Moonstick Instructions

A moonstick is a slide-rule-type device that can be used to calculate the moon phase for a given date. It consists of six specially designed rulers bundled together by two straps.

Basic Operation Examples

These examples are arranged in logical order. Each example illustrates a feature of the moonstick and requires a complete understanding of all previous examples.

First, let's put the moonstick in its standard arrangement. Press the moonstick from both ends to center all the rulers. Notice that each ruler is numbered at one or both ends on at least one of its three faces. Find ruler 0. Hold the moonstick so that ruler 0 is numbered at the bottom. Make sure that the remainder of the rulers follow in numerical order around to the right. If they do not, rearrange them now. (Slide rulers completely out to rearrange or reorient them.) Also, make sure that each of rulers 1, 2, 3, and 4 has a red indicator (triangular pointer) in the middle of its left half. If it does not, reorient it now. Finally, make sure that ruler 5 has a black indicator in the middle of its left half. If it does not, reorient it now. To now ensure that the moonstick is in its standard arrangement confirm that (1) the rulers are numbered in consecutive order around the bottom of the moonstick and (2) only red and black indicators are visible.

Now, let's calculate the moon phase for May 10, 3797. Beginning with the moonstick in its standard arrangement, slide ruler 1 down to align the indicator on its left side with the "3" on the right side of ruler 0. (Notice that we don't use "BC 3"; modern dates are not BC.) Next slide ruler 2 slightly up to align its indicator with the "7" on ruler 1. (Be careful not to disturb ruler 1.) Now slide ruler 3 up to align its indicator with the "9". And then slide ruler 4 to align its indicator with the "7". (Always ignore indications that are not between the straps.) You have now selected the year 3797. Slide the next ruler (ruler 5) to align its indicator with the month of May. Now notice how the days of the month on the right side of ruler 5 align with the moon phases on the left side of ruler 0. These are the moon phases for May of 3797. Notice that the 10th (near the bottom strap) is the first day after a new moon (●). Please note that the moonstick is easy to operate laying flat on a table.

Next, let's calculate the moon phase for September 23, 1997. Notice (on ruler 0) that you must choose either "OS 1" or "NS 1". The Old Style Calendar (OS) is used before the year 1582. After the year 1582, the New Style Calendar (NS) is used. For the year 1997 you will, of course, use "NS 1" (for New Style). Proceed as before. You should conclude that September 23, 1997 is the last day before a last quarter (◑).

Now, let's calculate the moon phase for January 20, 1957. Proceed as before. As you select the "7", notice that there is one toward the top and one toward the bottom. If you select the bottom one, part of the indicator disappears under the strap. If you select the top one, the indicator remains completely visible between the straps. Always select the indication that allows the indicator to remain completely visible between the straps. (Failure to do so will not change the results, but could make them unreadable.) So select the "7" toward the top. This day is the first after a waning gibbous (○).

Next, let's calculate the moon phase for April 14, 1912. Notice, as you select the "2", that it is blue. *The indicators that select the year must always match the color of the indication they select.* So reorient ruler 4 to use the blue indicator. This day is the first after an old crescent (◉).

Now, let's calculate the day(s) of the full moon(s) (○) in July of 1776. (Notice that the "6" requires a blue indicator.) The moon is full on both the 1st and the 30th. (As you may have assumed, the long lines on the right side of ruler 5 represent midnight.)

Next, let's calculate the day(s) of the new moon(s) (●) in February of 1900. (Don't forget to match the color of both "0"s. Don't worry about the upside-down numbers on the left side of ruler 3.) Notice as you select February, that it is green. Additionally notice that the "28" on ruler 5 is also green. This correspondence shows that February (of this year) has only 28 days. (According to the calendar reform of 1582, 1900 is *not* a leap year.) You should conclude that there is (only 28 days and thus) no new moon in February of 1900.

Now, let's calculate the time(s) of the full moon(s) (○) in January of 2001. (Notice that the "2" and both "0"s require blue indicators.) You should conclude that the moon is full around 5 PM, January 9. This is Universal Time (UT) (Greenwich Mean Time). To calculate Chicago Time (UT minus 6 hours (UT-6h)), align (instead of the center mark) *the first mark below* the center mark on the left side of ruler 5 with "JAN" on the right side of ruler 4. Notice that this mark corresponds to UT-6h. The moon is full 11 AM, January 9, Chicago Time. Please note that *when a time zone is not specified, Universal Time (UT) is assumed.*

Next, try October 12, 1492 (the last day before a last quarter (◑)); don't forget to use "OS 1" and match the color of each digit of the year. Now, try April 7, 30 (AD) (the first day after a full moon (○)); notice that you must enter the year in 4 digits ("0030"). Finally, try March 15, 44 BC (the last day before an old crescent (◉)); make sure that you use the "BC 0" indication on ruler 0.

Basic Operation Guidelines

The examples thus far have fully illustrated the basic operation of the moonstick. The following guidelines will help you avoid mistakes and confusion.

To make sure that the moonstick is set for a specific month, confirm that …
- the rulers are numbered in order from left to right (around the bottom of the moonstick),
- all indicators (triangular pointers) are completely visible between the straps,
- the thousands part of the year along with the era (AD/BC) (and style (NS/OS) if necessary) (on the right side of ruler 0) is selected with an indicator of matching color,
- the hundreds, tens, and ones digits of the year (on the right sides of rulers 1, 2, and 3 respectively) are each selected with an indicator of matching color, and
- the time zone (on the left side of ruler 5) is aligned with the month (on the right side of ruler 4).

Please be aware that …
- AD is assumed unless BC is specified,
- 1 AD directly follows 1 BC (there is no year 0),
- the calendar reform of 1582 omitted October 5 through October 14 of that year (October 15, 1582 (NS) directly follows October 4, 1582 (OS)),
- the previous two items are noted at the bottom of ruler 0,
- most indications appear more than once,
- "UT" denotes Universal Time, "h" denotes hours, "d" denotes days, and
- the color of each month on ruler 4 corresponds to the number of days in that month on ruler 5.

Here are the standard time zones for selected world cities.

Honolulu	UT-10h	Jerusalem	UT+2h
Anchorage	UT-9h	Jeddah	UT+3h
Los Angeles	UT-8h	Dubai	UT+4h
Denver	UT-7h	Karachi	UT+5h
Chicago	UT-6h	Dhaka	UT+6h
New York	UT-5h	Bangkok	UT+7h
Caracas	UT-4h	Hong Kong	UT+8h
Rio de Janeiro	UT-3h	Tokyo	UT+9h
London	UT±0h	Sydney	UT+10h
Paris	UT+1h	Noumea	UT+11h
Cairo	UT+2h	Wellington	UT+12h

Basic Operation Practice Problems

The time is formatted as follows: era, year, month, day, AM/PM, hour.

4000MAR1AM8 ○	7000DEC30PM8 ○
1457AUG13AM12 ◑	1929OCT29AM3 UT-5h ◉
1066SEP25PM4 ◉	BC490SEP2AM1 ◐
1564FEB15PM9 ◉	1765MAY19PM7 ●
1972DEC13AM5 ◐	1999FEB16AM2 UT+8h ●
325JUN23PM9 ◉	1953MAY28AM11 UT+6h ○
BC1DEC25PM9 ○	1931AUG17AM9 ◉
BC4713JAN3AM8 ◑	2000SEP17PM5 UT+10h ❍
1961APR11PM6 ◉	1977AUG10PM5 UT-5h ◉
1944JUN6AM7 ○	1997AUG29PM12 ◉
2000DEC25PM11 ●	2017AUG22AM12 UT-6h ●
526MAY19PM5 ◑	1556JAN23AM11 UT+6h ○

Advanced Operation Examples

Now that you are accustomed to using the moonstick, let's try some more difficult calculations. First, let's calculate the date of every first quarter (◐) in the year 1969. Select the year as before. Turn ruler 5 upside-down. Align the time zone (UT) on ruler 5 with the moon phase (◐) on ruler 0. Now determine the solutions from the junction of rulers 4 and 5 where the months align with the days of the month. The solutions are January 25, February 24, March 25, April 24, May 23, June 22, July 21, August 20, September 19, October 18, November 17, and December 16.

Now, let's determine the years, during the twenty hundreds (2000 through 2099), in which the moon phase is close to full moon (○) at midnight on Halloween night (NOV1AM12), New York Time (UT-5h). From the standard arrangement, turn ruler 3 upside-down. Select and/or align everything that is known (select the thousands

(over please)

part of the year, select the hundreds digit of the year, (now coming back from the right) align the day and time with the moon phase, and align the month with the time zone). Make sure that you keep all indicators between the straps. (Use a different indication if necessary.) Also align the indicator on (what is now the right side of) ruler 3 with the indicator on ruler 4. (The tens and ones digits of the year are not known, so the colors of the indicators on rulers 3 and 4 are not known; you will eventually try all combinations of colors to get all solutions.) Now compare (what is now) the left side of ruler 3 with the right side of ruler 2. Notice the digit pairs that are close to each other. Of these digit pairs, those that match the color combination of the pair of indicators on rulers 3 and 4 are solutions. Now try the rest of the color combinations to get the rest of the solutions. (Notice that, of all the color combinations, only four (red-red, blue-red, blue-blue, and red-blue) could possibly produce solutions.) The reasonably good solutions (within $^1/_{16}$ lunar month) are 2001, 2009, 2020, 2028, 2031, 2039, 2047, 2050, 2058, 2066, 2077, 2085, and 2096. (Remember that the indications on the left side of ruler 3 are upside-down. (9 looks like 6.)) The best solution is 2058.

Next, let's determine the moon phase at 12 AM on January 1 of each year during the nineteen nineties (1990 through 1999). Beginning from the standard arrangement, exchange rulers 3 and 5. Select and/or align everything that is known (select the thousands part of the year, select the hundreds digit of the year, align the time zone (UT) with the tens digit of the year, select the day and time, and select the month). Remember that the color of the indicator on ruler 3 must still match the color of the selected indication on ruler 2 (in this case, red). (The indeterminacy of the color of the indicator on ruler 4 is, in this case, irrelevant for it does not affect the solutions; you should eventually check this for yourself.) Now determine the solutions from the junction of rulers 3 and 0 where the ones digits of the years align with the moon phases. Within $^1/_{16}$ lunar month, the solutions are ◍ in '90, ○ in '91, ◍ in '92, ◐ in '93, ❍ in '94, ● in '95, ○ in '96, ◑ in '97, ◍ in '98, and ○ in '99.

As you can see, advanced operation is generally complex and dependent on the type of information needed. It is all but impossible to put forth a complete set of examples. Sufficient study of the moonstick should, however, allow one to perform complex calculations as needed.

Advanced Operation Practice Problems

The problem is to the left of the colon (:); the solution is to the right.

- BC46(JAN1-DEC31) ○: JAN27, FEB25, MAR27, APR25, MAY25, JUN23, JUL23, AUG21, SEP20, OCT19, NOV18, DEC18
- 1999(JAN1-DEC31) UT-5h ◍: JAN20, FEB19, MAR20, APR19, MAY18, JUN17, JUL16, AUG15, SEP13, OCT13, NOV12, DEC11
- 2101(JAN-DEC)1AM12 (●-◍)±$^1/_{16}$: JAN ●, FEB ◍, MAR ●, APR ◍, MAY ●, JUN ◍, JUL ●, AUG ◐, SEP ◐, OCT ◐, NOV ❍, DEC ❍
- 200(0-9)(JAN-DEC)1 ●: '0JUL, '3FEB, '3APR, '3MAY, '5NOV, '5DEC, '8AUG
- 191(0-9)(JAN20-FEB19) UT+8h ●: '0FEB9, '1JAN30, '2FEB18, '3FEB6, '4JAN26, '5FEB14, '6FEB4, '7JAN23, '8FEB11, '9JAN31
- 210(0-9)DEC31PM6 (●-◍)±$^1/_{16}$: '0 ●, '1 ○, '2 ◑, '3 ◍, '4 ○, '5 ◍, '6 ◐, '7 ❍, '8 ●, '9 ❍
- 19(00-99)JUL4PM9 UT-5h (❍-○): '06, '14, '25, '33, '44, '52, '63, '71, '82, '90

Specifications

- weight: ~ 3.86 ounces
- size: ~ 6.96 cubic inches (packing space)
  - base: regular hexagon (~ $^1/_2$ inch on each side)
  - length: ~ $9^1/_2$ inches (collapsed)
- output: mean moon phase
  - source formula: .20439731 + *t* • .03386319269 / day
    - such that ● = .0, ◐ = .25, ○ = .5, and ◑ = .75
    - where *t* = [Universal Time] - [12 AM, January 1, 2001]
- precision: ±$^1/_{512}$ lunar month (±~$1^1/_2$ hour)
  - with normal human error (±~$^1/_{256}$ inch):
    - ±$^1/_{256}$ lunar month (±~3 hour)
- range: 6999 BC through 10999 AD (6573687 days)
  - Julian Calendar (OS): 6999 BC through 1999 AD
  - Gregorian Calendar (NS): 1000 AD through 10999 AD
- basic operation response time: < 35 seconds
  - within the same month: 0
  - within the same year: < 2 seconds

Accuracy can be improved by adding a correction,
+ t^2 • (.6±.3)×10^{-14} / day^2
(where *t* is defined as before). (The practice problems do not include the correction.) Here, in units of the finest graduation ($^1/_{128}$), the correction is approximated for selected years.

6999 BC .....+7±3	1 AD .....+0±0	7000 AD.....+2±1
5999 BC .....+5±3	1000 AD.....+0±0	8000 AD.....+3±1
4999 BC .....+4±2	2000 AD.....+0±0	9000 AD.....+4±2
3999 BC .....+3±1	3000 AD.....+0±0	10000 AD.....+5±3
2999 BC .....+2±1	4000 AD.....+0±0	11000 AD.....+7±3
1999 BC .....+1±0	5000 AD.....+0±0	
999 BC .....+0±0	6000 AD.....+1±0	

Please note that, except for results of calculations (which have been truncated), all numerical values given throughout these instructions are understood to be exact.

Contact Information

Please contact us with questions, comments, or concerns, or for any reason you wish. We would like to be able to contact you if an output error is ever found. We are thankful for your interest and hope that you benefit from the use of your moonstick.

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Effect of Moon Phase on the Earth*

	moon phase	nighttime illumination†	time of high tide†	time of low tide†	tidal range†	
●	new moon	none all night	early morning, early evening	late morning, late evening	large	●
◍	young crescent	none except very early (very dim)	mid-morning, mid-evening	mid-day, mid-night	medium	◍
◐	first quarter	dim early, none late	late morning, late evening	early morning, early evening	small	◐
❍	waxing gibbous	moderate except very late (none)	mid-day, mid-night	mid-morning, mid-evening	medium	❍
○	full moon	bright all night	early morning, early evening	late morning, late evening	large	○
❍	waning gibbous	moderate except very early (none)	mid-morning, mid-evening	mid-day, mid-night	medium	❍
◑	last quarter	none early, dim late	late morning, late evening	early morning, early evening	small	◑
◍	old crescent	none except very late (very dim)	mid-day, mid-night	mid-morning, mid-evening	medium	◍

	hour angle of the moon‡	declination of the moon‡§								zodiacal sign of the moon§‖								
		DEC 21	FEB 5	MAR 22	MAY 7	JUN 21	AUG 6	SEP 21	NOV 5	DEC 21	FEB 5	MAR 22	MAY 7	JUN 21	AUG 6	SEP 21	NOV 5	
●	12:00 PM	23°S	16°S	0°	16°N	23°N	16°N	0°	16°S	♐♑	♒	♓♈	♉	♊♋	♌	♍♎	♏	●
◍	3:00 PM	16°S	0°	16°N	23°N	16°N	0°	16°S	23°S	♒	♓♈	♉	♊♋	♌	♍♎	♏	♐♑	◍
◐	6:00 PM	0°	16°N	23°N	16°N	0°	16°S	23°S	16°S	♓♈	♉	♊♋	♌	♍♎	♏	♐♑	♒	◐
❍	9:00 PM	16°N	23°N	16°N	0°	16°S	23°S	16°S	0°	♉	♊♋	♌	♍♎	♏	♐♑	♒	♓♈	❍
○	12:00 AM	23°N	16°N	0°	16°S	23°S	16°S	0°	16°N	♊♋	♌	♍♎	♏	♐♑	♒	♓♈	♉	○
❍	3:00 AM	16°N	0°	16°S	23°S	16°S	0°	16°N	23°N	♌	♍♎	♏	♐♑	♒	♓♈	♉	♊♋	❍
◑	6:00 AM	0°	16°S	23°S	16°S	0°	16°N	23°N	16°N	♍♎	♏	♐♑	♒	♓♈	♉	♊♋	♌	◑
◍	9:00 AM	16°S	23°S	16°S	0°	16°N	23°N	16°N	0°	♏	♐♑	♒	♓♈	♉	♊♋	♌	♍♎	◍

*All information is approximate. †The information in these columns decreases in relevance away from the equator until (at the poles) it is not relevant. ‡The point on the Earth's surface whose local time and latitude are approximated in these tables is the point of the moon's greatest visibility. Away from this point, visibility gradually decreases until (at a distance of about 6209 miles) the moon is no longer visible. For example, at 8 PM, December 31, 2000 (Universal Time), the moon phase is about $^1/_2$ of the way from ● to ◐ (determined with moonstick) and the date is approximately $^1/_4$ of the way from DEC21 to FEB5. Interpolating from the data given in the chart leads one to believe that the hour angle of the moon is about 4:30 PM and the declination of the moon is about 4°S. Since it is 8 PM Universal Time (8 PM at 0° longitude), one must conclude that 4:30 PM is to be found at about 52°W longitude. Therefore the moon is positioned approximately above 4°S 52°W (northern Brazil). Thus to spectators in northern Brazil, the moon is approximately overhead. In Alaska (over 6500 miles away), the moon is probably not visible. In England (about 5000 miles from northern Brazil), the moon is generally low in the southwest. §Calendar dates are most accurate for the New Style Calendar. ‖When two signs are shown, the moon is approximately on the boundary between them.