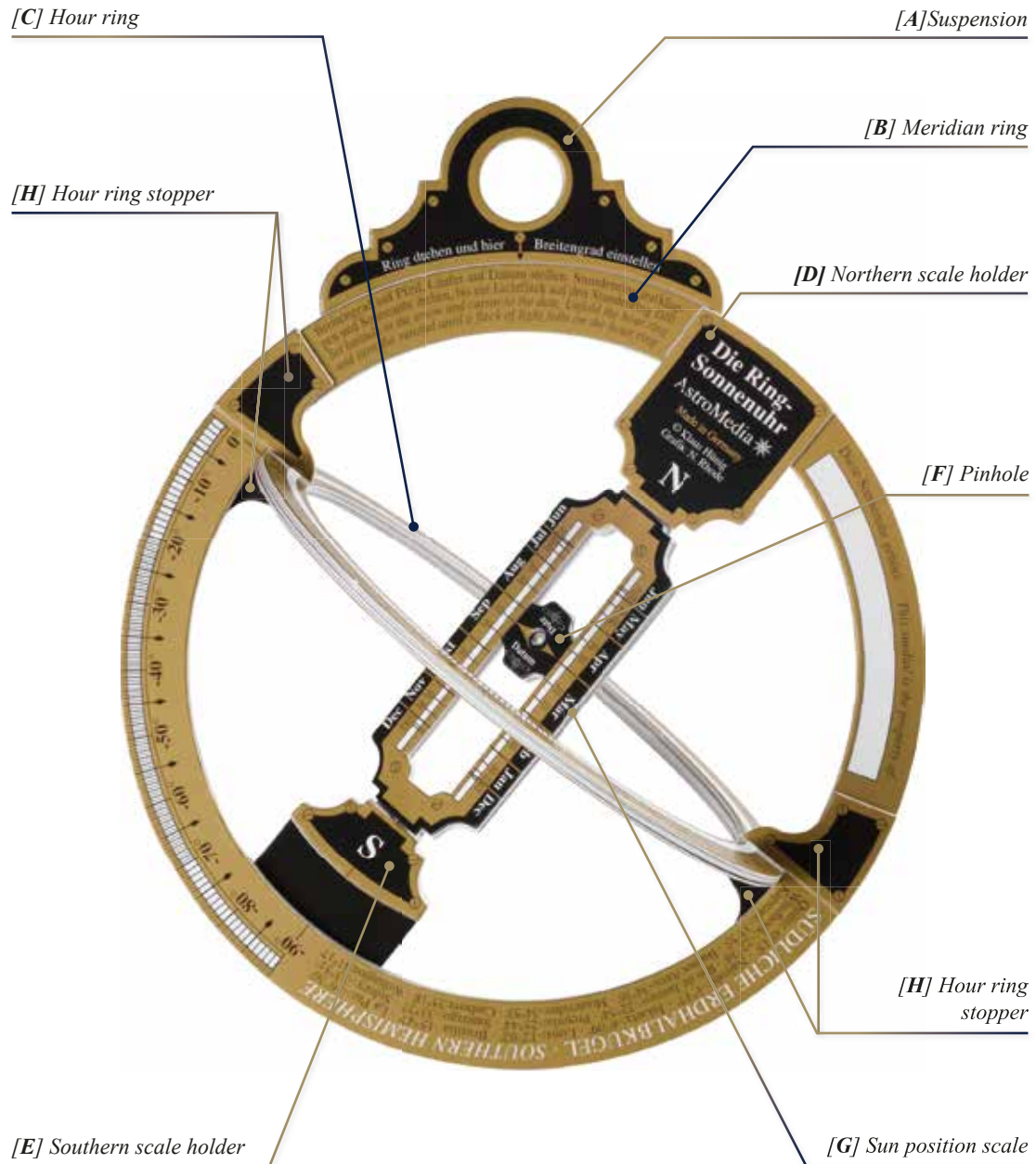


The Ring Sundial



AstroMedia 

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Ring sundials have been around since the end of the 14th century. They first appeared in their present form in England around 1620 and were in use until the 18th century. The few ring sundials that have survived can now be found in museums and are among their most treasured items.

From an astronomical point of view, the ring sundial is the queen of sundials: you can use it to tell the time anywhere on Earth, provided you know the latitude of the location as well as the date. Above all, in contrast to most other sundials, you do not have to know where the cardinal points are: A ring sundial will automatically point north, as long as you know whether it is morning or afternoon. All of this makes it the perfect travel sundial, especially since it can be folded flat.

When opened, a ring sundial resembles an armillary sphere*; both depict the heavens in miniature with their rings.

* A kit for an armillary sphere has also been released by AstroMedia: The Desktop Planetarium (Article No. 832.TPL)

The parts of the Ring Sundial:

- The indicator on the adjustable suspension shows the position of the zenith, the highest point of the sky, exactly vertically above the observer. The lowest point on the opposite side of the invisible half of the celestial sphere is called nadir.
- The hour ring shows the orientation of the celestial equator, the circle that divides the celestial sphere into a northern and a southern half, with the north celestial pole and south celestial pole in the middle. This is why it is sometimes called the “equatorial ring”.
- The ends of the sun position scale point in the directions of the celestial north and south poles.
- The pinhole, which can be moved up and down in the sun position scale, projects a tiny image of the Sun onto the inner

edge of the hour ring where the time is read off. The position on the scale shows the Sun’s declination, which changes over the course of a year. Its distance from the celestial equator varies between $\pm 23.44^\circ$. One side of the scale shows the declination in degrees, the other indicates the date. The combination of all these elements makes it possible that a ring sundial can display the time anywhere on Earth. It also has the unusual and useful property of automatically showing the cardinal points without needing a compass.

With the fully functional Ring Sundial from AstroMedia*, you can tell true local time to within a few minutes, just like with the ancient models. True local time is the time determined by the course of the Sun. The process is very simple and is described further down in these assembly instructions.

Tips for successful assembly:

1. You will need:

- A sharp knife (craft knife) to cut the parts from the cardboard, e.g. the AstroMedia Craft Knife (Article No 401.MES)
- A sharp pencil to draw temporary guide marks
- A good all-purpose glue. Solvent-based glue is better than water-based glue because it doesn’t warp the cardboard
- For perfectionists: Black and gold lacquer pens to paint the grey cardboard edges

2. The building instructions are divided into many small steps. It looks like a lot of text, but makes the assembly clearer and easier. Please read through each step completely before commencing and give yourself enough time. You will be rewarded with a more beautiful and precise ring sundial.

3. Only remove the parts from the cardboard as you need them. We recommend that you do not tear the parts out of the cardboard sheet, but cut through the thin connecting tabs with a sharp knife to make sure that the edges are smooth.

4. Each cardboard part has a name and a part number. The part number is composed of a letter for the construction phase and a number for the sequence within the construction phase. Each part number is printed in a white rectangle, e.g. **D2** means “section D, part 2”.

5. The surfaces of the cardboard parts that are meant to receive glue are printed in grey and have a symbol with the number of the part that is to be glued here, e.g. **A2** means “part A2 is glued here”.

Tip: If you want small pieces to stick faster, coat one side generously with glue, press the two parts together so that the glue is transferred equally to both surfaces, pull apart, and blow two or three times over the glue until it is almost dry. Then press the two parts together accurately and firmly. The glue will stick immediately. Do not use this method on parts that need to be corrected.

6. Protruding edges that look untidy or interfere with the function, e.g. if the rings cannot be folded into each other, you can sand down after the glue has dried with the enclosed piece of sandpaper or with a fine file, e.g. the AstroMedia Specialist Craft Files (Article No. 400.SBF).

This kit contains:

- 2 printed and punched sheets of construction cardboard
- 4 steel pins 1.7 x 10 mm
- 1 sheet of sandpaper 11.5 x 9 cm, grit 150

Building Instructions

Please read through each step completely before commencing.

A & B: The Suspension and the Meridian Ring

i The circular, adjustable suspension with which the sundial can be adapted to any given geographical latitude is fitted between the two outer parts of the meridian ring. The degrees of latitude are marked on both outer sides of the meridian ring. These are also called the east and west side, because when the sundial is read, the meridian ring hangs exactly in a north-south direction and accordingly its two sides point to the east and west, respectively. The west side has a complete scale of the northern degrees of latitude from 0° (equator) to +90° (north pole), the east side a complete scale of the southern latitudes from 0° (equator) to -90° (south pole).

Step 1 Remove **inner part 1** [A1, sheet 1] and **inner part 2** [A2, sheet 2] of the suspension from the cardboard sheets. As indicated by the glue marks, glue the two parts back to back so that the edges are exactly flush.



Step 2 Remove **inner part 1** [B1, sheet 1] and **inner part 2** [B2, sheet 2] of the meridian ring from the cardboard sheets. Both have two slots, each 1.7 mm wide, open to the inside of the rings. For production reasons they are only partly punched out. Open these slots with a sharp knife and glue the pieces back to back. Make sure that the slots are exactly flush.



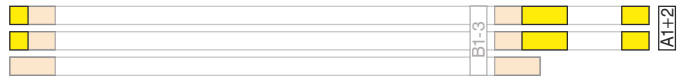
Step 3 Check that the **inner part of the meridian ring** [B1 + B2] fits inside the **inner part of the suspension** [A1 + A2] and can be rotated in it. If necessary, you need to sand down the edges of the inner part of the meridian ring until it can be rotated inside the inner part of the suspension without too much resistance.



Step 4 Remove the west side of the **meridian ring** [B3, sheet 1] from the cardboard sheet. With a sharp pencil make a mark on the inner edge of the ring and on its back exactly where the 0°-mark is. Then glue the two-layer inner part of the meridian ring onto it, so that the marking line is exactly in the middle of one of the two slots. Make sure that the inner edges of the rings are exactly flush with each other and that no glue enters the slots. Let dry well.



Step 5 Place the **inner part** of the suspension [A1 + A2] on top and make sure that the parts can be rotated against each other.



Step 6 Now glue the east side of the **meridian ring** [B4, sheet 2] to the inner part of the meridian ring. Do not glue it to the inner part of the suspension, which must remain free to move. Make sure that the 0°-mark on the west side is exactly opposite the 0°-mark on the east side. To do this, draw auxiliary lines on the inner edges of the cardboard rings with a pencil.

Important: Make sure you only apply glue to the inner part of the meridian ring, and not the inner part of the suspension; also don't let glue get into the bearing of the axle - otherwise the suspension will no longer rotate and the ring sundial cannot be adjusted to different degrees of latitude! Check that the suspension can be turned before the glue sets and, if necessary, take it apart again and remove any excess glue.



Step 7 Now glue **outer part 1** [A3, sheet 1] and **outer part 2** of the suspension [A4, sheet 2] on either side of the inner part of the suspension where it protrudes from the meridian ring. Again make sure that the suspension can be turned in the meridian ring. Some initial stiffness is normal and will reduce over time.



The meridian ring is now complete. Check and, if necessary, improve the smoothness of the inner edge of the meridian ring by sanding. If individual layers of cardboard protrude, it will later be hard to fold in the hour ring.

C: The Hour Ring

i The hour ring has a north and a south side because when you read the sundial, one side points to the north celestial pole and the other to the south celestial pole. The north side shows the hours from 1 to 24 in Arabic numerals, the south side in Roman numerals, twice the hours from I to XII.

Step 8 Using a sharp knife, open the punched 1.7 mm wide slots from **inner part 1** [C1, sheet 1] and **inner part 2** of the hour ring [C2, sheet 2] and glue the parts back to back. The slots must be exactly flush.



Step 9 Take the south side of the **hour ring** [C3, sheet 1], the one that is printed with Roman numerals. First draw a pencil mark on the inner edge of the ring and then also on its back, exactly where the line of the XII mark is printed on the front. Glue the inner part of the two-ply hour ring exactly flush onto the back of the south side, in such a way that the slits are precisely over the marking lines and thus over the XII markings.



Step 10 Insert a steel pin without glue into each of the holes in the inner edge of the meridian ring. These are the axes for the hour ring. One axis is where the west and east side of the meridian ring have their respective 0°-mark, the other one is on the opposite side. Place the three glued **parts of the hour ring** [C1 + C2 + C3] on your work surface so that the Roman hour numerals are facing down. Put the meridian ring on top of it so that its west side (with the positive degree scale 0° to +90°) is on top and the steel pins snap into the slots in the hour ring.



Step 11 Now glue the **north side of the hour ring** [C4, sheet 2] as the fourth layer onto the hour ring, glueing the axis pins to the hour ring at the same time. The 24-mark must be exactly above the steel pin that is at the 0°-mark of the meridian ring and therefore also opposite one of the two XII marks on the south side of the hour ring. Make sure that no adhesive seeps between the meridian ring and the hour ring. After drying, check that you can fold the hour ring to a right-angled position to the meridian ring and then back to its rest position.

Optional: The time will be read from the inner edge of the hour ring. This will be easier if you connect the ends of the hour lines and half hour lines across the inner rim with a thin black marker pen.



D & E: The Northern and Southern Scale Holders

i The two scale holders consist of a bridge and a glued-on axle bearing. They hold the rotatable sun position scale inside the ring sundial and at the same time are designed so that the hour ring can be folded flat into a recess. The northern scale holder is the one with the German inscription, the southern scale holder has the English one.

Note: There has been a misprint in part of the print run. Please check that the glue symbols on the axle bearing part [D3, sheet 1] read "D4" on the front and "D2" on the back, and correct them if necessary. Also check the axle bearing part [E3, sheet 2]. Its glue symbols must read "E4" on the front and "E2" on the back.

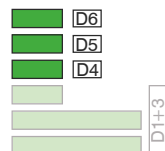
Step 12 Glue the **outer part of the bridge of the northern scale holder** [D1] and the **inner part** [D2, both on sheet 1] exactly flush back to back.



Step 13 Glue the **axle bearing part 1** [D3, sheet 1] to the marked position on the northern bridge. The stepped and curved edges must be flush with the edges of the bridge.



Step 14 Cut out the punched 1.7 mm wide slots of the two **axle bearings part 2** [D4] and **part 3** [D5, both on sheet 1] with a sharp knife and glue them on top of each other and onto the axle bearing part 1. Finally glue the **axle bearing part 4** [D6, sheet 1] on top. Here, too, the edges must be exactly flush. Now one end of the northern scale holder has the complete axle bearing with a square hole that will hold one of the steel pins.



Step 15 Assemble the **southern scale holder from parts** [E1] to [E6, all on sheet 2] in the same way.

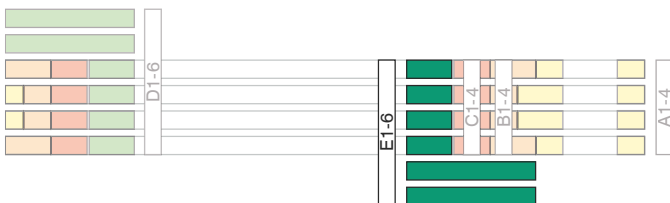


Step 16 Now glue the steel pins into the square holes of the two axle bearings. These are the two axes for the sun position scale. Important: The axes must not protrude less than 4.0 mm and no more than 4.3 mm from the holes.

Step 17 Place the meridian ring with the side that says “NORTHERN HEMISPHERE” down on your work surface so that the scale with the negative degrees from 0° to -90° is on top. The hour ring must be orientated so that its Arabic numerals from 1 to 24 are on top and the Roman numerals on the bottom. Now glue the northern scale holder onto the marked position of the meridian ring so that the axle bearing protrudes into the inside of the ring sundial. At the top, the edge of the scale holder is flush with that of the meridian ring. On the inside it grips with the axle bearing around the hour ring, which thus remains rotatable in only one direction. The thin black line on top of the axle bearing needs to point exactly on the Roman VI marking on the hour ring.



Step 18 In the same way, glue the southern scale holder on the opposite side onto the marked position on the meridian ring. The line on the axle bearing needs to point to the Arabic 18-mark on the hour ring.



F: The Pinhole

i The pinhole creates a small light spot from which the time is read. It sits in the sun position scale and can be moved up and down as if on rails and is set to the current date.

Step 19 Carefully remove the cardboard from the small holes in **pinhole inner part 1** [F1, sheet 1] and **inner part 2** [F2, sheet 2] and glue the parts back to back. The two holes must be exactly flush with each other.



Punching such small holes can sometimes lead to inaccuracies. If the hole in one of the inner parts of the pinhole is not in the centre, you have to make it bigger with a sharp knife or something similar. Enlarge the hole so that the correctly seated one in the middle of the other inner part is no longer covered when you glue the parts together.

Step 20 Remove the two **pinhole outer parts 1** and **2** [F3, sheet 1] and [F4, sheet 2] from the cardboard, as well as the **outer frame part 1** of the sun position scale [G3, sheet 1], which will be processed in the next step. Check that the pinhole outer parts fit in the opening of the sun position scale and can be pushed up and down. If they are too wide or jam, cut small slices off their outer edges until they fit.

Then glue the two pinhole outer parts onto the front and back of the inner part, so that the top and bottom edges are flush. On the left and right there are protruding wings which will slide in the inner frame of the sun position scale.

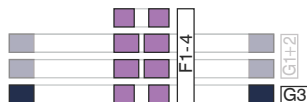


G: The Sun Position Scale

Step 21 On the inner frame of the **sun position scale, part 1** [G1, sheet 1] and **part 2** [G2, sheet 2], open the slots for the axes of rotation with a sharp knife and then glue both parts back to back.

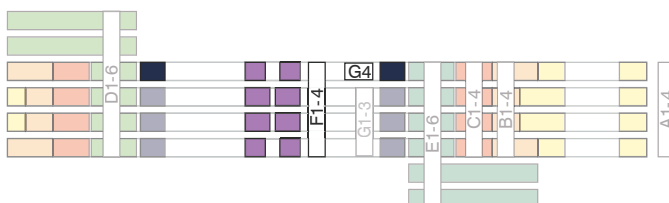


Step 22 Now glue the inner frame to the back of the outer frame of the **sun position scale, part 1** [G3, sheet 1], on which the date scale is printed. This creates a kind of stepped depression on both sides of the slot. Let dry well. Then place the pinhole in the recess, with the “date” side down, and check that it can slide up and down in it. If necessary, you can shorten the wings slightly.



Step 23 Place the folded ring sundial with the west side of the meridian ring (with the scale 0° to + 90°) facing down on the work surface. The side of the hour ring with the Roman numerals is then also facing down and the northern scale holder is facing up. Now place the sun position scale under the ring sundial so that the scale with the dates is facing down and the open inner frame is facing up. **Important:** The end of the scale with the month of June must point to the northern scale holder. The two axes of rotation of the scale holders snap into the slots in the inner frame of the sun position scale. If the scale does not fit exactly between the ends of the two scale holders, you can use a sharp knife to remove some cardboard from both ends.

Step 24 Now place the pinhole with the inscriptions “Datum” and “Date” downwards in the frame and glue the outer frame of the **sun position scale, part 2** [G4, sheet 2] onto it so that the positive number of degrees + 23.4° point to the north scale holder. Make sure that no glue gets into the inside of the frame or into the bearings of the axes, otherwise you will not be able to move the pinhole or rotate the scale.

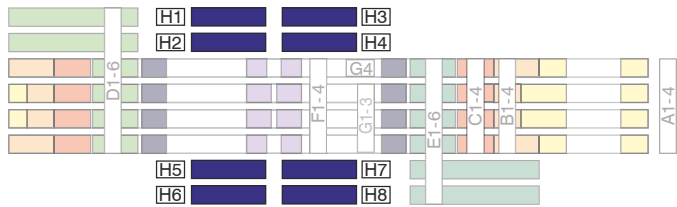


H: The Hour Ring Stoppers

i To ensure that the hour ring remains exactly at right angles to the meridian ring when it is folded out, four stoppers prevent it from turning any further.

Step 25 Glue the front of the **hour ring stopper 1 [H1]** and its **back [H2]**, both on sheet 1] exactly flush back to back. Then glue the **front and back of the stoppers 2, 3 and 4 [H3]** and **[H4]**, both on sheet 1], **[H5]** and **[H6]** as well as **[H7]** and **[H8]**, all on sheet 2] in the same way.

Step 26 Unfold the hour ring so that it is exactly at right angles in the meridian ring and the side with the Arabic hour numbers 1 to 24 points to the northern scale holder. The right angle can be checked very easily with a corner of the cardboard sheets. Then glue the 4 hour ring stoppers onto the marked positions on both sides of the meridian ring so that they point into the inside of the ring sundial. They will hold the hour ring with their wide straight edge when it is opened at right angles. It now can only be opened to 90° and no further.

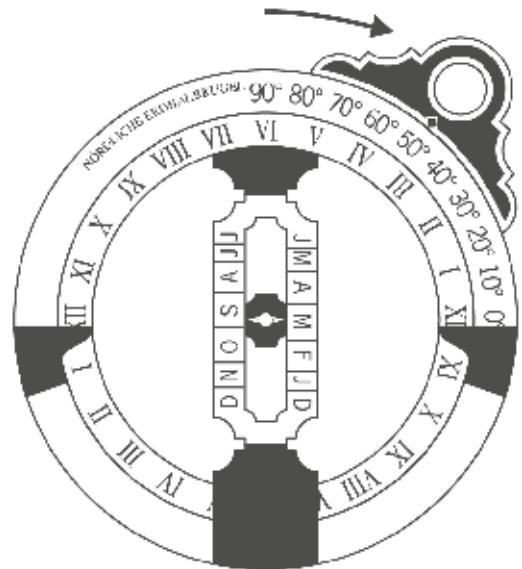


Congratulations - your ring sundial is now finished. To make it easier to use, pull a string through the hole in the suspension so that the sundial automatically hangs exactly vertically.

How to use the Ring Sundial:

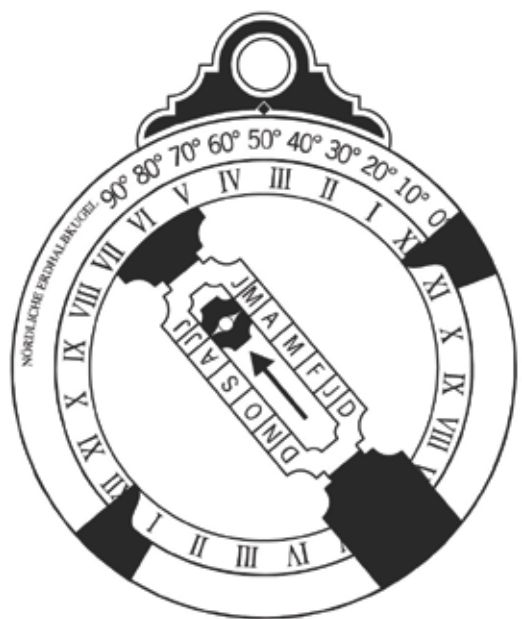
Step 1:

Set the ring sundial to the geographical latitude of your location by holding the meridian ring on the inside with one hand and sliding the suspension with the other until the small square mark points to the correct number of degrees of latitude. If you don't know your latitude, use the location closest to you from the ones listed on the edge of the meridian ring. The latitude for any place on Earth can be found very easily on the internet, e.g. on Wikipedia or Google Earth.



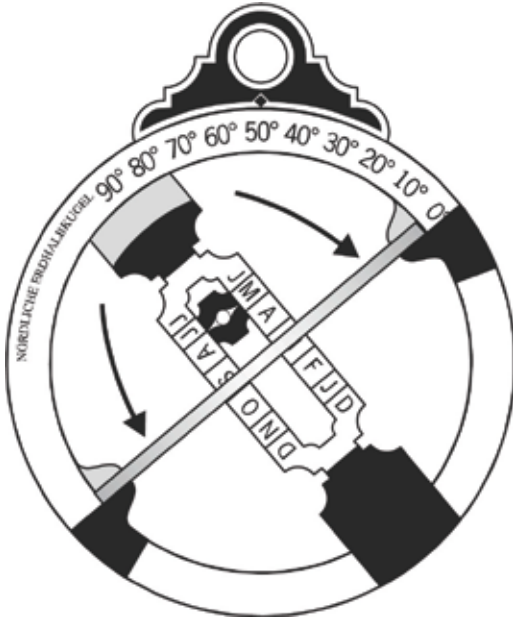
Step 2:

Set the sundial to today's date by sliding the pinhole on the date scale. If you know the declination of the Sun for this day, i.e. its angular distance to the celestial equator, you can align the pinhole using the degrees on the other side of the sun position scale accordingly.



Step 3:

Unfold the hour ring so that it is exactly at right angles to the meridian ring.



Step 4:

Hold the sundial by its suspension in the sunshine and turn it carefully until a beam of light falls through the pinhole onto the centre of the inner edge of the hour ring. Read off the time where the small circle of light appears. In the morning or afternoon you might have to turn the sun position scale towards the Sun so the light can shine through the pinhole.



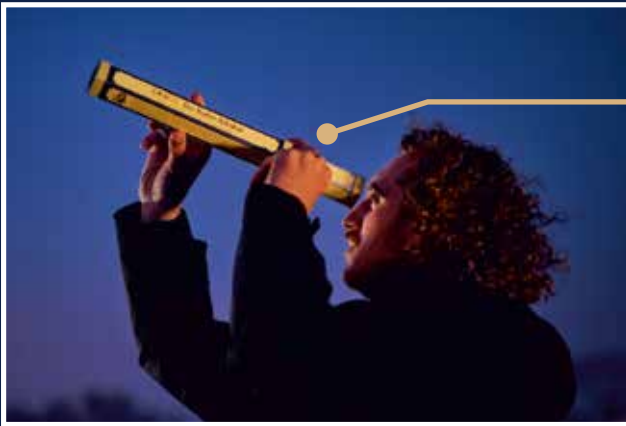
Important Information when Reading the Time:

1. A ring sundial always offers you two times, one in the morning and one in the afternoon, both of which are equidistant from 12 noon (e.g. 10:15 a.m. and 1:45 p.m.). In most cases, choosing the correct one is not a problem. However, the meridian only points north-south for the correct time.
2. In the days around 21st March and 23rd September, the spring and autumn equinoxes, the pinhole is level with the hour ring, which is why no light spot can fall onto its inner edge. It is still possible to determine the time: Carefully turn the sundial a little to the left and right until the light spot appears once at the top and once at the bottom of the inner edge, and estimate the time for the middle position.
3. Remember that a sundial does not show the usual standard time GMT (Greenwich Mean Time) or even summer time, but the True Local Time: the time that is valid at the respective location and is directly derived from the position of the Sun. In True Local Time it is always exactly 12 o'clock when the Sun peaks in the south. It is also called the Apparent Solar Time. Apparent Solar Time changes in an east-west direction because the Sun reaches its midday position earlier in areas further east than in areas further west, namely by 4 minutes for each degree of longitude. In Plymouth (about 4° west longitude) the Sun arrives about 20 minutes later in its midday position than in Norwich (about 1° east longitude): $4^\circ + 1^\circ = 5^\circ$ difference, $5 \times 4 \text{ minutes} = 20 \text{ minutes}$. Greenwich Mean Time (GMT), on the other hand, is a computationally averaged time that applies uniformly to the whole of the UK (and other countries). It also compensates for the advancing and lagging of the Sun on its course over the year (up to 16 minutes) due to the eccentricity of the Earth's orbit.
4. When the ring sundial shows the correct time, it automatically hangs exactly north-south. Therefore you can also use it as a compass if you know the date of the day and the geographical latitude.

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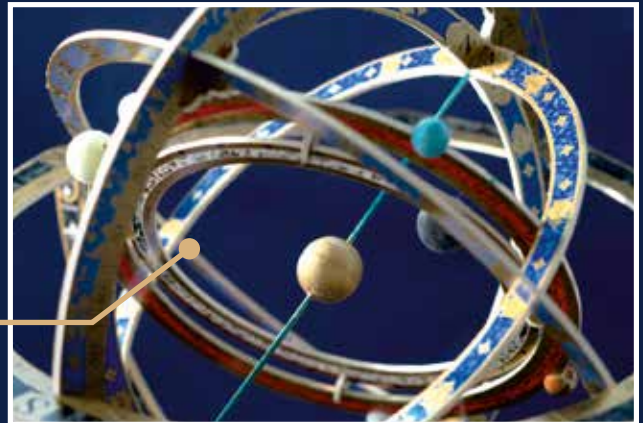
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