Chapter 9
Transformations
Geometry PAP

Name _________________________________
Period _____________
Teacher ____________

NOT SURE IF MATH PROBLEM IS EASY
OR I'M DOING IT ENTIRELY WRONG

Draw approximations of the following:
(a) A 30° angle
(b) A 90° angle
(c) A 180° angle

I LIKE THE EXTRA TOUCHES.
EXTRA TOUCHES?
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8-1 Translations and Vectors*

Use the translation \((x, y) \rightarrow (x - 5, y + 8)\).

1) What is the image of \(B(4,2)\)?

2) What is the image of \(D(-1,5)\)?

3) What is the preimage of \(F'(-3,-4)\)?

4) What is the preimage of \(H'(7,-5)\)?

5) What is the image of \(J(0,2)\)?

6) What is the preimage of \(K'(-4,6)\)?

Write a rule for the translation.

7) 1 units to the left and 1 unit up

8) 3 units down

9) 7 units to the left and 4 units down

10) 10 units right and 8 units up

\(\Delta A'B'C'\) is the image of \(\Delta ABC\) after translation. Write a rule for the translation. Then verify that the translation is an isometry. (Find the length of each segment)

11) [Diagram of \(\Delta ABC\) and \(\Delta A'B'C'\)]

12) [Diagram of \(\Delta ABC\) and \(\Delta A'B'C'\)]

Name the vector and write its component form.

13) [Diagram showing vector \(\overrightarrow{TM}\)]

14) [Diagram showing vector \(\overrightarrow{JD}\)]

15) [Diagram showing vector \(\overrightarrow{RS}\)]
Draw the following vectors:

16) $\overrightarrow{DV} (2, -5)$

17) $\overrightarrow{HY} (0, 3)$

18) $\overrightarrow{PU} (-4, -3)$

$\triangle ABC$ with vertices $A(-2, 4), B(6, 2), C(3, -2)$ is translated to $\triangle A'B'C'$. Determine the translation using vector in component form, and determine the coordinates of the remaining vertices.

19) $A'(-5, 5)$

20) $B'(2, -5)$

21) $C'(-4, -5)$

22) $B'(8, 6)$

In Exercises 23-25, use the following information.

**Skiing** A skier travels from point $A$ to point $D$. At point $B$ and $C$, the skier changes direction, as shown in the diagram. The distance in the diagram are in kilometers.

23. Write the component form of $\overrightarrow{AB}$, $\overrightarrow{BC}$, and $\overrightarrow{CD}$.

24. What is the total distance the skier travels?

25. Suppose the skier went straight from $A$ to $D$. Write the component form of the vector that describes this path. What is the distance?
8-2 Reflections

Graph the reflection of the polygon in the given line.

1) $x$-axis

\[
\begin{align*}
A(-3, 3) & \quad B(1, 5) & \quad C(4, 4) \\
B(1, 5) & \quad D(0, 2) & \quad C(4, 4) \\
\end{align*}
\]

2) $y$-axis

\[
\begin{align*}
M(-1, 4) & \quad N(2, 6) \\
N(2, 6) & \quad O(5, 5) \\
\end{align*}
\]

3) $x = -2$

\[
\begin{align*}
B(-5, 3) & \quad C(-3, 5) \\
C(-3, 5) & \quad D(-1, 4) \\
\end{align*}
\]

4) $y = -x$

\[
\begin{align*}
F(-6, 3) & \quad E(-3, 3) \\
E(-3, 3) & \quad G(-6, 1) \\
\end{align*}
\]

Find the coordinates of the image without using a coordinate plane. Then check your answer by plotting the image and preimage on a coordinate plane.

5) $M(3, 4)$ reflected in the line $y = 1$.

6) $N(-2, 2)$ reflected in the line $y = -1$.

7) $P(-2, 3)$ reflected in the line $x = -3$.

8) $Q(5, -2)$ reflected in the line $x = 3$.

Use the diagram to name the image of Segment 1 after the reflection.

9) Reflection in the $x$-axis
10) Reflection in the $y$-axis
11) Reflection in the line $y = x$
12) Reflection in the line $y = -x$
13) Reflection in the $y$-axis, followed by a reflection in the $x$-axis
14) Reflection in the $x$-axis, followed by a reflection in the $y$-axis
*Find the coordinates of each image.

15. $R_x$-axis (A)
16. $R_y$-axis (B)
17. $R_y = 1$ (C)
18. $R_x = -1$ (D)
19. $R_y = -1$ (E)
20. $R_x = 2$ (F)

*Coordinate Geometry Given points $M(3, 3)$, $N(5, 2)$, and $O(4, 4)$, graph $\Delta MNO$ and its reflection image as indicated.

21. $R_y$-axis
22. $R_x$-axis

23. $R_x = 1$
24. $R_y = -2$

The vertices of $\Delta ABC$ are $A(-4, 4), B(0, 7)$, and $C(-1, 3)$. Reflect $\Delta ABC$ in the first line. Then reflect $\Delta A'B'C'$ in the second line. Graph $\Delta A'B'C'$ and $\Delta A''B''C''$.

25) In $y = 4$, then in $x = -1$
26) In $x = -3$, then in $y = 5$
8-3 Rotations

Math the diagram with the angle of rotation. A. $60^\circ$ B. $130^\circ$ C. $95^\circ$

1) \hspace{2cm} 2) \hspace{2cm} 3)

Rotate the figure the given number of degrees about the origin. List the coordinates of the vertices of the image.

4) $90^\circ$

5) $180^\circ$

6) $270^\circ$

Point O is the center of regular hexagon BCDEFG. Find the image of the given point or segment for the given rotation.

7. $r_{120^\circ, O}(F)$
8. $r_{180^\circ, O}(B)$
9. $r_{300^\circ, O}(BG)$
10. $r_{360^\circ, O}(CD)$
11. $r_{60^\circ, O}(E)$
12. $r_{240^\circ, O}(FE)$
For Exercises 13–15, \( \triangle ABC \) has vertices \( A(2, 2) \), \( B(3, -2) \), and \( C(-1, 3) \).

13. Graph \( r_{90^\circ, O}(\triangle ABC) \).

14. Graph \( r_{180^\circ, O}(\triangle ABC) \).

15. Graph \( r_{270^\circ, O}(\triangle ABC) \).

17. The vertices of \( PQRS \) have coordinates \( P(-1, 5) \), \( Q(3, 4) \), \( R(2, -4) \), and \( S(-3, -2) \). What are the coordinates of the vertices of \( r_{270^\circ, O}(PQRS) \)?

18. The vertices of \( r_{90^\circ, O}(KLNM) \) have coordinates \( K'(-3, 2) \), \( L'(2, 3) \), \( M'(4, -2) \), and \( N'(-2, -4) \). What are the coordinates of the vertices of \( KLNM \)?

For Exercises 19–21, \( ABCD \) has vertices \( A(1, 1) \), \( B(1, 3) \), \( C(4, 3) \), and \( D(4, 1) \).

19. Graph \( r_{90^\circ, O}(ABCD) \).

To start, graph \( ABCD \).

\[
\begin{align*}
A' &= r_{90^\circ, O}(A) = (-1, \square) \\
B' &= r_{90^\circ, O}(B) = (-3, \square) \\
C' &= r_{90^\circ, O}(C) = (\square, 4) \\
D' &= r_{90^\circ, O}(D) = (\square, 4)
\end{align*}
\]

Then graph \( A', B', C', \) and \( D' \).
For Exercises 19–21, ABCD has vertices \( A(1, 1), B(1, 3), C(4, 3), \) and \( D(4, 1) \).

20. Graph \( r_{(180^\circ, O)}(ABCD) \).

21. Graph \( r_{(270^\circ, O)}(ABCD) \).

22. The vertices of \( \triangle PQR \) have coordinates \( P(1, 5), Q(3, 1), \) and \( R(-2, 1) \). What are the coordinates of the vertices of \( r_{(90^\circ, O)}(\triangle PQR) \)?

Find the value of each variable in the rotation.

23)

24)

25)
8-3 Worksheet Rotations of figure through a point that is not the origin*

**Directions:** Rotate each figure about point C, by the indicated degree measures. Make sure to list the first transformations as prime and second transformation as double prime.

1. Figure $B(2,-1), A(5,-3), D(1,-4)$ rotated $90^\circ$ and $270^\circ$
   counter clockwise around the point $C(1,1)$.

2. Figure $S(1,4), Q(3,2), U(6,5), A(4,7)$ rotated $180^\circ$ and $270^\circ$
   counter clockwise around the point $C(0,1)$. 

*Worksheet Rotations of figure through a point that is not the origin*
3. Figure $D(2,6), E(5,6), F(5,2)$ rotated $90^\circ$ and $270^\circ$ counter clockwise around the point $C(3,1)$.

4. Figure $T(-3,-1), R(-1,-1), A(1,-4), P(-5,-4)$ rotated $90^\circ$ and $180^\circ$ counter clockwise around the point $C(-2,1)$.
Worksheet 8-4 Symmetry

Tell what type(s) of symmetry each figure has. If it has line symmetry, sketch the line(s) of symmetry. If it has rotational symmetry, tell the angle of rotation.

1. [Diagram]
2. [Diagram with angles 58° and 58°]
3. [Diagram]
4. [Diagram]
5. [Diagram]
6. [Diagram]

Determine how many lines of symmetry each polygon has. Include a sketch to support your answer.

9. regular quadrilateral
10. regular pentagon
11. regular hexagon
12. regular octagon

13. Make a Conjecture What is the relationship between the number of sides of a regular polygon and the number of lines of symmetry?

14. How many lines of symmetry are found in a regular polygon with 40 sides?

Tell whether each three-dimensional object has reflectional symmetry in a plane, rotational symmetry about a line, or both.

15. a light bulb
16. a pair of pants
17. a rectangular table
18. a round table
19. a sand dollar
20. butterfly
Worksheet 8-5 Composite Transformations

The vertices of \( \triangle ABC \) are \( A(3, -1), B(7,1), \) and \( C(5,-4) \). Graph the image of \( \triangle ABC \) after a composition of the transformations in the order they are listed.

1) **Translation**: \((x, y) \rightarrow (x - 4, y + 1)\)  
   **Reflection**: in the line \( x = 1 \)

2) **Translation**: \((x, y) \rightarrow (x - 2, y + 3)\)  
   **Rotation**: 90° about (0, 2)

---

Perform the stated transformations on the preimage, \( \triangle ABC \). Give the coordinates of the image, \( \triangle A'B'C' \).

3. Reflection: in \( x = -2 \)
4. Translation: \((x, y) \rightarrow (x + 6, y + 4)\)
5. Rotation: 90° about the origin
6. Translation: \((x, y) \rightarrow (x - 5, y - 4)\)
7. Reflection: in the line \( y = -x \)
The vertices of $\triangle ABC$ are $A(3, -1)$, $B(7, 1)$, and $C(5, -4)$. Graph the image of $\triangle ABC$ after a composition of the transformations in the order they are listed.

8. Translation: $(x, y) \rightarrow (x - 4, y + 1)$
   Reflection: in the line $x = 1$

9. Translation: $(x, y) \rightarrow (x - 2, y + 3)$
   Rotation: $90^\circ$ about $(0, 2)$

Graph $F''G''$ after a composition of the transformations in the order they are listed. Then perform the transformations in reverse order. Does the order affect the final image $F''G''$?

10. $F(-2, -1)$, $G(-5, -3)$
    Rotation: $90^\circ$ about $(-2, 2)$
    Reflection: in the line $y = 1$

11. $F(3, -2)$, $G(6, 1)$
    Reflection: in the line $y = -x$
    Translation: $(x, y) \rightarrow (x + 4, y - 1)$
Describe the composition of transformations.

12. 

13. 

In the diagram, \( e \parallel h \), \( \overline{NP} \) is reflected in line \( e \), and \( \overline{NP} \) is reflected in line \( h \).

14. A translation maps \( \overline{NP} \) onto which segment?

15. Which lines are perpendicular to \( PP'' \)?

16. Name two segments parallel to \( \overline{NN''} \).

17. If the distance between \( e \) and \( h \) is 1.2 centimeters, what is the length of \( \overline{NN''} \)?

18. Is the distance from \( N' \) to \( h \) the same as the distance from \( N'' \) to \( h \)? Explain.

Find the angle of rotation that maps \( A \) onto \( A'' \).

19. 

20. 

\[ 70^\circ \] \[ 99^\circ \]
* The vertices of \( \triangle ABC \) are \( A(3, 1), B(1, 5), \) and \( C(5, 3) \). Graph the image of \( \triangle ABC \) after a composition of the transformations in the order they are listed.

21. Translation: \((x, y) \rightarrow (x + 3, y - 5)\)
    Reflection: in the \( y \)-axis

22. Translation: \((x, y) \rightarrow (x - 6, y + 1)\)
    Rotation: \(90^\circ\) about the origin

* Graph \( F''G'' \) after a composition of the transformations in the order they are listed. Then perform the transformations in reverse order. Does the order affect the final image \( F''G'' \)?

23. \(F(4, -4), G(1, -2)\)
    Rotation: \(90^\circ\) about the origin
    Reflection: in the \( y \)-axis

24. \(F(-1, -3), G(-4, -2)\)
    Reflection: in the line \( x = 1 \)
    Translation: \((x, y) \rightarrow (x + 2, y + 10)\)

* The endpoints of \( \overline{CD} \) are \( C(1, 2) \) and \( D(5, 4) \). Graph the image of \( \overline{CD} \) after the glide reflection.

25. Translation: \((x, y) \rightarrow (x - 4, y)\)
    Reflection: in the \( x \)-axis

26. Translation: \((x, y) \rightarrow (x, y + 2)\)
    Reflection: in \( y = x \)
Worksheet 8-7

Find the scale factor. Tell whether the dilation is a reduction or an enlargement. Then find the values of the variables.

1. \[ P' \]
   \[ 12.5 \]
   \[ \times \]
   \[ 5 \]
   \[ 8 \]
   \[ C \]

2. \[ P' \]
   \[ 9 \]
   \[ \times \]
   \[ 4 \]
   \[ y \]
   \[ x \]

3. \[ C \]
   \[ 5 \]
   \[ P' \]
   \[ \times \]
   \[ 7 \]
   \[ 9 \]
   \[ y \]
   \[ 13.5 \]
   \[ 6 \]
   \[ z \]

4. \[ P' \]
   \[ 18.4 \]
   \[ \times \]
   \[ 7.56 \]
   \[ 12.6 \]

Find the coordinates of the vertices of the image of the polygon after a dilation using the given scale factor and the origin as the center of dilation.

5. \( k = \frac{2}{3} \)

6. \( k = \frac{5}{2} \)

7.* An 8-inch by 10-inch photograph is being reduced by a scale factor of \( \frac{3}{4} \). What are the dimensions of the new photograph?

*Find the image matrix that represents a dilation of the polygon centered at the origin with the given scale factor. Then graph the polygon and its image.

8. \[ \begin{bmatrix} -6 & -4 & -2 \\ 2 & 4 & 2 \end{bmatrix} ; k = \frac{1}{2} \]

9. \[ \begin{bmatrix} -3 & -2 & 0 & 3 \\ -2 & 1 & 3 & 4 \end{bmatrix} ; k = 2 \]
In Exercises 10–15, refer to the diagram. First find the vertices of the image after the dilation described. Then use the vertices to draw the image and preimage in the same coordinate plane.

(I would suggest doing these on your own graph paper, so that you can use a 1 to 1 scale.)

10. Dilate $\triangle ABC$ using center $(6, 1)$ and scale factor 4.

11. Dilate $\triangle ABC$ using center $(4, 4)$ and scale factor 3.

12. Dilate $\triangle ABC$ using center $(-2, 13)$ and scale factor 2.

13. Dilate trapezoid $DEFG$ using center $(0, 1)$ and scale factor 2.

14. Dilate trapezoid $DEFG$ using center $(2, 3)$ and scale factor $\frac{3}{2}$.

15. Dilate trapezoid $DEFG$ using center $(0, 9)$ and scale factor $\frac{1}{2}$.
Use the origin as the center of the dilation and the given scale factor to find the coordinates of the vertices of the image of the polygon.

16. \( k = 3 \)

\[ \begin{array}{c}
\begin{array}{c}
\text{y}\\
1
\end{array}
\begin{array}{c}
\text{L}
\end{array}
\begin{array}{c}
1
\end{array}
\begin{array}{c}
\text{x}
\end{array}
\begin{array}{c}
0
\end{array}
\end{array} \]

\[ \begin{array}{c}
\begin{array}{c}
\text{N}
\end{array}
\begin{array}{c}
\text{M}
\end{array}
\begin{array}{c}
-1
\end{array}
\begin{array}{c}
\text{x}
\end{array}
\begin{array}{c}
0
\end{array}
\end{array} \]

17. \( k = \frac{1}{3} \)

\[ \begin{array}{c}
\begin{array}{c}
\text{y}\\
2
\end{array}
\begin{array}{c}
\text{H}
\end{array}
\begin{array}{c}
\text{G}
\end{array}
\begin{array}{c}
-2
\end{array}
\begin{array}{c}
\text{x}
\end{array}
\begin{array}{c}
0
\end{array}
\end{array} \]

18. \( k = 2 \)

\[ \begin{array}{c}
\begin{array}{c}
\text{y}\\
1
\end{array}
\begin{array}{c}
\text{D}
\end{array}
\begin{array}{c}
\text{A}
\end{array}
\begin{array}{c}
-1
\end{array}
\begin{array}{c}
\text{x}
\end{array}
\begin{array}{c}
0
\end{array}
\end{array} \]

19. \( k = \frac{5}{2} \)

\[ \begin{array}{c}
\begin{array}{c}
\text{y}\\
1
\end{array}
\begin{array}{c}
\text{S}
\end{array}
\begin{array}{c}
\text{R}
\end{array}
\begin{array}{c}
-1
\end{array}
\begin{array}{c}
\text{x}
\end{array}
\begin{array}{c}
0
\end{array}
\end{array} \]

The vertices of \( \square ABCD \) are \( A(1, 1), B(3, 5), C(11, 5), \) and \( D(9, 1) \). Graph the image of the parallelogram after a composition of the transformations in the order they are listed.

20. Translation: \((x, y) \rightarrow (x + 5, y - 2)\)

Dilation: centered at the origin with a scale factor of \( \frac{3}{5} \)

21. Dilation: centered at the origin with a scale factor of 2

Reflection: in the x-axis
**Review Chapter 9 Transformations**

Give the vertices of the image after it is reflected across the given line.

1) \( A(2,1), B(6,1), C(4,3) \) across the x-axis.

2) \( N(1,2), P(3,5), Q(3,7), R(1,6) \) across the line \( y = x \).

3) \( A(-4,2), B(-7,-1), C(0,1) \) across the y-axis.

Draw the line of symmetry for each figure, tell whether it has rotation symmetry.

6) Name the vector, and write vector in component form and give magnitude.

Translate the following figures given the vertices and the motion rule.

7) \( D(2,4), E(4,1), F(4,-2) \);
\( (x, y) \rightarrow (x-2, y-2) \)

8) \( J(-3,-1), K(-2,-3), L(1,-3), M(2,-1) \);
\( (x, y) \rightarrow (x+1, y+4) \)

Tell what kind of transformation each pair of figures simulates.
Rotate the following figure about the origin by the given angle measure.

13) \( P(4,-3), Q(2,-3), R(1,-2), S(3,0) \)
   180° counterclockwise rotation

14) \( A(4,4), B(2,1), C(0,3) \)
   90° clockwise rotation

Draw the image of the figure with the given vertices under a dilation with the given scale factor centered at the origin.

15) \( D(0,2), E(0,0), F(2,1), G(2,2) \)
    Scale factor: 2

16) \( A(4,4), B(2,0), C(0,0) \)
    Scale factor: \( \frac{1}{2} \)

Solve the following matrices.

17) \[
\begin{bmatrix}
-1 & 0 \\
0 & 2
\end{bmatrix}
\begin{bmatrix}
5 & 9 \\
6 & -7
\end{bmatrix}
\]

18) \[
\begin{bmatrix}
-2 & 3 \\
5 & -4
\end{bmatrix}
\begin{bmatrix}
-1 & 4 \\
7 & 5
\end{bmatrix}
\]

19) \[
\begin{bmatrix}
0.9 & 5 \\
-4 & -2
\end{bmatrix}
\begin{bmatrix}
3 & 0 \\
-4 & -3
\end{bmatrix}
\]

20) \[
\begin{bmatrix}
2 & 5 & 5 \\
1 & 0 & 3
\end{bmatrix}
\begin{bmatrix}
0 \\
-4 \\
2
\end{bmatrix}
\]
Do the following composite transformations:

21) Translate \((x, y) \rightarrow (x - 4, y + 1)\),
Reflect across the x-axis.

22) Rotate \(180^\circ\) counterclockwise,
Reflect across the y-axis.

23) Reflect \(x = 1\),
translate \((x, y) \rightarrow (x + 2, y - 4)\)

24) Reflect \(y = x\), Rotate \(90^\circ\) counterclockwise.

25) What is the value of \(x\)?

26) Find the value of \(x\) and \(y\)?

Make sure you can rotate a figure about a point that is not the origin and that you can dilate a figure through a point that is also not the origin.