CALCULATING THE UPOSATHA MOONDAYS

v0.3 · 4th August 2015 · link

TL,DR

Too Long, Didn't Read

- This is composed as a manual on how to calculate the Full- and New Moon day *uposathas*, indicating the astronomical cycles that underlie the method.
- The method is based on a set of formulas called *suriyayatra*, including additional rules observed in Thailand.
- Alternate 30 and 29 day lunar months, 12 months make one year. Add an extra month 7 times in every 19 years, add an extra day 11 times in every 57 years.
- Conventions on how to practise this can differ by countries and groups, resulting in self-consistent but different calendars.
- The Royal Thai Calendar defies exact prediction with unforeseen adjustments, the different monastic groups simply adjust the major moondays in their calendars for concord.

Much appreciation for the answers from the Venerable Ajahns who endured my questions. Comprehension and consistency was only possible with their experience and understanding.

Download this PDF or a ZIP archive with references.

Comments, corrections and further information would be greatly appreciated:

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Changelog:

2015-08-04

- New section: Uposatha Calendar Tutorial

2014-10-09

- Ven. Hāsapañño:
  - adhikavāra clarified
  - first and last day of a lunar month
  - occurrence of major moondays with the Pāli method

2014-10-07

- ready for feedback

1 UPOSATHA CALENDAR TUTORIAL

This section is a step-by-step guide for calculating the uposathas for a given year. Detailed explanation is left for later sections, we will only reference some tables for looking up information.

1.1 Collecting information about the year

We need to know the following:

- last uposatha of the previous lunar year
- extra lunar month (adhikamāsa)
  - in which month
  - first uposatha
  - last uposatha
- extra day (adhikavāra)

The last Full Moon of the previous lunar year may be in this January this year. This is the end (4th month) of the Rainy Season.

If there is an adhikamāsa, there will not be an adhikavāra.

Table 3.1 shows a few adhikamāsa years. If you see the year listed, take a note of:

- the month in which the adhikamāsa is added
- the first uposatha (a New Moon) of the season
- the last uposatha (a Full Moon) of the season

Table 2.1 shows a few adhikavāra years. Keep in mind that this is provisional. Even when a year qualifies for an adhikavāra, the calendar authorities may choose to add it in a different year.

Now we know that the year is either:

- a common year,
- an adhikamāsa year, or
- an adhikavāra year.

Gregorian leap years don't affect the lunar calendar, but it may be useful to check when planning ahead. Table 5.1 shows a few leap years.

1.2 Common year

1.2.1 Alternate 30 and 29 day months

Counting from the last Full Moon of the previous lunar year (which may be in January), the first month is 30 days, the second is 29 days:

15 days	● New Moon	First uposatha of the Cold Season
15 days	○ Full Moon	End of first month, 30 days
14 days	● New Moon	
15 days	○ Full Moon	End of second month, 29 days

A Full Moon is always on the 15th day. Every second New Moon is on the 14th day.

The ◐ Waxing- and ◑ Waning Moons are on the 8th day.

Keep alternating 30 and 29 day months. One season is four months, one year is three seasons: Cold-, Hot- and Rainy Season. See Table 4.3 for the Pāli names of months and seasons.

1.2.2 *Marking the Vassa and Major Moondays*

Mark the months and seasons according to Table 4.3.

The key annual events are:

	Lunar Month	
Māgha Pūjā	3rd	
Visākha Pūjā	6th	
Āsāḷha Pūjā	8th	Entering Vassa on the next day
Assayuja Pūjā	11th	Pavāraṇā Day, the end of Vassa

In a common year, the calendar is finished.

1.2.3 *Pāṭimokka announcement*

TODO

1.3 Adhikamāsa year

1.3.1 *Marking the Vassa and Major Moondays*

The extra month is a 30 day month. There is a Pali and a Thai method for inserting it and both are used in the same calendar!

We're gonna need some tables.

The Pali method adds it at different places in different years, see Table 3.1.

The Thai method always adds it as the month before the Vassa. The convention is to call this the 'second 8th' or 'second Āsāḷha', marked as 8/8.

The Major Moondays and the Pāṭimokka announcement of the seasons shift according to the Pali method, but the beginning of the Vassa, the names of months and seasons in the calendar are marked according to the Thai method.

In adhikamāsa years the Vassa starts 30 days later, after the 2nd Āsāḷha, on the day after the Full Moon uposatha of 8/8.

Table 1.1 shows a common year. Alternating 30 and 29 day months, three seasons, four months per season.

Table 1.2 shows the 2015 adhikamāsa year. Looking at Table 3.1 we see that the adhikamāsa is added:

- in the Rainy Season
- the first uposatha of the 5-month season is the New Moon of the 9th month (now as 8/8)

- its last uposatha is the Full Moon of the 12th month

Table 1.2 shows the 2012 adhikamāsa year. The adhikamāsa is added:

- in the Cold Season
- the first uposatha of the 5-month season is the New Moon of the 1st month
- its last uposatha is the Full Moon of the 5th month

1.4 Adhikavāra year

The extra day is inserted in the 8th month (Āsāḷha), making the 7th uposatha of the Hot Season a 15-day uposatha instead of the expected 14-day, and making Āsāḷha a 30-day month that year.[1]

In adhikavāra years the Vassa starts one day later.

order	name	days
6	Visākha	29
7	Jeṭṭha	30
8	Āsāḷha	**30**
9	Savaṇa	30
10	Bhaddapāda	29

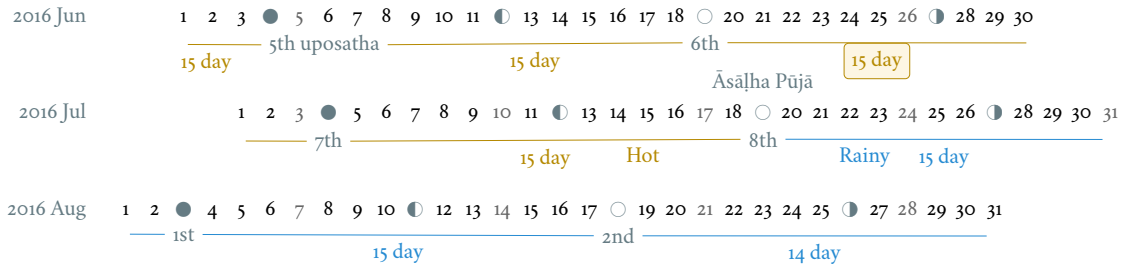

Table 1.1: Uposathas in a Common Year

1	30		New	1	Hemanta
			Full	2	
2	29		New	3	
			Full	4	
3	30		New	5	
		Māgha	Full	6	
4	29		New	7	
			Full	8	
5	30		New	1	Gimha
			Full	2	
6	29		New	3	
		Visākha	Full	4	
7	30		New	5	
			Full	6	
8	29		New	7	
		Āsāḷha	Full	8	
9	30	Enter Vassa	New	1	Vassāna
			Full	2	
10	29		New	3	
			Full	4	
11	30		New	5	
		Pavāraṇā	Full	6	
12	29		New	7	
			Full	8	

Table 1.2: Uposathas in 2015 with an adhikamāsa

				Thai		Pali	
1	30	2014 Nov 21	New	1	Hemanta	1	Hemanta
			Full	2		2	
2	29		New	3		3	
		2015 Jan 4	Full	4		4	
3	30		New	5		5	
			Full	6		6	
4	29		New	7		7	
		Māgha	Full	8		8	
5	30		New	1	Gimha	1	Gimha
			Full	2		2	
6	29		New	3		3	
		Visākha	Full	4		4	
7	30		New	5		5	
			Full	6		6	
8	29		New	7		7	
		Āsāḷha	Full	8		8	
8/8	30	2nd Āsāḷha	New	9		1	Vassāna
			Full	10		2	
9	30	Enter Vassa	New	1	Vassāna	3	
			Full	2		4	
10	29		New	3		5	
			Full	4		6	
11	30		New	5		7	
		Pavāraṇā	Full	6		8	
12	29		New	7		9	
			Full	8		10	

Table 1.3: Uposathas in 2012 with an adhikamāsa

				Thai		Pali	
1	30	2011 Nov 25	New	1	Hemanta	1+	Hemanta
			Full	2		2+	
2	29		New	3		3	
		2012 Jan 8	Full	4		4	
3	30		New	5		5	
			Full	6		6	
4	29		New	7		7	
		Māgha	Full	8		8	
5	30		New	1	Gimha	9	
			Full	2		10	
6	29		New	3		1	Gimha
			Full	4		2	
7	30		New	5		3	
		Visākha	Full	6		4	
8	**30**	30?	New	7		5	
			Full	8		6	
8/8	30		New	9+		7	
		Āsāḷha	Full	10+		8	
9	30	Enter Vassa	New	1	Vassāna	1	Vassāna
			Full	2		2	
10	29		New	3		3	
			Full	4		4	
11	30		New	5		5	
		Pavāraṇā	Full	6		6	
12	29		New	7		7	
			Full	8		8	

2 THAILAND, MAHĀNIKĀYA METHOD

2.1 Adding the extra month

The extra month (adhikamāsa) is added 7 times in every 19 year, in a repeating pattern of 3-3-2 - 3-3-3-2 years. This is a shorthand for the formulas at 4.1 which generate this pattern. Table 3.1 shows adhikamāsa years for 1996-2034.

In Thai practice, the extra month is a 30 day month inserted after the 8th month (*Āsāḷha*), at the end of the Hot Season. The convention is to call this the 'second 8th' or 'second *Āsāḷha*', marked as 8/8.

In adhikamāsa years the Vassa starts 30 days later, after the 2nd Āsāḷha, on the day after the Full Moon uposatha of 8/8.

order	name	days
8	Āsāḷha	29
8/8	2nd Āsāḷha	30
9	Savaṇa	30

2.2 Adding the extra day

The extra day (adhikavāra) is added 11 times in every 57 year.

Whether a year should have an extra day can be determined with the conditions at sec.4.4.

In Thai practice a year with an extra month is not allowed to also have an extra day. If the year should have an extra day, but it already has an extra month, the extra day is assigned to one of the flanking years (next or previous, in the case of planning several years in advance).

In adhikavāra years the Vassa starts one day later.

If the year is going to have an extra day, it is inserted in the 8th month (Āsāḷha), making the 7th uposatha of the Hot Season a 15-day uposatha instead of the expected 14-day, and making Āsāḷha a 30-day month that year.[1]

order	name	days
6	Visākha	29
7	Jeṭṭha	30
8	Āsāḷha	**30**
9	Savaṇa	30
10	Bhaddapāda	29

However, this is the most unpredictable variable in the calendars published for a given year, and the various calendar authorities add the extra day in a flexible manner, in some of cases according with the formula but differing from it in others.

Nonetheless they observe that:

- the count for 11 times in 57 years is maintained to keep the calendar at pace
- the extra day will not be in years that also have an extra month.

2.2.1 *Check: Adhikavāra prediction*

The formulas predict 2016 to have an adhikavāra. See below for the *kammacubala* (K), *avoman* (A) and *thaloengsok* (T) values produced with the formulas 4.1.

See description at sec.4.3 and sec.4.4.

The last adhikavāra year has been 2009, which makes 2016 a likely candidate. If relatively evenly distributed, the adhikavāra years are 5-6 years in distance, and 2015 would have probably been adhikavāra if not for the adhikamāsa.

2015 qualifies for adhikamat, but also for adhikawan, and so the adhikawan would be carried on to 2016.

AD	CS	type	K	A	T
2015	1377	m	188	0	28
2016	1378	d	781	566	9

2.3 Major Moondays

Buddhist communities observe key annual events on the Full Moon days of four lunar months:

	Lunar Month	
Māgha Pūjā	3rd	
Visākha Pūjā	6th	
Āsāḷha Pūjā	8th	Entering Vassa on the next day
Assayuja Pūjā	11th	Pavāraṇā Day, the end of Vassa

The Pāli method for adding the adhikamāsa at sec.3 is relevant here.

In adhikamāsa years the extra month is added as the 2nd Āsāḷha, but the numbering of months for determining the major moondays moves forward as if it was added in the season described by the Pāli method.

If the adhikamāsa falls in the Cold Season, the Sangha still observes it in that season when telling the season at the recitation of the Pāṭimokkha.

Also see sec.4.2 on *Thai* lunar months.

Table 2.1: Adhikavāra years

K, A, T for kammacubala, avoman and thaloengsok

Year	CS	K	A	T
1994	1356	535	54	6
2000	1362	93	627	11
2005	1367	658	656	7
2009	1371	630	119	22
2014	1376	395	137	17
2016	1378	781	566	9
2020	1382	753	29	24
2025	1387	518	47	19

3 ADDING THE EXTRA MONTH, PALI METHOD

The following is adapted from Ajahn Khemanando for recent years.[2]

Table 3.1 shows the 19-year cycle between 1996-2034.

Table 3.1: Adhikamāsa years for 1996-2034 and inserting the extra month according to Pali method.

	Δm for years since last adhikamāsa.						
Δ m				Month	Season	New	Full
	0	1996	2015	8	Rainy	9	12
	1						
	2						
3	3	1999	2018	5	Hot	5	8/8
	4						
	5						
3	6	2002	2021	2	Cold	1	5
	7						
2	8	2004	2023	10	Rainy	9	12
	9						
	10						
3	11	2007	2026	7	Hot	5	8/8
	12						
	13						
3	14	2010	2029	3	Cold	1	5
	15						
2	16	2012	2031	12	Cold	1	5
	17						
	18						
3	19	2015	2034	8	Rainy	9	12

Δ m: years since the last adhikamāsa

Month: the Pali lunar month into which the adhikamāsa is inserted

Season: the season in which the adhikamāsa falls in that particular year

New and Full: the first and last uposatha of the 5-month season in which the adhikamāsa falls, numbered in Pali lunar months

If the adhikamāsa falls on the 2nd, 3rd, or 12th Pali lunar month, there will be *two* 8th months (8 and 8/8) the following year.

E.g. In 2001, the adhikamāsa comes as the 2nd lunar month in the Cold Season, so the following year, 2002, has two 8th months (8 and 8/8). There will thus be *ten* uposathas in the Cold Season, the first being the New Moon of the 1st Pali lunar month (2002) and the last being the Full Moon of the 5th Pali lunar month, 2002.

4 THE THAI LUNI-SOLAR CALENDAR

Luni-solar calendars are constructed so to count years according to the *solar* cycle, but to count months according to the *lunar* cycle.

tropical year[1] of the Earth	365.24219 days
synodic month[2] of the Moon	~29.53 days, can vary up to 7 hours

The epoch of the Thai calendar is 25 March 638 AD.

The Thai luni-solar calendar is *procedural*, it uses a few constant, key numbers derived from astronomical observations, and applies a series of mechanical calculations (i.e. the "rules") again and again to generate the dates of lunar phases and new years.

> This working is deliberately concise, since it thereby reflects how the calculation would have been made by a South East Asian calendrist. Each stage is subjected to an operation learnt by rote, and the underlying theory disappears from view. The rote operations, however, will provide a valid answer for any date in any year. It seemed greatly preferable to set out the procedure thus starkly, rather than to give a detailed exposition of what is involved.[4]

Southeast Asian astronomers refined a fraction to obtain the length of the year:

$$\frac{292207}{800} = 365.25875 \text{ days}[4] \tag{4.1}$$

This is 0.01656 days longer than the modern measurement (accumulating 1 day in ~60 years). Remarkably, the *suriyayatra* accounts for this and generates accurate results:

> For instance, a Pagan inscription of 14 April 1288 AD maintains that at midnight the Sun's position was 0 signs, 19 degrees and 59 minutes: the computer program returns 0 19 59.[3]

Nonetheless, the calendar dates published in Thailand (historical or recent) in a given year reflect not only these principles, but also adjustments and omissions which cannot be foreseen or retraced.

> The historical record however, frequently defies prediction, forcing the conclusion that the pressure upon the *horas* (astronomers / astrologers) was not to follow the "rules" but merely, within some more leisurely constraints, to ensure that the calendar did not get out of control.[3]

4.1 Year Types

[1] tropical year: the time it takes the Earth to complete an orbit around the Sun
[2] synodic month: the time it takes the Moon to reach the same visual phase

We are concerned with three types of calendar years:

Cal A Normal with 354 days

Cal B Adhikavāra with 355 days

Cal C Adhikamāsa with 384 days

Comparing these to normal and solar leap years:

	A	B	C
Lunar	354	355	384
Solar	365	365	365
difference	+11	+10	-19

	A	B	C
Lunar	354	355	384
Solar Leap	366	366	366
difference	+12	+11	-18

4.2 The first and last day of a lunar month

In monastic practice, the Full Moon day is on the last day of a given month. The next month starts on the following day (first day of the waning phase), thus the first uposatha will be on a New Moon.

In many Thai calendars, the New Moon day is the last day of the month, and the Full Moon day is in the middle. This only changes the numbering of the months, not the actual moondays. In these calendars the thresholds of months are shifted two weeks forward relative to the monastic calendar.

The New Moon of the 7th *Thai* lunar month is the New Moon (1st uposatha) of the 8th *monastic* lunar month.

4.3 Adhikamat years

The *suriyayatra* principle to determine adhikamat years is:

> If the day of *thaloengsok* (astronomical New Year) lies either within 25 to 29 (in Citta-māsa) or 1 to 5 (in Visākha-māsa), then the year is adhikamat.[5]

The *thaloengsok* is the value of T in Figure 4.1.

4.4 Adhikawan years

> Two components of the *suriyayatra* are known as the *kammacubala* and the *avoman*, and it is the values of these two elements at the start of the year that determine the matter:
>
> - if the kammacubala value is 207 or less, then the year is leap year
> - in a leap year, if the avoman is 126 or less, the year will have an extra day
> - in a normal year, if the avoman is 137 or less, the year will have and extra day[4]

The *kammacubala* and *avoman* are the value of K and A in Figure 4.1.

In Thailand, years with an extra month are not allowed to also have an extra day, and the adhikawan will be assigned to the previous or next year.

4.5 Suriyayatra formulas

See Figure 4.1.

Figure 4.1: Finding astronomical values with the *suriyayatra* calculation[4]

Start with Y, the given Common Era year. Significant values are assigned names. K for *kammacubala*, A for *avoman*, T for *thaloengsok* (the New Year).

$$a = ((Y - 638) * 292207) + 373 \tag{4.2}$$
$$h = \lfloor a/800 + 1 \rfloor \tag{4.3}$$
$$K = 800 - (a \bmod 800) \tag{4.4}$$
$$A = ((h * 11) + 650) \bmod 692 \tag{4.5}$$
$$b = \lfloor ((h * 11) + 650)/692 \rfloor \tag{4.6}$$
$$T = (b + h) \bmod 30 \tag{4.7}$$

4.6 Names of the months

The name of a given month is determined by the astrological sign which the Full Moon enters at midnight. See Table 4.3.

5 Gregorian leap years

if (*year* is not exactly divisible by 4) **then** (it is a common year)
else
if (*year* is not exactly divisible by 100) **then** (it is a leap year)
else
if (*year* is not exactly divisible by 400) **then** (it is a common year)
else (it is a leap year) [6]

Bibliography

[1] Hāsapañño Bhikkhu. The lunar and solar zodiac, 2014.

[2] Khemanando Bhikkhu. The cycle of the adhikamāsa.

[3] J.C. Eade. The calendrical systems of mainland south-east asia (using the preview bits available on Google Books). 1995.

[4] J.C. Eade. Rules for interpolation in the thai calendar: *Suriyayatra* versus the *Sasana*. *Journal of the Siam Society*, 88(1 and 2), 2000. Accessed 2014-10-02.

[5] Prasert na Nagara. *Ngan charuk lae prawatisat*.

[6] Wikipedia. Leap Year.

Colophon

Org-mode and LaTeX. Sources at Github.

Comments, corrections and further information would be greatly appreciated.

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Last updated on 2015-08-04.

Table 4.1: Pali and Thai lunar months in a year

Nth	phase	month	Pali	Thai
1	New		1	12
2	Full		1	1
3	New		1	1
4	Full	Magasira	1	1
5	New		2	1
6	Full		2	2
7	New		2	2
8	Full	Phussa	2	2
9	New		3	2
10	Full		3	3
11	New		3	3
12	Full	Māgha	3	3
13	New		4	3
14	Full		4	4

Table 4.2: Adhikamat and adhikawan in the period 1958 to 1978 (CS 1320-1340).[4]

m for adhikamat, d for adhikawan years, Δm and Δd for years since last adhikamat and adhikawan.

Δ d		Δ m	year	type	Asalha	2nd Asalha
	0		1320	m	19:42	22:24
0	1		1321	d	21:05	
1	2		1322		20:40	
2	3	3	1323	m	19:12	22:00
3	4		1324		20:38	
4	4 5		1325	d	19:34	
5	6	3	1326	m	19:38	22:05
6	7		1327		21:15	
7	8	2	1328	m	19:20	22:55
8	9		1329		21:48	
9	5 10		1330	d	20:26	
10	11	3	1331	m	19:59	22:50
11	12		1332		21:20	
12	13		1333		20:02	
13	14	3	1334	m	19:03	21:33
14	5 15		1335	d	20:40	
15	16		1336		20:44	
16	17	3	1337	m	19:44	22:19
17	18		1338		21:11	
18	19	2	1339	m	19:45	22:35
19	5		1340	d	21:05	

Table 4.3: Lunar and Solar Months and Zodiacs[1]

Season		days	Lunar Month	Solar Month	Solar Zodiac (Western / Sanskrit)
Hemanta-utu	1	30	Magasira-māsa	December	Sagittarius / Dhanus
Cold Season	2	29	Phussa-māsa	January	Capricorn / Makara
	3	30	Māgha-māsa	February	Aquarius / Kumbha
	4	29	Phagguṇa-māsa	March	Pisces / Mīna
Gimha-utu	5	30	Citta-māsa	April	Aries / Meṣa
Hot Season	6	29	Visākha-māsa	May	Taurus / Vṛṣabha
	7	30	Jeṭṭha-māsa	June	Gemini / Mithuna
	8	29	Āsāḷha-māsa	July	Cancer / Karkaṭa
Vassāna-utu	9	30	Savaṇa-māsa	August	Leo / Siṃha
Rainy Season	10	29	Bhaddapāda-māsa	September	Virgo / Kanyā
	11	30	Assayuja-māsa	October	Libra / Tulā
	12	29	Kattika-māsa	November	Scorpio / Vṛścika

Table 5.1: Gregorian leap years

2004	2016	2028	2040
2008	2020	2032	2044
2012	2024	2036	2048