General Navigation

Plane of the ecliptic – The plane in which the planets orbit.

The axis of spin is through the GEOGRAPHIC poles.

The Earth's axis is deviated from the plane of the ecliptic by 66.5 Degrees. This means that the equator is deviated by 23.5º.

Latitudes –

- 66.5º N - Arctic Circle
- 23.5º N Tropic Of Cancer
- 23.5º S Tropic of Capricorn
- 66.5ºS Antarctic Circle.

Solstices – The Points at which the day/night is the longest.

Northern Hemisphere:

- Summer Solstice 21st June
- Winter Solstice 21st December

Equinoxes – The Points at which Day and Night are equal.

Northern Hemisphere:

- Spring Equinox 21st March
- Autumn Equinox 21st September

Insolation – The effect of the spreading of sunlight leading to the variation of temperature with latitude.

The Earth rotates always towards the East. This means that from the perspective of the North Pole it spins counter-clockwise. From the South Pole it appears to spin clockwise.

Likewise – The orbit of the Earth appears to be anticlockwise from the North Pole and Clockwise from the South Pole.

Perihelion – Closest Point - 4th January.
Aphelion – Furthest Point - 4th July

The shape of the earth is an oblate spheroid (compressed at the poles). The minor axis is 0.3% smaller (1/298) than the major axis (measured compared to the major axis). This is the compression factor of the earth / ratio of ellipticity.

- A meridian is a line running from the geographic north to the geographic south pole. Its opposite is its antemeridian.
- Parallels of latitude are lines running at 90º to the meridians and parallel to the equator.

Graticule – The collective meridians and latitudes.

Cardinal Directions:

- East – The direction in which the earth rotates.
- West – The opposite of East.
- North – Heading East, North lies to the left.
- South – The opposite of North.

Parallels of Latitude originate from the equator up to 90ºN or 90ºS.

Meridians / Longitudes originate from the Prime Meridian to 180º E/W

A Great Circle is defined as any circle that has it's centre at the centre of the Earth, with a radius the same as the earth.

- The shortest distance between two points on the surface of the Earth is ALWAYS along a great circle route/track.
- Flying a great circle you will be constantly be changing heading.

Small Circle – Any circle not passing through the centre of the earth.

Antipodal Points – Points that are exactly opposite to each other on the Earth.

- e.g. 52ºN 030ºE & 52ºS 150ºW.
- Note that whilst N&S are just swapped, the Longitude changes by 180º

Vertices of a great circle:

- Points that are furthest north and south. At these points your heading is always 090º or 270º.
- The latitude of the vertices equals the angle between the track and the equator (NOT the heading, which is 90º- Latitude).

Degrees can be further subdivided into minutes, with 60 minutes per degree.
Every degree is 60NM.
Every Minute is 1 NM.

Remember to check N or S when calculating, and whether in the same hemisphere – Best to draw it out.

ISA – 15°C at MSL, then lapse rate of 2°C per 1000 ft up to 36,090ft.

Variation – The difference between true north and magnetic north.
On a map there are lines of equal variation – these are Isogonals.
A line with 0 Variation is known as an agonic line.

Magnetic Dip – As you move towards the poles the vertical component of magnetism starts to overwhelm the horizontal component and reduce accuracy. At > 70° N/S the vertical component is such that the compass is useless.

Line of Equal Dip – Isoclinic Line. Line of 0 dip – Aclinic Line.

Compass North – A compass does not point directly to the magnetic north. Due to the electronics and the metal of the aircraft the compass is slightly off, and thus points to Compass North.

Deviation – The difference between Magnetic North and Compass North.
Cadburys **D**airy **M**ilk is **V**ery **T**asty

Compass	**Deviation**	**Magnetic**	**Variation**	**True**
090	**4+ →**	**94**	**2W ←**	**92**
120	**4- ←**	**116**	**3E →**	**119**
53	**6+ →**	**59**	**36E →**	**95**
227	**3- ←**	**224**	**85W ←**	**159**

Total Air Temperature (TAT) – The temperature of the air that is recorded by the aircraft. This is affected by heating from friction due to speed.

Static Air Temperature – The actual temperature of the air when unaffected by the aircraft.

Ram Rise – The temperature rise due to speed. This can be calculated using the blue arc on the CRP 5.

Converting CAS (IAS corrected for instrument and position error) to TAS:

Need to know – CAS, Pressure Altitude, Outside Air Temperature.

To find ISA Temp = 15 – (1000s of feet x2).
Then apply ISA Dev to find SAT`.

Then line up temperature with pressure altitude and read off ISA/TAS

TAS above 300 Knots – Need to apply Compression Correction – use the comp. Corr window with TAS/100 – 3 divisions and move in the direction stated.

In exams you may be given a compressibility correction factor to apply rather than using the window.

Press Alt	ISA	ISA Dev	SAT	CAS	TAS
5000	5	+6	11	120	131
12000	-9	-5	-14	150	179
37000	-56.5	-3	-59.5	240	452
20000	-25	-16	-41	198	260

Mach No. = TAS / LSS (Local Speed of Sound).

It is temperature based but NOT altitude based.
It DOES NOT suffer from compressibility error (but EASA may make you apply it anyway)
To Convert from mach to TAS or vice-versa:

1. Find Mach Marker under airspeed window.
2. Line up with SAT
3. Read Off TAS or Mach.

FL	ISA	ISA Dev	SAT	Mach	TAS
350	-55	+2	-53	0.78	451
050	5	+7	12	1.20	789
250	-35	-3	-38	0.82	490
330	-51	-12	-63	0.86	480
340	-53	+7	-46	0.72	420

Departure – Distance along a parallel of lattitiude.

Departure = Ch Long x Cos (Lat)

Ch Long = Departure / Cos (Lat)

A rhumb line is a line of constant heading. Parallels of latitude and meridians are rhumb lines.

Convergency – The convergence of meridians.
The value of convergency at the equator is 0. Convergence is at a minimum at the equator and at a maximum at the poles. At the poles the angle of convergence is equal to the difference in longitude.

Convergence = Ch Long x Sin (Mid Lat)

Mid Lat is the average lattitude along the path ((Original + Final)/2)

To Find out whether to add or subtract the value of convergency from the true heading:

D	I
I	D

1. If in the northern hemisphere just use the top, if in the southern hemisphere just use the bottom.
2. If going East then use the Right, If going west then use the left.

CRP 5

Altimeters suffer from:

- Pressure Error (where pressure is not 1013.25 hPa)
- Temperature Error

Low pressures and low temperatures mean that you are lower than your instruments tell you.
The CRP 5 assumes you are set to 1013.

1. Set Indicated Altitude against temperature in the ALTITUDE window.
2. Read Indicated on Inside.
3. True is on Outside.

Density Altitude – Increasing temperature reduces the air density and therefore the performance of the aircraft. Density altitude tells you how the aircraft will really respond.

1. Set OAT & Pressure altitude in AIRSPEED window
2. Read off density altitude from density altitude window.

Aircraft do not like Hot, High and Humid conditions.

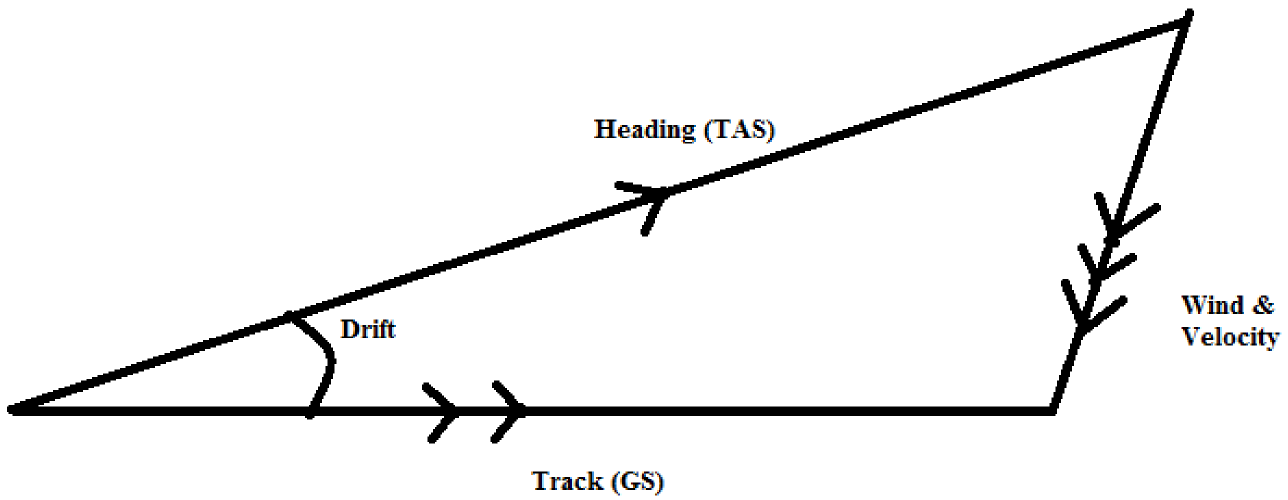
Converting Units:

1. Line up amount with units
2. Read off conversion (weight to weight or volume to volume).
    - Specific gravity is on left for Kgs and right for lbs.

Distance, Time and Speed Calculations:

1. triangle against speed.
2. Find NM on outside.
3. Read time off inside scale.

Triangle Of Velocities:



Wind ALWAYS goes from HEADING to TRACK
Wind direction is the direction the wind is coming FROM.

If you know any 4 of the 6 factors then you can find the other two.

CRP 5 Wind Side

Golden Rules

1. **Remove all previous markings.**
2. **Check which speed scale you are on.**
3. **Grommit is ALWAYS on TAS.**
4. **Put wind in first.**

Heading and Ground Speed:

1. Turn to wind heading.
2. Mark DOWN wind speed.
3. Ensure Grommit is on TAS
4. Turn to Track
5. Move in direction of Dot by number of degrees of drift.
6. Move in the direction that the dot MOVED by the difference between uncorrected and corrected.
7. Repeat 6 until Drift on the scale matches drift on the top.
8. Read off heading from top and ground speed from speed lines.

Track and Ground Speed

1. Mark Down Wind
2. Rotate to TAS
3. Read off drift
4. Add or subtract from track.
5. Read off GS.

Wind Velocity

1. Set Up Air Vector
    1. TAS on grommet
    2. Heading set on top.
2. Find Drift (difference between heading and track)
3. Mark on drift and GS
4. Rotate so wind is at bottom
5. Read off speed and direction.

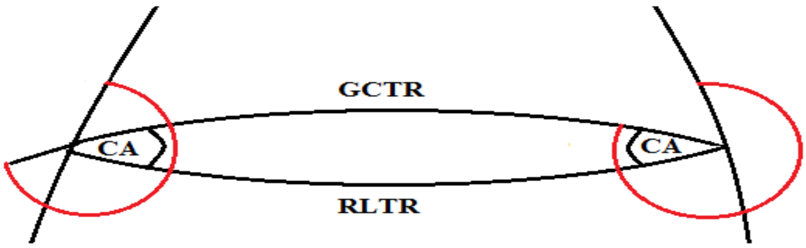
Rhumb Line – A line of constant heading. There is only one rhumb line between 2 points.

The GC TR is ALWAYS closer to the nearest pole, and the Rhumb Line is ALWAYS closer to the equator.

Conversion Angle – The angle between GC TR and RL TR (Rhumb line TR) is the same at the origin and the destination.
CA = ½ x Ch Long x Sin (Mid Lat)
OR Conversion Angle = ½ Convergency

At the midpoint of GCTR, the heading will equal that of RLTR.

If a rhumb line was allowed to continue indefinitely, it would spiral towards the nearest pole.



The above example is in the northern hemisphere. In the northern hemisphere the GCTR will always start off heading more to the north and finish heading more to the south than the RLTR.

Therefore, draw out a compass rose, and add or subtract conversion angle dependant on which way leads to a more northerly direction.

The opposite applies to the southern hemisphere.

Scale:

Scale = Chart Distance / Earth Difference e.g. 1/10,000

Or can be represented as a ratio, e.g. 1:10,000
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A larger scale (e.g. 1:1000), is one with a smaller denominator, and means a more zoomed in chart. As the denominator gets larger, the scale gets smaller.

Deviation is minimised by using a compass swing and adjusting the compass. What is left is RESIDUAL DEVIATION.
This is put on the compass deviation card.

Compass swinging needs to be done after:

Manufacture; Major Service; Change of Base; Change of Compass; Change of Equipment; Lightning Stike; Heavy Landing; Suspected Error; Magnetic Cargo.

Isoclinic Line – Line of Equal Variation.
Aclinic Line – Line of 0 Variation.
Maximum value of variation is 180 degrees (between magnetic and true south pole.

Magnetic Dip – Dip towards the magnetic pole.
Isoclinic Line – Line of equal Dip.
Aclinic line – Line of 0 dip. Occurs at the magnetic equator.

Runway QDM is MAGNETIC.
MET MAN/ METAR is TRUE
ATIS / ATC is MAGNETIC

Wind Component Calculations:

1) Grommet at 0 on graph paper.
2) Set Wind In.
3) Move to Track.
4) Crosswind is Across.
5) Headwind is Down (tailwind is up).

Finding Min & Max Windspeed

1) Turn To Track
2) Draw Min Headwind across
3) Draw Max crosswind on both sides vertically.
4) Turn to wind direction
5) Where lines cross Centre gives min and max wind speeds
   - Where Headwind crosses is minimum speed due to headwind
   - Where Crosswind crosses is maximum speed due to crosswind.

Plotting:

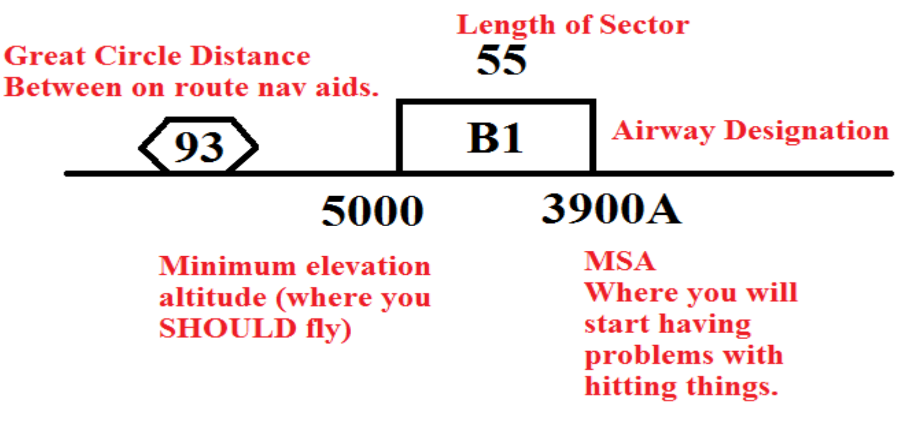
QDM – Magnetic Bearing “To”.
QTE – True Bearing “from”.
QDR – Magnetic Bearing “from”.

VOR – Very high frequency OmniRange – Has a morse code ident. Gives QDR irrespective of heading.

DME – Direction Measuring Equipment – VHF. Gives slant range. If flying to or from will also give you 'Time To' or Ground Speed.

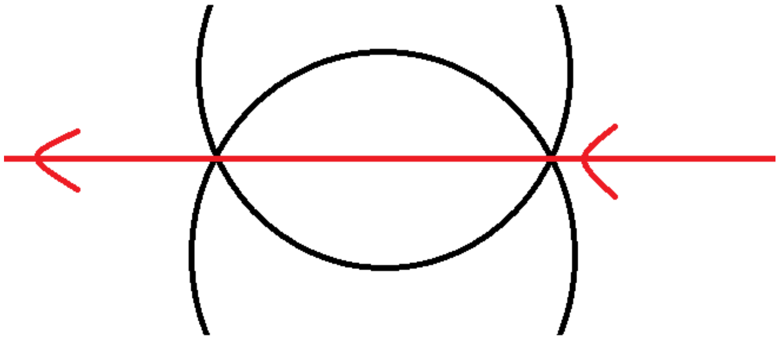
VOR/DME – Combination of the above giving radial and distance. Gives Fix.

NDB – 300-600khz – ADF equipment on the aircraft picks up and gives you QDM.



Grid Mora – Safety altitude within that grid whilst NOT on an airway.

All radials on the chart are MAGNETIC and thus can be used to line up on for magnetic bearings.



If heading 270:
DMEs Both Decreasing Must be at R position.
DMEs Both Increasing Must be at L position.

If Tuned to VOR - Apply variation at VOR POSITION.
If Tuned to NDB – Apply variation at NDB POSITION.

Relative Bearing - The bearing to something from the aircrafts true heading / nose. NOT TRACK.

True Bearing – Bearing from the object/aircraft measured from true north.

We tend to use true bearing from point to a/c as a/c is moving and the point usually isn't.

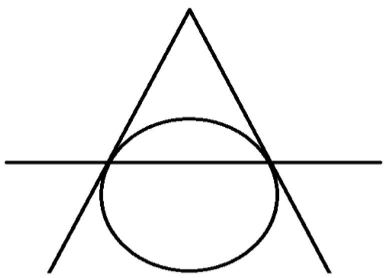
All weather radar can be used to pick up islands. Sometimes you are given the relative heading to an island and asked to find the true heading from island to aircraft.

If given the relative bearing to an NDBs at two points in time, plus a groundspeed.
As long as angular difference is 45 degrees, and there is a 90 degree angle, then the triangle formed is isoceles. Therefore distance covered in that time = distance to NDB.

Charts:

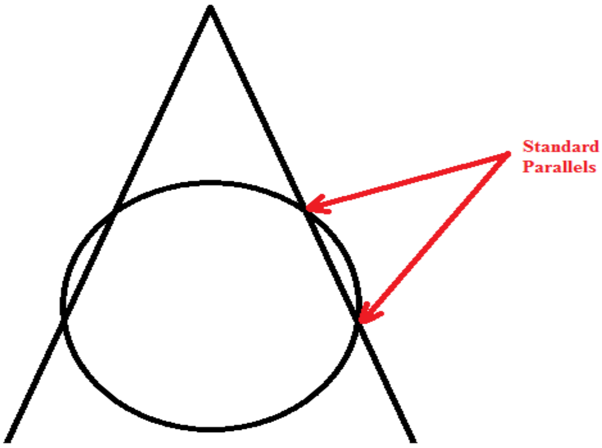
Conformal:
- Meridians and parallels of latitude meet at 90 degrees.
- Scale is equal in all directions at any single point.

Simple Conic Projection:



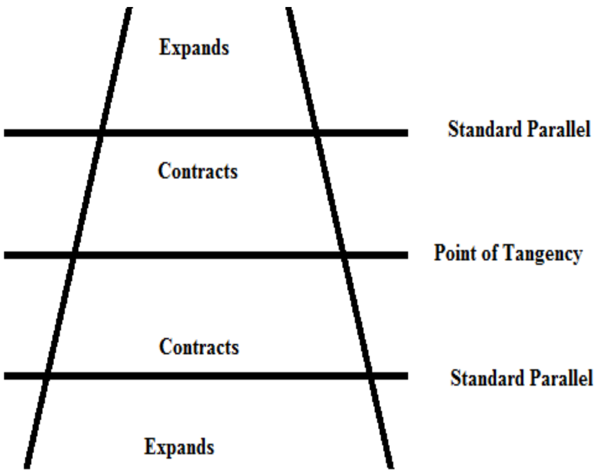
Only Correct at a very small range of latittudes.

Lamberts – Form of conic projection. Conformal.



Standard Parallels – Scale is ONLY correct on the 2 standard parallels.

Scale expands outwards from these, and contracts inwards from these.



The point of tangeny, or the parallel of origin, is the midpoint towards the two standard parallels.

It represents the point of largest scale (i.e. the point at which 1mm represents the smallest distance).

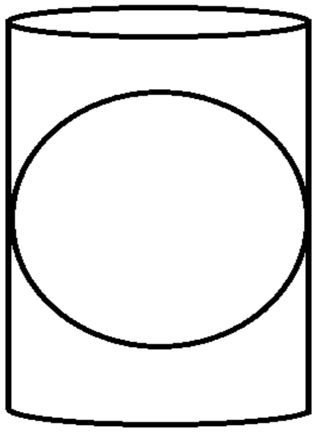
Earth Convergency = ChLong x Sin (Mid Lat)

Chart Convergency = ChLong x Sin (Parallel of Origin)
OR = ChLong x Constant of the Cone.

Rhumb lines look like curves. These are concave to the nearedt pole, and convex to the equator.

Great Circles – Straight for practical purposes. In reality a complex curve concave to the parallel of origin.

Mercator Chart:



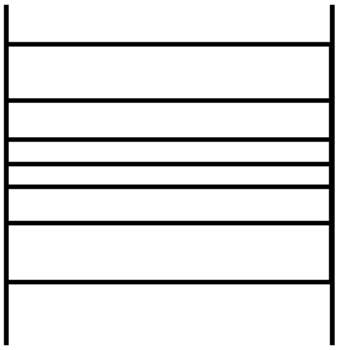
Direct / Equitorial – Point of tangency is at the equator.

This is the point at which scale is the most accurate. It is also the point at which chart and earth convergency equal exactly.

This chart design creates a stretching of higher/lower latitudes.

Scale expands with the secant (1/cos) of the latitude.

This means that the smallest scale is at the equator, and at the pole, the scale tends towards infinity.



Denominator = equatorial denominator x cos lat.

To find denominator at equator – Denominator at x / cos (lat x)

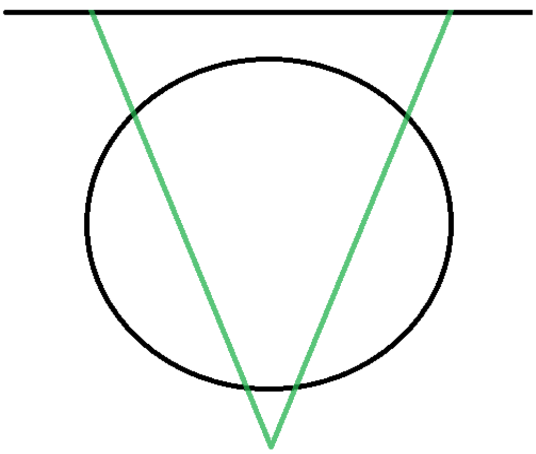
You must always go via the equator to find the scale at a given latitude when given scale at another latitude.

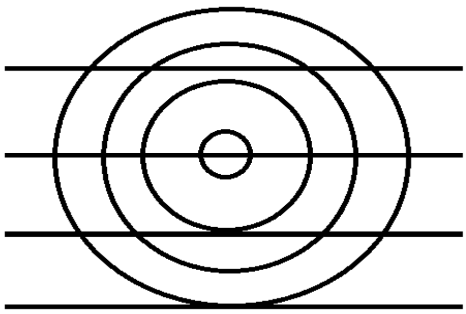
As all these charts are rectangular, if the chart measures 133 cm across, it measures this at any point.

RHUMB LINE – STRAIGHT
Great Circle – Curve concave to the equator / convex to nearest pole.

Remember that radio bearings follow a great circle track. Therefore, you will have to apply conversion angle to the chart when they are involved.

Polar Stereographic Charts:





Grid north is aligned to a set meridian. Normally this is the prime meridian for the north pole, and the antimeridian (180) for the south pole. However, it may be aligned differently.

Scale expands with increasing distance from the pole (which is the point of tangency).

There is NO grid convergency. Conversion factor is 1.

Great circles approximate to straight lines. Any point passing through the pole will be an exact great circle and also a rhumb line.
Any great circle is actually concave to the pole, and rhumb lines are more so.

Therefore the order from pole to equator is:

1. Straight Line
2. Great Circle
3. Rhumb Line

To solve problems on this chart, you need to draw a scale diagram.

If given 2 points and asked to find the GC TR between them:

1. Place a central mark, and draw a circle around it. West is on the left, East on the right.
    1. If two different lattitudes are given, then you need 2 circles.
    2. These Must be in scale to one another.

2. Put a line for north. For the north pole this is down the page, for the south pole it is up the page.

3. Use a protractor to draw in the longitudes.

4. Draw a line to connect the 2 co-ordinates.

5. Then use a protractor to measure the required angle. True north is the line leading to the centre.

If asked to convert to grid track from a true heading:

1. Draw a scale diagram as above, mark the co-ordinates of the aircraft.

2. Use the protractor to draw on the aircraft's heading against true north.

3. Draw a straight line parallel to the reference meridian (usually 000 or 180)

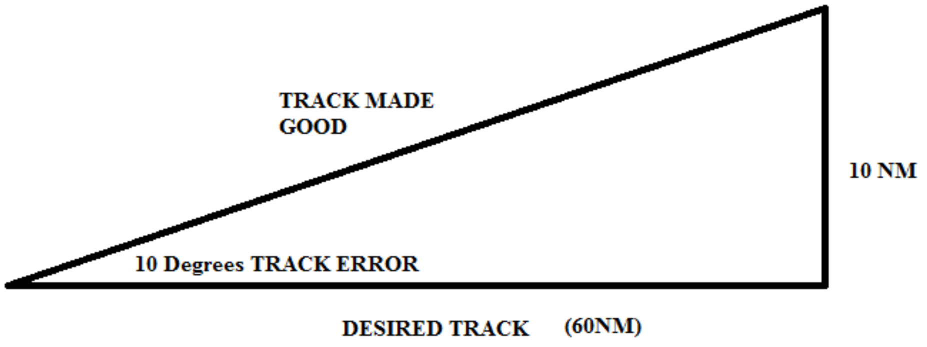
4. From this True North, measure the grid heading. Be careful whether it is from 000 or 180!

If asked to convert from Grid track to true heading:

1. Draw scale diagram, mark on a/c position.
2. Transpose a line parallel to the reference meridian.
3. From this mark on the grid heading (being careful as to whether it is from 000 or 180)
4. Measure your true heading from true north.

1 in 60 Approximations

All are APPROXIMATIONS.



For every 1 degree you are off course, over 60 NM you will be 1 NM off course.
Works up to 30 degrees off.
Track actually flown = Track Made Good.

To find correction angle / Total alteration to heading:

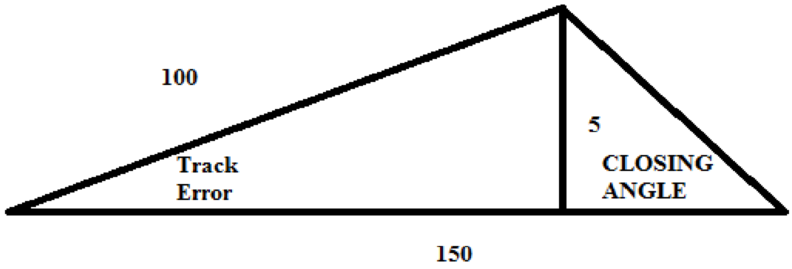
Double Track Error Method:

ONLY works if half way to destination.

Track Error = (Distance Off / Distance Flown) x 60

If halfway then double this to find the angle that you need to correct by.

Closing Angle Method:



Closing Angle = (Distance Off / Distance To Go) x 60.

Total alteration of heading = Track Error + Closing Angle]

In this case- Track Error = (5/100) x 60 = 3 Degrees.
Closing angle = (5/50) x 60 = 6 Degrees.
Alteration of heading = 9 Degrees RIGHT.

Dead reckoning – expected position based on flight plan.

Vertical Navigation:

Rate of Descent on glide path = (Groundspeed / 60) x Glide Path Angle x 100 (or 101.3)
101.3 = 6080/60 – conversion to feet per minute from knots.

Height of Glide Path = Distance From Threshold x Glide Path Angle x 100 (101.3)

Navigational Descent – Use Speed – Distance – Time calculations to find time available, and then :
Rate of Descent Required = Total Descent / Time Available
Time To Descend = Total Descent / Descent Rate
Distance Covered = Time to Descend x Ground Speed.

Time

Apparent Sun – Where the sun actually is in the sky.

Mean Sun – Where the sun should be based on a 24 hour day (leads and lags dependent on latitude).

Local Mean Time – Sun related. Based on the sun being directly overhead the local meridian (i.e. your position) at precisely midday.

Local Hour Angle- Angle of suns shadow compared to shadow cast at noon. At noon it is 0.

UTC/GMT/Zulu – A standard time that remains constant regardless of where you are in the world.

Standard Time – Watch/clock based. What the local authorities set as the time at your location.

Start of Morning Civil Twilight Time – When the sun reaches 6 degrees below the horizon. There is also nautical (12) and astronomical (18).

Sunrise – When top of sun's disc moves rises above the horizon – end of morning civil twilight time.

Duration of morning civil twilight – From Start to Sunrise. Varies significantly depending on latitude and time of year, greatest change at equinoxes.

Sunset – Top of sun's disc falls below horizon – start of evening civil twilight time.

End of Evening Civil Twilight Time – When centre of sun is at 6 degrees below horizon..

Above 66.5 degrees North the winter sun never reaches 6 degrees below the horizon.

In Almanac, on Sunrise / Sunset chart:

Permanent Night

Permanent Day

/ / / Permanent Twilight – Sun never fully sets, does get light between twilights.

Whenever you perform time conversions you MUST work through UTC/GMT/Zulu.

Moving E**A**ST – **A**dd Moving WEST– Subtract.

Always assume that daylight saving time is not applied unless specifically told (always adds 1 hour).

Local Mean Time Calculation (difference from UTC) = Longitude / 15

Grivation = Variation + Grid Convergence

Grid Convergence = Angle from TRUE NORTH to GRID NORTH

e.g. Variation = 15E ; Grid Convergence = 90W; Therefore, Grivation = 75W.

QFE – Pressure Setting at Airport Datum (altimeter reads 0).

QNH – Airfield Pressure Reduced to Sea Level by ISA standard adjustments.

For every 1 hPa decrease in pressure, altitude increases 27ft.

Standard Pressure Setting = 1013 hPa.

Change over from QNH to SPS when climbing at the Transition Altitude. This varies by airfield and is published in the AIP (Aeronautical Information Publication).

When descending, change from SPS to QNH at Transition Level. This is the first usable flight level above the transition altitude. It is given to you by ATC.

Transition Layer – Layer of air between transition altitude and transition level.

High To Low, Look Out Below – As pressure or temperature decreases, True altitude decreases (altimeter over reads).

Temperature Error Correction – 0.4% correction for every degree of ISA deviation. Applied to indicated altitude, this should be added for +ve ISA dev and subtracted for -ve ISA dev.
When going from True to Indicated, it is the other way around.

When told that an aircraft is circling a peak, its true altitude is fixed at the elevation of the peak. Therefore, a decrease in temperature or pressure will lead to the altimeter over reading, and the aircraft indicating that is above the peak.

When doing speed – time adjustment calculations between 2 points, be aware of 'hidden' wind vectors. You must therefore calculate both TAS and GS.

Visual Navigation:

- You need 3 unique features to identify a point on the ground.
- 2 parallel features can be used to find the current ground speed.
- Fly to the right when following linear ground features.
- At low altitudes, use larger scale charts (e.g. 1:500,000).
- At higher altitudes elevation of terrain loses its significance as a visual reference.
- Whiteout – Loss of ground and horizon references as a result of decreased contrast (e.g. when flying over the ocean, or in a snowy landscape on a cloudy day).
- Lost Procedure:
    - Ask ATC
    - Draw a circle of uncertainty around the last known fix.
    - Perform a precautionary landing before running out of fuel or light.

When given a series of conditions at different altitudes:
If climbing, use the altitude at 2/3 of the way up.
If descending, use the altitude at ½ the way down.

Temperature error correction ONLY needs to be done to find true altitude.

Convergency:

Lambert = Parallel of Origin
Mercator = 0
Polar = 1

Pressure Altitude – Altitude above 1013 level.

Rate of Descent – (Groundspeed / 60) x Glide Path Angle x 100 (101.3)