Digital Clock Cube Design

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WebSites	http://www.mementoslangues.fr/	http://www.randelshofer.ch/

Introduction

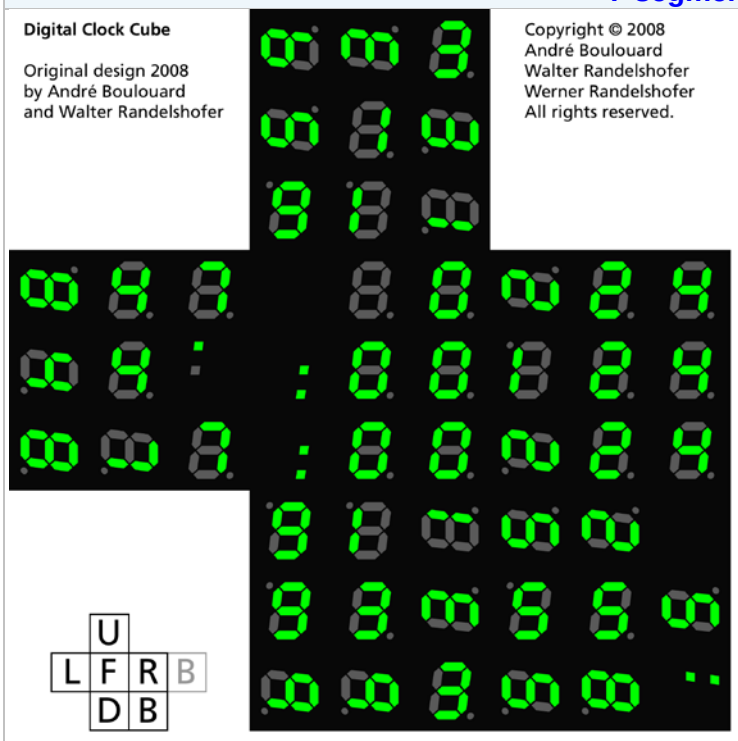
A **Digital Clock Cube** is a 3x3x3 **Rubik's Cube** used for indicating time. A **digital clock** is a type of clock that displays the time digitally, as opposed to an analog clock, where the time is displayed by hands. Seven-segment displays are widely used in digital clocks and other electronic devices for displaying digital information.

Digital Clock – Useful Links	
http://en.wikipedia.org/wiki/Clock	http://en.wikipedia.org/wiki/Digital_clock
http://en.wikipedia.org/wiki/Seven-segment_display	
http://en.wikipedia.org/wiki/Mathematical_constant	http://en.wikipedia.org/wiki/Physical_constant

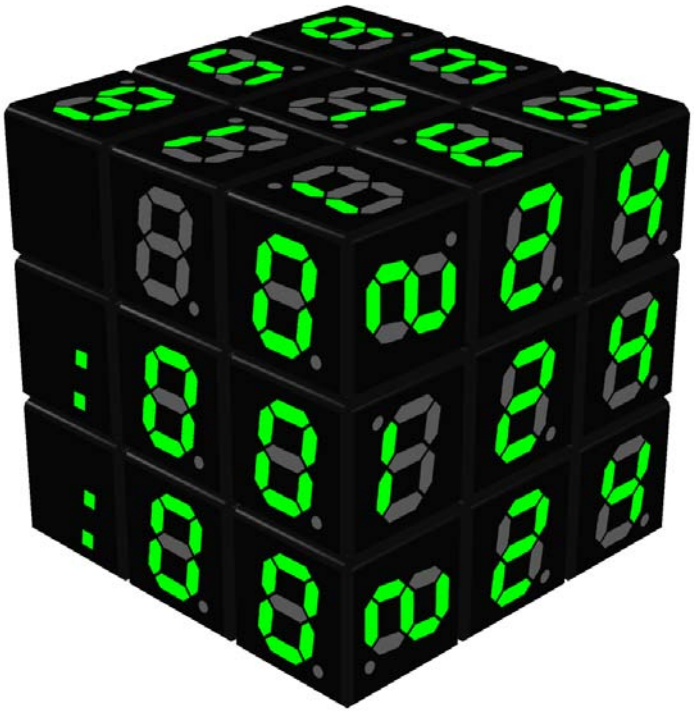
There are **Virtual Cubes** that can be *virtually* rotated and twisted on a computer screen and **Real Cubes** that can only be *physically* rotated and twisted by hand. A **Texture** is laid down on a Virtual Cube whereas real **Stickers** are stuck down on a Real Cube. A Digital Clock Cube is designed by placing numerals on a texture which is then laid down on a Virtual Cube (see http://www.randelshofer.ch/ for more details). The time of the day can be displayed on a *selected* Cube Face by rotating and twisting some parts of the Cube. The following example shows the *initial* state of the Cube where '0:00:00' is displayed on the front face.

Rubik's Cube Digital Clock – Initial State

7-segment Display



Cube Texture



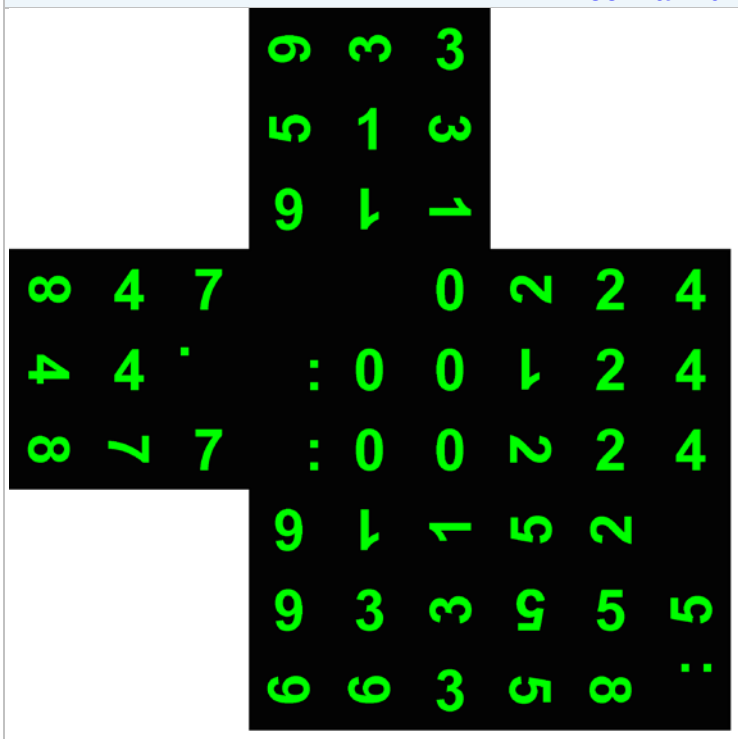
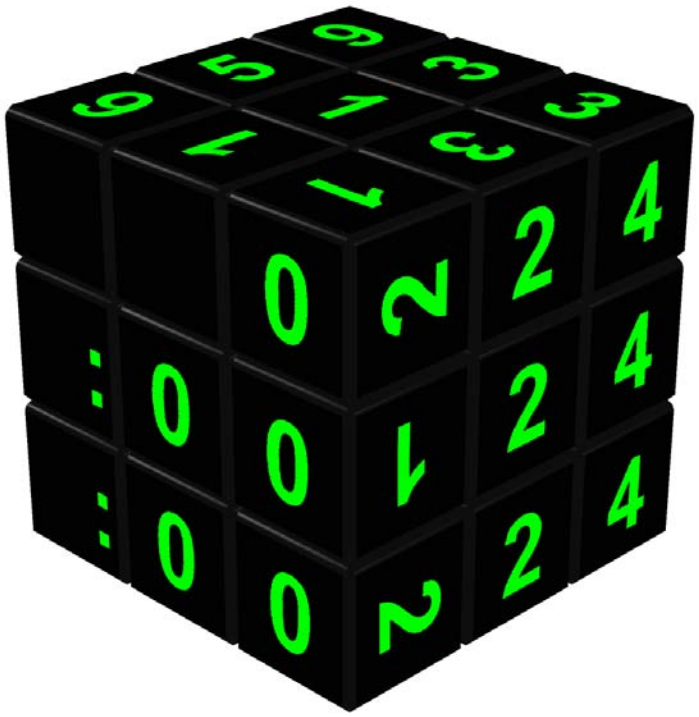
Virtual Cube

Digital Clock Cube Features

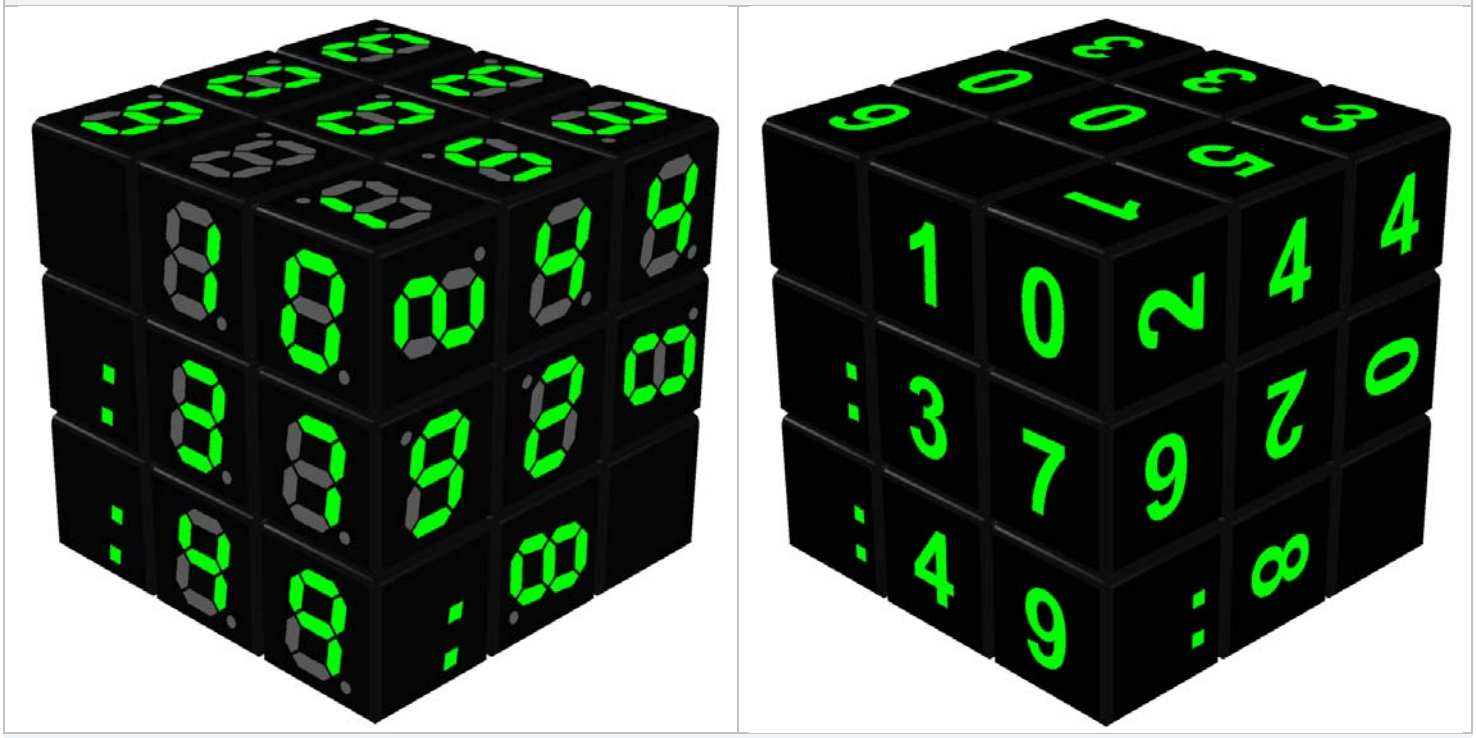
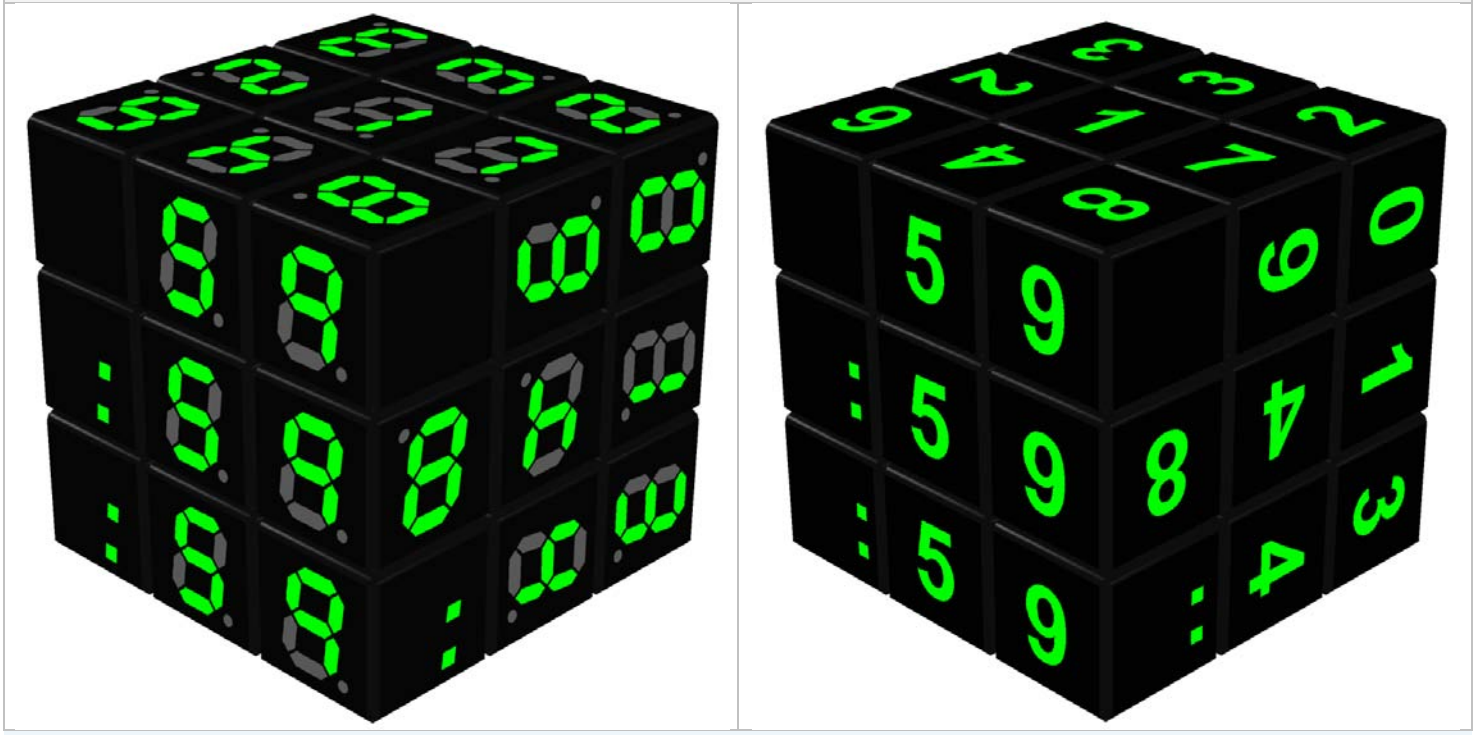
The Cube can be used in 3 modes:

1- Mode A (Digital Clock): from 0:00:00 up to 24:00:00 in 1 second steps
2- Mode B (Accumulated Time Counter): from 0:00:00 up to 59:59:59 in 1 second steps
3- Mode C (Mathematical & Physical Constants Display): see List of Constants

As there are 6 center cubelets, 6 different numbers (0, 1, 2, 3, 4, 5) can be displayed on these.This interesting feature is used to display minutes from :00 up to :59 in 1 minute steps on the **M**iddle **L**ayer.

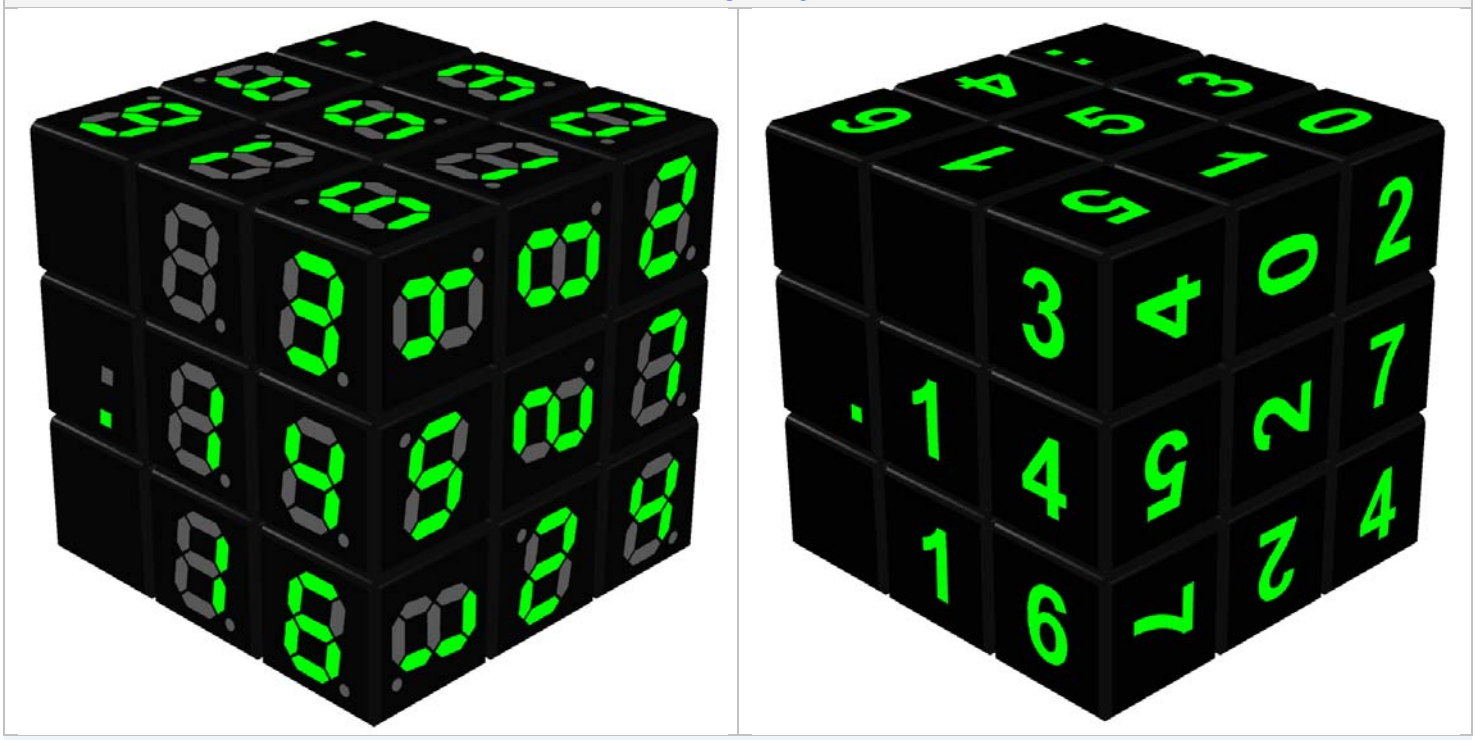
Rubik's Cube Digital Clock – Initial State Decimal Number Display	
	
Cube Texture	Virtual Cube

Examples of Digital Clock Cube Synthesized Algorithms

Digital Clock Cube Synthesized Algorithms
10:37:49

Setup Algorithm
CR U2 L2 B D' R L2 D B2 L2 U' B2 U R B2 R' D' B' D R' B2 R D' B D
59:59:59

Setup Algorithm
CU2 R B U2 D R L' B D2 B U' L U D B D' L' B L B U' B U R B2 R' B2 D B' D' B' D' B D L B2 L'

Digital Clock Cube Synthesized Algorithms

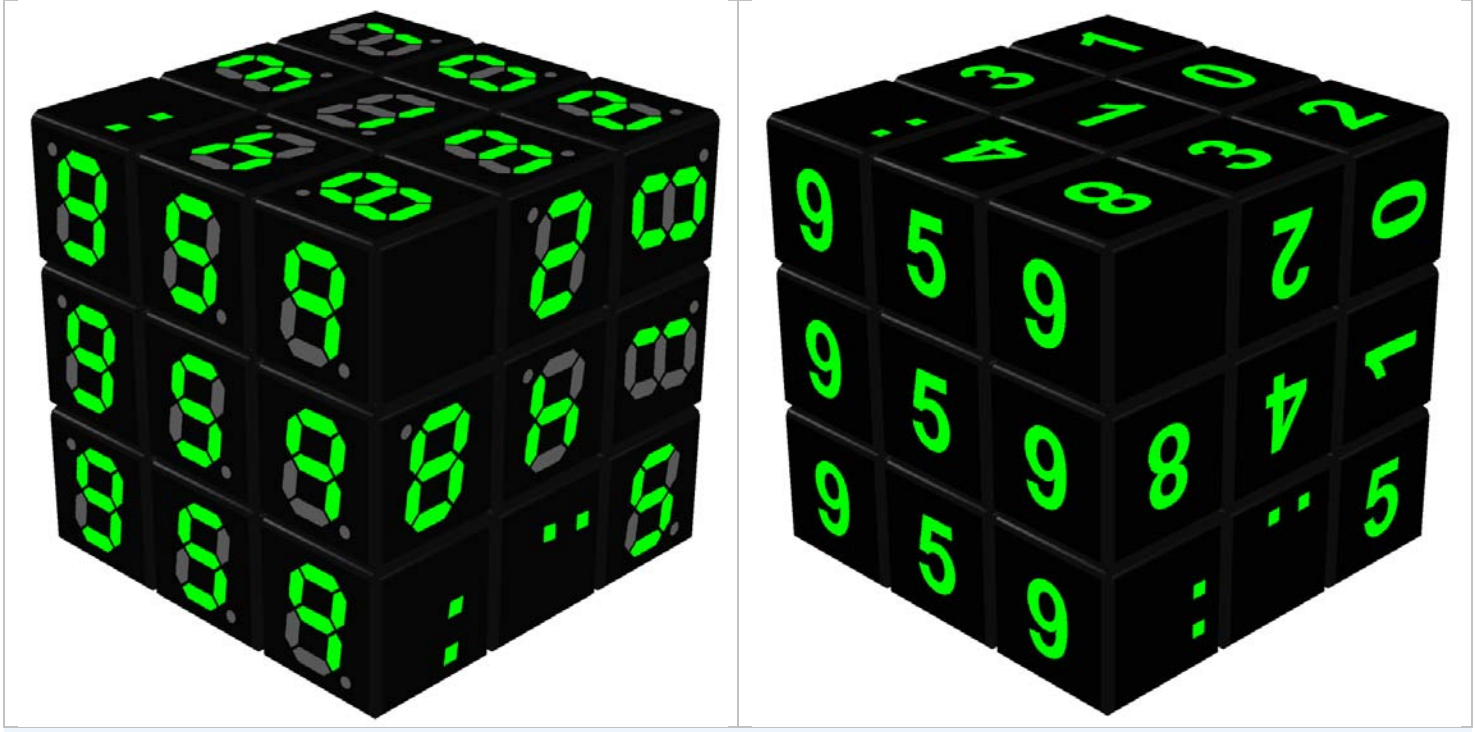
π = 3.1416



Setup Algorithm

CR' D2 B R' U R' D B R2 U' B2 U D2 D' B' D L2 B' U B' U' L' B2 L D U' B U D' B R' B R D B2 D' B L B' L'

959 959 959



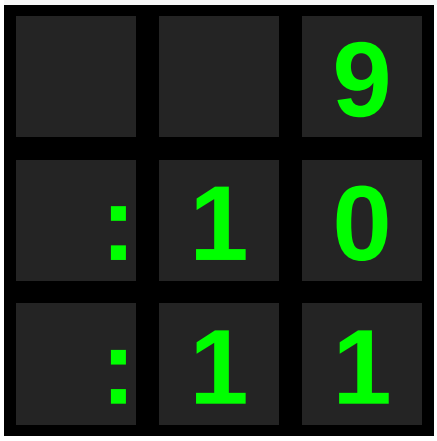
Setup Algorithm

CU2 R B U2 D R L' B D2 U2 L U2 R L' B L B' R' U' B2 U R' B2 R B2 L B' L'

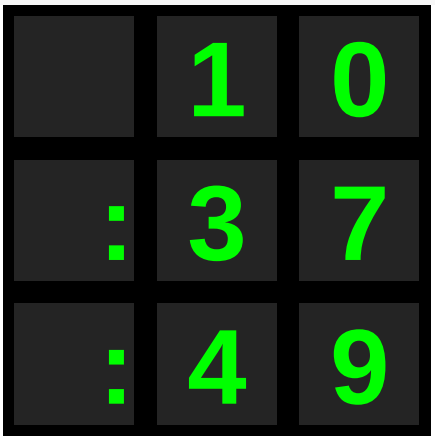
Digital Clock Cube Display Modes

Mode A: Digital Clock (0:00:00 to 24:00:00)

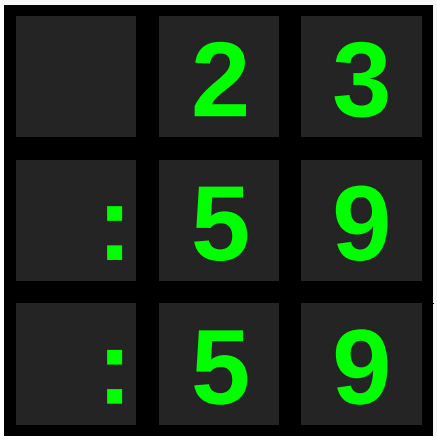
9:10:11



10:37:49

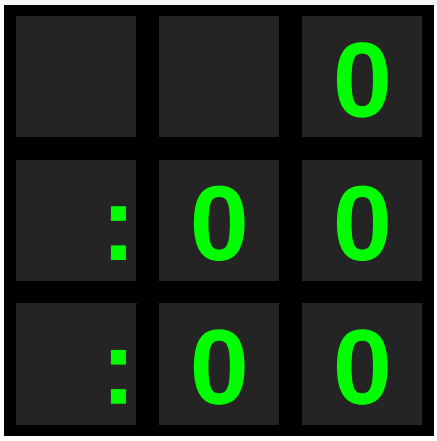


23:59:59

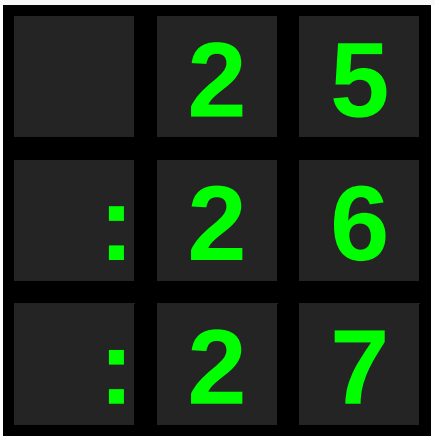


Mode B: Accumulated Time Counter (0:00:00 to 59:59:59)

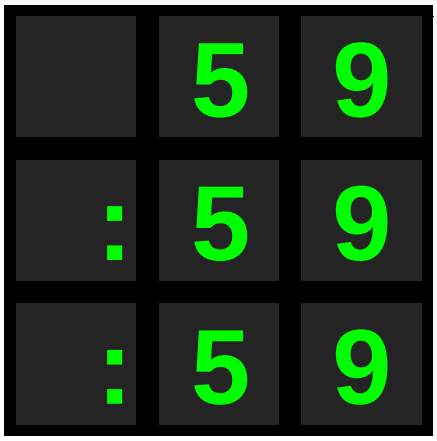
0:00:00



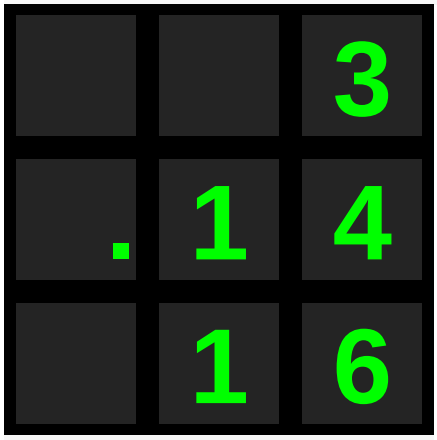
25:26:27



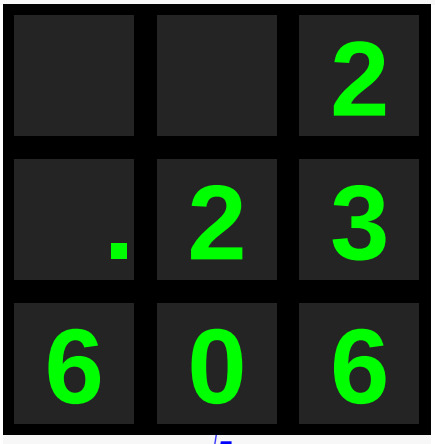
59:59:59



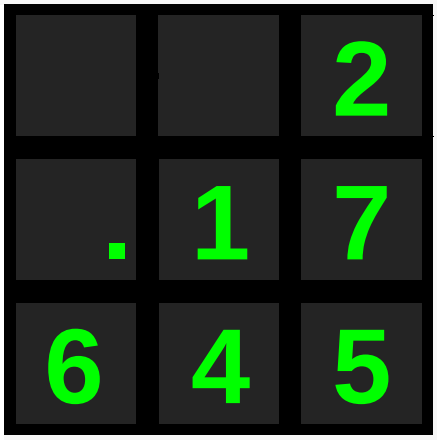
Mode C: Mathematical & Physical Constants



π



√5



Planck mass

List of Mathematical & Physical Constants

The following mathematical & physical constants values can be displayed on the cube.

Mathematical Constants		
Constant Name	*Abbreviated* Name	*Truncated* Constant Value
Archimedes' constant Pi (π)	π	3.1415 (3.1416)
√2 (Pythagoras' constant)	√2	1.4142
√5 (Pythagorian constant)	√5	2.23606
√10 (Pythagorian constant)	√10	3.1622
Plastic constant	ρ	1.3247
Feigenbaum constant	α	2.5029
Meissel-Mertens constant	M1	0.2614
Viswanath's constant	K	1.1319
Ramanujan-Soldner constant	μ	1.4513
Bernstein's constant	β	0.2801
Gauss-Kuzmin-Wirsing constant	λ	0.3036
Hafner-Sarnak-McCurley constant	σ	0.3532
Apéry's constant	ζ(3)	1.2020
Mills' constant	θ	1.30637
Sierpiński's constant	*K*	2.5849
Parabolic constant	*P2*	2.2955
Legendre's constant	B'_L	1.0836
Backhouse's constant		1.45607
Khinchin-Lévy constant		1.18656
Lévy's constant		3.2758
Physical Constants		
Constant Name	*Abbreviated* Name	*Truncated* Constant Value
Planck or Dirac constant	$\hbar$	1.0545 × 10^{-34} J·s
Planck mass	m_p	2.17645 ×10^{-8} kg
Planck time	t_p	5.3912 ×10^{-44} s
von Klitzing constant	R_K	2.5812 ×10^{4} Ω
Boltzmann constant	k or k_B	1.3806 × 10^{-23} J·K^{-1}
nuclear magneton		5.0507 × 10^{-27} J·T^{-1}
Bohr radius		0.52917 × 10^{-10} m
Fermi coupling constant		1.16639 × 10^{-5} GeV^{-2}
First radiation constant		1.1910 × 10^{-16} W·m^2 sr^{-1}
molar volume of an ideal gas		22.4139 × 10^{-3} m^3·mol^{-1}
weak mixing angle		0.2221
Other Numbers		
Number	Name	Displayed Value
959 959 959		959959959
656 656 656		656656656
$(6/5)^{5/6}$		1.1640
10/9		1.1111
7/6		1.1515
1/3		0.3333
4/3		1.3333
7/3		2.3333
10/3		3.3333

Digital Clock Cube Design

Top Layer Layout

Numerals on the **T**op **L**ayer are sorted out as follows:

1- 2 **T**op **L**eft blanks on corner cubes: blank, blank
2- 5 **T**op **C**enter numerals and 1 blank on edge cubes: blank, 1, 2, 3, 4, 5
3- 10 **T**op **R**ight numerals on corner cubes: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

Numerals and blanks are now combined on corner and edge cubes:

1- 3 **T**op **C**enter edge cubes: [blank, 1], [2, 3], [4, 5]
2- 4 **T**op **R**ight corner cubes: [0, 1, 2], [3, 4, 5], [6, 7, blank], [8, 9, blank]

Note 1 – This ensures that there is at least 1 **T**op **L**eft blank available at any time.

So, now there are 4 corner and 9 edge cubes left that can be used for the 2 remaining layers.

Middle Layer Layout

Numerals and symbols on the **M**iddle **L**ayer are sorted out as follows:

1- 2 **M**iddle **L**eft symbols on 1 edge cube: ':', '.'
2- 6 **M**iddle **C**enter numerals on center cubes: 0, 1, 2, 3, 4, 5
3- 10 **M**iddle **R**ight numerals on edge cubes: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

Letters are now combined on edge cubes:

1- 1 **M**iddle **L**eft edge cube: [':', '.']
2- 5 **M**iddle **R**ight edge cubes: [0, 1], [2, 3], [4, 5], [6, 7], [8, 9]

So, now there are 4 corner and 3 edge cubes left that can be used for the **B**ottom **L**ayer.

Bottom Layer Layout

Bottom Layer		
Mode A: Seconds	Mode B: Seconds	Mode C: Constants
		

Numerals and symbols on the **B**ottom **L**ayer are sorted out as follows:

1- 2 **B**ottom **L**eft symbols on corner cubes: ':', ':'
2- 6 **B**ottom **C**enter numerals on edge cubes: 0, 1, 2, 3, 4, 5
3- 10 **B**ottom **R**ight numerals on corner cubes: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9

Numerals and symbols are now combined on corner and edge cubes:

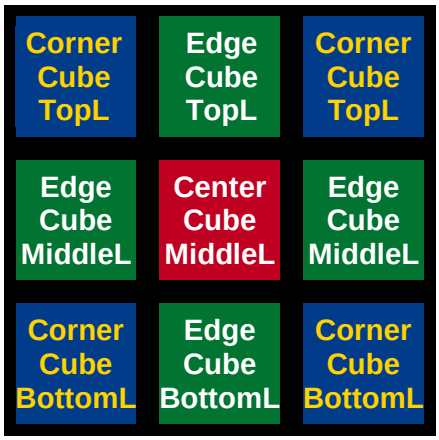
1- 3 **B**ottom **C**enter edge cubes: [0, 1], [2, 3], [4, 5]
2- 4 **B**ottom **R**ight corner cubes: [0, 1, 2], [3, 4, 5], [6, 7, ':'], [8, 9, ':'],

Note 2 – This ensures that there is at least 1 **B**ottom **L**eft symbol ':' available at any time.
Note 3 – There is no need for an additional blank corner facelet for blinking seconds, because displayed time already changes every second.

Digital Clock Cube Layout Table		
Top **L**eft – Corner cube	**T**op **C**enter – Edge cubes	**T**op **R**ight – Corner cubes
blank	blank, 1, 2, 3, 4, 5	0, 1, 2, 3, 4, 5, 6, 7, 8, 9
Middle **L**eft – Edge cubes	**M**iddle **C**enter – Center cubes	**M**iddle **R**ight – Edge cubes
':', '.'	0, 1, 2, 3, 4, 5	0, 1, 2, 3, 4, 5, 6, 7, 8, 9
Bottom **L**eft – Corner cubes	**B**ottom **C**enter – Edge cubes	**B**ottom **R**ight – Corner cubes
':'	0, 1, 2, 3, 4, 5	0, 1, 2, 3, 4, 5, 6, 7, 8, 9

Terminology

In a 3x3x3 **Rubik's Cube**, there are 8 *Corner Cubes*, 12 *Edge Cubes*, 6 *Center Cubes* and 6 *Cube Faces*. There are also 4 Corner Cube faces, 4 Edge Cube faces and 1 Center Cube face *per Cube Face*, as shown below.



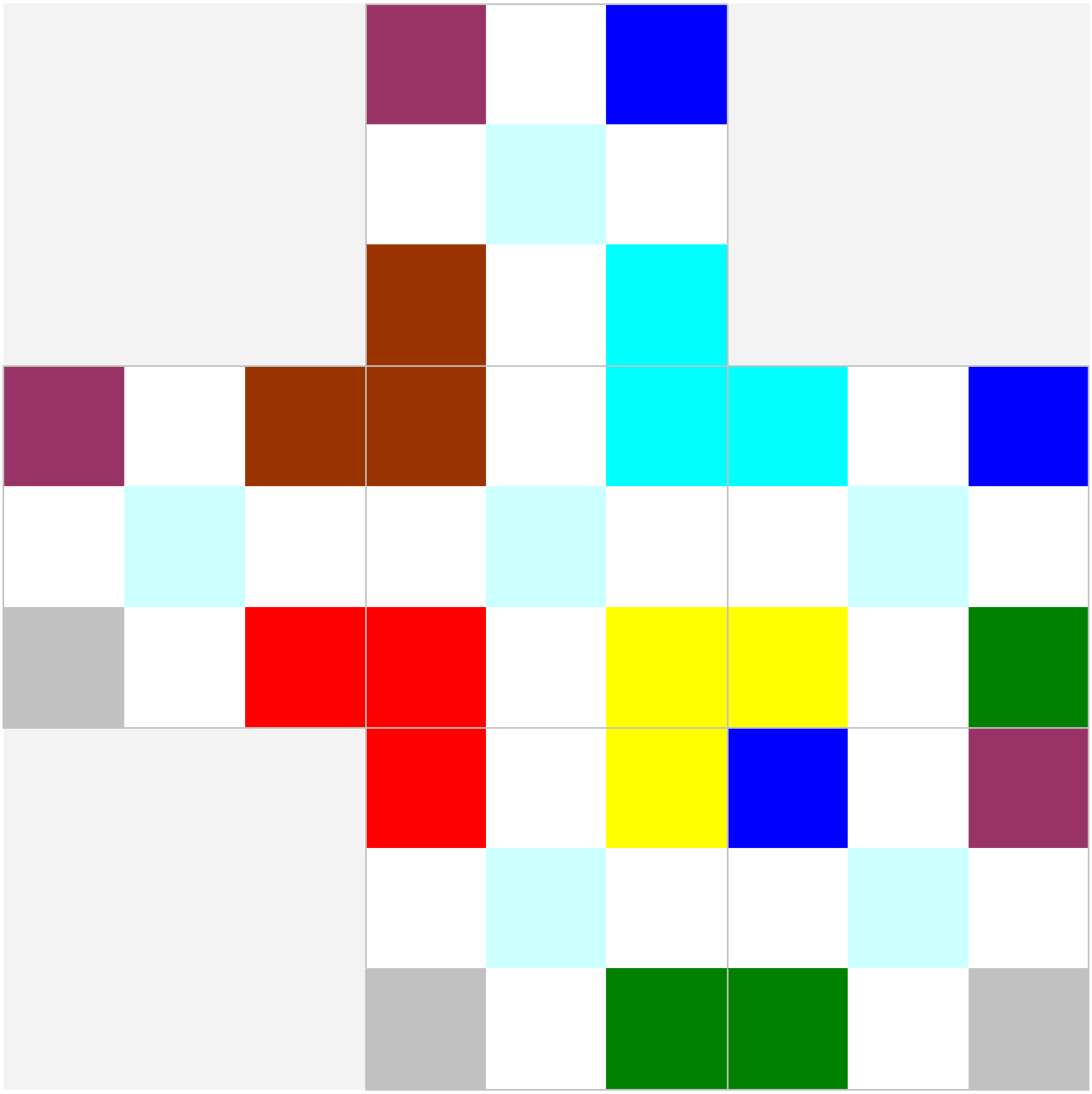
There are 1 face per Center Cube, 2 faces per Edge Cube and 3 faces per Corner Cube.

There are also 3 horizontal *Layers* called *Top*, *Middle* and *Bottom Layers*.

Cube Lexicon		
English	**Français**	**Deutsch**
Cube	Cube	Würfel
cubie, cube	cube, petit cube	Würfelteil, Teil des Würfels
face	face	Seite, Seitenfläche
front face	face avant	vordere Seite, vorne
back face	face arrière	hintere Seite, hinten
left face	face gauche	linke Seite, links
right face	face droite	rechte Seite, rechts
top face	face supérieure	obere Seite, oben
bottom face	face inférieure	untere Seite, unten
sticker	étiquette (autocollante), plaquette	Kleber, Farbkleber
tile	tuile, plaquette	Plättchen, Farbplättchen
center cube, center	cube central, centre	Mittelwürfel, Mittelstein, Mitte
edge cube, edge	cube-arête, arête	Kantenwürfel, Kantenstein, Kante
corner cube, corner	cube de coin, coin	Eckwürfel, Eckstein, Ecke
layer	couronne	Schicht, Scheibe
top layer	couronne supérieure	obere Schicht, obere Scheibe
middle layer	couronne intermédiaire	mittlere Schicht, mittlere Scheibe, Mittelschicht, Mittelscheibe
bottom layer	couronne inférieure	untere Schicht, untere Scheibe
orientation, direction	orientation	Orientierung
to solve	résoudre	lösen, zusammen drehen
to twist	pivoter	drehen
to rotate	tourner, effectuer une rotation	drehen
clockwise	dans le sens horaire	im Uhrzeigersinn
anticlockwise, counter-clockwise	dans le sens anti-horaire	im Gegenuhrzeigersinn

Corner Cubes Final Check

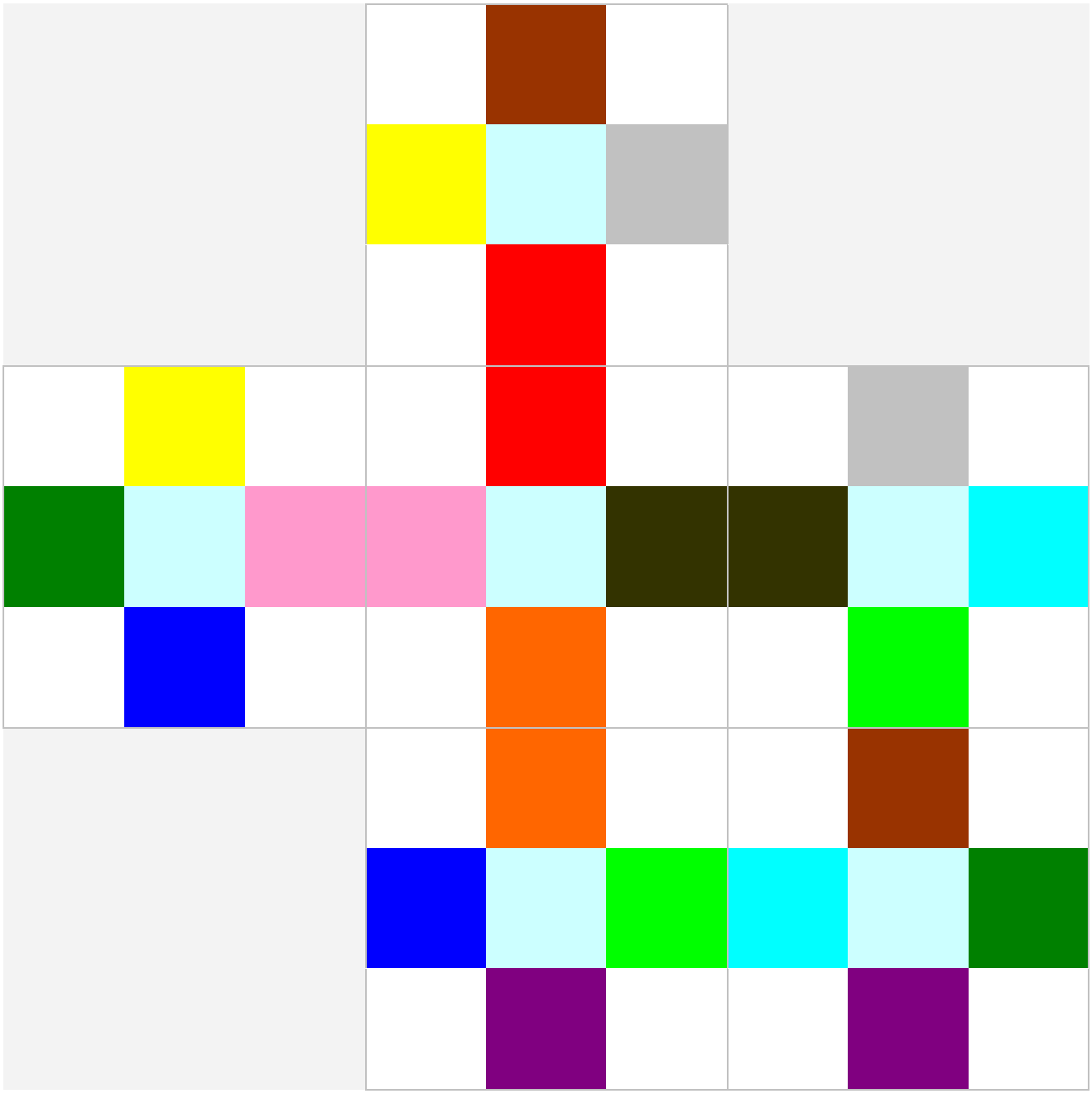
There are 8 Corner Cubes and 3 faces per Corner Cube. In the diagram below, each Corner Cube is displayed in 8 different colors and with the same color applied to each of its 3 faces. This diagram can be used as a convenient *visual aid* to check Design Rules (DRC).



	Up		
Left	**F**ront	**R**ight	**B**ack
	Down	**B**ack	

Edge Cubes Final Check

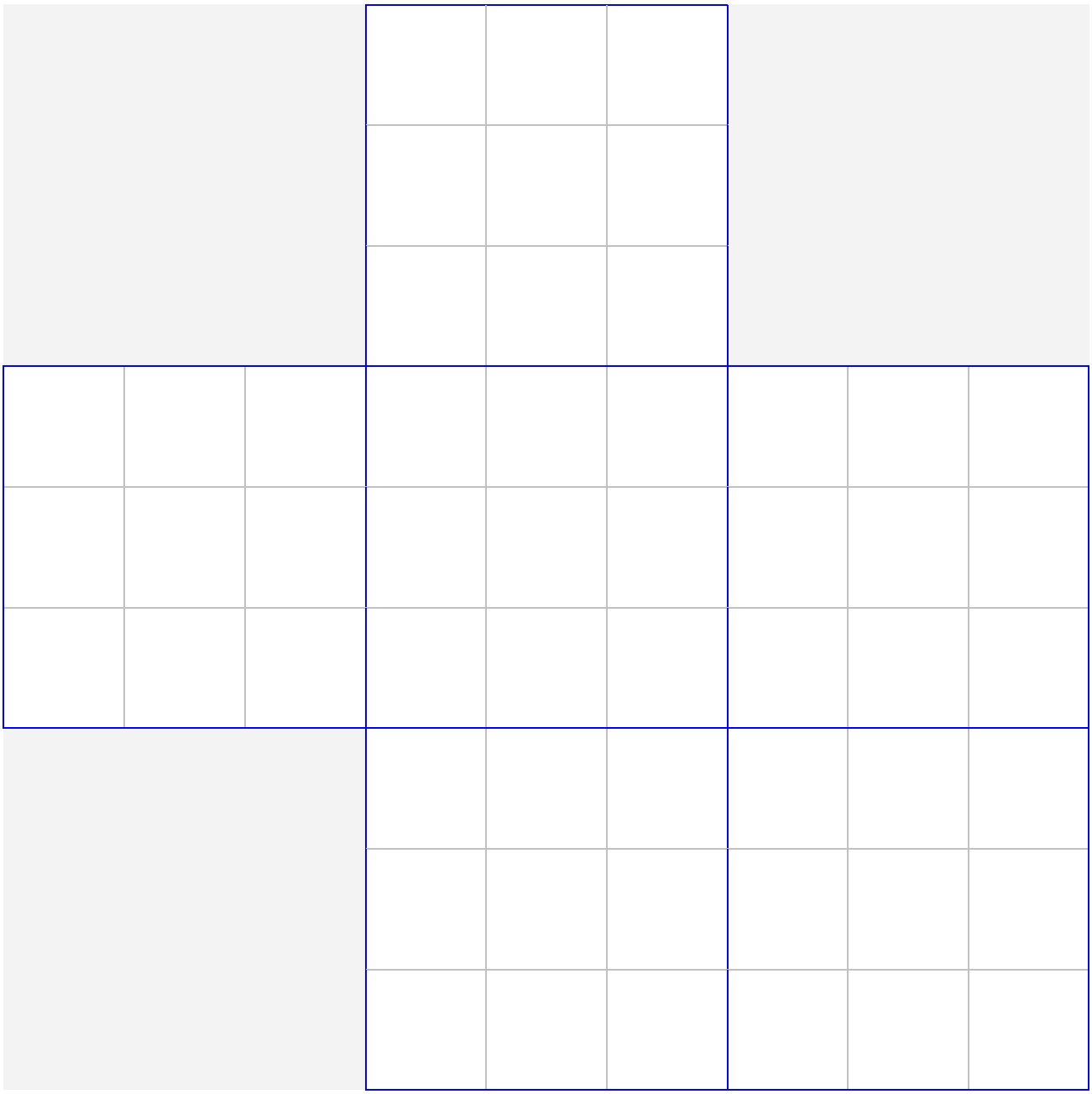
There are 12 Edge Cubes and 2 faces per Edge Cube. In the diagram below, each Edge Cube is displayed in 12 different colors and with the same color applied to each of its 2 faces. This diagram can be used as a convenient *visual aid* to check Design Rules (DRC).



	Up		
Left	**F**ront	**R**ight	**B**ack
	Down	**B**ack	

Texture Template

This is a texture template that can be printed out and used for writing down numbers and letters by hand *prior to* texture design. All is needed are pencil, rubber…and time.



	Up		
Left	**F**ront	**R**ight	**B**ack
	Down	**B**ack	