Insolation and the Seasons

Consider a piece of the Earth's surface with some specified size (say 1 m\(^2\))

- The **insolation** of this piece of surface is the amount of sunlight (or shortwave) hitting the surface over the course of a day

  - On average, higher insolation implies higher temperatures

- The insolation depends on two things:
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  1. \textbf{the number of daylight hours}
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• The insolation depends on two things:
  
  (1) the number of daylight hours
  
  (2) the surface's orientation relative to the Sun
Consider a surface of fixed size placed in a uniform light source. The amount of absorption depends on the orientation of the surface relative to the incoming light.

- For example, if the surface is perpendicular to the light source, then we might get 4 units of light absorbed (in this example)
Surface Angle and Insolation

• If we rotate the surface 45°, then we'd instead get 2.8 units of light absorbed

• And if we rotate the surface parallel to the source, then none of the light is absorbed at all. It all just goes right by.
So absorption decreases as the surface is rotated away from the perpendicular.

- To be precise, the absorption depends on the cosine of the rotation angle; i.e.,

\[
\begin{align*}
\cos(0^\circ) &= 1 \\
\cos(45^\circ) &= 0.71 \\
\cos(90^\circ) &= 0
\end{align*}
\]
Suppose we ignore the Earth's tilt for a moment and consider a surface of fixed size (say 1 m²) placed at different points on the Earth:
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**Conclusion:** The equator has maximum absorption, while the poles have minimum
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1. Surfaces in the NH rotate closer to perpendicular, increasing insolation.

2. Latitude circles in the NH have more daylight hours.
Now suppose the planet is tilted so that the Northern Hemisphere (NH) tilts toward the light source. Two effects:

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2. Latitude circles in the NH have more daylight hours.
3. And for both points, the opposite is true in the Southern Hemisphere (SH)
Now suppose the planet is tilted so that the Northern Hemisphere (NH) tilts toward the light source. Two effects:

1. Surfaces in the NH rotate closer to perpendicular, increasing insolation.

2. Latitude circles in the NH have more daylight hours.

3. And for both points, the opposite is true in the Southern Hemisphere (SH)

**Conclusion:** Insolation increases in the NH and decreases in the SH.
And of course, everything is opposite if we tilt the planet the other way:
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1. Surfaces in the NH rotate away from perpendicular, decreasing insolation
2. Latitude circles in the NH have fewer daylight hours
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And of course, everything is opposite if we tilt the planet the other way:

1. Surfaces in the NH rotate away from perpendicular, decreasing insolation
2. Latitude circles in the NH have fewer daylight hours
3. Of course, for both points, the opposite is true in the SH

**Conclusion:** Insolation increases in the SH, and decreases in the NH
Moral of the story: For a planet that's titled, insolation increases in the hemisphere tilted toward the sun, and decreases in the hemisphere tilted away from the sun.