Understanding Two-handed Siteswap

http://kingstonjugglers.club/r/siteswap.pdf
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Overview

Siteswap is a set of notations for describing a key feature of juggling patterns: the order in which objects are thrown and re-thrown. For an object to be re-thrown later rather than earlier, it needs to be out of the hand longer. In regular toss juggling, more time out of the hand means a higher throw. Any pattern with different throw heights is at least partly described by siteswap. Siteswap can be used for any number of "hands". In this guide we'll consider only two-handed siteswap; however, everything here extends to siteswap with three, four or more hands with just minor tweaks.

Core rules (for all patterns)

C1 Imagine a metronome ticking at some constant rate. Each tick is called a "beat."

C2 Indicate each thrown object by a number that tells us how many beats later that object must be back in a hand and ready to re-throw.

C3 Write a sequence of throws as a string of numbers, plus punctuation and the letter **x**. Imagine these strings repeat, so **531** is the same as …**531531531**… So are **315** and **153** — can you see why?

C4 The sum of all throw numbers in a siteswap string divided by the number of throws gives the number of objects. This must be a whole number. **531** is a three-object pattern, since (5+3+1)/3 = 3; however, **532** cannot be juggled since (5+3+2)/3 = 3⅓.

C5 Throws must balance catches. By rule **C4**, **432** would be three objects — but it can't be juggled since the **4**, **3** and **2** all need to be re-thrown at the same time and the pattern says they aren't.

Visualizing the numbers

For normal toss juggling and a given number of beats per minute, higher siteswap numbers mean higher throws. A faster beat means lower throws for all numbers; a slower beat means higher throws. You can understand the numbers as meaning roughly:

0 an empty hand
1 a quick pass or throw across, as in a shower
2 a quick "throw to the same hand" (possibly a hold)
3 a three-object cascade throw
4 a four-object fountain throw
5 a five-object cascade throw… and so on up to **9**, then
a a ten-object fountain throw (**a** instead of **10** so we don't confuse "ten" with "one-zero"; read a as "ten")
b an eleven-object cascade throw… and so on.

Alternating throws

Many juggling patterns are based on alternating right-hand and left-hand throws. We describe these using **asynchronous siteswap notation**.

A1 The right and left hands throw on alternate beats.

Rules **C2** and **A1** together require that odd-numbered throws end up in the opposite hand, while even numbers stay in the same hand. Here are a few asynchronous siteswap examples:

3 a three-object cascade
522 also a three-object cascade
42 two juggled in one hand, a held object in the other
40 two juggled in one hand, the other hand empty
330 a three-object cascade with a hole (two objects)
71 a four-object asynchronous shower
9151 a four-object "high-low" shower
53 a four-object half-shower
64 three in one hand, two in one the other, each at its regular height and rhythm — this is hard!
73 a five-object half shower (the harder one!)

Simultaneous throws

Some juggling patterns involve both hands throwing at the same time. We describe these using **synchronous siteswap notation**.

S1 The right and left hands throw at the same time (which counts as two throws) on every second beat. Write the simultaneous throws in parentheses and separate the hands with commas, always the same hand first.

S2 Inside parentheses, indicate throws that cross from hand to hand with an **x** (for 'xing').

S3 For convenience, if a pattern repeats mirrored on the opposite side, use a ***** to indicate mirroring. So **(6x,4)(4,6x)** can be written as **(6x,4)***.

Rules **C2** and **S1** taken together demand that there are only even numbers in valid synchronous siteswaps. Can you see why? The **x** notation of rule **S2** is required to distinguish patterns like **(4,4)** (synchronous fountain) from **(4x,4x)** (synchronous crossing). Unlike a **2**, a **2x** must always be thrown since it changes hands. Examples are on the next page.

Here are a few synchronous siteswaps:

(4,4)(4,0)	three-object columns (a.k.a. Two Up, One Up)
(4,2)	looks identical to **42** — The Fake, The Yo-yo, etc.
(6x,2x)	a four-object synchronous shower: compare to **71**
(8x,2x)(4x,2x)	a four-object synchronous "high-low" shower, compare to **9151**
(4,2x)(2x,4)	the Box, also written **(4,2x)***
(6x,4x)	the easier five-object half shower
(6,6)(6,6)(6,0)	Enrico Rastelli juggling five plates

Multiplex throws

In both alternating and simultaneous patterns we can throw multiple objects from the same hand at the same time. We describe this using **multiplex siteswap notation**, which can be embedded in both synchronous and asynchronous siteswap.

M1 Multiple objects thrown from the same hand count as one throw. Put the numbers in square brackets.

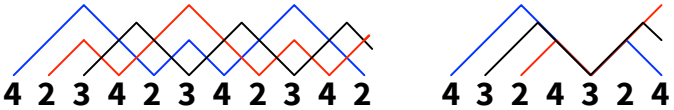
Applying **C4** and **M1** to the siteswap **[33]**, we sum the throw numbers 3+3 and divide by the number of throws (one) to give 6 — so **[33]** is a six object pattern; similarly **[54]24** is a five object pattern. In multiplex patterns **2**s inside square brackets with numbers that aren't **2**s are usually thrown. A few multiplex examples:

[33]	six objects juggled in groups of two as a three-cascade
[32]	five-object splits
[54][22]2	also five-object splits
[54]24	Gatto's Multiplex (five object version)
[76]26	Gatto's Multiplex (seven object version)
([44],[44])(4,0)	one up, four up

Is that siteswap valid?

First, check whether the throw average is a whole number, using rules **C4** and **M1**. If the average isn't a whole number, the pattern is invalid.

Then check rule **C5,** which tells us that the number of objects thrown on a beat must be equal to the number of objects needing to be thrown. You can do this with a diagram:



On the left is **423**. Since one line arrives for each object that needs to be thrown, **423** is valid. On the right is **432**. Here we see throws with no objects (the second **4** and **2**) and throws with too many objects (the second **3**). So **432** is invalid.

Generating new siteswaps

Given a valid siteswap we can generate new valid siteswaps with a little simple arithmetic. Here are some rules that always work:

1. Adding 1 to each number we get a valid pattern with one more object than the original. E.g., **633** (four objects) yields **744** (five objects).
2. Adding the number of throws in the siteswap to one of the throw numbers we get a pattern with one more object. E.g., **501** (two objects, length 3) gives us **801**, **531** and **504** which are all three object patterns.
3. Swapping two adjacent numbers then adding 1 to the first and subtracting 1 from the second give us a pattern with the same number of objects. E.g., take **561** (four objects), swap the first two numbers to get **651**, then add 1 to the **6** and subtract 1 from the **5** to get **741** (also four objects).

Some more fun ones

Here are a few more fun siteswap patterns:
501 · 423 · 441 · 4413 · 531 · 5313 · 534 · 801 · 55244 · 561 · 633 · [33]33 · [33][33]3 · [33] · [43]1421 · 4[43]1 · (4,4)(4x,4x) · (6x,2x)(2x,6x) · (6x,4)(4,2x)*(4,6x)(2x,4) · [32] · 4[43]1 · [54][22][2] · [54]24 · [322]

Training for five

Any siteswap with mostly fives in it is good training when learning five objects. Here are some useful ones.
522 · 50500 · 52512 · 55500 · 5551 · 50505 · 552 · 55550
My favourite is **552** in the early going, then **50505** and **55550** when you're getting better.

What siteswap doesn't show

Siteswap notation doesn't show us how a throw is made; for example Mills Mess has a siteswap of **3**, which completely ignores the sinuous arm crossing that makes it beautiful and fun to juggle. On the other hand it is useful to know that both Burke's Barrage and Windshield Wipers are juggled as **423**, even if that doesn't tell the whole story. Happy juggling!

There's lots more…

This is just a beginning! For lots more, start at
`http://juggle.wikia.com/wiki/Siteswap`

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