**Optional file (Sequence 3)**

# Simulate the seasonal changes of a gnomon's shadow

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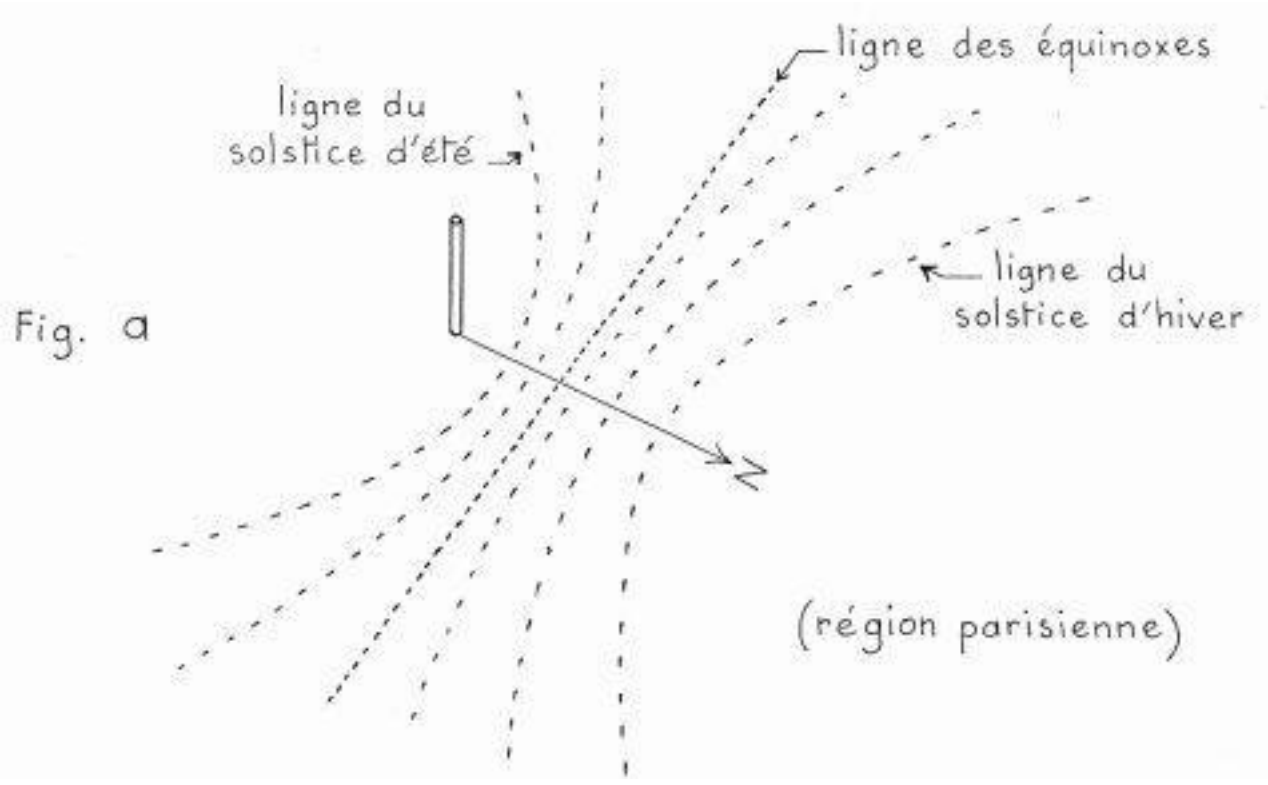
The simulations given here are about the evolution of the line made by the tip of a gnomon's shadow during the day, from season to season. There should be, prior to these, several sessions of surveys throughout the year (2 every 3 months at least).

## Simulation during spring (or autumn) equinox

After the surveys made in autumn or winter and the following simulations, your pupils will possibly think that the shape of the curve described by the tip of the shadow is the reversed reflection of that of the Sun (or their lamp). This new simulation will prove them against it. It would be best to make before a new survey very close equinox, after another made two weeks before, in order for your pupils to see that the curve slowly becomes a right line ! (prepare sheets with a simple right line, long enough, ahead of the gnomon's base). Using their lamp as before, the children will understand that is " has to " describe a curve ! ( And they will understand that the rules of geometry implied in that are not so simple as it seems… ).

If a new session comes shortly after the equinox, the pupils will see the new tendency of the line linking the ends of the drawings : tell them to anticipate what it will become, write down what they think, and check it on the field on the next session. It is probable that, towards the end of the project, some pupils will be able to predict effectively what the curve is going to look like during summer, and then autumn : but they will be able to check it only with a gnomon made at home. (the figure below is to be compared to figure B in the optional file " Sun calendar with a sample of shadow drawings ".)



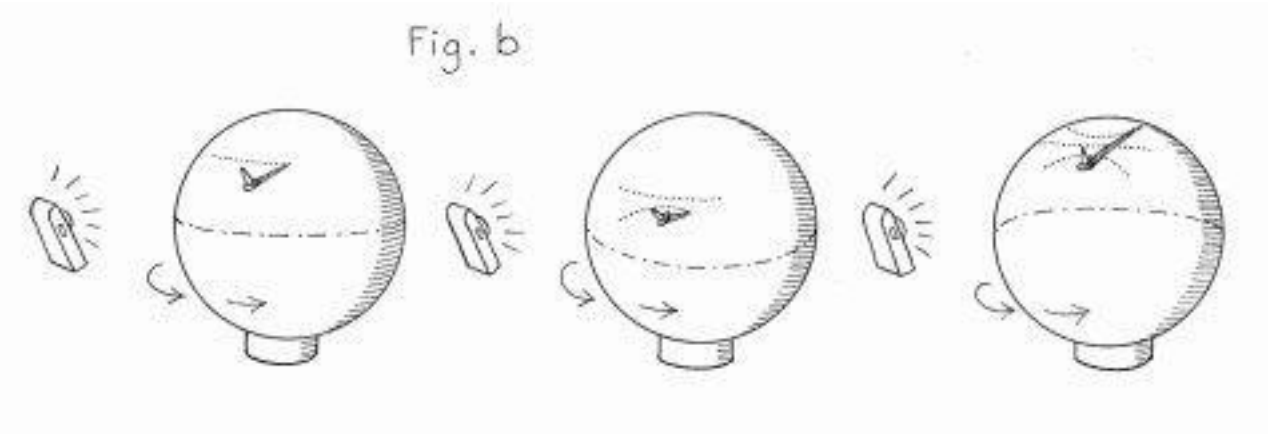

The two equinox have their interest also, relatively to the angles of sunbeams at solar midday, as well as… latitude. If your pupils already know these two notions and began a few measures of the angle, they will see that on any equinox day, the value of this angle is equal to the latitude of their school !

This day, Sun illuminates Earth in a very particular way. Our planet being lit by half, the circular limit of its " day " half goes exactly through the two poles : a gnomon -on the " real " Earth- placed on these two points would have an infinitely long shadow since the Sun strikes horizontally, and the angle goes up to 90° (effective latitude of the two poles).
Inversely, at the equator, the Sun striking the gnomon vertically (there would be no shadow), the angle would be null (latitude 0° for the equator). In the same way, all other places on the Earth get, this day, the precise value of their latitude for their angle at solar midday.

## Simulation of the seasonal changes with a balloon

(See before part 4 of session 3)

A tiny gnomon of modeling clay is fixed upon a balloon lit by a lamp. The pupils try to draw the moves of the shadow's tip as the balloon is slowly rotating with its moving base. They compare the line obtained (1) with the ones they already got on their tracing paper (outside) and they devise a way to reproduce one of these lines…
They are instructed to keep the lamp from moving and not to move the gnomon. They will finally understand that, on solar midday, they will have to slightly tip their balloon facing the lamp. Either to the fore for a " summer line " (2) or to the back for a " winter line " (3). On the following figure, the line of the equator shows how to do it :




But… Does Earth really tip in space during the year ?
This is a very interesting question the pupils will be able to solve, using this time a globe turning around a circle of lamps representing the Sun : they will see, for example in France, that to get the same effect during the course of the globe, its axis will have to be parallel to itself at every point : when the axis seems to tip towards the " Sun ", it will be summer in France, and when on the other side it seems to tip backwards, it will be winter. The pupils will deduce the position of the globe in spring and autumn.