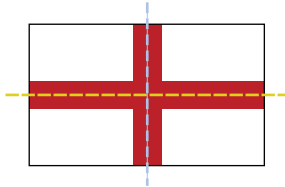# Answers

Chapter 1

1.1 Line Symmetry, pages 12–15
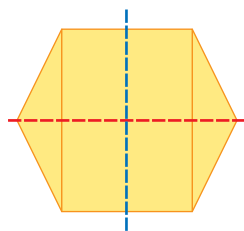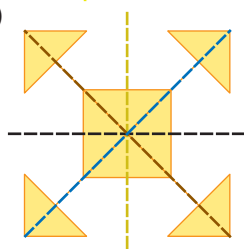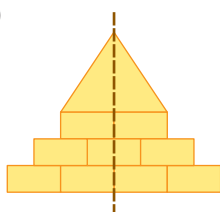
4. a)
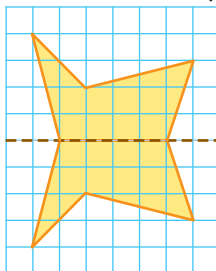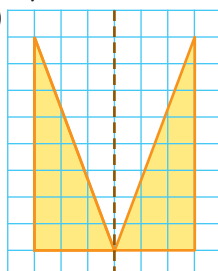

b)
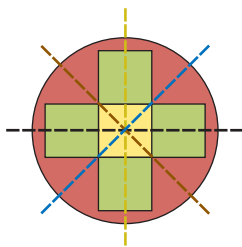
c)

5. a)

b)

c)

6. B, D, and E. They can be folded in two different ways so that they overlap exactly. Each of the other figures has more than two lines of symmetry.
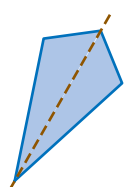
7. a)

b)

8. a)

b)
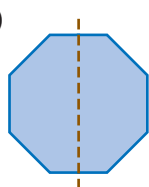
9. a)
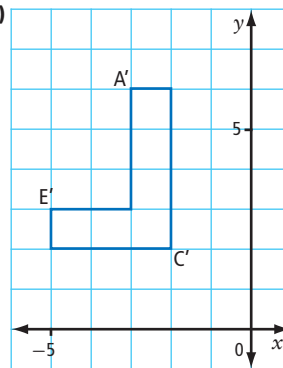
b) A′(−3, 6), C′(−2, 2), E′(−5, 3)   **c)** Yes, the original image and the reflected image show line symmetry. However, each individual figure does not show line symmetry within itself.

10. Example: **a)**
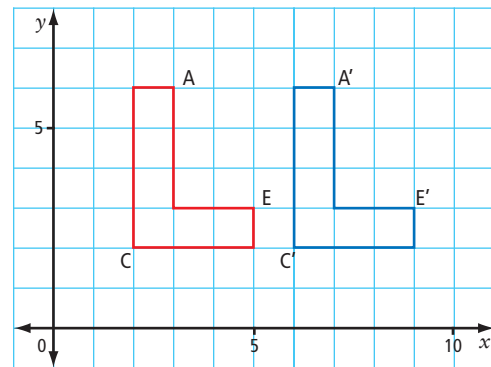
b) A′(7, 6), C′(6, 2), E′(9, 3)   **c)** No. The image was not reflected and does not contain line symmetry within itself.   **d)** No. See explanation in 10c).
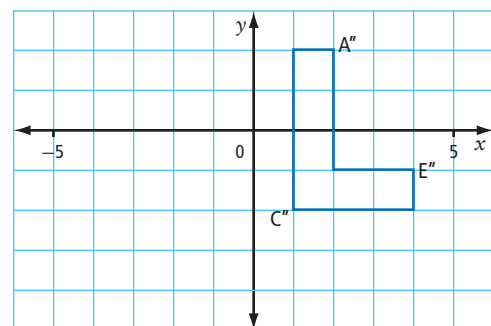
11. Example: I agree because these shapes show horizontal and/or vertical line symmetry within themselves, a horizontal or vertical translation of the shape results in line symmetry between the original and new images. A figure with only vertical line symmetry within itself will show line symmetry after a horizontal translation only.

12. a) Yes, the flag has horizontal line symmetry. If folded from bottom to top through the middle of the horizontal blue stripe, the upper and lower halves will overlap. **b)** Moving the vertical blue and white stripes to the centre of the flag would give it two lines of symmetry.
13. a) one horizontal   **b)** one vertical   **c)** two: one horizontal and one vertical   **d)** four: one horizontal, one vertical, and two oblique
14. Example:

0 lines   1 line   2 lines   4 lines

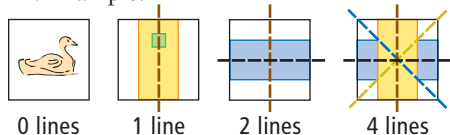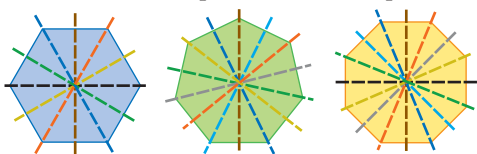**15. a)** B, C, D, E, H, I, K, O, X
b) A, H, I, M, O, T, U, V, W, X, Y   **c)** H, I, O, X
16. a) Example: WOW W HAH H
                     O   A
                     W   H
b) Example: HI H   **c)** Example: WHO W
                   I   H
                                          O

17. a) 0, I, 3, 8   **b)** Example: I00I   **c)** Example: 80I08
18. a)

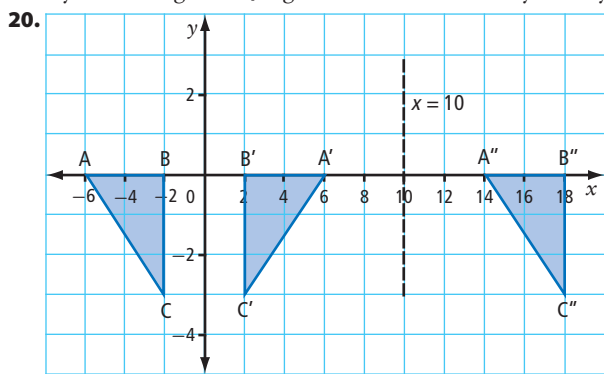**b)** The number of equal, interior angles equals the number of lines of symmetry.   **c)** Yes. As the number of interior angles increases, you approach a circle shape, which is symmetrical from all angles.
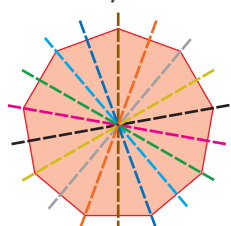

19. a) A   **b)** Different colours mean that figure B becomes a non-symmetric figure.   **c)** Figure A has five lines of symmetry.
**20.**

Triangle A″B″C″ is the result of a horizontal translation 20 units to the right.
21. a) If the two-dot separator in the digital clock is ignored, then both clocks show line symmetry at some time.

b) The digital clock can show horizontal line symmetry at 8:08, 8:38, 3:03 (not 1:01 or 10:10, etc., because of the shape of the number 1); the analogue clock can show line symmetry at any time when the line of symmetry bisects the angle between the hands and bisects the squares representing the numbers or when the time is 6:00 or 12:00.
22.
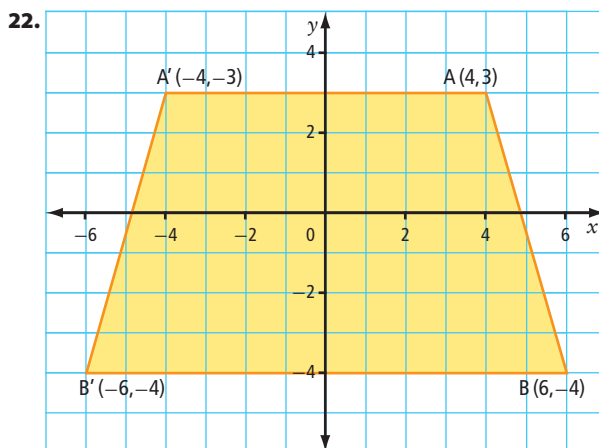
70 square units
23.
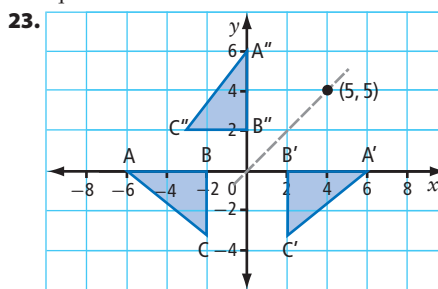
Triangle A″B″C″ is the image created by rotating the original triangle 90° about the origin.
24. Example: Yes, a three-dimensional object such as a cube is symmetric because all faces and edges are of equal size. A plane cutting the cube parallel to a face and through the centre will create two identical rectangular prisms.

1.2 Rotation Symmetry and Transformations, pages 21–25

4. a) order of rotation = 4, angle of rotation = 90°, fraction of a turn = $\frac{1}{4}$, centre of rotation is at centre of figure.   **b)** order of rotation = 2, angle of rotation = 180°, fraction of a turn = $\frac{1}{2}$, centre of rotation is at centre of figure.   **c)** order of rotation = 2, angle of rotation = 180°, fraction of a turn = $\frac{1}{2}$, centre of rotation is between 9 and 6.
5. a) Yes; angle of rotation = 90°   **b)** Yes; angle of rotation = 120°   **c)** Yes; angle of rotation = 180°
6. a) number of lines of symmetry = 6, order of rotation = 6
b) number of lines of symmetry = 2, order of rotation = 2
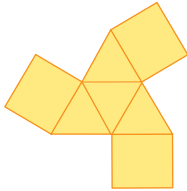**c)** number of lines of symmetry = 2, order of rotation = 2

7. a) number of lines of symmetry = 3, angle of rotation = 120° **b)** number of lines of symmetry = 5, angle of rotation = 72°

8. a)

b) Rotate the original figure 180° and join the two figures. Translate the new figure to the right so it does not overlap. Join the two figures. Now join this new figure with the original one on the right.

9. a) 3
b)

c) No, because the image does not show line symmetry.
10. a) Example: line symmetry: pu, pa; rotation symmetry: ki, ku;

11. a) Both. Lines of symmetry: the vertical black line with three red squares to its left and to its right in each row; the horizontal black line with two red squares above it and below it in each column. The centre of rotation is located where the two lines of symmetry intersect.
**b)** Neither. There would be a vertical line of symmetry through the noses of the centre column of faces if the face colours on each side of the line matched each other.
c) Neither. There would be 180° rotation symmetry if the pink and blue dolphins were the same colour.
d) Rotation symmetry only of order 4. The centre of rotation is at the centre of the figure.
12. a) The vertices of the images are:
A′(−4, 1), B′(−2, 1), C′(−2, 5), D′(−4, 5);
A″(−1, −4), B″(−1, −2), C″(−5, −2), D″(−5, −4);
A‴(4, −1), B‴(2, −1), C‴(2, −5), D‴(4, −5).
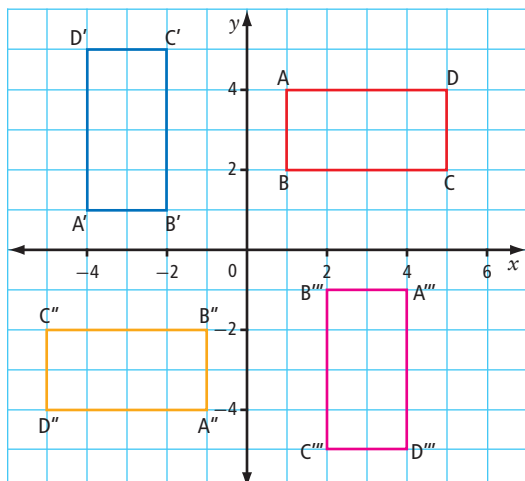
b) Each image is oriented with the longer dimension along the horizontal and the order of labelling switches between clockwise and counter-clockwise.
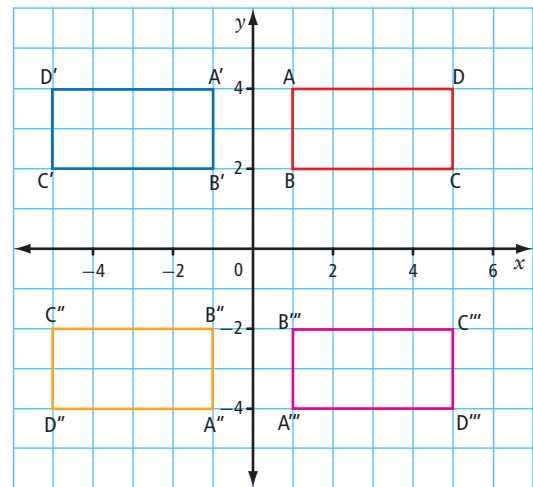
13. a) order of rotation = 4, angle of rotation = 90°
b) No; the rotation of the design makes line symmetry impossible.
14. a) There are eight lines of symmetry; the angle between the lines is 22.5°
b) order of rotation = 8, angle of rotation = 45°
15. Example:

16. a)

b)

MathLinks 9 **Chapter 1 Answers**

3

17. a) order of rotation = 5, angle of rotation = 72°
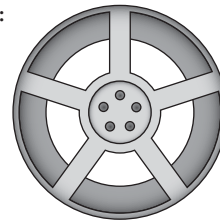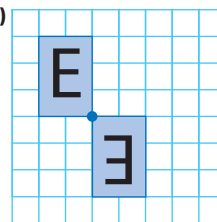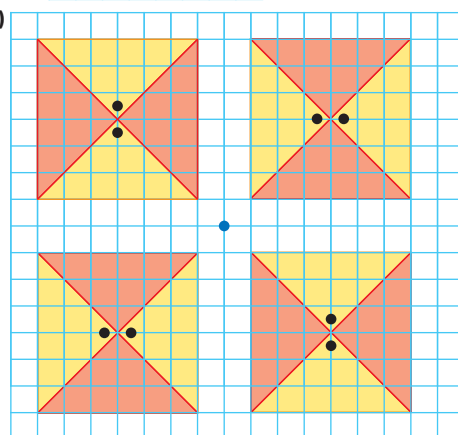**b)** order of rotation = 7, angle of rotation = 51.4°
c) order of rotation = 6, angle of rotation = 60°
d) order of rotation = 12, angle of rotation = 30°
18. a) Example: Some parts of the diagram appear to be rotated and projected five times, whereas others (such as the interior bolts) appear four times. Depending on which part is chosen, the order of rotation may seem different.
b) Adding another bolt so that the total on the inside rim is five would give this diagram rotation symmetry.
19. a) The top half of the card, along with the K symbol, is rotated 180° (rotation order 2). **b)** Cards are designed so they can be read while being held from either end.
c) No; attempting to fold the card along any line does not result in an overlap.
20. Rachelle is correct. Although there are 20 wedges on the board, the alternating red and green colours must be grouped together and then rotated to reproduce the image.
21. a) H, I, N, O, S, X, Z **b)** 0, I, 8 **c)** Example: X08OI
22. Example: A hexagon-shaped sign, a six-sided snowflake, or other object.
23. a) A: no symmetry because of the variation in overlap of green and blue circles in pairs of opposite rays; B: rotational symmetry of order 4 and line symmetry
b) Example: The logo of Sun Microsystems shows rotational symmetry, and UNESCO shows vertical line symmetry.
24. a) $m = 12$. The letter m represents the number of teeth in the gear. **b)** $n = 16$ **c)** 4.5 turns **d)** 6 turns
e) $\dfrac{(x)(m)}{y} =$ number of turns$_B$
25. a) All of the objects have at least one example of line symmetry. All of Group A show multiple lines of symmetry. Only the left object in Group B does not show rotation symmetry.
**b)** Example: A cube has many lines of symmetry because the edges are all of equal length.
26.
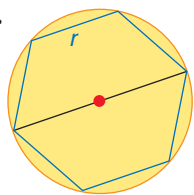
The shape made would be a hexagon. The order of rotation for the shape is 6.

1.3 Surface Area, pages 32–35

4. a) Estimate the total surface area of a solid, $2 \times 4 \times 5$ rectangular prism. The total surface area of the object is 72 cm². **b)** Estimate the total surface area of a solid, $4 \times 4 \times 6$ prism. The total surface area of the object is 112 cm².
5. a) 216 cm² **b)** 256 cm²
6. a) 12 cm² **b)** 214 cm²

7. a) 17 cm by 9 cm by 11 cm **b)** The surface area with the cutout is the same as the surface area without the cutout (4750 cm²).
8. a) For one box: width = 2 cm, height = 1 cm, depth = 3 cm **b)** 96 cm² **c)** one box: 22 cm²; six boxes: 132 cm². The ratio of the surface area for the six combined boxes to the surface area for six separate boxes is 8 : 11.
9. a) 4320 cm² **b)** 54 720 cm² **c)** Only three surface areas need to be calculated (shelf, side, back).
10. a) 36 cm² **b)** Example: A 1 cm × 2 cm × 5 cm rectangular prism has a surface area of 34 cm², while a 1 cm × 1 cm × 10 cm rectangular prism has a surface area of 42 cm².
11. Example: Surface area is important to consider when painting a building, icing a cake, and packaging items.
12. a) 0.06 m. This allows rainwater to flow away from the house, off the roof to the ground below.
b) 57.89 m²; You must assume that there is no bottom included in this calculation, all angles are 90°, the garage door is to be included, and an average height of 2.4 m.
13. a) left mug: 286.5 cm²; right mug: 298.6 cm²
b) The left mug has better heat-retaining properties. It has less surface area exposed to the air resulting in lower heat loss.
14. 1.92 m²
15. a) The object's top and bottom faces, left and right faces, and front and back faces are symmetrical.
b) 324.57 cm²
16. a) You must use the Pythagorean theorem three times.
b) 51.7 m² **c)** 33 bundles of shingles for a cost of $889.35
17. a) The two flues are each 24 cm wide and 20 cm tall.
b) 4672 cm²
18. 392 cm²; To calculate the surface area of the inside of the box, you must assume the metal has zero thickness.
19. a)

b)
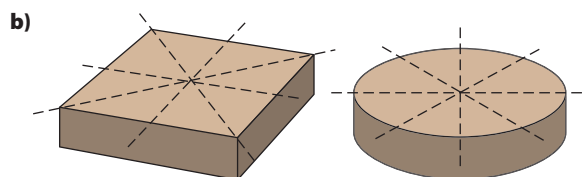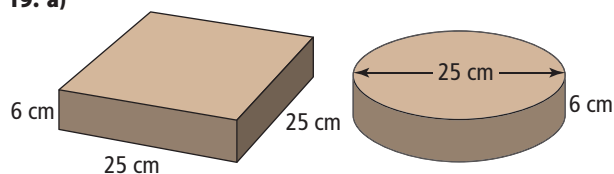
c) square cake: 1850 cm²; 8 square-cake slices: 3270.8 cm²; round cake: 1452.3 cm²; 8 round-cake slices: 2651.9 cm²; surface area increase of square cake: 1448.6 cm²; surface area increase of round cake: 1200 cm²; For both cakes, the eight equal slices increase the total surface area by almost double compared to the unsliced cakes.

20. The rice with the small grains has a smaller surface area per grain than the rice with larger grains. This means that more rice per cup can come into contact with the hot water with the smaller grains, meaning it can cook faster.
21. Example: Elephants' ears are very thin, but large, giving them a large surface area. This allows more skin to be exposed to air, and allows more skin to be cooled or warmed by the air, regulating the elephant's body temperature.
22. 12 201.95 cm²
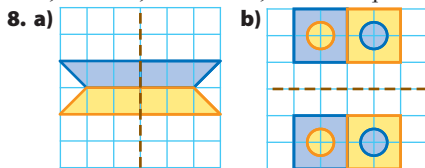**23.** 391 m²

Chapter 1 Review, pages 36–37

1. E
2. A
3. D
4. B
5. F
6. C
7. a) 4; vertical, horizontal, two oblique
b) 6; vertical, horizontal, four oblique
8. a)

b)

9. a) A′(5, 3), B′(5, 2), C′(1, 2), D′(1, 4), E′(3, 4), F′(3, 3). This shows a vertical line of symmetry with the original image. **b)** A″(1, 0), B″(1, −1), C″(5, −1), D″(5, 1), E″(3, 1), F″(3, 0). This does not show symmetry with the original image.
10. a) order of rotation = 4; angle of rotation = 90°, one quarter turn **b)** order of rotation = 8; angle of rotation = 45°, one eighth turn
11. There is an oblique line of symmetry from the top left corner to the bottom right corner.
**12. a)**
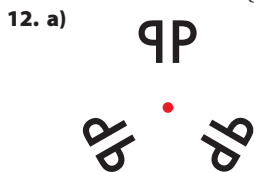
b) Example: The letter H in the image would make both line symmetry and rotation symmetry. Other possible answers include A, I, M, O, T, V, W, X, and Y.
13. The design has rotation symmetry only with an order of rotation of 3. Because of the colouring and overlapping, there is no line symmetry.
14. a) P′(−2, −4), Q′(−5, −4), R′(−5, −1), U′(−3, −1), V′(−3, −3), W′(−2, −3). Yes, the two images are related by rotation symmetry. **b)** P″(2, −4), Q″(5, −4), R″(5, −1), U″(3, −1), V″(3, −3), W″(2, −3). Yes, the two images are related by horizontal line symmetry.

c) P‴(−5, 4), Q‴(−2, 4), R‴(−2, 1), U‴(−4, 1), V‴(−4, 3), W‴(−5, 3). No, the images are not related by symmetry.
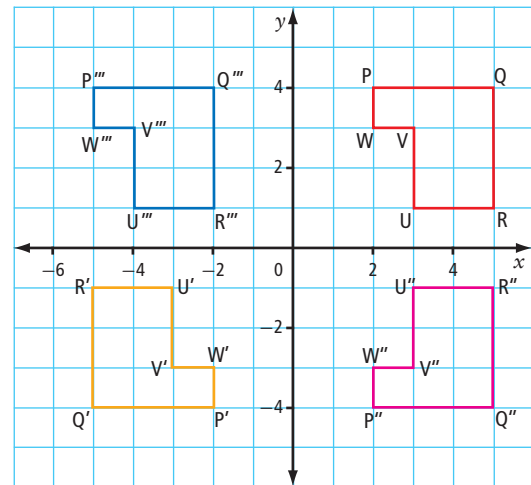
15. 35.1 cm²
16. a) top: 444 cm²; bottom: 1088 cm² **b)** 1244 cm²
17. a) 38 cm² **b)** 42 cm² **c)** 72 cm²