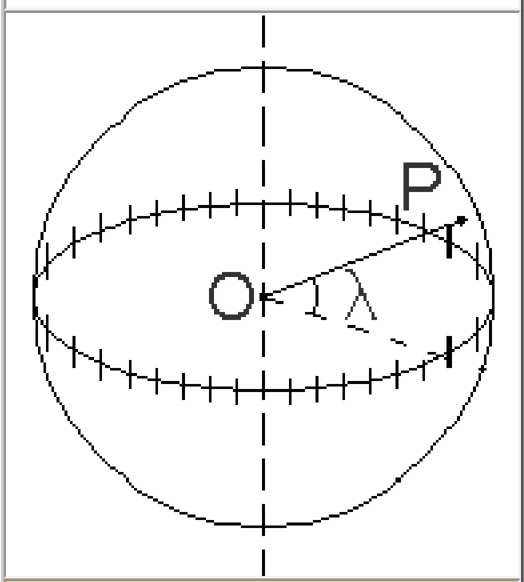
What are Latitude & Longitude?

Any location on Earth is described by two numbers--its **latitude** and its **longitude**. If a pilot or a ship's captain wants to specify position on a map, these are the "coordinates" they would use.

Actually, these are two **angles**, measured in degrees, "minutes of arc" and "seconds of arc." These are denoted by the symbols (°, ', ") e.g. 35° 43' 9" means an angle of 35 degrees, 43 minutes and 9 seconds (do not confuse this with the notation (', ") for feet and inches!). A degree contains 60 minutes of arc and a minute contains 60 seconds of arc--and you may omit the words "of arc" where the context makes it absolutely clear that these are **not** units of time.

Calculations often represent angles by small letters of the Greek alphabet, and that way latitude will be represented by l (lambda, Greek L), and longitude by f (phi, Greek F). Here is how they are defined.



The latitude angle lambda

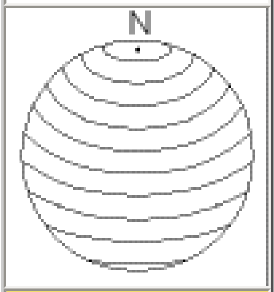
Latitude

Imagine the Earth was a **transparent sphere** (actually the shape is slightly oval; because of the Earth's rotation, its equator bulges out a little). Through the transparent Earth (drawing) we can see its equatorial plane, and its middle the point is O, the center of the Earth.

To specify the latitude of some point P on the surface, draw the radius OP to that point. Then the **elevation angle** of that point **above the equator** is its latitude --northern latitude if north of the equator, southern (or negative) latitude if south of it.

[How can one define the angle between a line and a plane, you may well ask? After all, angles are usually measured between two **lines**!

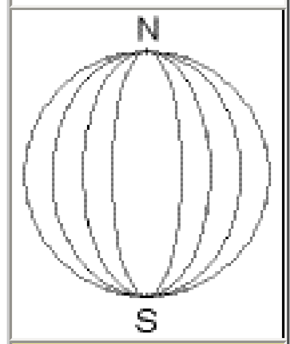
Good question. We must use the angle which completes it to 90 degrees, the one between the given line and one **perpendicular** to the plane. Here that would be the angle (90°-l) between OP and the Earth's axis, known as the **co-latitude** of P.]



Lines of latitude

On a globe of the Earth, lines of latitude are circles of different size. The longest is the **equator**, whose latitude is zero, while at the poles--at latitudes 90° north and 90° south (or -90°) the circles shrink to a point.

Longitude



Longitude lines or "meridians"

On the globe, lines of constant longitude ("meridians") extend **from pole to pole**, like the segment boundaries on a peeled orange.

Every meridian must cross the equator. Since the equator is a circle, we can divide it--like any circle--into 360 degrees, and the **longitude f of a point** is then the marked value of that division where its meridian meets the equator.

What that value is depends of course on where we begin to count--on where **zero longitude** is. For historical reasons, the meridian passing the old Royal Astronomical Observatory in Greenwich, England, is the one chosen as zero longitude. Located at the eastern edge of London, the British capital, the observatory is now a public museum and a brass band stretching across its yard marks the "prime meridian." Tourists often get photographed as they straddle it--one foot in the eastern hemisphere of the Earth, the other in the western hemisphere.

> A lines of longitude is also called a **meridian**, derived from the Latin, from **meri**, a variation of "medius" which denotes "middle", and **diem**, meaning "day." The word once meant "noon", and times of the day before noon were known as "ante meridian", while times after it were "post meridian." Today's abbreviations **a.m.** and **p.m.** come from these terms, and the Sun at noon was said to be "passing meridian". All points on the same line of longitude experienced noon (and any other hour) at the same time and were therefore said to be on the same "meridian line", which became "meridian" for short.

About time--Local and Universal

Two important concepts, related to latitude and (especially) longitude are **Local time (LT)** and **Universal time (UT)**

Local time is actually a measure of the position of the Sun relative to a locality. At 12 noon local time the Sun passes to the south and is furthest from the horizon (northern hemisphere). Somewhere around 6 am it rises, and around 6 pm it sets. Local time is what you and I use to regulate our lives locally, our work times, meals and sleep-times.

But suppose we wanted to time an astronomical event--e.g. the time when the 1987 supernova was first detected. For that we need a single agreed-on clock, marking time world-wide, not tied to our locality. That is **universal time** (UT), which can be defined (with some slight imprecision, no concern here) as the local time in Greenwich, England, at the zero meridian.

Local Time (LT) and Time Zones

Longitudes are measured from zero to 180° east and 180° west (or -180°), and both 180-degree longitudes share the same line, in the middle of the Pacific Ocean.

As the Earth rotates around its axis, at any moment one line of longitude--"**the noon meridian**"--faces the Sun, and at that moment, it will be **noon** everywhere on it. After 24 hours the Earth has undergone a full rotation with respect to the Sun, and the same meridian again faces noon. Thus each hour the Earth rotates by 360/24 = 15 degrees.

When at your location the time is 12 noon, 15° to the **east** the time is 1 p.m., for that is the meridian which faced the Sun an hour ago. On the other hand, 15° to the **west** the time is 11 a.m., for in an hour's time, **that** meridian will face the Sun and experience noon.

In the middle of the 19th century, each community across the US defined in this manner its own local time, by which the Sun, on the average, reached the farthest point from the horizon (for that day) at 12 oclock. However, travelers crossing the US by train had to re-adjust their watches at every city, and long distance telegraph operators had to coordinate their times. This confusion led railroad companies to adopt **time zones**, broad strips (about 15° wide) which observed the same local time, differing by 1 hour from neighboring zones, and the system was adopted by the nation as a whole.

The continental US has 4 main time zones--eastern, central, mountain and western, plus several more for Alaska, the Aleut islands and Hawaii. Canadian provinces east of Maine observe Atlantic time; you may find those zones outlined in your telephone book, on the map giving area codes. Other countries of the world have their own time zones; only Saudi Arabia uses local times, because of religious considerations.

In addition, the clock is generally shifted one hour forward between April and October. This "**daylight saving time**" allows people to take advantage of earlier sunrises, without shifting their working hours. By rising earlier and retiring sooner, you make better use of the sunlight of the early morning, and you can enjoy sunlight one hour longer in late afternoon.

The Date Line and Universal Time (UT)

Suppose it is **noon** where you are and you **proceed west**--and suppose you could travel **instantly** to wherever you wanted.

Fifteen degrees to the west the time is 11 a.m., 30 degrees to the west, 10 a.m., 45 degrees--9 a.m. and so on. Keeping this up, 180 degrees away one should reach midnight, and still further west, it is the previous day. This way, by the time we have covered 360 degrees and have **come back to where we are**, the time should be noon again--**yesterday** noon.

Hey--wait a minute! You cannot travel from today to the same time yesterday!

We got into trouble because longitude determines only the hour of the day--**not the date**, which is determined separately. To avoid the sort of problem encountered above, the **international date line** has been established--most of it following the 180th meridian--where by common agreement, whenever we cross it the date advances one day (going west) or goes back one day (going east).

That line passes the Bering Strait between Alaska and Siberia, which thus have different dates, but for most of its course it runs in mid-ocean and does not inconvenience any local time keeping.

Astronomers, astronauts and people dealing with satellite data may need a time schedule which is the same everywhere, not tied to a locality or time zone. The **Greenwich mean time**, the astronomical time at Greenwich (averaged over the year) is generally used here. It is sometimes called **Universal Time** (UT).

Right Ascension and Declination

The globe of the heavens resembles the globe of the Earth, and positions on it are marked in a similar way, by a network of **meridians** stretching from pole to pole and of **lines of latitude** perpendicular to them, circling the sky. To study some particular galaxy, an astronomer directes the telescope to its coordinates.

On **Earth**, the equator is divided into 360 degrees, with the zero meridian passing Greenwich and with the longitude angle f measured east or west of Greenwich, depending on where the corresponding meridian meets the equator.

In the sky, the equator is also divided into 360 degrees, but the count begins at one of the two points where the equator cuts the **ecliptic**--the one which the Sun reaches around March 21. It is called the **vernal equinox** ("vernal" means related to spring) or sometimes the **first point in Aries**, because in ancient times, when first observed by the Greeks, it was in the zodiac constellation of Aries, the ram. It has since then moved, as is discussed in the later section on precession.

The celestial globe, however, uses terms and notations which differ somewhat from those of the globe of the Earth. Meridians are marked by the angle a (alpha, Greek A), called **right ascension**, not longitude. It is measured from the vernal equinox, but only eastward, and instead of going from 0 to 360 degrees, it is specified in hours and other divisions of time, each hour equal to 15 degrees.

Similarly, where on Earth latitude goes from 90° north to 90° south (or -90°), astronomers prefer the **co-latitude**, the angle from the polar axis,equal to 0° at the north pole, 90° on the equator, and 180° at the south pole. It is called **declination** and is denoted by the letter d (delta, Greek small D). The two angles (a,d), used in specifying (for instance) the position of a star are jointly called its **celestial coordinates**.