A rotation requires a center and a degree measure. Write or say, "The center of Motion Man is the center of rotation; rotate him 90 degrees (clockwise)." For all students, ELLs in particular, it is important that these demonstrations include explicit practice with the terms and that visuals are posted for reference. Practice by having everyone start with his or her Motion Man in the same orientation. As you announce one of the moves, students translate, reflect, or rotate Motion Man accordingly.

As a follow-up, display two Motion Men side by side in any orientation. The task is to decide what motion or combination of motions will get the man on the left to match the man on the right. Students use their own man to work out a solution. Test the solutions that students offer.

Stop and Reflect

In the previous activity, instructions were given for one way to do each transformation. What slight shifts in the directions can adapt this task to provide more and different experiences for students to explore translations, reflections, and rotations in meaningful ways? ■

Tessellations

Tessellations are a motivating and artistic application of transformations. A *tessellation* is a tiling of the plane in which one or more shapes appear in a repeating pattern with no gaps or overlaps (Figure 13.18a). Tessellations are based on the circle—if the angle measures add up to 360 degrees, the shapes will fit together at a vertex with no overlaps or gaps. A *regular tessellation* is made of a single polygon. Therefore, only certain polygons can be used for regular tessellations.

Stop and Reflect

Which regular polygons can be used to form regular tessellations? Which combinations of polygons can be used to form semi-regular tesselations? ■

A regular triangle (equilateral) has angles of 60 degrees, so six triangles can form a tessellation. Likewise, four squares can form a tessellation, and so can three regular hexagons.

A *semi-regular tessellation* is made of two or more different regular polygons. These tessellations are defined by the series of shapes meeting at a vertex. An excellent activity for middle-school students is to explore which polygons can form a semi-regular tessellation and design their own illustration of that tessellation (Figure 13.18b).

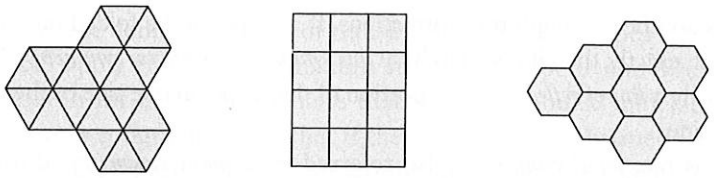
The Dutch artist M. C. Escher is well-known for his tessellations, in which the tiles are very intricate and often shaped like birds, horses, or lizards. Escher took a simple shape such as a triangle, parallelogram, or hexagon and performed transformations on the sides. For example, a curve drawn along one side might be *translated* (slid) to the opposite side (Figure 13.18c). If the altered line is rotated to an adjacent side, the shape will also be tessellated, and the objects will look as if they have turned. Once a tile has been designed, it can be traced over and over again.

technology note

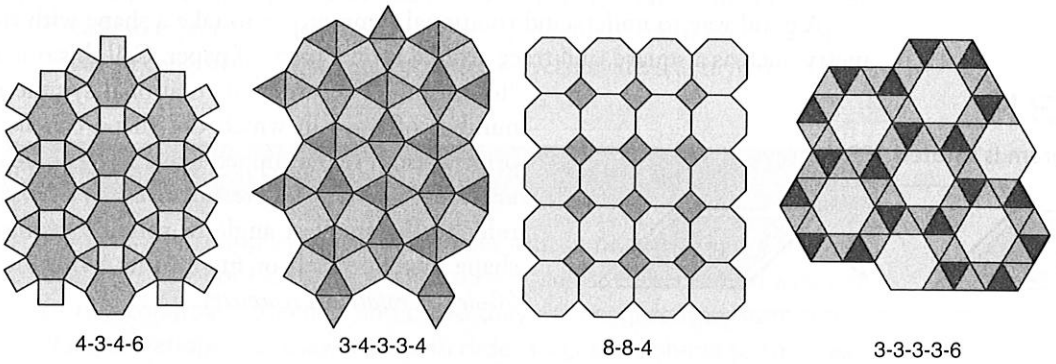
Tessellations can be created by hand or with technology. See, for example, "Semi-regular Tessellations" at http://nrich.maths.org/4832 or "Tessellate!" at www.shodor.org/interactivate/activities/Tessellate.

Figure 13.18 Regular and semi-regular tessellations with polygons.

(a) Regular Tessellations

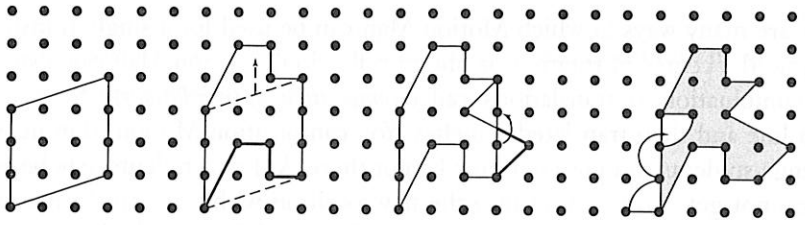


(b) Semi-Regular Tessellations



4-3-4-6 3-4-3-3-4 8-8-4 3-3-3-3-6

(c) Altering a Parallelogram to Create an Escher-Like Design



1. Start with a simple shape.
2. Draw the same curve on two opposite sides. This tile will stack up in columns.
3. Rotate a curve on the midpoint of one side.
4. Rotate a curve on the midpoint of the other side. Use this tile for tessellation (below).

A column of this tile will now match a like column that is rotated one complete turn. Find these rotated columns in the tessellation below.