Optional file (Sequence 3)

A " Sun calendar" with a sample of shadow drawings

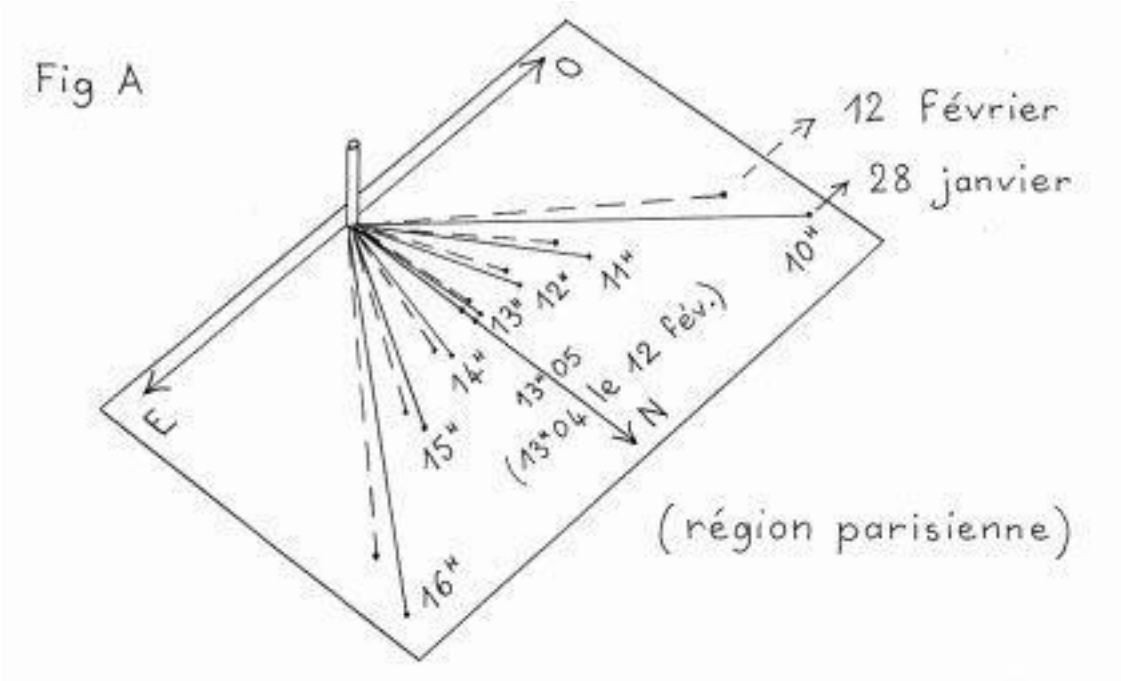
How can shadow be used as a " calendar ".

At least ten days (even more) after the great moment of the last shadow survey, the pupils put the gnomons back under the Sun with the sheet of paper of their previous drawings, to see if the shadow will get back to the place it were on the right time. In fact, no ! From the first observation in the morning there is a clear difference, as if the shadow was " late " (if after the 21st of December, or " soon " if it's before). So, the pupils can put another sheet of tracing paper upon the first, and, when they draw this shadow, they can see that it has shifted, and that it also is shorter (or longer). The gnomon cannot be responsible for that, and the pupils can deduce that " The Sun is not exactly at the same place as the other day ! ". The observations during the other hours of the day will confirm the phenomenon, except one moment : solar midday. This shadow has not shifted, it is only slightly shorter (or longer).

However, an exact reading at solar midday can show a slight shift regarding watch-time, which may mean that solar midday is not exactly as the same time as ten days before. Other readings will show that this shift changes all around the year, changing the time of solar midday compared to " official " time. This is because " official " time doesn't count some changes in the course of Earth, caused by the fact that the axis of the poles is not perpendicular to the plane of the course of our planet around the Sun, and that this course is not exactly circular, but slightly elliptic.

Note : It is also possible to observe these changes with a calendar showing sunrise and sunset, and study with a graph the changes of the time of midday (sunrise time minus sunset time divided by 2) during the year.

The pupils will see then that the changes in the new drawings show a symmetry regarding the spot of solar midday, their " fan " having slightly " opened " or " closed ".



If they know how to explain why the length of their drawings have changed, they will have problems to

explain why they " opened " or " closed ". This is in fact a question of space geometry (field of cones) : the tip of the shadow draws during the day a curve called hyperbola, evolving and reversing from one solstice to the other, becoming a simple line at the time of the middle phase of the two equinox. Reason of the interest of making other drawings several times in the year to follow the changes.

Useful notes about Sun " calendars ".

The figure below shows, in a theoretical way, the " fans " of shadow drawings of the same gnomon (under our latitudes) during the solstices and equinox. We can see that the symmetry is set by the shadow at the time of solar midday, simplified as midday hour. So, the two symmetrical drawings of each pair are of the same length. But there is generally a difference of length between the two, giving a general dissymetry to the fan, more or less important. Why ? It is because the surveys have been made each hour on the dot, and that the real time of solar midday, as we have seen, is not exactly at 1 PM (or 2 PM) in a given place : these readings cannot give the real axis. A second problem arises : the angles in the drawings of the same fan are not equal in fact, at a minimum in the early morning and late afternoon, and at a maximum around solar midday, for a question of space geometry the pupils would have problems to understand (but this won't affect the project itself).