Types of Altitude

Types of Speed

Six Pack

Degrees Compasses and Heading Indicators

Compass and Instrument Errors

What Happens When The Pitot Static System Malfunctions?

Inner Workings of an Attitude Indicator | Gyroscope

Gyroscopic Instruments in 3D

How a turn coordinator works

Types of Altitude

Cleared For the Option!

Lesson Objective

To develop understanding of the different altitude terms…not a good idea to get them confused

Definitions

True Altitude = true vertical distance of the aircraft above sea level. Airport, terrain, obstacle elevations all shown in true altitudes on charts.

Absolute Altitude = vertical distance of the aircraft above the surface of the earth

Indicated Altitude= altitude read directly from the altimeter after it is set to the current altimeter setting.

Pressure Altitude = altitude displayed when the Kollsman window is set to 29.92

Density Altitude = pressure altitude corrected for nonstandard temperatures

Short Versions

True = MSL

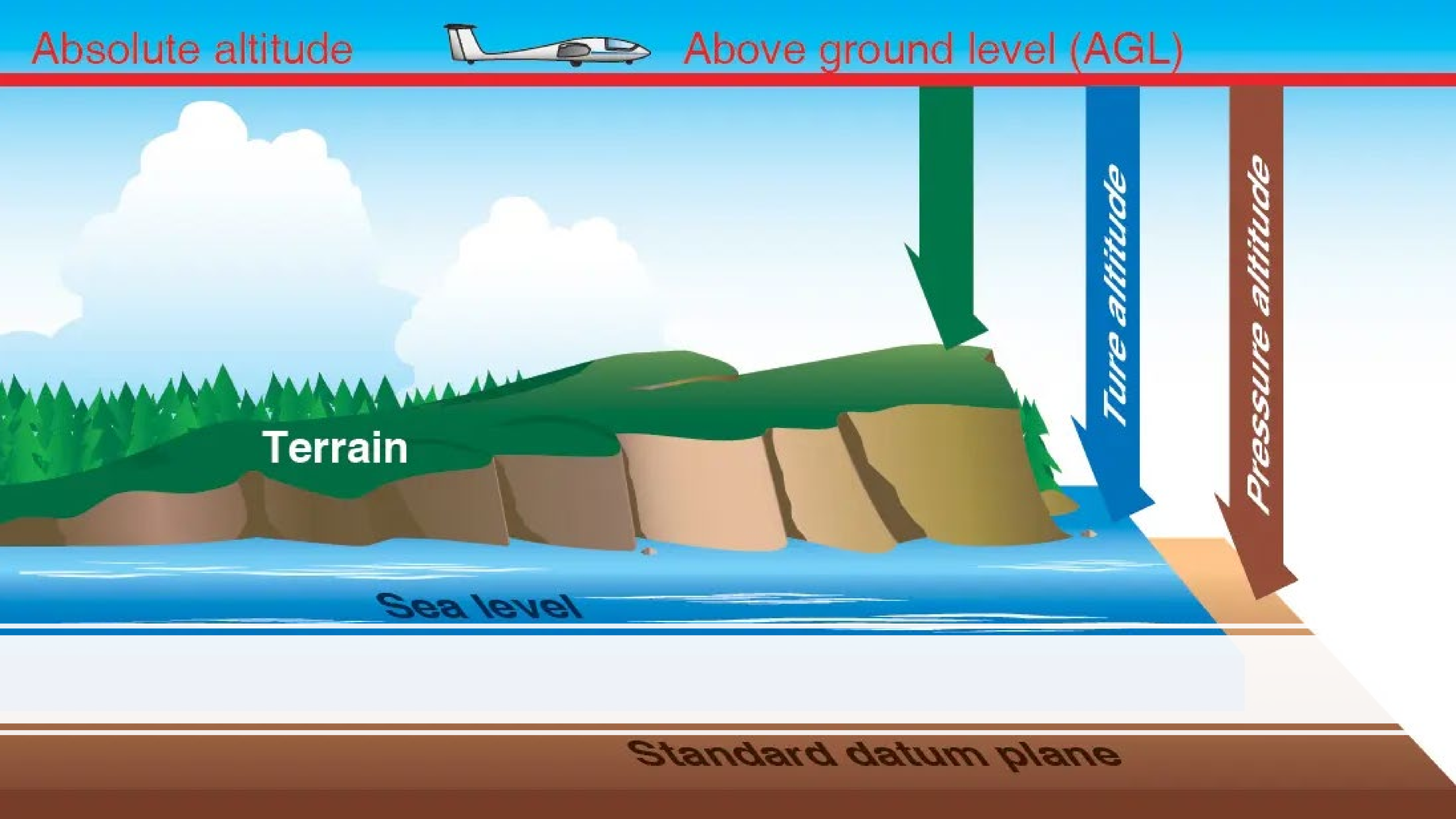
True = Altimeter when set to local pressure

Absolute = AGL (Above Ground Level)

Indicated = Look at the dashboard

Pressure = Look at altimeter when set to 29.92

Density = For performance charts



Absolute altitude
Above ground level (AGL)
Ture altitude
Pressure altitude
Terrain
Sea level
Standard datum plane

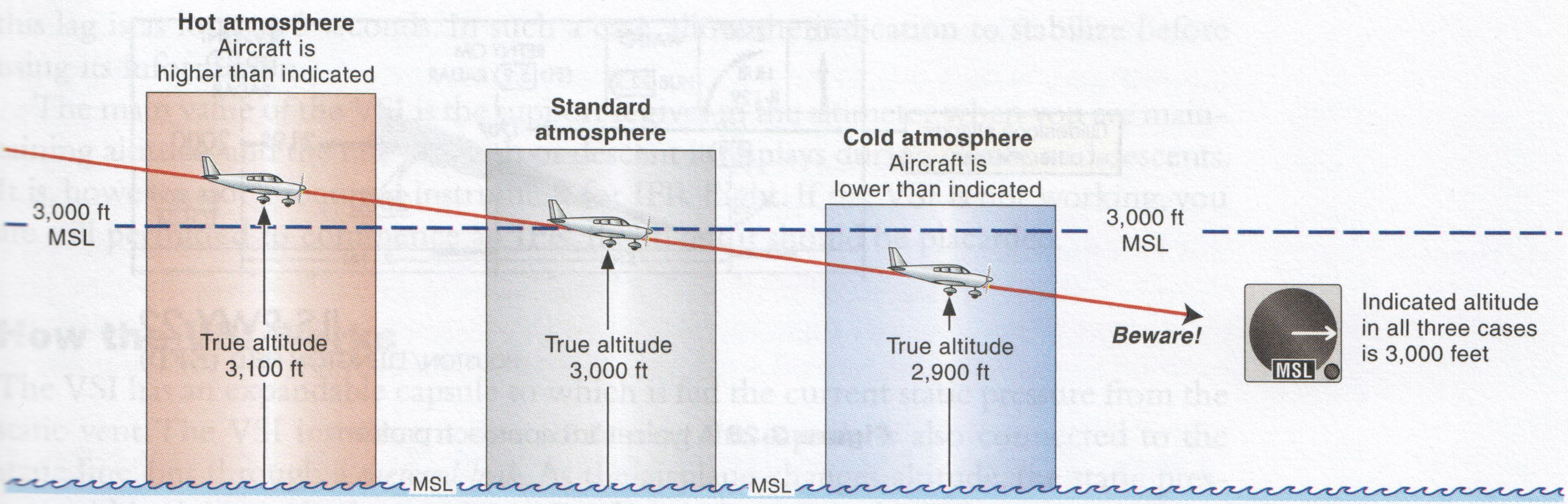
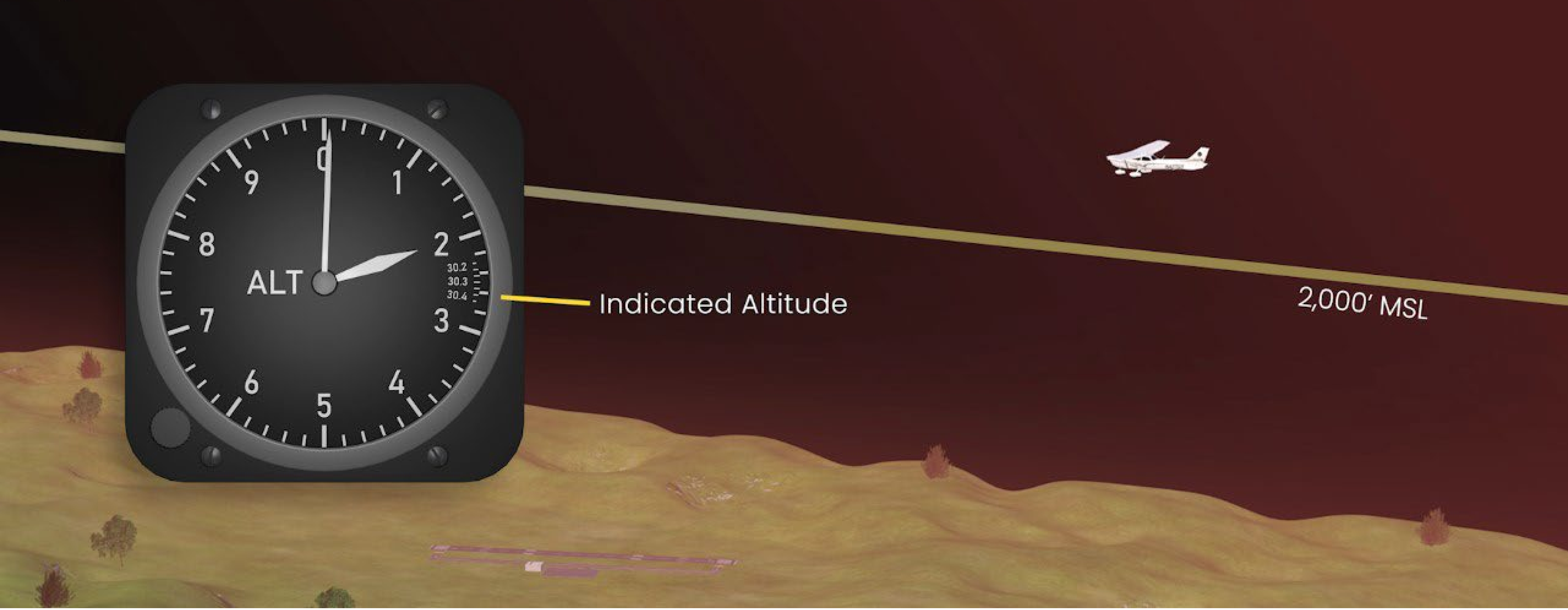
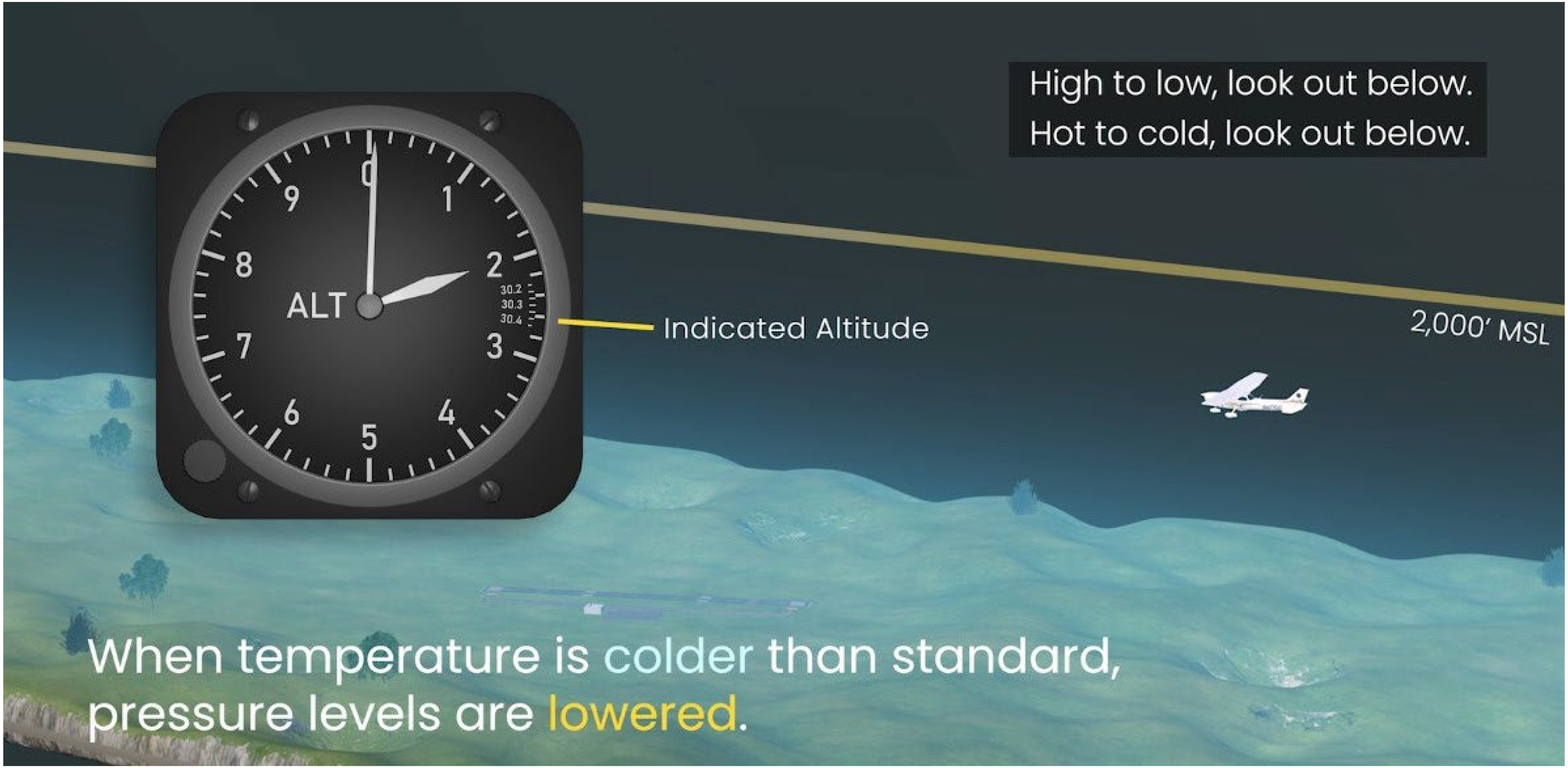


Figure 3-25 Indicated altitude may differ from true altitude.

When temperature is warmer than standard, pressure levels are raised.




High to low, look out below.
Hot to cold, look out below.
9
0
1
8
2
ALT
30.2
30.3
30.4
7
3
6
5
4
Indicated Altitude
2,000′ MSL
When temperature is colder than standard,
pressure levels are lowered.

Dialing in altimeter setting has direct correlation to indicated altitude.

Setting lower pressure indicates lower altitude.

Setting higher pressure indicates higher altitude.

Study

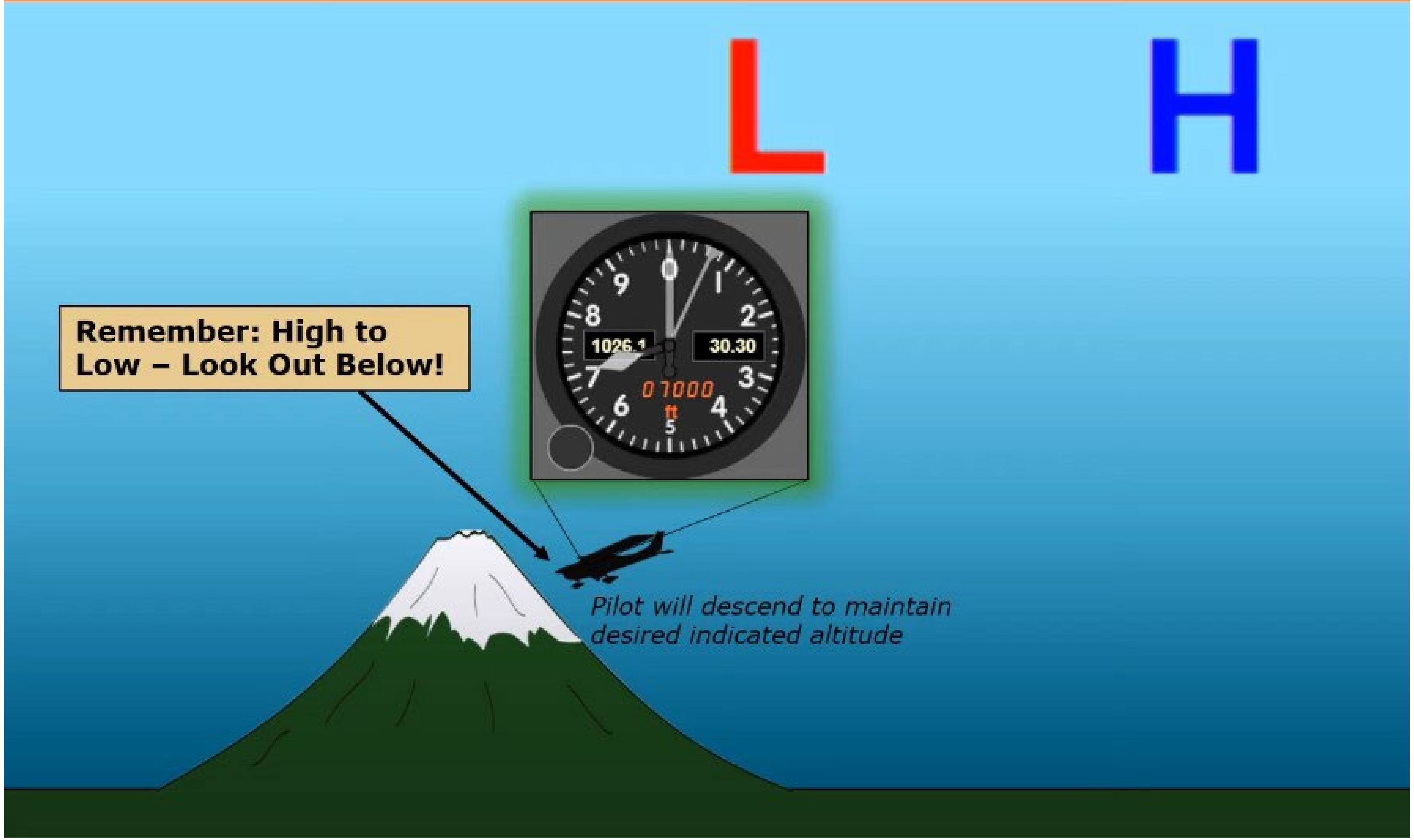
30.11 → 29.96

(1,000 ft. = 1 in. Hg)

$$\begin{array}{r} 30.11 \\ -\ 29.96 \\ \hline .15 \end{array} \qquad \begin{array}{r} .15 \\ \times\ 1{,}000' \\ \hline 150' \end{array}$$

30.11 ↓ 29.96 = 150’ lower

The altimeter will be inaccurate flying between areas of different pressures unless it is reset to a nearby reading



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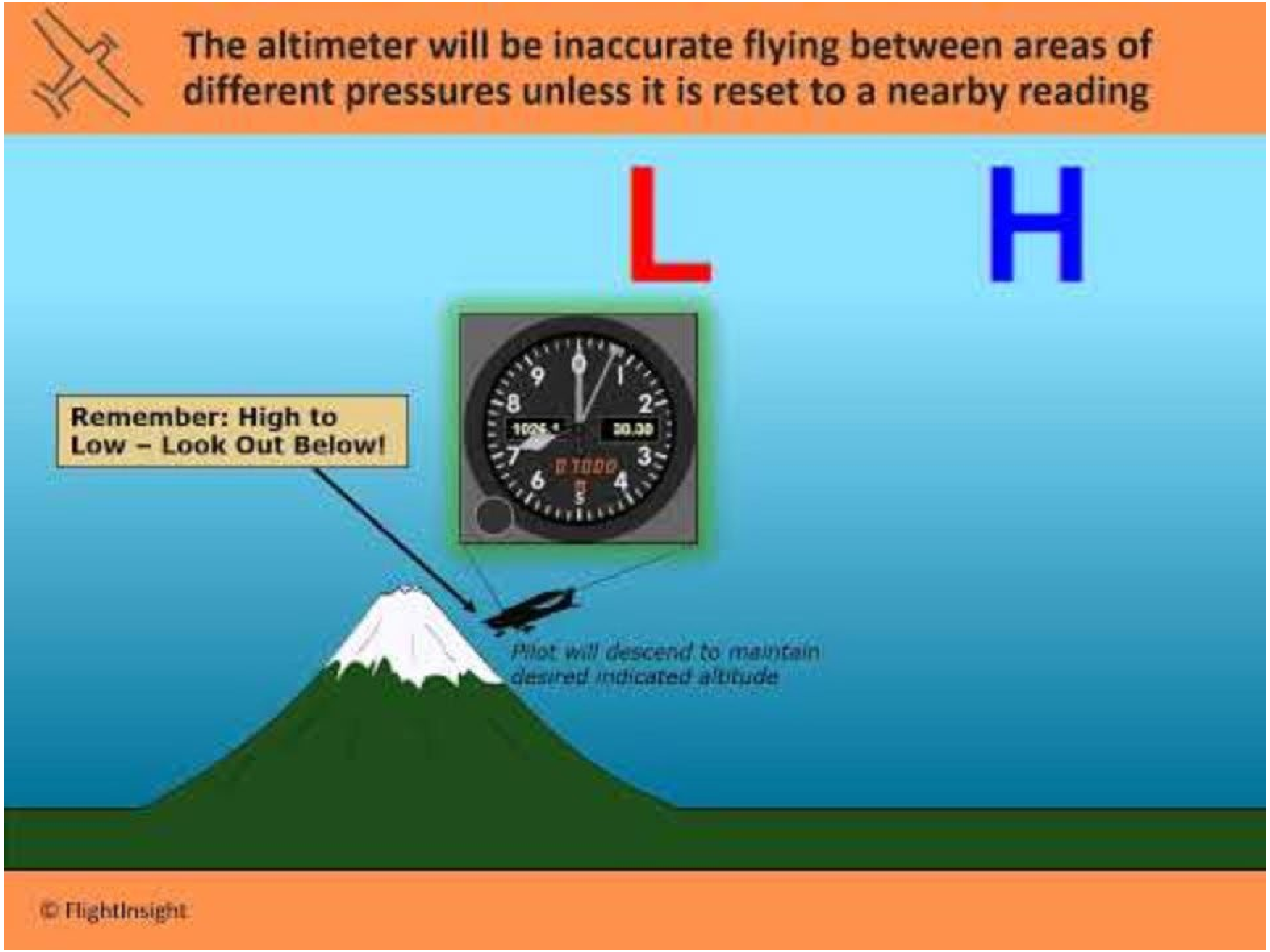


Pressure Altitude

Pressure altitude is the height above a standard datum plane (SDP).

The altitude above the standard datum plane (SDP) which is the pressure level of 29.92 at 15 degrees Celsius.

PA = 1,000 x (29.92-altimeter setting) + Elevation

Pressure Altitude

Pressure altitude is the altitude that your aircraft performs at on a non-standard day. The aircraft's performance is based on this pressure reading, including how fast it will climb, how much runway it needs for landing or lift-off, how fast it will fly, and how much fuel it will use.

Standard pressure, the baseline used universally, is 29.92 inches of mercury (inHg). This setting is equivalent to the atmospheric pressure at mean sea level (MSL) in the ISA. Pressure altitude is primarily used in aircraft-performance calculations and in high-altitude flight (i.e., above the transition altitude).

Pressure Altitude

29.7	205
29.8	112
29.9	20
29.92	0
30.0	−73
30.1	−165
30.2	−257
30.3	−348
30.4	−440

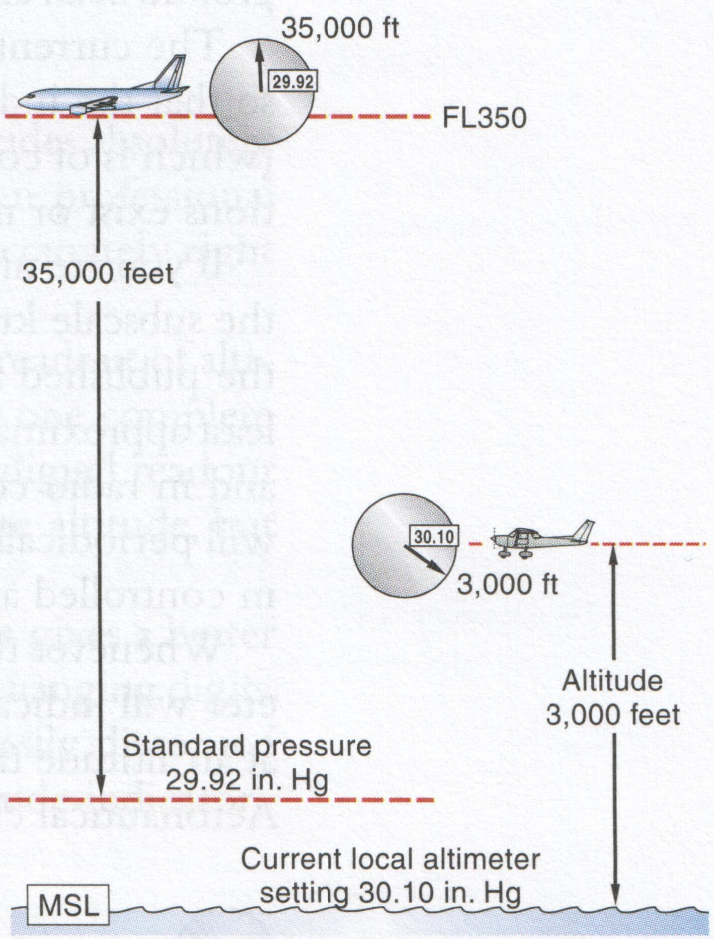


Figure 3-20

The altimeter measures altitude above the pressure level set in the pressure window.

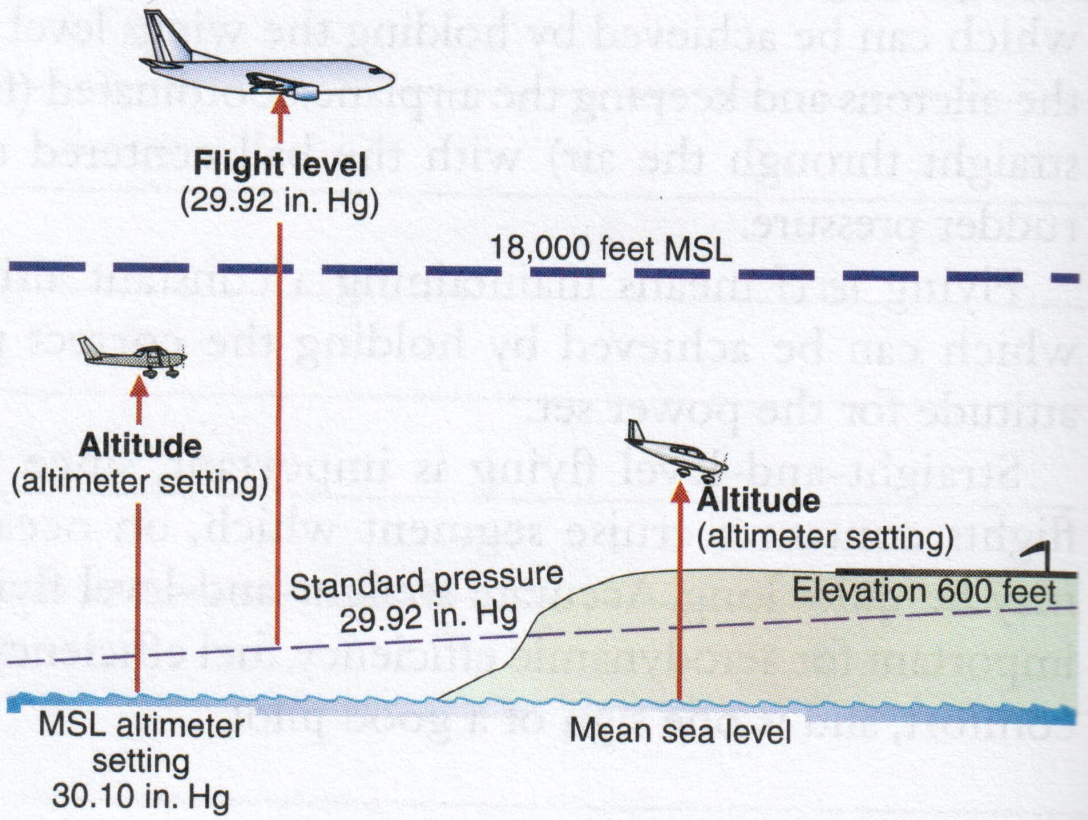
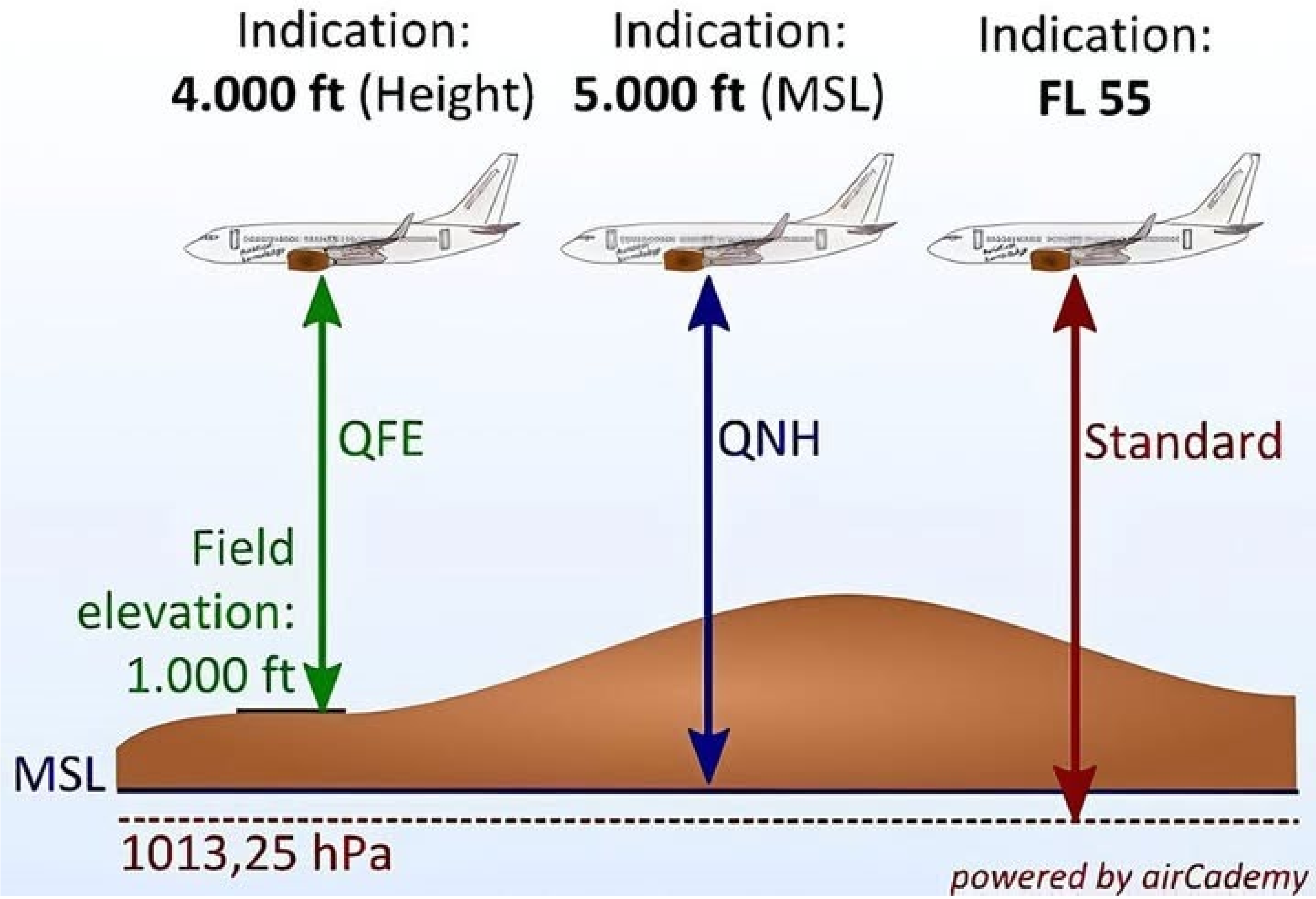
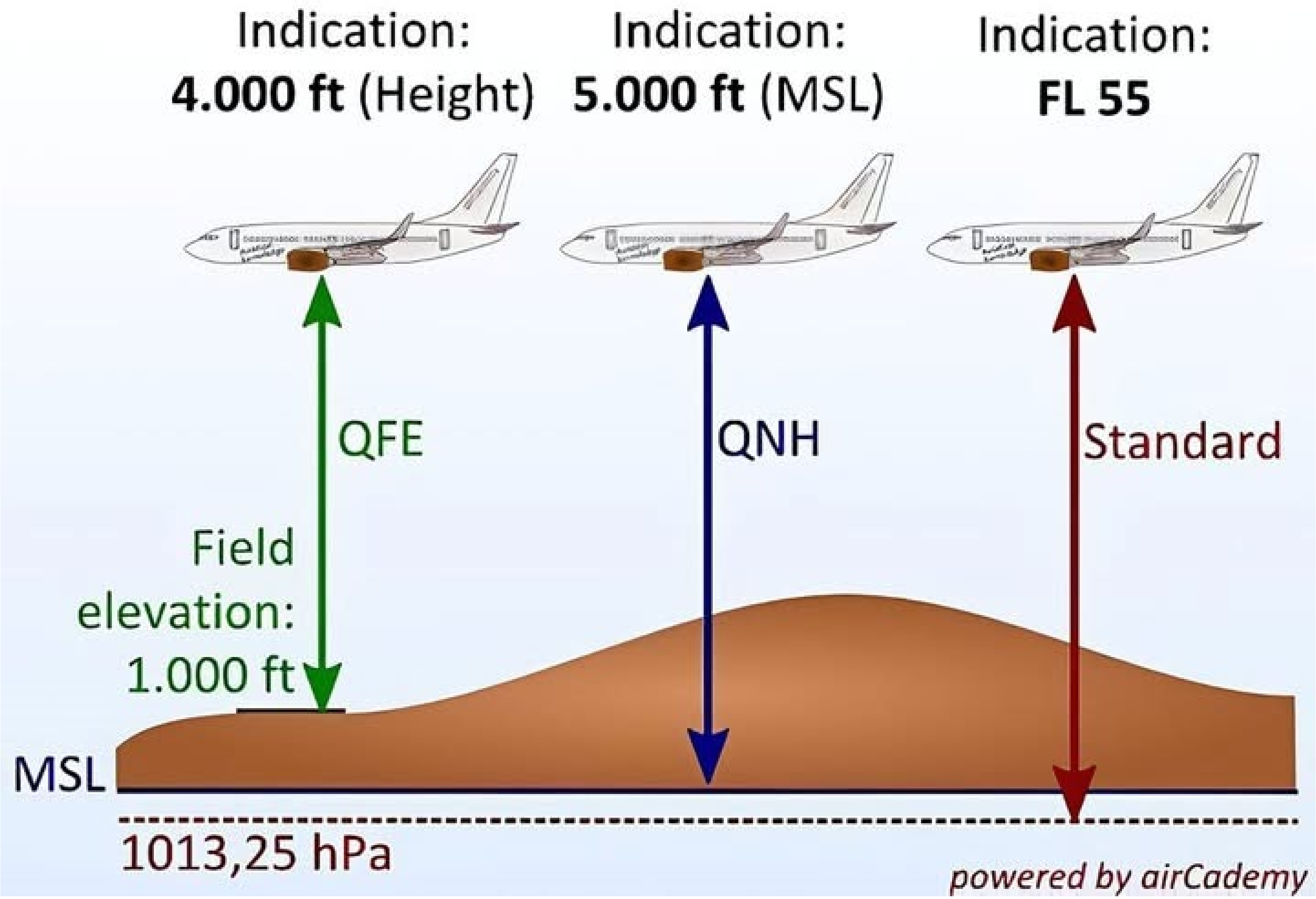


Figure 4-4 The correct pressure setting must be selected in the pressure window.


Indication:
4.000 ft (Height)
Indication:
5.000 ft (MSL)
Indication:
FL 55
QFE
QNH
Standard
Field
elevation:
1.000 ft
MSL
1013,25 hPa
powered by airCademy



Indication:
4.000 ft (Height)
Indication:
5.000 ft (MSL)
Indication:
FL 55
QFE
QNH
Standard
Field
elevation:
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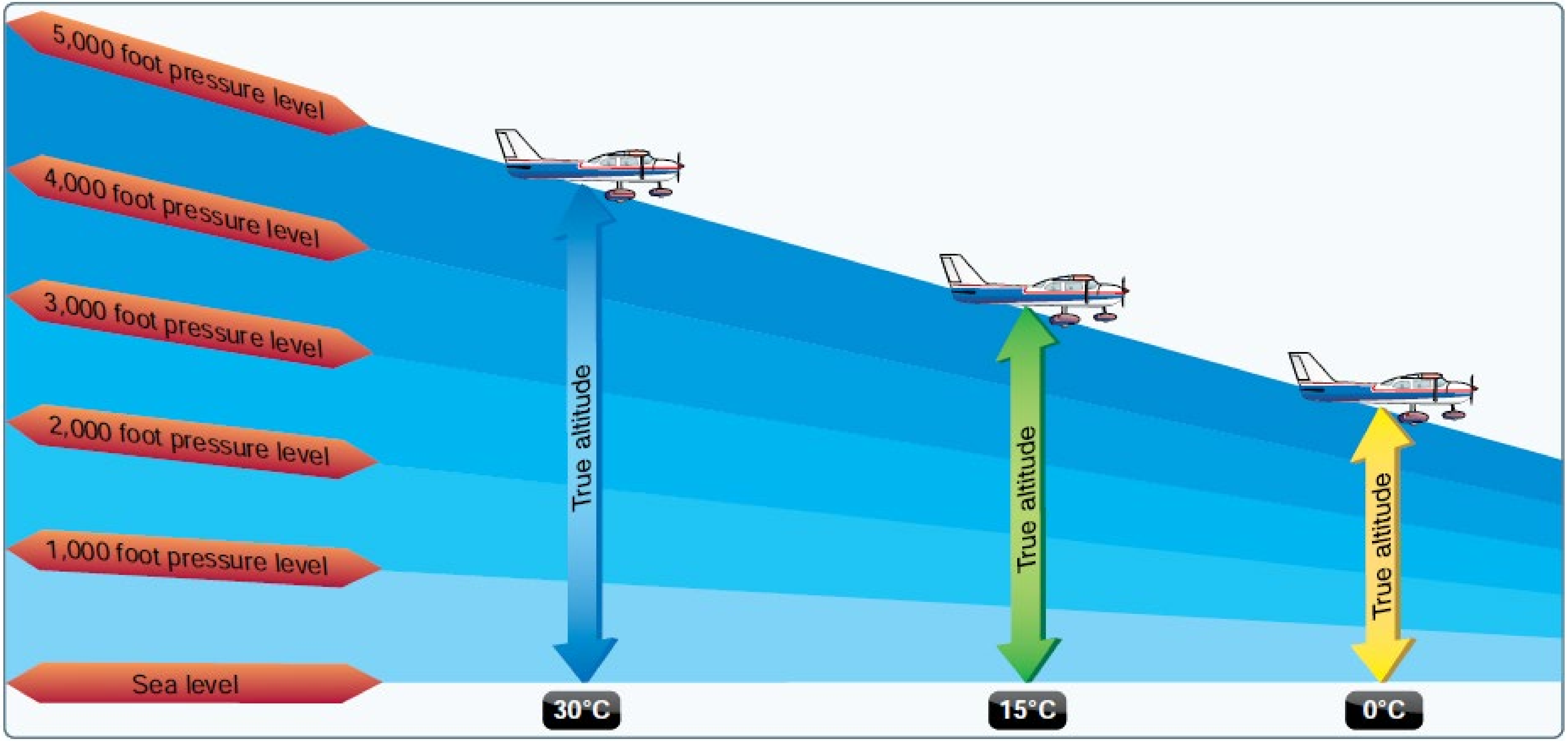
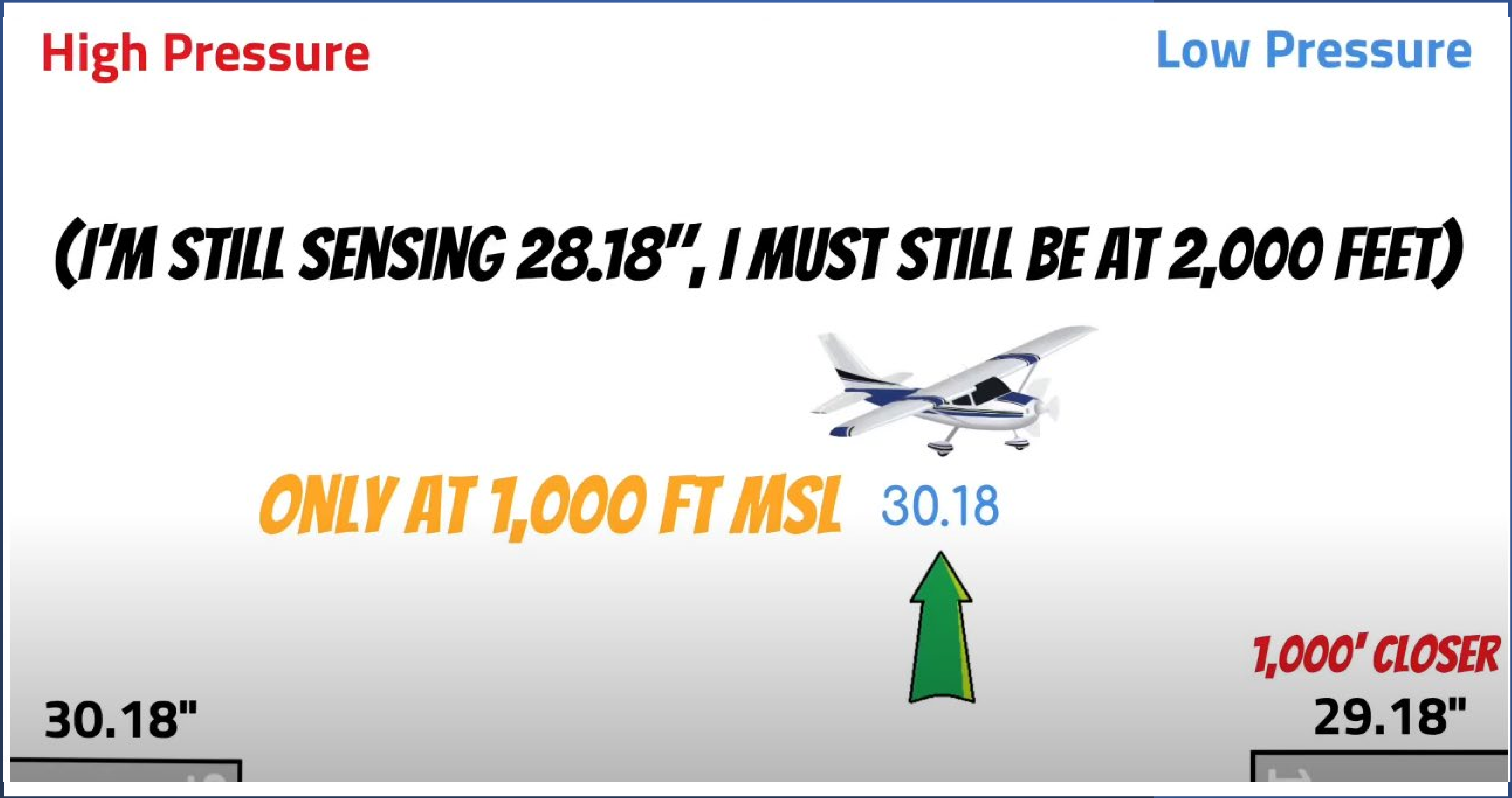
MSL
1013,25 hPa
powered by airCademy


5,000 foot pressure level
4,000 foot pressure level
3,000 foot pressure level
2,000 foot pressure level
1,000 foot pressure level
Sea level
True altitude
True altitude
True altitude
30°C
15°C
0°C


High Pressure
Low Pressure
(I'M STILL SENSING 28.18", I MUST STILL BE AT 2,000 FEET)
ONLY AT 1,000 FT MSL
30.18
1,000' CLOSER
30.18"
29.18"

Density Altitude

It is where the planes feels like it is at

Barometric Pressure, Temperature, Altitude and Humidity all affect air density

- Density varies directly with pressure - As pressure <u>increases</u>, density <u>increases</u> and vice versa
- Density varies inversely with temperature – As temp <u>increases</u>, density <u>decreases</u> and vice versa
- Density varies inversely with altitude - As altitude <u>increases</u>, density <u>decreases</u> and vice versa
- Density varies inversely with humidity – As humidity <u>increases</u>, density <u>decreases</u> and vice versa

For a given volume of atmospheric air, as humidity increases some of the dry air is replaced by water vapor

Density Altitude

DA = Density Altitude (ft)

PA = Pressure Altitude (ft)

OAT = Outside Air Temperature (Celsius)

ISA = Standard Temperature (Celsius)

$$DA = PA + (120 \times (OAT - ISA))$$

Calculate Density Altitude

(standard pressure minus your current pressure setting) times 1,000 plus field elevation equals pressure altitude

For example:

Current altimeter setting is 29.45

Field elevation is 5,000 feet

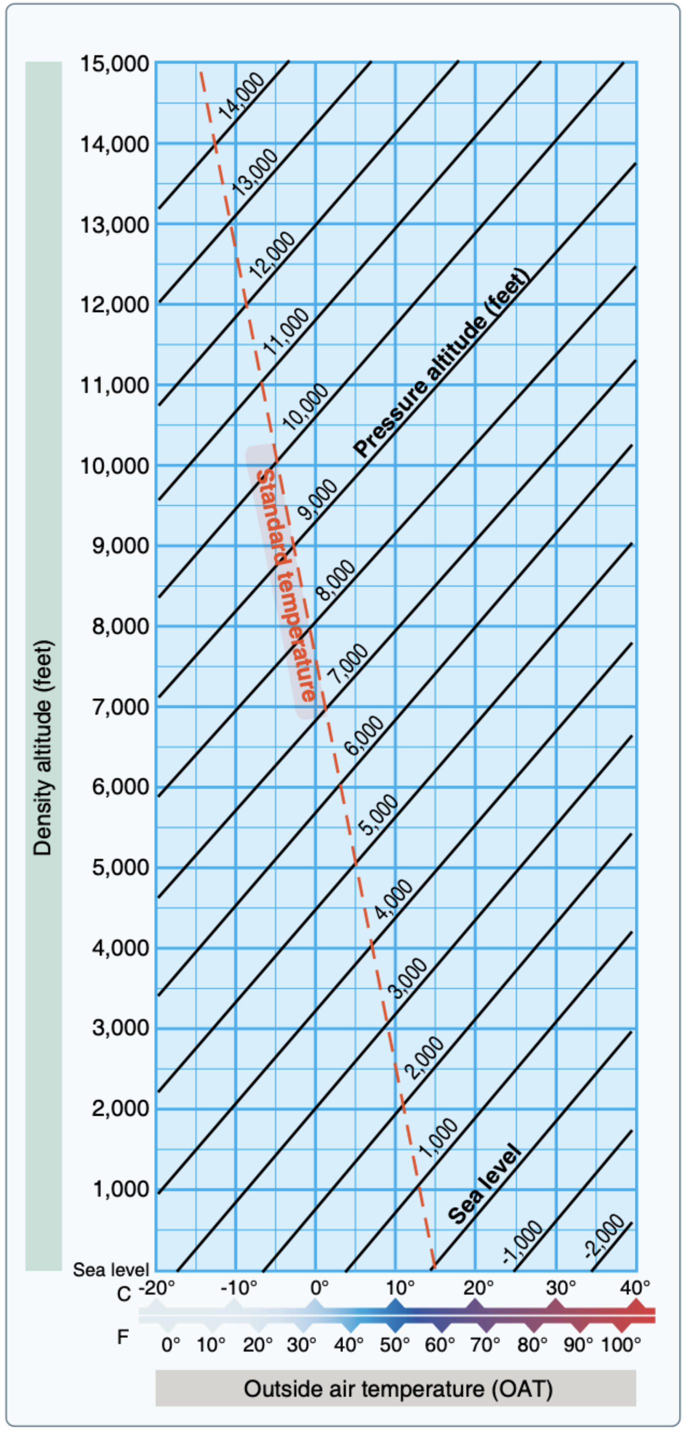
Pressure altitude formula -->

(29.92 – 29.45) x 1,000 + 5,000 = 5,470 feet.

PA = 5,470 feet

Then use on chart on next slide

Calculate Density Altitude



Calculate Density Altitude

Density Altitude Calculator

See density altitude for any airport. Airport ID ie: KJFK Go ×

Altimeter Setting to Pressure Altitude

Altimeter Setting [◉ in/hg | ○ hpa] :	29.98
Field Elevation [◉ ft | ○ mt] :	800
Pressure Altitude (ft)	740

What is the formula?

Pressure Altitude to Density Altitude

Pressure Altitude [◉ ft | ○ mt] :	740
True Altitude (ft)	800
Standard (ISA) Temperature [○ °C | ◉ °F] :	56.15
Air Temperature (OAT) [○ °C | ◉ °F] :	90
Density Altitude (ft)	2974

What is the formula?

Performance Issues

As the air becomes less dense, it reduces:

Power, since the engine takes in less air

Thrust, since the propeller is less efficient in thin air (less air is being moved for every rotation)

Lift, because the thin air exerts less force on the airfoils

High altitude, high temperature airports may not allow safe operation

Always be aware of the density altitude and accompanying performance when planning a flight

If necessary, delay until the performance is attainable or reduce weight to attain the performance

Pressure Altitude vs Density Altitude

The difference between pressure altitude and density altitude is that pressure altitude is corrected for different pressure levels but not temperature. Conversely, density altitude is pressure altitude corrected for deviations in temperature.

A note about Density Altitude

If density altitude ↑

Acceleration ↓

TAS ↑

Ground speed ↑

High, hot, and heavy!

From high pressure to low pressure – actual altitude is lower

High to low look out below!

At same indicated altitude but sun goes down

Hot to cold look out below!

Any time density altitude is very high, the plane will have poor performance

Quick Tip

If you adjust the altimeter from 30.11 to 29.96 the indicated altitude would be?

Remove the .

3011 - 2996 = 15

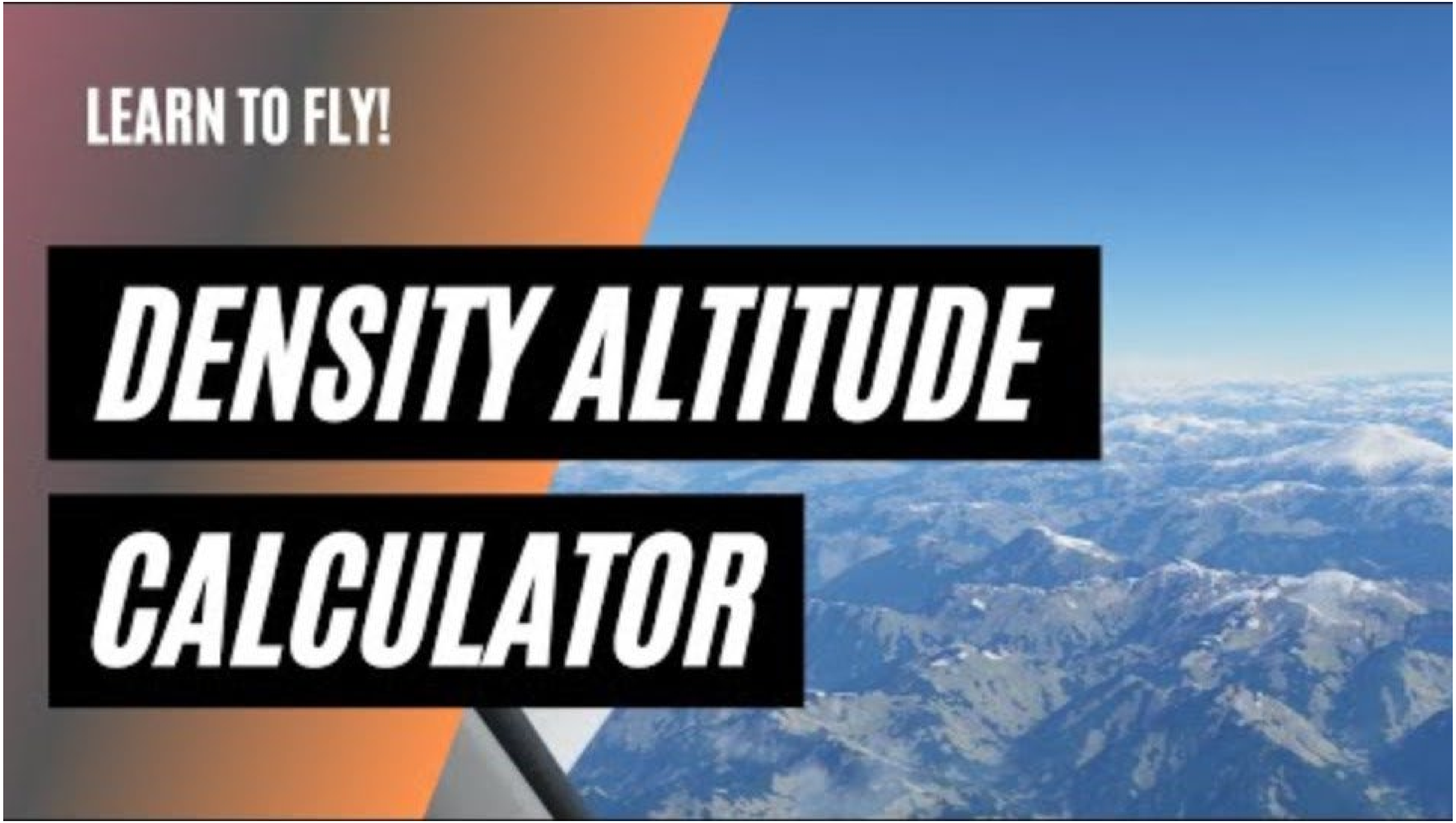
15 x 10 = 150

=> 150 feet lower

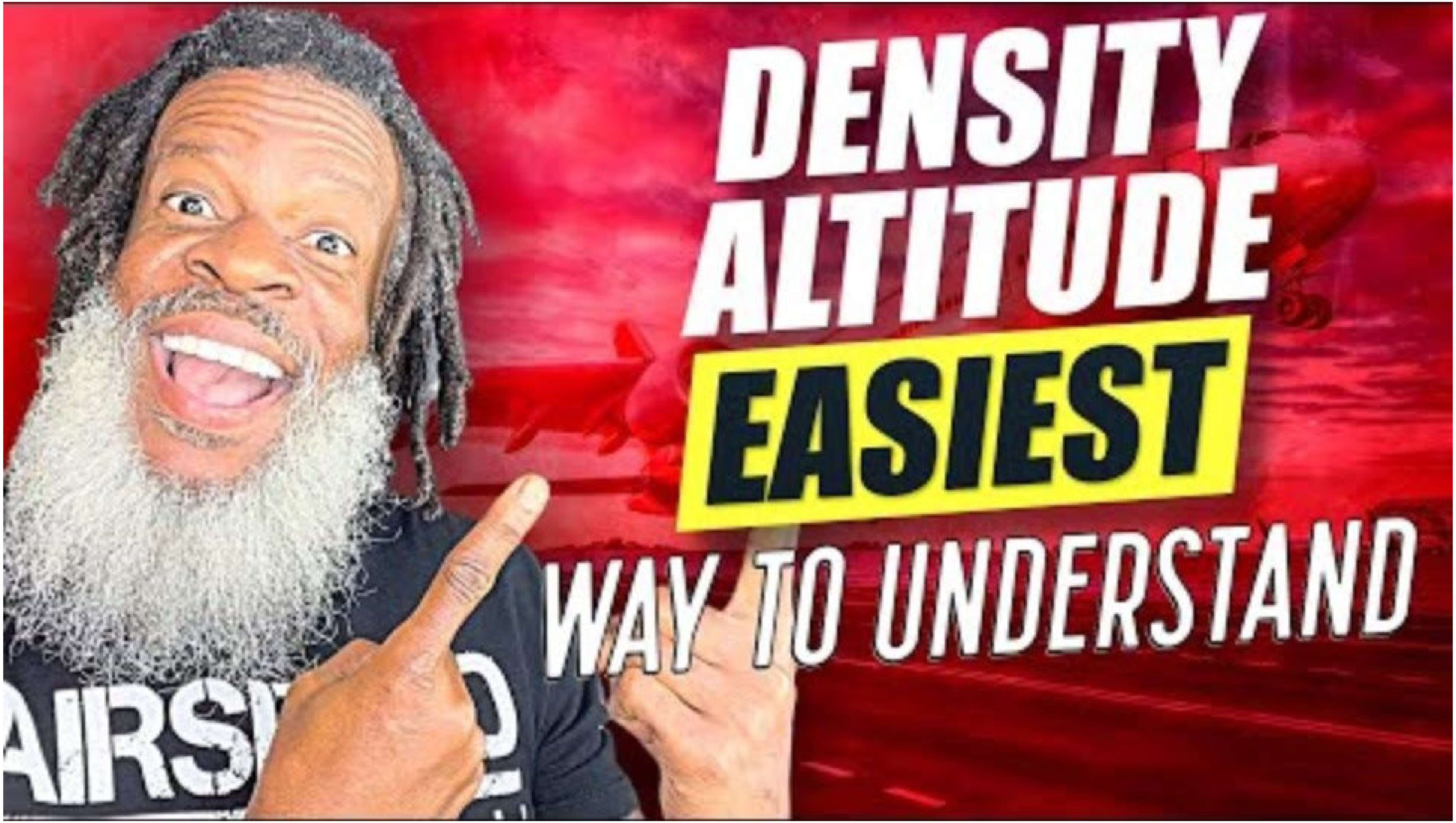
https://youtu.be/DABzwDfK9DA

https://youtu.be/KrKLrrnD4bw

https://youtu.be/CcIlRG6cf88



https://youtu.be/cC8G-Zjm8A4



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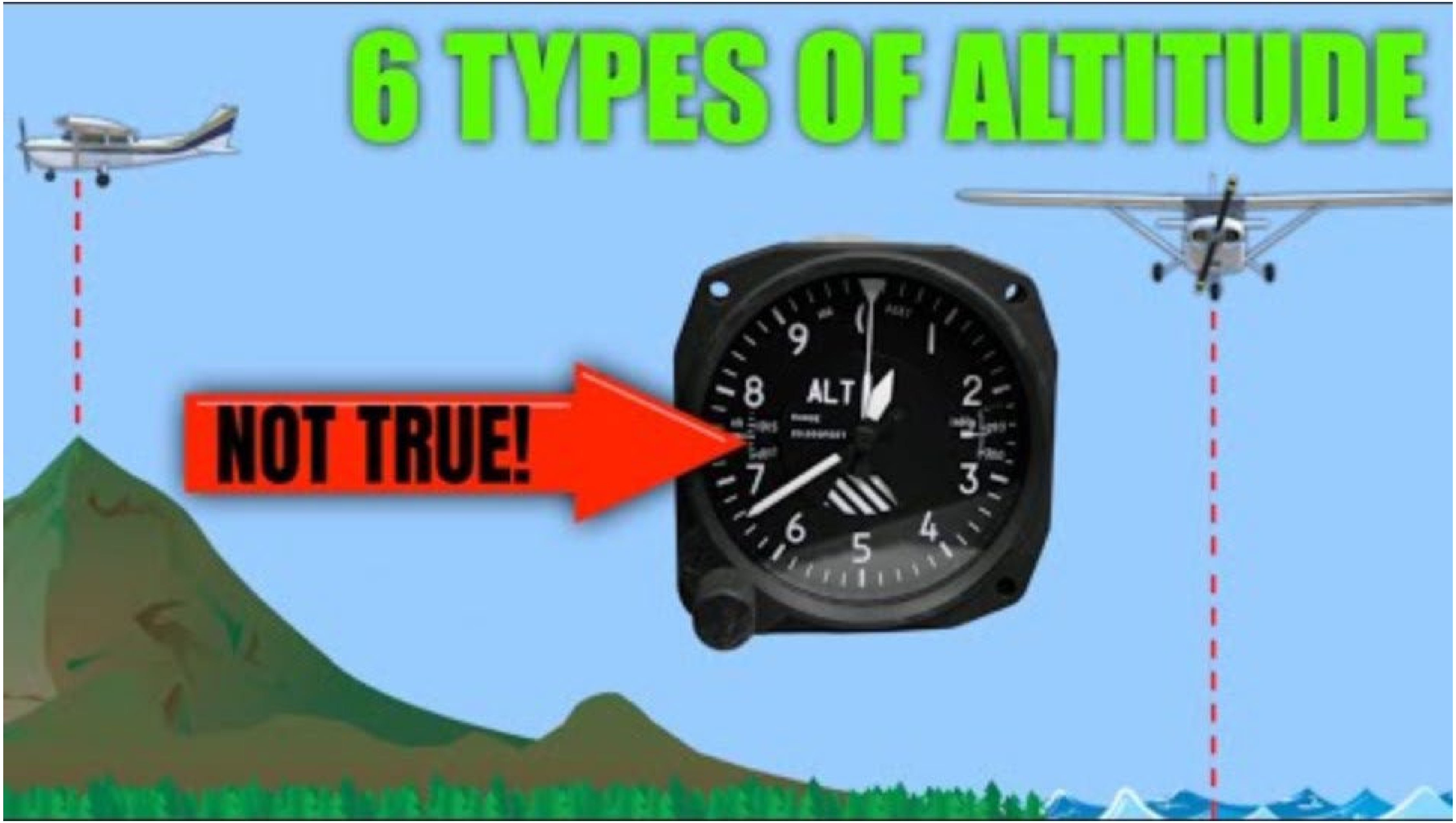
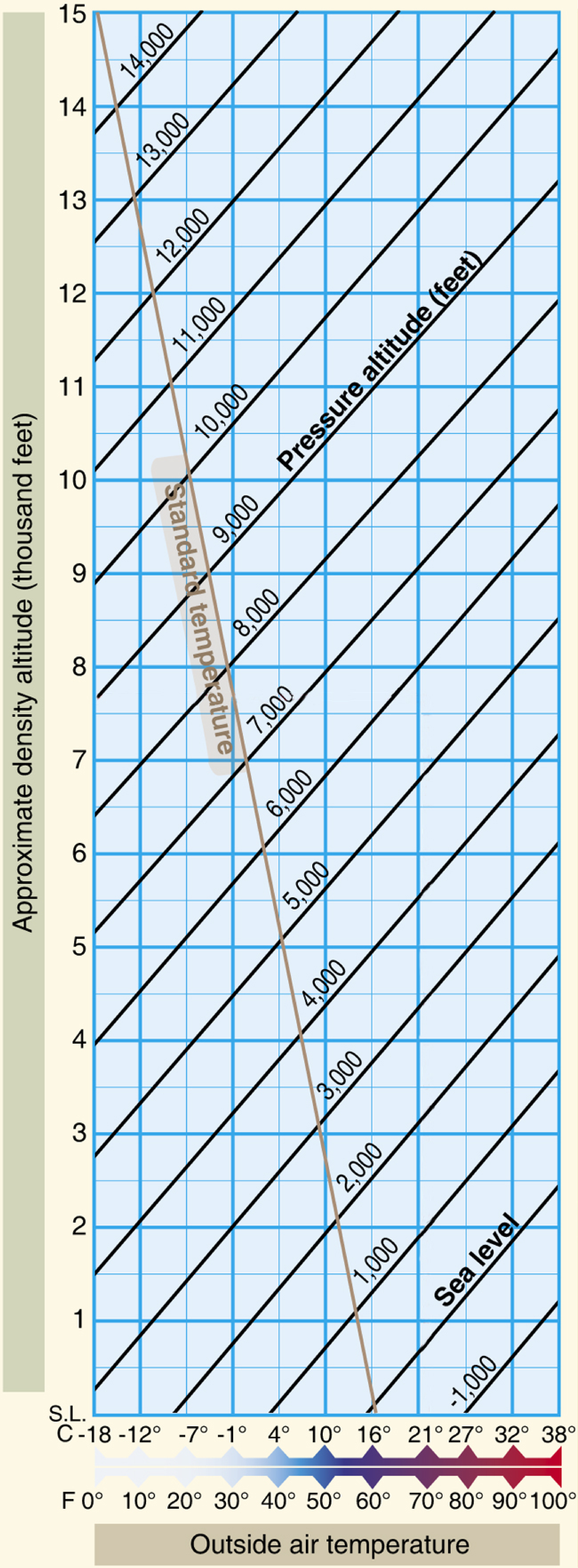
https://youtu.be/aUnI2VQ70sc



Any questions I can answer or follow up later on?



Altimeter setting ("Hg)	Pressure altitude conversion factor
28.0	1,824
28.1	1,727
28.2	1,630
28.3	1,533
28.4	1,436
28.5	1,340
28.6	1,244
28.7	1,148
28.8	1,053
28.9	957
29.0	863
29.1	768
29.2	673
29.3	579
29.4	485
29.5	392
29.6	298
29.7	205
29.8	112
29.9	20
29.92	0
30.0	–73
30.1	-165
30.2	–257
30.3	–348
30.4	–440
30.5	–531
30.6	–622
30.7	–712
30.8	–803

Density Altitude Chart

Types of Speed

Lesson Objective

To develop understanding of the different speed terms

Definitions

Indicated Airspeed (IAS)—the speed of an aircraft as shown on the airspeed indicator.

Calibrated Airspeed (CAS)—indicated airspeed of an aircraft, corrected for installation and instrument errors.

True Airspeed (TAS)—the speed at which an aircraft is moving relative to the surrounding air. CAS corrected for density altitude.

Groundspeed Airspeed (GS)—the speed of an aircraft in relation to the ground.

Indicated Airspeed (IAS)

This one's pretty simple. It's read right off your airspeed indicator and is usually what you’ll reference in the cockpit for speed changes.

The speed limits of the sky, like not exceeding 250 knots below 10,000 feet MSL, are all written as indicated airspeed values.

True Airspeed (TAS)

True airspeed is the speed of your aircraft relative to the air it's flying through.

As you climb, true airspeed is higher than your indicated airspeed.

Pressure decreases with higher altitudes, so for any given true airspeed, as you climb, fewer and fewer air molecules will enter the pitot tube.

Because of that, indicated airspeed will be less than true airspeed. In fact, for every thousand feet above sea level, true airspeed is about 2% higher than indicated airspeed.

So at 10,000 feet, true airspeed is roughly 20% faster than what you read off your airspeed indicator.

Many aircraft, such as those with gas turbine engines, can reach a higher TAS at higher altitudes because their engines are more efficient at higher altitudes.

The movement of your airplane relative to the ground is called groundspeed.

It's true airspeed corrected for wind.

With a true airspeed of 100 knots and a tailwind of 20 knots, you'd be flying a groundspeed of 120 knots.

Groundspeed (GS)

Calibrated Airspeed (CAS)

Calibrated airspeed is indicated airspeed corrected for instrument and positional errors.

At certain airspeeds and with certain flap settings, the installation and instrument errors may total several knots.

This error is generally greatest at low airspeeds, with nose high pitch attitudes.

When flying at sea level under International Standard Atmosphere (ISA) conditions (15 degrees Celsius, 29.92 inches of mercury, 0% humidity), calibrated airspeed is the same as true airspeed.

If there is no wind it is also the same as ground speed.


59% Power
DNW iaf
ZIBIV
DIS 8.1NM
ETE 03:28
COM1 RX 118.075 ↔ 133.250
COM2 RX 124.550 118.325
GPS
YD VPTH
ALTS
11000
160
150
140
135
120
110
14100
14000
13880
13800
13700
13600
-900
30.13IN
270
260°
GS 141KT
TAS 168KT
306°T
33KT
OPERATING
NORMAL
HDG UP
GPS
TERM
XPDR 3766 ALT
UTC 23:44:43
OAT -11°C
INSET
SENSOR
PFD
CDI
XPDR
IDENT
TMR/REF
NRST
ALERTS

Title 14 Part 1 Definitions

Va = design maneuvering speed

Vb = design speed for maximum gust intensity

Vc = design cruising speed

Vd = design diving speed

Vdf = demonstrated flight diving speed

Vef = speed at which the critical engine is assumed to fail during takeoff

Vf = design flap speed

Vfc = maximum speed for stability characteristics

Vfe = maximum flap extended speed

Vfto = final takeoff speed

Vh = maximum speed in level flight with maximum continuous power

Vle = maximum landing gear extended speed

Vlo = maximum landing gear operating speed

Title 14 Part 1 Definitions

Vlof = lift-off speed

Vmc = minimum control speed with the critical engine inoperative

Vmo = maximum operating limit speed

Vmu = minimum unstick speed

Vne = never-exceed speed

Vno = maximum structural cruising speed

Vr = rotation speed

Vref = reference landing speed

Vs = the stalling speed or the minimum steady flight speed at which the airplane is controllable

Vs0 = the stalling speed or the minimum steady flight speed in the landing configuration

Vs1 = the stalling speed or the minimum steady flight speed obtained in a specific configuration

Title 14 Part 1 Definitions

V_{sr} = reference stall speed

V_{sro} = reference stall speed in the landing configuration

V_{sr1} = reference stall speed in a specific configuration

V_{sw} = speed at which onset of natural or artificial stall warning occurs

V_{toss} = takeoff safety speed for Category A rotorcraft

V_x = speed for best angle of climb

V_y = speed for best rate of climb

V_1 = the maximum speed in the takeoff at which the pilot must take the first action (eg, apply brakes, reduce thrust, deploy speed brakes) to stop the airplane within the accelerate-stop distance V_1 also means the minimum speed in the takeoff, following a failure of the critical engine at V_{EF}, at which the pilot can continue the takeoff and achieve the required height above the takeoff surface within the takeoff distance

V_2 = takeoff safety speed

V_{2min} = minimum takeoff safety speed

Vx vs Vy

<u>What is Vx?</u>

Vx is the airspeed to the best angle of climb.

It results in the greatest amount of altitude over the shortest distance.

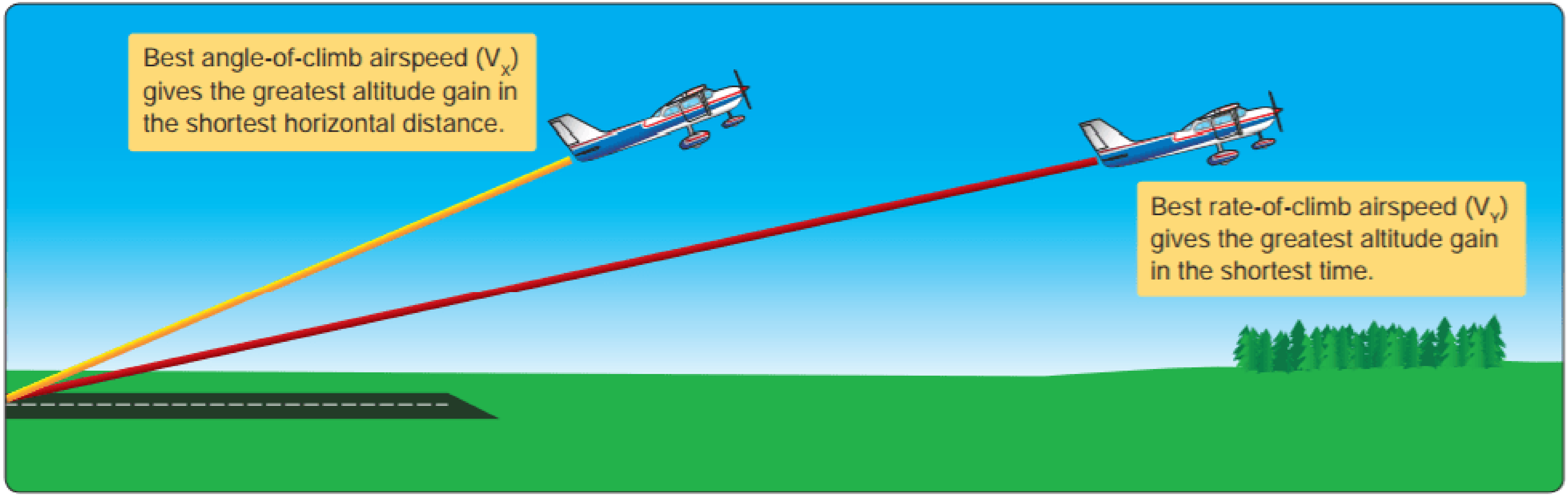
This is needed for a short field takeoff or when you are concerned about obstacles ahead of you…typically trees.

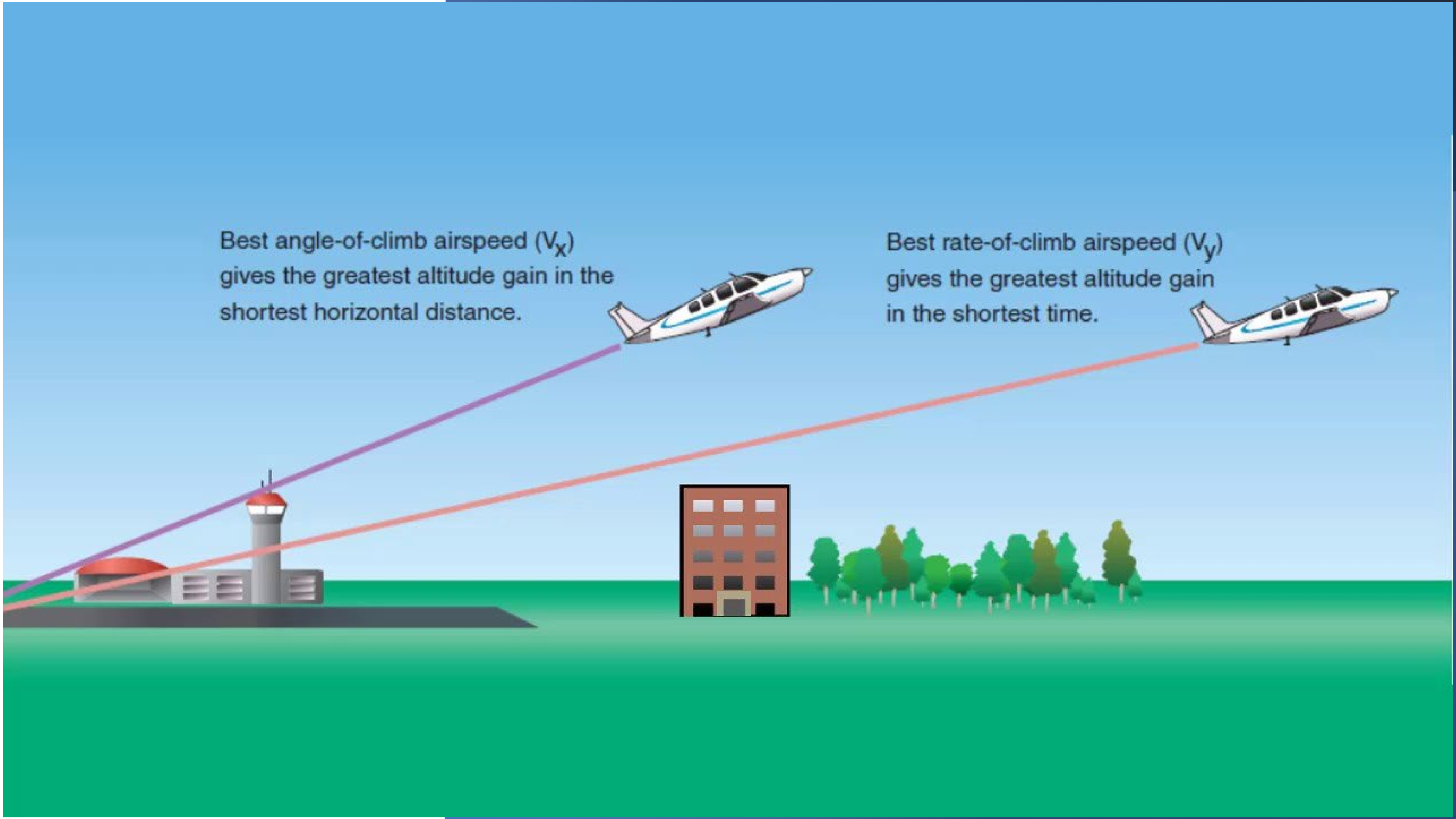
<u>What is Vy?</u>

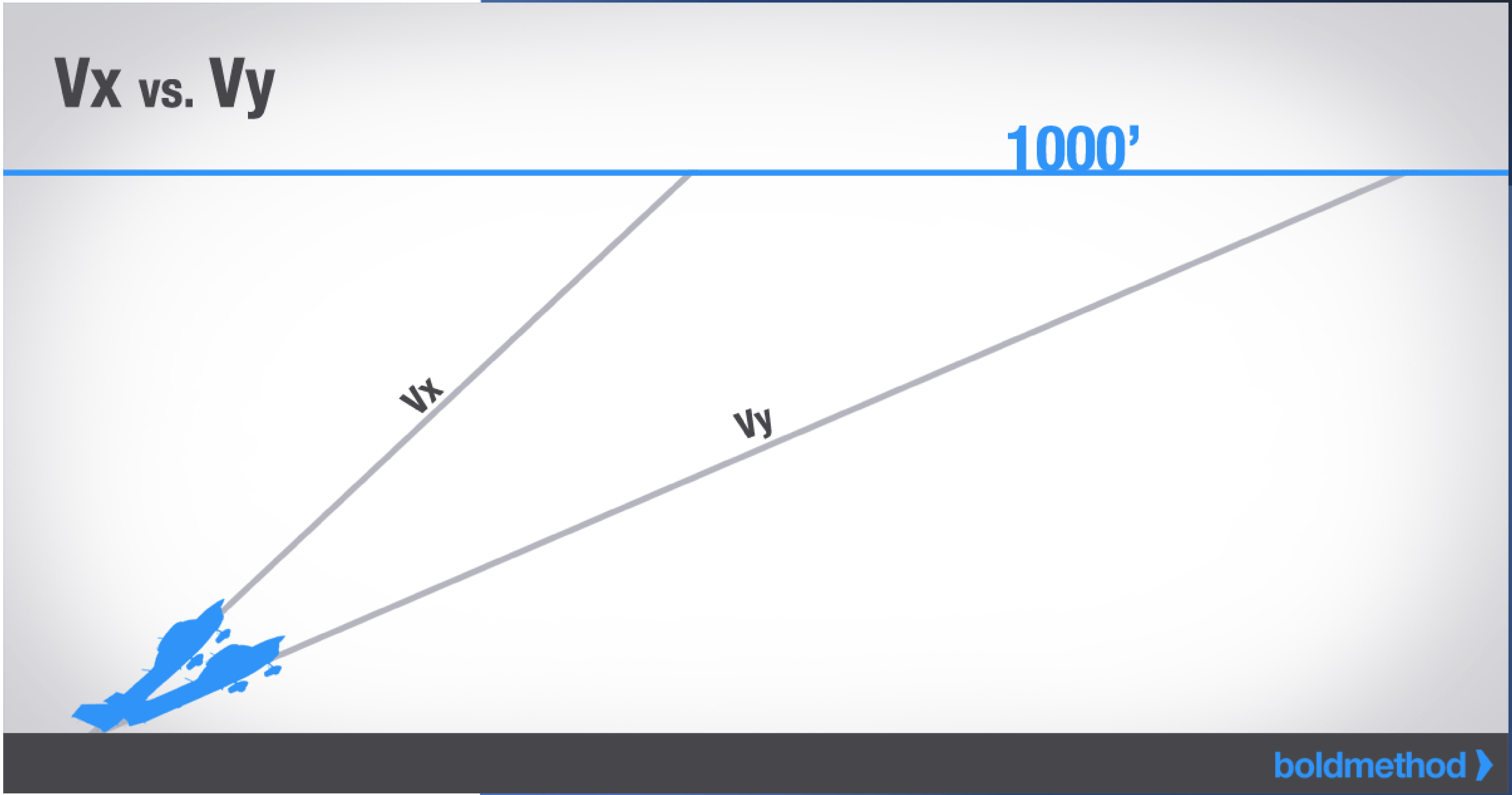
Vy is the airspeed for the best rate of climb.

This airspeed produces the greatest amount of altitude gain over the shortest period of time.

This is the standard speed used.


Best angle-of-climb airspeed (V_X) gives the greatest altitude gain in the shortest horizontal distance.
Best rate-of-climb airspeed (V_Y) gives the greatest altitude gain in the shortest time.


Best angle-of-climb airspeed (V_x) gives the greatest altitude gain in the shortest horizontal distance.
Best rate-of-climb airspeed (V_y) gives the greatest altitude gain in the shortest time.


Vx vs. Vy
1000'
Vx
Vy
boldmethod

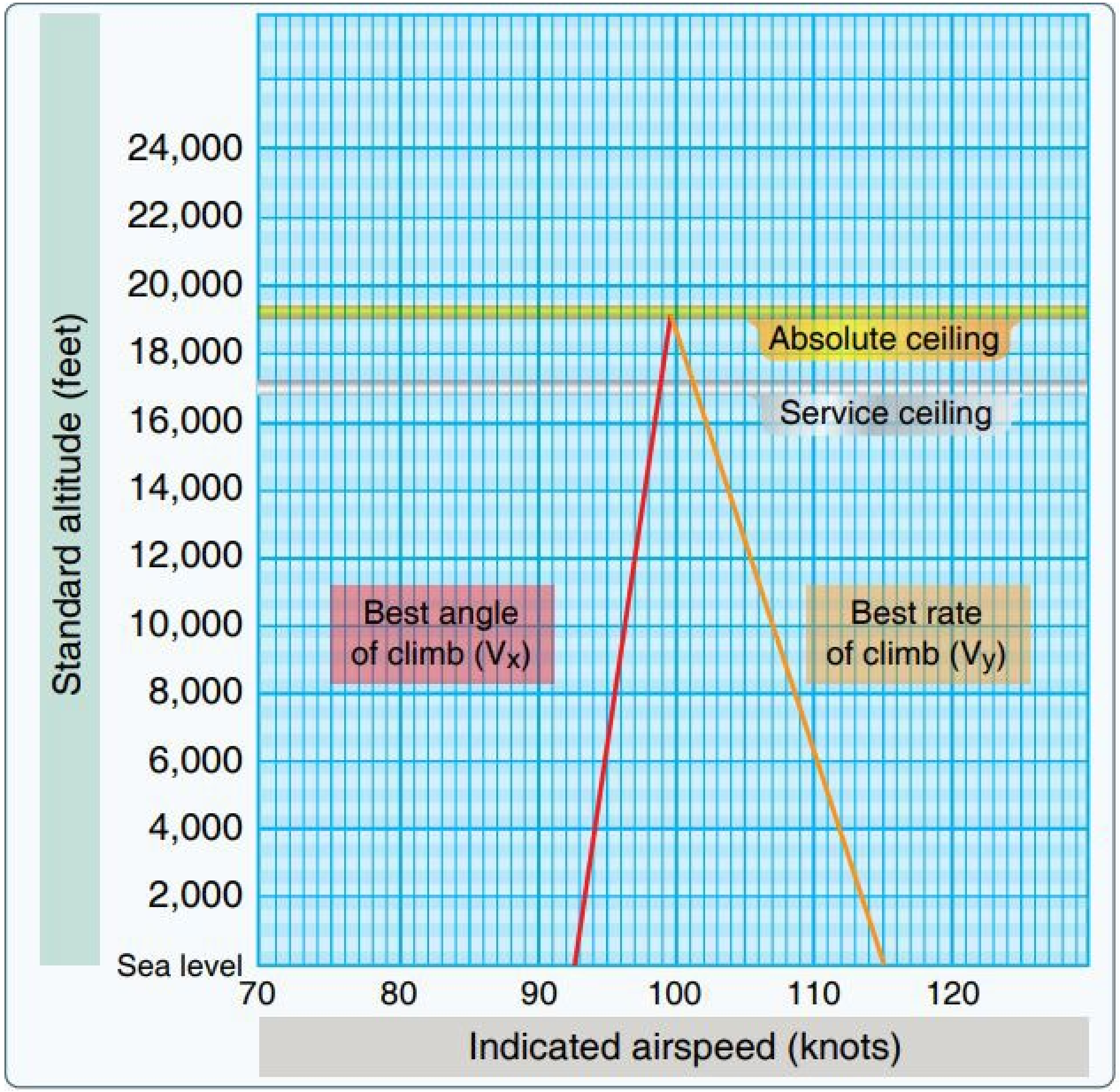
https://youtu.be/m3OiHERMyWM

Maneuvering Speed What is it?

An aircraft's maneuvering speed (Va) is the maximum speed at which it can fully deflect its flight controls without damaging its structure.

If an aircraft is flying at or below its Va, it will stall before the structure is damaged if the pilot makes a full deflection of a flight control, such as the elevator or rudder.

However, some flight control inputs, like a rapid rudder reversal, can cause damage even at speeds below Va.



Standard altitude (feet)
24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
Sea level
Absolute ceiling
Service ceiling
Best angle of climb (V_X)
Best rate of climb (V_Y)
70
80
90
100
110
120
Indicated airspeed (knots)

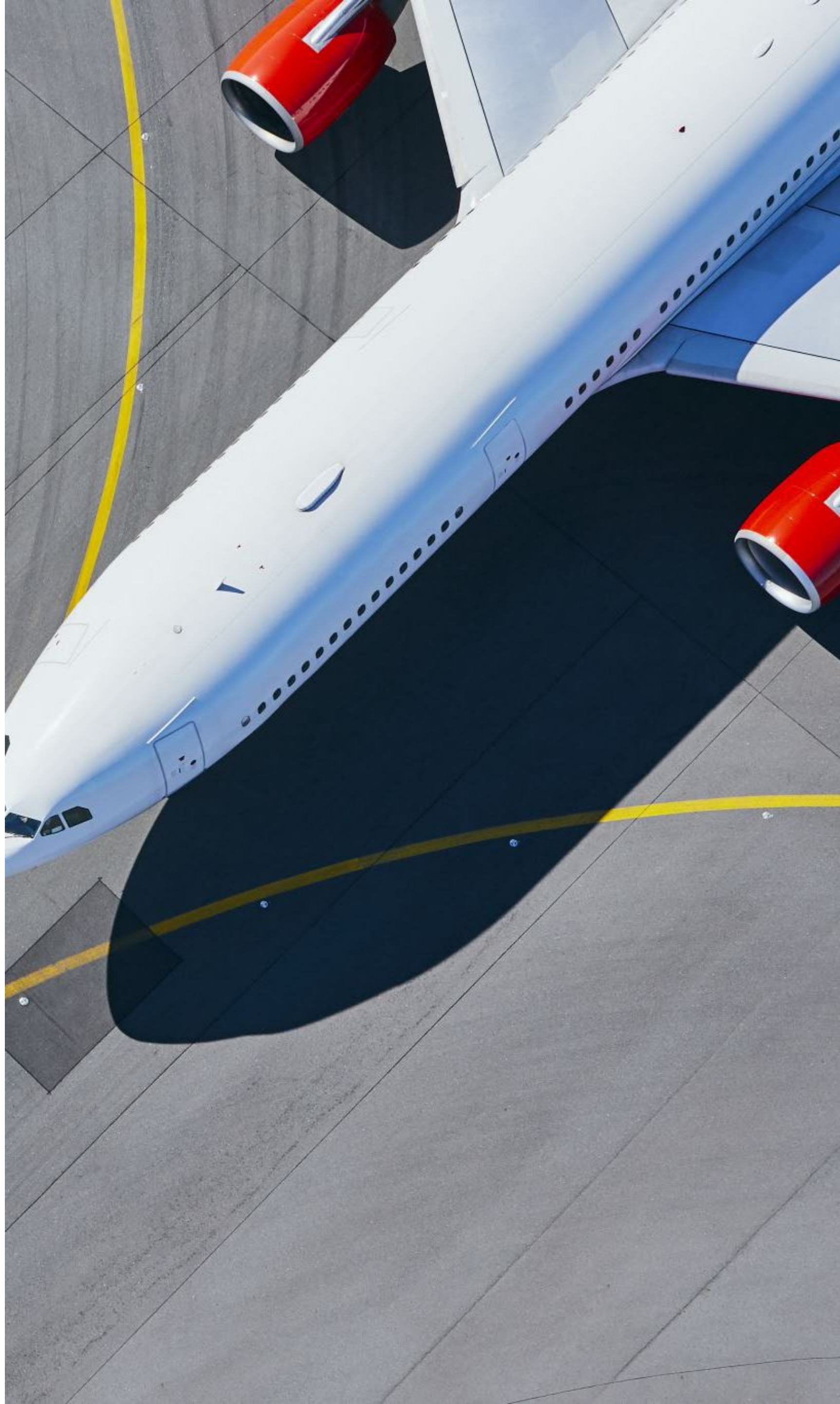
Relationship Of Weight And Maneuvering Speed

When your aircraft is certified, its maneuvering speed is determined at maximum gross weight.

As your aircraft gets lighter, your maneuvering speed gets slower.

Instead of thinking about the relationship between Va and weight, let's add a step between the two:

Increased Weight → Increases AOA → Increases Va

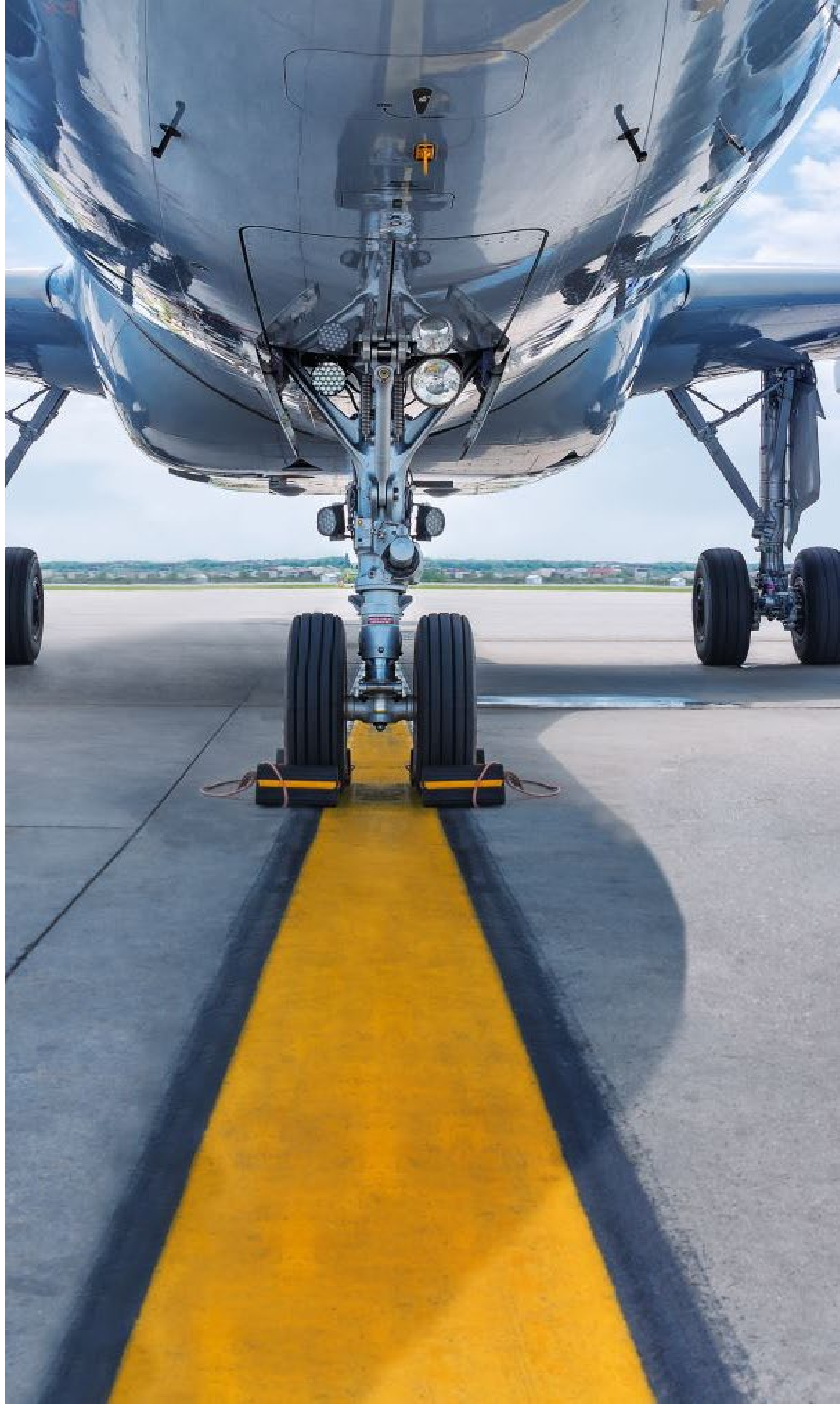


Relationship Of Weight And Maneuvering Speed

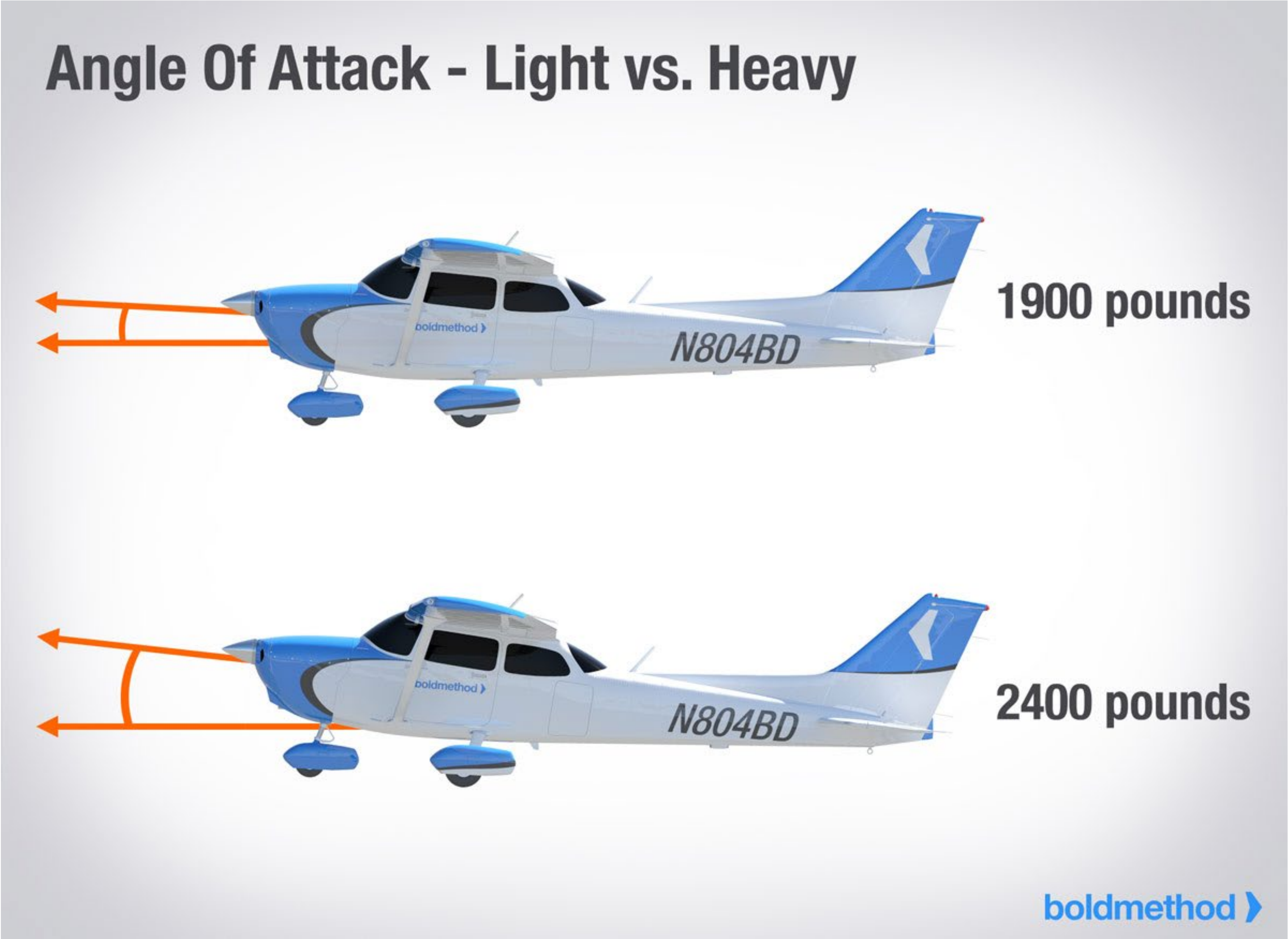
Aircraft weight affects the Angle of Attack (AOA) you fly at to maintain level flight.

While a lower weight might only require one or two degrees of nose-up pitch to maintain level flight, a heavier aircraft might require a few more degrees of pitch up to stay level, assuming the aircraft's speed and configuration remain the same.

This is because, at the same speed and configuration, a heavier aircraft needs to fly at a higher angle of attack to produce enough lift to counter the aircraft's weight in level flight.



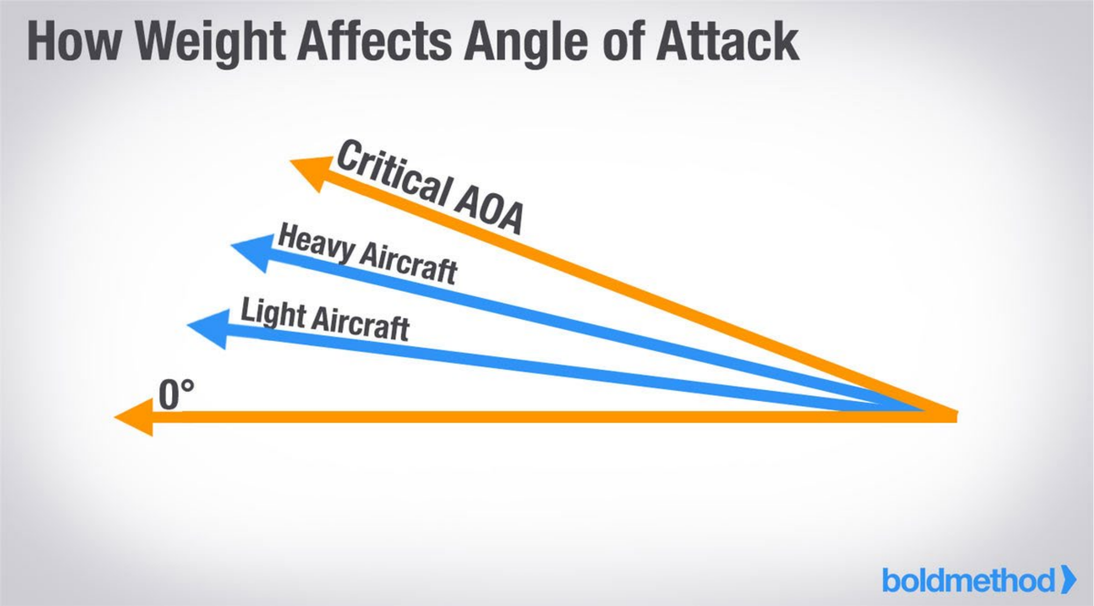
Relationship Of Weight And Maneuvering Speed



AOA

With a heavier aircraft, your AOA in cruise is closer to the critical AOA, causing you to stall at a faster airspeed.

A lighter aircraft will have more degrees of AOA to increase before it encounters the critical AOA, causing you to stall at a lower airspeed.



More about Maneuvering Speed

Airplanes flown at weights below their gross weight require less lift for straight and level flight.

Less lift means the airplane can be flown at a smaller angle of attack.

In other words, an airplane at 2,500 pounds may require a 4.5 degree angle of attack at 110 knots to remain in level flight.

Decreasing the weight to 1,800 pounds may require only a 3 degree angle of attack to remain in level flight at this speed.

More about Maneuvering Speed

With a speed of 110 knots, at this lower weight, a sudden and very strong gust could increase the angle of attack from 3 to 18 degrees.

From our previous example, this produces six times the original lift for a force of 6 Gs.

This is way beyond the limit of a normal category airplane.

At lighter weights, what can we do to keep from exceeding our example limit of 4 Gs when in turbulence?

More about Maneuvering Speed

The answer is to slow the airplane down.

At a slower speed (95 knots for example) a larger angle of attack (let’s say 4.5 degrees) is necessary for level cruise flight at this lower weight.

At this speed, we can increase the angle of attack four times before the airplane stalls.

Ninety-five knots becomes our new maneuvering speed if we want to limit ourselves to 4 Gs.

Thus, decreasing weight requires a decrease in the airplane’s maneuvering speed.

Average Ground Speed

Use distance in cruise…as climbs would throw it off

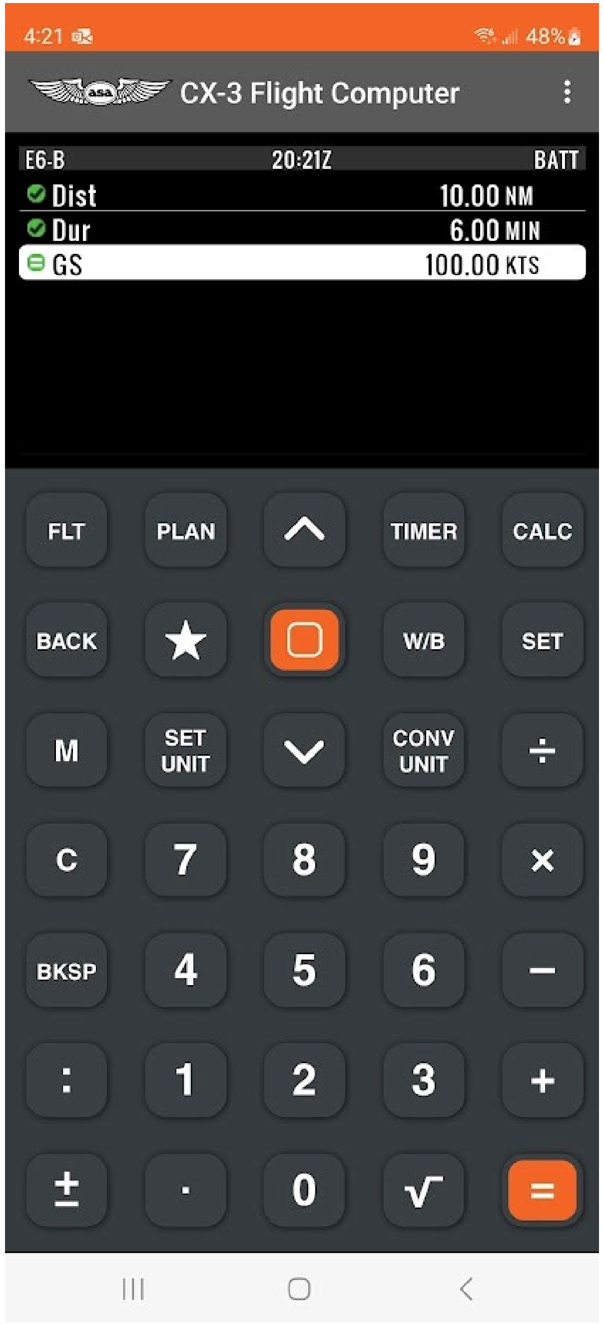
Avg Ground Speed = Distance Traveled / Time in Minutes * 60

Example

10 NM / 6 minutes * 60 = 100 kts

This can be done with a simple phone calculator

Average Ground Speed



DMMS

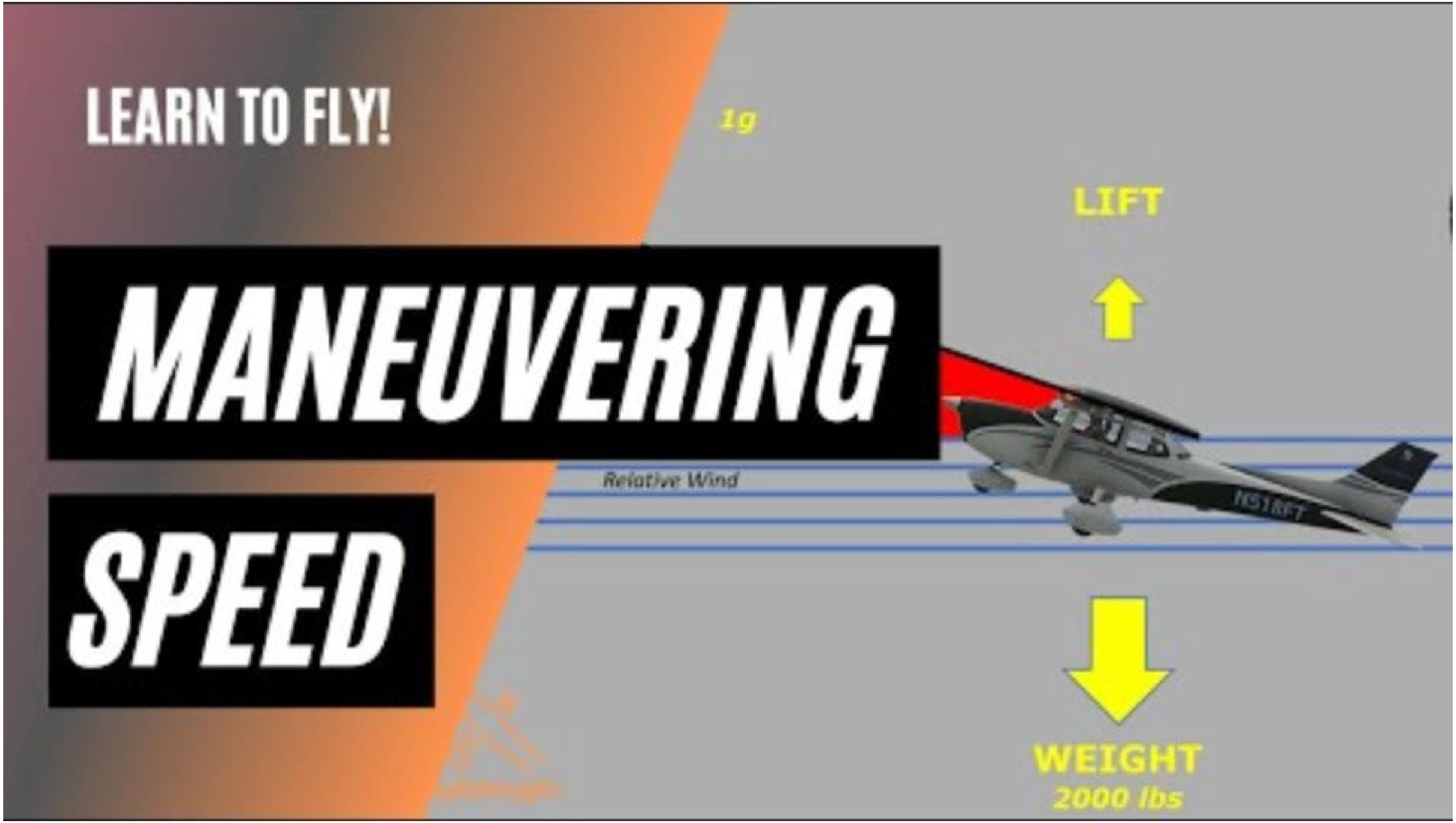
DMMS is Defined Minimum Maneuvering Speed.

The speed below which you should not be banking to avoid a stall while airspeed is low. It is an additional safety factor to remember to avoid excessive banking when the airspeed is low.

1.404 times Vs1 stall speed with flaps up.

https://youtu.be/1YRqbXeeMiE

https://youtu.be/Hv0NoDaOPEM



Any questions I can answer or follow up later on?

Flight Instruments
Six Pack Style

Lesson Objective

To develop understanding of the six pack.

When you are in the brown…you are going down.

Who had to figure out that Vne would break the plane?

The Layout

<u>Top row left to right</u>

Airspeed indicator (ASI)

Attitude Indicator (AI)

Altimeter (Alt)

<u>Bottom row left to right</u>

Turn Coordinator (TC)

Heading Indicator (HI)

Vertical Speed Indicator (VSI)

Airspeed Indicator

Airspeed indicators in many Light and Recreational aircraft can only show the pilot Indicated Airspeed (IAS).

For planes with newer avionics, they can also show True Airspeed (TAS).

Airspeed Indicator markings use a set of standardized colored bands and lines on the face of the instrument.

The white range is the normal range of operating speeds for the aircraft with the flaps extended as for landing or takeoff.

The green range is the normal range of operating speeds for the aircraft without flaps extended.

The yellow range is the range in which the aircraft may be operated in smooth air, and then only with caution to avoid abrupt control movement.

A redline mark indicates VNE, or velocity (never exceed).

Airspeed Indicator

See Lesson on Types of Speeds for more detail.

White arc = Vso (stall speed with full flaps) to Vfe (flaps extended max)

Green arc = Vs1 (crusing stall speed) to Vno (max cruising speed)

Yellow arc = Vno (max cruising speed) to Vne (never exceed speed)

Above the Red line = crash

Attitude Indicator

An attitude indicator (AI), also known as gyro horizon or artificial horizon is an instrument used in an aircraft to inform the pilot of the orientation of the aircraft relative to Earth's horizon.

It indicates pitch and bank.

It is a primary instrument for flight in instrument meteorological conditions.

Attitude Indicator

The essential components of the indicator are:

- The "miniature airplane", horizontal lines with a dot between them representing the actual wings and nose of the aircraft.

- The center horizon bar separating the two halves of the display, with the top half usually blue in color to represent sky and the bottom half usually dark to represent earth.

-The degree indices marking the bank angle. They run along the edge of the dial. On a typical indicator, there is a zero angle of bank index, there may be 10 and 20 degree indices, with additional indices at 30, 60 and 90 degrees.

Altimeter

The altimeter simple indicates the height in feel above sea level.

Altitude can be determined based on the measurement of atmospheric pressure.

The greater the altitude, the lower the pressure.

When a barometer is supplied with a nonlinear calibration so as to indicate altitude, the instrument is called a pressure altimeter or barometric altimeter.

Altimeter Setting

You must be cautious and keep the altimeter setting current to wherever you may be at the time.

Before you taxi out you should listen to the ATIS/AWOS for the current setting and change the altimeter to indicate it.

As you travel, ATC will give you the local setting as you are handed off.

Turn and Slip Indicator

In aviation, the turn and slip indicator (T/S, a.k.a. turn and bank indicator) and the turn coordinator (TC) variant are essentially two aircraft flight instruments in one device.

One indicates the rate of turn, or the rate of change in the aircraft's heading, the other part indicates whether the aircraft is in coordinated flight, showing the slip or skid of the turn.

Turn Coordinators display the rate of turn and roll information, as well as quality and coordination of the turn.

Turn and Slip Indicator

Slipping and skidding within a turn is sometimes referred to as a sloppy turn, due to the perceptive discomfort it can cause to the pilot and passengers.

When the aircraft is in a balanced turn (ball is centered), passengers experience gravity directly in line with their seat (force perpendicular to seat).

With a well-balanced turn, passengers may not even realize the aircraft is turning unless they are viewing objects outside the aircraft.

Magnetic Compass

The magnetic compass is the primary direction indicator in an aircraft, but it is prone to a number of errors due to acceleration and turbulence.

They can also be hard to read especially when the sun is bright, or it is night.

We use a direction indicator based on a gyro.

They are stable, usually accurate, and easy to read.

During preflight and at intervals throughout flight, you will need to adjust the HI to the compass or by looking outside.

Vertical Speed Indicator

The Rate of Climb and Rate of Descent are indicated on the Vertical Speed Indicator (VSI).

This is measured in Feet Per Minute, and displayed in Hundreds of FPM.

The pilot relies on both the Altimeter and the Vertical Speed Indicator to monitor altitude and altitude changes.

At a glance, the VSI shows the pilot if they are flying at a steady altitude, or if they are ascending or descending, and the rate at which their altitude is changing in feet per minute.

Vertical Speed Indicator

When you initially start climbing or descending, your VSI needle will start moving, but it can't immediately indicate how fast you're climbing.

This is what's called trend information.

When you see the directing of the needle moving up, you know your climb rate is increasing, and when it moves down, you know your climb rate is decreasing. You just don't know how much...at least yet.

G1000

The Six Pack is in a reinvented format

It is great to have all the info we do but you have to learn to deal with info overload

You must learn what to focus on at critical times

Any questions I can answer or follow up later on?

Degrees Compasses and Heading Indicators

Lesson Objective

To develop understanding of degrees, compasses, and heading indicators.

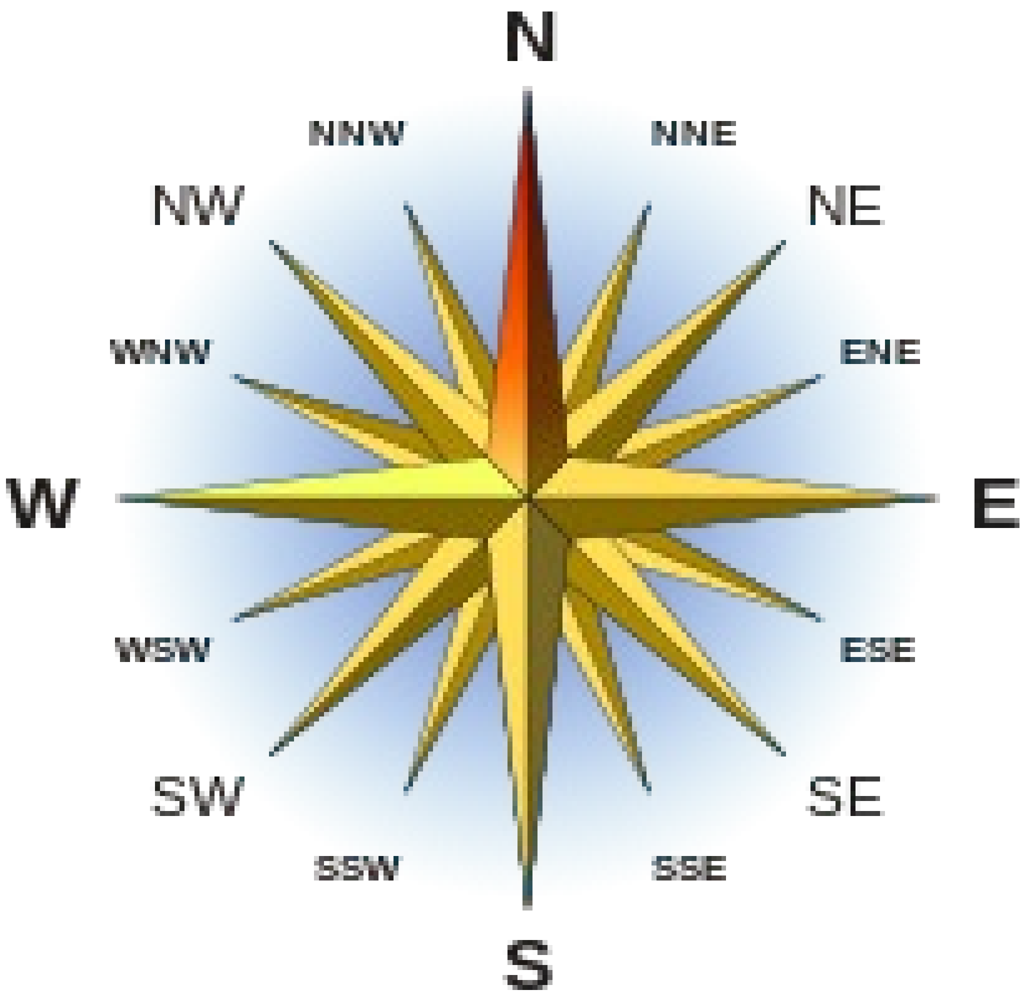
Turn to ‘two six zero’.

Points

There are four cardinal points on a compass - North, South, East, and West.

When reading a compass, and telling other people directions, you need to wipe "right" and "left" out of your vocabulary.

Right and Left are relative directions and differ depending on your location and direction, but the cardinal points are constant.



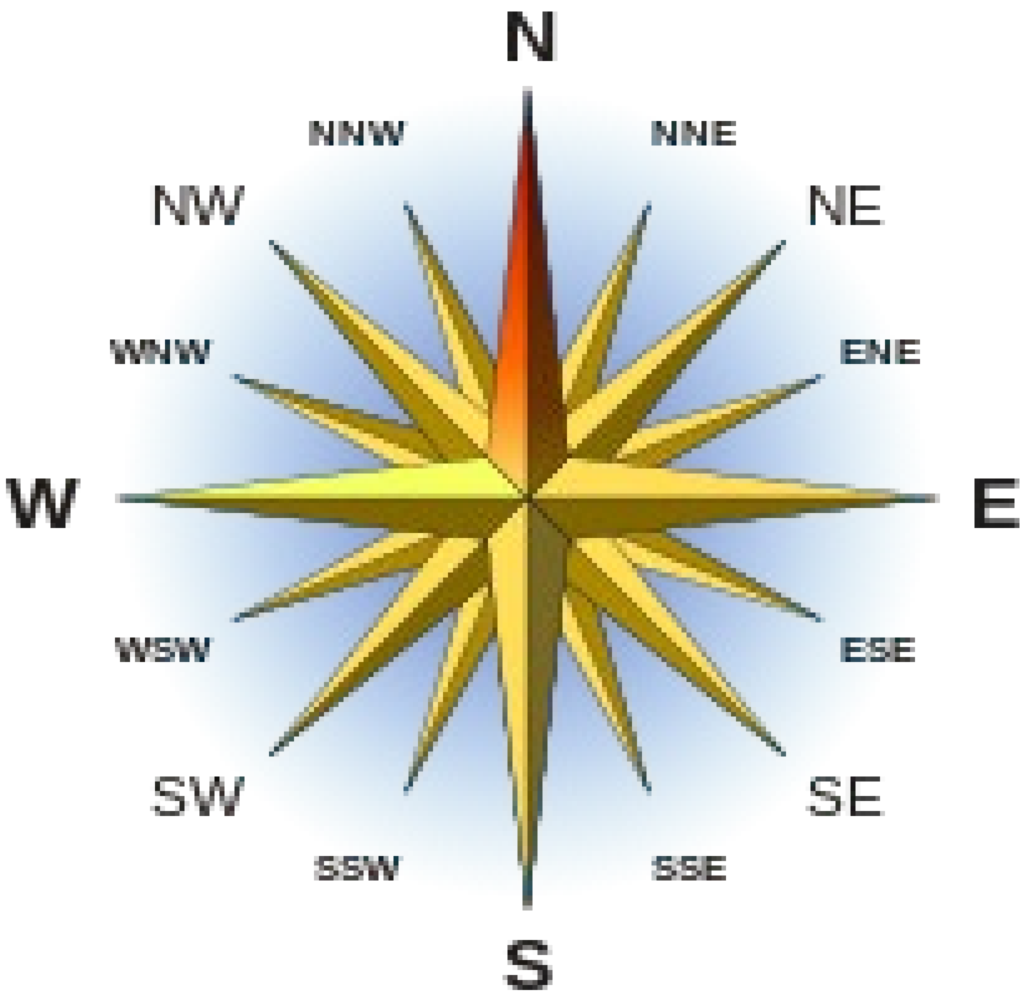
More

The direction halfway between North and East is an intercardinal point and is called NorthEast. The other three intercardinal points are SouthEast, SouthWest, and NorthWest.

Finally, there are secondary intercardinal points halfway between each cardinal point and intercardinal point. These are North-NorthEast, East-NorthEast, East-SouthEast, South-SouthEast, and so on.

With these directions, you can give someone a fairly good idea of what direction they need to go.

We could add additional points, continuing to break each section in half over and over, but this would get confusing fast.



Degrees

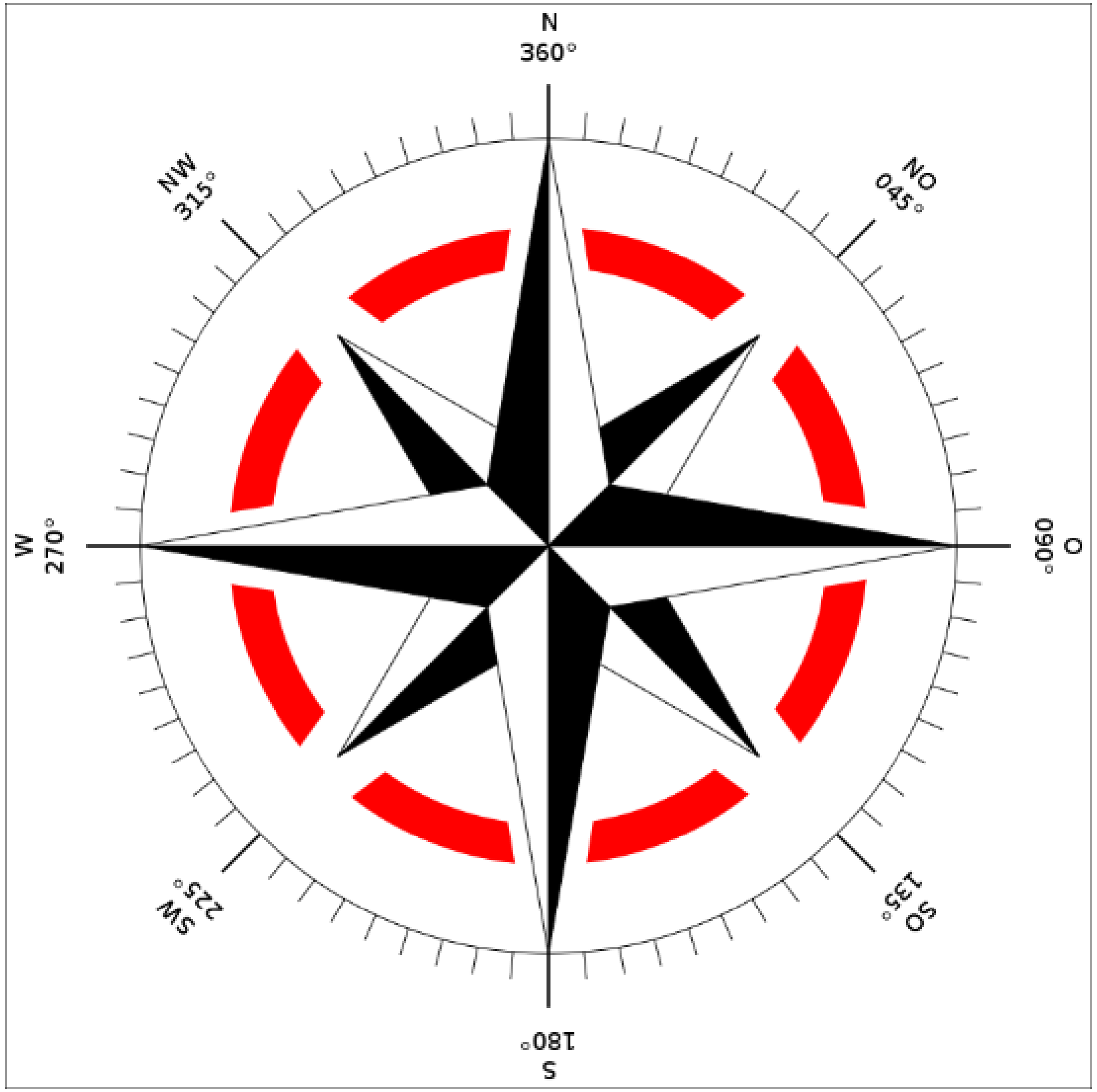
A compass divided into 360 degrees is the most common unit of measurement.

North is at 0 degrees and 360 degrees

East is 90 degrees

South is 180 degrees

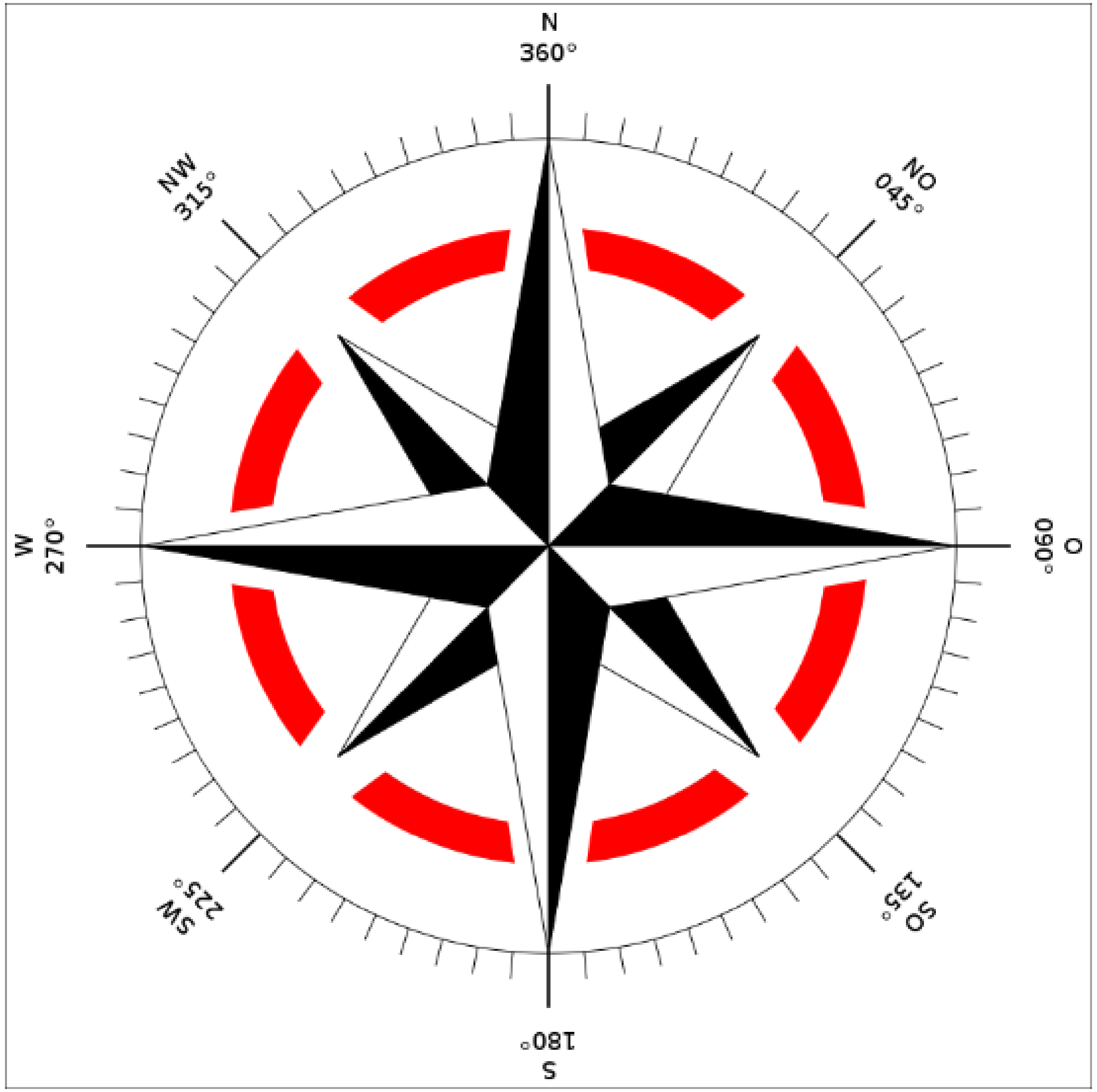
West is 270 degrees.



Degrees

Each degree is divided into 60 minutes, each minute into 60 seconds.

A handheld compass is not able to measure down to a minute, let alone a second, but those units are used for precise locations using latitude and longitude.



Magnetic Compass

You will find a magnetic compass on top of the dashboard of the aircraft or mounted at the top of the front window.

You would think that the more expensive instruments in the dash would be more accurate but usually you adjust other instruments based on this.

Magnetic Compass

The magnetic compass is the most familiar compass type.

The compass functions as a pointer to "magnetic north", the magnetic meridian, because the magnetized needle at its heart aligns itself with the horizontal component of the Earth's magnetic field.

The magnetic field exerts a torque on the needle, pulling the North end or pole of the needle approximately toward the Earth's North magnetic pole, and pulling the other toward the Earth's South magnetic pole.

Types of North – Magnetic North

Magnetic North = A compass needle points to the magnetic north pole.

The magnetic north pole is currently located in the Baffin Island region of Canada, and from the UK, is west of true north.

The horizontal angular difference between True North and Magnetic North is called magnetic variation/declination.

Types of North – True North

True North = Each day the Earth rotates about its axis once.

The ends of the axes are the True North and South poles.

True North on a map is the direction of a line of longitude which converges on the North Pole.

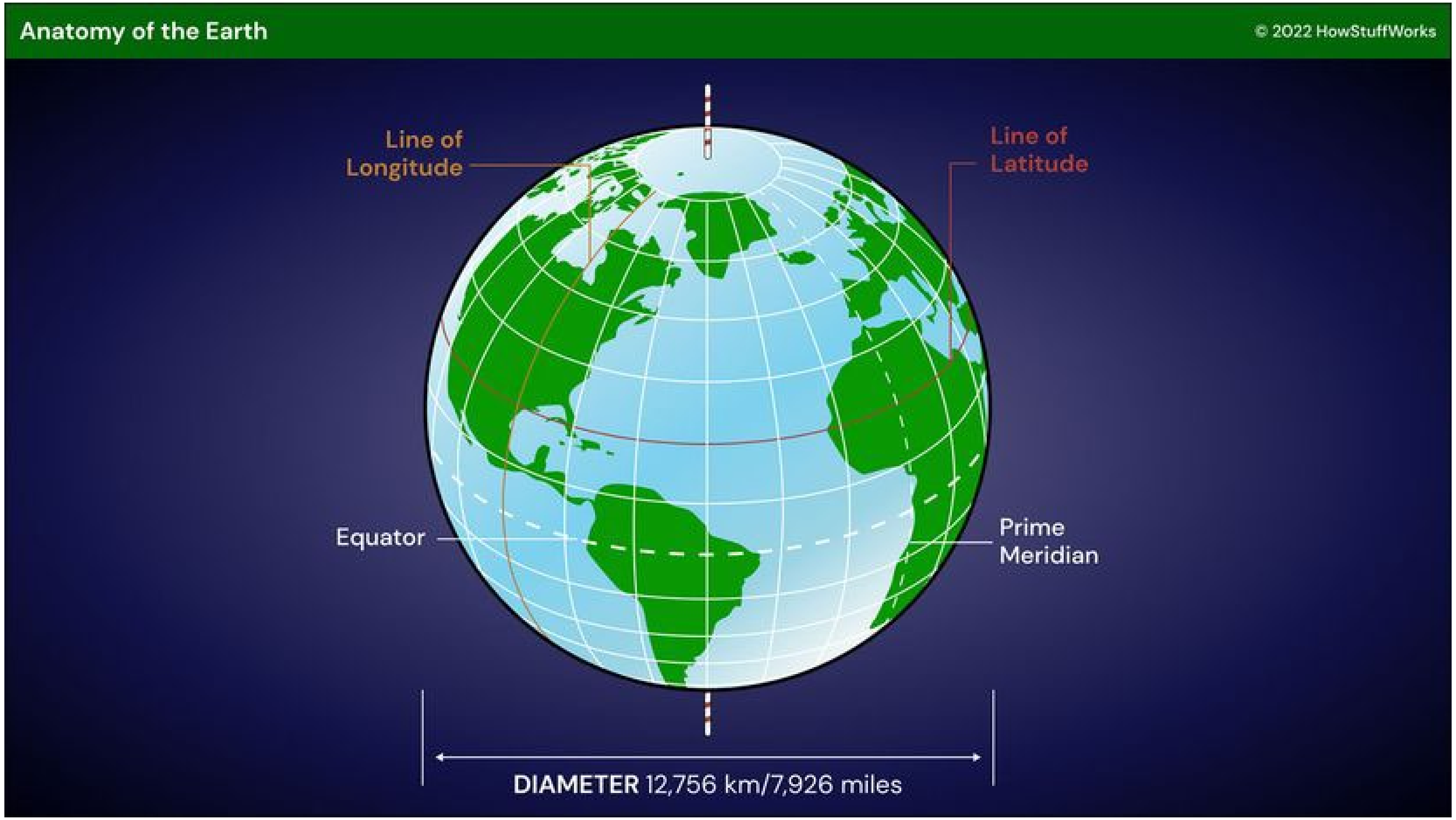
Think of a globe that spins.

True vs Magnetic

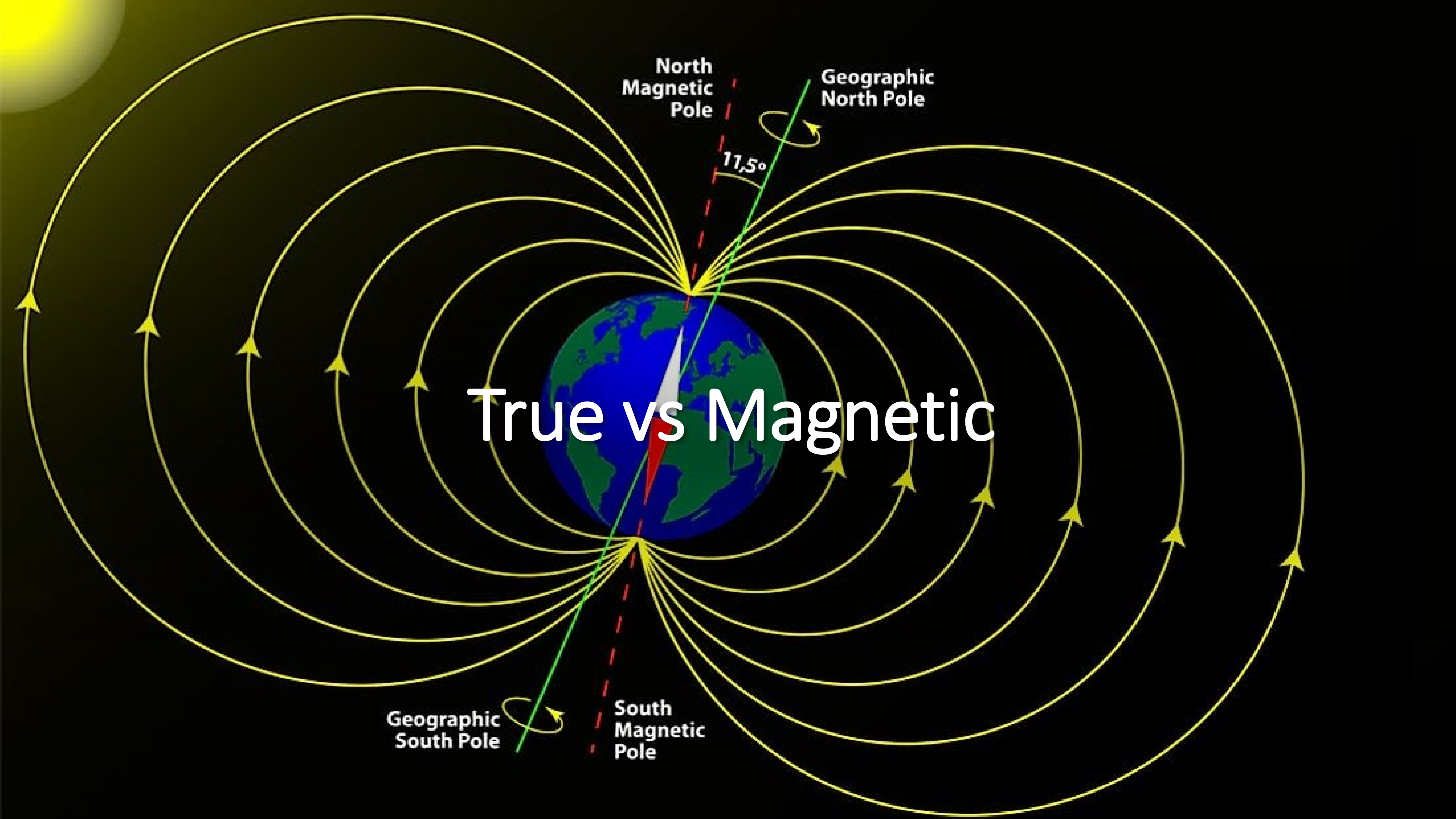
Magnetic declination, or magnetic variation, is the angle on the horizontal plane between magnetic north (the direction the north end of a magnetized compass needle points, corresponding to the direction of the Earth's magnetic field lines) and true north (the direction along a meridian towards the geographic North Pole).

This angle varies depending on position on the Earth's surface and changes over time.

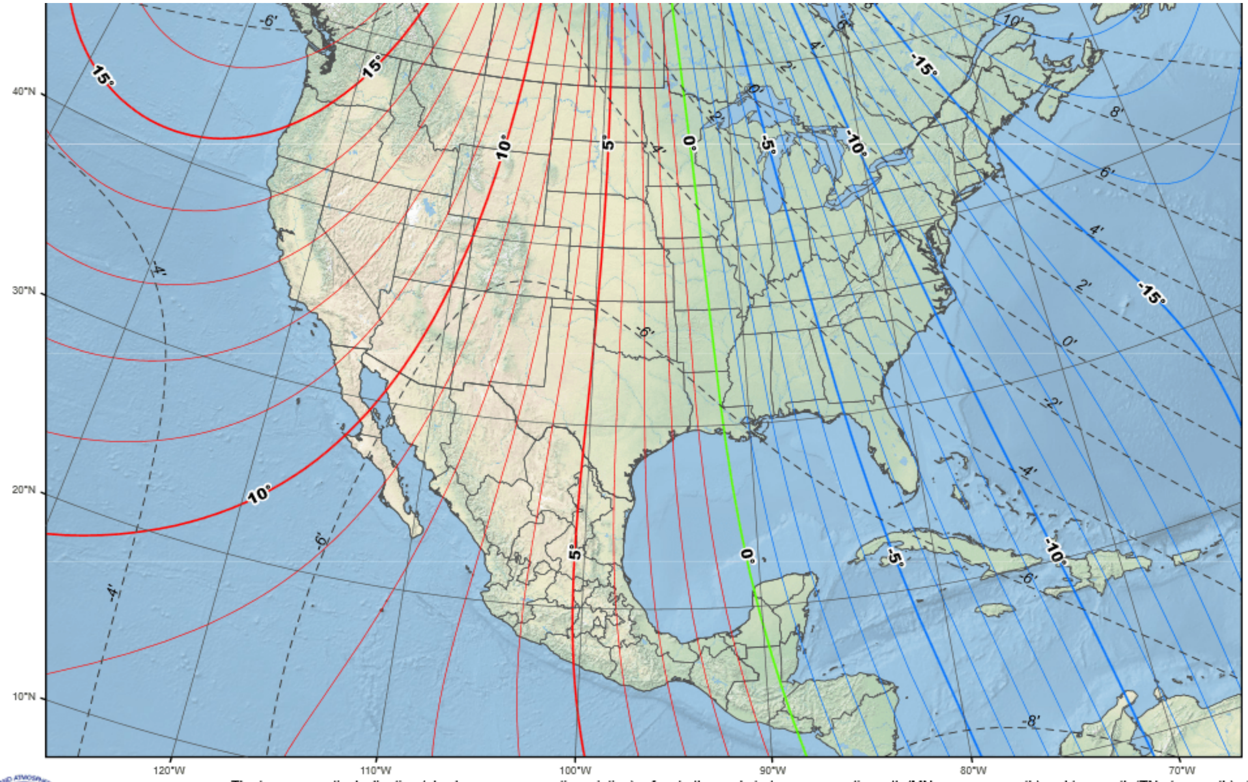
True vs Magnetic



True vs Magnetic



True vs Magnetic



The term magnetic declination (also known as magnetic variation) refers to the angle between magnetic north (MN - compass north) and true north (TN - true north) at any given latitude/longitude. The **green** contour line shows the imaginary line along which the declination is zero (MN and TN converge). The magnetic declination increases as one moves east or west from this line. **Red lines** show positive (east) declination contours and **blue lines** show negative (west) declination contours. The degrees of declination required to orient the compass with the map are **added east** of this line and **subtracted west** of this line (e.g. 10° east would indicate that MN lies 10° degrees clockwise from TN). Magnetic declination gradually changes with time and location. The dashed gray lines show the expected annual change in the magnetic declination in arc-minutes per year (there are 60 arc-minutes per degree). The above map was produced from the World Magnetic Model (WMM 2020) for the year 2020.

Magnetic Heading

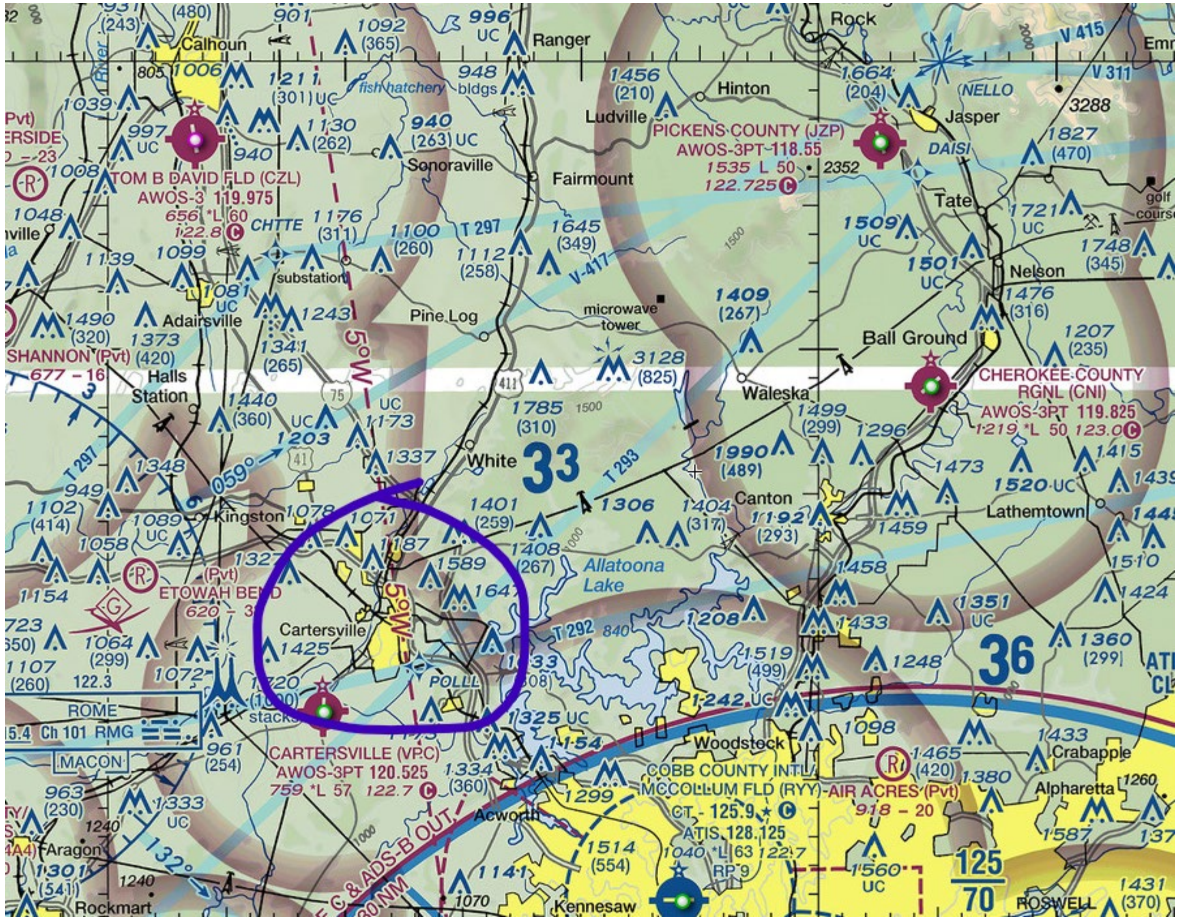
We plan for True Course, but we need to use magnetic heading to vector the plane

Magnetic Heading = True Heading + Variation + Deviation

KJZP -> KAHN

MH = 131.36 + 5 – 1 = 135.4

(deviation example for a particular 172 I used before)



Types of North – Grid North

Grid North = The grid lines on Ordnance Survey maps divide the UK into one kilometer squares, east of an imaginary zero point in the Atlantic Ocean, west of Cornwall.

The grid lines point to a Grid North, varying slightly from True North.

The difference between grid north and true north is very small and for most navigation purposes can almost always be ignored.

Heading Indicator

The heading indicator is a flight instrument used in an aircraft to inform the pilot of the aircraft's heading.

It is sometimes referred to by its older names, the directional gyro or DG, and also direction indicator or DI.

They can’t fit 180, 210, etc so you will just see S, 21, etc.

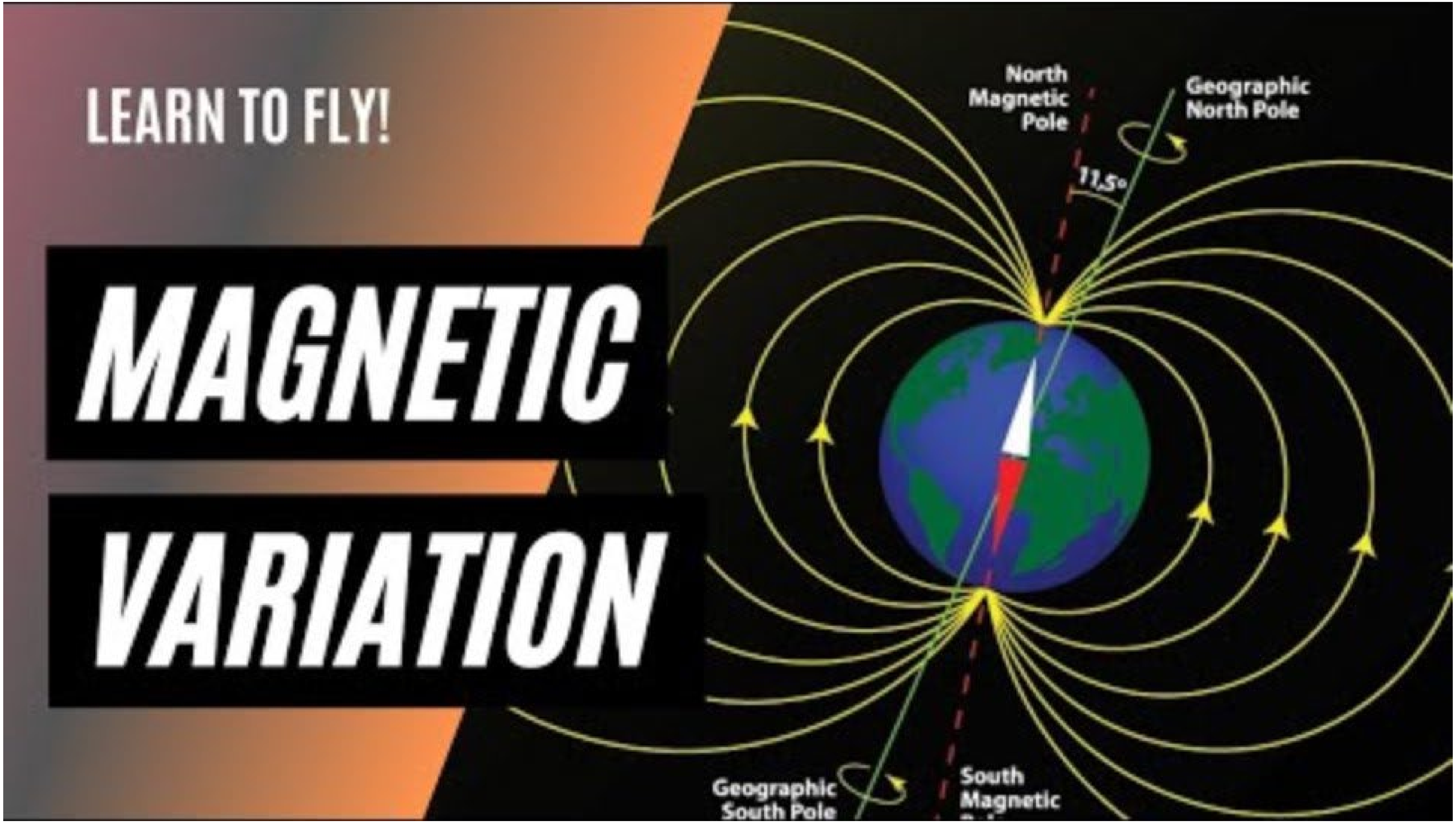
Heading Indicator

The primary means of establishing the heading in most small aircraft is the magnetic compass, which, however, suffers from several types of errors, including that created by the "dip" or downward slope of the Earth's magnetic field.

To remedy this, the pilot will typically maneuver the airplane with reference to the heading indicator, as the gyroscopic heading indicator is unaffected by dip and acceleration errors.

The pilot will periodically reset the heading indicator to the heading shown on the magnetic compass.

https://youtu.be/DiqFY3Nk9iw



Any questions I can answer or follow up later on?

CANADA
BEAUFORT SEA
EAST SIBERIAN SEA
ARCTIC OCEAN
Banks Island
Victoria Island
New Siberian Islands (RUSSIA)
LAPTEV SEA
Tiksi
RUSSIA
1831
1904
1948
1962
1973
1984
1994
2001
2007
2017
North Magnetic Pole
Queen Elizabeth Islands (CANADA)
Geographic North Pole
North Geomagnetic Pole
Alert
Qaanaaq (Thule)
Severnaya Zemlya (RUSSIA)
Dikson
KARA SEA
Baffin Island
Baffin Bay
WANDEL SEA
Station Nord
Franz Josef Land (RUSSIA)
Fram Strait
Novaya Zemlya (RUSSIA)
GREENLAND (DENMARK)
Longyearbyen
Svalbard (NORWAY)
BARENTS SEA
GREENLAND SEA
Davis Strait
Arctic Circle
90 W
90 E

Compass and Instrument Errors

Lesson Objective

To develop understanding of compass and instrument errors.

Why does it show me climbing? I didn’t try to climb.

In General

Despite that we need to put supreme trust in our instruments we must be aware that they will not be perfect every second of flight.

We need to know what to look for.

Airspeed Changes Show Climbs and Descents

Airspeed ↑ => attitude indicator shows <u>climb</u>

Airspeed ↓ => attitude indicator shows <u>descent</u>

Deviation

The difference between the direction indicated by a magnetic compass not installed in an airplane and one installed in an airplane is called compass deviation.

Magnetic fields produced by metals and electrical accessories in the airplane disturb the compass needles.

Deviation varies for different headings of the same aircraft.

Deviation

Not long ago in my plane I went to adjust the heading indicator.

I was confused as to why the actual compass was not pointing south but I knew 100% the plane was.

I took my ipad off the dashboard and it spun towards south.

Acceleration and Deceleration

If heading west or east in the northern hemisphere.

ANDS = Accelerate North Decelerate South

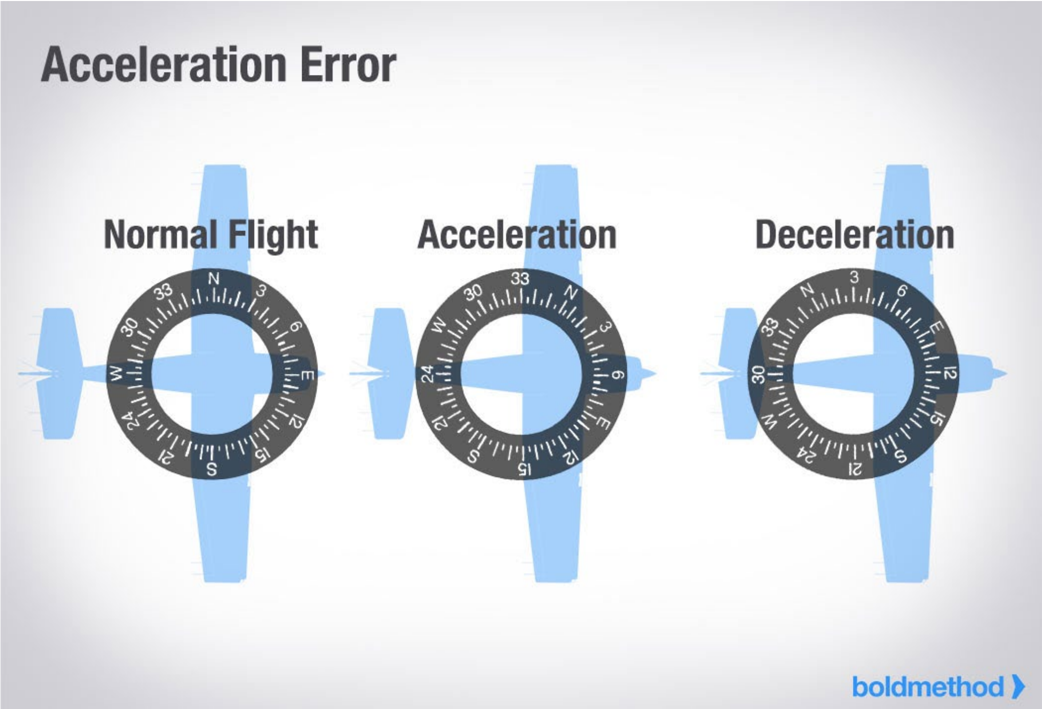
A magnetic compass will indicate a turn toward the north during acceleration going E/W.

=> Airspeed ↑ shows North

A magnetic compass will indicate a turn toward the south during deceleration going E/W.

=> Airspeed ↓ shows South

It does not occur when heading north or south.



Turning Away

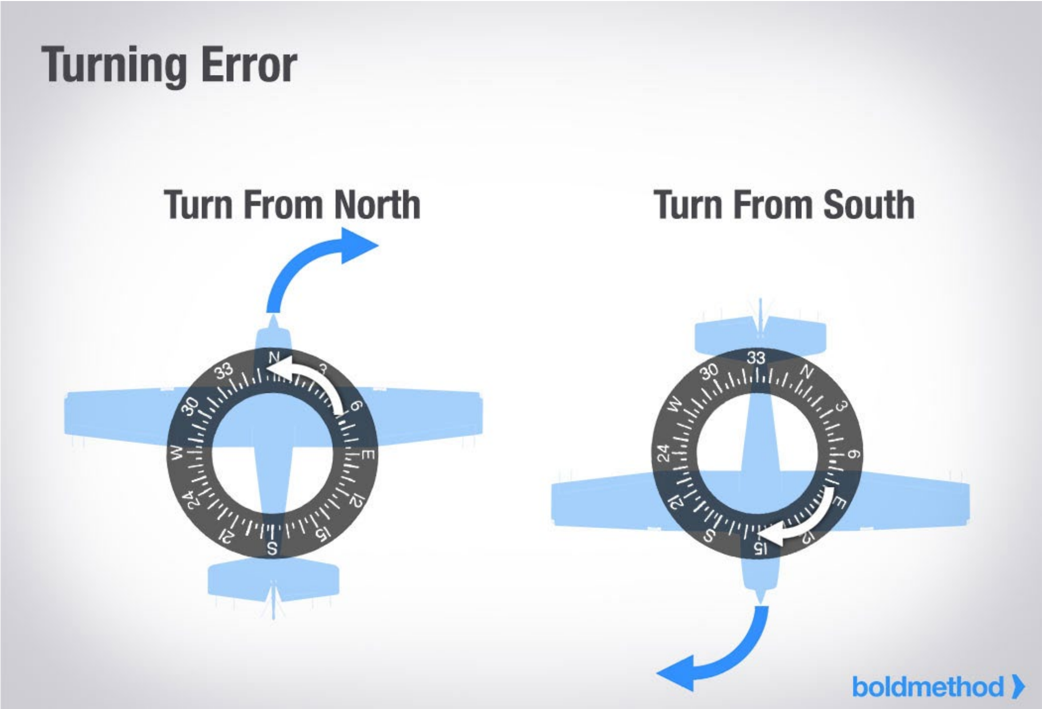
Occurs when turning **away** from a north or south heading.

When turning from a northerly heading the magnetic compass indicates a turn in the other direction. Heading north when turning heading indicator lags.

When turning from a southerly heading the magnetic compass indicates the turn but at a faster rate than is occurring. Heading south when turning heading indicator precedes.

NOSE = North Opposite South Exaggerated

When heading east or west it is accurate



Turning Towards

UNOS = Undershoot North Overshoot South

Undershoot or overshoot by rough latitude

<u>Examples</u>

Turning from West to North

→ aim for 330 (360-30)

Turning from West to South

→ aim for 150 (180+30)

At the equator, turning errors would be negligible

Any questions I can answer or follow up later on?