

The Computus Digitorum

*Presenting a Period method of Discerning the Date of Easter,
and a Modern Tool to determine the Canonical Hours and
Construct a Personal Liturgical Calendar
for these
Current Middle Ages*



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This project began in the mid-1990s as an investigation into the Canonical Hours. As with most projects, it didn't stop there, but expanded to include a general Liturgical Calendar. Next I added the Roman Calendar notation. I had included the table of the Golden Numbers early on, but they were essentially cosmetic, so I had to find out exactly what they had been used for in period. Extrapolating from there, I developed a technique of determining the date of Easter from the Golden Numbers and made them truly functional.

The goal then for this calendar is to develop a method of constructing a medieval-style Liturgical calendar for the current modern year that the medievalist can feel a connection to the Middle Ages in form, but maintain modern observances. I believe I have accomplished this by providing a computerized method to remove the tedium of calendar building, but maintaining the flexibility to customize the calendar for personal beliefs and practices. Herein lies the fruits of my research – this documentation of the Medieval Roman Liturgical Calendar in general, and the Excel calendar spreadsheet in specific.

A note on the term *Computus Digitorum*. I came across this phrase in an abstract discussing the Venerable Bede's book *de temporum ratione* (*The Reckoning of Time*). The *computus* (Latin: computation) is the technique for calculating the date of Easter, or, more generally, for techniques used in developing a calendar. Bede referred to a method of calculating using his fingers, the *computus digitorum*. I thought this was an appropriate pun in our modern world of digital computers and thus adopted the name for my computerized calendar.

This document and the computerized version are works in progress. I appreciate comments on how you found it useful or problems you've encountered.

The Roman Calendar

The calendar utilized in western Europe during the middle ages was not the universally standardized version we enjoy today. The unifying structure was the major festivals of the Church. Some of these celebrations occurred on fixed dates such as St. John the Baptist or Christmas, while others occurred relative to the movable date of Easter (such as Pentecost). Dates were commonly referred to by their Church festival rather than the familiar month/day/year used in modern times. It was also quite common to see documents with the dates given in the style used in the ancient Roman empire.

The calendar used in the middle ages in lands that had been in contact with the Romans was developed for Julius Caesar and enacted in 46 BC, and known to us by his name – the Julian Calendar. The Romans set year 1 of their calendar to glorify the founding of Rome in 753 BC. Years counted under this system were referred to as “from the founding of the city,” *ab urbe condita* (AUC). In antiquity the Romans had used year lengths of 10, 11, and 12 months, but by the fall of the Empire the calendar had settled into 12 months with each month having the same number of days as we are familiar with in the 21st century.

Roman Inclusive Counting

Before looking closer at the Roman calendar, there is a quirk of Roman counting that is essential to understanding their system. The Romans used “inclusive” counting which counts both the beginning and ending points, unlike the way we would count in modern times. Using this system, the number of days between dates is one more than the way we would count it. For example, tomorrow would be the second day from now – today=1, tomorrow=2. Have you ever been confused by the Easter story of Jesus being 3 days in the tomb? In modern times we would consider Friday evening to Sunday morning to be a day and a half, or two if you were being generous. However, using the Roman method, you would count Friday as day one, Saturday as day two, and Sunday as the third day.

Division of the Roman Month

The month in the Julian calendar was divided into irregular segments, likely to have originally been connected with the phases of the moon. The first day of the month is the Kalends and originally occurred at the new moon. The name comes from the Latin *calere* – “to call” as the pontifex would “call out” the announcement of the new month as signaled by

the sighting of the moon just past new. The next division was the Nones occurring 9 days prior to the Ides and fell on the 5th or 7th of the month. The Ides represented the full moon. The name is derived from *iduate* – to divide. The Ides is the 15th of the month in March, May, July, and October, and the 13th in January, February, April, June, August, September, November, and December. The remaining days of the month are counted as the number of days before the next Kalends, Nones, or Ides (counting inclusively) and are labeled, e.g. *ante diem III Kalends Martius* which would be the 28th of February in a leap year. The day before the Kalends, Nones, or Ides is *pridie* (e.g. *pridie Kalends Martius* – the last day of February).

Roman Months

Insert Roman names of months

Leap Year

A problem that has plagued all calendar systems is there aren't an even number of lunar months in a solar year. This causes the calendar dates to drift in relation to the seasons. Julius Caesar attempted to fix this drift by adding an extra day to every 4th year to give an average of 365.25 days per year. This was much closer to the actual length of year of 365.2422 days. This slowed the drift of the seasons, but over several centuries it became obvious the dates in the calendar were shifting through the seasons.

Pope Gregory XIII instituted a more refined system in 1582 that we are still using in our Modern Middle Ages. Leap years occur every 4th year except century years divisible by 400 (e.g., 1600 and 2000). This brings the average days per year to 365.2425 – very close to the actual 365.2422. The actual leap day is inserted after *a. d. VI kalendis Martias* (24 Feb) and called *bis a. d. VI kalendis Martias*, and is the origin of the term *bissextile* to describe a leap year.

The New Year

Even though Dionysius Exiguus defined year one of the calendar when he developed his tables of Easter in the early 6th century, there was still a lot of confusion as to the actual date when the new year started:

“If we suppose a traveler to set out from Venice on 1 March 1245, the first day of the Venetian year, he would find himself in 1244 when he reached Florence: and if after a short stay he went on to Pisa, the year 1246 would already have begun there. Continuing his journey westward, he would find himself again in 1245 when he entered Province, and on arriving in France before Easter (16 April) he would be once more in 1244.” *Cheney p 8.*

The starting points of the calendar that have been used include Christmas, the Annunciation (March 25), Easter, and January first. Christmas Day makes sense since a year numbered based on the birth of Jesus would start on the date celebrated as his birthday. It was used in various locations as late as 14th century. The Annunciation is also called “Lady Day” and was commonly considered the start of the new year in England until the Gregorian calendar was adopted in British lands in 1752. Some areas were one off on the starting year and used dates one year earlier than other locations. Easter Day was used in some parts of France. What goes around, comes around, as January 1 was historically used by the Romans and was recommended for use by both Dionysius and Pope Gregory XIII. It was formally adopted in England with the change to the Gregorian calendar.

The Date of Easter

Though details are sketchy, the date of Easter was declared by the Council of Nicea as having to be on a Sunday, rather than on whatever day of the week the Jewish Passover fell on. This was further clarified by Dionysius Exiguus with the tables he published in 525 AD. Easter was then defined as the first Sunday following the first full moon following the vernal (spring) equinox. These landmarks are not the astronomical ones that you would see if you were looking at the spring sky, but were set mathematically. The vernal equinox was defined as 21 March, whereas astronomically it can occur on 20 or 21 March. The full moon is likewise a calculated value. The earliest possible date for Easter is 22 March and the latest 18 April.

There is a simple formula to determine the date of Easter, however, this is not period. The period method was to have professional astronomers build tables of the dates of Easter. The method they used is fairly straightforward.

The ancients recognized that the cycles of the phases of the moon and the seasons didn't completely agree. [Insert details on Meton]. The Metonic cycle is 19 years in which the lunar cycle of 13 months a year and the solar cycle of 12 months a year come together. The position of the current year in the Metonic cycle is called the Golden Number. It can be calculated by:

$$\text{Golden Number} = 1 + \text{MOD}(\text{Year}, 19)$$

Where MOD means divide Y by 19 and throw away everything but the remainder. Thus 2004 would be

$$\text{MOD}(2004, 19) = 9 \text{ (2004 divided by 19 equals 105 remainder 9)}$$

$$9 + 1 = 10$$

therefore 2004 has a Golden Number of 10. Similarly, 2005 has a Golden Number of 11.

Most medieval calendars include a column containing Roman numerals. This serves as a lunar almanac. The Roman numerals represent the date of the calculated new moons for a year with that Golden number. For example, February 28 has the number *iv* next to it, therefore it is considered a new moon date in years with a Golden number of 4.

**Calendar Fragment for
Calculating the Date of**

Calculating Easter from the Tables

The attached calendar fragment is for useful for calculating the date of Easter for the years 1900 – 2099 AD. First, look at March 21. This is the date that is defined as the Vernal Equinox for the purpose of Easter calculations and is labeled in blue on in the *Computus Digitorum*. Using 2007 as an example, The Dominical Letter after the leap day is G (labeled in red), which means any date with a G by it is a Sunday. The Golden number is 13, so any date on the chart with an *xiii* by it is the calculated (not actual) new moon. The Paschal New Moon will be the new moon closest to the Equinox (occurs in the range 9 March – 5 April). Referring to the calendar excerpt, the Paschal new moon is on March 19 (again marked in red). The full moon following that will be 14 days later (or 15 days if you are using inclusive counting), 2 April (outlined in red). This is a Monday (day letter A). Easter would then be the next Sunday (letter G), 8 April.

The table of Golden Numbers used in the *Computus Digitorum* was developed by first shifting the table from the Julian calendar as used in period to the Gregorian calendar used in Catholic Europe since 1582 and England (and the Colonies) since 1752. The numbers were hand-tweaked by comparing the numerically-calculated date of Easter with the table-calculated version until harmony was reached.

Equinox

Easter

March	8	<i>xiv</i>		
	9	<i>iii</i>	E	vii Ides
	10		F	vi Ides
	11	<i>xi</i>	G	v Ides
	12		A	iv Ides
	13	<i>xix</i>	B	iii Ides
	14	<i>viii</i>	C	prid. Ides
	15		D	Ides
	16	<i>xvi</i>	E	xvii Kal
	17	<i>v</i>	F	xvi Kal
	18		G	xv Kal
	19	<i>xiii</i>	A	xiv Kal
	20	<i>ii</i>	B	xiii Kal
	21		C	xii Kal
	22	<i>x</i>	D	xi Kal
	23		E	x Kal
	24	<i>xviii</i>	F	ix Kal
	25	<i>vii</i>	G	viii Kal
	26		A	vii Kal
	27	<i>xv</i>	B	vi Kal
	28	<i>iv</i>	C	v Kal
	29		D	iv Kal
	30	<i>xii</i>	E	iii Kal
	31	<i>i</i>	F	Prid. Kal
April	1		G	Kalends
	2	<i>ix</i>	A	iv Nones
	3	<i>xvii</i>	B	iii Nones
	4	<i>vi</i>	C	prid. Nones
	5		D	Nones
	6	xiv	E	viii Ides
	7	iii	F	vii Ides
	8		G	vi Ides
	9	xi	A	v Ides
	10		B	iv Ides
	11	xix	C	iii Ides
	12	viii	D	prid. Ides
	13		E	Ides
	14	xvi	F	xviii Kal
	15	v	G	xvii Kal
	16		A	xvi Kal
	17	xiii	B	xv Kal
	18		C	xiv Kal

The Liturgical Year

Advent
Christmas
Epiphany
Lent
Eastertide
Pentecost
Common time

The Movable Feasts

Several of the major celebrations of the Church are based on the date of Easter. The first of these is Ash Wednesday which marks the beginning of the Lenten season. It occurs 46 days prior to Easter. This gives 40 days of Lent, since the six Sundays aren't considered to be a part of Lent. Shrove Tuesday is the day prior to Ash Wednesday and was the last day meat products were allowed before Easter, thus the term carnival (Latin *carne vale*), which means "goodbye meat."

Next comes Palm Sunday which ushers in Holy Week. This is the Sunday before Easter. The days of Holy Week are Holy Monday, Holy Tuesday, Holy Wednesday, Maundy Thursday, Good Friday, and Holy Saturday. The next day is Easter, beginning the Octave of Easter (Easter Sunday through the Sunday after). The Ascension is 10 days before Whitsunday (Pentecost), which is 49 days after Easter (50 if you use inclusive counting).

The week following Whitsunday is Trinity Sunday. The feast of Corpus Christi (not the town in Texas) is 12 days (inclusive) after Trinity Sunday.

Other movable dates that don't depend directly on Easter are the four Sundays before Christmas which mark the beginning of the Christian year with the season of Advent.

Ember days are times of special prayers for each season and are the Wednesday, Friday, and Saturday after Ash Wednesday, after Whitsunday, after the Exaltation of the Cross (14 September), and after St. Lucia (13 December).

Rogation days are days of fasting and prayer to appease God's anger with man's transgressions. They are the Major Rogation day on April 25, and the minor Rogation days the three day prior to the Feast of the Ascension.

The Fixed Feasts

Like many facets of medieval society, the feasts celebrated by the Church had a lot of room for variation, when properly approved by the local bishop, of course. The main outline of the festivals of the year were standard, but many of the minor saints' day celebrations varied by region or country. Especially favored were saints that had a connection to the local area. The dates I've chosen heavily follow English usage. I've attempted to use the date for the celebration as used in the middle ages, unless it is also a well-known modern date. In making a calendar for your own use, you can of course include any saints or celebrations that fit your persona or modern preferences.

Hagiography

A hagiography is a book or listing of Saints. I use it here in conjunction with feasts which occur on a fixed date to discuss the Feasts I have chosen to include in this version of *The Computus Digitorum*.

January

- 1 The Circumcision of our Lord
- 6 Epiphany

February

Xx

March

Xx

April

Xx

May

Xx

June

Xx

July

Xx

August

Xx

September

Xx

October

Xx

November

Xx

December

Xx

Liturgical Colors

White

Red

Green

Violet

Black

Rose

Blue

The Division of the Day

The monastic day was divided into at least seven times of prayer as called for in Psalm 119:164: “Seven times a day I have given praise to thee, for the judgments of thy justice.” The actual times of the services varied widely due to local custom, the monastic order, and the actual length of the day and night.

The divisions of the day were not the uniform hours we use today. The period from sunrise to sunset was divided into 12 equal hours as was the period from sunset to sunrise. Therefore, a day hour was a different length than a night hour. The length of an hour also varied season-to-season, especially in northern Europe. The hours were numbered starting with the first hour at sunrise, on through the 11th hour just before sunset. The hours of the night started at sunset. Thus noon was the sixth hour of the day. This system can be seen in the King James version of the Bible from 1611. Mechanical timepieces were not commonly available until the mid to late 1400s and since they were more adept at keeping a uniform hour the equal hour slowly came to be the dominant form of timekeeping (hours “of the clock” or o’clock).

Though some of the Canonical hours were combined or moved to give the monks more time to sleep (especially during the short winter nights of northern Europe), I have adopted a system of Hours spaced every three unequal hours. Keeping the tradition of the ancients, the day began at sunset. The first of the Canonical Hours, at sunset, was Vespers. Compline was the prayer time before bed and is halfway between Vespers and midnight. At the midpoint of the night comes Matins. Halfway from midnight to dawn is Lauds, which in period was often combined with Matins (which gives seven periods of prayer). Sunrise marks the first hour of the daytime, thus the name Prime (Latin for first). The beginning of the third hour of the day (halfway from sunrise to noon) is Terce (from the Latin for third). Noon is the sixth hour of the day, therefore Sext was the noontime prayer. Mid-afternoon brought None (the ninth hour). This brings us back to Vespers.

Computus Digitorum calculates the time of sunrise and sunset for each day and uses the length of the day and night to calculate the unequal hours. The Canonical Hours are then calculated and the modern clock time for each of the Offices is given for each day. The calendar correctly corrects for daylight saving time as implemented in the United States.

Computus Digitorum version 1

The *Computus Digitorum* Excel spread sheet has been under development for over 7 years. I serendipitously found a routine that calculates sun rise and set times, immediately removing the major tedium from preparing the calendar. This enticed me to work to further automate it. In approximately 24 hours, the calendar transformed from almost complete manual entry to almost complete automation. Of course, I've spent many more hours tweaking and documenting the Calendar.

Nota bene: You must have Excel's Analysis ToolPak Add-in installed. This can be found on the Tools...Add-Ins menu. If Analysis ToolPak doesn't have a check mark by it, check it and hit OK then follow the instructions. You may need the install disk.

What's calculated automatically:

1. Modern Calendar Date (column A)
2. The day of the week (column B)
3. The Golden Number (column D), used to determine Paschal New Moon
4. The Dominical Letter (column E, Sunday highlighted in red)
5. Roman-style date (column F)
6. Times for stylized Canonical Hours (columns H - O)
7. Sunrise, sunset, length of night and day, length of unequal hours (columns P - U)
8. The Canonical Hours evenly spaced as described above.
9. Properly adjusts for US Daylight Saving Time
10. Leap years are handled appropriately
11. The date of the Paschal New Moon (red, bold, italic Roman numeral in column D in March or April)
12. Date of the Paschal Full Moon (red box in column D in March or April, 13 days after Paschal New Moon). The Sunday following this date is Easter.

Calculated, but not automatically placed into calendar:

1. Date of Easter (Location and Movable Feasts sheets)
2. Dates of other movable feasts based on date of Easter

Items that still have to be entered manually:

1. The Saint's days, feasts, and liturgical colors in column G
2. Lunar phases (column C)

To fill in the Calendar:

1. Set the correct year in the location tab.
2. Move any of the fixed feasts that fall on Sunday to the following Monday (except Christmas). Use Copy/Paste rather than Cut/Paste (messes with formatting). Consider marking feast as "transferred".
3. Put in the movable feasts, moving any fixed feasts one day later if necessary (Don't move feasts for Ember or Rogation days).
4. Label the Sundays in January prior to Epiphany as Sundays after Christmas (white).
5. Common days prior to Epiphany are white.
6. Common days from Epiphany to Ash Wednesday are green.
7. The first Sunday after Epiphany is the Baptism of Christ (white).
8. Remaining Sundays prior to Ash Wednesday are "Nth Sunday after Epiphany". The Sunday just prior to Ash Wednesday is "Last Sunday after Epiphany". All are green.
9. Starting with Ash Wednesday, common days are purple
10. Sundays in Lent are "Nth Sunday in Lent" up to Palm Sunday. They are purple.
11. Palm Sunday through Holy Saturday are red or purple. Good Friday may be black.
12. Easter through Pentecost is white.
13. The Sunday after Easter is the "Second Sunday of Easter" and numbered sequentially through the Sunday before Pentecost.
14. Pentecost is red.
15. Common days and Sundays after Pentecost are green. This season goes all the way to Advent.
16. The Sunday after Pentecost is Trinity Sunday (white).

17. Sundays after Trinity Sunday start with “Second Sunday after Pentecost” and are numbered in sequence.
18. The last Sunday in Advent is Christ the King (white).
19. Common days and Sundays in Advent are Purple. Advent III may use pink.
20. Christmas to the end of the year is white.

This is the first public release of *Computus Digitorum* and it has not been thoroughly tested for all years in the valid period nor on a wide variety of computers or versions of Excel. The dates of Easter and its graphic calculation have been verified from 1900 – 2099. The routine to mathematically calculate Easter dies outside this period. The program was developed on Excel 2000 (9.0.2720). I would appreciate feedback on any problems and other comments or suggestions.

Essential References

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Calculation of local times of sunrise, and sunset based on the calculation procedure by NOAA (<http://www.srrb.noaa.gov/highlights/sunrise/sunrise.html>)

The calculations in the NOAA Sunrise/Sunset are based on equations from *Astronomical Algorithms*, by Jean Meeus. NOAA also included atmospheric refraction effects. The sunrise and sunset results were reported by NOAA to be accurate to within +/- 1 minute for locations between +/- 72° latitude, and within ten minutes outside of those latitudes.

This Excel VBA translation was tested for selected locations and found to provide results within +/- 1 minute of the original NOAA Javascript code.

This VBA translation does not include calculation of prior or next sunsets for locations above the Arctic Circle and below the Antarctic Circle, when a sunrise or sunset does not occur.

Translated from NOAA's Javascript to Excel VBA by:

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