

Quadrilaterals

Close
Tuesday, January 20, 2026 8:54 AM

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Quadrilater...

Module 7: Quadrilaterals Geometry

Content Objective

Close

Students apply and prove theorems about the properties of parallelograms.

Students use the properties of rectangles to determine whether a parallelogram is a rectangle and to write proofs.

Students apply and prove the properties of rhombi and squares.

Students recognize and apply the properties of trapezoids and kites.

MA.912.GR.1.4

Prove relationships and theorems about parallelograms. Solve mathematical and real-world problems involving postulates, relationships and theorems of parallelograms.

MA.912.GR.3.2

Given a mathematical context, use coordinate geometry to classify or justify definitions, properties and theorems involving circles, triangles or quadrilaterals.

MA.912.GR.3.3

Use coordinate geometry to solve mathematical and real-world



geometric problems involving lines, circles, triangles and quadrilaterals.

Close

MA.912.GR.1.5

Prove relationships and theorems about trapezoids. Solve mathematical and real-world problems involving postulates, relationships and theorems of trapezoids.

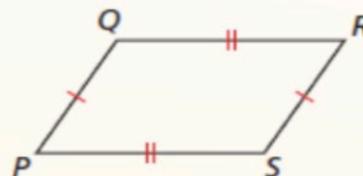
Theorems

Theorem 7.3 Parallelogram Opposite Sides Theorem

If a quadrilateral is a parallelogram, then its opposite sides are congruent.

If $PQRS$ is a parallelogram, then $\overline{PQ} \cong \overline{RS}$
and $\overline{QR} \cong \overline{SP}$.

Proof p. 368

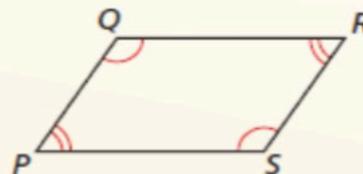


Theorem 7.4 Parallelogram Opposite Angles Theorem

If a quadrilateral is a parallelogram, then its opposite angles are congruent.

If $PQRS$ is a parallelogram, then $\angle P \cong \angle R$
and $\angle Q \cong \angle S$.

Proof Ex. 37, p. 373



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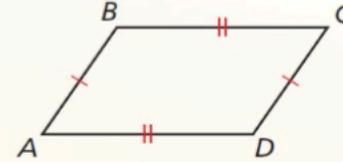
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Theorems

Theorem 7.7 Parallelogram Opposite Sides Converse

If both pairs of opposite sides of a quadrilateral are congruent, then the quadrilateral is a parallelogram.

If $\overline{AB} \cong \overline{CD}$ and $\overline{BC} \cong \overline{DA}$, then $ABCD$ is a parallelogram.

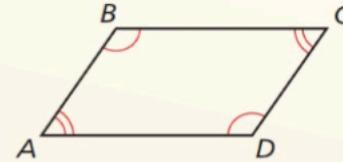


Theorem 7.8 Parallelogram Opposite Angles Converse

If both pairs of opposite angles of a quadrilateral are congruent, then the quadrilateral is a parallelogram.

If $\angle A \cong \angle C$ and $\angle B \cong \angle D$, then $ABCD$ is a parallelogram.

Proof Ex. 39, p. 383



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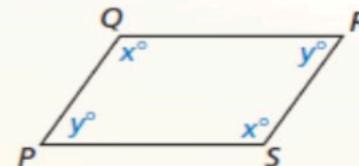
Theorems

Theorem 7.5 Parallelogram Consecutive Angles Theorem

If a quadrilateral is a parallelogram, then its consecutive angles are supplementary.

If $PQRS$ is a parallelogram, then $x^\circ + y^\circ = 180^\circ$.

Proof Ex. 38, p. 373



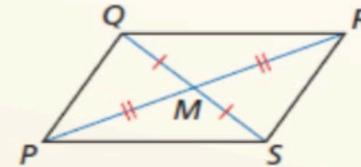
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Theorem 7.6 Parallelogram Diagonals Theorem

If a quadrilateral is a parallelogram, then its diagonals bisect each other.

If $PQRS$ is a parallelogram, then $\overline{QM} \cong \overline{SM}$ and $\overline{PM} \cong \overline{RM}$.

Proof p. 370



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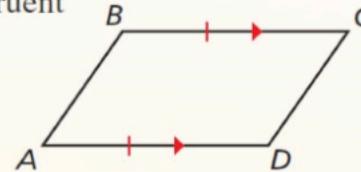
Theorems

Theorem 7.9 Opposite Sides Parallel and Congruent Theorem

If one pair of opposite sides of a quadrilateral are congruent and parallel, then the quadrilateral is a parallelogram.

If $\overline{BC} \parallel \overline{AD}$ and $\overline{BC} \cong \overline{AD}$, then $ABCD$ is a parallelogram.

Proof Ex. 40, p. 383

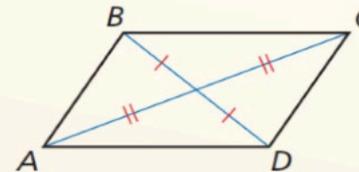


Theorem 7.10 Parallelogram Diagonals Converse

If the diagonals of a quadrilateral bisect each other, then the quadrilateral is a parallelogram.

If \overline{BD} and \overline{AC} bisect each other, then $ABCD$ is a parallelogram.

Proof Ex. 41, p. 383



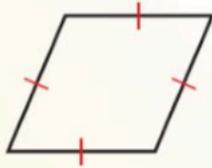
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Core Concept

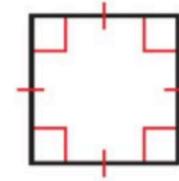
Rhombuses, Rectangles, and Squares



A **rhombus** is a parallelogram with four congruent sides.



A **rectangle** is a parallelogram with four right angles.



A **square** is a parallelogram with four congruent sides and four right angles.



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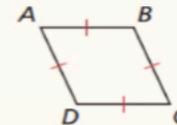
Corollaries

Corollary 7.2 Rhombus Corollary

A quadrilateral is a rhombus if and only if it has four congruent sides.

$ABCD$ is a rhombus if and only if $\overline{AB} \cong \overline{BC} \cong \overline{CD} \cong \overline{AD}$.

Proof Ex. 81, p. 396



Corollary 7.3 Rectangle Corollary

A quadrilateral is a rectangle if and only if it has four right angles.

$ABCD$ is a rectangle if and only if $\angle A$, $\angle B$, $\angle C$, and $\angle D$ are right angles.



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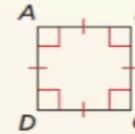
Proof Ex. 82, p. 396

Corollary 7.4 Square Corollary

A quadrilateral is a square if and only if it is a rhombus and a rectangle.

$ABCD$ is a square if and only if
 $\overline{AB} \cong \overline{BC} \cong \overline{CD} \cong \overline{AD}$ and $\angle A$, $\angle B$, $\angle C$,
and $\angle D$ are right angles.

Proof Ex. 83, p. 396



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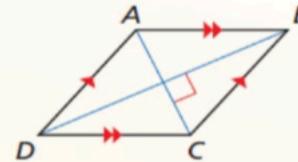
Theorems

Theorem 7.11 Rhombus Diagonals Theorem

A parallelogram is a rhombus if and only if its diagonals are perpendicular.

$\square ABCD$ is a rhombus if and only if $\overline{AC} \perp \overline{BD}$.

Proof p. 390; Ex. 72, p. 395

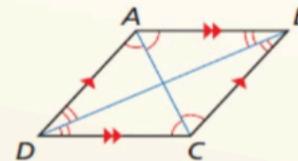


Theorem 7.12 Rhombus Opposite Angles Theorem

A parallelogram is a rhombus if and only if each diagonal bisects a pair of opposite angles.

$\square ABCD$ is a rhombus if and only if \overline{AC} bisects $\angle BCD$ and $\angle BAD$, and \overline{BD} bisects $\angle ABC$ and $\angle ADC$.

Proof Exs. 73 and 74, p. 395



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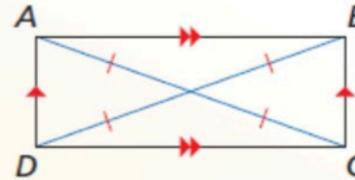
Theorem

Theorem 7.13 Rectangle Diagonals Theorem

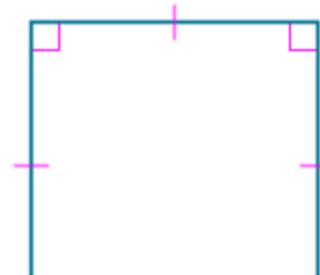
A parallelogram is a rectangle if and only if its diagonals are congruent.

$\square ABCD$ is a rectangle if and only if $\overline{AC} \cong \overline{BD}$.

Proof Exs. 87 and 88, p. 396



A **square** is a parallelogram with all four sides and all four angles congruent. All of the properties of parallelograms, rectangles, and rhombi apply to squares. For example, the diagonals of a square bisect each other



(parallelogram), are congruent (rectangle), and are perpendicular (rhombus).



Close



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Theorems: Conditions for Rhombi and Squares

Theorem 7.17

If the diagonals of a parallelogram are perpendicular, then the parallelogram is a

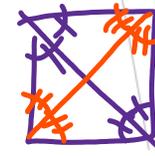
rhombus, square



Theorem 7.18

If one diagonal of a parallelogram bisects a pair of opposite angles, then the parallelogram is a

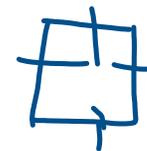
square, rhombus



Theorem 7.19

If two consecutive sides of a parallelogram are congruent, then the parallelogram is a

square, rhombus



Theorem 7.20

If a quadrilateral is both a rectangle and a rhombus, then it is a

square



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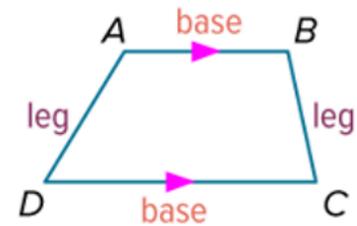


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A **trapezoid** is a quadrilateral with at least one pair of parallel sides. In a trapezoid that is not a parallelogram, the parallel sides are called the **bases** and the nonparallel sides are called **legs**.

A **base angle** is formed by a base and a leg. In trapezoid $ABCD$, $\angle A$ and $\angle B$ are one pair of base angles, and $\angle C$ and $\angle D$ are the other pair. If the legs are congruent, then a trapezoid is an **isosceles trapezoid**.

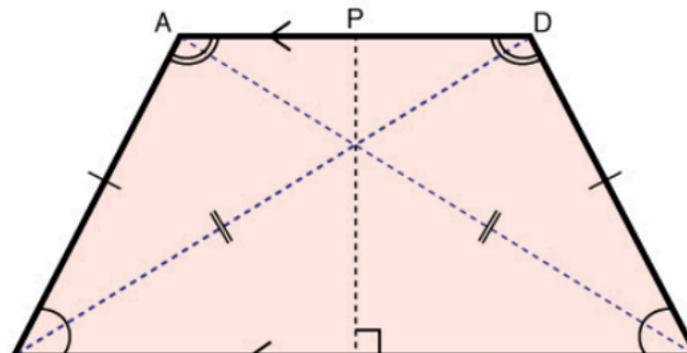


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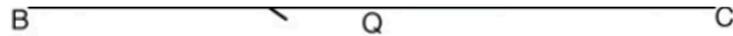


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Properties of an Isosceles Trapezoid



MATH
MONK!

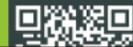


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- ① Has one pair of parallel and unequal opposite sides (bases)
- ② Has one pair of congruent non-parallel sides (legs)
- ③ Lower base angles & upper base angles are congruent
- ④ Diagonals are congruent
- ⑤ Any lower base angle is supplementary to any upper base angle
- ⑥ Has one line of symmetry connecting the bases at their midpoints



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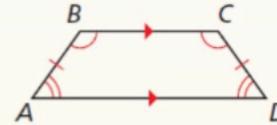
Theorems

Theorem 7.14 Isosceles Trapezoid Base Angles Theorem

If a trapezoid is isosceles, then each pair of base angles is congruent.

If trapezoid $ABCD$ is isosceles, then $\angle A \cong \angle D$
and $\angle B \cong \angle C$.

Proof Ex. 39, p. 405

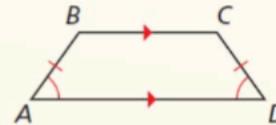


Theorem 7.15 Isosceles Trapezoid Base Angles Converse

If a trapezoid has a pair of congruent base angles, then it is an isosceles trapezoid.

If $\angle A \cong \angle D$ (or if $\angle B \cong \angle C$), then trapezoid
 $ABCD$ is isosceles.

Proof Ex. 40, p. 405

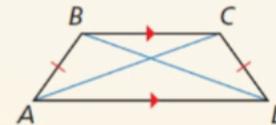


Theorem 7.16 Isosceles Trapezoid Diagonals Theorem

A trapezoid is isosceles if and only if its diagonals are congruent.

Trapezoid $ABCD$ is isosceles if and only
if $\overline{AC} \cong \overline{BD}$.

Proof Ex. 51, p. 406



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Theorem

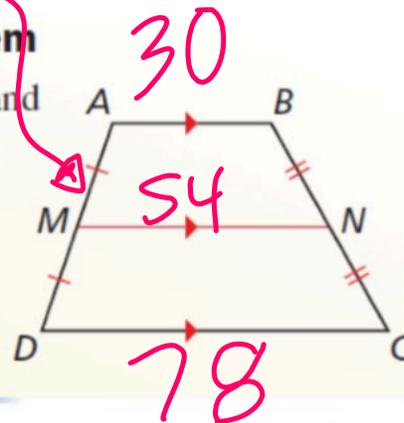
$$\frac{30+78}{2} = \frac{108}{2} = 54$$

Theorem 7.17 Trapezoid Midsegment Theorem

The midsegment of a trapezoid is parallel to each base, and its length is one-half the sum of the lengths of the bases.

If \overline{MN} is the midsegment of trapezoid $ABCD$, then $\overline{MN} \parallel \overline{AB}$, $\overline{MN} \parallel \overline{DC}$, and $MN = \frac{1}{2}(AB + CD)$.

Proof Ex. 49, p. 406



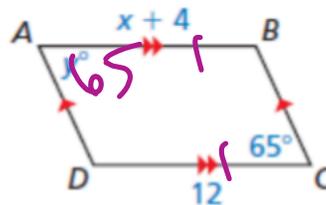
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*Find all angles and side measures for all problems on this page!

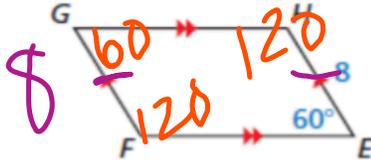
Find the values of x and y .



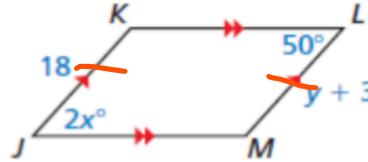
$$\begin{array}{r} x+4=12 \\ -4 \quad -4 \\ \hline x=8 \end{array}$$

$$14 = 2 + 3$$

1. Find FG and $m \angle G$.



2. Find the values of x and y .



$$\frac{2x}{2} = \frac{50}{2}$$

$$x = 25$$

$$\frac{10}{15} = \frac{y}{y}$$

Close

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Example 2 Use Properties of Rectangles and Algebra

$$6x + 2 = 2x + 9$$

$$MK = 6x + 2$$

$$x = 1.75$$

Check

$$\frac{6x}{-2x} = \frac{2x + 7}{-2x}$$

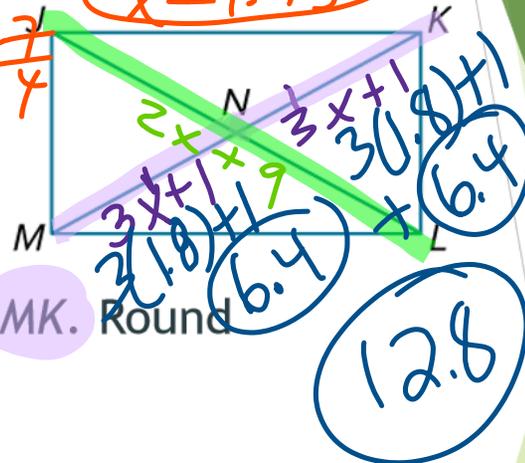
$$\frac{4x}{4} = \frac{7}{4}$$

Quadrilateral JKLM is a rectangle.

Part A

$$JL = 2x + 9$$

If $MN = 3x + 1$ and $JL = 2x + 9$, find MK . Round to the nearest tenth if necessary.



$$1.75$$

$$1.8$$

$$12.8$$



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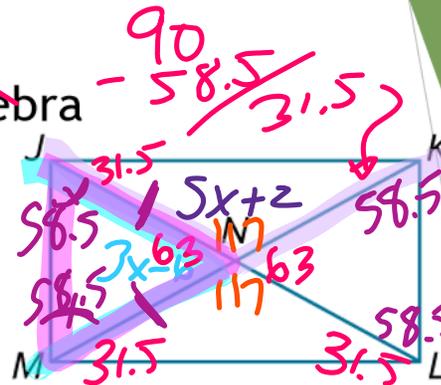
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Example 2

Use Properties of Rectangles and Algebra

Check

Quadrilateral JKLM is a rectangle.



linear pair
180
Supplementary

$$\frac{8x - 4}{4} = \frac{180}{4}$$

Part B

If $m\angle JNK = (5x + 2)^\circ$ and $m\angle JNM = (3x - 6)^\circ$, = 180

find $m\angle JNK$ and $m\angle JNM$. Part C: Find all angle degrees!

5(23)+2 = 117
3(23)-6 = 63
 $\frac{8x}{8} = \frac{184}{8}$
 $x = 23$

$$\begin{array}{r} 180 \\ - 63 \\ \hline 117 \\ \hline 58.5 \end{array}$$



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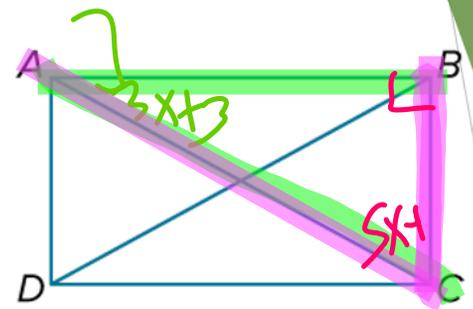
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Example 2

Quadrilateral ABCD is a rectangle.

If $m\angle BAC = (3x + 3)^\circ$ and
 $m\angle ACB = (5x - 1)^\circ$, find the value of x.



$3x + 3 + 5x - 1 = 180$

Close

$$\begin{aligned} 90 + 5x - 1 + 5x + 5 &= 180 \\ 92 + 8x &= 180 \\ -92 & \quad -92 \\ \hline 8x &= 88 = 11 \end{aligned}$$



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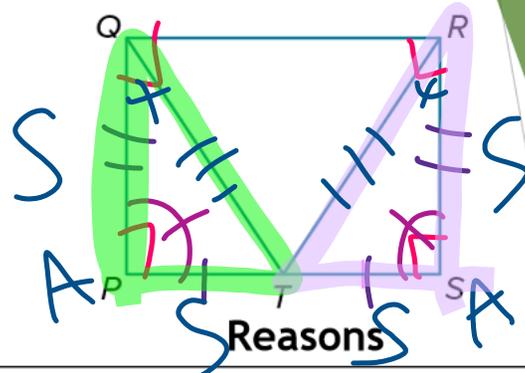
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Example 3

Prove Rectangular Relationships

Given: PQRS is a rectangle; $\overline{PT} \cong \overline{ST}$.

Prove: $\overline{QT} \cong \overline{RT}$



Statements

Reasons

1. PQRS is a rectangle; $\overline{PT} \cong \overline{ST}$
2. PQRS is a parallelogram
3. $\overline{PQ} \cong \overline{SR}$
4. 4 Right Angles 90°
5. $\angle S \cong \angle P$
6. $\triangle PQT \cong \triangle SRT$
7. $\overline{QT} \cong \overline{RT}$

1. Given
2. Definition of rectangle
3. Opp. sides of a \square are \cong .
4. Definition of rectangle
5. All right angles are congruent.
6. SAS
7. CPCTC



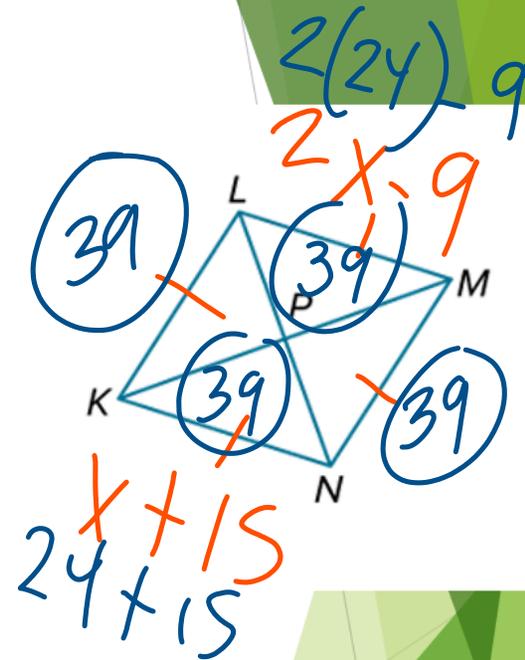
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If $LM = 2x - 9$ and $KN = x + 15$ in rhombus $KLMN$, find the value of x .

Find all side lengths!

$$\begin{array}{r}
 2x - 9 = x + 15 \\
 +9 \quad +9 \\
 \hline
 2x = x + 24 \\
 -x \quad -x \\
 \hline
 x = 24
 \end{array}$$

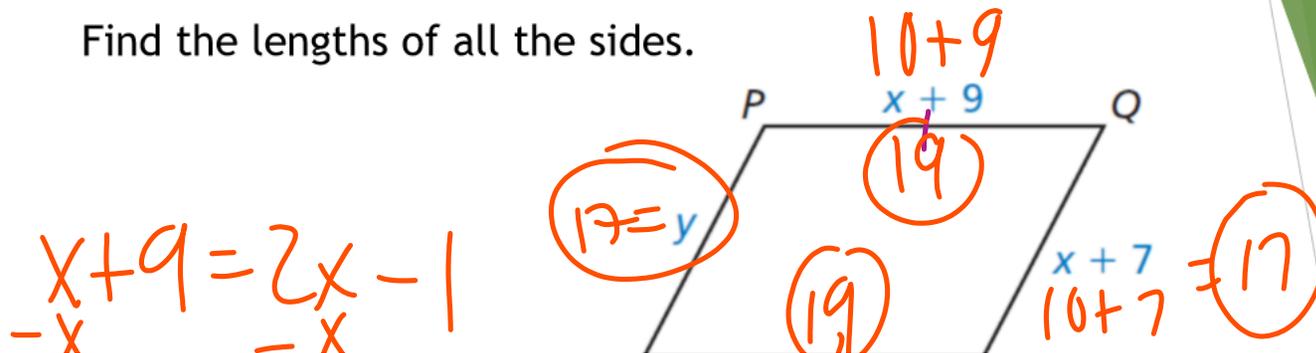


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For what values of x and y is quadrilateral $PQRS$ a parallelogram?

Find the lengths of all the sides.



Close

$$\begin{array}{r}
 \wedge \qquad \wedge \\
 9 = x - 1 \\
 + 1 \qquad + 1 \\
 \hline
 10 = x
 \end{array}$$

$$\begin{array}{c}
 S \text{-----} 2x - 1 \text{-----} R \\
 2(10) - 1
 \end{array}$$



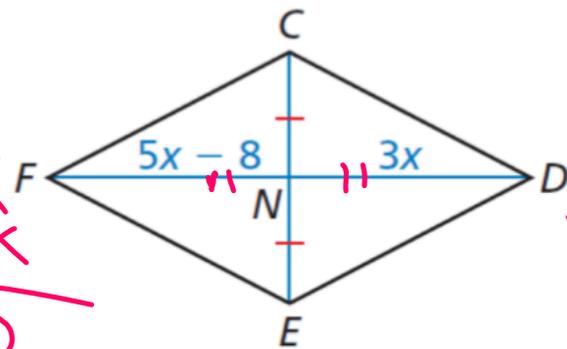
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For what value of x is quadrilateral $CDEF$ a parallelogram?

$$\begin{array}{r}
 5x - 8 = 3x \\
 - 3x \quad - 3x \\
 \hline
 2x - 8 = 0 \\
 + 8 \quad + 8 \\
 \hline
 2x = 8 \\
 \hline
 x = 4
 \end{array}$$



$$\begin{array}{r}
 5x - 8 = 3x + 8 \\
 + 8 \\
 \hline
 5x = 3x + 8
 \end{array}$$

$$\begin{array}{r}
 5x - 8 = 3x \\
 - 5x \quad - 5x \\
 \hline
 - 8 = - 2x \\
 \hline
 - 2 \quad - 2 \\
 \hline
 4
 \end{array}$$



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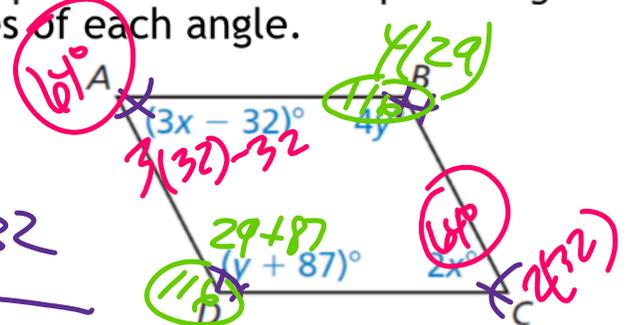
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Close

For what values of x and y is quadrilateral $ABCD$ a parallelogram? Determine the measures of each angle.

$$\begin{array}{r}
 3x - 32 = 2x + 32 \\
 + 32 \quad + 32 \\
 \hline
 3x = 2x + 32 \\
 - 2x \quad - 2x \\
 \hline
 x = 32
 \end{array}$$



$$\begin{array}{r}
 4y = 1y + 87 \\
 - 1y \quad - 1y \\
 \hline
 3y = 87 \\
 \frac{3y}{3} = \frac{87}{3} = 29
 \end{array}$$



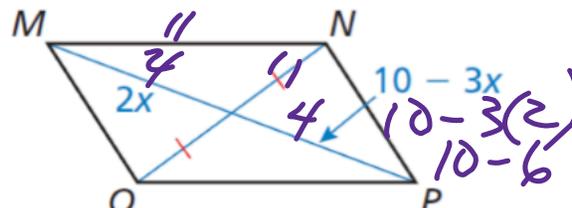
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For what value of x is quadrilateral $MNPQ$ a parallelogram?

$$\begin{array}{r}
 2x = 10 - 3x \\
 + 3x \quad + 3x \\
 \hline
 5x = 10 \\
 \frac{5x}{5} = \frac{10}{5} = 2
 \end{array}$$



Close

$$\frac{5x}{5} = \frac{10}{5}$$
$$x = 2$$



Students, draw anywhere on this slide!

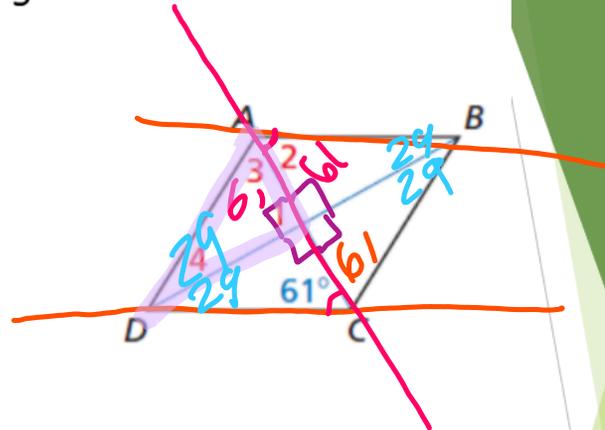
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Find the measures of the numbered angles in rhombus $ABCD$.

$$\begin{array}{r} 61 \\ + 90 \\ \hline 151 \end{array}$$

$$180 - 151 = 29$$

$$\begin{aligned} \angle 1 &= 90^\circ \\ \angle 2 &= 61^\circ \\ \angle 3 &= 61^\circ \\ \angle 4 &= 29^\circ \end{aligned}$$

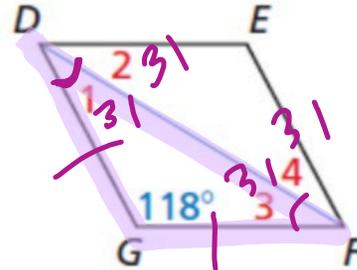


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Close

Find the measures of the numbered angles in rhombus $DEFG$.



$$\begin{array}{r} 180 \\ - 118 \\ \hline 62 \\ \underline{2} \\ 2 \end{array} = 31$$

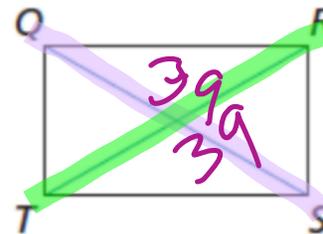


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In rectangle $QRST$, $QS = 5x - 31$ and $RT = 2x + 11$.
Find the lengths of the diagonals of $QRST$.

$$\begin{array}{r} 5x - 31 = 2x + 11 \\ - 2x \quad - 2x \end{array}$$



Close

$$\begin{array}{r} 3x - 31 = 11 \\ + 31 \quad + 31 \\ \hline 3x = 42 \\ \frac{3x}{3} = \frac{42}{3} \end{array} \quad x = 14$$

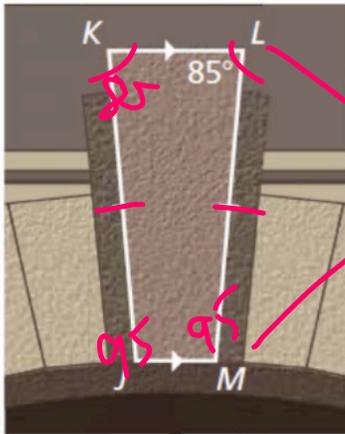


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The stone above the arch in the diagram is an isosceles trapezoid. Find $m \angle K$, $m \angle M$, and $m \angle J$.



$$\begin{array}{r} 180 \\ - 85 \\ \hline 95 \end{array}$$



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Close

MUSIC The body of the guitar shown is a trapezoidal prism. The front face of the guitar is an isosceles trapezoid.

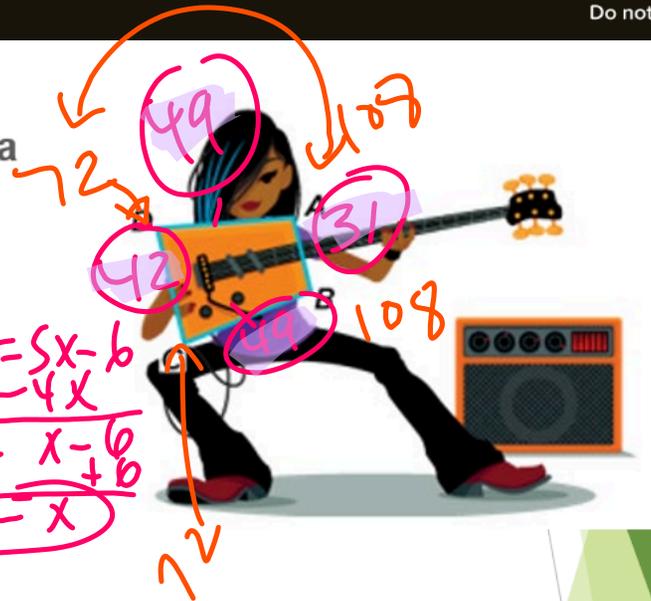
$AB = 3x - 2$, $CD = 3x + 9$,
 $AD = 4x + 5$, and $BC = 5x - 6$.

Part A Prove $x = 11$.

Part B Find $m\angle A$ if $m\angle C = 72^\circ$.

Part C Find the perimeter of the front face of the guitar in centimeters.

$42 + 31 + 49 + 49 =$
 171



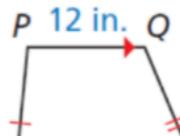
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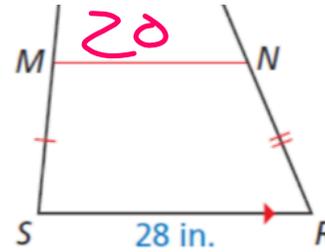
In the diagram, \overline{MN} is the midsegment of trapezoid $PQRS$.
Find MN .

$12 + 28 = 40 =$



Close

2 2

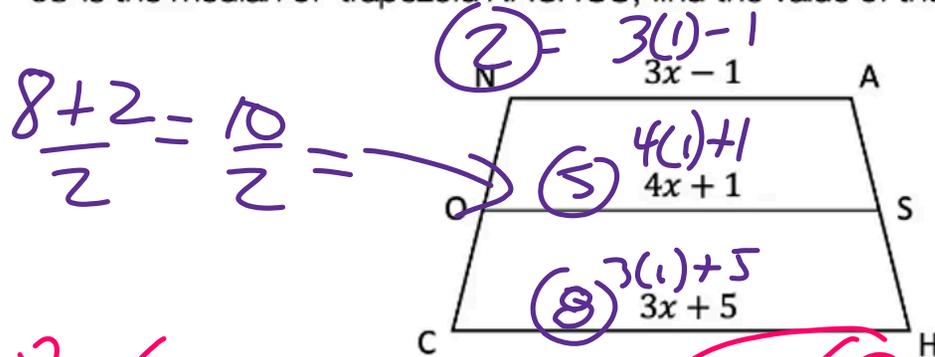


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\overline{OS} is the median of trapezoid NACHOS, find the value of the median, given the following:



$$\frac{8+2}{2} = \frac{10}{2} = 5$$

~~$$\frac{6x+4}{2} = 4x+1$$~~

$$\begin{array}{r} 6x+4 = 8x+2 \\ -6x \quad -6x \\ \hline 4 = 2x+2 \end{array}$$

$$\begin{array}{r} 4 = 2x+2 \\ -2 \quad -2 \\ \hline 2 = 2x \end{array}$$

$$\frac{2}{2} = \frac{2x}{2}$$

$$1 = x$$



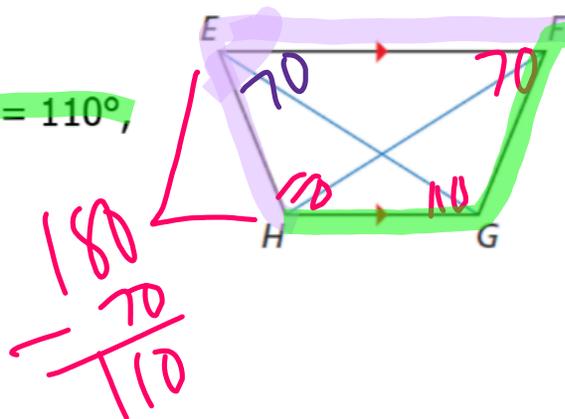
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If $EG = FH$, is trapezoid $EFGH$ isosceles?

If $m \angle HEF = 70^\circ$ and $m \angle FGH = 110^\circ$,
is trapezoid $EFGH$ isosceles?



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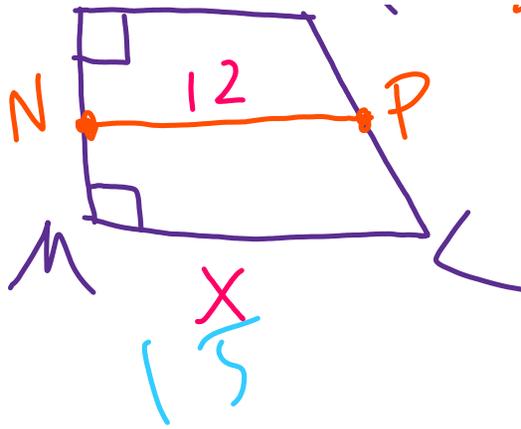
In trapezoid $JKLM$, $\angle J$ and $\angle M$ are right angles, and $JK = 9$

centimeters. The length of midsegment \overline{NP} of trapezoid $JKLM$ is 12 centimeters. Sketch trapezoid $JKLM$ and its midsegment. Find ML .

ML .

J 9 K ~~$2(x + 9 - 12) = 2$~~

Close



$$\begin{array}{r} x + 9 = 24 \\ - 9 \quad - 9 \\ \hline \end{array}$$

$$x = 15$$



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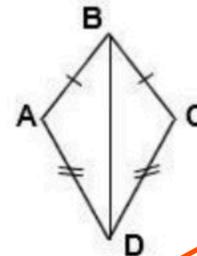
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If a quadrilateral is a kite, it has one diagonal forming two congruent triangles.

Given: kite ABCD

Prove: $\triangle BAD \cong \triangle BCD$

Proof:



Statements	Reasons
1. kite ABCD	1. _____
2. $\overline{AD} \cong \underline{\hspace{1cm}}$; $\overline{AB} \cong \underline{\hspace{1cm}}$	2. A kite has two distinct sets of adjacent, congruent sides.
3. _____	3. Reflexive property.
4. $\triangle BAD \cong \triangle BCD$	4. _____



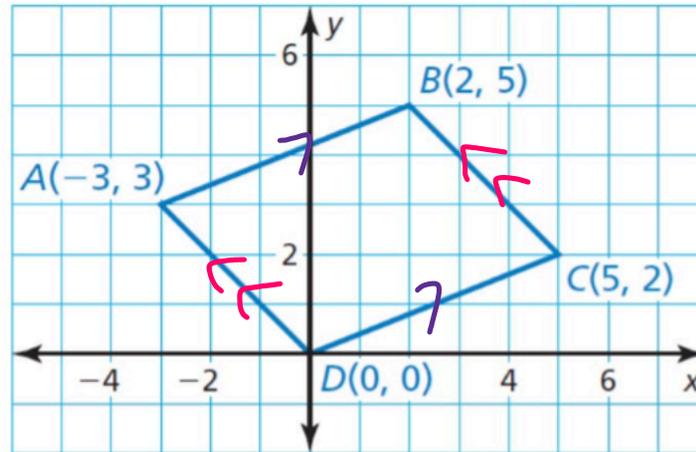


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Show that quadrilateral $ABCD$ is a parallelogram.

$AB \cong DC$
Slope
 $\frac{2}{5}$ $\frac{2}{5}$
Same Slopes
parallel



$AD \cong BC$
Slope
 $-\frac{3}{3}$
 $-\frac{1}{1}$



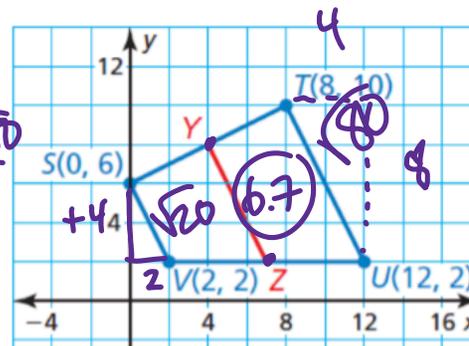
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Find the length of midsegment \overline{YZ} in trapezoid $STUV$.

$$\frac{\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}}{2}$$
$$\frac{\sqrt{(12 - 8)^2 + (2 - 10)^2}}{2}$$

$$\frac{\sqrt{24 + 80}}{2}$$



Close

$$4^2 + (-8)^2$$

$$16 + 64$$

$$\sqrt{80}$$



$$\sqrt{(2-0)^2 + (2-6)^2}$$

$$2^2 + (-4)^2$$

$$4 + 16$$

$$\sqrt{20}$$

$$8^2 + 4^2$$

$$64 + 16$$

$$\sqrt{80}$$



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The points $A(-5, 6)$, $B(4, 9)$, $C(4, 4)$, and $D(-2, 2)$ form the vertices of a quadrilateral. Show that $ABCD$ is a trapezoid. Then decide whether it is isosceles yes

Slope AB

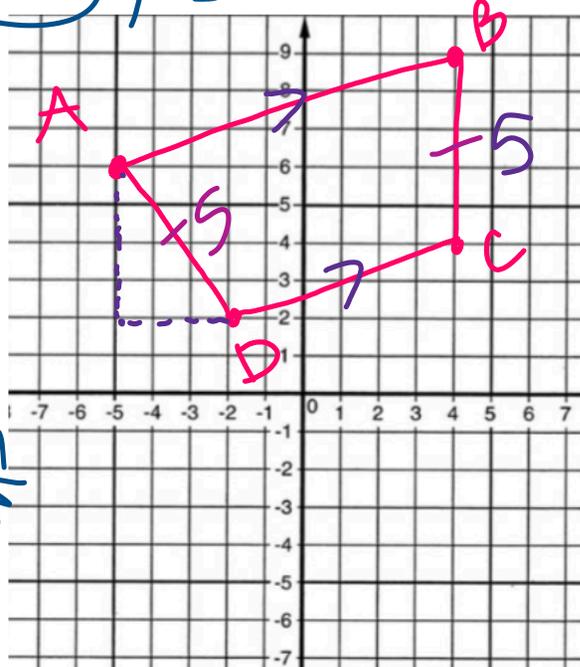
Rise

Run

$$\frac{9-6}{4-(-5)}$$

DC

$$\frac{4-2}{4-(-2)}$$



$$\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

$$\sqrt{(-2 - 4)^2 + (2 - 4)^2}$$

$$3^2 + (-2)^2$$

$$9 + 4$$

$$\sqrt{13}$$



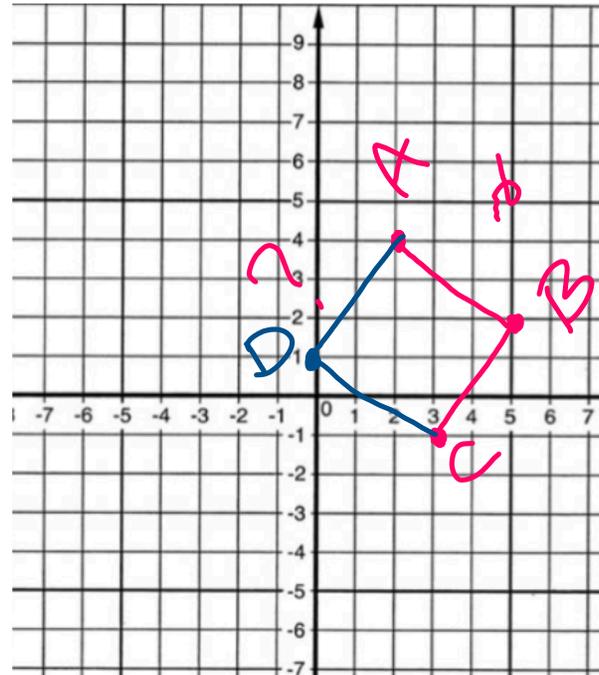


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Three vertices of $\square ABCD$ are $A(2, 4)$, $B(5, 2)$, and $C(3, -1)$. Find the coordinates of vertex D .

$(0, 1)$



Slope $-\frac{2}{3}$

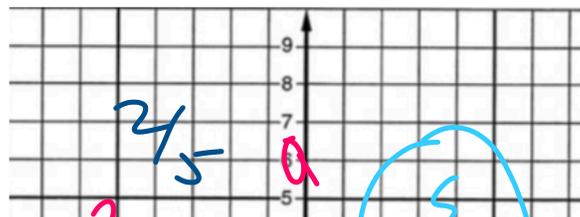


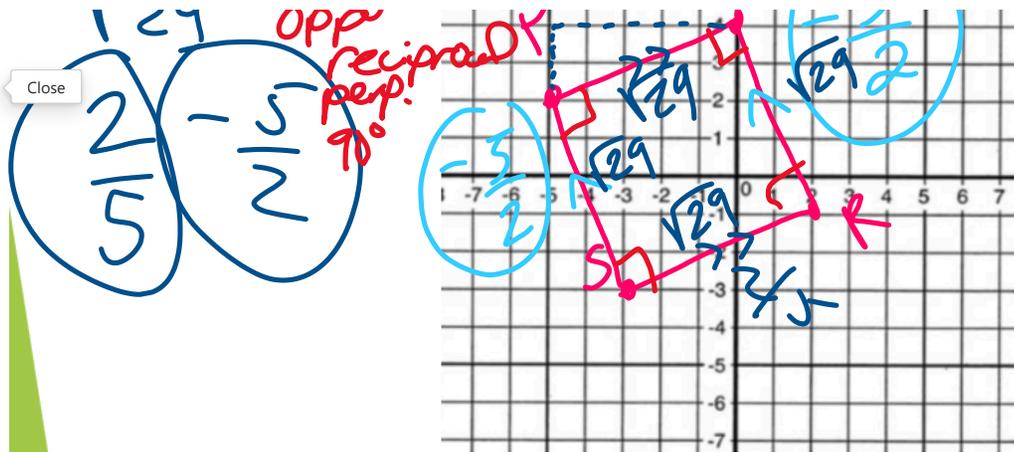
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Decide whether $\square PQRS$ with vertices $P(-5, 2)$, $Q(0, 4)$, $R(2, -1)$, and $S(-3, -3)$ is a rectangle, a rhombus, or a square. Give all names that apply.

$$\begin{array}{l} 2^2 + 5^2 \\ 4 + 25 \\ \hline 29 \end{array} \text{ req.}$$



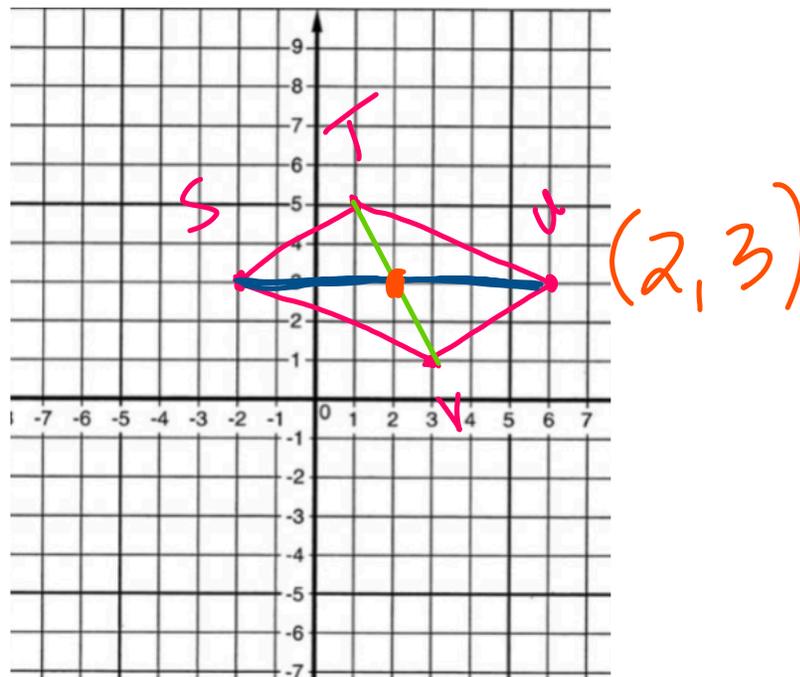


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Find the coordinates of the intersection of the diagonals of $\square STUV$ with vertices $S(-2, 3)$, $T(1, 5)$, $U(6, 3)$, and $V(3, 1)$.



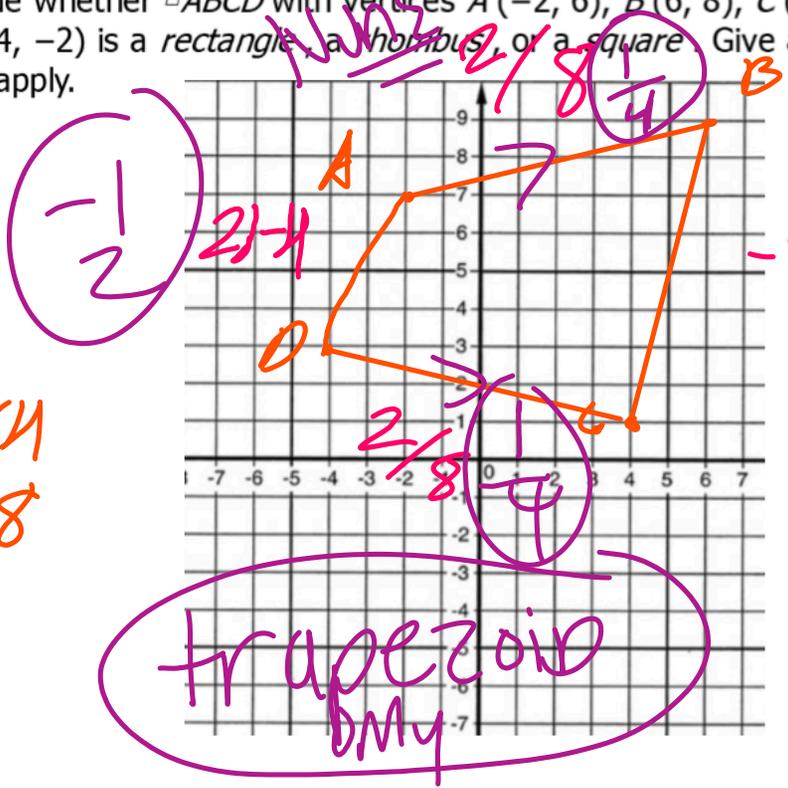


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Decide whether $\square ABCD$ with vertices $A(-2, 6)$, $B(6, 8)$, $C(4, 0)$, and $D(-4, -2)$ is a *rectangle*, a *rhombus*, or a *square*. Give all names that apply.

Rise
Run
AB = $\frac{2}{8}$
DC = $\frac{2}{8}$
AD = $\frac{2}{-4}$
BC = $\frac{2}{-4}$



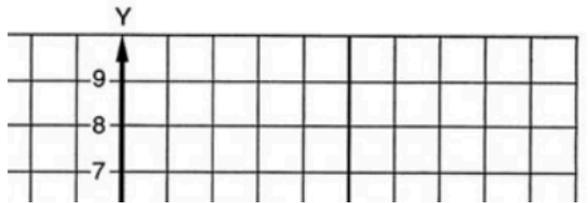
$\frac{2}{8} = \frac{1}{4}$
 $\frac{2}{-4} = -\frac{1}{2}$
 $-\frac{8}{2} = -4$



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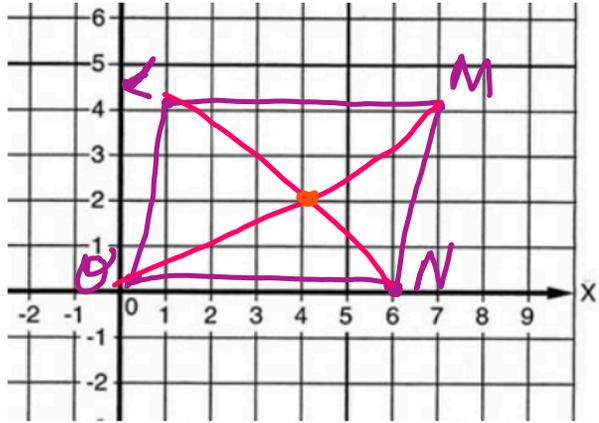
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Find the coordinates of the intersection of the diagonals of $\square LMNO$ with vertices $L(1, 4)$, $M(7, 4)$, $N(6, 0)$, and $O(0, 0)$.



Carlin was here

Close



(4, 2)



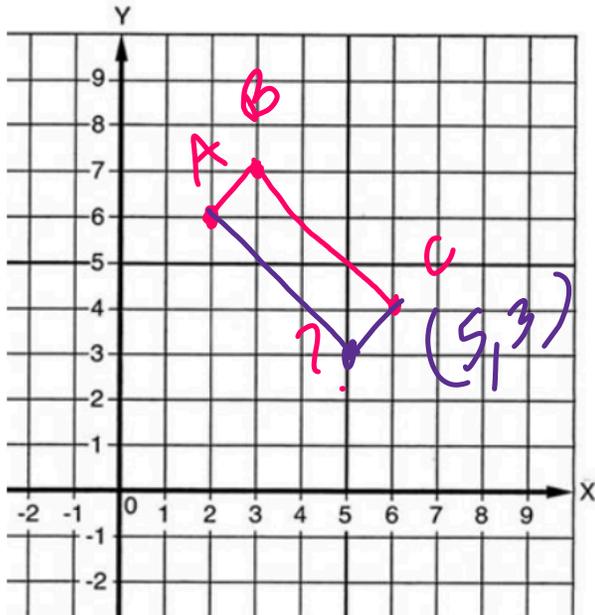
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Check

A quadrilateral has vertices $A(2, 6)$, $B(3, 7)$, and $C(6, 4)$. Which of the following points would make $ABCD$ a rectangle?



rise slope
run
AB
1
1

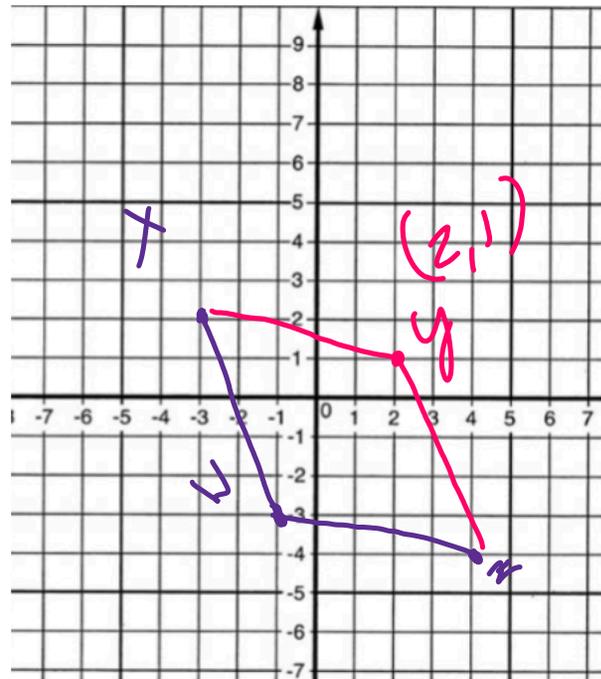


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Three vertices of $\square WXYZ$ are $W(-1, -3)$, $X(-3, 2)$, and $Z(4, -4)$. Find the coordinates of vertex Y .

slope
wz
 $-\frac{1}{5}$



XW
 $-\frac{5}{2}$



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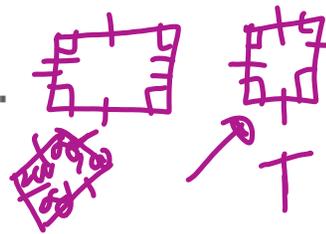
Which statements are *true*, and which are *false*?

1. All parallelograms are quadrilaterals. T

2. No rhombus is a parallelogram. F

Close

- 3. All squares are rhombi. **F**
- 4. Some rectangles are squares.
- 5. Some rhombi are rectangles.



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Answer *true or false*.

- 1. All rectangles are parallelograms. **T**
- 2. All squares are rectangles. **T**
- 3. All rhombi are squares. **F**
- 4. All squares are parallelograms. **T**
- 5. All rhombi are parallelograms. **T**



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