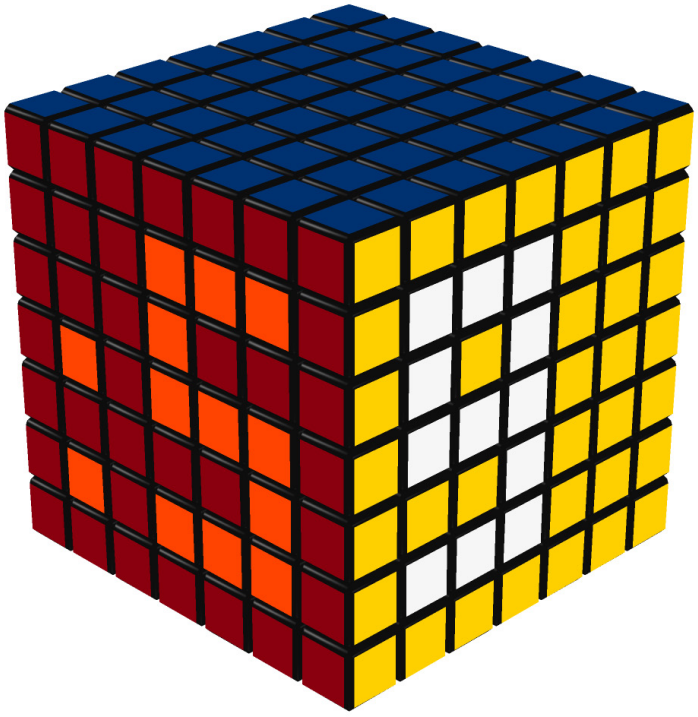
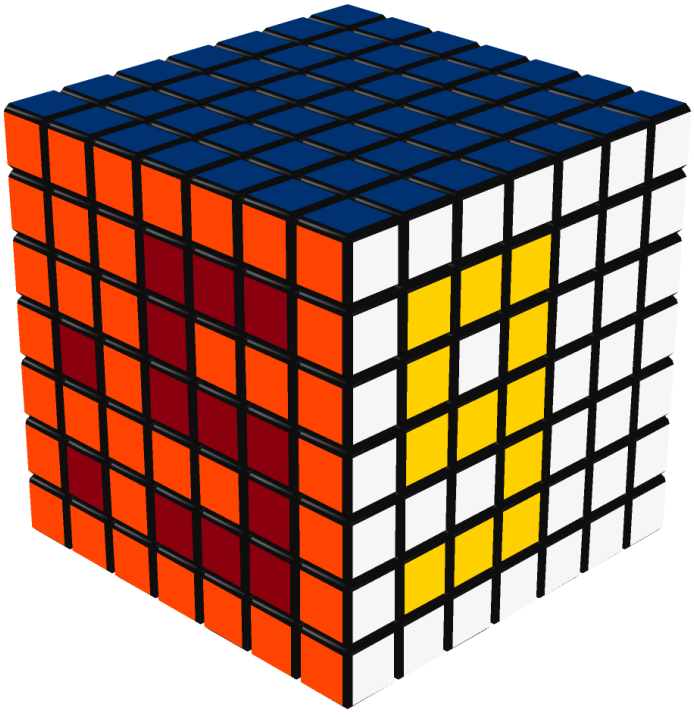
Clock Cube

Introduction

Many pretty patterns have already been designed to be displayed on NxNxN cubes. It may also be of interest to create specific patterns that could be animated using virtual cubes. Among these are clock patterns that would not use textures but only colored facelets of regular cubes.

Hexadecimal Display

Numbers from 0 to 9, letters from A to F plus a decimal point can be displayed on 4 opposed faces of a 7x7x7 cube, the same way as they would on an 7-segment hexadecimal display. By animating these numbers each second of time, a digital clock can then be displayed on the cube.

Clock Cube Patterns – Seconds of Time	
:59	:59
	
Faces F and R	Faces B and L

Cycle Structures

Centers can be moved either individually by 2-cycles or by blocks of 2 or more pieces. It is easier to use 2-cycles to move pieces but at the expense of longer sequences of moves. A good strategy would probably be to first use 2-cycles to try to display a pattern and see if it is suitable or not, and then search for shorter sequences by using block moves.

Sequences of 2-cycles can be used on a per orbit basis. If each orbit parity is even, then each orbit can be solved separately. If the number of 2-cycles in a given orbit is even, then the orbit parity is also even. But if the number of 2-cycles is odd, the orbit parity may then be either odd or even. To toggle an orbit parity from odd to even, simply convert two 2-cycles into one 4-cycle, if this is possible.

Permutation of True Centers

Due to mechanical restrictions, true centers do not behave exactly as other centers do. But the same permutation laws apply to them with the added feature of orientation parity. Main restrictions are listed below:

1- Only 4-spot and 6-spot true center permutations are legal
2- Opposed centers will always stay opposed through any legal move
3- For a solved cube, the sum of the orientations of all centers will always be equal either to 0° or 180° modulo 360°

Cycle structures of true center permutations, shown in the table below, are either of even or of odd parity. Odd parity permutations imply that other pieces are messed up, eg. edges, so they aren't really usable for displaying letters on cube centers only. In the 6-spot even parity case, there are two 3-cycles of true centers. Again this is not a suitable case because only opposed centers are to be swapped, ie only 2-cycles can be used. The only remaining case is thus the 4-spot two 2-cycles case. This means that only 0 or 2 letters using true centers can be displayed on the cube.

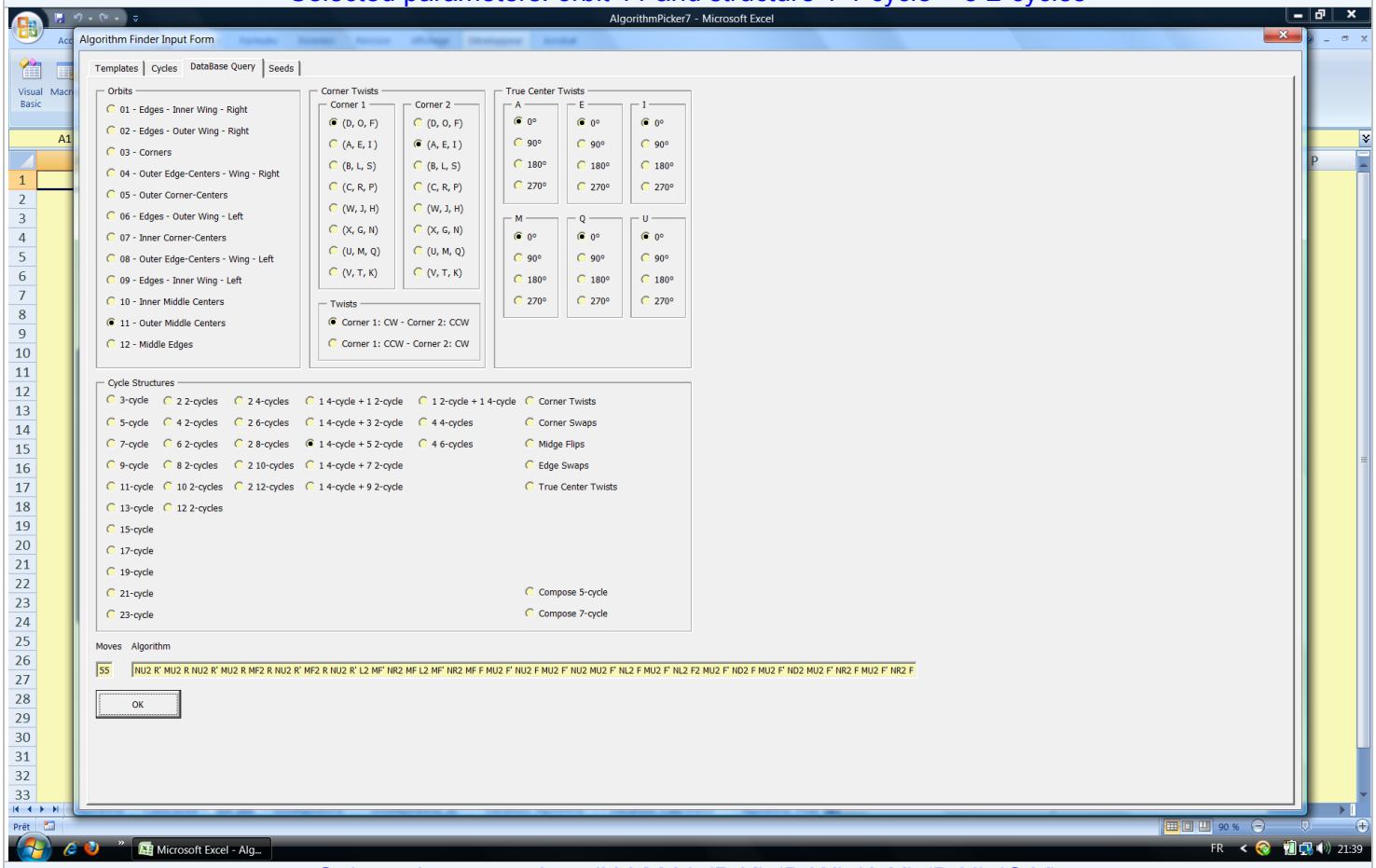
True Centers – Cycle Structures			
N-spot	Cycle Structure	Note	Permutation Parity
4-spot	2-cycle + 2-cycle	2-cycles: 2 *opposed* centers	even
4-spot	2-cycle + 2-cycle + 2-cycle	–	odd
6-spot	3-cycle + 3-cycle	3-cycles: 3 *adjacent* centers	even
6-spot	2-cycle + 2-cycle + 2-cycle	–	odd

Algorithm Picker 7 – UserForms

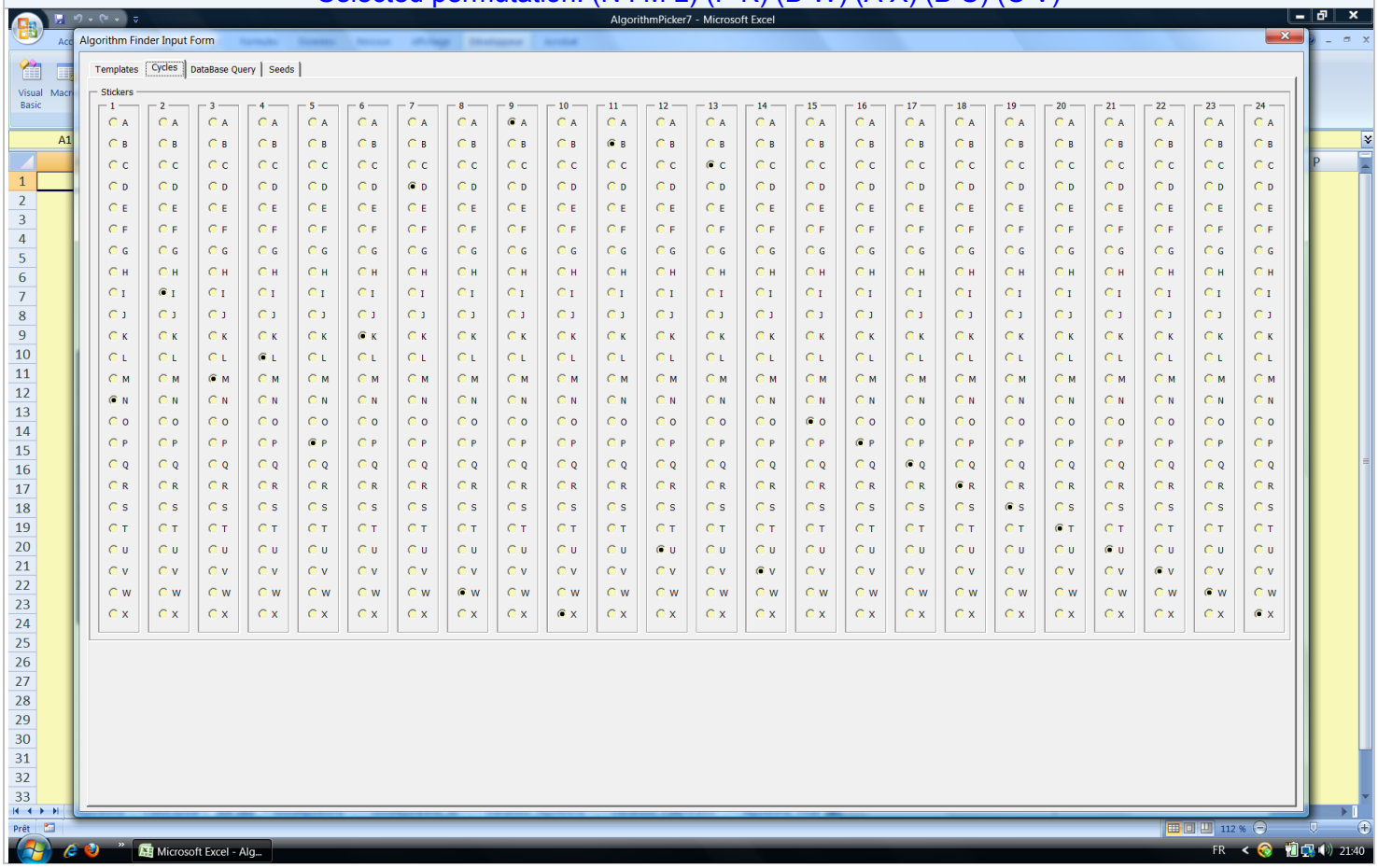
Algorithms of combinations of 2-cycles and 4-cycle + 2-cycles can be found using Algorithm Picker.

Clock Pattern – Excel/VBA UserForms

Selected parameters: orbit 11 and structure 1 4-cycle + 5 2-cycles

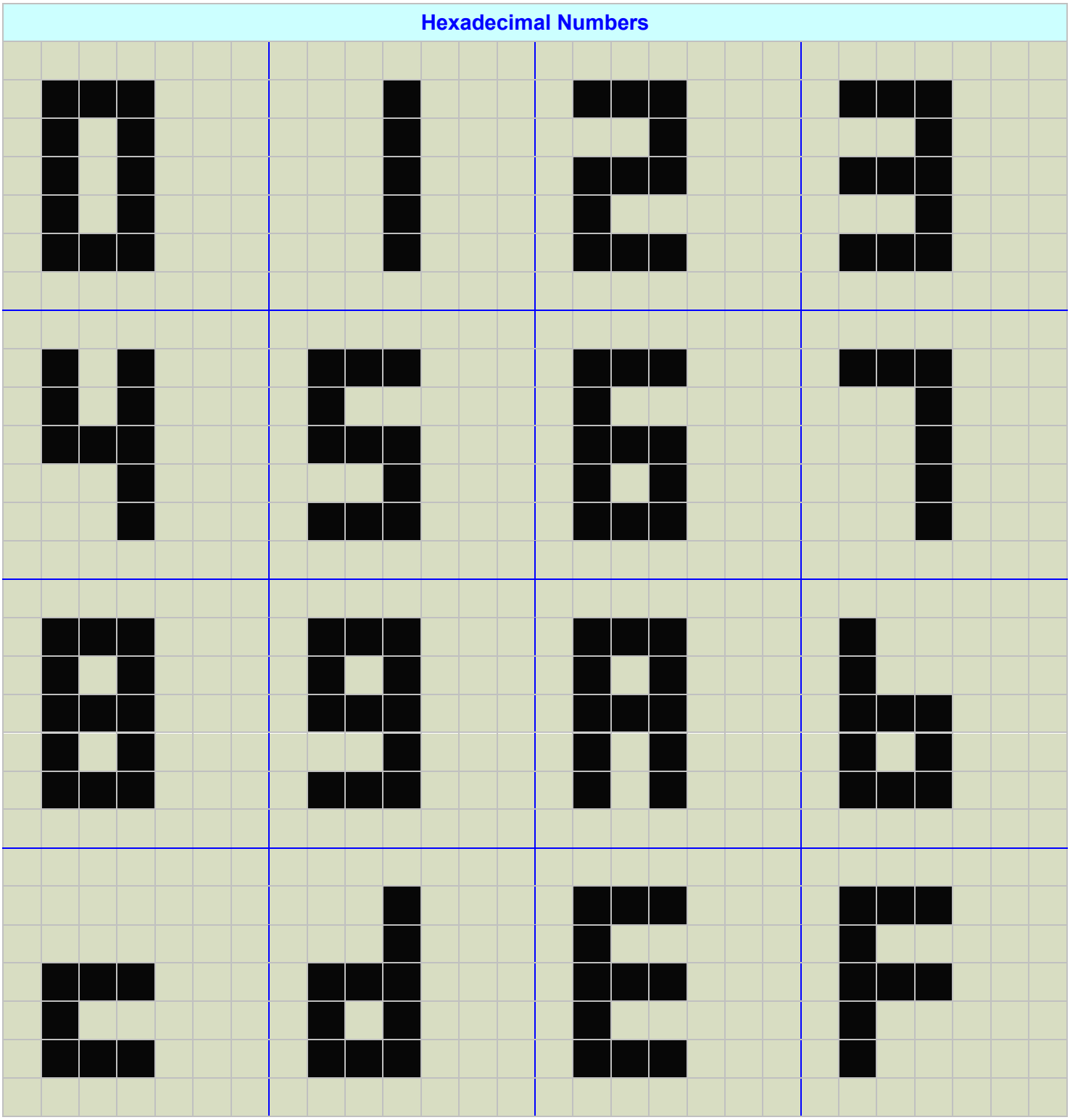


Selected permutation: (N I M L) (P K) (D W) (A X) (B U) (C V)

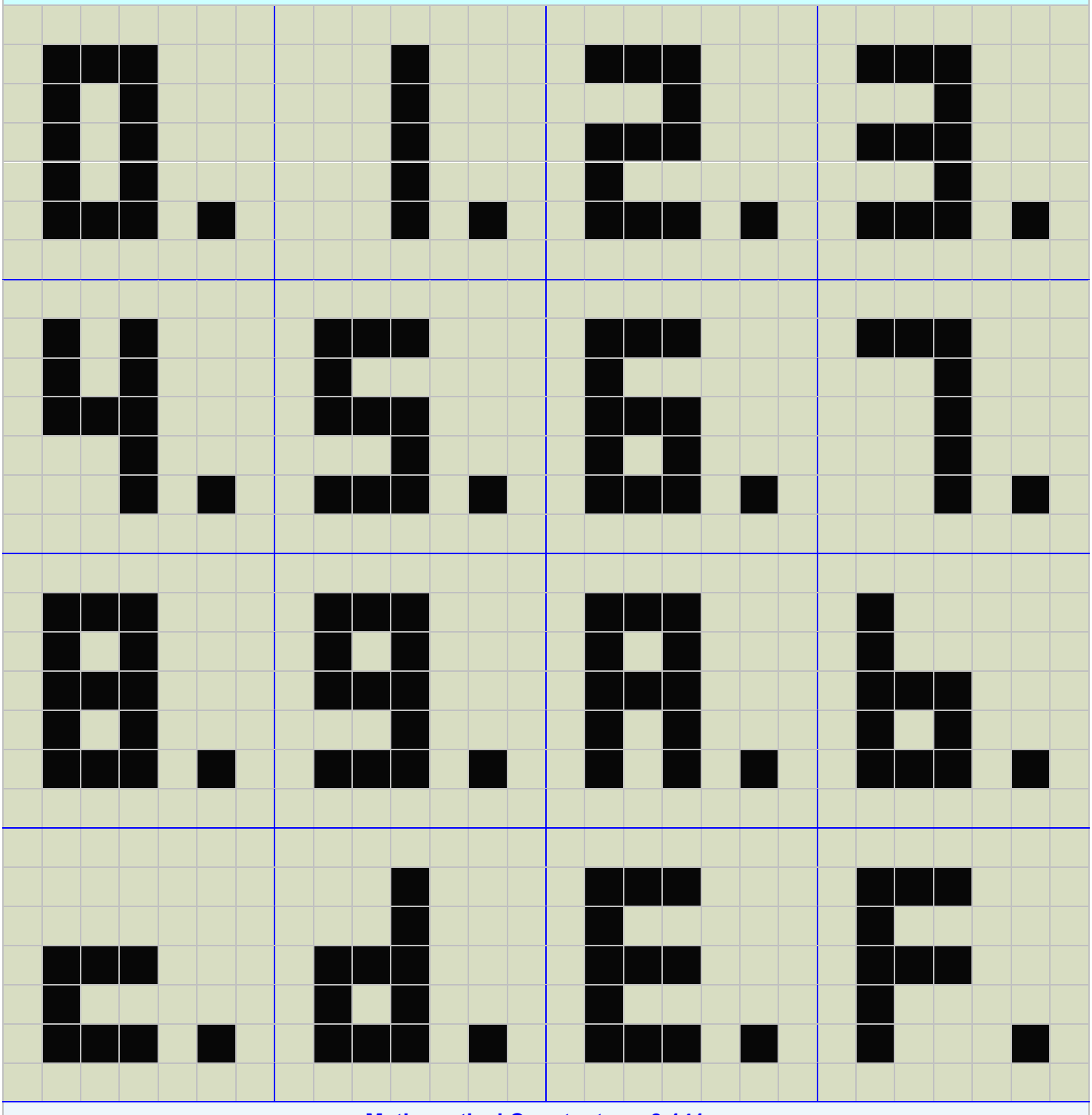


Hexadecimal Display – 7x7x7 Cube

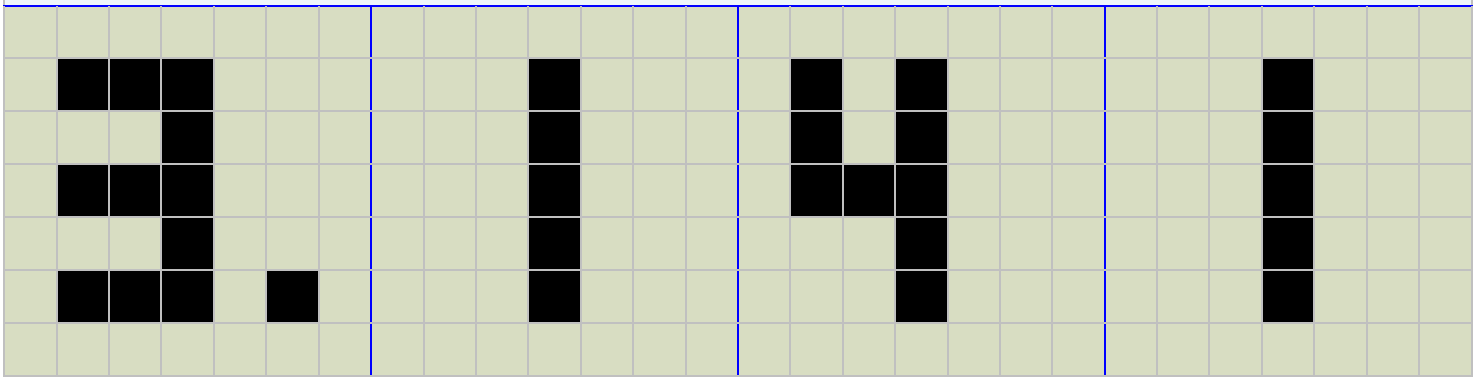
Hexadecimal numbers plus a decimal point can be displayed on 4 opposed faces of a 7x7x7 cube. Each letter or number *must* include a true center in their pattern, so as to make true centers permutation parity even, in a 4-spot pattern and a two 2-cycles arrangement.



Hexadecimal Numbers Plus Decimal Point



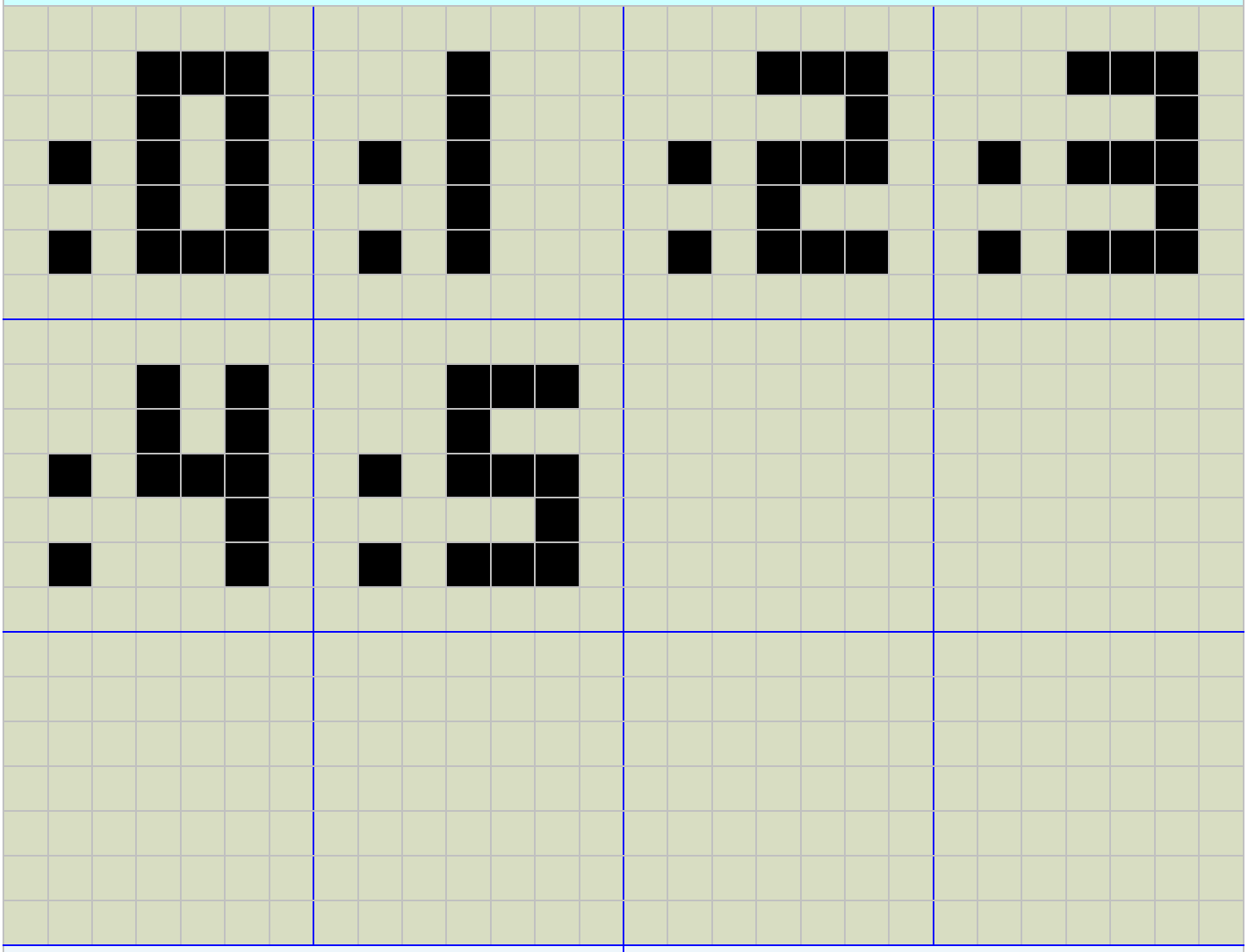
Mathematical Constant π = 3.141…



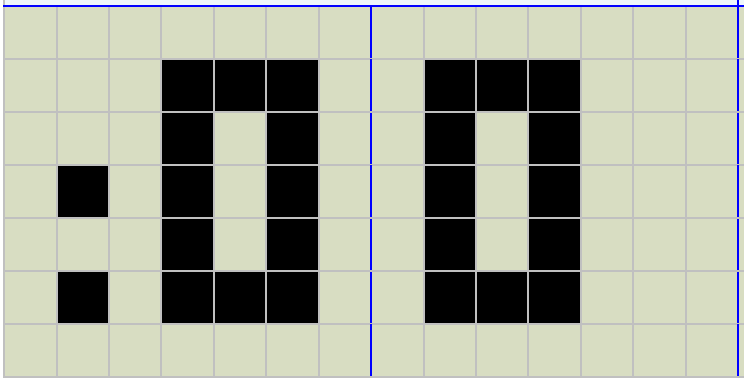
Time Display – 7x7x7 Cube

By placing a semi-column just before or after a decimal number, the Time Of the Day (TOD) can also be displayed as a two-digit number. Variations are possible, depending on displayed values, which can be either seconds, minutes or hours. If a semi-column is placed just before and/or after a digit, then hours, minutes and seconds can be displayed alternatively on faces F and R (plus B and L). Semi-columns can even be blinked each half second on an animated cube.

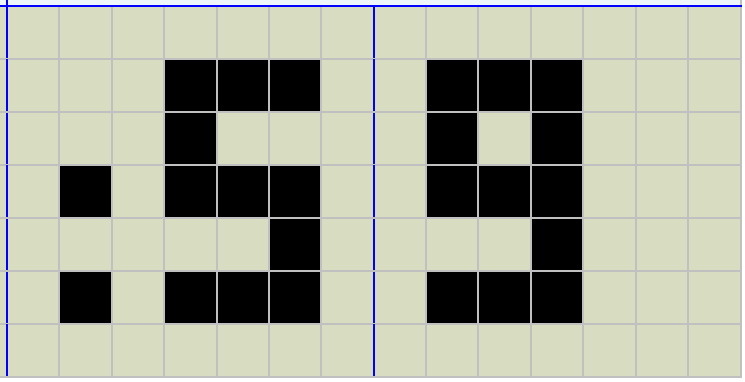
Time Display – Seconds/Minutes First Digit



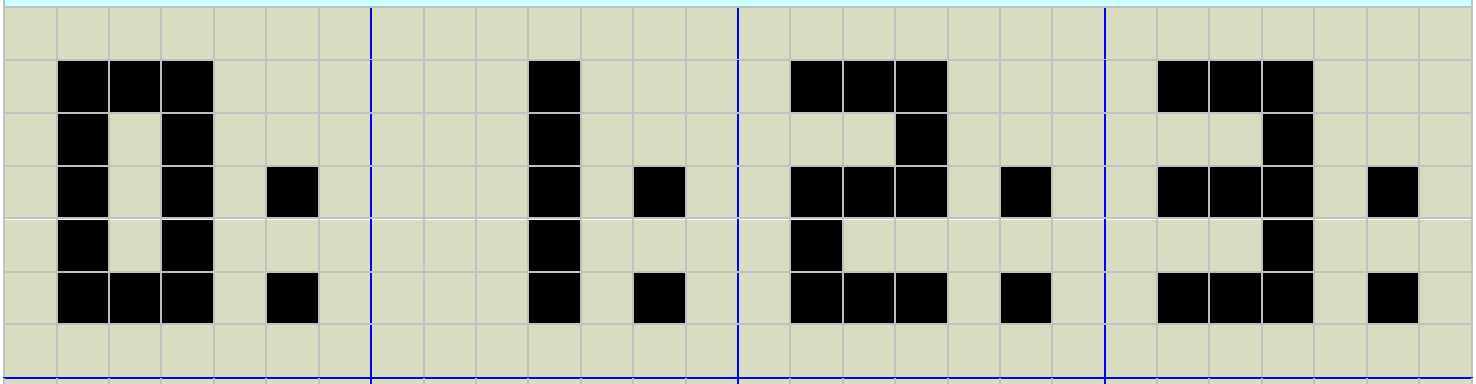
Time Display: 0 second

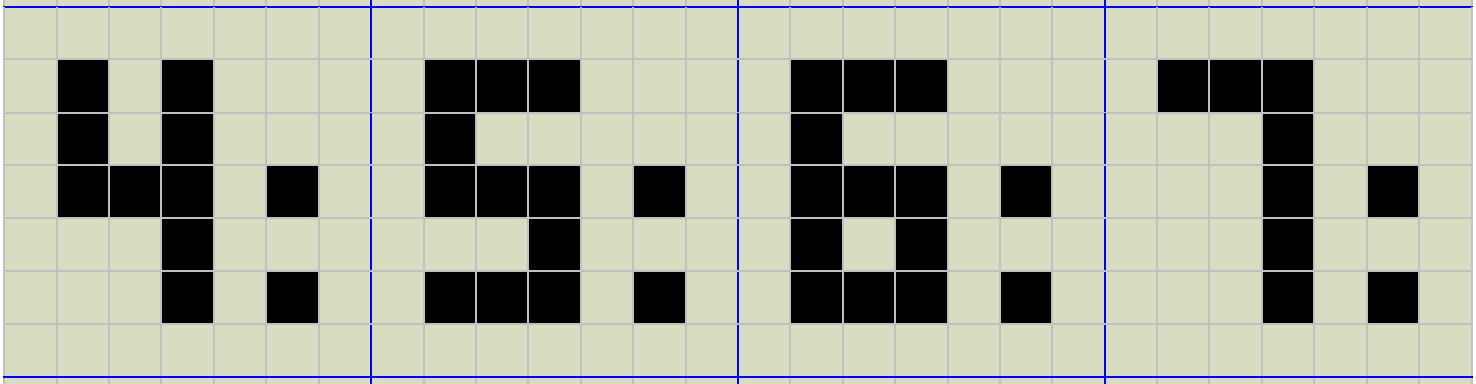


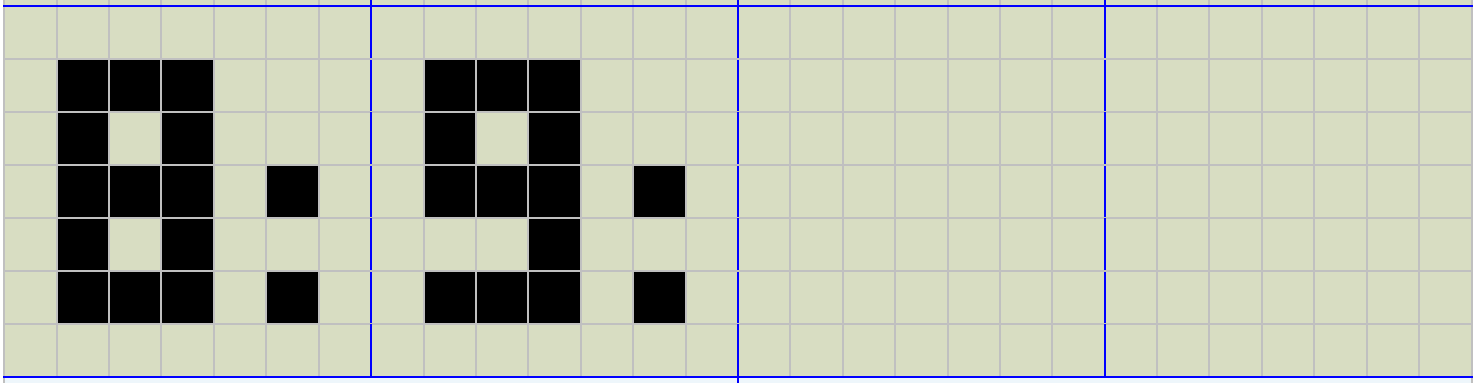
Time Display: 59 seconds



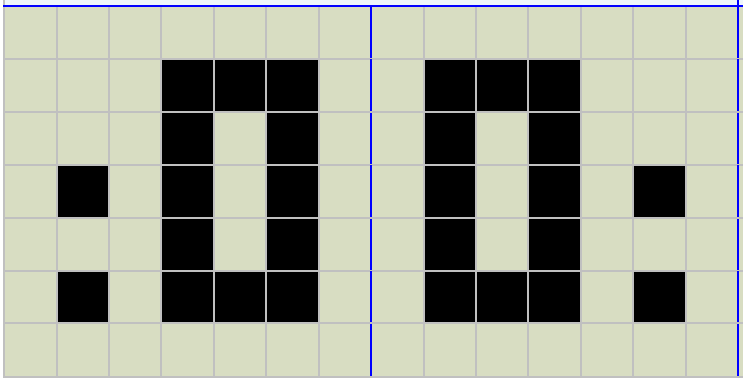
Time Display – Hours/Minutes Last Digit



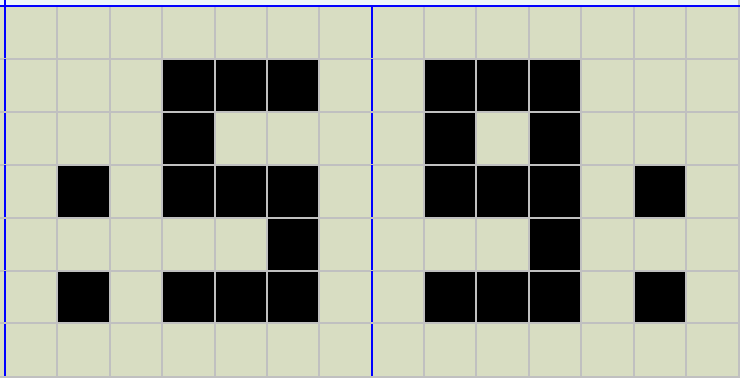




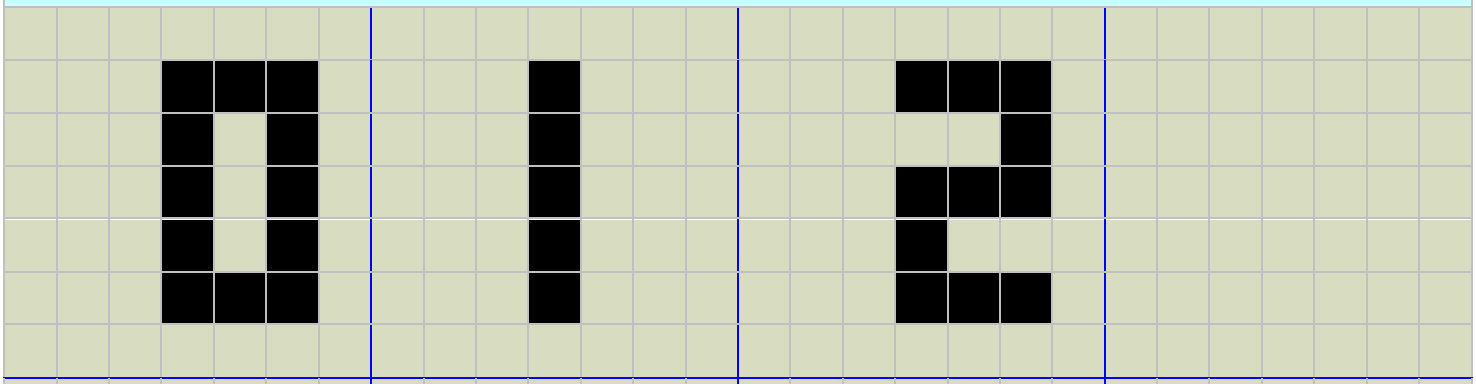
Time Display: 0 minute

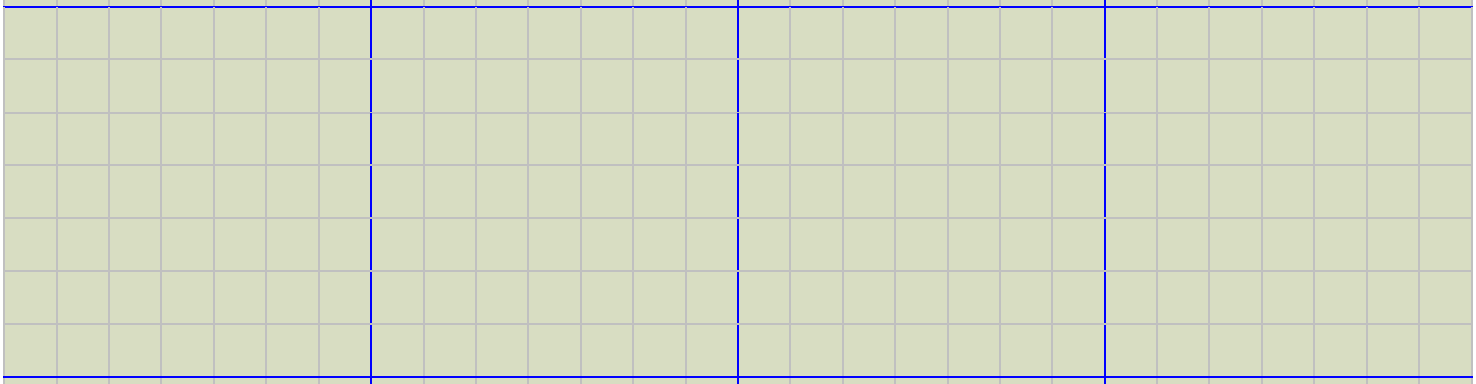


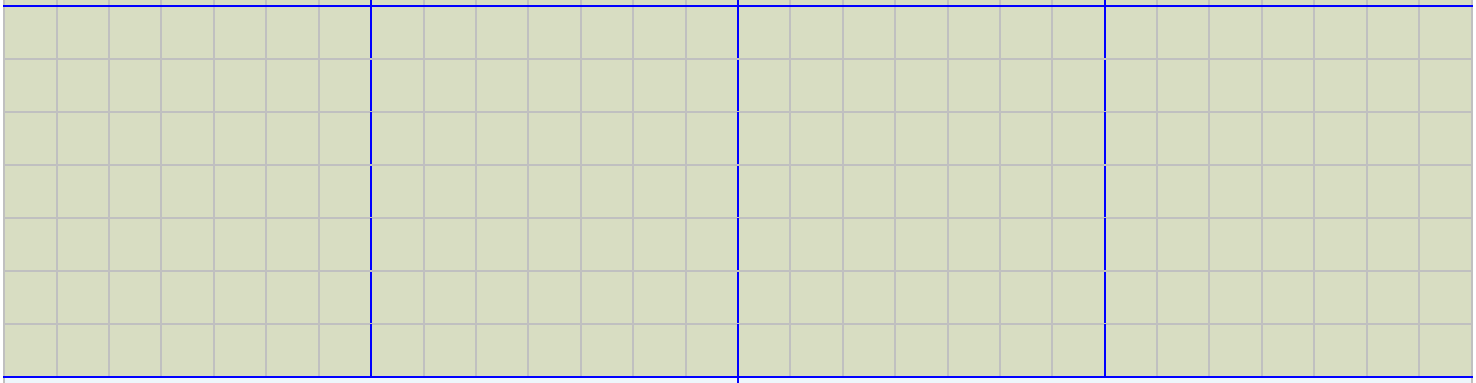
Time Display: 59 minutes



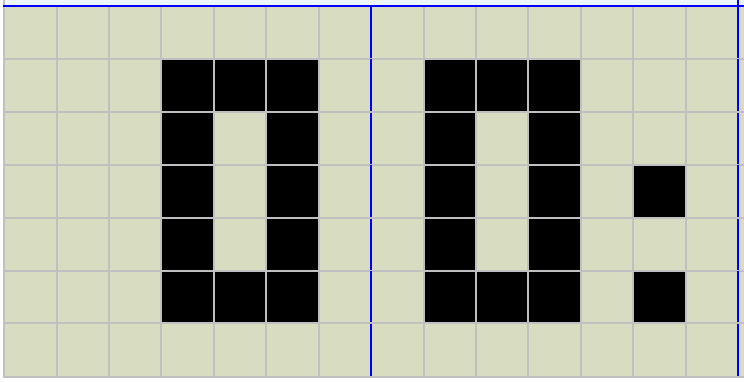
Time Display – Hours First Digit



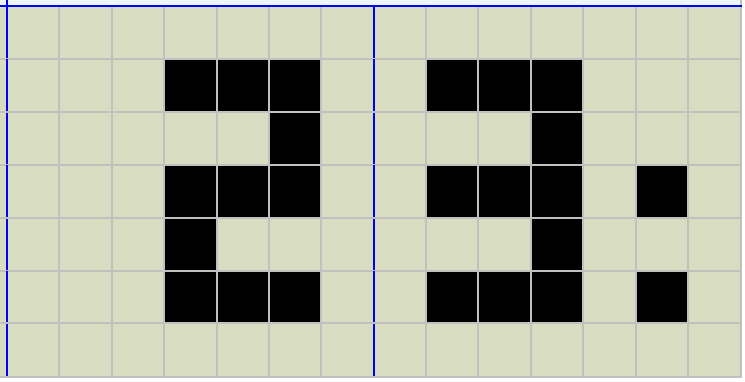




Time Display: 0 hour



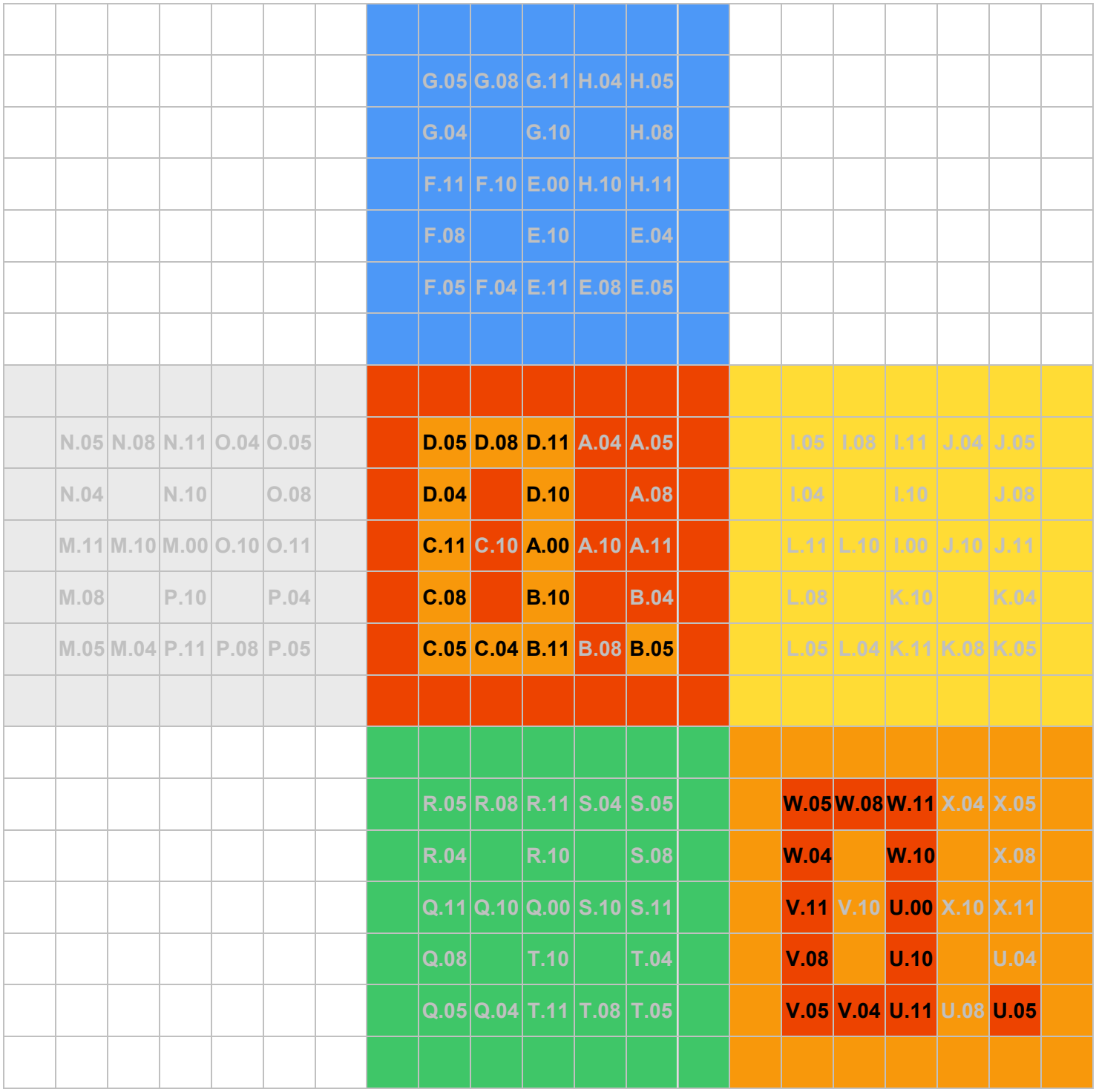
Time Display: 23 hours



Orbit Cube Texture – Centers – 7x7x7

								G.05	G.08	G.11	H.04	H.05							
								G.04		G.10		H.08							
								F.11	F.10	E.00	H.10	H.11							
								F.08		E.10		E.04							
								F.05	F.04	E.11	E.08	E.05							
	N.05	N.08	N.11	O.04	O.05			D.05	D.08	D.11	A.04	A.05			I.05	I.08	I.11	J.04	J.05	
	N.04		N.10		O.08			D.04		D.10		A.08			I.04		I.10		J.08	
	M.11	M.10	M.00	O.10	O.11			C.11	C.10	A.00	A.10	A.11			L.11	L.10	I.00	J.10	J.11	
	M.08		P.10		P.04			C.08		B.10		B.04			L.08		K.10		K.04	
	M.05	M.04	P.11	P.08	P.05			C.05	C.04	B.11	B.08	B.05			L.05	L.04	K.11	K.08	K.05	
								R.05	R.08	R.11	S.04	S.05			W.05	W.08	W.11	X.04	X.05	
								R.04		R.10		S.08			W.04		W.10		X.08	
								Q.11	Q.10	Q.00	S.10	S.11			V.11	V.10	U.00	X.10	X.11	
								Q.08		T.10		T.04			V.08		U.10		U.04	
								Q.05	Q.04	T.11	T.08	T.05			V.05	V.04	U.11	U.08	U.05	

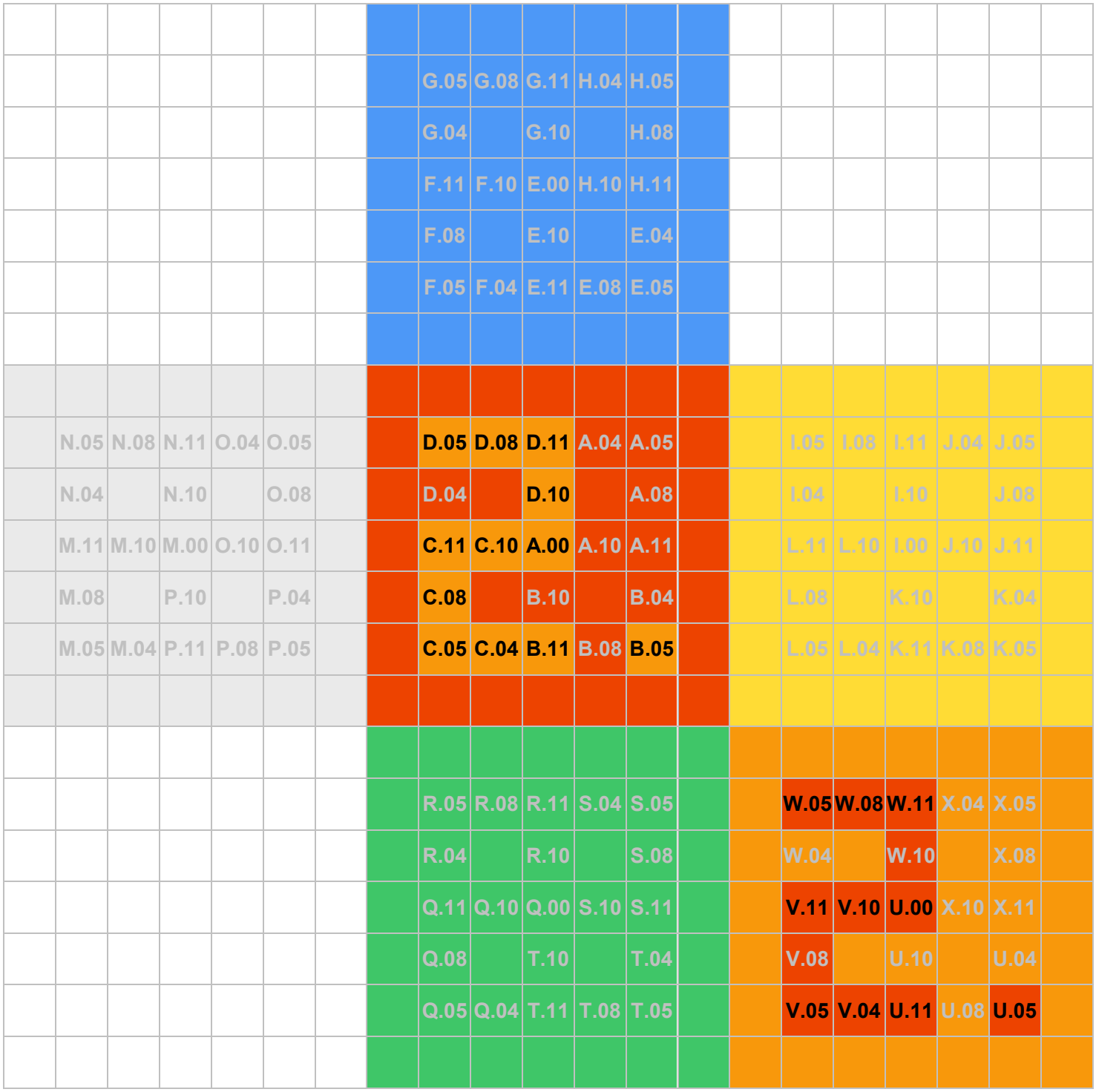
Numeral '0.'


G.05 G.08 G.11 H.04 H.05
G.04 G.10 H.08
F.11 F.10 E.00 H.10 H.11
F.08 E.10 E.04
F.05 F.04 E.11 E.08 E.05
N.05 N.08 N.11 O.04 O.05
D.05 D.08 D.11 A.04 A.05
I.05 I.08 I.11 J.04 J.05
N.04 N.10 O.08
D.04 D.10 A.08
I.04 I.10 J.08
M.11 M.10 M.00 O.10 O.11
C.11 C.10 A.00 A.10 A.11
L.11 L.10 I.00 J.10 J.11
M.08 P.10 P.04
C.08 B.10 B.04
L.08 K.10 K.04
M.05 M.04 P.11 P.08 P.05
C.05 C.04 B.11 B.08 B.05
L.05 L.04 K.11 K.08 K.05
R.05 R.08 R.11 S.04 S.05
W.05 W.08 W.11 X.04 X.05
R.04 R.10 S.08
W.04 W.10 X.08
Q.11 Q.10 Q.00 S.10 S.11
V.11 V.10 U.00 X.10 X.11
Q.08 T.10 T.04
V.08 U.10 U.04
Q.05 Q.04 T.11 T.08 T.05
V.05 V.04 U.11 U.08 U.05

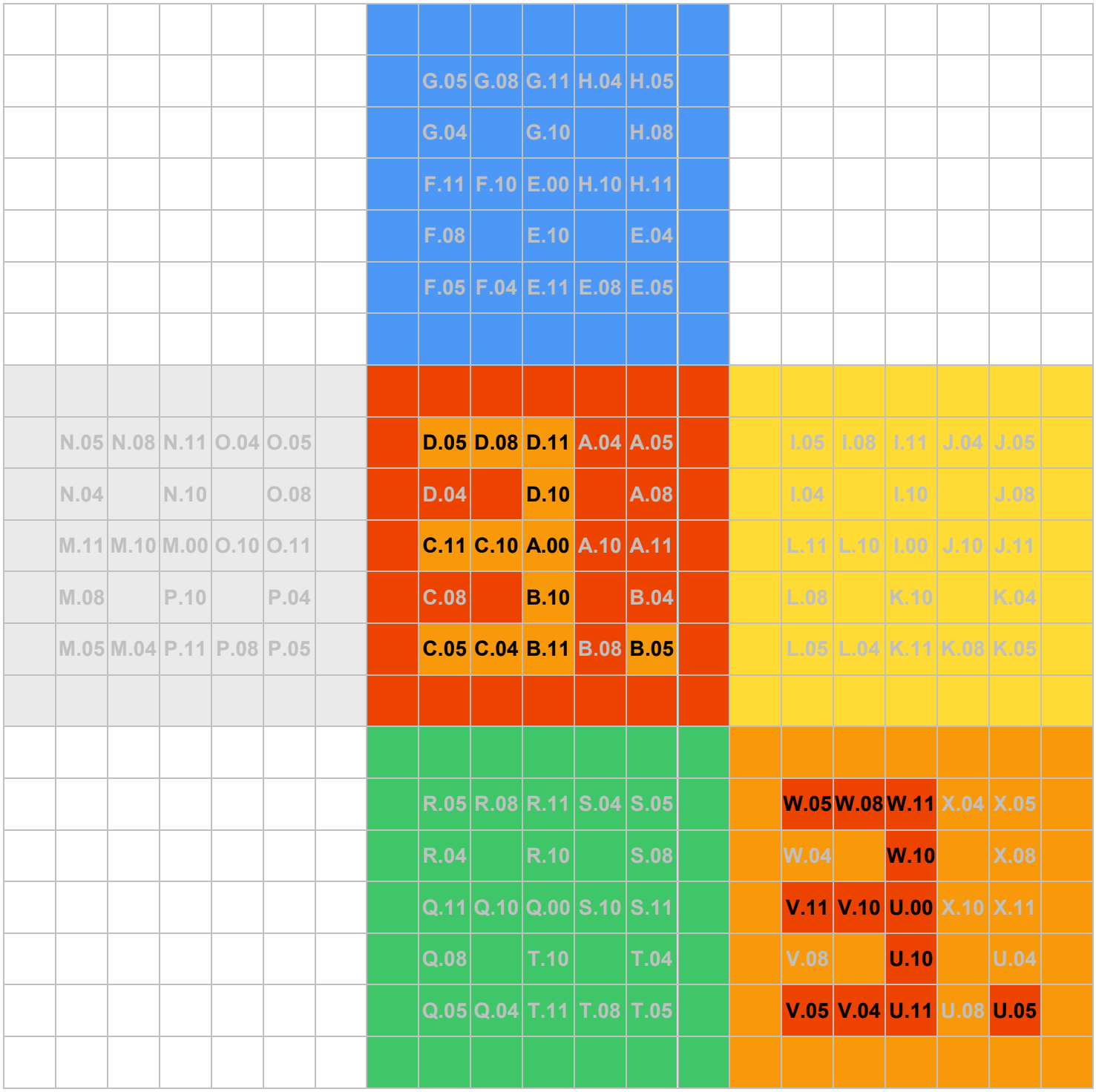
Numeral '1.'

								G.05	G.08	G.11	H.04	H.05							
								G.04		G.10		H.08							
								F.11	F.10	E.00	H.10	H.11							
								F.08		E.10		E.04							
								F.05	F.04	E.11	E.08	E.05							
	N.05	N.08	N.11	O.04	O.05			D.05	D.08	D.11	A.04	A.05			I.05	I.08	I.11	J.04	J.05	
	N.04		N.10		O.08			D.04		D.10		A.08			I.04		I.10		J.08	
	M.11	M.10	M.00	O.10	O.11			C.11	C.10	A.00	A.10	A.11			L.11	L.10	I.00	J.10	J.11	
	M.08		P.10		P.04			C.08		B.10		B.04			L.08		K.10		K.04	
	M.05	M.04	P.11	P.08	P.05			C.05	C.04	B.11	B.08	B.05			L.05	L.04	K.11	K.08	K.05	
								R.05	R.08	R.11	S.04	S.05			W.05	W.08	W.11	X.04	X.05	
								R.04		R.10		S.08			W.04		W.10		X.08	
								Q.11	Q.10	Q.00	S.10	S.11			V.11	V.10	U.00	X.10	X.11	
								Q.08		T.10		T.04			V.08		U.10		U.04	
								Q.05	Q.04	T.11	T.08	T.05			V.05	V.04	U.11	U.08	U.05	

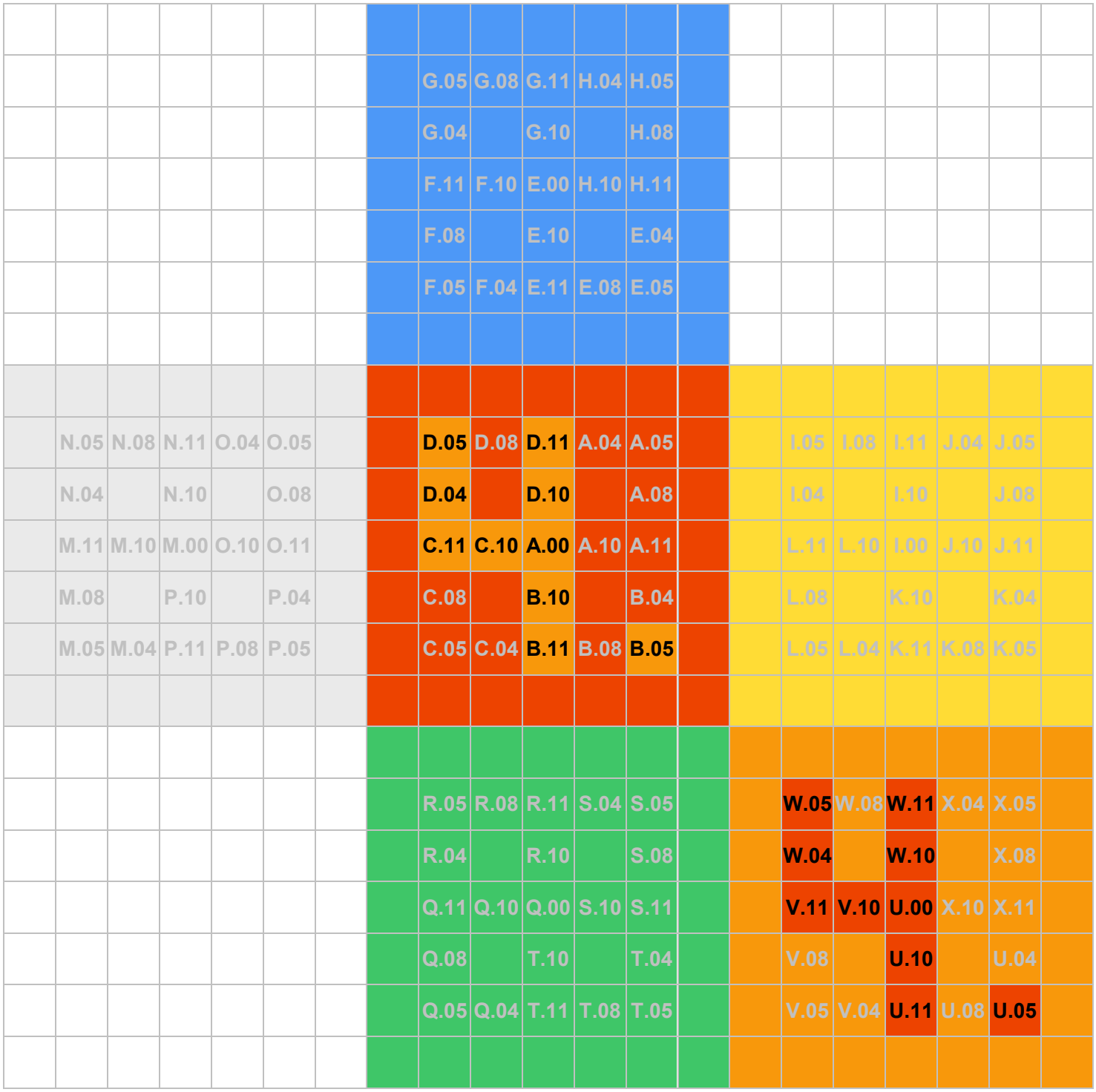
Numeral '2.'


G.05 G.08 G.11 H.04 H.05
G.04 G.10 H.08
F.11 F.10 E.00 H.10 H.11
F.08 E.10 E.04
F.05 F.04 E.11 E.08 E.05
N.05 N.08 N.11 O.04 O.05
D.05 D.08 D.11 A.04 A.05
I.05 I.08 I.11 J.04 J.05
N.04 N.10 O.08
D.04 D.10 A.08
I.04 I.10 J.08
M.11 M.10 M.00 O.10 O.11
C.11 C.10 A.00 A.10 A.11
L.11 L.10 I.00 J.10 J.11
M.08 P.10 P.04
C.08 B.10 B.04
L.08 K.10 K.04
M.05 M.04 P.11 P.08 P.05
C.05 C.04 B.11 B.08 B.05
L.05 L.04 K.11 K.08 K.05
R.05 R.08 R.11 S.04 S.05
W.05 W.08 W.11 X.04 X.05
R.04 R.10 S.08
W.04 W.10 X.08
Q.11 Q.10 Q.00 S.10 S.11
V.11 V.10 U.00 X.10 X.11
Q.08 T.10 T.04
V.08 U.10 U.04
Q.05 Q.04 T.11 T.08 T.05
V.05 V.04 U.11 U.08 U.05

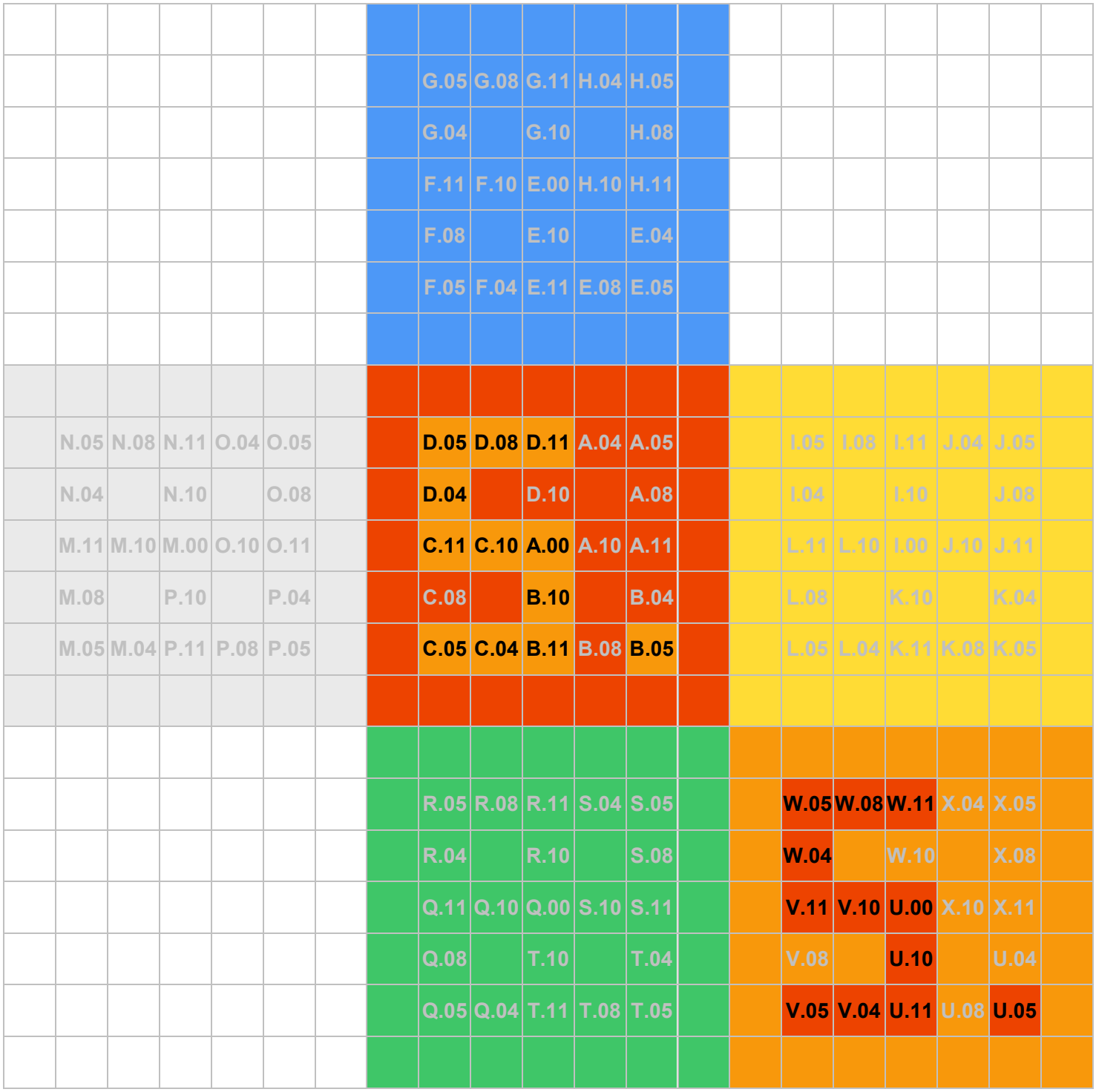
Numeral '3.'


G.05 G.08 G.11 H.04 H.05
G.04 G.10 H.08
F.11 F.10 E.00 H.10 H.11
F.08 E.10 E.04
F.05 F.04 E.11 E.08 E.05
N.05 N.08 N.11 O.04 O.05
D.05 D.08 D.11 A.04 A.05
I.05 I.08 I.11 J.04 J.05
N.04 N.10 O.08
D.04 D.10 A.08
I.04 I.10 J.08
M.11 M.10 M.00 O.10 O.11
C.11 C.10 A.00 A.10 A.11
L.11 L.10 I.00 J.10 J.11
M.08 P.10 P.04
C.08 B.10 B.04
L.08 K.10 K.04
M.05 M.04 P.11 P.08 P.05
C.05 C.04 B.11 B.08 B.05
L.05 L.04 K.11 K.08 K.05
R.05 R.08 R.11 S.04 S.05
W.05 W.08 W.11 X.04 X.05
R.04 R.10 S.08
W.04 W.10 X.08
Q.11 Q.10 Q.00 S.10 S.11
V.11 V.10 U.00 X.10 X.11
Q.08 T.10 T.04
V.08 U.10 U.04
Q.05 Q.04 T.11 T.08 T.05
V.05 V.04 U.11 U.08 U.05

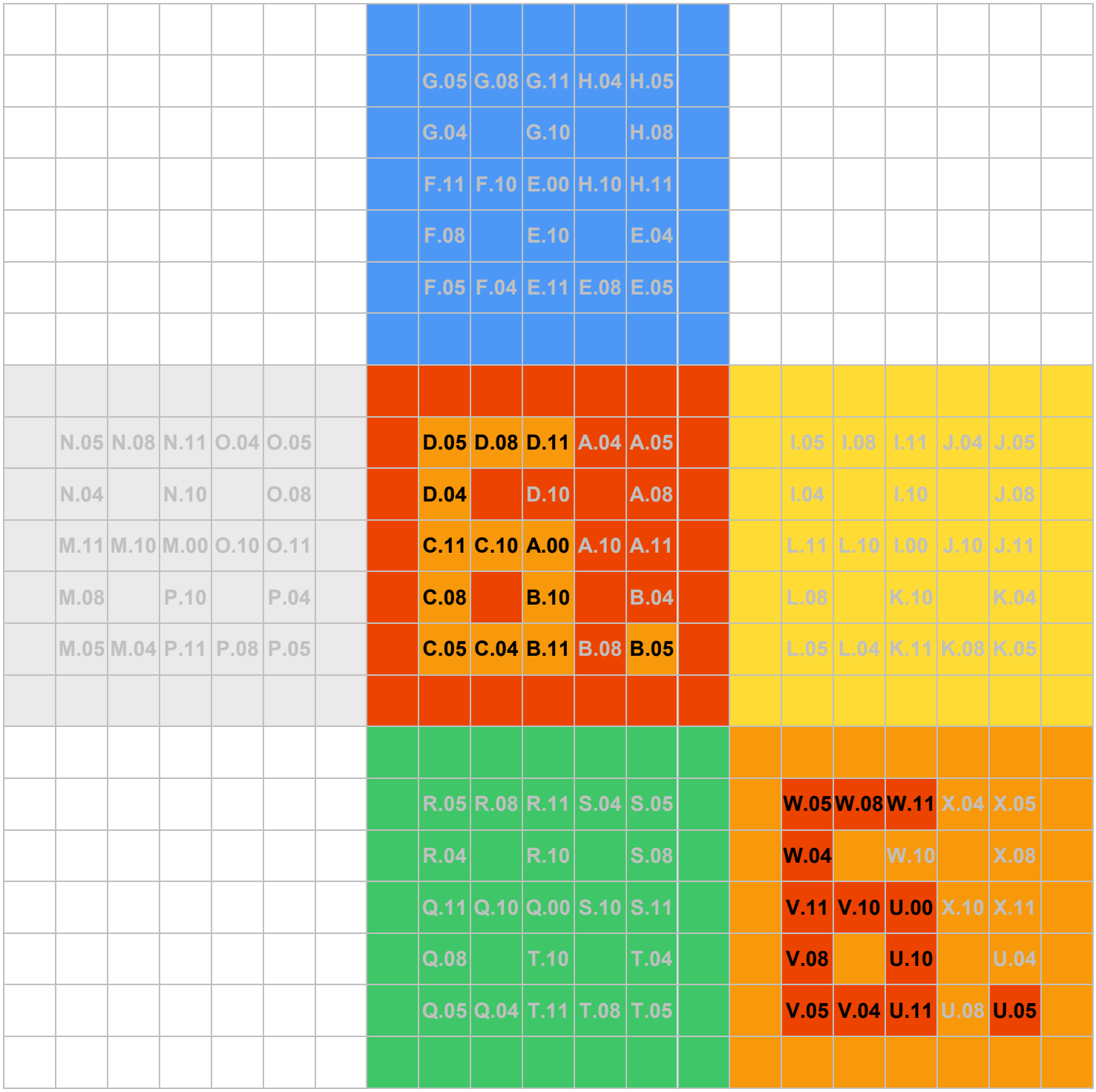
Numeral '4.'


G.05 G.08 G.11 H.04 H.05
G.04 G.10 H.08
F.11 F.10 E.00 H.10 H.11
F.08 E.10 E.04
F.05 F.04 E.11 E.08 E.05
N.05 N.08 N.11 O.04 O.05
D.05 D.08 D.11 A.04 A.05
I.05 I.08 I.11 J.04 J.05
N.04 N.10 O.08
D.04 D.10 A.08
I.04 I.10 J.08
M.11 M.10 M.00 O.10 O.11
C.11 C.10 A.00 A.10 A.11
L.11 L.10 I.00 J.10 J.11
M.08 P.10 P.04
C.08 B.10 B.04
L.08 K.10 K.04
M.05 M.04 P.11 P.08 P.05
C.05 C.04 B.11 B.08 B.05
L.05 L.04 K.11 K.08 K.05
R.05 R.08 R.11 S.04 S.05
W.05 W.08 W.11 X.04 X.05
R.04 R.10 S.08
W.04 W.10 X.08
Q.11 Q.10 Q.00 S.10 S.11
V.11 V.10 U.00 X.10 X.11
Q.08 T.10 T.04
V.08 U.10 U.04
Q.05 Q.04 T.11 T.08 T.05
V.05 V.04 U.11 U.08 U.05

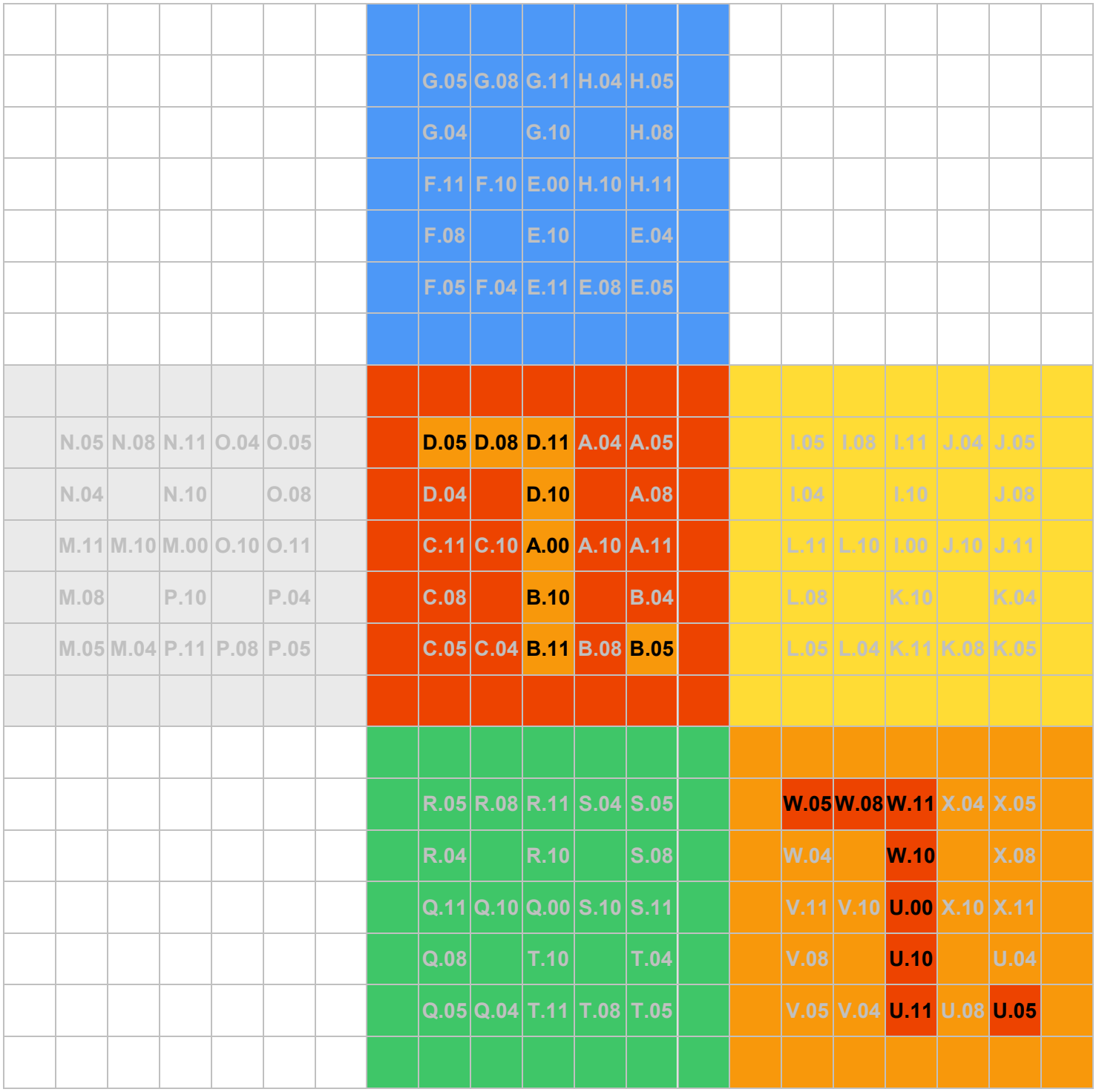
Numeral '5.'


G.05 G.08 G.11 H.04 H.05
G.04 G.10 H.08
F.11 F.10 E.00 H.10 H.11
F.08 E.10 E.04
F.05 F.04 E.11 E.08 E.05
N.05 N.08 N.11 O.04 O.05
D.05 D.08 D.11 A.04 A.05
I.05 I.08 I.11 J.04 J.05
N.04 N.10 O.08
D.04 D.10 A.08
I.04 I.10 J.08
M.11 M.10 M.00 O.10 O.11
C.11 C.10 A.00 A.10 A.11
L.11 L.10 I.00 J.10 J.11
M.08 P.10 P.04
C.08 B.10 B.04
L.08 K.10 K.04
M.05 M.04 P.11 P.08 P.05
C.05 C.04 B.11 B.08 B.05
L.05 L.04 K.11 K.08 K.05
R.05 R.08 R.11 S.04 S.05
W.05 W.08 W.11 X.04 X.05
R.04 R.10 S.08
W.04 W.10 X.08
Q.11 Q.10 Q.00 S.10 S.11
V.11 V.10 U.00 X.10 X.11
Q.08 T.10 T.04
V.08 U.10 U.04
Q.05 Q.04 T.11 T.08 T.05
V.05 V.04 U.11 U.08 U.05

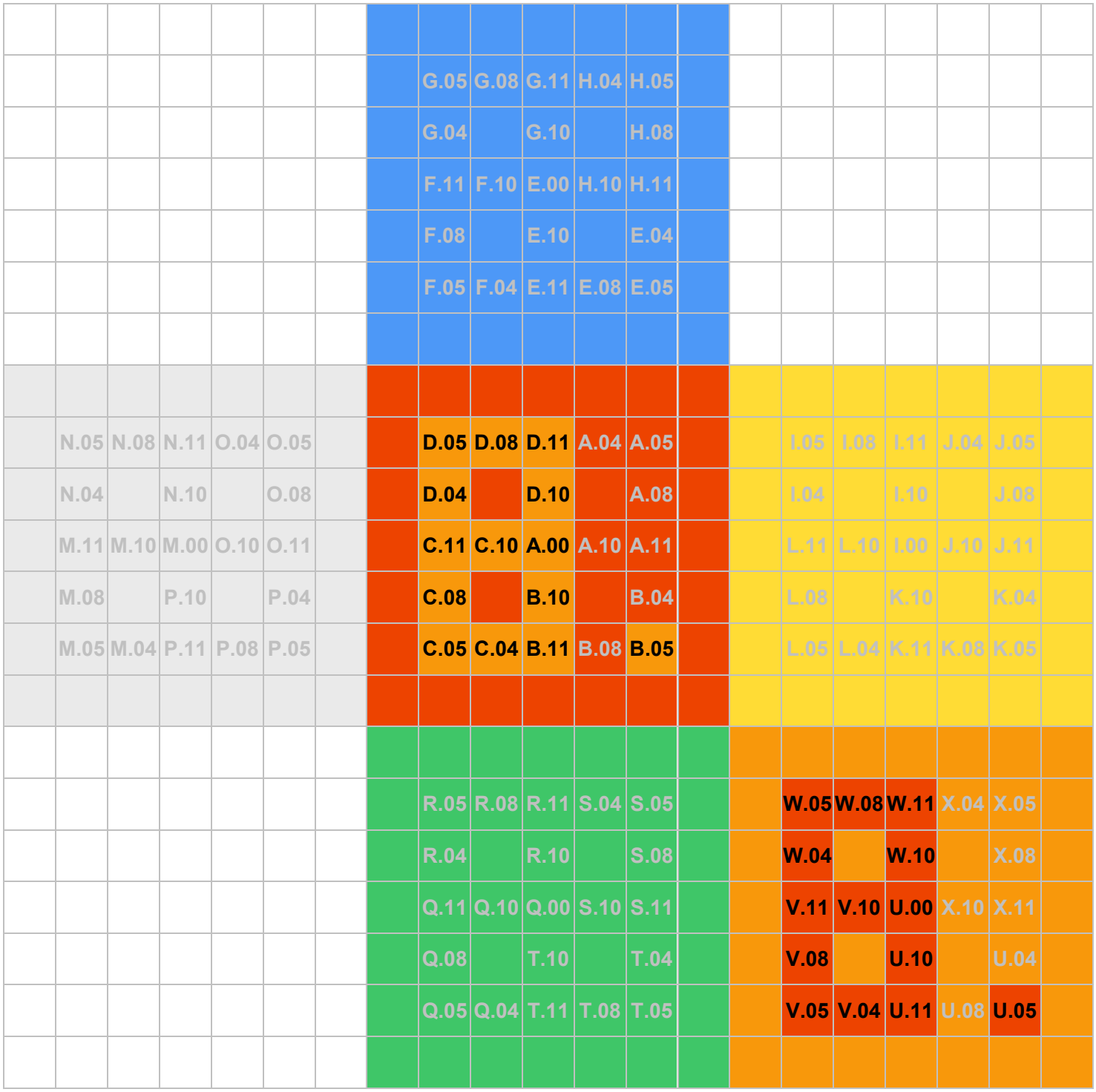
Numeral '6.'


G.05 G.08 G.11 H.04 H.05
G.04 G.10 H.08
F.11 F.10 E.00 H.10 H.11
F.08 E.10 E.04
F.05 F.04 E.11 E.08 E.05
N.05 N.08 N.11 O.04 O.05
D.05 D.08 D.11 A.04 A.05
I.05 I.08 I.11 J.04 J.05
N.04 N.10 O.08
D.04 D.10 A.08
I.04 I.10 J.08
M.11 M.10 M.00 O.10 O.11
C.11 C.10 A.00 A.10 A.11
L.11 L.10 I.00 J.10 J.11
M.08 P.10 P.04
C.08 B.10 B.04
L.08 K.10 K.04
M.05 M.04 P.11 P.08 P.05
C.05 C.04 B.11 B.08 B.05
L.05 L.04 K.11 K.08 K.05
R.05 R.08 R.11 S.04 S.05
W.05 W.08 W.11 X.04 X.05
R.04 R.10 S.08
W.04 W.10 X.08
Q.11 Q.10 Q.00 S.10 S.11
V.11 V.10 U.00 X.10 X.11
Q.08 T.10 T.04
V.08 U.10 U.04
Q.05 Q.04 T.11 T.08 T.05
V.05 V.04 U.11 U.08 U.05

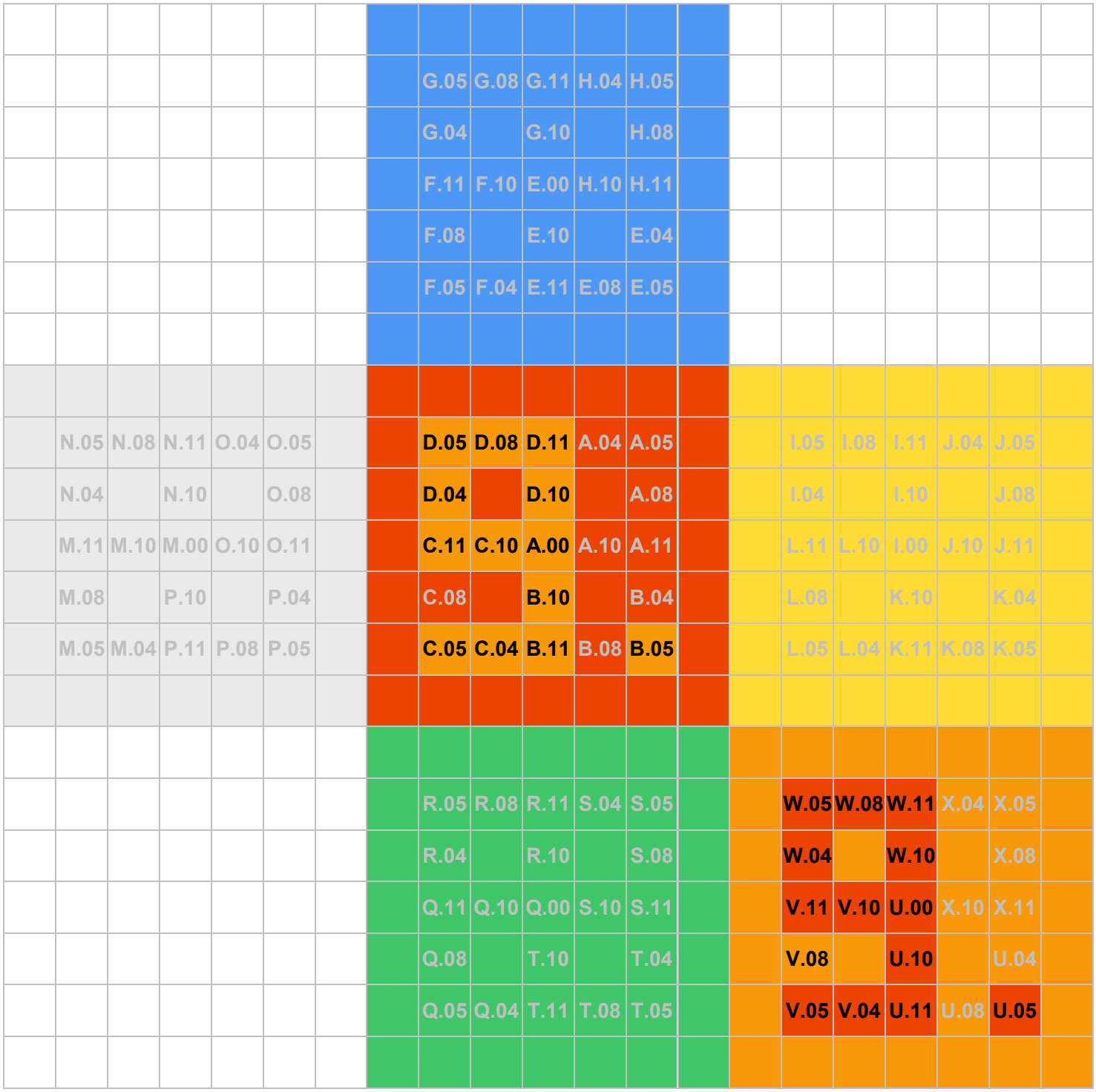
Numeral '7.'


G.05 G.08 G.11 H.04 H.05
G.04 G.10 H.08
F.11 F.10 E.00 H.10 H.11
F.08 E.10 E.04
F.05 F.04 E.11 E.08 E.05
N.05 N.08 N.11 O.04 O.05
D.05 D.08 D.11 A.04 A.05
I.05 I.08 I.11 J.04 J.05
N.04 N.10 O.08
D.04 D.10 A.08
I.04 I.10 J.08
M.11 M.10 M.00 O.10 O.11
C.11 C.10 A.00 A.10 A.11
L.11 L.10 I.00 J.10 J.11
M.08 P.10 P.04
C.08 B.10 B.04
L.08 K.10 K.04
M.05 M.04 P.11 P.08 P.05
C.05 C.04 B.11 B.08 B.05
L.05 L.04 K.11 K.08 K.05
R.05 R.08 R.11 S.04 S.05
W.05 W.08 W.11 X.04 X.05
R.04 R.10 S.08
W.04 W.10 X.08
Q.11 Q.10 Q.00 S.10 S.11
V.11 V.10 U.00 X.10 X.11
Q.08 T.10 T.04
V.08 U.10 U.04
Q.05 Q.04 T.11 T.08 T.05
V.05 V.04 U.11 U.08 U.05

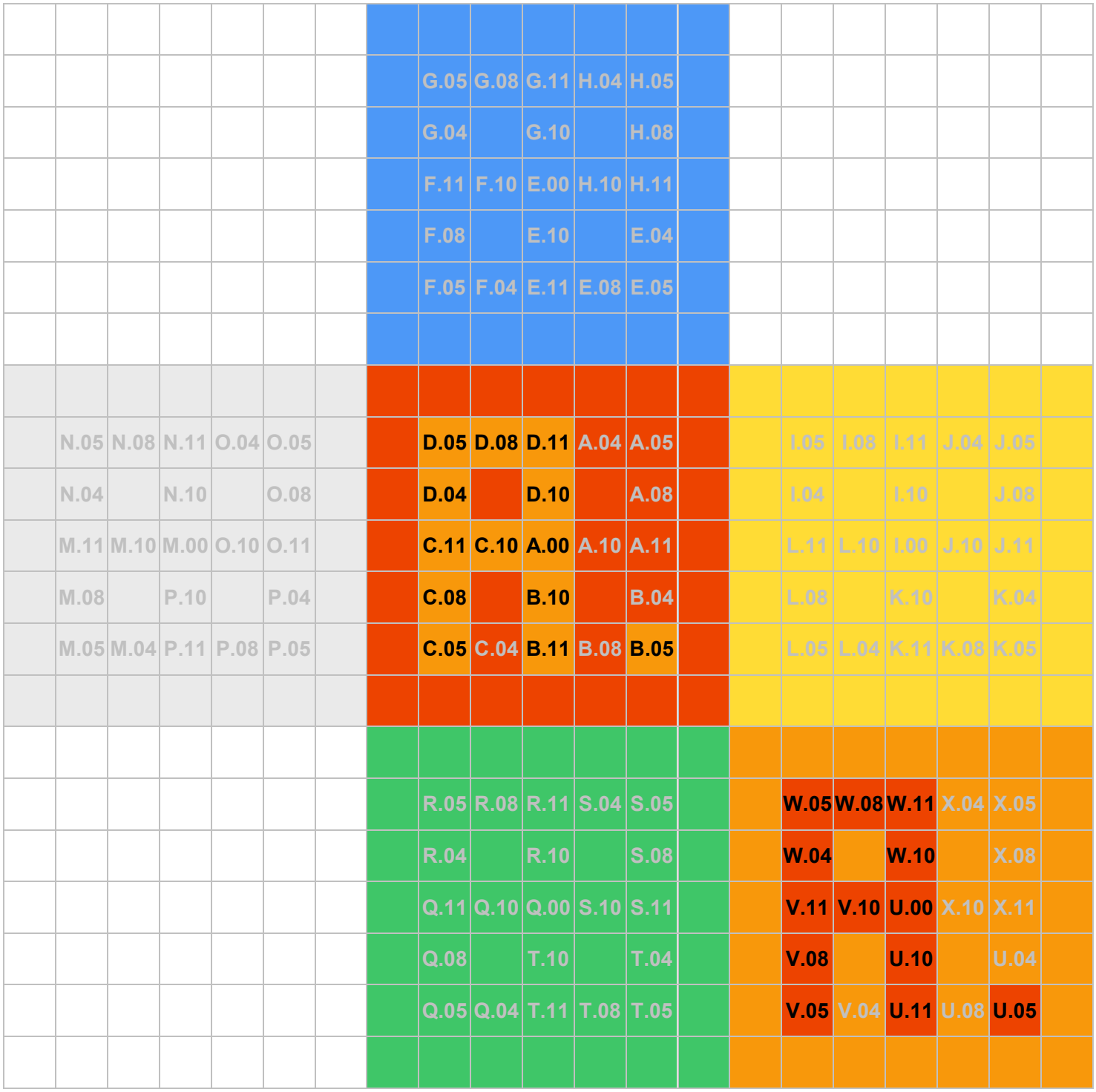
Numeral '8.'


G.05 G.08 G.11 H.04 H.05
G.04 G.10 H.08
F.11 F.10 E.00 H.10 H.11
F.08 E.10 E.04
F.05 F.04 E.11 E.08 E.05
N.05 N.08 N.11 O.04 O.05
D.05 D.08 D.11 A.04 A.05
I.05 I.08 I.11 J.04 J.05
N.04 N.10 O.08
D.04 D.10 A.08
I.04 I.10 J.08
M.11 M.10 M.00 O.10 O.11
C.11 C.10 A.00 A.10 A.11
L.11 L.10 I.00 J.10 J.11
M.08 P.10 P.04
C.08 B.10 B.04
L.08 K.10 K.04
M.05 M.04 P.11 P.08 P.05
C.05 C.04 B.11 B.08 B.05
L.05 L.04 K.11 K.08 K.05
R.05 R.08 R.11 S.04 S.05
W.05 W.08 W.11 X.04 X.05
R.04 R.10 S.08
W.04 W.10 X.08
Q.11 Q.10 Q.00 S.10 S.11
V.11 V.10 U.00 X.10 X.11
Q.08 T.10 T.04
V.08 U.10 U.04
Q.05 Q.04 T.11 T.08 T.05
V.05 V.04 U.11 U.08 U.05

Numeral '9.'


G.05 G.08 G.11 H.04 H.05
G.04 G.10 H.08
F.11 F.10 E.00 H.10 H.11
F.08 E.10 E.04
F.05 F.04 E.11 E.08 E.05
N.05 N.08 N.11 O.04 O.05
D.05 D.08 D.11 A.04 A.05
I.05 I.08 I.11 J.04 J.05
N.04 N.10 O.08
D.04 D.10 A.08
I.04 I.10 J.08
M.11 M.10 M.00 O.10 O.11
C.11 C.10 A.00 A.10 A.11
L.11 L.10 I.00 J.10 J.11
M.08 P.10 P.04
C.08 B.10 B.04
L.08 K.10 K.04
M.05 M.04 P.11 P.08 P.05
C.05 C.04 B.11 B.08 B.05
L.05 L.04 K.11 K.08 K.05
R.05 R.08 R.11 S.04 S.05
W.05 W.08 W.11 X.04 X.05
R.04 R.10 S.08
W.04 W.10 X.08
Q.11 Q.10 Q.00 S.10 S.11
V.11 V.10 U.00 X.10 X.11
Q.08 T.10 T.04
V.08 U.10 U.04
Q.05 Q.04 T.11 T.08 T.05
V.05 V.04 U.11 U.08 U.05

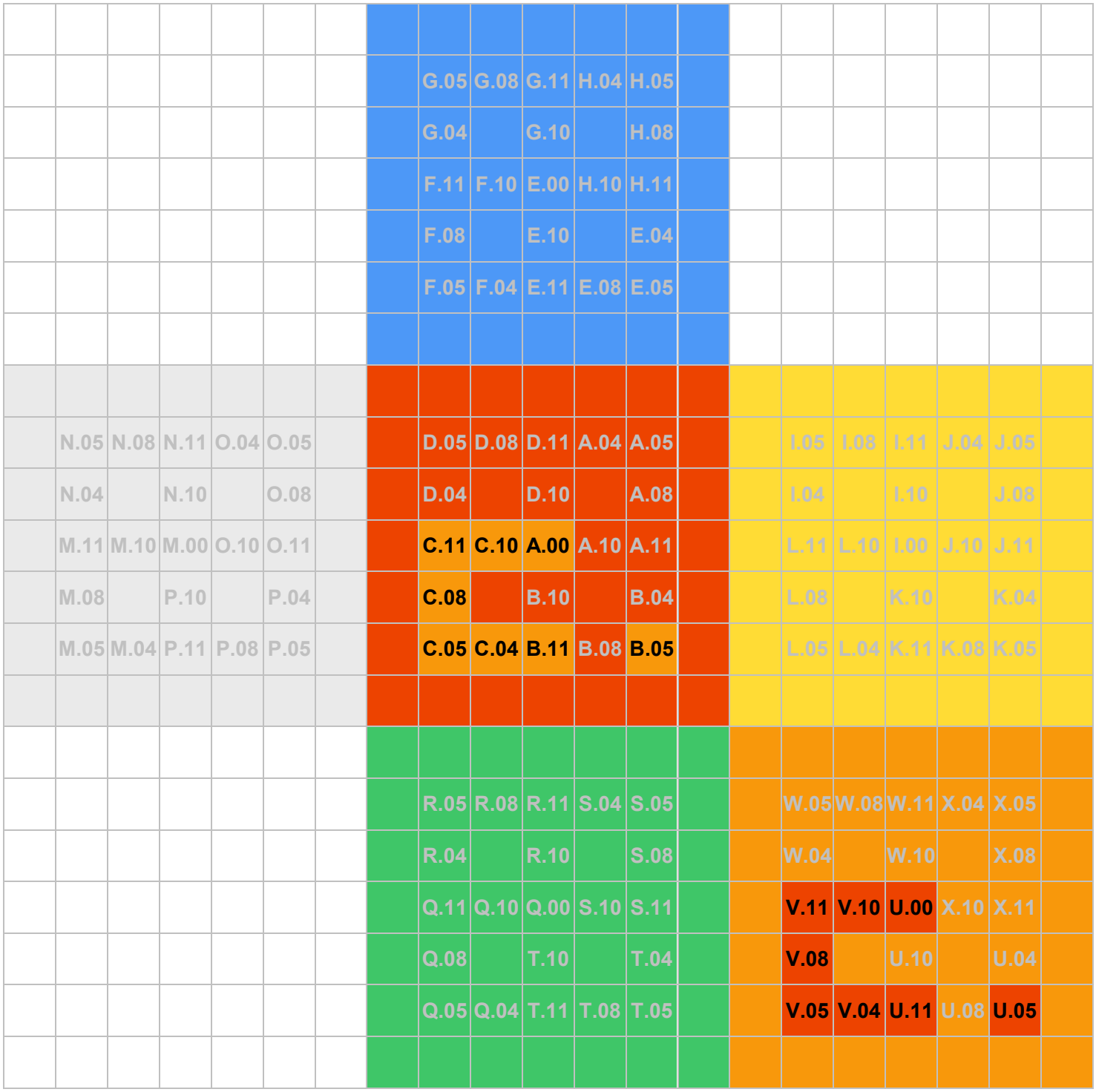
Letter 'A.'


G.05 G.08 G.11 H.04 H.05
G.04 G.10 H.08
F.11 F.10 E.00 H.10 H.11
F.08 E.10 E.04
F.05 F.04 E.11 E.08 E.05
N.05 N.08 N.11 O.04 O.05
D.05 D.08 D.11 A.04 A.05
I.05 I.08 I.11 J.04 J.05
N.04 N.10 O.08
D.04 D.10 A.08
I.04 I.10 J.08
M.11 M.10 M.00 O.10 O.11
C.11 C.10 A.00 A.10 A.11
L.11 L.10 I.00 J.10 J.11
M.08 P.10 P.04
C.08 B.10 B.04
L.08 K.10 K.04
M.05 M.04 P.11 P.08 P.05
C.05 C.04 B.11 B.08 B.05
L.05 L.04 K.11 K.08 K.05
R.05 R.08 R.11 S.04 S.05
W.05 W.08 W.11 X.04 X.05
R.04 R.10 S.08
W.04 W.10 X.08
Q.11 Q.10 Q.00 S.10 S.11
V.11 V.10 U.00 X.10 X.11
Q.08 T.10 T.04
V.08 U.10 U.04
Q.05 Q.04 T.11 T.08 T.05
V.05 V.04 U.11 U.08 U.05

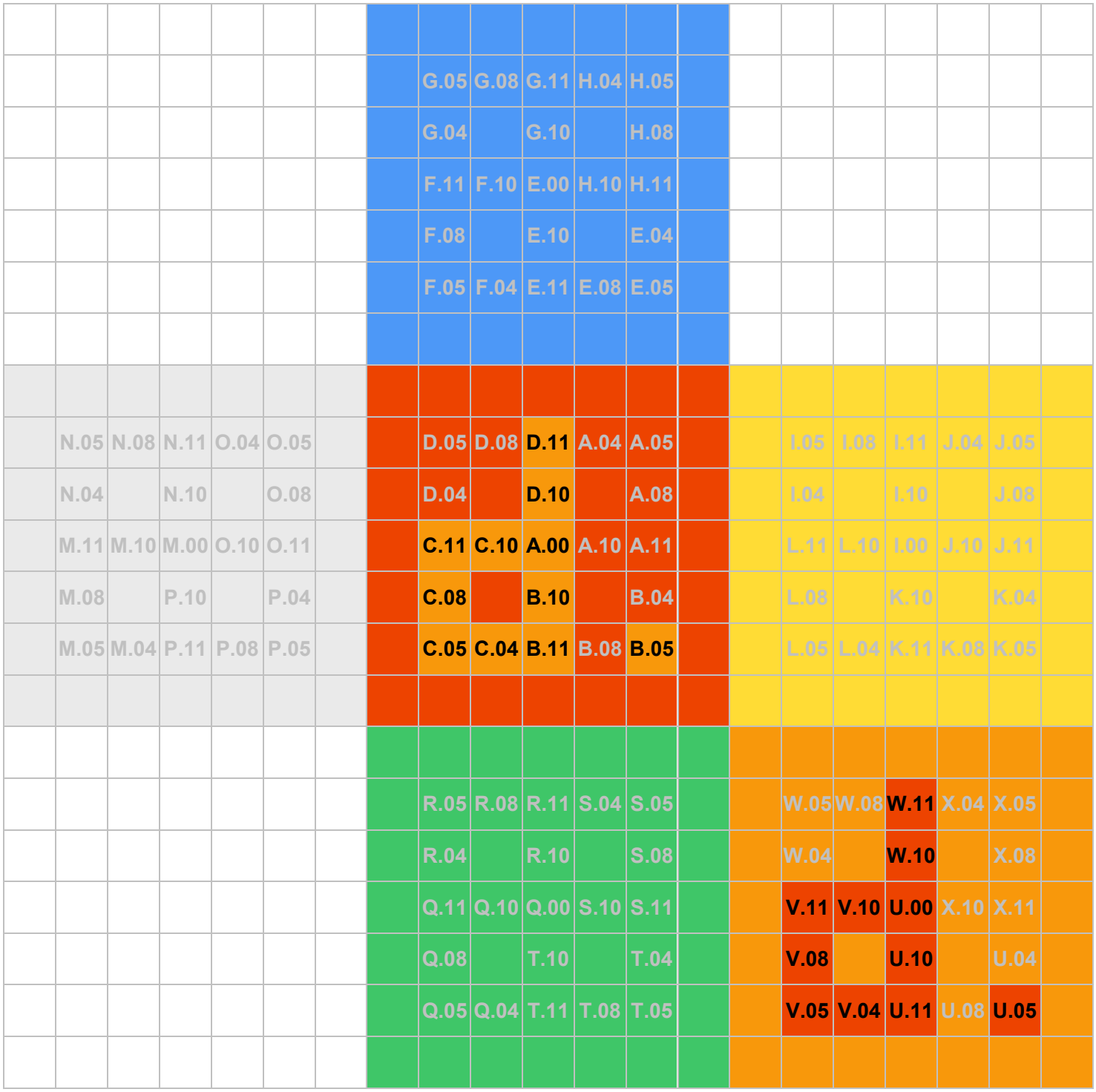
Letter 'B.'

								G.05	G.08	G.11	H.04	H.05							
								G.04		G.10		H.08							
								F.11	F.10	E.00	H.10	H.11							
								F.08		E.10		E.04							
								F.05	F.04	E.11	E.08	E.05							
	N.05	N.08	N.11	O.04	O.05			D.05	D.08	D.11	A.04	A.05			I.05	I.08	I.11	J.04	J.05	
	N.04		N.10		O.08			D.04		D.10		A.08			I.04		I.10		J.08	
	M.11	M.10	M.00	O.10	O.11			C.11	C.10	A.00	A.10	A.11			L.11	L.10	I.00	J.10	J.11	
	M.08		P.10		P.04			C.08		B.10		B.04			L.08		K.10		K.04	
	M.05	M.04	P.11	P.08	P.05			C.05	C.04	B.11	B.08	B.05			L.05	L.04	K.11	K.08	K.05	
								R.05	R.08	R.11	S.04	S.05			W.05	W.08	W.11	X.04	X.05	
								R.04		R.10		S.08			W.04		W.10		X.08	
								Q.11	Q.10	Q.00	S.10	S.11			V.11	V.10	U.00	X.10	X.11	
								Q.08		T.10		T.04			V.08		U.10		U.04	
								Q.05	Q.04	T.11	T.08	T.05			V.05	V.04	U.11	U.08	U.05	

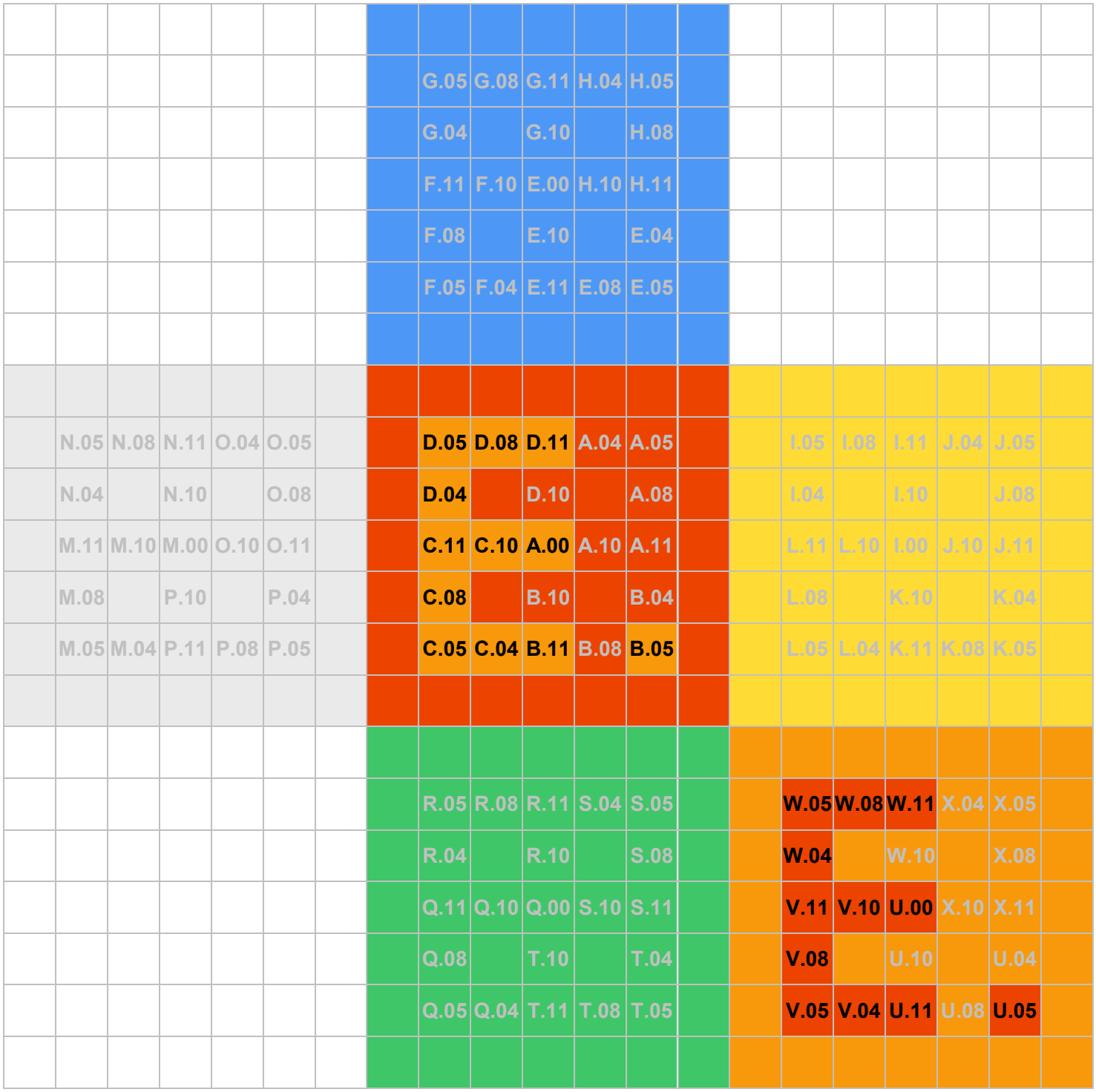
Letter 'C.'


G.05 G.08 G.11 H.04 H.05
G.04 G.10 H.08
F.11 F.10 E.00 H.10 H.11
F.08 E.10 E.04
F.05 F.04 E.11 E.08 E.05
N.05 N.08 N.11 O.04 O.05
D.05 D.08 D.11 A.04 A.05
I.05 I.08 I.11 J.04 J.05
N.04 N.10 O.08
D.04 D.10 A.08
I.04 I.10 J.08
M.11 M.10 M.00 O.10 O.11
C.11 C.10 A.00 A.10 A.11
L.11 L.10 I.00 J.10 J.11
M.08 P.10 P.04
C.08 B.10 B.04
L.08 K.10 K.04
M.05 M.04 P.11 P.08 P.05
C.05 C.04 B.11 B.08 B.05
L.05 L.04 K.11 K.08 K.05
R.05 R.08 R.11 S.04 S.05
W.05 W.08 W.11 X.04 X.05
R.04 R.10 S.08
W.04 W.10 X.08
Q.11 Q.10 Q.00 S.10 S.11
V.11 V.10 U.00 X.10 X.11
Q.08 T.10 T.04
V.08 U.10 U.04
Q.05 Q.04 T.11 T.08 T.05
V.05 V.04 U.11 U.08 U.05

Letter 'D.'


G.05 G.08 G.11 H.04 H.05
G.04 G.10 H.08
F.11 F.10 E.00 H.10 H.11
F.08 E.10 E.04
F.05 F.04 E.11 E.08 E.05
N.05 N.08 N.11 O.04 O.05
D.05 D.08 D.11 A.04 A.05
I.05 I.08 I.11 J.04 J.05
N.04 N.10 O.08
D.04 D.10 A.08
I.04 I.10 J.08
M.11 M.10 M.00 O.10 O.11
C.11 C.10 A.00 A.10 A.11
L.11 L.10 I.00 J.10 J.11
M.08 P.10 P.04
C.08 B.10 B.04
L.08 K.10 K.04
M.05 M.04 P.11 P.08 P.05
C.05 C.04 B.11 B.08 B.05
L.05 L.04 K.11 K.08 K.05
R.05 R.08 R.11 S.04 S.05
W.05 W.08 W.11 X.04 X.05
R.04 R.10 S.08
W.04 W.10 X.08
Q.11 Q.10 Q.00 S.10 S.11
V.11 V.10 U.00 X.10 X.11
Q.08 T.10 T.04
V.08 U.10 U.04
Q.05 Q.04 T.11 T.08 T.05
V.05 V.04 U.11 U.08 U.05

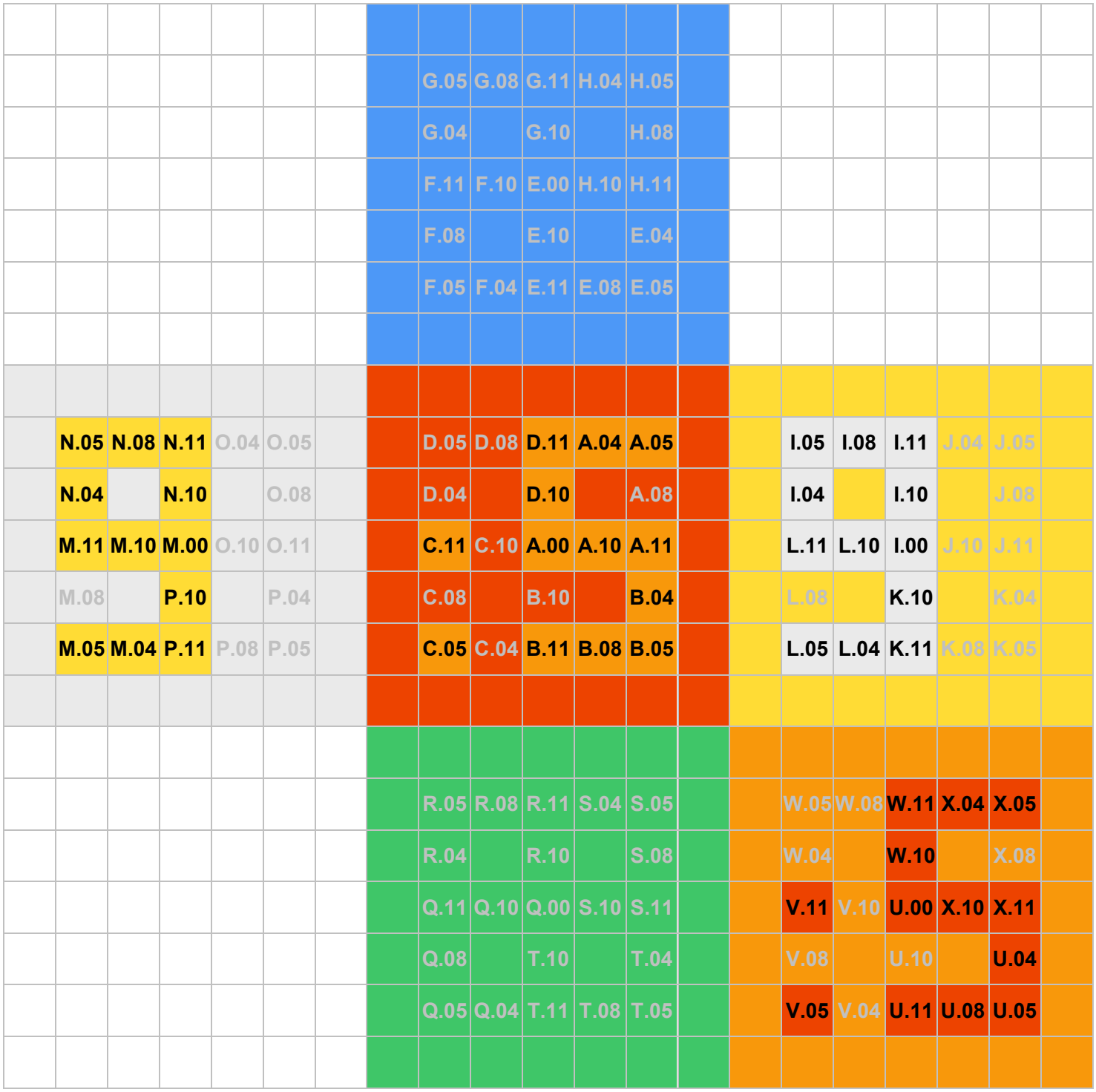
Letter 'E.'


G.05 G.08 G.11 H.04 H.05
G.04 G.10 H.08
F.11 F.10 E.00 H.10 H.11
F.08 E.10 E.04
F.05 F.04 E.11 E.08 E.05
N.05 N.08 N.11 O.04 O.05
D.05 D.08 D.11 A.04 A.05
I.05 I.08 I.11 J.04 J.05
N.04 N.10 O.08
D.04 D.10 A.08
I.04 I.10 J.08
M.11 M.10 M.00 O.10 O.11
C.11 C.10 A.00 A.10 A.11
L.11 L.10 I.00 J.10 J.11
M.08 P.10 P.04
C.08 B.10 B.04
L.08 K.10 K.04
M.05 M.04 P.11 P.08 P.05
C.05 C.04 B.11 B.08 B.05
L.05 L.04 K.11 K.08 K.05
R.05 R.08 R.11 S.04 S.05
W.05 W.08 W.11 X.04 X.05
R.04 R.10 S.08
W.04 W.10 X.08
Q.11 Q.10 Q.00 S.10 S.11
V.11 V.10 U.00 X.10 X.11
Q.08 T.10 T.04
V.08 U.10 U.04
Q.05 Q.04 T.11 T.08 T.05
V.05 V.04 U.11 U.08 U.05

Letter 'F.'

								G.05	G.08	G.11	H.04	H.05							
								G.04		G.10		H.08							
								F.11	F.10	E.00	H.10	H.11							
								F.08		E.10		E.04							
								F.05	F.04	E.11	E.08	E.05							
	N.05	N.08	N.11	O.04	O.05			D.05	D.08	D.11	A.04	A.05			I.05	I.08	I.11	J.04	J.05	
	N.04		N.10		O.08			D.04		D.10		A.08			I.04		I.10		J.08	
	M.11	M.10	M.00	O.10	O.11			C.11	C.10	A.00	A.10	A.11			L.11	L.10	I.00	J.10	J.11	
	M.08		P.10		P.04			C.08		B.10		B.04			L.08		K.10		K.04	
	M.05	M.04	P.11	P.08	P.05			C.05	C.04	B.11	B.08	B.05			L.05	L.04	K.11	K.08	K.05	
								R.05	R.08	R.11	S.04	S.05			W.05	W.08	W.11	X.04	X.05	
								R.04		R.10		S.08			W.04		W.10		X.08	
								Q.11	Q.10	Q.00	S.10	S.11			V.11	V.10	U.00	X.10	X.11	
								Q.08		T.10		T.04			V.08		U.10		U.04	
								Q.05	Q.04	T.11	T.08	T.05			V.05	V.04	U.11	U.08	U.05	

Clock Pattern Example: ':59'



':59' Pattern – Cycle Decomposition			
Orbit 00			
Patterns	Cycles	Parity	Centers
':5'	2-cycle	odd	2
'9'	2-cycle	odd	2
All Cycles	(2-cycle) + (2-cycle)	even	4
Composition	Two 2-cycles	even	4
Permutation	(A U) (I M)	even	4
Orbit 04			
Patterns	Cycles	Parity	Centers
':5'	2-cycle + 2-cycle	even	4
'9'	2-cycle + 2-cycle	even	4
All Cycles	(2-cycle + 2-cycle) + (2-cycle + 2-cycle)	even	8
Composition	Four 2-cycles	even	8
Permutation	(A X) (B U) (N I) (M L)	even	8
Orbit 05			
Patterns	Cycles	Parity	Centers
':5'	2-cycle + 2-cycle + 2-cycle = 4-cycle + 2-cycle*	even	6
'9'	2-cycle + 2-cycle	even	4
All Cycles	(4-cycle + 2-cycle) + (2-cycle + 2-cycle)	even	10
Composition	4-cycle + 2-cycle + Two 2-cycles	even	10
Permutation	(A X B U) (CV) (N I) (M L)	even	10
Orbit 08			
Patterns	Cycles	Parity	Centers
':5'	2-cycle	odd	2
'9'	2-cycle	odd	2
All Cycles	2-cycle + 2-cycle	even	4
Composition	Two 2-cycles	even	4
Permutation	(B U) (N I)	even	4
Orbit 10			
Patterns	Cycles	Parity	Centers
':5'	2-cycle + 2-cycle	even	4
'9'	-cycle + 2-cycle + 2-cycle = 4-cycle + 2-cycle*	even	4
All Cycles	(4-cycle + 2-cycle) + (2-cycle + 2-cycle)	even	8
Composition	4-cycle + 2-cycle + Two 2-cycles	even	8
Permutation	(N I M L) (P K) (D W) (A X)	even	8
Orbit 11			
Patterns	Cycles	Parity	Centers
':5'	2-cycle + 2-cycle + 2-cycle + 2-cycle	even	4
'9'	2-cycle + 2-cycle + 2-cycle = 4-cycle + 2-cycle*	even	4
All Cycles	(2-cycle + 2-cycle + 2-cycle + 2-cycle) + (4-cycle + 2-cycle)	even	8
Composition	Four 2-cycles + 4-cycle + 2-cycle	even	8
Permutation	(N I M L) (P K) (D W) (A X) (B U) (C V)	even	8
*Two 2-cycles are grouped into a 4-cycle to keep permutation parity even.			

':59' Pattern – Algorithms
Orbit 00 Only
MR2 MU MR2 MU'
Orbit 04 Only
NU2 F N3D2 F' NU2 F N3D2 F2 NU2 F N3D2 F' NU2 F N3D2 N3U2 R' NB2 R N3U2 R' NB2 R2 N3B2 R' ND2 R N3B2 R' ND2
Orbit 05 Only
NR NF' NU' NF U NF' NU NF U' NR' NU' NL NB NL' B' NL NB' NL' B NU ND L2 ND' F2 ND NF2 ND' F2 ND NF2 L2 ND' NF' U' NR NU NR' U NR NU' NR' NF2 NU' NL' NU L NU' NL NU L' NF'
Orbit 08 Only
F ND L2 N3F NL' N3F' L2 N3F NL N3F' ND' F' R NU N3R NB' N3R' B2 N3R NB N3R' B2 NU' R'
Orbit 10 Only
N3U2 R' MU2 R N3U2 R' MU2 R MF2 R N3U2 R' MF2 R N3U2 R' L2 MF' N3R2 MF L2 MF' N3R2 MF F MU2 F' N3U2 F MU2 F' N3U2 MU2 F' N3L2 F MU2 F' N3L2 F
Orbit 11 Only

NU2 R' MU2 R NU2 R' MU2 R MF2 R NU2 R' MF2 R NU2 R' L2 MF' NR2 MF L2 MF' NR2 MF F MU2 F' NU2 F MU2 F' NU2 MU2 F' NL2 F MU2 F' NL2 F2 MU2 F' ND2 F MU2 F' ND2 MU2 F' NR2 F MU2 F' NR2 F

Complete Pattern

MR2 MU MR2 MU'
NU2 F N3D2 F' NU2 F N3D2 F2 NU2 F N3D2 F' NU2 F N3D2 N3U2 R' NB2 R N3U2 R' NB2 R2 N3B2 R' ND2 R N3B2 R' ND2
NR NF' NU' NF U NF' NU NF U' NR' NU' NL NB NL' B' NL NB' NL' B NU ND L2 ND' F2 ND NF2 ND' F2 ND NF2 L2 ND' NF' U' NR NU NR' U NR NU' NR' NF2 NU' NL' NU L NU' NL NU L' NF'
F ND L2 N3F NL' N3F' L2 N3F NL N3F' ND' F' R NU N3R NB' N3R' B2 N3R NB N3R' B2 NU' R'
N3U2 R' MU2 R N3U2 R' MU2 R MF2 R N3U2 R' MF2 R N3U2 R' L2 MF' N3R2 MF L2 MF' N3R2 MF F MU2 F' N3U2 F MU2 F' N3U2 MU2 F' N3L2 F MU2 F' N3L2 F
NU2 R' MU2 R NU2 R' MU2 R MF2 R NU2 R' MF2 R NU2 R' L2 MF' NR2 MF L2 MF' NR2 MF F MU2 F' NU2 F MU2 F' NU2 MU2 F' NL2 F MU2 F' NL2 F2 MU2 F' ND2 F MU2 F' ND2 MU2 F' NR2 F MU2 F' NR2 F