Name ______________________ Date ______________

Properties of Triangles
Angle Relationships in a Triangle

Vocabulary

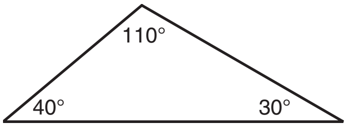
Match each word with its definition.

1. acute triangle	**a.** an angle formed by one side of a triangle and an extension of another side
2. obtuse triangle	**b.** The measure of an exterior angle of a triangle is greater than the measure of either of its remote interior angles.
3. right triangle	**c.** a triangle with three equal angles
4. equiangular triangle	**d.** a triangle with three acute angles
5. exterior angle	**e.** a triangle that has one right angle
6. remote interior angles	**f.** a triangle with one obtuse angle
7. Exterior Angle Inequality Theorem	**g.** the two angles of a triangle that are not supplementary to a given exterior angle

Problem Set

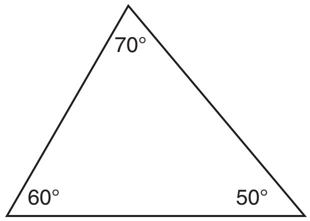
Classify each triangle as acute, obtuse, right, or equiangular.

1.



obtuse

2.



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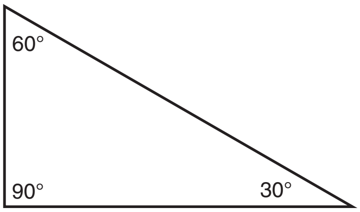

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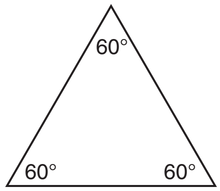

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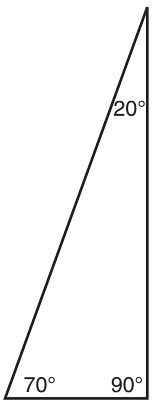

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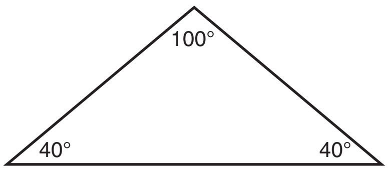

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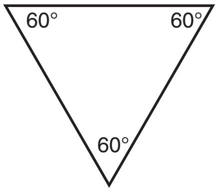

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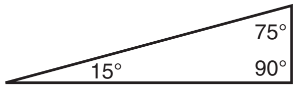

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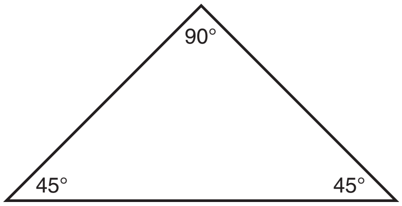

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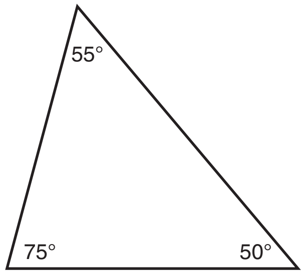

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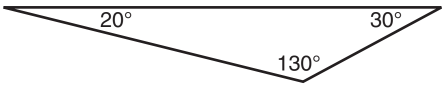

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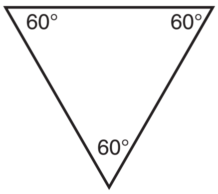

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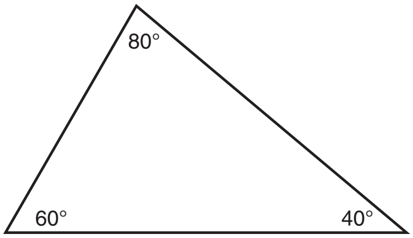

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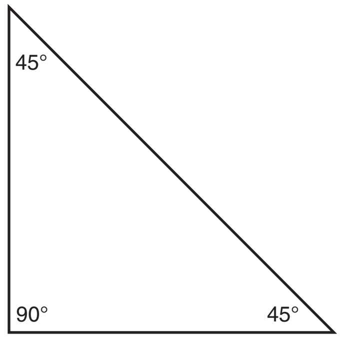

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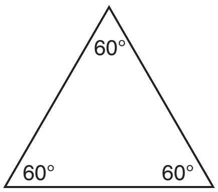

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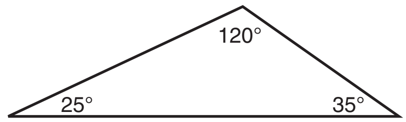
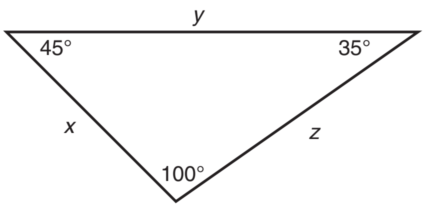


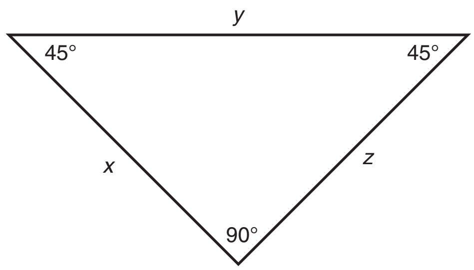
Identify the shortest and longest side of each triangle. Identify any sides that have the same length.

17.



x is the shortest,
y is the longest

18.



5

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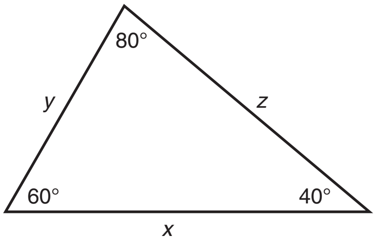

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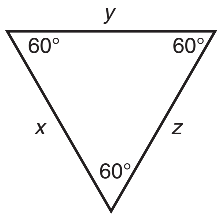

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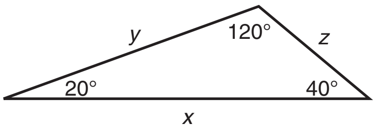

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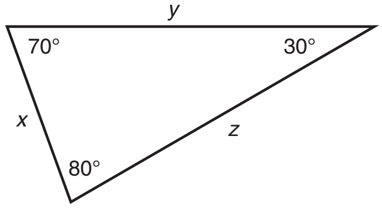
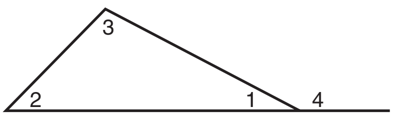


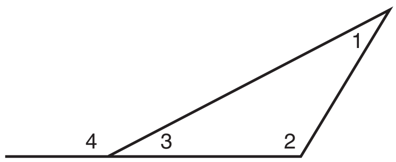
Identify the remote interior angles of each exterior angle.

23.



$\angle 2$, $\angle 3$

24.



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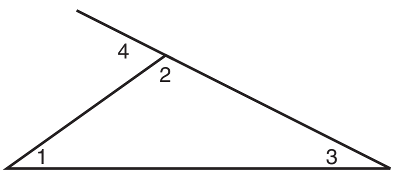

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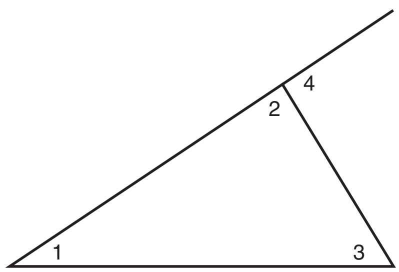
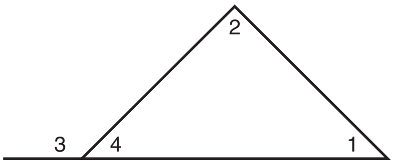


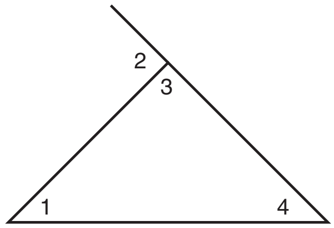
Identify the exterior angle of each triangle.

27.



∠3

28.



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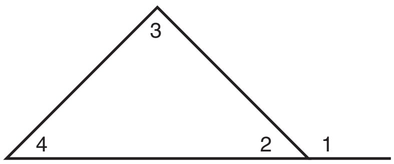

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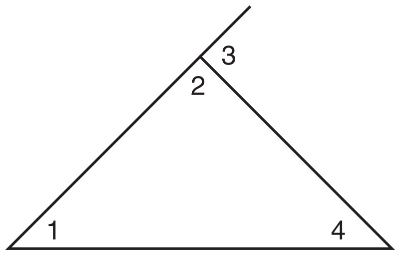
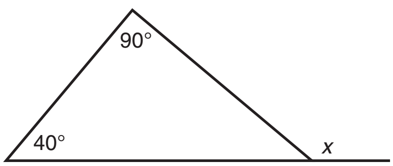


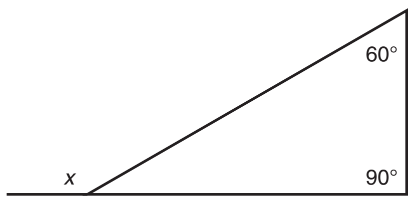
Solve for x in each triangle.

31.



$x = 130°$

32.



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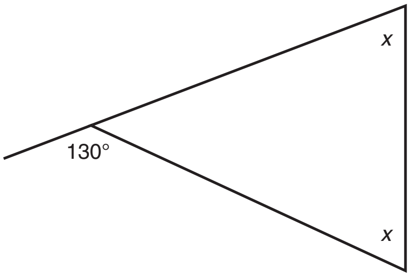
33.



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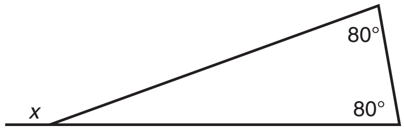

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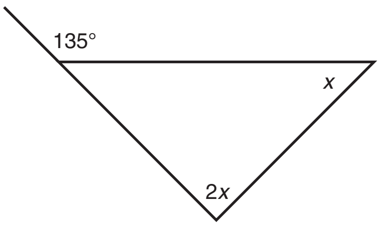
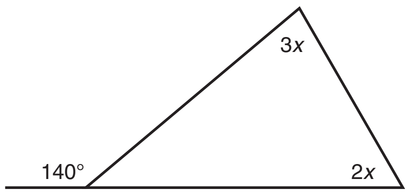
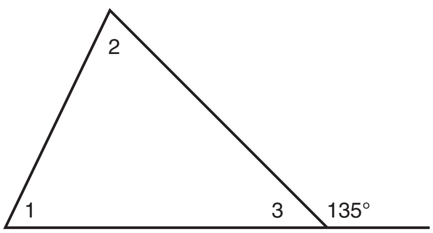


36.



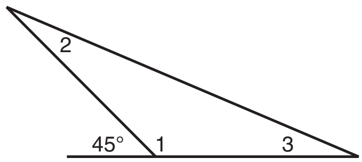
Use the Exterior Angle Inequality Theorem to describe the angles of each triangle.

37.



An exterior angle is equal to the sum of the remote interior angles. In this case, ∠1 + ∠2 = 135°. Because ∠1 and ∠2 must be positive, and because their sum is 135°, then both ∠1 and ∠2 must be less than 135°. In other words, the measure of the exterior angle, 135°, is greater than the measure of ∠1 and greater than the measure of ∠2.

38.



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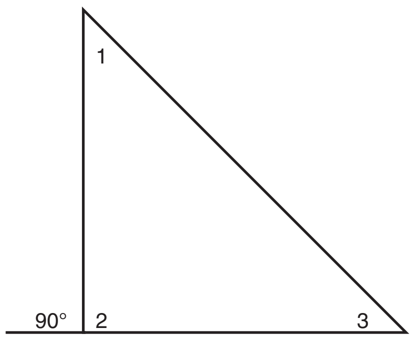
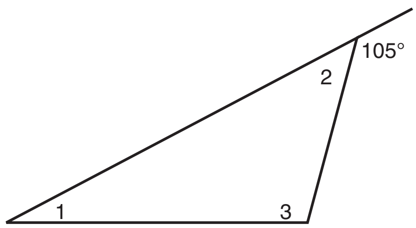


40.



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Properties of Triangles
Side Relationships of a Triangle

Vocabulary

Define each term in your own words.

1. scalene triangle

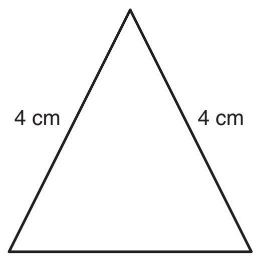
2. isosceles triangle

3. equilateral triangle

Problem Set

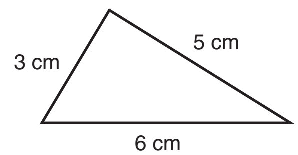
Identify each triangle as scalene, isosceles, or equilateral.

1.

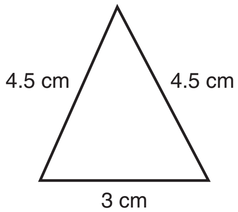


equilateral

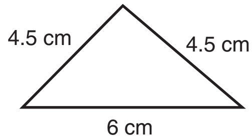
2.



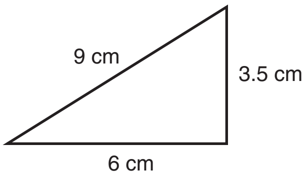
3.


4.5 cm
4.5 cm
3 cm

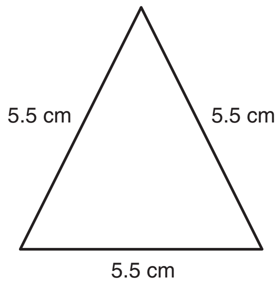
4.


4.5 cm
4.5 cm
6 cm

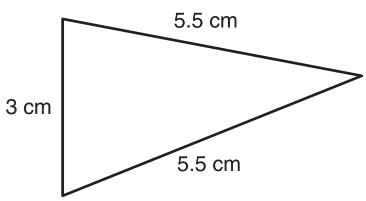
5.


9 cm
3.5 cm
6 cm

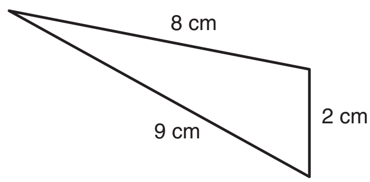
6.


5.5 cm
5.5 cm
5.5 cm

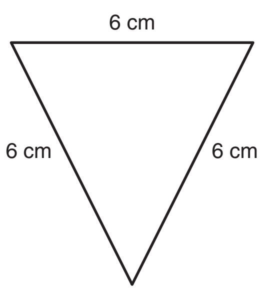
7.


5.5 cm
3 cm
5.5 cm

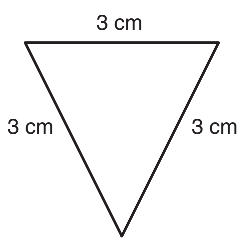
8.


8 cm
2 cm
9 cm

9.


6 cm
6 cm
6 cm

10.


3 cm
3 cm
3 cm

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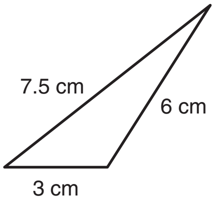
11.



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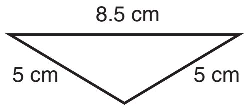
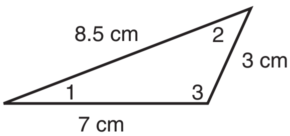
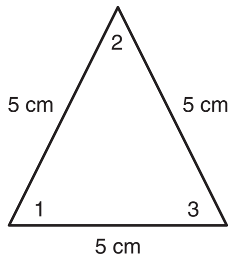


Identify the smallest and largest angle in each triangle. Identify any angles that have the same measure.

13.

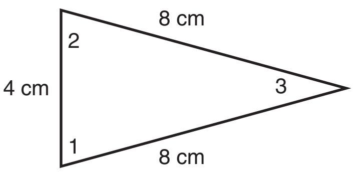


14.



∠1 is the smallest, ∠3 is the largest

15.



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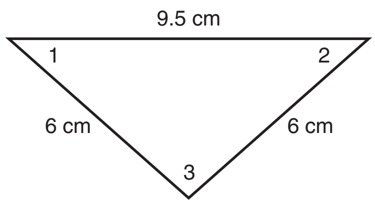

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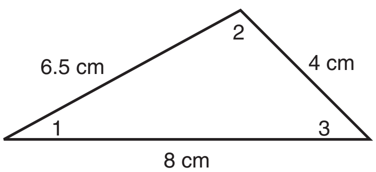

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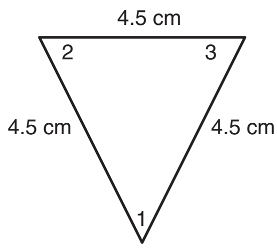
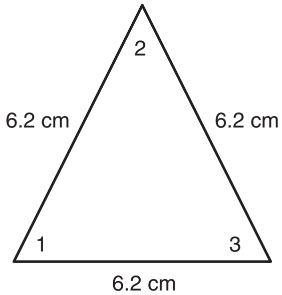


19.



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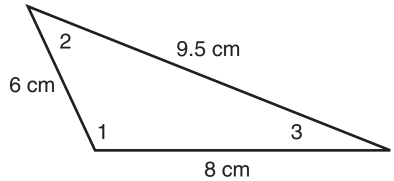

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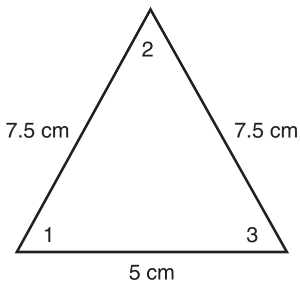

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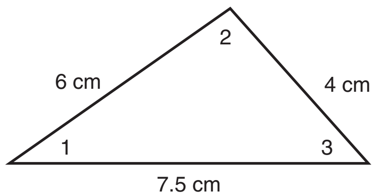

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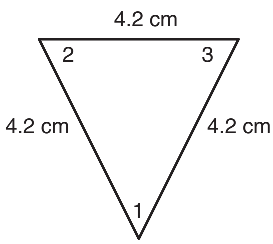

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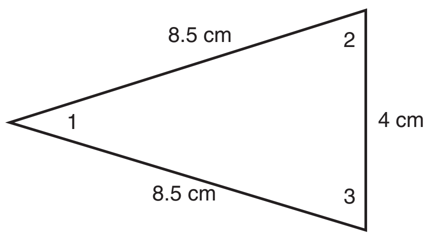

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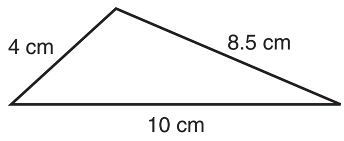
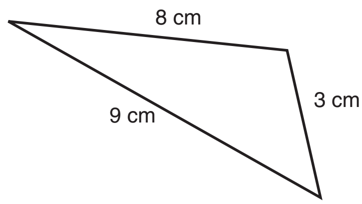
Explain why the Triangle Inequality Theorem is true for each triangle.

25.

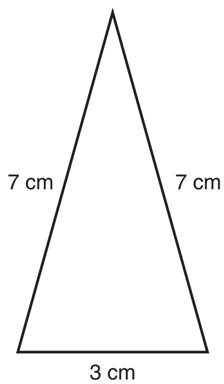


The measure of the longest side, 10 centimeters, is less than the sum of the measures of the two other sides: 4 cm + 8.5 cm = 12.5 cm.

26.

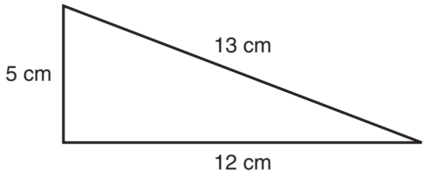


27.

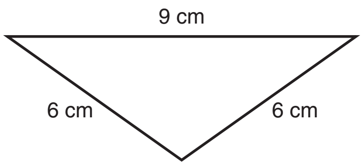


5

28.



29.



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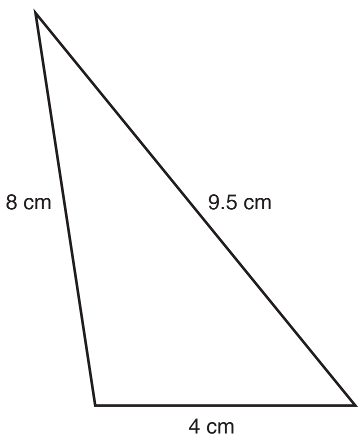

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Name ______________________________ Date ______________

Determine whether each set of segment lengths can form a triangle.

31. 4 cm, 6 cm, 9 cm

Yes

32. 4 in., 6 in., 10 in.

33. 12 ft, 12 ft, 25 ft

34. 2 m, 20 m, 21 m

35. 17 yd, 18 yd, 32 yd

36. 12 mm, 13 mm, 30 mm

37. 1 in., 11 in., 12 in.

38. 14 cm, 14 cm, 20 cm

5

Name ____________________ Date ____________

Properties of Triangles
Points of Concurrency

Vocabulary

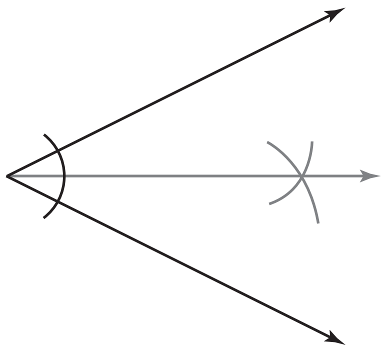
Write the term that best completes each statement.

1. A(n) ____________ is a line that divides a segment into two smaller segments of equal length.
2. The ____________ of a triangle is the point at which the three medians intersect.
3. Three or more lines that intersect at a common point are called ____________.
4. A(n) ____________ of a triangle is a line segment that connects a vertex to the midpoint of the side opposite the vertex.
5. The ____________ of a triangle is the point at which the three perpendicular bisectors intersect.
6. The point at which three or more lines intersect is called the ____________.
7. A(n) ____________ is a segment bisector that is also perpendicular to the line segment.
8. The ____________ of a triangle is the point at which the three angle bisectors intersect.
9. To divide an angle into two smaller angles of equal measure is to ____________.
10. A perpendicular line segment that is drawn from a vertex to the opposite side is called an ____________.
11. A(n) ____________ is a line that divides an angle into two smaller angles of equal measure.
12. The ____________ of a triangle is the point at which the three altitudes intersect.
13. To divide a segment into two smaller segments of equal length is to ____________.

Problem Set

Use a compass and straightedge to construct an angle bisector of each angle.

1



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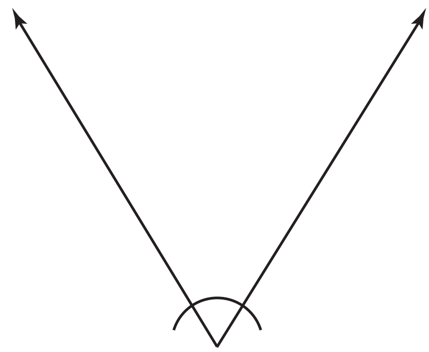

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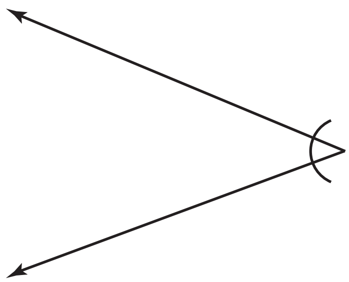

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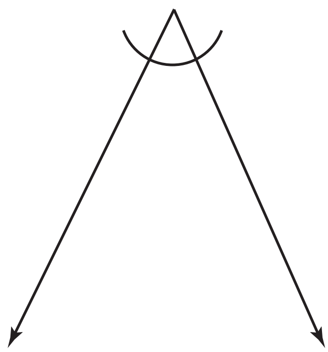

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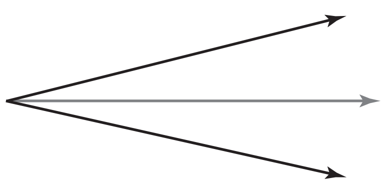
Trace each angle onto patty paper and construct an angle bisector on the patty paper.

5.



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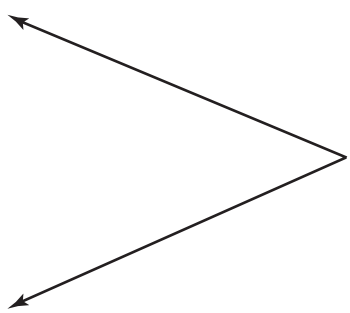

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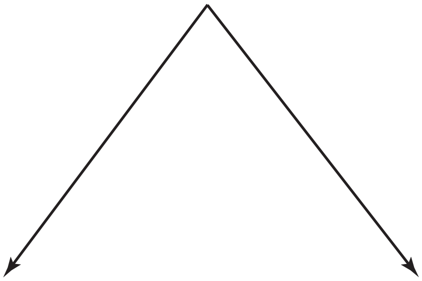

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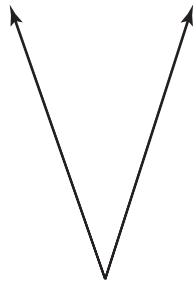
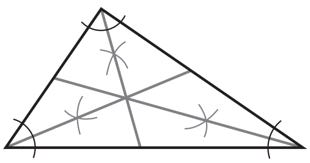


Use a compass and straightedge to construct angle bisectors for each angle of the triangle to construct the incenter of the triangle. Then, using patty paper, trace the triangle and construct the incenter on the patty paper to see if you get the same result.

9.



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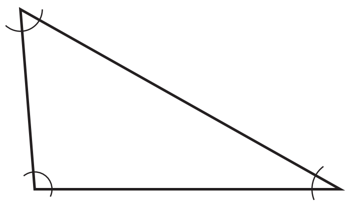

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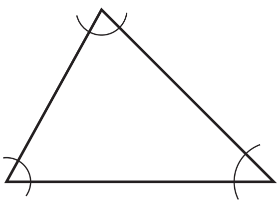

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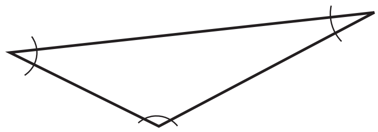

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Use a compass and straightedge to construct the perpendicular bisector of each line segment. Then, using patty paper, trace the line segment and construct a perpendicular bisector with the patty paper to see if you get the same result.

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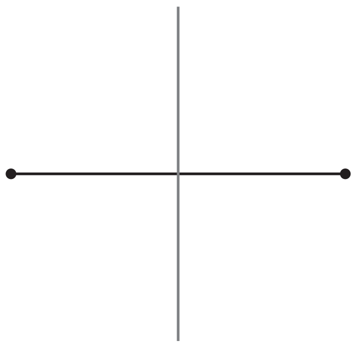

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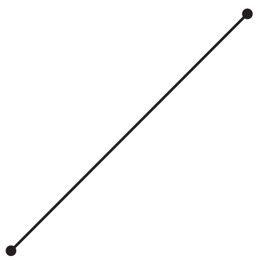

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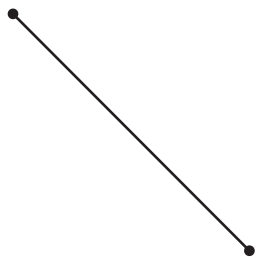
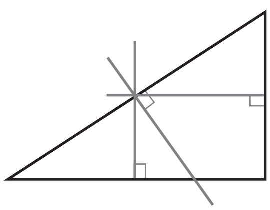


Use a compass and straightedge to construct the perpendicular bisector of each side of the triangle and then construct the circumcenter of the triangle.

17.



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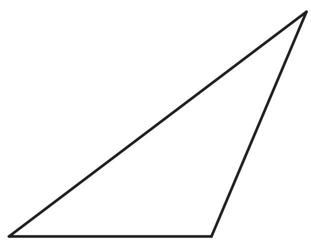

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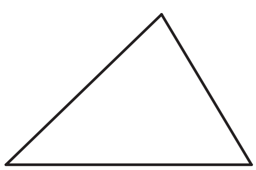

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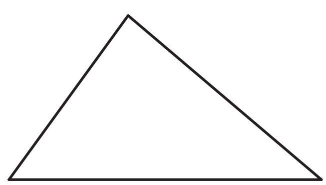

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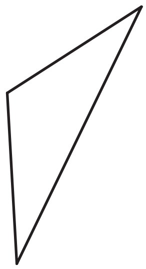

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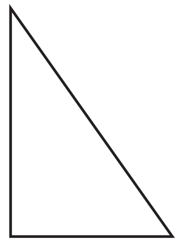
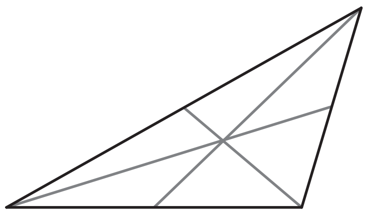


Use a compass and straightedge to construct the three medians of the triangle and construct the centroid. Then, using patty paper, trace the triangle and construct the centroid with the patty paper to see if you get the same result.

23.



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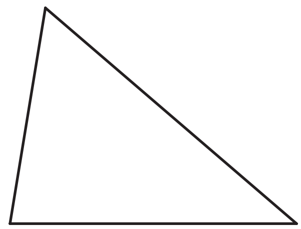

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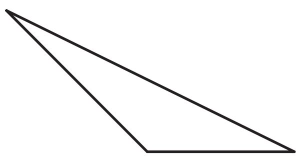

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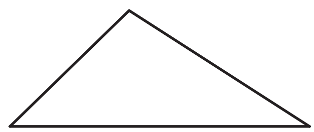
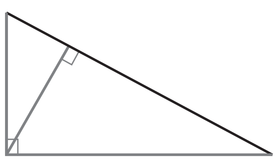


Use a compass and straightedge to construct the three altitudes of the triangle and construct the orthocenter. Then, using patty paper, trace the triangle and construct the orthocenter with the patty paper to see if you get the same result.

27.



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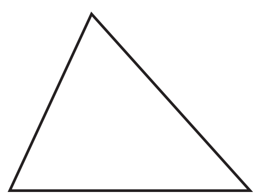

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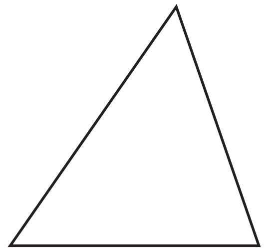

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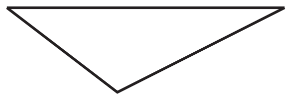

Compare the parts of the given types of triangles.

32. Compare the placement of the incenter and circumcenter for acute, obtuse, and right triangles.

For acute triangles, both the incenter and the circumcenter lie on the inside. For right triangles, the incenter lies on the inside of the triangle, while the circumcenter lies on the hypotenuse. For obtuse triangles, the incenter lies on the inside, while the circumcenter is outside the triangle.

5

33. Compare the placement of the incenter and centroid for acute, obtuse, and right triangles.

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34. Compare the placement of the incenter and orthocenter for acute, obtuse, and right triangles.

35. Compare the placement of the circumcenter and centroid for acute, obtuse, and right triangles.

36. Compare the placement of the circumcenter and orthocenter for acute, obtuse, and right triangles.

37. Compare the placement of the centroid and orthocenter for acute, obtuse, and right triangles.

Name ______________________________ Date ______________

Properties of Triangles
Direct and Indirect Proof

Vocabulary

Write the term that best completes each statement.

1. A(n) ______________________ is a way of writing a proof such that each step is listed in one column and the reason for each step is listed in the other column.

2. The ______________________ says an exterior angle of a triangle is greater than either of the two remote interior angles of the triangle.

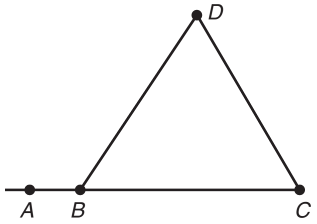
3. According to the ______________________ , if $a = b + c$ and $c > 0$, then $a > b$.

4. The ______________________ says that the measure of an exterior angle of a triangle is equal to the sum of the measures of the two remote interior angles of the triangle.

5. The ______________________ means assuming the opposite of the conclusion.

Problem Set

For the triangle shown, use a direct proof to prove each statement.

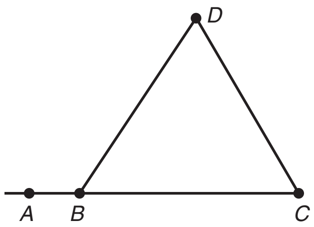


1. $m\angle ABD > m\angle C$

Statements	Reasons
1. Angle *ABD* is an exterior angle of triangle *BCD*.	**1.** Given
2. $\angle CBD + \angle C + \angle D = 180°$	**2.** Triangle Sum Theorem
3. $\angle ABD$ and $\angle CBD$ are a linear pair	**3.** Linear Pair Postulate
4. $m\angle ABD + m\angle CBD = 180°$	**4.** Definition of a linear pair
5. $m\angle C + m\angle D = m\angle ABD$	**5.** Subtraction Property of Equality
6. $m\angle D > 0$	**6.** Definition of angle measure
7. $m\angle ABD > m\angle C$	**7.** Inequality Property

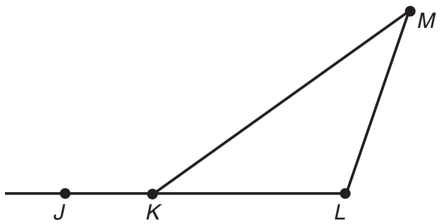
5

Name ______________________ Date ____________



2. $m\angle ABD > m\angle D$

Statements	Reasons
1. Angle *ABD* is an exterior angle of triangle *BCD*.	**1.** Given
2.	**2.**
3.	**3.**
4.	**4.**
5.	**5.**
6.	**6.**
7.	**7.**

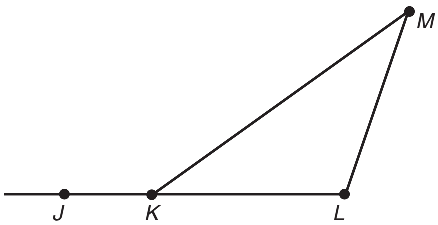


3. $m\angle JKM > m\angle L$

Statements	Reasons
1. Angle *JKM* is an exterior angle of triangle *KLM*.	**1.** Given
2.	**2.**
3.	**3.**
4.	**4.**
5.	**5.**
6.	**6.**
7.	**7.**

5

Name ______________________ Date ____________



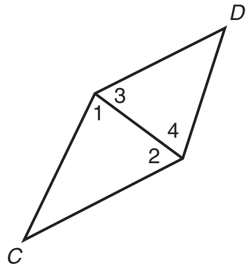
4. $m\angle JKM > m\angle M$

Statements	Reasons
1. Angle *JKM* is an exterior angle of triangle *KLM*.	**1.** Given
2.	**2.**
3.	**3.**
4.	**4.**
5.	**5.**
6.	**6.**
7.	**7.**

5

Complete each proof using the indicated method.

5. Use a direct proof to prove the statement.



Given: $m\angle 1 = m\angle 4$, $m\angle 2 = m\angle 3$

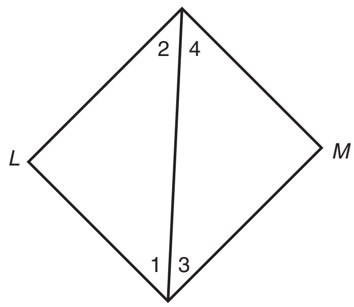
Prove: $m\angle C = m\angle D$

Statements	Reasons
1. $m\angle 1 = m\angle 4$	**1.** Given
2. $m\angle 2 = m\angle 3$	**2.** Given
3. $m\angle 1 + m\angle 2 + m\angle C = 180°$	**3.** Triangle Sum Theorem
4. $m\angle 3 + m\angle 4 + m\angle D = 180°$	**4.** Triangle Sum Theorem
5. $m\angle 1 + m\angle 2 + m\angle C = m\angle 3 + m\angle 4 + m\angle D$	**5.** Substitution using equations from steps 3 and 4
6. $m\angle 1 + m\angle 2 + m\angle C = m\angle 1 + m\angle 2 + m\angle D$	**6.** Substitution using equations from steps 1, 2, and 5
7. $m\angle C = m\angle D$	**7.** Subtraction Property of Equality

5

Name ____________________ Date ____________

6. Use a direct proof to prove the statement.



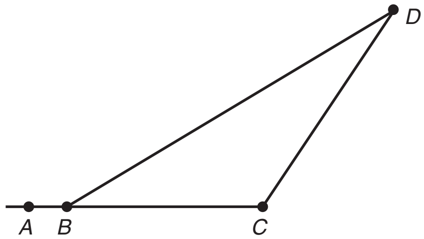
Given: $m\angle 1 = m\angle 4$, $m\angle 2 = m\angle 3$

Prove: $m\angle L = m\angle M$

Statements	Reasons
1.	**1.**
2.	**2.**
3.	**3.**
4.	**4.**
5.	**5.**
6.	**6.**
7.	**7.**

5

7. Use an indirect proof with proof by contradiction to prove the statement.



Given: $\angle ABD$ is an exterior angle of $\triangle BCD$

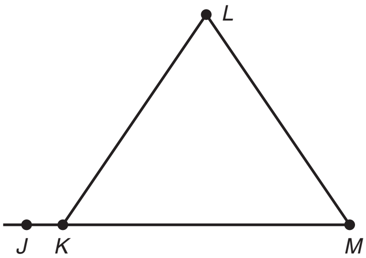
Prove: $m\angle ABD > m\angle C$

Statements	Reasons
1. Angle *ABD* is an exterior angle of triangle *BCD*.	**1.** Given
2.	**2.**
3.	**3.**
4.	**4.**
5.	**5.**
6.	**6.**
7.	**7.**
8.	**8.**
9.	**9.**
10.	**10.**

5

Name ______________________________ Date ______________

8. Use an indirect proof with proof by contradiction to prove the statement.



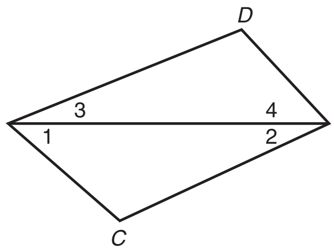
Given: $\angle JKL$ is an exterior angle of $\triangle KLM$.

Prove: $m\angle JKL > m\angle M$

Statements	Reasons
1. Angle *JKL* is an exterior angle of triangle *KLM*.	**1.** Given
2.	**2.**
3.	**3.**
4.	**4.**
5.	**5.**
6.	**6.**
7.	**7.**
8.	**8.**
9.	**9.**
10.	**10.**

5

9. Use an indirect proof with proof by contradiction to prove the statement.



Given: $m\angle 1 = m\angle 4$, $m\angle 2 = m\angle 3$

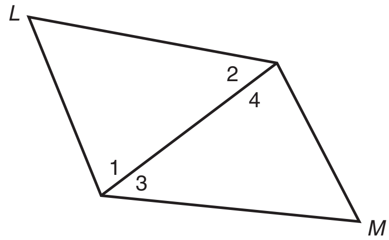
Prove: $m\angle C = m\angle D$

Statements	Reasons
1.	**1.**
2.	**2.**
3.	**3.**
4.	**4.**
5.	**5.**
6.	**6.**
7.	**7.**
8.	**8.**

5

Name ______________________________ Date ______________

10. Use an indirect proof with proof by contradiction to prove the statement.



Given: $m\angle 1 = m\angle 4$, $m\angle 2 = m\angle 3$

Prove: $m\angle L = m\angle M$

Statements	Reasons
1.	**1.**
2.	**2.**
3.	**3.**
4.	**4.**
5.	**5.**
6.	**6.**
7.	**7.**
8.	**8.**

5

Name ______________________________ Date ________________

Computer Graphics
Proving Triangles Congruent: SSS and SAS

Vocabulary

Match each term with its definition.

1. Side-Side-Side Congruence Theorem

2. Side-Angle-Side Congruence Theorem

3. paragraph proof

a. If two pairs of corresponding sides of triangles are congruent, and the included angles are congruent, the triangles themselves are congruent.

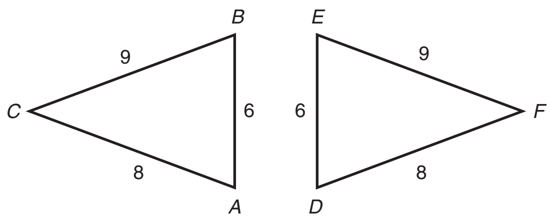
b. a proof written in paragraph form

c. If the corresponding sides of two triangles are congruent, then the triangles themselves are congruent.

Problem Set

Complete the two-column proof and use the Side-Side-Side Similarity Postulate to prove that the two triangles are congruent.

1.



Statements	Reasons
1. $AB = DE = 6, BC = EF = 9, CA = FD = 8$	1. Given
2. $\frac{AB}{DE} = 1, \frac{BC}{EF} = 1, \frac{CA}{FD} = 1$	2. Division Property of Equality
3. $\frac{AB}{DE} = \frac{BC}{EF} = \frac{CA}{FD}$	3. **Transitive Property of Equality**
4. $\Delta ABC \sim \Delta DEF$	4. SSS Similarity Postulate
5. $\angle A \cong \angle D, \angle B \cong \angle E, \angle C \cong \angle F$	5. Definition of similar triangles
6. $\Delta ABC \cong \Delta DEF$	6. **Definition of congruence**

5

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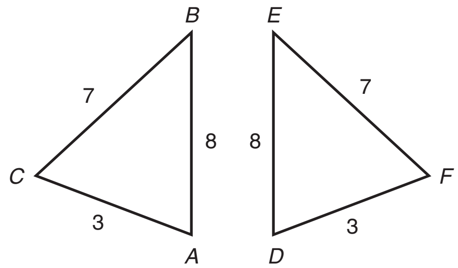
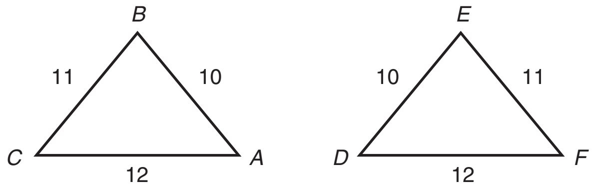
2.



Statements	**Reasons**
1. $AB = DE = 8$, $BC = EF = 7$, $CA = FD = 3$	**1.**
2. $\frac{AB}{DE} = 1$, $\frac{BC}{EF} = 1$, $\frac{CA}{FD} = 1$	**2.**
3.	**3.** Transitive Property of Equality
4. $\Delta ABC \sim \Delta DEF$	**4.**
5.	**5.** Definition of similar triangles
6.	**6.** Definition of congruence

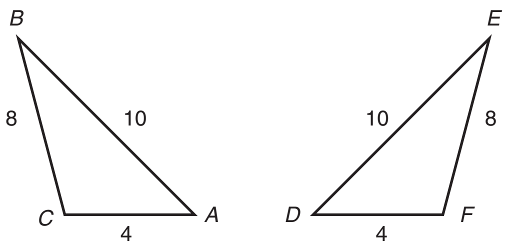
5

3.



Statements	Reasons
1.	**1.** Given
2.	**2.** Division Property of Equality
3. $\frac{AB}{DE} = \frac{BC}{EF} = \frac{CA}{FD}$	**3.**
4.	**4.** SSS Similarity Postulate
5. $\angle A \cong \angle D$, $\angle B \cong \angle E$, $\angle C \cong \angle F$	**5.**
6.	**6.** Definition of congruence

4.

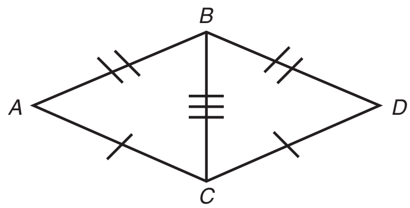


Statements	Reasons
1. $AB = DE = 10$, $BC = EF = 8$, $CA = FD = 4$	**1.**
2.	**2.** Division Property of Equality
3. $\frac{AB}{DE} = \frac{BC}{EF} = \frac{CA}{FD}$	**3.**
4.	**4.** SSS Similarity Postulate
5. $\angle A \cong \angle D$, $\angle B \cong \angle E$, $\angle C \cong \angle F$	**5.**
6.	**6.** Definition of congruence

Name ______________________________ Date ______________

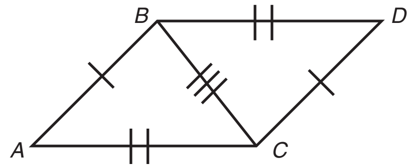
Use either the Side-Side-Side Congruence Theorem or the Side-Angle-Side Congruence Theorem to show that each pair of triangles is congruent.

5.



From the figure, $\overline{AB} \cong \overline{BD}$, $\overline{AC} \cong \overline{CD}$, $\overline{BC} \cong \overline{BC}$. Thus $\Delta ABC \cong \Delta DBC$ by the SSS Congruence Theorem.

6.



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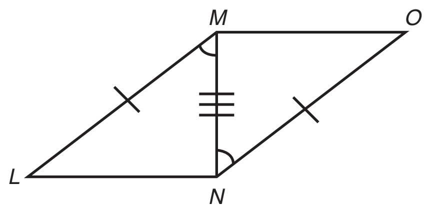

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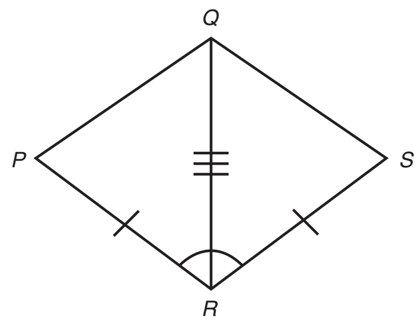

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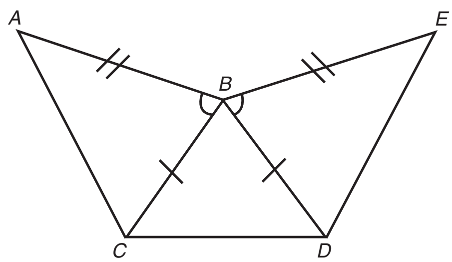

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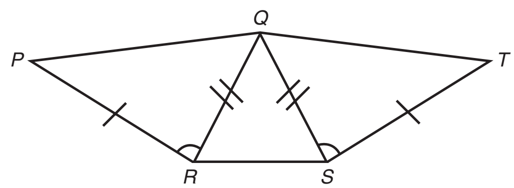

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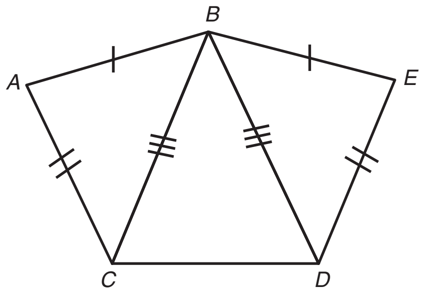

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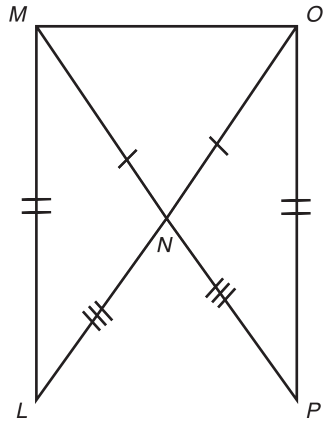

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Name ______________________________ Date ____________________

Wind Triangles
Proving Triangles Congruent: ASA and AAS

Vocabulary

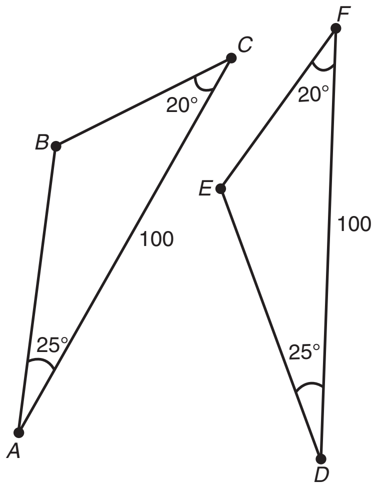
Explain the similarities and differences between the two terms.

1. Angle-Side-Angle Congruence Postulate and Angle-Angle-Side Congruence Theorem

Problem Set

Use the ASA Postulate to show that each pair of triangles is congruent.

1.



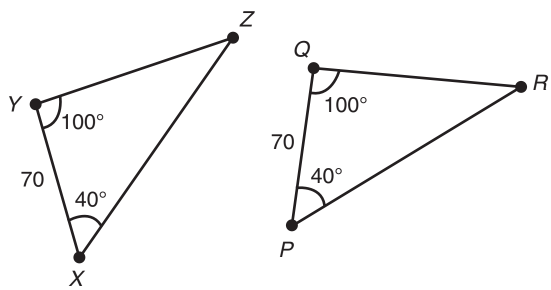
$\angle A = 25°$, $\angle C = 20°$, $\overline{AC} = 100$

$\angle D = 25°$, $\angle F = 20°$, $\overline{DF} = 100$

Therefore $\angle A \cong \angle D$, $\angle C \cong \angle F$, $\overline{AC} \cong \overline{DF}$, and by the ASA Postulate,

$\Delta ABC \cong \Delta DEF$.

2.



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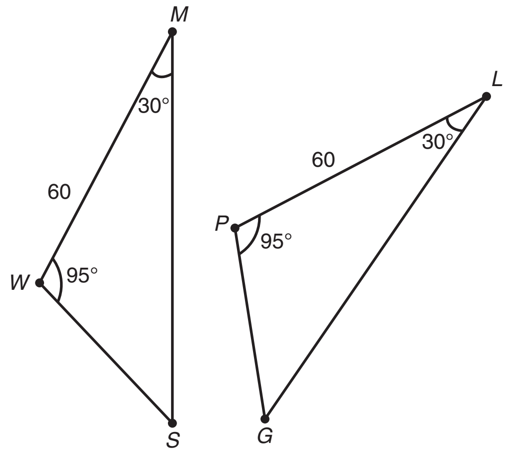
3.



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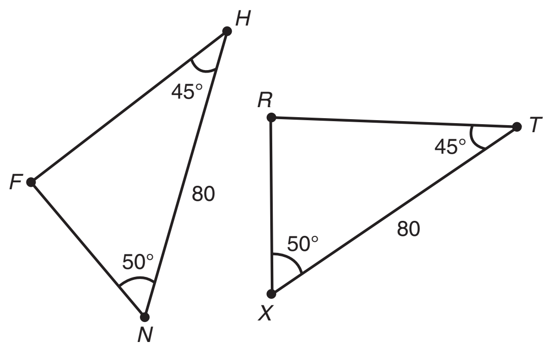

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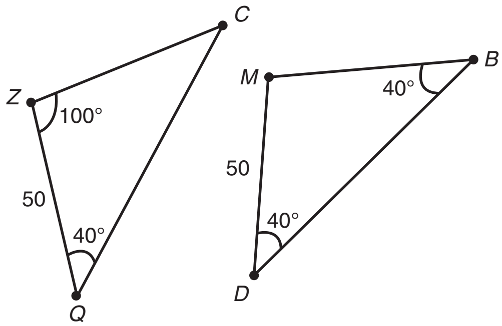

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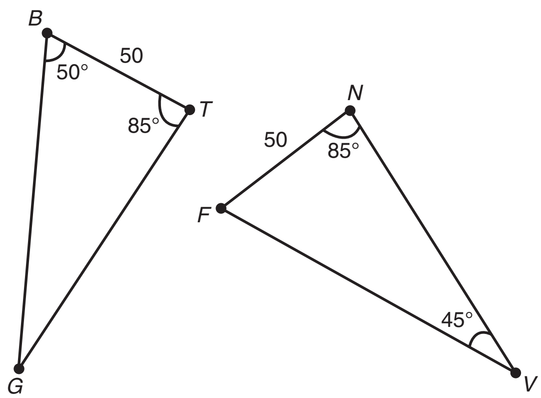

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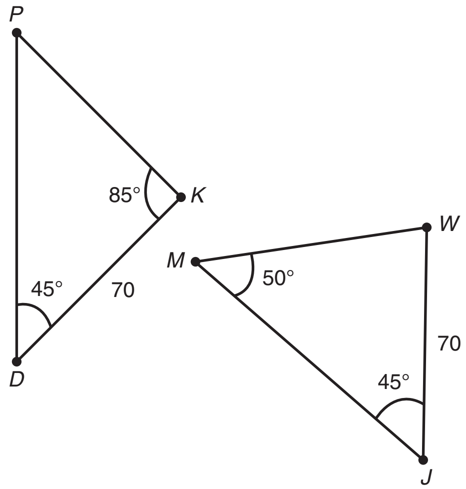

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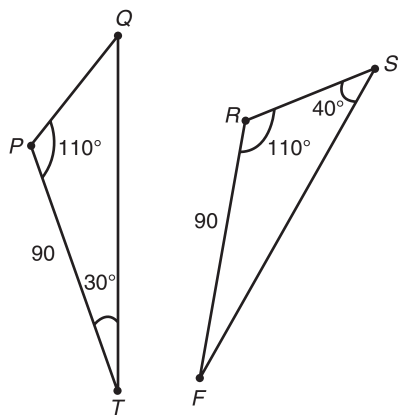

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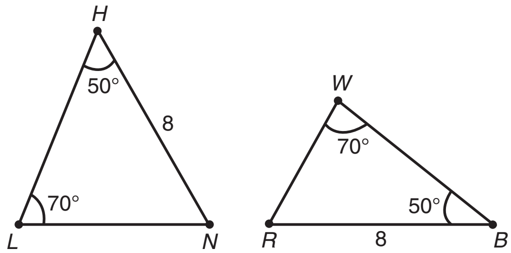
Use the AAS Theorem to show that each pair of triangles is congruent.

9.



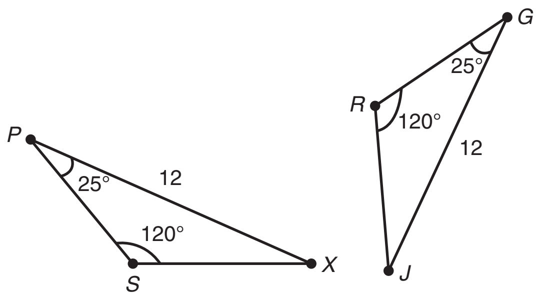
$\angle L = 70°$, $\angle H = 50°$, $\overline{HN} = 8$

$\angle W = 70°$, $\angle B = 50°$, $\overline{BR} = 8$

Therefore $\angle L \cong \angle W$, $\angle H \cong \angle B$, $\overline{HN} \cong \overline{BR}$, and by the AAS Theorem,

$\Delta LHN \cong \Delta WBR$.

10.



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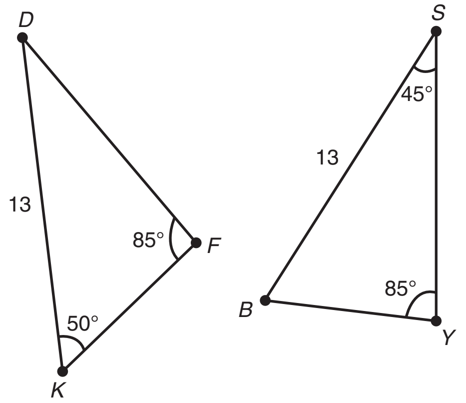

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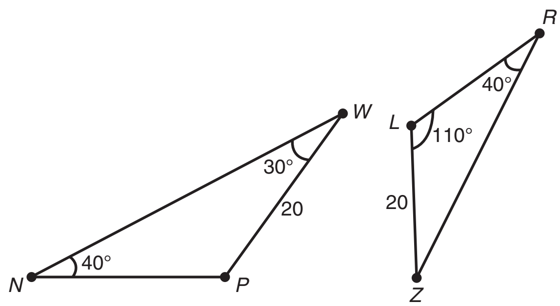

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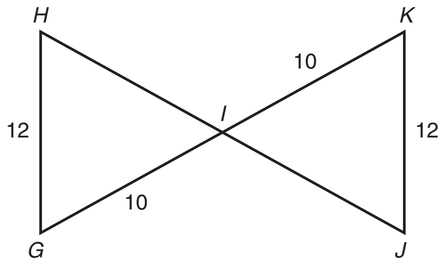
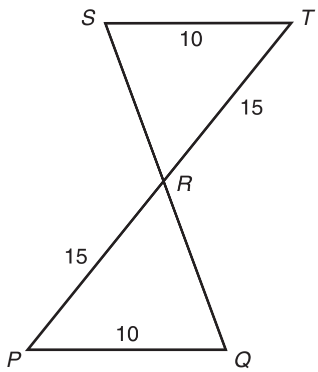
Determine whether there is enough information to tell whether the two triangles are congruent. If there is enough information, determine whether they are congruent.

13.



No, there is not enough information. We can see that $\angle HIG \cong \angle JIK$, and we know that $\overline{GI} = \overline{KI} = 10$ and $\overline{HG} = \overline{JK} = 12$, so two pairs of sides are congruent and one pair of angles is congruent. But these are not the included angles, and the relationship between the remaining angles cannot be determined, so none of the congruence postulates or theorems can be used.

14.



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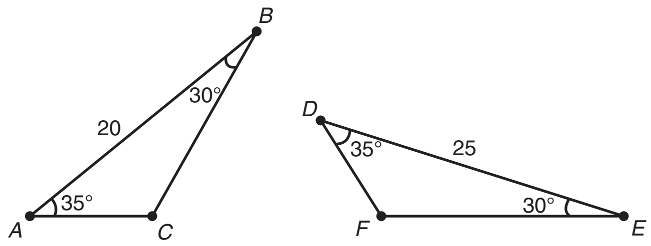
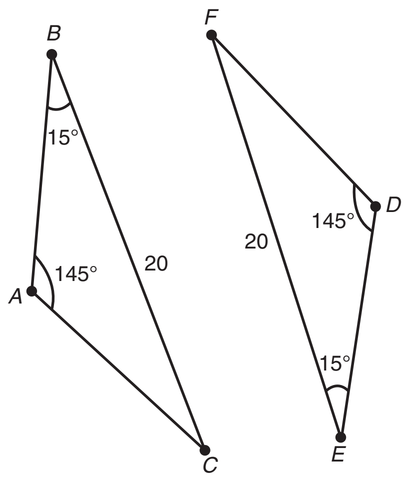
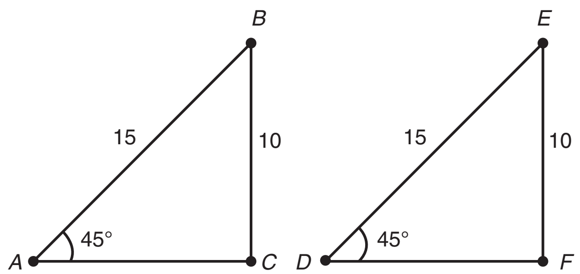
15.


B
30°
20
A
35°
C
D
35°
25
30°
F
E

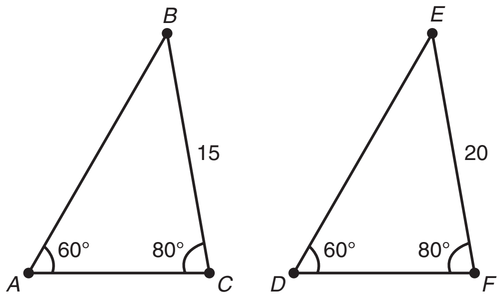
16.


B
15°
145°
20
A
C
F
D
145°
20
15°
E

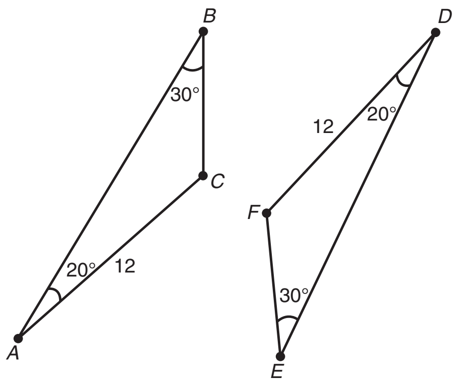
17.


B
15
10
A
45°
C
E
15
10
D
45°
F

18.

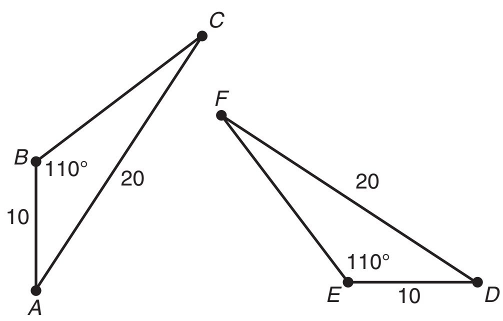

B
15
60°
80°
A
C
E
20
60°
80°
D
F

19.


B
30°
C
20°
12
A
D
12
20°
F
30°
E

5

20.


C
B
110°
20
10
A
F
20
110°
E
10
D

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Planting Grape Vines
Proving Triangles Congruent: HL

Vocabulary

Define each term in your own words.

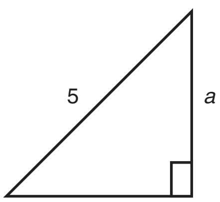
1. hypotenuse

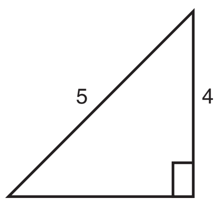
2. Hypotenuse-Leg Congruence Theorem

Problem Set

Show that the two triangles in each figure are congruent.

1.





In the first triangle, you can apply the Pythagorean Theorem to get a value for *a*:

$3^2 + a^2 = 5^2$

$9 + a^2 = 25$

$a^2 = 16$

$a = 4$

Similarly, in the second triangle, you can apply the Pythagorean Theorem to get a value for *b*:

$b^2 + 4^2 = 5^2$

$b^2 + 16 = 25$

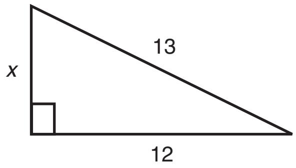
$b^2 = 9$

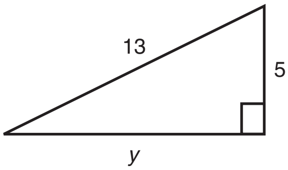
$b = 3$

Thus the two right triangles have both legs congruent, and by the SAS, SSS, or HL Theorems, the two triangles are congruent.

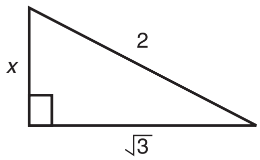
5

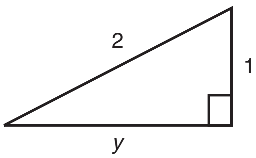
2.





3.





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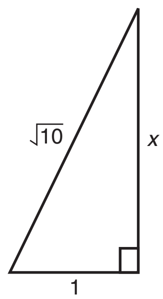
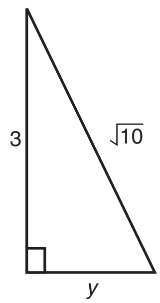
4.





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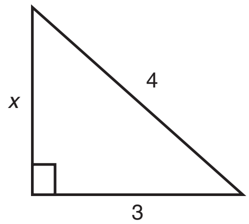

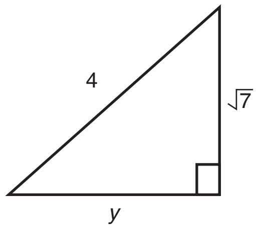

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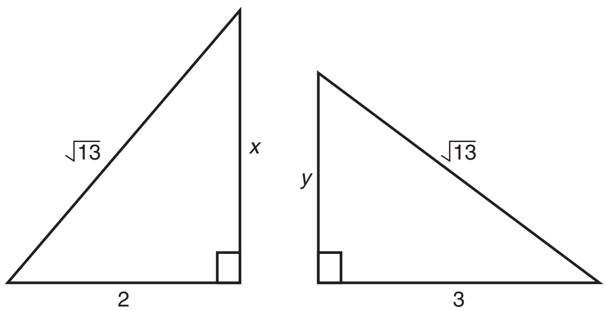
6.

Use the Hypotenuse Leg Congruence Theorem to show that the two triangles in each figure are congruent.

7.



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In the first triangle, you can apply the Pythagorean Theorem to get a value for *x*:

$2^2 + x^2 = (\sqrt{13})^2$

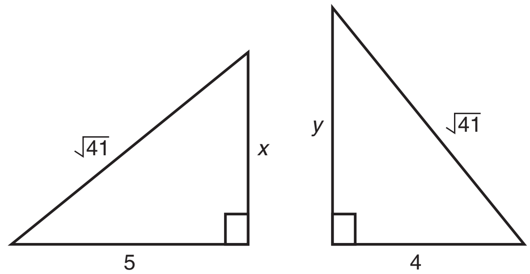
$4 + x^2 = 13$

$x^2 = 9$

$x = 3$

Now the hypotenuse and one leg of the first right triangle are congruent to the hypotenuse and one leg in the other right triangle. Thus by the Hypotenuse-Leg Congruence Theorem, the two triangles are congruent.

8.



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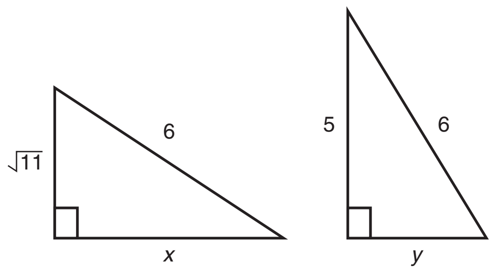

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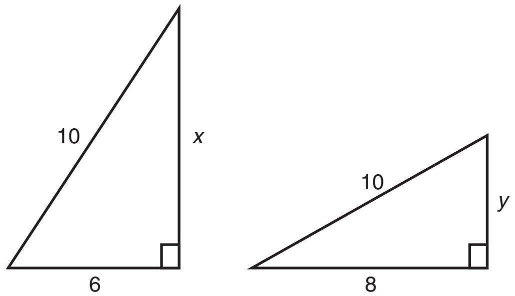

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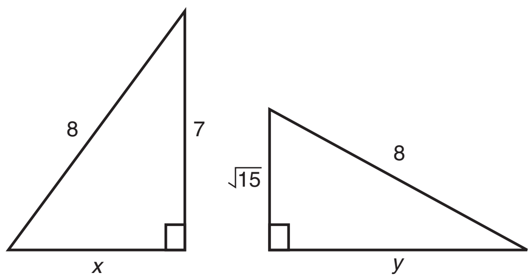

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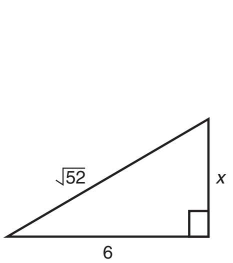
12.



Show that the two triangles in each figure are congruent.

13.

In the first triangle, you can apply the Pythagorean Theorem to get a value for x:

$x^2 + 3^2 = (\sqrt{13})^2$

$x^2 + 9 = 13$

$x^2 = 4$

$x = 2$

You can also apply the Pythagorean Theorem to the second triangle to solve for y:

$y^2 + 3^2 = (\sqrt{13})^2$

$y^2 + 9 = 13$

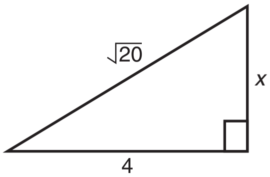
$y^2 = 4$

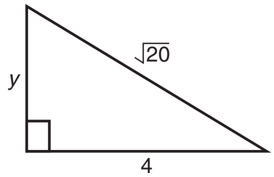
$y = 2$

Therefore, both right triangles have legs of length 2 and 3 and a hypotenuse of length $\sqrt{13}$. By the SAS or SSS Theorems, the two triangles are congruent.

5

14.





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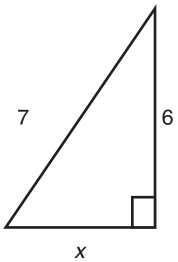

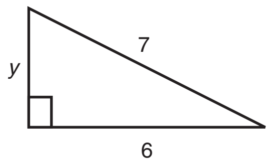

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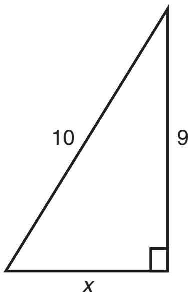
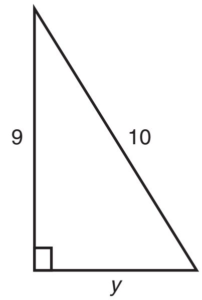
16.





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