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2.16

4. **Standardized Test Prep** Which of the following statements is NOT true about a quadrilateral in a plane?

   A. Except for its endpoints, all the points on at least one of a quadrilateral's diagonals lie in the interior of the quadrilateral.

   B. At least one diagonal of a quadrilateral divides the quadrilateral into two triangles.

   C. The sum of the measures of the interior angles of a quadrilateral is 360°.

   D. The four vertices of every quadrilateral lie on a unique circle.

Review the following triangle theorems. Then complete Exercises 5–8.

- The sum of the measures of the angles of a triangle is 180°.
- The sum of the lengths of any two sides of a triangle is greater than the length of the third side.

5. The sum of the measures of the angles of a quadrilateral is always 360°. Explain why this is true.

6. Is the sum of the measures of the angles of a self-intersecting quadrilateral always 360°? Explain.

7. Is the sum of the measures of the angles of a skew quadrilateral always 360°? Explain.

How would you define the angles of a self-intersecting quadrilateral?

8. **Take It Further** Prove that the sum of the lengths of any three sides of a quadrilateral is greater than the length of the fourth side. Determine whether your proof works for each type of quadrilateral listed below.

   - concave
   - self-intersecting
   - skew

   If your proof does not work for one or more types of the quadrilaterals listed above, can you write a different proof that will hold? Or does the proof fail because the property is not a characteristic of that type of quadrilateral?

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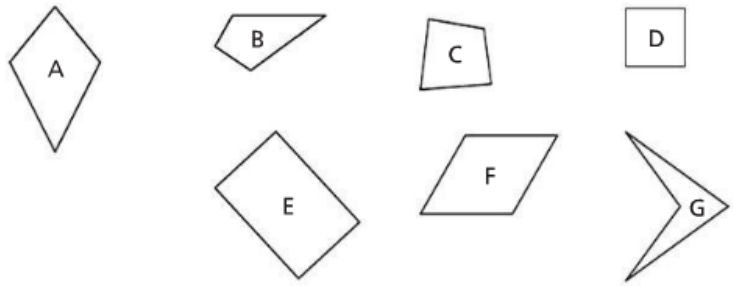
12. Which of the following figures appear to be kites? Explain.



For Exercises 13–17, complete each sentence with *always, sometimes,* or *never* to make the statement true.

13. The sum of the measures of the angles of a kite is ? 360°.

14. The diagonals of a kite are ? perpendicular.

15. A kite ? has two congruent angles.

16. A kite ? has a right angle.

17. One diagonal of a kite ? bisects one of its angles.

18. **Standardized Test Prep** Which of the following statements is always true?

I. A kite has at least one pair of congruent adjacent sides.

II. A kite has at least one pair of congruent opposite angles.

III. The diagonals of an isosceles trapezoid are congruent.

A. I only **B.** I and II only **C.** I and III only **D.** I, II, and III

19. Prove that the symmetry diagonal of a kite bisects two angles of the kite.

20. Prove that the diagonals of a kite are perpendicular.

2.18

For Exercises 9–28, complete each sentence with *always, sometimes,* or *never* to make the statement true.

9. A parallelogram ? has two congruent sides.

10. A parallelogram ? has three congruent sides.

11. A parallelogram ? has exactly three congruent sides.

12. A parallelogram ? has four congruent sides.

13. A parallelogram ? has congruent diagonals.

14. A quadrilateral with congruent diagonals is ? a parallelogram.

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15. If one diagonal of a quadrilateral divides it into two congruent triangles, then the quadrilateral is _?_ a parallelogram.

16. If two consecutive angles of a quadrilateral are supplementary, then the quadrilateral is _?_ a parallelogram.

17. A quadrilateral with one right angle is _?_ a parallelogram.

18. A quadrilateral with exactly one right angle is _?_ a parallelogram.

19. A quadrilateral with two right angles is _?_ a parallelogram.

20. A quadrilateral with exactly two right angles is _?_ a parallelogram.

21. A quadrilateral with exactly two right angles opposite each other is _?_ a parallelogram.

22. A quadrilateral with three right angles is _?_ a parallelogram.

Hint: Can a quadrilateral have exactly three right angles?

23. A quadrilateral with diagonals that bisect each other is _?_ a parallelogram.

24. If the longer diagonal of a quadrilateral bisects the shorter diagonal, then the quadrilateral is _?_ a parallelogram.

25. A quadrilateral with two congruent sides is _?_ a parallelogram.

26. A quadrilateral with three congruent sides is _?_ a parallelogram.

27. A quadrilateral with exactly three congruent sides is _?_ a parallelogram.

28. A quadrilateral with four congruent sides is _?_ a parallelogram.

29. **Standardized Test Prep** Which of the following statements is NOT true?

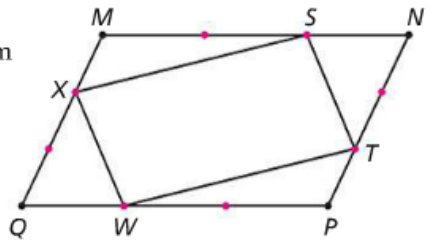
A. Every parallelogram has at least one line of symmetry.

B. The diagonals of a parallelogram always bisect each other.

C. Opposite angles of a parallelogram are congruent.

D. Consecutive angles of a parallelogram are supplementary.

30. **Take It Further** In the figure at the right, the sides of parallelogram *MNPQ* are trisected. Four of the trisection points form quadrilateral *STWX*.



A segment is **trisected** if it is divided into three congruent parts.

a. List some facts that you can prove about quadrilateral *STWX*.

b. What type of quadrilateral is *STWX*? Prove your conjecture.

c. Suppose you draw $\overline{SW}$ and $\overline{TX}$. What can you say about these two segments?

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14. Standardized Test Prep Which of the following statements is NOT true?

A. A square is different from a rhombus because a square has four congruent sides.

B. A rectangle is a parallelogram with four congruent angles.

C. A square is a rectangle with four congruent sides.

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

15. Prove that a parallelogram with one right angle is a rectangle.

16. Prove that if the diagonals of a parallelogram are congruent, then the parallelogram is a rectangle.

17. What type of quadrilateral do you form when you connect the midpoints of a rectangle's sides? Prove your conjecture.

In Exercises 17 and 18, make sure you do not assume that the quadrilateral is a parallelogram.

For Exercises 18–23, prove each statement.

18. If a quadrilateral has four congruent sides, then it is a rhombus.

19. Either diagonal of a rhombus divides the rhombus into two isosceles triangles.

20. The diagonals of a rhombus bisect the vertex angles of the rhombus.

21. The diagonals of a rhombus are perpendicular.

22. If the diagonals of a parallelogram are perpendicular, then the parallelogram is a rhombus.

23. If one diagonal of a parallelogram bisects two opposite angles of the parallelogram, then the parallelogram is a rhombus.

24. Draw a square and connect the midpoints of its sides. Prove that the figure formed is also a square.

Habits of Mind

Think it through. To prove that a quadrilateral is a square, can you just prove that its four sides are congruent?