How Long is My Shadow ?

The Use of Declination Lines in the Design of Analemmatic Sundials

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NASS Hartford Oct 99

Walking Shadow Designs

Analemmatic Dial Pictures

- Calgary Telus tower
- Biarritz, France: ocean promonade
- Seattle Gas Works Park
- Woodbridge Ont (Mark Kyle)

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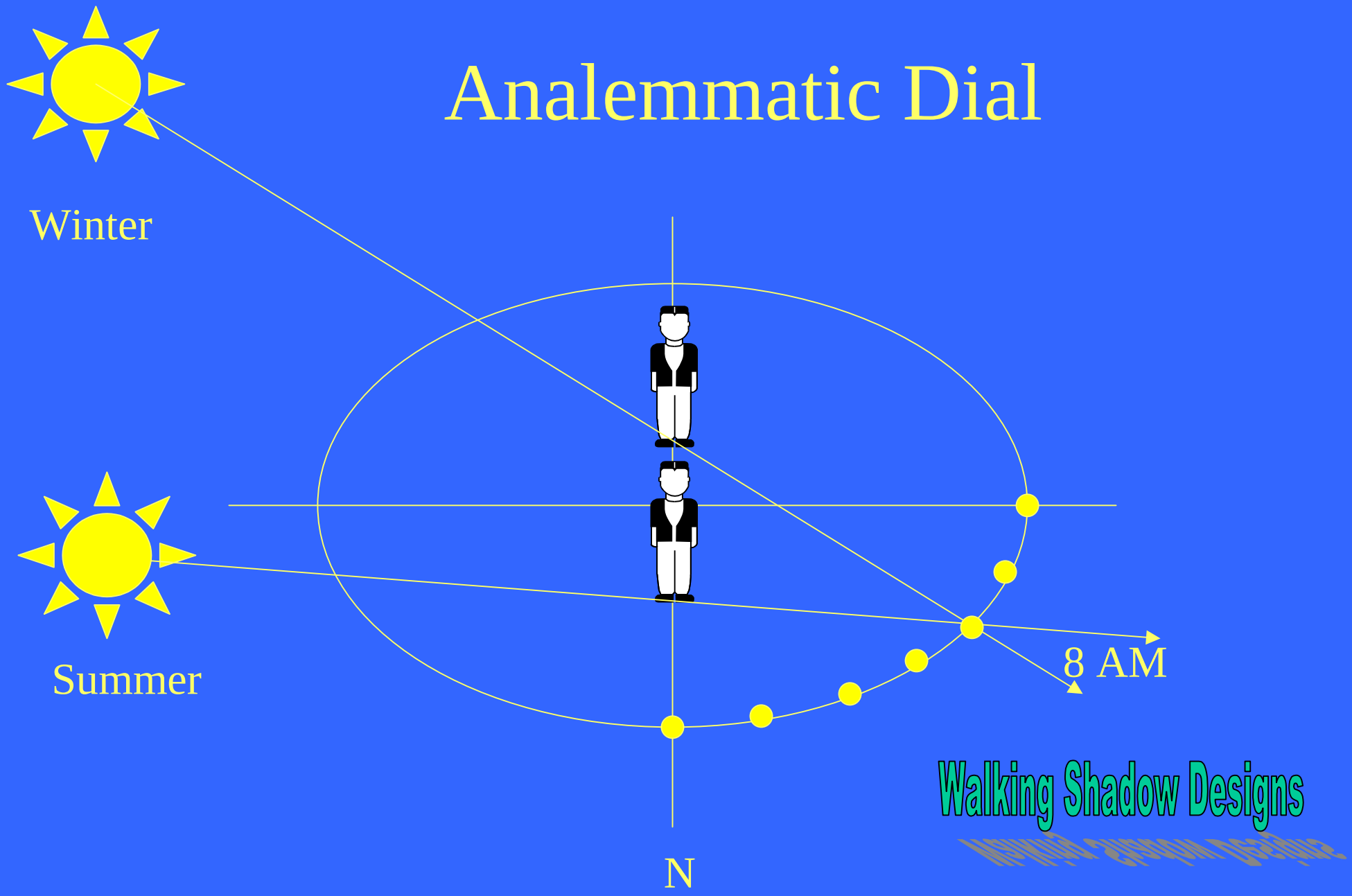
Analemmatic Dial



Analemmatic Sundials

- The “Sundial of Human Involvement”
  - Interactive: You are the gnomon
  - Your shadow tells the time
- Where you stand depends on the date
- Your shadow falls on hour markers on an ellipse

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Analemmatic Sundial Design

- Equator projected on a horizontal plane
- Equatorial circle projects as an ellipse
  - East/West semi-major axis $a = \text{radius}$
  - North/South semi-minor axis $b = a \sin L$
  - Hour Markers: $X = a \sin t$, $Y = a \cos t \sin L$
  - Gnomon: $X = 0$, $Y = a \cos L \tan D$

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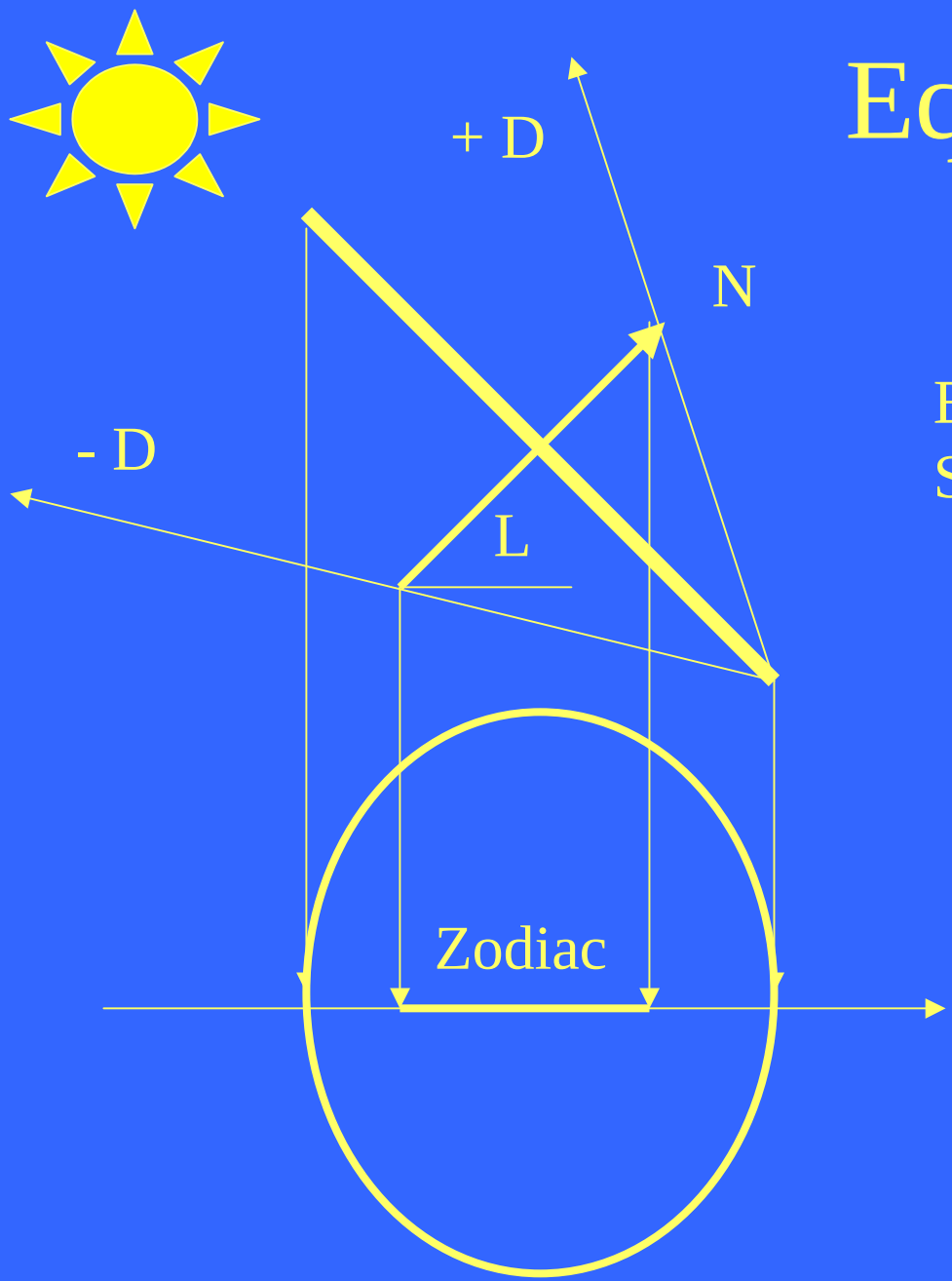
Equator Projection Dial



Equatorial ring projects as an ellipse
Shape depends on latitude

Gnomon projects as Zodiac
on north south axis for
various solar declinations

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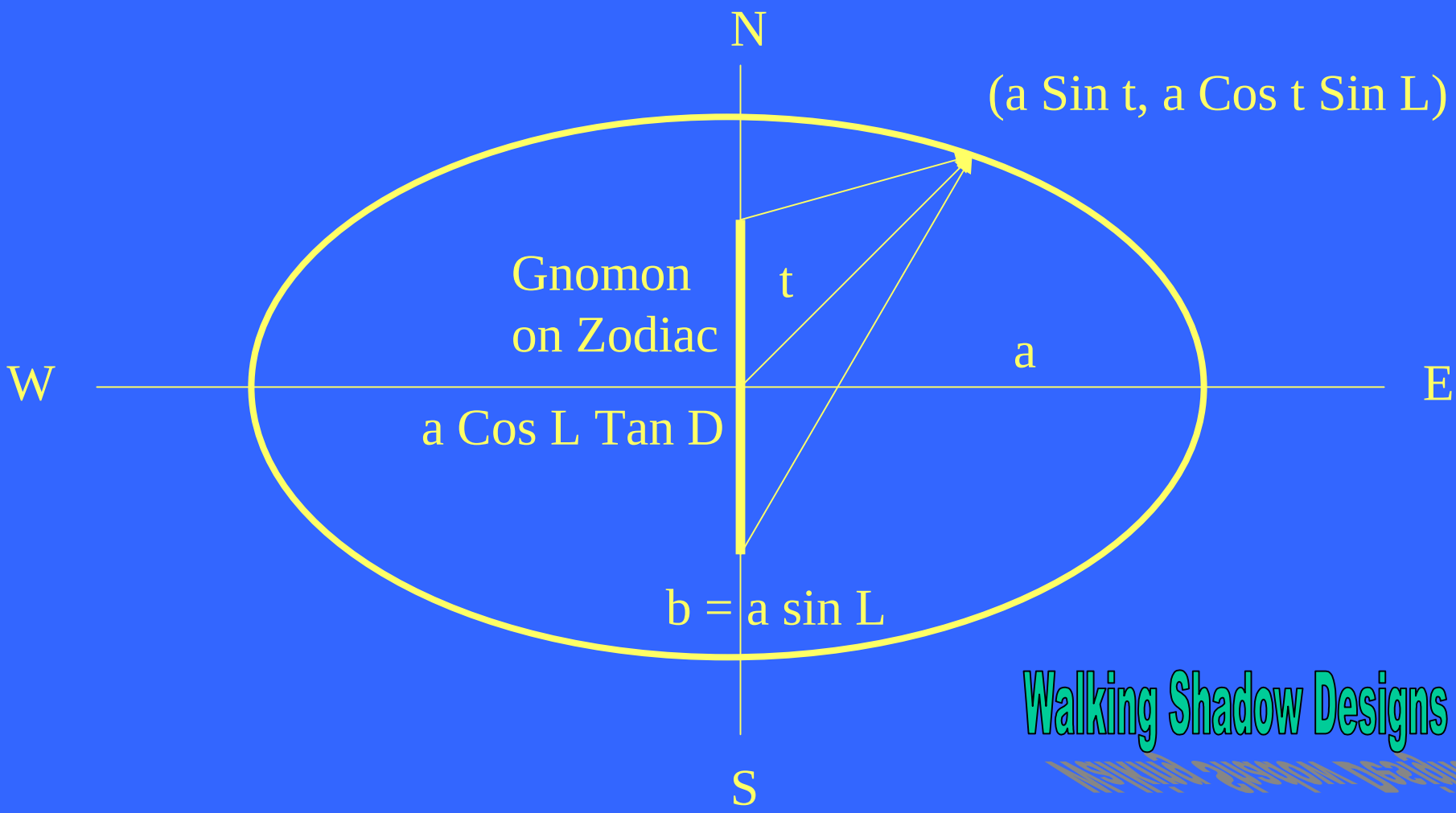
Analemmatic Sundial Design



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How Long is My Shadow ?

- Shadow length should interact with hour markers
- Shadow length depends on height of typical user
- Shadow length depends on altitude (H) of the sun
  - time of day (t), latitude (L)
  - season of year (solar declination D)

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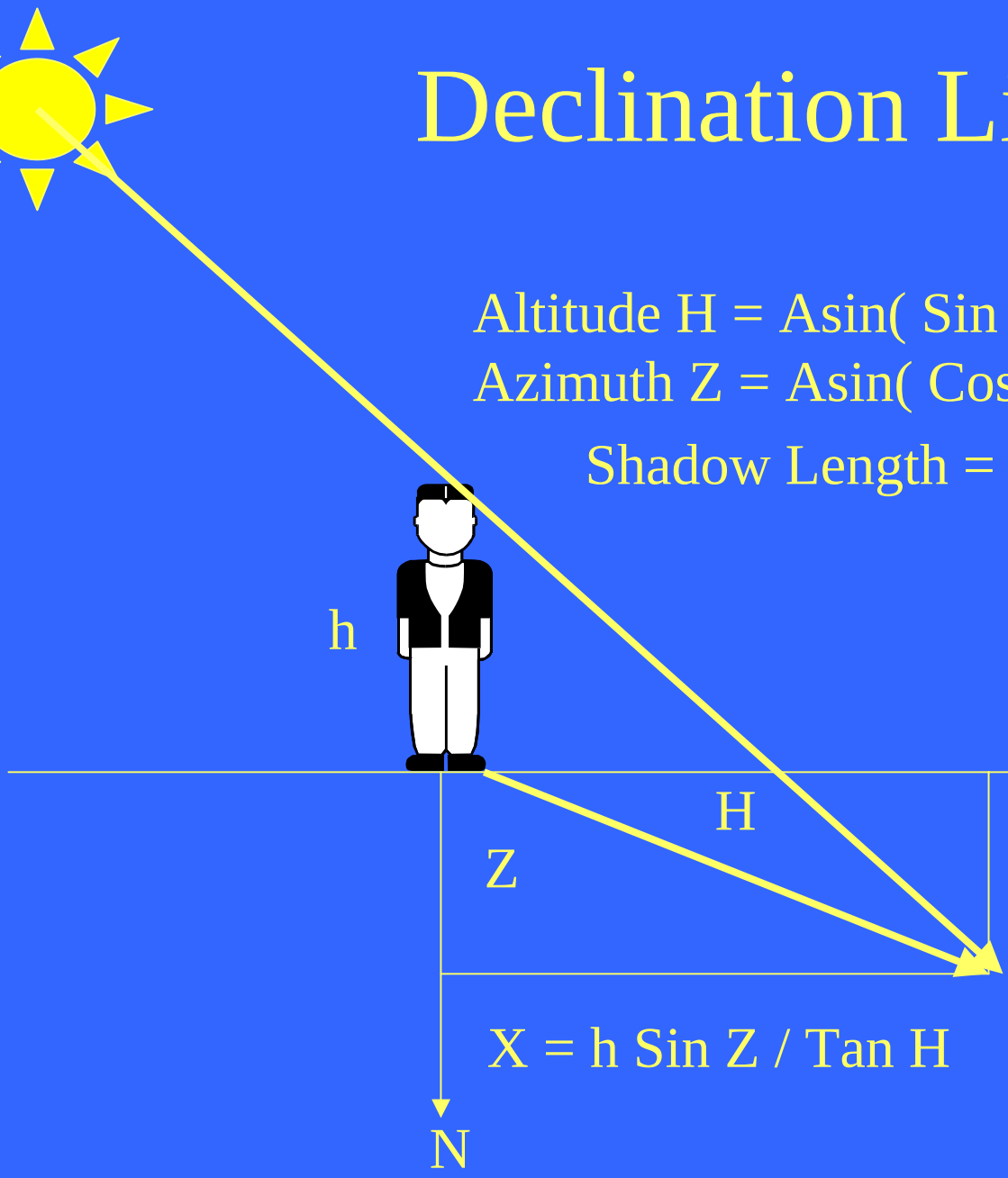
Declination Lines

Altitude H = Asin(Sin L Sin D + Cos L Cos D Cos t)

Azimuth Z = Asin(Cos D Sin t / Cos H)

Shadow Length = height / Tan H



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Design Spreadsheet

- Input parameters:
  - Latitude and Longitude
  - Declination of Sun
  - Height of Gnomon
  - Size (a) of Ellipse
- Outputs:
  - Design drawings
  - Data Tables
  - Declination and EQT chart
- Calculations:
  - Ellipse co-ordinates a, b, c
  - Hour markers
  - Declination vs date
  - Equation of time
  - Zodiac layout
  - Path of shadow
  - Declination lines

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Spreadsheet Pictures

- Input Table
- Output Table
- Zodiac Table
- Charts
  - Design Basis: Declination vs date
  - Shadow lengths for various declinations

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Calgary Science Centre Pictures

- Dome buildings
- Amazement Park, grassy knoll
- Layout and construction
- Finished dial
  - Hour markers
  - Zodiac
  - Use

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Specific Design Basis: Calgary Science Center

- Gnomon height for typical user
  - 12 to 14 years old, 1.6 to 1.7 meters tall
- Season of use: Summer
  - Maximum use: mid May to early Sept
  - Possible use: mid March to mid October
  - Design basis: August 1st, Declination = 18°
- Time of use: 10:30 to 17:00 DST
  - Solar Time: 9:00 to 15:30

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Construction

- Determine North South Y axis at solar noon
- Lay out East West X axis perpendicular to Y
- Mark out ellipse a, b and c on axes
- Scribe ellipse with string loop 2(c+a) from foci +/-c
- Lay out hour marks from x, y offsets
- Lay out Zodiac date marks on Y axis
- Install hour markers and Zodiac

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Design Test Layout

- Sundeck at home in Canmore, Alberta
  - Latitude 51° N, Longitude 115° W
- Summer use: Dec 8° to 23.5°
  - Mountain shadows and snow are problems
- Size: a = 2 meters
- Orientation: south 49° west
- CD hour markers

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Canmore Dial Pictures

- House with Walking Shadow dial
- Deck layout, analemma
- CD hour markers
- Test use

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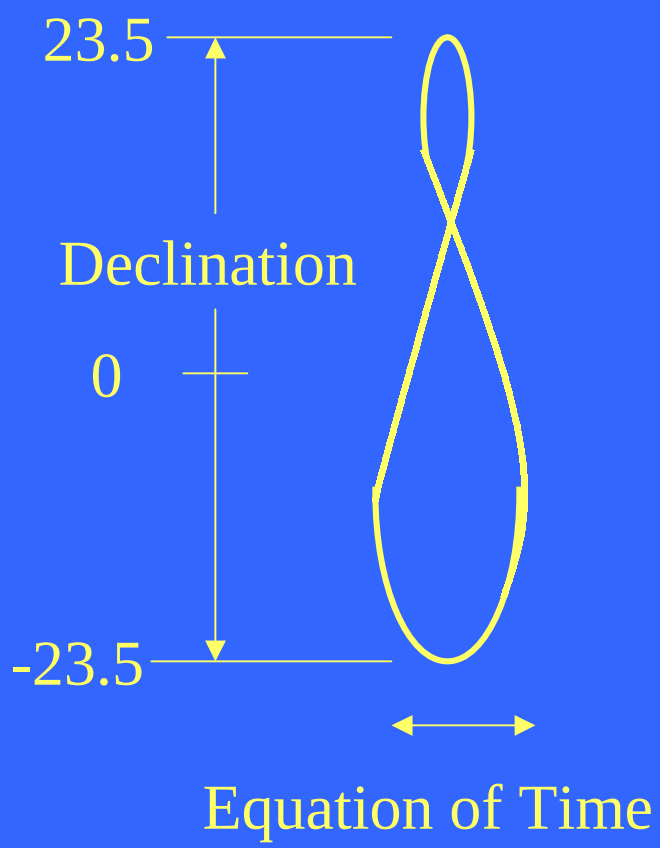
Where is the Analemma?



- Analemma definitions
  - a graphical procedure or instrument
  - the figure of eight path of the sun at the same clock time throughout the year (EQT vs Declination)
- An analemmatic dial has no analemma!

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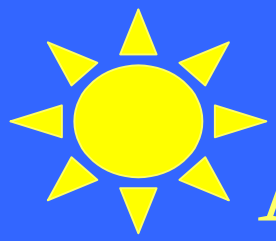

Analemma on an Analemmatic Dial

- Zodiac is the projection of declination on N/S axis
- Add the projection of Equation of Time on E/W axis
- Scale analemma to time at solar noon
- ***Not*** a noon mark but an estimate of EQT
- ***Not*** a place to stand on the Zodiac
- Included in design spreadsheet
- Too confusing for a public dial

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Conclusions

- Spreadsheets can be useful design tools for analemmatic and other sundials
- Specific design can incorporate the location, time of use and length of shadows
- Size matters, the width as much as the length of the shadow
- Design passes the “Cool! test”

Walking Shadow Designs