Upeo wako na Bonyeza za Jua
Local Horizon and Sundials

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Malengo
Goals

- **Kufahamu mwendo wa Jua kwa siku**
- **Kufahamu mwendo wa Jua kwa mwaka**
- **Kufahamu mwendo wa tufe ya anga**
- **Kufahamu kutengeneza bonyeza ya Jua**

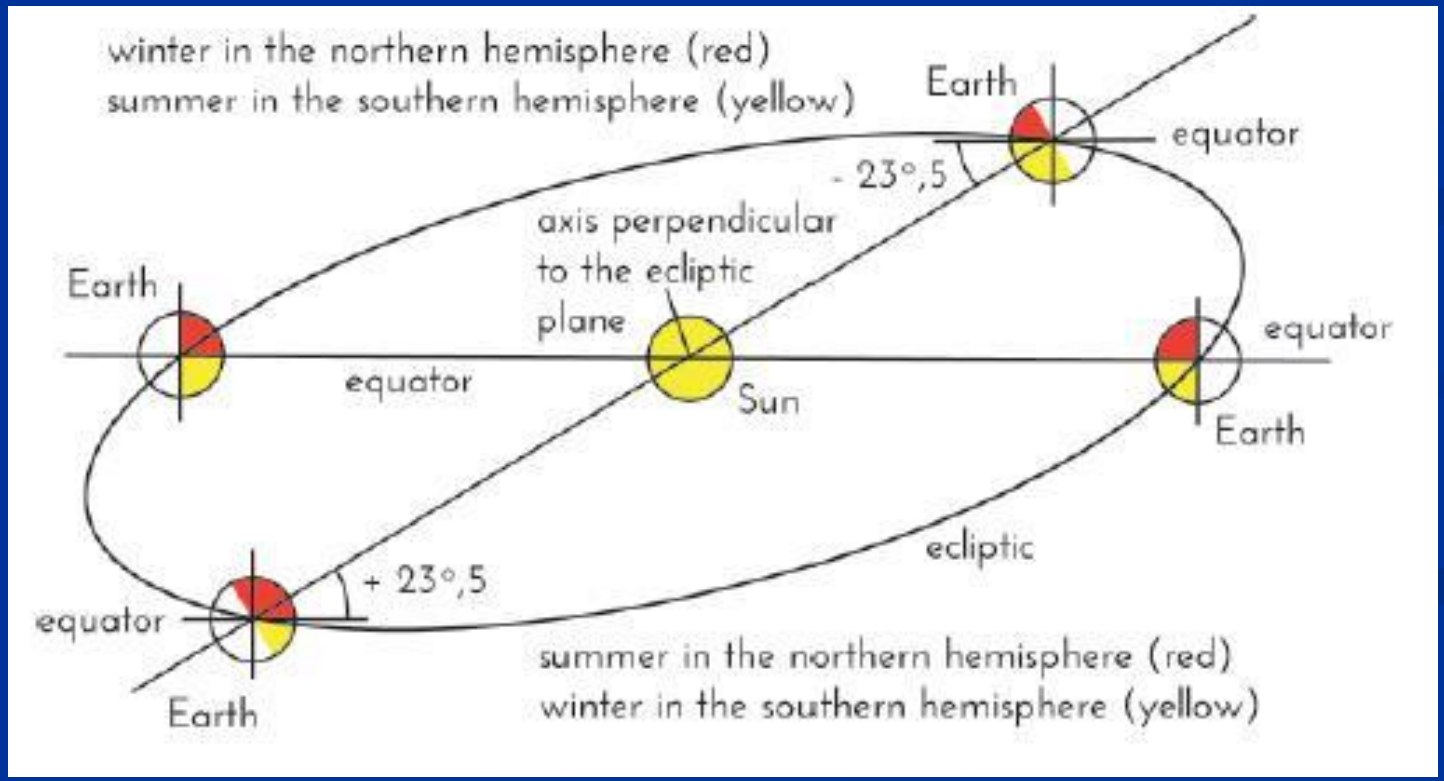
- Understand the diurnal movement of the Sun
- Understand the annual movement of the Sun
- Understand the movement of the celestial sphere
- Understand the construction of sundials

Dunia inajizungusha kwenye mhimili wake na inasogea
Mzunguko kwenye mhimili (mchana/usiku)
Nafasi yake katika obiti (misimu)

The Earth rotates and moves

rotation (day / night)

orbital position (seasons)



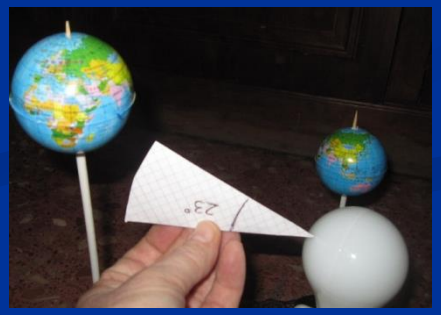
Zoezi 1: Tufe nne za Dunia na Jua (taa) katikati

Activity 1: Four Earth spheres with the Sun (a lamp) in the middle.

Mstari kutoka katikati ya Jua hadi katikati ya Dunia unaunda pembe ya nyuzi 23.5o na sakafu

(ambayo inawakilisha bapa ya Ikweta)

The line from the centre of the Sun to the centre of the Earth makes a 23.5° angle with the ground (which represents the plane of the Equator).



Msimu baridi katika Nusutufe ya Kaskazini

Msimu joto katika Nusutufe ya Kusini

Msimu joto katika Nusutufe ya Kaskazini.

Msimu baridi katika Nusutufe ya Kusini.

Winter in the Northern Hemisphere

Summer in the Southern Hemisphere

Summer in the Northern Hemisphere

Winter in the Southern Hemisphere

Zoezi 2: Dunia Sambamba

Activity 2: Parallel Earth

Taa kali inamulika tufe mbili kwa usawa na kutoa maeneo sawia za mwanga na kivuli

A spotlight illuminates two spheres in the same way and produces the same areas of light and shadow

Zoezi 2: Dunia Sambamba

Activity 2: Parallel Earth

*Toa tufe ya Dunia kutoka mwegemo wake na peleka juani na weka juu ya bilauri au kopo

*Elekeza mhimili wake kwa uangalifu uelekee Kaskazini-Kusini kwa kutumia kitafuta dira

*Zungusha tufe hadi mji wako upo juu

* Remove the globe from its mounting, take it outside and stand it on a glass

* Carefully orientate its rotational axis with a compass

* Turn it so our location is at the top

Zoezi 2: Dunia Sambamba

Activity 2: Parallel Earth

Weka:

***doli juu ya tufe mahala pa mji wako**

***vipande vya udongo mfinyanzi kwenye mpaka wa mwanga na kivuli (mpaka huu utabadilika jinsi muda unavyoenda)**

***bandika njiti wima sehemu mbali mbali kwa ajili ya kuelewa mabadiliko ya vivuli vyake**

Place:

*** a doll indicating our position**

*** pieces of clay to mark the light / shadow line**
(it advances with time)

*** pieces of toothpick to create shadows to study**

Zoezi 2: Dunia Sambamba

Activity 2: Parallel Earth

***Ncha ya Kaskazini ipo kwenye mwanga wa Jua kwa hiyo Nusutufe ya Kaskazini ina msimu joto (na Ncha ina Jua la usiku wa manane)**

***Na Ncha ya Kusini ipo kwenye giza basi Nusutufe ya Kusini ina msimu baridi**

* The North Pole is on the sunny side so it is summer in the Northern Hemisphere (the midnight sun)

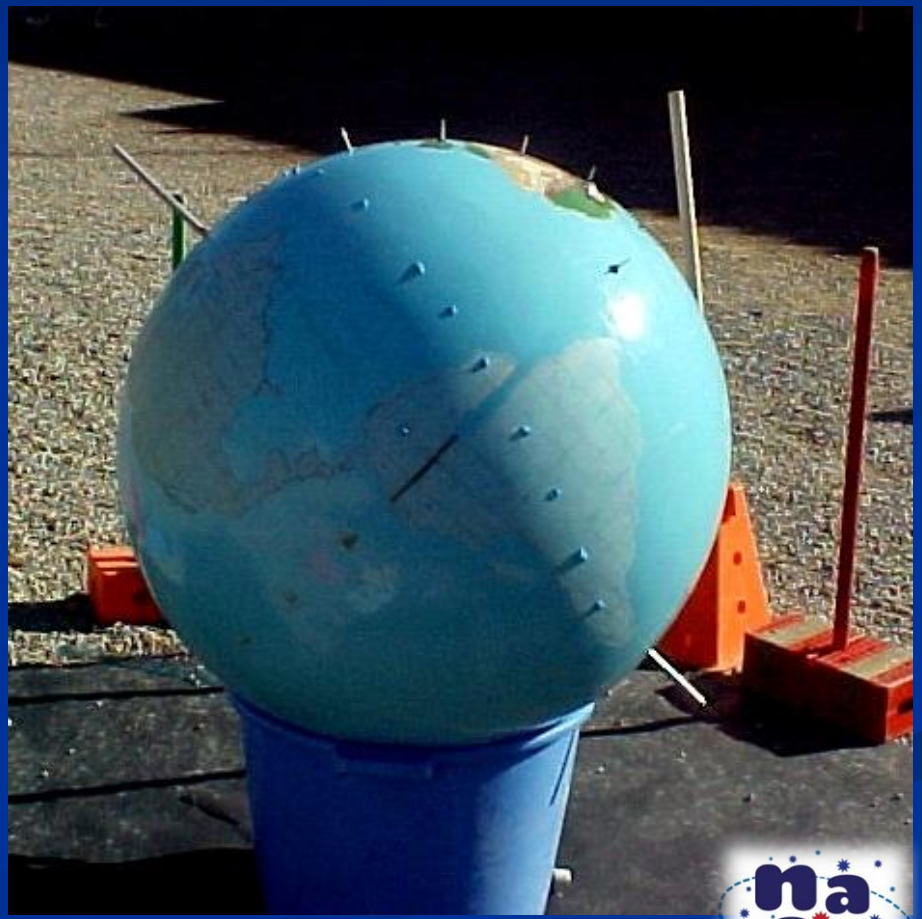
* The South Pole is in shadow and therefore in the Southern Hemisphere it is winter

Zoezi 2: Dunia Sambamba

Activity 2: Parallel Earth

*Ncha ya Kaskazini ipo kwenye giza kwa hiyo Nusutufe ya Kaskazini ina msimu baridi (na Ncha inakuwa katika giza masaa 24)

*Na Ncha ya Kusini ipo kwenye mwanga basi Nusutufe ya Kusini ina msimu joto



* The North Pole is within the area at darkness, so it is in the Northern hemisphere's winter.

* South Pole is illuminated and so it is summer in the Southern hemisphere.

Zoezi 2: Dunia Sambamba

Activity 2: Parallel Earth

Mpaka wa kivuli cha mchana/usiku unapopita kwenye ncha zote mbili za Dunia, basi Duniani kote inakuwa sikusare aidha ya Machi au ya Septemba

When the day / night shadow line passes through both poles, it is the first day of spring or the first day of autumn.

Zoezi 2: Dunia Sambamba (kwa pamoja)

Activity 2: Parallel Earth

Nusutufe Kaskazi msimu joto
North H. summer

Sikusare kote Duniani
North H. equinoxes

Nusutufe Kaskazi msimu baridi
North H. winter

Nusutufe Kusi msimu baridi
South H. winter

Sikusare kote Duniani
South H. equinoxes

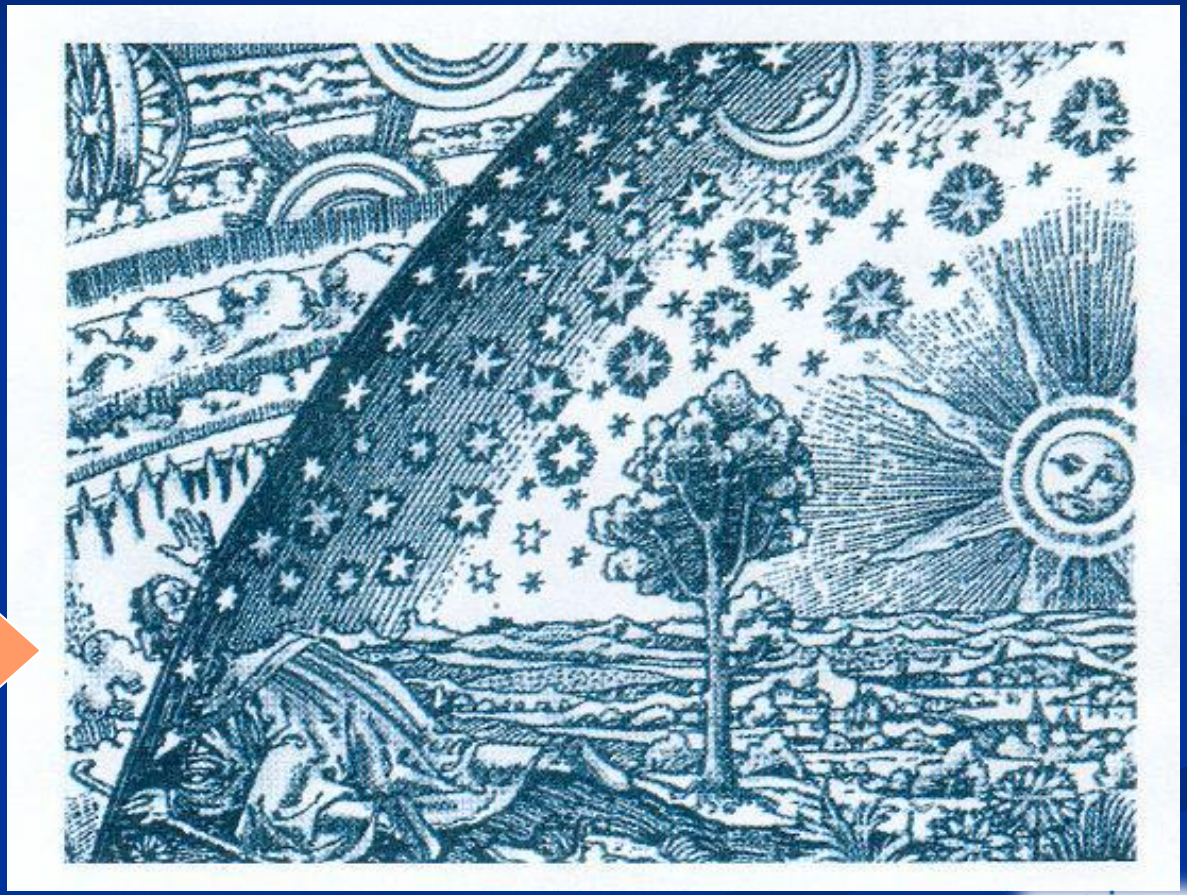
Nusutufe Kusi msimu joto
South H. summer

Mzunguko na mwendo mchana na usiku wa tufe anga

Rotation and celestial movements of day and night

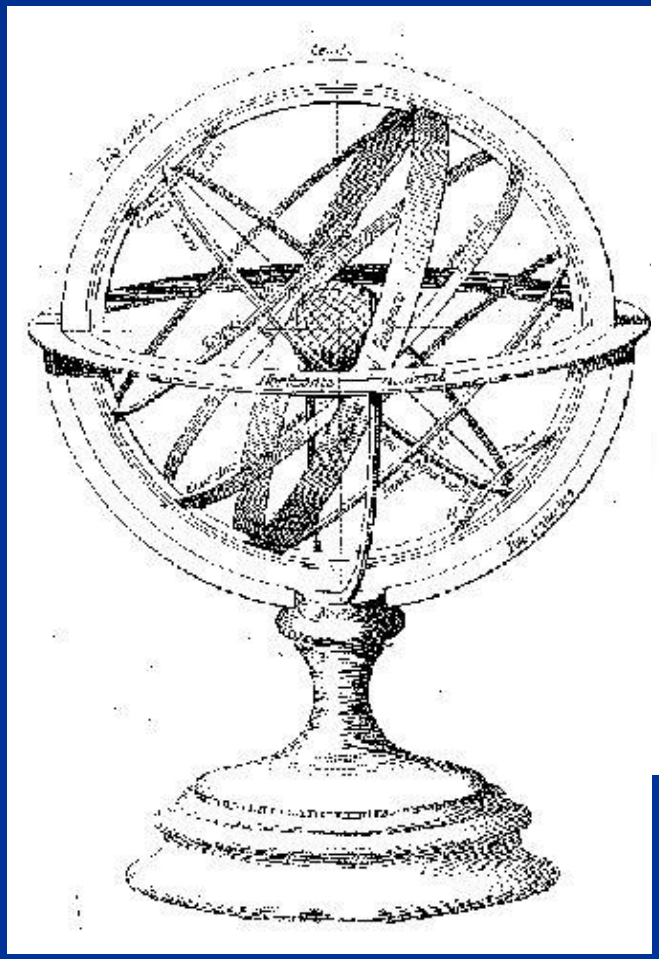
- Siyo sawa inapoangaliwa kutoka nje na ndani

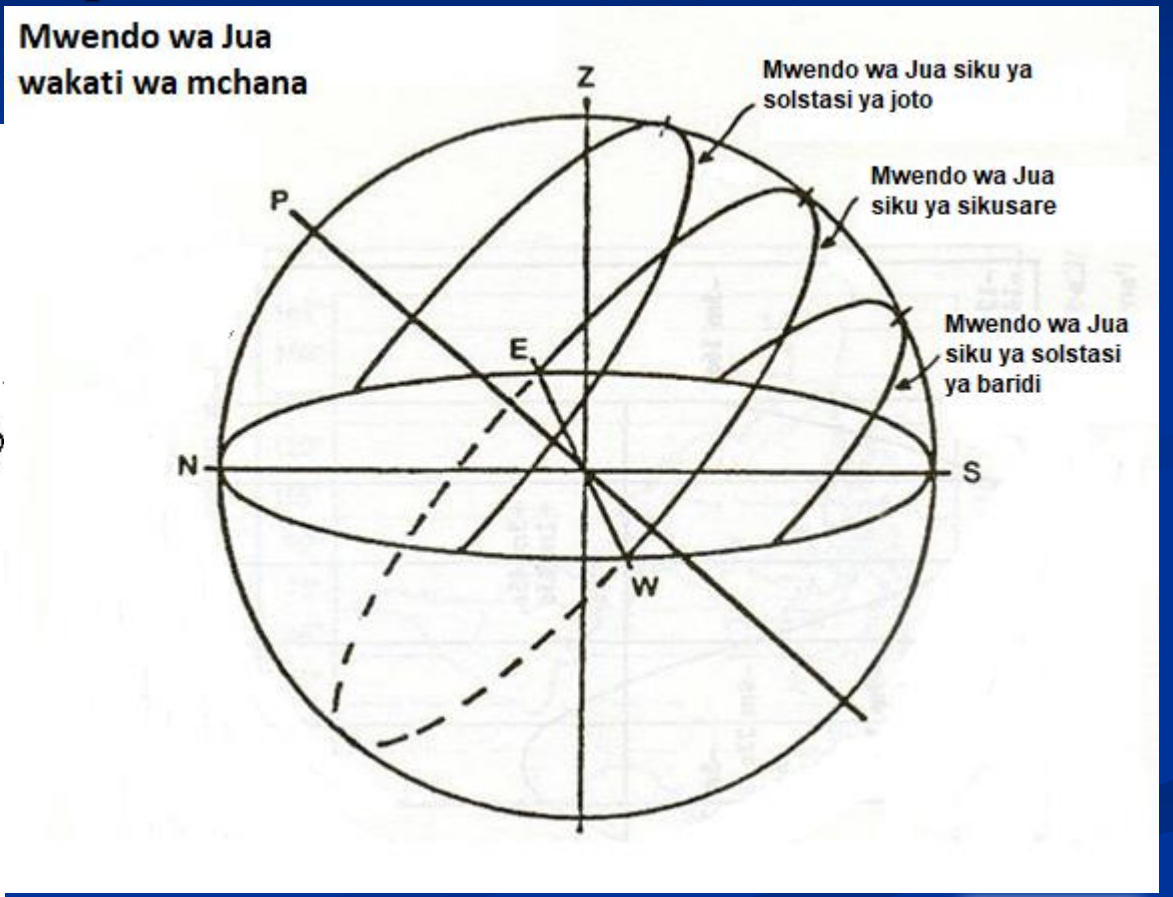
Not the same when seen from inside and outside



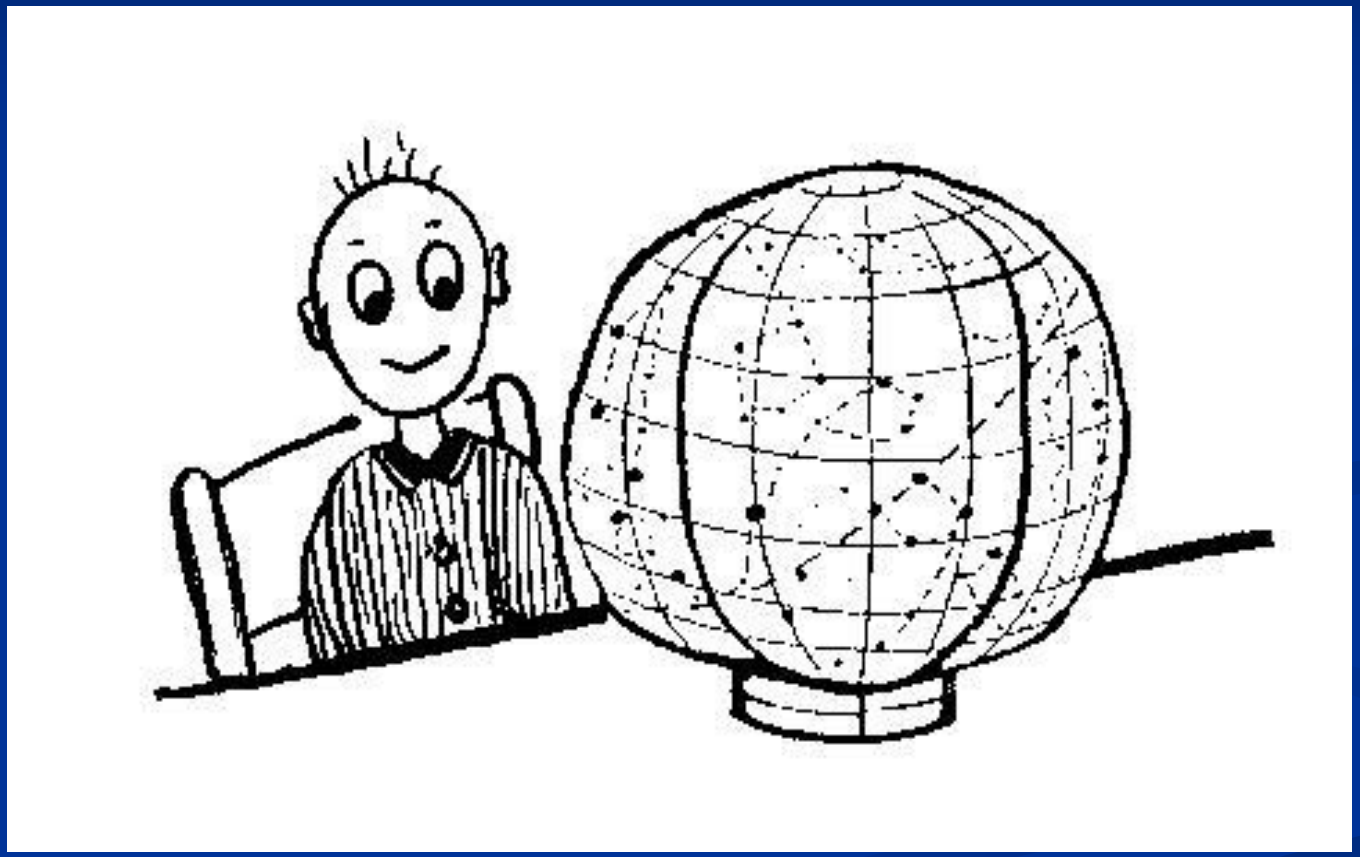
Tufe ya anga linapoangaliwa "kutoka nje“

Celestial sphere "from outside"





...inaelekea vyote vimeeleweka…

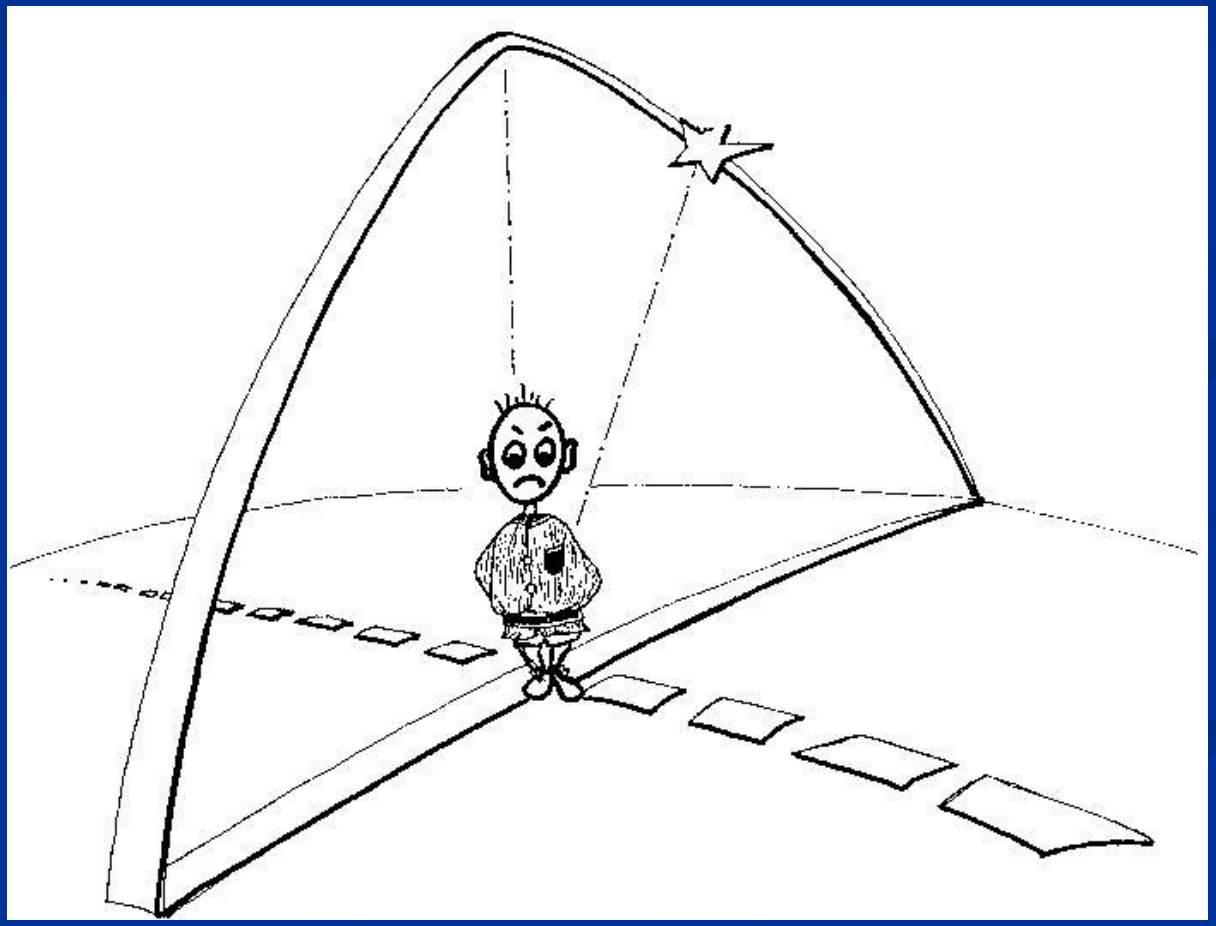


... it seems that everything is understood

...ila baada ya kutoka darasani,

...akajikuta amechanganyikiwa

… but after class, ... he is disconcerted



Kila shule ina "Maabara ya Astronomia“

All schools have an "Astronomy Laboratory"

- Zina uwanja wa michezo au eneo la mikusanyiko
- Zina anga wazi juu
- Kuna siku na usiku wazi bila mawingu
- VYOTE HIVI VITUMIKE !

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

Zoezi 3: Tutatengeneza mfano wa upeo unaoonekana kutoka shuleni

Activity 3: We will build a model of the horizon visible from school

Anza kwa kupiga picha maeneo yote yanayozunguka shule kutoka mahala ulipo na uchapishe picha zako

Begin by photographing all round your location

- **upeo kutoka ulipo**

  local horizon

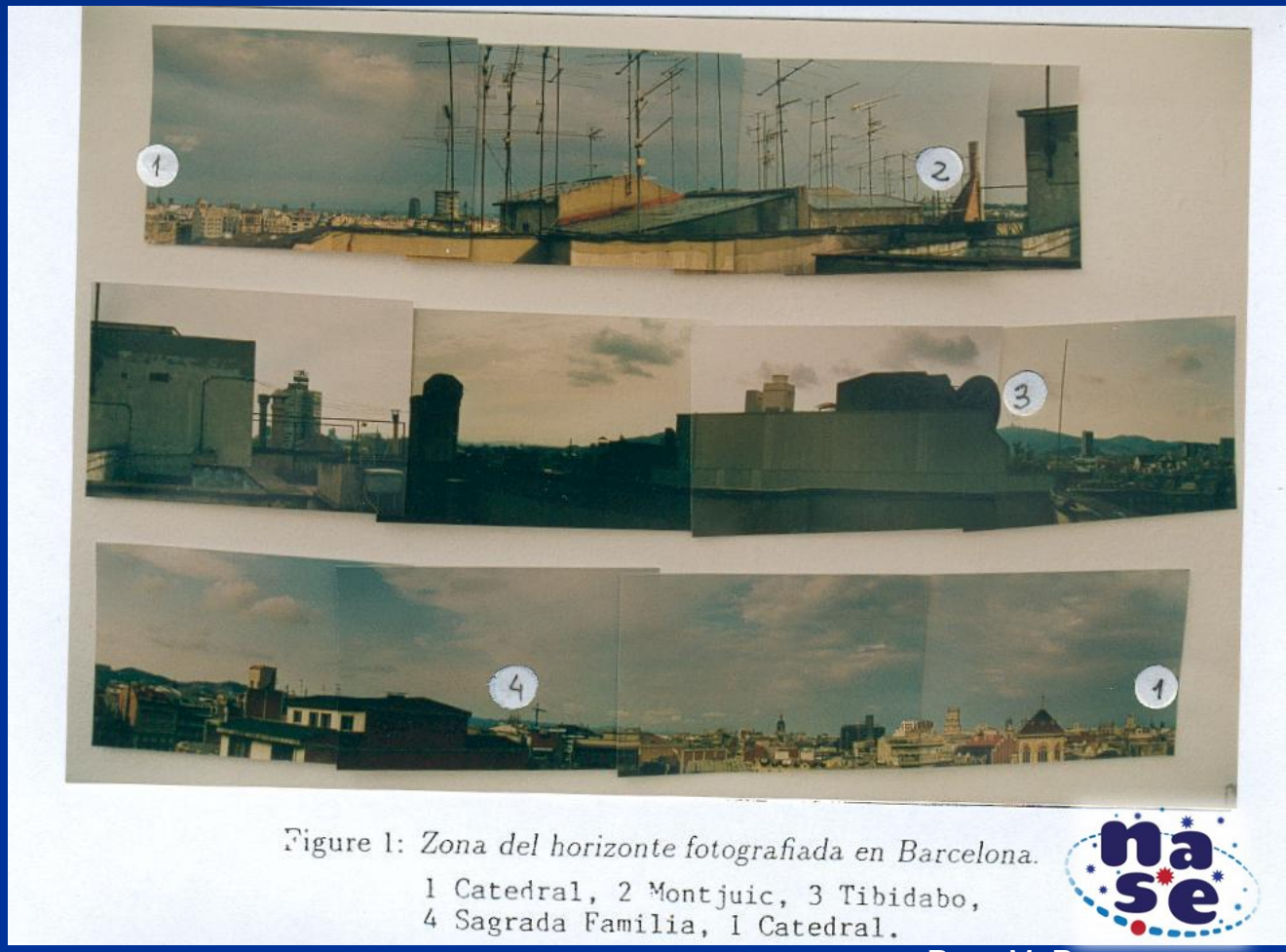


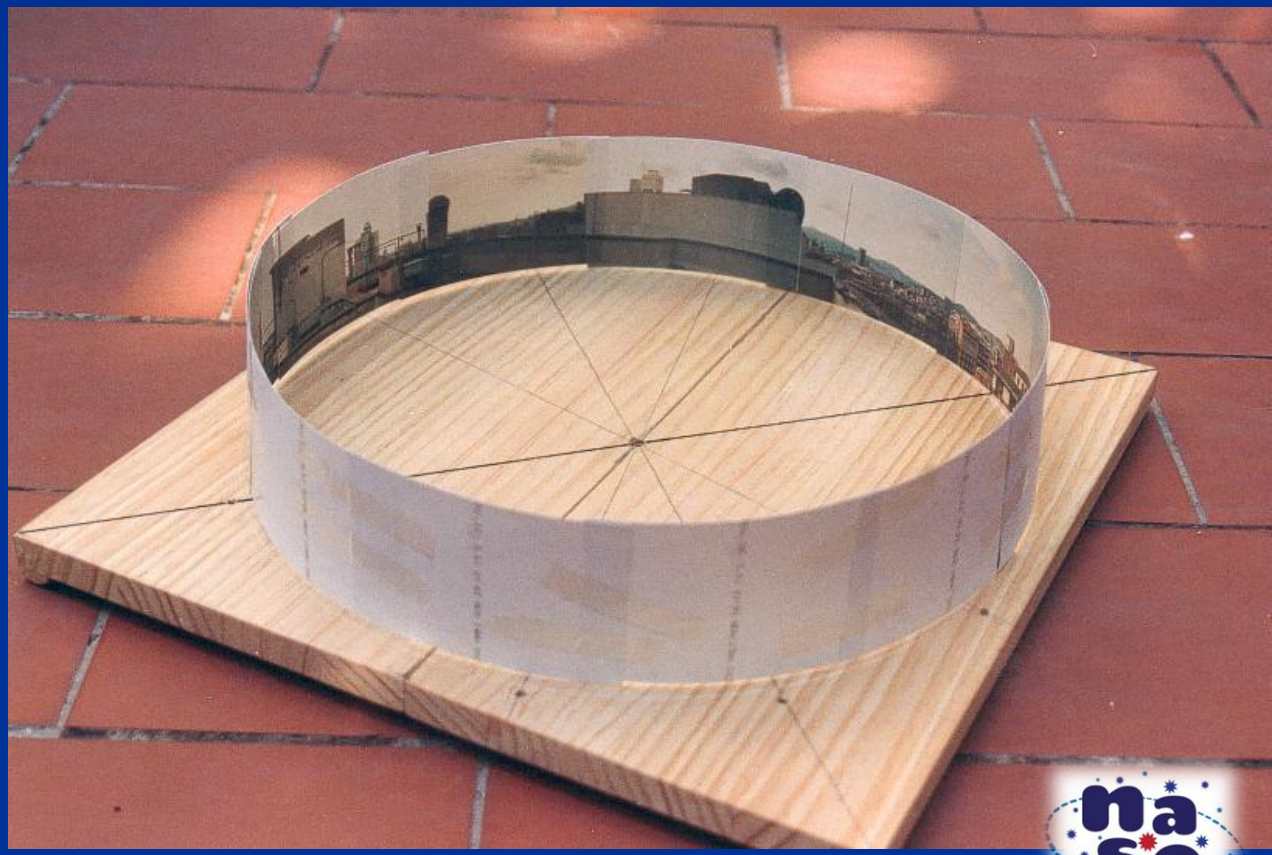
Figure 1: *Zona del horizonte fotografiada en Barcelona.*
1 Catedral, 2 Montjuic, 3 Tibidabo,
4 Sagrada Familia, 1 Catedral.

Tuunganishe picha zote juu ya fremu

Let's glue the photos together on a supporting platform

- **upeo kutoka ulipo**

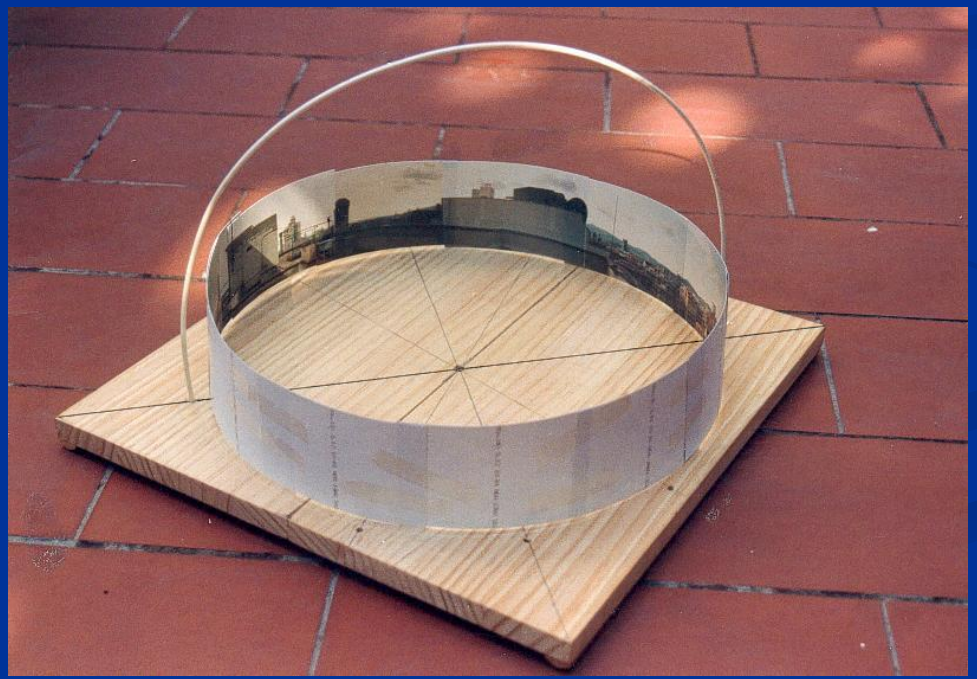
  local horizon



...itahitajika kuoanisha upeo uliopigwa picha na upeo halisi

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

- **Mstari wa Kaskazi-Kusi pamoja na meridi (longitudo) yako**
- The N - S line and local meridian



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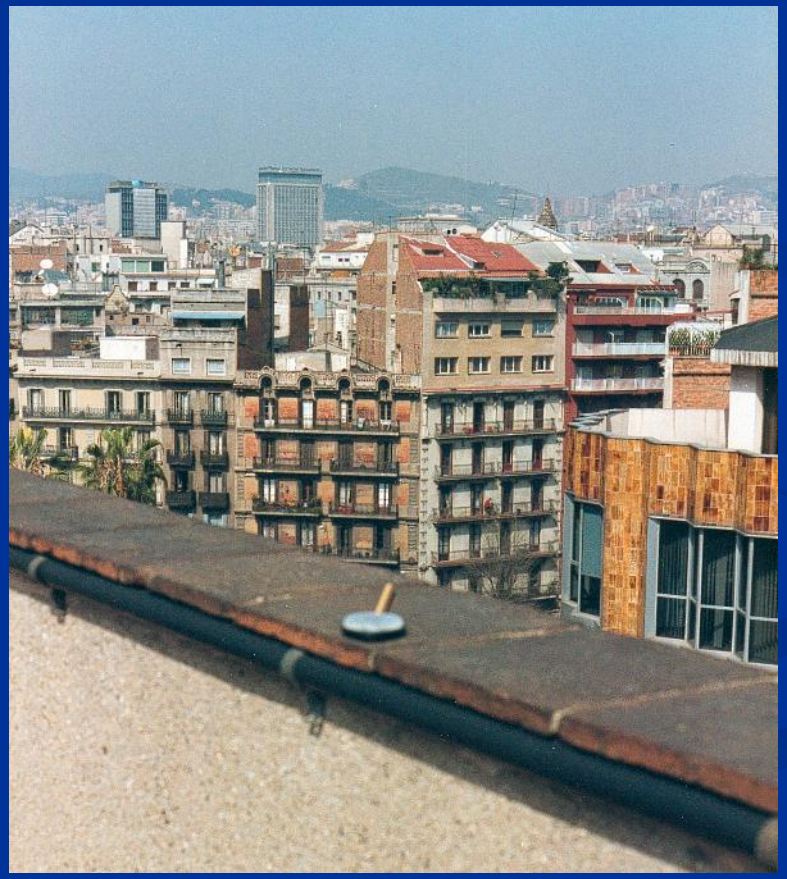
Ili kuelekeza mfano wetu wa upeo tunaweza kutumia kitafuta dira, au bora zaidi, tunaweza kutumia mchomozo wa Ncha juu ya upeo

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

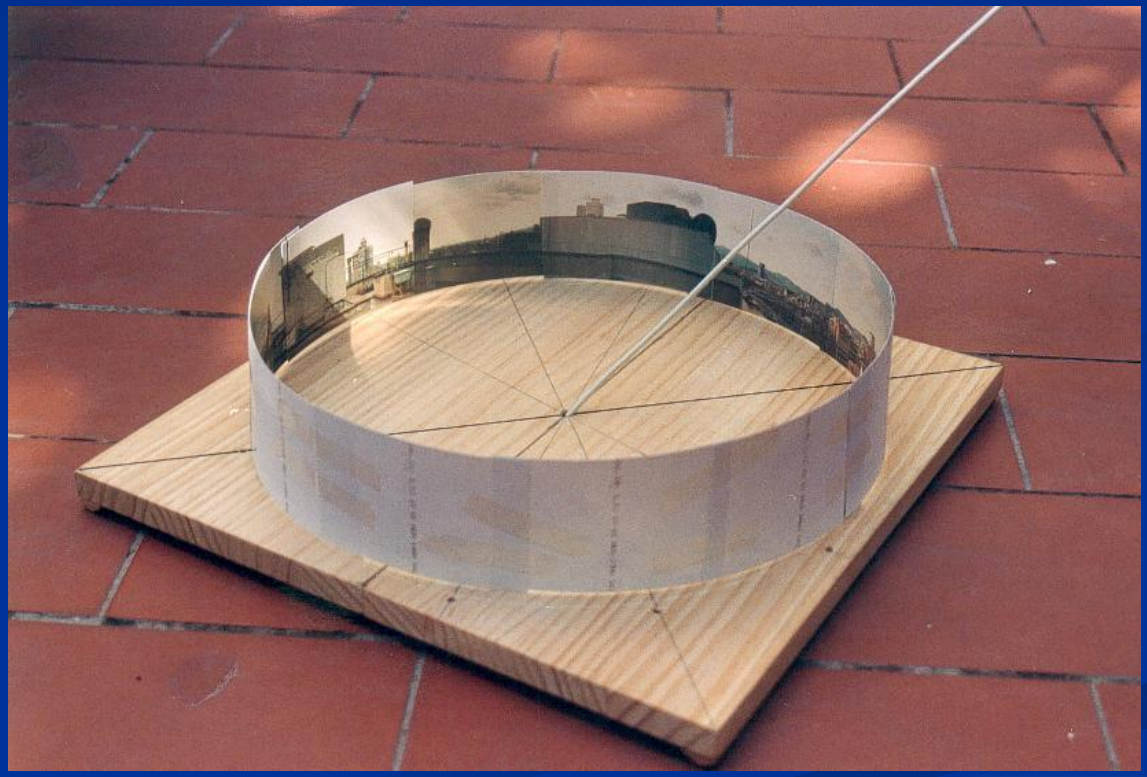


Kuingiza mzunguko wa Dunia katika mhimili wake

Introducing the Earth's rotation

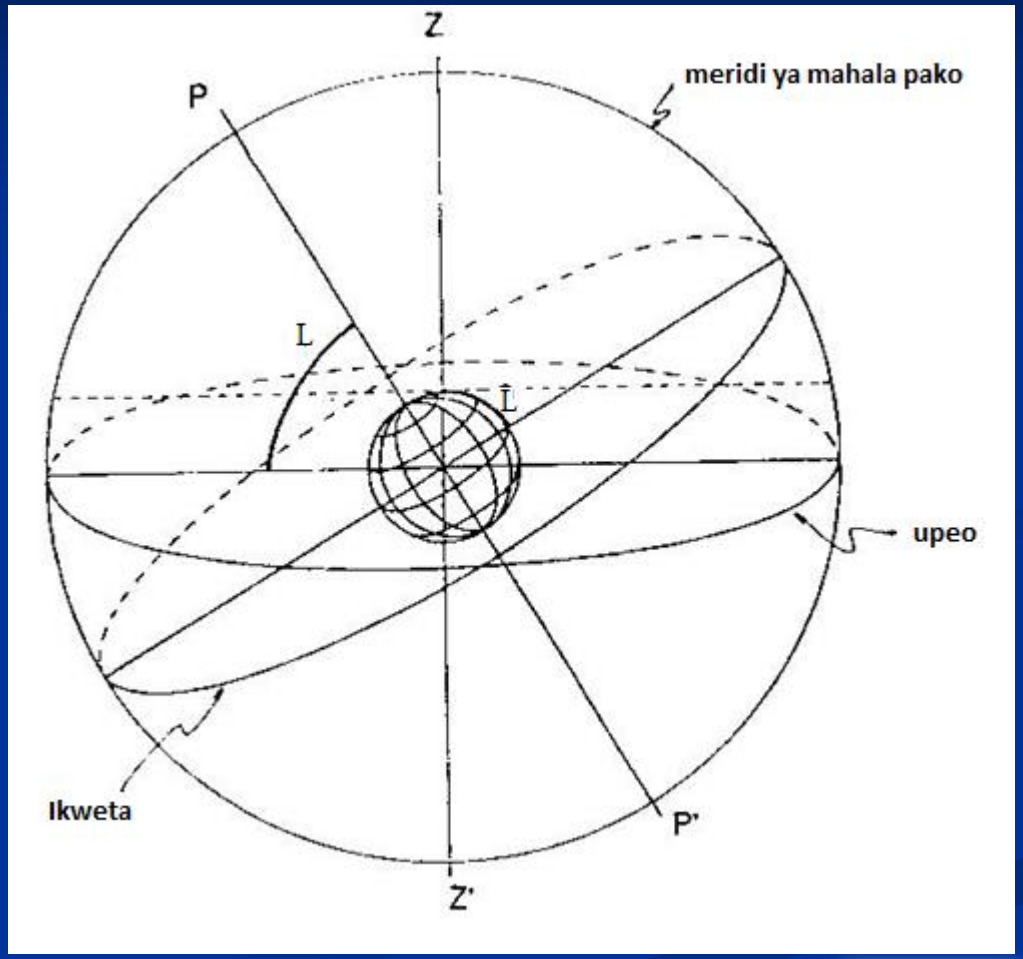
- **Mhimili wa Dunia unavyopita mahala ulipo**

  axis of the Earth



Kimo cha Ncha juu ya upeo ni sawa na latitudo yako

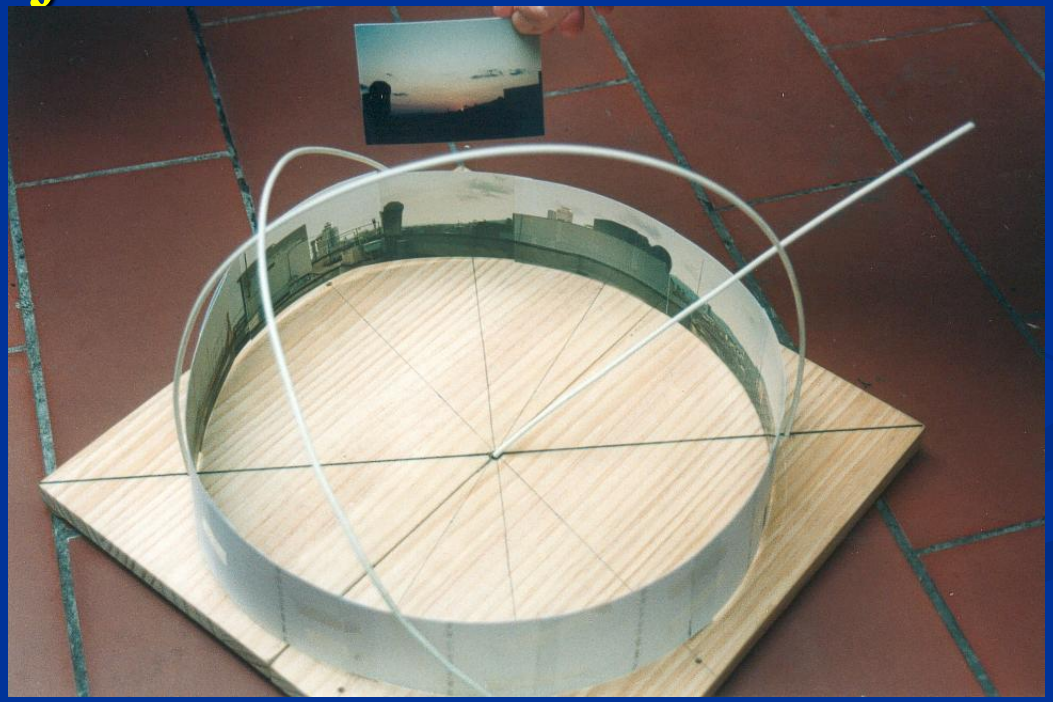
The altitude of the pole is equal to your latitude



Onesha njia ya Jua angani siku ya sikusare ya Machi au ya Septemba

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

- Tumia picha za kuchomoza (machweo) au kuzama (mawio) ya Jua
  - Use the Sunrise or Sunset photos



Mwendo kutokana na mzunguko wa Dunia kwenye mhimili wake
Angalia mwinamo wa mpito wa Jua

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

- **Siku - Picha kadhaa za Jua karibu na kuzama (machweo)**

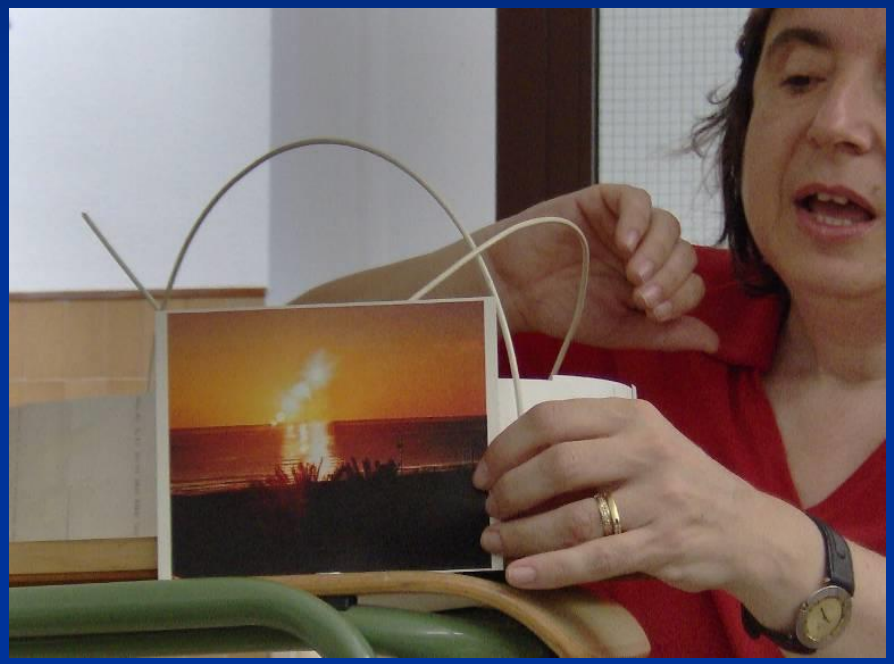
- Day - several images near sunset

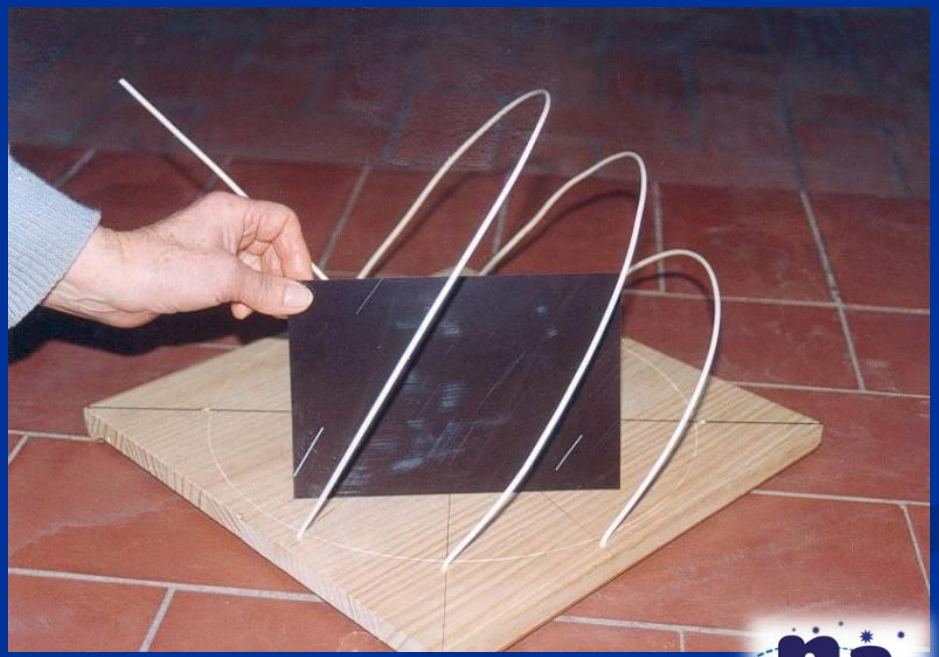
Mwendo kutokana na Dunia kuzunguka kwenye mhimili wake:
Angalia mwinamo wa mistari ya nyota

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

- **Usiku - picha za nyota iliyopigwa kwa kuweka kamera wazi kwa muda**
- Night – a time exposure of the stars

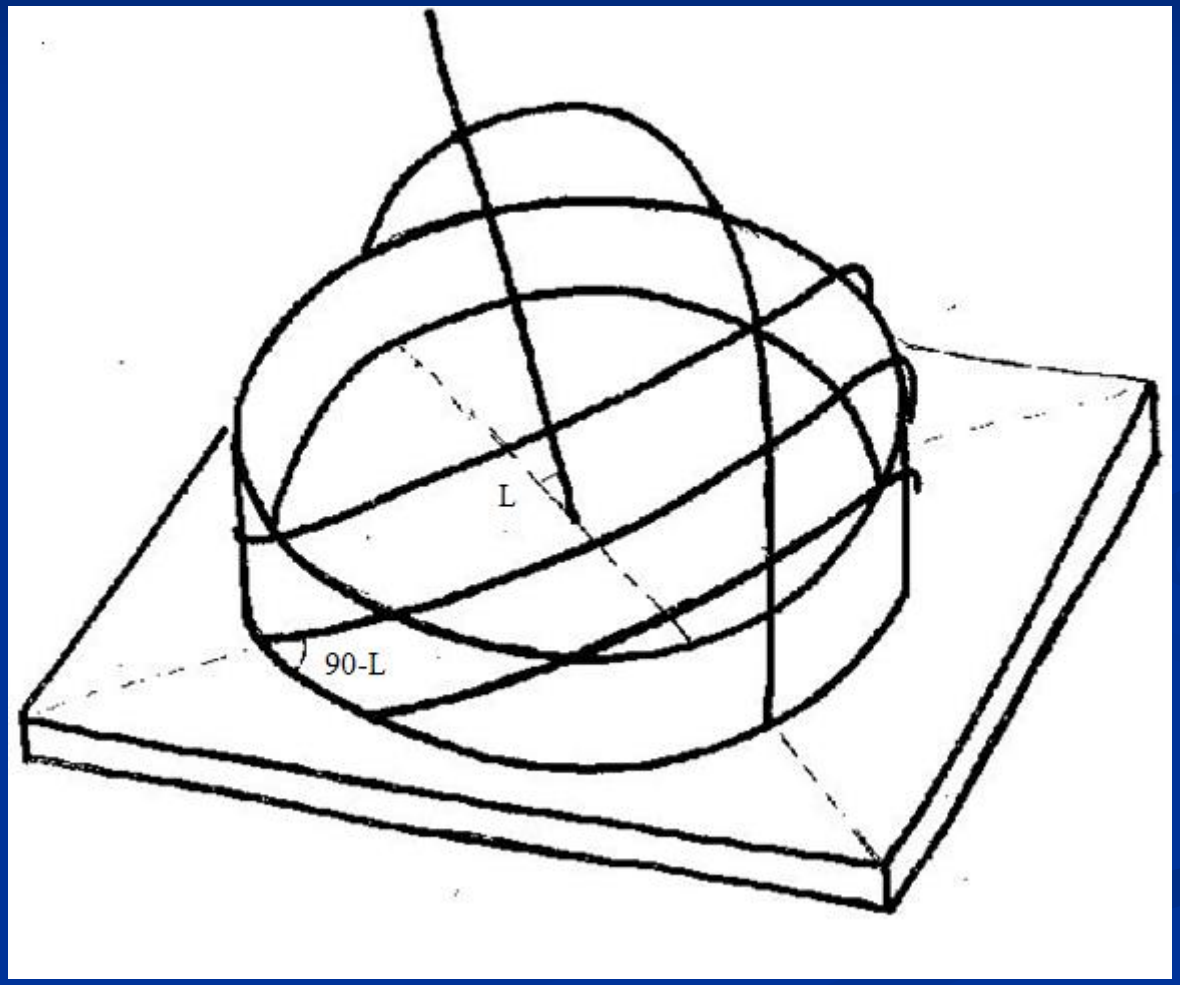
Kupata mwendo wa mzunguko katika mfano wetu





Rotational movement in the model

Mwinamo wa njia ya Jua angani na ule wa mistari ya nyota hutegemea latitudo

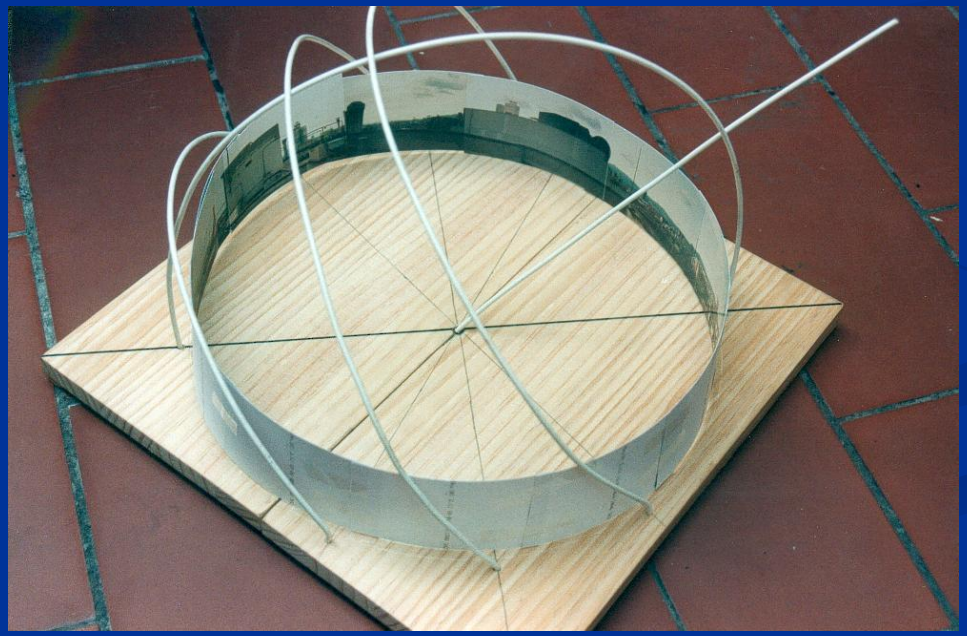


The inclination of the Sun's apparent path and of the star trails depend on latitude

Njia za Jua kwa siku ya kwanza ya kila msimu (Ona tofauti ya muda kati yao)

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

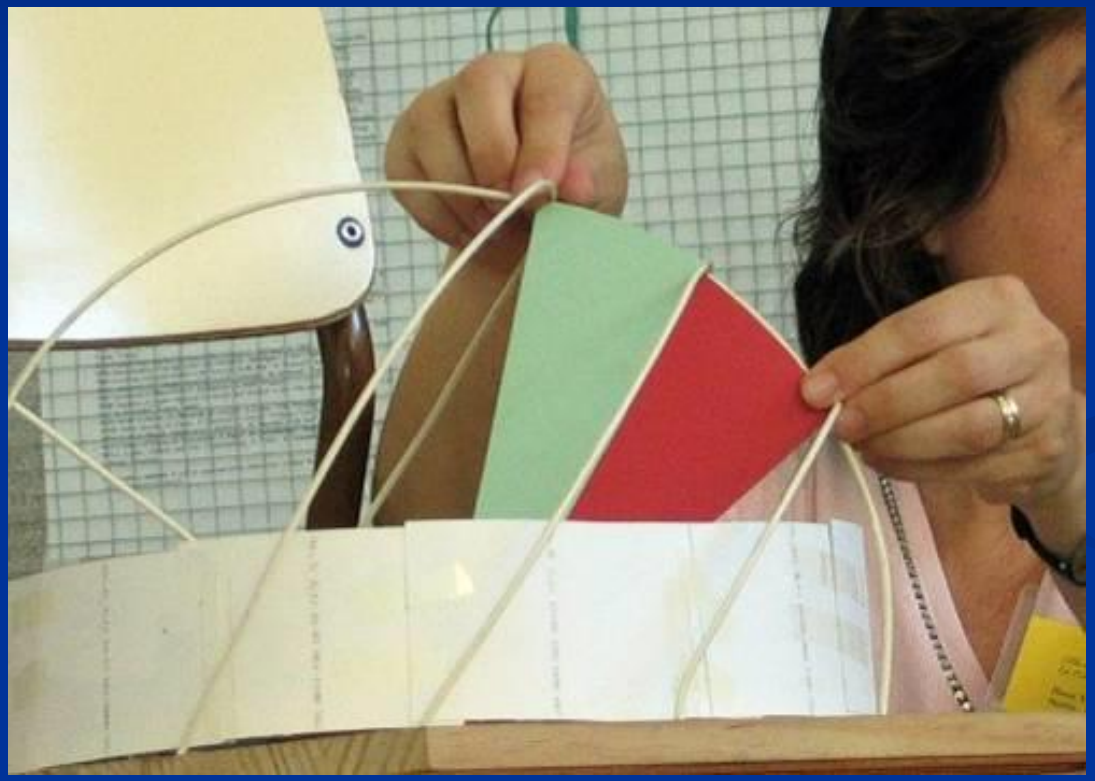
- Solstasi ya Juni
- Sikusare ya Machi na ya Septemba
- Solstasi ya Desemba



Summer Solstice
Autumnal /Vernal Equinox
Winter Solstice

Mwendo katika obiti kusababisha nafasi za kimisimu

Orbital motion leads to the seasonal positions



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

- Joto
- Mvua
- Baridi

- Summer
- Spring / Autumn
- Winter

- Pembe kati ya Ikweta na Tropiki ya Kansa au Tropiki ya Kaprikoni ni 23.5º

Mwendo wa Dunia katika obiti husababisha badiliko katika mahala pakuzama kwa Jua kila siku

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

- **Mizamo 3 ya Jua:**
  Baridi-Mvua-Joto

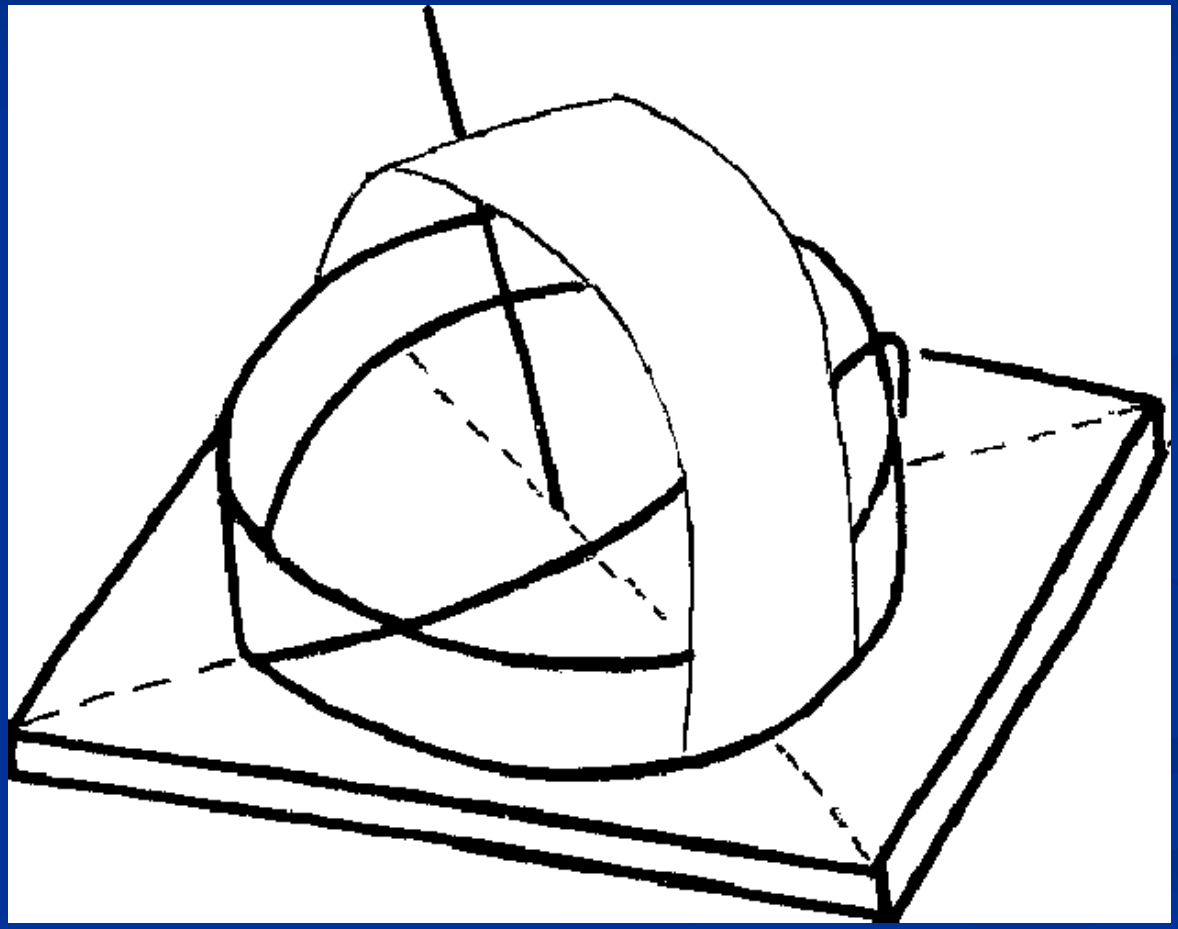
3 sunsets:
Winter – Spring or Autumn – Summer

Mwendo wa mzunguko wa dunia unasababisha mabadiliko ya nafasi ya kuchomoza kwa jua kila siku

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

Muonekano wa "meridi" (longitudo) katika mfano

Viewing the "meridian" in the model



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...sehemu za Ncha – miduara

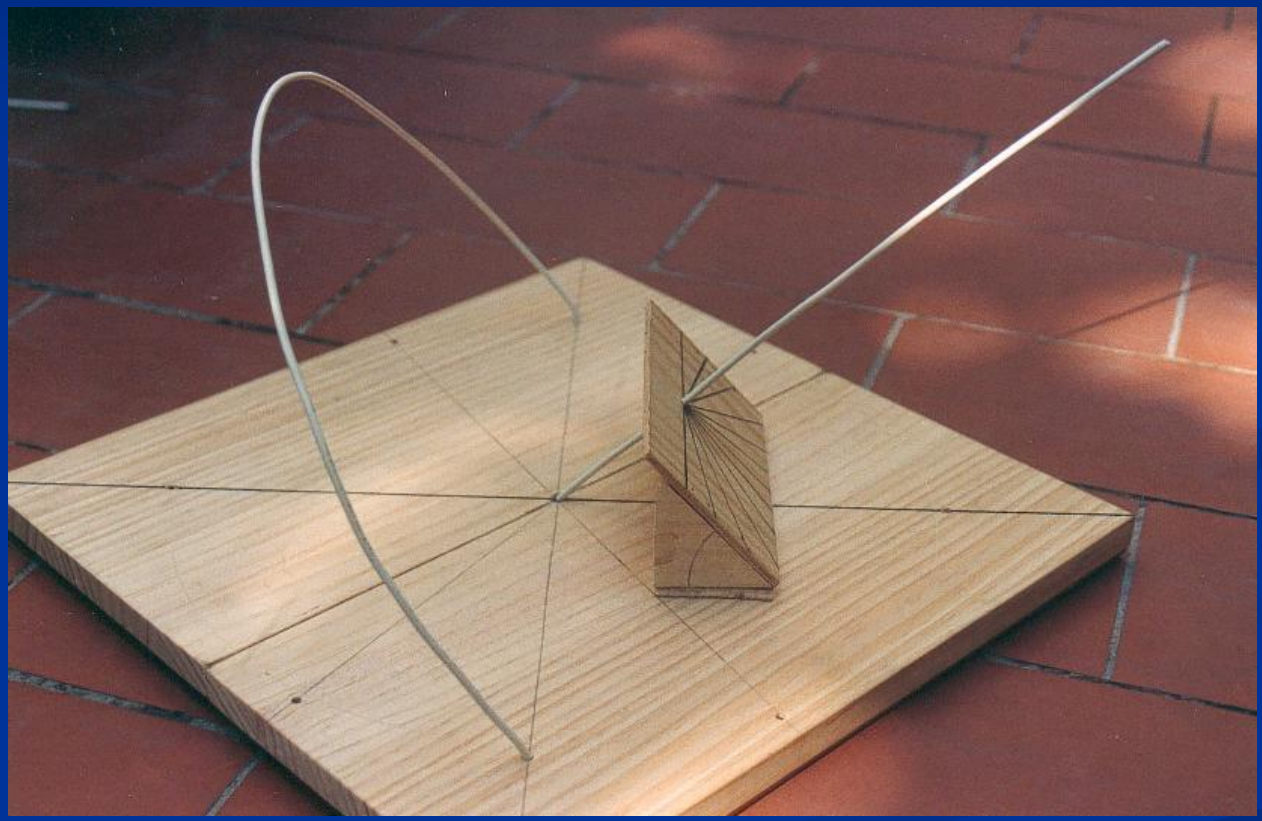
…around the pole - circles

…jirani na ikweta mistari ya nyota inabadilika kutoka mbonyeo hadi mbinuo

…near the equator the paths change from concave to convex

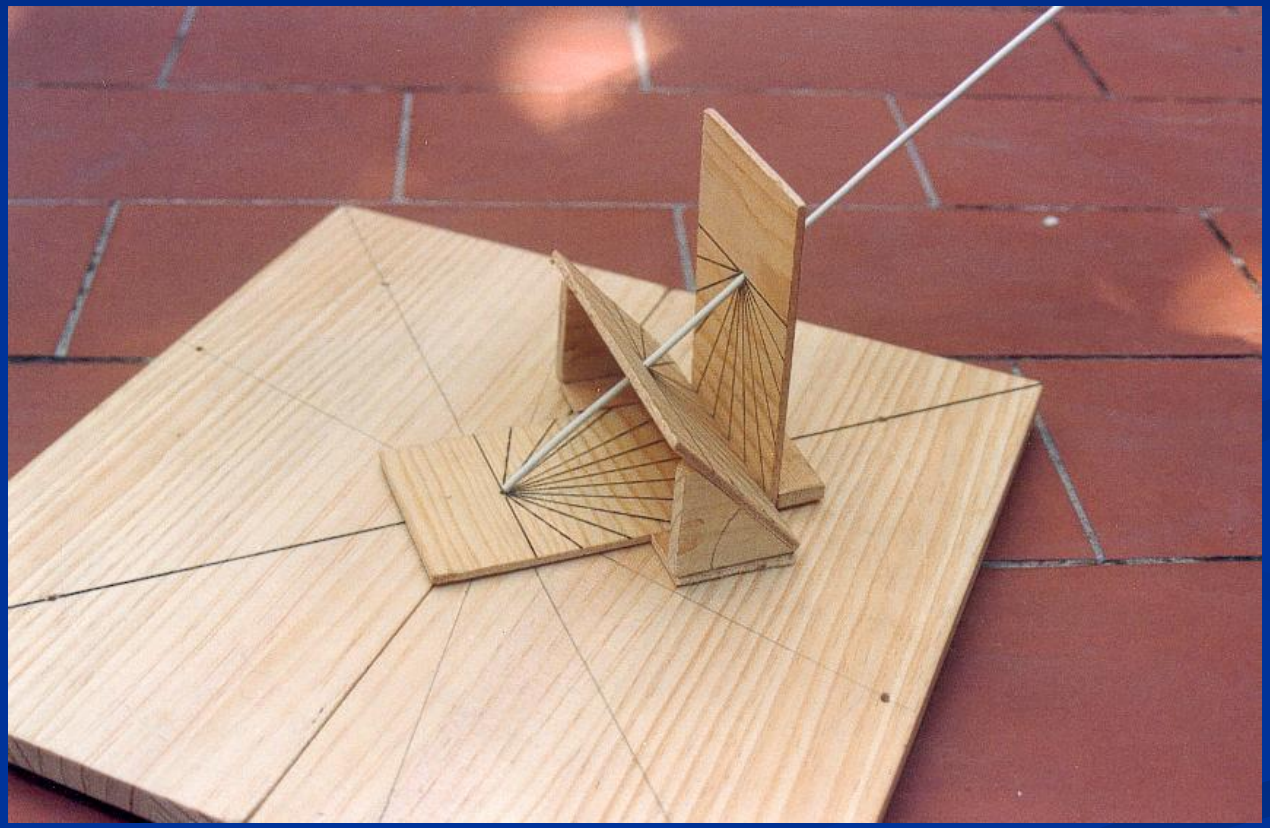
...mfano huu ni sawa tu na Bonyezo ya Ikweta

…the model is no more than an Equatorial Sundial!



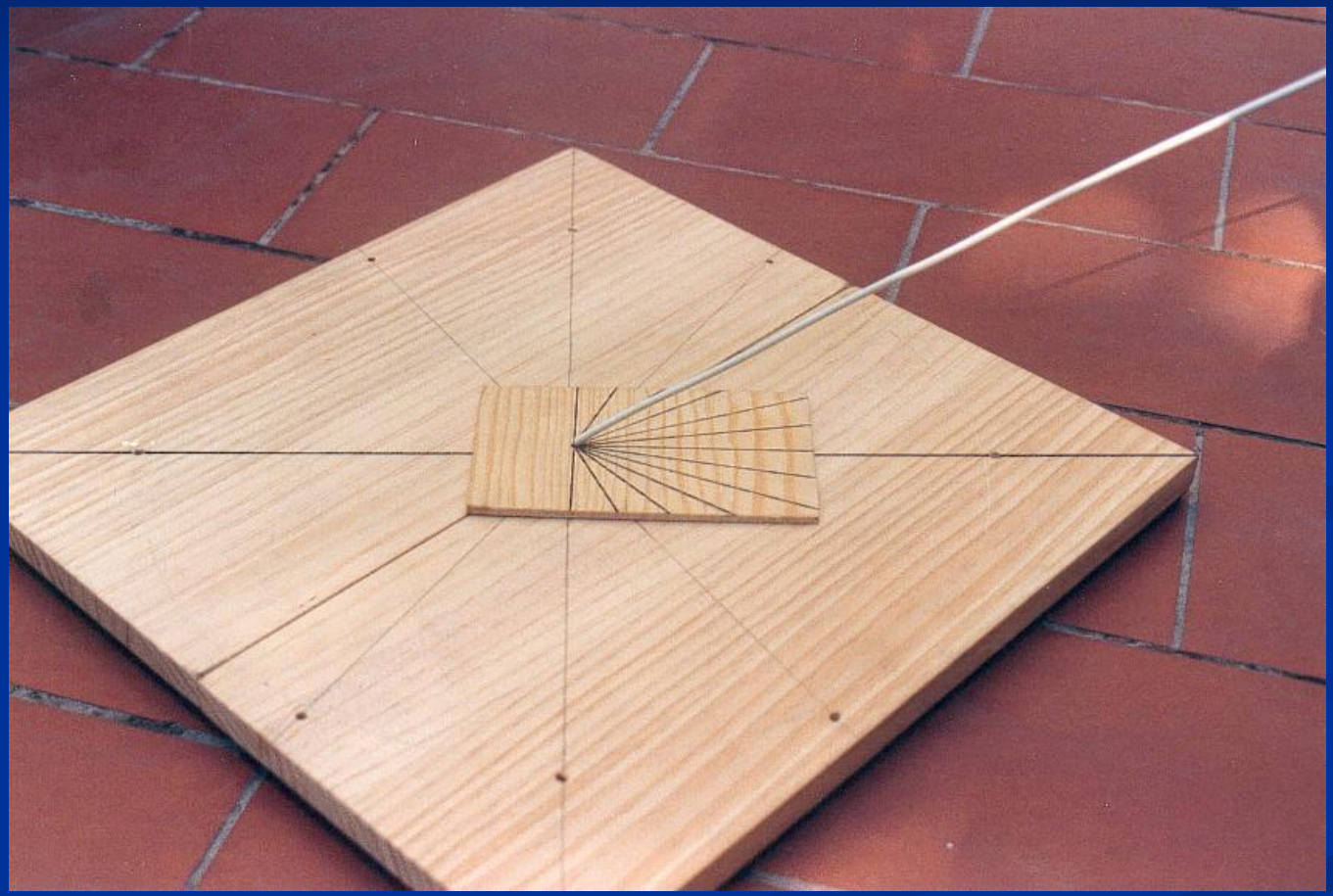
...bonyezo zingine zinaweza kutengenezwa kutokana na ile ya Ikweta

…other sundials can be made from the equatorial one



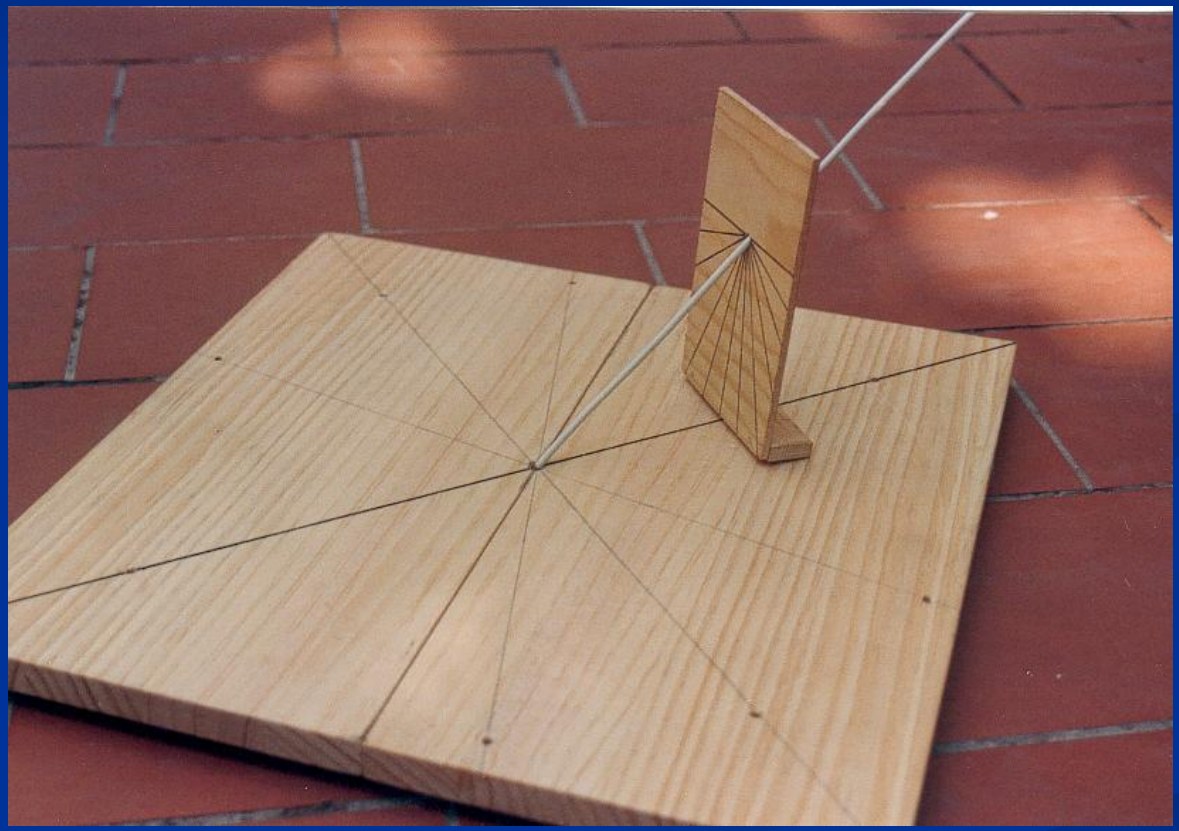
...bonyezo mlalo

… the horizontal sundial



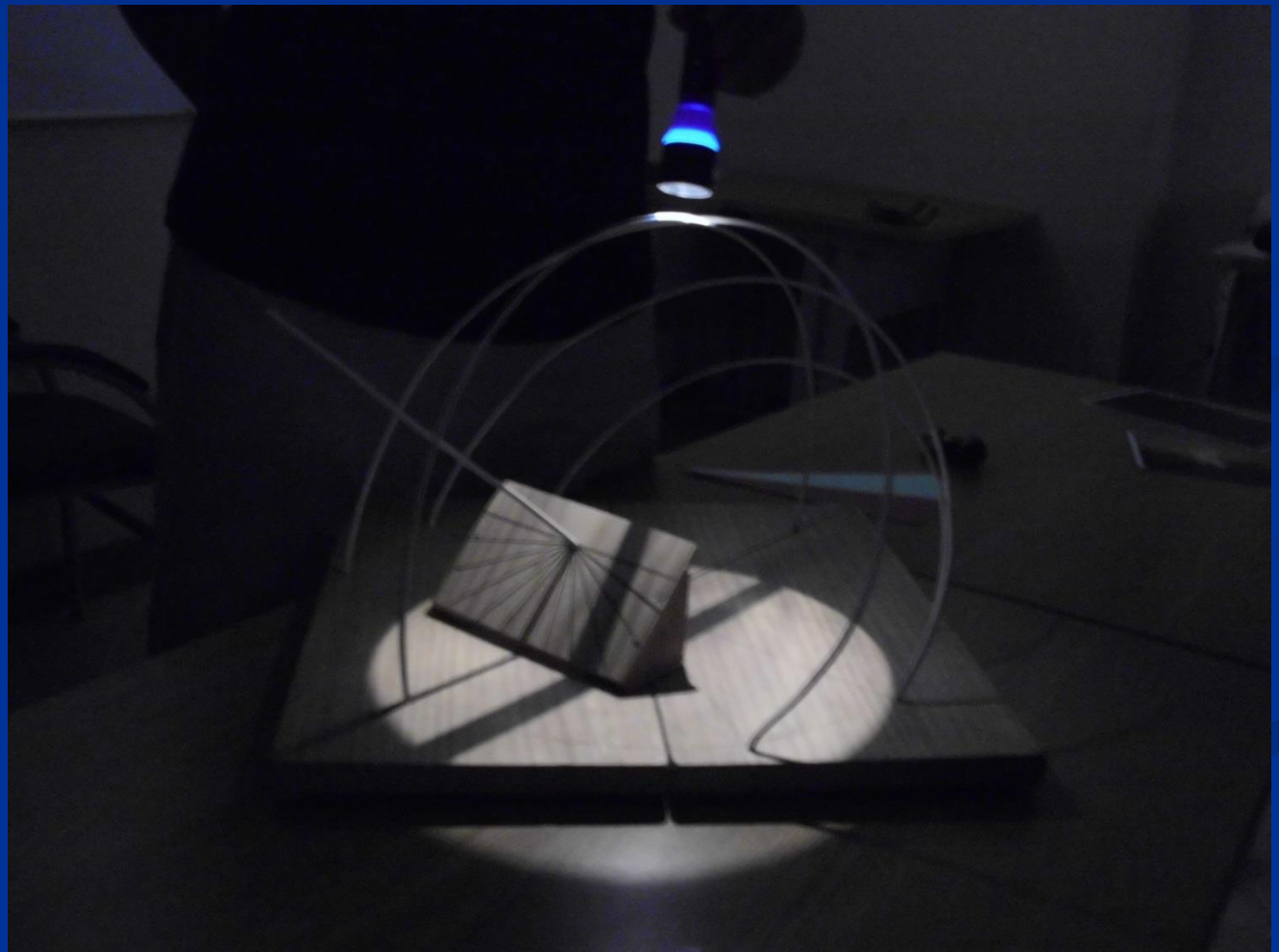
...na bonyezo wima iliyoelekezwa Mashariki-Magharibi

…and the vertically oriented E-W sundial



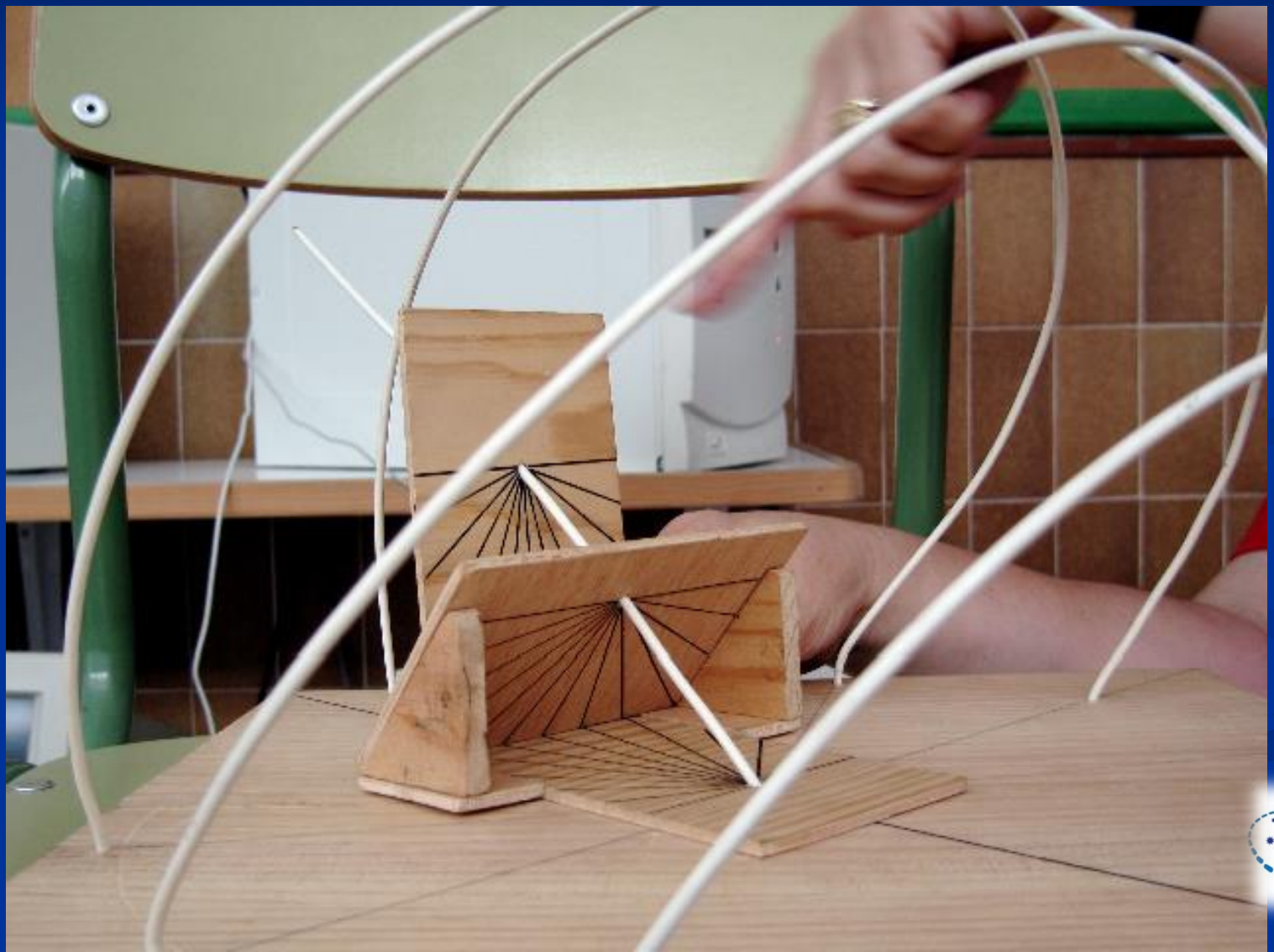
...na kwa kutumia mwanga wa Jua (au wa tochi kali) tunaweza kuona mfano wetu ukifanya kazi kama bonyezo

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



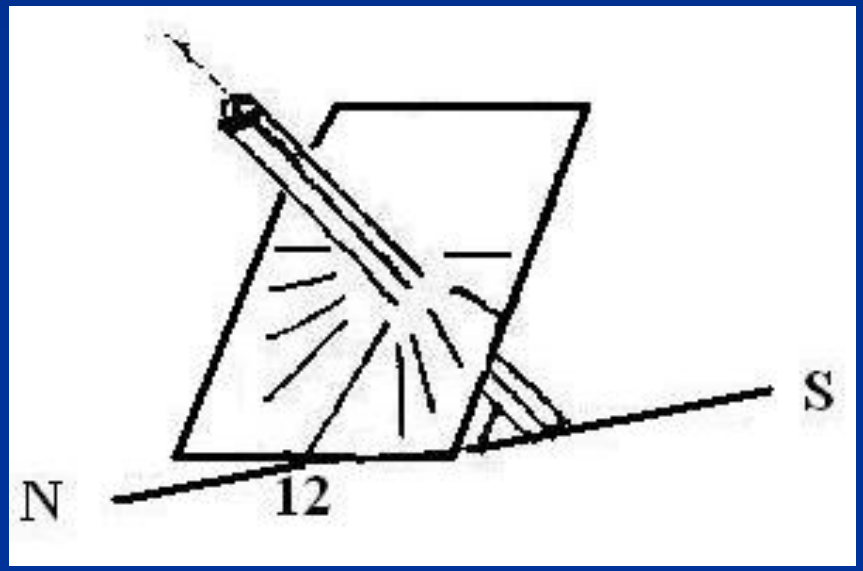
Bonyezo aina tatu katika mfano wetu

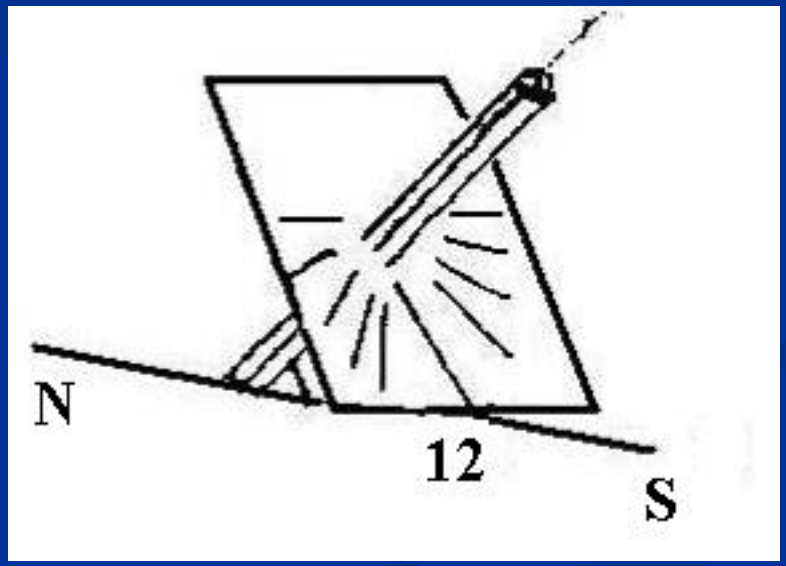
The three sundials in the model



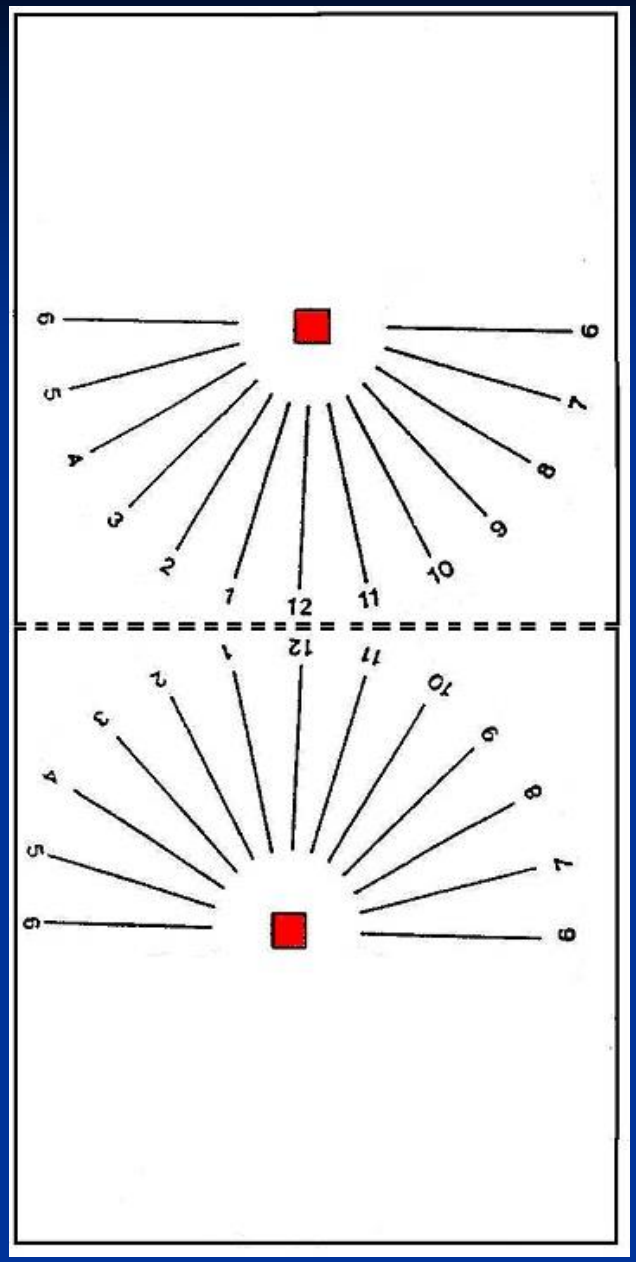
Zoezi 4: Tuangalie namna ya kutengeneza bonyezo sahili kabisa ya "kiikewta“

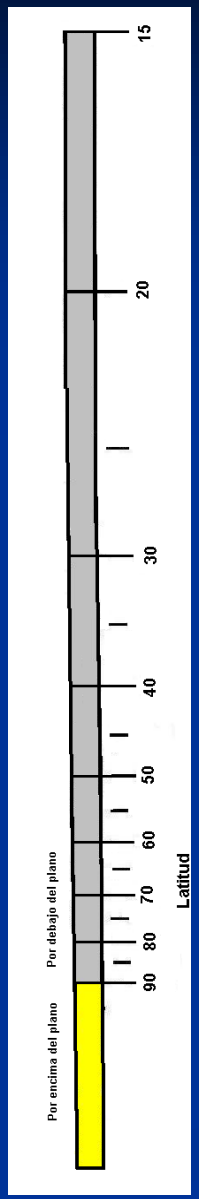
Activity 4: Let's see how to build a very simple “equatorial” sundial!





- **Nusutufe ya Kaskazini**
  Northern Hemisphere
- **Nusutufe ya Kusini**
  Southern Hemisphere





Zoezi 4: Bonyezo la "ikweta"

Activity 4: "equatorial" sundial!

- Kunja mchoro huu kwenye mstari uliokatikakatika
- Kata njiti ya latitudo yako. Sehemu ya manjano inawekwa juu ya bapa

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

Zoezi 5: Namna ya Kusoma Muda

Activity 5: How to Read the Time

Muda wa Jua + Jumla ya rekebisho = muda wa saa ya mkononi

Solar Time + Total Adjustment = Wristwatch Time

Jumla ya rekebisho =

- Rekebisho la logitudo
- Rekebisho la muda wa majira joto/baridi
- Rekebisho la Mlinganyo wa Muda (Equation of Time)

Total Adjustment =

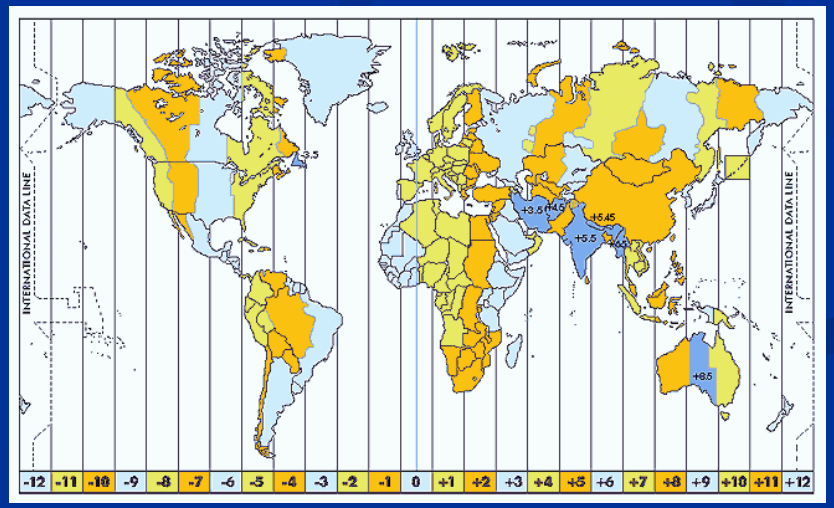
- Longitude Adjustment
- Summer / Winter Adjustment
- Equation of Time Adjustment

Zoezi 5: Kusoma muda, Rekebisho la Longitudo

Activity 5: Read the time, Longitude Adjustment

- Dunia imegawanywa katika kanda 24 kuanzia sifuri ambayo inaitw Meridi ya Griniwichi
- Lazima tufahamu longitudo ya mahala tulipo pamoja na longitudo ya "kiwangogezi" kwa eneo lako
- Tumia alama + kwa Mashariki, na alama – kwa Magharibi.
- Andika longitudo kwa muundo wa h, (saa), m (dakika) na s (sekunde) (nyuzi moja 1º = dakika 4).

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



Zoezi 5: Kusoma muda, Rekebisho la msimu

Activity 5: Read the time, Summer / Winter Adjustment

- Nchi nyingi za kaskazini na kusini huongeza saa moja wakati wa msimu joto
- Badiliko hili linafanywa kwa uamuzi wa serikali husika

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

Zoezi 5: Kusoma muda, Rekebisho la mlinganyo wa Muda

Activity 5: Read the time,
Equation of Time Adjustment

- Dunia huzunguka Jua kufuatana na kanuni ya eneo, yaani, mwendokasi yake hubadilika. Tunafasili muda wastani (wa saa za kawaida) kuwa ni wastani kwa mwaka mzima.
- Mlinganyo wa Muda ni tofauti kati ya “Saa Halisi ya Jua" na “Wastani wa Muda” katika dakika

- 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

day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	+3m 33s	+13m 35s	+12m 22s	+3m 54s	-2m 54s	-2m 12s	+3m 50s	+6m 21s	+0m 2s	-10m 18s	-16m 24s	-11m 1s
6	+5m 50s	+14 m 5s	+11m 17s	+2m 27s	-3m 23s	-1m 22s	+4m 45s	+5m 54s	-1m 23s	-11m 51s	-16m 22s	-9m 1s
11	+7m 55s	+14m 14s	+10m 3s	+1m 4s	-3m 38s	-0m 23s	+5m 29s	+5m 13s	-3m 21s	-13m 14s	-15m 31s	-6m 49s
16	+9m 45s	+14m 4s	+8m 40s	-0m 11s	-3m 40s	+0m 39s	+6m 3s	+4m 17s	-5m 7s	-14m 56s	-15m 15s	-4m 27s
21	+11m 18s	+13m 37s	+7m 12s	-1m 17s	-3m 27s	+1m 44s	+6m 24s	+3m 10s	-6m 54s	-15m 21s	-14m 10s	-1m 58s
26	+12m 32s	+12m 54s	+5m 42s	-2m 12s	-3m	+2m 49s	+6m 32s	+1m 50s	-8m 38s	-16m 1s	-12m 44s	+0m 31s
31	+13m 26s		+4m 12s		-2m 21s		+6m 24s	+0m 21s		-16m 22s		+2m 57s

Zoezi 5: Kusoma muda, Barcelona

Example 1: Barcelona (Spain) on May 24th

Marekebisho	Maelezo	Majibu
1. Longitudo	Barcelona, Hispania ipo katika kanda “kiwango" kama ile ya Griniwichi. Longitudo yake ni 2° 10’ Mashariki = 2.17° Mashariki = dk -8.7 (1° ni sawa na dk 4)	dakika -8.7
2. Saa ya Msimu Joto	Kwa Hispania, muda wa kuokoa masaa ya mwanga inaongezwa saa 1 = dakika 60	+ dakika 60
3. Mlinganyo wa Muda	Tunasoma jedwali kwa mwezi Mei tarehe 24	dakika -3.4 m
Jumla		dk +47.9

Kwa mfano saa 6 mchana (kwa saa ya Bonyeza) hapo Barcelon, saa za mkononi zitasoma:

Saa 6 (Saa ya Bonyeza) + dakika 33.6 = saa 6 na dakika 33.6 (saa ya mkononi)

Activity 5: Reading Time

Example 1: Barcelona (Spain) on May 24th

Adjustment	Comment	Result
1. Longitude	Barcelona is in the same "standard" zone as Greenwich. Its longitude is 2º 10' E = 2.17º E = -8.7 m (1° is equivalent to 4 m)	-8.7 m
2. Summer Time	May has daylight saving of +1 h	+ 60 m
3. Equation of Time	We read the table for May 24th	-3.4 m
Total		+47.9 m

For example at 12h of solar time (noon), our watches indicated (Solar time) 12h + 47.9 m = 12h 47.9 m (wristwatch time)

Zoezi 5: Kusoma muda

Mfano 2: Dodoma (Tanzania) Mei 24

Marekebisho	Maelezo	Majibu
1. Longitudo	Dodoma,Tanzania ipo katika kanda “kiwangogezi” ya 45°. Longitudo yake ni 35° 45’ Mashariki = 35.75° Mashariki ambayo ni 9.25° Magharibi ya meridian ya kiwangogezi = = 9° 15’ Magharibi = dakika +37 (1° ni sawa na dk 4)	Dakika +37
2. Saa za Msimu	Tanzania haina badiliko la masaa ya kuokoa muda wa mwanga	0
3. Mlinganyo wa Muda	Tunasoma jedwali kwa mwezi Mei tarehe 24	Dakika -3.4 m
Jumla		Dakika +33.6

Kwa mfano saa 6 mchana (kwa saa ya Bonyeza) hapo Dodoma, saa za mkononi zitasoma:

Saa 6 (Saa ya Bonyeza) + dakika 33.6 = saa 6 na dakika 33.6 (saa ya mkononi)

Activity 5: Reading Time

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

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

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

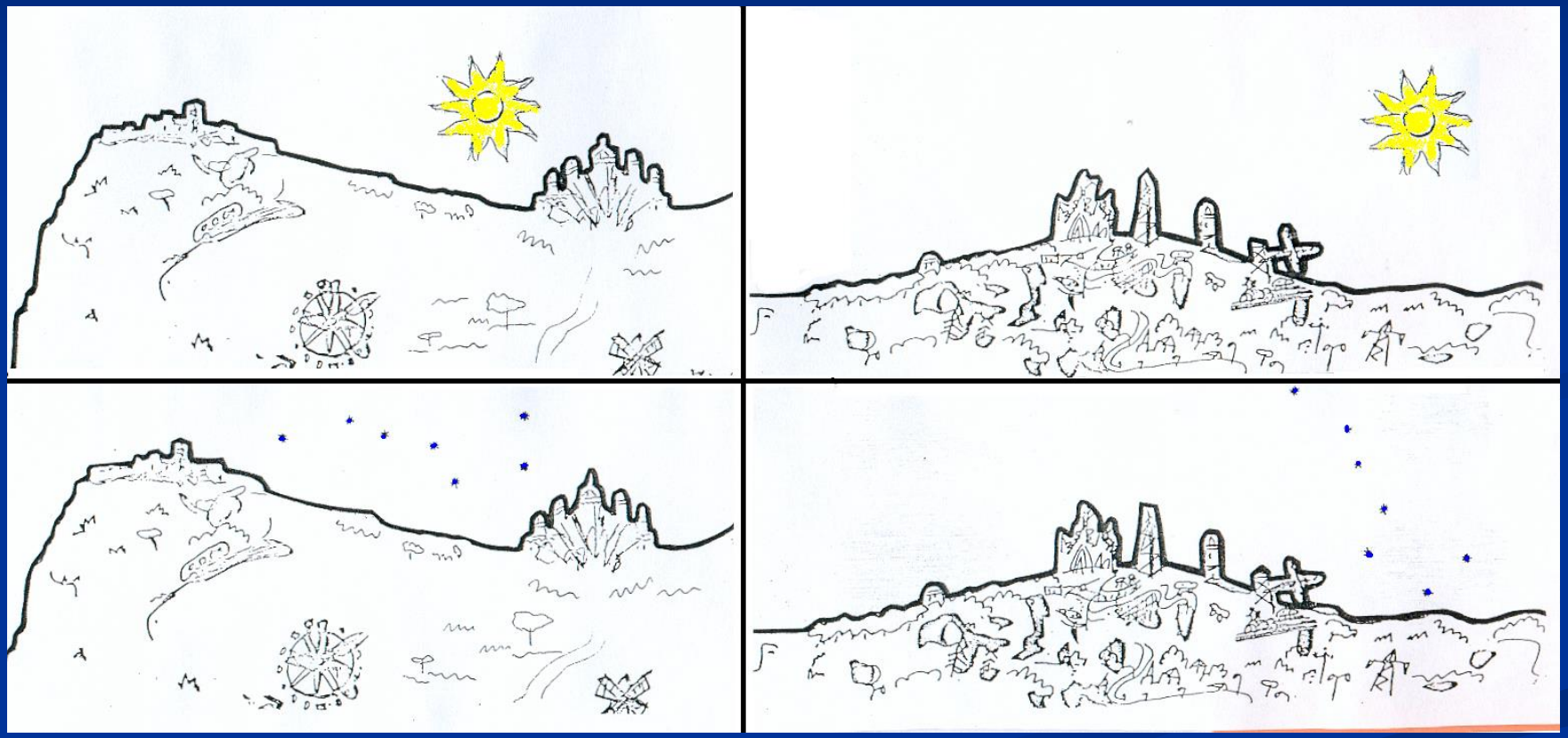
Zoezi 5: Kusoma muda

Mfano 3: Tulsa, Oklahoma (Marekani) Novemba 16

Marekebisho	Maelezo	Majibu
1. Longitudo	Meridiani kiwangogezo ya Tulsa ni 90° Magharibi. Longitudo yake ni 95° 58’ = Magh = 96° Magharibi, ambayo ni 6° Magh kutoka meridian ya kiwangogezi = dakika 24 (1° ni sawa na dakika 4)	Dakika +24
2. Saa za Msimu baridi	Siku ya Novemba 16 haina masaa ya kuokoa masaa ya mwanga	0
3. Mlinganyo wa Muda	Tunasoma jedwali kwa mwezi Novemba 16	Dakika -15.3
Jumla		Dakika + 8.7

Kwa mfano saa 6 mchana (saa ya bonyeza), saa za mkononi zitasoma:
Saa 6 (saa ya bonyeza) + dakika 8.7 = saa 6 na dakika 8.7

mfano wetu umetuwezesha kupata mielekeo...



the model serves to orientate us …

...kujifunza kwa vitendo na kuelewa...

… to observe and understand …

Hitimisho

Conclusions

- Tumejifunza “muonekano" wa mfano kutoka ndani na nje
- Tumefikia hatua ya kuwa na uwezo wa kuwazia ambao utatusaidia kusoma vitabu kwa kuelewa na kuweza kutoa maoni.
- Tunaweza kuhisi ulivyo upeo halisi.
- Tumeona kwamba Jua halichomozi Mashariki kila siku na halizami Magharibi kila siku.
    - We understand the "views" of the model from inside and outside
    - We reach levels of abstraction that let us read books and make comments
    - We feel oriented to the real horizon
    - We see that the sunrise is not always due East and that the Sunset is not always due West

Asanteni sana kwa usikivu wenu!

Thank you very much
for your attention!