Unit 8 - Geometry

QUADRILATERALS

NAME _____________________________

Period ____________


A little background...

Polygon is the generic term for a closed figure with any number of sides. Depending on the number, the first part of the word “Poly” is replaced by a prefix. The prefix used is from Greek. The Greek term for 5 is Penta, so a 5-sided figure is called a Pentagon. We can draw figures with as many sides as we want, but most of us don't remember all that Greek, so when the number is over 12, or if we are talking about a general polygon, many mathematicians call the figure an “n-gon.” So a figure with 46 sides would be called a “46-gon.”

**Vocabulary**

**Polygon** - A closed plane (two-dimensional) figure made up of several line segments that are joined together. The sides do not cross each other. Exactly two sides meet at every vertex.

**Types of Polygons**

**Regular** - all angles are equal and all sides are the same length. Regular polygons are both equiangular and equilateral.

**Irregular** - Any polygon with any angles NOT equal and any sides NOT the same length.

**Equiangular** - all angles are equal.

**Equilateral** - all sides are the same length.

<table>
<thead>
<tr>
<th>Convex</th>
<th>a straight line drawn through a convex polygon <strong>crosses at most two sides</strong>. Every interior angle is less than 180°.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Concave</td>
<td>you can draw at least one straight line through a concave polygon that <strong>crosses more than two sides</strong>. At least one interior angle is more than 180°.</td>
</tr>
</tbody>
</table>

**Polygon Parts**

<table>
<thead>
<tr>
<th>Side</th>
<th>one of the line segments that make up the polygon.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vertex</td>
<td>point where two sides meet. Two or more of these points are called vertices.</td>
</tr>
<tr>
<td>Diagonal</td>
<td>a line connecting two vertices that isn’t a side.</td>
</tr>
<tr>
<td>Interior Angle</td>
<td>Angle formed by two adjacent sides inside the polygon.</td>
</tr>
<tr>
<td>Exterior Angle</td>
<td>Angle formed by one side of a triangle and the extension of another side.</td>
</tr>
</tbody>
</table>
Special Polygons

**Special Quadrilaterals** - square, rhombus, parallelogram, rectangle, and the trapezoid.

**Special Triangles** - right, equilateral, isosceles, scalene, acute, obtuse.

Polygon Names

*Generally accepted names*

<table>
<thead>
<tr>
<th>Sides</th>
<th>Name</th>
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</thead>
<tbody>
<tr>
<td>n</td>
<td>N-gon</td>
</tr>
<tr>
<td>3</td>
<td>Triangle</td>
</tr>
<tr>
<td>4</td>
<td>Quadrilateral</td>
</tr>
<tr>
<td>5</td>
<td>Pentagon</td>
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<td>6</td>
<td>Hexagon</td>
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<td>7</td>
<td>Heptagon</td>
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<td>8</td>
<td>Octagon</td>
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<td>10</td>
<td>Decagon</td>
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<tr>
<td>12</td>
<td>Dodecagon</td>
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</table>

Vocabulary from [http://www.math.com/tables/geometry/polygons.htm](http://www.math.com/tables/geometry/polygons.htm)
<table>
<thead>
<tr>
<th>NUMBER OF SIDES OF THE POLYGON</th>
<th>NAME OF POLYGON</th>
<th>NUMBER OF INTERIOR ANGLES</th>
<th>NUMBER OF DIAGONALS POSSIBLE FROM ONE VERTEX POINT</th>
<th>NUMBER OF TRIANGLES FORMED FROM ONE VERTEX POINT</th>
<th>SUM OF MEASURES OF INTERIOR ANGLES</th>
<th>ONE INTERIOR ANGLE MEASURE (REGULAR POLYGON)</th>
<th>ONE EXTERIOR ANGLE MEASURE (REGULAR POLYGON)</th>
<th>SUM OF EXTERIOR ANGLES MEASURED</th>
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<tbody>
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<td>3</td>
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<td>2</td>
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<td>12</td>
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<td>1800°</td>
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a) Compare the number of triangles to the number of sides. Do you see a pattern?

b) How can you use the number of triangles formed by the diagonals to figure out the sum of all the interior angles of a polygon?

c) Write an expression for the sum of the interior angles of an n-gon, using n and the patterns you found from the table.
Section 8 – 1: Angles of Polygons

Notes

Diagonal of a Polygon: A segment that ______________ any two ______________ vertices.

Theorem 8.1: Interior Angle Sum Theorem:
If a convex polygon has \( n \) sides and \( S \) is the sum of the ______________ of its interior angles, then ________________.

Example #1: Find the sum of the measures of the interior angles of the regular pentagon below.

Example #2: The measure of an interior angle of a regular polygon is 135. Find the number of sides in the polygon.

Example #3: Find the measure of each interior angle.
Theorem 8.2: Exterior Angle Sum Theorem:
If a polygon is ______________, then the sum of the measures of the ______________ angles, one at each ______________, is 360.

Example #4: Find the measures of an exterior angle and an interior angle of convex regular nonagon $ABCDEFGHJ$. 
Find the sum of the measures of the interior angles of each convex polygon.

1. 11-gon  
2. 14-gon  
3. 17-gon

The measure of an interior angle of a regular polygon is given. Find the number of sides in each polygon.

4. 144  
5. 156  
6. 160

Find the measure of each interior angle using the given information.

7. Quadrilateral $RSTU$ with:
   - $m \angle R = (2x + 15)^\circ$  
   - $m \angle S = (3x - 20)^\circ$  
   - $m \angle T = (x + 15)^\circ$  

8. Quadrilateral $RSTU$ with:
   - $m \angle R = 6x - 4$  
   - $m \angle S = 2x + 8$

Find the measures of an interior angle and an exterior angle for each regular polygon. Round to the nearest tenth if necessary.

9. 16-gon  
10. 24-gon  
11. 30-gon

Find the measures of an interior angle and an exterior angle given the number of sides of each regular polygon. Round to the nearest tenth if necessary.

12. 14  
13. 22  
14. 40

15. CRYSTALLOGRAPHY Crystals are classified according to seven crystal systems. The basis of the classification is the shapes of the faces of the crystal. Turquoise belongs to the triclinic system. Each of the six faces of turquoise is in the shape of a parallelogram. Find the sum of the measures of the interior angles of one such face.
Properties of Parallelograms Activity

Step 1 Using the lines on a piece of graph paper as a guide, draw a pair of parallel lines that are at least 10 cm long and at least 6 cm apart. Using the parallel edges of your straightedge, make a parallelogram. Label your parallelogram MATH.

Step 2 Look at the opposite angles. Measure the angles of parallelogram MATH. Compare a pair of opposite angles using your protractor.

The opposite angles of a parallelogram are ________________.

Step 3 Two angles that share a common side in a polygon are consecutive angles. In parallelogram MATH, \( \angle MAT \) and \( \angle HTA \) are a pair of consecutive angles. The consecutive angles of a parallelogram are also related.

Find the sum of the measures of each pair of consecutive angles in parallelogram MATH.

The consecutive angles of a parallelogram are ________________.

Step 4 Next look at the opposite sides of a parallelogram. With your ruler, compare the lengths of the opposite sides of the parallelogram you made.

The opposite sides of a parallelogram are ________________.

Step 5 Finally, consider the diagonals of a parallelogram. Construct the diagonals \( MT \) and \( HA \). Label the point where the two diagonals intersect point B.

Step 6 Measure \( MB \) and \( TB \). What can you conclude about point B? Is this conclusion also true for diagonal \( HA \)? How do the diagonals relate?

The diagonals of a parallelogram ________________.
Key Concept (Parallelogram):
A ______________ is a quadrilateral with _______ pairs of opposite sides ______________.

Ex:

Symbols:

Theorem 8.3: Opposite sides of a parallelogram are ______________.

Theorem 8.4: ______________ angles in a parallelogram are congruent.

Theorem 8.5: Consecutive angles in a parallelogram are ______________.

Theorem 8.6: If a parallelogram has one _________ angle, it has four right angles.

Theorem 8.7: The ______________ of a parallelogram bisect each other.
Example #1: \( RSTU \) is a parallelogram. Find \( m\angle URT \), \( m\angle RST \), and \( y \).

Theorem 8.8: Each diagonal of a parallelogram separates the parallelogram into congruent triangles.
8-2 Practice

Parallelograms

Complete each statement about \(\square LMNP\). Justify your answer.

1. \(LQ \equiv \) 

2. \(\angle LMN \equiv \) 

3. \(\angle LMP \equiv \) 

4. \(\angle NPL\) is supplementary to \(\).

5. \(LM \equiv \)

ALGEBRA Use \(\square RSTU\) to find each measure or value.

6. \(m\angle RST = \) 

7. \(m\angle STU = \) 

8. \(m\angle TUR = \) 

9. \(b = \) 

COORDINATE GEOMETRY Find the coordinates of the intersection of the diagonals of parallelogram \(PRYZ\) given each set of vertices.

10. \(P(2, 5), R(3, 3), Y(-2, -3), Z(-3, -1)\) 

11. \(P(2, 3), R(1, -2), Y(-5, -7), Z(-4, -2)\)

12. PROOF Write a paragraph proof of the following.
   Given: \(\square PRST\) and \(\square PQVU\)
   Prove: \(\angle V \equiv \angle S\)

13. CONSTRUCTION Mr. Rodriguez used the parallelogram at the right to design a herringbone pattern for a paving stone. He will use the paving stone for a sidewalk. If \(m\angle 1\) is 130, find \(m\angle 2, m\angle 3,\) and \(m\angle 4.\)
Conditions for a Parallelogram: By definition, the opposite sides of a parallelogram are parallel. So, if a quadrilateral has each pair of opposite sides parallel it is a parallelogram.

Key Concept (Proving Parallelograms):

**Theorem 8.9:** If both pairs of ______________ sides of a quadrilateral are ______________, then the quadrilateral is a parallelogram.

Ex:

**Theorem 8.10:** If both pairs of opposite ______________ of a quadrilateral are ______________, then the quadrilateral is a parallelogram.

Ex:

**Theorem 8.11:** If the ______________ of a quadrilateral ________ each other, then the quadrilateral is a parallelogram.

Ex:

**Theorem 8.12:** If one pair of opposite sides of a quadrilateral is both ______________ and ______________, then the quadrilateral is a parallelogram.

Ex:
Example #1: Find $x$ and $y$ so that each quadrilateral is a parallelogram and justify your reasoning.

a.)

b.)
Given: \(\square VZRQ\) and \(\square WQST\)

Prove: \(\angle Z \cong \angle T\)

<table>
<thead>
<tr>
<th>Statements</th>
<th>Reasons</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. (\square VZRQ)</td>
<td>1. Given</td>
</tr>
<tr>
<td>2. (\angle Z \cong \angle Q)</td>
<td>2. Opposite angles of a parallelogram are congruent</td>
</tr>
<tr>
<td>3. (\square WQST)</td>
<td>3. Given</td>
</tr>
<tr>
<td>4. (\angle Q \cong \angle T)</td>
<td>4. Opposite angles of a parallelogram are congruent</td>
</tr>
<tr>
<td>5. (\angle Z \cong \angle T)</td>
<td>5. Transitive</td>
</tr>
</tbody>
</table>
8-3  Practice

Tests for Parallelograms

Determine whether each quadrilateral is a parallelogram. Justify your answer.

1.  

2.  

3.  

4.  

COORDINATE GEOMETRY  Determine whether a figure with the given vertices is a parallelogram. Use the method indicated.

5.  \( P(-5, 1), S(-2, 2), F(-1, -3), T(2, -2); \) Slope Formula

6.  \( R(-2, 5), O(1, 3), M(-3, -4), Y(-6, -2); \) Distance and Slope Formula

ALGEBRA  Find \( x \) and \( y \) so that each quadrilateral is a parallelogram.

7.  

8.  

9.  

10.  

11. TILE DESIGN  The pattern shown in the figure is to consist of congruent parallelograms. How can the designer be certain that the shapes are parallelograms?

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Section 8 – 4: Rectangles

Notes

Rectangle:
✓ A quadrilateral with __________ ____________ angles.
✓ Both __________ of _____________ angles are _____________.
✓ A rectangle has all the ______________ of a ________________.

Theorem 8.13: If a parallelogram is a ____________, then the __________ are congruent.
Ex:

Key Concept (Rectangle):
Properties:
➢ Opposite __________ are congruent and parallel.
   Ex:

➢ Opposite __________ are ________________.
   Ex:

➢ _________________ angles are supplementary.
   Ex:

➢ All __________ angles are ____________ angles.
   Ex:
Example #1: Quadrilateral $RSTU$ is a rectangle. If $RT = 6x + 4$ and $SU = 7x - 4$, find $x$.

Example #2: Quadrilateral $LMNP$ is a rectangle.

a.) Find $x$.

b.) Find $y$.

**Theorem 8.14:** If the ____________ of a parallelogram are congruent, then the parallelogram is a ________________.

Ex:
Properties of Rectangles  A rectangle is a quadrilateral with four right angles. Here are the properties of rectangles.

A rectangle has all the properties of a parallelogram.

- Opposite sides are parallel.
- Opposite angles are congruent.
- Opposite sides are congruent.
- Consecutive angles are supplementary.
- The diagonals bisect each other.

Also:

- All four angles are right angles. \( \angle UTS, \angle TSR, \angle SRU, \) and \( \angle RUT \) are right angles.
- The diagonals are congruent. \( TR \cong US \)
Practice
Rectangles

ALGEBRA $RSTU$ is a rectangle.

1. If $UZ = x + 21$ and $ZS = 3x - 15$, find $US$.

2. If $RZ = 3x + 8$ and $ZS = 6x - 28$, find $UZ$.

3. If $RT = 5x + 8$ and $RZ = 4x + 1$, find $ZT$.

4. If $m\angle SUT = 3x + 6$ and $m\angle RUS = 5x - 4$, find $m\angle SUT$.

5. If $m\angle SRT = x^2 + 9$ and $m\angle UTR = 2x + 44$, find $x$.

6. If $m\angle RSU = x^2 - 1$ and $m\angle TUS = 3x + 9$, find $m\angle RSU$.

$GHJK$ is a rectangle. Find each measure if $m\angle 1 = 37$.

7. $m\angle 2$  
8. $m\angle 3$

9. $m\angle 4$  
10. $m\angle 5$

11. $m\angle 6$  
12. $m\angle 7$

COORDINATE GEOMETRY Determine whether $BGHL$ is a rectangle given each set of vertices. Justify your answer.

13. $B(-4, 3), G(-2, 4), H(1, -2), L(-1, -3)$

14. $B(-4, 5), G(6, 0), H(3, -6), L(-7, -1)$

15. $B(0, 5), G(4, 7), H(5, 4), L(1, 2)$

16. LANDSCAPING Huntington Park officials approved a rectangular plot of land for a Japanese Zen garden. Is it sufficient to know that opposite sides of the garden plot are congruent and parallel to determine that the garden plot is rectangular? Explain.
Properties of Rhombi and Squares:

A Rhombus is a Parallelogram with all 4 sides Congruent.
A square is a special type of rhombus.

<table>
<thead>
<tr>
<th>Rhombus</th>
<th>Square</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. A Rhombus has all the properties of a parallelogram</td>
<td>1. A square has all the properties of a parallelogram</td>
</tr>
<tr>
<td>2. All sides are Congruent</td>
<td>2. A square has all the properties of a rectangle</td>
</tr>
<tr>
<td>3. Diagonals are Perpendicular</td>
<td>3. A square has all the properties of a rhombus</td>
</tr>
<tr>
<td>4. Diagonals bisect the angles of Rhombus</td>
<td></td>
</tr>
</tbody>
</table>
Date____________________

In-Class Activity
Build, Measure, Compare

Directions: Mark all properties that apply to each figure built.

Chart the property

<table>
<thead>
<tr>
<th>Property</th>
<th>Figure (A)</th>
<th>Figure (B)</th>
<th>Figure (C)</th>
<th>Figure (D)</th>
<th>Figure (E)</th>
<th>Figure (F)</th>
<th>Figure (G)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both pairs of opposite sides are $\parallel$</td>
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<td>All sides are $\cong$</td>
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<td>Diagonals are $\perp$</td>
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<td>Diagonals bisect each other</td>
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<td>Diagonals bisect pair of opposite $\angle$</td>
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<td>Both pairs of opposite $\angle$ are $\cong$</td>
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<tr>
<td>Consecutive $\angle$s are $\cong$</td>
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<td>All $\angle$s are $\cong$</td>
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</tbody>
</table>

Questions to answer:

1. What is the one thing that is different about the diagonals between the two types of figures created in this activity?

2. What is the one thing that is different about the angles between the two types of figures created in this activity?
Figures for activity

Figure A

Figure B

Figure C

Figure D

Figure E

Figure F

Figure G

In class activity figures A- G
Section 8 – 5: Rhombi and Squares

Notes

Rhombus:

➢ A _____________ is a special type of parallelogram called a _________________.

➢ A rhombus is a quadrilateral with all four sides _________________.

➢ All of the _________________ of parallelograms can be applied to rhombi.

Key Concept (Rhombus):

Theorem 8.15: The _________________ of a rhombus are perpendicular.

Ex: 

Theorem 8.16: If the diagonals of a _________________ are _________________, then the parallelogram is a rhombus.

Ex: 

Theorem 8.17: Each diagonal of a rhombus ___________

a pair of opposite _______________.

Ex:
Example #1: Use rhombus $LMNP$ and the given information to find the value of each variable.

a.) Find $y$ if $\angle 1 = y - 54$

b.) Find $\angle PNL$ if $\angle MLP = 64$.

Square:
- If a quadrilateral is both a ___________ and a ___________, then it is a square.
- All of the properties of parallelograms and rectangles can be applied to ___________.


Section 8-5 Homework

ABCD is a rhombus.

1.) If $\angle BAD = 60$, find $\angle BDC$.  

2.) If $AE = 8$, find $AC$.

3.) If $AB = 26$ and $BD = 20$, find $AE$. 

4.) Find $\angle CEB$.

5.) If $\angle CBD = 58$, find $\angle ACB$.

6.) If $AE = 3x - 1$ and $AC = 16$, find $x$.

7.) If $\angle CDB = 6y$ and $\angle ACB = 2y + 10$, find $y$.

8.) If $AD = 2x + 4$ and $CD = 4x - 4$, find $x$.

Use rhombus $PRYZ$ with $RK = 4y + 1$, $ZK = 7y - 14$, $PK = 3x - 1$, and $YK = 2x + 6$.

9.) Find $PY$.  

10.) Find $RZ$.

11.) Find $RY$.  

12.) Find $m\angle YKZ$.  

Use rhombus $PRYZ$ with $RK = 4y + 1$, $ZK = 7y - 14$, $PK = 3x - 1$, and $YK = 2x + 6$.

1. Find $PY$.
2. Find $RZ$.

3. Find $RY$.
4. Find $m\angle YKZ$.

Use rhombus $MNPQ$ with $PQ = 3\sqrt{2}$, $PA = 4x - 1$, and $AM = 9x - 6$.

5. Find $AQ$.
6. Find $m\angle APQ$.

7. Find $m\angle MNP$.
8. Find $PM$.

COORDINATE GEOMETRY Given each set of vertices, determine whether $\square BEFG$ is a rhombus, a rectangle, or a square. List all that apply. Explain your reasoning.

9. $B(-9, 1), E(2, 3), F(12, -2), G(1, -4)$

10. $B(1, 3), E(7, -3), F(1, -9), G(-5, -3)$

11. $B(-4, -5), E(1, -5), F(-7, -1), G(-2, -1)$

12. TESSELATIONS The figure is an example of a tessellation. Use a ruler or protractor to measure the shapes and then name the quadrilaterals used to form the figure.
Section 8 – 6: Trapezoids

**Notes**

**Trapezoid:**
- A quadrilateral with exactly _______ _________ of parallel _________.
- The ________________ sides are called ____________.
- The base _____________ are formed by the base and one of the ________.
- The ___________________ sides are called __________.

**Isosceles Trapezoid:**
- A trapezoid that has _________________ legs.

![Diagram of an isosceles trapezoid]

- **Theorem 8.18:** Both pairs of base _____________ of an isosceles trapezoid are _________________.
  
  Ex:

- **Theorem 8.19:** The _________________ of an isosceles trapezoid are congruent.
  
  Ex:
**Median:** The segment that joins ______________ of the _______ of a trapezoid.

**Theorem 8.20:** The median of a trapezoid is ______________ to the bases, and its measure is ______________ the sum of the measures of the bases.

**Ex:**

![Diagram of a trapezoid with medians]

**Example #1:** $DEFG$ is an isosceles trapezoid with median $MN$.

![Diagram of an isosceles trapezoid]

a.) Find $DG$ if $EF = 20$ and $MN = 30$.

b.) Find $m\angle 1$, $m\angle 2$, $m\angle 3$, and $m\angle 4$ if $m\angle 1 = 3x + 5$ and $m\angle 3 = 6x - 5$. 
Properties of Trapezoids:

A Trapezoid is a QUADRILATERAL with exactly one pair of parallel sides.

AND

The parallel sides are called bases

In an Isosceles Trapezoid, the legs are congruent.

AND

Both pairs of base angles are congruent

AND

The diagonals are congruent

The Median of a trapezoid is a line segment that joins the midpoints of the legs.

AND

It is parallel to the bases and is equal to \( \frac{1}{2} \) the sum of the lengths of the bases.

\[
EF = \frac{1}{2} (AB + DC)
\]
COORDINATE GEOMETRY \( RSTU \) is a quadrilateral with vertices \( R(-3, -3), S(5, 1), T(10, -2), U(-4, -9) \).

1. Verify that \( RSTU \) is a trapezoid.

2. Determine whether \( RSTU \) is an isosceles trapezoid. Explain.

COORDINATE GEOMETRY \( BGHJ \) is a quadrilateral with vertices \( B(-9, 1), G(2, 3), H(12, -2), J(-10, -6) \).

3. Verify that \( BGHJ \) is a trapezoid.

4. Determine whether \( BGHJ \) is an isosceles trapezoid. Explain.

ALGEBRA Find the missing measure(s) for the given trapezoid.

5. For trapezoid \( CDEF \), \( V \) and \( Y \) are midpoints of the legs. Find \( CD \).

6. For trapezoid \( WRLP \), \( B \) and \( C \) are midpoints of the legs. Find \( LP \).

7. For trapezoid \( FGHI \), \( K \) and \( M \) are midpoints of the legs. Find \( FI \), \( m \angle F \), and \( m \angle I \).

8. For isosceles trapezoid \( TVZY \), find the length of the median, \( m \angle T \), and \( m \angle Z \).

9. CONSTRUCTION A set of stairs leading to the entrance of a building is designed in the shape of an isosceles trapezoid with the longer base at the bottom of the stairs and the shorter base at the top. If the bottom of the stairs is 21 feet wide and the top is 14, find the width of the stairs halfway to the top.

10. DESK TOPS A carpenter needs to replace several trapezoid-shaped desktops in a classroom. The carpenter knows the lengths of both bases of the desktop. What other measurements, if any, does the carpenter need?
<table>
<thead>
<tr>
<th>Define each type of figure</th>
<th>draw an example</th>
<th>special characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>(some things to ask yourself: Diagonals =, diagonals bisect each other, diagonals bisect angle, diagonals perpendicular, angle measures equal, angle measures supplementary, sides equal, sides parallel,)</td>
<td></td>
<td></td>
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<tr>
<td>1. quadrilateral</td>
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<tr>
<td>2. parallelogram</td>
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<tr>
<td>3. square</td>
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<td>4. rectangle</td>
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<td>5. rhombus</td>
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<td>6. kite</td>
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<td>7. trapezoid</td>
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<tr>
<td>8. Isosceles trapezoid</td>
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