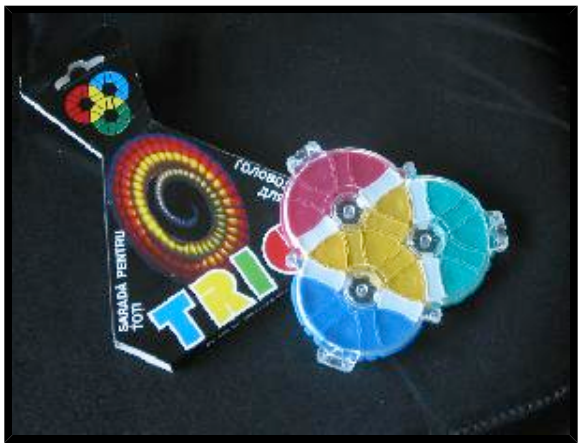
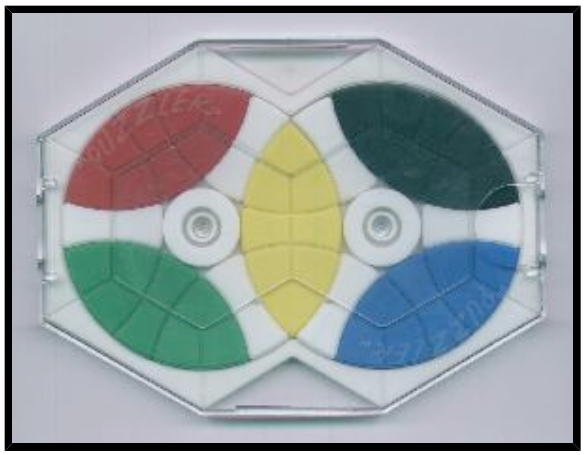
Jaap's Puzzle Page

Turnstile, Puzzler





The Turnstile puzzle consists of two overlapping circular disks. Each disk has 12 pieces, 6 are triangular ('corners'), 6 rectangular ('edges') alternating along the rim of the disk around a hexagonal centre. The pieces have curved sides. The disks have three pieces in common, two corners and one edge, so there are altogether 10 corners and 11 edges. Each disk can be rotated. A rotation should be a multiple of 60 degrees since only then can the other disk move again.

There are 5 bright colours used for the corners, a pair of each colour. There is one edge of each of those colours, and the remaining 6 edges are grey. The aim is to put together all pieces of the each colour. The only way to do this is by forming coloured 'lozenges' of two adjacent corners and the edge between them. These lozenges are separated from each other by the grey edges. The rim of the puzzle has small coloured markings, so that the colours of the lozenges should be such that they match the markings.

Turnstile was manufactured by Binary Arts (now called ThinkFun). There is also a version called TwinSpin that was made in the far East. Turnstile was licensed however from Douglas A. Engel who originally invented and produced it. He patented it on 15 November 1983, US4,415,158. He first called it Engel's Enigma, but later marketed it as The Puzzler with three different designs of varying difficulty:

a. **Novice:** The pieces of one disc are blue, the rest red.
b. **Challenger:** The top half of the discs is green, the bottom half yellow, and the three edge pieces in the middle are black.
c. **Avenger:** Like Turnstile, but with the colours yellow, red, green, blue and black, and using white edges to separate them. There are no colour markings on the puzzle rim.

Note that the Puzzlers sold in the USA were manufactured there and have a hexagonal white base, whereas those sold in the rest of the world were made in Taiwan and have a black oval base.

These puzzles were invented by Douglas A. Engel, who also invented various other puzzles such as:

- Battle Gear
- Farmland Gear puzzles
- Palette 21
- Palette 7
- Palette Mix 4
- Slide Rule Duel (Binary Bisection 5)
- Slide Rule Duel Pentaplenty and Heptalive

If your browser supports it, you can click on the link below to play with a Javascript version of the Turnstile puzzle or any Puzzler variation.

Javascript Turnstile
Javascript Puzzler

A related puzzle is made in Russia, and called Trio. It has three intersecting disks, arranged in a triangle. The pieces are inside a casing transparent on both sides, and has a slightly different colour scheme on each side. The pieces in the overlapping areas are yellow, the rest of the three disks are red, green, and blue. The other side is the same except that six edges adjacent to the yellow centre are coloured white.

The number of positions:

There are 10 corners and 11 edges, so there are at most 11!·10! positions. This limit is not reached on any of these variations because there are many sets of identical pieces. The following table shows the numbers for each variation.

Puzzle	Corners	Edges	Positions	
Puzzler Novice	4, 6	5, 6	$10!\cdot11!\ /\ (4!\cdot5!\cdot6!^2)$	97,020
Puzzler Challenger	5, 5	3, 4, 4	$10!\cdot11!\ /\ (3!\cdot4!^2\cdot5!^2)$	2,910,600
Puzzler Avenger /Turnstile	2, 2, 2, 2, 2	1, 1, 1, 1, 1, 6	$10!\cdot11!\ /\ (2!^5\cdot6!)$	6,286,896,000

Remember however that the Puzzler avenger actually has 5!=120 solutions due to the lack of markings. Equivalently you can consider the positions that differ by a permutation of colours to be the same, and then it has one solution but only $10!\cdot11!\ /\ (2!^5\cdot6!\cdot5!)=52,390,800$ positions.

I have done a computer analysis of the Puzzler Novice and the Puzzler Challenger in order to find God's Algorithm for them. The results are in the tables below. Analogous to the Rubik's cube, there are two ways to count the moves. The Face Turn Metric means that a turn of either disk by any amount is a single move. The "Quarter" Turn Metric means that only 60 degree turns are single moves. The tables show that they both can be solved in no more than 13 face turns, or that they need at most 18 or 19 sixth turns respectively.

Puzzler Novice:

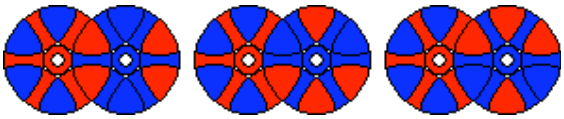
Face turn metric

0	1	2	3	4	5	6	7	8	9	10	11	12	13	Total

Quarter turn metric

0	1													**1**
1		2												**2**
2		2	4											**6**
3		1	8	8										**17**
4			8	24	14									**46**
5			4	34	50	24								**112**
6			1	25	98	116	32							**272**
7				7	121	294	200	34						**656**
8					85	424	687	296	18					**1,510**
9					35	397	1,327	1,265	262	16				**3,302**
10					6	225	1,539	3,048	1,546	225	11			**6,600**
11						68	1,115	4,381	5,051	1,391	98	2		**1,210**
12						7	432	3,681	9,064	5,193	557	12		**18,946**
13							56	1,510	8,701	10,398	2,260	72		**22,997**
14							3	194	3,393	9,719	4,864	372		**18,545**
15								10	299	3,101	4,532	947	16	**8,905**
16									7	192	1,376	921	84	6 **2,586**
17										1	62	209	97	12 **381**
18												11	16	3 **30**
Total	**1**	**5**	**25**	**98**	**409**	**1,555**	**5,391**	**14,419**	**28,341**	**30,236**	**13,760**	**2,546**	**213**	**21 97,020**

The three most difficult positions are shown here:



Puzzler Challenger:

Face turn metric

	0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**Total**
0	1														**1**
1		4													**4**
2		4	8												**12**
3		2	16	12											**30**
4			16	36	24										**76**
5			8	56	96	48									**208**
6			2	52	200	232	82								**568**
7				32	252	612	516	148							**1,560**
8				12	228	980	1638	1132	232						**4,222**
9				2	140	1130	3334	4350	2044	200					**11,200**
10					56	904	4922	10475	9882	2688	78				**29,005**
11					12	500	5198	18460	29879	16130	1628	16			**71,823**
12					2	220	3658	22980	62220	61987	13273	368	4		**164,712**
13						54	1530	19084	88973	155887	65166	4096	48		**334,838**
14							309	9514	80520	250552	204084	25234	548		**570,761**
15							24	2298	39498	232216	376516	95187	2918	8	**748,665**

quarter turn metric														
	16					176	8176	99035	340627	189255	10502	14	**647,785**
	17						448	13915	107117	144389	18108	30	**284,007**
	18						4	372	6752	25210	8100	28	**40,466**
	19								24	338	293	2	**657**
	Total	**1**	**10**	**50**	**202**	**1,010**	**4,680**	**21,211**	**88,617**	**321,876**	**832,982**	**1,115,265**	**484,093**	**40,521**	**82**	**2,910,600**

The two most difficult positions are shown here:

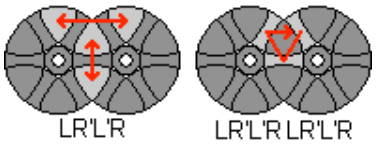
Links to other useful pages:

ThinkFun homepage, the new name of the manufacturer Binary Arts.
PuzzleAtomic is Douglas Engel's site, where he sells many different types of circle puzzle.

Notation:

Let a clockwise 60 degree rotation of the left disk be denoted by L. Rotations of 120, 180, 240, 300 degrees are then denoted by L2, L3, L4 and L5. Note that L5 can also be considered an anti-clockwise 60 degree turn, and is therefore also denoted by L'. Turns of the right disk are denoted in the same way, but using the letter R.

A solution for any variation of the puzzle is fairly easily constructed by the use of the simple move sequence LR'L'R. This sequence swaps two pairs of corners, and also does a 3-cycle of edges. If you perform it twice then the corners remain unmoved but it is still a 3-cycle of edges. If you perform it three times then the edges remain unmoved but still does a double swap of corners, though if you solve the corners before solving the edges you don't need to do this. Below I will explain a solution to the standard Turnstile and Avenger puzzles which uses some shortcuts instead of applying this move sequence all the time.



Solution to Turnstile and Puzzler Avenger:

Phase 1: Pair up the corners.

a. First place two corners of the same colour next to each other. This is very easy. If there is not already a pair, turning only one of the disks is nearly always sufficient.
b. Rotate the pair to the overlapping region, and then do L2 to place them at the bottom left of the left disk.
c. Find the corner matching the colour of the upper left corner. If it does not lie at the top of the left disk (i.e. it is not yet paired up) then it must lie in the right disk. Turn the right disk to bring it to the top and do L R' L'. The left disk must now have two corner pairs.
d. If the right disk has one or more pairs then rotate it to bring a pair to the overlapping region, otherwise rotate it so that its top and bottom corners have the same colour.
e. Only 4 possibilities remain for the corners other than the three pairs position.
   1. If there are two pairs on the right disk then do R' L R L R.

2. If there is one pair on the right disk then do R3 L4 R3 L2 R.
3. If each pair of corners lie on the opposite sides of the disk then do L2 R2 L2 R2 L.
4. Otherwise do R2 L2 R3 L' R L.

Phase 2: Place the edges correct.

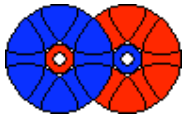
a. Find a coloured edge which is in a spot where a grey edge belongs (i.e. it does not lie between a matched pair of corners).
b. Find the corner pair of the same colour as the edge.
c. The following steps should bring the corners to the overlapping region and the edge adjacent to it.
   1. If the edge and its corners lie in the same disk then rotate it to bring the corners to the overlapping region. If the edge is not yet adjacent to the corners then rotate the other disk 120 degrees and go to step 2.
   2. If the edge and its corners lie in different disks and are not in the overlapping region then rotate the edge to a position adjacent to the overlap and then turn the other disk to place the corners in the overlap.
d. The edge can now be placed between the corners by using one of the following four similar sequences TWICE. Which one you need depends on the position of the edge piece:
   1. Edge is at top left: R'L R L'
   2. Edge is at top right: L R'L'R
   3. Edge is at bottom left: R L'R'L
   4. Edge is at bottom right: L'R L R'
e. Repeat step a-d for all the edges. If all the grey edges are correct but the coloured ones are not, then you can use the procedure above to insert a grey edge in an incorrectly coloured 'lozenge' to free up a coloured edge for step a.

Phase 3: Place the lozenges correct.

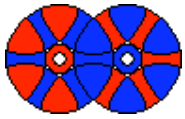
a. This phase mostly uses only 120 degree turns of the discs, so that the lozenges will not broken be up. First put the correct lozenge in bottom left position which is trivial.
b. Find the lozenge belonging at the top left position. If it is not yet in position then rotate it to the top right, and do L2 R4 L4.
c. Rotate the right disc to bring the correct lozenge to the overlapping region.
d. If the final two colours are not correct then we must break them up and rebuild them by performing the sequence
   L R L' R L R4 L'.
   to swap the corners and then solve the remaining edge as in phase 2 by using:
   R2 L R' L' R L R' L' R.

Pretty Patterns for Puzzler:

1. L R L R L R L R3 L R' L' R'

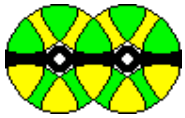


2. L R' L R' L R' L R' L R'



3. L R L2 R' L' R L' R' L R' L R4

4. L4 R' L R L3 R L' R L' R L' R L2 R L'



5. R L R4 L R L' R2 L

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