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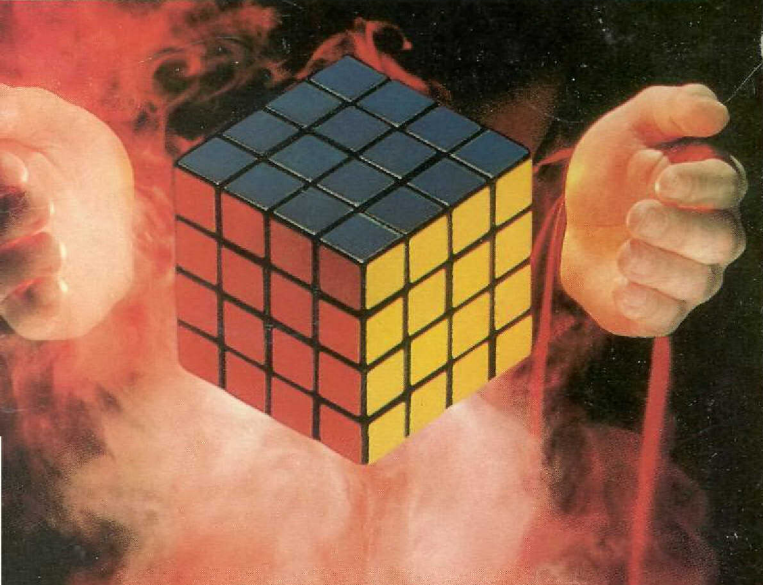
HOW TO SOLVE Rubik's Revenge™*

FULL-COLOR STEP-BY-STEP INSTRUCTIONS TO SOLVE THE SUPERCUBE



JEFFREY ADAMS

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Introduction

Mastering the Cube was just the beginning — now there's the Supercube, alias Rubik's Revenge.™ It's a lot harder, but don't despair. Here is a complete, step-by-step solution to the 4x4x4 Supercube.

This book will help you solve the Supercube, and more. You will understand the Supercube, because before you get bogged down in the step-by-step solution you learn the Basic Moves which *alone* are enough to solve it! These are the *only* moves you need to solve this mind-boggling puzzle.

The nine Basic Moves are listed for convenience on a fold-out flap on the back cover so you can refer to them easily as you follow the solution. You will soon be

able to dispense with the step-by-step solution, and remember only these moves. To make things even simpler, the Basic Moves (with one exception) are all based on a single Basic Basic Move, called a commutator (see pg. 14). It is one of the marvels of the Supercube that one simple procedure allows you to solve this fantastically complex puzzle. There is very little memorization needed! And if you are familiar with the original cube, you will soon see that solving the Supercube isn't much harder.

Don't worry about speed at first. This solution is *conceptual* and *easy to follow* rather than fast, and requires very little memorization. Anyhow, no matter how fast you can solve it there's bound to be someone half your age who can do it twice as fast! The beauty of the puzzle lies in its extraordinary complexity yet ultimate simplicity, in its symmetry and in its patterns. With an understanding of the Supercube you can begin to explore the fascinating world of Supercube patterns.

For those of you set on breaking records (and wrists) there are shortcuts to help you speed up the solution. We have included a sketch of an alternative solution in which you solve the centers first. You may be interested in some more advanced processes, and a sample of possible Supercube patterns. And for the experts there is a brief section on Supercube-theory.

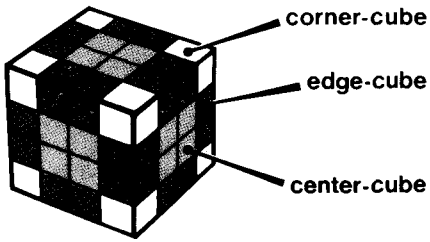
Happy Cubing!

Guide to the Solution

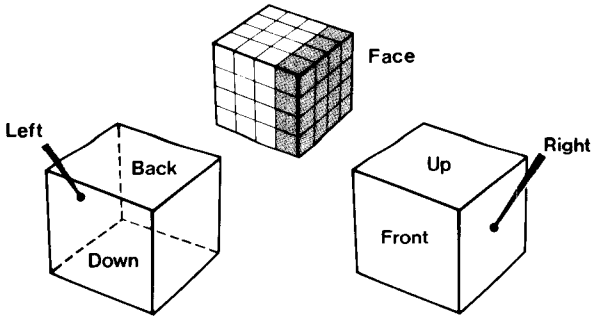
We need a convenient notation to denote moves, parts of the cube, and so forth. We use a simple extension to the Supercube of the notation developed by David Singmaster in Notes on Rubik's Magic Cube, (somewhat of a standard in the industry). If you are familiar with his notation you may wish to skim this section quickly.

Parts of the cube

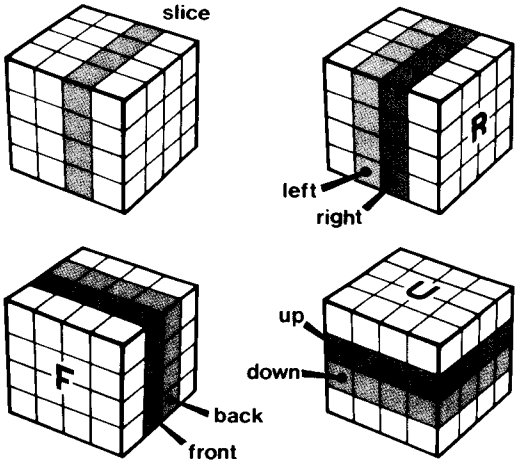
There are 56 sub-cubes in the cube:
24 center-cubes, 24 edge-cubes
and 8 corner-cubes.



There are 6 faces consisting of 16 visible sub-cubes. These are labelled as follows: Up, Down, Left, Right, Front and Back; or U, D, L, R, F and B for short.

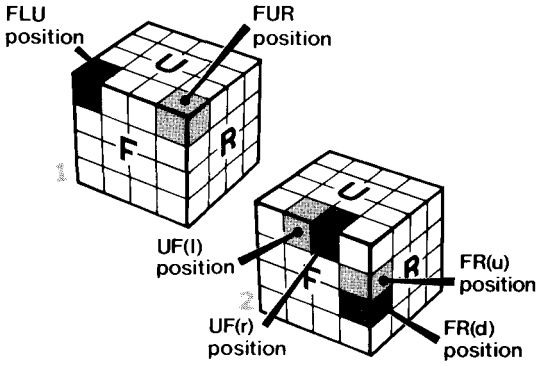


There are also 6 slices consisting of 12 visible sub-cubes. These are labelled as follows: up, down, left, right, front and back; or u, d, l, r, f and b for short.



We label positions within the cube as follows: the position at the Front-Up-Right corner of the cube is called the Front-Up-Right position,[1] or FUR-position. The Front-Left-Up position is called the FLU-position, and so on.

It is not enough to refer to the UF-position for an edge position since there are two such; we distinguish them by using UF(r) and UF(l).[2] The same holds for FR(u) and FR(d),[3] UR(f) and UR(b), and so on. We will not bother labelling centers.

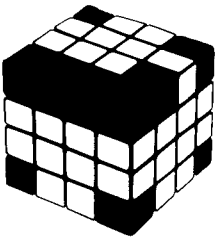


In a 3x3x3 cube the centers are fixed, so you know where every sub-cube must go. So if a corner-cube must go to the FUR-position, we call it the FUR corner-cube. Similarly for edges.

Unfortunately there are no fixed centers in a Super-cube. However, at each step some sub-cubes will be considered fixed, so we label the other sub-cubes in reference to them. For example after Step I the corners are all solved and must remain fixed. Then if your cube looks like this,[3] the UF(r)-edge and the UF(l)-edge are the two with blue and red sides. The FR(u)-edge and FR(d)-edge are the ones with blue and green sides. So in this example, an FR(u or d) edge is in the

UR(f)-position. (The FR(u) and FR(d) edges have the same colors, and are essentially indistinguishable, see pg. 34).

As another example in Step I you fix the FLU-corner.[4] This determines the rest of the corners. For example, if your cube is like this one[4] the FUR corner-cube is the one with the red, blue and green sides. The FRD corner-cube has blue, green and yellow sides.



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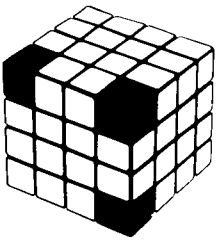

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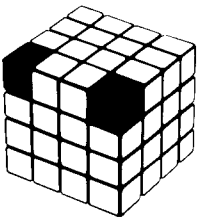
We say a corner sub-cube is correctly oriented if (it is in the correct position and) its colors are aligned correctly (with respect to whatever is considered fixed). Otherwise it is incorrectly oriented. For example, in diagrams[5] and,[6] the FLU-corner is considered fixed, and the FUR-corner is incorrectly or correctly oriented respectively.

We use the same terminology for edges even though strictly speaking an edge which looks incorrectly oriented is really in the wrong position (see pg. 34).



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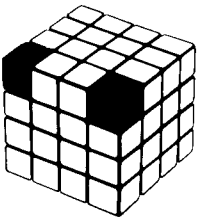

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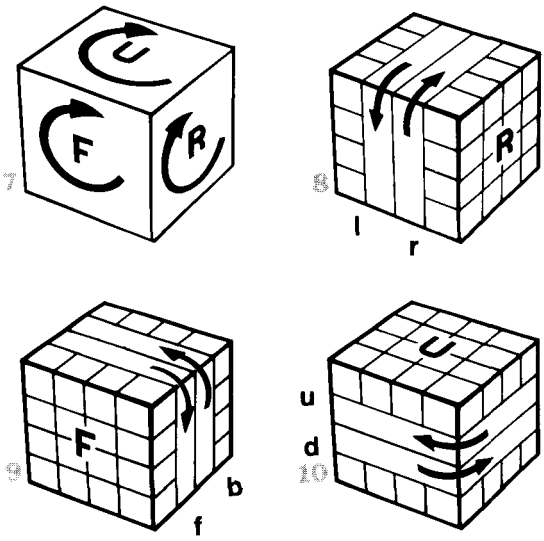
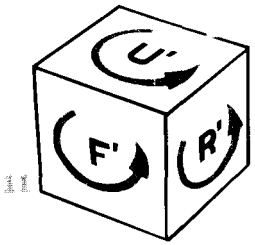
Moves

R means: turn the Right face one turn (90 degrees) clockwise.[7] The clockwise move is determined by looking directly at the face. Similarly **L**, **F**, **B**, **U** and **D**. **r** means: turn the right slice one turn (90 degrees) clockwise.[8] Clockwise for the right slice is determined by looking at the Right face. **l**, **f**, **b**, **u** and **d** are similar.[9,10] Note that **r** and **l** appear to go in opposite directions.



R′ ("R-prime") means: turn the Right face one turn counter-clockwise; also **L′**, **F′**, **B′**, **U′**, and **D′**; and **r′**, **l′**, **f′**, **b′**, **u′** and **d′**.



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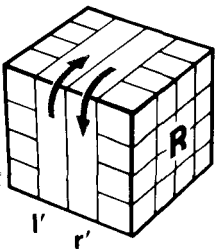

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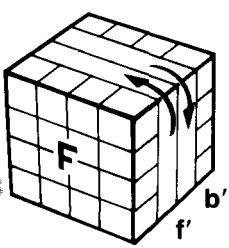

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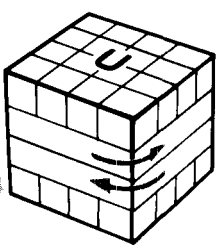


14

A sequence of moves is given by a string: **R′URU′** means apply **R′**, then **U**, then **R**, and finally **U′**.

Parentheses or brackets simply clarify the moves: **L(F′UFU′)L** = **LF′UFU′L**. Brackets [ ] will be used to indicate that the process involves conjugation (see pg. 14). Superscript ² means done twice: **R²** = **RR**, **(R′URU′)²** = **R′URU′R′URU′**.

Note that **RR′** does not do anything; neither does **(FR′lU)(U′l′RF′)**. That is, to undo a sequence of moves, reverse their order, change all primes to non-primes, and vice-versa. This move which undoes a given move is called its inverse, and is denoted by a ′: **(FR′lU)′** = **U′l′RF′**.

Basic Moves

The catalogue of Basic Moves contains all the moves you need to solve the Supercube. We suggest you familiarize yourself with these moves, especially Basic Move 5, before going on to the step-by-step solution.

It is time we explained the unifying principle behind these moves. Look at Basic Move 1: R'URU'. It moves four corners and 6 edges (in three pairs) in a very simple way. A $3 \times 3 \times 3$ cube may be completely solved using only this move and a few variants of it! This move is the simplest example of a commutator. Any move of the form (move A) (move B) (inverse of move A) (inverse of move B) is called a commutator. *Commutators are the key to the cube and to the Supercube.*

COMMUTATOR =
(A B)(-A-B) = AB·A'B'

They are the building blocks of the solution. It is easy to break up any process you like into smaller ones achievable with commutators. Although this does not always give the fastest way to do something, remember, what we are after first is clarity, not speed. Speed will come later.

All the Basic Moves but 7 and 8 are commutators, and Basic Move 8 has a commutator in it: Sometimes, as in Basic Moves 5 and 6, we build commutators on top of commutators and voilà: a ten-move sequence that only affects three edges.

Another essential part of this solution (any solution, for that matter) is a similar process — *conjugation*. This allows you to increase the usefulness of any process. For example Basic Move 3 very conveniently orients two adjacent corners. But what if (as happens in Step I.C., pg. 30) you want to orient two opposite corners? No need to find a whole new process; simply move the two corners into adjacent positions, apply the given move (Basic Move 3) and move them back the way they came. That is in this case, one applies L [Basic Move 3]L'.

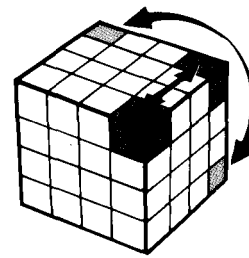
Any move of the form (move A) [move B] (inverse of move A) is called a conjugate of move B. It has the same effect as move B, on different parts of the cube. Brackets [ ] are used to point these moves out — they are used extensively in Step II.

CONJUGATE =

A • B • −A

Basic Move 1: (Steps I-A and B)

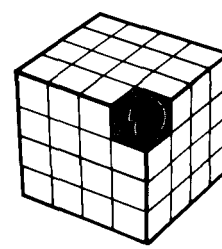
R'URU'



This moves four corners, just like on a $3 \times 3 \times 3$ cube. It also moves three pairs of edges. Its inverse is
UR'U'R.

Also

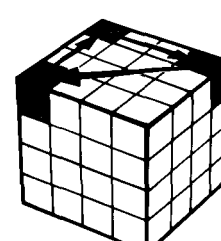
$(R'URU')^2$



orients the FUR corner. It also orients three corners on the Back face, and moves three pairs of edges. Its inverse is
$(UR'U'R)^2$.

Basic Move 2: (Step I-B)

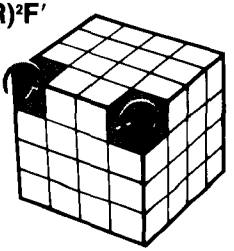
L'(URU')L(UR'U')



This moves three corners clockwise. Basic Moves 1 and 2 are all that you need to get all corners in place. Its inverse is
(URU')L'(UR'U')L.

Basic Move 3: (Step I-C)

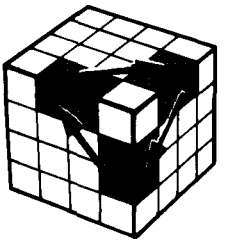
move W = $(R'URU')^2F(UR'U'R)^2F'$



This orients two corners, and is all you need to orient the corners. Its inverse is **move W′ = $F(R'URU')^2F'(UR'U'R)^2$.**

Basic Move 4: (Steps II-A, B and C)

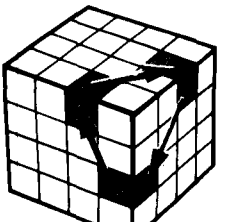
(RBLF)U(F'L'B'R')U'



This moves three pairs of adjacent edges as if they are glued together. It does not affect corners or centers. Its inverse is **U(RBLF)U'(F'L'B'R').**

Basic Move 5: (Steps II-B and C)

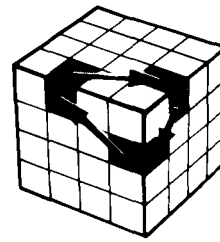
move X = (F'rFr')U(rF'r'F)U'



This moves three edges without affecting corners or centers. It is the workhorse of this solution. It and Basic Move 6 form two halves of Basic Move 4. Its inverse is **move X′ = U(F'rFr')U'(rF'r'F).**

Basic Move 6: (Steps II-B and C)

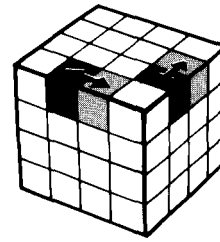
move Y = (F'I'FI)U(I'F'IF)U'



This also moves three edges; see Basic Move 5. This is included for the sake of completeness. In the step-by-step solution we use only Basic Move 5. We use this move in the shortcuts; see Section 6. Its inverse is **move Y' = U(F'I'FI)U'(I'F'IF).**

Basic Move 7: (Steps II-A, B and C)

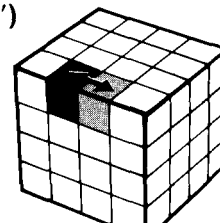
R'U²R²UR'U'R'U²•LFRF'L'



This exchanges two pairs of edges, essentially orienting them. It does not affect corners or centers. It comes from the same move on a $3 \times 3 \times 3$ cube which flips two edges in place. Its inverse is itself.

Basic Move 8: (Step II-C)

I²D²[uF'u'F]D²I²•(LUL')u'(LU'L')

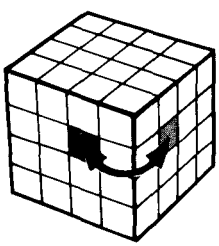


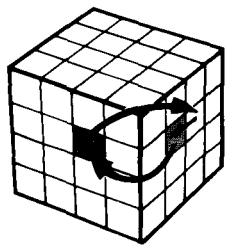
This switches just two edges (which is impossible on a $3 \times 3 \times 3$ cube). It also moves some centers. For a move which does not affect centers see Section 8. This move is only used once in the solution. Its inverse is (essentially) itself.

See p. 60

Basic Move 9: (Steps III-A and B)

R'(fr'f')R(frf')





This essentially switches two centers on adjacent faces without affecting corners or edges. That is, it moves three centers as shown, but if you ignore centers shuffling around a single face you can think of it as above. This is all you need to solve the centers. Its inverse is **(fr'f')R'(frf')R.**

Summary of Notation

Faces:

F - Front	L - Left	U - Up
B - Back	R - Right	D - Down

Slices:

f - front	l - left	u - up
b - back	r - right	d - down

Sub-cubes and Positions:

FUR: Front-Up-Right *corner* (cube or position)
UF(r): Up-Front-(right slice) *edge* (cube or position)

Moves:

R: turn the Right face one turn clockwise
R′: turn the Right face one turn counter-clockwise
r: turn the right slice one turn clockwise
r′: turn the right slice one turn counter-clockwise
RB′lF : R, then **B′**, then **l**, then **F**
(RB′) (lF): RB′lF
(RB′lF)′: RB′lF "Inverse" = **F′l′BR′**
$(RB'lF)^2$: = RB′lFRB′lF
R[UD]R′: = RUDR′ (same as parentheses but only used in conjugation)
†:see shortcuts (Section 6)