12. **If two segments don't intersect, then they're always parallel.** This is false. To see this, draw two segments that don't cross but that point at each other. The lines through them will cross so the segments aren't parallel.

13. **Skew lines never intersect.** This is true. By the definition, if two lines are skew then they don't intersect in addition to being non-coplanar.

Answer the following questions in complete sentences.

14. **If you draw a plane and then draw a line in it, how many other lines in the same plane are parallel to it?** There are infinitely many lines parallel to the first line.

15. **If I give you two parallel lines, is it possible to draw a third line that's parallel to one of the two but not the other?** It is *not* possible to draw a line that's parallel to only one of the two original parallel lines.

16. **If I give you two parallel lines, is it possible to draw a third line in the same plane as the first two that's parallel to one but not the other?** It isn't possible to draw a line in the same plane that's parallel to only one of two parallel lines.

Technical Writing

17. **Explain the difference between parallel lines and skew lines.** Parallel lines never intersect and have to be in the same plane. Skew lines never intersect but are *not* in the same plane.

18. **Explain the relationship between parallel lines and parallel rays.** Parallel rays are contained in parallel lines. In order for two rays to be parallel, the lines that contain them have to be parallel.

Section 2.2 – Transversals

In This Section

In this chapter, we take the next logical step and let a third line cross our parallel lines. This creates angles that have interesting relationships. We'll look more closely at that in the next section. In this one, you should focus on knowing the names of the different pairs of angles formed by a transversal. They'll come up repeatedly throughout the rest of this chapter and on occasion throughout the rest of the text.

Learning Objectives

1. Identify the transversal crossing two lines.

2. Given two lines and a transversal, identify corresponding angles, alternate interior angles and alternate exterior angles

Required Material

Students should understand the difference between parallel and non-parallel lines.

Teaching Suggestions

Warm Up Questions Say I give you three lines to play with. How many different ways can the lines cross? (Another way of saying this is, "At how many different points can the lines cross?") Try actually drawing some lines on a piece of paper. Your students should come up with

1. **0 intersections** This would look like three parallel lines.

2. **1 intersection** The lines all cross in a single point making a shape like an asterisk.

3. **2 intersections** Two parallel lines with a third line that cuts across them.

4. **3 intersections** In this arrangement, the lines form the shape of a triangle.

What does the English word "transverse" mean? How does that relate to our definition of a "transversal"?

Medicine Doctors have a special meaning for the word "transverse" that's similar but not identical to ours. In medicine, a "transverse" is something that lies perpendicular to the long axis of something else. For example, the transverse colon is the part that runs across the top of the abdomen from left to right, perpendicular to the long axis of the body, i.e. the one that runs from your head to your feet. For another example, have your students research the "transverse ligament".

Distance between Lines In Chapter One, where we allowed lines to intersect, there was no point in discussing the distance between lines. By picking the right two points, you could literally get any distance you wanted. With parallel lines, we can be more precise. Because the lines never cross, it's possible to find the shortest distance between the points. Try to find this on your own. Draw a pair of parallel lines, pick a point on one of them and measure the distance to random points on the other line. You should find that the shortest distance belongs to the segment that's perpendicular to both of the two parallel lines.

A Short Application – Distance between Lines If you need to determine the distance between two parallel lines, the best way is to construct a line perpendicular to them. The length of the segment on the perpendicular line that lies between the two parallel lines will be the distance between them. The application section at the end of this chapter gives a procedure for constructing a pair of perpendicular lines.
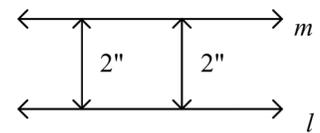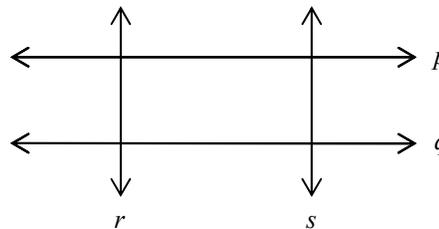
Exercise Solutions

List all of the transversals and the lines they cross in the following pictures.

1. *l* is a transversal of *m* and *n*
    m is a transversal of *l* and *n*
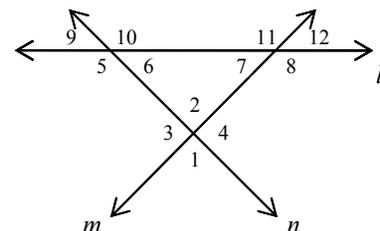   *n* is a transversal of *l* and m
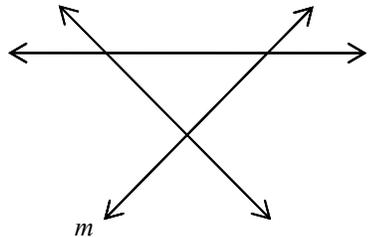
2. *r* and *s* are both transversals of *p* and *q*
    p and *q* are both transversals of *r* and *s*

Use the figure to the right to answer questions 3 through 6.

3. **List three pairs of alternate interior angles.**
    There are six all together: $\angle 6$ and $\angle 3$, $\angle 2$ and $\angle 5$, $\angle 7$ and $\angle 4$, $\angle 2$ and $\angle 8$, $\angle 7$ and $\angle 10$, $\angle 6$ and $\angle 11$

4. **List two pairs of corresponding angles.**
   There are twelve all together: ∠10 and ∠2, ∠6 and ∠4, ∠9 and ∠3, ∠5 and ∠1, ∠2 and ∠11, ∠3 and ∠7, ∠12 and ∠4, ∠1 and ∠8, ∠9 and ∠11, ∠ 10 and ∠12, ∠5 and ∠7, ∠6 and ∠8

5. **List three pairs of alternate exterior angles.**
   There are six all together: ∠10 and ∠1, ∠9 and ∠4, ∠12 and ∠3, ∠11 and ∠1, ∠9 and ∠8, ∠5 and ∠12

6. **How many pairs of alternate interior angles are there in the figure?**
   There are six all together: ∠5 and ∠2, ∠6 and ∠3, ∠2 and ∠8, ∠4 and ∠7, ∠10 and ∠7, ∠6 and ∠11

Use the figure to the right to answer questions 7 through 11.

7. **For which lines is line *p* a transversal?** Lines *l* and *m*, lines *m* and *n*, lines *m* and *q*, lines *l* and *n* and lines *l* and *q* . Not lines *n* and *q* because it only crosses them in one point where the definition says there has to be at least two.

8. **For which lines is line *m* a transversal?** *m* is a transversal for lines *p* and *n*, lines *p* and *q* and lines *n* and *q*.

9. **How many transversals do lines *m* and *l* have?** There are 3: *n*, *p* and *q*.

10. **List all of the transversals of lines *n* and *q*.** They have 2: *l* and *m*. *p* is not a transversal because it only crosses *n* and *q* in one point where the definition says it has to cross in at least two.

11. **Give three lines that intersect but where none of the lines is a transversal of the other two.** Lines *n*, *p* and *q* all intersect but no one of them crosses the other two in two different points.

12. **How many pairs of corresponding angles are formed by two parallel lines and a transversal?** There are four pairs of corresponding angles.

13. **How many pairs of corresponding angles are formed by two parallel lines and two transversals?** Pick two parallel lines and one of the transversals. This combination has four pairs of corresponding angles. If you pick the same two parallel lines and the second of its transversals, you get a second set of four pairs for a total of eight. Each of the parallel lines also creates four corresponding angles with one of the non-parallel lines and four more with the other non-parallel line for a grand total of 16.
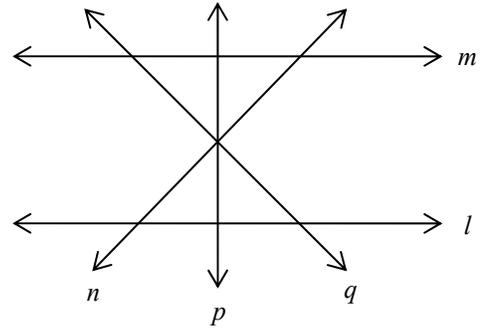
Section 2.3 – Properties of Parallel Lines

In This Section

So now we know what parallel lines are and we also have some useful language for describing the angles that are created when a third line cuts across two others whether they're parallel or not. In this section, we look at some of the properties of those angles.

Learning Objectives

1. Use the relationships between the pairs of angles formed by parallel lines and a transversal to determine the measures of pairs of angles formed by the lines.

Required Material

Students should be able to identify parallel lines and a transversal. They should also be able to identify the special pairs of angles formed by a transversal.

Teaching Suggestions

Angle Relationships Have your students draw a pair of parallel lines and with a transversal crossing them. Next, measure all eight of the angles formed by the three lines. If you pick a pair of angles, e.g. a pair of alternate interior angles or a pair of corresponding angles, you should see that some of the pairs congruent where others are