Throw Away Your Wristwatch

Pennsic 44 Edition

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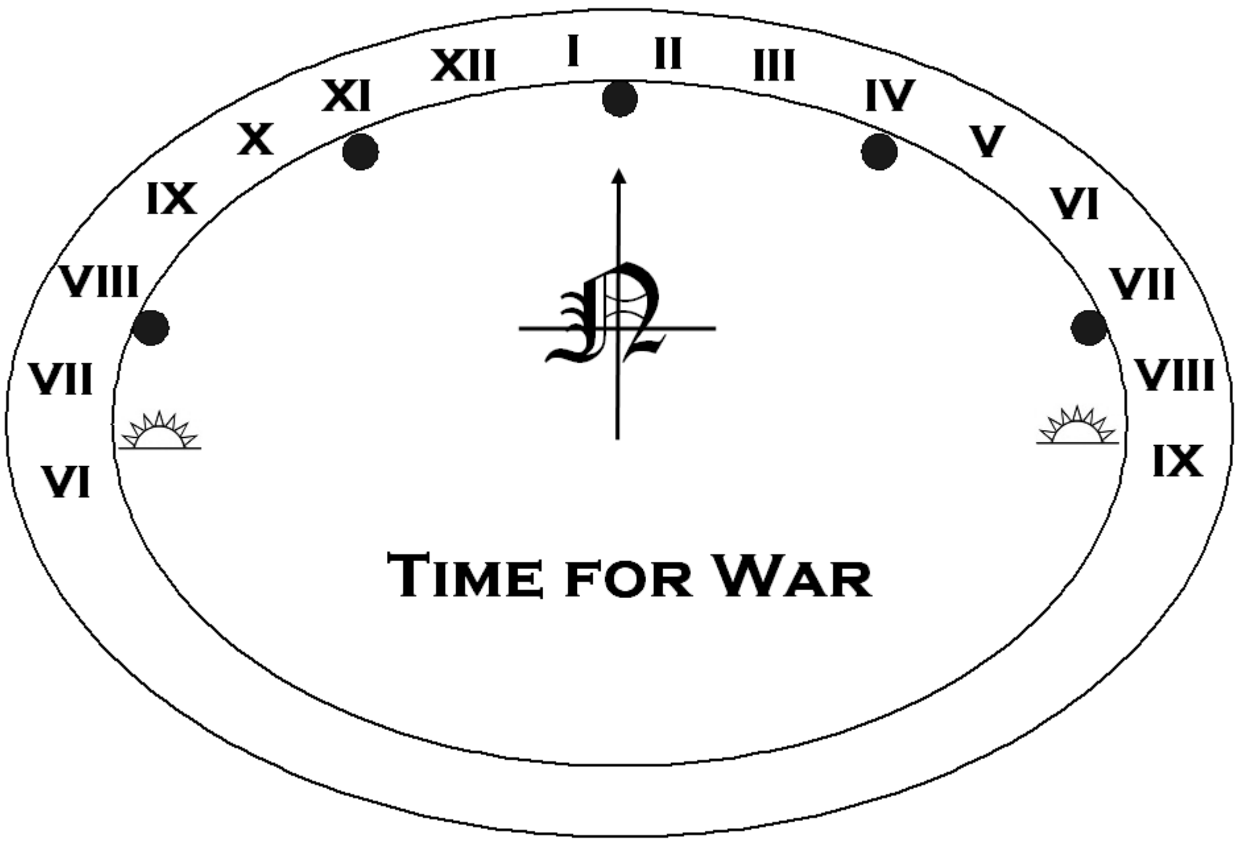
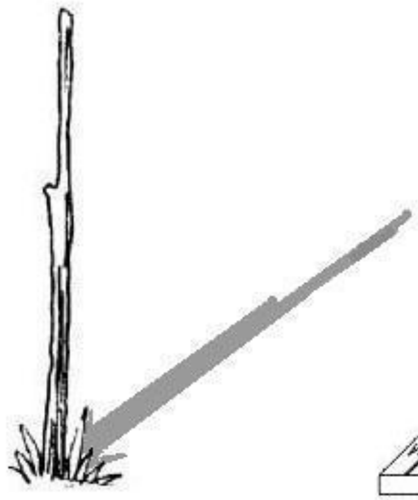
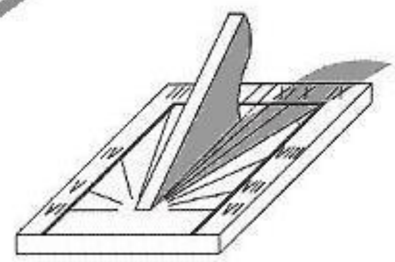
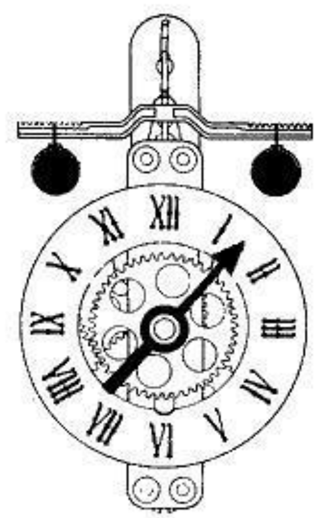
ADVANCED



Sundials have been used by every culture throughout history. For many people a sundial wasn't even necessary. You got up when the sun came up, ate lunch when the sun was directly overhead, and went to bed when the sun went down. It mattered little to you, living near London, that dawn to dusk in the summer took twice as long as it did in the winter. You measured time in temporary, or unequal hours, where dawn was the first hour and dusk was twelfth hour everyday and life followed a natural rhythm.

But one day they installed a large mechanical clock in the town hall to chime the hours and soon the "natural" unequal hours were put aside for mechanically defined equal hours. Ironically, that clock was so unreliable it had to be reset almost daily by referring to a sundial.

As clocks improved, people noticed that 12 noon on the sundial varied up to 30 minutes from spring to fall when compared to 12 of the clock (today called 12 o'clock). And since mechanical clocks could indicate the time, day or night, sunny skies or cloudy, clocks eventually displaced sundials and clock time diverged more from "natural" time.

When clocks improved farther and became smaller, people set their portable clocks to match the city clock. But they noticed that when they set their clock in London and then travelled to Wales, their clock was off by 12 minutes when compared to the city clock in Cardiff. So time zones were established taking us farther from "natural" time.

And later, when countries desired more daylight in the afternoons, Daylight Saving Time took us even farther from "natural" time so now your sundial can be off by one and a half hours or more.

> *There is no "s" at the end of the word "Saving" in the phrase "Daylight Saving Time". Think of it as being analogous to "Dog Walking Time" or "Beer Drinking Time".*

Adapting to modern influences

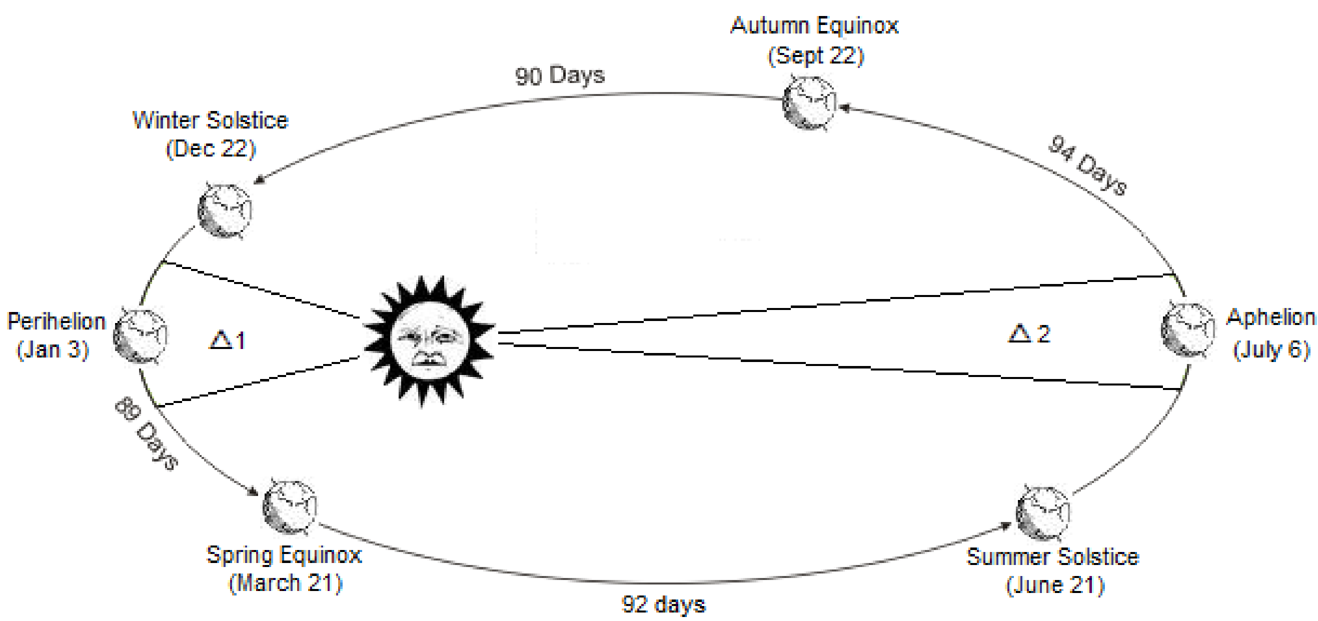
EDUCATION ALERT!
A good sundialist is also a physicist, a cartographer and a mathematician.

- You must be a physicist to understand how the orbit of the earth around the sun affects the sundial.
- You must be a cartographer to understand how latitude and longitude and the "lay of the land" can affect your sun dial.
- You must be a mathematician so that you can design a sundial that accounts for the physics and cartography affects so you can read clock-time directly off the sun dial.

Physics
Sundials "run" fast and slow due to the tilt of the earth and the earth's orbit around the sun. There are four significant orbital events that are essential for sun-dialing: The Summer and Winter solstices and the Spring and Autumn equinoxes.

- A solstice occurs when the Sun's apparent position in the sky reaches its northernmost or southernmost extremes.
- An equinox occurswhen the tilt of the Earth's axis is inclined neither away from nor towards the Sun, the centre of the Sun being in the same plane as the Earth's equator.

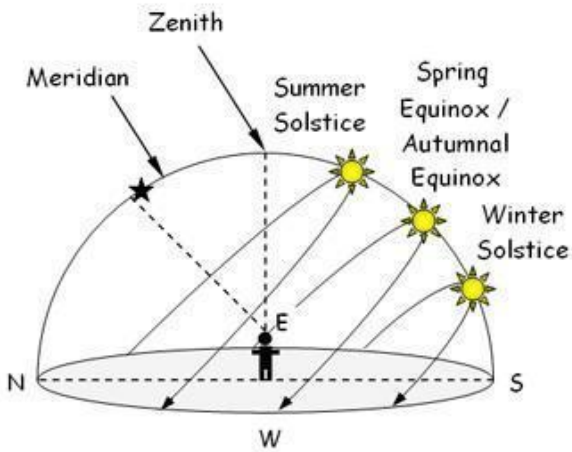
Orbit
The dates for the solstices and the equinoxes are indicated on the diagram. The dates for when the earth is closest and farthest from the sun (Perihelion and Aphelion) are also included.

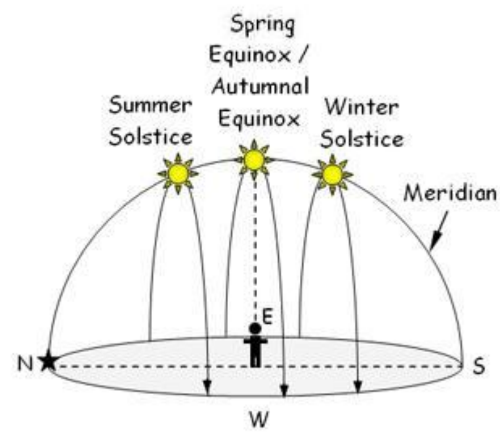


Seasons have nothing to do with how close the earth is to the sun.

Tilt

From the ground, the orbital events look something like this. The picture on the left is for about 45 degrees north latitude. If you were standing on the equator(the picture on the right) the equinoxes would be directly over head.

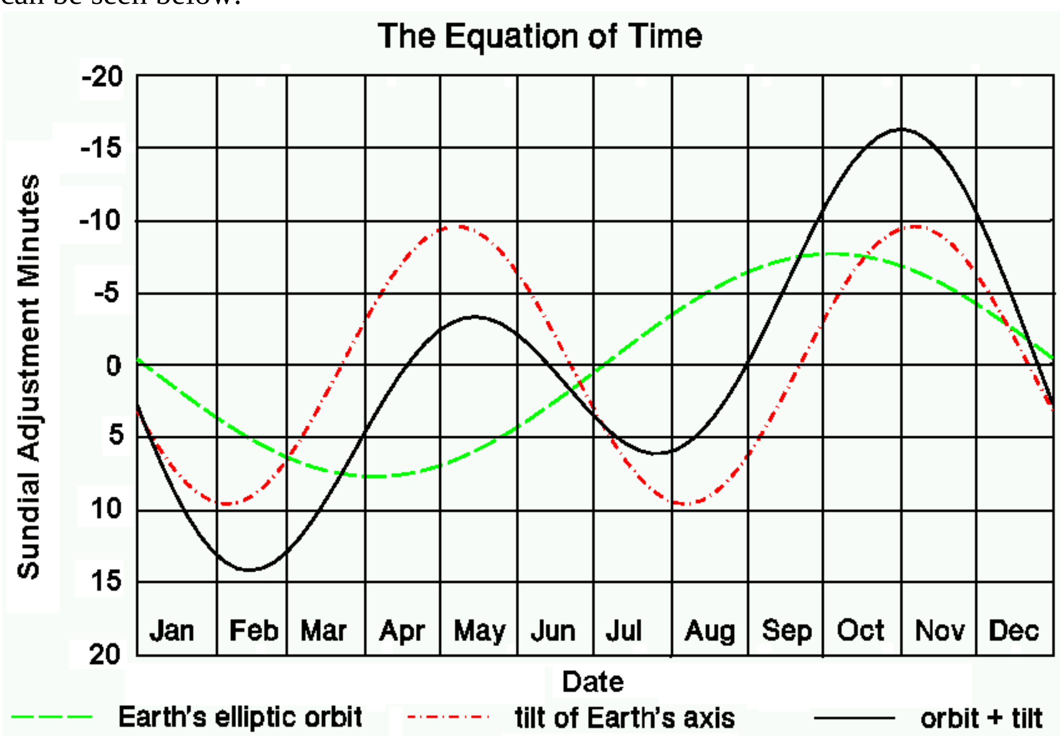




So at the Summer Solstice, at about 45°latitude, we have about 15 hours of daylight. At the Winter Solstice, 9 hours. And of course at the equinoxes an equal 12 hours of daylight and 12 hours of night.

EoT

The way these two natural eventsinteract, the tilt of the earth and the earth's orbit around the sun, yields the Equation of Time (Google "Equation of Time" for an orbital physics lesson). Its effects can be seen below.



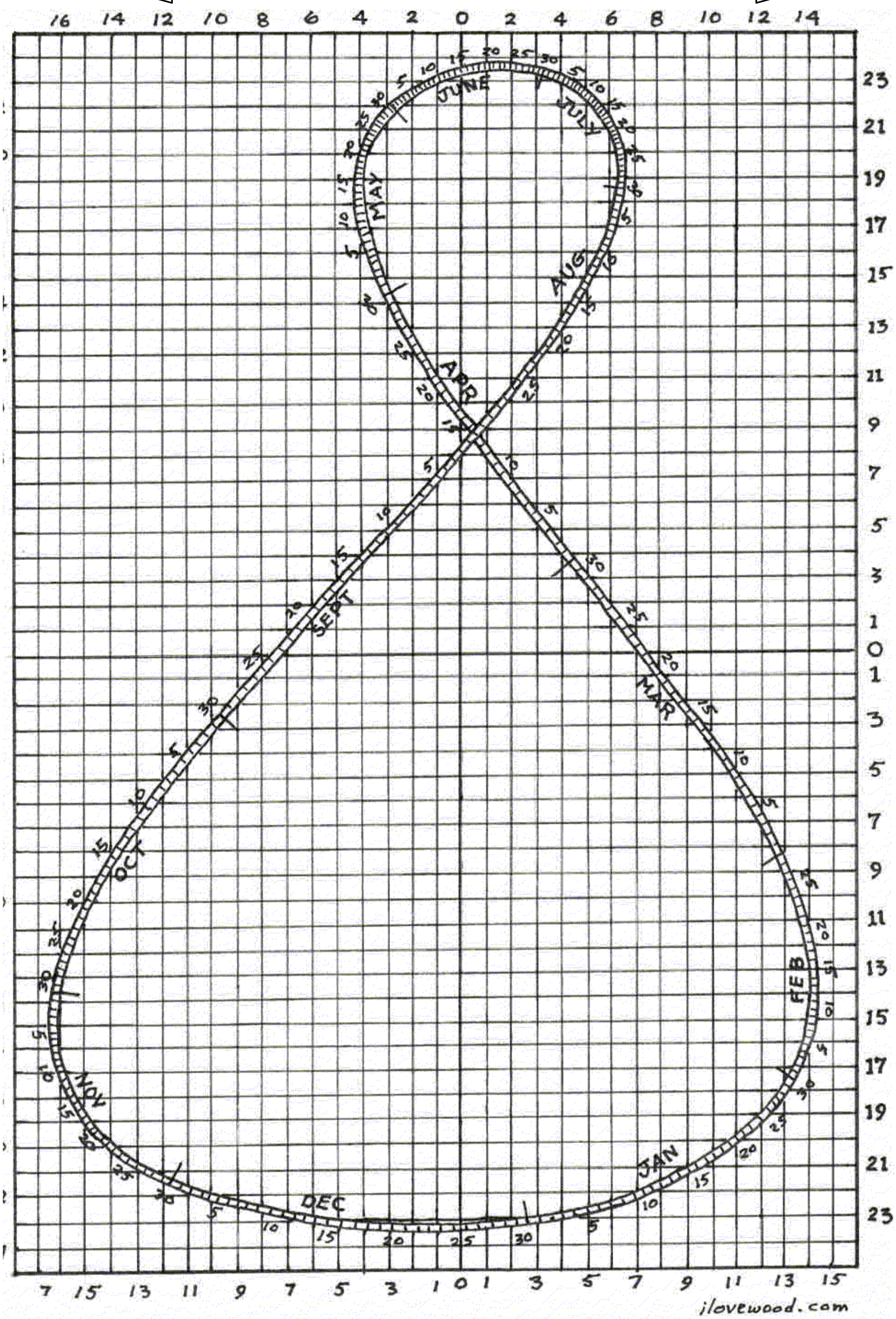
So on February 11th, your sundial will be about14 minutes slow (add 14 minutes to indicated sundial time) and on November 3rd, your sundial will be about 16 minutes fast (subtract 16 minutes from indicated sundial time).

See the next page for an easier to use Equation of Time, called an analemma.

Analemma

(Equation of Time)

Subtract from apparent time | Add to apparent time



Unequal Hours

Prior to the advent of mechanical clocks, our day had 12 hours of daylight, every day, regardless of the season. A common sundial at the time was the “Saxon Sundial.” These were often found on church walls throughout England. Everyday at sunrise and sunset a rod protruding from the wall would cast a shadow directly alongthe horizontal line. Everyday at noon, when the sun is at its highest point in the sky, the same rod would cast a shadow directly alongthe vertical line. These are what are referred to as local apparent times.

For the church, the lines relate to the canonical hours of prayer, Prime, Terce, Sext, None, Vespers, Compline and Matins. These were originally intended to be said at the first hour of the day, then at the third, sixth, ninth and eleventh hours, with Compline after dark and Matins just before dawn.

A sundial of this type is said to have “unequal” or “seasonal” hours. The 1st hour was sunrise, the sixth hour was “noon” and the 12th hour was sunset. At the equinoxes there is 12 hours of daylight so an hourwould be 60 minutes long, as per modern time. But at the Summer Solstice we have about 15 hours of daylight (45 degrees latitude) and at the Winter Solstice, 9 hours. So for the sun’s shadow to move one hour line on a Saxon Sundial it would take 48 minutes of clock time in the summer and 90 minutes in the winter. (Hence, when mechanical clocks appeared, they used “equal” hours).

An imaginary line drawn from the ground through each day’s local apparent noon is called the meridian (see top of page 4). It is morning when the sun is rising up to the meridian and it is afternoon when the sun is sinking past the meridian. In Latin, before the meridian is called ante meridiem (or a.m.) and after the meridian it is called post meridiem (or p.m.).

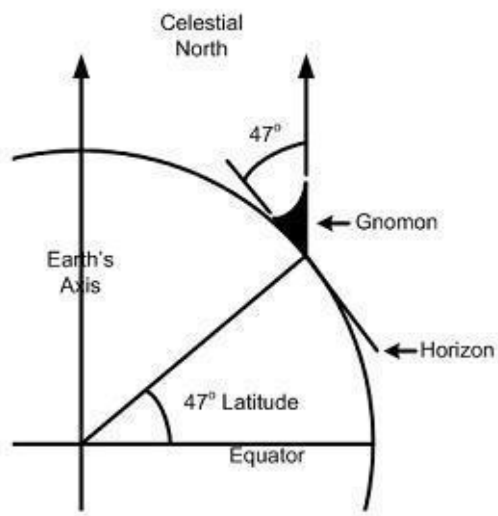
**7th century Saxon Sundial in the porch at Bishopstone in Sussex. It is inscribed with the name Eadric, King of Kent in 685. From: Wall, J. Charles (1912), Porches &Fonts.Pub. London: Wells, Gardner, Darton & Co., Ltd., p. 67.*

Cartography (and just a smidge of math)

LATITUDE - If you want your permanently mounted garden sundial to be clock-accurate, you must install it properly for your latitude. The gnomon of your garden sundial must be parallel to the north celestial pole (essentially pointing at Polaris; the North Star).

> *The gnomon is the part of a sundial that casts the shadow. Gnomon is an ancient Greek word meaning "pointing thing" (actually it means "indicator").*

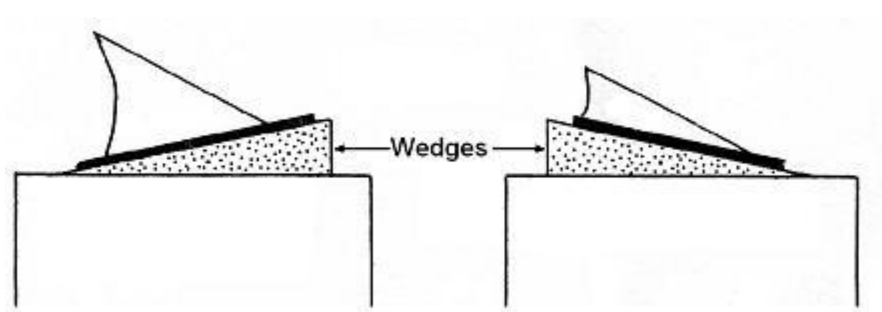
Gnomonic sundials, to be accurate, must be set at your latitude.



Most sundials that you buy at your local garden center are set at 40° latitude, which happens to run right through the center of the United States. It'll work just fine if you live in Dayton, OH, but if you set it up in Seattle, WA, it won't be accurate.

> *Sundials bought in Great Britain are set at 52.5° north latitude, which runs right through the middle of England and Ireland. Get a protractor and measure the angle of your gnomon. It should measure 40° for an American dial and 52.5°for a British dial.*

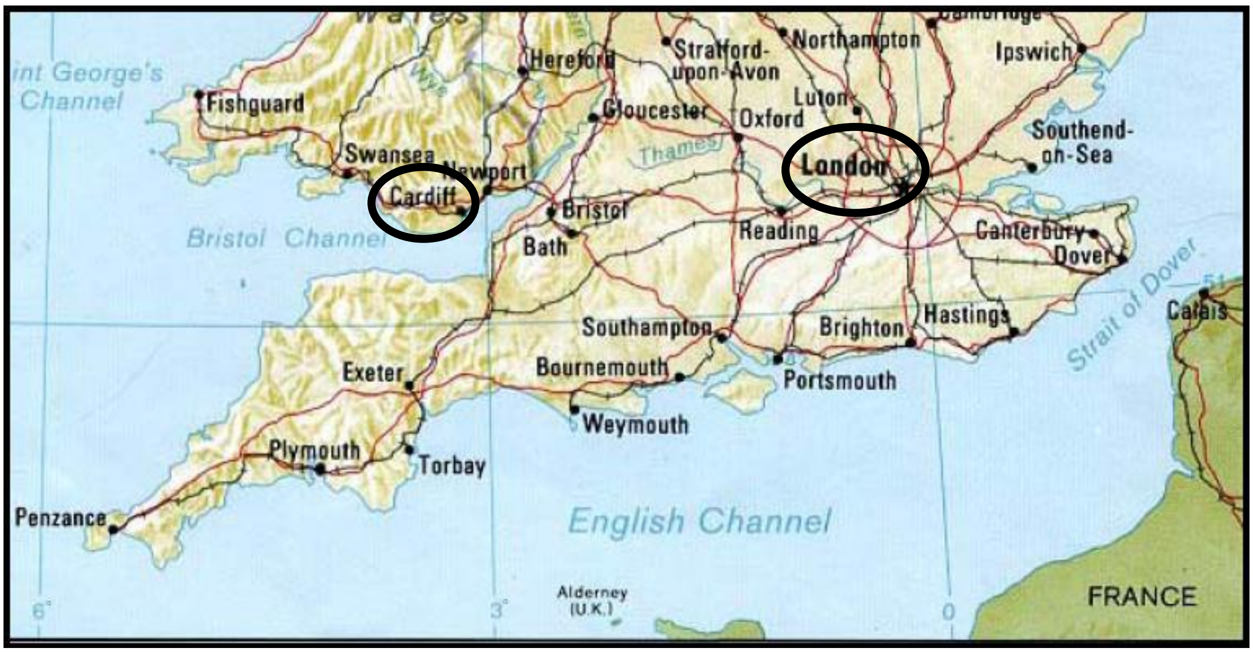
If you live inSeattle, you live near 47° north latitude, so you'll need to add a wedge to your garden sundial to tilt it 7°higher (or 5.5°lower if you have a British sundial).



LONGITUDE - There is an19th century phenomena we must account for known as time zones. There are 24 main time zones around the world centered around a longitude line of a multiple of 15 degrees (Zero degrees for Greenwich Time. 75 degrees for Eastern Time. 105 degrees for Mountain Time).

Sundials are accurate only when they are located EXACTLY on the line of longitude associated with a particular time zone. On a longitude line, local apparent noon is 12 o'clock.There are 24 hours in a day and our spherical earth is divided into 360 degrees of longitude. There are 60 minutes in an hour, so a 24 hour day has 1440 minutes. This means it takes the sun 4 minutes to move one degree of longitude. Therefore we must subtract or add four minutes of clock time for each degree our sundial is east or west of that time zone's associated line of longitude in order for noon on our sundial to match our clock.

All of the British Isles are included in the Greenwich Time Zone and the Greenwich Prime Meridian (Zero Longitude) is very near London. On page 2 it was noted that a portable clock set in London did not match the time in Cardiff, Wales. Since Cardiff is located 3 degrees west of London, 12 minutes must be added to the sundial to get the correct clock time.



When the British Isles shift to British Summer Time another hour must be added to the sundial to get the correct clock time.

<u>Mathematics</u>

If we wanted to we could use the actual equation of time to account for the earth's orbit and the earth's tilt.

$$\Delta t = \frac{M + \lambda_p - \alpha}{\omega_E}$$

Fortunately we can use the analemma (page5).

If you were designing your own garden sundial, you would need to use this equation. But we'll save that for the graduate level class.

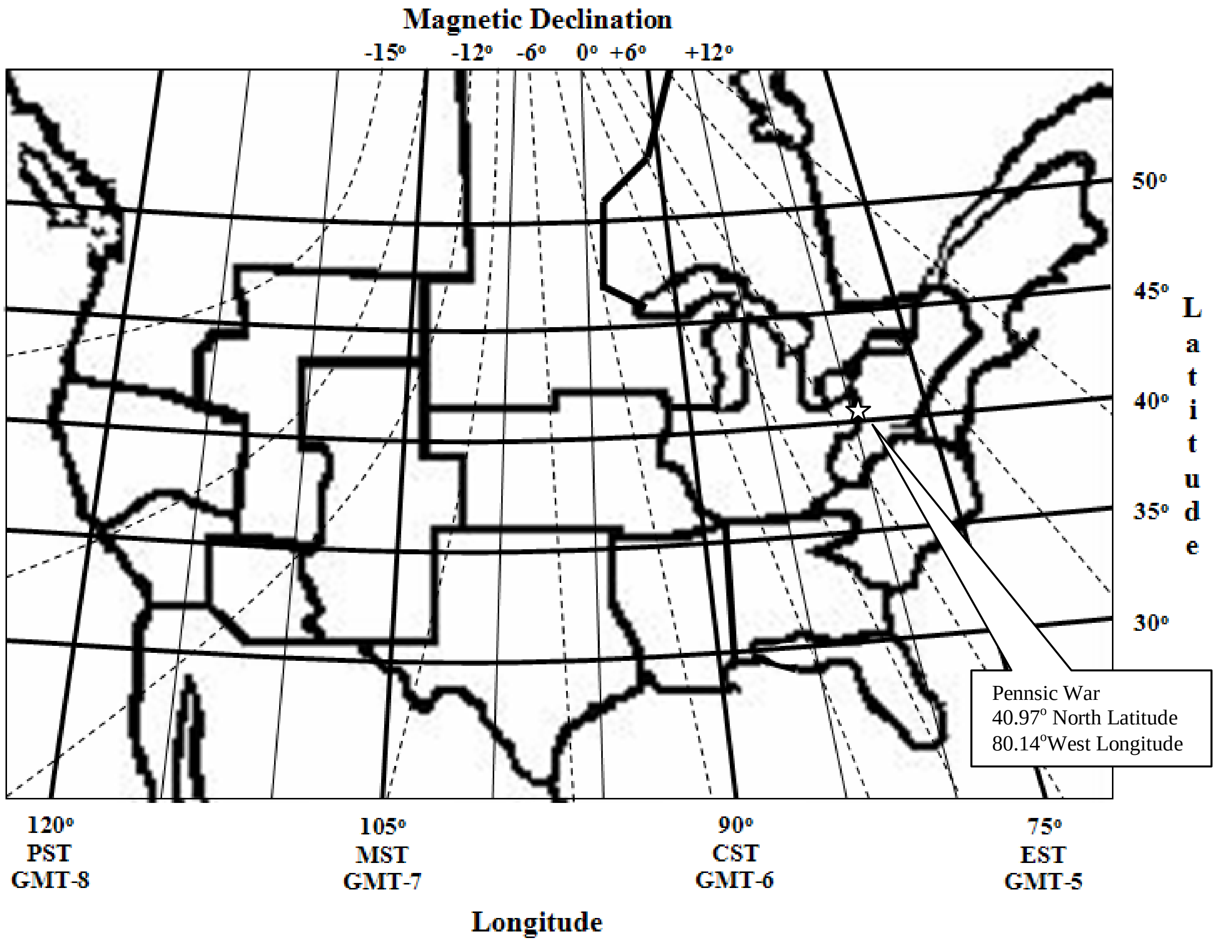
$$\tan\theta = \sin\lambda\tan(15^\circ \times t)$$

So in summary, to read clock time off of a sundial, you must:

- Add for Daylight Saving Time, if applicable
- Add/subtract for deviation from standard time zone meridian (4 minutes/degree)
- Add/subtract for equation of time (see analemma)

QUIZ TIME!

Here at Pennsic it's late July / early August and we're on Eastern Daylight Time. Pennsic is located at approximately 80 degrees longitude (5 degrees west of 75 degrees longitude). How many hours and / or minutes do you need to add or subtract to the time indicated on your sundial?



For the Pennsic War

- Add 1 hour (Eastern Daylight Saving Time)
- Add 20 minutes (80 ^{o} longitude. 4 minutes/degree. 5 degrees west of EST)
- Add 6 minutes (Equation of time for July30th)

Total correction to local apparent time = + 1 hour 26 minutes

Telling Time by Day

Did you know you could tell the time by pacing off the length of your shadow? It worked for Geoffrey Chaucer around 1400 CE. From the Canterbury Tales "Parson's Prologue" he relates, "***It was four o'clock according to my guess / Since eleven feet, a little more or less / My shadow at the time did fall / Considering that I myself am six feet tall***." Seems pretty straight forward doesn't it? All you need to know is how many paces your shadow is long, at different times of the day. However, in Chaucer's "Man of Law's Tale" he states, ***"…the shadow of each tree / had reached a length of the same quantity / As was the body which had cast the shade; / and on this basis he conclusion made: / …for that day, and in that latitude, / The time was ten o'clock…***" Did you notice that he says something about "that day" and "that latitude"? They knew then that there was more daylight in the summer than in the winter and correspondingly the sun travels higher in the sky in the summer than in the winter and also correspondingly your shadow will be shorter in the summer andlonger in the winter. Even the Venerable Bede knew this around 700 CE when he related the following information (citing "unequal" hours).

Length of one's shadow in "feet" for various hours of the day at various times of the year

Hour of the day	Jan / Dec	Feb / Nov	Mar / Oct	Apr / Sep	May / Aug	Jun / Jul
1 or 11	29	27	25	23	21	19
2 or 10	19	17	15	13	11	9
3 or 9	17	15	13	11	9	4
4 or 8	15	13	11	9	7	5
5 or 7	13	11	9	7	5	3
6	11	9	7	5	3	1

If you want be able to tell time by the length of your shadow use the table to the right. At the corresponding times pace off your shadow and enter the value into the appropriate box. Pacing off your shadow using the heel to toe method will yield the best accuracy (assuming you wear the same pair of shoes every day). See next page to make a Pennsic chart.

Paces	Time
	7 am
	8 am
	9 am
	10 am
	11 am
	12 noon
	1 pm
	2 pm
	3 pm
	4 pm
	5 pm
	6 pm
	7 pm
	8 pm

QUIZ TIME!

At Pennsic, when will your shadow be shortest? 12 noon? Noooo! Your shadow will be shortest at 1:26pm. Haven't you been paying attention?

If you want to have tables like this for other SCA events you'll need to create one for each event. Also, remember that each event will have its own adjustment for longitude, Daylight Saving Time and the Equation of Time. Adding 1 hour, 26 minutes only works for Pennsic.

**The Chaucer and Bede references were extracted from "Sundials: Their Theory and Construction" by Albert Waugh. I highly recommend this book for beginning sundialers.*

Pennsic Shadow Clock

(Where your feet become hands)

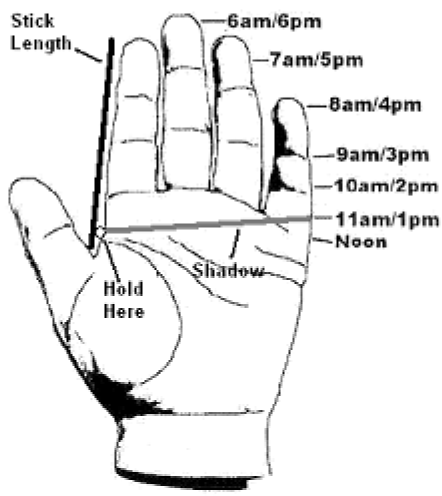
Max's Feets	Time			My feets
3.25	1:00 pm	or	1:30 pm	
3.50	12:30 pm	or	2:00 pm	
3.75			2:30 pm	
4.00	12:00 pm			
4.25			3:00 pm	
4.75	11:30 am			
5.00			3:30 pm	
5.50	11:00 am			
6.00			4:00 pm	
6.50	10:30 am			
7.00			4:30 pm	
8.00	10:00 am			
8.50			5:00 pm	
10.00	9:30 am			
10.50			5:30 pm	
12.50	9:00 am			
13.25			6:00 pm	
16.00	8:30 am			
17.50			6:30 pm	
22.50	8:00 am			
25.00			7:00 pm	
35.25	7:30 am			
42.00			7:30 pm	
77.00	7:00 am			

Another method for daytime time telling

J. Prevost relates in his 1584 book “Clever and Pleasant Inventions, Part One” an interesting way to use a shadow’s length to find the time. He writes,

> ***“… place the wrist of your left hand to point towards the sun; that is to say, turn your back to the sun and hold your hand and its fingers stretched out fully, so that the rays of the sun strike your wrist from behind. Then take a straw or a small peeled stick (to serve as an indicator) of the length there is from the root of the thumb to the tip of the index finger. Hold it by one end, between the thumb and the mount of the index finger, at the beginning of the life line.”***

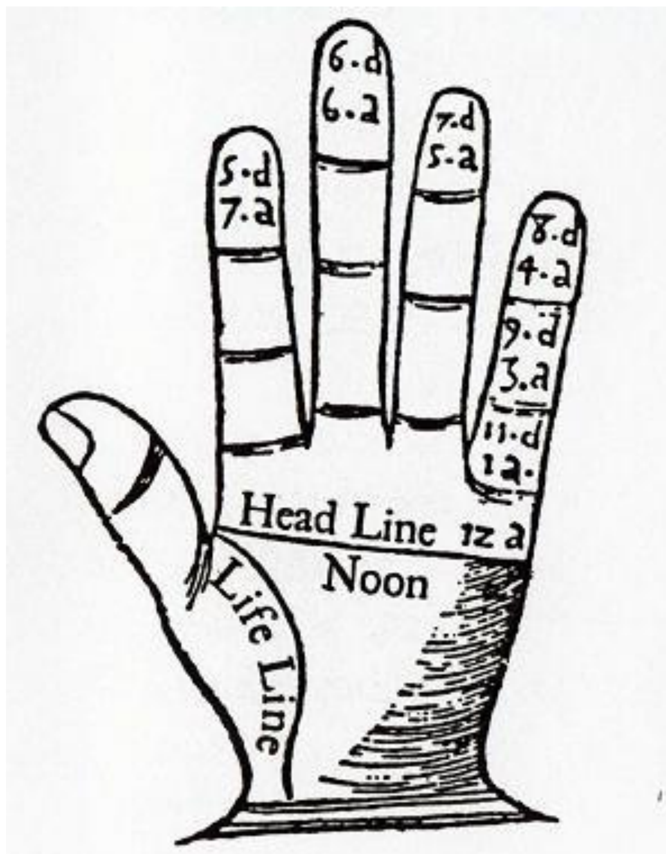
He continues on in quite a verbose manner (see next page), but this illustration sums it up nicely



Get a stick that is at least as long as your index finger. Hold the stick straight up and down, perpendicular to your hand,with your thumb knuckle. Remember a shadow is shortest at local apparent noon and is progressively longer each hour before and after local apparent noon. The shortest dimension on your hand sundial is the width of your hand, so this point is local apparent noon (You’ll have to adjust the height of your stick from summer to winter since winter’s shadows are longer). Throughout the course of the day, turn your body until the top of the shadow falls on some point along the edge of your hand and “read” the time according to the illustration. Don’t forget to add or subtract for modern influences. With a bit of practice you should be able to tell time to within 15 minutes between 6 am and 6 pm local apparent time (outside of those times the shadow is too long for your hand).

**I’m not convinced J. Prevost’s method works exactly as he relates it. My interpretation; based on his method; does. See the next page for the full description.*

Because one does not always have a clock or a watch or sundial, here is a most ingenious method to serve you on the spot, by using the hand instead of a watch. Thus, during the spring and summer, place the wrist of your left hand to point towards the sun; that is to say, turn your back to the sun and hold your hand and its fingers stretched out fully, so that the rays of the sun strike your wrist from behind. Then take a straw or small peeled stick (to serve as an indicator) of the length there is from the root of the thumb to the tip of the index finger. Hold it by one end, between the thumb and the mount of the index finger, at the beginning of the life line. Keep it pressed with the thumb straight out and held low, so that the stick passes beyond the palm of the hand, with as much projecting, or the same length, as the index finger to its tip. If you wish to use this device, having first placed and positioned the stick as described, without letting it shift from one side to another, make it so that the shadow of the thickness of the thumb, that is to say the base of the thumb, touches the life line. Then lift the straw or stick little by little (taking care not to change the position of your body) until the very tip of the stick will show you what hour it shall be, according to how you see it marked in the drawing of the hand here represented below, from five o'clock in the morning or forenoon, until noon, and immediately after noon, until seven o'clock in the evening. Note well that in our drawing the "d" denotes the hours before noon, and the "a" those after. Then the place where the shadow of the straw falls will show you the hour. However, I shall further explain it to you, so that you may understand it more easily. Five o'clock in the morning, that is, of the forenoon, s as you see on the first joint (marked 5d), near the end of the index finger. Six o'clock is at the outer joint of the middle finger; seven o'clock on the outer of the ring finger. Eight o'clock is on the end of the little finger; nine o'clock, on the joint beneath it; ten o'clock, on the one below that. Eleven o'clock is found on the mount of the same



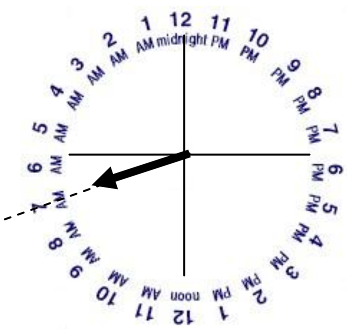
little finger; and twelve o'clock, that is noon, on the head line. Then, coming back up after noon, one o'clock in the afternoon (marked I.a) is found on the mount of the same little finger (which at the bottom indicated eleven o'clock in the morning).Two o'clock is now on the first joint of thesame little finger; three o'clock on the joint above; four o'clock on the top joint of the little finger. Five o'clock is on the outer joint of the ring finger. Six o'clock is on the end of the middle finger, and seven o'clock on the outer joint of the index finger, as you can see in the following drawing. There are those who use this natural sundial in winter and in autumn by turning the hand and body toward the sun in a different manner, but I have not yet tried this. We shall therefore content ourselves with using this method six months out of the year.

Page 21-22

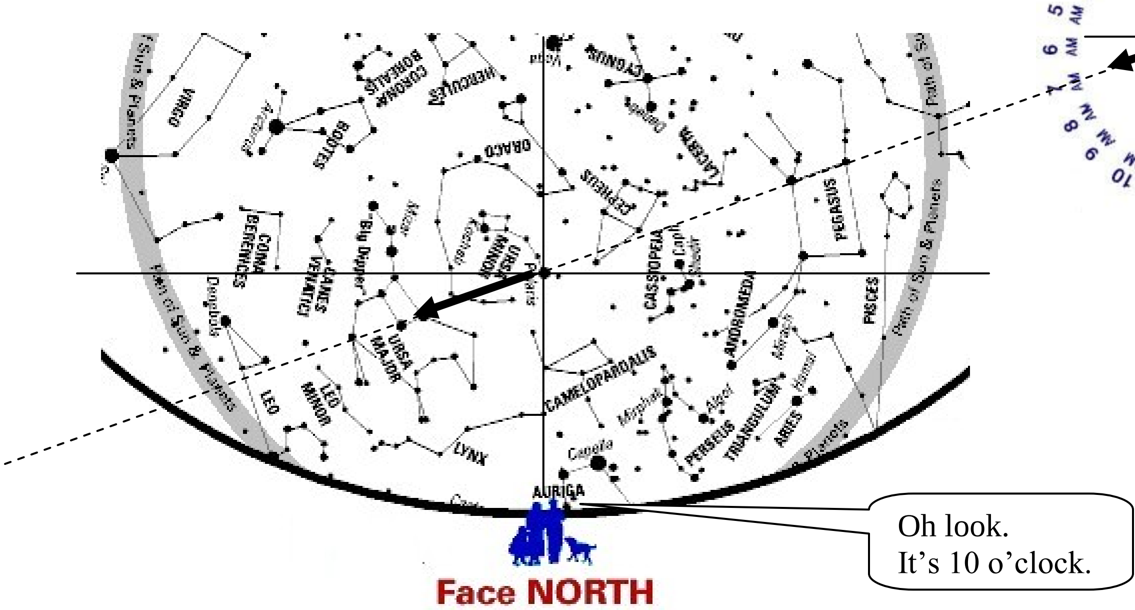
Telling Time byNight

Everyone knows how to find Polaris, the North Star, correct? (Everyone in the northern hemisphere at least). Did you also know you can use the position of Ursa Major, the Big Dipper, to tell time? And none of this mucking about with longitudes and the Equation of Time either. Where talking about a Galactic clock, not a mere solar clock. The nighttime sky is a great big, backwards running, 24-hour clock. You just need to learn how to read it.

- Find the Big Dipper and Polaris.
- Visualize Polaris at the center of a 24-hour, backwards running clock.
- The line running from Polaris to the Big Dipper is the hour hand
- Add/subtract for time of year
- Add for Daylight Saving Time



Pennsic Night Sky



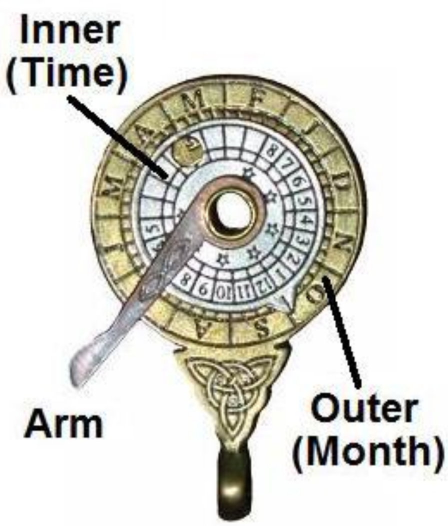
Nocturnal Clock Seasonal Adjustment (for the 10th day of each month)							
JAN 10	+4	APR 10	-2	JUL 10	-8	OCT 10	+10
FEB 10	+2	MAY 10	-4	AUG 10	-10	NOV 10	+8
MAR 10	+0	JUN 10	-6	SEP 10	+12	DEC 10	+6

So for Pennsic, subtract 9 hours (-10 for time of year, +1 for DST)

Using a Nocturnal

Beginning in the 15th century, one could determine the time at night thanks to an instrument known as a nocturnal (and a nocturnal cantell time accurately without having to use any math!) The “rotation” of the stars across the night sky is consistent and not significantly influenced by the orbit of the earth around the sun. The position of the stars relative to each other will always be the same on the same date each year independent of longitude. Your latitude only affects how high they are in the sky.

All nocturnals have three independently rotating parts. An outer ring, an inner ring and an indicator arm. The outer ring indicates the twelve months of the year. The inner ring has an indicator bump that allows you to set the nocturnal for the time of year (this is the seasonal adjustment from the previous page). The arm will indicate the time on the inner ring.



To use it:

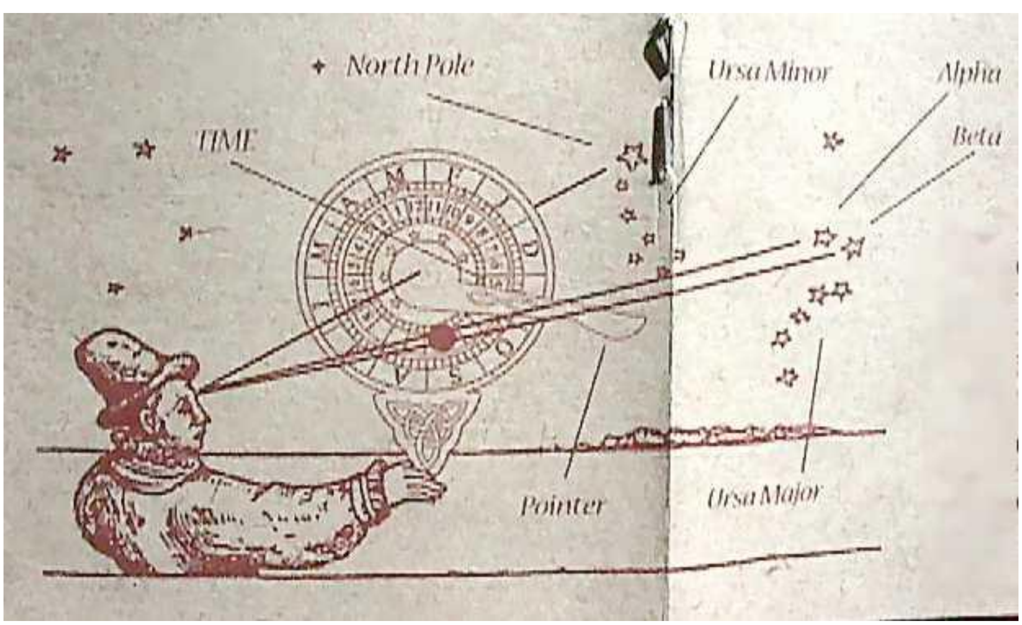
Set the bump of the inner ring to the appropriate date (October 1st in picture to the left).

Hold the dial by the handle with the front facing you.

Sight the North Star through the center hole.

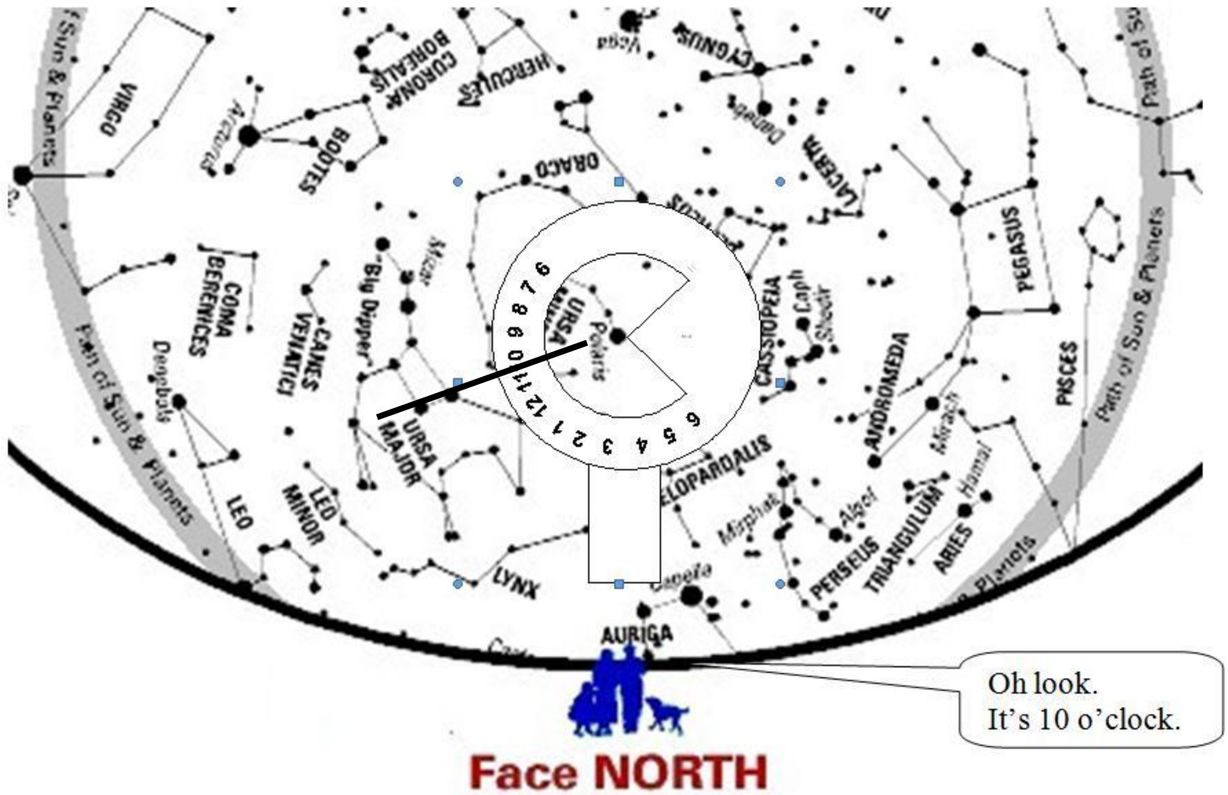
Move the dial's arm to align with the pointer stars of the Big Dipper.

Read the time on the inner dial where the arm crosses the hour mark (7:30 pm in picture below).

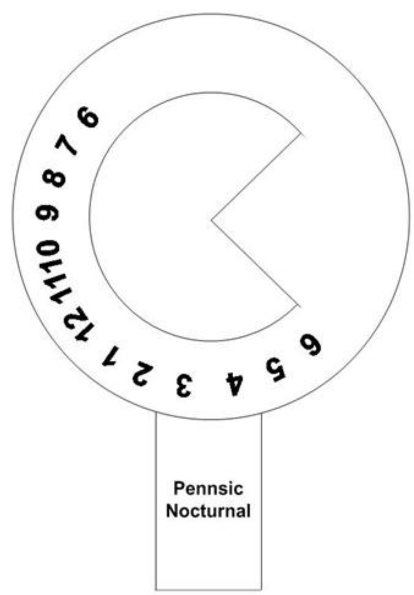


APennsicNocturnal

Hold it up. Read the time.



Cut out the center of the Pennsic Nocturnal (the Pac-man shaped piece). Hold the nocturnal by the handle. Hold it in front of your face so the tip of the center triangle points at Polaris and the Big Dipper is just inside of the hole. Visualize a line extending from Polaris to the lip of the Big Dipper (the reverse of finding the North Star). Extend the line onto the nocturnal and read the time directly. With some practice you should be able to tell time without having to use the nocturnal at all.



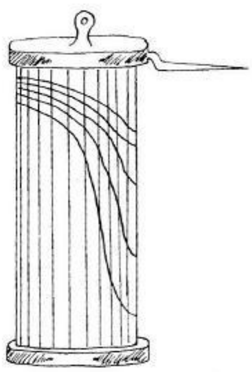
Now before you get to thinking that you now have a fool-proof way to determine the time at night all year around, read the handle of the nocturnal. It's only good during Pennsic, or, more generally at the end of July and beginning of August. But this nocturnal will work anywhere in the northern hemisphere during Pennsic, not just at Cooper's Lake.

Types of Sundials

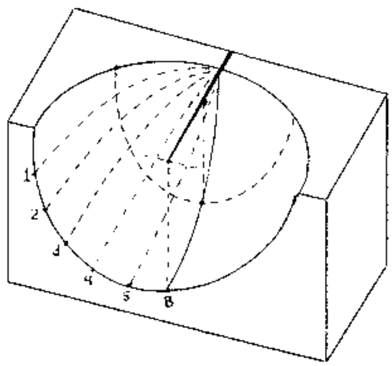
Sundials are divided into two main groups; altitude dials and azimuth dials. Altitude dials determine the time from the sun's altitude (the sun's height above the horizon) and azimuth dials determine the time from the hour angle of the sun (the sun's angle on its daily trip across the sky). All azimuth dials need to be aligned with polar north*. Most altitude dials do also, with the ring dial being the notable exception (see page 19).

**Polar north is not always magnetic north (see page 9 for magnetic declination).*

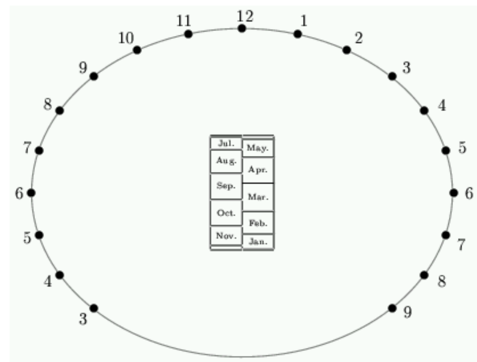
Altitude Dials



Cylindrical Dial



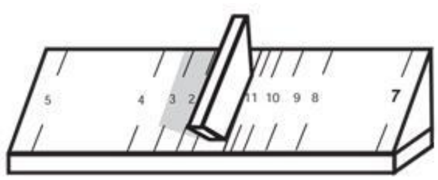
Conical Dial



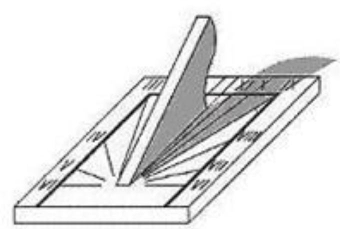
Analemmatic Dial
(See cover)

Azimuth dials

Equatorial (Universal) dial



Polar Dial



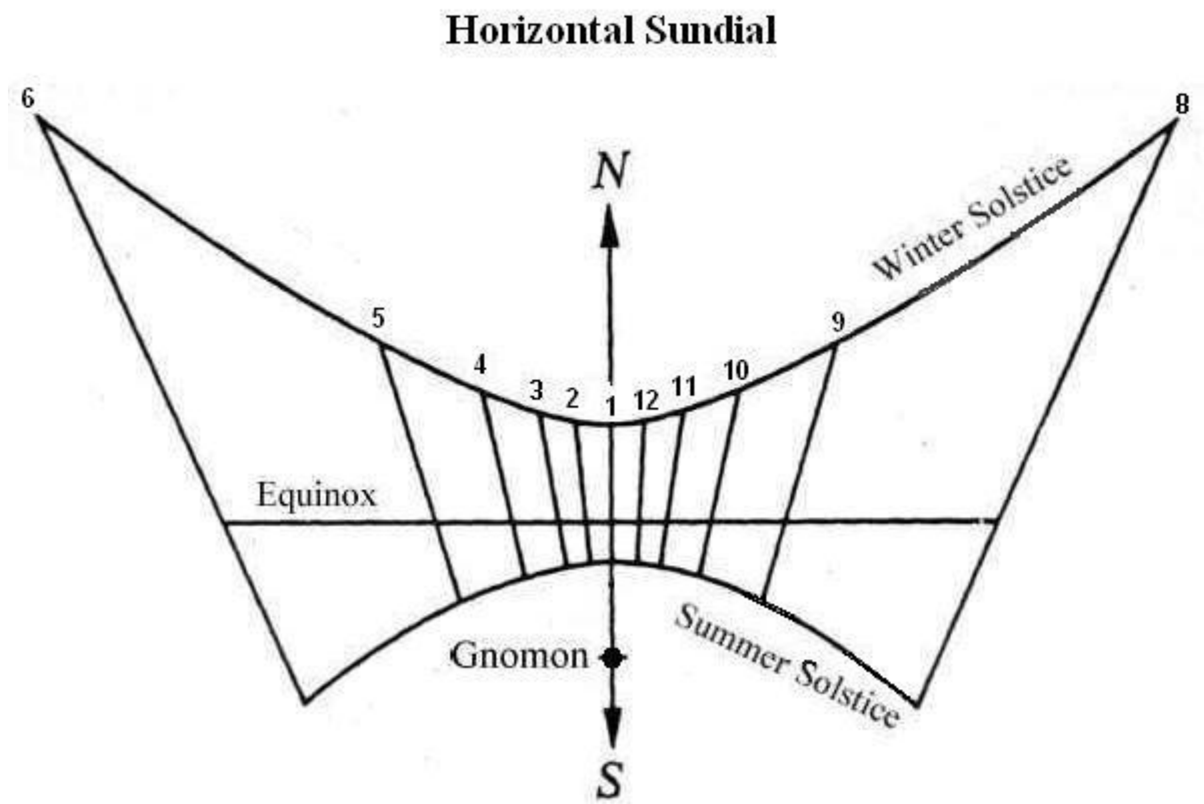
Horizontal Dial

On the cover of this document, I have provided you with a Pennsic Analemmatic Dial. It's a Pennsic dial because ithas the modern influences built into it. If you face due north (alongside I-79 this is real easy) you can determine the time by the position of your shadow. Directly in front of you means it's about 1:30 pm. Directly to your left means it about 7:30am. If it's about 45^o past solar noon (about 1:30 pm), then it's about 4:00pm. With a little bit of practice your should be able to determine the time during the day at Pennsic, without referring to thedial on the cover.

Analyzing a stationary altitude sundial

By now you have learned that in order to read clock time off your sundial you must compensate for your latitude, your location within your time zone, Daylight Saving Time, the Equation of Time andthe time of year. Incredibly enough, it is possible to build a stationary sundial from which you can read the time with reasonable accuracy.

Take a look at the horizontal sundial illustrated below. For this horizontal dial the gnomon is simply a vertical rod placed at the spot marked gnomon.

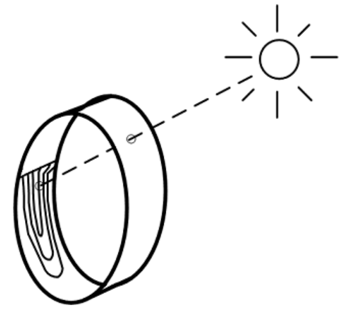


As the sun rises and sets from summer to winter, the top of the shadow of the gnomon would trace out the pattern see here. This butterfly shape compensates for the time of year. Notice that 12 o'clock is not on the N-S line where you would expect it to be. This compensates for longitudinal offset. Also, if like most people, you only use your sundial in the summer, shifting the numbers can also compensate for Daylight Saving Time. Referring to the analemma (Page 5), in May this dial is 4 minutes fast, in July it is 6 minutes slow, and in mid-September it is 4 minutes fast again. So this horizontal sundial is accurate to about 5 minutes of clock time during the summer.

Since the sun rises in the east, the gnomon's shadow starts to the left and works its way to the right. So now you know how clockwise became clockwise.

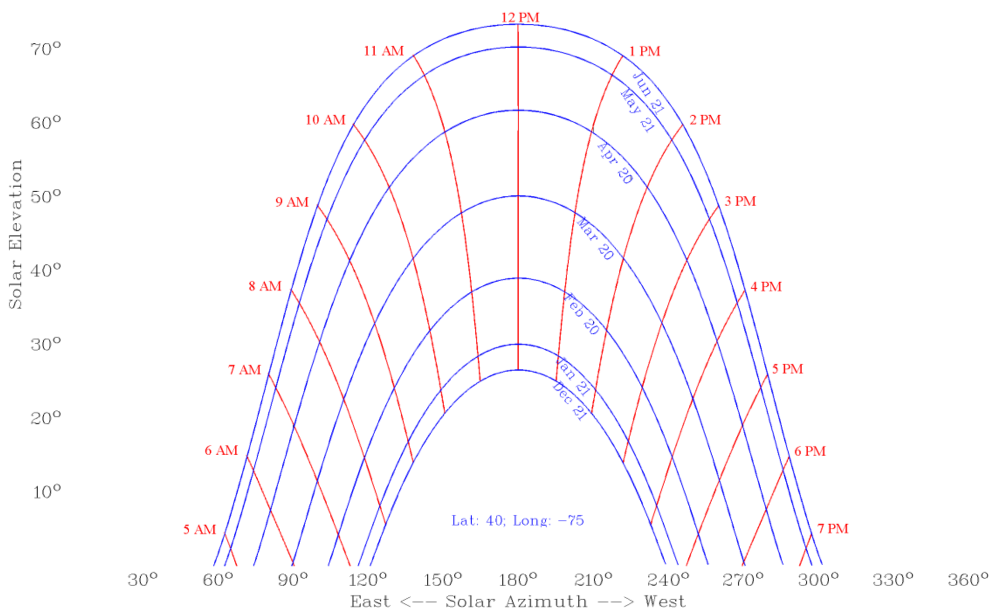
Eleanor didn't use no Aquitaine

> "In 1152, Eleanor of Aquitaine gave a sundial ring to Henry II so that he would know when to leave the hunt for their love trysts. Moved by her love, Henry ordered his jewelers to make a copy for Eleanor – inlaid with diamonds and engraved with the Latin words Carpe diem (seize the day). This ring is an adaptation of the one that Eleanor gave to Henry II."

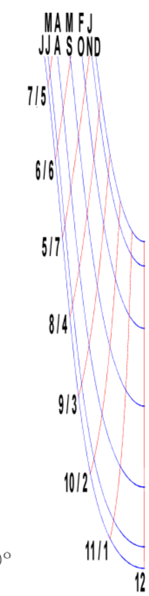


Just about every website that sells Aquitaines has some version of this story on their webpage. I, too, accepted this story as fact. But knowing what I know now about sundailing (and have hopefully coherently explained it to you) I began to question the stories accuracy.

The Aquitaine is a special form of ring dial. Ring dials are altitude dials thathave a small hole pierced in them that allow sunlight to filter through and cast an image on a scale displayed on the inside of the ring.

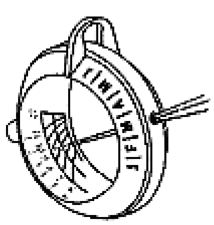


Local Solar Elevation versus Azimuth Graph



Ring Dial Graph

As the sun passes through the sky like the chart on the left, the ring dial would indicate local apparent solar time on a graph similarto that on the right (then you must adapt for modern influences). Ring dials are typically designed for a single latitude.



The Aquitaine, on the other hand, has the hole pierced through a second, adjustable ring that allows you to set the hole to a specific date. The Aquitaines that you can buy today for about $30, although perfectly period (I've seen museum pieces from the 16th century) typically do not keep accurate time (nor do I think the museum pieces did).

I tried off and on for several years trying to get my Aquitaine to keep accurate time. Heck, it worked or Henry and Eleanor, and I know how to adapt for modern influences, why can't I get it to read clock time?

On a ring dialthe number 12 is near the bottom of the dial. The sun is highest at this time, so the sun will shine a spot on the lowest point inside the dial. One hour before and one hour after noon, the sun's relative angle is the same; hence 1 & 11 are the same. Two hours before and after noon, 2 & 10 are the same. Et cetera. (See J. Provost's hand – page 12& 13).

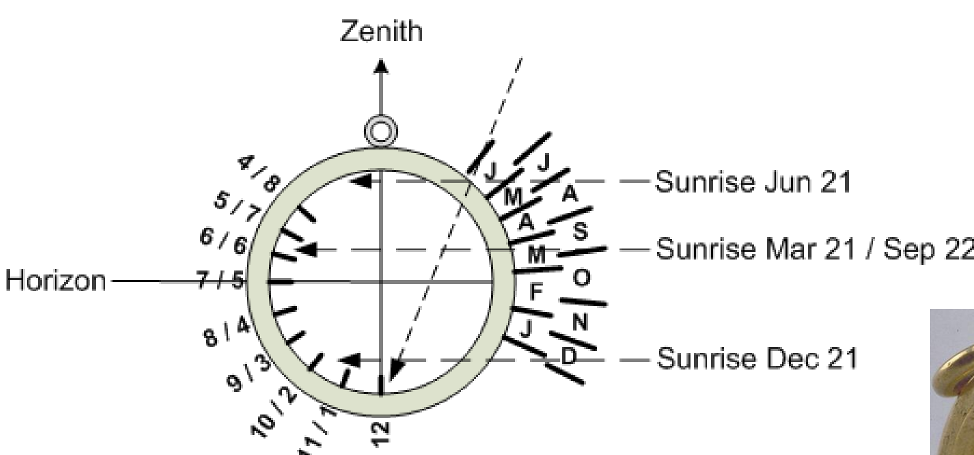
> *But, Henry and Eleanor lived in the 13th century, before mechanical clocks and before equal hours were prevalent. For them, sunrise was the first hour of the day, noon was the 6^{th} hour and sunset was the 12^{th} hour. So the 6 should be at the bottom of the dial. Never mind, the ring dial is an "adaptation" of the one Eleanor gave to Henry.*
>
> *But, also, summers have more daylight hours then winter, so how could one scale work for all the seasons? Oh wait, that's why there's that second, adjustable ring. That should solve it.*

So taking into account all we've learned, let's analyze an Aquitaine.Sunrise is always parallel to the horizon. Turn the ring so the hole is on March21^{st} / September 22^{nd} (it should be the same place on the dial because those are the equinoxes). Looking at side of the Aquitaine, drawn an imaginary line straight across from the hole, parallel to the horizon (I've graphed my Aquitaine below). It should align with the 6am / 6pm mark which is sunrise and sunset for everyone on earth for the equinox (So far, so good). But beyond these dates the dial geometry deteriorates. From the solar elevation chart on the previous page, sunrise on December 21^{st} is 7:15 am. Turn the hole to December 21^{st} and my Aquitaine reads 10 am.Sunrise on June 21^{st} is about 4:45 am. My Aquitaine is off the scale, maybe 3 am if I'm charitable.

For Solar Noonon June $21^{st}$the Aquitaine reads pretty close to 12. But if you set it to November, December, January or February,the hole is lower than the horizon line and it can't possibly shine a spot on the inside of the Aquitaine.

So since an Aquitaine gives the correct time at least three times a year I guess it's better than a broken watch, but not much better.

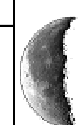
> *The analysis show here prompted me to research Eleanor of Aquitaine further. Nowhere in any of the five biographies I read about her did anyone mention that Eleanor gave Henry a sundial of any sort for any reason, let alone to schedule romantic rendezvous. So what we have is a Medieval Urban Legend.*



Pennsic Planetary Events

(Pennsic Local Times)

		Sunrise	"Noon"	Sunset	Moonrise	Transit	Moonset	Moonrise
Wed	Jul 29	6:14 AM	1:26 PM	8:38 PM	-	-	4:20 AM	7:03 PM
Thurs	Jul 30	6:15 AM	1:26 PM	8:37 PM	-	12:12 AM	5:23 AM	7:53 PM
Fri	Jul 31	6:16 AM	1:26 PM	8:36 PM	-	1:09 AM	6:30 AM	8:38 PM
Sat	Aug 1	6:17 AM	1:26 PM	8:35 PM	-	2:06 AM	7:41 AM	9:20 PM
Sun	Aug 2	6:18 AM	1:26 PM	8:34 PM	-	3:02 AM	8:53 AM	9:59 PM
Mon	Aug 3	6:19 AM	1:26 PM	8:32 PM	-	3:57 AM	10:04 AM	10:36 PM
Tue	Aug 4	6:20 AM	1:26 PM	8:31 PM	-	4:51 AM	11:15 AM	11:13 PM
Wed	Aug 5	6:21 AM	1:26 PM	8:30 PM	-	5:44 AM	12:24 PM	11:51 PM
Thurs	Aug 6	6:22 AM	1:26 PM	8:29 PM	-	6:37 AM	1:32 PM	-
Fri	Aug 7	6:23 AM	1:26 PM	8:28 PM	12:30 AM	7:31 AM	2:37 PM	-
Sat	Aug 8	6:24 AM	1:25 PM	8:27 PM	1:13 AM	8:24 AM	3:39 PM	-



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Sundials - Their Theory and Construction
Albert E. Waugh, Dover Books, 1973, ISBN 0-486-22947-5
http://store.doverpublications.com/0486229475.html, $9.95

Clear and Pleasant Inventions, Part One
J. Prevost (1584 - France)

Useful Websites

Mine
http://www.michiganleftturn.org/

Scientific Instruments of Medieval and Renaissance Europe
http://www.mhs.ox.ac.uk/epact/

For sun and moon positions:

http://www.timeanddate.com/worldclock/sunrise.html

For star charts:

http://skymaps.com/

For lots of sundialing links:

http://sundials.org/

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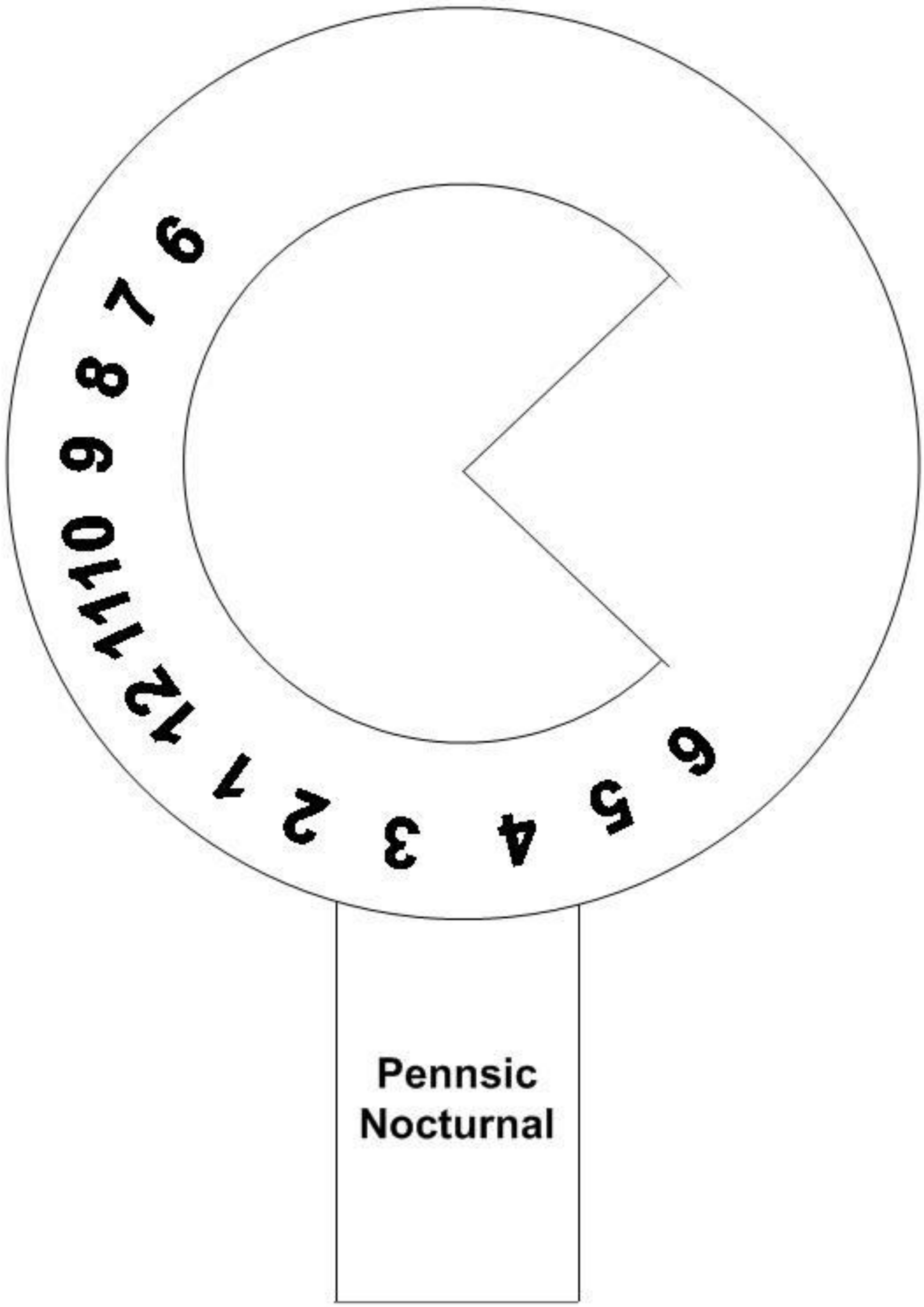
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2015 Changes

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