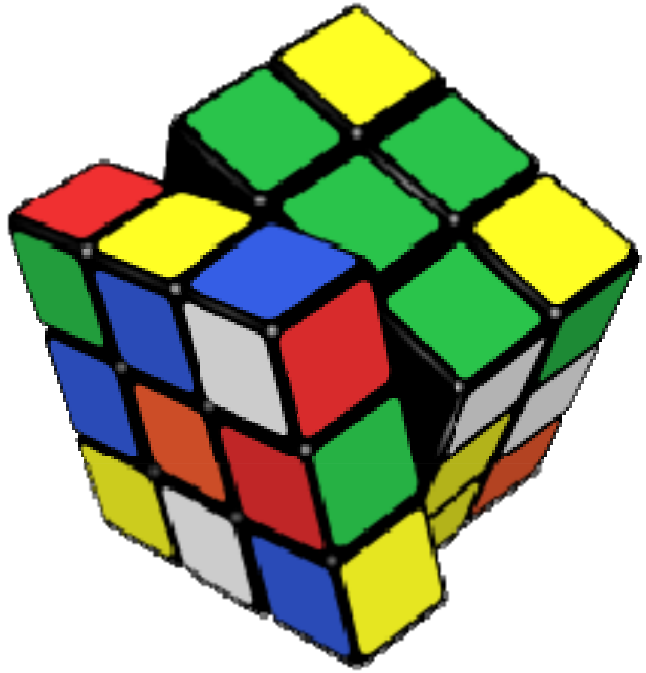
INTRODUCTION TO RUBIK'S CUBE



Rubik’s cube is a fascinating puzzle that was invented in 1974 by a Hungarian sculptor and professor of architecture named Ernös Rubik, but it wasn’t until 1980 that the puzzle began to be marketed in the United States by Ideal Toy Corporation and, subsequently, became widely popular. The puzzle itself is deceptively simple in appearance. You have a cube with six faces, and each face of the cube is divided into several smaller cubes, and then the faces themselves can be rotated in several directions in order to create an almost unfathomable number of permutations of the colored squares on each little cube. Many a person has spent many an hour trying to figure out how to unscramble their cube only to simply take it apart with a screwdriver and then reassemble it!

When we look at the cube, we quickly realize that there are six basic moves that we can perform on the cube, and we'll denote these moves by the letters *R*, *L*, *U*, *D*, *F*, and *B*. These moves represent making quarter-turns in the clockwise direction, respectively, of the right face, left face, up face, down face, front face, and back space of the cube. Some people, however, like to write these letters in the order *BFUDLR* so that it will appropriately be pronounced "befuddler."

If we now want to rotate, for example, the right face of the cube two quarter-turns clockwise, then that move is usually denoted either by R^2 or $2R$ or $R2$. Similarly, we'll use R^3 or $3R$ or $R3$ to indicate that one should turn the right face of the cube clockwise through three quarter-turns. Notice also that R^4 (or $4R$ or $R4$) is the same as doing nothing at all. Furthermore, if we want to turn the right face a quarter-turn in the counterclockwise direction, then the usual notations for that are either R^{-1} or R' or r.

When we are specifying a sequence of moves to be performed on the cube, the custom is to specify those moves in order from left to right. Thus, $R^{-1}DR$ means rotate the right face a quarter-turn counterclockwise, then rotate the down face a quarter-turn clockwise, and finally, rotate the right face a quarter-turn clockwise. Also, clockwise and counterclockwise are defined with respect to what we would see if we were looking at a particular face straight on.

As you might imagine, the mathematics of permutations has an awful lot to do with helping us understand the structure of Rubik's cube, and as you might also guess, the mathematics of symmetry is additionally going to be important. Fortunately, there is one branch of higher mathematics that covers both of these things, and it is known as *group theory*. Thus, this course is going to be both a brief introduction to the wonders of group theory and to the wonders of Rubik's cube, and how the knowledge of one can help us with the other.

Your first task, though, is simply to buy a Rubik's cube and learn how to solve it. I recommend starting with the standard model that is currently sold by Hasbro (see www.hasbrogames.com) and that comes with a good set of instructions. This cube is pretty durable and won't easily fall apart. Later on, you might want a speed cube that is easier to turn, but these also separate into pieces more easily if you are not careful. I also recommend downloading and installing two, free software programs. The first one is called *Rubik* and is found at http://www.geometer.org/rubik/index.html. It will allow you to easily experiment with the cube, and then, with the click of a button, to restore it to its original configuration. The second program is called *Group Explorer* by Nathan Carter, and it can be found at www.platosheaven.com. You'll also be able to find links to both of these pages at my own website, www.docbenton.com as well as instructions on how to solve Rubik's cube. So, let the journey begin!

FACT: There are $43,252,003,274,489,856,000$ permutations that can be made of the little colored squares on the faces of Rubik's cube.

FACT: Any scrambled Rubik's cube can, in theory, be restored to its original configuration in 20 moves or less. This number 20 is known by mathematicians and cube enthusiasts as *God's number!*