Sundial projects for you to make

http://www.sundials.co.uk/projects.htm

Project One - An Equatorial Sundial

For this project, you will need:

- a piece of card slightly wider than the protractor and say 25cm (10 in.) long
- a drinking straw or knitting needle
- a protractor

1. Draw lines across the card dividing the length into sections of 1, 10, 14, and 1 cm. (The length of 14 is alright for latitudes of 50 deg. or more, but if you live at a lower latitude, you will need to make this length longer) We'll call these lines A, B,and C. Mark the centre point O of line A, and the centre point P of line C. Draw a line OP connecting the two centre points.
2. Place the centre of the protractor on O and draw round it. Make a pin hole through O, turn the card over, and place the centre of the protractor on the pin hole. Draw round the protractor again so you have two semicircles back to back
3. Mark 15 degree intervals and number the hours as shown, on both semi-circles.
4. Score and fold the card along the lines A, B, and C
5. Enlarge the pin hole at O and push the straw through. Make sure the straw is at 90 deg. to the card around O.
6. Move the bottom end of the straw along the line OP until the angle it makes with the horizontal is the same as the latitude of the place where you are (this is about 30 deg. for Perth and for New Orleans, 45 deg for Bordeaux and for Minneapolis, 51.5 deg. for London, and 55 deg for Edinburgh)

   You may find it easier to calculate the correct angle, and mark off the correct length along the straw. The correct length is 10 x (cotangent of the latitude). In the examples above, the correct lengths would be 17.3 cm. for Perth or for New Orleans, 10 cm for Bordeaux and for Minneapolis, 8 cm for London, and 6.9 cm for Edinburgh

7. When you've found the correct location for the bottom end of the straw, bend up a tab as shown in the diagram, or put a pin through from the other side to hold the straw in the right place

8. The straw forms the gnomon. The shadow of the gnomon will fall on the hour lines on the top of the dial in summer, and on the underside in winter.
9. You can colour your dial and write a motto such as "AIM HIGHER THAN THE MARK" underneath.

You now have a working equatorial sundial. The dial plate, with the 15 degree angles marked on it, is parallel to the equator, and the straw forming the gnomon is parallel to the earth's axis. The sun appears to revolve round the earth's axis at 360 deg. every day, which is 15 deg. every hour (which is why you marked out your hour lines at 15 deg. intervals)
You can also see from your model how a horizontal sundial is constructed. Wait till the shadow is exactly on one of your hour lines, and mark a line where the shadow of the base of your straw falls on the horizontal piece of your card, and mark the hour alongside.
When you have marked out a number of lines in this way, you will see that the angles are not a regular 15 deg. on the horizontal surface. You will also see that the shadow line along the "equator" surface meets the shadow line along the horizontal surface, along the line of the fold B. The hour lines on the horizontal surface are, in fact, the projection, on the horizontal surface, of the 15 deg. lines on the equatorial surface. This forms the basis of the graphical method of determining the hour lines for horizontal sundials, which of course are different for each latitude.

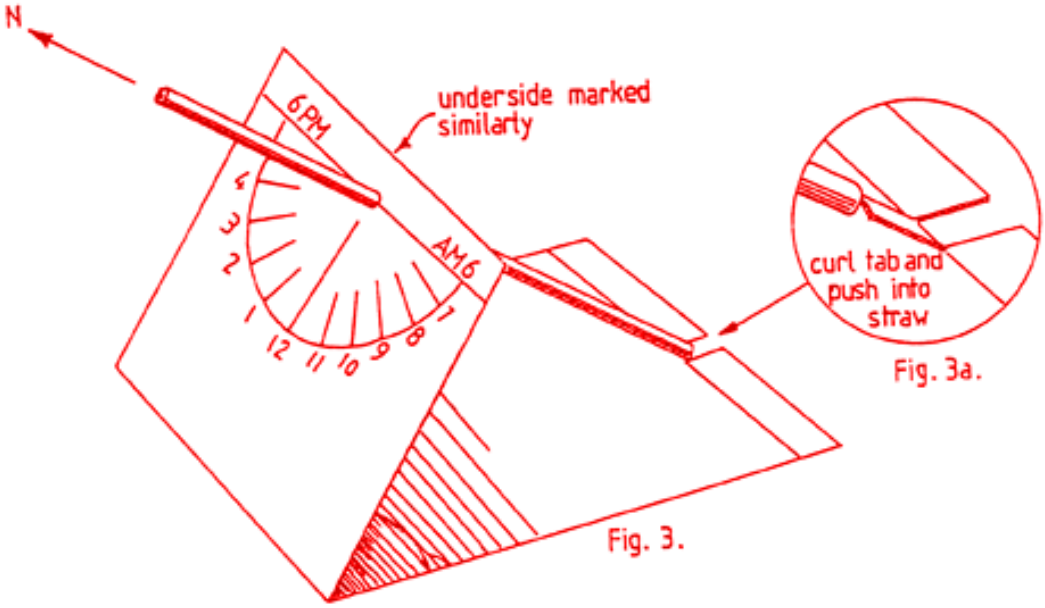
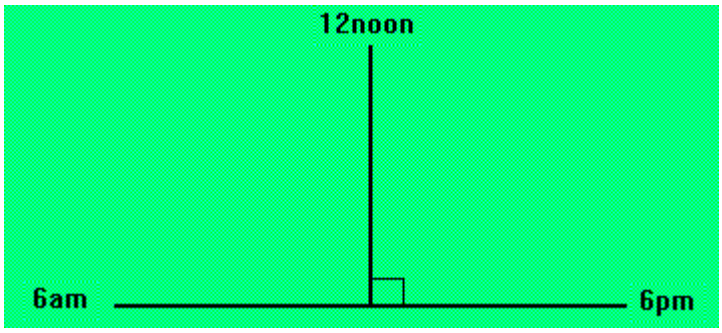


Fig. 3a.

Fig. 3.

Project 2 - A horizontal sundial

The first step is to mark out the hour angles. A base line with a centrally rising perpendicular gives the noon, 6am and 6pm lines as follows:-



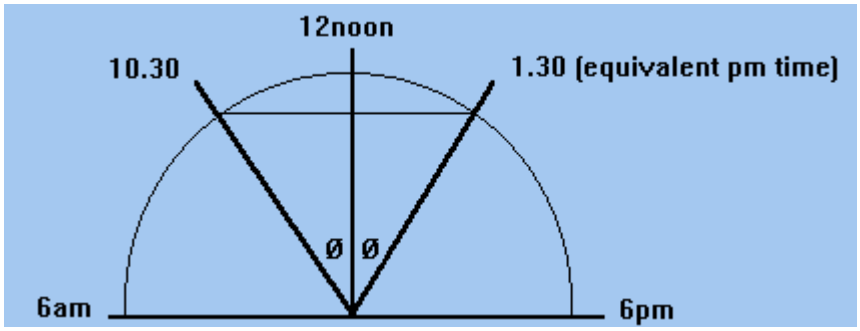
Various methods exist for generating the remaining hour angles, we will use the computational method. The formula for calculating the angles quoted in many works on the subject is:

log tan D = log tan t + log sin Ø

and was used in this form to save the need for long multiplication of fractions. However in these days of pocket calculators we can use the more straightforward:

tan D = (tan t)(sin Ø)

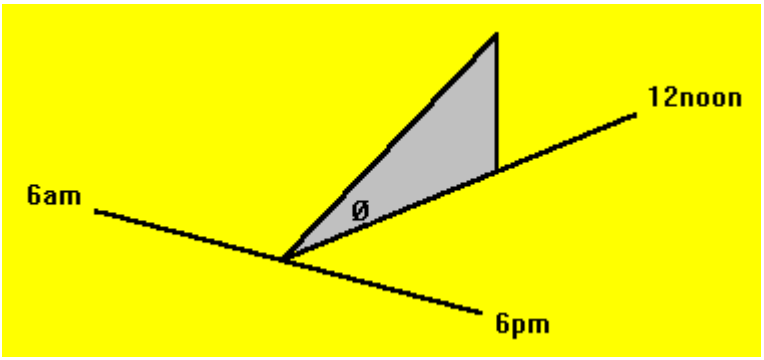
In both these formula D is the angle which the hour line makes with the noon line, t is the is the time measured from noon in degrees and minutes of arc [the earth completes the 360° round the sun in 24 hours so 1 hour = 15° and 1 minute = 15' of arc], and Ø is the latitude of the place where the dial is to be positioned. Each angle calculated for times before noon also gives the angle for the equivalent times after noon:-



It's best to draw up a table:

time	t	tan t	sin Ø	tan D	D
9.30 (2.30)	37°30'	0.7673	0.7749	0.5945	30.73°

I have put in one set of figures assuming a latitude of 50°48' (Ø = 50.8). Of course this is an obvious spreadsheet application. Having plotted all the hour angles required, normally hours and half hours, the shadow casting component, known as a gnomon or style, can be fitted along the noon line as shown below. The angle or height of the style is equal to the latitude of the dial location.



It is a good idea to draw the whole thing out on a large sheet of paper fixed to a board and make a style out of thin card. This will check the design before committing it to a more permanent medium. The sundial should be positioned where it will be in the sun for the maximum length of time with the dial plate perfectly level and with the noon line pointing directly north.

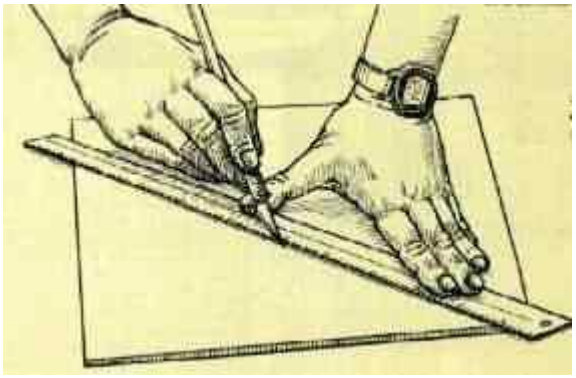
Project 3 - How to make a sundial

One might imagine that we could measure time simply by setting up a vertical pole on level ground. After a few days, it would become clear that tis idea does not work. The shadow of a vertical object does not fall in the same direction nor extend to the same distance at the same time on successive days. This is because the Sun passes across the sky each day on a path which rises and falls with the changing seasons.

This difficulty is overcome by observing the shadow cast by a fixed object set up so that its straight edge, known as the style, is parallel to the Earth's polar axis. This is achieved by elevating it at the same angle from the northern horizon as the latitude of the intended location of the sundial.

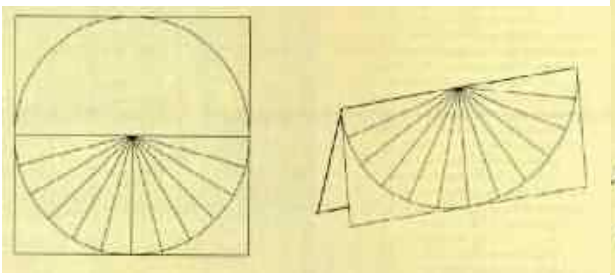
Of course, our sundial will indicate Sun Time, which may differ from the time told by a watch. For one thing, the apparent circular motion of the Sun varies in speed with the time of year, so that a day may last for slightly more, or slightly less, than the annual average of 24 hours. At certain times of year, this causes Sundial Time and Clock Time to differ by as much as 16 minutes.

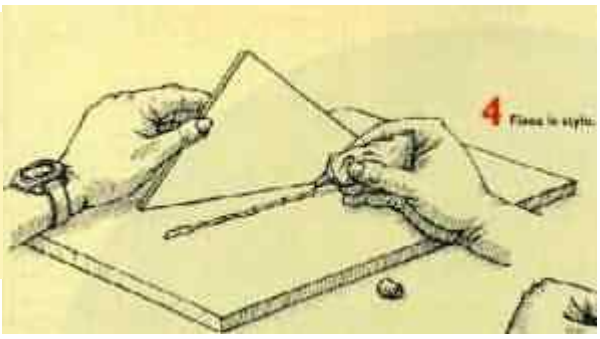
1. Choose your materials for the style and dial face on the basis of appearance, durability and ease of working.



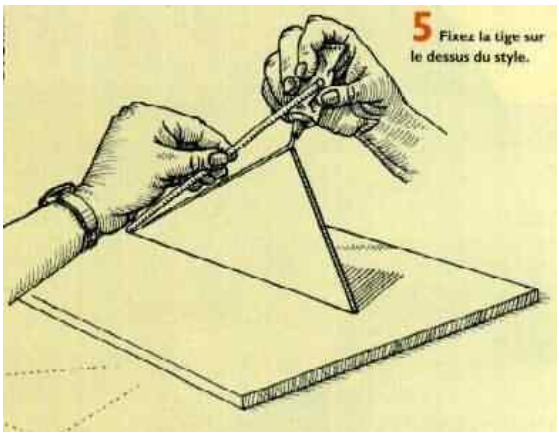
2. Cut out the style as shown and cut a straight rod, slightly longer than the sloping upper edge. The style angle (at the point that is to be fixed at the centre of the dial) must equal the latitude of the place where it will stand, as shown on a map of your country. .

3. Draw a semi-circle on the lower half of a piece of stiff paper, marking out angles of 15 degrees with a protractor. Fold back the upper half of the paper.
4. Attach the style to the dial face.

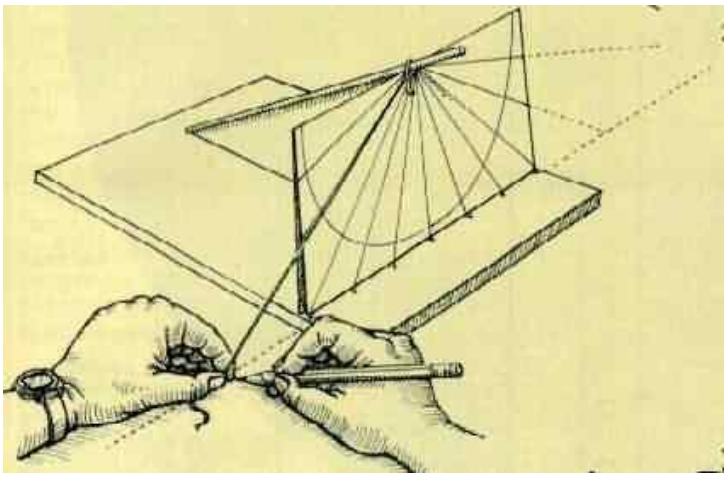




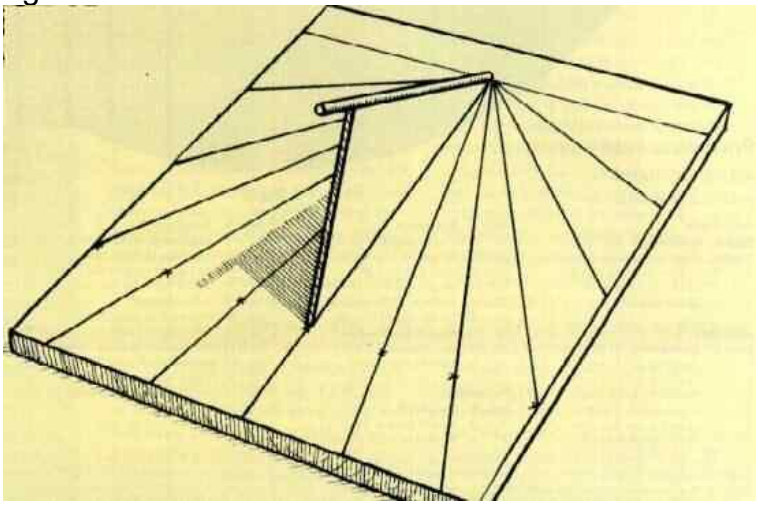
5. Fasten the rod along the sloping edge of the style..



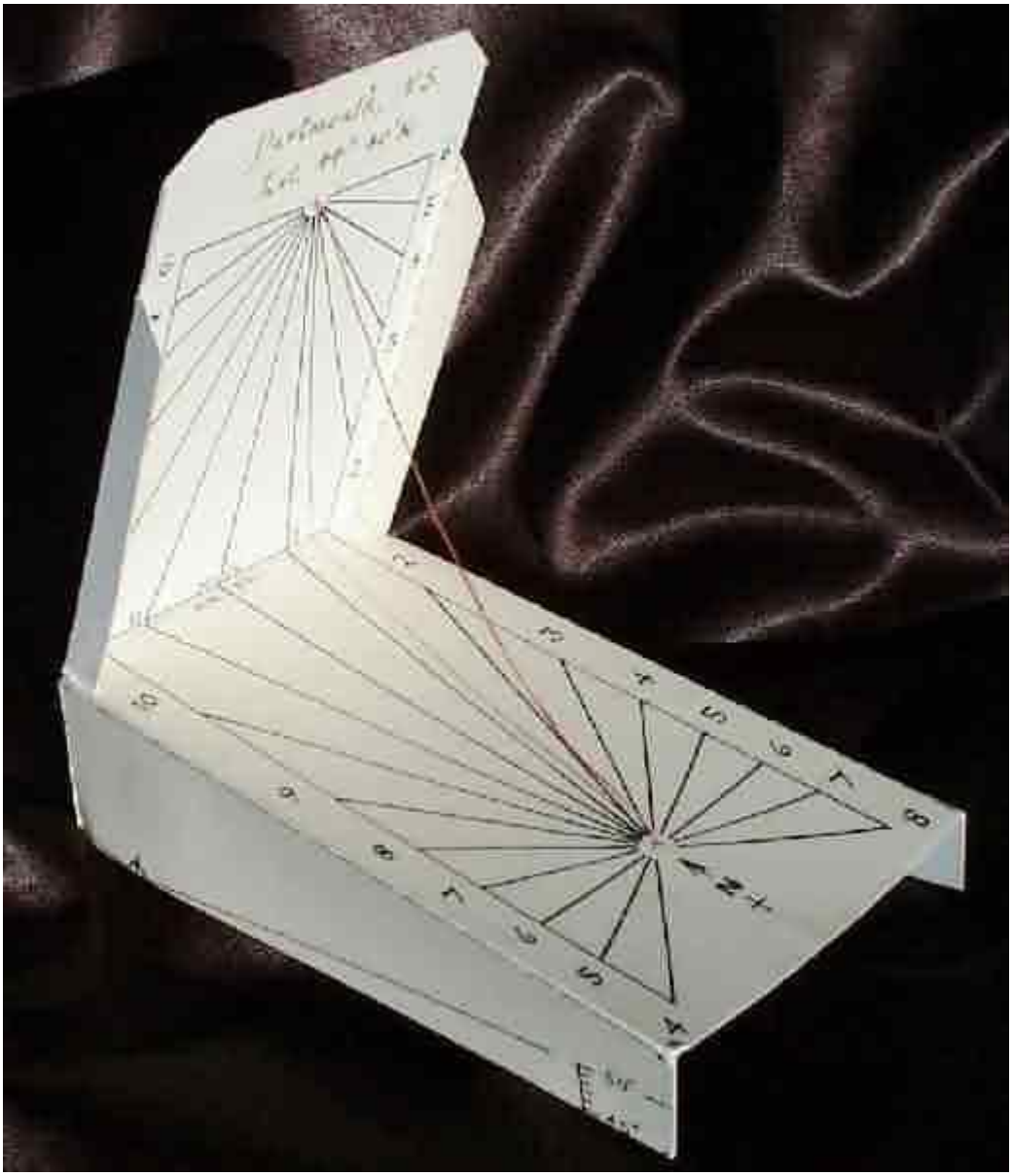
6. Fit the paper semi-circle so that it rests against the end of the style plate opposite to the measured angle and fits closely around the sloping rod. Attach one end of a length of cord around the rod and, but stretching it in line with each 15 degree line, mark out point to left and right across the dial face. Temporary extensions to left and right of the dial face will be needed, where points can be added in line with the wider angles. Remove the paper protractor and with a straight ruler, draw in the hour lines of the sundial, joining the marked points to the point of emergence of the sloping style..



7. Use a magnetic compass to orientate the sundial, so that the base of the style is in line with the North/South axis. Remember that the compass indicates magnetic north, and all for the magnetic declination.

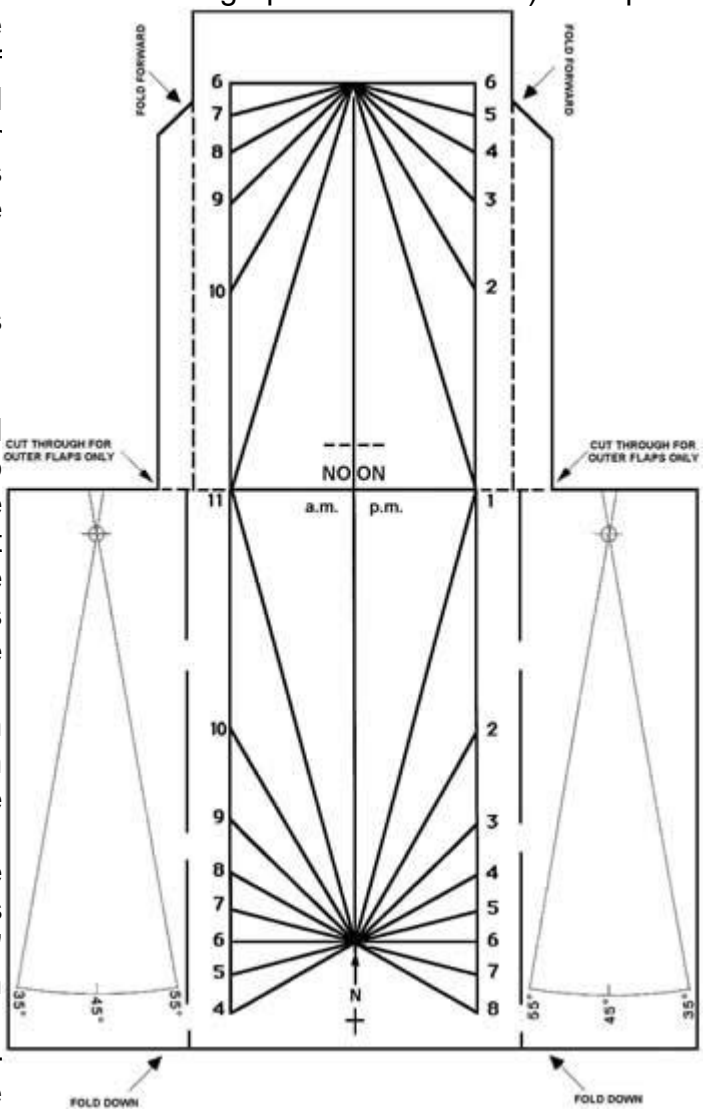


Project 4 - The diptych dial



The folding sundial you are about to make is called a diptych dial. Such dials have been made for four or five centuries and were traditionally made of ivory or boxwood.

Step 1: Print the template dial (provided as JPEG graphics to download) on a piece of A4 or letter sized paper. The downloaded files may be resized if desireable. Paste the paper dial onto a piece of bristol board or heavy card making sure that glue is spread evenly over the entire surface.



Step 2: Trim along the outside lines on the template diagram.

Step 3: To provide accurate time, the sundial must be orientated properly. The first step is to determine the latitude of the site using an atlas. On the right and left of the lower half of the dial (the base), you will see two scales marked 35°-55°. Once you have determined the required latitude, mark the latitude angle off on both scales drawing lines through each of the X symbols at the top. Cut the flaps off along these lines.

At the top you may want to write the location and latitude and/or perhaps your name, i.e. "Sam Smith, Fecit" (Fecit is Latin for "maker" and often appears on early instruments).

NB: If your site is outside the 35-55° latitude range, you can move the position of the "X" until you get the required tilt to the dial's base.

Step 4: Note the dashed lines; two of these are marked "score on back, fold forward" and two marked "score on front, fold down". Folds must be made along these lines and if you score these lines lightly with a sharp craft knife, the folds will be sharper and the sundial will stand better and look more finished. However, in making these scores, do not cut all the way through the card backing! After scoring, make the necessary folds in the direction indicated.

Step 5: Along the line with "Noon" above and "a.m. p.m." below, make another score line on the back and fold the upper section forward so that the two panels make a right angle.

Step 6: To finish the dial attach a string (preferably elastic string) through holes at the top and bottom at the points where all the hour lines converge. The easiest way to accomplish this is to use a thick needle and thread the string through tying knots on each end so that the string is taught when the dial is folded and ready for use. This string is the gnomon (pronounced no-mon) and casts the shadow to indicate the time.

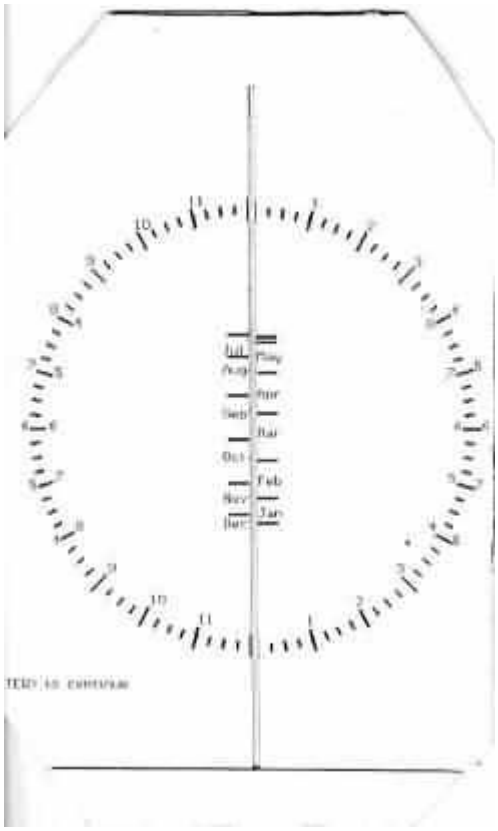
Step 7: You may wish to embellish the back of your dial with an old-style graphic from a book on sundials, a drawing of your pet or whatever appeals to you. This is where you can individualize your diptych dial!

Positioning your sundial:

The sundial must be orientated with the gnomon pointing north/south and, of course, the dial must be located where a shadow will be cast by the gnomon most of the day (though one can move the dial from window to window as the day progresses if necessary).
Method 1: (The Purist's Method) To determine the orientation without reference to other mechanical devices, North can be found by observing Polaris, the North Star, at night. In orientating the sundial, the gnomon is actually being pointed to the North Celestial Pole which is within 1° of the North Star. Thus, if you can find Polaris at the end of the Little Dipper, line up your dial by pointing the gnomon towards Polaris. You might want to record the orientation for your dial by making light pencil marks on a window sill for future reference. Those in southern latitudes will not be able to use this method as there is no bright star near the South Celestial Pole.
Method 2: (The Practical Method) A magnetic compass may be used to determine the north/south line, but, because of the difference between magnetic north and true north, the dial reading could be out by an hour or more depending on the local difference between magnetic and true north (or south if in southern latitudes).
Method 3: (The Lazy Person's Method) To a first approximation, the orientation can be found by finding the orientation at any time from a clock or watch and orientating the dial so the shadow shows the correct time. However, if left in this position, there could be an error of up to 30 minutes over the year as a result of what is known as the "equation of time". Because of the Earth's orbital motion around the Sun, the solar day (apx. 24 hours) is not exactly the same length from day to day varying by up to ±16 minutes a day. However, if the orientation is carried out on April 15, June 10, Sept. 1 or Dec. 20, this error will be negligible and any orientation made between April 15 and 1 Sept. will be in error by, at most, a few minutes (but don't forget the effect of daylight savings time).

Happy dialling!

Project 5 - The equiangular dial

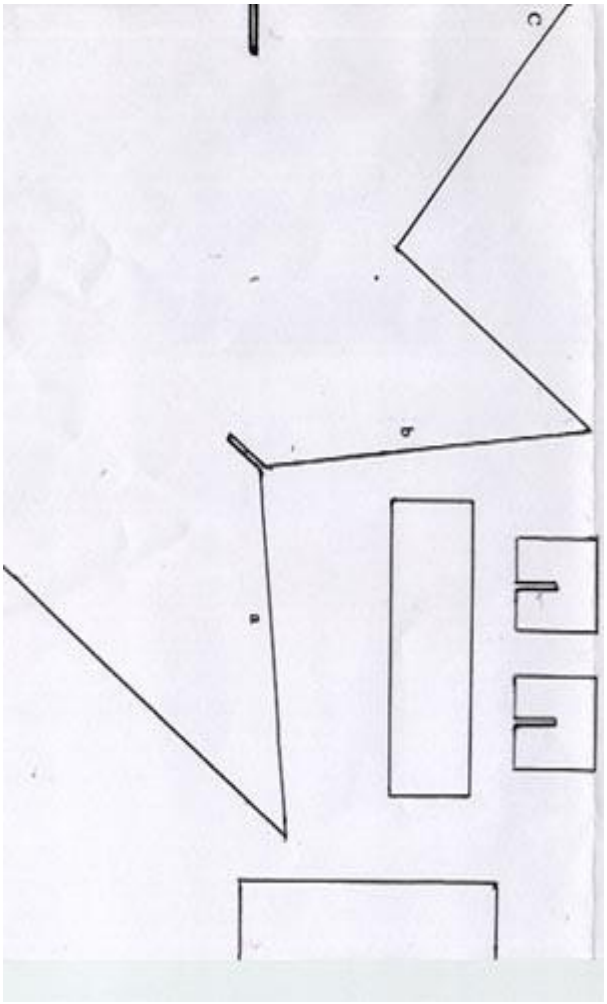


This dial is of a rather unusual and not very well-known type. It was invented by Samuel Foster in the seventeenth century and has been forgotten and re-discovered more than once since then. Unlike a common vertical or horizontal dial with a fixed gnomon, this one has its hour lines equafly spaced on the circumference of a circle, and no calculations involving latitude are required. The positioning of the dial does not depend on a prior knowledge of the North- South meridian and it can be used as a sun compass.

DIRECTIONS FOR EQUIANGULAR DIAL ASSEMBLY

Step 1. Take the page of patterns and paste it to a piece of card at least 1.3 mm thick. Suitable material can be obtained from a good stationer or artists' supplier.

Step 2. Using a sharp knife or scalpel, cut out the two rectangular pieces with the hour scales: also the gnomon, taking particular care with the shadow-casting edges, a and b. The angle C is 51.50, the latitude of London. If the dial is to be used at a different latitude, the angle should be altered accordingly, but sides a and b must always be at right angles to each other. Step 3. Join the two rectangular pieces, using pasted strips of card applied along the dotted lines. A gap should be left, just sufficient to admit the gnomon.



Step 4. The slotted squares help to maintain the gnomon vertical and the hour-plate at right angles to it.