

Earth, Moon, and Sun

- **Seasons** are not caused by distance but **by 23.5 degree tilt of earth's axis**. Distance of Earth to Sun does not change significantly enough (only 3%) to change heating in earth, and in north America its closest to sun during winter (January)
- Greater tilt = more extreme seasons
- **Seasons:** Significant variations in heat from the sun during the course of the year, different amounts of sunlight
- Season difference more pronounced further north/south, seasons in south hemisphere opposite to the north
- In the North, the winter has less sun energy and is colder due to that, darker due to that, in the spring we get a bit more, and in summer we get hotter and longer days due to more sun energy

Leaning towards Sun = Summer (in North), **Leaning away = Winter** (in North)

Tilt always relatively same angle, but tilt + placement in orbit = leaning towards or leaning away
Can see how North hits the sun more directly, and south hits less (for summer), and vice versa for winter, hence opposite seasons in North and South.

Top is spring and bottom is fall/autumn

Winter closest to sun, fall second closest (winter closest and this the transition), spring 3rd, summer furthest

Sun's path (ecliptic) on celestial sphere

See when North leaning away (summer) sun's path spends more time in the sky (15 hours in US) compared to 9 hours in winter. Below path above horizon huge in summer.

- But there is wobble in the tilt (wobble like spinning top around a z axis), it doesn't always point towards polaris, but it takes 26 000 years, in 15 000 AD it will point towards star Vega, don't have enough from 13k years ago to know what earth was like before current tilt direction, but that would impact the seasons
- **Polar Night:** From the tilt, and the arctic circle (North pole at the center of it) leaning away from the sun in winter, it is consistently dark in winter.
- You then see the opposite in summer where it's consistently day, the sun never sets.
- Canada's latitude not that extreme compared to place like Sweden
- Can see from above diagram how equator pretty much stays the same, doesn't lean towards or away as much, **latitude affecting different seasons**
- In summer sun looks higher in sky
- Keep in mind Earth's atmosphere refracts light, so even when the suns a bit below the horizon, can still see a bit of its light, which slightly affects calculations and temperatures
- **Day** or Sidereal day = Earth rotating once around its axis in 23 hours, 56 mins, and 4.07 seconds
- Solar day: Point for sun to hit the same place in the sky, 24 hours, orbit around sun causing slight difference to sun being same place in the sky

- aka mean solar day - avg value of solar day since sun not in sky same amount every day, so we take the avg
- **Sidereal day** is one spin around axis, **Solar day** is one spin + a little more to get sun same place in the sky
- Astronomers prefer sidereal for calculations
- **Apparent solar time** based on position of sun in the sky, used by ancient peoples today slightly different with midnight at starting point, noon where sun hits meridian
- Apparent solar time very awkward as, relating to Solar day, sun keeps moving
- **Sidereal month**: Moon orbiting Earth in 27.3 days (measuring moon going around earth in orbit to the same spot).
- **Synodic month** aka solar month taking 29.5 days (moon going back to its original phase). To get back to same phase turns a bit more due to Earth's orbit.
- **Sidereal year**: Earth completes one orbit around sun
- **Tropical year**: Earth completes one cycle of seasons, 365.25 days - 20 mins shorter than tropical year
- Related to tropical year, to keep calendar in synch add a day every 4 years, Feb 29, leap year
- Planetary period measured with respect to stars (sidereal) or to apparent position of sun (synodic), same idea as sidereal day vs solar day
- **Sidereal** follows actual orbit, same place in sky, **solar/tropical/synodic** all about humans want day related to sun in the sky, moon phases, these tangible things that are always slightly different
- **Course Definition Sidereal vs Synodic**: "sidereal" refers to events that are timed with respect to the distant stars, and "synodic" refers to special alignments of astronomical bodies, such as the Earth, Moon, and Sun.
- Timezones not logical but political, China has 1 timezone despite technically being different times in a bunch of areas
- Keeping calendar synchronised requires us to keep adjusting calendar

Phases and Motion of The Moon

- Moons orbit around earth (27.3 days) causes **Lunar Phases**, it takes a month to hit all the phases
- Half of the Moon is illuminated by the Sun and half is dark. We see a changing combination of the bright and dark faces as the Moon orbits Earth.
- Moon always half in sun half out, but the orbit movement, we see from an angle, so we see different phases
- Usually when u see big moon, actually seeing moon lower in horizon, an illusion
- Supermoon = full moon at closest position, not big deal
- New moon like when its directly facing sun and can't see it
- From full moon, starts waning in 3 stages til new moon, then starts waxing in 3 stages til back to full, and repeat
- A day on the moon is the same as a month

- Moon rotates on its axis once every 27.3 days (sidereal period), orbits Earth once every 27.3 days, synchronous rotation, according to chatgpt **tidal locking**, this why Earth sees same side of the moon
- “Dark side” of the moon = side we never see (its not dark, whole moon gets illuminated)
- Gravity of moon slightly distorts Earth, causing tides. Water on side of Earth facing moon flows toward moon.
- Land masses stop flow of water so we don’t see insane tides.

Moon Phases

Shadow on the right = waning, shadow on the left = waxing

The moon rises around 50 mins later each day

Eclipses

- When either Earth or moon pass into each others shadows we have an **eclipse**
- Sun 400x larger than moon, yet also 400x farther away, so sometimes the moon covers the sun
- **Umbra** = deepest part of earths shadow (all light blocked), **penumbra** = some light blocked but not all
- Lunar eclipse way more common than solar eclipse
- **Lunar eclipse** when Earth between sun and moon and see earths shadow on the moon
- Moon looks orange/red from light bouncing off earth's atmosphere, red for same reason sun looks red
- Moons appearance during lunar eclipse changes more when through umbra, change more subtle when just through penumbra
- **Solar eclipse** when moon between sun and earth, and appears that moon is covering the sun, moon casting shadow on to earth
- **Totality** when moon covers **photosphere** (main bright part of the sun) completely, and only see Corona (usually washed out by photosphere), only time you can look at the sun
- Eclipses **partial** (near total eclipse), **total**, or **annular** (moon at centre of sun but not able to cover entire photosphere)
- Annular moon too close to sun, too far from Earth, to block whole thing, moon appearing smaller in the sky
- From annular, see moon and sun near exact same size in earths sky
- Eclipses a huge coincidence, that moon and sun near exact same
- Moon getting slightly farther from us, in some time in future there will be no more solar eclipses, will be too small to cover the sun
- Why don't we see lunar and total eclipses every month
- Moon does not go around earth in same ecliptic plane as earth around sun, 5 degree difference with every once and awhile coincidental line up for total solar eclipse
- Nodes = when moon crosses ecliptic plane
- **For eclipse** moon must be near full moon (lunar) or new moon (solar) and cross the ecliptic (cross a node), and due to this get around 2 eclipse seasons each year
- Remember new moon nearest to the sun (covering for eclipse)

More Text Notes

- Earth's Axis of rotation connects poles
- Earth rotates towards East
- **Great circle** on a sphere when center of that circle also the center of the sphere, ie the equator right in the middle around earth
- **Multiple Meridians**, great circles perpendicular to equator, the vertical/upright lines
- Notice many meridians, connecting north and south poles, for longitude
- Any point on earth has a meridian passing through it, connecting the poles
- **Longitude** = number of degrees east or west of the prime meridian (place in Britain Greenwich w 0 longitude, political crap as to why its there)
- **Universal Time UT = Greenwich Mean Time GMT**
- **Latitude** = number of degrees north or south of equator
- **Celestial coordinates** on celestial sphere for marking "latitude and longitude" of items in space, but called declination and right ascension
- **Declination** = latitude for celestial sphere, RA or Right Ascension like longitude on celestial sphere, but doesn't use Greenwich like Earth does
- Jean Foucault pendulum demonstrating earth's rotation

From Midterm: Planet in **opposition** to the Earth means behind the Earth