

Rigid Motions and Transformations: practice solutions, Grade 10 – download the PDF

Written solutions to the chapter problems. Check each step, then correct yourself.

1 Translating points



The rule is $(x, y) \rightarrow (x - 4, y + 5)$.

a. $P' = (3 - 4, -2 + 5) = (-1, 3)$.

b. $Q' = (0 - 4, 6 + 5) = (-4, 11)$.

2 Three reflections



a. $(x, y) \rightarrow (x, -y)$, so $A'(4, -7)$.

b. $(x, y) \rightarrow (-x, y)$, so $B'(3, 2)$.

c. $(x, y) \rightarrow (y, x)$, so $C'(5, 5)$. The point does not move because it lies on the line $y = x$, and points on the line of reflection are fixed.

3 Turning about the origin



- a. $(x, y) \rightarrow (-y, x)$: $A'(-1, 3)$.
- b. $(x, y) \rightarrow (-x, -y)$: $B'(2, -4)$.
- c. $(x, y) \rightarrow (y, -x)$: $C'(-2, -5)$.

4 True or false?



- a. False. A translation preserves distances, so the size never changes.
- b. True. If the vertices are read counterclockwise on the preimage, they are read clockwise on the image.
- c. True. A full turn brings every point back to its starting position.
- d. False. A dilation with scale factor 2 doubles every length, so distances are not preserved.

5 Counting symmetries



- a. 2 lines; 180° .
- b. 3 lines; $360^\circ \div 3 = 120^\circ$.
- c. 6 lines; $360^\circ \div 6 = 60^\circ$.
- d. 1 line (through the midpoints of the parallel sides); none.
- e. 0 lines; 180° .

6 Finding the translation



- a. $\langle -1 - 2, 9 - 5 \rangle = \langle -3, 4 \rangle$.
- b. $B' = (0 - 3, 0 + 4) = (-3, 4)$.
- c. Undo the move: $(7 + 3, -2 - 4) = (10, -6)$.

7 Lengths do not change



$$PQ = \sqrt{(5-1)^2 + (5-2)^2} = \sqrt{16+9} = 5.$$

$$P' = (4, -2) \text{ and } Q' = (8, 1), \text{ so } P'Q' = \sqrt{4^2 + 3^2} = 5.$$

The two lengths are equal, as they must be for a rigid motion.

8 A vertical mirror line



A point at horizontal distance d from the line goes to the other side at the same distance, so x becomes $2 \cdot 3 - x = 6 - x$.

$$(7, 2) \rightarrow (-1, 2); (1, -4) \rightarrow (5, -4); (3, 6) \rightarrow (3, 6) \text{ (on the line).}$$

$$\text{Rule: } (x, y) \rightarrow (6 - x, y).$$

9 A horizontal mirror line



The x-coordinate stays the same. The y-coordinate is reflected about -1 : its new value is $2(-1) - y = -2 - y$.

$$(2, 3) \rightarrow (2, -5); (-4, -1) \rightarrow (-4, -1), \text{ fixed because it is on the line; } (0, -6) \rightarrow (0, 4).$$

10 Reflecting a triangle in $y = x$



Swap the coordinates: $A'(4, 1)$, $B'(0, 3)$, $C'(2, 5)$.

Area of ABC by the shoelace formula:

$$\frac{1}{2} |1(0 - 2) + 3(2 - 4) + 5(4 - 0)| = \frac{1}{2} |-2 - 6 + 20| = 6.$$

$$\text{Area of } A'B'C': \frac{1}{2} |4(3 - 5) + 0(5 - 1) + 2(1 - 3)| = \frac{1}{2} |-12| = 6.$$

The areas are equal, which is expected for a rigid motion.

11 Order matters



a. T : $(6, 2)$. Then M : $(-6, 2)$.

b. M : $(-4, -1)$. Then T : $(-2, 2)$.

The results $(-6, 2)$ and $(-2, 2)$ are different, so the order of the moves matters.

12 A clockwise quarter turn



A clockwise quarter turn is $(x, y) \rightarrow (y, -x)$.

$D'(0, -2)$, $E'(1, -4)$, $F'(3, -3)$.

The same image comes from a rotation of 270° counterclockwise.

13 Drone on a grid map



a. $x: 2 + 4 - 6 + 1 = 1$. $y: 3 + 1 + 2 - 7 = -1$. The drone finishes at $(1, -1)$.

b. Add the vectors: $\langle 4 - 6 + 1, 1 + 2 - 7 \rangle = \langle -1, -4 \rangle$. Check:

$$(2 - 1, 3 - 4) = (1, -1).$$

It finishes 1 meter left and 4 meters down from where it started.

14 Are these triangles congruent?



a. $AB = 6$, $AC = 2$, $BC = \sqrt{36 + 4} = \sqrt{40}$. $DE = 6$, $DF = 2$,

$EF = \sqrt{4 + 36} = \sqrt{40}$. The three pairs of sides are congruent (SSS), so the triangles are congruent.

b. Translate by $\langle 1, 1 \rangle$: $A \rightarrow (1, 1) = D$, $B \rightarrow (7, 1)$, $C \rightarrow (1, 3)$. Then rotate 90° counterclockwise about $D(1, 1)$: B is 6 units right of D , so it goes 6 units above D , at $(1, 7) = E$. C is 2 units above D , so it goes 2 units left of D , at $(-1, 1) = F$.

15 Two parallel mirrors



- a. Reflection in $x = 1$: $x \rightarrow 2 - x$, so $P \rightarrow (4, 3)$. Reflection in $x = 5$: $x \rightarrow 10 - x$, so $(4, 3) \rightarrow (6, 3)$.
- b. In general $x \rightarrow 10 - (2 - x) = x + 8$ and y is unchanged: the translation by $\langle 8, 0 \rangle$. The lines are 4 units apart and $2 \times 4 = 8$. Test: $(0, -2) \rightarrow (2, -2) \rightarrow (8, -2)$, which is $(0 + 8, -2)$.

16 Two mirrors that meet



- a. $(x, y) \rightarrow (x, -y) \rightarrow (-x, -y)$: a rotation of 180° about the origin. The axes meet at 90° and $2 \times 90^\circ = 180^\circ$.
- b. $(x, y) \rightarrow (y, x) \rightarrow (-y, x)$: this is the 90° counterclockwise rotation about the origin. The lines meet at 45° and $2 \times 45^\circ = 90^\circ$. Test: $(3, 4) \rightarrow (4, 3) \rightarrow (-4, 3)$, and the rule gives $(-4, 3)$.

17 Finding the mirror line



- a. The line is the perpendicular bisector of $\overline{AA'}$. Midpoint: $(\frac{1+5}{2}, \frac{6+2}{2}) = (3, 4)$. Slope of $\overline{AA'}$: $\frac{2-6}{5-1} = -1$, so the mirror line has slope 1 . Through $(3, 4)$: $y - 4 = x - 3$, that is $y = x + 1$.
- b. $B(0, 1)$: $0 + 1 = 1$, so B is on the line and is not moved.

18 Glide reflection and orientation



- a. Reflection: $(-4, -2)$, $(-1, -2)$, $(-3, -5)$. Translation: $R''(2, -1)$, $S''(5, -1)$, $T''(3, -4)$.
- b. Before: $-4(2 - 5) - 1(5 - 2) - 3(2 - 2) = 12 - 3 + 0 = 9$. After: $2(-1 + 4) + 5(-4 + 1) + 3(-1 + 1) = 6 - 15 + 0 = -9$. The absolute value is the same (area 4.5), but the sign changes: the orientation has been reversed by the reflection.

19 Rotating about another center



Subtract C , rotate about the origin, add C .

- a. $P - C = (3, 3) \rightarrow (-3, 3) \rightarrow (-1, 4)$.
- b. $Q - C = (0, -4) \rightarrow (0, 4) \rightarrow (2, 5)$.
- c. $R - C = (4, 0) \rightarrow (0, -4) \rightarrow (2, -3)$.

20 Why reflections keep distances



$P'(-a, b)$ and $Q'(-c, d)$. Then

$$P'Q'^2 = (-c + a)^2 + (d - b)^2 = (a - c)^2 + (b - d)^2 = PQ^2, \text{ so } P'Q' = PQ.$$

Check: $PQ = \sqrt{3^2 + 4^2} = 5$. $P'(-2, 3)$, $Q'(1, 7)$: $P'Q' = \sqrt{3^2 + 4^2} = 5$.

21 Symmetry detective



- a. 8 lines; $360^\circ \div 8 = 45^\circ$.
- b. $360^\circ \div 5 = 72^\circ$, so the angles are $72^\circ, 144^\circ, 216^\circ, 288^\circ, 360^\circ$.
- c. $n = 360 \div 24 = 15$: a regular 15-gon (15 sides).

22 The Ferris wheel



- a. $360^\circ \div 12 = 30^\circ$.
- b. $210 \div 30 = 7$ positions, so car 5 reaches position $5 + 7 = 12$.
- c. $90 \div 30 = 3$ positions: $10 + 3 = 13$, which wraps around to position 1.



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