Problem 2.2

Algorithm to solve a Rubik’s Cube

Chose a target edge cubelet, call it X.

Step 1—Place The Edge Cubelets in the UP Layer (ignoring orientation):

- If X is in the UP Layer.
  - If X is in the proper positions (orientation may be incorrect), chose a different X.
  - Apply $F^2$, $R^2$, $B^2$, or $L^2$ such that the move places X in the BOT Layer (this is the layer underneath the MID Layer).
  - Apply D until X is placed underneath its correct position.
  - Apply $F^2$, $R^2$, $B^2$, or $L^2$ to move X into its proper location
  - If not all UP edge cubelets are placed, chose another UP edge cubelet, call it X, and repeat step 1.
- If X is in the MID Layer (this is the layer underneath the UP Layer)
  - Apply U until an application of L, R, F or B permutes X while keeping the already placed edge cubelets in the UP layer. Call this process Z.
  - NOTE: this is possible since not all of the UP edge cubelets have been placed.
  - Apply L, R, F or B such that it places X in the BOT Layer
  - Apply $Z^\text{-1}$
  - Apply D until X is placed underneath its correct position.
  - Apply $F^2$, $R^2$, $B^2$, or $L^2$ to move X into its proper location
  - If not all UP edge cubelets are placed, chose another UP edge cubelet, call it X, and repeat step 1.
- If X is in the BOT Layer (this is the layer underneath the MID Layer)
  - Apply D until X is placed underneath its correct position.
  - Apply $F^2$, $R^2$, $B^2$, or $L^2$ to move X into its proper location
  - If not all UP edge cubelets are placed, chose another UP edge cubelet, call it X, and repeat step 1.

Step 2—Orient the UP Edge Cubelets

While there is a UP Edge Cubelet with incorrect orientation
- Chose a UP edge cubelet with incorrect orientation, call it X.
- Reorient the cube such that X is facing you
- Apply $F\text{R}^{\text{-1}}D^{\text{-1}}RF^2$
- Continue if there is a UP Edge Cubelet with incorrect orientation

Step 3—Place UP corner cubelets with position and orientation
- Chose a target UP corner cubelet, call it X.
• If X is in the UP Layer
  o If X is in the correct position with proper orientation chose another X
  o Reorient the cube such that X is facing you and on the left
  o Apply LDL^(-1)
• X is now in the BOT Layer
  o Apply D until X is underneath its correct position
  o Apply D^2
  o Reorient the cube such that X is facing you and on the left
  o NOTE: X is in the (f d l) position and its correct position is (b r u); i.e. they are "opposite"
  o If the permutation (f d l, b r u)... places X correctly
    ▪ Apply B^(-1)D^2B
    ▪ Repeat step 1 if needed
  o If the permutation (f d l, u b r) ... places X correctly
    ▪ Apply RD^2R^(-1)
    ▪ Repeat step 1 if needed
  o If the permutation (f d l, r u b) ... places X correctly
    ▪ Apply RD^2R^(-1)
    ▪ NOTE: X is in the correct spot, but wrong orientation
    ▪ Apply [B^(-1)D^2B][RD^2R^(-1)]
• Repeat Step 3 while more UP edge cubelets must be placed.

Step 4—Place MID Layer Edge Cubelets (ignoring orientation)

Chose a target edge cubelet, call it X

While there is a misplaced MID edge cubelet
• If X is not in the BOT Layer
  • If X is in the MID Layer and correct position chose another X
  • If X is in the MID Layer, but in the incorrect positions
    ▪ Reorient the cube such that X is in the (f r) position
    ▪ Apply L^(-1)D^(-1)(F^2D^2)^3DL
    ▪ NOTE: Now X is in the BOT Layer
  • Reorient the cube such that X’s correct position is in the (f r) position
  • Apply D until X is in the (d l) position
  • Apply L^(-1)D^(-1)(F^2D^2)^3DL
  • X is now in the correct position, repeat if needed; otherwise go to Step 5

Step 5—Orient MID Layer Edge Cubelets

Chose a MID layer edge cubelet with incorrect orientation and call it X

While there are incorrectly oriented MID edge cubelets
• Orient the cube such that X is in the (f r) position
• Apply L^(-1)D^(-1)(F^2D^2)^3DL
• Apply D^2
• Apply FD^(-1)F(-1)DF^2F(-1)DFD^(-1)FD^(-1)
• Repeat if needed; otherwise go to Step 6

Step 6—Place BOT Layer Corner Cubelets (ignoring orientation)

Apply B until at least one BOT corner cubelet is in its correct position

While all the corner cubelets are not in their correct positions
• If there are three corner cubelets not positioned correctly
  o NOTE: There is a pair of corner cubelets (that are in the same face) such that swapping those edge cubelets will correctly place one of them.
  o Reorient the cube such that those corner cubelets are in the front face
  o Apply R^(-1)D^(-1)RFDF^(-1)R^(-1)DRD^2
  o NOTE: Now there are only two misplaced corner cubelets
  o Repeat Step 6

• If there are two corner cubelets not positioned
  o Chose a corner cubelet that has not been placed, call it X
  o Reorient the cube such that X is in the (f d l) position
  o If the other unplaced corner cubelet is in the (r b d) position
    ▪ Reorient the cube such that X is in the (b l d) position
    ▪ Apply R^(-1)D^(-1)RFDF^(-1)R^(-1)DRD^2
    ▪ Reorient the cube such that X is in the (f d l) position
    ▪ Apply R^(-1)D^(-1)RFDF^(-1)R^(-1)DRD^2
    ▪ NOTE: Now there are two unplaced corner cubelets that are in the same face.
    ▪ Reorient the cube such that those corner cubelets are in the front face
    ▪ Apply R^(-1)D^(-1)RFDF^(-1)R^(-1)DRD^2
    ▪ Continue to step 7
  o Otherwise the two unplaced corner cubelets are in the same face
    ▪ Reorient the cube where that face is the front face
    ▪ Apply R^(-1)D^(-1)RFDF^(-1)R^(-1)DRD^2
    ▪ Continue to step 7

Step 7—Orient the bottom corner cubelets

NOTE: R^(-1)D^(-1)RD^(-1)R^(-1)D^2RD^2 fixes all corner cubelets and all UP edge cubelets while changing the orientation of the (f r d), (r b d) and (l b d) corner cubelets

• If none of the BOT corner cubelets have correct orientation
  o Apply R^(-1)D^(-1)RD^(-1)R^(-1)D^2RD^2 until at least one cubelet has proper orientation.
  o Reorient the cube such that the properly oriented corner cubelet is in the (f l d) position.
Continue applying $R^(-1)D^(-1)RD^(-1)R^(-1)D^2RD^2$ until all BOT corner cubelets have correct orientation.

- Otherwise reorient the cube such that one of the properly oriented BOT corner cubelets in the (f l d) position and apply $R^(-1)D^(-1)RD^(-1)R^(-1)D^2RD^2$ until all BOT corner cubelets have correct orientation.

Step 8—Place BOT Layer Edge Cubelets (with correct orientation)

Let $Z = L^(-1)RF^(-1)LR^(-1)D^2L^(-1)RF^(-1)LR^(-1)$

$Y = FLB^(-1)L^(-1)BF^(-1)DBD^(-1)B^(-1)$

**NOTE:**

$Z = (r\ d\ ,\ l\ d\ ,\ d\ b)$

$Y = (r\ d\ ,\ b\ d\ ,\ d\ l)$

While the cube is not solved

- Choose a misplaced BOT Edge Cubelet
- Reorient the cube if necessary and apply $Z$ or $Y$ such that $X$ is placed correctly with correct orientation

**NOTE:** Do not simply place $X$ choose $Z$ or $Y$ such that it places $X$ with correct orientation.

- Repeat if necessary

End Algorithm