

Introduction to Y11 Astronomy

General overview notes

Notes still a work in progress. They show suggested order for learning but lack general depth in some areas, eg. Coriolis Effect. Hyperlinks are given to further information. These notes are available at DeepScience.com.

Introduction

1. **Spin of the Earth**
 - Day and night
 - Changes of temperature during the day and night
 - Formation and direction of winds in the Southern hemisphere - direction of surface ocean current flows in the Pacific Ocean
2. **Orbit of Moon around Earth**
 - Phases of the Moon
 - Formation of tides
 - Neap and Spring tides.
3. **Orbit of Earth around Sun**
 - Solar System Fun (but not for assessment)
 - Inclusion of eclipses (but not for assessment) – 14th November 2012
 - Seasons (and effect of the Earth's tilt and the heating effect of the Sun.)
 - Seasonal changes at the North and South poles, latitude of New Zealand, Tropics of Cancer and Capricorn, and the Equator

Introduction:

Space is Big – video intro 1 – Stars are big

What space looks like through telescopes – powerpoint intro 2

7 minutes of terror: landing a nuclear powered tank with 20inch rims and a laser cannon on mars – video intro 3

Space events this month - Sky map from www.skymaps.com for southern hemisphere

Find and label:

The Southern Cross (Crux)

The Two Pointers (α , β): Alpha Centauri, Beta Centauri

South Celestial Pole

Achernar

Questions:

1. Why does Alpha Centauri have a line?
2. What is the SCP?
3. What are two ways of finding the SCP at night?

The SCP is the point around which all the stars seem to be rotating.

Other space stuff:

Closest star: Proxima Centauri, 4.22 light years away. It takes light 4.22 years to travel that distance. Light speed is 3×10^8 m/s. 100kph is about 27 m/s

Comets – bodies orbiting the sun in eccentric orbit (flattened circle). When they get closer to the sun evaporated gases can form a long tail that points away from the sun regardless of the direction it is moving, eg. Halley's Comet

Meteors – Dust or other material that hits Earth's atmosphere and burns up (Shooting star).

Meteorites – Meteor that gets through the atmosphere to actually hit the surface of the Earth.

Asteroids – smaller planetoids orbiting the sun, usually between the orbits of Mars and Jupiter.

Spin of the Earth:

The Earth rotates on its axis once every 24 hours. The rotation of the Earth means that the side that is facing the Sun is always changing. This causes day and night. The Earth is a sphere (ball). The size of the Earth's sphere was first calculated about 500BC by the Greek Pythagoreans.

Urban Legend #1: "Chris Columbus wanted to go sailing to prove the Earth was round." Nope, just rewriting of history. No large group of people have ever held to the belief that the Earth is flat. This myth is usually retold by people wanting to discredit the church.

There are several ways of describing day and night.

Science language: The Earth rotates

Common: The sun rose and then set

Both are right. You have to take context and perspective into account. Lovers don't look at a sunset and sigh "ohh look at the beautiful Earth rotation."

Our rotation tells us something about what other planets might be doing too. Some of the first astronomy was done by people noting surface marks on other planets and even the sun and then seeing how they moved over time, in order to calculate their rotation. You can do this yourself.

Rotation vs Orbit

Rotation is an object turning around on the spot.

Orbit is an object moving around another object.

1 rotation of the earth on its own axis is 1 day

1 orbit of the moon around the earth is about 1 month

1 orbit of the earth around the sun is 1 year

"Once in a blue moon" – When you get two full moons in the same calendar month.
eg. Aug. 31, 2012. Next one is January 2014.

Effects of Earth Spin:

Coriolis - The spin of the Earth causes the air to move. This is called [the Coriolis effect](#).

Temperature - Night and day causes major temperature changes over land masses. Temperature change over water is less.

Orbit of Moon around Earth:

A moon is a natural object orbiting a planet.

A planet is a larger body orbiting a star.

Pluto is not considered to be a planet now because 1) it is so small and 2) its orbit is crazy and 3) there's a bunch more rocks out there that are even bigger.

The solar system rotates around a common centre of mass located just beneath the surface of the sun. The Earth and Moon rotate around their own common centre of mass as well. This means the Sun and Earth wobble a bit. The sun-earth-moon system sometimes line up, and sometimes make a right angle.

Phases of the Moon

The moon takes about 29.5 days to *orbit the Earth* (synodic). This is one **month**.

Synodic orbit: time for moon to reappear at same point in sky *relative to the sun* from Earth

Sidereal orbit: Time for one full orbit of the moon around the Earth relative to the stars (27.3d)
 Earth goes anticlockwise around the Sun. The Moon goes anticlockwise around the Earth.
 The moon has to take a longer journey to get back in between the Earth and Sun and this makes the Synodic period longer.

The moon rotates at exactly the same speed it orbits which means the same side always faces Earth regardless of which side is facing the Sun. One side of the moon is always lit from the sun.

Example question: “Describe the phases of the moon and what causes them.”

The moon is a ball hanging in space lit from one side.

When that side is facing the Earth we see a full moon.

When the lit side is facing away from the Earth (ie, the Moon is somewhere between the Sun and the Earth) then it is a “new Moon” because the side facing us is in complete shadow.

The other phases of the moon are when we only see a portion of the lit side. It is curved (crescent) because the moon is a curved surface (ball).

This cycle takes a month.

The dark side of the moon is the side facing away from the sun, *not* the one facing away from the Earth. (Year11 ESA book p261, 262 – copy first diagram and read the guff)

Sometimes “Earthshine” occurs when light reflects off Earth’s clouds and slightly illuminates a new moon.

The (full) moon only has a small chance of going into the shadow of the earth (a lunar eclipse) because it is so far away.

Problem: How far would the moon be from the Earth if the Earth was only 0.3m in diameter?

Average mean distance to moon = 384,400km, Earth diameter = 12,756km

Answer: about 9 metres

Effects of moon orbit:

Formation of tides

Tides are caused by the *gravitational pull of the moon*.

The actual tide at a given location is determined by astronomical forces accumulated over many days, not the current location of the moon.

Tides are the movement of water – the sea rises and falls twice every day. (12 ½ hours)

Tides do *not* follow the moon around the Earth.

The continents get in the way.

Waves don't move that quickly.

Tides tend to be pushed in local circles. The tides around New Zealand move anticlockwise around the country resulting in a high tide and lower tide in Auckland at the same time in the two harbours. The tidal flow through the Cook Strait is extreme.

Neap and Spring tides

Neap tides: Sun, Earth, moon at 90 degrees. The gravity cancels a little so produces a smaller tide than normal (extremes are less).

King/spring tides: Sun, Earth, and moon in a line (syzygy). The sun’s gravity contributes to make a tide that is bigger than normal. A bigger tide means the height between the low tide and high tide is bigger.

These extra low and extra high tides usually occur 1 or 2 days after the moon has been in the above described location. This is the *tide's age*.

Orbit of Earth around Sun:

The Earth takes 365.25 days to *travel around the sun*. One **year** is usually 365 days. Every four years we have a leap year with 366 days to make up for the missing $\frac{1}{4}$ days. How we know the length of a year: Seasons (caused by the tilt of the Earth), length of shadows, position of stars.

This orbit helps us to study the stars. **Parallax** – The apparent motion of near objects with respect to far objects, eg. When driving in a car a fence on the side of the road appears to move past quickly, a tree in the field moves slower, and a mountain in the distance seems stationary. Near stars move against a stationary background of distant stars as Earth orbits the sun. Only a few stars are close enough for us to notice parallax.

The Solar System

The sun is a big ball of burning gas.

There are 8 major planets plus several dwarf planets (eg. Pluto) that orbit the sun. Some are very small (Mercury) and some are very large (Jupiter).

Interesting facts on each planet:

1. Mercury – hard to see because its close to the sun. Little atmosphere.
2. Venus – Hottest planet because of thick atmosphere with clouds of acid. Usually the brightest in the sky (apart from the moon and sun).
3. Earth – has a moon that controls tides. $\frac{1}{6}$ gravity on moon. Best planet for parties.
4. Mars – cold, two moons, frozen water, dry ice. Red.
5. Jupiter – Biggest gas giant. Has a storm that looks like a big red spot. 63 moons. One (Ganymede) is bigger than Mercury.
6. Saturn – Gas giant. Rings!
7. Uranus – ice giant with coldest atmosphere in solar system (water, methane, ammonia) -224°C (only -18°C in your freezer). No visible features. Thin black rings.
8. Neptune – ice giant with visible storms. Fastest winds recorded in solar system 2100 km/h

Space temperature = -270°C

Absolute zero = -273.15°C

Weight for it...

Weightlessness in space is not the absence of gravity. It is caused by the object and the floor falling at the same rate. If the floor stopped falling you would notice the gravity. There is gravity in space! It's what keeps satellites in orbit, the moon up, the Earth going around the sun....

We see the moon because light from the sun reflects off the moon into our eyes. Same with the planets. But we see the stars because they make their own light.

Effects of Planet orbits:

Eclipses - Several times a year the moon precisely lines up with the Sun and Earth creating a shadow.

14th November 2012 Eclipse!

Solar Eclipse: Shadow from moon falls onto the Earth

Lunar Eclipse: Shadow from Earth falls onto the moon

The moon goes around the earth.

The earth goes around the sun.

Sometimes they all line up.

This creates a shadow.

Eclipses are fun.

Seasons - Effect of the Earth's tilt and the heating effect of the Sun.

Seasons are caused by the tilt of the Earth (23.5 degrees) and the journey of the Earth around the Sun. You need to see a picture to understand what is going on with this.

In winter the light is less intense because:

- More atmosphere the light has to go through at an angle
- Same amount of light spread over greater area
- NZ winter is when the Earth is actually further from the sun.

Seasonal changes at the North and South poles, latitude of New Zealand, Tropics of Cancer and Capricorn, and the Equator.

Southern hemisphere summers are particularly dangerous for getting sun burnt because:

- Ozone layer holes – more radiation gets through
- Earth's elliptical orbit means the Earth is actually a bit closer during SH summer.

The closer to the poles you get (the greater the latitude), the greater the seasonal temperature effect of the tilt of the Earth, and the lower the sun will appear in the sky.

Day and night is 6 months long at the poles.

"The sun at the North Pole is continuously above the horizon during the summer and continuously below the horizon during the winter... When the sun is visible in the polar sky, it appears to move in a horizontal circle above the horizon. This circle gradually rises from near the horizon just after the vernal equinox to its maximum elevation (in degrees) above the horizon at summer solstice and then sinks back toward the horizon before sinking below it at the autumnal equinox..."

These effects are caused by a combination of the Earth's axial tilt and its revolution around the sun. The direction of the Earth's axial tilt, as well as its angle relative to the plane of the Earth's orbit around the sun, remains very nearly constant... At northern midsummer the North Pole is facing towards the sun to its maximum extent. As the year progresses and the Earth moves around the sun, the North Pole gradually turns away from the sun until at midwinter it is facing away from the Sun to its maximum extent. A similar sequence is observed at the South Pole, with a six-month time difference." [\(wiki\)](#)

Definition of the Tropics

"The Tropic of Cancer, also referred to as the Northern tropic, is the circle of latitude on the Earth that marks the most northerly position at which the Sun may appear directly overhead at its zenith. This event occurs once per year, at the time of the June solstice, when the Northern Hemisphere is tilted toward the Sun to its maximum extent." [\(wiki\)](#)

The Tropic of Capricorn is the Southern tropic and is a fair way north of New Zealand. This means the sun will never quite be directly overhead in NZ, even in the middle of summer.

Astronomy Diagrams you should know.

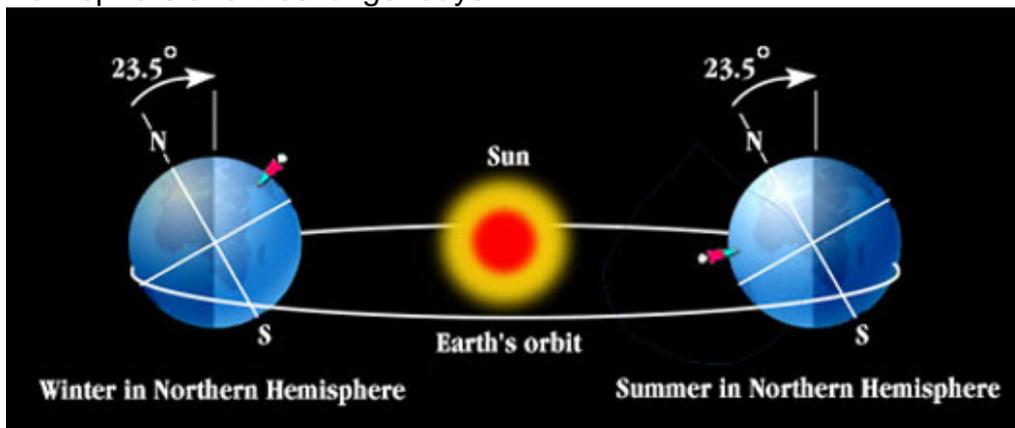
- [Phases of moon](#)
- [Seasons/ day and night at poles/tilt of Earth](#) (French website but cool pictures)
- [Angle of sunlight during summer and winter](#)

- [Gravity of moon](#)
- [Neap and Spring Tides](#)

Topic Summary Questions: Digging deeper

1. What causes day and night?

- Rotation vs orbit of planet. Spinning on own axis vs moving around another body.
- Time for one Earth rotation is 24 hours
- Side facing sun is lit up – day!
- Side facing away from sun is in shade – night!
- Length related to rotation of Earth with respect to the sun, not to the same direction in space. As the Earth orbits the sun the direction Earth is facing with respect to the stars when NZ is pointing at the sun changes. Earth orbits anticlockwise around the sun while rotating anticlockwise (if North is at the top). This means Earth actually rotates slightly more than 360 degrees before getting back to midday for the same location.
- The tilt of the Earth also changes the angle at which the sun appears in the sky during the year. If the sun appears overhead at midday the duration of daylight will be longer than if the sun appears low in the sky at midday.
- It takes 24 hours for Earth to rotate but during the summer a greater part of that 24 hours will be daylight. This is because the Earth is tilted on its axis of rotation. If the Southern Hemisphere (SH) is tilted towards the sun it will have more light than the Northern Hemisphere and thus longer days.



- On left: NZ summer, more of the Southern Hemisphere (area below the equator) lit by the sun gives longer days and warmer temperatures.
- On right: NZ winter, less of the SH lit by the sun gives shorter days and cooler temperatures.

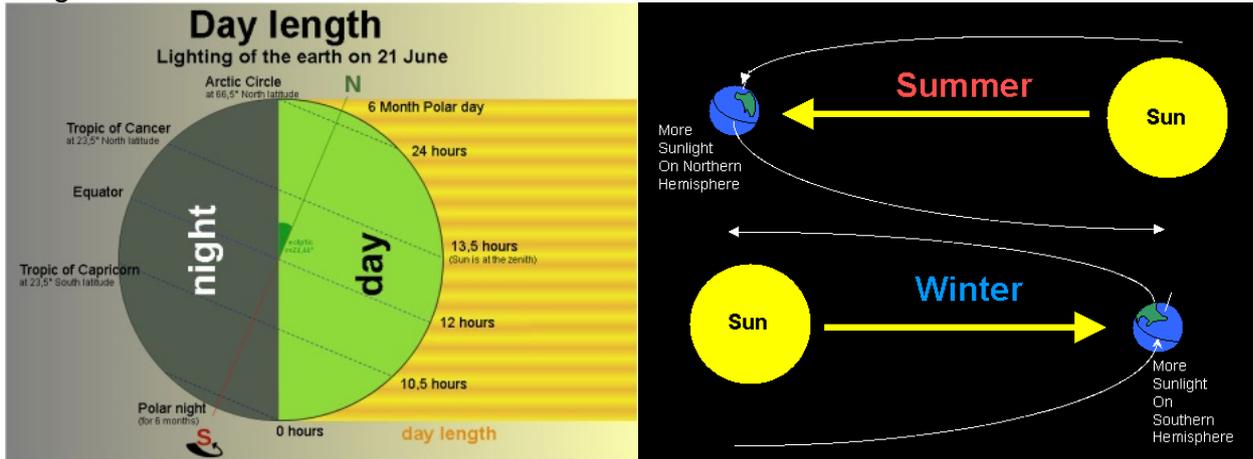
2. What causes temperature differences during the day and night?

- Surface temperature is related to solar radiation (energy from sun heating Earth) and terrestrial radiation (heat from Earth radiating out into space).
- When NZ is facing the sun (daytime) the incoming energy from the sun is greater than the outgoing radiation into space and so the local temperature goes up.
- Water does not change its temperature very easily so islands like NZ tend to not have sharp changes in temp between day and night.
- Death Valley in California is in a rain shadow and is very dry. It can go up to 57C degrees during the day during the northern hemisphere summer.
- The tilt of the Earth means that during our summer NZ is tilted towards the Sun and receives more direct light that has to go through less atmosphere to hit the surface. This increases the incoming solar radiation during summer.
- The tilt of the Earth means that the daylight hours are longer during summer and this means that there is more time for solar radiation to heat the surface.

- The tilt of the Earth means that night time hours are longer during the winter and this means that there is more time for terrestrial radiation to release heat into space making the surface cooler.
- Another cause of local temperature change is the wind patterns caused by the spin of the Earth. Coriolis forces near the equator cause large spinning wind systems called cyclones that can carry warm or cold air over NZ.
- The hottest time of the day is mid afternoon even though the sun is giving the most direct light at mid-day because it takes a while for the atmosphere to heat up.

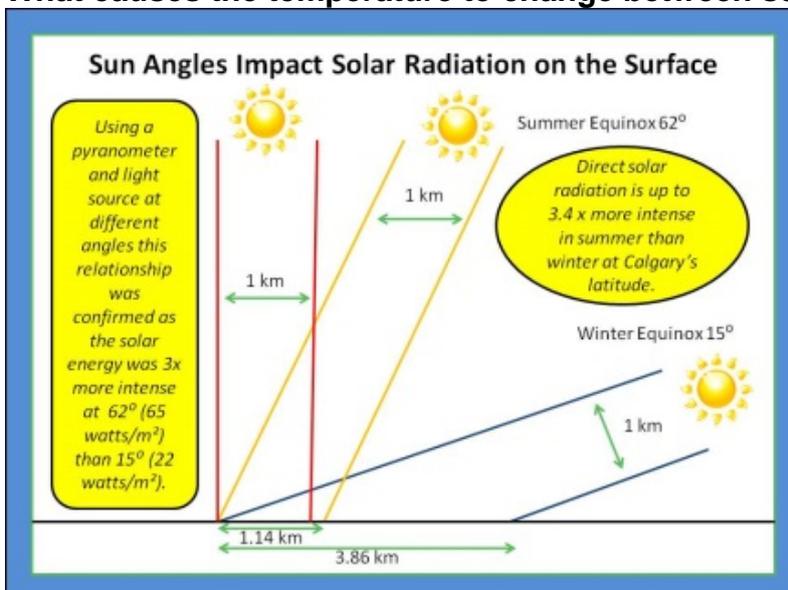
3. What causes different day lengths in different seasons?

- The Earth axis is tilted at 23.5 degrees with respect to its path around the Sun.
- Diagrams are useful to show this.



- This tilt means that for 6 months the North pole is in daylight and the Sun does not set, while at the South pole the Sun does not rise over the horizon. Each pole has only one sunrise and one sunset per year.
- The NZ summer solstice is Dec 21-22 and is our longest day as the southern hemisphere is tilted towards the Sun. The NZ winter solstice is June 21-22 and is our shortest day because we are tilted away from the sun.
- Long days in summer means lots of sunlight and warmer temperatures. Short days in winter means less sunlight and colder temperatures.
- Average day length results in average incoming daylight and average temperatures and gives us the seasons Spring and Autumn.

4. What causes the temperature to change between seasons?



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- In the NZ summer the southern hemisphere is tilted towards the sun. This means that the same energy from the sun can be absorbed by a smaller area, increasing the intensity. The light travels the most direct route through the atmosphere to the surface so less energy is absorbed on the way through. This makes summer hot.
- The NZ winter is when the southern hemisphere is tilted away from the sun. This means that the same amount of energy from the sun is spread over a greater area, decreasing the intensity. The light has to travel at a steep angle through the atmosphere to the surface so more energy is absorbed on the way through. This makes winter cold.
- The closer to the poles you get (the greater the latitude), the greater the seasonal temperature effect of the tilt of the Earth, and the lower the sun will appear in the sky.
- The summer solstice (longest day) isn't the hottest day of the year as it takes a while for the atmosphere to warm up - just like mid-afternoon is usually the warmest time of day instead of midday.
- The orbit of the Earth around the sun is not quite circular. Earth is slightly closer to the sun during the NZ summer. There are ozone holes in the atmosphere in the Southern hemisphere which allow more ultra violet light through than in the northern hemisphere. These mean that we are far more likely to get sun burned in NZ. Despite these points, European summers are still hotter due to the greater land mass in the north. The ocean keeps the NZ summer moderate.

