Juggler's Slide Rule

SYSTEM TOMBEUR

Instructions For Use

Simple Rules

S2 & *S3*

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& D Rance

Juggling is a physical skill involving the manipulation of objects for recreation, entertainment or sport. It can be the manipulation of one object or many objects at the same time, using one or many hands, and has been in recorded history for 4000 years. The most recognizable form of juggling is toss juggling where props, usually balls or clubs and outnumbering the hands used, are thrown and caught so that at least one object is always in the air. Juggling is often described as an art, it can be performed anywhere, and everyone can learn to do it.

Introduction

The Simple Juggler's Slide Rule enables quick calculation and comparison of heights and speeds of common ball juggling patterns where two hands throw alternately to a regular beat of time.

These instructions apply to the *S2* (standard) and *S3* (pocket) models, which share the same scale layout. The *S3* has abbreviated labels. No prior knowledge or aptitude for juggling is needed but it is assumed that the reader is familiar with the mechanics of using a slide rule.

The scales are optimised for theoretically neat patterns where each hand is full (between catching and throwing) for the same length of time that it is empty (between throwing and catching).

Juggling Basics

Common juggling patterns usually consist of a number of balls all thrown to the same height, or a sequence of throws of different heights which lock into a repeating pattern. Throws are made from two hands alternately and regularly to a beat. The time between each beat, known as the Beat Time, determines the speed of the pattern. The weight of the throw of a ball, measured in beats, indicates when that ball will be next thrown in the pattern.

In patterns where all the balls in the pattern are consistently thrown the same, the weight of each throw is the number of balls in the pattern. Patterns like this that are based on an odd number of balls are known as 'cascades', whereas those based on an even number of balls are known as 'fountains'.

For example, in a 3-ball cascade (Fig. 1), each hand throws a ball alternately once per beat and all the balls are thrown are the same. Since there are three balls, then each ball is next thrown three beats later, so the weight of each throw is called a 'three' (or '3'). Similarly, in a 4-ball fountain, all throws are the same so the weight of each throw is a '4'.

The pattern '534', has four balls thrown with the repeating weights '5' then '3' then '4'. More complex patterns like this are usually named with the repeating part of the sequence, in this case '534' from 534534534534…

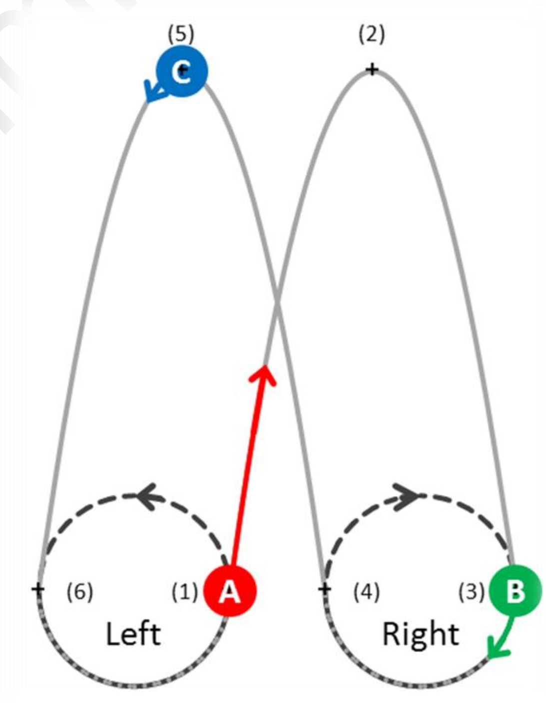


Fig. 1 : 3-ball cascade

In the theoretically neat pattern the hands trace small circles at a constant rate, so when a ball is thrown by one hand another ball is caught by the opposite hand. Each hand is full for one beat and empty for one beat.

The weight of each throw determines the airtime (in beats) of the ball thrown as its weight minus one, since each ball is held in a hand for one beat. The flight of the ball is predictable according to the laws of projectile motion, and its maximum height can be determined from its airtime. Hence for different throw rates, heights for different weights can be calculated or compared. Similarly, throw rates for different weights and heights can be calculated or compared.

Layout and Scales

The single sided closed frame slide rule has 3 scales – one on each of the top and bottom front faces of the stock and the third on the slide. A cursor with single hairline aids calculations and comparisons.

- 'HEIGHT' scale, 1-100, on the top of the stock can represent centimetres or metres.
- 'BEAT' scale, 0.1-1 second, is in the middle on the slide.
- 'THROW' scale, 11-21 and 3 -10, on the bottom of the stock is graduated for throw weights (or number of balls in a pattern where all throws are the same) of 3 to 21, with values 3 and 21 sharing the same tick/graduation mark.

Summary instructions and methods for determining magnitudes are printed on the back of the stock with a blind stamped production date (MM & YYYY) on the left and a blind stamped serial number (nnn) on the right.

Determinations & Comparisons

To determine the maximum height achieved by a ball thrown at a certain weight and at a particular beat time in seconds, first set either the left or right-hand index of the slide (0.1 or 1 mark) to the throw weight mark on the THROW scale. Find the beat time on the BEAT scale on the slide, and then read the height directly against it on the HEIGHT scale. If the desired beat time falls outside of the HEIGHT scale use the index on the other end of slide. Magnitudes for height can be determined as follows:

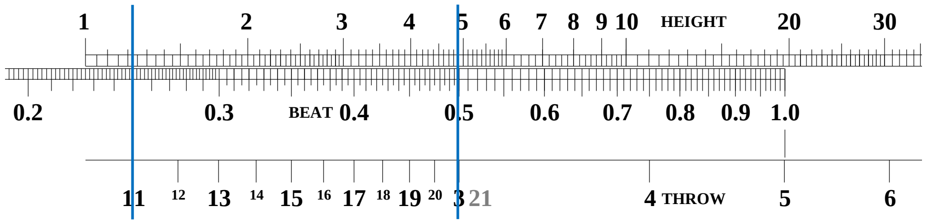
- For throw weights *up to 10*, and when the slide protrudes from the stock to the *right*, then the height is in *centimetres*.
- For throw weights *up to 10*, and when the slide protrudes from the stock to the *left*, then the height is in *metres*.
- For throw weights *11 and above*, and when the slide protrudes from the stock to the *right*, then the height is in *metres*.
- For throw weights *11 and above*, and when the slide protrudes from the stock to the *left*, then the height is in *metres times 100*.

Once an index on the slide is set to a weight mark on the THROW scale, corresponding heights can be read for all values on the BEAT scale that are in the HEIGHT scale range. Setting the other index to the weight enables heights to be read against beat times that were previously off the scale.

Similarly, beat times can be read on the BEAT scale for specific heights on the HEIGHT scale, and setting the correct index on the slide to the weight mark on the THROW scale will ensure that values can always be read.

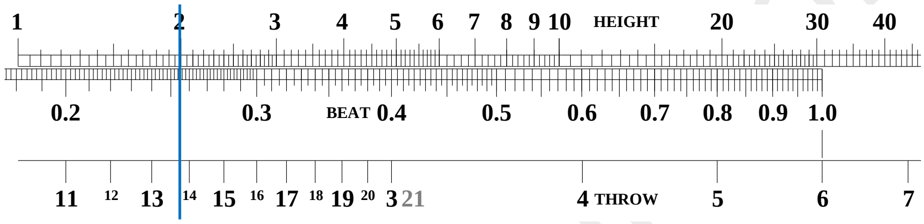
The graduations on the BEAT scale can also be used for beat times from 1 to 10 seconds rather than 0.1 to 1 seconds. Height magnitudes are determined by using the rules above, and factoring again by 100.

Example 1 : To what respective heights would the balls in a 5-ball cascade have to be thrown to achieve a throwing beat or rhythm of 0.25 seconds or 0.5 seconds?



Set the right-hand index of the BEAT scale against "5" on the bottom THROW scale. Next position the cursor hairline over "0.25" on the BEAT scale. Using the hairline the corresponding throw height of ***1.23 metres*** *can now be read off on the top HEIGHT scale. Simply repositioning the cursor hairline over "0.5" on the BEAT scale gives the alternative throw height of* ***4.91 metres*** *on the HEIGHT scale.*

Example 2 : What throwing beat or rhythm is needed to sustain a 6-ball fountain when the balls are juggled/thrown to a height of 2 metres?

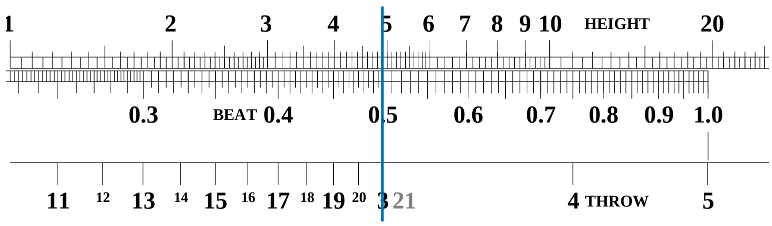


Set the right-hand index of the BEAT scale against "6" on the bottom THROW scale. This time place the cursor hairline over "2" on the top HEIGHT scale. The corresponding throwing beat or rhythm of ***0.253 seconds*** *is under the hairline on the middle BEAT scale.*

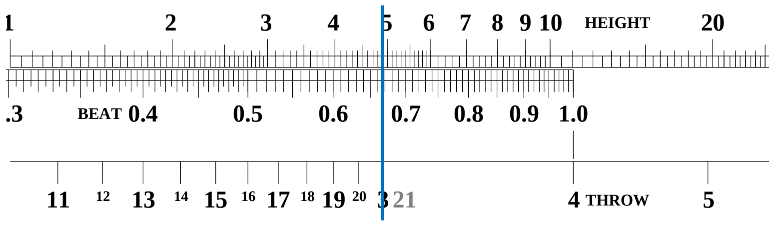
To find the beat times for different throw weights to the same height, position the cursor hairline over the height on the HEIGHT scale (which could be the result of a previous calculation) and move the left or right-hand index of the slide to different throw weights marks on the THROW scale. For each throw weight set, the cursor hairline gives the corresponding beat time in seconds on the BEAT scale.

Example 3 : The height of a 5-ball cascade thrown to a beat of 0.5 seconds is 4.91 metres. What would the rhythm need to be to maintain this height with a 4-ball fountain and an 11-ball cascade?

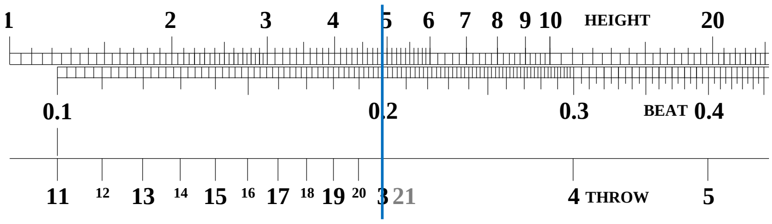
As before, set the right-hand index of the BEAT scale against "5" on the bottom THROW scale and position the cursor hairline over "0.5" on the BEAT scale.



Now move the slide so that the right-hand index of the BEAT scale is against the "4" on the THROW scale. Read the corresponding rhythm of ***0.667 seconds*** *on the middle BEAT scale under the hairline.*



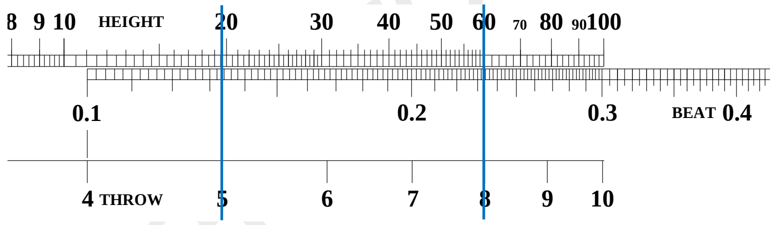
Re-position the slide so the left-hand index of the BEAT scale is against the "11" on the THROW scale. Again read the rhythm on the BEAT scale under the hairline of ***0.2 seconds****.*



Multiples of beat time or throw height for different throw weights can easily be determined. Set the left or right-hand index on the slide to the lower throw weight mark on the THROW scale. Read the value on the BEAT scale against any higher throw weight mark. This value (ignoring the decimal) is the beat time multiple when these two different throw weights are to the same height. Set the left-hand index on the slide to 1 on the HEIGHT scale, read the value on the 'HEIGHT scale against the beat time multiple on the BEAT scale. This value is the height multiple for these two throw weights when they are thrown to the same beat time.

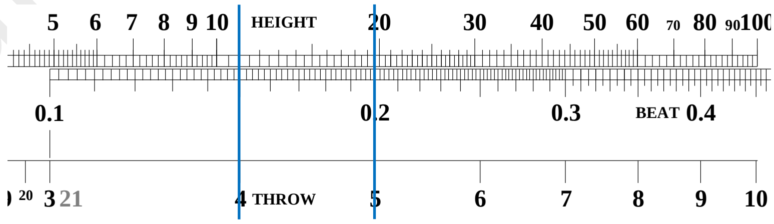
Example 4 : How many times faster than a 4-ball fountain would a 5-ball cascade and 8-ball fountain need to be juggled if their heights were all kept the same?

Set the left-hand index of the BEAT scale against the "4" on the THROW scale. Place the cursor hairline over the "5" on the THROW scale and read ***1.33 times*** *under the hairline on the BEAT scale. Now move the cursor hairline over the "6" on the THROW scale and read* ***2.33 times*** *on the BEAT scale under the cursor hairline.*

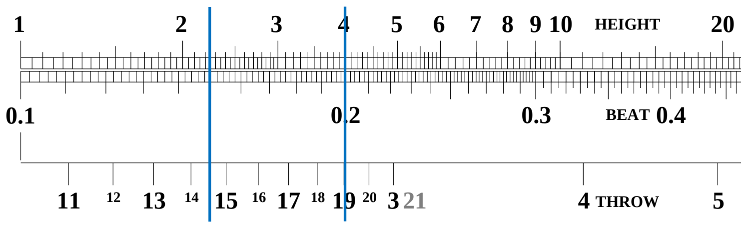


Example 5 : In the pattern '534', how many times higher than the '3' would the '4' and '5' have to be thrown respectively?

First set the left-hand index of the BEAT scale against "3" on the THROW scale. Using the cursor note the values 1.5 and 2 on the BEAT scale corresponding to the "4" and "5" marks on the THROW scale.



Then set the left-hand index on the BEAT scale against the "1" on the HEIGHT scale. Move the cursor hairline over 1.5 and then 2 on the BEAT scale and read the corresponding results of ***2.25 times*** *and* ***4 times*** *higher on the HEIGHT scale.*



Care of the Slide Rule

When using the slide rule, hands should be clean, dry and grease free. Care should be taken not to put undue pressure on the moving parts. The slide rule should not be subjected to extreme changes in temperature and humidity, and prolonged exposure to direct sunlight avoided. Ideally the slide rule should be kept in a case when not in use. Cleaning should only be done using a soft damp cloth; the rule must not get wet and detergents should not be used. The slide can be lightly lubricated with a dry lubricant such as unscented talcum powder if necessary.

Slide rules were invented in the early 17^{th} century, but the first slide rule for Jugglers was not designed until September 2011. The first Juggler's rule has been refined into the models listed below. All models are constructed from seasoned hardwood, either mahogany or walnut, feature precision printed paper scales faced with perspex, and a wood and perspex cursor.

S2 Simple Juggler's rule; 3-scale *SYSTEM TOMBEUR*, $9\frac{9}{16}$ inch scale length, hairline cursor. For quick calculations and comparisons of the basic juggling concepts of speed and height at different throw weights.

S3 Simple Juggler's rule, 3-scale *SYSTEM TOMBEUR*, $5\frac{3}{32}$ inch scale length. Pocket version of the *S2*.

A2 Advanced Juggler's rule, 9-scale *SYSTEM TOMBEUR*, $9\frac{9}{16}$ inch scale length, hairline cursor. Allows advanced juggling calculations and comparisons of speed and height for different throw weights incorporating variable hold times, with additional scales to calculate of angles of trajectory and object velocities in relation to pattern width. Inclusion of the conventional Mannheim scales (A, B, C & D) offers standard slide rule calculation and familiarity to all slide rule users.

All Juggler's slide rules are handmade to order, for more information see :

www.countbelmiro.com