Daylighting is the prime purpose of windows. Giving a view and harvesting solar energy are secondary.

A common daylighting problem is getting sufficient light to the back of a deep room on a dull day. There is an internationally defined 'CIE overcast sky' for which a mathematical equation defines the hypothetical variation of brightness in the sky when the sky is overcast. (CIE = 'Commission Internationale d'Eclairage', ie, International Commission on Illumination.)

Points to note about this overcast sky:

- It is three times as bright overhead as at the horizon.
- It is equally bright north, south, east and west.
- Its brightness is not given, only the variation in its brightness over the hemisphere of the sky.

**Light from the sky**

The brightness of the sky can be assessed by measuring the illuminance produced by the sky on an unobstructed horizontal plane, so light is received from the whole hemisphere of the sky.

Here are some examples of natural illumination with typical figures:

<table>
<thead>
<tr>
<th></th>
<th>Lux</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunny day</td>
<td>50,000</td>
</tr>
<tr>
<td>Overcast day</td>
<td>5,000</td>
</tr>
<tr>
<td>Extremely dark day</td>
<td>100</td>
</tr>
<tr>
<td>Twilight</td>
<td>10</td>
</tr>
<tr>
<td>Full moon</td>
<td>0.5</td>
</tr>
<tr>
<td>Only starlight</td>
<td>0.001</td>
</tr>
</tbody>
</table>

**Typical illumination from a hemispherical sky**

(For a more about 'lux' – the unit of illuminance – see the Footnote.)

Indoors, for comfortable reading and writing an illuminance of something like 500 lux is desirable – though reading for a short while in 50 lux is quite possible.

**Daylight factor**

The 'daylight factor' at a particular point indoors is the illuminance at that point expressed as a percentage of the illuminance outdoors if the sky were an unobstructed hemisphere. (Direct sunlight is excluded.) So if the daylight factor at a particular point in a room is, say, 2%, then the illuminance at that point with a typical overcast sky outside would be 100 lux. (Using the table above, 100 = 0.02 x 5000.)

A daylight factor of 2% is rather poor, whereas a daylight factor of 5% is good. (The BS Code of Practice for Daylighting recommends that the average daylight factor in a room should be at least 5%.)

Daylight factor = SC + ERC + IRC,
For good daylighting at the back of a room, at least a tiny patch of sky should be visible from the back of the room. (See the 'No Sky Line' rule, below.) Roof windows are very effective in this respect. Velux have published a 'Daylight Study' which shows that a roof window gives better daylighting than a side window of the same size (and much better daylighting than a dormer window). (See Further Info.)

The working out of daylight factors may be required for offices and workshops, but it is probably over the top for a selfbuild. Nonetheless, if calculations are wanted, a formula for calculating the average daylight factor for a room can be found in Designing Buildings for Daylight. The book also gives a formula for the maximum depth of a room if it is to be successfully daylit.

And it is desirable that the area of a window area should be at least 20% of the area of the surrounding wall – for the sake of the view, as much as for daylighting.

The 25° rule of thumb

BRE have published an Information Paper, Site Layout Planning for Daylight. This gives a simple rule of thumb for estimating whether or not an obstruction opposite a window (eg, another building) will have a substantial effect on diffuse daylighting through the window:

*If none of the obstruction is at an elevation of more than 25°, measured from the middle of the window, then the obstruction is unlikely to have any substantial effect on the daylighting.*

No Sky Line rule

This rule is more reliable than the simple rule of thumb above.
An imaginary 'working plane' is considered 85cm above the floor. If the working plane furthest from the window can receive any light, however little, directly from the sky, then the room is considered to be adequately lit.

![Diagram](image)

**No sky visible at back of room – inadequate lighting**

**Daylighting and the Code for Sustainable Homes**

Some CSH credits are available for daylighting; the standards required are low. One credit is available for each of:

- **Kitchen:**
  An average daylight factor of at least 2%.

- **Living room, dining room, study, etc (not bedrooms):**
  An average daylight factor in each room of at least 1.5%.

- **Kitchen, living room, dining room, study, etc (not bedrooms):**
  In each of these rooms, at least 80% of the working plane receives direct light from the sky.

  (The building regulations do not contain any requirements for daylighting, as such. But the requirement for purge ventilation by means of openable windows does result incidentally in a very low level of daylighting.)

**Reflected light**

A substantial proportion of the light at the back of a room is likely to be reflected light – maybe all of it. It does not come directly from the sky, but has been reflected from:

- **Objects outside, such as trees, buildings, and the ground (ERC).**

- **The floor, ceiling, walls and furniture inside the room (IRC).**

  It is common for walls and ceilings to be lightly coloured to reflect a lot of light. But it is also useful, when considering daylighting, to have a lightly coloured floor, especially near the window. Light may be reflected several times before it is finally absorbed, having bounced around off the floor, ceiling, walls and furniture.
### Reflectance

<table>
<thead>
<tr>
<th>Reflectance</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>White ceiling</td>
<td>0.7</td>
</tr>
<tr>
<td>Pale wall</td>
<td>0.5</td>
</tr>
<tr>
<td>Floor and furniture</td>
<td>0.3</td>
</tr>
<tr>
<td>Outside ground</td>
<td>0.1</td>
</tr>
</tbody>
</table>

Some typical reflectances – according to the BS Code of Practice for Daylighting.

Sundry points:

- A room with windows in more than one wall feels light and airy. Shadows are softened.
- Lighting the back of a deep room requires the window head to be high – which may require a high ceiling. (Alternatively, if it is possible, place an extra window in a side wall – see the point above.)
- A roof light gives a more even distribution of light than side lighting.
- A building that is an obstruction in front of a window (e.g., a detached garage) will reflect more light through the window if its walls are good reflectors of light. The walls could be white rendering, or lightly coloured brickwork (e.g., yellow stocks) – not the usual dark brickwork.
- For a similar reason, if the plan of the house is not a simple rectangle and some of its walling is visible through some of its windows, then for better daylighting it would be preferable for the walling to be light rather than dark.
- Window boards (cills) and splayed reveals (uncommon nowadays) help to direct light into a room, especially if they are white or lightly coloured.
- The figure given in the table for the reflectance of a white ceiling (70%) seems rather low. See the following section.

### Light Reflectance Value, LRV

The Light Reflectance Value is the percentage of light reflected by a surface. It varies between 0, for an ideal black, and 100, for an ideal white. Paint swatches for professionals show the LRV of each colour. In practice, most black paints have a LRV of about 5, and white paints about 90. A typical magnolia has a LRV of about 80.

The 'Absolute White' in Dulux's 'Light & Space' range has an outstanding LRV of 94.

There may not seem to be very much difference between a light reflectance of 90% and 94%, but if the light is being reflected multiple times within a room, the difference becomes more appreciable. For example, if some of the light at the back of a room has been reflected three times off white walls and ceiling with an LVR of 90, the cumulative reflectance is 0.73. \((0.73 = 0.90^3)\). Whereas with an LVR of 94, the cumulative reflectance is 0.83. \((0.83 = 0.94^3)\) – appreciably higher.

For lighting the back of a room, the LRV's of the ceiling and back wall are important – the LRV's of the side walls are less significant.

In writing this article, I noticed that Leyland Paints claim in their Product & Colour Guide that their British Standard White paint has an incredible LRV of 99. I queried this with them, and they admitted the LRV should be 90. “It will be refreshing when our
Marketing Department actually check with the Colour Advisory Department before going to print!"

How much other dodgy information are we being offered by cavalier marketeers?

FURTHER INFO:

**Designing Buildings for Daylight**
By Bell and Burt.
Published by Construction Research Communications for BRE, 1996. 98 pages. £30.

**Daylighting and Window Design**
Published 1999 by CIBSE (Chartered Institution of Building Services Engineers).
90 pages. £68.

**Site Layout Planning for Daylight**
6 pages, £11-40.

**Radiance**
Free software for analysing and visualising lighting in architectural designs – more for architects than selfbuilders.

**Daylight Study**
Published by Velux, in Slovenia! It is based on Danish research using Radiance (as above). Free download:

**Velux Daylight Visualizer**
Shows daylighting for side windows as well as roof windows. Download the free software:

FOOTNOTE:

The 'brightness' of light can refer to different quantities:

- **Luminous flux**
  Luminous flux is the total amount of light coming from a light source – measured in lumens. (The measurement takes account of the sensitivity of the eye to different wavelengths.) Example: the obsolete 100W tungsten bulb gave off about 1,500 lumens in total.
  (A LED bulb producing 1500 lumens – when it becomes available – will require less than 20 Watts.)
• **Luminous intensity**

Luminous intensity is the amount of light per unit solid angle emitted by a light source in a particular direction – measured in candelas. A specified, standard candle has a luminous intensity of 1 candela in every direction. (But needless to say, a candle is no longer used to define the candela.)

If the 100W tungsten bulb mentioned above emitted its light equally in all directions, its luminous intensity would be 120 candela in every direction. (120 ≈ 1500 / 4.Π – a reader familiar with three dimensional geometry could easily derive this formula.)

• **Illuminance**

Illuminance is the intensity of light falling on a surface – measured in lux. By definition:

1 lux = 1 lumen/m².

Examples of natural illuminance are given in the table at the start of the article. Illuminance can be easily measured with a light meter – which can be purchased for upwards of £10 (eg, the HS1010 light meter).

The illuminance decreases with the square of the distance from a point source of light. (Again, this is easily derived by the use of three dimensional geometry.)

• **Luminance**

Luminance is the amount of light reflected off a surface in a particular direction, measured in candela/m² (where m² refers to the area of the surface).

Illustration of terms used for lighting  
(Source: Autodesk)

A more intuitive grasp of these measures can be grasped with imperial units, based on the light from a standard candle. This has a luminous intensity of 1 candela in every direction. And at a distance of one foot from the candle, the illuminance is one foot-candle.

The lumen was originally defined so that

1 foot-candle = 1 lumen per square foot.

As: 1 square foot = 0.093 m²

1 foot-candle = 1 / 0.093 lumen per square metre

= 10.8 lumen per square metre.
So we have: 1 foot-candle = 10.8 lux.

(Like British Thermal Units, the foot-candle is still widely used in the USA.)

Words: 1942.

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