

## ***BACK TO BASICS***

A new column by Claude Hartman - A column for the novice written by a novice

I continue to look for the simplest answers and clearest examples, with as little mathematics as possible.

My thanks to those who have dropped me some ideas. Richard Hill noted that if you have difficulty getting the time on the Internet, the Association of Lunar & Planetary Observers' web site has USNO time that pops up for 20 sec. when you first log on at: <http://www.lpl.arizona.edu/alpo>. To get another 20 sec. just hit refresh.

One person noted that calculators might have problems or errors with trigonometric functions. *What issues or difficulties have you had with that?* I will be reviewing computing in June.

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Here is the proposed list for future discussions. If any of you have ideas on these questions, please drop me a line:

June: Drawing dials - simple ways to compute.

Can we merely treat trigonometric formulas as a "button on a cheap calculator"? Can you "compute" the EOT? I have a note from someone who can do this with simple arithmetic and the newspaper!

September: Construction - setting up, adjusting, materials, methods.

How do you make a correcting wedge for both Latitude and longitude? The latitude is easy, what about longitude? Are there any easier, less calculating ways than those in Compendium 7-2? I think I have one but it seems complicated to set up rotating about the polar axis. Is it worth it? Have any of you actually done this?

December: Other questions - got one?

This issue's article

So far, I am following my plan to review the basics each year. If I have missed one of your favorites, let me know. This month I review what to look for on good sundials.

### *Looking at Sundials*

You see a beautiful sundial. Is it a good one? Here are some thoughts on evaluating a sundial.

Mayall and Mayall had a number of comments about selecting a sundial in chapter IV, "Selecting the Dial to Make or Buy: Guidelines and Materials". The most immediate item is, how sturdy and "well made" is it. After that, how can you tell if it is "correctly" made?

The NASS web site has a section called FAQ, **Frequently Asked Questions**. Unfortunately, evaluating or checking a sundial is not listed among these. It is found under number 3. "I have a sundial. How do I set it up?" Then under that question there is "Aligning a dial to True North". The first part of the linked page has a list of 4 things to check which I think are the most useful so I quote it here:

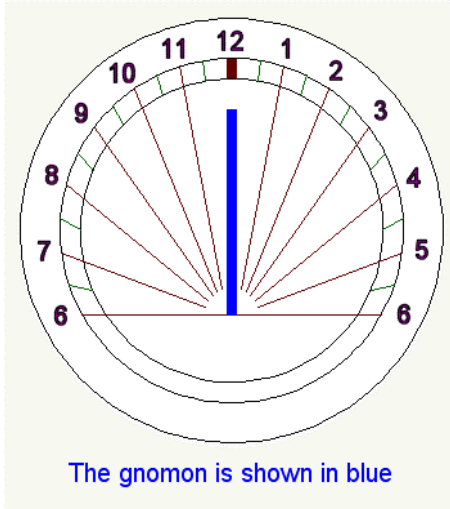
1. The high end of the gnomon should point directly to 12:00. If it doesn't, your commercial dial is incorrect.

If you have a handmade dial, it may include a longitude correction, in which case the gnomon will not point precisely to 12:00. Unless it is designed for your location, setting it up is beyond the scope of this FAQ.

2. If the dial includes 6:00 AM and 6:00 PM, they should be at the ends of a single straight line, which is at a right angle to the sub-style - the line where the gnomon meets the dial face. *And the line just touches this point (see the drawing).*

3. Since the gnomon must have a finite width, the indication for 12:00 must have an equivalent width.

Readers may remember the discussion of "Wide Gnomons" in the **December 2001** Compendium. From this it is obvious that the above discussion is limited to styles that are on the top of the gnomon and do not include hours before 6 AM or after 6 PM.



A sketch of a dial that meets conditions 1 through 3. Note that the straight line connecting 6am and 6pm also goes through the point that the gnomon penetrates the dial face

The FAQ continues . . .

4. If you want to test further . . .

Measure the style height - the vertical angle the gnomon makes with the dial face.

Measure the angle on the dial face between the sub-style and the 3:00 or 9:00 hourline. (These two angles should be the same.)

*This is true for all hours differing from noon the same amount: the dial should be symmetric about the noon line if horizontal or a direct South facing vertical.*

The sine of the style height should equal the tangent of the 3:00 hourline.

This trick can also be used to determine the style height, and hence the original latitude, for a dial that is missing its gnomon.

Now, that last "trick" would be good if I normally carried a scientific calculator and a protractor in my pocket. (Maybe we need a credit card sized protractor. See the end. ) However, when I see what looks like a good dial, I am not usually so prepared. So, I began to think, how can I make use of this trick and why does it work?

### Why does it work?

A very basic equation for hour lines is,

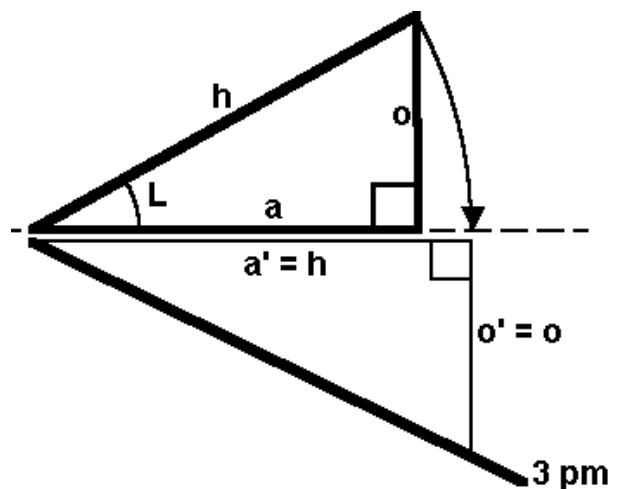
$$\tan(\text{angle of an hour line}) = \frac{\sin(\text{latitude}) \times \tan(\text{hour in degrees})}{1}$$

Since 15 degrees is one hour, 9 AM or 3 PM differ from noon by 3 x 15, or 45 degrees. Since the tangent of 45 degrees is exactly one, this equation at 9 AM or 3 PM becomes,

$$\tan(\text{angle of an hour line}) = \sin(\text{latitude}) \times 1.$$

### How can I easily use this?

I thought back at the meaning of sines and tangents in right triangles. The common horizontal dial's gnomon often looks like a little right triangle. Since the latitude angle is the angle such a gnomon would make, here was the answer!



A right triangle gnomon and the 3 PM hour line.

Remember that the sine of an angle is the ratio of the sides of a right triangle, opposite side  $o$  over the hypotenuse  $h$ , that is  $o/h$ . The tangent is the ratio of the opposite side over the adjacent,  $o/a$ .

In those terms, the hour line equation for a 3 PM line, would be,  $o/h = o'/a'$ .

This shows that the "trick" is that the lengths of the sides must be in the same ratio. If the adjacent side  $a'$ , the adjacent side in the right triangle for the hourline, is deliberately made equal to the length  $h$ , then the opposite sides must also be identical. This can be easily done as shown in the diagram.

Take something that can be stretched along the style of the gnomon - a string or a dollar bill. Take the length  $h$  of the style on the gnomon and lay it down along the foot of the gnomon. This is done in the drawing with a little separation to make it clear. Now we have made the adjacent side  $a'$  equal to  $h$ . If the sundial's 3 PM line is correct, the perpendicular distance from the end of this length  $o'$  must be equal to  $o$ .

There are a number of ways to measure first  $h$  then  $o$  and  $o'$ . Just remember "lay the style down" and take the perpendicular to 9 AM (or 3 PM).

Here is one way using a dollar bill. First lay it along the style and mark or hold where the end of the bill is on the style. Then stretch the bill vertically down to the dial face. The square end helps make it vertical to the surface. Mark it or hold that length on the bill as you then stretch it along the gnomon base (the sub style or 12 hour line). (If the bill is crisp, creasing it on the style will "mark" it.) At the end, stretch it out perpendicular (square end) to the base of the gnomon. Does the 9 AM or 3 PM hour line cross at the same distance as the one you are holding (or marked)? Also check the other hour line, 3 PM or 9 AM. Both lines should have the same angle.

If it is the correct distance we have at least found that the sundial has been correctly drawn for whatever latitude the angle of the gnomon may be. Most sundials can be corrected if that angle is not the desired latitude angle. In September I will review the making of such correcting wedges.

This trick can be used on any direct facing vertical sundial as well as horizontal dials. (Remember that a direct vertical dial is just a horizontal dial drawn for 90 degrees from the latitude.) Unfortunately it would not work for a declining dial.

Of course this only checks two lines, what about the rest of the dial? If you pack around a dialing rule you could check all the lines on the spot!

### *Additional Things for a Closer Look*

If the above inspection seems to make it a "valid" sundial, what else might be examined? Patrick Powers sent me some notes on what he has looked for in his years as the British Sundial Society Registrar. Here are his comments that are in addition to what has already been said.

*My first check on seeing a dial is always to see if I can 'sight' across the gnomon and see if its two styles align with the hour lines – do the hour lines when extended arrive at the correct point. Sometimes you can spot a dial with an incorrectly made replacement gnomon this way or one where the gnomon was wrongly placed in the first place.*

*Some good painted dials - especially ones that may have been repainted many times over several centuries may be 'good' but suffer from creep where the painters have not always followed the same lines as before. The famous Queen's College Dial at Cambridge is a case in point here.*

In general, he advises that for one to spot the "fake" but well-made dial . . . "The best way to recognize them is probably to build up a knowledge of the dials that this firm made." A photograph or a "rubbing" would aid in researching this.

Finally, for a dial that has been installed, does it read the correct time? For this you need the Equation of Time, or EOT. Considering this need, there is a Word document (included with the digital issue of *The Compendium*) that prints 2 credit card sized abbreviated EOTs on a 4" by 6" card. The second page places a protractor on the back of the card. Cut along the outline of the EOT chart for a 2" by 3" credit card size. If the margin alignments have not been changed, the protractor should be aligned on the opposite side. With luck you can make your own *Sundial Inspector's Card!*

Keep in mind that even a poorly made or badly aligned dial may read correctly at some times of the year!

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