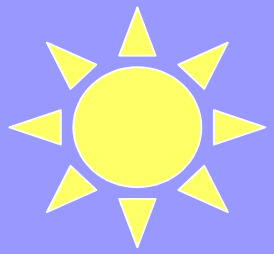


Designing a Sundial from Scratch

Roger Bailey

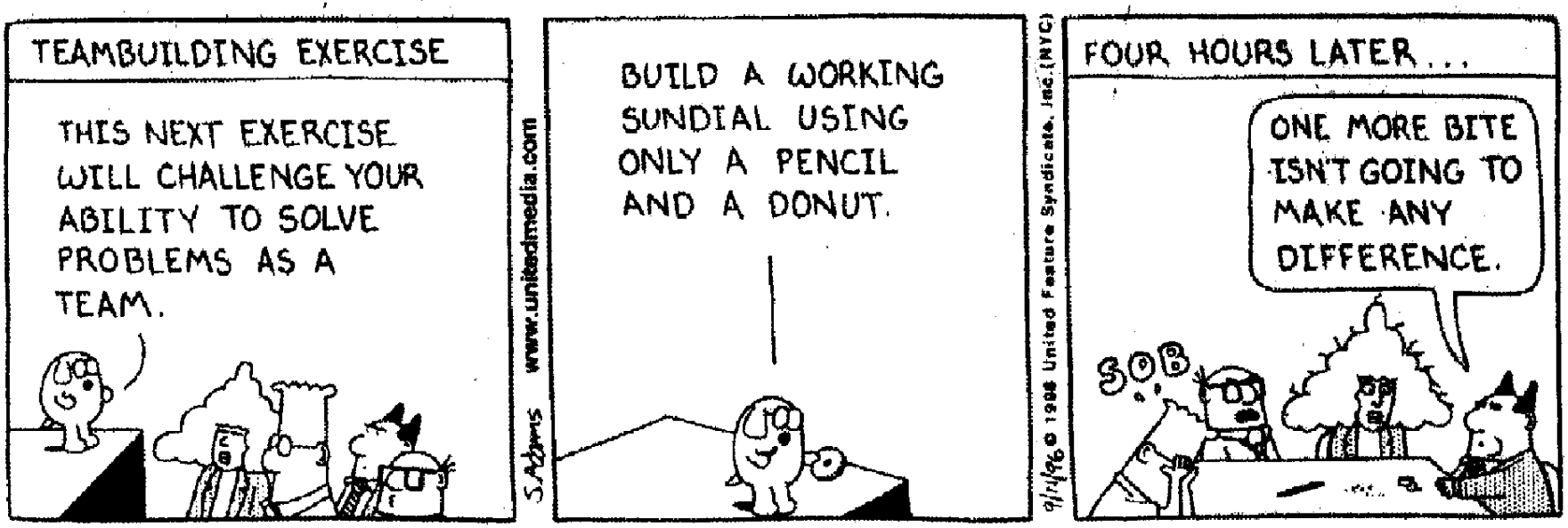
NASS 2003 Banff

Walking Shadow Designs

Designing a Sundial from Scratch

- No reference books
- No computers or design software
- No Internet access
- Use Greek geometry: Ruler and Compass
- Use geometric construction
- Extend geometry to derive trigonometry
- Protractor? Trig tables? Calculator?
- Teambuilding exercise?

Dilbert


TEAMBUILDING EXERCISE
THIS NEXT EXERCISE WILL CHALLENGE YOUR ABILITY TO SOLVE PROBLEMS AS A TEAM.
BUILD A WORKING SUNDIAL USING ONLY A PENCIL AND A DONUT.
FOUR HOURS LATER...
ONE MORE BITE ISN'T GOING TO MAKE ANY DIFFERENCE.
SOB
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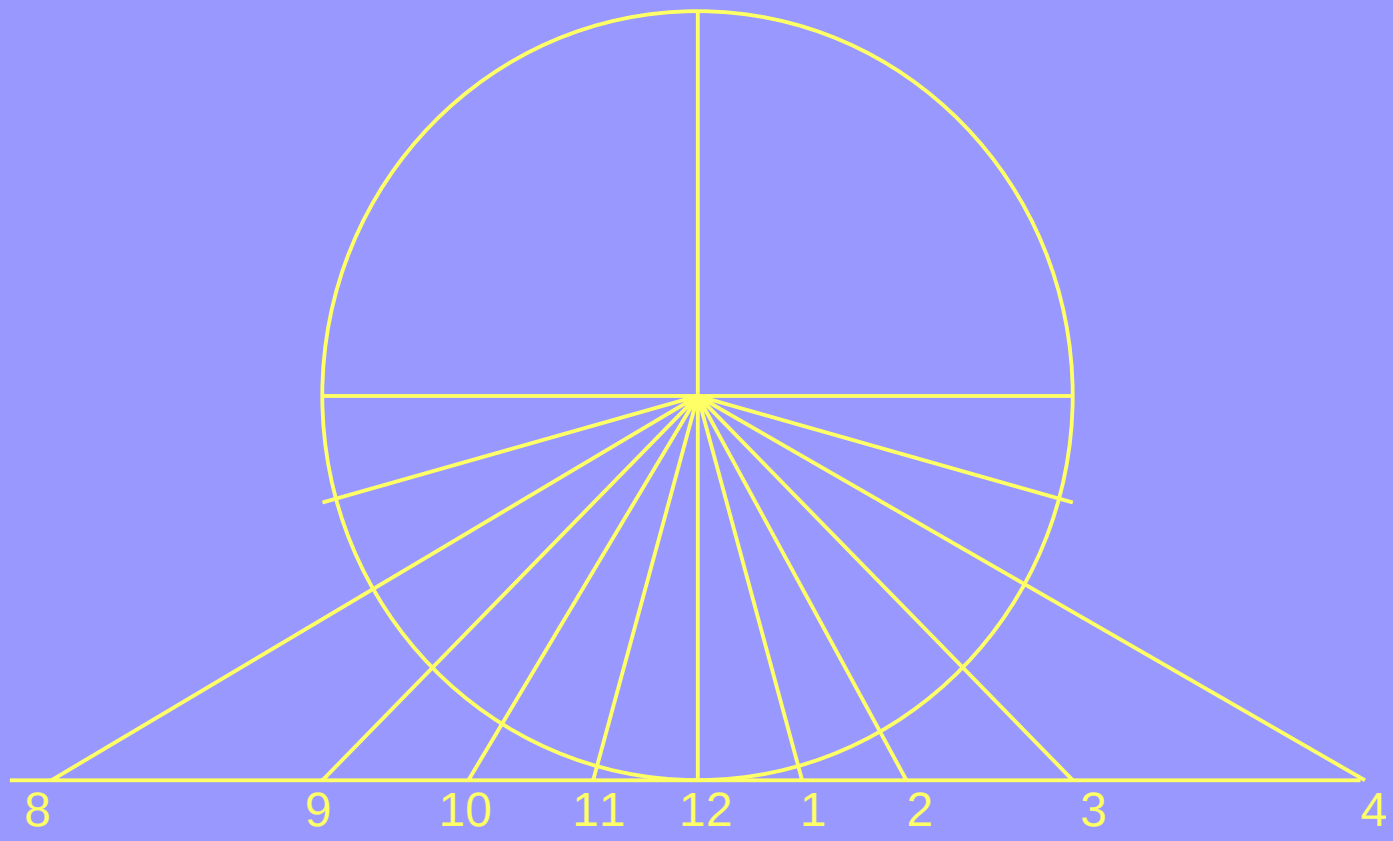
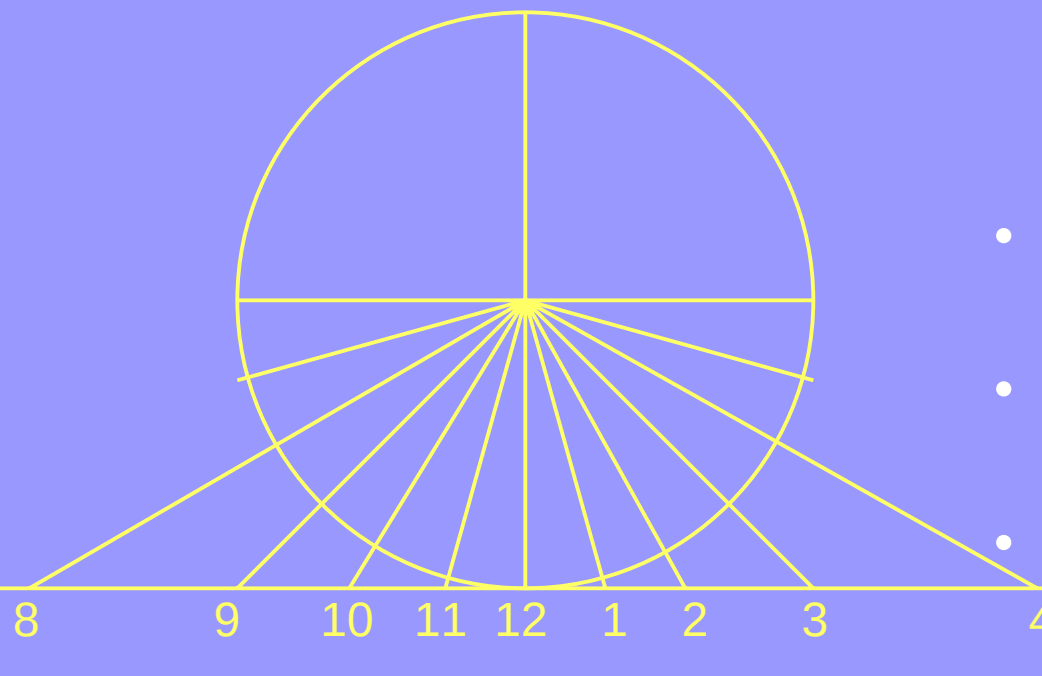
Equinoctial Tangent Line



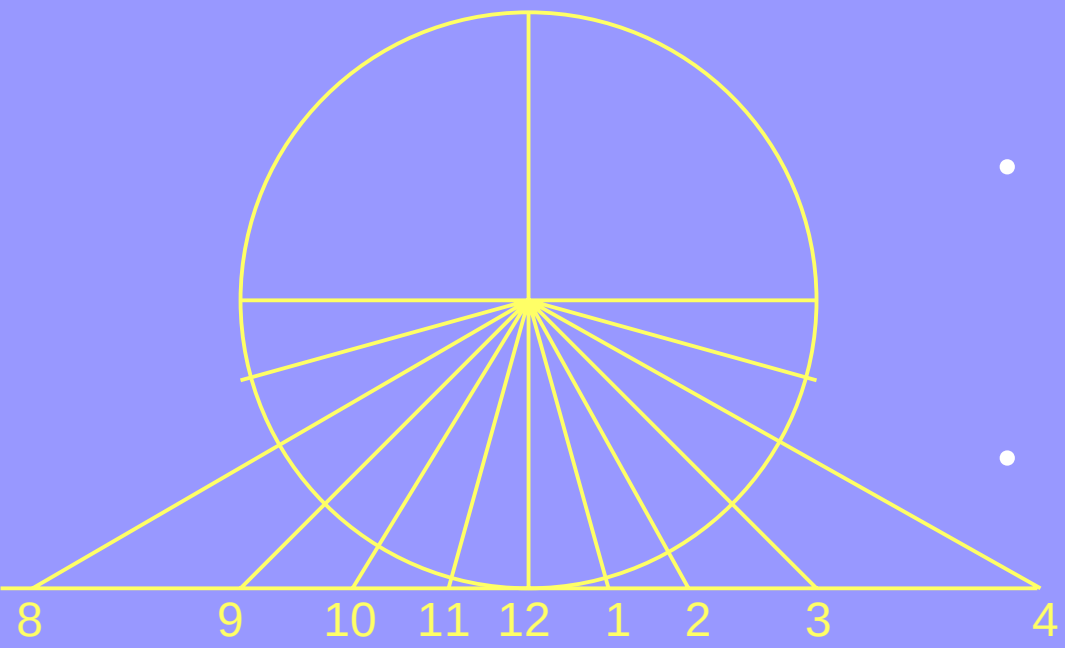
Equinoctial Tangent Line



- Picture an Armillary Sphere or equatorial sundial looking down the polar axis at Equatorial plane
- Equatorial disc as a circle, time angles 15°
- Angles (90, 60, 45, 30,15) using ruler and compass
- Horizontal Tangent line

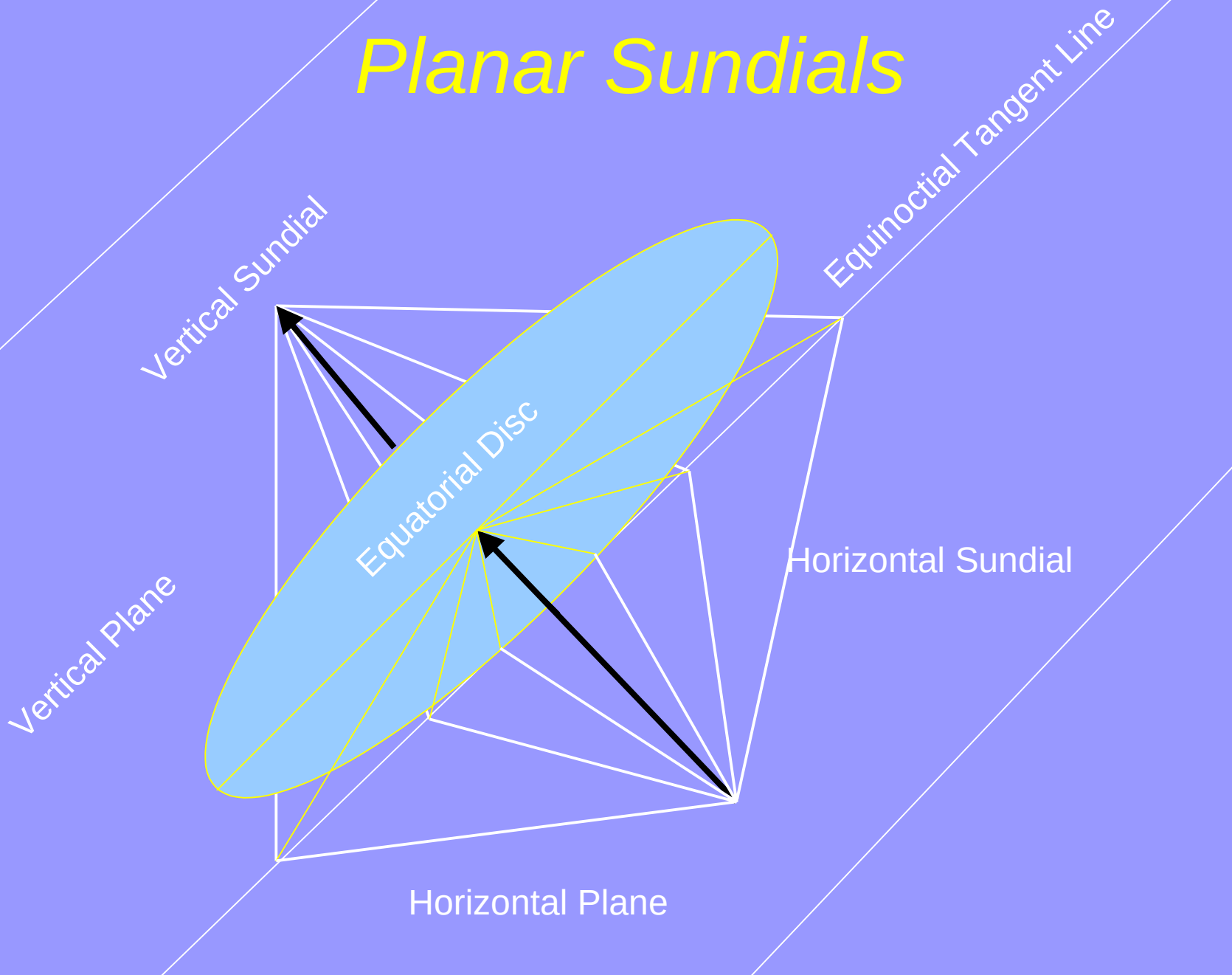
$$d = r \ \mathrm{Tan}\ t$$

Equinoctial Tangent Line



- Equinoctial Line defines the Polar Sundial where the plane is parallel to the gnomon
- Equatorial Line is the intersection line at the base of horizontal and vertical south facing sundials
- The gnomon intersection point and the distances on define the hour angles for horizontal and vertical sundials

Planar Sundials

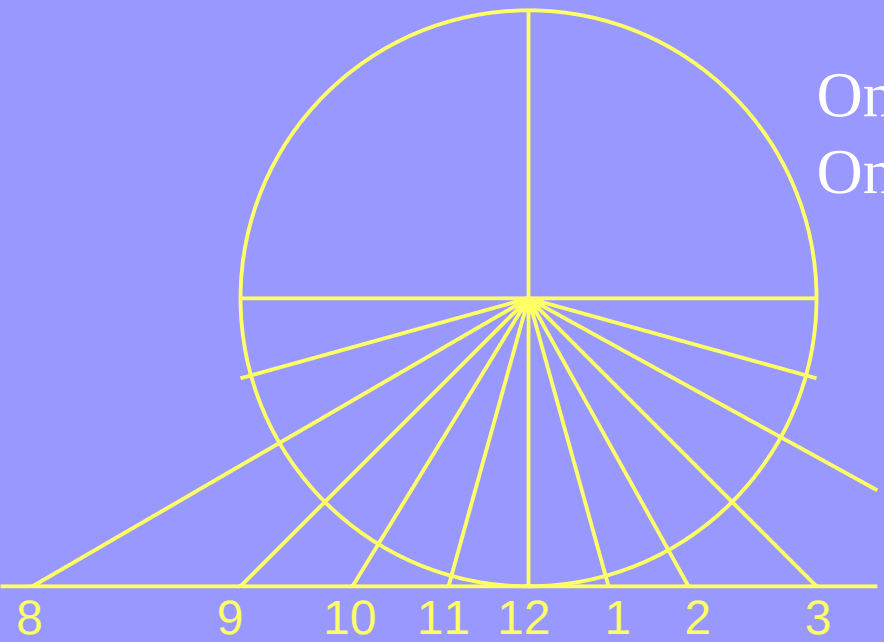


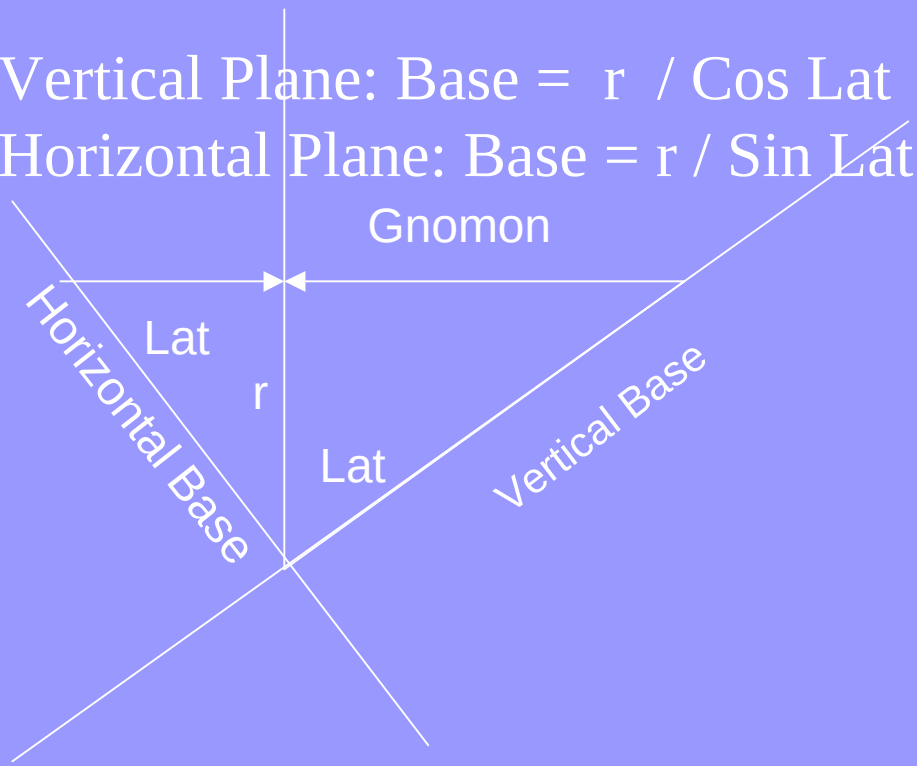
Gnomon Base Lengths

Gnomon Bases on the planes are the hypotenuse of the right angle triangles with one side = r and containing the Latitude.

On Vertical Plane: Base = r / Cos Lat

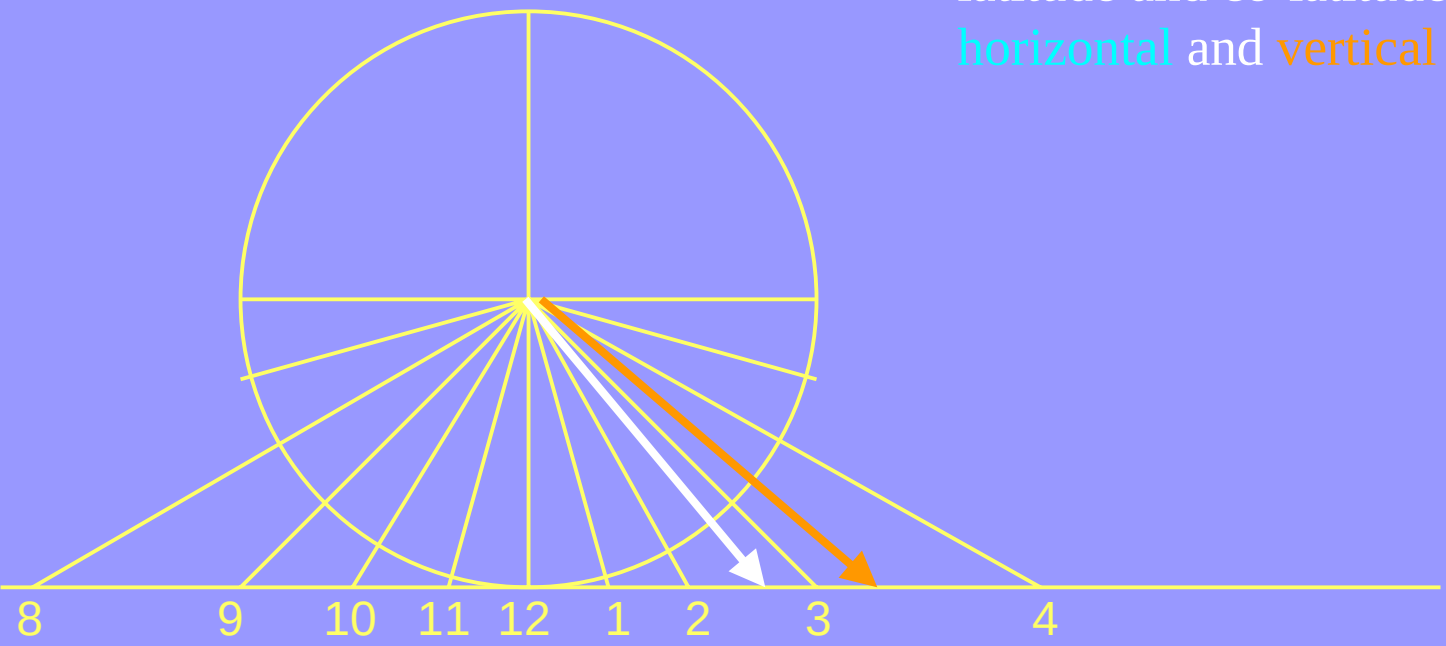
On Horizontal Plane: Base = r / Sin Lat



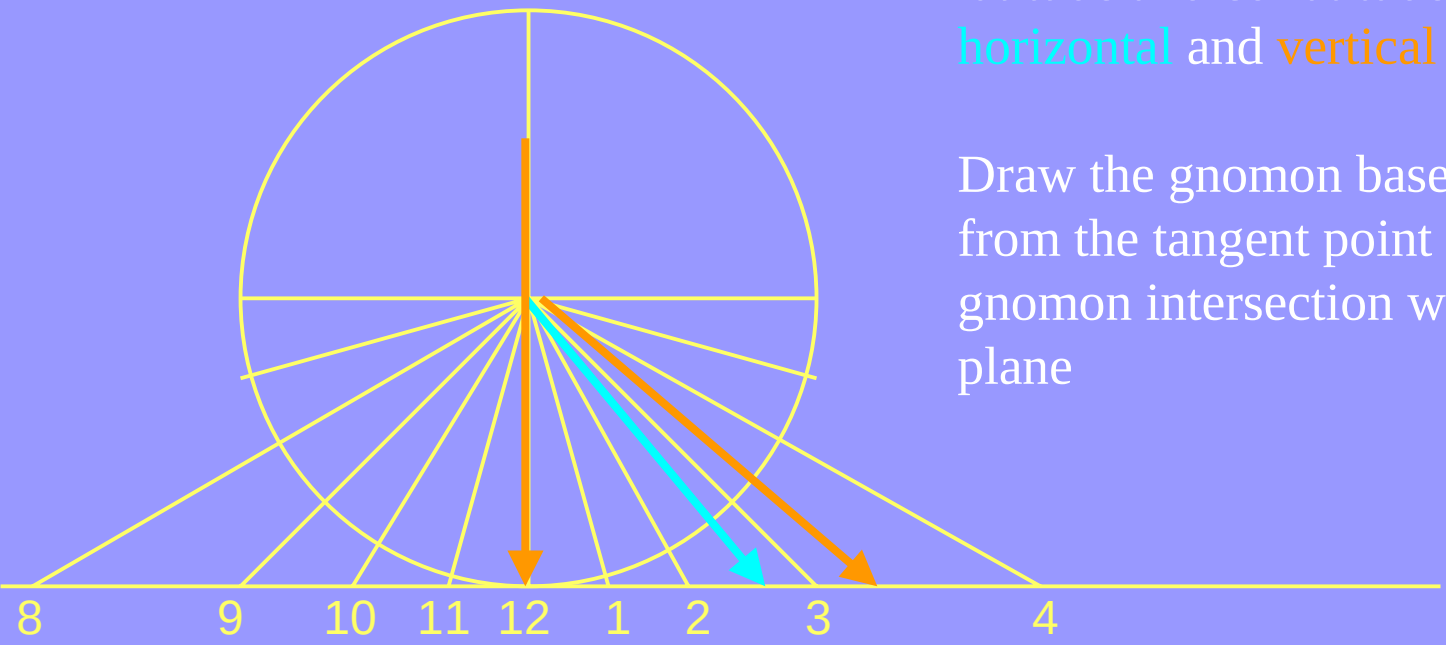


Gnomon Base Lengths

Use the tangent line and r to find the gnomon base lengths for the latitude and co-latitude for horizontal and vertical dials.



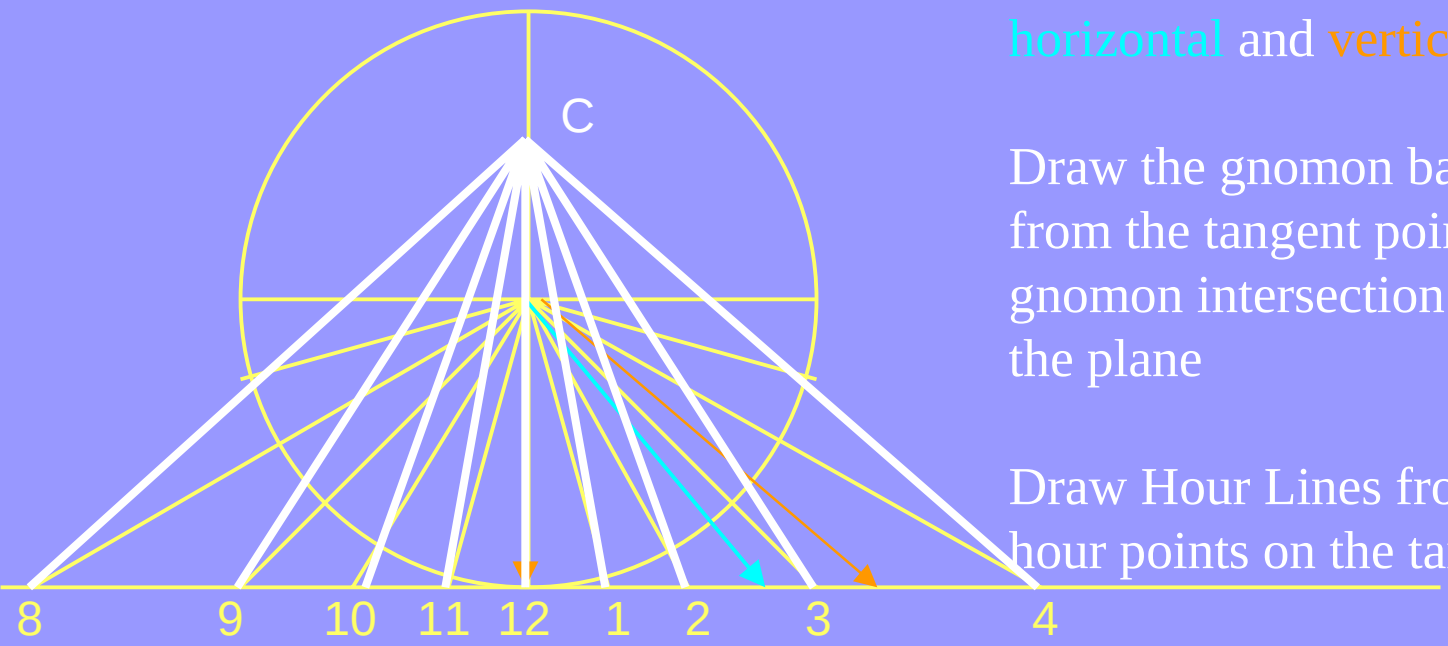
Gnomon Base Lengths



Use the tangent line and r to find the gnomon base lengths for the latitude and co-latitude for horizontal and vertical dials.

Draw the gnomon base vertically from the tangent point to set the gnomon intersection with the plane

Hour Lines

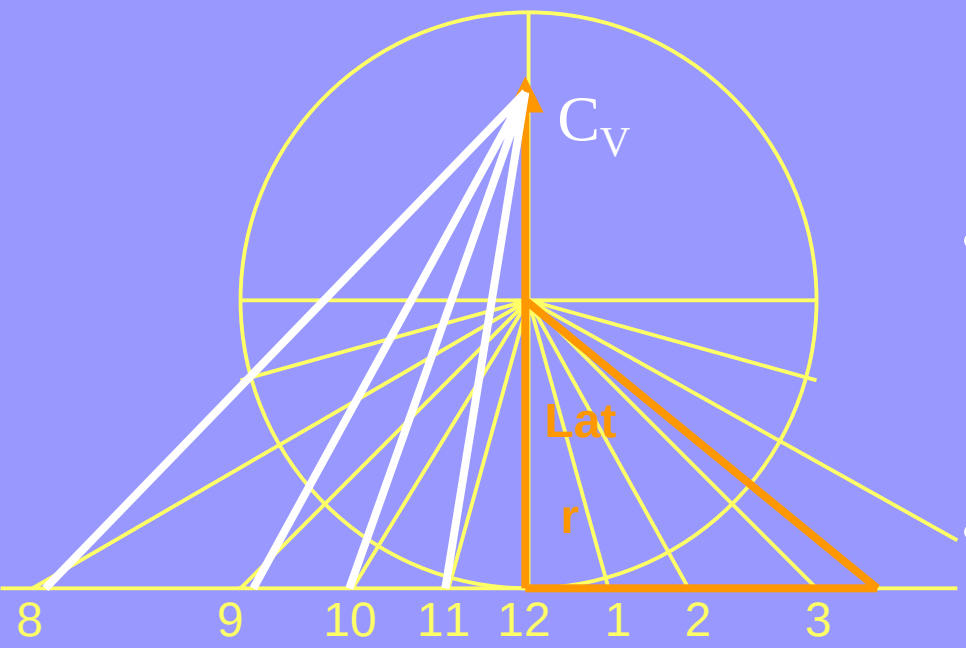


Use the tangent line and r to find the gnomon base lengths for the latitude and co-latitude for horizontal and vertical dials.

Draw the gnomon base vertically from the tangent point to set the gnomon intersection point C with the plane

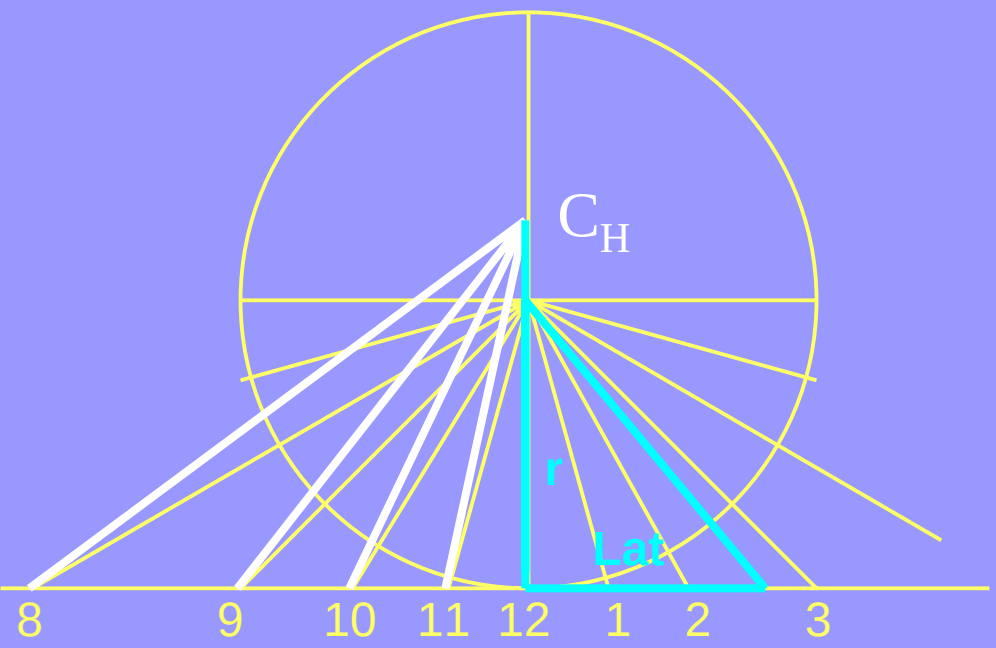
Draw Hour Lines from C to the hour points on the tangent line

Vertical Sundial



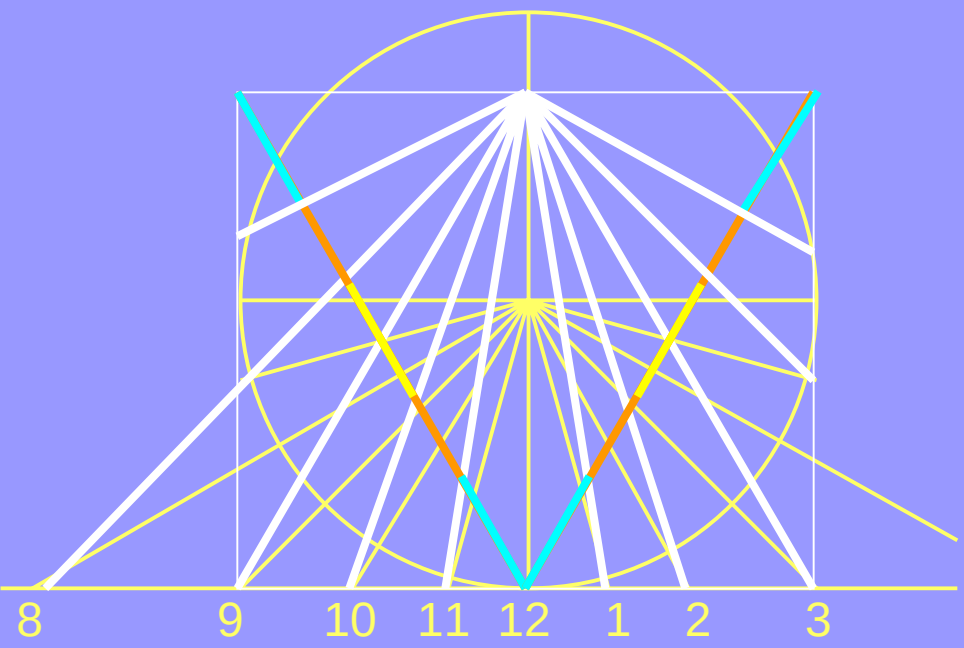
- Draw right angle triangle to determine gnomon base length. Latitude angle at centre of disc, radius is from centre to tangent point
- Hypotenuse (Gnomon Base) is = r / Cos Lat. Draw to set gnomon intersection point C_V with vertical plane
- Draw Hour Lines from base to tangent line distances
- Tan HA = r Tan t / base or
- Tan HA = Tan t x Cos Lat

Horizontal Sundial



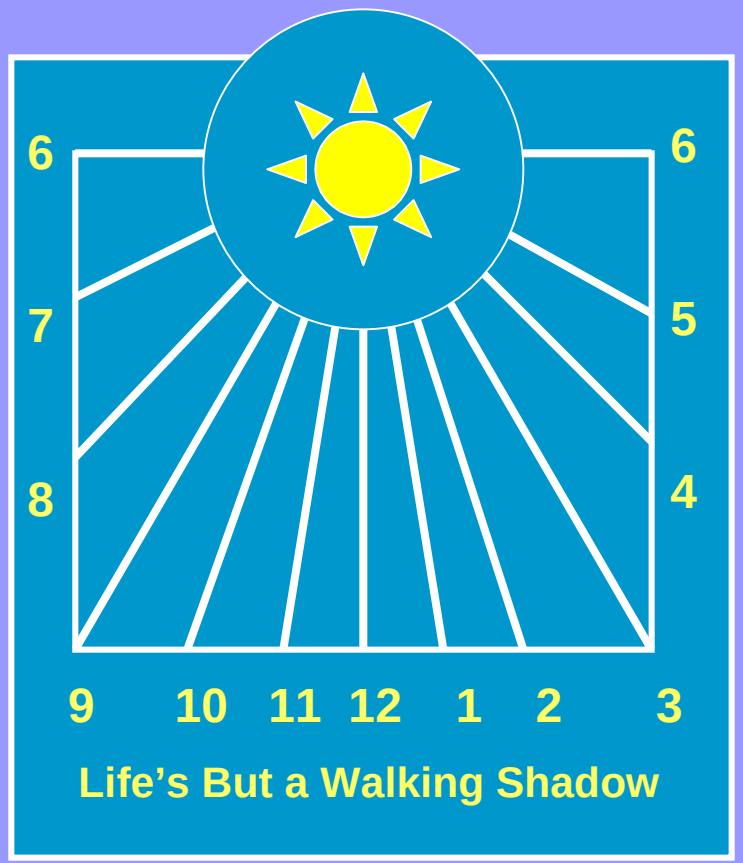
- Draw right angle triangle to determine gnomon base length. Latitude angle at tangent line; radius is from disc centre to tangent point
- Hypotenuse (Gnomon Base) is = r / Sin Lat. Draw to set gnomon intersection point C_H with horizontal plane
- Draw Hour Lines from base to tangent line distances
- Tan HA = r Tan t / base or
- Tan HA = Tan t x Sin Lat

Problem with Infinity



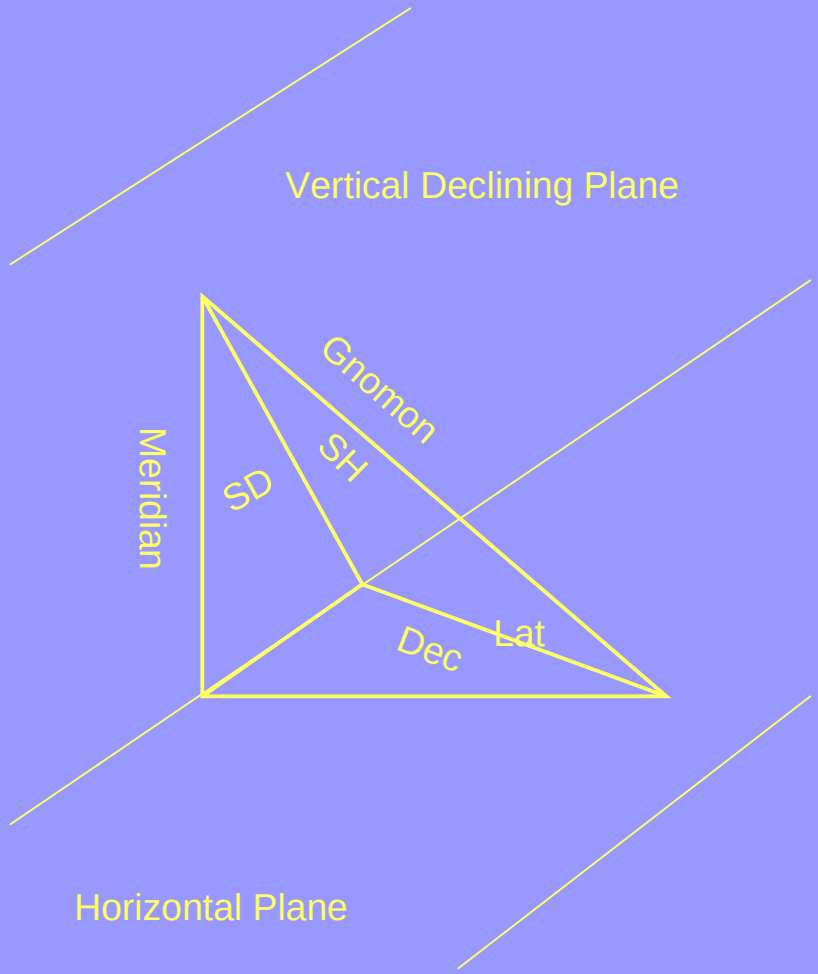
- Six o'clock line is infinite but defined
- 7 am and 5 pm are off scale
- Turn the corner at 9 am and 3 pm (45°)
- Box the circle through gnomon base point
- Scale from diagonal line (Waugh's technique)

Finish the Dial



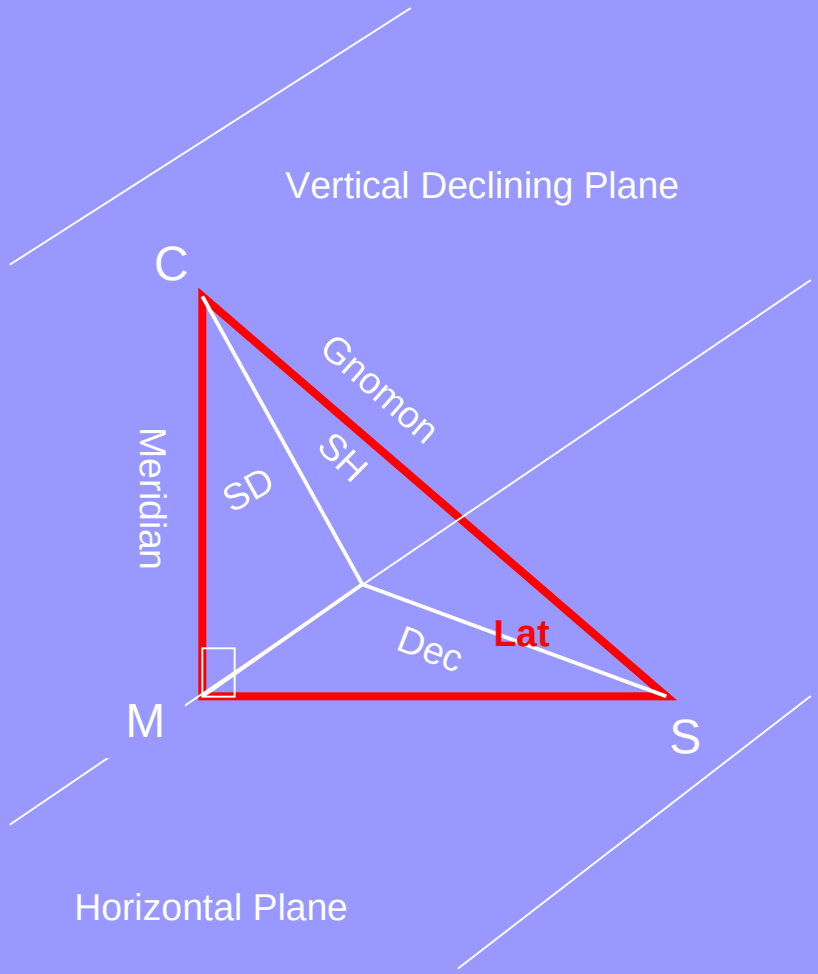
- Delete the construction lines
- Add a border and frame
- Trim the hour lines
- Add the numbers, text and decoration

Vertical Declining Sundial



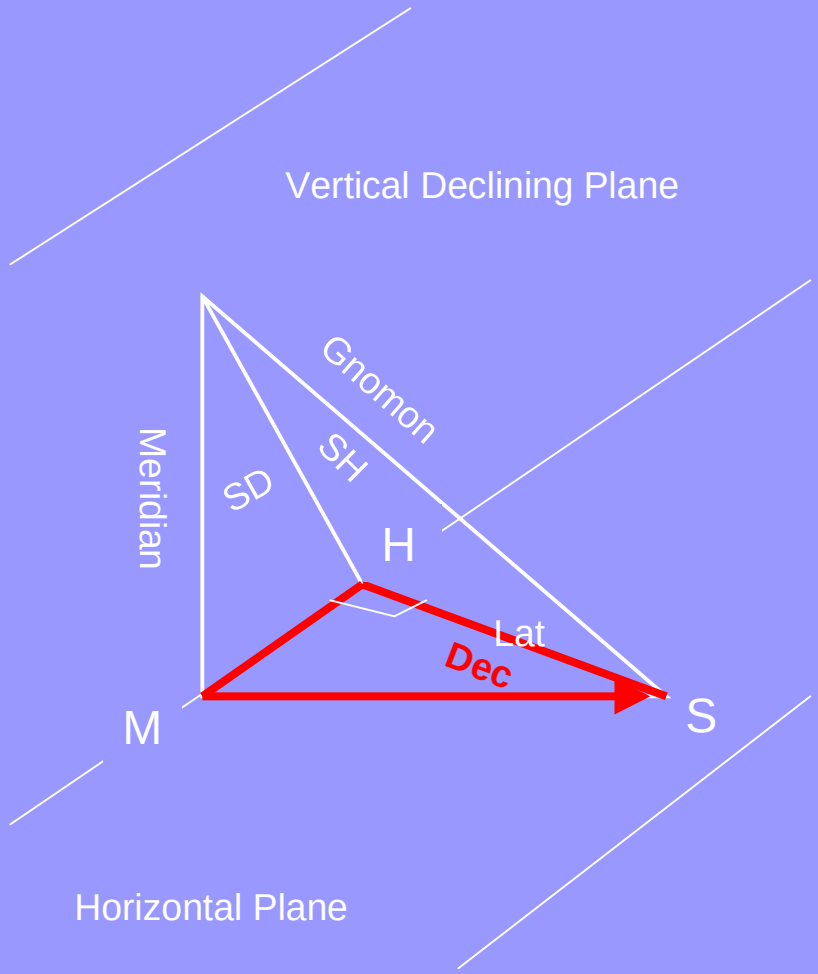
- Treat declining sundial as south facing equivalent
- Solve VD Tetrahedron for Substyle Distance SD and Substyle Height SH
  - Vertical Meridian Plane
  - Horizontal Declination Plane
  - Vertical SD Plane
  - Sloped SH Plane

Meridian Plane: Latitude Triangle



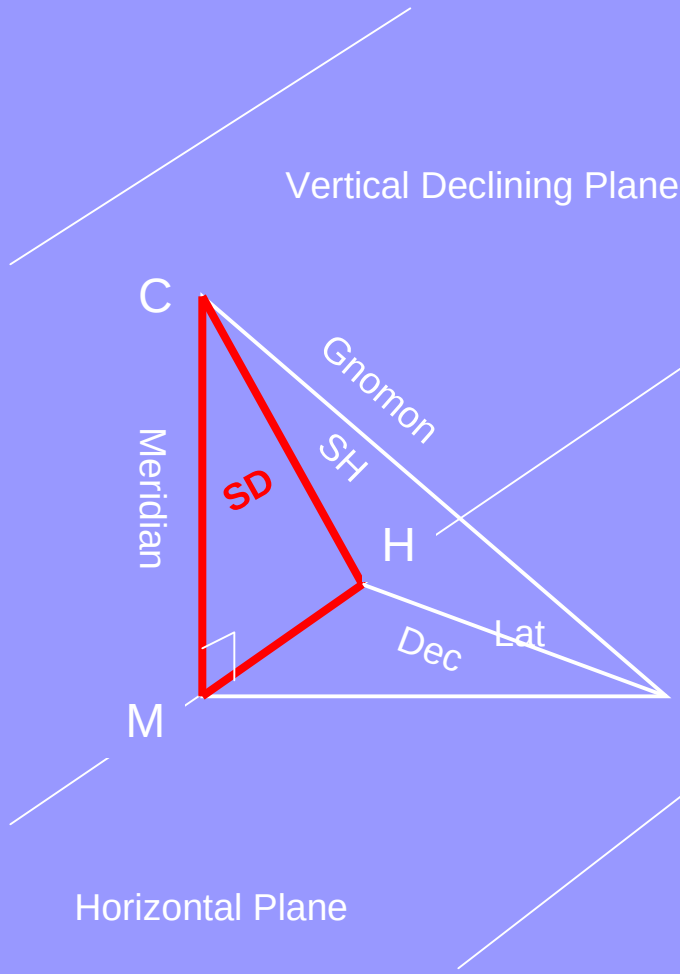
- For all vertical planes
  - Gnomon points south
  - Noon shadow is vertical
- For Meridian Plane
  - Gnomon is true length
  - Gnomon angle with horizontal is true Latitude
- CM = G x Sin (Lat)
- MS = G x Cos (Lat)

Horizontal Plane: Declination Triangle



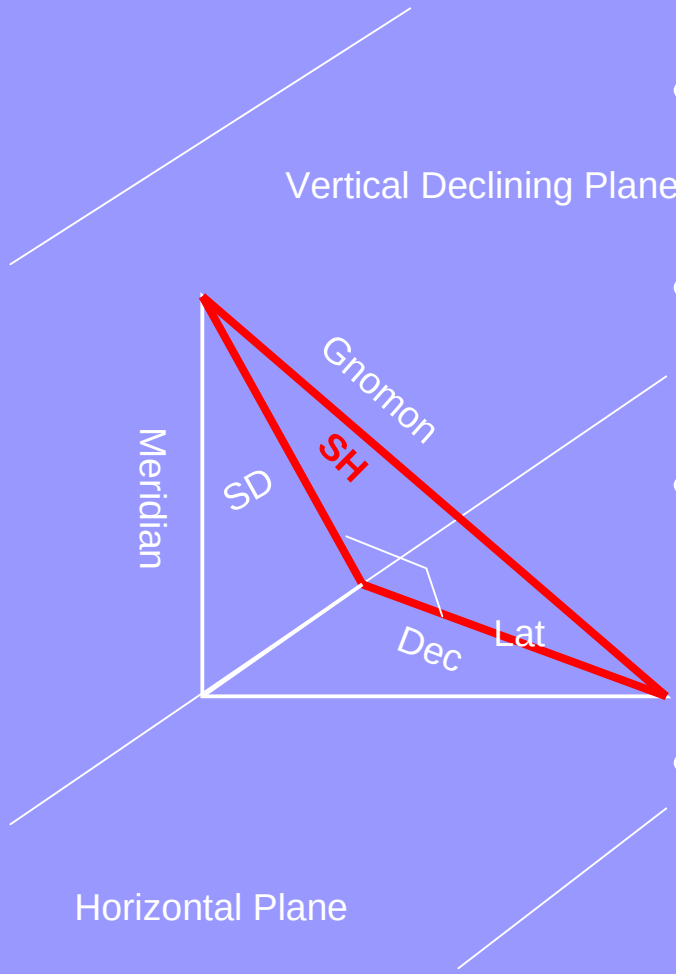
- MH = MS x Sin(Dec)
  MH = G x Cos(Lat) x Sin(Lat)
- HS = MS x Cos(Dec)
  HS = G x Cos(Lat) x Cos(Dec)

Vertical Declining Plane



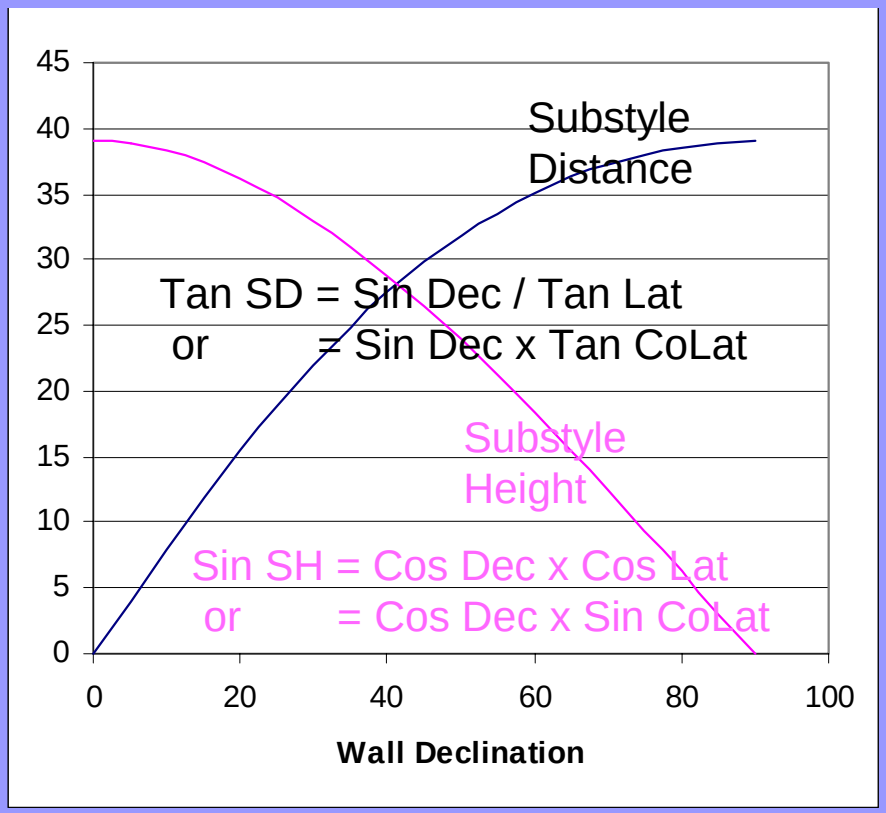
- Tan (SD) = MH / CM
- Tan(SD) = G x Cos(Lat) x Sin(Dec)/(G x Sin(Lat))
- Tan(SD) = Sin(Dec)/Tan(Lat)

Inclined Declining Plane



- For Substyle Height SH
- Sin(SH) = HS / G
- Sin(SH) = G x Cos(Lat) x Cos(Dec) / G
- Sin(SH) = Cos(Lat) x Cos(Dec)

Substyle Distance & Height



- Substyle Distance increases with wall declination from zero to Co-Latitude
- Substyle Height decreases from Co-Latitude to zero with wall declination

Sundials from Scratch

- Draw circle and Tangent Line
- Draw time segments to Tangent Line
- Find gnomon base point using the tangent line
- Draw Hour Lines from base point to tangent points
- Scale from diagonal for hours near 6 o’clock
- For vertical declining dials, first solve VD tetragon for Substyle Distance and Height

Dilbert


TEAMBUILDING EXERCISE
IT'S HOPELESS! YOU'RE LOSERS! WE'LL NEVER MAKE A SUNDIAL OUT OF A PENCIL AND AN EATEN DONUT!
ZZZ
E-mail: SCOTTADAMS@AOL.COM
HEE HEE! ALL YOU HAD TO DO WAS STICK THE PENCIL IN THE DONUT.
WE JUST BROKE ALL KINDS OF UNION RULES.
BUT HEY! LOOK AT THE SHADOW FROM THE PENCIL!