CALCULATING THE UPOSATHA MOONDAYS

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TL,DR

Too Long, Didn't Read

- The aim here is to describe the practical steps to calculate the uposatha Full- and New Moon days, and indicate the astronomical cycles that underlie the method.
- 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 consistent but different calendars.
- Unforeseen adjustments to the predicted uposatha days in the published Royal Thai Calendar can be expected.

Much appreciation for the answers from the Venerable Ajahns who endured my questions and described their experience.

Unresolved Questions:

- The formulas predict 2016 to have an adhikavāra, see 1.3.1
- Where in the year is the adhikavāra inserted?
- Only Mahānikāya adds adhikavāra?
- Where is the Pāli method in sec.2 used?
- Thai text in references folder: Calendar and Era use in Thailand from *The Journal of the Royal Institute of Thailand* – does it have relevant notes?

This document is work-in-progress and represents only what I've been able to find description of. See the Bibliography at sec.3.5 or download a .zip of this document with sources.

Comments, corrections or further information would be greatly appreciated:

`Gambhiro Bhikkhu <gambhiro.bhikkhu.85@gmail.com>`

1 THAILAND, MAHĀNIKĀYA METHOD

1.1 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
15 days	● New Moon	
14 days	○ Full Moon	End of second month, 29 days

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

	Su						Su							Su							Su							Su
2016 Jan	1	◑	3	4	5	6	7	●	9	10	11	12	13	14	15	◐	17	18	19	20	21	22	○	24	25	26	27	28	29	30	◑
2016 Feb	1	2	3	4	5	6	●	8	9	10	11	12	13	14	◐	16	17	18	19	20	21	○	23	24	25	26	27	28	29		

Keep alternating 30 and 29 day months. One season is four months, one year is three seasons: Cold-, Hot- and Rainy Season. In a year with nothing special, the calendar is finished. See Table 3.2 for the Pāli names of months and seasons.

In some years an extra month (adhikamāsa) or an extra day (adhikavāra) has to be added.

1.2 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 3.1 which generate this pattern. Table 2.1 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.

Vassa starts 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

1.3 Adding the extra day

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

1.3.1 Checkme: 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 3.1.

See description at sec.3.2 and sec.3.3.

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

AD	CS	type	K	A	T
2014	1376	d	395	137	17
2015	1377	m	188	0	28
2016	1378	d	781	566	9

Also weird because two years in succession (2014 and 2015) would qualify for adhikawan.

2014 is *edge-case*, having avoman 137, perhaps the condition is $A < 137$ and not $A <= 137$? Possible, if the interpretation of the rule is to index day values from 0, not from 1.

More past calendars with adhikawan are needed to look-up and formalize testing.

1.4 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 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.

2 ADDING THE EXTRA MONTH, PĀLI METHOD

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

Table 2.1 shows the 19-year cycle between 1996-2034.

Δ m: years science the last adhikamāsa

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

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

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

If the adhikamāsa falls on the 2nd, 3rd, or 12th Thai 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 12th Thai lunar month (2001) and the last being the Full Moon of the 5th Thai lunar month, 2002.

Table 2.1: Adhikamāsa years for 1996-2034 and inserting the extra month according to Thai and Pāli method.

				Δm for years since last adhikamāsa.				
Δ m				Month (Thai)	Month (Pāli)	Season	New	Full
	0	1996	2015	8/8	8	Rainy	8	12
	1							
	2							
3	3	1999	2018	8/8	5	Hot	4	8/8
	4							
	5				2	Cold	12	5
3	6	2002	2021	8/8		Cold	12	5
	7							
2	8	2004	2023	8/8	10	Rainy	8	12
	9							
	10							
3	11	2007	2026	8/8	7	Hot	4	8/8
	12							
	13				3	Cold	12	5
3	14	2010	2029	8/8		Cold	12	5
	15							
	16				12	Cold	12	5
3	17	2013	2032	8/8		Cold	12	5
	18							
2	19	2015	2034	8/8	8	Rainy	8	12

3 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:

$$\frac{292207}{800} = 365.25875 \text{ days}[4] \tag{3.1}$$

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 additional adjustments 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]

[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

3.1 Year Types

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

3.2 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 3.1.

3.3 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 3.1.

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

3.4 Suriyayatra formulas

See Figure 3.1.

Figure 3.1: 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).

$$a = ((Y - 638) * 292207) + 373 \tag{3.2}$$
$$h = \lfloor a/800 + 1 \rfloor \tag{3.3}$$
$$K = 800 - (a \bmod 800) \tag{3.4}$$
$$A = ((h * 11) + 650) \bmod 692 \tag{3.5}$$
$$b = \lfloor ((h * 11) + 650)/692 \rfloor \tag{3.6}$$
$$T = (b + h) \bmod 30 \tag{3.7}$$

Table 3.1: 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	

3.5 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 3.2.

Table 3.2: Lunar and Solar Months and Zodiacs[1]

* marks 29 day months having a 14 day New Moon (*amāvasī cātuddasī*).

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

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

[3] J.C. Eade. The calendrical systems of mainland south-east asia. 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*.

COLOPHON

Org-mode and LaTeX. Sources at Github.

Comments, corrections or further information would be greatly appreciated.

`Gambhiro Bhikkhu <gambhiro.bhikkhu.85@gmail.com>`

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