Navigation

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Precision vs Accuracy

- Precision and accuracy are not the same.
- Precision refers to how small an area coordinates can be defined or plotted.
- GPS lat/long coordinates can be defined to 1/10 of a second.
- Accuracy refers to how closely a GPS receiver can calculate its position relative to its true location.
- GPS accuracy can vary from a few millimeters to several meters.

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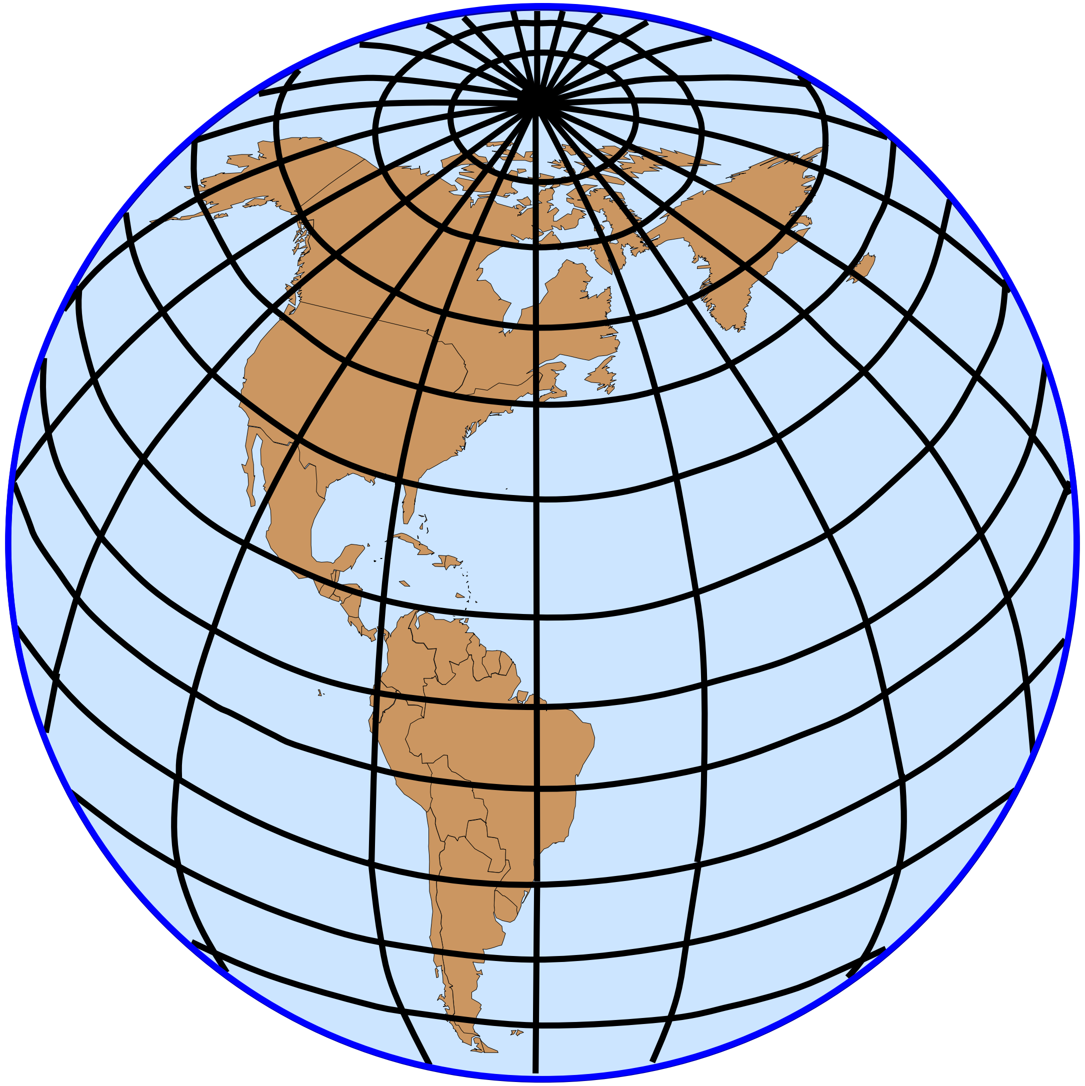
Latitude & Longitude



Latitude & Longitude

- A geographic (spherical) coordinate system.
- Angular coordinates are perfectly suited to the ellipsoidal shape of the earth.
- Coordinates are expressed in degrees, minutes and seconds or decimal degrees
- Position coordinates are based on an angular distance from a known reference point.
- That reference point is where the Prime Meridian and equator intersect.
- Lat/long is the predominant coordinate system used for nautical and aeronautical navigation.

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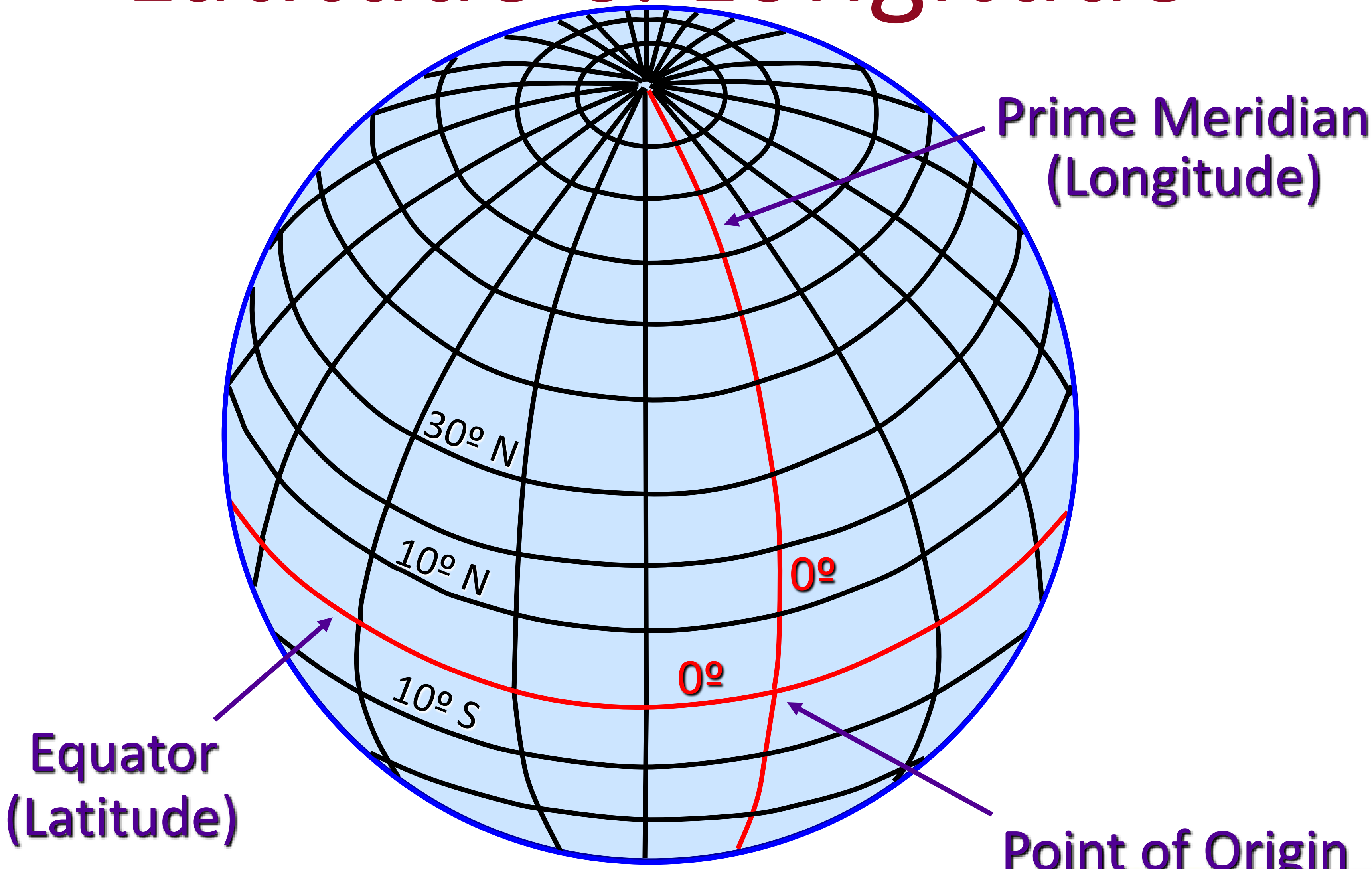
Latitude & Longitude



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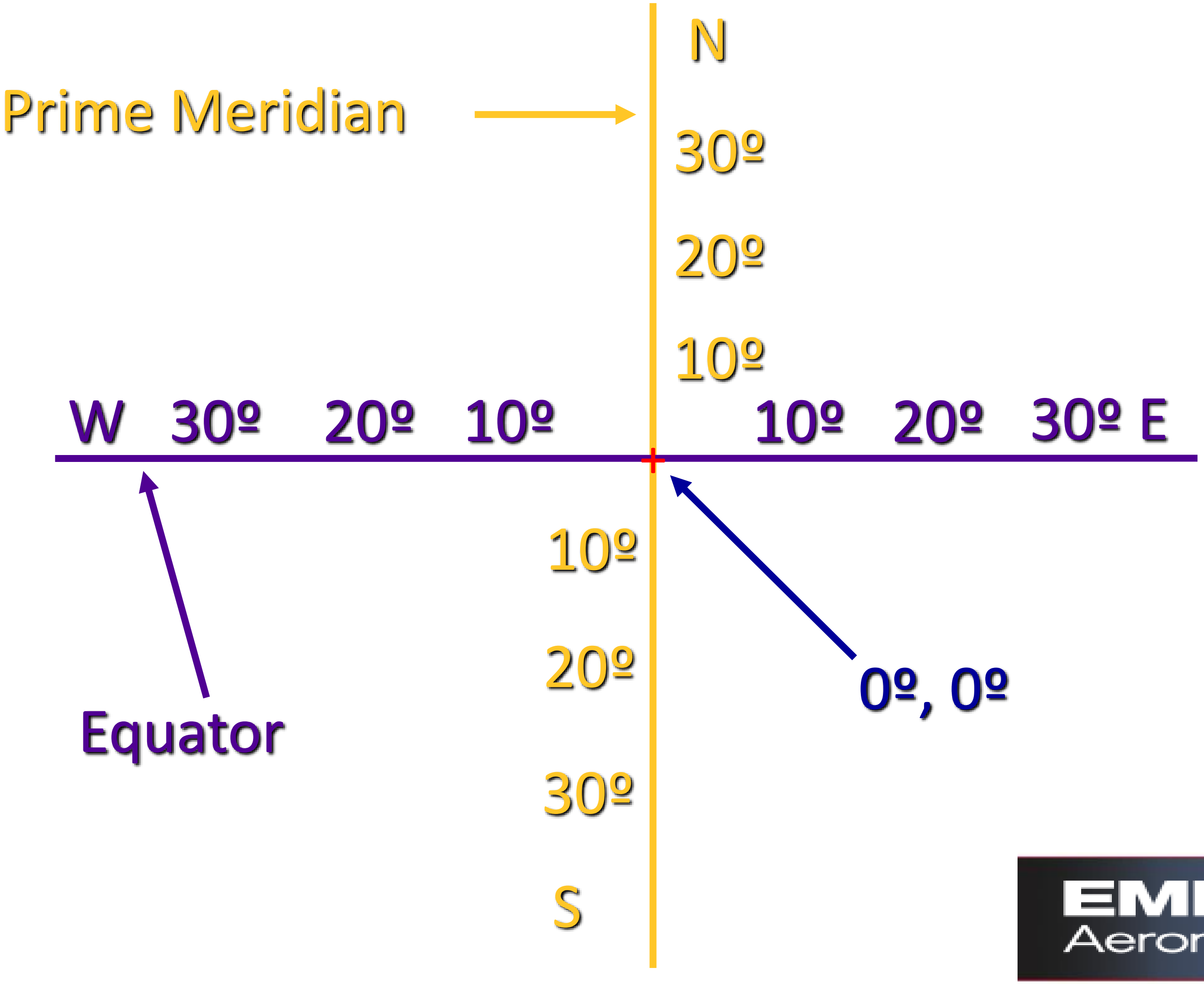
Latitude & Longitude



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Latitude

- Latitude is comprised of parallels, which are equally spaced circles around the earth paralleling the equator.
- Parallels are designated by their angle north or south of the equator (10º, 20º, etc) .
- The equator is 0º latitude, and the north and south poles are at 90º angles from the equator.
- The linear distance between parallel (latitude) lines never changes, regardless of their position on the earth.

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The earth

The circumference of Earth at the equator is **about 40,075 km**
but from pole-to-pole — Earth circumference is only **40,008 km**
One degree of latitude = 40008 km/360 = 111.3km

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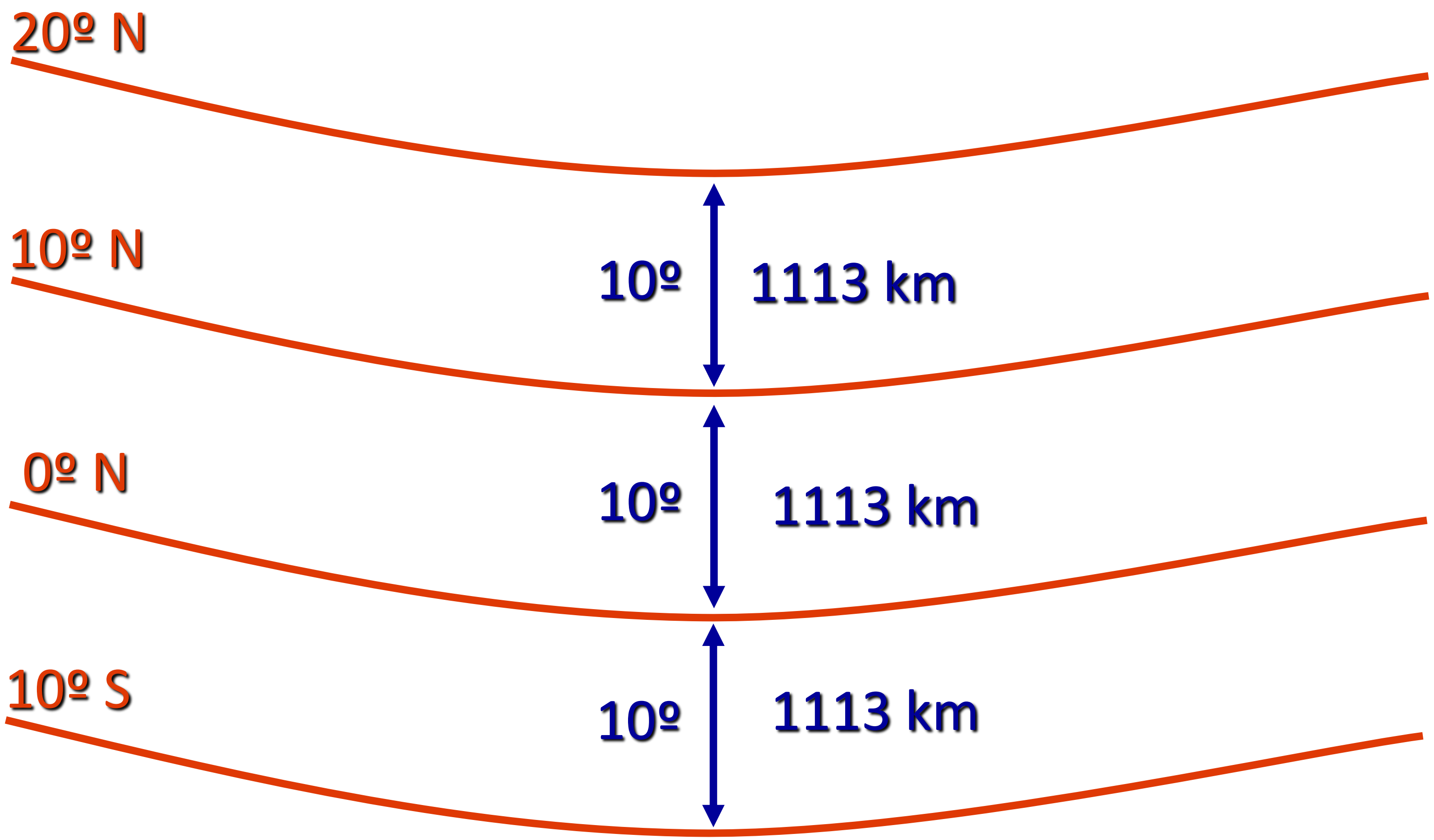
Parallels of Latitude



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Longitude

- Longitude is comprised of meridians that form one-half of a circle, or plane.
- Meridians are designated by their angle west or east of the prime meridian.
- The prime meridian is designated 0º and extends from the north pole to the south pole through Greenwich, England.
- Meridians are angled, and do not parallel each other.
- The linear distance between one degree of longitude at the equator is approximately 69 statute miles.
- The linear distance between one degree of longitude at the arctic circle is only about 26 statute miles.

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One degree of longitude depends on the location on earth.
At the equator, one degree of longitude = 40075/360 = 111.3km
But the distance varies with latitude
One degree of longitude = 111.3km cos(latitude)
At 20 degrees of latitude, one degree of longitude=111.3km cos(20 deg)
= 104.6km
At 70 degrees of latitude, one degree of longitude =111.3km cos(70 deg)
= 38km

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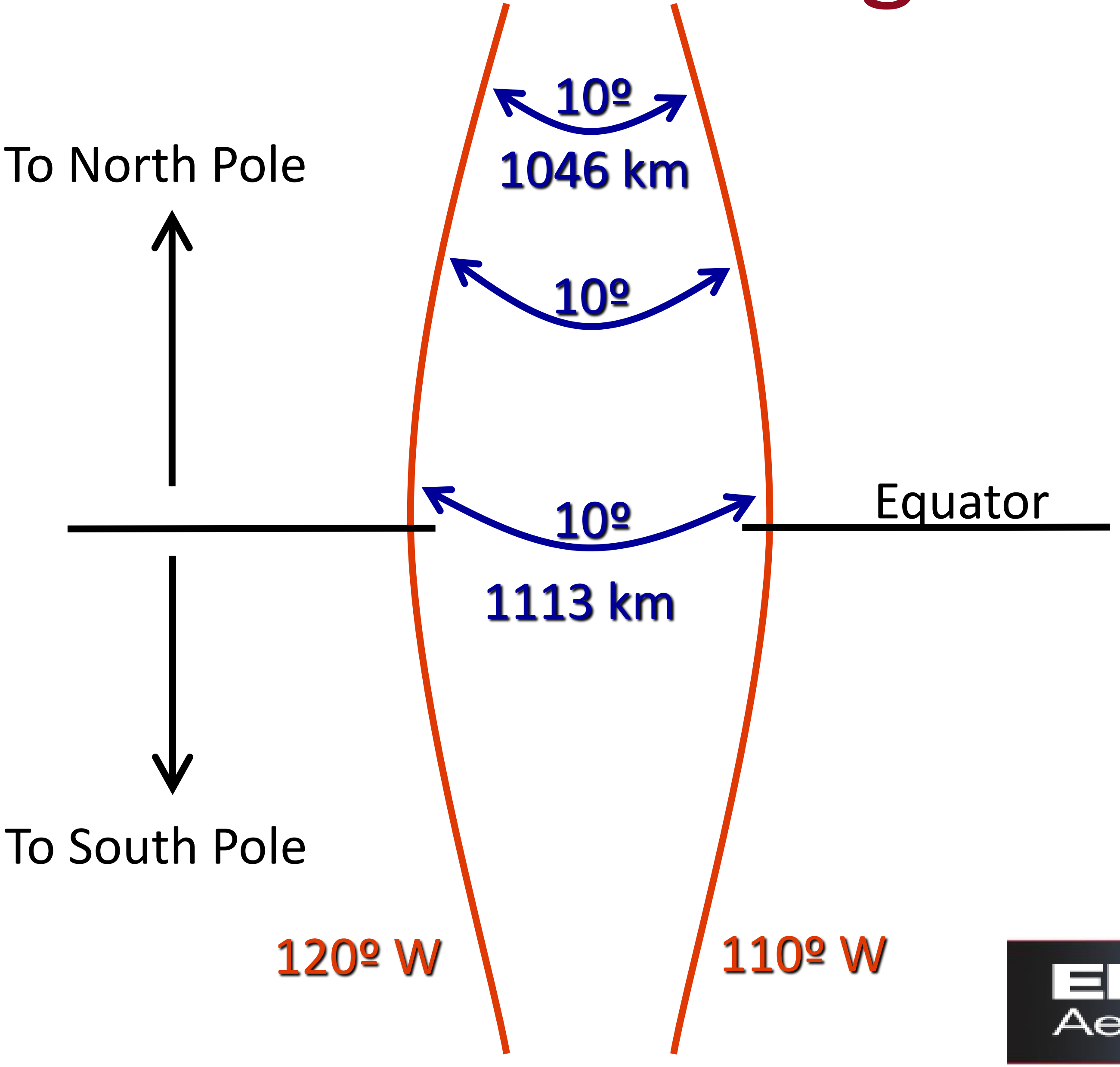
Meridians of Longitude



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Decimal degrees and Degrees, minutes seconds

There are 60 minutes in a degree

There are 60 seconds in a minute

There are 3600 seconds in a degree

45°10’30’’

=45 +10/60+30/3600 = 45 + 0.167+.008=45.175

But remember 1 degree is 111.3km so one second is 1/3600 of a degree is .039km or 39 meters.

We will need more digits of precision for 1 meter accuracy

Navigation

I start at 29.3000 , -81.1000

I travel at heading south for 100 meters.

What is my new location?

1 degree of latitude = 111.3km

100m/111.3km = 0.898x10^-4 degrees

New location is 29.3000-.000898,-81.1000 = 29.2991, -81.1000

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I start at 29.3000 , -81.1000
I travel at heading west for 100 meters.
What is my new location?
1 degree of longitude = 111.3km * cos(29.3) = 97.1km
100m/97.1km = 1.03x10^-3 degrees
New location is 29.3000,-81.1000-.00103 = 29.3, -81.1010

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I start at 29.3000 , -81.1000
I travel at heading north east (45 degrees) for 100 meters.
What is my new location?
Traveled 100m *cos(45) = 70.7m east
Traveled 100m*sin(45) = 70.7m north
1 degree of latitude = 111.3km
1 degree of longitude =97.1km
70.7m/111.3km= 6.35x10^-4 degrees north
70.7m/97.1km = 7.28x10^-4 degrees east
New location is 29.3000+.000635,-81.1000+.000728
=29.300635,-81.09927

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Navigation using the accelerometer

In this example we will assume we have a quadrotor flying in heading hold.
Accelerations in the x-axis result in motion only on the x-axis
Accelerations in the y-axis result in motion only on the y-axis
Start at 0,0 with an initial velocity of 0 and an initial acceleration of 0
At t=0.1 seconds the accelerometer reads 0.5g in the x direction and 1g in the y direction.

Calculating the velocity for the time interval

Suppose the vehicle is at rest and is subjected to an acceleration of 1g for one second.

The acceleration is $9.8 m/s^2$.

After one second the vehicle velocity will have increased by 9.8 m/s.

The acceleration will produce a linear increase in velocity from the starting velocity to the final velocity

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Calculate the velocity for the time interval

The velocity for any time interval can be given by

Vnew=Vold+a*dt

In this case,

Vx(.1)=Vx(0)+ax(0)*dt

Vx(.1)= 0+ 0.5*9.8*0.1 = 0.49 m/s

Vy(.1)=0 + 1.0 *9.8*0.1 = 0.98 m/s

(dt= 0.1 s)

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Calculating the position

The vehicle velocity was not constant. It increased linearly over the time interval.

To compute the distance traveled we can use the average velocity.

Dnew=Dold+0.5*(v(new)+v(old))*dt

Dx(.1)= 0 + 0.5 * 0.49*0.1 = .0095 m

Dy(.1)= 0 + 0.5 * 0.98*.1 = 0.019m

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Suppose the accelerations stay the same

Vx(.2)=Vx(.1)+ax(.2)*dt = 0.49+0.5*9.8*.1=0.98 m/s
Vy(.2)=Vy(.1)_ay(.1)*dt = 0.98+1.0*9.8*.1= 1.96 m/s

Dx(.2)=Dx(0.1)+0.5*(Vx(.2)+Vx(.1))*dt= 0.0095+0.5*(0.98+0.49)*0.1= 0.083 m
Dy(.2)=Dy(0.1)+0.5*(Vy(.2)+Vy(.1))*dt= 0.019+0.5*(1.96+0.98)*0.1 = 0.166m