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pattern that the sun shows when photographed at civil noon each day. There are two causes for this effect: the fact that the orbit of the earth is not circular but elliptic, and the fact that the axis of the earth is not square to its orbital plane. The author did not find an explanation of the physical and mathematical issues involved, and therefore set out to investigate.
This first part deals with the elliptic orbit and its effects. Figure 2 shows why a solar day is longer than a star day: the earth has moved on in its orbit, and has to make up for this by rotating somewhat more than one rotation in order to have the sun in the south again. This extra bit is variable over the year, because the speed of the earth in its orbit is not constant, in according with Kepler's second law. It is largest in January, when the earth is closest to the sun, and smallest in July. If it were the only effect, the solar day would be 8.23 seconds over 24 hours on January 3, and 7.82 seconds under half a year later. These differences accumulate, and a sundial would be a maximum of 7.64 minutes slow or fast, as figure 5 shows. In reality, of course, it can be more than that.
Part two therefore will deal with the second effect, which will about double the maximum difference between the real and the mean sun.

A small noon dial *J.A.F. de Rijk* *20*
De Rijk has a weakness for paper sundials. The butterfly sundial was his latest for quite a while (it is easily found on our website), but further experiments produced the paper noon dial. It is a polar dial, on which a small sun image shows noon on an equation-of-time loop. It suits the window-ledge quite nicely.
Included is a cardboard cut-out for readers to construct their own copy. For sufficiently differing latitudes, the design should be modified using the equations provided, where *Hoek alpha* means angle alpha, and *Gnomon hoogte* is the gnomon height.

A sundial behind double glazing *F.J. de Vries* *22*
When there is a gnomon on the outside of the windowpane and an hour line pattern on the inside, the refractive index of the glass will necessitate a modification of the pattern as compared to one in free air. Today's dwellings are normally equipped with double glazing, so that refraction occurs twice. How will we calculate the pattern is this case? Thijs de Vries published a practical sundial calculation method as early as 1981. The *Zonnewijzerkring* website describes it in detail; the principle is to describe the position of the sun in x, y, z coordinates with respect to the equatorial plane, and then to rotate this plane about the x, y, z axes into the sundial face, transforming the coordinates as one goes along. The final x and y in the dial face give the pertinent shadow point.
Now, in the double glazing problem, situation is divided into four parts, with a gnomon in each part. So, we have the real gnomon on the outside; an imaginary one in the outer pane; one in the air between the panes; and one in the inner pane. Each nodus shadow will be the location for the nodus of the next gnomon; and so on until the shadow of the last, which is the requested point. Its final coordinates are the sum of the corresponding local coordinates of the shadows.
The addendum repeats the x, y, z method for the construction of any plane dial, and supplements this with the modification needed to account for the refractive index.

Sundials in The Netherlands *A.G.M. Bron* *26*
All the sundials in this instalment are in Friesland, where Bron visited 14 dials in two days. Incredibly, the weather remained fine.
Drachten 04. A sturdy 80cm diameter armillary with meridian, moveable Arabic numerals (of which 12 is missing). Inscription on style bottom reads: Presented by employees and staff of De Brug Corporation. Pole style elevation is 48 degrees (instead of about 53), but the meridian is reasonable. Overall condition is miserable.
Drachten 03. West declining vertical sundial, 148x94cm, on the front of a balcony. Hour lines from 9 till 5 (17); roman numerals IX, XII, IV; MET*. By De Jager, probably 1965. Excellent condition.
Tzum 02. Granite sphere, 40cm diameter, 80kg; set in two triangular stainless steel sheets of 86x77cm (WxH) on an upturned round concrete trough. Around the equator, between the tropics, are the eight I Ching trigrams: heaven, wind, water, mountain, earth, thunder, fire, lake. Stainless steel pins, protruding 10cm, tell time: the pin

corresponding to the correct hour has the shortest shadow. By Cor Peters.
Franeker 05. Slightly west declining vertical sandstone sundial, probably 17th century, on the rear of Churn House. Restored in 1994. Arabic numerals from 6 till 6 (18) and half-hour points, for local apparent time. Two-point style fixing.
Franeker 07. An analemmatic terrace dial, 8x6.4m; bluestone date scale 1x2.2m. All 24 hour points present; MET. Roman numerals V till VIII (20); the remaining hour points are star-shaped and lighted at night. Design: Eise Eisinga Planetarium. Calculations: Hans Molema. Commissioned by the borough of Franekeradeel; finished 2005.

J. Mandl's Altitude Abac *F.J. de Vries* *30*
This is based on F.W.Sayer's article of the same name in Compendium. – The first figure shows the relation between declination, altitude and time for 40 degrees latitude. It is a simple matter to expand the figure for other latitudes, as shown in the last figure. Sawyer has integrated the solar altitude measurement into the abac. The shadow of a solid astroid gnomon, placed over the altitude scale and, together with the abac, turned into the sun, indicates the altitude (second figure). This will not work correctly, however, for altitudes over 54°44'. Sawyer solved this problem with an intermediate scale (third figure). An appendix lists all pertinent equations.

Literature, 1580…1583 *Verschuuren, Theunissen, Maes* *34*

Leaflet: Bakkeveen multiple sundial *F.W. Maes* *39*
A hand-out description of the Slotplaats sundial for interested visitors and for promotional purposes. It describes all sides in detail, pointing out the use of the edges as pole styles, of which there are twelve, serving sixteen horizontal, vertical, (plane and cylindrical) polar, and equatorial dials. There is also an explanation of the difference between civil and local apparent time with an equation-of-time graph, as well as a short history of the sundial. Naturally, the *Zonnewijzerkring* is mentioned.

Equation of Time and Declination for 2008 *T.J. de Vries* *41*

Cut-out: Small noon dial *Editors* *47*
Printed on thin cardboard stock, this noon dial is ready to cut out and build.

Correction for the May bulletin: If you have not already, please discard the original contents and colophon pages in the May bulletin, and replace them with the new ones supplied with the September issue. This will correct an omission in the table of contents, and update the Committee information.