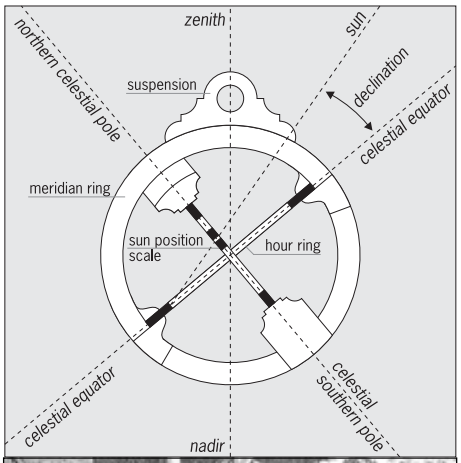
# The Universal Sundial Ring




The universal sundial ring is the queen of all sundials. It is closely related to the armillary sphere, because similar to this, it depicts the surrounding firmament with its rings:
The revolving **suspension** shows with its reference point the position of the **zenith** (the highest point of the firmament). The lowest point lying opposite, which is on the hidden half of the celestial sphere, is called the **nadir**.
The **meridian ring** indicates the position of the **meridian**. Here you find the "midday line" (lat. Meridies "midday"). This is the line where you find the sun at its highest position of the day. In the sky, this circle passes from the southern point of the horizon, over the zenith, to the northern point and the nadir, and back to the southern point.
The **hour ring** shows the position of the **celestial equator**. This is the circle which indicates where the celestial sphere is split into a northern and a southern half, in the centre of which are the northern and southern celestial poles. This ring is also sometimes known as the "equatorial ring".
The two ends of the **sun position scale** points into the directions of the northern and southern **celestial poles**.
The **cursor** on the sun position scale shows the declination of the sun depending on the time of year, that is its distance from the celestial equator. On the one side of the sun scale the declination is given in degrees, on the other side as a date.
The co-ordination of all these elements lets the sundial ring not only show the time at every place on earth, but also enables it to find North and South without the aid of a compass. Sundial rings, which first showed up at the end of the 14th century, first appeared in their present form in England around 1620 and were in use until the 18th century. Some of them can still be found in museums where they count among the most valuable treasures. With this fully functioning sundial ring you can measure Real Solar Time (also called Real Local Time, the time determined by the course of the sun), exactly as sailors, travellers and astronomers did in the past. The reading is precise down to a few minutes and very easy to do, as is explained after the building instructions.

# Assembly Instructions for the Sundial Ring

**Please read through each section carefully before you start.**
**Contents of the kit:**
2 printed and pre-perforated sheets of cardboard, 2 pieces of roundwood Ø 2mm, 1 circular diaphragm Ø 1.5mm.
You will need a sharp knife in order to loosen parts from the cardboard sheets and cut the roundwood, a pencil with a sharp point and a good adhesive glue. Solvent based glue is more suitable than water based glue because it doesn't make the surface of the cardboard swell or form ripples. This is how you can speed up the drying process: Put enough glue on one part, press both parts together so that the glue is spread evenly and then pull them apart again. Blow on them 2 to 3 times and fit the parts together exactly – the glue will hold immediately. In the gluing process there may be occasions when you might need to make later adjustments. In this case it is recommended to let the glue dry more slowly.
The assembly of the kit is not difficult because all parts are pre-perforated to fit together exactly. Remember that more precisely you glue the parts together, the more likely it is that the sundial will show an exact time.
Cardboard is a natural material and reacts to temperature, atmospheric humidity and other environmental factors. A high degree of precision was taken during the manufacturing of this product to ensure that little or no adjustments would need to be made later. However, if you find that some pieces do not fit together exactly, sandpaper and / or a sharp knife can be used to make the appropriate adjustments.
Every part is marked with a component number - (A1), (A2),(B1),(B2), etc. - next to its name. The letter of the component is always the same within each specific section of the assembly.

## Suspension and Meridian Ring

Between the outer sides of the meridian ring, you will find the circular, adjustable suspension with which the sundial can be adapted to any given geographical latitude. 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 east and respectively west. The west side has a complete scale of the northern degrees of latitude from 0° (equator) to +90° (north pole), whereas the east side has a complete scale of the southern degrees of latitude from 0° (equator) to –90° (south pole).
**Step 1:** Loosen the two blank inner parts of the suspension (A1) and (A2) from the cardboard and glue them exactly against each other so they fit together precisely.
**Step 2:** Separate the two blank inner parts of the meridian ring (B1) and (B2) from the cardboard. Both have two partly perforated slits measuring 2mm in width opening towards the centre of the rings. Cut out these slits with a sharp knife and glue the parts together, making sure the slits are lined up exactly.
**Step 3:** Loosen the west side of the meridian ring (B3), the one with the positive latitudes 0° to +90°, from the cardboard and on the blank side make a mark with a pencil to indicate the position of 0°. The inner part of the meridian ring (B1/B2) now is positioned on the blank back side of the west side of the meridian ring, so that the 0° mark is in the middle of one of the two slits. The inner edges of the rings must sit exactly on top of each other. Be careful not to let the glue run into the slits. Leave to dry well.
**Step 4:** Put the inner part of the suspension (A1/A2) on top. With its inner diameter it will fit exactly over the inner part of the meridian ring like on an axis. Make sure it can be turned and if need be, remove any unnecessary remaining glue.
**Step 5:** The east side of the meridian ring (B4) is now be glued onto the inner part. The 0° latitude mark on the west side must lie exactly back to back with the 0° mark on the east side. It may be helpful if you mark a reference line on the inner edge with a pencil line.
*Attention: Make sure you only glue the inner part of the meridian ring and not the inner part of the suspension. If this happened, the suspension would not be able to turn and the sundial would not be able to show the different degrees of latitude. Check before the glue dries to see whether the suspension can turn.*
**Step 6:** Glue to two outer parts of the suspension (A3) and (A4) on both sides of the projecting inner part of the suspension (A1/A2). Again you need to make sure that the suspension can turn inside the meridian ring.
Check the smoothness of the inner edge of the meridian ring, which now consists of four layers of cardboard, and if necessary make corrections. If any layer is jutting out, the hour ring will have difficulty turning.

## The Hour Ring

The hour ring has a north and south side because when reading the sun dial, one side shows towards the celestial north pole, the other towards the celestial south pole. The north side shows Arabic numerals from 1 to 24 and the south side has Roman numerals from I to XII, which are displayed twice.
**Step 7:** With a sharp knife, cut the partly perforated 2mm wide slits from the blank inner parts of the hour ring (C1) and (C2) and glue both pieces together.
**Step 8:** Glue the inner parts (C1/C2) on to the blank back of the hour ring (C4) (north side, the one with Arabic numerals) so that the two slits lie exactly behind the 12 and 24 hour lines.
**Step 9:** Cut off two 12 mm long pieces from the roundwood to be used as axis of rotation for the hour ring, and without using glue, insert them into the holes on the inner rim of the meridian ring. One axis is inserted where the west and east side of the meridian ring have the 0° mark, the other on the opposite side.
**Step 10:** Place the hour ring (C1/C2/C3) on your working surface with the printed side down and position the meridian ring on it, so that its west side (with the scale of positive latitudes 0° to +90°) is on top and the two axes of rotation lock into position in the slits of the hour ring.
***Important:*** *If you now turn everything round, the 24 hour mark must lie next to the 0° mark of the meridian ring and the 18 hour mark next to the –90° mark. If not, you must turn the hour ring accordingly.*
**Step 11:** Now glue the south side of the hour ring (C3), the one with the roman numerals, onto the hour ring (C1/C2/C3) as the 4th layer. The two XII hour marks have to lie exactly on top of the two axes of rotation, which puts them next to the 0° mark of the meridian ring and opposite the 12 hour and 24 hour mark on the north side of the hour ring. At this occasion both axis of rotation are glued into the hour ring. Be careful that no glue drips out between the meridian ring and the hour ring. When the glue has dried well, in order to control the function of the hour ring turn it into a position rectangular to the meridian ring and then back into

its neutral position. If necessary sand down the outer edge of the hour ring a little to allow for smooth turning.

**Step 12:** (optional): When the sundial is finished, the time will be read off the inner rim of the hour ring. Reading will be easier, if you connect the ends of all hour lines and half hour lines across the inner rim with a thin black marker pen.

## Northern and Southern Scale Holder

The scale holders consist of a bridge and, glued onto it, the bearing for the scale axis. They will later be glued onto the meridian ring and will hold the revolving sun position scale in the inner ring of the sundial. The northern scale holder is recognised by the "Die Ring-Sonnenuhr" printed on the bridge, the bridge of the southern scale holder reads "Astromedia..."

**Step 13:** Glue the outer bridge (D1) precisely onto the blank side of the inner bridge of the northern scale holder (D2).

**Step 14:** Glue the blank lower axle bearing (D3) onto the lower white half of inner side of the bridge (D1/D2). Make sure the edge with the small curves and angles sits right on top of the identically cut edge of the bridge.

**Step 15:** With a sharp knife, completely cut out the 2mm wide pre-perforated slits from both of the blank inner axle bearings (D4) and (D5), then glue them one on top of the other and onto the lower axle bearing. The edges of the inner and lower axle bearings cover each other exactly.

**Step 16:** Glue the upper axle bearing (D6) onto the inner axle bearing. At one end of the northern scale holder there is now a complete axle bearing with a square hole.

**Step 17:** Assemble the southern scale holder in the same way, using the parts (E1) to (E6).

**Step 18:** Cut two 12mm long pieces from the roundwood, to act as axes of rotation for the sun-scale, and glue them into the square holes of the axle bearings of both scale holders.

*Important: The axles shouldn't jut out less than 4.0 mm from the holes and not more than 4.3 mm.*

**Step 19:** Glue the northern scale holder onto the marked position of the meridian ring, so that the axis juts into the inner ring of the sundial. On the outside, its edge should be level with that of the meridian ring. On the inside, the axle bearing grasps around the hour ring, which still is able to be turned in one direction. The thin line on the axle bearing points exactly to the VI hour mark of the hour ring.

**Step 20:** In the same way glue the southern scale holder opposite it, on the marked position on the other side of the meridian ring. Here the line on the axle bearing points to the 18 hour mark of the hour ring.

## The Cursor

**Step 21:** Glue the circular diaphragm made from white plastic material over the hole in the blank back side of the inner part of the cursor (F1). The holes of the cursor and the diaphragm must lie exactly over each other.

**Step 22:** Glue the other inner part of the cursor (F2) with its blank back side onto the diaphragm. Make sure that both the inner parts' edges are exactly on top of one another and that the hole of the diaphragm is in the centre on both sides of the cursor.

**Step 23:** Glue the outer parts (F3) and (F4) onto the two sides of the inner part of the cursor. Once again the holes have to be exactly on top of each. Now from the left and right sides of the cursor, a wing juts out, which will slide inside the inner frame of the sun position scale.

## The Sun Position Scale

**Step 24:** Cut out both of the pre-perforated slits in the two ends of the inner frame (G1). Do the same with the other inner frame (G2), then glue both parts one on top of the other and onto the blank back side of the outer frame of the scale bearing the names of the months (G3). Make sure that cursor can move easily inside the two layers of the inner frame. If necessary, shorten the wings of the cursor slightly with a knife.

**Step 25:** Place the sundial ring on your work surface with the west side of the meridian ring (scale of positive latitudes 0° to +90°) face down. The side of the hour ring with the roman numerals should likewise be lying face down and the northern scale holder facing upwards.

Now place the sun position scale under the sundial, making sure the scale with the date inscriptions is lying on the work surface and the open inner frame is facing upwards. Important: The end of the scale marked **Jun** must lie next to the **northern** scale holder, the other end marked **Dez** next to the **southern** scale holder. Both of the axles jutting out from the scale holders snap into the slits of the inner frame. If the scale is too long to fit exactly between the scale holders, it is possible to shorten both ends of the scale with the knife.

**Step 26:** Now place the cursor with the side bearing "Datum" (date) facing downwards into the frame. Glue the outer frame of the scale (G4) onto the inner frame so that the **positive** numbers of 23.44° point to the **northern** and the negative numbers to the **southern** scale holder. This will place 23.44° back to back with **Jun** and –23.44° with **Dez**. Make sure there is no glue either in the inside of the frame, or in the bearings of the axes, otherwise the cursor cannot be moved and the scale turned.

## Hour Ring Stoppers

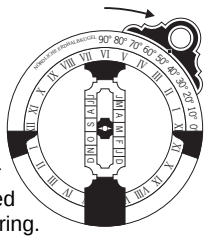
**Step 27:** Glue the front side of the stopper (H1) onto the back side (H5) with their blank sides back to back. Do the same with the front and back sides of the other stoppers (H2) + (H6), (H3) + (H7) and (H4) + (H8).

**Step 28:** Turn the hour ring so that it forms an exact right angle with the meridian ring. This can be controlled very easily with a corner of the cardboard sheet. Glue the four stoppers onto the marked positions of the meridian ring, so that they point into the inner part of the sundial and their broad, straight edges lock the hour ring into position when it is opened up at a right angle. It will then only turn 90° and no further.

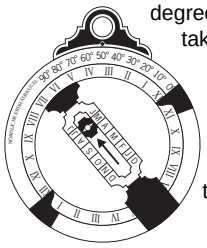
**Now your Universal Sundial Ring is complete. Congratulations!**

In order to make your sundial easier to use, pull a piece of cord through the hole in the suspension – this will help the sundial to hang in an exact downward position.

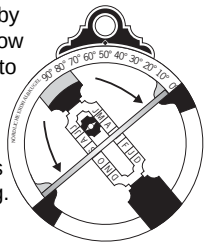
# How to use the sundial ring



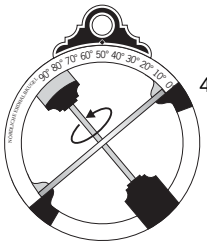
1. Adjust the sundial to the geographical latitude of your position. In one hand hold the meridian ring on the inside, and with the other hand move the suspension until the small square pointer shows the wanted degree. If you do not know your latitude, look it up in an atlas or take the one of the town nearest to you which you find printed on the meridian ring.



2. Adjust the runner on the date scale to the correct date by moving it up or down. On the back it will automatically show the corresponding declination of the sun, that is its angle to the celestial equator.



3. Open the hour ring until it touches the stoppers and stands exactly at a right angle to the meridian ring.



4. Hold the sundial by the cord in the suspension. Hold it to the sun and turn it slowly, until a ray of light comes through the hole in the cursor and falls into the centre of the inner rim of the hour ring. Here you can read Real Local Time. If necessary turn the face of the sun scale a little towards the sun.

## Special Properties of the universal Ring sundial:

1. This sundial always offers a set of two times, a morning and an afternoon time, both of which are at the same distance from 12 o'clock (for example 10:15 and 13:45). In the majority of cases there is no problem in deciding on the correct one.

2. Around the 21st March and the 23rd September, the spring and autumn equinoxes, the hole in the cursor is level with the hour ring, so no ray of light can fall into the inner edge. Nevertheless it is possible to determine the time by turning the sundial a little to the left and a little to the right until the ray of light touches the top and at the bottom of the inner rim. From there it is possible to estimate the centre point.

3. Keep in mind that the sundial does not show the GMT (Greenwich Mean Time) nor Central European Time (CET) but Real Local Time (RLT). The latter is valid only at a specific location and all places directly north and south of it. RLT is defined by the position of the sun: it is always precisely 12 o'clock when the sun reaches its highest point in the south. Real Local Time differs in the east – west direction, because in a place further in the east the sun reaches its midday position earlier, and in a place further in the west later. The difference is 4 minutes for every degree of longitude. For example in Newport/Wales (+3°) the sun is in its midday position 3 x 4 = 12 minutes later than in Greenwich/London (0°) and 13 x 4 = 52 minutes later than in Hamburg/Germany (-10°). In comparison Greenwich Mean Time (GMT) is an artificial time standard valid by agreement in a larger area. It is based on the noon times measured at Greenwich but levelling out the slightly slower or faster movement of the sun, as compared with a clockwork, a difference which can sum up to ±15 minutes.

4. If the sundial ring shows the correct time, the meridian ring hangs automatically in a north-south direction. So, if you know the date and geographical latitude, you can easily determine the cardinal points.