



MUSTANSIRIYAH UNIVERSITY
COLLEGE OF SCIENCES
DEPARTMENT OF ATMOSPHERIC SCIENCES

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Renewable Energy

Welcome Students

TO LECTURE FIVE



Solar Energy

Hour angle

- Hour angle (ω) is another representation of solar time
- It can be calculated as:

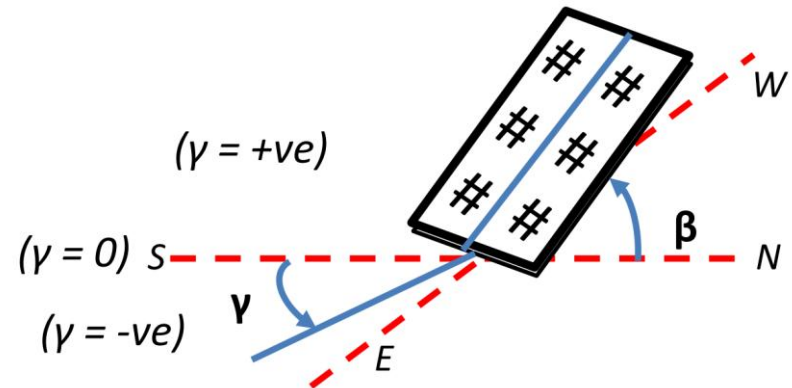
$$\omega = (ST - 12) \times 15$$

(-ve before solar noon, +ve after solar noon)

11:00am	12:00pm	01:00pm
$\omega = -15^\circ$	$\omega = 0^\circ$	$\omega = +15^\circ$

A plane at earth's surface

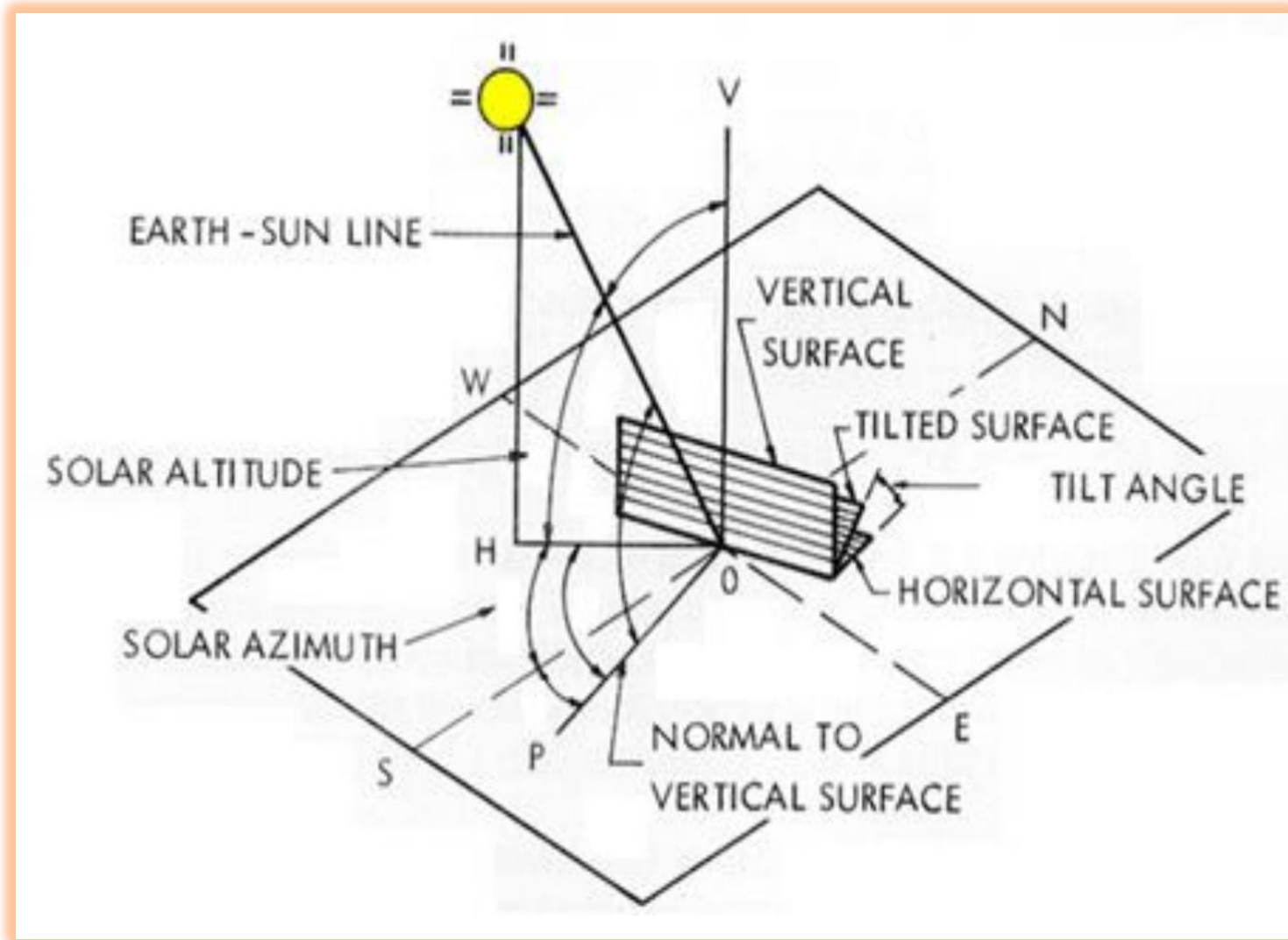
- Tilt, pitch or slope angle: β (in degrees)
- Surface azimuth or orientation: γ (in degrees, 0° due south, -ve in east, +ve in west)





Solar Energy

Summary of solar angles





Solar Energy

Interpretation of solar angles

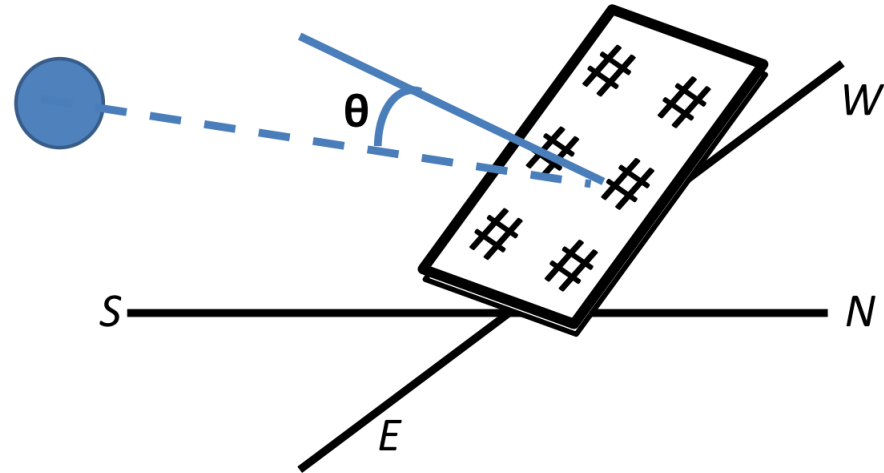
Angle		Interpretation	Set#
Latitude	ϕ	Site location	} 1
Declination	δ	Day (Sun position)	
Hour angle	ω	Time (Sun position)	} 2
Solar altitude	α_s	Sun direction (Sun position)	
Zenith angle	θ_z	Sun direction (Sun position)	} 3
Solar azimuth	γ_s	Sun direction (Sun position)	
Tilt angle	β	Plane direction	} 4
Surface azimuth	γ	Plane direction	



Solar Energy

Angle of incidence

Angle of incidence (θ) is the angle between normal of plane and line which is meeting plane and passing through the sun



- **Angle of incidence (θ) depends upon:**

- Site location (1): θ changes place to place.
- Sun position (2/3): θ changes in every instant of time and day.
- Plane direction (4): θ changes if plane is moved.

- **It is 0° for a plane directly facing sun and at this angle, maximum solar radiations are collected by plane.**