**High School: Geometry**

*Conditions for Parallelograms*

#### This learning progression was designed primarily for 9th grade students in an honors geometry course. The Common Core State Standards that it will be satisfying are the following: [HSG.GPE.B.4](http://www.corestandards.org/Math/Content/HSG/GPE/B/4/) and [*HSG.GPE.B.5*](http://www.corestandards.org/Math/Content/HSG/GPE/B/5/)*.* While the math practices that we will be implementing are: [MP1](http://www.corestandards.org/Math/Practice/MP1/), [MP2](http://www.corestandards.org/Math/Practice/MP2/), and MP[3](http://www.corestandards.org/Math/Practice/MP8/).

Common Core State Standards

**Content Standards to meet**

#### Use coordinates to prove simple geometric theorems algebraically

[CCSS.MATH.CONTENT.HSG.GPE.B.4](http://www.corestandards.org/Math/Content/HSG/GPE/B/4/)  
Use coordinates to prove simple geometric theorems algebraically. *For example, prove or disprove that a figure defined by four given points in the coordinate plane is a rectangle; prove or disprove that the point (1, √3) lies on the circle centered at the origin and containing the point (0,* [*CCSS.MATH.CONTENT.HSG.GPE.B.5*](http://www.corestandards.org/Math/Content/HSG/GPE/B/5/)Prove the slope criteria for parallel and perpendicular lines and use them to solve geometric problems (e.g., find the equation of a line parallel or perpendicular to a given line that passes through a given point).

**Mathematical Practices**

CCSS.MATH.PRACTICE.MP1

Make sense of problems and persevere in solving them.

CCSS.MATH.PRACTICE.MP2

Reason abstractly and quantitatively.

#### [CCSS.MATH.PRACTICE.MP3](http://www.corestandards.org/Math/Practice/MP3/) Construct viable arguments and critique the reasoning of others.

#### Content Standards met

#### [CCSS.MATH.CONTENT.HSG.CO.C.9](http://www.corestandards.org/Math/Content/HSG/CO/C/9/) Prove theorems about lines and angles.

#### [CCSS.MATH.CONTENT.HSG.CO.C.10](http://www.corestandards.org/Math/Content/HSG/CO/C/10/) Prove theorems about triangles

#### [CCSS.MATH.CONTENT.HSG.CO.C.11](http://www.corestandards.org/Math/Content/HSG/CO/C/11/) Prove theorems about parallelograms.

[*CCSS.MATH.CONTENT.HSG.SRT.B.5*](http://www.corestandards.org/Math/Content/HSG/SRT/B/5/)Use congruence and similarity criteria for triangles to solve problems and to prove relationships in geometric figures.

The curriculum these students are going through is produced by Holt. More specifically, the students are working from the 2009 Geometry textbook from the same publisher. Students should have already met the following standards: HSG.CO.C.9, HSG.CO.C.10, HSG.CO.C.11, and HSG.SRT.B.5. The standards HSG.CO.C.9, HSG.CO.C.10, and HSG.SRT.B.5 were covered weeks ago in various other lessons. They will all be satisfied by the students while they try to figure out how to do various assigned problems. HSG.CO.C.11 was covered yesterday. Students will now use all of these theorems to prove that given quadrilaterals are or are not parallelograms.

At the very beginning of this lesson progression students will be going through classifying shapes as regular or irregular polygons and then by their number of sides. This should all be review for the students but it will help build confidence in their own mathematical abilities. After reviewing these shape names, we will move on to discovering the measure of their interior and exterior angles. This will originally be taught using a mix between the Socratic Method and Direct Instruction. Students will then have to take this information and apply it to mathematics problems that are given to them. As they work on these problems the teacher will walk around and assessing their work. The students will be allowed to talk to their table partners to check answers and tutor one another. As they are doing this the teacher will insert themselves into conversations that are headed the wrong direction, coming to a lull when it is clear one of both of the students is still lost or when the students are simply getting off task. Once the students complete the assigned problems the teacher will draw students’ names out of a hat to have them come up to the whiteboard and write their answers down. Although this is a very public form of formal assessment, in that all of the student’s peers will see if they got the correct answer or not, the writer believes it is still an effective one. For instance, the fear of getting an answer wrong in front of the class will motivate students to actually talk to their table partner. The fact that they will be called on randomly also makes it so they are less likely to try and get away with not doing their work. This assessment both checks for the correct answer and holds them accountable to actually working.

Lesson 1

Tell whether the polygon is regular or irregular. If it is regular, then tell whether it is concave or convex.



Figure 1 Figure 2

Find the measure of each interior angle of the regular polygon listed below. Round to the nearest tenth if necessary.

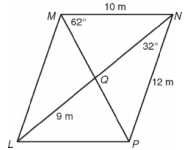
*Heptagon*

Find the measure of each exterior angle of the regular polygon listed below. Round to the nearest tenth if necessary.

*Octagon*

Lesson 2

Find the measure of the missing side lengths and angles in the diagram below:



The coordinates of the three vertices of a parallelogram are given. Find the coordinates of the fourth vertex.



Some of the problems from this section that the teacher will make sure to ask students to answer can be seen to the right. Figures 1 and 2 as well as the following two problems are all benchmark assessments for this section. The two questions about the shapes regularity are not as strong of benchmark assessments simply because some students might be able to guess the correct response but that is why instead of simply having one benchmark assessment there are two. Then the next two benchmark assessments are nearly impossible to guess correctly so as the teacher is walking around, while the students are working on the assigned work, checking these particular questions, they will be able to tell exactly how well the students are understanding the material. Once the students are proficient at these types of problems, they will be assigned their homework and class will move on.

At the beginning of the next day the teacher will go over the correct answers to the homework from the previous day. This will give students a chance to check their own understanding of the material. If the students are confused by any question, at this point they will be able to ask questions about what is going on.

Next, a lesson that covers the properties of parallelograms will be taught. Once again the teacher will use a method of instruction that combines the Socratic Method and Direct Instruction. They will inform students of the properties of a parallelogram. These students will then be expected to determine the measures of various parts of the parallelogram using the given properties.

The students once again will be working with their partner to determine the correct answers. As they are doing so the teacher will be walking around to check specific benchmark assessments the students are filling out on the worksheet. These questions can be seen in the right margin.

Randomly chosen students will then be asked to come to the board to present their answers to the questions that were assigned. This will ensure that the students are actually doing their work and not just sitting around and talking.

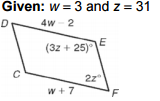
Lesson 3

**Properties of Parallelograms**

* Both pairs of opposite sides are parallel
* Both pairs of opposite sides are congruent
* Both pair of opposite angles are congruent
* Consecutive angles are supplementary
* Diagonals bisect each other

Lesson 4

Show that the given quadrilateral is a parallelogram for the given values



Determine if the following quadrilateral must be a parallelogram and justify your answer.



Finally, at the end of the day the students will be assigned the homework they are to finish before the next day of class. This will give the teacher a better look into who understands the material and who is willing to put in the time and effort to understand it.

At the beginning of day 3 of this learning segment the students will be expected to produce their homework. The teacher will then go around and stamp the students work to see who all finished the it. By doing this the teacher will get a picture of which problems the students generally struggled with the most. This is a form of formative assessment.

The teacher will then ask the students which problems they struggled with and if they had any questions. If the students say they understand everything and yet did not complete the homework the students’ inconsistency will be addressed.

The teacher will then guide the students through the construction of a manipulative that describes different qualities of various polynomials. The list of qualities of a parallelogram can be seen in the right margin. Creating this manipulative will take the rest of the time but it should be well worth it for the kinesthetic and visual learners.

Finally, the methods of instruction and assessment in the last lesson in the learning segment will be similar to those used in lessons 1 and 2. The teacher will not have to start off the day with the correction of homework since none will have been assigned the previous day. Instead she will have the students express what they have learned in the last few days. Having individual students express to the entire class what they have learned in the last few days will give the other students a benchmark as to how much they too should have learned thus far.

Next the teacher will begin leading the class in an investigation of how to apply the material they have learned. Some of the Benchmark Assessments that will be used are listed in the right margin.

After the students complete their class work they will be given an exit task they must complete before the day is over. The exit task will include two Benchmark Assessments that can be seen in the right margin. Then the students will complete a survey that addresses how they are feeling about the math they have just completed. Finally, they will be asked if they have any questions, what they think they should have learned, and they will be asked to list 4 out of the 6 properties of parallelograms. This will give the teacher concrete evidence of what the students have learned throughout this learning progression. After a quick review and quiz the students will be ready to move on to the next learning progression.

Exit task

