Welcome

Course code: EEE471
Non-conventional

EEE471 Non-Conventional Energy
3 Credits, 3 hours/week

Solar Geometry:
Motion of the earth about the sun, Angle of declination, Solar time, Location of the sun relative to a horizontal plane.
Solar Intensities:
Solar spectrum and intensities above the atmosphere, Instrumentation for measuring solar intensities, solar intensities at earth level normal to the sun, Insolation on surfaces, Direct and Diffuse Radiation.
Solar Heating & Storage Systems:
Energy Flow and Efficiency of Flat-Plate collectors, Frames, Boxes, Insulation and Glazing, Absorber plates and Heat-transfer Fluids. Sensible heat storage, Phase-change storage and Other types of storages.
Silicon Solar Cells:
Principles, Efficiency and efficiency limiting factors. Design consideration, cell fabrication, Construction of Solar Modules & Panels.
Other Cells and Materials:
MIS Solar cells and other Device structures, Cell Materials.
Other Nonconventional Sources of Energy:
Biomass; Wind power; Water power & Tidal power.

Books Recommended:

1. **Solar Energy: Principles of Thermal Collection and Storage** - Suhas Pandurang Sukhatme

EEE472 Non-Conventional Energy Lab
0.75 Credits, 3/2 hours/week

Laboratory experiments based on theory and concepts learnt in EEE471.

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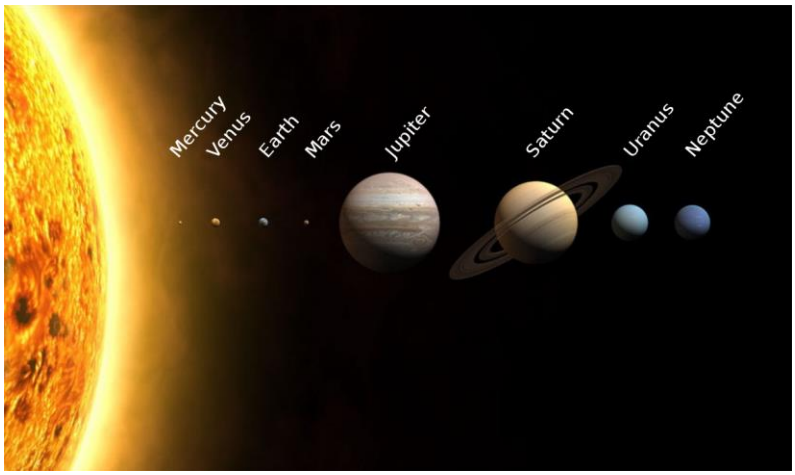
Chapter 1
Solar Geometry

Solar System

- The Solar System is the gravitationally bound system of the Sun and the objects that orbit it, either directly or indirectly.



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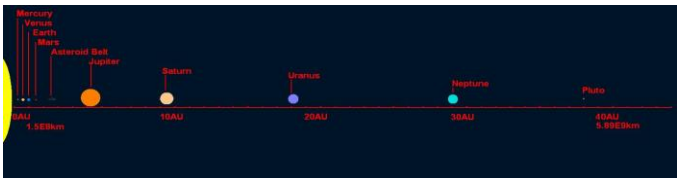
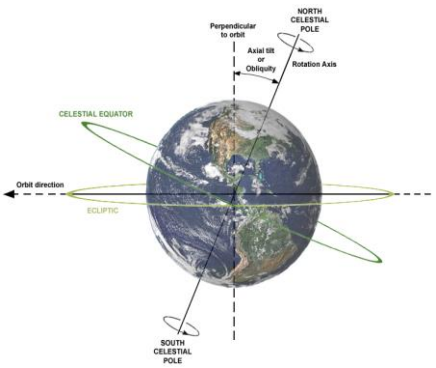
Solar System



Solar geometry

Motion of the Earth about the sun

- Imagine a line passing through the center of Earth that goes through both the North Pole and the South Pole.
- This imaginary line is called an axis.
- Earth spins around its axis.
- This spinning movement is called Earth's **rotation** (24 hours).



- It also orbits, or revolves around the Sun. This movement is called **revolution** (365.24 days).

*Leap-year

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Solar time

- Solar time is a calculation of the passage of time based on the position of the Sun in the sky.
- The fundamental unit of solar time is the day.
- Two types of solar times are apparent solar time (sundial time) and mean solar time (clock time).
- In September the Sun takes less time (as measured by an accurate clock) to make an apparent revolution than it does in December
- 24 "hours" of solar time can be 21 seconds less or 29 seconds more than 24 hours of clock time.
- Is due to the eccentricity of the Earth's orbit (meaning that the Earth–Sun distance varies throughout the year), and the fact that the Earth's axis is not perpendicular to the plane of its orbit (the so-called obliquity of the ecliptic).
- The effect of this is that a clock running at a constant rate – cannot follow the actual Sun; instead it follows an imaginary "mean Sun" that moves along the celestial equator at a constant rate.
- This is "mean solar time", which is still not perfectly constant from one century to the next but is close enough for most purposes.
- Currently a mean solar day is about 86,400.002 SI seconds.

Length of apparent solar day (1998)[9]

Date	Duration in mean solar time
February 11	24 hours
March 26	24 hours − 18.1 seconds
May 14	24 hours
June 19	24 hours + 13.1 seconds
July 25/26	24 hours
September 16	24 hours − 21.3 seconds
November 2/3	24 hours
December 22	24 hours + 29.9 seconds

*Local Solar Time (LST), Local Standard Time Meridian (LSTM)and Local Time (LT)

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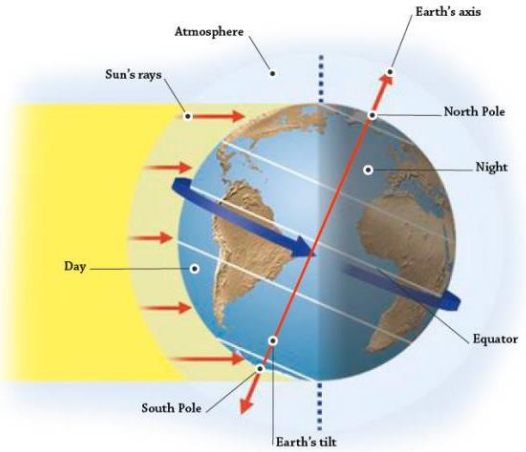
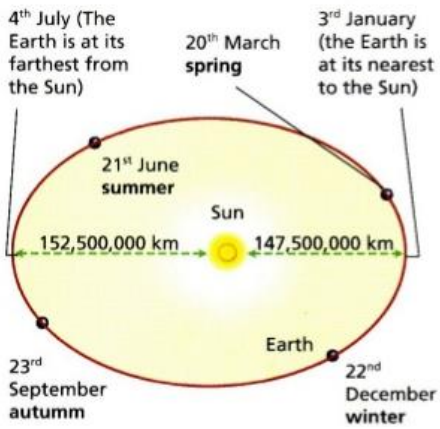
Motion of the Earth about the sun

- At the equator, the Earth rotates at a speed of about 1,700 km per hour, but at the poles the movement speed nearly nothing.
- Earth's orbital path is an ellipse.



Motion of the Earth about the sun

- At perihelion (147 million km) on about January 3rd
- At aphelion (152 million km) on July 4th
- Earth travels at an average distance of about 150 million km in one revolution.
- Earth revolves around the Sun at an average speed of about 27 km (17 mi) per second.



- Rotation seen from North Pole is anticlockwise (west to east)

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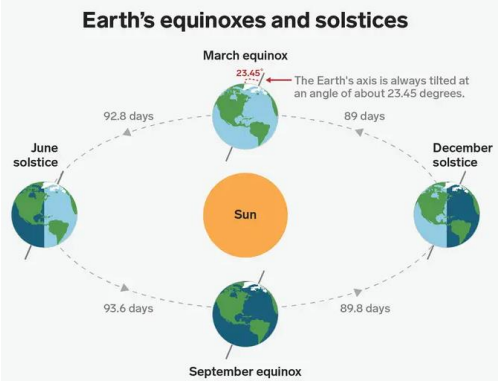
Angle of Declination (Solar)

- The axis about which the earth rotates is tilted at an angle of 23.45 degrees to the plane of the earth's orbital plane and the sun's equator, called **solar angle of declination**.
- If the Earth were not tilted on its axis of rotation, the solar declination would always be 0°
- **Solar declination** angle varies plus or minus this amount.

$$\delta = -23.45^{\circ} \times \cos\left(\frac{360}{365} \times (d + 10)\right)$$

where the d is the number of days since the start of the year

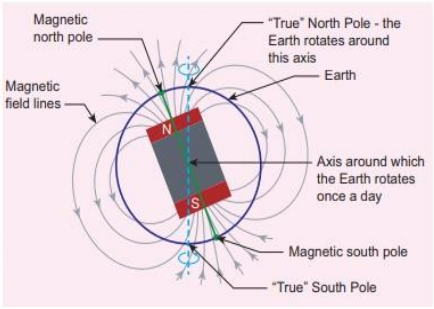


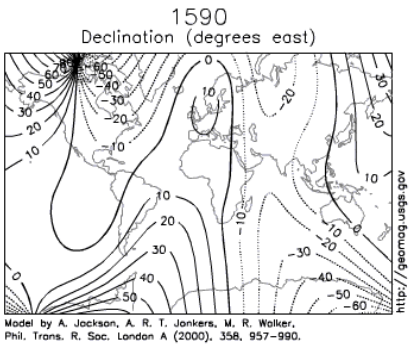
**zero at the equinoxes (March 22 and September 22), June 22 which is 23.45°, December 21-22 which is of -23.45°*

***The equation also assumes the orbit of the sun to be a perfect circle and the fraction of 360/365 converts the number of days to the position in the orbit.*

Angle of Declination (Magnetic)

- **Magnetic declination**, or magnetic variation, is the angle on the horizontal plane between magnetic north and true north.
- This angle varies depending on position on the ***Earth's surface** and changes over ***time**.
- The magnetic declination in a given area may (most likely will) change slowly over time, possibly as little as 2–2.5 degrees every hundred years or so, depending upon how far from the magnetic poles it is.





***molten iron and nickel ****complex motion of them**

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