Sunlight: angle and duration

Insolation means incoming solar radiation, Earth's main energy input. Latitude, time of day and season change the sunlight received by a location.

1. THE SAME BEAM CAN COVER DIFFERENT AREAS



Equal-width parallel beams carry equal power here. Oblique rays spread that power over more ground, reducing energy received per unit area. Beam footprints are shown in dark blue; diagrams ignore atmospheric losses.

2. LATITUDE CHANGES THE AVERAGE SOLAR ANGLE

Earth's curved surface receives sunlight more directly at low latitudes than near the poles. On an annual-average basis, incoming radiation per unit area is generally greatest in tropical regions and decreases poleward. This is not a rule that the equator receives the largest total on every individual day.

3. LONGER DAYLIGHT ADDS MORE ENERGY

For the same average incoming power per unit area, twice as many daylight hours gives twice the daily energy per unit area.

Illustration: 100 W/m^2 for 4 h = 400 Wh/m^2; for 8 h = 800 Wh/m^2. Real sunlight varies through the day, so the daily total combines changing intensity and duration.

Angle and day length work together; neither alone describes daily insolation.

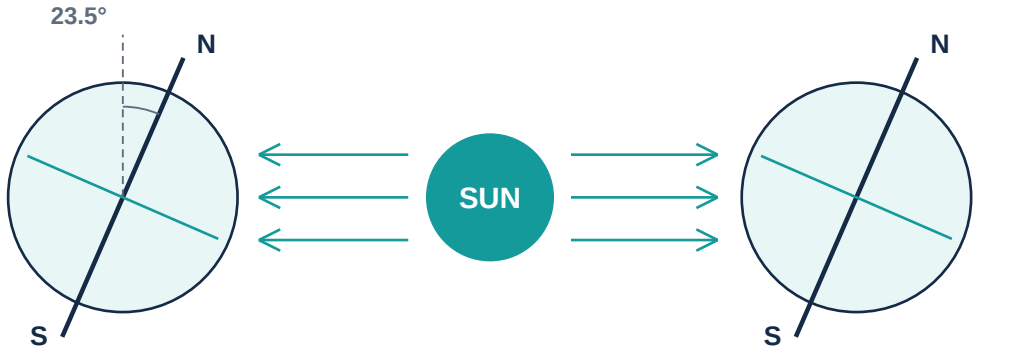
Solar geometry and latitude/day-length patterns: NASA, Climate and Earth's Energy Budget.
Core angle and seasonal relationships: College Board, ENG-2.A.1-4.

Scope: College Board AP Environmental Science CED, Topic 4.7, p. 86.

Tilt creates opposite seasons

Earth's rotation axis is tilted about 23.5° from the line perpendicular to its orbital plane. Over one year, the axis stays pointed in nearly the same direction in space.

1. TWO POSITIONS, SIX MONTHS APART



JUNE SOLSTICE

North: summer

South: winter

DECEMBER SOLSTICE

North: winter

South: summer

Sizes and distances not to scale. Teal line on each Earth marks the equator.

2. TILT CHANGES BOTH ANGLE AND DAY LENGTH

When a hemisphere tilts toward the Sun, its middle latitudes receive a higher midday Sun and longer daylight. Both increase daily solar input. Six months later that hemisphere tilts away, giving a lower midday Sun and shorter daylight. The other hemisphere experiences the opposite seasonal pattern.

3. DISTINGUISH ROTATION FROM REVOLUTION

Rotation is Earth's daily spin, producing the regular day-night cycle at most locations. Revolution is its yearly journey around the Sun; together with axial tilt, it produces the seasonal cycle. The axis does not flip toward the Sun halfway through the year. Near the poles, daylight or darkness can persist for months.

Axial orientation, orbit and opposite seasons: NASA Space Place, What Causes the Seasons?
Tilt, daylight and polar illumination: NOAA NESDIS, Summer and Winter Solstices.

Scope: College Board AP Environmental Science CED, Topic 4.7, p. 86.

Read the seasonal landmarks

Solstices mark the greatest northward or southward position of the overhead Sun. At equinoxes, the overhead Sun crosses the equator. These are astronomical markers, not fixed weather forecasts.

1. FOUR POINTS IN THE YEAR

EVENT / APPROX. DATE	OVERHEAD SUN	NORTH	SOUTH
March equinox March 19-21	Equator, 0°	Spring	Autumn
June solstice June 20-22	Tropic of Cancer 23.5° N	Summer	Winter
September equinox September 22-24	Equator, 0°	Autumn	Spring
December solstice December 20-22	Tropic of Capricorn 23.5° S	Winter	Summer

Dates vary by year and time zone. North/south columns show the astronomical season beginning in each hemisphere.

2. DAYLIGHT EXTREMES AND NEAR-EQUALITY

The local summer solstice gives the longest daylight period and the winter solstice the shortest. Around an equinox, day and night are approximately 12 hours each at most locations. Polar regions have special sunrise/sunset conditions; atmospheric refraction also prevents a universal exact 12-hour split.

3. AVOID TWO COMMON MIX-UPS

Distance is not the main cause of Earth's seasons: both hemispheres are effectively the same distance from the Sun but have opposite seasons. Also, the longest day need not be the hottest day. Land and oceans can keep gaining heat after the summer solstice, creating a seasonal temperature lag.

Solstices, equinoxes and overhead-Sun latitudes: NOAA NESDIS, What Is a Solstice?
Seasonal lag and polar daylight: NOAA NESDIS, Summer and Winter Solstices.

Scope: College Board AP Environmental Science CED, Topic 4.7, p. 86.