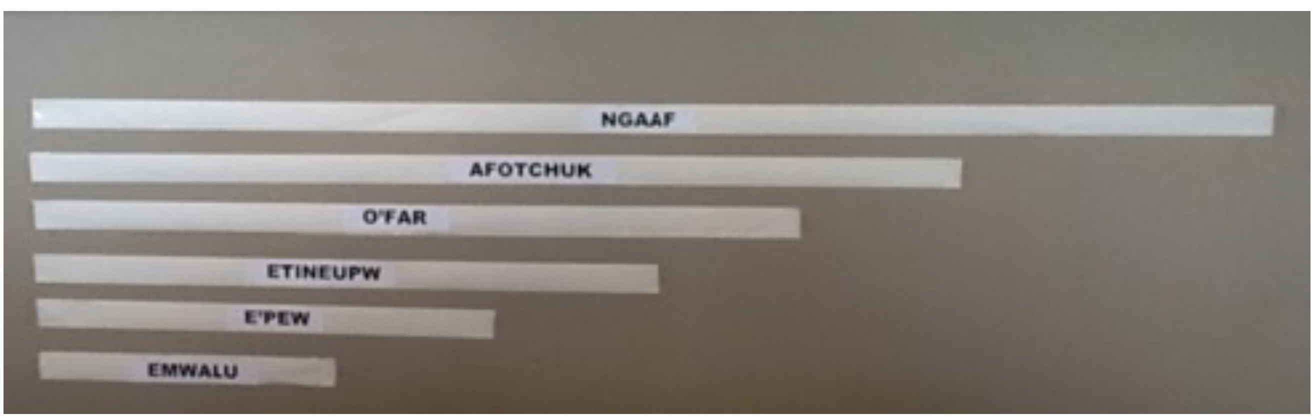
Make the arm gestures for *o'far* and ask the class to name the measure, and repeat for *e'pew*.

Introduce the measures *o'far* and *e'pew* and relationship between them.

Have students in teams of two measure these.

Write on the paper strips and post the names of the two new measures based on those of the person who was used to establish the other standard measures.

This chart shows comparative lengths for various measures:



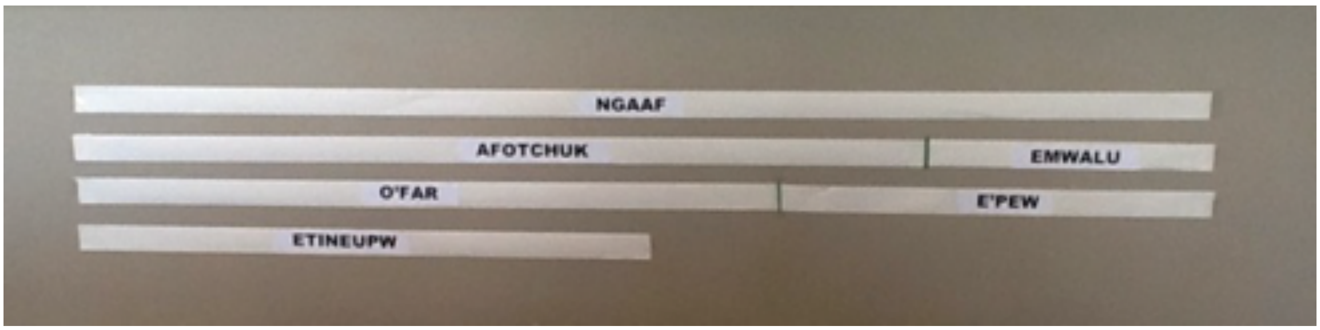
Teacher Activities

Teacher Notes

Instruct students to use their ropes or paper strips for the two new measures in order to measure appropriate objects and structures, for example:

- objects found in the classroom, like chairs, tables, mats, books, posters
- structures found anywhere on the school campus, inside or outside, like shelves, doorways, pathways, fences, steps

The figure below shows the relationships between the measures.



Plenary for Lesson Three

10 minutes

Choose some English words from the Word Wall and locate their definitions in the Glossary.

Ask students to write the definitions on pieces of paper and put the correct word at the bottom right hand corner of the paper.

Or use the papers in <u>Resource 3e: Word Wall game</u>.

Put the folded definition papers into a container.

Invite a student to pick one and read the definition aloud to the class.

The first student to call out the correct word (bottom right corner of the paper) gets to pick the next definition paper and read it to the class.

Have the game continue until there are no more papers in the container.

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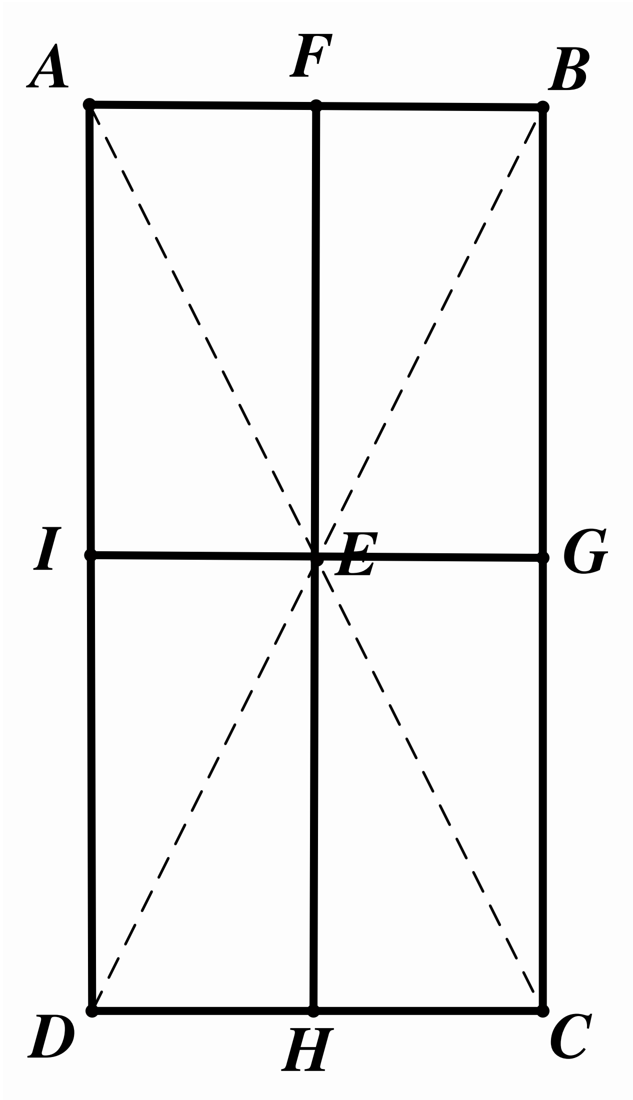
❖ Resource 3a: Cross rectangle

Rectangle ABCD



F, G, H, and I are the midpoints of sides

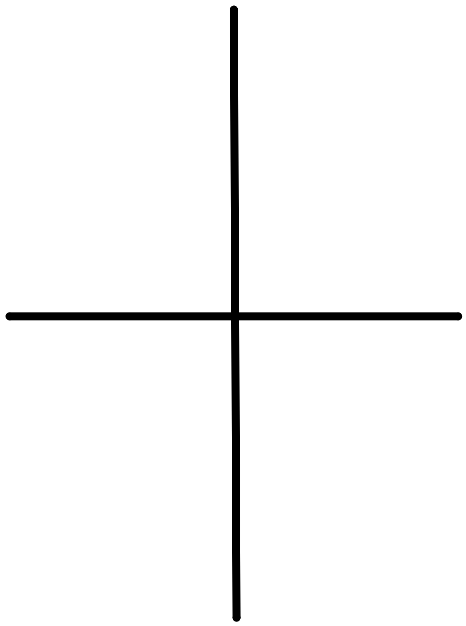
FH and IG intersect at E, the center or centroid of the rectangle

FH and IG cut the rectangle into four congruent rectangles

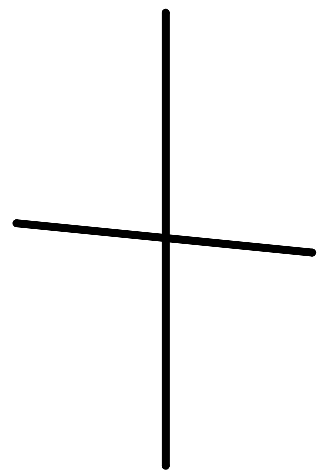
AC and BD are the diagonals of the rectangle

❖ Resource 3b: Building rectangles - I

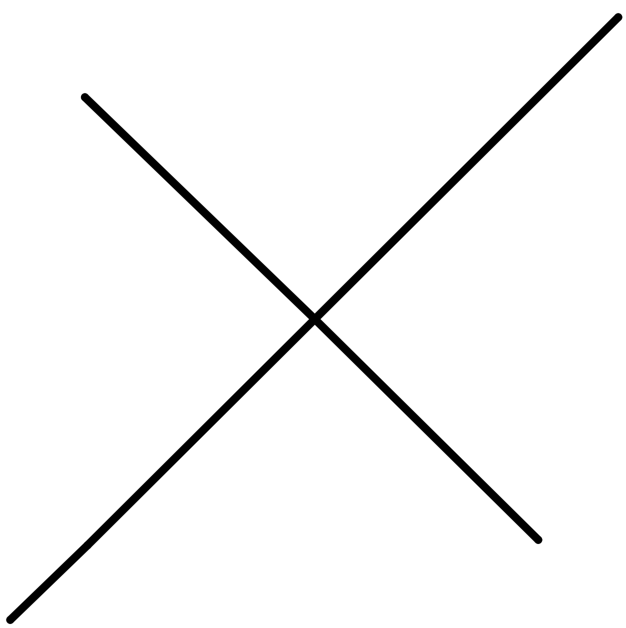
I. Build a rectangle around the bisecting lines below:



A



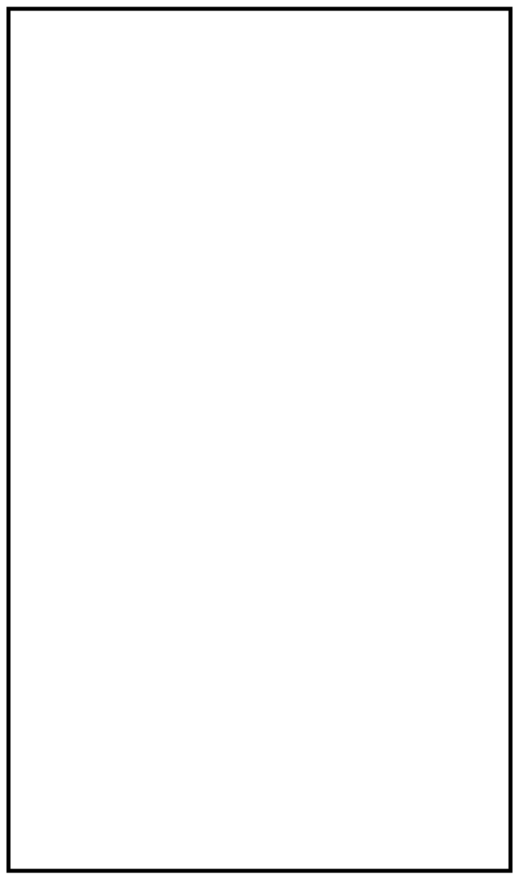
B



C

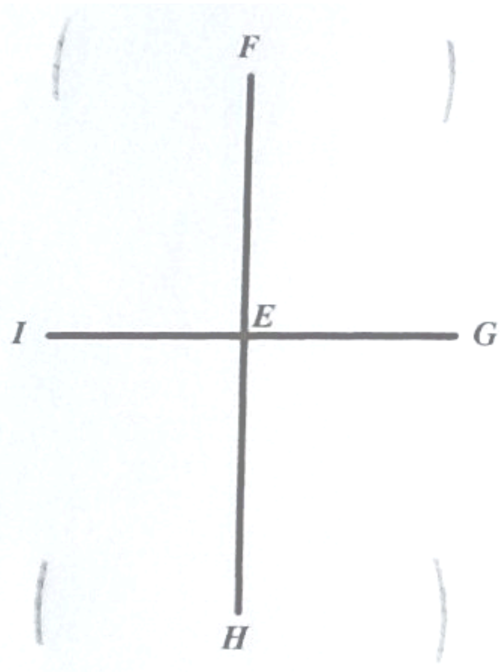
❖ Resource 3b: Building rectangles - II

II. Draw the bisecting length and width lines in the rectangle below:

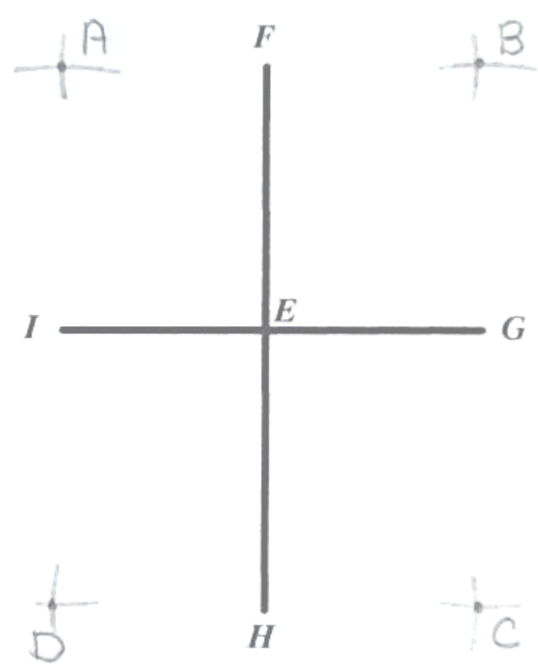


❖ Resource 3c: Rectangle solutions - I

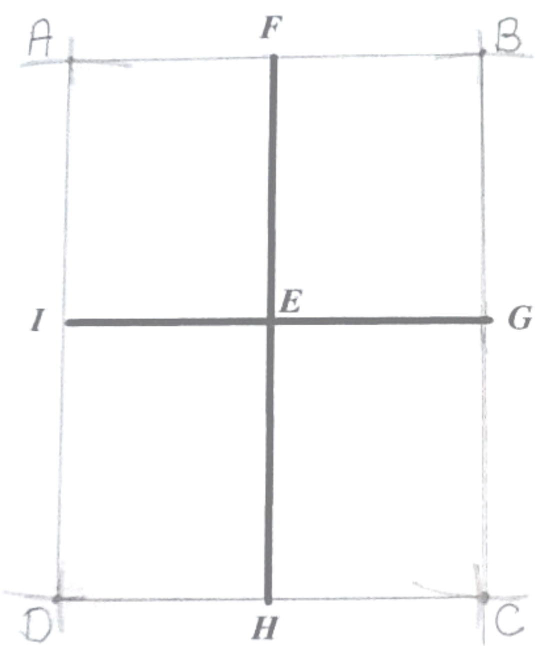
Building a rectangle around figure A:



Step 1



Step 2



Step 3

Step 1: Open the compass to the width of EG. Putting the point of the compass on F, draw an arc of a circle to the right and left of F. Then with the point of the compass on H, draw arcs to the right and left of H.

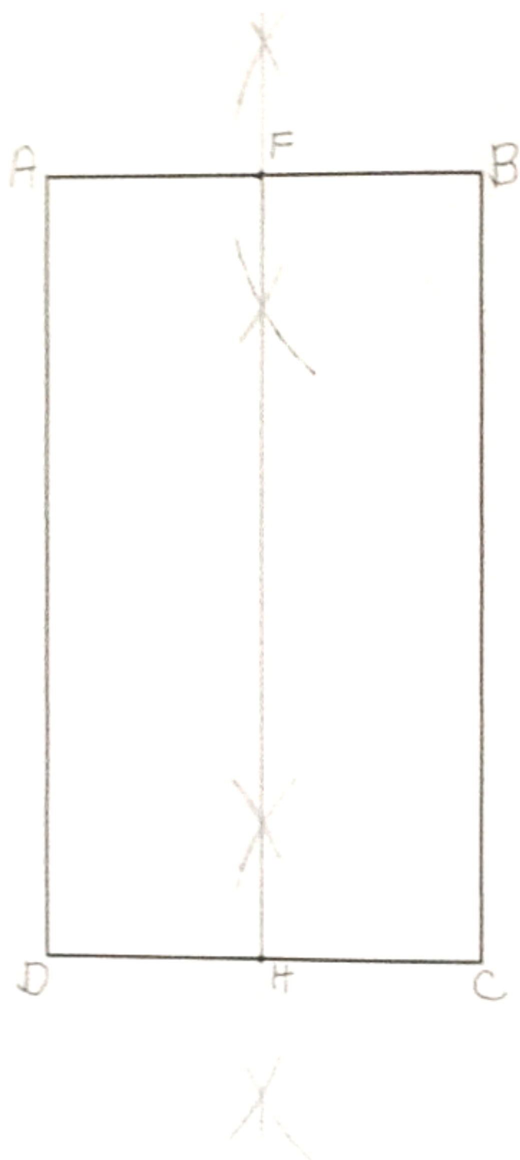
Step 2: Open the compass to the width of EF. Putting the point of the compass on G, draw an arc above and below G. Then with the point of the compass on I, draw arcs above and below I.

Step 3: Where the arcs cut, mark the points A, B, C and D. Join the points to make the rectangle.

Follow the same procedure for figures B and C. Note that since the lines in figure B are not perpendicular, the resulting construction will be a parallelogram.

❖ Resource 3c: Rectangle solutions - II

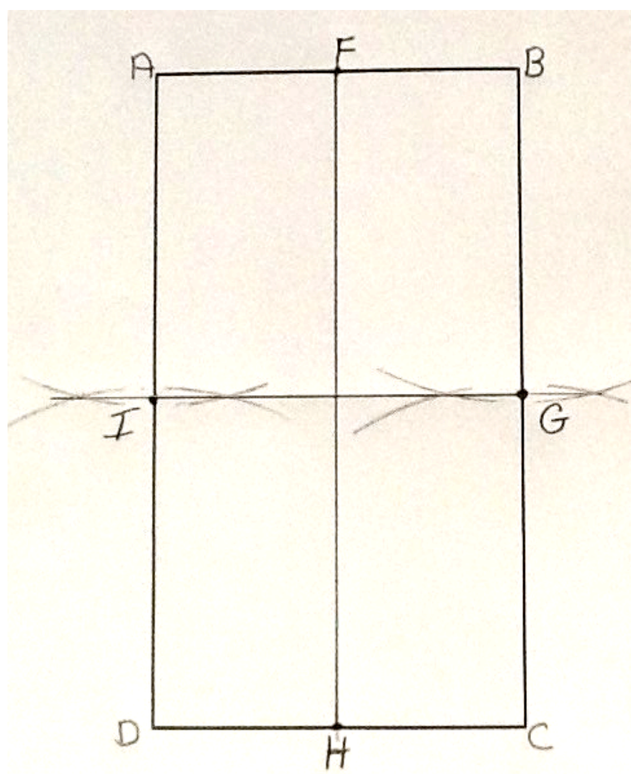
Drawing the perpendicular length and width lines in the rectangle:



Step 1: Bisect AB by putting the compass point at A and drawing an arc above and below AB. Then put the compass point at B and draw arcs above and below AB. Join the points where the arcs meet. Where this line cuts AB is the midpoint of AB. Label it F.

Step 2: Bisect CD in the same way and label the midpoint of CD, F. Join FH. This is the length line.

Step 3: Bisect AD and BC and label their midpoints I and G. Join I and G. IG is the width line.



❖ Resource 3d: Two more arm measures

Unit of Measurement	Number Indicators	Description
O'FAR	1. o'far No number indicators	Distance from thumb tip on the outstretched arm to the outside end of the opposite shoulder
E'PEW	1. e'pew No number indicators	The length of the whole arm

Relationship: o'far + e'pew = engaf

❖ Resource 3e: Word wall game

Not straight or level; bent, curved, twisted (CROOKED)
Having identical size and shape (CONGRUENT)
A triangle having two sides of equal length (ISOSCELES TRIANGLE)
A polygon with four sides (QUADRILATERAL)
Lines at right angles to each other (PERPENDICULAR LINES)
A point of intersection of two sides of a polygon (VERTEX)
A rectangle with sides of equal length (SQUARE)
Lines that are always the same distance from each other (PARALLEL)

Cut out and fold the 8 definitions and place the folded papers in a container (bowl, basket, box, hat…). The first student pulls a definition paper from the container and reads it aloud to the class. Warn reader not to read the answer, which is in brackets. The first person to say the correct word corresponding to the definition gets to pick the next paper and read the definition to the class.

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Lesson Four

LOCATING THE CORNER POSTS

Objectives: *Students will*

- recognize, perform and analyze the creation of an isosceles triangle in the rope work involved in situating the corner posts.
- recognize, perform and analyze transformations, particularly rotations (turns), in the rope work involved in situating the corner posts.

Resources

4a Making an isosceles triangle

4b Sliding the rope

4c Constructions

4d Rotating lines and triangles

4e Rotation solutions

4f Rotating the triangle

Materials Needed

Measuring ropes for length and width ropes

Lengths of lighter rope or string for creating the isosceles triangle

Paper strips, marker pen and tape or putty for Word Wall

A copy of Resources 4c and 4d for each student

A straight edge and compass for every student (or one shared between two students)

Vocabulary for Word Wall

rotation center of rotation	angle of rotation	reflection flip	transformation	translation slide

Teacher Activities

1.1. Continuing the Story

Experiences: Remembering and reading on
Enacting the story - part one

1.2. Triangles on Paper

Experiences: Sabrina's geometry review
Rotating triangles

1.3. Back to the story

Experience: Enacting the story - part two

Teacher Notes

Suggested total time for each lesson is 120 minutes.

Teacher notes provide additional information

Resources for this lesson are in a separate file.

The lesson ends with a plenary.

Teacher Activities

Teacher Notes

Activity 4.1. Continuing the Story

40 minutes

Here the students work in teams of 4. Each team has 2 ropes. The questions to be explored are either posted or given verbally by the teacher.

Experience: Remembering and reading on

Question 1: What has happened so far in the story?

Have students take turns retelling the story until now, with particular attention to what happened on page 6.

Recall points might be:

- Four friends built a house with some materials they were given.
- It was crooked and a *souiimw* who saw it told them that he would help them rebuild it, but first they had to take it down.
- They chose a center for the house, a length and a width.
- The *souiimw* measured the length rope (*fengaf*), and then the friends folded it in two and marked its center.
- They lay the length rope with its center on the house center and in the direction of the house length.
- The souiimw measured the width rope (*ruengaf-etineup*) and marked its center.
- They lay the width rope over the length rope with its center over the other two centers and in the direction of the house width.

Continue the story by reading page 8. and re-reading the first paragraph on page 8.

Emphasize the information in page 8.

Experience: Enacting the story - part one

Question 2: *What happens next?*

Group students into teams of four.

Have one team of four place the length and width ropes on the ground as they did in the first experience in Lesson 3 (with the centers of the length and width ropes over the house center)

Ask a second team to continue following the story's description of the rope work:

- They hold ropes tightly between the two students at either end of the width rope and the student at the top of the length rope.
- The student at the top of the length rope ties the two ropes with a secure knot positioned at the top of the end rope.

Directions continue…

Teacher Activities | **Teacher Notes**

Invite a third team to replace the students in the four positions.

- Holding the ends of the width rope and the thinner knotted rope securely on the ground, the student at the top of the thinner rope slides the rope through his finger as he pulls as far away as he can from the house center.
- That student marks the position of the vertex of the triangle that he or she has created on the ground.

Replace this team with a fourth team.

Direct the new team members at either end of the length rope to now straighten the length rope so its top end is at the marked triangle vertex and its center remains over the house center.

Ask all students if the length and width ropes now form a perfect cross.

In other words, do they look perpendicular?

Ensure that all students have an opportunity to experience making an isosceles triangle by sliding the rope through their hands:

See Resource 4a: Making an isosceles triangle for a model that may or may not have been part of Lesson 1

- In their teams of 4, students secure a loop of rope at either end by tying it to table legs or by two other students holding the ends securely.
- Students take turns pulling the rope through their fingers to find the point where the vertex becomes one of an isosceles triangle.

Discuss how Sabrina's thought might explain why their rope work had succeeded in making the two ropes perpendicular.

Sabrina's thought, "There was something they had learned about triangles."

Activity 4.2. Triangles on Paper

45 minutes

In this activity, students will be working in the classroom with paper and geometry instruments. They will reflect first on the experience they just had with ropes.

Experience: Sabrina's geometry review

Question 3: *How does geometry represent what happened?*

Check that all students have the "feel" of making an isosceles triangle with the rope before talking more about triangles.

Teacher Activities

Ask students to tell Sabrina what they know about triangles.

In analyzing the isosceles triangle MJN students should recognize:

- JM and JN have equal lengths
- IL, JL, and KL have equal lengths
- angles JMN and JNM are equal
- triangles JML and JNL are congruent
- **angles JLN and JLM are right angles, making MN (width rope) perpendicular to JO.**

Distribute Resource 4c: Constructions

Give students about 10 minutes to do the three constructions.

Discuss each of the constructions with the class.

Notes for the discussion of Resource 4c:

1. Finding the midpoint of GF or bisecting GF
   - Students place the compass point at G, and then at F, and draw arcs above and below GF.
   - They join the two points corresponding to the intersection of the arcs and where the resulting line crosses GF is the midpoint.

   Point out that the procedure could be used to construct congruent isosceles triangles on either side of GF.
2. Working with lines on paper instead of ropes
   - Students start by constructing a right bisector to DB, using the procedure in the previous construction.
   - Then with the compass point at E and the compass open to A, they draw a circle with center E and radius the measure of AE, or simple arcs of that circle to cut the right bisector at A' and C'.
   - Students should see that A'C' is the same length as AC and meets DB at right angles (right bisector).

   *Point out that we have essentially **rotated** the line AC in a clockwise direction, with E as the center of **rotation**.*
3. Constructing a perpendicular line that is not a bisector
   - Students extend the line MN to the left of M.
   - Then with the compass point on M, they draw an arc to cut the extension and MN.
   - Now placing the compass point in turn on each of the points of intersection of the arcs with the line, students draw arcs above and below the extended line MN.

   Point out that the line joining the meeting points of these two arcs is the perpendicular to MN at M.

Teacher Notes

This "brain storming" might be enriched by reproducing the geometric drawing in Resource 4b: Sliding the rope.

This last point is the most important one.

"Finding the midpoint of GF, or bisecting GF" is a grade 7 benchmark (MAT. 2.7.1), which is also in Lesson 3 (when finding the mid-points of the sides of a rectangle).

"Working on with lines on paper" corresponds to the rope activity in 4.1.(when enacting the story).

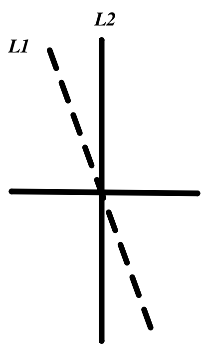
*We will be talking more about **rotations** in the next activity.*

Teacher Activities

Teacher Notes

Experience: Rotating triangles

In the rope work analyzed above, the final step involved moving the length rope so that it was perpendicular to the width rope. This can be seen as a rotation of the width rope about its center.



The original position of the length rope is represented by the dashed line L1.

The final position of the length rope is represented by the solid line L2.

In this case the rotation is about 20º.

The center of rotation is where all lines meet, the house center in our rope work.

Here we will do some paper and pencil work on rotations to prepare students for the continuation of the rope work which involves two rotations about a point.

Question 4: *Did we rotate the length rope about its center?*

Work with students on the problems in Resource 4d: Rotating lines and triangles, which show resulting rotations.

Post words to the Word Wall as they are introduced and define words that are unfamiliar to the students (see Glossary).

Note that we have restricted rotations to 45º, 90º, and 180º so that the use of a protractor may not be necessary. Paper folding any scrap of paper can produce the necessary angles.

Activity 4.3. Back to the Story

20 minutes

Here we return to the story on page 8 and students return to their ropes as they left them at the end of second experience in activity 1.1.

Experience: Enacting the story - part two

Question 5: *What happens next?*

Read aloud the second paragraph on page 8.

Have students suggest the steps they will go through in their rope work. The should say that they would

- pick up the rope triangle,
- circle through 180º, and then
- mark the position of the two vertices that situate the corner posts.

MACIMISE

Teacher Activities

Teacher Notes

If the ropes are no longer in position on the ground, ask for a team of 4 to repeat the rope work done in activity 1.1, in the second experience:

Ask for 3 volunteers to find the positions of the top two corner posts by following the steps in paragraph 2.

Ask students to mark the positions of the corner posts.

Have students identify the center of rotation and the angle of rotation.

Read aloud the third paragraph on page 8.

Ask another three students to do the rope work suggested in the story.

Mark the other two corner posts (a stick in the ground or a stone can be a good marker).

Once again have students identify the center and the angle of rotation.

See Resource 4f: Rotating the triangle for a geometric representation of the rope work here.

Plenary for Lesson 4

Lead the students in a collective re-telling of the story on page 8, bringing in the key words added to the Word Wall in this lesson.

Review, and post on the Word Wall, the names of the three transformations:

15 minutes

- rotations (turns),
- translations (slides)
- reflections (flips).

Point out that the final rotation of the rope triangle could also be considered a reflection (or flip) of the triangle over the house center and, with the original position of the width rope, as the axis of reflection.

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❖ Resource 4a: Making an isosceles triangle

In Lesson 1, students made an isosceles triangle with a rope. One of the strategies presented there was illustrated in Resource 1c and is reproduced below. This is the strategy we use in the rope work when we make an isosceles triangle between 3 students.

Making an isosceles triangle with 3 students (A, B and C):

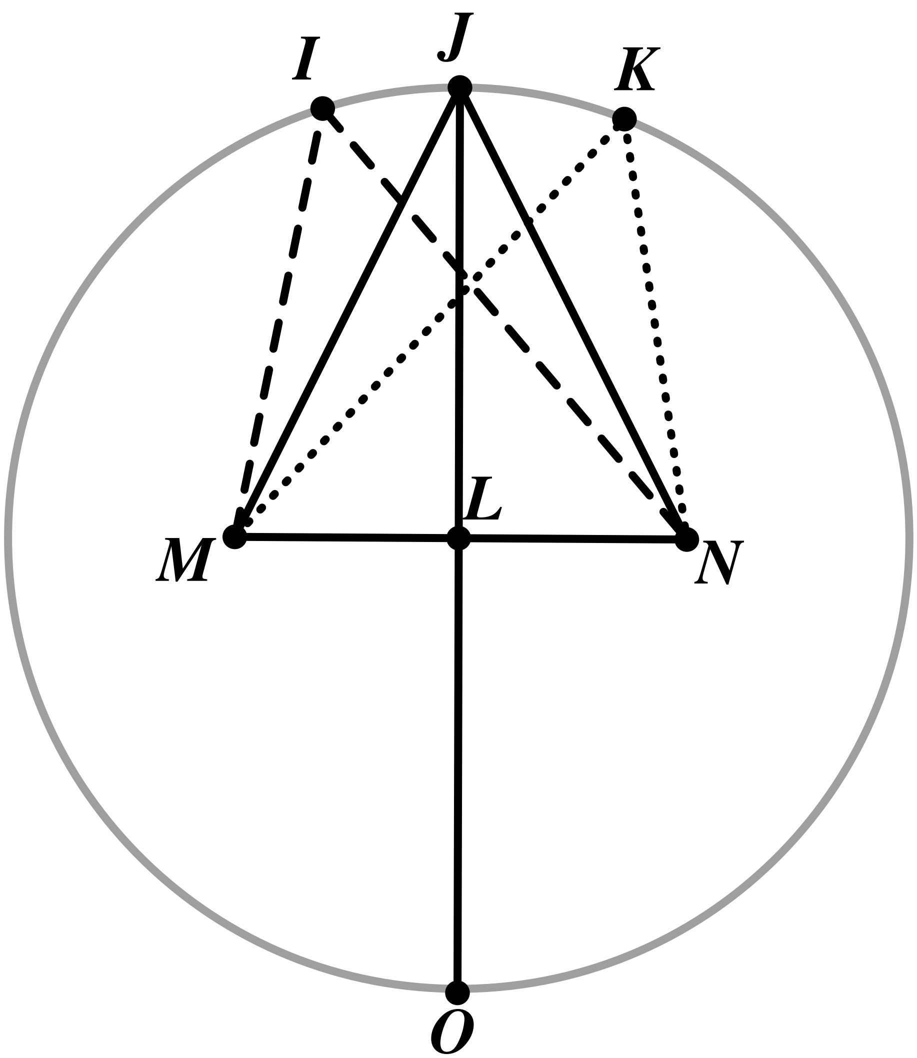
Students A, B and C start in the position of their scalene triangle. Only one student needs to move to make an isosceles triangle. We choose Student C.

Student C moves to the right letting the rope slide through his fingers while keeping it tight.

Student C stops when he feels he is the furthest away from A and B (and the rope between them) as he can be. At this point, ABC is in the shape of an isosceles triangle with AC equal in length to BC.

❖ Resource 4b: Sliding the rope

A geometric illustration of sliding the rope to the point where the triangle becomes isosceles:



Students hold the rope at points M and N. MN represents the width rope.

The dashed line represents the initial position of the rope loop held by the student at point I.

The dotted line shows what happens if the rope is pulled beyond J to point K

The grey circle (center at L and radius equal to half of the length rope or *ruengaf* in the story) is the path of the student sliding the rope tightly through his fingers.

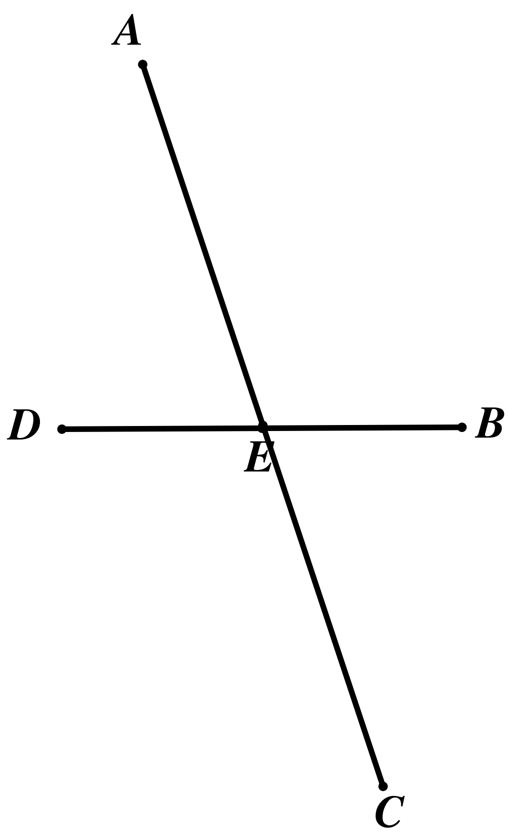
At position J, the student is the furthest away from MN and equal distance from M and from N.

❖ Resource 4c: Constructions

Using compass and straight edge:

1. Find the midpoint of GF

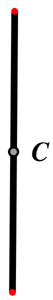
2. Draw A'C' so that it is a right bisector of DB



3. Construct at M, a line perpendicular to MN

❖ Resource 4d: Rotating lines and triangles

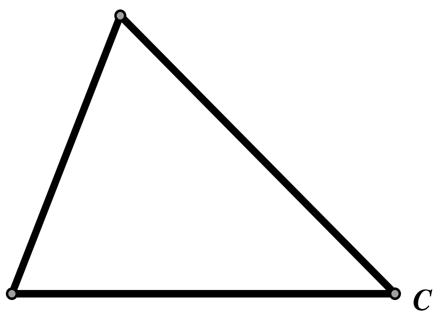
Rotate (turn), clockwise, the lines and triangles the number of degrees indicated (∠R for angle of rotation). C indicates the center of rotation, the point around which the line or triangle turns.



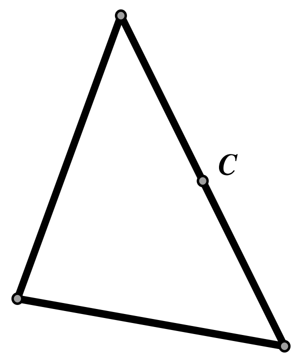
∠R = 90°

∠R = 45°

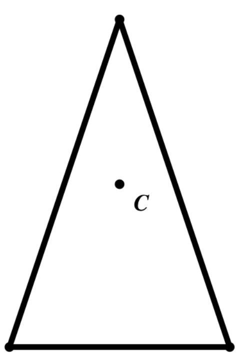
∠R = 180°



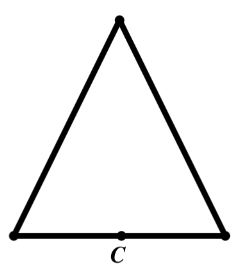
∠R = 90º



∠R = 45º



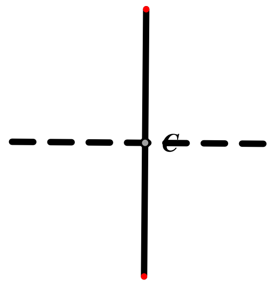
∠R = 180º



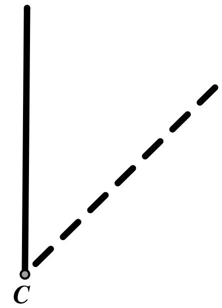
∠R = 180º

❖ Resource 4e: Rotation solutions

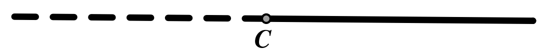
The dashed lines or shapes represent the solutions:



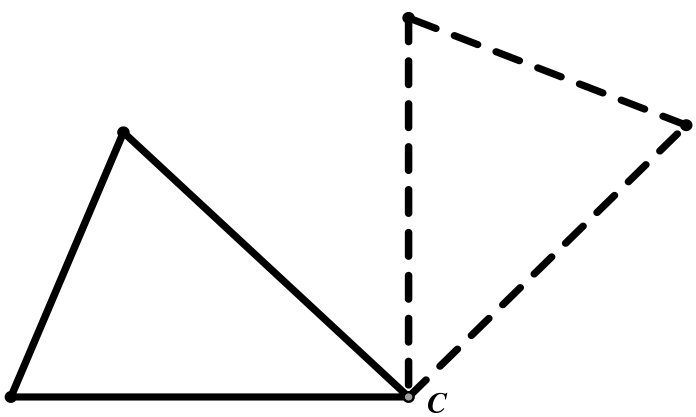
∠R = 90º



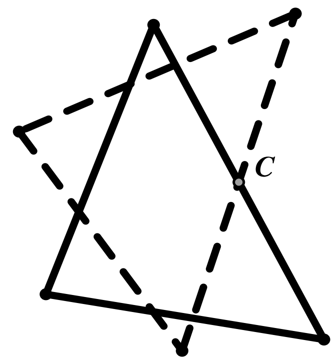
∠R = 45º



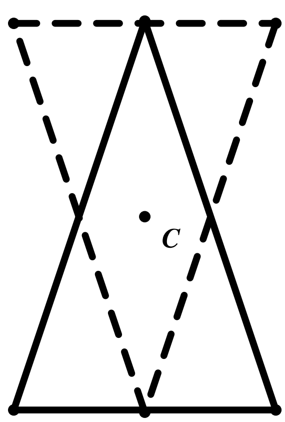
∠R = 180º



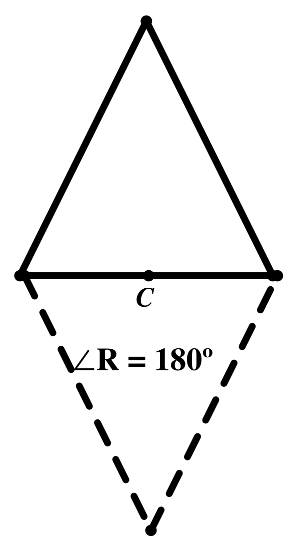
∠R = 90º



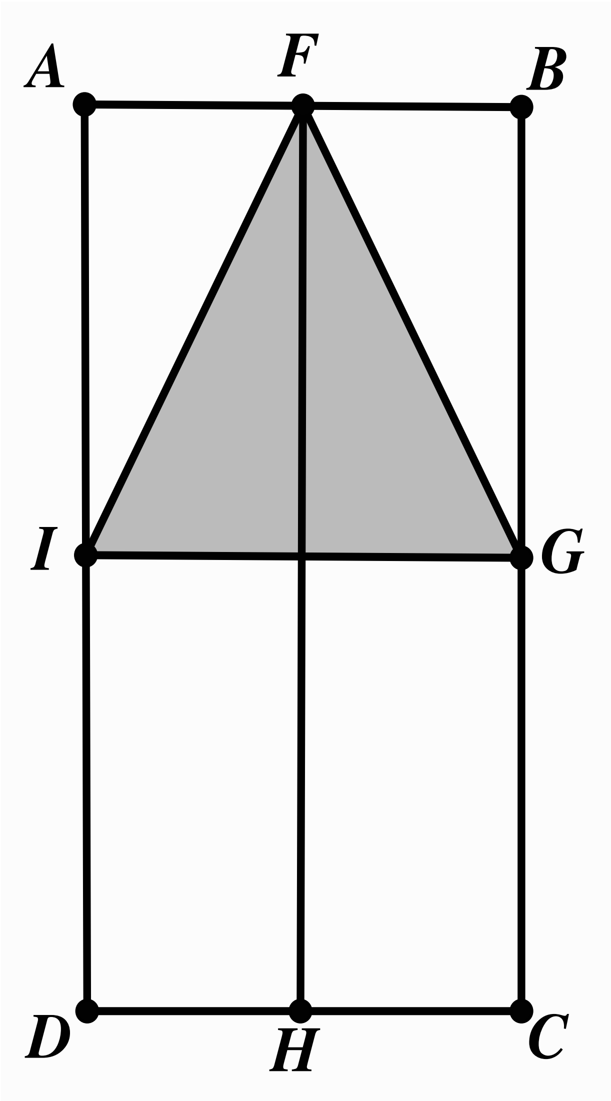
∠R = 45º



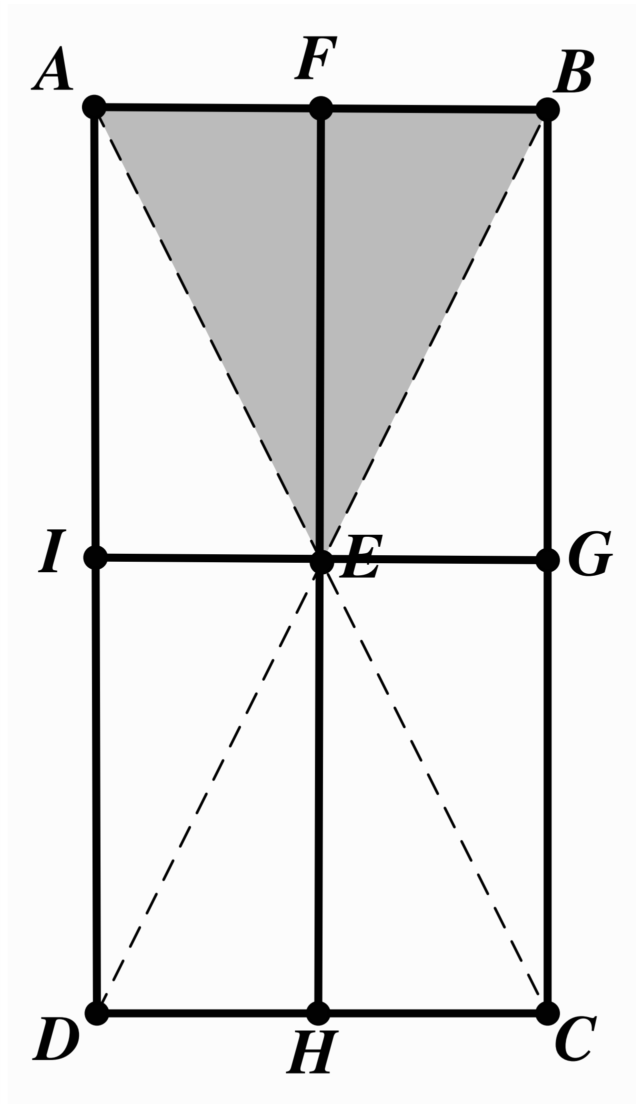
∠R = 180º



❖ Resource 4f: Rotating the rope triangle - I

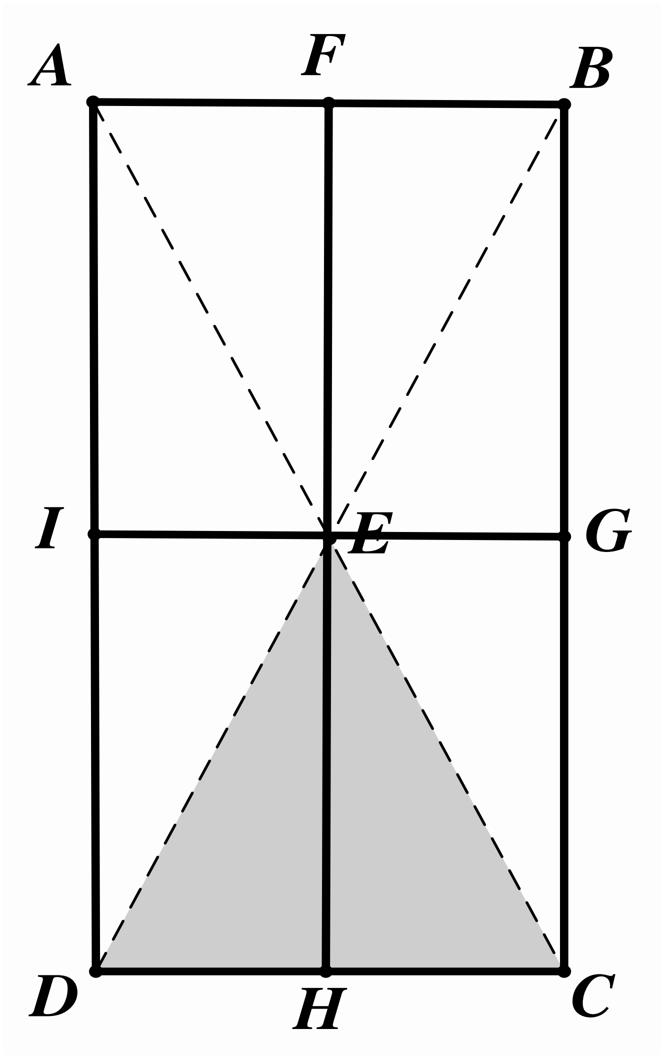


Original position of rope triangle (grey)



Rope triangle after students rotate in paragraph 2.
Center of rotation: midpoint of segment EF.
Angle of rotation: 180°

❖ Resource 4f: Rotating the rope triangle - II



A and **B** are the positions of the first two corner posts, marked after the first rotation about the midpoint of FE.

C and **D** are the positions of the other two corner posts marked after the second rotation of the rope triangle about E.

Center of rotation: point E
Angle of rotation: 180°

Rope triangle after second rotation (paragraph 3)

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Lesson Five

ERECTING THE CORNER POSTS

Objectives: *Students will*

- reflect on the geometry behind the placing of the corner posts
- apply the geometry of diagonals to house building
- introduce proportions in the human body
- extend thinking in 2-D geometry to 3-D, the rectangle to the rectangular prism

Resources

Resource 5a The Vitruvian man

Resource 5b Checking corner posts

Resource 5c Checking corner posts: discussion

Resource 5d Vertical corner posts

Materials Needed

Four sticks and base (foam or earth) to model the four corner posts

Straight sticks or doweling that can be cut into sticks for students to make a model

Paper strips, rope or string to measure height and arm span, and rope to measure diagonals

A copy of Resource 5b as well as a compass or divider for each student

Vocabulary for Word Wall

vertical	horizontal	rectangular prism

Teacher Activities

5.1. Putting in the corner posts

Experiences: *Continuing the story*

The height of the corner posts

5.2. Straightening the corner posts

Experiences: Checking the bottoms of the posts

Checking the tops of the posts

Applying the diagonal test

Teacher Notes

Suggested total time for each lesson is 100-120 minutes.

Teacher notes provide additional information

Resources for this lesson are in a separate file.

The lesson ends with a plenary.

Teacher Activities

Teacher Notes

Activity 5.1. Putting in the Corner Posts

45 minutes

Experience: Continuing the story

Question 1: *What is the action on page 10?*

Remind students that we are at the point in the story where the ground is marked for the positions of the four corner posts.

Post a few questions about how the story continues and ask students to read page 10 and answer questions.

Here are suggested questions:

- What is the action here?
- How did they ensure the corner posts were all the same height?
- How did they check that the posts were vertical?

Discuss students' understanding of the story.

Ask students to re-read the first paragraph.

Experience: The height of the corner posts

Question 2: *How high above the ground are the corner posts?*

The story tells us that the corner posts are the height of the *souiimw* so the question becomes: *How tall is the souiimw?*

Invite students to work in pairs to help each other find their height.

If students have never measured their height before, demonstrate with a volunteer.

- One student stands against a solid wall, with heels and back of head touching the wall and head level.
- The partner places a flat solid object (e.g., book) on the top of the student's head.
- Make a mark on the wall level with the top of the student's head.
- Use the rope or strip of paper to mark off the distance between the floor and the mark on the wall.
- Use the rope or paper strip with the student's height marked off and measure his or her arm span.

In most cases the height will be a little greater than the arm span.

Every student should, with the help of his or her partner, do this comparison.

Discuss results with the class.

Ask the students: "What is the height of the corner posts?"

Answer: a little bit more than engaf, since the souiimw measures a bit more than his arm span and his arm span was used as the standard engaf measure.

Teacher Activities

Teacher Notes

Question 3: *Why do many people say our arm span is almost equal to our height?*

Tell students about the measurements done by Leonardo da Vinci and how he drew a man in a square with the middle finger tips of his extended arms touching opposite sides of the square and his head and feet the other two opposite sides.

See Resource 5a: The Vitruvian man.

We measured arm span from thumb tip to thumb tip but there are others, including Leonardo da Vinci, who measure from the middle fingertip to middle fingertip.

Have students help each other (in their previous teams of 2) to make the finger tip to finger tip measure on a rope or strip of paper and to once again compare it to their height.

Post a few results and discuss them.

Results should be pretty close.

Activity 5.2: Straightening the Corner Posts

45 minutes

Experience: Checking the bottoms of the posts

Read the second paragraph on page 10 aloud to the class and make sure the class understands what happened.

Question 4: *Why did the diagonal rope work satisfy the souiimw that the posts were in the 'right spots'?*

If the markers the students placed for the house center and the corner posts are still in place, have them enact the diagonal rope work:

- stretch a rope between diagonally opposite markers (for the posts)
- find and mark its center
- stretch the same rope length between the other pair of vertically opposite post markers

It should fit as in the story and its center should lie over the house center.

Distribute Resource 5b: Checking corner posts (with compass or divider).

Have students work through the three problems.

Remind students of the two important properties of the diagonals in a rectangle: they are the same length (congruent) and they bisect each other.

When students have finished, discuss the three figures with the students and how none represent the correct placement of the corner posts.

Figure C is important because although the diagonals are the same length, they do not bisect each other.

See Resource 5c: Checking corner posts: discussion.

Teacher Activities

Teacher Notes

Experience: Checking the tops of the posts

Until now we have been working on a flat surface: the ground or a paper. With the installation of the corner posts we move into 3 dimensional shapes. If the posts are perfectly vertical, they represent the height of a rectangular prism.

Prepare a model of four corner posts: the four corner posts are the same height above ground and placed correctly (at the vertices of a rectangle).

The model could be made with 4 sticks stuck in the ground or in a foam base.

Question 5: *Why is it important to check that the centre of the diagonal rope is above the nukeniféw?*

See Resource 5d: Vertical corner posts for a possible model and demonstration of the importance of the diagonal work.

Have students examine the model of four corner posts.

Direct students to use a piece of string or strip of heavy paper to verify the diagonals both on the ground and over the tops of the posts.

Point out that they should see that the centers of the diagonals are above the house center (where the ground diagonals cross).

Push the tops of the corner posts so all four posts are leaning in the same direction, at about a 15 degree angle from the vertical.

Point out how the center of the diagonals shift in the same direction as the leaning posts and it is no longer over the house center.

MACIMISE

Teacher Activities **Teacher Notes**

Experience: Checking the tops of the posts

Question 5: *Can you use the diagonal test (at the bottoms and tops of the posts) to "fix" the posts?*

In the story, the diagonal test told the *souiimw* that the posts were correctly placed and vertical. But it is possible that the diagonal test indicated that there was a problem.

Ask students to work in teams of 3 or 4.

Invite students to make a model of the corner posts and use the diagonal test to "fix" them (position and verticality).

For this, each team will need 4 sticks and can use the ground for the base.

Ask teams to report on what problems they encountered and how they solved them.

Plenary for Lesson Five

10 minutes

In this lesson we moved back and forth between the construction task of putting in the corner posts and the geometric analysis of this.

We worked essentially with 8 points: the four vertices of the rectangle on the ground and the four tops of the posts.

These 8 points form the vertices of a rectangular prism if our work was well done.

In this plenary, ask students to identify the rectangular prism in their models.

Review the lesson in terms of this geometric language, where the posts form four of the edges of this prism.

Advise students that the next lesson will begin with a discussion of rectangular prisms and that they should prepare with review (see homework).

Homework: Prepare for the next lesson by reviewing anything learned to date about the 3-D shapes, e.g., definition, description of sides, volume, and so on.

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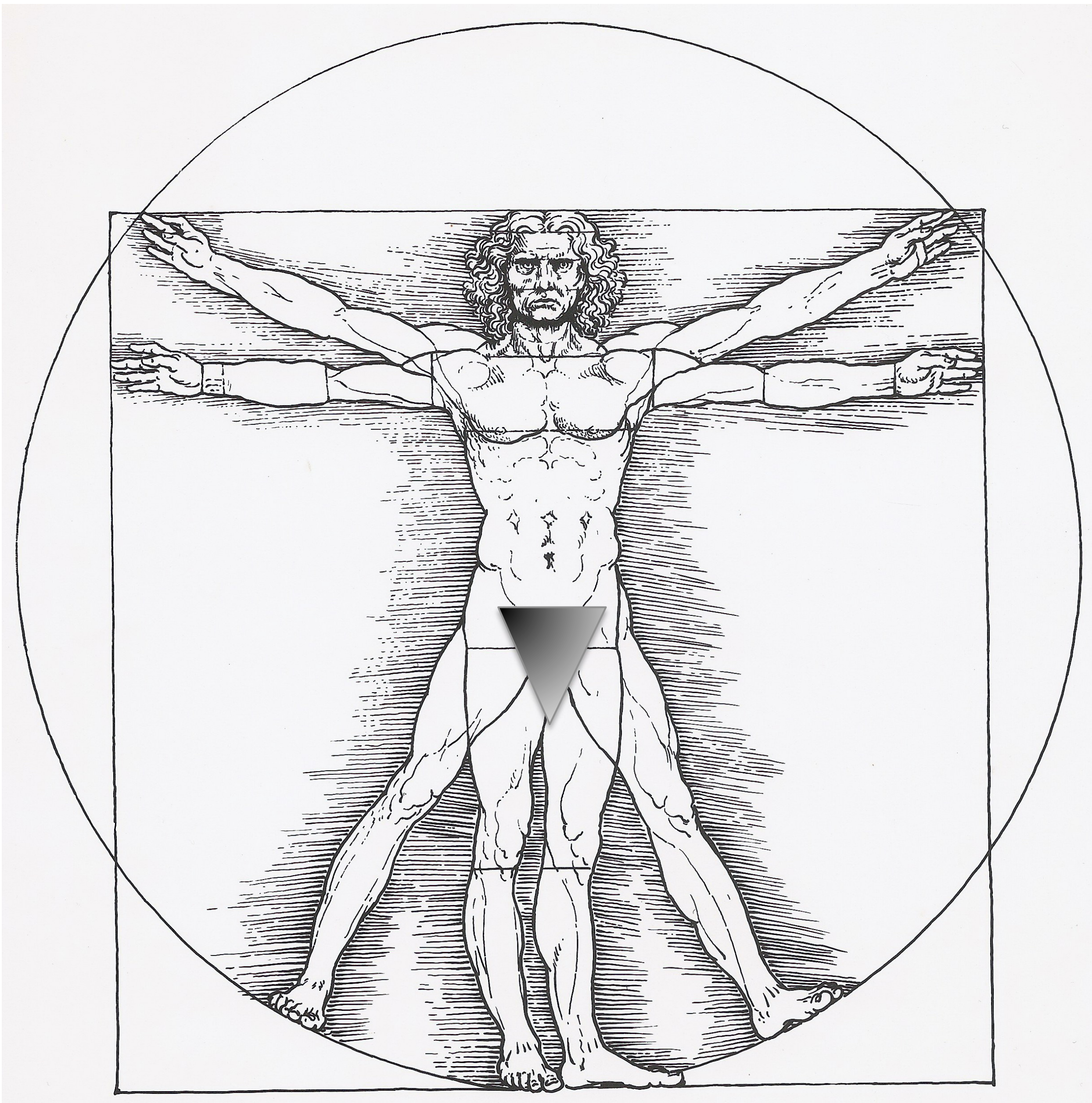
❖ Resource 5a: The Vitruvian man

In the famous drawing that has come to be known as the Vitruvian man, Leonardo da Vinci represented the model first standing straight in a square with his arm span measuring the same as his height. Then he shows him with his legs apart and his arms raised level with the top of his head, fitting in a circle. As an artist, da Vinci was very interested in measures and proportions in the human body.



Resource 5b: Checking corner posts

The dots below represent the positions of corner posts for a traditional house. Use your knowledge of rectangles to decide which posts are placed correctly and explain why.

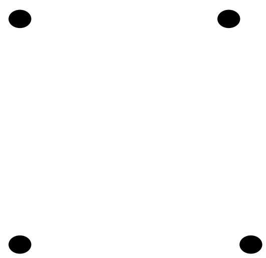


Figure A

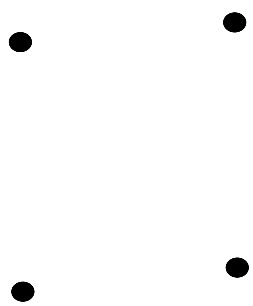


Figure B

Figure C

❖ Resource 5c: Checking corner posts - discussion

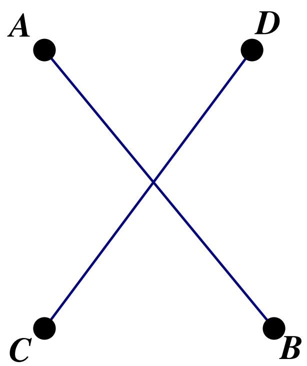


Figure A

Comparing the lengths of diagonals with a compass (or other instrument) we see that AB is a bit longer than CD. Because the diagonals are not equal in length, ADBC is not a rectangle. So the corner posts are not placed correctly.
Students may also have found that AD is shorter than BC, which is another reason ADBC is not a rectangle.

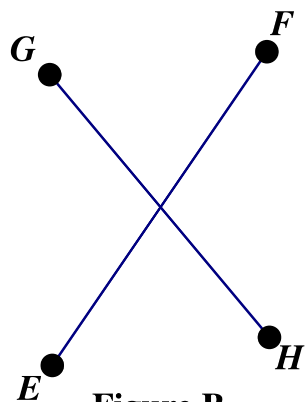


Figure B

Here we find that GH is shorter than EF. Although the diagonals appear to bisect each other, they are not of equal length so the corner posts are not placed correctly.

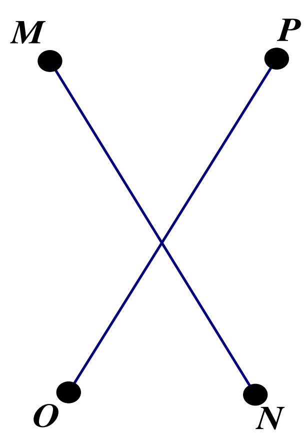
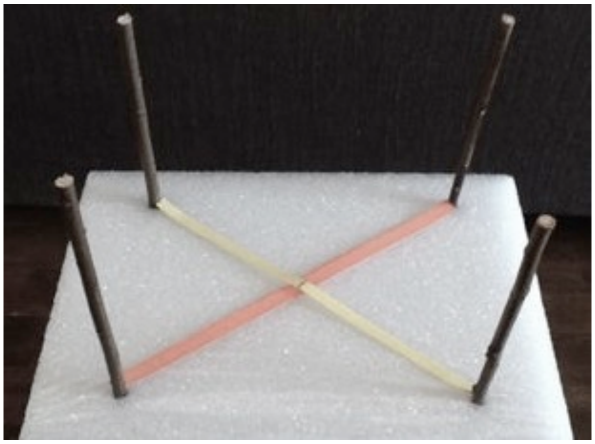


Figure C

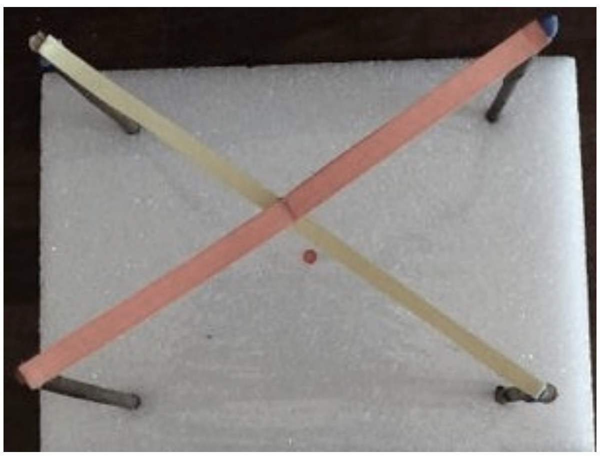
Comparing the lengths of MN and OP, the two diagonals, we find they are equal. However, the diagonals do not bisect each other. If we name the point where they cut each other C, we see that the lengths of MC and CN are not the same. So the corner posts are not correctly placed.

❖ Resource 5d: Vertical corner posts

A straight house



The diagonal test on the ground: the strips of paper represent the diagonal ropes of equal length or the two positions of one diagonal rope with its center marked and lying on the house center.



The diagonal test at the top of the posts: the same two strips of paper represent the diagonal rope(s) at the top of the posts with center(s) above the house center.

A crooked house

Here the posts are all leaning about the same amount to the right. The same two diagonal measures meet at their centers but are not over the house center.

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MACIMISE

Lesson Six

TINÉW & OUCHAMW

Objectives: *Students will*

- consolidate knowledge of rectangular prisms
- be introduced to triangular prisms
- **c**ontinue building knowledge of the construction of a traditional house
- approach an open-ended problem-solving situation requiring modelling and estimation

Resources

Resource 6a The rectangular prism

Resource 6b Practice with prisms

Resource 6c Triangular prisms

Resource 6d Tying the beams

Resource 6e Singóón problem

Resource 6f Model work

Resource 6g Laying wall and end beams

Materials Needed

A large box or other object to represent a rectangular prism

A copy of Resource 6b for each student or team of two students

A foam block or heavy paper to make a triangular prism

A copy of Resource 6d and a piece of rope measuring the class standard *engaf* for every team of students

A few short logs of wood (or plastic water bottles or other substitute) students can use for tying

Sticks or doweling to make end and length beams for the house model and string to tie the beams to the corner posts - and a a bit of poster putty or other adhesive

Vocabulary for Word Wall

triangular prism	cube	surface area volume	*tinéw* *ouchamw* *pwéét*	polygon polygonal

Teacher Activities

6.1. Geometric prisms

Experiences: *Recalling rectangular prisms*
Introducing triangular prisms

6.2. Placing the wall and end beams

Experience: Back to the story
Enacting the story

Teacher Notes

Suggested total time for each lesson is 100-120 minutes.

Teacher notes provide additional information

Resources for this lesson are in a separate file.

The lesson ends with a plenary.

Teacher Activities

Teacher Notes

Activity 6.1. Geometric Prisms

30 minutes

Experience: Recalling rectangular prisms

See Chuuk Standards and Benchmarks:
MAT.2.3.2 and MAT.2.3.3
MAT 3.5.6

Although rectangular prisms were first named in Grade 3, the concept of the volume of rectangular prisms was introduced in Grade 5.

In Grade 7 the work with rectangular prisms is deepened. Students must master finding their volume and surface area and, given the volume, finding a missing dimension.

Question 1: *What do you know about rectangular prisms?*

Put students into small groups to share their knowledge of rectangular prisms (homework from Lesson 5)

Or begin the lesson with the whole class sharing.

Follow with a time for the whole class to share.

Choose an object to represent a rectangular prism, such as a large box, and show it at the front of the class.

See Resource 6a: The rectangular prism for the points that should come out in this activity.

If students do not mention some points, ask questions, for example,

- How do we find the volume of a rectangular prism?
- How many vertices does a rectangular prism have?

Distribute Resource 6b: Practice with prisms to every student or team of students so they can practice finding surface area and volume.

When they are ready to correct their work, ask each student or team to pass their copy to another student or team.

Discuss any difficulties that students encountered.

Answers for Resource 6b

The top prism:

The surface area is 2(3 x 3 + 3 x 6 + 3 x 6) u^2 or **A = 90 u^2** and the volume is **V = 54 u^3**

The second prism:

The surface area **A = 126 u^2** and the volume **V = 48.6 u^3**

Since the bottom prism is a cube, l = w = h, so V = w^3.

Since V = 64 u^3, w^3 = 64 and w = 4.

The length, width and height of the cube all measure **4 u**.

The surface area of each face is 16 u^2 so the total surface area is 6 x 16 u^2. **A = 96 u^2**.

Teacher Activities

Experience: Introducing triangular prisms

Question 2: *What changes when the prism base is a triangle?*

Introduce the triangular prism. If possible show a model and compare it to the rectangular prism (box).

Have students compare its features to a rectangular prism: faces, edges, vertices, surface area and volume.

Tell students that they will study triangular prisms in more detail in grade 8. The reason for mentioning triangular prisms here will be more evident once the king posts are in place and we look at the space defined by the rafters, wall and end beams, and the ridgepole.

Activity 6.2: Placing the wall and end beams

Experience: Back to the story

Question 3: *What is the next step after installing the corner posts?*

Ask students *Question 3* and then have them read page 12 of the story.

Question them about their understanding, or ask them to list what happens in the order it happens.

Here is a possible sequence of events:

- They sat and discussed plans.
- They learned how to tie beams and practiced this.
- Tasks were assigned (Issack and Sabrina measured, Jake cut, Enson helped the *souiimw* placed the beams).
- End beams or *ouchamw* were measured (same as the width), and their centers marked and then placed across the corner posts.
- wall beams, *tinéw*, were measured (longer than length rope) and placed over the end beams.
- the beams were tied to the corner posts, the *úúr*.

Teacher Notes

A model of a triangular prism will be helpful for introducing it and for comparing it to the rectangular prism (box).

See Resource 6c: Triangular prisms for some ideas on making a triangular prism, as well as other information about this 3-D shape.

60 minutes

Teacher Activities | **Teacher Notes**

Experience: Enacting the story

Question 4: *How much singóón do you need to tie the corner posts?*

Distribute Resource 6d: Tying the beams to teams of students (2 to 4 students per team)

Ask them to try to answer the question under the picture.

This is a very open ended question, so encourage students to explore their own way to respond.

Some students may want to try to replicate the tying using a couple of pieces of wood while others may want to guess at the measurements and use their knowledge of circles.

The key to guessing the measurements in the photo is the width of the student's hands. For those who want to replicate the tying, it is important to have a few short lengths of wood available and some rope.

Note that the answer is not important.

Follow up with discussion.

Have groups volunteer to demonstrate how they tackled the problem.

See Resource 6e: Singóón problem for two possible strategies.

Question 5: *Can we model the work the friends achieved?*

Direct students, in their teams, to continue their house model by adding the end and side beams.

See Resource 6f: Model work for photos of a model.

Plenary for Lesson Six

Have students tell the construction story (so far) in Chuukese, using all the Chuukese words on the Word Wall.

See Resource 6g: Laying wall and end beams for a labeled photo of the beams on the corner post.

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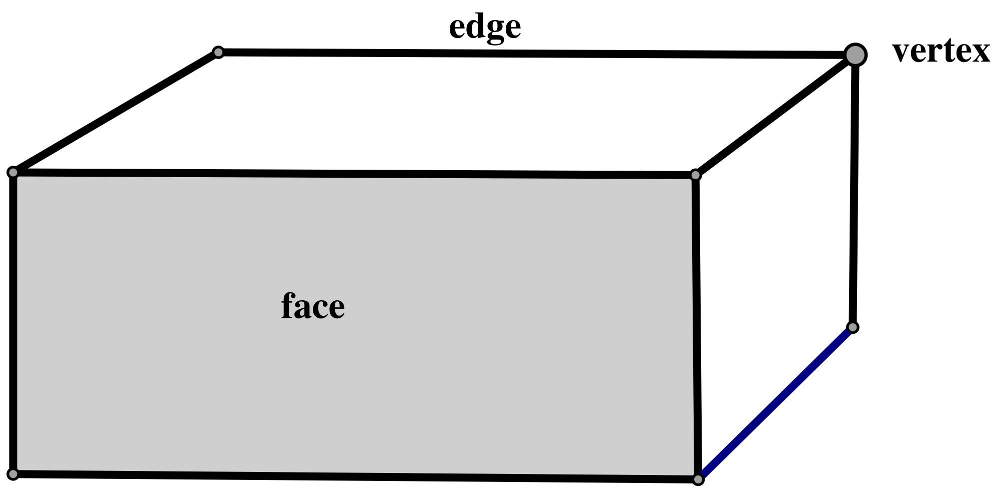
❖ Resource 6a: The rectangular prism

Definition: a solid figure, or its surface, that has 6 rectangular sides or faces and all interior angles are right angles (examples: a box, a brick)



A rectangular prism has 12 edges, 6 faces, and 8 vertices.

All faces are rectangles.

Edges are either perpendicular or parallel to each other.

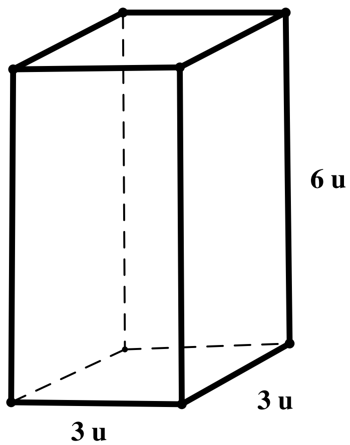
At each vertex 3 edges meet.

The **surface area** of a rectangular prism is 2(lw + wh + lh) where l, w, and h represent the measures of the length, width and height and where lw represents the product of the length and width.

The **volume** of a rectangular prism is lwh, the product of the length, width and height.

❖ Resource 6b: Practice with prisms

For the rectangular prisms below, find the surface area and the volume. Note that the unit of measurement is defined simply as u, so the area will be in $u^2$and the volume in u^3.

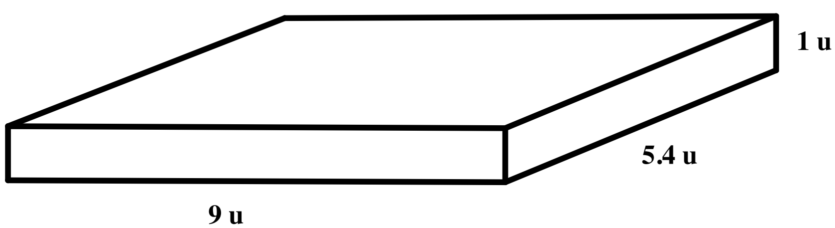


Surface area: ______________________________

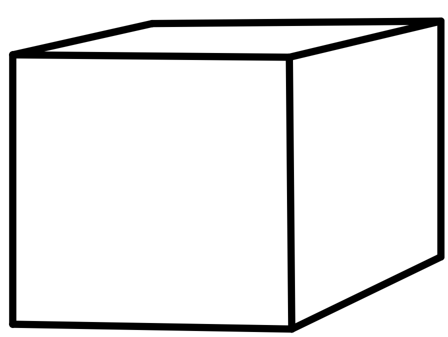
Volume: ______________________________

Surface area: ______________________________

Volume: ______________________________



Find the dimensions and surface area of the cube below knowing that it has a volume $V = 64\ u^3$.

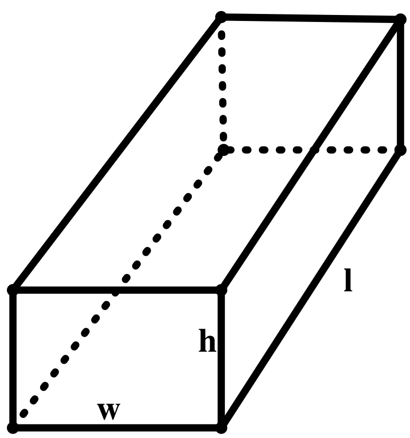
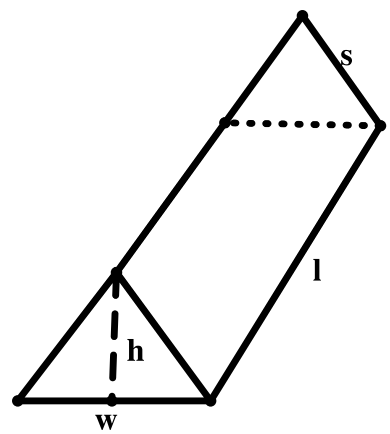


❖ Resource 6c: Triangular prisms - I

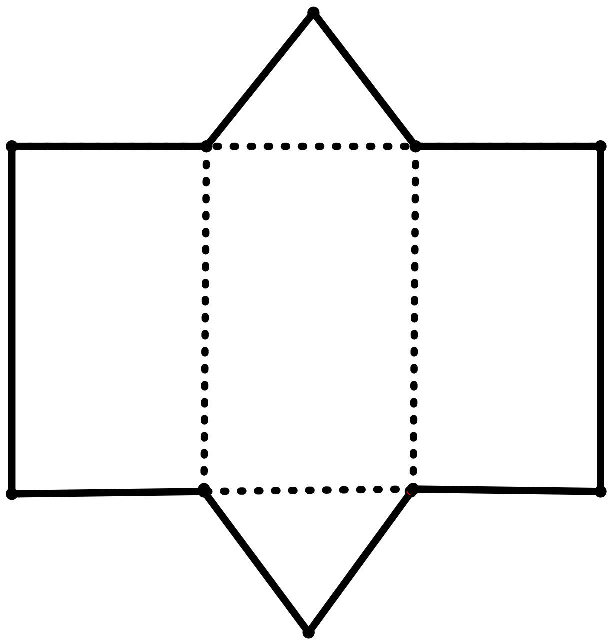
A prism is a solid figure with two congruent, parallel, polygonal bases. If the polygon base is a rectangle, the prism is called a rectangular prism. If the polygon base is a triangle, the prism is called a triangular prism. It is the polygon base that gives its name to the prism.

A cylinder is a lot like a prism but because its base is not a polygon (its base is a circle) we do not call it a prism.

Comparing rectangular and triangular prisms

	
Rectangular prism	**Triangular prism**
- has 6 faces - all faces are rectangles	- has 5 faces - 3 faces are rectangles; 2 faces are triangles
- has 12 edges - has 8 vertices	- has 9 edges - has 6 vertices
- any face can be taken as the base - all cross sections parallel to the base are rectangles	- the two triangular faces are taken as the base - all cross sections parallel to the base are triangles
- V = area of base x height - V = hwl (the product of the length, width and height)	- V = area of base x height - V = $\frac{hwl}{2}$ (half the product of the length, width and height)
- Surface area = 2(hw + hl + lw)	- Surface area = hw + lw +2ls

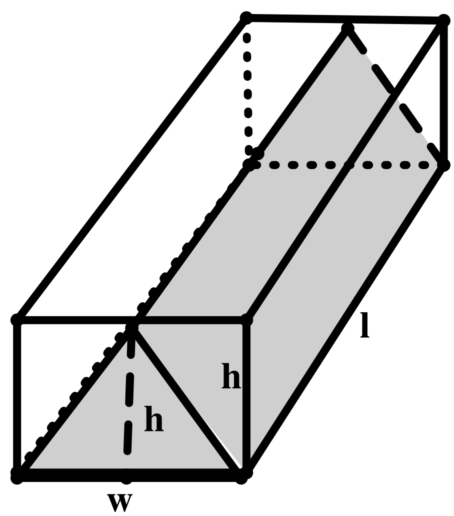
❖ Resource 6c: Triangular prisms - II



On the left is a pattern for making a triangular prism out of paper or cardboard.

Cut around solid lines and fold on dotted lines. Tape edges together.

Replacing the triangles by rectangles having the same height and width will make a rectangular prism pattern.



In this figure on the left we see the triangular prism inside the rectangular prism. It is easy to see why the volume of the triangular prism is half the volume of the rectangular prism having the same height, width and length.

The figure also shows how we can slice a rectangular prism (a block made of Styrofoam for example) to make a triangular prism.

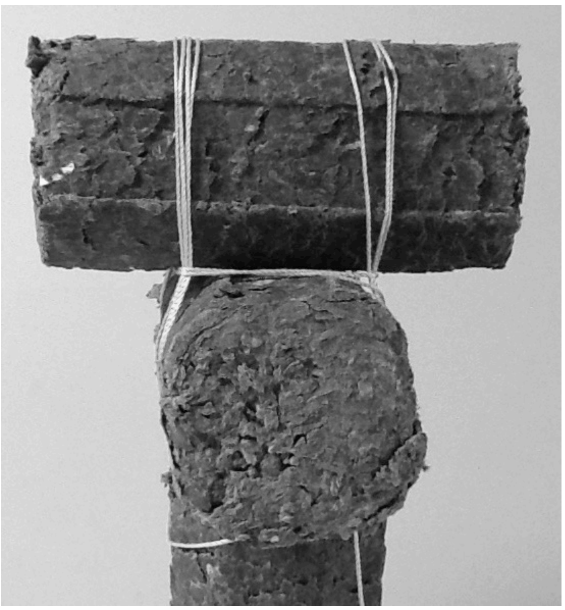
❖ Resource 6d: Tying the beams

In this photo, a student is tying the beams to one of the corner posts.

Question: Will *singóón* measuring *engaf* be long enough to tie these beams to the corner post?

❖ Resource 6e: *Singóón* problem

Below is **an attempt** to answer the problem in Resource 6.4 by modeling the beam tying on some similar sized posts.

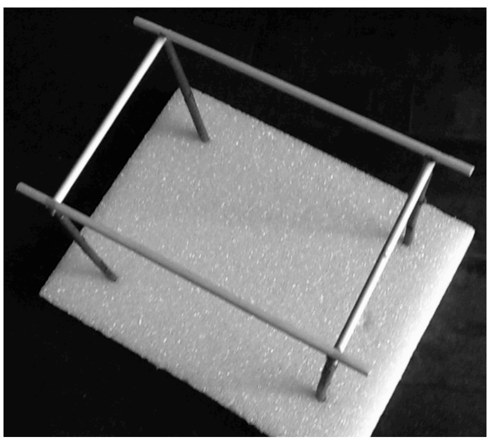


When the string used in this model was measured in *ngaaf*, it was much longer than *engaf*. It was in fact about *unungaf.*

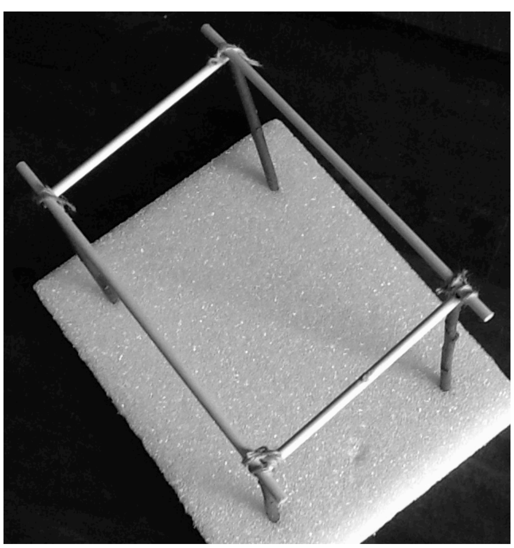
A **second attempt** to estimate the quantity of *singóón* needed for this tying was based on an estimation of the approximate number of times the string would be wrapped around a post the width of the student's palm. The width of the student's palm was taken as the diameter of each post. Using the formula C = πd where d is the diameter and C is the circumference, and the estimation of 16 wrappings around a post, it was calculated there would be 16 x 3.14 or about 50 palm widths of string. A string of length *etineup* was used to measure off palm widths by wrapping it around the palm. It was found there are about 8 palm widths in *etineup* and so, the double, 16 palm widths in *engaf*. Once again, this calculation led to the conclusion that it would take about *unungaf* of rope to tie the beams to a corner post.

❖ Resource 6f: Model work

End beams in position over corner posts.



Wall beams in position over end beams.



End and wall beams tied to corner posts.

❖ Resource 6g: Laying wall and end beams

(wall beam) ***tinéw***

(corner post) ***úúr***

Ouchamw

(end beam)

In this picture, the *úúr* is notched (a V shape at the top) and the *ouchamw* is placed in the notch.

The *tinéw* rests on top of the *ouchamw* and extends beyond it.

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MACIMISE

Lesson Seven

EITIITÁ

Objectives: *Students will*

- create and use non-arithmetic number patterns
- understand and use the technique of successive halving
- follow and reproduce (in a model) the steps involved in placing the ridgepole and rafters

Resources

Resource 7a: Halving a rope

Resource 7b: Model photos

Materials Needed

A long strip of paper or long pole or any long object that can be used to represent the ridgepole between the two *ouchamw*

A piece of string slightly longer than the ridgepole representation

Small sticks for modelling the rafters

A dowel or stick the length of the *tinéw* (or slightly longer) to represent the ridgepole on the house model

Paper strips for practice of the halving technique

Vocabulary for Word Wall

eitiitá	rafters	arithmetic pattern	halving	common ratio
uung	ridgepole	geometric pattern	sequence	common difference

Teacher Activities

Activity 7.1: Repeated Halving

Experiences: Rope work
Positioning the rafters
Looking at the numbers

Activity 7.2: Building the Model

Experience: Model additions

Teacher Notes

Suggested total time for each lesson is 100 minutes.

Teacher notes provide additional information

Resources for this lesson are in a separate file.

The lesson ends with a plenary.

Teacher Activities

Teacher Notes

Activity 7.1. Repeating Halving

60 minutes

Have students read page 14.

Ask some questions to be sure students have understood.

Sample questions:

- What are rafters/*eitiitá* for?
- What is a ridgepole/*uung*? How many do we need?
- How far apart will the *eitiitá* be?
- Where will they be attached?

Encourage students to ask their questions and to try to answer the questions of others.

Experience: Rope Work

Question 1: *What happens to a half if you keep halving it?*

Remind the students that the ridgepole was placed across the center of the *ouchamw* at either end of the house.

Ask students how they found the center.

Draw a long line on the board or point to any object.

Ask students to show how they would find the center.

Encourage students to recall that they used a length of rope the same length as the object, folded it in half to find the rope center and used the folded rope to mark off the center of the object.

Have students focus on the folded rope and write ½ on the board.

The rope is now one half the length it was.

Have a student fold the rope in half again.

Ask students how long the folded rope is now.

Write ¼ on the board.

Continue halving the rope and noting the fraction on the board.

Refer to Resource 7a: Halving a rope for a representation of this.

Check what students remember about arithmetic sequences, e.g., are they familiar with the language and symbolism used?

Post key words on the Word Wall.

If students have not yet worked with geometric sequences, this halving experience provides a good introduction to the theme.

See Resource 7a for a bit of the formalization of geometric sequences.

Teacher Activities

Teacher Notes

Experience: Positioning the rafters

Question 2: *How did the souiimw mark the ridgepole by successive halving?*

Post a long strip of paper on the board or display a long pole horizontally at the front of the class.

This pole or paper strip will represent the part of the ridgepole between the end beams or ouchamw.

Again use rope halving to find the middle of this strip.

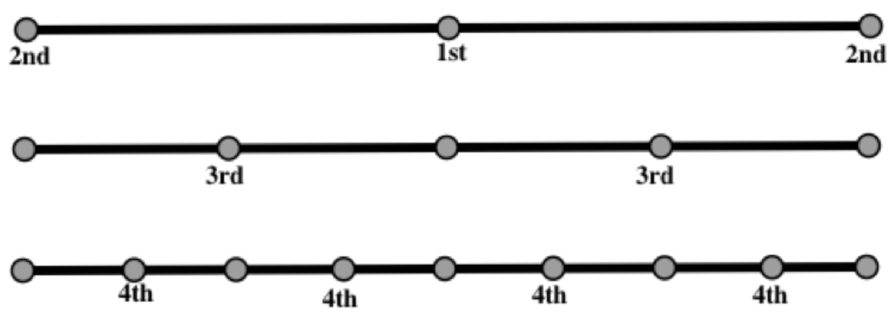
Point out that this is where the *souiimw* marks the ridgepole for the first pair of rafters.

Place a mark at each end of the paper strip, or pole, for the next set of rafters.

Ask a student to come up and mark the midpoints between those points for the next set of rafters.

Ask one or more students to come up and mark the four midpoints between the positions for the five pairs of rafters.

The illustration below shows the order of marking the ridgepole and placing the rafters:



Invite students to count the positions to be sure there are 9 positions for the pairs of rafters.

Ask students how many pairs of rafters there would be if we did another round of halving.

Answer: 8 more pairs so 17 pairs.

Divide the class in teams and distribute lengths of paper strips

Have them use the halving technique to position 5 pairs of rafters.

Ask students if it would be possible to position 7 pairs of rafters using the halving technique.

Answer: No because, as we will see in the next experience, only 3, 5, 9, 17 etc. are possible.

Teacher Activities

Teacher Notes

Experience: Looking at the numbers

***Question 3**: Is there a pattern in the number of pairs of rafters we can place using the halving method?*

Ask students to work in their teams to explore the number of rafter pairs produced by each halving.

Have them start with 3 pairs, and ask them to find what numbers are possible and what are not.

When they have explored this for a bit, have them discuss their findings

Suggested sequence for discussion:

Looking at the above illustration, we can see that 3, 5, 9, and 17 are possible.

This section addresses standard MAT.4.7.1.

What comes after 17?

How many line segments are there between 17 markings on the ridgepole?

The answer, is **16** so after 17 comes 17 + 16 = 33.

Look at this number pattern. Have you ever seen a growing pattern like this before?

Write the number pattern on the board: 3, 5, 9, 17, 33…

Is it an arithmetic sequence?

No because the difference between the terms is not constant. (In other words, there is no common difference. See how the differences between the terms are 2, 4, 8, 16 and so on.)

Is it a geometric sequence?

No because there is no common ratio.

See Resource 7a.

Yet there seems to be a pattern.

All the numbers are odd numbers, which according to Sabrina has something to do with the ends: “What about the ends?”

Let's make a new sequence by subtracting 1 from each term in the sequence.

The new sequence will be: 2, 4, 8, 16, 32, ...

This is a familiar geometric sequence: each term is found by multiplying the previous term by 2, the common ratio.

We could also write this new sequence as: 2, 2^2, 2^3, 2^4, 2^5, ... The general term would be 2^n.

We can now express our sequence 3, 5, 9, 17, 33, ... as $2 + 1$, $2^2 + 1$, $2^3 +1$, $2^4 +1$, $2^5 + 1$, ...

The general term: $2^n +1$.

Preparing for Activity 2:

In the video of the house building, the length of the building was ruengaf and five pairs of rafters were tied to the ridgepole at this stage (see photo below). The rafters would be etineupw apart as in the story (where the length of the building was fengaf).

Teacher Activities | Teacher Notes

Activity 7.2: Building the Model

30 minutes

Experience: Model Additions

In their teams, students work on their model houses adding the ridgepole and rafters in the order used by the *souiimw* (the halving technique).

Depending on the size of the model house, students may want to stop at 5 pairs of rafters rather than try to crowd 9 pairs onto the ridgepole.

See Resource 7.2: Model photos

Plenary for Lesson Seven

10 minutes

Review the vocabulary for the house parts in both English and Chuukese found in the back of the storybook.

Ask students to name the parts that have not yet been put in place.

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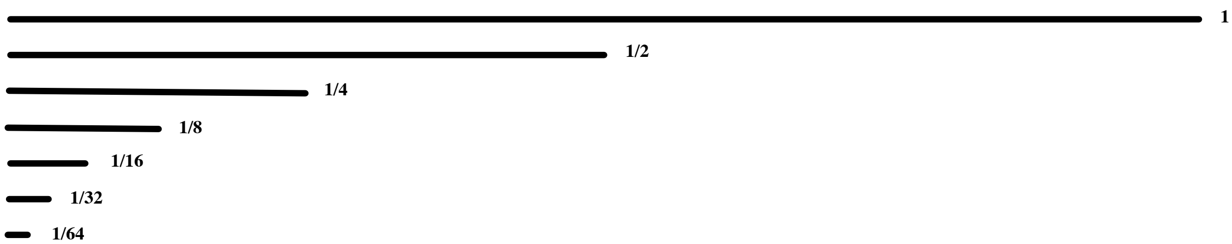
❖ Resource 7a: Halving a rope



Number pattern: $\mathbf{1}, \frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{16}, \frac{1}{32}, \frac{1}{64}, \ldots.$

Each term in this number pattern is found by multiplying the previous term by $\frac{1}{2}$.

We can also write the number pattern as: $1, \frac{1}{2}, \frac{1}{2^2}, \frac{1}{2^3}, \frac{1}{2^4}, \frac{1}{2^5}, \frac{1}{2^6}, \ldots.$

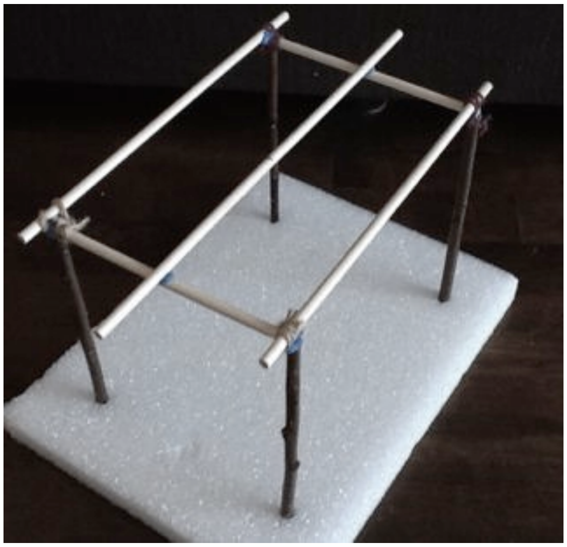
n	1	2	3	4	5	6		n	
Term	1	$\frac{1}{2}$	$\frac{1}{4}$	$\frac{1}{8}$	$\frac{1}{16}$	$\frac{1}{32}$		$\frac{1}{2^{n-1}}$	

A geometric sequence is an ordered list of numbers where each term is found by multiplying the previous term by a fixed amount (called the common ratio).

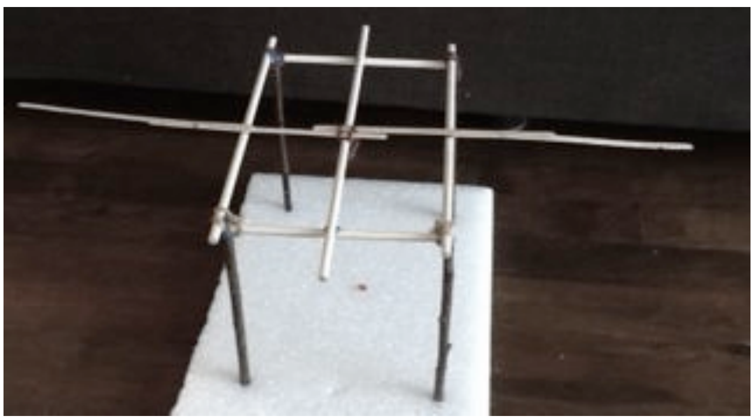
The halving sequence is a geometric sequence with a common ratio of ½.

In general, a geometric sequence satisfies the formula $a_n = a_1 r^{n-1}$ where a_1 is the first term in the sequence, a_n is the n^{th} or any term in the sequence, and r is the common ratio.

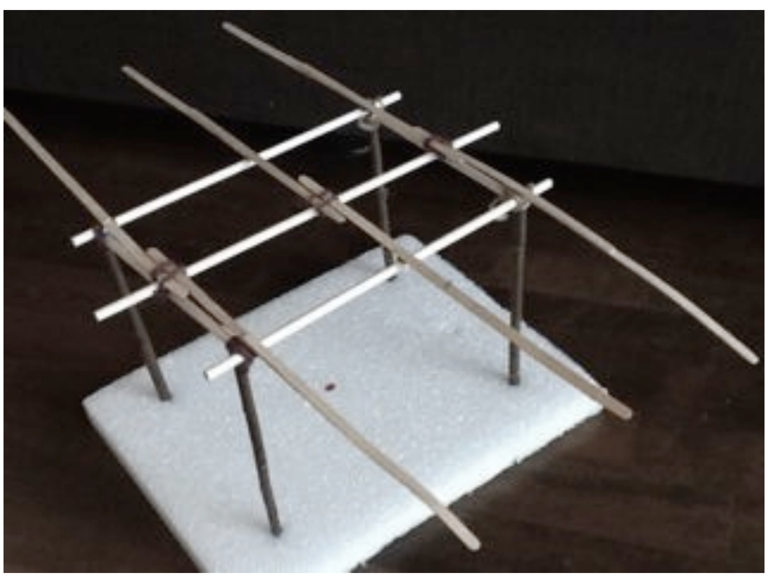
❖ Resource7b: Model photos - I



Uung is laid across the centers of the *ouchamw.*

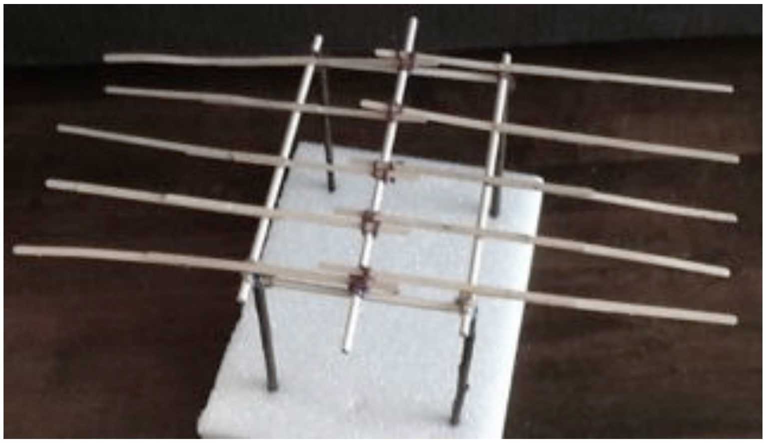


The first pair of *eitiitá* is tied to the center of the *uung*.



Pairs of *eitiitá* are tied to the *uung* at each end of the house.

❖ Resource7b: Model photos – II



Pairs of *eitiitá* are placed between the three *eitiitá* already in place. The halving method is used to space the rafters evenly.

Using the halving method once again, the last four pairs of *eitiitá* are placed midway between the five pairs already in place.

There are now 9 pairs of *eitiitá* tied to the *uung*.

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Lesson Eight

RAISING THE ROOF

Objectives: *Students will*

- understand and appreciate the work involved in raising a (heavy) roof
- complete and consolidate the English and Chuukese vocabulary for the parts of a house
- impose the geometry of prisms on the house frame and practice calculating surface area and volume of a real structure
- represent a shape in a scale drawing and to read a scale drawing
- solve right-angled triangles

Resources

Resource 8a: A tool for lifting

Resource 8b: Modeling the house frame

Resource 8c: The house of prisms

Resource 8d: Scale drawing

Resource 8e: Building from a scale drawing

Materials Needed

Two or more short logs and a long pole that can be used to simulate lifting the ridgepole with the king posts

Four poles or rafter type sticks and some rope to lash them together to make a lifting tool

Sticks or doweling to make the false ridgepoles and the king posts in the house models

String to tie the rafters and carpenters' glue to hold the models together before tying

A model of the prisms (heavy paper or cardboard) for Activity 8.2

Squared paper for scale drawings

A copy of Resource 8e for every team of two students

Vocabulary for Word Wall

pwéét *kuning*	king post false ridgepole	Pythagorean theorem	scale drawing scale

Teacher Activities

Activity 8.1: Inserting the *pwéét*

Experiences: How to raise a roof
Modeling the completed house frame

Activity 8.2: A geometric look at the house frame

Experience: Working with prisms

Activity 8.3: Drawing to scale

Experiences: Scaling down
Scaling up

Teacher Notes

Suggested total time for each lesson is 120 minutes.

Teacher notes provide additional information

Resources for this lesson are in a separate file.

The lesson ends with a plenary.

Teacher Activities

Teacher Notes

Activity 8.1: Inserting the *pwéét*

45 minutes

Read the first three paragraphs on page 16.

Question the students about what they have understood.

Review the steps involved in getting the ridgepole secured on top of the king post:

- The *uung* is lying across the centers of the *ouchamw* and the *eitiitá* are tied to the *uung* and resting on the *tinéw.*
- The false ridgepole/*kuning* is placed above the *uung* and rests on the tied *eitiitá.*
- Two ropes are tied to each end of the ridgepole and then each is given to one of the students.
- Two *pwéét* are prepared.
- The men each take a *pwéét* and use it to lift the ridgepole.
- As the men lift, the students steady the ridgepole over the *pwéét* with the ropes.
- When the *uung* is high enough the men place the bottom of the *pwéét* so it rests on the center of the *ouchamw.*
- The *souiimw* helps one of the students climb up on the *ouchamw* to tie the ridgepole to the *pwéét.*
- The *eitiitá* are tied to the *tinéw.*

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Teacher Activities

Teacher Notes

Experience: How to raise a roof

Question 1: *Why did the souiimw bring a helper?*

Have students reflect on the heights and weights involved in raising the roof and how it would be very difficult to lift one end at a time.

If the material is available (2 short posts and a long beam) students might try to lift the beam as high as they can using the two posts. This will also give them a good idea why the steadying ropes are used.

Share information with the class about a tool for lifting the ridgepole.

Discuss how the tool makes the lifting easier.

See a description of the tool in Resource 8a: A tool for lifting.

If the students have had the experience of simulating the lifting of the ridgepole with the king post, suggest to them that they make the V-stick, try again, and share their impressions.

Experience: Modeling the completed house frame

Invite students to return to their house models and insert the king posts and place the false ridgepole.

Suggest they use a bit of glue if needed.

The glue helps to hold things in place until the rafters can be tied to the wall beams.

Refer to Resource 8b: Modeling the house frame for photos of a completed house frame for 5 and 9 pairs of rafters respectively.

Activity 8.2: A geometric look at the house frame

In Lesson 6 we looked at the geometry of rectangular and triangular prisms. If we look at the interior of the house we can see that the space can be viewed geometrically as a triangular prism on top of a rectangular prism.

Both prisms have the same length and width. The height of the rectangular prism is approximately *engaf* and the height of the triangular prism is about *etineupw*. Remembering that the length is *fengaf* and the width is *ruengaf-etineupw*, we can apply a bit of the geometry of prisms here.

See Resource 8c: The house of prisms.

It would be helpful to prepare a paper or cardboard model of the two prisms for class discussion

MACIMISE

Teacher Activities

Teacher Notes

Experience: Working with prisms

Question 2: *What would a geometer see in our house frame?*

This activity addresses standards MAT.3.7.2 & MAT.3.7.3

Set up a paper prism model on display at the front of the class.

Ask students to put on their geometer's glasses, to look at their house models as a geometer would.

Invite them to meet in their model-building teams to discuss and note everything geometric they see.

Begin a whole class discussion and ask teams to offer their findings.

These could include

- naming 2-D shapes (triangles, rectangles)
- pointing to parallel and perpendicular lines, and hopefully, some 3-D shapes

If the prism shapes are not mentioned, lift the triangular prism off the rectangular prism in your prism model and ask them to try to identify these in their house models.

Once the prism identification is established, review the naming of the parts of each prism and how they found the volume and surface areas.

Put the triangular prism back on top of the rectangular prism and ask if anything is changed.

Establish that the volume is not affected but that the surface area is reduced by 2lw, the area of the bottom of the triangular prism and the area of the top of the rectangular prism.

Question 3: *What is the volume of the house the students built?*

Have students turn back the pages of *The Little Crooked House* to find the dimensions of the house in the story.

Note that the only dimension not given is the length of the king posts, which we will take to be about *etineupw*.

Explain that since we want to use the same unit for all our measures, we will convert everything into *ngaaf*.

This means etineupw will be converted to 0.5 ngaaf.

The chart below shows the dimensions students will find.

Teacher Activities

Teacher Notes

Dimension	Measure	Measure in *ngaaf*
width	*ruengaf-etineupw*	2.5 *ngaaf*
length	*fengaf*	4 *ngaaf*
height of rectangular prism	*engaf*	1 *ngaaf*
height of triangular prism	*etineupw*	0.5 *ngaaf*

Have students find the volume of the combined prisms.

- Volume of the rectangular prism = 4 x 2.5 x 1 = 10 n^3
- Volume of the triangular prism = ½ x 2.5 x 0.5 x 4 = 2.5 n^3
- Total volume = 12.5 n^3, where n^3 represents a volume of a cube measuring *engaf* (or an arm span) on each side.

Question 4: *What is the surface area of the prism model of a house?*

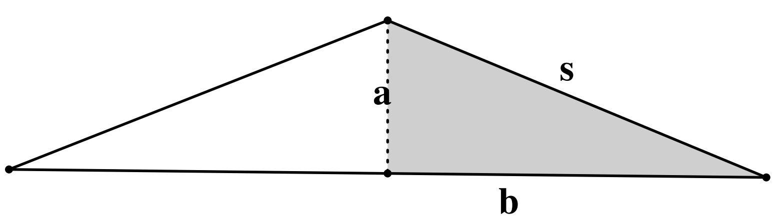
In order to find the surface area of the triangular prism, we need to find the measure of the side, **s**, of the triangle at each end.

Draw a large triangle on the board with base 5 times as long as its height.

This activity addresses standard MAT.2.7.4.

Give students the formula expressing the relationship between the sides of a right-angled triangle: the Pythagorean theorem.

Given a and b, students should be able to find the measure of **s**.



$a^2 + b^2 = s^2$

Here a = 0.5, b = 1.25

$s^2 = 0.25 + 1.56 = 1.81$

s = 1.35

Once there is agreement on the measure of s, direct students to use the table above and find the surface areas of the combined prism having the dimensions of the house.

Answer: about 35 n^2

MACIMISE

Teacher Activities

Teacher Notes

Activity 8.3: Drawing to scale

45 minutes

In this activity we will have students make a scale drawing of the end view of the house frame in the story and then interpret a scale drawing of a house frame (in the video done in March 2015) for which they will have a photo. For the scale drawing, larger squared (cm^2) graph paper is preferable. If students have not yet encountered scale drawings in class,they should be introduced to them before tackling this activity.

This activity addresses standard MAT.1.7.10.

The graph paper can be downloaded from the Internet and printed, if available.

Experience: Scaling down

Post the dimensions of the house frame in the story book.

Tell students that the rafters are twice as long as the line segment representing the rafter between the top of the king post and the top of the corner post. In other words the rafters measure 2**s**.

See the table of dimensions (above).

Question 5: *How does an illustrator shrink a house onto a page?*

Distribute the squared (graph) paper.

Tell students they are to make a scale drawing of the end of the house.

Help them get started by discussing an appropriate scale so that the widest part of the house fits on the paper.

Point out that if they use the graph paper in landscape view, they could produce a much bigger house frame.

Discuss students' scale drawings and the difficulties they encountered.

Suggest that they may want to compare their scale drawings with the house illustrations in the book as well as with the end views of their house models (which were not done to scale).

Note the widest part is between the end of the rafters on either side.

See Resource 8d: Scale drawing for a possible result as well as a geometric analysis of the drawing that allows for a review and reinforcement of students' knowledge of parallel and perpendicular lines, congruent triangles, symmetry and so on.

Experience: Scaling up

Review the six arm measures and the relationships between them (Lessons 1 to 3).

Question 6: *How does an engineer build something from a drawing?*

Distribute Resource 8e: Building from a scale drawing.

Read the instructions carefully with the students.

Have them work in teams of two to answer the two questions under the drawing.

This work will require the use of some dimensions we haven't used much until now.

Teacher Activities

Answers for questions in Resource 8e

Question 1

height of king posts: *etineupw*

height of corner posts: *engaf-emwalu* (taking *emwalu* as about half of *etineupw*)

width of house: *engaf-etineupw*

Question 2

Using the scale drawing, we find the hypotenuse, s, of the triangle with sides 4 and 6, $s = \sqrt{52} \approx 7.2$ **and** $2s = 14.4$ units.

Since 8 units represents *engaf*, the length of the rafters is *engaf* plus 6.4/8 *engaf*.

Approximating this extra length as about ¾ of an arm span, we can say that it is about *afotchuk*.

So the length of the rafters is *engaf-afotchuk.*

In the discussion ask students to compare the dimensions of the two houses.

Plenary for Lesson Eight

Ask students to select from the Word Wall all words pertaining to the parts of a house — Chuukese and English words.

Distribute them so no student has more than one word card.

The activity here is to order these word cards by the order of their appearance in the building of the house.

Ask what comes first.

ANSWER: "house center" and "*nukeniféw*"

The students holding these two words post their cards side by side at the top of the board or wall, creating an English and a Chuukese column.

After each posting ask the class "What comes next?"

The class responds with the answer.

The students holding those word cards place them under the words already posted.

See the next page for a completed posting of the order.

Teacher Notes

Note: The house filmed in March 2015 was about half the width and length of the story house. However the heights of the king posts were the same and the corner posts were slightly higher.

30 minutes

MACIMISE

Teacher Activities

Teacher Notes

Confirm that the word choices give the order of what appears when building a house:

English words	Chuukese words
house center	*nukeniféw*
rope	*singóón*
corner posts	*úúr*
end beam	*ouchamw*
wall beam	*tinéw*
ridgepole	*uung*
rafters	*eitiitá*
false ridgepole	*kuning*
king posts	*pwéét*

When the last words are posted, ask the class, "What comes next?"

The answer to this is in the last paragraph on page 16.

This will be the theme in Lesson Nine: Thatching the Roof.

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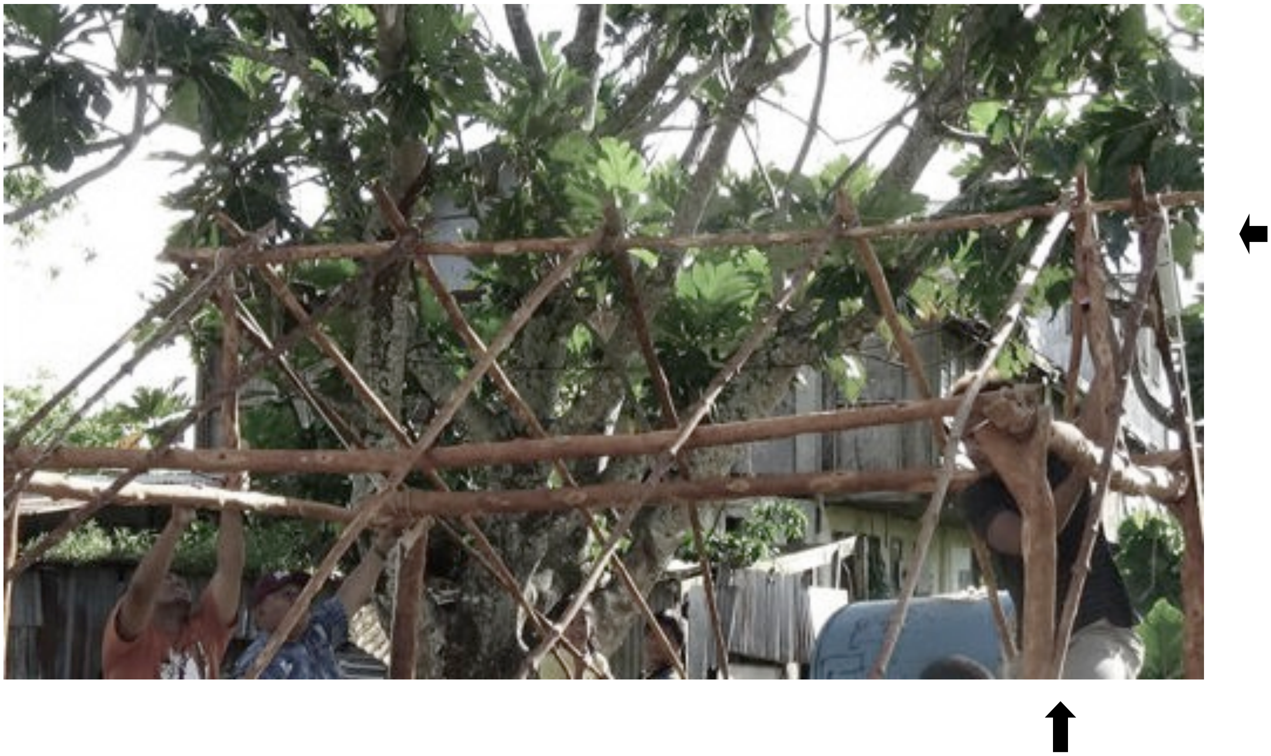
❖ Resource 8a: A tool for lifting - I

Photo taken during the building of a traditional house in March 2015.



On the far right we see the tool used for lifting the ridgepole. It looks like another pair of tied rafters. The house has five pairs of rafters and what looks like another pair at either end is actually the tool for lifting. Two people hold this tool and so the lifting is shared by two. Because the ridgepole sits in the V of the crossed poles, it is much easier to keep steady and centered. Once the ridgepole is high enough, the king post is put in place and the ridgepole lowered onto it.

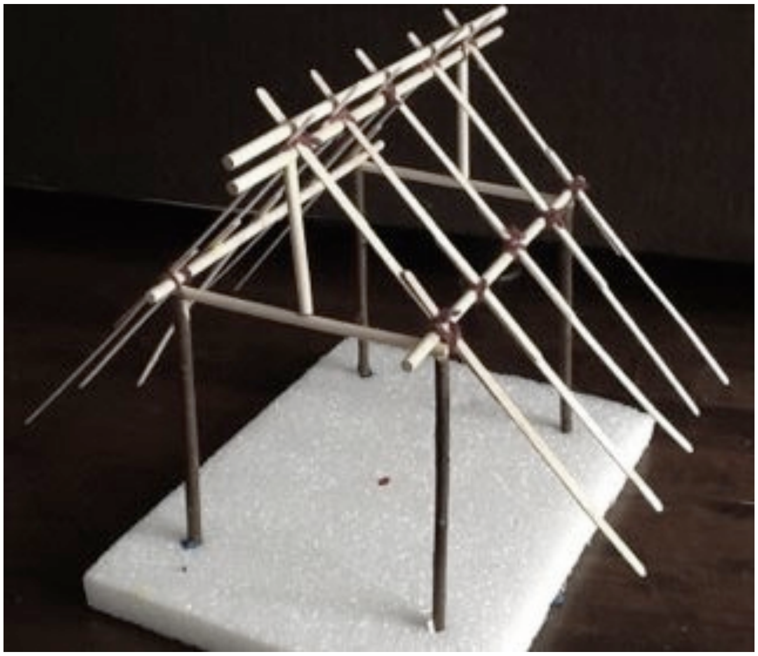
❖ Resource 8a: A tool for lifting - II

The sketch represents the two lifting tools (made of crossed poles tied together where they cross) with the ridgepole set in the V of each.

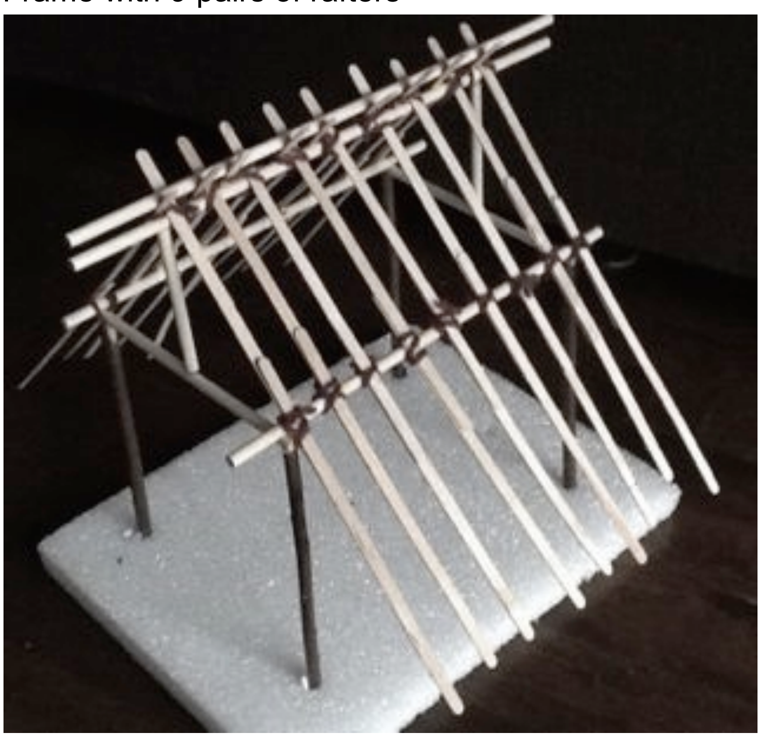
Four people, one at each pole, do the lifting.

❖ Resource 8b: Modeling the house frame

Frame with 5 pairs of rafters

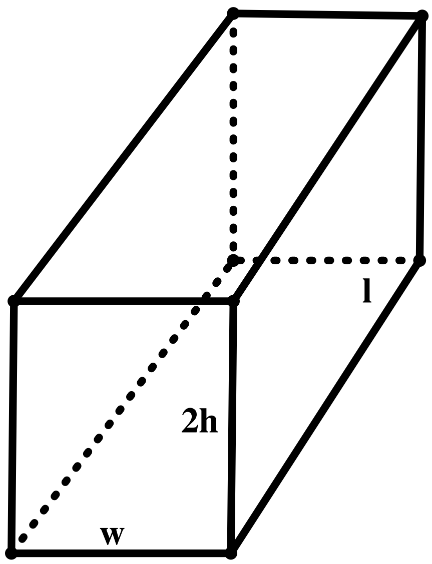


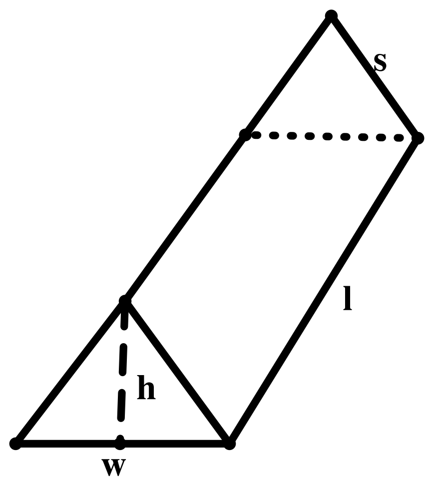
Frame with 9 pairs of rafters



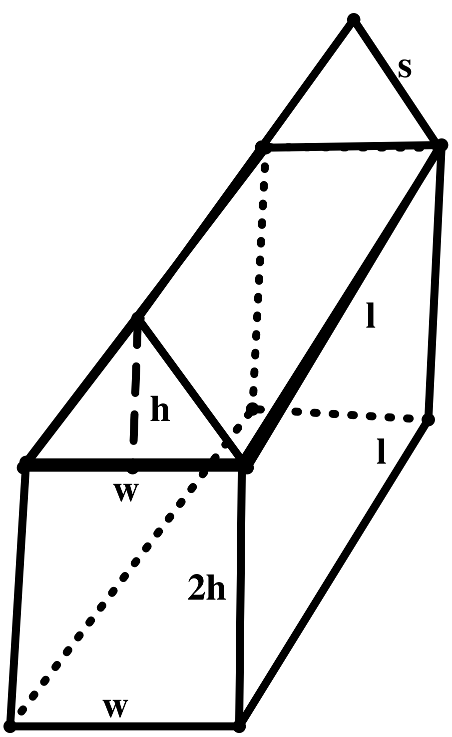
❖ Resource 8c: The house of prisms

The rectangular prism (on the left) is twice the height of the triangular prism (on the right).





The triangular prism is placed on top of the rectangular prism to give the shape of the traditional house.



h is the height of the king post

w is the width of the house

l is the length of the house

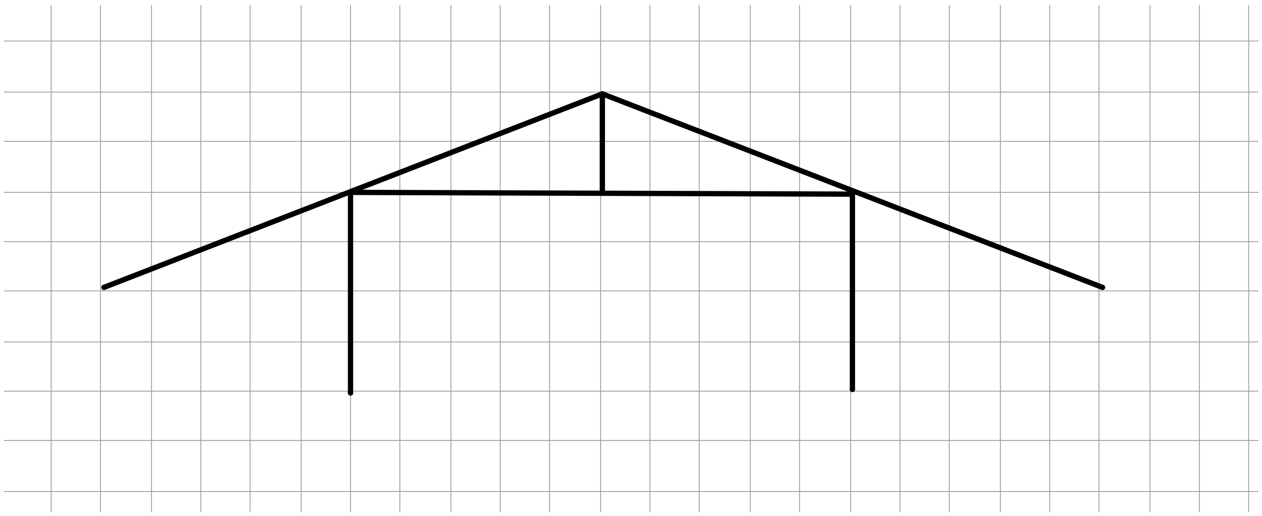
2h is the height of the corner posts

This combined prism has 12 + 9 – 4 = 17 edges; 8 + 6 – 4 = 10 vertices; and 6 + 5 – 2 = 9 faces.

Its volume is the combined volumes of the prisms: $2hwl + \frac{hwl}{2} = \frac{5}{2}hwl$

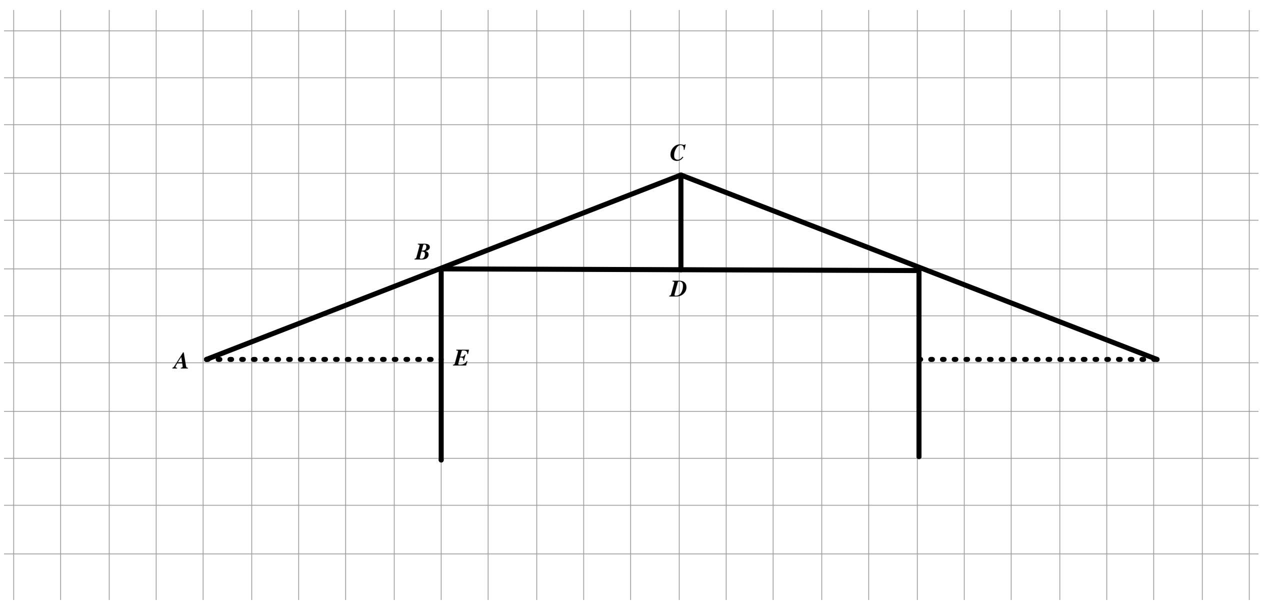
Its surface area is the sum of the two surface areas minus 2wl, the area lost when the two prisms are put together:
(4hw + 4hl + 2wl) + (hw + wl + 2ls) – 2wl = 5hw +4hl + wl + 2ls

❖ Resource 8d: Scale drawing



Scale: 4 units to *engaf*

Height of corner posts: *engaf* (4 units)
Height of king post: *etineupw* or half of *ngaaf* (2 units)
Length of rafters: twice the length from the top of the corner post to the top of the king post
Width of house: *ruengaf-etineup* or 2.5 *ngaaf* (10 units)



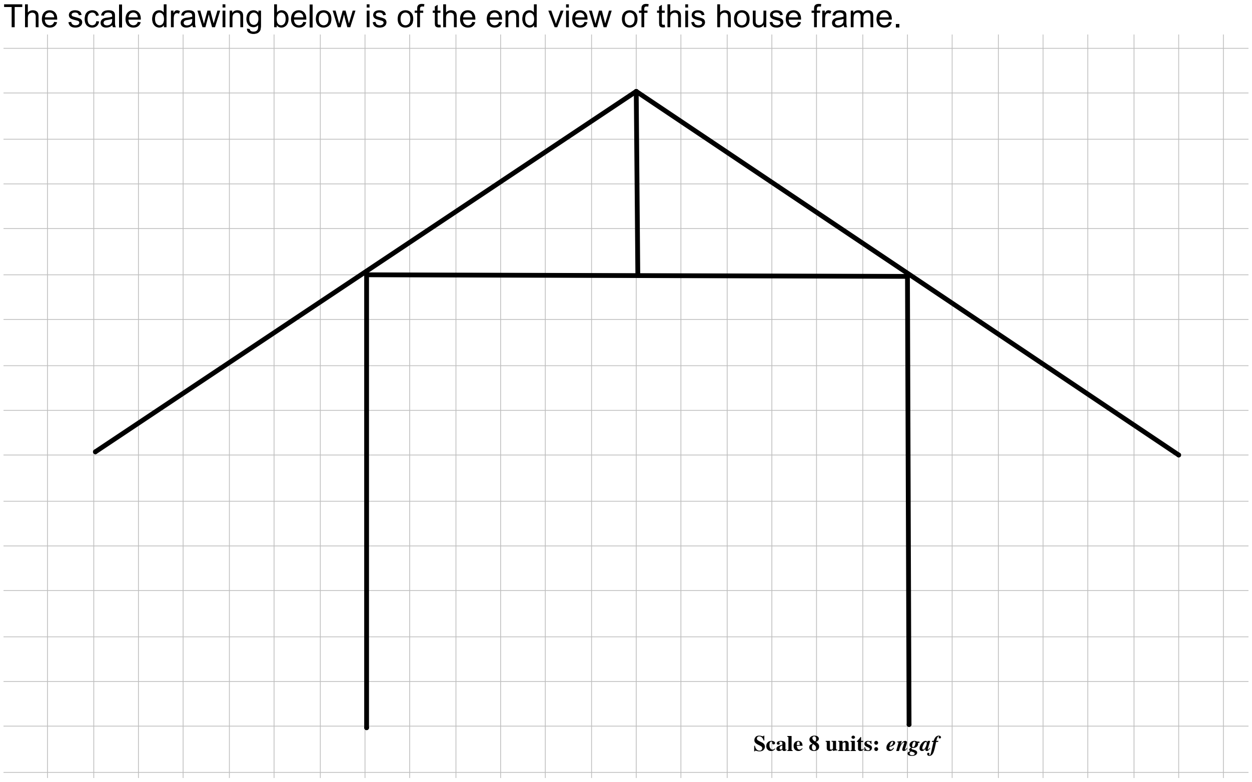
Looking at the geometry of the scale drawing:

Line segments AB and BC are congruent; line segments CD and BE are congruent; and segments AE and BD are congruent. So ∆ABE and ∆BCD are congruent. AE is parallel to BD. The house is symmetric about the axis passing through CD.

❖ Resource 8e: Building from a scale drawing

Below is a photo of a house frame that was constructed in March 2015 by five students with the help of a *souiimw* and a couple of teachers.

The scale drawing below is of the end view of this house frame.



1. Find the heights of the corner and king posts and the width of the house.
2. Using your knowledge of triangles, estimate the length of the rafters.

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MACIMISE

Lesson Nine

ADDING THE THATCH

Objectives: *Students will*

- develop and apply estimating techniques to solve problems
- apply proportional reasoning in new contexts
- link the Chuukese units of measure to the U.S. customary units and to the metric system
- find the U.S. customary units of inch, foot, and yard and the metric units of centimeter and meter on the students' arms and hands

Resources

Resource 9a: Roof thatching

Resource 9b: Estimating strategies

Resource 9c: Measurements in 3 systems

Resource 9d: Sample response to 9c

Materials Needed

A sheet of letter-sized paper (8.5 by 11 inches) for each team of students

Scissors for each team

Measuring tape in inches for each team of 2 students (rope and foot rulers can be substituted)

Measuring tape in centimeters for each team of 2 students

A copy of Resource 9c for each student

Vocabulary for Word Wall

estimate thatch	pace	inch foot yard	centimeter meter

Teacher Activities

Activity 9.1: Estimating the thatch

Experience: Refining our guesses

Activity 9.2: Other measurement systems

Experiences:

Relating Chuukese measure to U.S. & metric measure

Relating U.S. and metric measure to arm measures

Teacher Notes

Suggested total time for each lesson is 120 minutes.

Teacher notes provide additional information

Resources for this lesson are in a separate file.

The lesson ends with a plenary.

Teacher Activities

Teacher Notes

Activity 9.1: Estimating the Thatch

45 minutes

Read the last paragraph on page 16 and continue with page 18.

Re-read the last paragraph on page 16.

Raise the question as to how many sheets of thatch are needed and give students a few minutes to think about it and talk to others.

Ask students to vote on their estimates by raising hands for one of the following five options:

- 25 pieces
- 50 pieces
- 75 pieces
- 100 pieces
- more than 100.

Write beside each the number of votes and leave this on the board.

EXPERIENCE: Refining our guesses

Question 1: *What do we need to know to estimate the quantity of thatch needed for the roof?*

Have students work in teams of 2 to 4 on this question.

Encourage them to list everything they need to know.

Begin a whole class discussion.

Write the suggestions on the board. (Where appropriate, ask students why we need this information.)

The list will likely include the following:

- the dimensions of the roof (length and width of roof)
- the dimensions of a sheet of thatch (length and width of woven part)

Students may also want to know what a sheet of thatch looks like and how it is attached.

See Resource 9a: Roof thatching for some photos of the thatch and the thatching process.

Share these with the students or describe the material and the process.

A sheet of thatch to show the students would be very helpful.

Teacher Activities

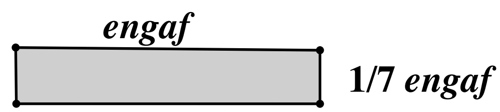
Draw a rectangle on the board.

Question students about the dimensions of the roof.

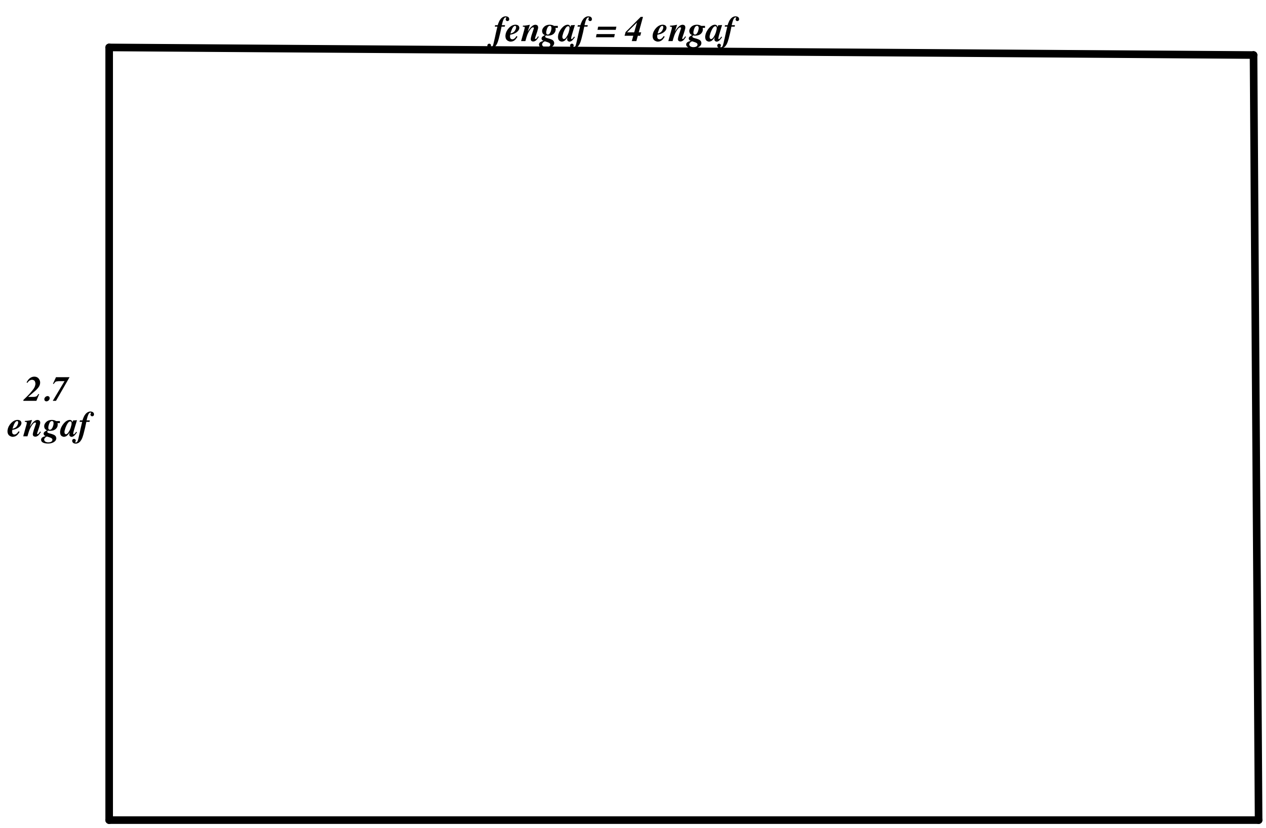
Write the dimensions on the sides of the rectangle: for the thatch, give the length as *engaf* and the width as about 1/7 *engaf*.

Remind students that when measuring the thatch we only measure the woven part.

Dimensions of Thatch



Dimensions of Roof



Question 2: *How can we find the number of thatch sheets needed to cover the roof?*

Ask teams to develop a strategy to calculate the number of thatch sheets.

Have them share their strategies (probably after about 15 minutes).

Discuss each strategy offered and the merits of each.

Teacher Notes

See the drawing below for a sketch that to some extent respects the proportions of the roof dimensions and those of the roof to the thatch.

See Resource 9b: Estimating strategies for a description of two strategies the students will likely suggest.

Teacher Activities

Teacher Notes

Have students try the area strategy to estimate the quantity of thatch needed.

See Resource 9b: Estimating Strategies - I for a sample calculation.

Discuss students' results and the practical side of thatching that may require more thatch than calculated.

For example,

- too many thatch sheets might measure slightly under *engaf*. This would mean that some rows might require 5 rather than 4 thatch sheets.
- some overlapping of rows of thatch improves the quality of the roof. This would require additional rows of thatch to compensate for the overlap.
- we want to cover the overhang at either end with thatch. This is usually the case and a pair of rafters is added at either end to support the thatch. The four lengths of thatch to make a row would have to be increased to five, which would add 38 pieces of thatch to the total in the case of 19 rows of thatch.

Ask students to try the scale model strategy and compare their results.

Encourage students to compare their results with those of the area strategy and look at the similarities.

See Resource 9b: Estimating Strategies - I for a description and application of this strategy.

Note: If the scale model is accurately done it should give the same result as the area model here. This is because area is simply the covering of a surface with a unit of area and counting how many of those units are needed. The same practical considerations apply as mentioned above.

Activity 9.2: Other measurement systems

45 minutes

In these lessons, we have remained within the Chuukese system of length measure and we have even invented some area and volume measures in order to stay within that system.

The most common other system is the metric system. However, the United States is one of three nations in the world that does not use the metric system (Liberia and Burma are the other two). See more background, below.

The metric system is used globally in science, trade, commerce and the military. Therefore, it is important that students master both the American and metric systems.

Activity 9.2 will have us look across the three systems of measurement while keeping the relationship to body measurement.

We will find what the various arm measures are in the U.S. and metric systems and we will find what the U.S. and metric units look like in arm measures.

Teacher Activities | **Teacher Notes**

Background

The U.S. Customary units developed from the British units that were used while the U.S. was still a colony of Britain, that is, before independence. The British system was based on the English units that developed from measurements on the body and of certain objects.

For length measurement, the foot was an actual measurement of a foot and a mile was based on one's stride for 1000 steps (1000 paces).

Gradually these measurements became standardized and today they are all standardized in terms of the metric system. For example, 1 yard = 0.9144 meters.

Experience 2: *Relating Chuukese measure to U.S. and metric measure*

Distribute to each student the Resource 9c: Measurements in 3 systems and, to each team of two students, measuring tapes in centimeters and in inches.

Or give materials for students to make these.

Invite the student pairs to help each other with their measurements.

Direct them to fill out their own questionnaires because the body measurements will be different for each student.

Discuss the students' results, particularly question 2, which gives a good indication of the accuracy of their measuring.

See Resource 9d: Sample response to 9c.

EXPERIENCE 3: *Relating U.S. and metric measure to arm measures*

Body measures

The great advantage of measurement related to the body, arm measures in this case, is that we can measure lengths wherever and whenever we want. We do not need to carry a measurement tool with us, for example, a yardstick, ruler, or tape.

Even in countries with standard systems of measurement, people don't carry around measuring tools in case they might need them. Most women know how to measure a yard or a meter of cloth with their arms (usually thumb tip to some point on the opposite shoulder or chest). Some people know their hand span in the standard units; others know their foot length or stride length and use these to pace off distances.

Here students will find on their bodies some of the standard units in both the U.S. and metric systems.

Teacher Activities

Have students find a yard length on their bodies and compare it to *o'far*.

Have them find a meter length. This will be a bit further towards or around their opposite shoulder.

Have students compare their yard and meter arm gestures, all of which will be different depending on their size.

Have students measure and note their hand span measure in inches and in centimeters.

The hand span, from tip of thumb to the tip of the end finger (baby finger) on the outstretched hand, is a useful measuring tool for smaller lengths.

Ask students to measure their desks or benches in hand spans.

Ask them to convert these into inches and centimeters.

Ask them to then re-measure with measuring tapes and see how accurate their approximations were.

Now have students find an inch and a centimeter on their hands.

An inch is often the distance between two finger lines and a centimeter can be the width of the small finger.

The width of the palm of the hand is another useful measuring tool. Students may suggest others. They may want to know in inches and centimeters how long their feet are, for example.

Teacher Notes

Hand spans will vary around 8 inches or 20 cm.

This could be useful for toe-to-heel measuring.

Have students record their measurements in a table, for example:

Body measure description	U.S. conventional	Metric
	1 yard	
		1 meter
hand span		
	1 inch	
		1 centimeter
width of palm		
length of foot		

Teacher Activities

Teacher Notes

Plenary for Lesson Nine

15 minutes

Play a quick game of arm (including hand) gestures:

- Pick a student to start the game off calling out a unit of measurement in any of the three systems (Chuukese, U.S., metric).
- The rest of the class makes the gesture as quickly as possible.
- The student who called out the unit of measurement picks the person who was seen to have the correct gesture first.
- That student comes to the front of the class and calls out the next unit of measurement.

The measures that students use should be up on the Word Wall.

Suggestion: group the words on the wall together for this game.

They will include *ngaaf, afotchuk, o'far, etineupw, e'pew, emwalu*, meter, yard, inch, and centimeter.

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❖ Resource 9a: Roof Thatching

The first layer of thatch is tied to the rafters, topside up. Here 3 lengths of thatch are being used. Note that a pair of rafters has been added at either end of this house, making the length to be covered about *ruengaf-etineupw.*

The second layer of thatch is being tied to the *eitiitá*. All layers are placed with their undersides facing up.

Note how the students overlap the 3 lengths of thatch in order to fit them into the desired space.

Now students need to stand on a bench to tie the higher rows of thatch to the rafters. There appear to be about 11 rows of thatch at this point.

❖ Resource 9b: Estimating strategies - I

Area strategy

Here students use their knowledge of the area of a rectangle and divide the area of the big rectangle (the roof) by the area of the small rectangle (the thatch).

Scale model strategy

Students make a scale model of the roof and some thatch and by laying the thatch model on the roof model they count and calculate the number of thatch pieces needed.

Applying the area strategy

Area of a piece of thatch, A_T: *engaf* x 1/7 *engaf* = 1/7 *engaf*^{2}
Area of roof rectangle, A_R: 4 *engaf* x 2.7 *engaf* = 10.8 *engaf*^{2}

$\frac{A_T}{A_R} = \frac{10.8}{\frac{1}{7}} = 10.8 \times 7 = 75.6$ and since we can't have a fraction of a piece of thatch, we can round it off to 76. Check to make sure 76 completes a row (divisible by 4). For the two sides of the roof it will take 2 x 76 = 152 pieces of thatch.

Note: this area calculation does not take into account any overlapping of the rows of thatch. If some overlapping is desired, then a few more rows of thatch will have to be used (4 pieces per row on each side).

Applying the scale model strategy

Students make a scale model of the roof and a piece of thatch using the scale modeling strategies of Lesson 8. Another way of making a good size scale model is to use a piece of letter size paper turned landscape (11 inch edge on top). Draw a line and cut off the bottom inch and use that to make a model of the thatch pieces.

Have students verify that a 11 in. by 7.5 in. paper makes a fairly accurate scale model of a fengaf by 2.7 engaf roof.

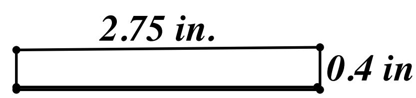
The calculation involves showing that 11 : 7.5 is approximately equal to 4 : 2.7 or, written in fraction form, $\frac{11}{7.5} \approx \frac{4}{2.7}$.

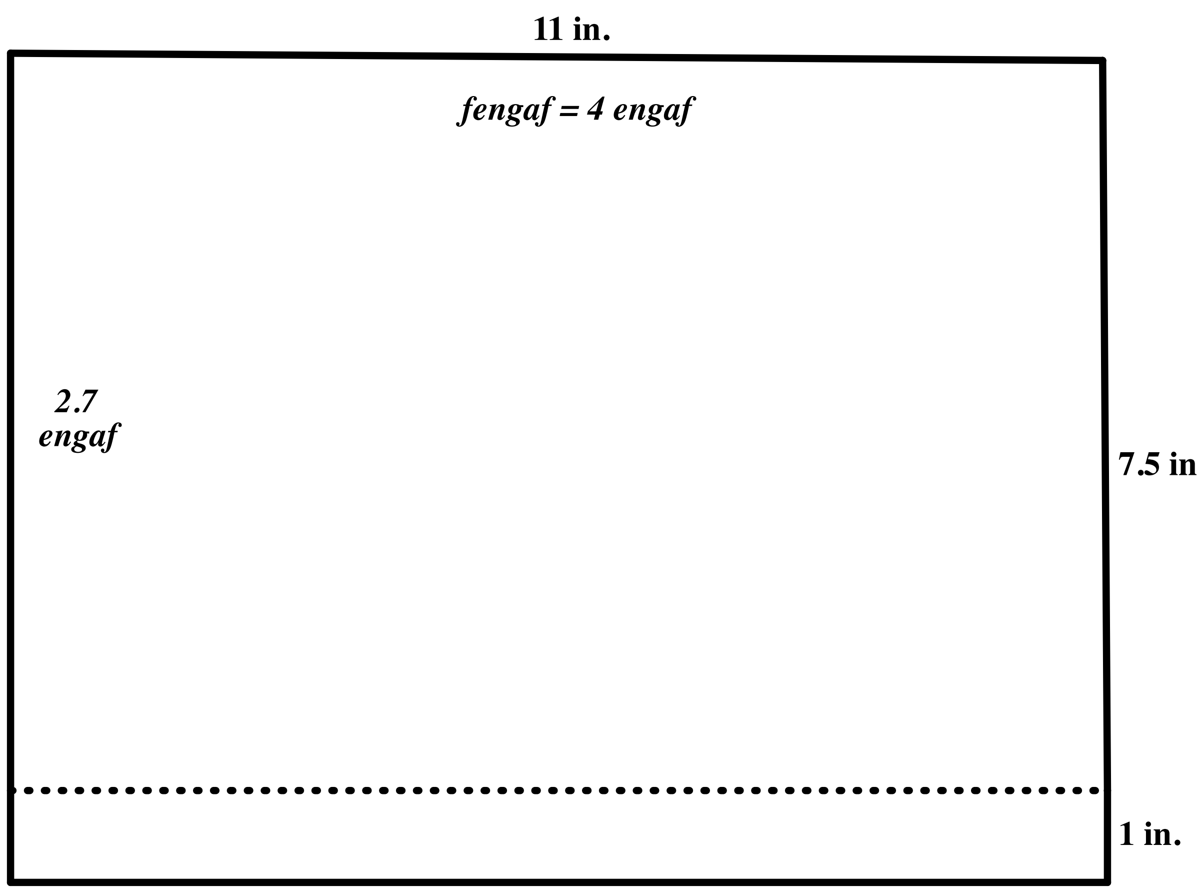
In the drawing below, the sheet of letter paper is shown in landscape view.

MACIMISE

❖ Resource 9b: Estimating strategies - II

The dotted line indicates the cutting off line to make it a model for the house roof.
The scale thatch pieces are cut out of the strip that is 11 in. by 1 in. at the bottom. Pieces will be 2.75 in. long and 1/7 x 2.75, or about 0.4 inches wide.





❖ Resource 9c: Measurements in 3 systems

1. Using a tape measure or a rope and ruler, find your arm measurements in U.S. Customary units (inches) and Metric units (centimeters). Fill in the table below:

Chuukese measure	U.S. Customary measure (inches)	Metric measure (centimeters)
ngaaf		
afotchuk		
o'far		
etineupw		
e'pew		
emwalu		

2. Verify that the relationships among the Chuukese units hold in both the U.S. Customary and Metric systems. In other words, check the relationships between *ngaaf* and *etineupw*, *o'far* and *e'pew*, *afotchuk* and *emwalu*.

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3. In our rafter and thatch calculations, we have approximated the Chuukese measure *emwalu* as about one quarter of *engaf*. In other words, we took four *emwalu* measures to be approximately equal to *engaf*. Looking at the measures of *emwalu* in centimeters and inches, what do you think of this approximation?

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❖ Resource 9d: Sample response to 9c.

1. Using a tape measure or a rope and ruler, find your arm measurements in U.S. Customary units (inches) and Metric units (centimeters). Fill in the table below:

Chuukese measure	U.S. Customary measure (inches)	Metric measure (centimeters)
engaf	60"	152 cm
afotchuk	46"	117 cm
o'far	37"	94 cm
etineupw	30"	76 cm
e'pew	23"	58 cm
emwalu	14"	35 cm

2. Verify that the relationships among the Chuukese units hold in both the U.S. Customary and Metric systems. In other words, check the relationships between *engaf* and *etineupw*, *o'far* and *e'pew*, *afotchuk* and *emwalu*.

etineupw + *etineupw* = 30" + 30" = 60" = *engaf*

= 76 cm + 76 cm = 152 cm = *engaf*

o'far + *e'pew* = 37" + 23" = 60" = *engaf*

= 94 cm + 58 cm = 152 cm = *engaf*

afotchuk + *emwalu* = 46" + 14" = 60" = *engaf*

= 117 cm + 35 cm = 152 cm

The important point is that the relationships hold, no matter what the measurement system is.

3. In our rafter and thatch calculations, we have approximated the Chuukese measure *emwalu* as about one quarter of *engaf*. In other words, we took four *emwalu* measures to be approximately equal to *engaf*. Looking at the measures of *emwalu* in centimeters and inches, what do you think of this approximation?

Using our U.S. Customary measures, four *emwalu* measures make 56", which is 4" short of *engaf*. Similarly in Metric units, four *emwalu* makes 140 cm, which is under *engaf* as well. Had we taken our measurements using middle finger tips instead of thumb tips, this might have been a closer approximation. Have students bend an arm to the chest as they do when they measure *etineupw*. They will see that their fingertips of the bent arm come to the middle of the chest.

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Glossary

Note: Chuukese words for parts of a house can be found in the glossary at the back of T*he Little Crooked House*. Chuukese length measurement words are defined in resources in the early lessons.

arithmetic pattern – a sequence of numbers where going from one term to the next the same number is added or subtracted.

bisect – to divide (a geometrical figure) into two equal parts

bisector – a straight line or plane that bisects a geometrical figure (usually an angle or a line)

center – the middle point of a line, circle or sphere

centimeter – one hundredth of a meter (centi- means a 100th)

circle – a closed plane curve with every point the same distance from a fixed point, the center

common difference – the number added or subtracted at each stage of an arithmetic sequence

common ratio – the number multiplied or divided at each stage of a geometric sequence

congruent – having identical size and shape

crooked – not straight or level; bent, curved, twisted

cube – a rectangular prism where all six faces are squares

diagonal – a line joining any two vertices of a polygon that are not connected by an edge

divider – an instrument (found in most geometry sets) that looks like a compass but has two metal points and is useful for comparing lengths in geometric drawings

edge – a line along which two faces of a solid meet

equilateral triangle – a triangle having all three sides of equal length

estimate – as a noun, a rough calculation; as a verb, to make an estimate or rough calculation

face – one of the plane (flat) surfaces forming a polyhedron (a 3-D figure bounded by flat surfaces)

false ridgepole – a second ridgepole at the very top of the house frame to which the cover thatch is attached

foot (pl. feet) – a unit of length in the U.S. customary system. Since 1959, it has been defined as 0.3048 meters (abbreviation is ft, symbol is ')

geometric pattern – a sequence of numbers where going from one term to the next involves multiplying or dividing by the same number

halving – dividing into two equal parts (halves)

hexagon - a closed plane figure with 6 straight sides and 6 vertices; in a regular hexagon, all sides and all angles are congruent

horizontal – parallel to the plane of the horizon (where the earth appears to meet the sky); going side to side like the horizon

inch – (plural: inches, abbreviation: in., symbol: ") is one twelfth of a foot and is now defined as 2.54 cm

isosceles triangle – a triangle having two sides of equal length

king post – (or kingpost) a vertical beam between a horizontal beam, the end beam, and the ridgepole

kite – a quadrilateral with two pairs of equal adjacent sides

measure – as a noun, the size or quantity found by measuring; the degree, extent or amount of a thing ('measurement' is also used); - as a verb, to find the extent or quantity of a thing by comparison with a fixed unit.

meter – (also spelled metre) is the basic unit in the Système International (international system of measure). It used to be defined by the length of a bar of platinum kept in Paris; now it is defined with relation to the speed of light.

pace – the length of a brisk (quick) step and defined as 30 inches in the U.S. system

parallel – two or more lines (or planes) that are always the same distance from each other

parallelogram – a quadrilateral with opposite sides parallel and therefore equal in length

pentagon – a closed plane (2-D) figure with 5 straight sides and 5 vertices

perpendicular bisector – a line which cuts a line segment into two equal parts at 90°

perpendicular lines – lines at right angles to each other

polygon – a closed plane (2-D) figure with 3 or more straight line segment sides and angles

polygonal – (adjective) having a polygon shape

Pythagorean theorem – the square on the hypotenuse of a right triangle is equal to the sum of the squares on the two adjacent sides

quadrilateral – a polygon with 4 sides

rafters – the sloping beams forming the framework of a roof

rectangle – a quadrilateral having four right angles; a parallelogram having four right angles

rectangular prism – a solid figure, or its surface, that has 6 rectangular sides or faces and all interior angles are right angles (examples: a box, a brick)

rhombus (or diamond) – a parallelogram whose four sides are equal

ridgepole – the horizontal pole in a roof used to support the upper ends of the rafters

right angle – the angle between two perpendicular lines; an angle measuring 90 degrees

scale – is a ratio between a unit of measure in a scale drawing and a unit of measure of the real object (expressed in words, as a ratio, or as a fraction)

scale drawing – a drawing that shows a real object with measurements reduced or enlarged by a certain amount (called the scale)

scalene triangle – a triangle having three unequal sides

sequence – an ordered set of objects especially numbers

square – an equilateral rectangle; a rectangle with sides of equal length

straight line - a line lying in the shortest path between any two of its points; never curves

surface area – is a measure of the total area that an object occupies thatch – as a noun, the roof covering made of woven straw, palm leaves, or other similar materials; as a verb, to cover a roof with thatch

trapezoid – a quadrilateral with two parallel sides of unequal length

triangular prism – a solid figure, or its surface, that has 3 rectangular sides and a triangular base with a congruent side opposite it and parallel to it (more precisely, this is a right triangular prism)

vertex (pl. vertices) – a point of intersection of two sides of a polygon

vertical – in an up-down position; upright; perpendicular to the horizontal

volume – is a measure of the amount of space that an object occupies

yard – a unit of measurement in the U.S. customary system, originally defined by the length of a standard metal yardstick and defined in 1959 as 0.9144 meters (abbreviation: yd).

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