INDIAN CALENDARS

The word Calendar has its origin from the Roman word Calends or Kalends meaning a method of distributing time into certain periods adopted for the purpose of civil life.

Thus a calendar may be defined as a system of reckoning time over extended intervals by combining various convenient periods of time.

Before we go into the details of various calendars used in India let us first understand basic quantities which are integral part of any calendar.

The Time

It may be understood in one of the following two ways :

(i) is the general term for the conscious experience of duration.
(ii) is the interval between two non-simultaneous occurrence of events.

In physics time and space are considered fundamental quantities and hence they can not be measured in terms of any other quantities. Thus the only definition possible is an operational one in which time is defined by process of measurement of an interval and the units chosen.

Measurement of Time : It involves establishing a precise system of reference for specifying when any event occurs i.e. specifying an epoch and establishing a standard interval of time.

Astronomy and civil affairs are concerned with both epoch and time interval whereas physics deals almost entirely with time intervals.

Our senses are not a good judge of equal intervals and if any accuracy is required then a clock of some sort must be used. A clock, in general sense, may be defined as anything which can be used to measure an elapsed interval of time.

In nature there are phenomena that recur at regular intervals and hence can be used as a clock and for defining units of time. Some artificial units of time, which are not connected with any natural phenomenon, are also used for convenience in civil use.

Various units of time both natural and artificial in use are :

Natural Units of Time : Day, Month, Year

Artificial Units of Time : Hour, Minutes, Seconds, Week, Decade, Century etc.

Natural Units of Time

The year is defined by a complete revolution of the Sun in the sky along the ecliptic, the month by a complete revolution of the Moon around the Earth and the day by a complete rotation of the Earth on its axis.

We can define the ***year*** in the following ways.

The Sidereal Year : It the time required by the Sun to make a complete circuit of the ecliptic (apparent path of the Sun in the sky) i.e. moving exactly 360^{o}. The length of this year is 365.256363 mean solar days (msd).

The Tropical Year : It is the average time interval between two consecutive passages of the Sun through the vernal equinox (the γ point). As this point moves backwards due to precession the Sun covers slightly less than 360^{o}. The length of tropical year is 365.242190 msd.

The relationship between sidereal and tropical years is :

Sidereal Year : Tropical Year = 360^{o} : (360^{o} – 50.”29)

For civil purposes it is more convenient to use the tropical year which is closely related to seasons.

Like the year the ***month*** is defined in the following ways.

Sidereal Month : It is the interval of two consecutive passages of the Moon from some point on the ecliptic to the same point again.
Its length is 27.321661 msd.

Synodic Month : It is the interval from new-moon to next new moon or from one full moon to next full moon. Its length is 29.530588 msd.

The ***day*** is defined by the alteration of daylight and night. This duration is taken in one of the following ways for civil and calendar use.

(a) Sun rise to Sun rise : used in Hindu calendars
(b) Sun set to Sun set : used in Islamic calendars
(c) midnight to midnight : used in Gregorian Calendar
(d) noon to noon : used in astronomy

The Mean Solar Time : Our civil life greatly depends on the position of the Sun in the sky. But the Sun’s apparent motion in the sky is non-uniform due to its motion in an elliptic orbit (Kepler’s 2nd law) and the obliquity of the ecliptic. Hence the true solar time varies throughout the year, which is not convenient for civil

purposes. Therefore a mean solar time was introduced; it is based on a fictitious Sun which moves along the equator with uniform speed but takes exactly the same time to make one complete revolution as the true sun takes in moving along the ecliptic.

The difference between the true solar time and the mean solar times is called the equation of time. This is the same as the difference between the Sun dial time and the local mean time at any place.

During a year the equation of time attains the following extreme values.

Date :	Feb. 12	May 14	Jul. 26	Nov. 4
Equation of time :	$-14^m.3$	$+3^m.7$	$-6^m.4$	$+16^m.4$

The mean solar day used above is the average time interval between two successive passages of the Sun over the meridian of a place i.e. average time between one noon to the next.

Mean solar time is different for each meridian. To simplify things Earth has been divided into different time zones. Each country adopts a suitable time zone for the entire country. For example the Greenwich Mean Time (GMT) or Universal Time (UT) is the mean solar time for the Greenwich meridian. The Indian Standard Time (IST) is the mean solar time at a meridian 5h 30m east of Greenwich. The time is measured starting with $0^h.00$ at midnight and ending with 24^h at the next midnight.

Artificial Units of Time

The Week : The most common of all artificial periods of time is the week, which is a period of seven days. Originally it was not an integral part of any calendar. It gradually became established in its present form in the Roman Calendar during 1 or 2 BC. After getting established the cycle of succession of the days of the week has not been altered and no breaks in the sequence have occurred.

Order of the week days : Ancients recognized the order of planets by the time they took to complete a circumference of the heavens. The order was Moon, Mercury, Venus, Sun, Mars, Jupiter and Saturn. Astrologically each of the seven planets was supposed to rule in turn over various hours of the day in succession in the order Saturn to Moon. The day is named after the planet which rules the first hour. Thus if Saturn is the ruler of the first hour of the day then Jupiter will be ruler of the second hour and so on. Thus Sun will be the ruler of the 25^{th} hour or the first hour of the next day. In this way Saturday is followed by Sunday and so on.

Decade : It is a period of 10 years.

Century : It is a period of 100 years. (Julian century = 36525 msd)

Other division are : Hour = 1 / 24 of a day
Minutes = 1 / 60 of an hour
Seconds = 1/ 60 of a minutes

Hindu Calendar Divisions : Savan din = 60 Ghati (24 Hours)
Pahar = 1 / 8 of a din (3 Hours)
Pal = 1 / 60 of a ghati (24 seconds)

Kalpa = 4.3×10^9 years
Manvantar = 3.08×10^8 years (1/14 of a Kalpa)
Maha Yuga = 4.32×10^6 years (1/71 of a Manvantar)
Krata Yuga = 1.73×10^6 years (4/10 of a Mahayuga)
Treta Yuga = 1.30×10^6 years (3/10 of a Mahayuga)
Dwapar Yuga = 8.64×10^5 years (2/10 of a Mahayuga)
Kali Yuga = 4.32×10^5 years (1/10 of a Mahayuga)

Categories of Calendars

All calendars used throughout the word can be grouped into the following three categories.

(i) **The Solar Calendars** : These calendars are based on the yearly motion of the Sun, which could be either sidereal or tropical. Roman, French, Gregorian calendars are solar calendars where tropical year is used as the year length where as Indian solar calendars followed in Assam, Bengal, Tripura, Haryana, Punjab, Orrisa, Tamil Nadu and Kerla, etc. are having sidereal year as the year length of their calendars.

(ii) **The Lunar Calendars** : Lunar calendar is based on the monthly cycle of phases of the Moon i.e. synodic month and has no relation with the yearly motion of the Sun. Islamic Hejira Calendar is a pure lunar calendar.

(iii) **The Luni-Solar Calendars** : These calendars take into account both the monthly motion of the Moon and the yearly motion of the Sun. Jews and Babylonian calendars are luni-solar calendars. India calendars used in Andhra Pradesh, Gujrat, Maharastra, Karnataka, Bihar, Kashmir, Madhya Pradesh, Rajasthan, Uttar Pradesh etc are luni-solar calendars.

The Requirement of an Ideal Calendar

(i) The civil year and month must have an integral number of days.
(ii) The stating day of the year and of the month should be suitably defined. The dates must correspond strictly to seasons.
(iii) For purpose of continuous dating an Era should be used and it should be properly defined.
(iv) The civil days should be properly defined for use in the calendar.
(v) If lunar months have to be kept then there should be convenient devices for seasonal adjustments (i.e. with solar year)

A correct and satisfactory solution to the above requirements has not yet been obtained. The main reason being the non-commensurability of various natural periods. Many attempts to find solutions to these problems have resulted in hundreds of calendars which have been used throughout the word during historical times.

India, being a very ancient civilization with a rich history and cultural diversification, developed its own methods of time keeping. These methods vary slightly in different regions and thus many different systems of Indian (Hindu) calendar making emerged.

In the following we explain the salient features of the Solar, the Lunar and the Luni-solar calendars.

Solar Calendar

A *solar calendar* is designed to approximate the tropical year or sidereal year using days. As there are no integral number of days in a actual solar year therefore in order to synchronize the calendar with the actual year length of a solar year days are sometimes added, forming leap years, to increase the average length of the calendar year. A solar calendar year can be divided into months but these months ignore the lunar month.

The Gregorian calendar is a solar calendar with a common year having 365 days and a leap year having 366 days. Every fourth year is a leap year unless it is a century year not divisible by 400. The Indian national Calendar is also a solar calendar about which we will discuss later.

Lunar Calendar

A *lunar calendar* consists of 12 lunar months forming a year with each month covering the period between two successive new moons. Each lunar month has an average length of about 29.5 days. This amounts to about 12 x 29.5 = 354 days a year i.e. around 11 days shorter than the tropical year. Hence a lunar

calendar does not remain in tune with the seasons, which depend on the motion of the Sun in a tropical year.

The Muslim calendar is a lunar calendar. We can see that the muslim festivals always fall about 11 days earlier in the next Gregorian calendar year.

Lunisolar Calendar

A *lunisolar calendar* is designed to keep in phase with the tropical year or sidereal year while using lunar months. As we have seen above that 12 lunar months are short by about 11 days compared to a solar year, hence a whole lunar month is occasionally added at every few years interval (about 2.5 years) to help the calendar keep up with the solar year. This additional month is known as the *leap month* or the *intercalary month*.

The Indian luni-solar calendars are made to be in tune with the sidereal year instead of the tropical year.

The Indian Solar Calendars

There are about four solar calendars used in India. They are constructed using similar calendrical rules. As stated above the year is sidereal instead of tropical. The basic structure of the Indian solar calendar is the following.

The sidereal year is called the *nirayana year* and is the actual time required for the Earth to revolve once around the Sun with respect to a starting point on the ecliptic that is taken to be directly opposite the bright star called Chitra. The longitude of the star Chitra from this point is 180^{o}. The Indian solar calendar is made to keep in phase with the nirayana year. The starting point of the nirayana year coincided with the March Equinox in the year AD 285. Since the stars are fixed with respect to the ecliptic, the starting point remains unchanged, hence the name nirayana.

The Solar Months

The ecliptic is divided into 12 divisions of 30^{o} each called rasis. The first rasi starts from the same point as that of the start the nirayana year. A solar month is determined by the entrance of the Sun into a *rasi*. The length of a solar month is the time taken for the Sun to travel completely in the rasi, that is, to travel 30^{o} of its elliptical orbit. Hence a nirayana year has 12 solar months. Since the solar calendar has several local variations, the start of the nirayana year and names of the month may differ. The following table gives the names of the rasis and their corresponding solar months in several solar calendars. The months in bold indicates the start of the nirayana year in that region.

Relationships between rasis and solar months

Rasi No.	Name of Rasi	Name of corresponding solar month in most solar calendars	Name of corresponding solar month in the Tamil solar calendar	Name of corresponding solar month in the Malayali (Kerala) solar calendar
1	Mesha	**Vaisakha**	**Chittirai**	Mesha
2	Vrish	Jyaistha	Vaikasi	Vrisha
3	Mithuna	Ashadha	Ani	Mithuna
4	Karkata	Sravana	Adi	Karkata
5	Simha	Bhadra	Avani	**Simha**
6	Kanya	Asvina	Purattasi	Kanya
7	Tula	Kartika	Arppissi	Tula
8	Vrischika	Agrahayana (Margasirsha)	Karthigai	Vrischika
9	Dhanus	Pausha	Margali	Dhanus
10	Makara	Magha	Thai	Makara
11	Kumbha	Phalguna	Masi	Kumbha
12	Mina	Chaitra	Panguni	Mina

As per Kepler's second law the Sun's motion around the Earth, is not uniform. This causes the length of each solar month to vary. The mean length of a solar month is about 30.4369 days but its actual length can vary from 29.45 days to 31.45 days. The entry of the Sun into a rasi is called a *samkranti* and therefore there are 12 samkrantis in a nirayana year.

Rules for deciding the beginning of a solar month

The samkranti can occur at any time of the day. Hence it is not convenient to start a solar month at the exact time of a concerned samkranti. Instead, the beginning of a solar month is chosen to be from a sunrise that is close to the concerned samkranti. Consequently, the civil day becomes the basic unit of the Indian solar calendar.
From the actual length of a solar month, we see that each solar month can have 29 to 32 days. Solar months with their corresponding rasis near the aphelion will most probably have 32 days while solar months that are linked to rasis near the perihelion will likely to have 29 days. In other words, months with corresponding rasis Vrisha, Mithuna and Karkata can have 32 days while months with corresponding rasis Vrischika, Dhanus and Makara can have 29 days.

For determining the starting day of a solar month, there are several rules of samkranti that are followed. Some of the common rules are:

1. *The Orissa rule*
Solar month begins on the same day as the samkranti.

2. *The Tamil rule*
Solar month begins on the same day as the samkranti if the samkranti falls before the time of sunset on that day. Otherwise the month begins on the following day.

3. *The Malayali rule*
Solar month begins on the same day as the samkranti if the samkranti occurs before the time of aparahna on that day. Otherwise the month starts on the following day.
(Aparahna is the time at 3/5th duration of the period from sunrise to sunset. For example if the times of sunrise and sunset are 6am and 6pm respectively. Then the time of the aparahna = [(3/5) x (18 – 6) + 6]am = 1.12pm.)

4. *The Bengal rule*
When samkranti takes place between the time of sunrise and midnight on that day, the solar month begins on the following day. If it occurs after midnight, the month begins on the next following day, that is, the third day. This is the general rule. In some special circumstances, there are some deviations from this rule.

We shall call the solar calendars following the four stated rules in the order above as the Orissa, Tamil, Malayali and Bengal calendars respectively. There exists other diversification but we will not discuss them here.

The Calendar or Civil Year and the Solar Eras

As mentioned in the above table Orissa, Tamil and Bengal calendars begin their civil year with the solar month that corresponds to the Mesha rasi. The Malayali calendar starts the year at the solar month that links with the Simha rasi.

The solar eras being used in the solar calendars are the Kali Yuga, the Saka, the Bengali San and the Kollam eras.

Regions in India using the Indian solar and luni-solar calendars

It may be noted that the following differences arise in Indian solar calendars used in different regions.

1. The starting day of the solar month may differ by one or two days in different parts of India.

2. The number of days of different solar months also varies from 29 to 32.

3. The length of the solar month (number of days in that month) is not fixed but changes from year to year.

Likewise there are differences in luni-solar calendars of different regions. The month in some start from new moon while in others it starts from full moon. The beginning of year also differs. It may be from Chaitra, Kartika or Asadha.

The Indian National Calendar

Noting that there are slight differences in various calendars used in India**, The Council of Scientific and Industrial Research, Government of India,** appointed a Calendar Reform Committee in November 1952 under the chairmanship of the renowned scientist Dr. Meghnad Saha. The committee's objective was to examine all existing calendars used in India and to propose an accurate and uniform all-India calendar for both civil and religious use. After close examination, the Committee recommended a unified solar calendar for civil use. The Government of India accepted the proposal and introduced it as the Indian national calendar with effect from 22 March 1957. However the Government continued to use the Gregorian Calendar for administrative use.

The proposed National Calendar is a modification of the existing Indian solar calendars. The principle unit of the calendar remains the civil day. The solar era chosen is the Saka national era. The following features are different from the traditional Indian solar calendars.

The national calendar is made to approximate the tropical or the *sayana* year and not the traditional sidereal or nirayana year.

The calendar year starts on the day after the March Equinox day.

Unlike the traditional solar calendars the solar months have fixed number of days restricted to either 30 or 31 days.

This length still depended on the time taken for the Sun to travel the concerned tropical rasi instead of sidereal rasi. The first rasi Mesh begins at the March equinox which is also the starting point of the sayana year. The five months from the second to the sixth have mean lengths over 30.5 days and so their lengths are rounded up to 31 days. The remaining months have 30 days. Names for the solar months are kept the same as those of the Indian solar calendar listed in colunm 3 of the above table. However, the first month is named as Chaitra, followed by Vaisakha and so on.

Lengths of different solar months reckoned from the March Equinox

Name of months in the traditional solar calendar	Ecliptic arc covered by the Sun measured from the March Equinox point	Mean time taken by the Sun to cover the respective 30^o arc	Integral number of Days Taken	Name of months in the National solar calendar	Gregorian Calendar dates of beginning of National Calendar Months
Vaisakha	0^o - 30^o	30^d 11^h $25^m.2$	30^d 31^d in a leap year	Chaitra	22 March 21 March (In case of leap year)
Jyaistha	30^o – 60^o	30^d 23^h $29^m.6$	31^d	Vaisakha	21 April
Ashadha	60^o – 90^o	31^d 8^h $10^m.1$	31^d	Jyaistha	22 May
Sravana	90^o – 120^o	31^d 10^h $54^m.6$	31^d	Ashadha	22 June
Bhadra	120^o – 150^o	31^d 6^h $53^m.1$	31^d	Sravana	23 July
Asvina	150^o – 180^o	30^d 21^h $18^m.7$	31^d	Bhadra	23 August
Kartika	180^o – 210^o	30^d 8^h $58^m.2$	30^d	Asvina	23 September
Agrahayana	210^o – 240^o	29^d 21^h $14^m.6$	30^d	Kartika	23 October
Pausha	240^o – 270^o	29^d 13^h $8^m.7$	30^d	Agrahayana	22 November
Magha	270^o – 300^o	29^d 10^h $38^m.6$	30^d	Pausha	22 December
Phalguna	300^o - 330^o	29^d 14^h $18^m.5$	30^d	Magha	21 January
Chaitra	330^o - 360^o	29^d 23^h $18^m.9$	30^d	Phalguna	20 February

The occurrence of leap years in the National Calendar is made to fall in the same leap year as that in the Gregorian Calendar to keep the relation of the dates between these two calendars the same. When leap year occurs, Chaitra would have 31 days instead of 30 days.

However, most calendar-makers do not accept the National calendar mainly because the sayana system was adopted instead of the nirayana system. To them, this change was too drastic because traditionally solar calendars are kept in line with the nirayana year and the calendar-makers would not want to abandon this principle.

Therefore all the calendars both solar and luni-solar existing before the formation of the Calendar Reforms Committee continue to be used.

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Acknowledgement:

The Indian Map is adapted from the dissertation on Indian Calendars of Mr. Leow Choon Lian of Department of Mathematics, Faculty of Science, National University of Singapore (2000/ 2001).

Further Reading:

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