

Sun Study Tools

Sophomore Architecture Studio: Lighting

Lecture 1:

- Introduction to Daylight (part 1)
- Survey of the Color Spectrum
- Making Light
- Controlling Light

Lecture 2:

- Daylight (part 2)
- Design Tools to study Solar Design
- Architectural Applications

Lecture 3:

- Light in Architecture
- Lighting Design Strategies

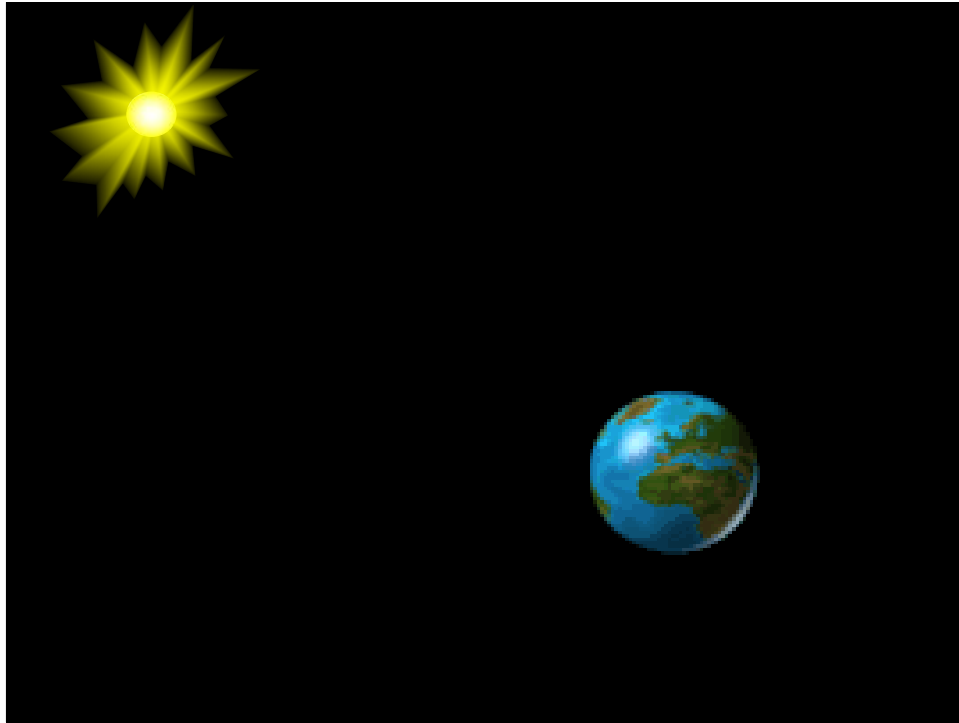
Sun Tool Options

1. Paper and Pencil
2. Build a Model
3. Use a Computer

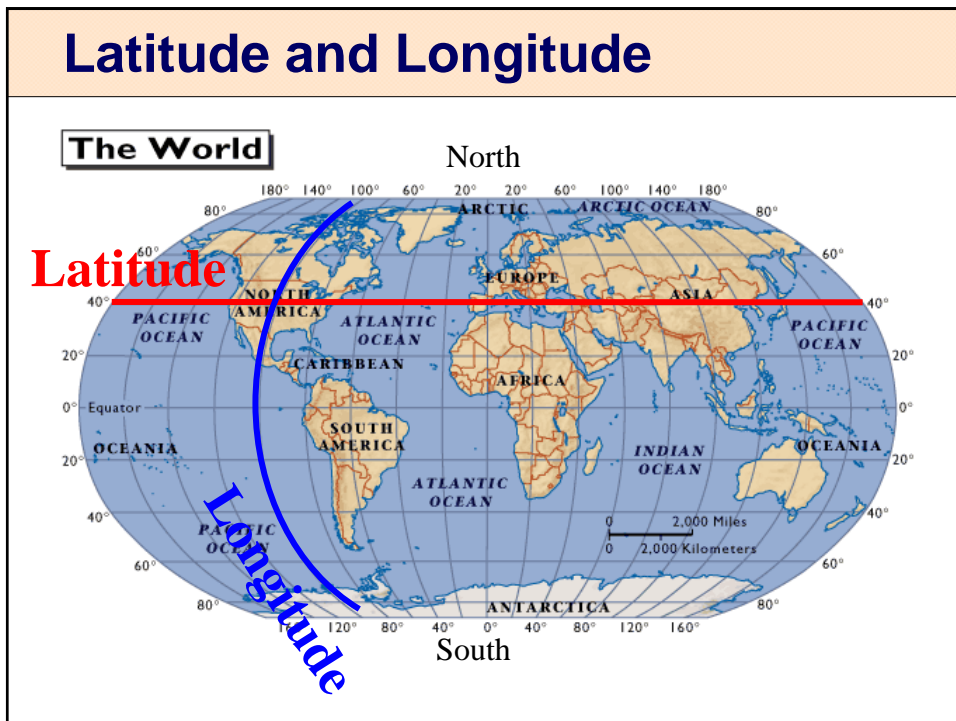
The first step to any of these options is to define....

Where is the site?

Sun Study Tools



Latitude and Longitude

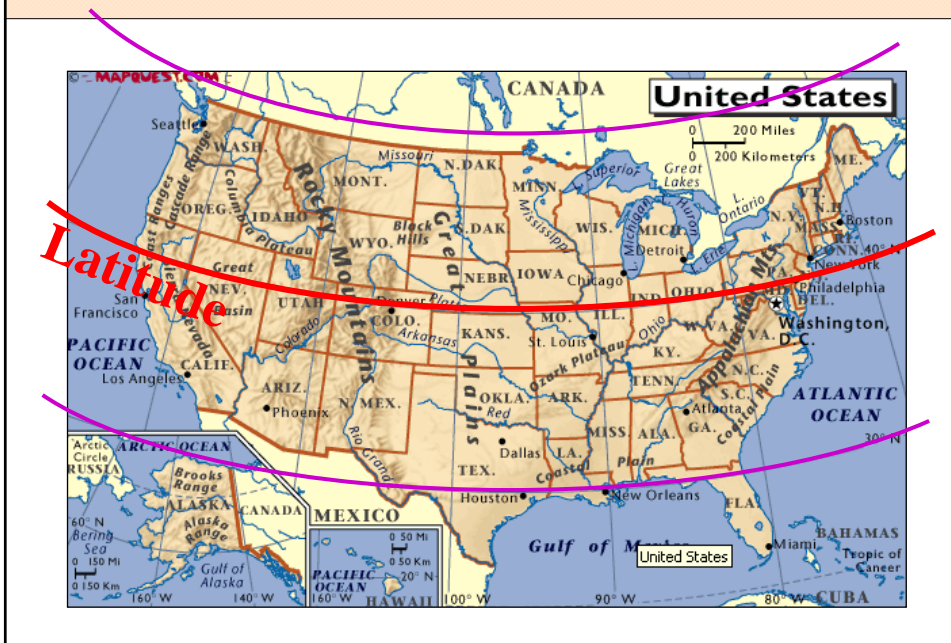


Sun Study Tools

North America



United States



Sun Study Tools

New York



Site Location

Country/City	Latitude		Longitude	
	Degrees	Radians	Degrees	Radians
Canada				
Ottawa, ON	45	0.79	76	1.33
Montreal, PQ	46	0.80	74	1.29
Toronto, ON	44	0.77	79	1.38
Vancouver, BC	49	0.85	123	2.15
Winnipeg, MB	50	0.87	97	1.69
Mexico				
Mexico City	19	0.33	99	1.73
United States				
Anchorage, AK	61	1.06	150	2.62
Big Rapids, MI	44	0.77	85	1.48
Boulder, CO	40	0.70	105	1.83
Chicago, IL	42	0.73	88	1.54
Cleveland, OH	41	0.72	82	1.43
Dallas, TX	33	0.58	97	1.69
Honolulu, HI	21	0.37	158	2.76
Los Angeles, CA	34	0.59	118	2.06
Miami, FL	26	0.45	80	1.40
New York, NY	41	0.72	74	1.29
Philadelphia, PA	40	0.70	75	1.31
Seattle, WA	48	0.84	122	2.13
Troy, NY	43	0.75	74	1.29
Washington, DC	39	0.68	77	1.34

Latitude and Longitude of Some North American Cities

The site location is specified by a latitude l and a longitude L . Latitudes and longitudes may be found in any standard atlas or almanac. Chart shows the latitudes and longitudes of some North American cities.

Conventions used in expressing latitudes are:

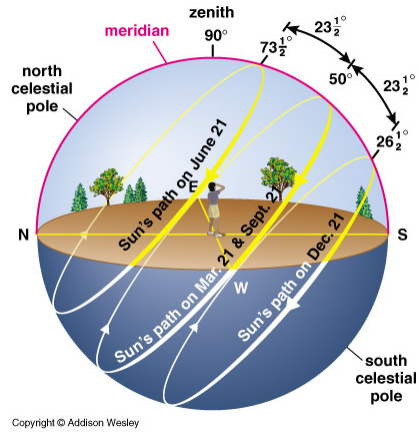
Positive = northern hemisphere
 Negative = southern hemisphere

Conventions used in expressing longitudes are:

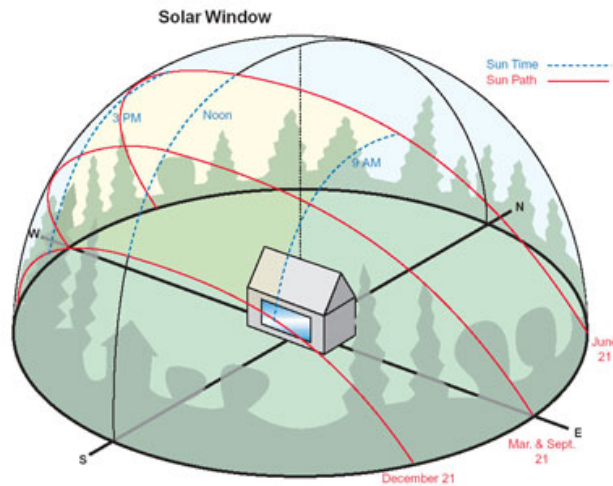
Positive = west of prime meridian (Greenwich, United Kingdom)
 Negative = east of prime meridian

Sun Study Tools

Solar Path



Suns Position



The position of the sun is specified by the solar altitude and solar azimuth and is a function of site latitude, solar time, and solar declination.

Sun Study Tools

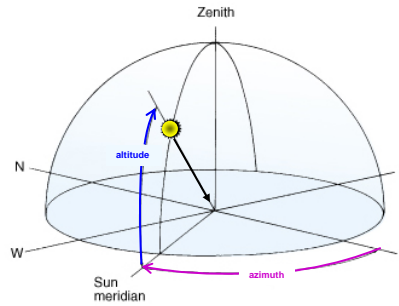
Suns Position

The rotation of the earth about its axis, as well as its revolution about the sun, produces an apparent motion of the sun with respect to any point on the earth's surface.

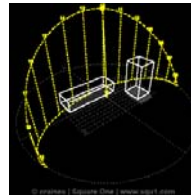
The position of the sun with respect to such a point is expressed in terms of two angles:

solar azimuth, which is the horizontal angle of the sun from due south in the northern hemisphere.

the solar altitude, which is the vertical angle of the sun above the horizon

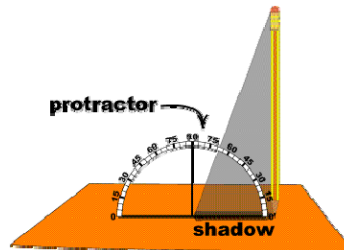
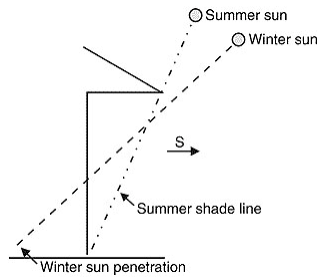


The sun's position in terms of solar altitude (a_s) and azimuth (a_z) with respect to the cardinal points of the compass.



Animation showing changing sun-path on the 21st day of each month for latitude -32°.

Sun Angle: Draw It!

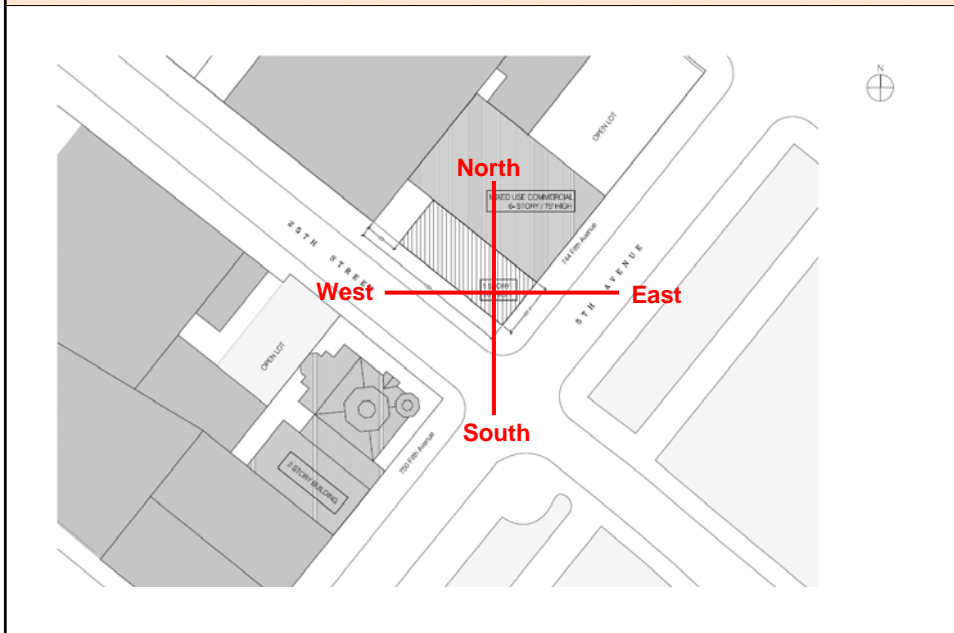


	A	B	C	D	E	F
1	SOLAR ANGLES					
2	Clock					
3	time	Azimuth	Altitude	Modified azimuth		
4	9:00	117	31	243		
5	10:00	131	41	229		
6	11:00	150	49	211		
7	12:00	172	53	188		
8	13:00	163	52	163		
9	14:00	-142	46	142		
10	15:00	-126	37	126		
11	16:00	-113	27	113		
12	17:00	-102	16	102		



Sun Study Tools

Sun Angle: Draw It!



Sun Angle: Draw It!

$$dx = \frac{h \cdot \sin(\alpha)}{\tan(\alpha)}$$

$$dy = \frac{h \cdot \cos(\alpha)}{\tan(\alpha)}$$

Shadow of a POINT

Shadow of a PLANE

Shadow of a PLANE

Shadow of a VOLUME

Plan / April 21

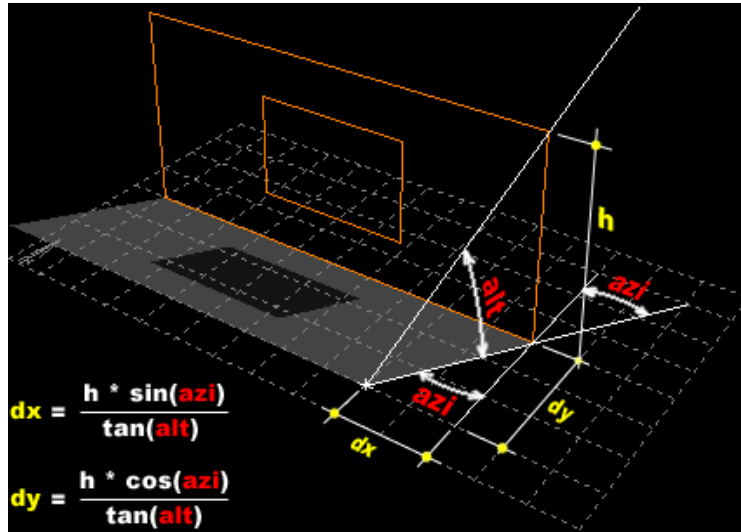
Perspective / April 21

Perspective / April 21

Rotate the Pathway of the Sun on April 21. It rises at 15° North of East (rotate Cursor to extreme right edge of Sun Path line and read sun-time grid, as it directs in the sky swings in an arc toward True South. The Profile Angle of

Sun Study Tools

Sun Angle: Draw It!



Find the Sun Position

Books - Web: Online Generators - Pilkington Sun Angle Calculator

The collage features several key resources:

- Solar Energy Pocket Reference**: A practical guide for solar energy applications.
- THE PASSIVE SOLAR ENERGY BOOK**: A comprehensive guide to passive solar home, greenhouse, and building design by Edward Mazria.
- University of Oregon Solar Radiation Monitoring Laboratory**: A website providing sun path chart programs and data.
- Sustainable By Design**: A website offering resources for sustainable building design.
- Sun Path Chart**: A physical tool used for determining sun position and shading.

Sun Study Tools

<http://www.susdesign.com/>

SUSTAINABLE BY DESIGN SEATTLE, WASHINGTON
tools consulting about contact solar cooking

Welcome to Sustainable By Design!

Sustainable By Design is the consulting firm of Christopher Gronbeck, Seattle, Washington, USA.

Christopher provides solar engineering, green building consulting, graphic design, and web site design and programming services, primarily within the sustainable energy and architecture fields.

What would you like more information about?

- [Design Tools](#)
- [Consulting Services](#)
- [Christopher & Sustainable By Design](#)
- [Contacting Christopher](#)
- [Solar Cooking](#)

SunAngle Software

FEATURED TOOL

Light Penetration

A new tool to help you visualize the penetration of sunlight into a room.



Susdesign.com: Sun Angle Tools

SUSTAINABLE BY DESIGN SEATTLE, WASHINGTON
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Design Tools

Sustainable By Design provides a suite of shareware design tools on sustainable energy topics:

SUN ANGLE TOOLS

-  **SunAngle**
the premiere tool for solar angle calculations
-  **SunPosition**
calculates a time series of basic solar angle data
-  **Sol Path**
visualization of the path of the sun across the sky

WINDOW TOOLS

-  **Window Overhang Design**
visualization of the shade provided by a window overhang at a given time

Sun Study Tools

Sun Angle: Draw It!

Sol Path


This tool provides a graphical representation of the sun's apparent path through the sky. It can be used to rapidly determine course sun angle data, or to assist in a general understanding of the sun's movement. Please read the important [instructions](#), [notes](#), and [FAQ](#) pages before using the tool.

Yes, there is an App for that!

iTunes Preview What's New What is iTunes What's on iTunes iTunes Charts How To

Helios Sun Position Calculator By Chemical Wedding [View More By This Developer](#)

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\$29.99
 Category: Photography
 Updated: Mar 21, 2011
 Current Version: 3.6
 3.0 (iOS 4.0 Tested)
 Size: 10.7 MB
 Language: English
 Seller: Chemical Wedding
 © 2010 Chemical Wedding
 Rated 4+

Requirements: Compatible with iPhone, iPod touch, and iPad. Requires iOS 3.1 or later

Customer Ratings
 We have not received enough ratings to display an average for the current version of this application.

All Versions

Description

Helios is a Sun Position Calculator that graphically represents the position of the sun from dusk to dawn, on any given day, in any given place.

[Chemical Wedding Web Site](#) [Helios Sun Position Calculator Support](#) [More](#)

What's New in Version 3.6

Fixed issues resulting from app staying in background with multitasking.

iPhone Screenshots

Sun Study Tools

Pilkington Sun Angle Calculator

Sun path diagrams can be very useful (they combine coordinates of time and position) and allow analysis of:

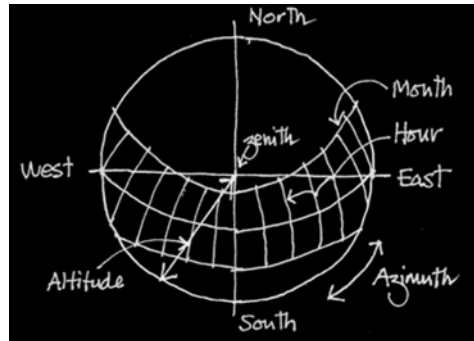
1. Sun's position at any time
2. A building's radiation need (using month vs hour grid)
3. Shading from the site - horizon profiles
4. Solar geometry - overlays for profile angle
5. Radiation impact
6. Shading from some shading devices
7. Availability of natural illumination



The Libbey-Owens-Ford Sun Angle Calculator (LOFSAC) - trusted by architects for generations

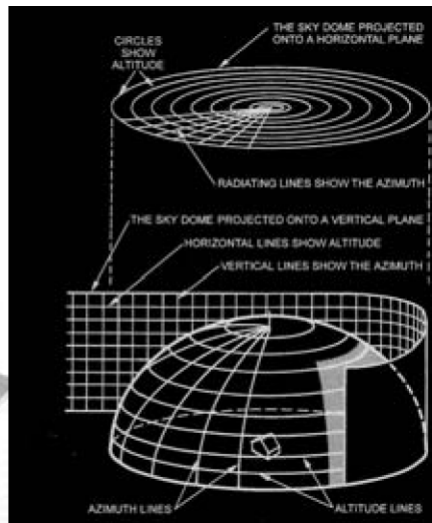
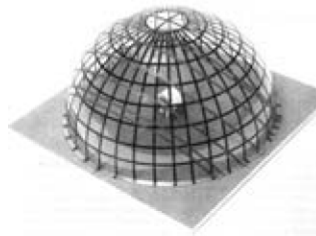
<http://www.sbse.org/resources/sac/>

<http://www.sbse.org/resources/sac/>



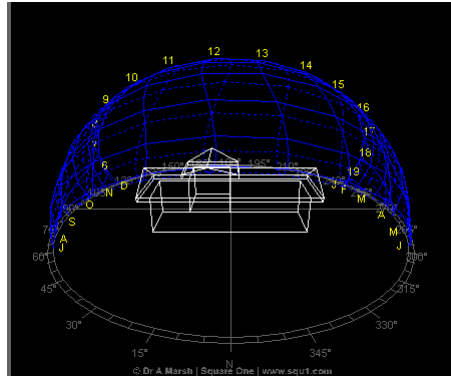
Pilkington Sun Angle Calculator

All Sun Path Diagrams represent the hemisphere of sky directly above and relative to the ground plane. Coordinates are altitude and azimuth.



Sun Study Tools

Pilkington Sun Angle Calculator



Sun Angle Calculator

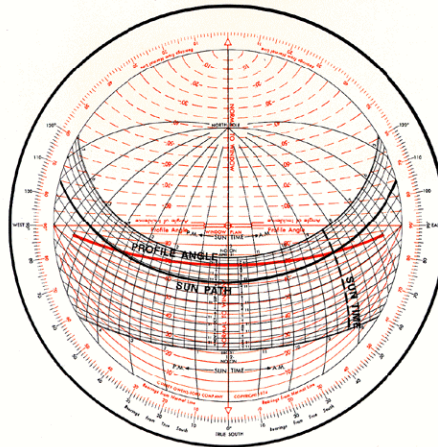
USING THE SUN ANGLE CALCULATOR

Find the latitude of the structure under consideration by using the map inside the back cover. Disassemble the Calculator, and select the Sun Chart nearest that latitude. Place this on top. Add the red Overlay and Cursor and reassemble.

Determining the Profile Angle

It is necessary to know the Profile Angle to establish the position and dimensions of overhangs and also to determine the penetration of the sun's rays into a room or the length of a shadow cast by an opaque object.

1. Rotate red Overlay to line up the solid line, "Normal to Window," with the orientation of the window indicated on the black peripheral scale, "Bearings from True South."
2. Locate the curved black Sun Path line for the date being considered. Lines are shown for the 1st, 11th and 21st of each month. These dates are adequate for calculating Sun Angles for most architectural design problems. Interpolation can be used for other dates.
3. Follow the Sun Path line to the right or left until it intersects the black Sun Time line for the hour desired. The time lines are marked above and below the date lines. The heavy lines are hours, and the light lines are at twenty minute intervals. The intersection of the Sun Path and the Sun Time lines establishes the Position of the Sun for that day and hour.
4. The curved red line on the Overlay nearest the Position of the Sun is the Profile Angle. Interpolate if necessary. If the location in question lies between the latitudes of the Sun Charts and more exacting data is desired, find the Profile Angle for the higher and the lower latitude and interpolate.

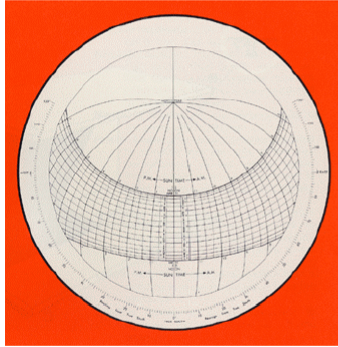


Sun Study Tools

Sun Angle Calculator

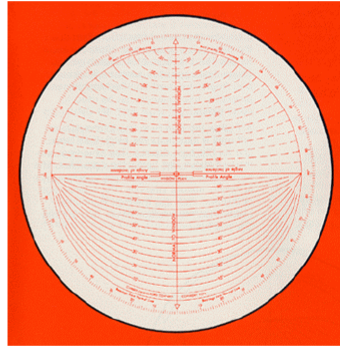
2. Sun Chart

There is a Sun Chart for each four degrees of North latitude from 24 deg to 52 deg. The Charts are printed in black on both sides of the board. The curved lines represent the Position of the Sun on the earth's surface, as seen from above, at that latitude and date. The lines radiating from the North Pole represent Sun Time, with the light lines positioned at twenty minute intervals.



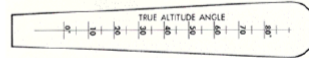
3. Red Transparent Overlay

The circular overlay is applied to all Sun Charts. In the center is a plan view showing the window under study. That part of the Overlay with the solid red lines is used to determine the Profile Angles. That part with the broken red lines is used to find the Angles of Incidence.



4. Cursor

The wedge-shaped Cursor is used for reading the Bearing of the Sun from True South and from Normal to the Window where it intersects the scales along the perimeter of the Sun Chart and Overlay. Its own scale is used to read the True Altitude of the Sun.



Sun Angle Calculator

Bearing of the Sun (Azimuth)

The Angle of the Sun to True South is called Bearing or Azimuth. This is also necessary to determine the position and dimensions of fins, other vertical projections and lengths of overhangs.

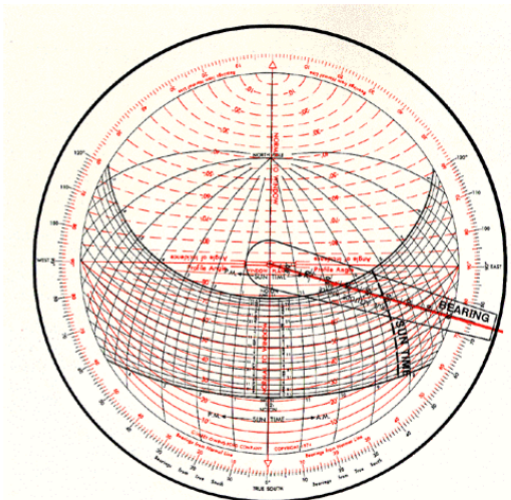
To find the Bearing of the Sun, rotate the Cursor until its centerline intersects the Position of the Sun. The black scale on the periphery of the Sun Chart indicates the Bearing from True South and, on the Overlay, the red scale gives the Bearing from Normal.

True Altitude

True Altitude is read on the Cursor where the center line crosses the Position of the Sun.

Angle of Incidence

The Angle of Incidence of the sun to a window is determined by rotating the Overlay 180° to the broken red line "Normal to Window" and to the same reading on the peripheral scale. The Angle of Incidence is the broken red line coinciding with the Position of the Sun.



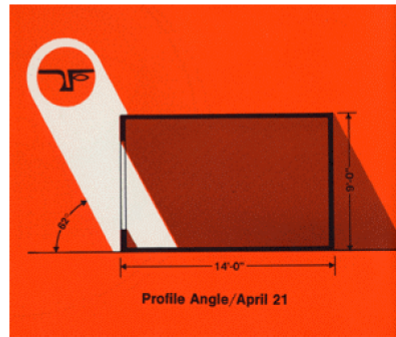
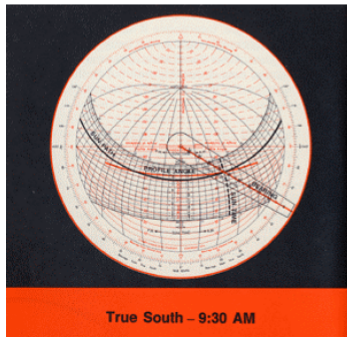
Sun Study Tools

Sun Angle Calculator

Using the Sun Angle Calculator – Example A

Building located in Columbus, Ohio at 40 deg North latitude, with windows facing True South. Time is 9:30 AM on April 21 and December 21. Find the Profile Angle, Bearing of the Sun and True Altitude.

1. Select 40 deg Sun Chart, place on top, add red Overlay and Cursor. Line up solid Normal to Window line with True South on Sun Chart.
2. Locate April 21 on the curved black Sun Path line and follow across until it intersects the Sun Time line for 9:30 AM. This is the Position of the Sun for that instant.
3. The curved red line intersecting the Position of the Sun is the Profile Angle for that time and date. The reading is 65 deg.
4. To find the Bearing of the Sun, rotate the Cursor until its center line intersects the Position of the Sun. The black scale on the periphery of the Sun Chart indicates the Bearing from True South for April 21 at 9:30 AM is 60 deg 30 min East of True South.
5. True Altitude is read on the Cursor where it intersects the Position of the Sun. True Altitude is 47 deg.



Fisheye Tool

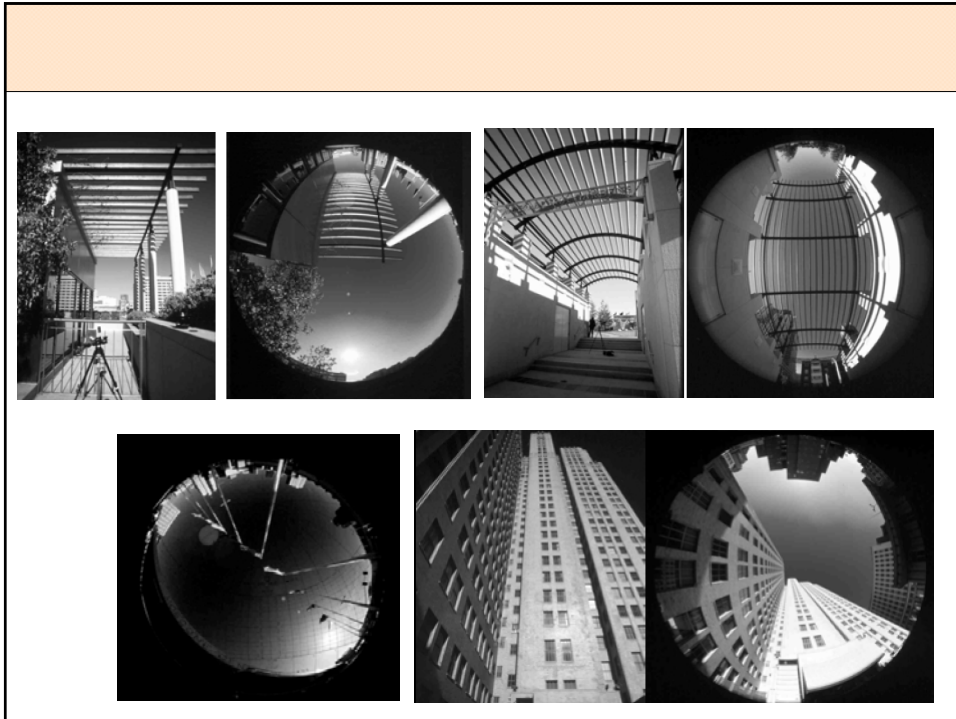


SITE SOLAR ANALYSIS Tools of the Trade

1. Direct Observation of horizon using instruments
2. Fisheye photographs of sky and Sun Path Diagrams (LOFSAC)
3. Horizon shading overlays for Sun Path Diagrams (LOFSAC)
4. Casting Shadows on Architectural Models
5. Casting Shadows in Drawings
6. Using Profile Angles



Sun Study Tools

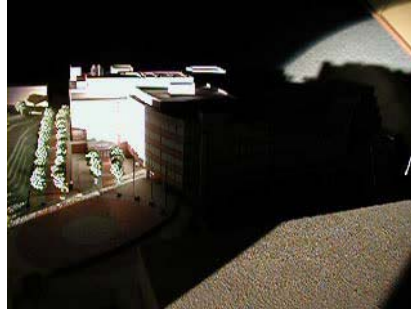


Build A Model



Sun Study Tools

Build A Model



Building a Model



Sun Study Tools

The Heliodon

The heliodon is used to examine how the direct rays of the sun interact with an architect's building design. It is comprised of

- a tilting/rotating table (the earth)
- a stationary 1000 watt theatrical light source (the sun).

The table can be adjusted to represent the latitude, tilted to simulate any month of the year, and rotated to analyze any time of day.

Typically these studies seek to examine shading devices that eliminate direct sun from areas where visual tasks are critical. Direct sun can cause problems of heat gain and debilitating glare.

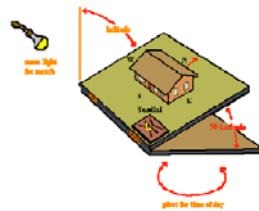
The heliodon takes the guesswork out of complex sun-angle geometry and often will provide surprising results.



Parsons Lighting Lab - Heliodon

The top light is summer, middle is spring/fall and bottom is winter.

The colors of the dichroic lamps should be summer-red, equinox-blue and winter-green. this sequence works best with viewing either the equinox alone (blue), the solstices together (yellow), or all three at once (white). it will also put your knowledge of additive color mixing to the test as students ask which shadow are from which solar position.
hint: shadows are the compliment color.



The table top should be tilted so that the angle between the plane of the table and the plane of the floor corresponds to the co-latitude (90- latitude) of the study site. This will produce an equinox noon altitude that is also the co-latitude.

Some other notes:

- 1) The study area of the model should be level with the equinox lamp position
- 2) Make sure the table is in the right position- the ground should be marked with the center of the table.
- 3) Make sure the lamps are pointing at the tabletop
- 4) Mount a sundial on the model level in the proper orientation, at a height level with the equinox lamp position, to verify tabletop alignment by rotating the tabletop through a day

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Sun Study Tools

Sky Simulators

the overcast sky simulator

Testing for the overcast condition occurs in a mirror-box artificial sky.

The mirror-box overcast sky simulates a dome of light that provides diffuse light equally from all sides. *Note that a patch of overcast sky is up to 10 times brighter than a section of clear blue sky.*

Method of testing design decisions in the overcast sky is through photography. This allows us to examine

- the perceptual quality of a space,

- the feeling of brightness (diffuse light on vertical surfaces and ceilings), and

- to ensure that a balanced luminous environment (from perimeter to deep interior) is created.

Photocells are used to measure the percentage of available daylight (Daylight Factor) entering a space..

Overcast sky light is ideal for providing gentle, diffuse daylight to building occupants.



Sky Simulators



Sun Study Tools

The Sundial



www.shadowspro.com

Shadows Pro Understanding and designing sundials and astrolabes

Shadows Pro Sundials Astrolabes Photos Astronomy

Key Points Features Download Shadows Buy Shadows Pro FAQ Testimonials Press

A genuine sundial or astrolabe at your home

Shadows is a program used to design sundials and astrolabes. It can be used by everybody without any required technical skills. Shadows will calculate everything and print the drawing according to the user's preferences. Shadows is used by thousands of users around the world.

Key points of Shadows

- ✓ Totally free of charge in its entry level
- ✓ The simplest tool for designing a sundial or an astrolabe
- ✓ Calculates, draws and prints drawings at real scale
- ✓ Simulates, displays and animates the shadow of the style
- ✓ Data base of 2800 locations with latitude, longitude and time zone
- ✓ Exports drawings to other drawing or CAD applications (in DXF or WMF format)
- ✓ Plane sundials with polar style of any orientation or reclinacion
- ✓ Analemmatic, cylindrical and bifilar sundials
- ✓ Planispheric and universal astrolabes (front and back)
- ✓ Rotation of the astrolabe rete and alidade
- ✓ Complete solar ephemeris
- ✓ Solar diagram with horizon mask
- ✓ Graphs of Equation of time
- ✓ Optimization of solar panels orientation

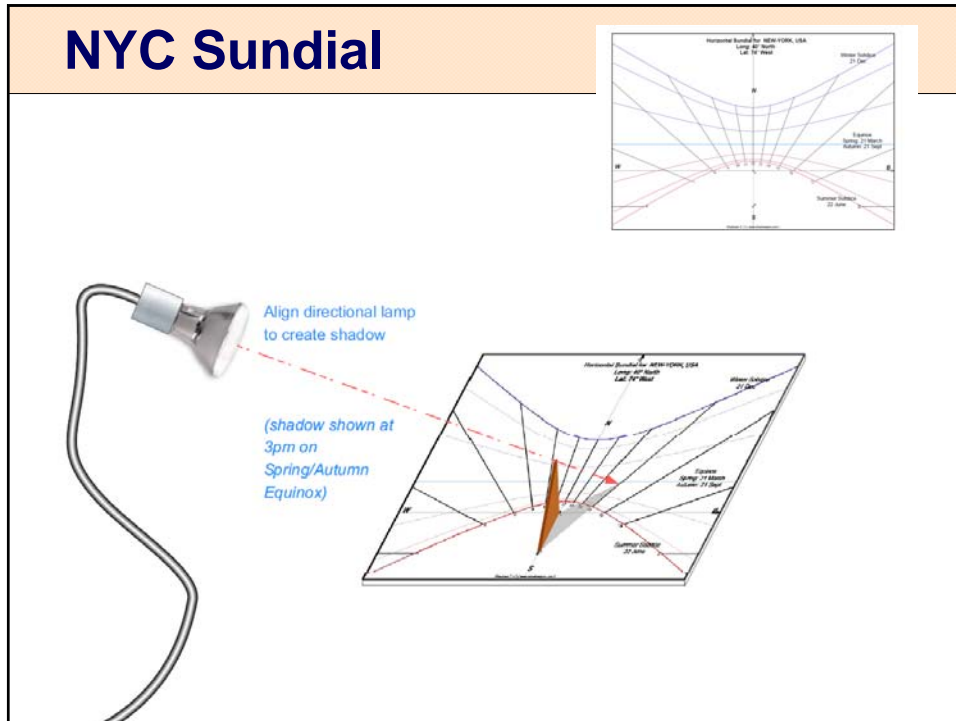
Try Shadows!

Download freely the software and try it without time limit.

- ➔ Free Download...
- ➔ Shadows, Shadow Expert & Shadow Pro...

Sun Study Tools

NYC Sundial



Tip 1



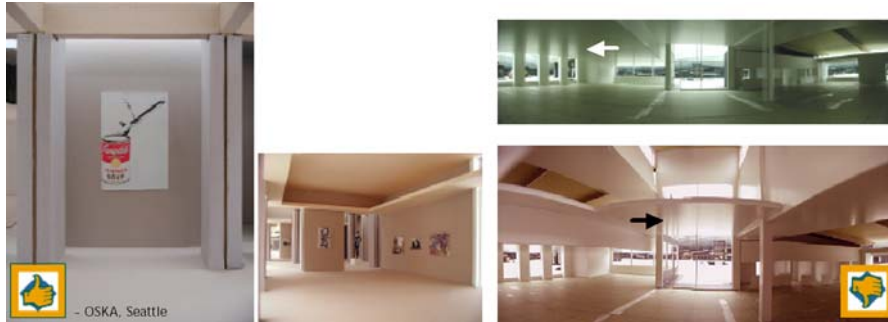
Do not use Foam Core – the material glows and creates light leaks

Use black paper on white board and cover or tape all light leaks

Black Foam Core is expensive.

Sun Study Tools

Tip 2



White Foam Core is reflective and shiny.

Cover the insides with appropriate surface reflectance or color material.

Tip 3



Make a modular model with interchangeable parts.

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Tip 4



- Covenant Christian School, Nils Finne Architect, Seattle

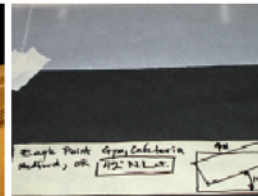
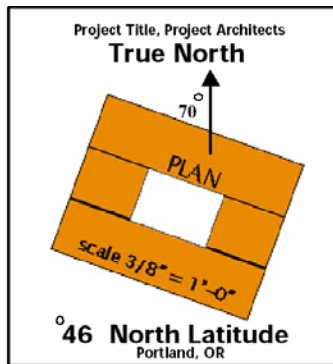


- Yoste Grube Hall, Portland

Mirrors can enhance the depth of a model.

Mirrors are useful in large space with respective plans.

Tip 5



Know true north and latitude.

Draw north arrow on your model.

Sun Study Tools

Tip 6



Include accessible large view ports.

Large enough for use cameras or yield a good view of the interior.

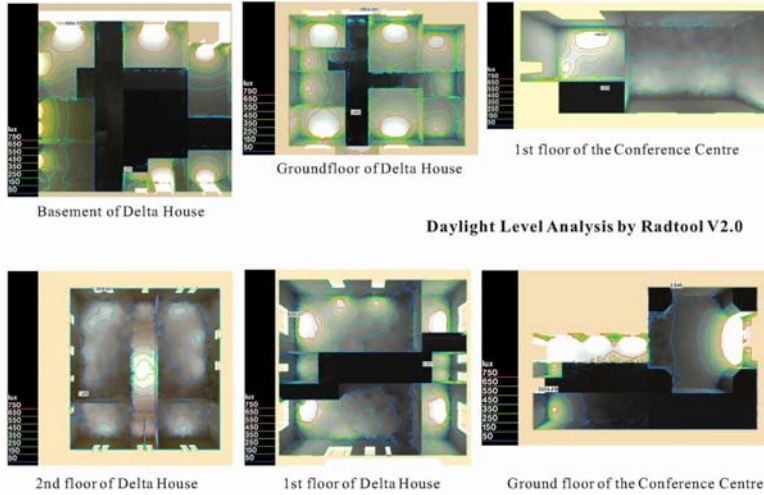
Tip 7



Include people or objects for scale.

Sun Study Tools

Computer Simulation



Autodesk: Ecotect

www.ecotect.com

Autodesk

| ecotect.com | Autodesk® Ecotect™
architecture, sustainability, building performance, environmental design, architectural science...

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ECOTECT blew me away -- I had never seen anything quite like it before and it's something that every architect should have access to.

Martyn Day, AEC Magazine

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[Read more...](#)

Early design focus Most visual and interesting

Sun Study Tools

Ecotect: Solar Tool

Autodesk

ecotect.com | Autodesk® Ecotect™
architecture, sustainability, building performance, environmental design, architectural science...

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ECOTECT WEATHER TOOL SOLAR TOOL UTILITIES SYSTEM REQUIREMENTS

THE SOLAR TOOL

With its interactive user interface, the Solar Tool makes the process of accurately sizing and positioning overhangs, shading devices and louvers easy. This tool helps architects, planners and building services engineers who need to consider the extent of solar penetration into buildings, overshadowing or the most appropriate means of shading a window.

Project Details :: Download Trial :: Location Data

The program uses a flexible, parametric model on which can be placed any number of horizontal, vertical and detached shades. You can select any date, time or location, seeing immediately the resulting shadows. As well as being able to interactively manipulate the size and shape of the model with the mouse or enter the parameters directly, you can choose to automatically optimise the size of any shades over any range of dates and times you require.

SEARCH THIS SITE

SOME QUICK LINKS

- Discussion Forums
- Frequently Asked Questions
- Glossary

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- Ecotect Community Wiki

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Spanish [Go]

Google Software: Sketch-up

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SketchUp

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News

- New! Create your own sketchy styles with Style Builder
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Aerial View of Park South

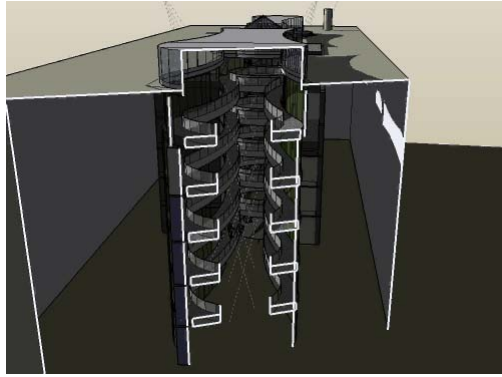
The Phoenix Project South

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Sun Study Tools

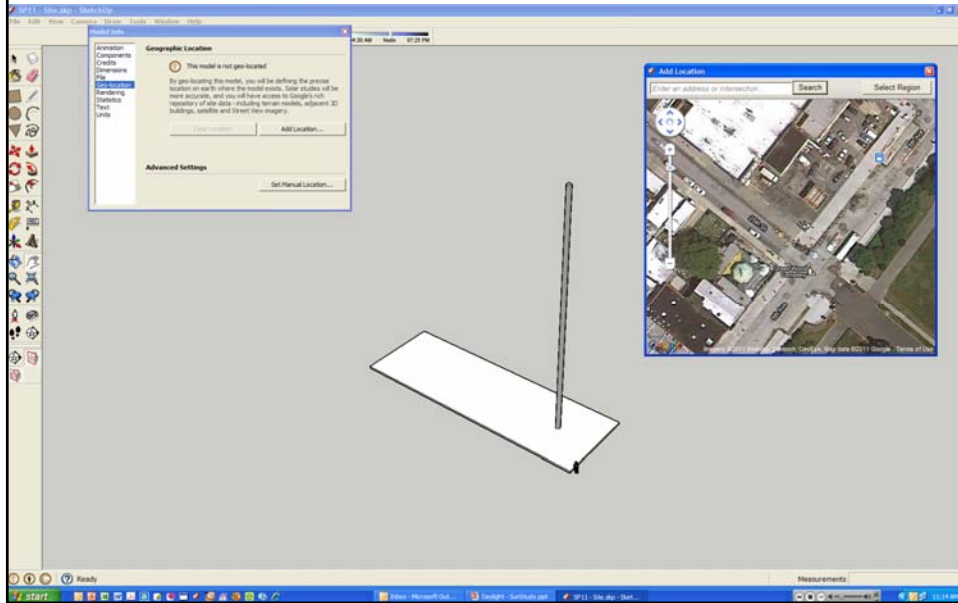


Sketch-up w/Podium Renderings

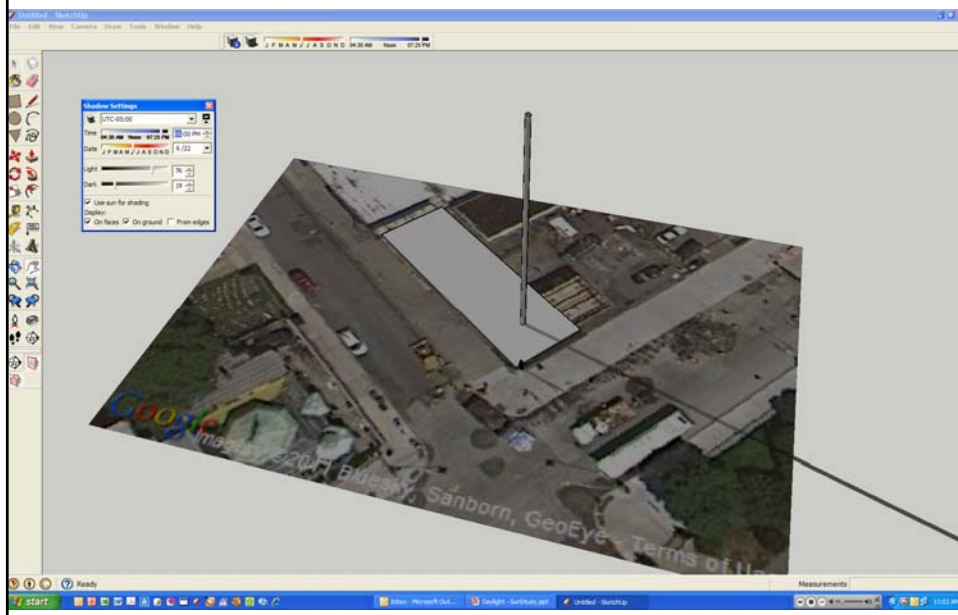


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Sketch-Up: Add Geo Location



Sketch-Up



Sun Study Tools

Type of Daylight Fenestrations

Sidelight (Windows)



Unilateral Section



Bilateral Section



Side Lights

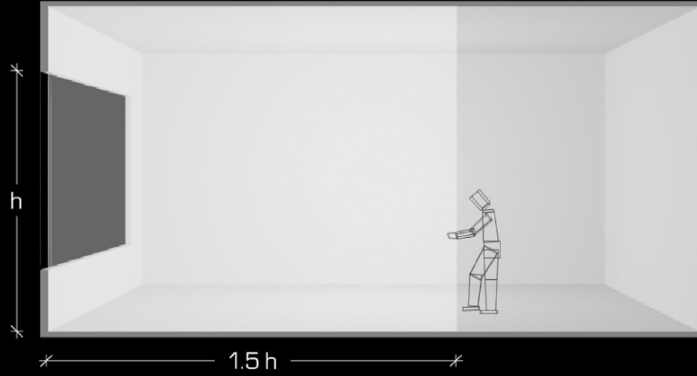


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Sidelight Rules of Thumb / Tips

QUICK TIPS 1

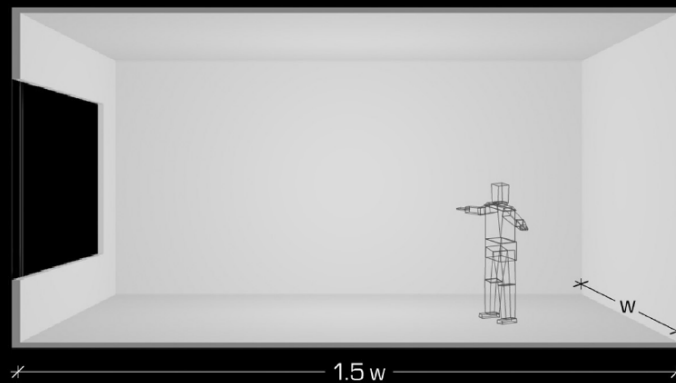
DEPTH \leq 1.5X WINDOW HEIGHT



Sidelight Rules of Thumb / Tips

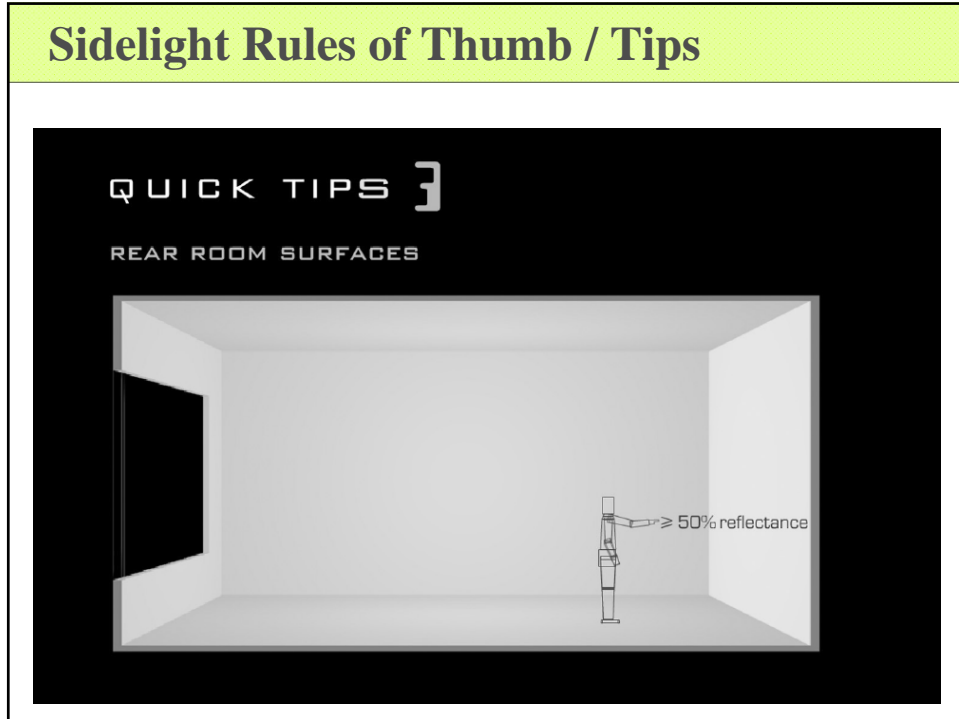
QUICK TIPS 2

DEPTH $>$ 1.5 WIDTH

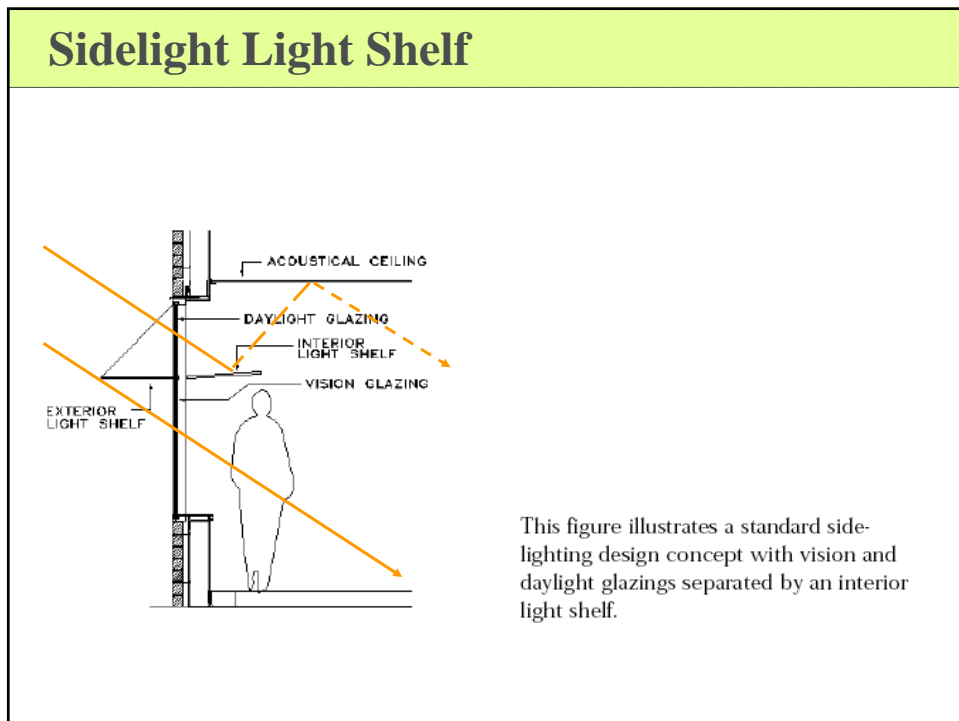


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Sidelight Rules of Thumb / Tips

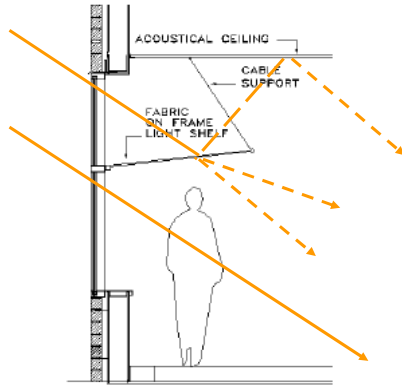


Sidelight Light Shelf



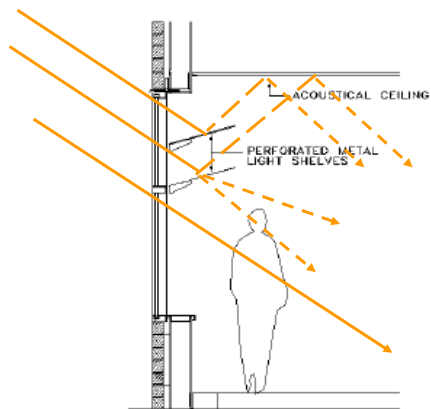
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Sidelight Light Shelf



A simple sidelighting concept with a fabric light shelf was designed for the Sacramento Municipal Utility District (SMUD) headquarters building.

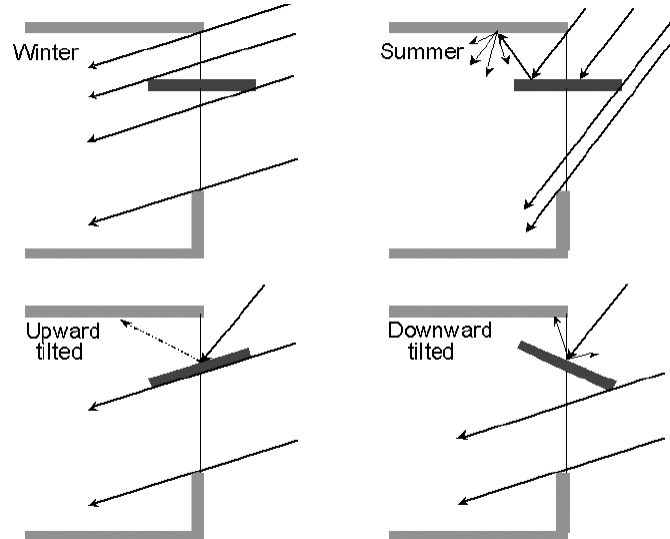
Sidelight Light Shelf



The double light shelf concept is used to provide direct beam daylight control while minimizing light shelf depth.

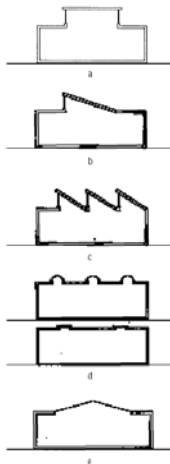
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Side Light Shelf



Type of Daylight Fenestrations

Top or Roof lights (Skylights)



Top lighting provide daylight access through roof top apertures, allowing for optimal separation of vision and daylight glazing. The five basic top lighting concepts are illustrated in these simplified building sections:

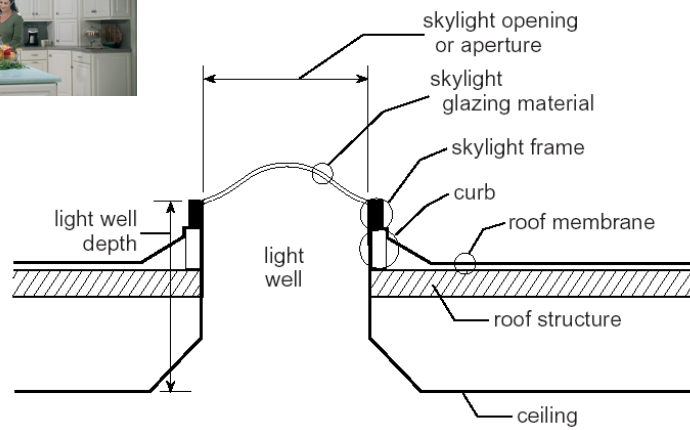
- Roof monitor
- Clerestory
- Saw Tooth
- Skylight(s)
- Atrium

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Roof Lights

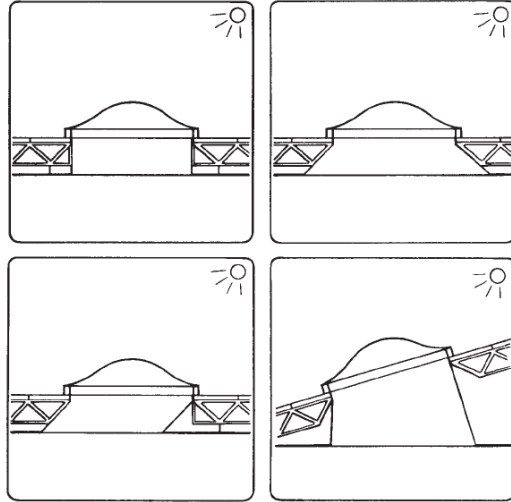


Skylight Construction Terminology



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Light Wells



Light wells are a primary component of a skylight system. They bring the light through the roof and ceiling structure, and they simultaneously provide a means for controlling the incoming daylight BEFORE it enters the main space.

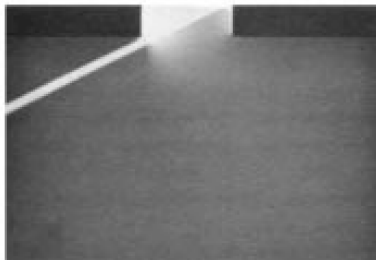
- Similar to the housing of an electric light fixture
- Designed to distribute the light and shield the viewer from an overly bright light source.

The shape and size of the light well is often determined by the roof and ceiling construction.

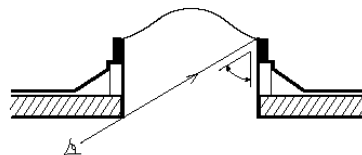
Light Well Design

In designing wells for skylights, a number of factors must be considered:

1. **Solar Geometry** – the height and orientation of the sun change both daily and seasonally. The direct sunlight that enters a clear glazing skylight can be prevented from penetrating down to the task surface by light wells.



A wide cut-off angle allows more of the bright skylight surface to be visible to the occupants.

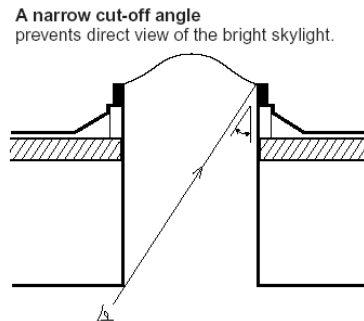
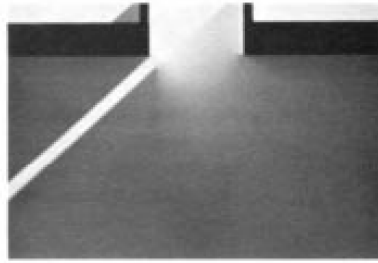


Sun Study Tools

Light Well Design

In designing wells for skylights, a number of factors must be considered:

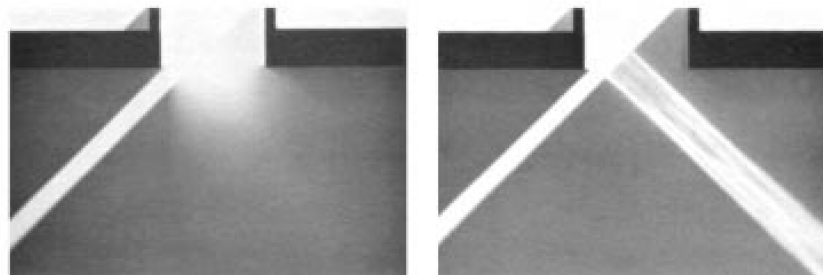
1. **Solar Geometry** – the height and orientation of the sun change both daily and seasonally. The direct sunlight that enters a clear glazing skylight can be prevented from penetrating down to the task surface by light wells.



Light Well Design

In designing wells for skylights, a number of factors must be considered:

1. **Surface Reflection** – light wells reflect and diffuse sunlight as it bounces from the skylight to the task surface.

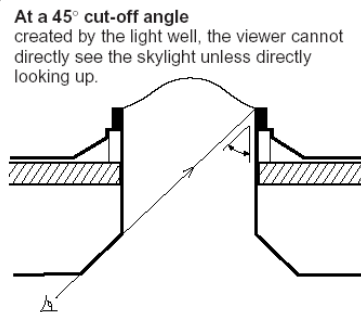
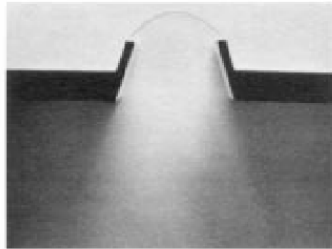


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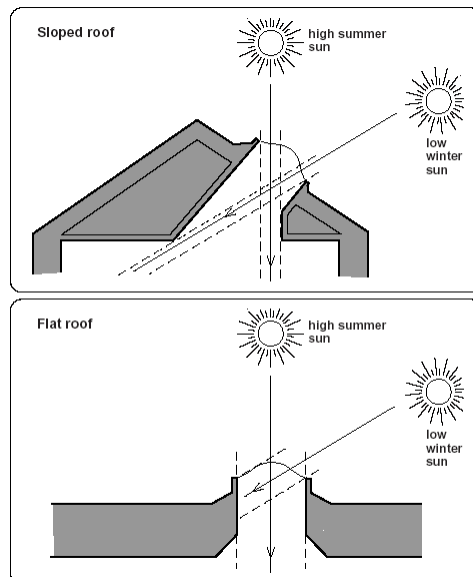
Light Well Design

In designing wells for skylights, a number of factors must be considered:

1. **Wall Slope** – the slope of the light well helps to determine the distribution of light in the space.

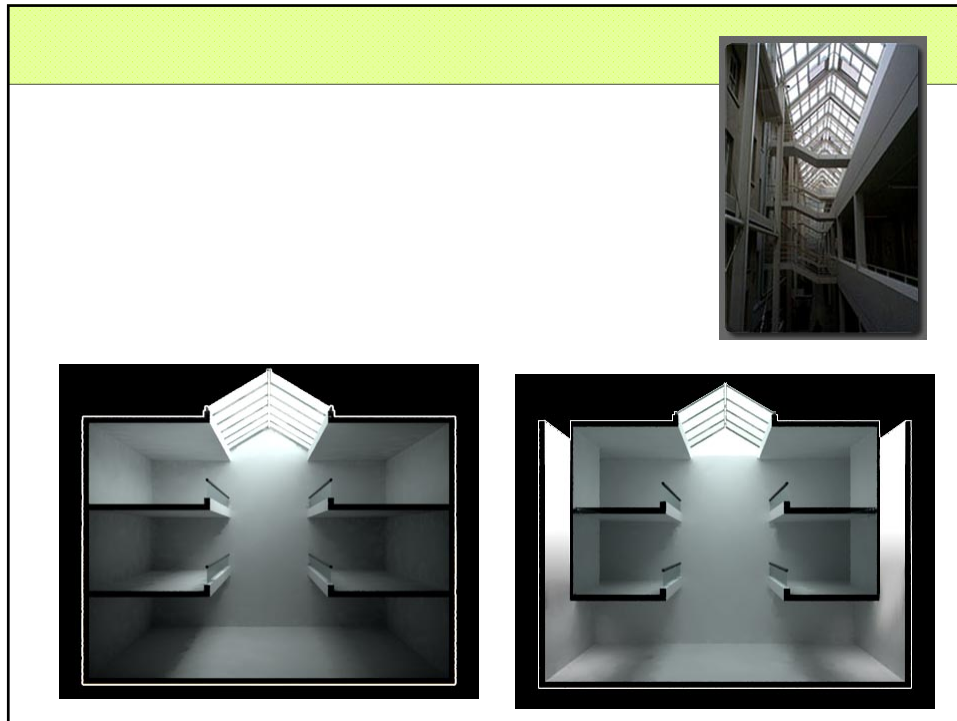


Light Well Design

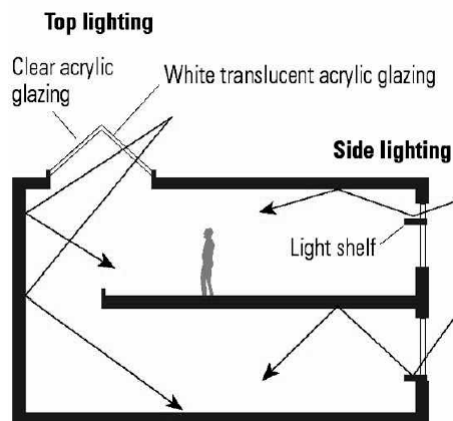


THE SLOPE AND ORIENTATION OF THE ROOF AND THE LIGHT WELL HAVE A MAJOR IMPACT ON HOW MUCH SUNLIGHT PENETRATES INTO THE INTERIOR OF THE BUILDING.

Sun Study Tools



Design Recommendations



This schematic shows a mixture of top and sidelighting strategies in a multi-story building. Quality daylighting designs generally provide daylight from a variety of sources and directions.

Sun Study Tools

Design Recommendations

A number of design strategies should be understood and explored during the design process. These strategies are briefly described below.

1. Increase perimeter daylight zones-extend the perimeter footprint to maximize the usable daylighting area.
2. Allow daylight penetration high in a space. Windows located high in a wall or in roof monitors and clerestories will result in deeper light penetration and reduce the likelihood of excessive brightness.
3. Reflect daylight within a space to increase room brightness. A lightshelf, if properly designed, has the potential to increase room brightness and decrease window brightness.
4. Slope ceilings to direct more light into a space. Sloping the ceiling away from the fenestration area will help increase the surface brightness of the ceiling further into a space.
5. Filter daylight. The harshness of direct light can be filtered with vegetation, curtains, louvers, or the like, and will help distribute light.
6. Avoid direct beam daylight on critical visual tasks. Poor visibility and discomfort will result if excessive brightness differences occur in the vicinity of critical visual tasks.
7. Understand that different building orientations will benefit from different daylighting strategies; for example light shelves which are effective on south-facades are often ineffective on the east or west elevations of buildings.

