

INTRODUCTION

Richele Baburina

Welcome to the study of Practical Geometry—a new and exciting pathway to be explored in the Principality of Mathematics.

In Charlotte Mason schools, the study of Practical Geometry traditionally took place once a week, on Friday, with the first four days given to the continued study of Arithmetic. Taken thus, the student finds that Geometry and Arithmetic are not two separate sciences, but are connected by converging pathways in the wondrous realm of Mathematics.

When my eldest son and I first began our own venture into Practical Geometry, I recall how he proclaimed with confidence that two straight lines could enclose a space. Unable to prove this with straightedge and paper, he moved outdoors, where he was sure a couple of two-by-fours would surely do the trick, but—try as he might—he could not validate his statement. Rather than being defeated by a wrong answer, he became animated and excited to learn more about the properties and behavior of lines. Charlotte tells us,

“It is a great thing to be brought into the presence of a law, of a whole system of laws, that exist without our concurrence,—that two straight lines cannot enclose a space is a fact which we can perceive, state, and act upon but cannot in any wise alter, should give to children the sense of limitation which is wholesome for all of us, and inspire that *sursum corda* which we should hear in all natural law.”

A Philosophy of Education, pp. 230, 231

She also realized that a child is much more than a mind into which information is to be poured, but a person made up of body, mind, emotion, and will. It is with this view to educating the whole child that she took as her school motto, “Education is an atmosphere, a discipline, a life.” You will find these three educational keys at work in the approach taken throughout the study of Practical Geometry. For example:

Atmosphere. As parents, we can create a healthy atmosphere in our homes where our children are encouraged to enjoy their work as they progress in their own understanding and at their own pace. A child should never be discouraged from the study of Mathematics by making him feel behind, led to believe he isn't a “math person,” or pushed and pulled through a lesson. While the Practical Geometry lesson is just 30 minutes long, it should be given when your child is mentally fresh—with ample time given to him for thinking, reasoning, and the careful making of drawings. Since these lessons often require concentrated hands-on work, be sure to alternate the math

lesson before and after with lessons that use a different part of the brain or body, such as History, Bible, or Picture Study.

Discipline. In these lessons, the child learns to handle mathematical tools, such as the straightedge, compass, and set squares (or triangles) to train the hand in neatness and the eye in precision. Through practical examples of measurement and observation, the student learns to reason inductively and form correct judgements. The physical habits of precision and accuracy gained through Practical Geometry allow the student to concentrate on more complex ideas and constructions when formal proof-based Geometry is introduced.

Life. Through the practical exercises found in this book, the student is able to explore foundational ideas and discover properties of geometric principles himself. This is clearly evidenced in a Practical Geometry lesson written by one of Charlotte's own teaching students when "let them find out for themselves" is repeated no less than four times in the one-page lesson plan.¹ Furthermore, the foundational ideas explored in an experimental hands-on way builds interest in the more formal study of Geometry, while opening the eyes to the beauty and wonder of laws of practical labor that we are powerless to change.

Sursum corda,

Richele Baburina

1. Willkinon, W.T., *The Parents' Review*, 1903, pp. 545–547

GEOMETRY CONCEPTS IN PART 1

- Solid shapes: edges, faces, and vertices
- Lines and line segments
- Points
- Curves
- Intersections of lines
- Enclosing spaces
- Measurements: US standard and metric
- Acceptable error in measurements
- Estimating measurements
- Use of drawing compass
- Recording measurements in fraction and decimal form
- Parts of a circle: circumference, radius, center, diameter, chord, arc
- Overlapping and concentric circles
- Bisecting line segments
- Stepping off distances
- Parts of angles: ray, vertex, arm
- Types of angles: acute, obtuse, right, straight, reflex
- Measuring angles
- Drawing and naming angles
- Adjacent and supplementary angles
- Vertical angles
- Copying angles
- Bisecting angles
- Parallel and perpendicular lines
- Using set squares
- Transversals
- Interior, exterior, corresponding, alternate, consecutive, and congruent angles
- Triangles: equilateral, isosceles, scalene
- Triangles: acute, obtuse, right

OVERVIEW OF LESSONS

Welcome to the study of practical geometry! Since ancient times, people have been utilizing geometric concepts with only two simple tools: a straightedge and a compass. These lessons incorporate those same simple tools to not only make learning basic elements of geometry a fun, hands-on experience, but also to give a better foundation of geometric principles before students begin a formal study of geometry in high school.

Although the lessons are designed to only take approximately 30 minutes each to complete, their length really depends on each student. If you complete one lesson per week, then it will take one school year to complete this book. You could, of course, choose to take an accelerated path, doing more lessons each week. Regardless of the chosen pace, the lessons begin very gently, starting with how to draw a point and hold a ruler and progressing to more challenging constructions, such as beautiful and exact images like these.

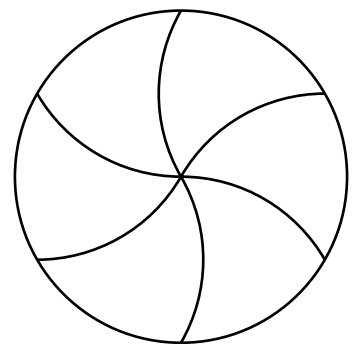
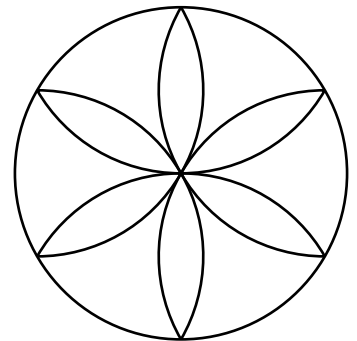
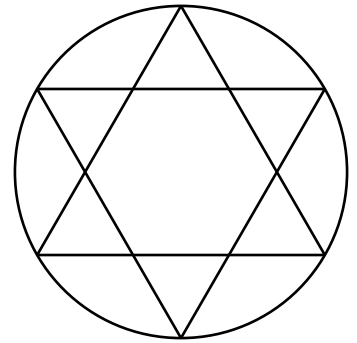
LESSON STRUCTURE

Each lesson begins with a few Review questions. These are meant to be answered quickly and orally. If your student struggles with a question, provide a quick reminder and move on. Following the Review, new ideas are explored with engaging exercises found throughout the lesson. At the conclusion of each lesson is a Math Notebook Entry prompt. The prompt provides your student an opportunity to recall what was learned by writing a short narration in his own words. These narrations could be written in paragraph form or by drawing and labeling the ideas. All three aspects of the lesson are vital, but the bulk of lesson time should be spent on the new ideas and exercises. Answers for all exercises are provided in the back of the book. Exercise steps are numbered, and questions that have corresponding answers are marked with letters.

There are eight Euclidean constructions presented in this book, each used in different ways to aid in the understanding of many geometric concepts. These lessons will provide an opportunity for students to work with drawing tools and explore relationships between ideas.

WRITTEN WORK AND GOOD HABITS

While your student may be able to visualize the solutions of the exercises, it is the process of constructing the figures that is the key. These constructions are what will take your student from knowing about these geometric concepts as abstract ideas to understanding them personally for himself. Doing the constructions will instill these geometric concepts in his mind and allow him to know, without doubt, the truth of them. Encourage him to have fun creating these geometric ideas for himself.



Precision and accuracy are foundational to the study of mathematics, and both habits apply to life outside of math as well. Some students may struggle with a lack of caring about accuracy, but some struggle with finding a balance between accuracy and perfection. Encourage your student to keep a growth mindset as part of the atmosphere of the practical geometry lesson. In order to maintain such an atmosphere, it can be helpful to think of the lessons as more of a discussion between you and your student. If a student gives an incorrect answer, instead of directly correcting him, continue the conversation of the lesson by asking a question that guides him toward the correct answer which, in turn, will build his confidence in his mathematical abilities.

For instance, suppose your student says that a cube has seven sides. Instead of saying something like, “No, actually, a cube has 6 sides,” you could say, “Let’s grab the dice from a game and count the sides!” We suggest taking a die yourself, along with your student. Inspecting the die in your hands, ask, “How can we make sure we don’t count one of the sides twice?” Listen to your student’s ideas for this, and go along with him if possible. If not, offer a suggestion, such as using the dots on the die or marking off the sides with a dry erase marker. This is similar to the process of thinking of a hypothesis in a science lesson and then experimenting to see if the hypothesis is correct.

This kind of discussion can be used for any exercise, especially with the use of the Solutions Guide in the back of this book. As the teacher, you can reference the solution to an exercise in order to know the direction these discussions need to go. As students give their answers, keep in mind the vocabulary or terms found in the solutions. For instance, if your student answers a question correctly by stating that an angle was cut exactly in half, then you can reply, “Yes! The angle has been cut in half. You *bisected* it. Great job!” If the solution does not help you understand, or your student needs more than the coaching you are able to give, you can even look at the solution with your student. Then you both can determine how this answer can be achieved given the information from the exercise. Remember: as the teacher, you are not the bearer of all knowledge. Rather, you are the guide into this wonderful world of numbers and patterns.

VIDEO LIBRARY

In addition to the exercises and solution guide available in this book, your purchase includes access to our Practical Geometry Video Library, which offers visual walk-throughs of many components of the course. You can watch these videos independently before you teach your student, or you can watch them together as part of your lesson. You can access these videos through your account at simplycharlottemason.com. If you have any trouble accessing the files, reach out to Simply Charlotte Mason at contact@simplycharlottemason.com.

SKILL DEVELOPMENT

As you guide your student with these rich discussions, remember that he is developing the skills to use geometric tools and to do each construction. Thus, some of his

measurements may be slightly different from the solutions. In fact, some small amount of error is almost certain to occur on a regular basis, as we are imperfect beings using imperfect tools. We have included discussions and reminders about possible errors in measurement and good expectations for the student throughout the text, along with lessons on acceptable error. If your student struggles with achieving an accurate measurement with his ruler or with using a compass well, but otherwise demonstrates an understanding of the exercise, simply encourage him to keep working on his skills and precision. There is no need to keep reworking the exercise until the measurement or construction is *exactly* correct. Practice using the tools is more important.

EXAMS

There are three exams in this text. Each takes place at the end of a 12-week term, following 11 geometry lessons. The exams are meant to be a chance for the student to demonstrate what he has learned. It is a chance to both celebrate progress as well as assess understanding.

OPTIONAL LESSONS

In addition to the collection of 33 lessons and 3 exams that make up this book, we have included three types of optional lessons for families who wish to explore the concepts in more depth. Outdoor Extras, Outdoor Geography, and Creative Extras appear throughout the book. You can do these lessons on the same day as a geometry lesson or save it for another time during the week.

TIP: Keep the lessons short and fun. Remember your student will see these geometric ideas again throughout high school geometry study. Join in with your student and enjoy the beauty of mathematics!

LESSON ICON KEY

 REVIEW


 CONSTRUCTIONS

 MATH JOURNAL ENTRY

 OUTDOOR EXTRA

 VIDEO

SUPPLIES NEEDED

 A visual overview of some of the required supplies is available with the Practical Geometry Video Library.

- Gridded math notebook (sized according to the student's handwriting: $\frac{3}{4}$ " , $\frac{1}{2}$ " , or $\frac{1}{4}$ "). This can be a section of the student's regular math notebook or a separate book. Available from Simply Charlotte Mason.
- Geometry tools
 - US standard ruler with measurements marked to $\frac{1}{16}$ of an inch
 - Metric ruler with measurements marked to 1 mm
 - Drawing compass
 - Protractor
 - Set squares (triangular rulers)
- Examples of various shapes
 - Cylinder (canned good, oatmeal container)
 - Cube (a die, a wooden block)
 - Sphere (ball, globe)
 - (optional) Cone (ice cream sugar cone, party hat)
 - (optional) Triangular prism
 - (optional) Square pyramid
- Light-colored thick-tip marker
- Medium-colored fine-tip marker
- Finely sharpened pencil or mechanical pencil
- Straightedge without measurements (an index card will work)
- Colored pencils or pens in at least five distinct colors
- Dime
- Tracing paper (approximately 10 sheets)
- Blank sheets of paper (approximately 10 sheets)
- Template for lesson 32, exercise 6 (download at simplycm.com/pg32)
- Scissors
- Round object to trace a circle (such as a drinking glass or can)
- String (approximately 6 in. in length)
- Cardstock (one 8.5x11" sheet)
- Straight pin and cardboard OR brad
- For optional outdoor geography lesson after lesson 23:
 - Drinking straw
 - Tape
 - String (approximately 8 in. long)
 - Weight or metal nut
 - Tape measure