

African Mask



*Designed and made with a 3D printer by Diniar Namdarian, 2018; sleeve added by J. Storer.
(plastic box 4.1 x 5.2 x 1/2 inches, 10 plastic pieces, and directions with solution pdf)*

The problem is to exchange the eyes. The circles slide on top of the pieces, where each have a raised portion, named "eyebrows" by the puzzle designer, that each can pass over everything except the opposite eyebrow. The precision afforded by this nice example of 3D printing provides for smooth sliding of the pieces.

In addition to allowing curved pieces, the solution that comes with the puzzle allows a piece (or a number of interlocking pieces) to push another piece (or a collection of interlocking pieces) as it moves; we refer to this as *generalized rectilinear movement*. For example, steps 16, 19, 25, 39, 49 of this solution move two pieces at once. Although this solution is presented as 65 generalized rectilinear moves, it appears that it can be improved to 59 generalized rectilinear moves, by combining steps 21+23, 26+27, 33+34, 44+45, 50+51, and 62+63.

At first, the puzzle looks to have a relatively simple solution that exchanges an eye with the mouth, then exchanges the two eyes, and then exchanges the other eye with the mouth. Without the eyebrows, this idea works and a solution of 41 rectilinear moves (37 generalized rectilinear moves) is shown on the following three pages.

However, with the eyebrows, solving is more complicated. Following the three pages of the solution without eyebrows, is a 68 rectilinear moves (61 generalized rectilinear moves) solution.

Shorter solutions are possible by allowing the circles to be half on a piece and half hanging over empty space, but such movement is not allowed by the puzzle directions, and is not natural.

Solution Ignoring Eyebrows

#0: LLL M M M M M M R R R L M M R L L M M M R R L A L 1 A 1 2 B 2 R B R L A A A A 1 2 B B B B R L L L 1 1 1 2 2 2 R R R 3 C 3 4 C 4 3 C C C C 4 3 3 3 4 4 4	#1. Rotate A 90 degrees CW: LLL M M M M M M R R R L A A M M R L A L M M M M R R L A L 1 1 2 B 2 R B R L A A 1 2 B B B B R L L L 1 1 1 2 2 2 R R R 3 C 3 4 C 4 3 C C C C 4 3 3 3 4 4 4	#2. Rotate B 90 degrees CC: LLL M M M M M M R R R L A A M M B B R L A L M M M M R B R L A L 1 1 2 2 R B R L A A 1 2 B B R L L L 1 1 1 2 2 2 R R R 3 C 3 4 C 4 3 C C C C 4 3 3 3 4 4 4
#3. Move 3+4+C east 3 units: LLL M M M M M M R R R L A A M M B B R L A L M M M M R B R L A L 1 1 2 2 R B R L A A 1 2 B B R L L L 1 1 1 2 2 2 R R R 3 C 3 4 C 4 3 C C C C 4 3 3 3 4 4 4	#4. Move 1 ending west: LLL M M M M M M R R R L A A M M B B R L A L M M M M R B R L A L 1 1 2 2 R B R L A A 1 2 B B R L L L 2 2 2 R R R 1 1 3 C 3 4 C 4 1 1 3 C C C C 4 1 1 3 3 3 4 4 4	#5. Move 2 ending south: LLL M M M M M M R R R L A A M M B B R L A L M M M M R B R L A L 1 2 R B R L A A B B R L L L R R R 1 1 2 2 3 C 3 4 C 4 1 1 2 3 C C C C 4 1 1 1 2 2 3 3 3 4 4 4
#6. Move M south 3 units: LLL R R R L A A B B R L A L R B R L A L M M M M M R B R L A A M M B B R L L L M M M M R R R 1 1 2 2 3 C 3 4 C 4 1 1 2 3 C C C C 4 1 1 1 2 2 2 3 3 3 4 4 4	#7. Rotate C 90 degrees CW: LLL R R R L A A B B R L A L R B R L A L M M M M M R B R L A A M M C C B B R L L L M M M C M R R R 1 1 2 2 3 C 3 4 C 4 1 1 2 3 C C C 4 1 1 1 2 2 2 3 3 3 4 4 4	#8. Move M+3+C north 3 units: LLL M M M M M M R R R L A A M M C C B B R L A L M M M C M R B R L A L 3 C 3 R B R L A A 3 C C B B R L L L 3 3 3 R R R 1 1 2 2 3 C 3 4 C 4 1 1 2 3 C C C 4 1 1 1 2 2 2 4 4 4
#9. Rotate B+C 180 degrees: LLL M M M M M M R R R L A A M M B B C C R L A L M M M B M R C R L A L 3 B 3 R C R L A A 3 B B C C R L L L 3 3 3 R R R 1 1 2 2 4 4 1 2 4 1 1 1 2 2 2 4 4 4	#10. Move M+3+B south 3 units: LLL R R R L A A C C R L A L M M M R C R L A L 3 B 3 R C R L A A 3 B B C C R L L L M M B M R R R 1 1 2 2 3 B 3 4 C 4 1 2 3 B B 4 1 1 1 2 2 2 3 3 3 4 4 4	#11. Rotate B 90 degrees CC: LLL R R R L A A C C R L A L R C R L A L M M M M M R C R L A A M M C C R L L L M M M M R R R 1 1 2 2 3 B 3 4 B 4 1 2 3 B B B 4 1 1 1 2 2 2 3 3 3 4 4 4
#12. Move M north 3 units: LLL M M M M M M R R R L A A M M C C R L A L M M M R C R L A L R C R L A A C C R L L L R R R 1 1 2 2 3 B 3 4 B 4 1 2 3 B B B B 4 1 1 1 2 2 2 3 3 3 4 4 4	#13. Move 2 ending east: LLL M M M M M M R R R L A A M M C C R L A L M M M R C R L A L 2 2 R C R L A A 2 C C R L L L 2 2 2 R R R 1 1 3 B 3 4 B 4 1 1 3 B B B B 4 1 1 3 3 3 4 4 4	#14. Move 1 ending north: LLL M M M M M M R R R L A A M M C C R L A L M M M R C R L A L 1 1 2 2 R C R L A A 1 2 C C R L L L 1 1 1 2 2 2 R R R 3 B 3 4 B 4 3 B B B B 4 3 3 3 4 4 4
#15. Move 3+4+B west 6 units: LLL M M M M M M R R R L A A M M C C R L A L M M M R C R L A L 1 1 2 R C R L A A 1 2 C C R L L L 1 1 1 2 2 2 R R R 3 B 3 4 B 4 3 B B B B 4 3 3 3 4 4 4	#16. Move 2 ending east: LLL M M M M M M R R R L A A M M C C R L A L M M M R C R L A L 1 R C R L A A 1 C C R L L L 1 1 1 R R R 3 B 3 4 B 4 3 B B B B 4 3 3 3 4 4 4	#17. Move 1 ending south: LLL M M M M M M R R R L A A M M C C R L A L M M M R C R L A L R C R L A A C C R L L L R R R 3 B 3 4 B 4 1 1 2 2 3 B B B B 4 1 2 3 3 3 4 4 4 1 1 1 2 2 2

(solution ignoring eyebrows continued)

#18. Move M south 3 units: L L L R R R L A A C C R L A L R C R L A L M M M M M M R C R L A A M M C C R L L L M M M M R R R 3 B 3 4 B 4 1 1 2 2 3 B B B B 4 1 2 3 3 3 4 4 4 1 1 1 2 2 2	#19. Rotate B 90 degrees CC: L L L R R R L A A C C R L A L R C R L A L M M M M M M R C R L A A B B M M C C R L L L M B M M M R R R 3 3 4 B 4 1 1 2 2 3 B B 4 1 2 3 3 3 4 4 4 1 1 1 2 2 2	#20. Move M+4+B north 3 units: L L L M M M M M M M R R R L A A B B M M C C R L A L M B M M M R C R L A L 4 B 4 R C R L A A B B 4 C C R L L L 4 4 4 R R R 3 3 1 1 2 2 3 1 2 3 3 3 1 1 1 2 2 2
#21. Rotate A+B 180 degrees: L L L M M M M M M R R R L B B A A M M C C R L B L M A M M M R C R L B L 4 A 4 R C R L B B A A 4 C C R L L L 4 4 4 R R R 3 3 1 1 2 2 3 1 2 3 3 3 1 1 1 2 2 2	#22. Move M+4+A south 3 units: L L L R R R L B B C C R L B L R C R L B L M M M M M M R C R L B B A A M M C C R L L L M A M M M R R R 3 3 4 A 4 1 1 2 2 3 1 2 3 3 3 4 4 4 1 1 1 2 2 2	#23. Rotate A 90 degrees CW: L L L R R R L B B C C R L B L R C R L B L M M M M M M R C R L B B M M C C R L L L M M M M R R R 3 A 3 4 A 4 1 1 2 2 3 A A A A 4 1 2 3 3 3 4 4 4 1 1 1 2 2 2
#24. Move M north 3 units: L L L M M M M M M R R R L B B M M C C R L B L M M M R C R L B L R C R L B B C C R L L L R R R 3 A 3 4 A 4 1 1 2 2 3 A A A A 4 1 2 3 3 3 4 4 4 1 1 1 2 2 2	#25. Move 1 ending west: L L L M M M M M M R R R L B B M M C C R L B L M M M R C R L B L 1 1 R C R L B B 1 C C R L L L 1 1 1 R R R 3 A 3 4 A 4 2 2 3 A A A A 4 2 3 3 3 4 4 4 2 2 2	#26. Move 2 ending north: L L L M M M M M M R R R L B B M M C C R L B L M M M R C R L B L 1 1 2 R C R L B B 1 2 C C R L L L 1 1 1 2 2 2 R R R 3 A 3 4 A 4 3 A A A A 4 3 3 3 4 4 4
#27. Move 3+4+A east 6 units: L L L M M M M M M R R R L B B M M C C R L B L M M M R C R L B L 1 1 2 R C R L B B 1 2 C C R L L L 1 1 1 2 2 2 R R R 3 A 3 4 A 4 3 A A A A 4 3 3 3 4 4 4	#28. Move 1 ending west: L L L M M M M M M R R R L B B M M C C R L B L M M M R C R L B L 2 2 R C R L B B 2 C C R L L L 2 2 2 R R R 3 A 3 4 A 4 1 1 3 A 3 4 A 4 3 A A A A 4 1 3 A A A A 4 1 1 1 3 3 3 4 4 4	#29. Move 2 ending south: L L L M M M M M M R R R L B B M M C C R L B L M M M R C R L B L 1 1 2 3 A 3 4 A 4 L B B 1 2 3 A A A A 4 1 1 1 2 2 2 3 3 3 4 4 4
#30. Move M south 3 units: L L L R R R L B B C C R L B L R C R L B L M M M M M R C R L B B M M C C R L L L M M M R R R 1 1 2 2 3 A 3 4 A 4 1 2 3 A A A A 4 1 1 1 2 2 2 3 3 3 4 4 4	#31. Rotate A 90 degrees clockwise: L L L R R R L B B C C R L B L R C R L B L M M M M M R C R L B B M M A A C C R L B B M M A A C C R L L L M M M A M R R R 1 1 2 2 3 A 3 4 4 1 2 3 A A 4 1 1 1 2 2 2 3 3 3 4 4 4	#32. Move M+3+A north 3 units: L L L M M M M M M R R R L B B M M A A C C R L B L M M M A M R C R L B L 3 A 3 R C R L B B 3 A A C C R L L L 3 3 3 R R R 1 1 2 2 4 4 1 2 4 1 1 1 2 2 4 4 4
#33. Rotate A+C 180 degrees: L L L M M M M M M R R R L B B M M C C A A R L B L M M M C M R A R L B L 3 C 3 R A R L B B 3 C C A A R L L L 3 3 3 R R R 1 1 2 2 4 4 1 2 4 1 1 1 2 2 2 4 4 4	#34. Move M+3+C south 3 units: L L L R R R L B B A A R L B L R A R L B L M M M M M M R A R L B B M M C C A A R L L L M M M C M R R R 1 1 2 2 3 C 3 4 4 1 2 3 C C 4 1 1 1 2 2 2 3 3 3 4 4 4	#35. Rotate C 90 degrees CC: L L L R R R L B B A A R L B L R A R L B L M M M M M M R A R L B B M M A A R L L L M M M M R R R 1 1 2 2 3 C 3 4 C 4 1 2 3 C C C 4 1 1 1 2 2 2 3 3 3 4 4 4

(solution ignoring eyebrows continued)

#36. Move M north 3 units: LLLMMMMMRRR LBBAAR LBLMMRAR LBLRAR LBBAAAR LLLRRR 11223C34C4 123CCC4 11122333444	#37. Move ending east: LLLMMMMMRRR LBBAAR LBLMMRAR LBL22RA LBB2AAR LL222RR 113C34C4 13CCC4 11333444	#38. Move 1 ending north: LLLMMMMMRRR LBBAAR LBLMMRAR LBL122RA LBB12AAR LLL111222RR 3C34C4 3CCC4 333444
#39. Rotate B 90 degrees CC: LLLMMMMMRRR LMMAAR LLMMRAR LBL1B122RA LBBB12AAR LLL111222RR 3C34C4 3CCC4 333444	#40. Move 3+4+C west 3 units: LLLMMMMMRRR LMMAAR LLMMRAR LBL1B122RA LBBB12AAR LLL111222RR 3C34C4 3CCC4 333444	#41. Rotate A 90 degrees CW: LLLMMMMMRRR LMR LLMMR LBL1B12A2RA LBBB12AAAAR LLL111222RR 3C34C4 3CCC4 333444

Note: For a solution of 37 generalized rectilinear moves (where pieces can be pushed by others), combine 3+4 (1 pushes 3+4+C east and continues north), 12+ 13 (2 pushes M north and continues east), 24+25 (1 pushes M north and continues west), 36+37 (2 pushes M north and continues east).

A Full Solution With Eyebrows

#0: LLL M M M M M M R R R L M M R L L M M M R R L A L 1 A 1 2 B 2 R B R L A A A A 1 2 B B B B R L L L 1 1 1 2 2 2 R R R 3 C 3 4 C 4 3 C C C 4 3 3 3 4 4 4	#1. Rotate A 90 degrees CW: LLL M M M M M M R R R L A A M M R L A L M M M M R R L A L 1 1 2 B 2 R B R L A A 1 2 B B B B R L L L 1 1 1 2 2 2 R R R 3 C 3 4 C 4 3 C C C 4 3 3 3 4 4 4	#2. Rotate B 90 degrees CC: LLL M M M M M M R R R L A A M M B B R L A L M M M M R B R L A L 1 1 2 2 R B R L A A 1 2 B B R L L L 1 1 1 2 2 2 R R R 3 C 3 4 C 4 3 C C C 4 3 3 3 4 4 4
#3. Move 4 west 3 units: LLL M M M M M M R R R L A A M M B B R L A L M M M M R B R L A L 1 1 2 2 R B R L A A 1 2 B B R L L L 1 1 1 2 2 2 R R R 3 C 3 4 C 4 3 C C C 4 3 3 3 4 4 4	#4. Move 2 ending east: LLL M M M M M M R R R L A A M M B B R L A L M M M M R B R L A L 1 1 R B R L A A 1 B B R L L L 1 1 1 R R R 3 C 3 4 C 4 3 C C C 4 3 3 3 4 4 4	#5. Move 3+4+C east 3 units: LLL M M M M M M R R R L A A M M B B R L A L M M M M R B R L A L 1 1 R B R L A A 1 B B R L L L 1 1 1 R R R 3 C 3 4 C 4 2 3 C C C 4 2 3 3 3 4 4 4 2 2 2
#6. Move L+A south 3 units: M M M M M M R R R M M B B R M M M M R B R L L L 1 1 R B R L A A 1 B B R L A L 1 1 R R R L A L 3 C 3 4 C 4 2 2 L A A 3 C C C 4 2 L L L 3 3 3 4 4 4 2 2 2	#7. Move M west 3 units: M M M M M M R R R M M B B R M M M M R B R L L L 1 1 R B R L A A 1 B B R L A L 1 1 R R R L A L 3 C 3 4 C 4 2 2 L A A 3 C C C 4 2 L L L 3 3 3 4 4 4 2 2 2	#8. Move 1 ending north: M M M M M M 1 1 R R R M M B B R M M M M 1 1 1 R B R L L L R B R L A A B B R L A L R R R L A L 3 C 3 4 C 4 2 2 L A A 3 C C C 4 2 L L L 3 3 3 4 4 4 2 2 2
#9. Move 3+4+C north 3 units: M M M M M M 1 1 R R R M M 1 B B R M M M M 1 1 1 R B R L L L 3 C 3 4 C 4 R B R L A A 3 C C C 4 B B R L A L 3 3 3 4 4 4 R R R L A L 2 2 L A A 2 L L L 2 2 2	#10. Move 2 west 6 units: M M M M M M 1 1 R R R M M 1 B B R M M M M 1 1 1 R B R L L L 3 C 3 4 C 4 R B R L A A 3 C C C 4 B B R L A L 3 3 3 4 4 4 R R R L A L 2 2 L A A 2 L L L 2 2 2	#11. Rotate C 90 degrees CW: M M M M M M 1 1 R R R M M C C 1 B B R M M M C M 1 1 1 R B R L L L 3 C 3 4 4 R B R L A A 3 C C 4 B B R L A L 3 3 3 4 4 4 R R R L A L 2 2 L A A 2 L L L 2 2 2
#12. Move 4 south 3 units: M M M M M M 1 1 R R R M M C C 1 B B R M M M C M 1 1 1 R B R L L L 3 C 3 R B R L A A 3 C C B B R L A L 3 3 3 R R R L A L 2 2 4 4 L A A 2 4 L L L 2 2 2 4 4 4	#13. Move 1 south 3 units: M M M M M M R R R M M C C B B R M M M C M R B R L L L 3 C 3 1 1 R B R L A A 3 C C 1 B B R L A L 3 3 3 1 1 R R R L A L 2 2 4 4 L A A 2 4 L L L 2 2 2 4 4 4	#14. Rotate C 90 degrees CC: M M M M M M R R R M M B B R M M M M R B R L L L 3 C 3 1 C 1 R B R L A A 3 C C C 1 B B R L A L 3 3 3 1 1 R R R L A L 2 2 4 4 L A A 2 4 L L L 2 2 2 4 4 4
#15. Move R+B south 3 units: M M M M M M M M M M M M L L L 3 C 3 1 C 1 R R R L A A 3 C C C 1 B B R L A L 3 3 3 1 1 R B R L A L 2 2 4 4 R B R L A A 2 4 B B R L L L 2 2 2 4 4 4 R R R	#16. Move M east 6 units: M M M M M M M M M M M M L L L 3 C 3 1 C 1 R R R L A A 3 C C C 1 B B R L A L 3 3 3 1 1 R B R L A L 2 2 4 4 R B R L A A 2 4 B B R L L L 2 2 2 4 4 4 R R R	#17. Rotate C 90 degrees CC: M M M M M M C C M M M C M M M L L L 3 3 1 C 1 R R R L A A 3 C C 1 B B R L A L 3 3 3 1 1 R B R L A L 2 2 4 4 R B R L A A 2 4 B B R L L L 2 2 2 4 4 4 R R R

(full solution with eyebrows continued)

#18. Move 3 ending west:	#19. Move M west 3 units:	#20. Move R+B north 3 units:
3 3 M M M M M 3 C C M M 3 3 3 M C M M M L L L 1 C 1 R R R L A A C C 1 B B R L A L 1 1 1 R B R L A L 2 2 4 4 R B R L A A 2 4 B B R L L L 2 2 2 4 4 4 R R R	3 3 M M M M M 3 C C M M 3 3 3 M C M M M L L L 1 C 1 R R R L A A C C 1 B B R L A L 1 1 1 R B R L A L 2 2 4 4 R B R L A A 2 4 B B R L L L 2 2 2 4 4 4 R R R	3 3 M M M M M R R R 3 C C M M B B R 3 3 3 M C M M M R B R L L L 1 C 1 R B R L A A C C 1 B B R L A L 1 1 1 R R R L A L 2 2 4 4 L A A 2 4 L L L 2 2 2 4 4 4
#21. Move 4 east 3 units:	#22. Move 2 ending north:	#23. Rotate B 180 degrees:
3 3 M M M M M M R R R 3 C C M M B B R 3 3 3 M C M M M R B R L L L 1 C 1 R B R L A A C C 1 B B R L A L 1 1 1 R R R L A L 2 2 4 4 L A A 2 4 L L L 2 2 2 4 4 4	3 3 M M M M M M R R R 3 C C M M B B R 3 3 3 M C M M M R B R L L L 1 C 1 2 B 2 R R L A A C C 1 2 B B B R L A L 1 1 1 2 2 2 R R R L A L 4 4 L A A 4 L L L 4 4 4	3 3 M M M M M M R R R 3 C C M M B B R 3 3 3 M C M M B M R R L L L 1 C 1 2 B 2 R R L A A C C 1 2 B B B R L A L 1 1 1 2 2 2 R R R L A L 4 4 L A A 4 L L L 4 4 4
#24. Move M+1+2+B+C south 3 units:	#25. Rotate B 90 degrees CC:	#26. Rotate A+C 180 degrees:
3 3 R R R 3 R 3 3 3 R R L L L M M M M M M R R L A A C C M M B B R L A L M C M M B M R R R L A L 1 C 1 2 B 2 4 4 L A A C C 1 2 B B B 4 L L L 1 1 2 2 2 4 4 4	3 3 R R R 3 R 3 3 3 R R L L L M M M M M M R R L A A C C M M R L A L M C M M M R R R L A L 1 C 1 2 B 2 4 B 4 L A A C C 1 2 B B B 4 L L L 1 1 2 2 2 4 4 4	3 3 R R R 3 R 3 3 3 R R L L L M M M M M M R R L C C A A M M R L C L M A M M M R R R L C L 1 A 1 2 B 2 4 B 4 L C C A A 1 2 B B B B 4 L L L 1 1 2 2 2 4 4 4
#27. Move M+1+A north 3 units:	#28. Move 2+4+B west 3 units:	#29. Move R south 3 units:
3 3 M M M M M M R R R 3 A A M M R 3 3 3 M A M M M R R L L L 1 A 1 R R L C C A A 1 R L C L 1 1 1 R R R L C L 2 B 2 4 B 4 L C C 2 B B B B 4 L L L 2 2 2 4 4 4	3 3 M M M M M M R R R 3 A A M M R 3 3 3 M A M M M R R L L L 1 A 1 R R L C C A A 1 R L C L 1 1 1 R R R L C L 2 B 2 4 B 4 L C C 2 B B B B 4 L L L 2 2 2 4 4 4	3 3 M M M M M M 3 A A M M 3 3 3 M A M M M L L L 1 A 1 R R R L C C A A 1 R L C L 1 1 1 R R R L C L 2 B 2 4 B 4 R R L C C 2 B B B B 4 R L L L 2 2 2 4 4 4 R R R
#30. Move M+1+A east 3 units:	#31. Move 3 ending south:	#32. Rotate A 90 degrees CW:
3 3 M M M M M 3 A A M M 3 3 3 M A M M M L L L 1 A 1 R R R L C C 2 B B B B 4 L C L 2 B 2 4 B 4 R R L C C 2 B B B B 4 R L L L 2 2 2 4 4 4 R R R	M M M M M M A A M M M A M M M L L L 3 3 1 A 1 R R R L C C 3 A A 1 R L C L 3 3 3 1 1 1 R R L C L 2 B 2 4 B 4 R R L C C 2 B B B B 4 R L L L 2 2 2 4 4 4 R R R	M M M M M M M M M M L L L 3 A 3 1 A 1 R R R L C C 3 A A A 1 R L C L 3 3 3 1 1 1 R R L C L 2 B 2 4 B 4 R R L C C 2 B B B B 4 R L L L 2 2 2 4 4 4 R R R
#33. Move M west 6 units:	#34. Rotate A 90 degrees CW:	#35. Move 1 ending east:
M M M M M M M M M M M M L L L 3 A 3 1 A 1 R R R L C C 3 A A A 1 R L C L 3 3 3 1 1 1 R R L C L 2 B 2 4 B 4 R R L C C 2 B B B B 4 R L L L 2 2 2 4 4 4 R R R	M M M M M M M M A A M M M A M L L L 3 A 3 1 1 R R R L C C 3 A A 1 R L C L 3 3 3 1 1 1 R R L C L 2 B 2 4 B 4 R R L C C 2 B B B B 4 R L L L 2 2 2 4 4 4 R R R	M M M M M M 1 1 M M A A 1 M M M A M 1 1 1 L L L 3 A 3 R R R L C C 3 A A R L C L 3 3 3 R R L C L 2 B 2 4 B 4 R R L C C 2 B B B B 4 R L L L 2 2 2 4 4 4 R R R

(full solution with eyebrows continued)

#36. Move M east 3 units: M M M M M M 1 1 M M A A 1 M M A M 1 1 1 L L L 3 A 3 R R R L C C 3 A A R L C L 3 3 3 R R L C L 2 B 2 4 B 4 R R L C C 2 B B B 4 R L L L 2 2 2 4 4 4 R R R	#37. Move L+C north 3 units: L L L M M M M M M 1 1 L C C M M A A 1 L C L M M M A M 1 1 1 L C L 3 A 3 R R R L C C 3 A A R L L L 3 3 3 R R 2 B 2 4 B 4 R R 2 B B B B 4 R 2 2 2 4 4 4 R R R	#38. Move 2+4+B west 3 units: L L L M M M M M M 1 1 L C C M M A A 1 L C L M M M A M 1 1 1 L C L 3 A 3 R R R L C C 3 A A R L L L 3 3 3 R R 2 B 2 4 B 4 R R 2 B B B B 4 R 2 2 2 4 4 4 R R R
#39. Move M+3+A south 3 units: L L L 1 1 L C C 1 L C L 1 1 1 L C L M M M M M M R R R L C C M M A A R L L L M M M A M R R 2 B 2 4 B 4 3 A 3 R R 2 B B B B 4 3 A A R 2 2 2 4 4 4 3 3 3 R R R	#40. Rotate B 90 degrees CC: L L L 1 1 L C C 1 L C L 1 1 1 L C L M M M M M M R R R L C C B B M M A A R L L L M B M M A M R R 2 2 4 B 4 3 A 3 R R 2 B B 4 3 A A R 2 2 2 4 4 4 3 3 3 R R R	#41. Rotate A 180 degrees: L L L 1 1 L C C 1 L C L 1 1 1 L C L M M M M M M R R R L C C B B M M A A R L L L M B M M M R A R 2 2 4 B 4 3 3 R A R 2 B B 4 3 A A R 2 2 2 4 4 4 3 3 3 R R R
#42. Move M+4+B north 3 units: L L L M M M M M M 1 1 L C C B B M M 1 L C L M B M M M 1 1 1 L C L 4 B 4 R R R L C C B B 4 A A R L L L 4 4 4 R A R 2 2 3 3 R A R 2 3 A A R 2 2 2 3 3 R R R	#43. Rotate B+C 180 degrees: L L L M M M M M M 1 1 L B B C C M M 1 L B L M C M M M 1 1 1 L B L 4 C 4 R R R L B B C C 4 A A R L L L 4 4 4 R A R 2 2 3 3 R A R 2 3 A A R 2 2 2 3 3 R R R	#44. Move M+4+C south 3 units: L L L 1 1 L B B 1 L B L 1 1 1 L B L M M M M M M R R R L B B C C M M A A R L L L M C M M M R A R 2 2 4 C 4 3 3 R A R 2 C C 4 3 A A R 2 2 2 4 4 4 3 3 3 R R R
#45. Move 1 west 6 units: L L L 1 1 L B B 1 L B L 1 1 1 L B L M M M M M M R R R L B B C C M M A A R L L L M C M M M R A R 2 2 4 C 4 3 3 R A R 2 C C 4 3 A A R 2 2 2 4 4 4 3 3 3 R R R	#46. Rotate C 90 degrees CW: L L L 1 1 L B B 1 L B L 1 1 1 L B L M M M M M M R R R L B B M M A A R L L L M M M M R A R 2 C 2 4 C 4 3 3 R A R 2 C C C C 4 3 A A R 2 2 2 4 4 4 3 3 3 R R R	#47. Move R+A north 3 units: L L L 1 1 R R R L B B 1 A A R L B L 1 1 1 R A R L B L M M M M M M R A R L B B M M A A R L L L M M M M R R R 2 C 2 4 C 4 3 3 2 C C C C 4 3 2 2 2 4 4 4 3 3 3
#48. Move 3 east 3 units: L L L 1 1 R R R L B B 1 A A R L B L 1 1 1 R A R L B L M M M M M M R A R L B B M M A A R L L L M M M M R R R 2 C 2 4 C 4 3 3 2 C C C C 4 3 2 2 2 4 4 4 3 3 3	#49. Move 2+4+C east 3 units: L L L 1 1 R R R L B B 1 A A R L B L 1 1 1 R A R L B L M M M M M M R A R L B B M M A A R L L L M M M M R R R 2 C 2 4 C 4 3 3 2 C C C C 4 3 2 2 2 4 4 4 3 3 3	#50. Move L+B south 3 units: 1 1 R R R 1 A A R 1 1 1 R A R L L L M M M M M M R A R L B B M M A A R L L L M M M M R R R L B L 2 C 2 4 C 4 3 3 L B B 2 C C C C 4 3 L L L 2 2 2 4 4 4 3 3 3
#51. Move 1 west 3 units: 1 1 R R R 1 A A R 1 1 1 R A R L L L M M M M M M R A R L B B M M A A R L B L M M M M R R R L B L 2 C 2 4 C 4 3 3 L B B 2 C C C C 4 3 L L L 2 2 2 4 4 4 3 3 3	#52. Move M north 3 units: 1 1 M M M M M M M R R R 1 M M A A R 1 1 1 M M M R A R L L L R A R L B B A A R L B L R R R L B L 2 C 2 4 C 4 3 3 L B B 2 C C C C 4 3 L L L 2 2 2 4 4 4 3 3 3	#53. Move 2+4+C north 3 units: 1 1 M M M M M M M R R R 1 M M A A R 1 1 1 M M M R A R L L L 2 C 2 4 C 4 R A R L B B 2 C C C C 4 A A R L B L 2 2 2 4 4 4 R R R L B L 3 3 3 L B B 3 L L L 3 3 3

(full solution with eyebrows continued)

#54. Move 3 west 6 units: 1 1 M M M M M M R R R 1 M M A A R 1 1 1 M M M R A R L L L 2 C 2 4 C 4 R A R L B B 2 C C C C 4 A A R L B L 2 2 2 4 4 4 R R R L B L 3 3 L B B 3 L L L 3 3 3	#55. Move R+A south 3 units: 1 1 M M M M M M 1 M M 1 1 1 M M M M L L L 2 C 2 4 C 4 R R R L B B 2 C C C C 4 A A R L B L 2 2 2 4 4 4 R A R L B L 3 3 L B B 3 L L L 3 3 3	#56. Move M east 3 units: 1 1 M M M M M M 1 M M 1 1 1 M M M M L L L 2 C 2 4 C 4 R R R L B B 2 C C C C 4 A A R L B L 2 2 2 4 4 4 R A R L B L 3 3 L B B 3 L L L 3 3 3
#57. Rotate C 90 degrees CC: 1 1 M M M M M M 1 C C M M 1 1 1 M C M M M L L L 2 2 4 C 4 R R R L B B 2 C C 4 A A R L B L 2 2 2 4 4 4 R A R L B L 3 3 R A R L B B 3 A A R L L L 3 3 3 R R R	#58. Move 2 north 3 units: 1 1 2 2 M M M M M M 1 2 C C M M 1 1 1 2 2 2 M C M M M L L L 4 C 4 R R R L B B C C 4 A A R L B L 4 4 4 R A R L B L 3 3 R A R L B B 3 A A R L L L 3 3 3 R R R	#59. Move 3 north 3 units: 1 1 2 2 2 M C M M M 1 2 C C M M 1 1 1 2 2 2 M C M M M L L L 3 3 4 C 4 R R R L B B 3 C C 4 A A R L B L 3 3 3 4 4 4 R A R L B L R A R L B B A A R L L L R R R
#60. Rotate C 90 degrees CW: 1 1 2 2 M M M M M M 1 2 M M 1 1 1 2 2 2 M M M M L L L 3 C 3 4 C 4 R R R L B B 3 C C C C 4 A A R L B L 3 3 3 4 4 4 R A R L B L R A R L B B A A R L L L R R R	#61. Move 3+4+C south 3 units: 1 1 2 2 M M M M M M 1 2 M M 1 1 1 2 2 2 M M M M L L L R R R L B B A A R L B L R A R L B L 3 C 3 4 C 4 R A R L B B 3 C C C C 4 A A R L L L 3 3 3 4 4 4 R R R	#62. Move 2 ending east: 1 1 M M M M M M 1 M M 1 1 1 M M M M L L L 2 2 R R R L B B 2 A A R L B L 2 2 2 R A R L B L 3 C 3 4 C 4 R A R L B B 3 C C C C 4 A A R L L L 3 3 3 4 4 4 R R R
#63. Move 1 ending south: M M M M M M M M M M M M L L L 1 1 2 2 R R R L B B 1 2 A A R L B L 1 1 1 2 2 2 R A R L B L 3 C 3 4 C 4 R A R L B B 3 C C C C 4 A A R L L L 3 3 3 4 4 4 R R R	#64. Move M west 3 units: M M M M M M M M M M M M L L L 1 1 2 2 R R R L B B 1 2 A A R L B L 1 1 1 2 2 2 R A R L B L 3 C 3 4 C 4 R A R L B B 3 C C C C 4 A A R L L L 3 3 3 4 4 4 R R R	#65. Move L+B north 3 units: L L L M M M M M M L B B M M L B L M M M M L B L 1 1 2 2 R R R L B B 1 2 A A R L L L 1 1 1 2 2 2 R A R 3 C 3 4 C 4 R A R 3 C C C C 4 A A R 3 3 3 4 4 4 R R R
#66. Rotate B 90 degrees CC: L L L M M M M M M L M M M L L M M M M L B L 1 B 1 2 2 R R R L B B B B 1 2 A A R L L L 1 1 1 2 2 2 R A R 3 C 3 4 C 4 R A R 3 C C C C 4 A A R 3 3 3 4 4 4 R R R	#67. Move R+A north 3 units: L L L M M M M M M R R R L M M M A A R L L M M M R A R L B L 1 B 1 2 2 R A R L B B B B 1 2 A A R L L L 1 1 1 2 2 2 R R R 3 C 3 4 C 4 3 C C C C 4 3 3 3 4 4 4	#68. Rotate A 90 degrees CW: L L L M M M M M M R R R L M M R L L M M M R R L B L 1 B 1 2 A 2 R A R L B B B B 1 2 A A A A R L L L 1 1 1 2 2 2 R R R 3 C 3 4 C 4 3 C C C C 4 3 3 3 4 4 4

Note: For a solution of 61 generalized rectilinear moves (where pieces can be pushed by others), combine 12+13 (1 pushes 4 south), 21+22 (2 pushes 4 east and continues north), 30+31 (3 pushes M+1+A east and continues south), 48+49 (2+4+C pushes 3 east), 52+53 (2+4+C pushes M north), 58+59 (3 pushes 2 north), 61+62 (2 pushes 3+4+C south and continues east).