ABINGDON SCIENCE PARTNERSHIP

5.Solar System Observation (5.5-5.8)

Edexcel GCSE Astronomy Course

5.5 Understand the observed retrograde motion of planets

To understand the problem of retrograde motion and how it changed ideas about the structure of the solar system follow the information and activities in this document:

The Weird Problem of Mars Going Backwards

You will also need to print a copy of this worksheet:

Retrograde Motion of Mars

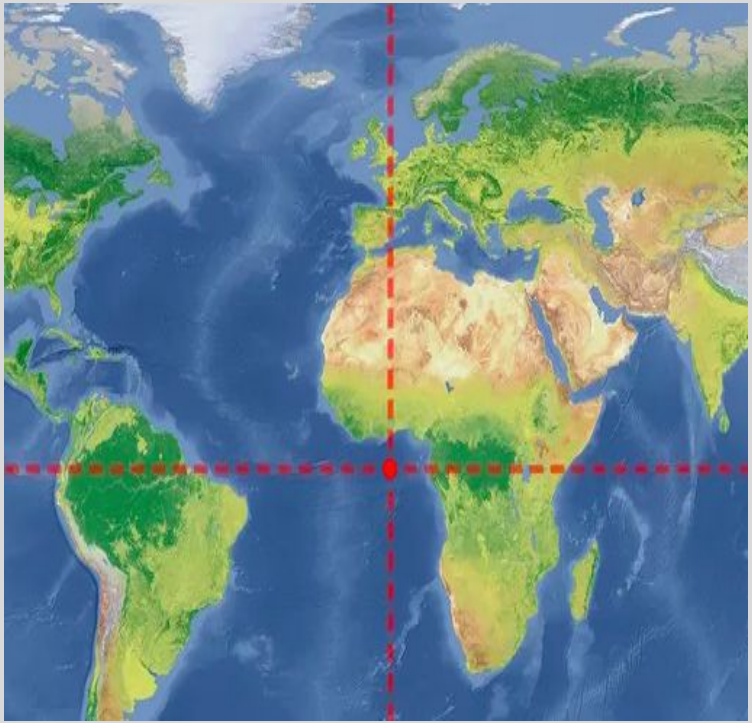
Topic 5.6:

In this task you will need to learn some new vocabulary:

- Read the slides and then make your own notes of definitions and explanations of all highlighted words and phrases.
- Be prepared to:
  - Recall these written definitions in answers to exam questions
  - Be able to identify points and coordinate systems on sky charts and diagrams in exam questions

5.6 Understand the terms First Point of Aries and First Point of Libra

On the Earth's surface we use the Latitude and Longitude grid to locate places
The 0^o of latitude line is the equator for good, geographical reasons as it denotes the centre line around the sphere of the planet
The 0^o of longitude line doesn't have a logical, geographical justification - it was defined for geopolitical purposes to run through Greenwich, near London, when the UK dominated world affairs
The 0^o of longitude line could have been chosen anywhere around the planet



A map showing the point of intersection of the equator (0^o Latitude) and the prime meridian (0^o Longitude)

(5.6 Understand the terms First Point of Aries and First Point of Libra)

In the same way as we need a reference grid to navigate on the Earth's surface, we need a similar grid to navigate around the sky, which we call **'The Celestial Sphere'.**

Imagine it as a glass ball, with you standing at the centre and a grid etched onto the glass. You would see lines on the sky like in this animation:

Earth_within_celestial_sphere.gif

The numbering of the grid needs zero lines just like latitude and longitude do so what do we use as reference lines?

(5.6 Understand the terms First Point of Aries and First Point of Libra)

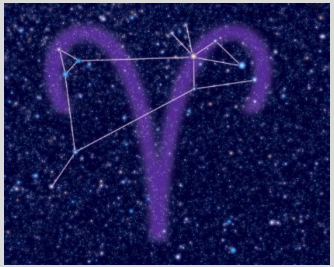
The celestial equivalent of latitude is called **declination** and it is the angle measured above and below the 0º line which is the **ecliptic**.

The **ecliptic** is the flat plane on which objects in the solar system lie - imagine holding a dinner plate with the planets being various, round vegetables like peas and sprouts. They all lie on the plate, not floating above or below it - most of the orbits of the planets are close to the **ecliptic.**

Knowing where the **ecliptic** is helps to Find the planets in the night sky as they track along it as they orbit the Sun. This is shown in this Stellarium screen from April 2020 when Mars, Saturn and Jupiter were close in the sky. The red line is the **ecliptic.**

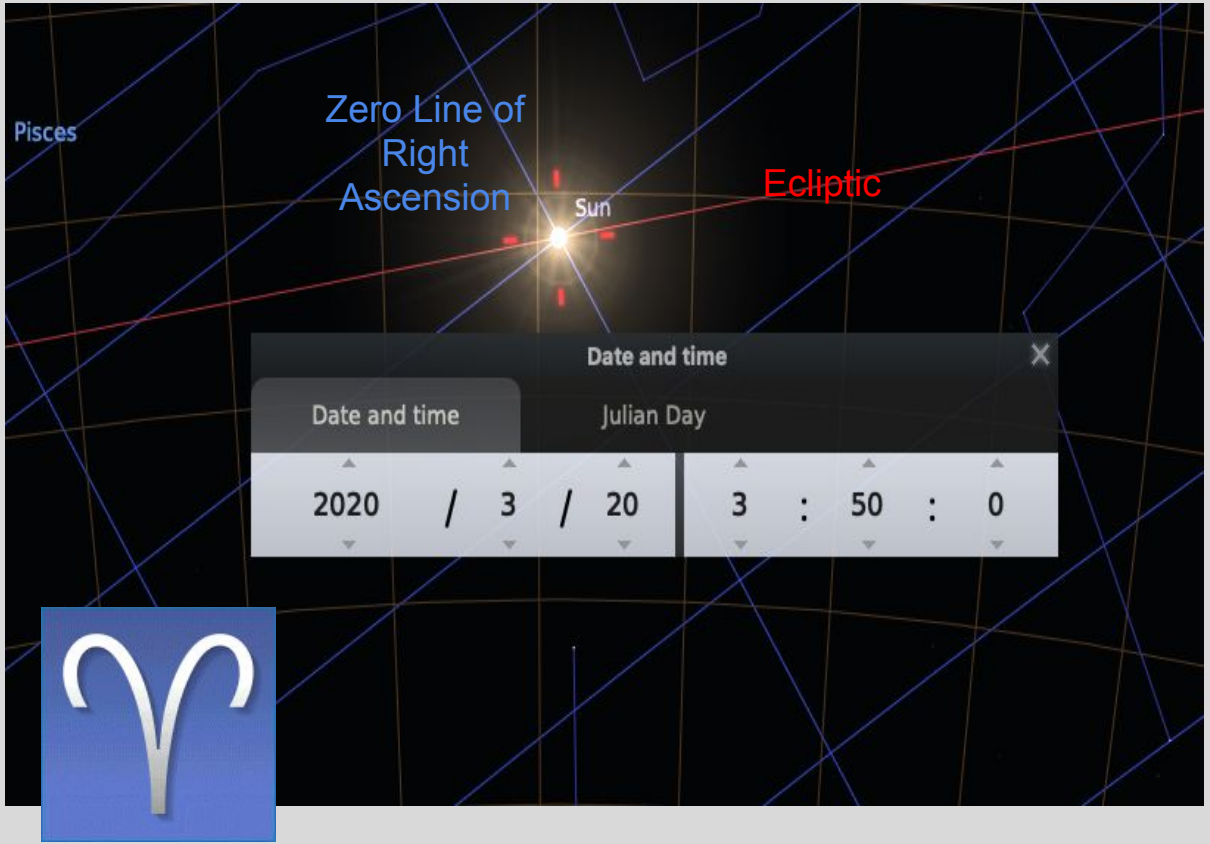
(5.6 Understand the terms First Point of Aries and First Point of Libra)

Just like with longitude, defining the ‘meridian’ lines in the sky is a bit more tricky - you just have to choose a zero line.
Astronomers chose ‘**The First Point of Aries’** to define this line.
The lines parallel to it, just like the meridian or longitude lines, are like the segments of an orange on each side and are called the **right ascension** lines.
So, instead of giving latitude and longitude lines to locate somewhere in the sky, astronomers use **declination** and **right ascension (**or **RA** and **dec** for short).
The only thing left to understand is *where is the **First Point of Aries** ?*
The Stellarium screen on the next slide will help to explain this.



(5.6 Understand the terms First Point of Aries and First Point of Libra)

Just as the Greenwich meridian has been arbitrarily chosen as the zero point for measuring longitude on the surface of the Earth, the **first point of Aries** has been chosen as the zero point in the **celestial sphere**. It is the point at which the Sun crosses the celestial equator moving from south to north along the **ecliptic** (at the vernal Equinox in other words). This point is known as the **'First Point of Aries'** because in 150 B.C. when Ptolemy first mapped the constellations, Aries lay in that position. However, although still named the '**first point of Aries**', due to precession, the vernal equinox now lays in the constellation Pisces.
The **First Point of Aries** is usually represented by the 'ram's horn' symbol shown here:



(5.6 Understand the terms First Point of Aries and First Point of Libra)

An example of coordinates in right ascension and declination for M31 The Andromeda Galaxy:

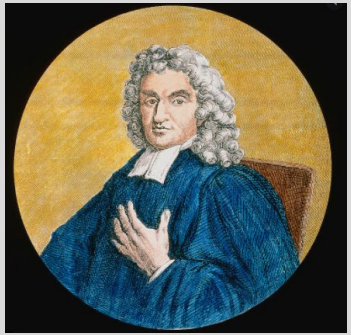
RA 0h 42m 44s | Dec +41° 16′ 9″

This is interesting - look at those units! RA is measured in hours, minutes and seconds. This relates to the rate of rotation of the Earth if you lined up a telescope along RA 0h0min0s then 1 hour later the Earth would have turned by 15^{o} and your telescope would be looking at RA 1h0min0s.
Dec is just the angle you would tilt your telescope to above or below the ecliptic.
So, to find M31 you could line up with RA 0h0min0s, wait 42min and 44s and tilt your telescope to 41^{o}16’and9” (16/60 or minutes of arc and 9/3600 or seconds of arc) and, hey presto, you would see:

So, you don’t even always need to move a telescope to and fro parallel to the ecliptic - you can just wait for the Earth to do it for you.

This is John Flamsteed’s telescope at the Royal Observatory Greenwich which he used to produce star charts for navigation in the late 1600’s. Basically, it just rested on the rungs of a ladder to change **dec** and he waited for the Earth to change the **RA** for him.

https://www.rmg.co.uk/royal-observatory/history



(5.6 Understand the terms First Point of Aries and First Point of Libra)

So what is the **First Point of Libra** then. Well, it's the opposite of the **First Point of Aries**:

The point on the celestial sphere diametrically opposite the first point of Aries. It is the same as the autumnal equinox. It has right ascension 12h and declination zero. It is the point at which the Sun passes from north to south of the celestial equator, which happens on September 22 or 23 each year. Because of precession, it no longer lies in Libra but in neighbouring Virgo.

- A useful exercise would be to look up the date and time of the next autumnal equinox and then to locate it in Stellarium - search for the Sun at the correct date and time and check that it is crossing the ecliptic from north to south at the point of intersection with RA 0h0min0secs.

Symbol and location of the First Point of Libra

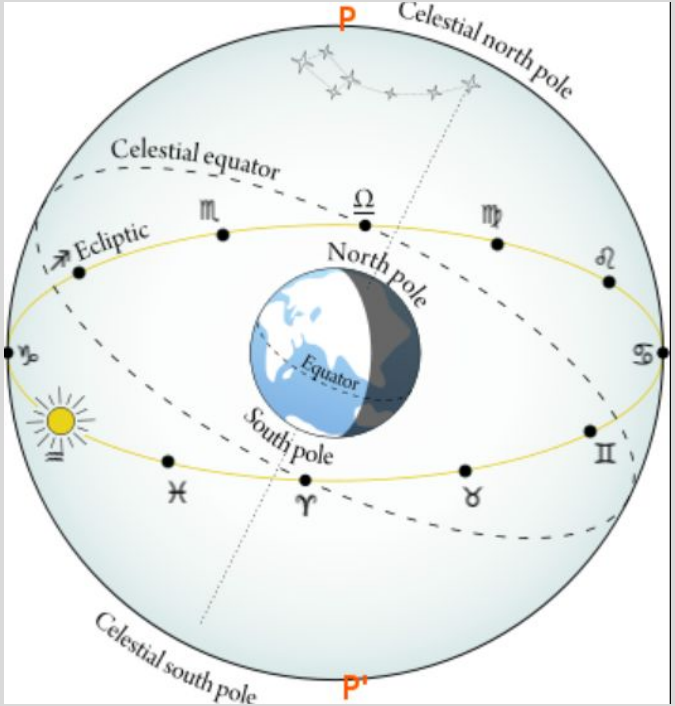
Here you can see that the two ‘First Points’ are opposite each other - Aries at the front and Libra at the back.

Remember that the **First Point of Libra** is

Therefore at **RA 12h0min0secs**

Its symbol is λ and the symbol for

Libra is Ω



5.7 Understand the appearance and cause of meteors and meteor showers, including determination of the radiant

First, let's get the terminology right - this site is an excellent introduction to the correct terms to use. Cut and paste this table into your course notes and fill in the definitions from the website (https://starchild.gsfc.nasa.gov/docs/StarChild/questions/question12.html)

Term	**Definition**
Meteor	
Meteoroid	
Meteorite	
Meteor shower	
Comet	

5.7 Understand the appearance and cause of meteors and meteor showers, including determination of the radiant

Observing meteor showers:

This guide from the Royal Greenwich Observatory tells you which meteor showers are visible from the UK in 2020 (they will be around the same dates in any year):

https://www.rmg.co.uk/discover/explore/meteors-and-meteorites

Finding the radiant point of a meteor shower is one of the GCSE Astronomy Observational Tasks, in both Unaided and Aided lists (remember you cannot do the same task for both Unaided and Aided observations though).

Even if you are not going to do these tasks, it's a good idea to understand the process of planning how to observe meteor showers and how to estimate the radiant point (i) because it could be an exam question (ii) because seeing real meteors is a magical experience!

A2	**Finding the radiant point of a meteor shower** Use naked-eye drawings of the paths of meteors to determine the radiant point of a meteor shower	**B2**	**Finding the radiant point of a meteor shower** Use photographs of the paths of meteors to determine the radiant point of a meteor shower

5.7 Understand the appearance and cause of meteors and meteor showers, including determination of the radiant

Using the Royal Greenwich Observatory guide, from the link copied again below, plan to observe a meteor shower using Stellarium (https://stellarium.org/) to guide you.

Pick a target meteor shower based on the following criteria:

1. The rate per hour - the bigger the better, the more meteors you are likely to see
2. The time of year and time of day - how dark will the sky be for a summer meteor shower? Would a winter one be better? What time will you be able to observe?
3. Where is the predicted radiant? How good a view will you get from your observing location?

https://www.rmg.co.uk/discover/explore/meteors-and-meteorites

Keep scrolling down the web page for plenty of advice on how to watch a meteor shower. If you have a suitable camera cand know how to take images of the night sky, try photographing the trails, you might get lucky on a long exposure and a high rate of meteors per hour.

Here's an amazing website to help you plan for observing a meteor shower
https://www.timeanddate.com/astronomy/meteor-shower/

A suggested plan for finding the radiant of a meteor shower:

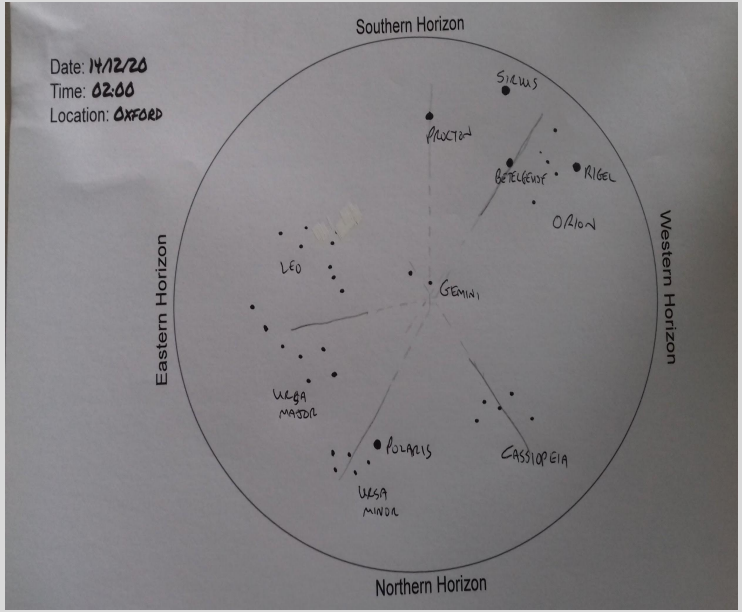
Here is an example of a method you to could use to record observations to estimate the radiant point of the Geminid meteor shower which occurs around 14 December every year.

- First, prepare a recording sheet for your observations - see the next slide for an example.
- Next, sketch onto it some key stars and constellations that you know you can recognise. You can use Stellarium to help with this - here's the sky for Dec 14 2020 at around 2am from Oxford when the Geminids should be at their peak:

A suggested plan for finding the radiant of a meteor shower (continued):

- Here's an example using a simple template (the blank version is on the next slide)
- The observer has sketched a few prominent constellations and stars onto the template using Stellarium for reference
- They have recorded date, time and location
- Then they have sketched observed meteor trails as they occurred
- Finally they extended the dotted lines back, with a ruler, to see where they intersect at the estimated radiant

(Note, when sketching reference stars and constellations, remember to orient Stellarium or your star chart correctly. Stellarium shows you what is above your head so the template you sketch will be a mirror image of this - unless you can hold it above your head of course!)

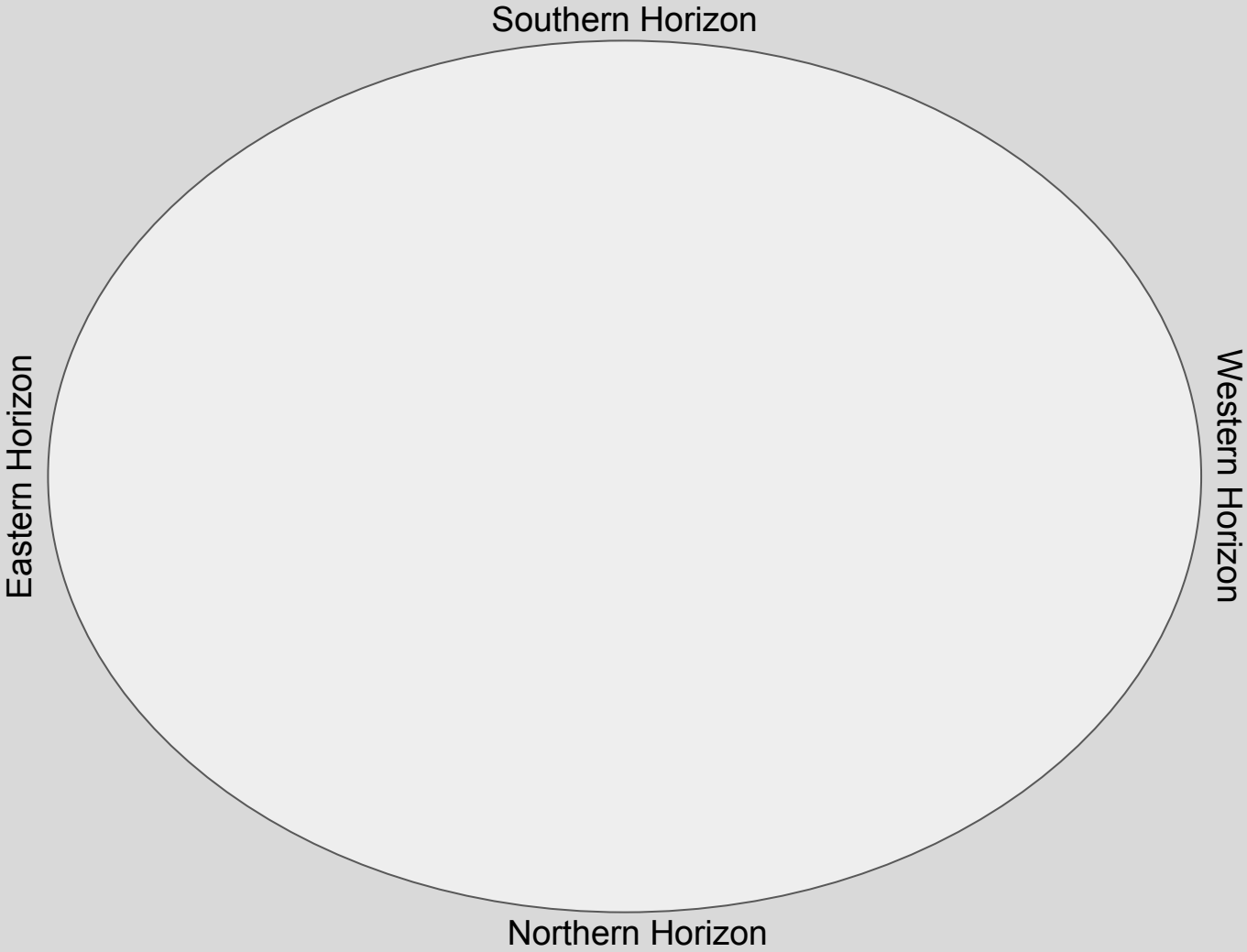


You could use free star chart downloads instead, but they are for fixed times and may not suit your observing time:

whatsouttonight.com/Resources/2020DecSkyWhttp://wOT.pdf

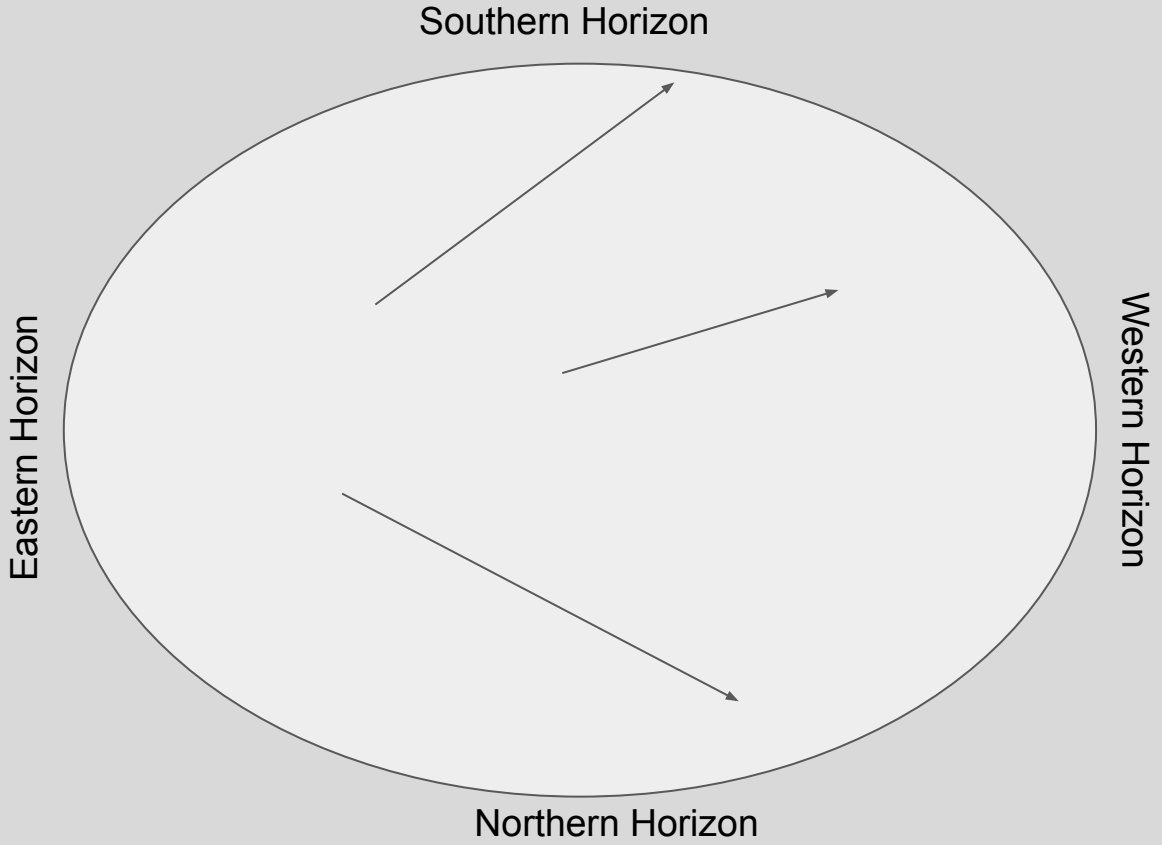
http://www.skymaps.com/downloads.html

Date:
Time:
Location:



Exercise to try - here is an observer's record of a meteor shower. However, they have not sketched any reference points on their sheet. Use Stellarium to identify which shower they have observed.

Date: **17 Nov 2020**
Time: **00:00**
Location: **Abingdon**



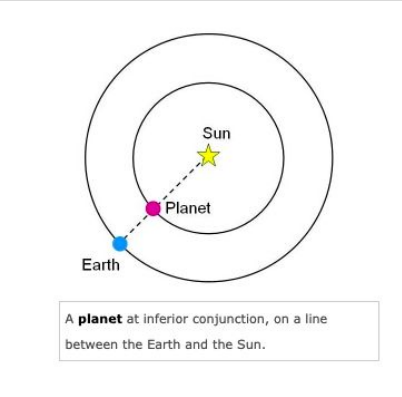
5.8 Understand the terms: a conjunction (superior and inferior) b opposition c elongation d transit

a Conjunction (superior)

A **superior conjunction** occurs when a Solar System body, such as a planet, asteroid or comet, lies along a straight line joining the Earth and the Sun, but is on the opposite side of the Sun from the Earth.

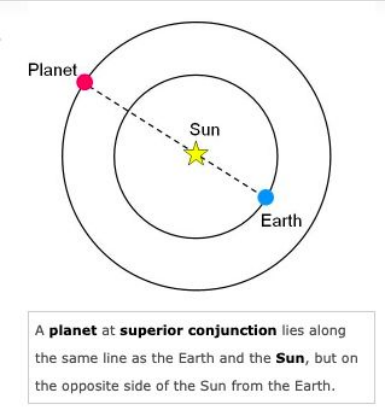
a Conjunction (inferior)

An **inferior conjunction** occurs when a **Solar** System body lies along a straight line between the Earth and the **Sun**. At this point, the **elongation** is zero degrees, and the body will have the same **right ascension** on the **celestial sphere** as the Sun.



Learning tip:

Inferior is inside

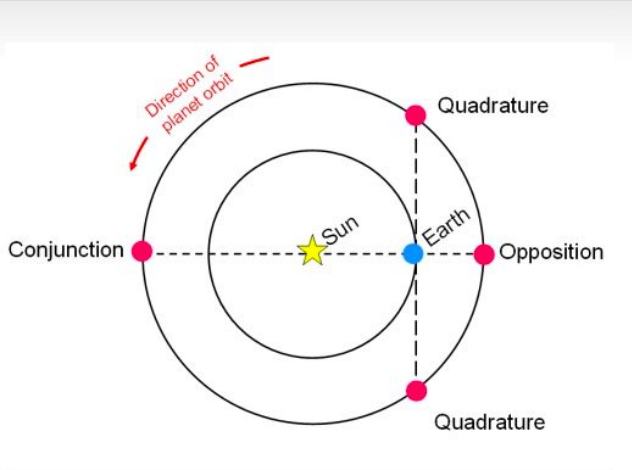


5.8 Understand the terms: a conjunction (superior and inferior) b opposition c elongation d transit

b Opposition

A Solar System body, such as a **planet**, **comet** or **asteroid**, is at opposition when it is on the opposite side of the Earth from the Sun. The **elongation** of a Solar System body at opposition is 180 degrees.

The inferior **planets**, or other objects with **orbits** closer to the Sun than the Earth, can never be at opposition.



A **Solar** System body at opposition, on the opposite side of the Earth from the **Sun**.

Learning tip:

Opposition is opposite side from the Sun

5.8 Understand the terms: a conjunction (superior and inferior) b opposition c elongation d transit

c Elongation -

This definition is taken from the website below - you will need to learn the first sentence:

The **elongation** is the angular separation between the **Sun** and a **planet** or other **Solar** System body as observed from the Earth.

Elongations are measured in degrees eastward or westward of the Sun. The greatest eastward or westward elongation is the maximum **angle** between the Sun and a Solar System body.

Go to the website for some further, useful information about elongation:

https://astronomy.swin.edu.au/cosmos/E/Elongation

5.8 Understand the terms: a conjunction (superior and inferior) b opposition c elongation d transit

d Transit -

Here is a website with a video, explanatory text and nice images of transits:

https://www.universetoday.com/129283/what-are-planetary-transits/

You will need to learn a definition:

In astronomy, a transit is a phenomenon when a celestial body passes directly between a larger body and the observer.

Here is some additional explanation of how transits can be used to detect exoplanets:

https://www.cfa.harvard.edu/~avanderb/tutorial/tutorial.html

End of Topic 5 - Review your work

Check that you have covered all the specification learning points 5.1 to 5.8