Local Horizon and Sundials

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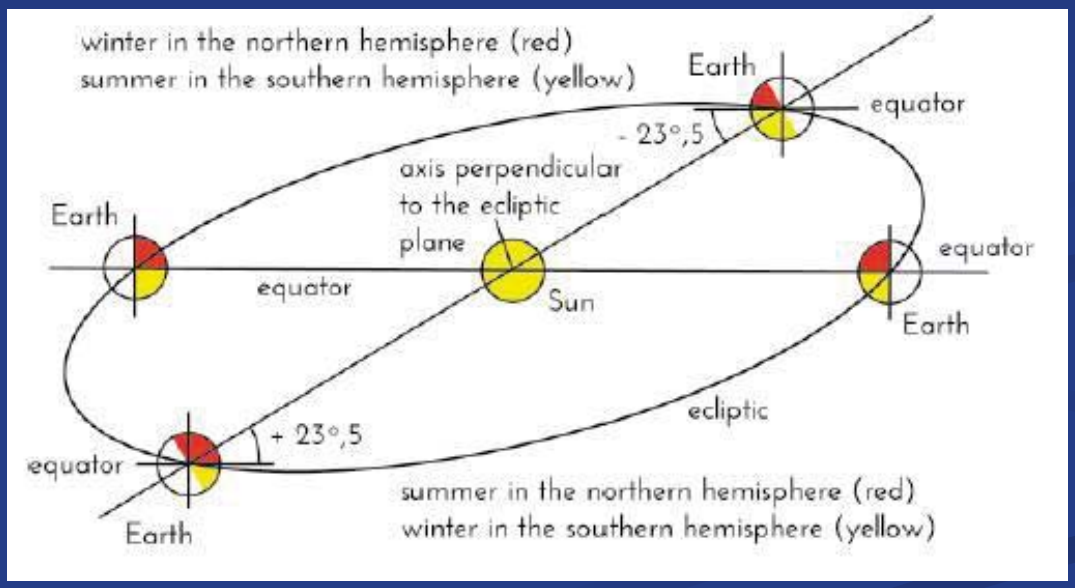
Goals

- Understand the diurnal movement of the Sun
- Understand the annual movement of the Sun
- Understand the movement of the celestial sphere
- Understand the construction of sundials

The Earth rotates and moves

rotation (day / night)
orbital position (seasons)



Model: Four Earth spheres with the Sun (a bulb) in the middle.

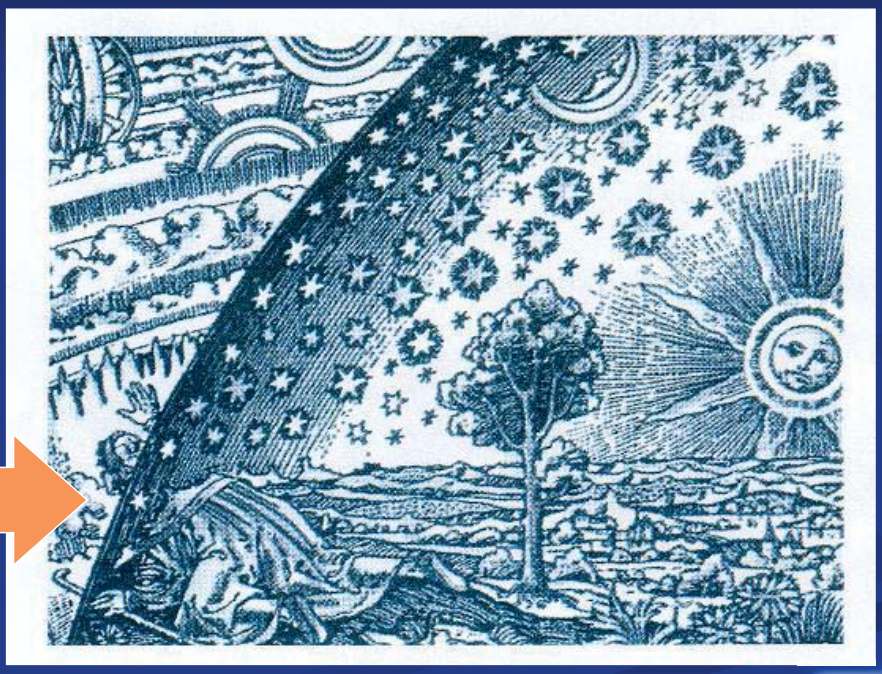
The line from the center of the Sun to the center of the Earth makes a 23 ° angle with the ground (which represents the plane of the Equator).

position A: Sun to +23.5 º:
summer in the northern hemisphere
winter in the southern hemisphere

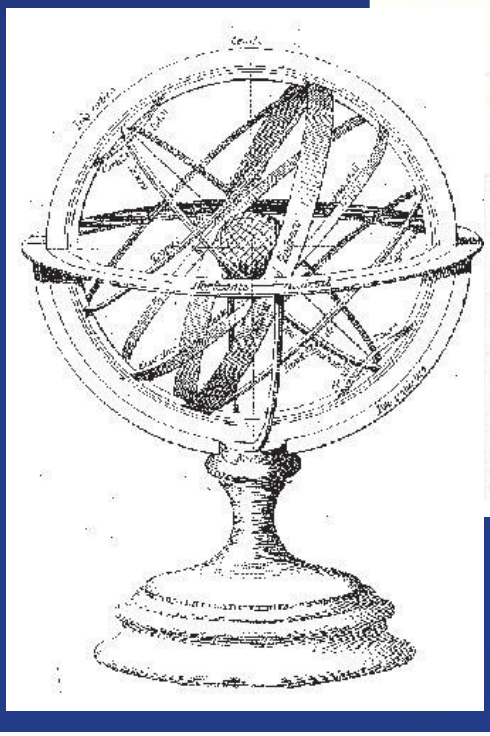
position C: Sun to -23.5 º :
winter in northern hemisphere
summer in the southern hemisphere

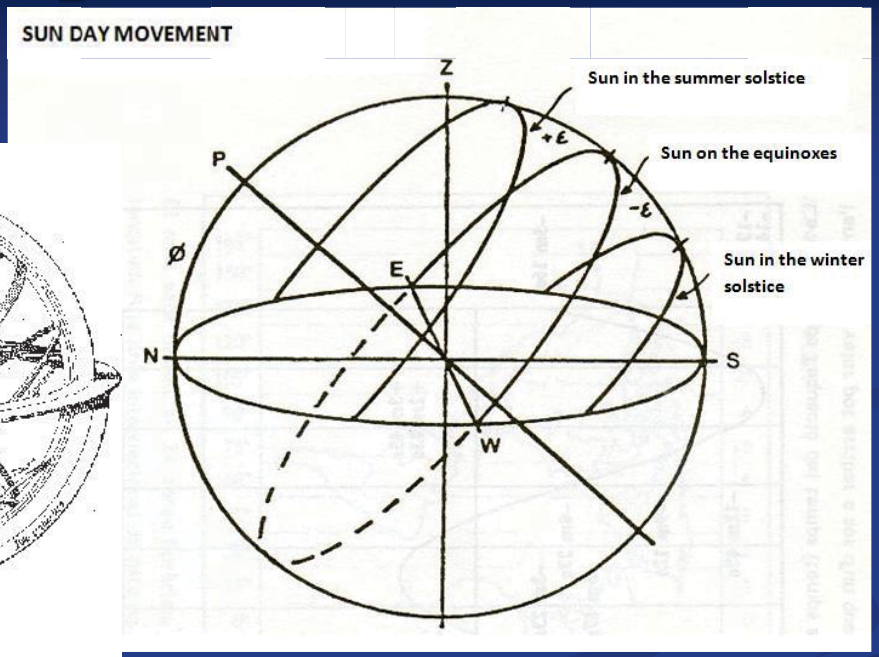
Rotation and celestial movements of day and night

- Not the same as seen from inside or outside

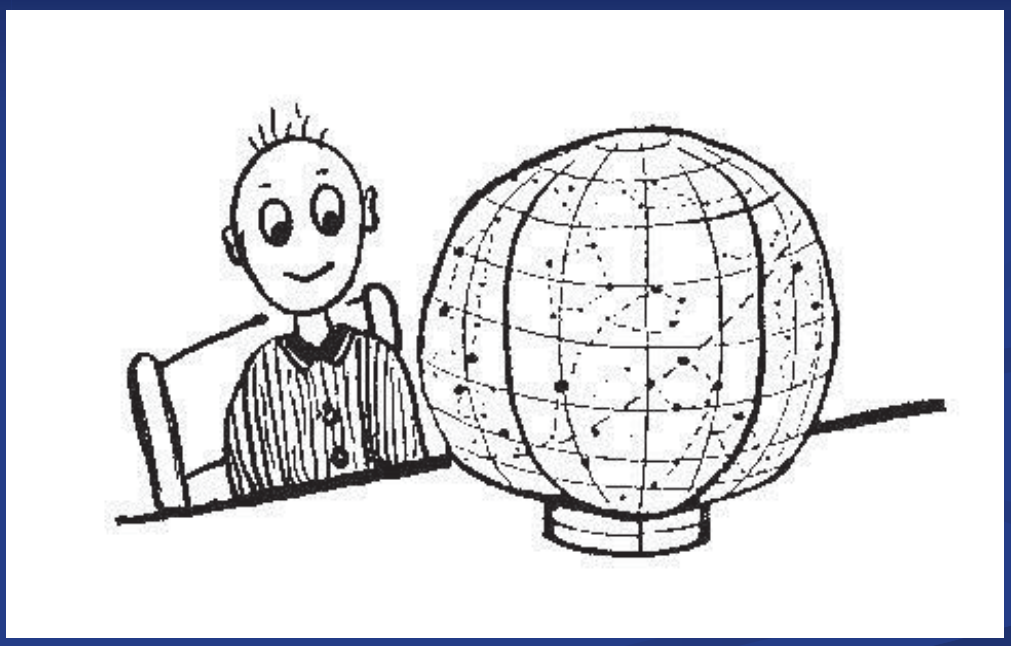


Celestial sphere "from outside"

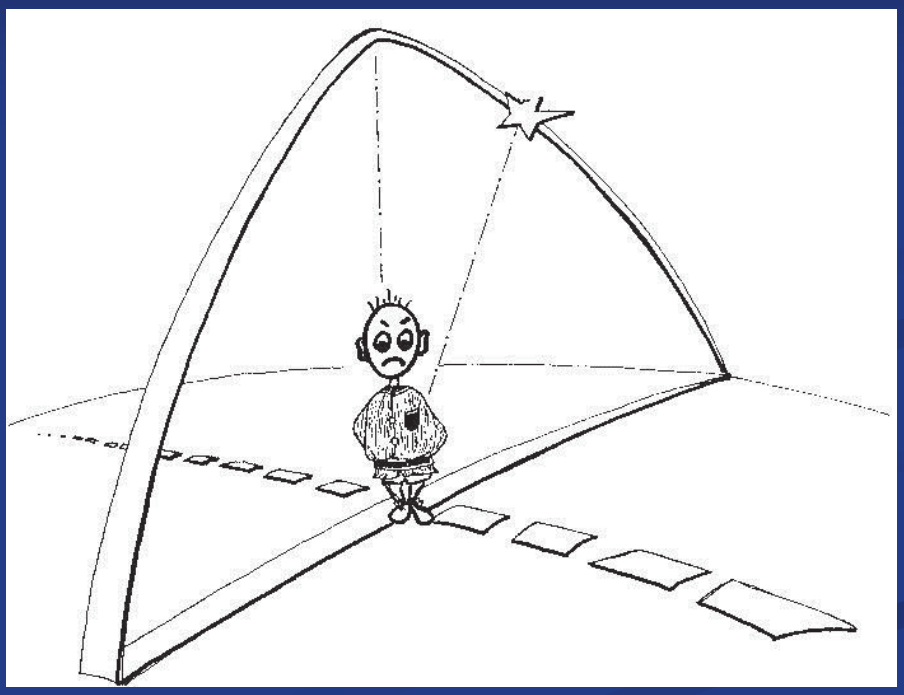




... it seems that everything is controlled



but after class, ... he is disconcerted



All schools have an "Astronomy Laboratory"

- They have a playground or school yard.
- They have the sky above
- They have clear days / nights
- THESE MUST BE USED!

We will build a model of the visible horizon from school

We begin by photographing the place of observation

- local horizon

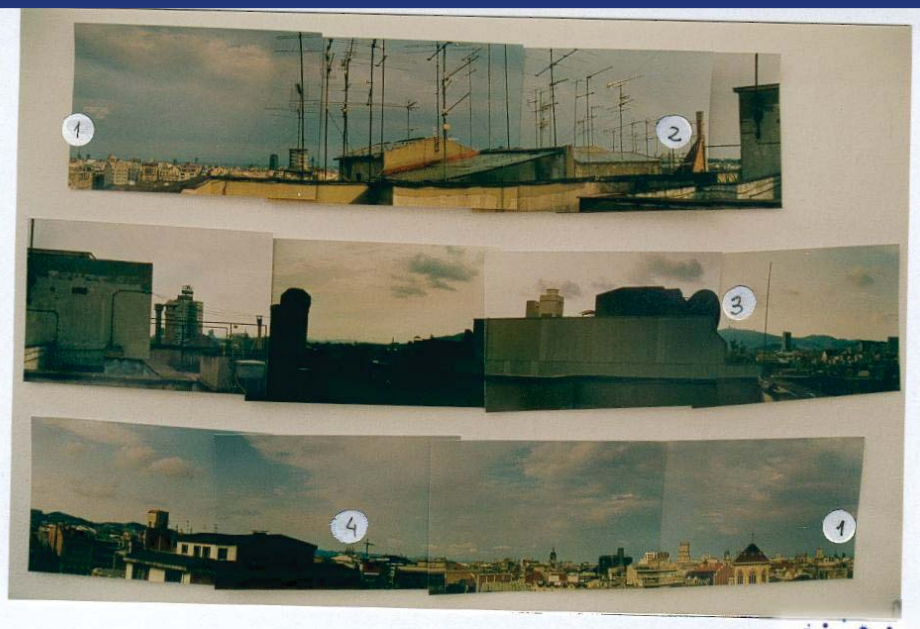
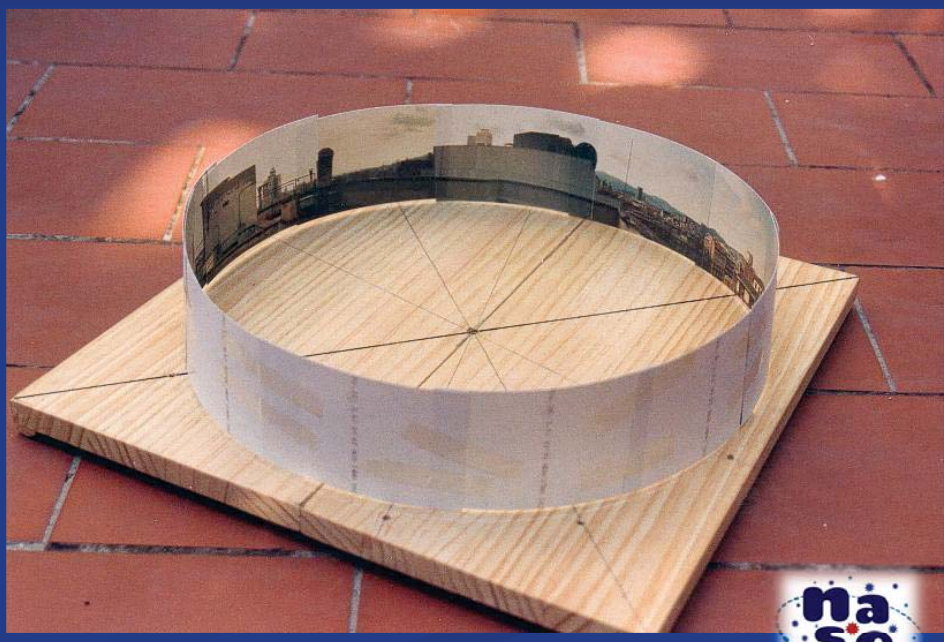


Figure 1: *Zona del horizonte fotografiada en Barcelona.*
1 Catedral, 2 Montjuic, 3 Tibidabo,
4 Sagrada Familia, 1 Catedral.

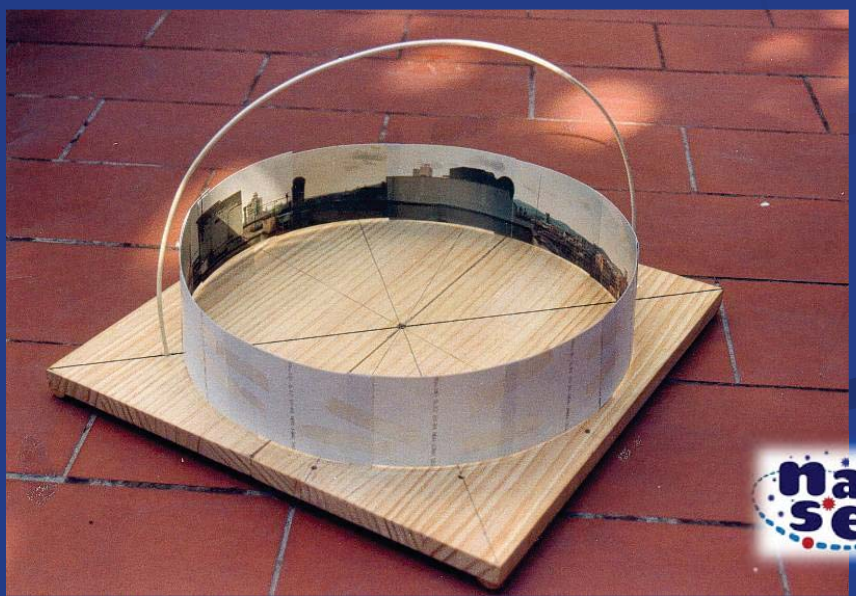
Let's put the photos together on a support platform

- local horizon

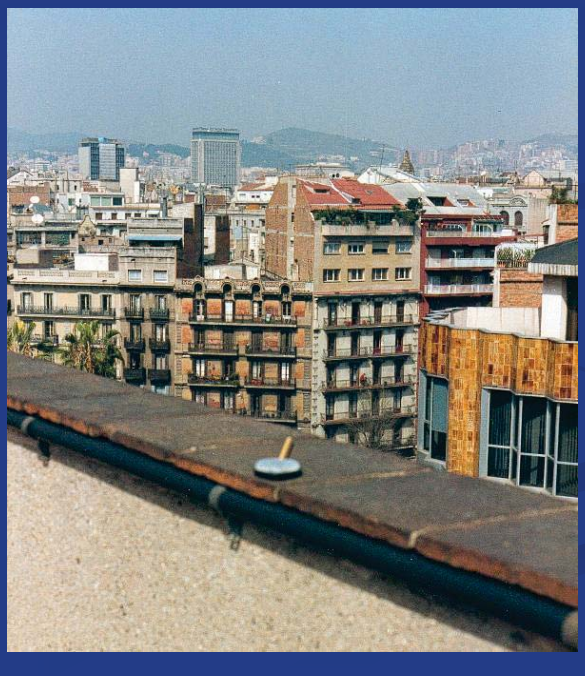


… we must adjust the photographed horizon to align with the real horizon

- The line N - S and local meridian

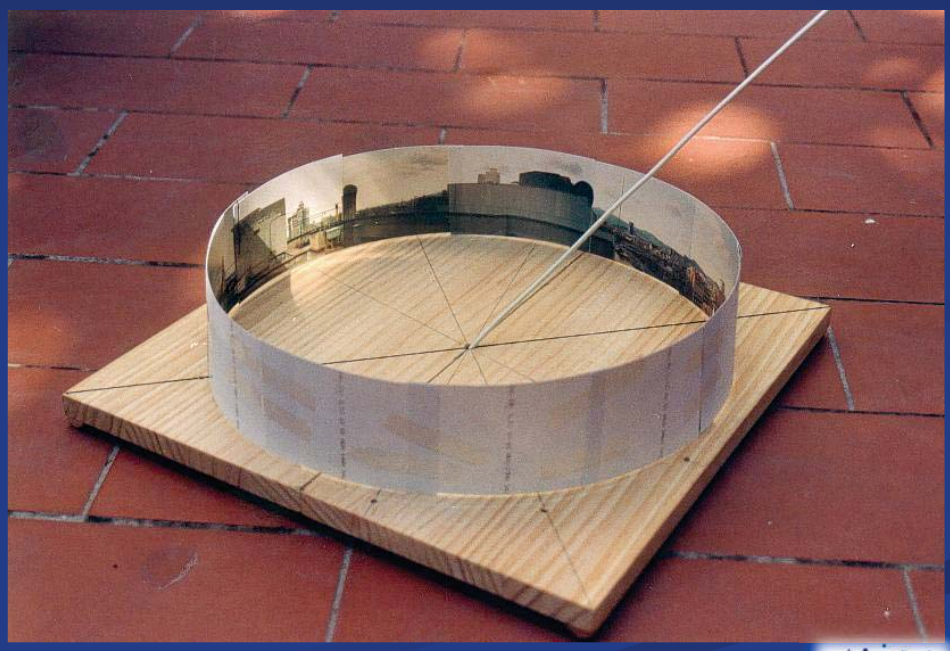


To position the model we can use the compass direction, or better, we can use the projection of the pole above the horizon

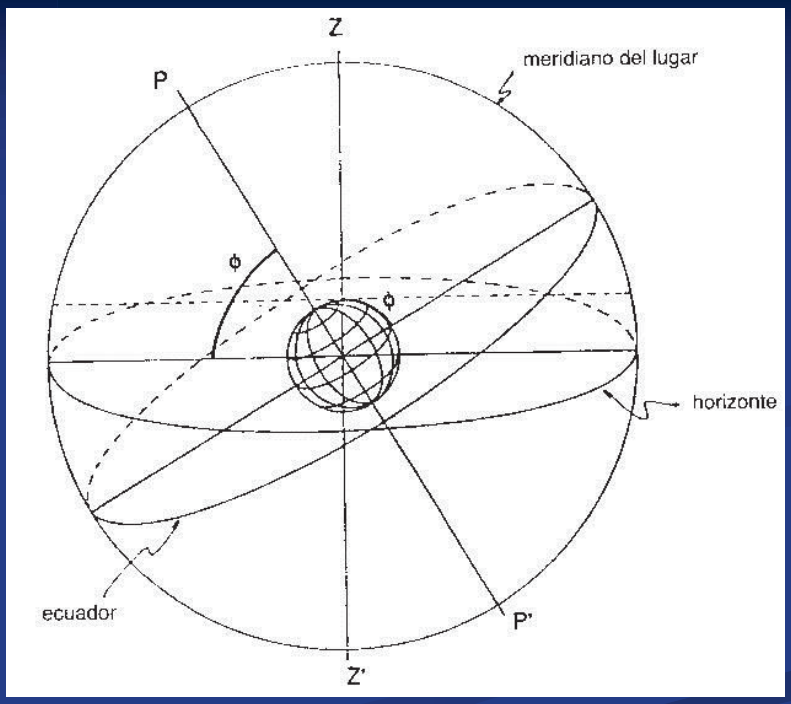


Introduce Earth's rotation

- axis of the Earth

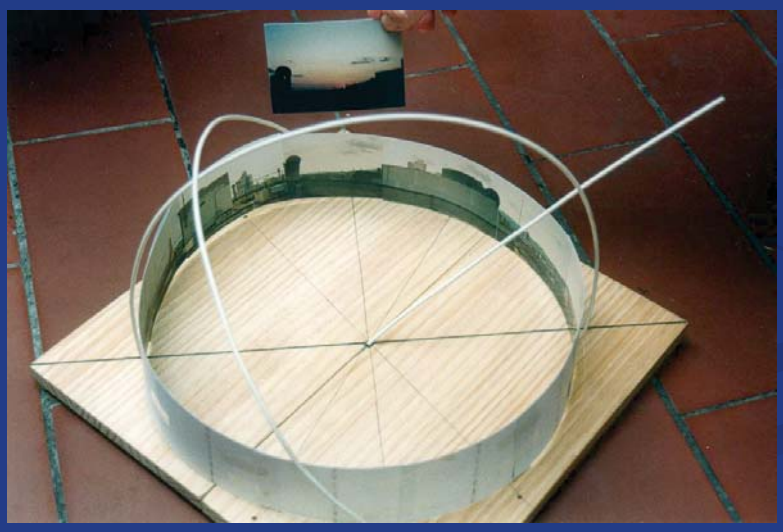


Your latitude is equal to the altitude of the pole



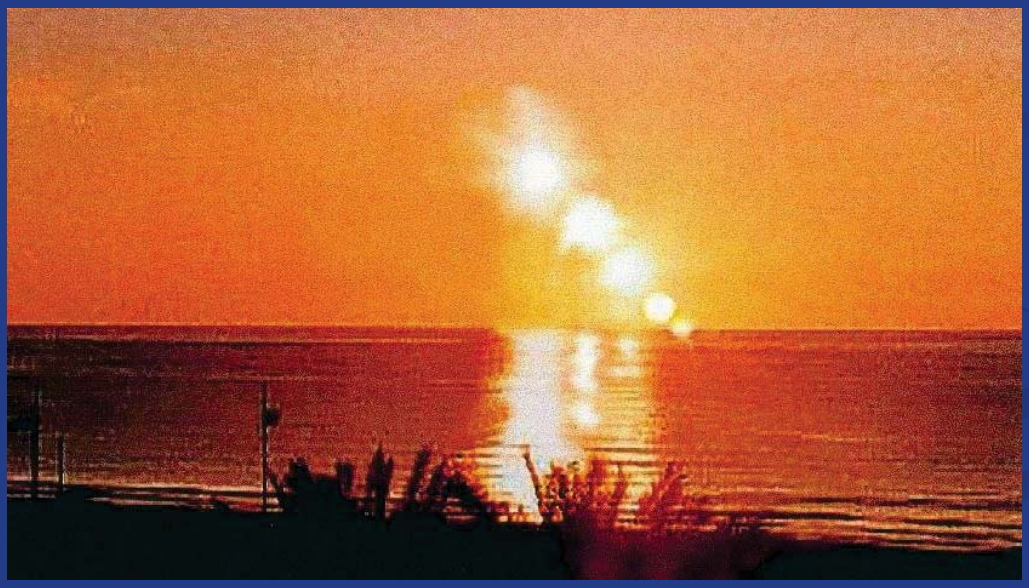
Indicate the apparent path of the sun on the first day of spring / autumn

- Use the Sunrise/Sunset photos



Movement due to Earth's rotation: Note the angle of the sun's path

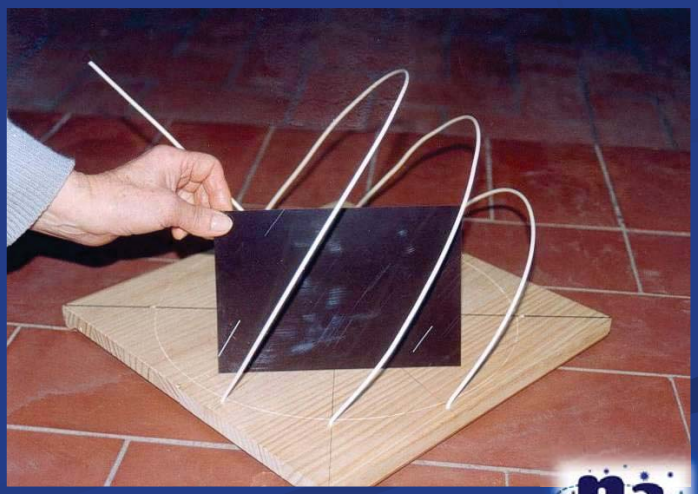
- Day - several images near sunset



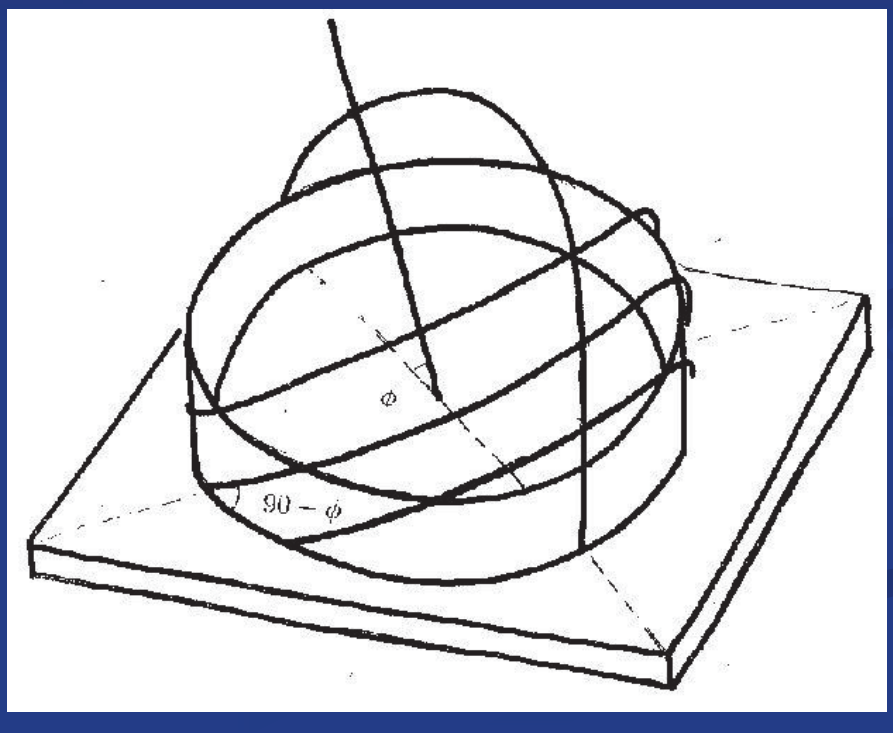
Movement due to Earth's rotation: : Note the angle of the star trails

- Night – time exposure of stars

Rotation movement in the model

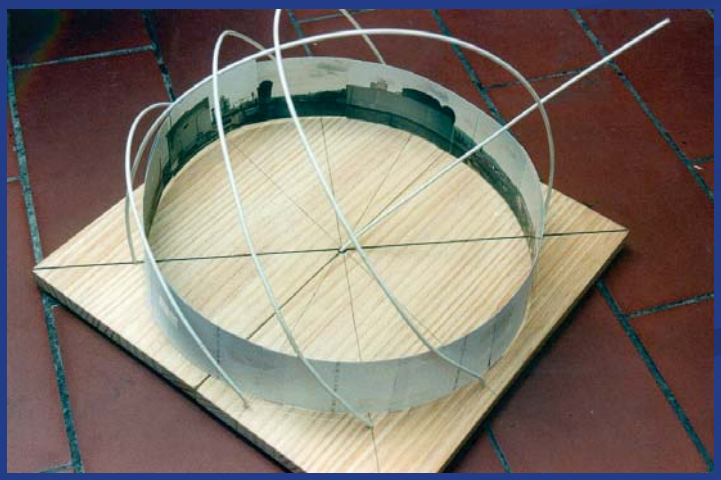


The inclination of the sun's apparent path and star trails depend on latitude

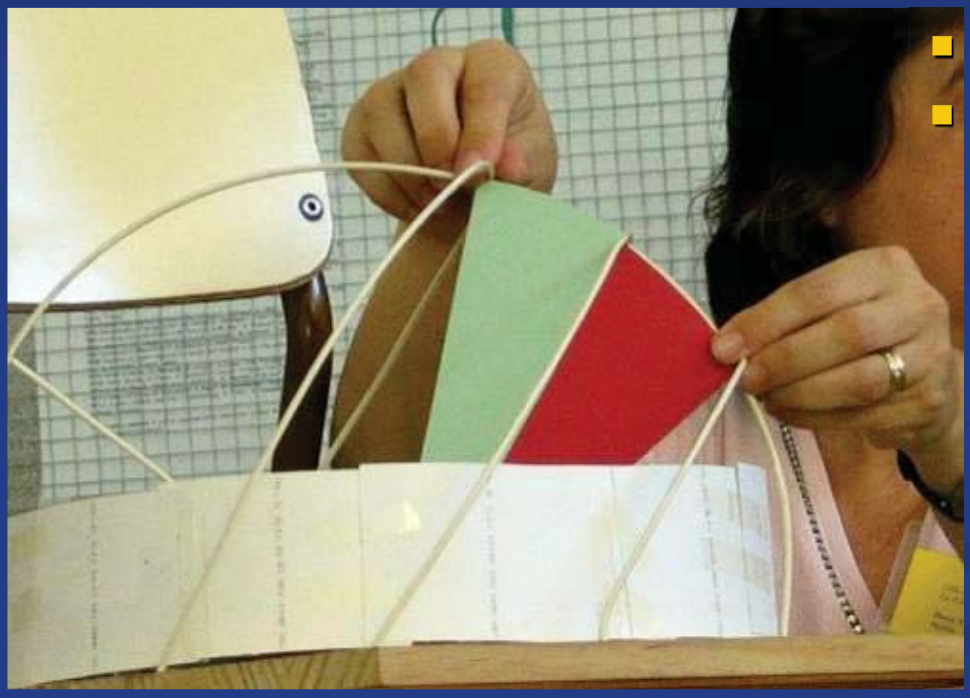


Solar paths on first day of each season (note the different durations)

- Summer Solstice
- Autumnal/Vernal Equinox
- Winter Solstice



Orbital motion leads to the seasonal positions



- Summer
- Spring / Autumn
- Winter

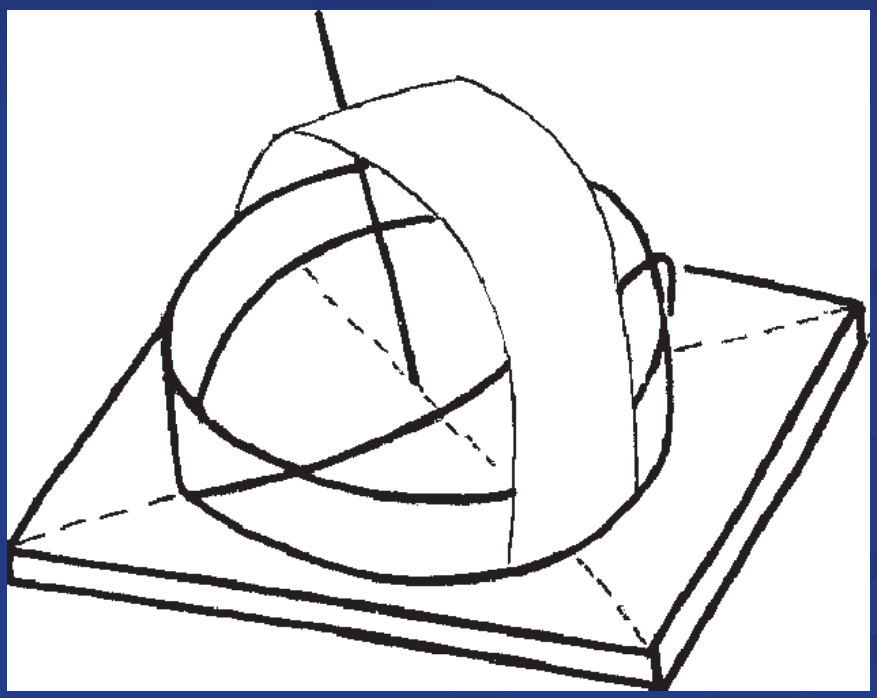
- Angle between equator and Tropic and Cancer or Tropic of Capricorn = 23.5 °

Earth's orbital motion leads to change the position of sunsets every day

- 3 sunsets:

Winter - Spring / Autumn - Summer

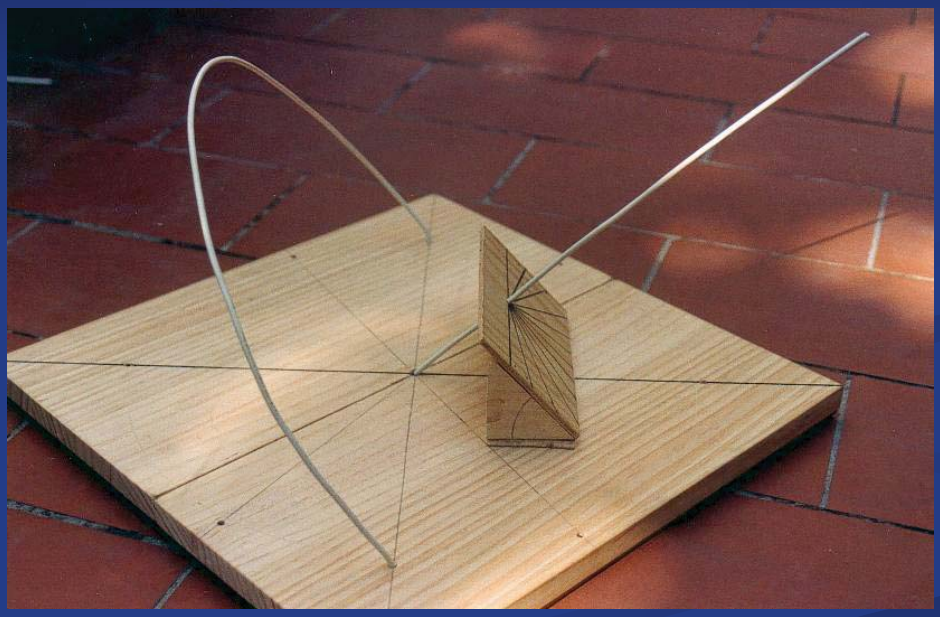
Viewing the "meridian" in the model



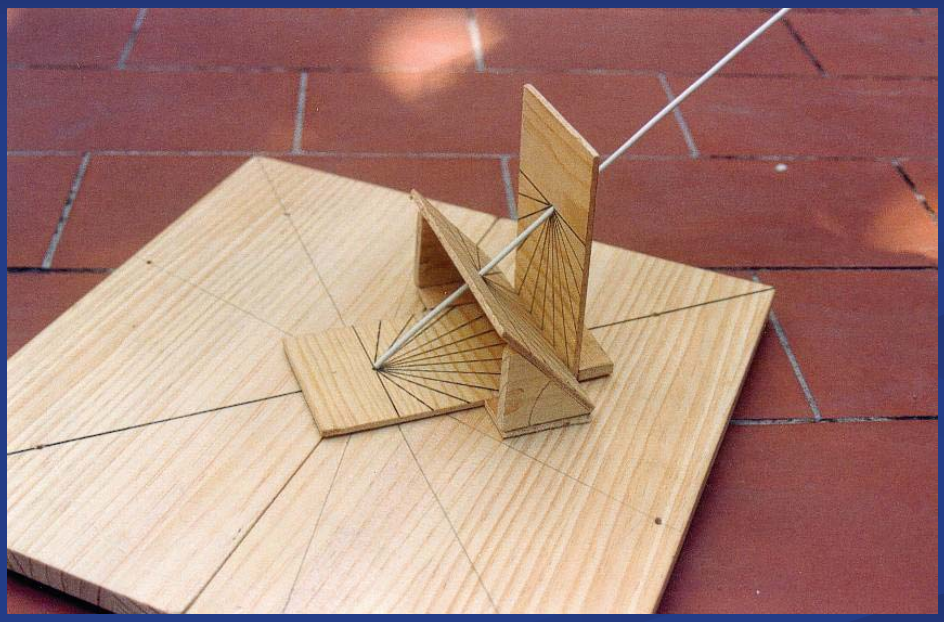
…around the pole: circles

…near the equator the trajectories change from concave to convex

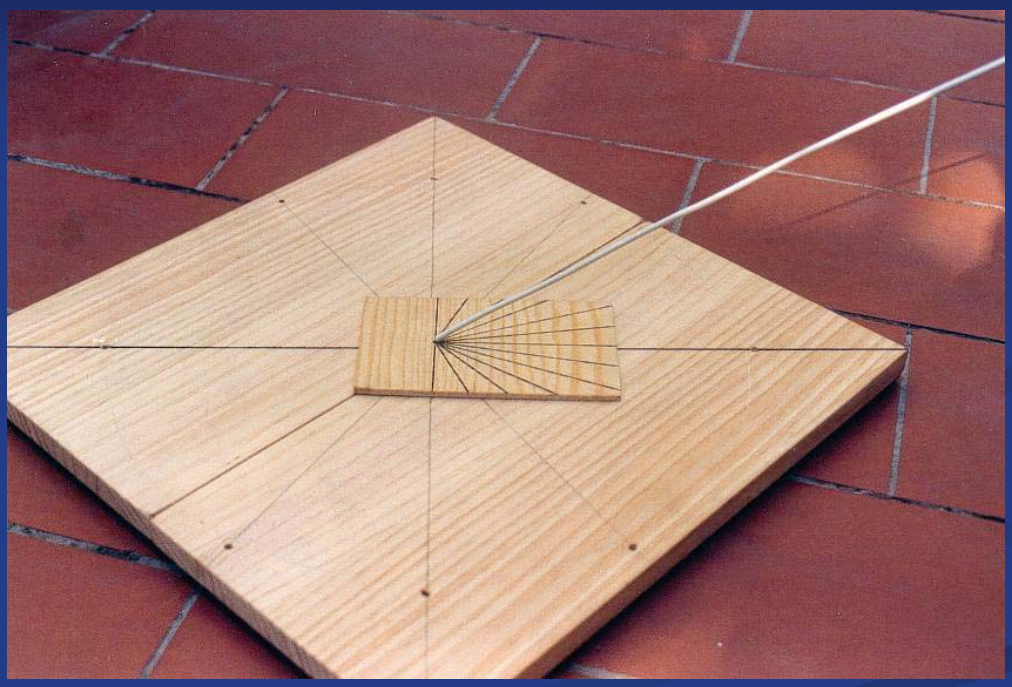
…the model is no more than an equatorial sundial!



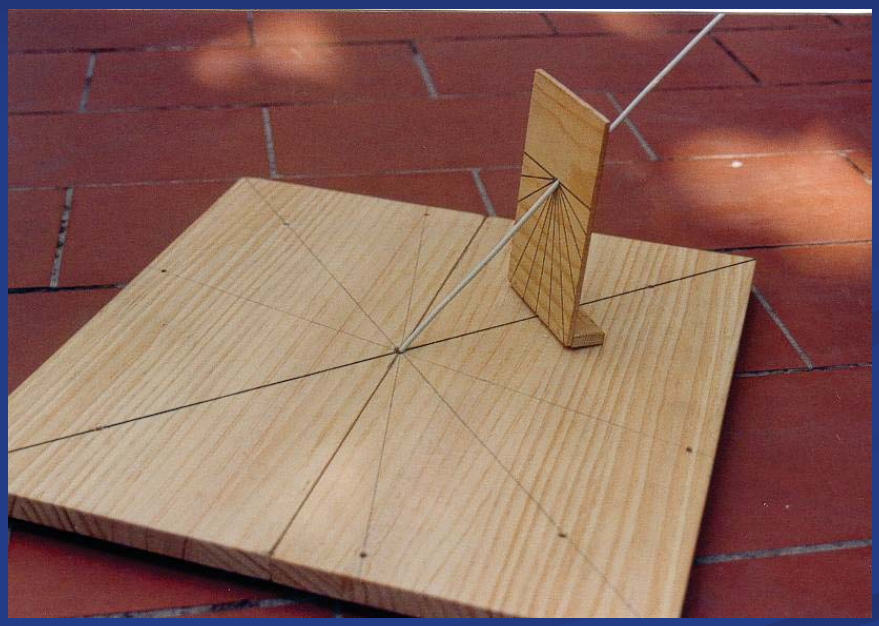
…and from it other sundials can be made from the equatorial one



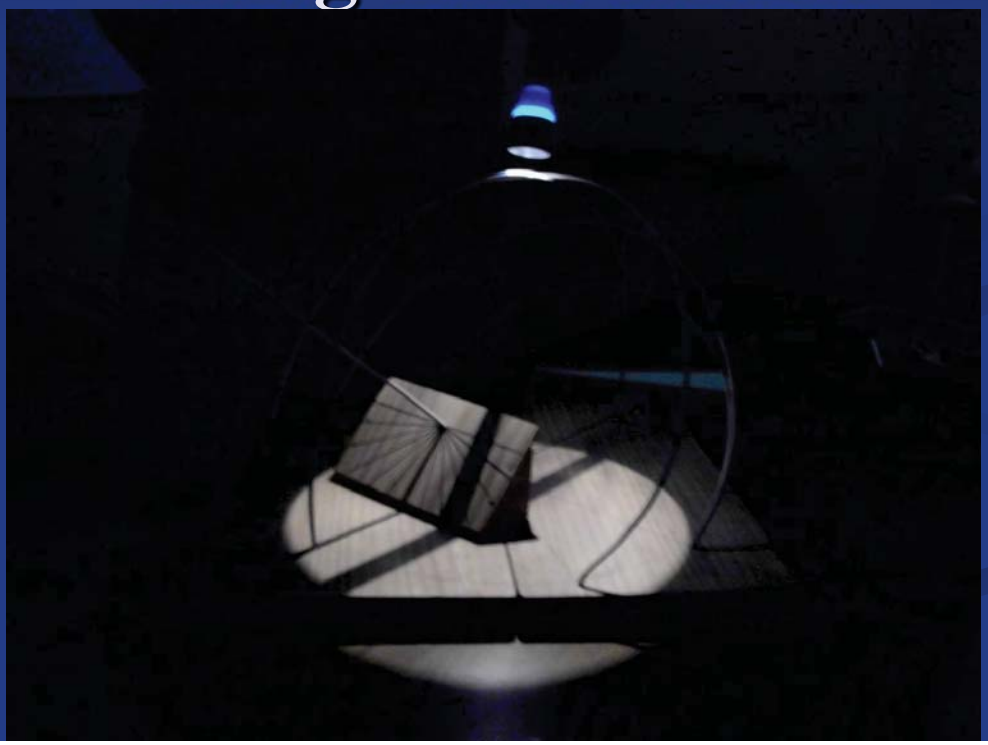
… the horizontal sundial



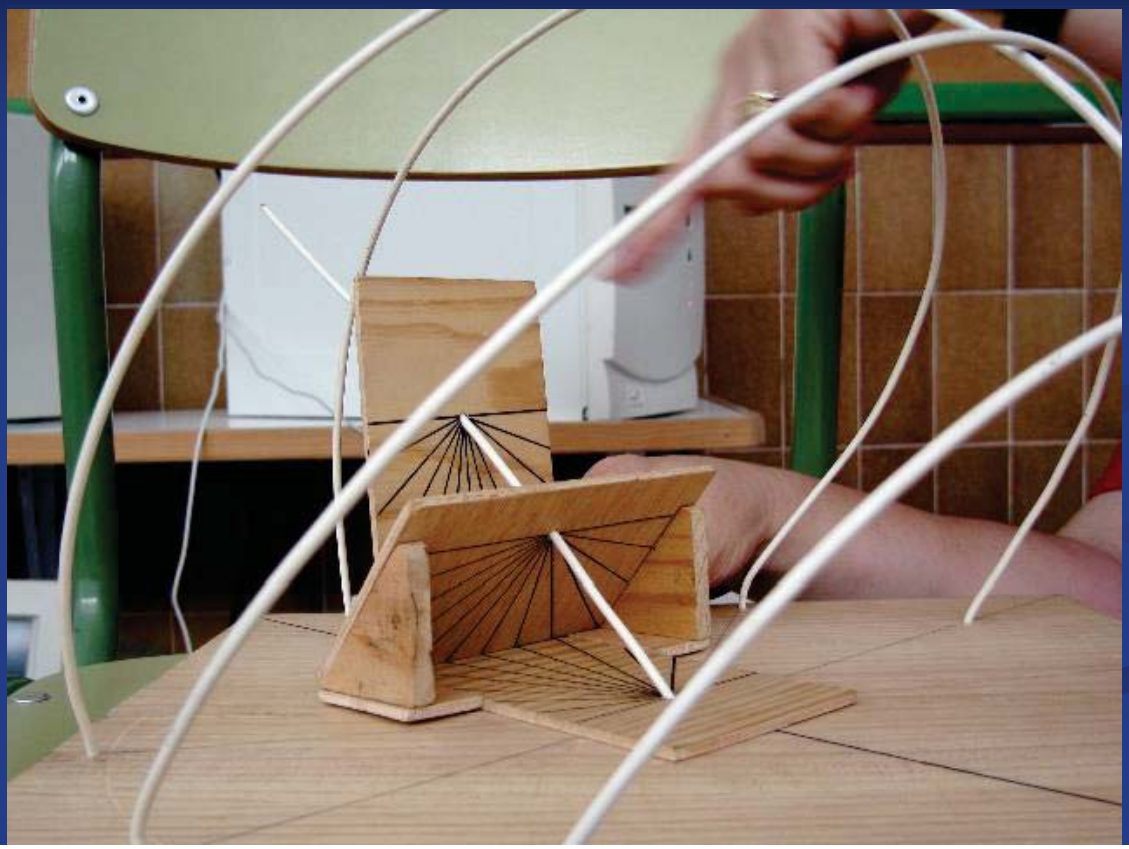
…and the vertically oriented sundial



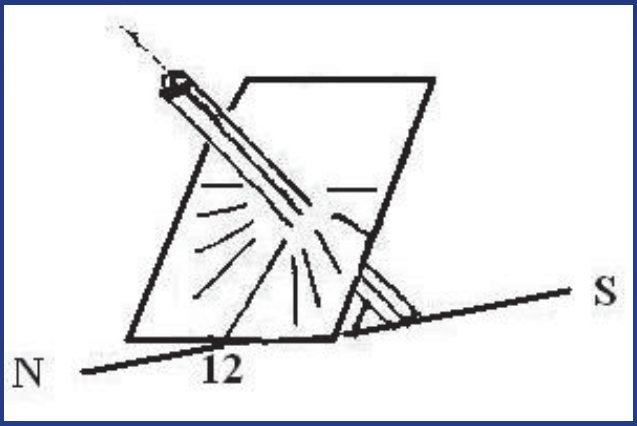
… and with the Sun (or with a flashlight) we observe the model acting like a sundial

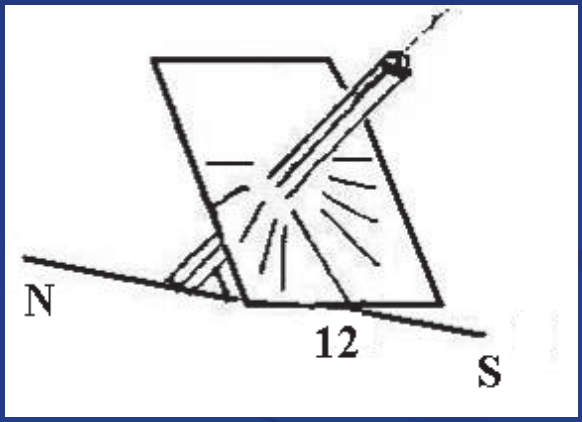


The three sundials in the model

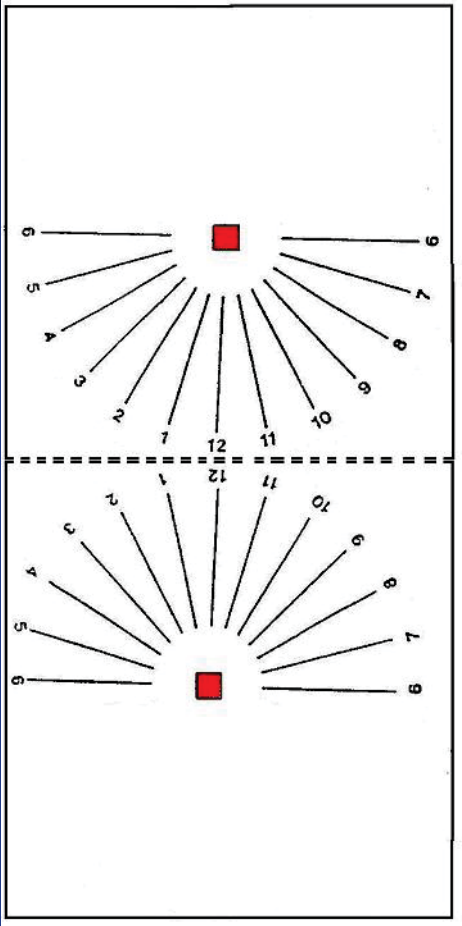


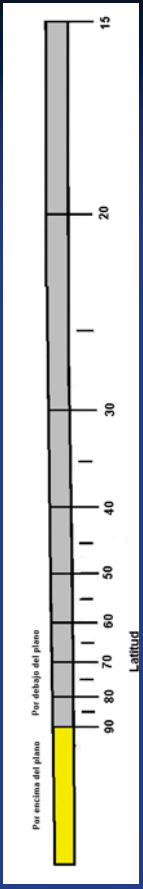
Let's see how to build a very simple “equatorial” sundial !





- Northern hemisphere
- Southern Hemisphere





- Fold the pattern on the dotted line
- Cut the stylus for your latitude. The yellow part goes above the plane

How to Read Time

Solar Time + Total Adjustment = wristwatch time

Total Adjustment =

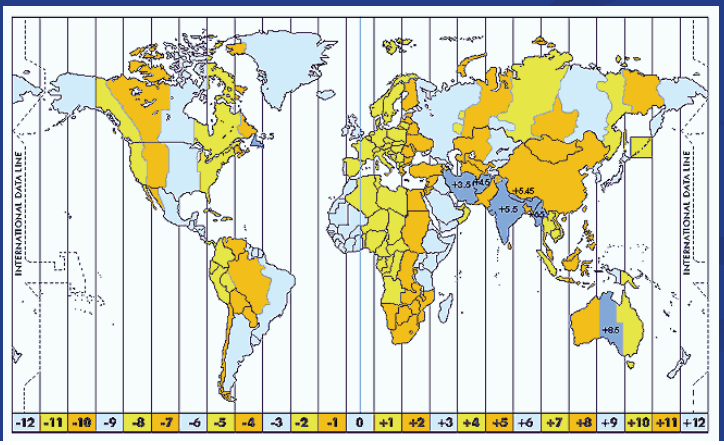
- **Longitude Adjustment**
- **Summer/winter Adjustment**
- **Equation of Time Adjustment**

Adjust of summer / winter.

- Almost all countries add an hour in summer.
- The change of summer / winter is a decision of the government of the country.

Longitude Adjustment

- The world is divided into 24 time zones from the zero meridian or Greenwich meridian.
- We must know the local longitude and "Standard" meridian longitude in your area.
- Use sign + to the East and sign - to the West.
- Write longitudes in h, m and s (1°=4m).



summer/winter Adjustment

- Many countries add a hour in summer.
- This change of clocks for summer / winter is a decision of the government of the country.

Equation of Time Adjustment

- The Earth revolves around the Sun according the law of areas, i.e. not a constant motion. We define the average time (of mechanical watches) as the average over a full year.
- The equation of time is the difference between "Real Solar Time" and "Mean Time" in Minutes of time

date	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	+3.4	+13.6	+12.5	+4.1	-2.9	-2.4	+3.6	+6.3	+0.2	-10.1	-16.4	-11.2
6	+5.7	+5.1	+11.2	+2.6	-3.4	-1.6	+4.5	+5.9	-1.5	-11.7	-16.4	-9.2
11	+7.8	+7.3	+10.2	+1.2	-3.7	-0.6	+5.3	+5.2	-3.2	-13.1	-16.0	-7.0
16	+9.7	+9.2	+8.9	-0.1	-3.8	+0.4	+5.9	+4.3	-4.9	-14.3	-15.3	-4.6
21	+11.2	+13.8	+7.4	-1.2	-3.6	+1.5	+6.3	+3.2	-6.7	-15.3	-14.3	-2.2
26	+12.5	+13.1	+5.9	-2.2	-3.2	+2.6	+6.4	+1.9	-8.5	-15.9	-12.9	+0.3
31	+13.4		+4.4		-2.5		+6.3	+0.5		-16.3		+2.8

Reading Time from your sundial

Example 1: Barcelona (Spain) on May 24th

Adjustment	Comment	Result
1. Longitude	Barcelona is in the same area "standard" as Greenwich. Its longitude is 2 º 10'E = 2.17 º E =-8.7m (1 ° is equivalent to 4 m)	-8.7 m
2. Summer Time	May has daylight saving+1 h	+ 60 m
3. Equation of Time	We read the table for May 24	-3.6 m
Total		+47.7 m

For example at 12h of solar time (noon), our watches indicated (Solar time) 12h + 47.7 m = 12h 47.7 m (Wristwatch time)

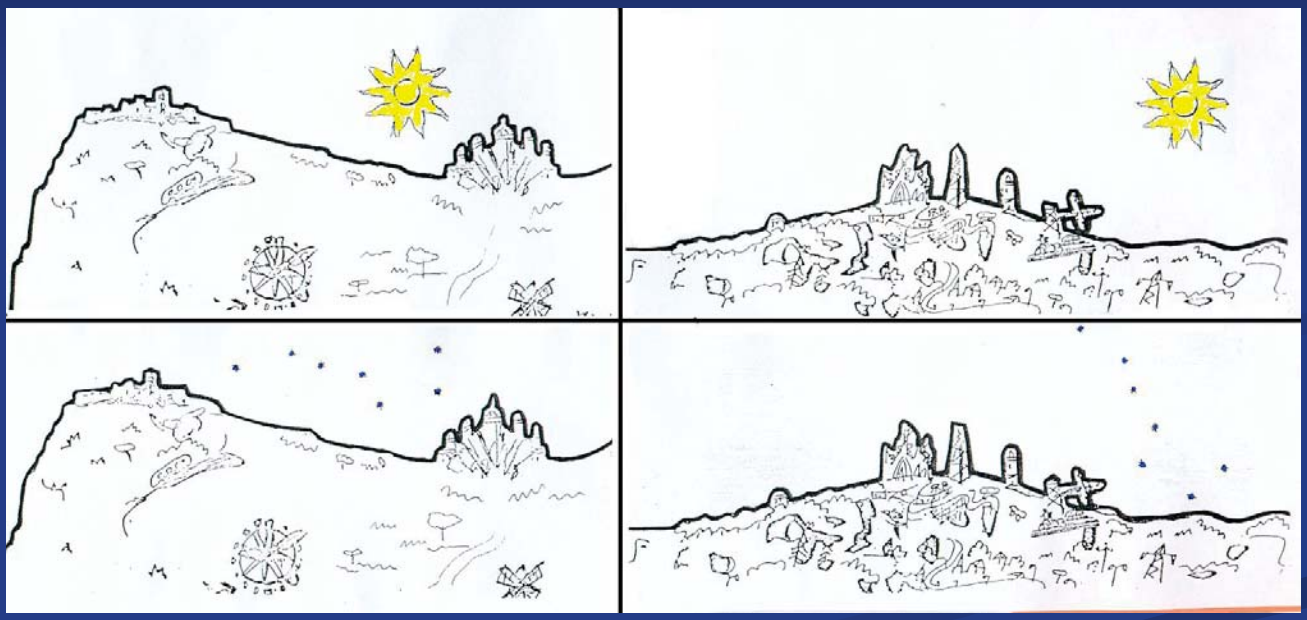
Read Time

Example 2: Tulsa, Oklahoma (USA) November 16th

Adjustment	Comment	Result
1. Longitude	The standard meridian of Tulsa is 90 ° W. Its longitude is 95 º 58'W = 96 º W, then is 6 ° W from the standard meridian (1 ° is equivalent to 4 m)	+24 m
2. Winter Time	November 16 does not have daylight saving	0
3. Equation of Time	We read the table for November 16	-15.3 m
Total		+ 8.7 m

For example at 12h of solar time (noon), our watches indicated (Solar time) 12h + 8.7 m = 12h 8.7 m (Wristwatch time)

The model serves to orient …



… to observe and understand …

Conclusions

- We understand the figures "views" from within and outside
- We reach levels of abstraction that let us read books and comment
- We feel oriented to the real horizon
- We see that the sunrise is not always due east and the sunset due west

Thank you very much for your attention!