MAKING MATHEMATICS DELICIOUS

SOLVING SIXTH-GRADE MATH PROBLEMS
IN THE KITCHEN & IN THE GARDEN

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CHEZ PANISSE FOUNDATION

Cultivating a New Generation

FOREWORD

Our mission at the Chez Panisse Foundation is to educate, nurture, and empower students to build a more sustainable future. Our program, the Edible Schoolyard, brings this mission to life by involving students in growing, harvesting, cooking and enjoying simply-cooked, seasonal, organic meals. We lure students into the kitchen with delicious smells and flavors and find them excited by the simple pleasures of the garden—picking raspberries, digging up beds, or planting seeds.

"Learning by doing" is central to the way we teach at the Edible Schoolyard. In our kitchen and garden classes, students participate fully in the cycle of producing organic and seasonal foods. They may bring kitchen and garden waste to the compost pile, for example, turn and tend the pile, spread the finished compost on garden beds before planting lettuce or tomatoes, then use the harvest from these plants in a delicious salad for sharing.

We also strive to bring the academic classroom to life, whether it's through a social studies lesson on ancient grains or a science lesson on the composition and properties of soil. For the last two years we have also been exploring how to weave meaningful mathematics into our instruction. We do this because all students need mathematics skills to become socially responsible leaders and productive citizens and, in the short term, to enter college without need for remediation.

This book is not a comprehensive math curriculum. Rather, it offers a window onto our approach to teaching and learning. Teachers may adapt these lessons according to the resources and concerns of their own classrooms, or simply use them for inspiration. Our goal is to empower students to grapple with the intrinsic complexities of mathematics in a way that is purposeful and not devoid of common sense; with this book, we hope to provide a starting place.

Carina Wong
Executive Director
Chez Panisse Foundation

When we began thinking about the importance of integrating kitchen and garden learning into the academic classroom, we did not have a mathematics book in mind. Soon, however, teachers at the Edible Schoolyard began developing their own strategies for engaging students with mathematics. *Making Mathematics Delicious* is one product of the collective wisdom we have developed.

This book differs from many supplementary curriculum materials is its alignment with California mathematics standards for middle school.This table lists the mathematics content standards that inform our lessons:

Grade	Content Strand Mathematics Content	Standard
6	Number Sense	6NS1.0
	Students compare and order positive and negative fractions, decimals, and mixed numbers. Students solve problems involving fractions, ratios, proportions, and percentages.	
6	Number Sense	6NS2.0
	Students calculate and solve problems involving addition, subtraction, multiplication, and division.	
6	Algebra & Functions	6AF2.0
	Students analyze and use tables, graphs, and rules to solve problems involving rates and proportions.	
6	Measurement and Geometry	6MG1.0
	Students deepen their understanding of the measurement of plane and solid shapes and use this understanding to solve problems.	
6	Measurement and Geometry	6MG2.0
	Students identify and describe the properties of two-dimensional figures.	

The context for each assignment is drawn directly from the original Edible Schoolyard at Martin Luther King Jr., Middle School in Berkeley, California. However, middle school teachers from all regions will find these assignments relevant and useful for any mathematics classroom, with or without an adjoining school garden.

These mathematics assignments are what we call *tasks*. Tasks are problem-based and set in a real-world context. They involve mul-

tiple steps and usually cannot be completed in one class period. Nor can the tasks simply be assigned to the students as handouts. The tasks require conversation, experimentation, and at times collaboration. You may also notice that the tasks involve a lot of reading; this is because a task must require sense-making on the part of the student if it is to be a truly useful tool for learning. Each task is also designed to be accessible for all learners and to promote mathematical thinking over imitative computation work.

When students make bread dough in the kitchen, for example, they must estimate to decide when it has doubled in volume. Thus making bread provides an excellent opportunity for students to understand the relationship between concomitant increases in volume and linear dimensions. In the garden, students make potting soils to nurture plants through various stages of growth. The recipe for each type of soil is presented in a variety of standard and non-standard units because in the real world, gardeners often use cans, wheelbarrows, and spades to measure. This experience allows students to hone their quantitative literacy while also deepening their understanding of how gardeners work.

HOW THIS BOOK IS ORGANIZED

This book includes five tasks for use with sixth-grade students. Each task is introduced using handmade recipes, drawings, or images from the Edible Schoolyard. For the teacher, a set of notes is provided to explain underlying mathematical concepts and how to approach the lesson. The solution to each task is also included. Related tasks are outlined in booklets for seventh and eighth grades.

We published the three grades as a set so you could see how similar recipes or contexts can provide tasks of increasing difficulty. For example, the sixth grade lesson using a structure in the Edible Schoolyard called the Ramada involves measuring angles and calculating area. At the eighth-grade level, the Ramada task involves constructing a scale model using measurements from the actual structure at the Edible Schoolyard.

We hope that these tasks will inspire you to look around and find the math in your kitchen, garden, or community.

MAKING MATHEMATICS DELICIOUS · GRADE 6

PROBLEMS & QUESTIONS FOR STUDENTS

TEACHER NOTES & SOLUTIONS

THE MATHEMATICS OF ORANGE VINAIGRETTE

1 teaspoon orange zest

juice of 1 orange

1 clove garlic - peeled + minced

3 Tablespoons white vinegar

3 Tablespoons balsamic vinegar

3/4 cup olive oil

1/2 teaspoon salt

8 grinds pepper

Combine all ingredients except the olive oil in a mixing bowl. Add the olive oil slowly, whisking constantly.

Useful Conversions:

- There are 16 tablespoons in 1 cup.
- The juice of 1 orange equals about ¼ cup.

1. *Create a chart that could be used to convert measures given in cups to tablespoons.*

2. *What proportion of the liquid in this recipe is vinegar?*

3. *What proportion of the liquid in this recipe is oil?*

4. *What proportion of the liquid in this recipe is orange juice?*

5. *Make a drawing to show the proportions of oil, orange juice, and vinegar to the total liquid used in the recipe.*

THE MATHEMATICS OF 10-GRAIN CEREAL

Ingredients:

- 1/3 cup rye
- 1/3 cup hard wheat berries
- 1/4 cup flax seed
- 1/3 cup soybeans
- 1/2 cup brown rice
- 1/4 cup blue corn
- 1/3 cup pearl barley
- 1 cup oats
- 1/4 cup millet
- 1/3 cup soft wheat berries

Method:

Measure and record the volume of each grain. Grind the grains. Then measure and record each grain's volume after grinding. In a large bowl, combine all of the ground grain. Boil 7 cups of water in a stock pot. Add grains, stir well, and add water if needed. Cook until cereal is soft and creamy. Serve with fresh fruit, brown sugar or maple syrup.

Data for 10-Grain Cereal

type of grain	volume before grinding		volume after grinding	
	cups	*ml.*	*cups*	*ml.*
rye	*1*	*237*	*1*	*237*
hard wheat berries	*1*	*237*	*1G*	*296*
flax seed	*i*	*177*	*0.85*	*201*
soybeans	*1*	*237*	*1G*	*296*
brown rice	*1G*	*355*	*1.90*	*450*
blue corn	*i*	*177*	*i*	*177*
pearl barley	*1G*	*355*	*1.90*	*450*
oats	*3*	*710*	*2.9*	*686*
millet	*i*	*177*	*l*	*148*
soft wheat berries	*1*	*237*	*1G*	*296*

1. *Which grains decreased, increased, and remained the same in volume after grinding?*

2. *Which grain had the largest after-grinding decrease?*

3. *What was the largest decrease?*

4. *Which grain had the largest after-grinding increase?*

5. *What was the largest increase?*

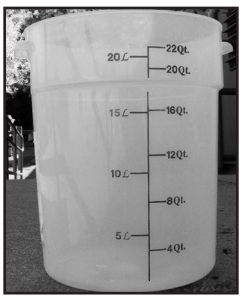
THE MATHEMATICS OF APPLE JUICE

Making Apple Juice in the Garden

In the fall, sixth-grade math students made apple juice in the garden class.

The students started with 4 varieties of apples. Roughly, there was an equal number of apples of each variety. In all, there were 57 apples.

The students stacked all the apples in a large container that weighed 1 pound. The students then weighed the apples on a scale and found that the their weight was 20 pounds.



Next students used a bucket of water containing 10 liters of water to measure the volume of the apples. Students found that the volume of the apples alone was 12 liters.

Then students began pressing the apples to extract the juice. Students collected the apple juice and measured its volume. They found that they had made 3.5 liters of juice.

The apple juice was shared equally among the 30 people in the garden class. This number included students, teachers, and visitors.

Counting and Weighing the Apples

1. *How many different varieties of apples were used in the garden class?*

2. *How many apples were used in all?*

3. *About how many of each variety were provided?*

4. *What was the total weight of the apples?*

5. *If the apples were roughly the same size, calculate the approximate weight of each apple.*

Finding the Volume of the Apples

6. *In your own words, describe how the bucket of water was used to measure the volume of the apples.*

7. *What was the initial amount of water in the bucket?*

8. *After the apples were submerged in the bucket, by how much did the water level rise?*

Pressing the Apples

9. *How much juice was extracted from the apples?*

10. *Assuming that all the juice was collected and measured, what proportion of the apples was juice?*

11. *What proportion of the apples was fiber?*

12. *About how much juice was provided by each apple?*

Enjoying the Juice

13. *How many people were served juice in the garden?*

14. *About how much juice was each person served?*

15. *How many apples per person were used in this garden class?*

THE MATHEMATICS OF POTTING SOIL

Mixing Soil in the Edible Schoolyard

When small seedlings are planted in the Edible Schoolyard, this Speedling Mix is used to accelerate growth:

Speedling Mix

- ½ wheelbarrow potting soil
- ½ wheelbarrow sifted compost
- 10 gallons peat moss
- 2 gallons perlite
- 2 gallons vermiculite
- ½ pint oyster shells
- ½ pint algae

When the seedlings have become sturdy, they are planted in the following Lunch Mix:

Lunch Mix

- ⅛ bucket sifted compost
- 2 buckets peat moss
- ½ bucket perlite
- ¼ bucket vermiculite
- ⅛ pint gypsum
- ⅛ pint kelp

1. *Make a list of the non-standard units of measure used in each recipe.*

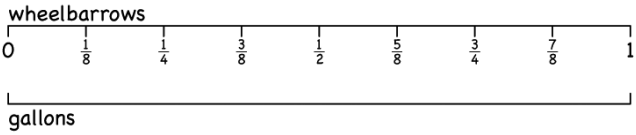
2. *Make a list of the standard units of measure used in each recipe.*

Useful Conversions

- The capacity of a typical wheelbarrow used in the Edible Schoolyard is 45 gallons.
- There are 8 pints in 1 gallon.
- The capacity of a typical bucket used in the Edible Schoolyard is 5 gallons.

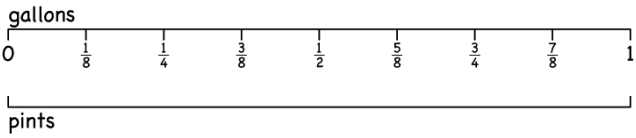
3. *Complete this conversion chart.*

Conversion Chart: Wheelbarrows to Gallons



4. *Complete this conversion chart.*

Conversion Chart: Gallons to Pints



5. *Use your charts to rewrite the recipe for Speedling Mix using only gallons.*

6. *Use your charts to rewrite the recipe for Lunch Mix using only gallons.*

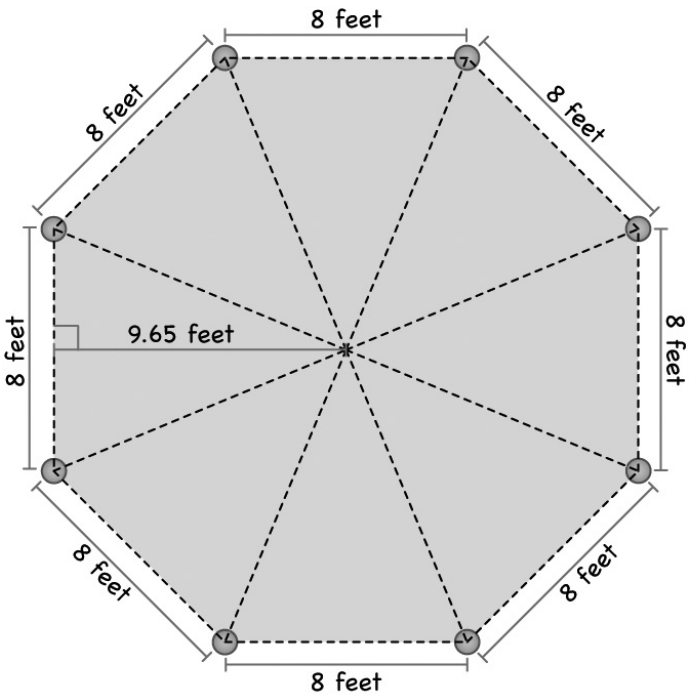
7. *Make a drawing to show the proportion of each ingredient in Speedling Mix.*

8. *Make a drawing to show the proportion of each ingredient in Lunch Mix.*

THE MATHEMATICS OF THE RAMADA

Measuring a Structure

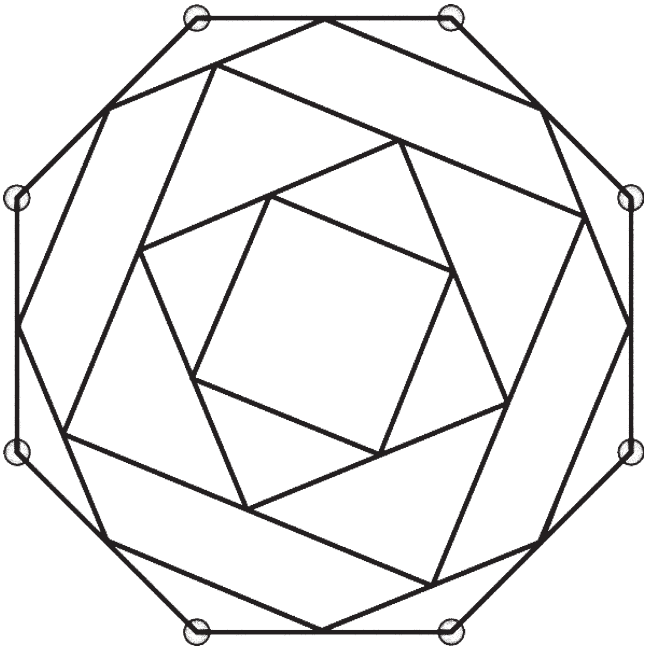
This is a floor plan for the Ramada in the Edible Schoolyard.



1. *Find the area of the floor of the Ramada. Show all your work so someone can follow what you did.*

2. *Find the measure of each angle in the floor plan of the Ramada.*

This plan shows the the ceiling of the Ramada in the Edible Schoolyard.



3. *Find the measure of each angle in the ceiling of the Ramada. Do not measure the angles using a protractor. Show all your work so someone can follow what you did.*

TEACHER NOTES & SOLUTIONS · GRADE 6

THE MATHEMATICS OF ORANGE VINAIGRETTE—NOTES AND SOLUTION

Notes

In the first part of the Orange Vinaigrette task, students convert measures of ingredients from cups to tablespoons. Thus they are being asked to engage in an activity that is an important part of most sixth-grade mathematics courses. This task, however, allows students to make the conversions in the familiar context of preparing a dish and with units that they are likely to encounter in everyday life.

In the second part of the Orange Vinaigrette task, students calculate the proportion of liquid in the recipe that is vinegar, oil, and orange respectively. Thus, here too, they are being asked to engage in an activity that is an important part of sixth grade mathematics. This task is designed to give students the opportunity to explore and work with the concept of proportionality in the familiar context of preparing a dish.

Our goal here is to create the opportunity for the important and difficult sixth-grade concepts of unit conversion and proportionality to become more accessible to students as they explore them in context of the kitchen.

Solution

1. *Create a conversion chart that could be used to convert measures given in cups to tablespoons.*

cups	3	2	1	¼	½	¼	⅛	1/16
tablespoons	48	32	16	12	8	4	2	1

2. *What proportion of the liquid in this recipe is vinegar?*

total liquid in vinaigrette = juice + vinegar + olive oil

= ½ cup + 6 Tbs. + ¼ cup

= 8 + 6 + 12 tablespoons

total liquid is 26 tablespoons

The proportion of the liquid in Orange Vinaigrette that is vinegar is $^{6}/_{26}$ tablespoons or $^{3}/_{13}$ tablespoons.

3. *What proportion of the liquid in this recipe is oil?*

   The proportion of the liquid in Orange Vinaigrette that is oil is $^{12}/_{26}$ tablespoons or $^{6}/_{13}$ tablespoons.

4. *What proportion of the liquid in this recipe is orange juice?*

   The proportion of the liquid in Orange Vinaigrette that is orange juice is $^{8}/_{26}$ tablespoons or $^{4}/_{13}$ tablespoons.

5. *Make a drawing to show the proportions of oil, orange juice, and vinegar to the total liquid used in the recipe.*

THE MATHEMATICS OF 10-GRAIN CEREAL—NOTES AND SOLUTION

Volume, Percentages, and Proportionality

Notes

This task gives students the opportunity to explore the concept of volume in a way that involves neither formulas nor computation. Instead the task asks students to measure the volume of ten grains both before and after grinding. Students are asked to measure the before- and after- volumes of grains in both cups and milliliters because milliliters allow for more accurate measurements than do fractions of a cup.

Solution

1. *Which grains decreased, increased, and remained the same in volume after grinding?*

   decreased: oats, millet

   increased: hard wheat berries, flax seed, soybeans, brown rice, pearl barley, soft wheat berries

   stayed the same: rye, blue corn

2. *Which grain had the largest after-grinding decrease?*

   millet

3. *What was the largest decrease?*

   ½ cup or 29 ml.

4. *Which grain had the largest after-grinding increase?*

   brown rice and pearl barley

5. *What was the largest increase?*

   0.4 cups, $^{2}/_{5}$ cup or 95 ml.

THE MATHEMATICS OF APPLE JUICE—NOTES AND SOLUTION

Volume, Weight, and Proportionality

Notes

In this task, students are given the opportunity to figure out the volume of a number of apples, the volume of juice pressed from the apples, and the proportion of each apple that is juice.

Solution

Counting and Weighing the Apples

1. *How many different varieties of apples were used in the garden class?*

   4 varieties

2. *How many apples were used in all?*

   57 apples

3. *About how many of each variety were provided?*

   57 ÷ 4 = 14.25 = approximately 14 apples

4. *What was the total weight of the apples?*

   20 lbs.

5. *If the apples were roughly the same size, calculate the approximate weight of each apple.*

   20 ÷ 57 = 0.35 lbs. each

Finding the Volume of the Apples

6. *In your own words, describe how the bucket of water was used to measure the volume of the apples.*

   The original volume of water occupying space in the bucket is known, so any increase in volume after the addition of the apples tells the volume of space

the apples are occupying. The following calculation illustrates this:

volume of apples = end volume (apples + water) – start volume (water alone)

7. *What was the initial amount of water in the bucket?*

   10 liters

8. *After the apples were submerged in the bucket, by how much did the water level rise?*

   12 liters

Pressing the Apples

9. *How much juice was extracted from the apples?*

   3.5 liters

10. *Assuming that all the juice was collected and measured, what proportion of the apples was juice?*

    3.5 out of 12 liters = 29% was juice

11. *What proportion of the apples was fiber?*

    If 3.5 liters were juice, the remaining 8.5 liters of the 12 liters total must have been fiber. 8.5 out of 12 liters = 71% was fiber.

12. *About how much juice was provided by each apple?*

    3.5 liters = 3500 ml provided by 57 apples, so 1 apple provided 3500 ÷ 57 or 61 ml. of juice.

Enjoying the Juice

13. *How many people were served juice in the garden?*

    30 people

14. *About how much juice was each person served?*

    3.5 liters = 3500 ml., between 30 people is 3500 ÷ 30 or 117 ml. each.

15. *How many apples per person were used in this garden class?*

    57 apples between 30 people is 57 ÷ 30, or 1.9 apples each.

THE MATHEMATICS OF POTTING SOIL—NOTES AND SOLUTION

Standard and Non-standard Units of Measure

Notes

One of the most important topics in school mathematics is measurement. Facility with measurement is critical to the development of quantitative literacy and to success in school mathematics. Opportunities to develop quantitative literacy abound in the Edible Schoolyard. This is particularly true when students complete the task below, as it requires them to engage naturally and functionally with standard and non-standard units of measure.

Solution

1. *Make a list of the non-standard units of measure used in each recipe.*

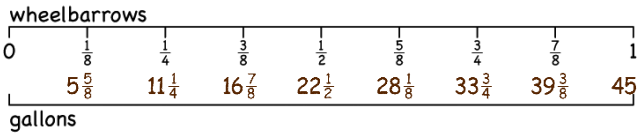
   wheelbarrow and bucket

2. *Make a list of the standard units of measure used in each recipe.*

   pint and gallon

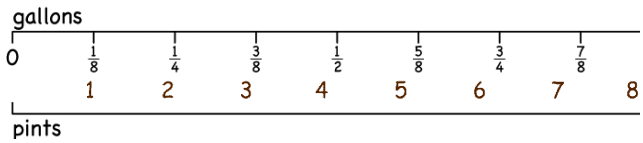
3. *Complete this conversion chart.*

   Conversion Chart: Wheelbarrows to Gallons



4. *Complete this conversion chart.*

   Conversion Chart: Gallons to Pints



5. *Use your charts to rewrite the recipe for Speedling Mix using only gallons.*

22½ gallons potting soil; 11½ gallons sifted compost; 10 gallons peat moss; 2 gallons perlite; 2 gallons vermiculite; 1/16 gallon oyster shells; 1/16 gallon algae

6. *Use your charts to rewrite the recipe for Lunch Mix using only gallons.*

1 gallons sifted compost; 10 gallons peat moss; 1½ gallons perlite; 3 gallons vermiculite; 1/24 gallon gypsum; 1/24 gallon kelp

7. *Make a drawing to show the proportion of each ingredient in Speedling Mix.*

PS = potting soil; S = sifted compost; PM = peat moss; P = perlite; V = vermiculite; O = oyster shells; A = algae

8. *Make a drawing to show the proportion of each ingredient in Lunch Mix.*

S = sifted compost; PM = peat moss; P = perlite; V= vermiculite; G = gypsum; K = kelp

THE MATHEMATICS OF THE RAMADA—NOTES AND SOLUTION

Area and Angles of a Polygon

Notes

This task challenges students to use their understanding of geometry in a real-world context. The first steps ask students to find the area of the floor of the Ramada, a shade structure and gathering place in the Edible Schoolyard. Later steps ask students to find the measure of each angle in the floor plan. Finally, students find the measure of each angle in the ceiling of the Ramada.

Solution

1. *Find the area of the floor of the Ramada. Show all your work so someone can follow what you did.*

   Each triangle of the Ramada can be divided into two right-angled triangles as shown in the diagram of the Ramada's floor plan; these angles each have a base of 4 ft. and a height of 9.65 ft.

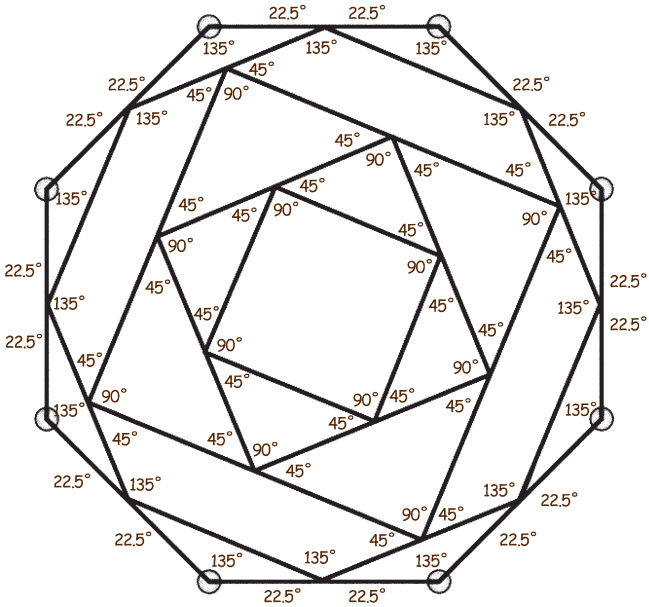
   Since the area of a triangle = ½ base × height, ½ × 4 × 9.65 = 19.3 ft^2.

   There are two right-angled triangles in each large triangle of the Ramada, so one large triangle is 38.6^2 ft. There are 8 of these triangles in total so the total area of the Ramada is 308.8 ft^2.

2. *Find the measure of each angle in the floor plan of the Ramada.*

   The floor of the Ramada can be divided into 8 congruent triangles which come together at a point, thus the sum of angles at this point is 360° and the angle at the vertex of each individual triangle is 360 ÷ 8 = 45°. The sum of angles of each triangle is 180° and as it is an isosceles triangle, the base angles are equal, so each base angle is 180 – 45 = 135 ÷ 2 = 67.5°.

3. *Find the measure of each angle in the ceiling of the Ramada. Do not measure the angles using a protractor. Show all your work so someone can follow what you did.*



Starting at outermost angle of octagon and working towards center:

Each interior angle of the octagon is 135° because the angle sum of the interior angles of an octagon is 1080°; an octagon can be decomposed into 6 triangles (180 × 6 = 1080). Thus, 1080 ÷ 8 = 135°.

The perimeter of the ceiling can be thought of as a series of congruent isosceles triangles each with a vertex angle of 135°. The sum of the remaining 2 angles is 45°. So each angle is 22.5°.

The angles of the congruent trapezoids are considered next. The angles touching octagon must each be 135° because 180 – 22.5 – 22.5 = 135°. The angles of the outmost square are 90°. Thus the remaining two angles of the trapezoid are each 45°.

The vertices of the outermost square also form right-angled isosceles triangles, the base angles of which are found by taking the right angle from the angle sum, 180 – 90 = 90°. The base angles are equal so each is 45°.

The angles of the medium-sized square and right-angled isosceles triangles formed follow the same pattern.

The final, innermost angles are 90° as they make up the corners of the innermost and center square.

A WORD OF GRATITUDE

Ann Shannon developed these materials with support from staff at the Edible Schoolyard and teachers from Martin Luther King Jr. Middle School. Special thanks to Esther Cook for the delicious recipes and Susie Walsh Daloz for the garden lessons included here. Our thanks also to the Educational Foundation of America and Wendy Ettinger for funding the development of these materials. So many individuals and other foundations have supported our work at the Edible Schoolyard over the last year, including Newman's Own Foundation, the Compton Foundation, the Lattner Foundation, the Zimmerman Foundation, Helen Schwab Foundation, and Mark and Susie Buell.

About the Chez Panisse Foundation

Founded by Alice Waters in 1996, the Chez Panisse Foundation develops and supports educational programs that use food traditions to teach, nurture, and empower young people. The Foundation envisions a curriculum, integrated with the school lunch service, in which growing, cooking, and sharing food at the table gives students the knowledge and values to build a humane and sustainable future.

The Edible Schoolyard is a thriving one-acre garden and kitchen classroom for all 950 students at Martin Luther King Jr. Middle School. Through the Edible Schoolyard, students experience all aspects of growing, cooking, and sharing food at the table. Garden classes introduce the origins of food, plant life cycles, community values, and the pleasures of work, while kitchen classes allow students to prepare and eat delicious, nutritious, seasonal dishes made from produce they have grown in the garden. The Edible Schoolyard is a program of the Chez Panisse Foundation.

For more information about our work and other publications, please visit our website at www.chezpanissefoundation.org.

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