

Rubik's Cube Solution Sheet

Layer-by-Layer Solution (See [Jaap's Puzzle Page](#))

Notation

Let the faces be denoted by letters L, R, F, B, U and D (Left, Right, Front, Back, Up and Down). Clockwise quarter turns of a face are denoted by the appropriate letter, anti-clockwise quarter turns by the letter with an apostrophe (i.e. L', R', F', B', U' or D'). Half turns are denoted by a letter followed by number 2 (i.e. L2, R2, F2, B2, U2 or D2).

Phase 1: Solve Top Layer Edges (First Cross)

Find an edge piece that belongs to the Top Layer but which is not already located there. If there is an edge located on the Top Layer but not positioned correctly, then rotate the side (half-turn) containing this edge to place it in the Bottom Layer.

Rotate the Bottom Layer to place the piece *just below* its destination location, and then hold the cube so that *both* the piece and its destination location are on the Front Face.

- 1- To move DF to UF, do F2
- 2- To move FD to UF *without* disturbing other First Layer edges, do U' F' R F U

If the edge is in the Middle Layer, then hold the cube so that the piece is at the Front Right side, and do one of the following:

- 1- To move RF to UF, do F'
- 2- To move RF to UR, do U F' U'
- 3- To move RF to UB, do U2 F' U2
- 4- To move RF to UL, do U' F' U
- 5- To move FR to UF, do U' R U
- 6- To move FR to UR, do R
- 7- To move FR to UB, do U R U'
- 8- To move FR to UL, do U2 R U2

With experience you can save many turns of the U Face and choose the *order* in which you solve the edges so that this phase should usually takes no more than 7 or 8 moves in total.

Phase 2: Solve Top Layer Corners

Find a corner piece in the Bottom Layer that belongs to the Top Layer. If there is a corner already located on the Top Layer but not positioned correctly, then hold the cube so that this corner is located at UFR.

If the corner piece front color is the same as the Front Face color, then do R' D R otherwise do R' D' R.

Rotate the Bottom Layer to place the corner piece below its destination, and hold the cube so that the piece and its destination location are on the Front Right side. Then do one of the following:

- 1- To move FRD to URF, do F D F'
- 2- To move RDF to URF, do R' D' R
- 3- To move DFR to URF, do F D' F' R' D2 R

By *first* solving corners which do *not* display the U Face color on the D Face, the longer sequence of case 3 can often be avoided.

Phase 3: Solve Middle Layer Edges

Find an edge piece in the Bottom Layer that belongs to the Middle Layer. If there is an edge already located in the Middle Layer and if it is not positioned correctly, then choose any other *valid* edge from the bottom edges to displace this edge from the Middle Layer down to the Bottom Layer. Hold the cube so that the edge destination place is located at the Front Right side, then rotate the Bottom Layer to move the edge piece on the Front Face.

Do one of the following to place the edge correctly:

- 1- To move FD to FR, do D' R' D R D F D' F'
- 2- To move DF to FR, do D2 F D' F' D' R' D R

Phase 4: Position Bottom Corners

Rotate the Bottom Layer until *at least* two corners are positioned correctly, ignoring their orientations.

If you need to swap two corners, then do one of the following:

- 1- To swap DLF and DFR, do $R' D' R F D F' R' D R D2$
- 2- To swap DLF and DRB, do $R' D' R F D2 F' R' D R D$

Phase 5: Orient Bottom Corners

- 1- If *four* corners are twisted, then hold the cube so that there is one *clockwise* twisted corner on the Front Left side (the D Face color is displayed on the *left* side of this corner).

If there are *three* twisted corners, then hold the cube so that the corner which is *not* twisted is located on the Front Left side (the D Face color is displayed on the *bottom* side of this corner).

If there are *two* twisted corners, then hold the cube so that the corner which is *anticlockwise* twisted is located on the Front Left side (the D Face color is displayed on the *front* side of this corner)

- 2- Perform $R' D' R D' R' D2 R D2$
- 3- Repeat steps 1-2 until all four corners are correctly oriented.

Phase 6: Position Bottom Edges

Do one of the following:

- 1- To swap DL-DR and DF-DB, do $L2 R2 U2 L2 R2 D L2 R2 U2 L2 R2 D'$
- 2- To swap DF-DR and DL-DB, do $R2 L2 U F2 R2 L2 B2 R2 L2 U' R2 L2$
- 3- To cycle DR->DB->DL->DR, do $L' R F L R' D2 L' R F L R'$
- 4- To cycle DL->DB->DR->DL, do $L' R F' L R' D2 L' R F' L R'$

You may not need to use sequences 1 and 2 because edges can be solved by applying sequences 3 or 4 *twice*.

Phase 7: Orient Bottom Edges

Do one of the following:

- 1- To flip DF, DR, do $F U' D R2 U2 D2 L D' L' D2 U2 R2 D' U F' D$
- 2- To flip DF, DB, do $F U' D R2 U2 D2 L D2 L' D2 U2 R2 D' U F' D2$
- 3- To flip *all* four edges, apply either of the above sequences *twice*

Phase 8: Orient Face Centers

This phase is only necessary for picture cubes or for Rubik's World cube, where face centers have a visible orientation.

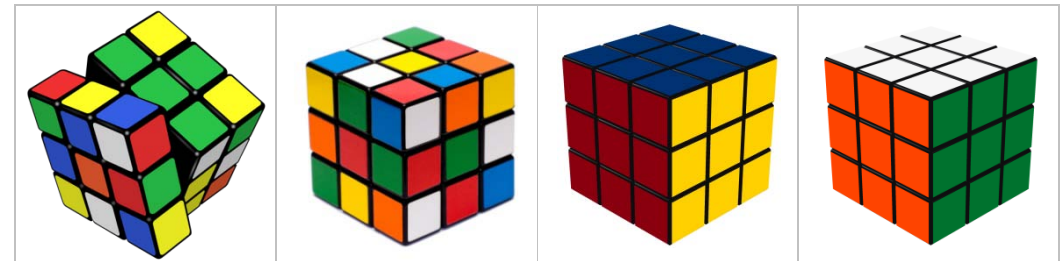
If two face centers need twisting, then hold the cube such that one of the centers is on located the Top Layer and the other one is located either on the Bottom layer or on the Right face. Then do one of the following:

- 1- To turn centers U and R', do $R L' F B' U D' R' U' D F' B R' L U$
- 2- To turn centers U2 and R2, do $R L' F B' U D' R2 U' D F' B R' L U2$
- 3- To turn centers U' and R, do $R L' F B' U D' R U' D F' B R' L U'$
- 4- To turn centers U and D', do $R L' F2 B2 R L' U R L' F2 B2 R L' D'$
- 5- To turn centers U2 and D2, do $R L' F2 B2 R L' U2 R L' F2 B2 R L' D2$
- 6- To turn centers U' and D, do $R L' F2 B2 R L' U' R L' F2 B2 R L' D$

Note that it is possible to take care of the top and side centers during the first 7 phases, so that at most only the Bottom Face center needs twisting. This step is then unnecessary.

If any face center needs a half turn, then hold the cube with that face on the top, and do the following:

To turn center U2, do $R L U2 R' L' U R L U2 R' L' U$.



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Corners First Solution (See [Jaap's Puzzle Page](#))

Below is a corners first solution, i.e. all corners are solved first, then edges. Conceptually this is a good idea, since slice moves can be used (a slice move is a middle layer move), which only involves edges. This kind of method is relatively easy to understand and remember. It can be quite fast, but generally uses more moves than a layer method because slice turns are often counted as two moves.

Notation

Let the faces be denoted by letters L, R, F, B, U and D (Left, Right, Front, Back, Up and Down). Clockwise quarter turns of a face are denoted by the appropriate letter, anti-clockwise quarter turns by the letter with an apostrophe (i.e. L', R', F', B', U' or D'). Half turns are denoted by a letter followed by number 2 (i.e. L2, R2, F2, B2, U2 or D2).

The only slice moves used in the following solution are moves of the middle layer M, i.e. the layer between U and D. Let M (or MU) denotes a clockwise quarter turn of the middle layer when looking from above, i.e. in the same direction as the U move.

Phase 1: Solve Corners

Use any method you like. Use parts of the Layer-by-Layer Solution, or use the method for the mini-cube. Afterwards the top and bottom centers should match their corners, but the centers in the Middle Layer need not match.

Phase 2: Solve Edges in U/D Layers

- Find the edge piece that belongs to the top of the Front Face. If this edge is not found in the Middle Layer, then rotate the whole cube around the U/D axis to bring it to the Front Face and do $F M^2 F'$.
- Hold the cube with the destination location of the piece at the top of the Front Face and turn M to bring the piece to the Back Right. Then do one of the following:
 - To move BR to UF, do $F M F'$
 - To move RB to UF, do $F' M^2 F$.

- Find the edge piece that belongs to the bottom of the Front Face. If it already lies at the bottom of the Front Face and is not upside down, then do $F' M' F M' F M' F'$ to flip it around. If it does not lie in the Middle Layer and is not at the front of the Bottom Layer, then rotate the whole cube around the U/D axis to bring it to the Front Face and do $FM^2 F'$.
- Hold the cube with the destination location of the piece at the bottom of the Front Face and turn M to bring the piece to the right of the Back Face. Then do one of the following:
 - To move BR to DF, do $F' M' F M F' M F$
 - To move RB to DF, do $F' M' F^2 M' F'$
- Repeat a-d for each pair of edges in the U/D layers.

Phase 3: Solve Middle Layer

- Turn M to place the centers correctly with respect to the U/D layers.
- Place the edges correctly by doing one of the following:
 - To swap FR-BL, FL-BR do $M L^2 R^2 M' L^2 R^2$
 - To swap FR-BR, FL-BL do $R^2 M^2 R^2 M^2$
 - To cycle FL->FR->BR->FL do $R^2 M' R^2 M$
 - To cycle FR->FL->BR->FR do $M' R^2 M R^2$
- Orient the edges by doing one of the following:
 - To flip FR and BR do $RM' RM' RM' RM^2 RM' RM' RM' R$ or $(RM')^3 RM^2 (RM')^3 R$
 - To flip FL and BR do $RM' RM' RM' RM RM' RM' RM' RM$ or $((RM')^3 RM)^2$
 - To flip FR, FL, BR, BL do $BUB' RM' RM' RM' RM' BU'B'$ or $BUB' (RM')^4 BU'B'$

