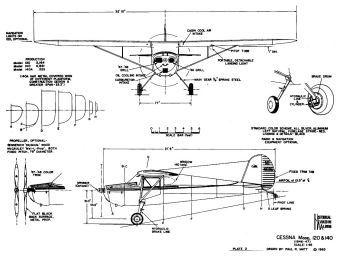
GROUND SCHOOL

AIRCRAFT GENERAL KNOWLEDGE 5



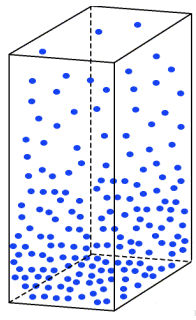
GROUND SCHOOL

LECTURE FIVE: INSTRUMENTATION

1. Altimeter
2. Vertical Speed Indicator
3. Airspeed Indicator
4. Magnetic Compass

GROUND SCHOOL

INSTRUMENTS: ALTIMETER



The force exerted by the molecules in the air on a unit of surface area is ATMOSPHERIC PRESSURE

The nearer the earth's surface, the more air molecules are pressing down from above

Atmospheric pressure, therefore, INCREASES with a DECREASE in altitude

An aircraft at 3000 feet is experiencing less atmospheric pressure than one at 1000 feet.

The rule of thumb: For every 30 feet gained in altitude the pressure drops by 1 hPa

INSTRUMENTS: ALTIMETER

GROUND SCHOOL

Displays vertical displacement from the pressure datum set

Uses Static Pressure only

Basically a barometer with a scale in feet

INSTRUMENTS: ALTIMETER

GROUND SCHOOL

Indicates 10,000s of feet

Hatching shows aircraft is below 10,000 feet

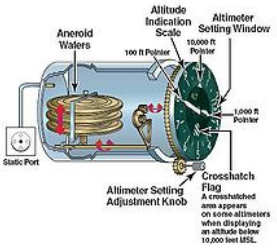
Altimeter subscale (here shows US format of inches, we have hPa in UK/Europe)

Short pointer shows 1000s of feet

Long pointer shows 100s of feet

INSTRUMENTS: ALTIMETER

GROUND SCHOOL



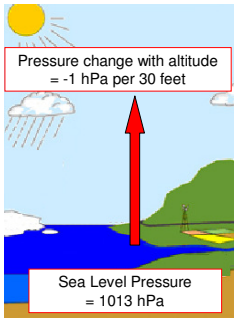
As aircraft climbs, atmospheric pressure drops and capsule expands

This is because the pressure inside the case is less than the pressure inside the capsule and so allows the expansion to occur

As aircraft descends, atmospheric pressure increases and capsule compresses

INSTRUMENTS: ALTIMETER: ISA

GROUND SCHOOL



All altimeters are calibrated to the International Standard Atmosphere (ISA)

More details in the Meterorology lectures!

INSTRUMENTS: ALTIMETER: ERRORS

GROUND SCHOOL

INSTRUMENT ERROR

Known errors caused by manufacture of the instrument

INSTRUMENT LAG

Rapid pressure changes will be displayed with a slight lag while capsule expands / contracts

POSITION ERROR

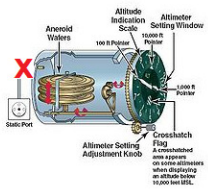
Caused by poor siting of the static port (reduced in aircraft with two static ports)

BLOCKAGES OF THE STATIC PORT

Caused by ice / insects / sticky tape over the static port

INSTRUMENTS: ALTIMETER: ERRORS

GROUND SCHOOL



STATIC BLOCKED, AIRCRAFT CLIMBS

Pressure inside case should decrease but it will not – all inputs will stay the same

STATIC BLOCKED, AIRCRAFT DESCENDS

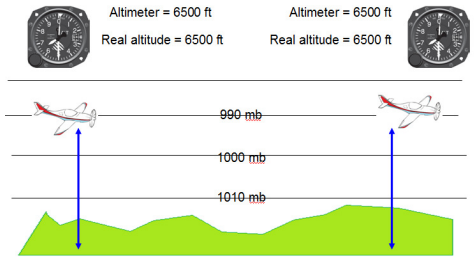
Pressure inside case should increase but it will not – all inputs will stay the same

PUD SOD

If the static vent is blocked, the altimeter will continue to read the altitude indicated when the blockage occurred

INSTRUMENTS: ALTIMETER: PRACTICAL USES

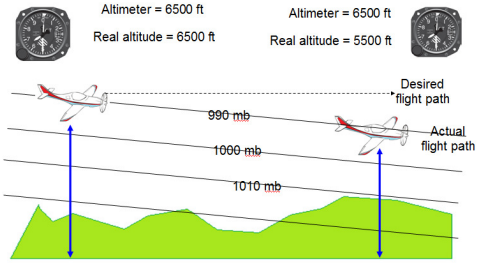
GROUND SCHOOL



Altimeters would be easy if the pressure changes in the atmosphere happened like this

INSTRUMENTS: ALTIMETER: PRACTICAL USES

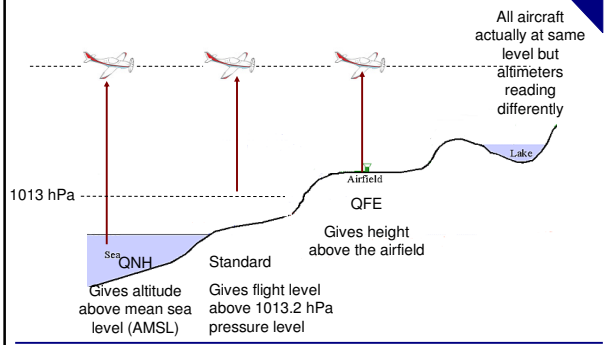
GROUND SCHOOL



This situation is more likely and so it is VITAL that the altimeter is set correctly to the required setting

INSTRUMENTS: ALTIMETER: PRACTICAL USES

GROUND SCHOOL



INSTRUMENTS: VERTICAL SPEED INDICATOR

GROUND SCHOOL

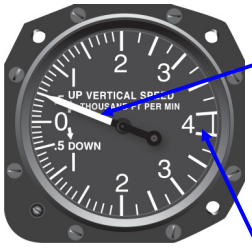
Displays a rate of change indication in 100s or1000s of feet per minute

Uses Static Pressure only

Uses the principle of lag for its operation

INSTRUMENTS: VERTICAL SPEED INDICATOR

GROUND SCHOOL

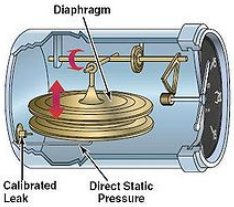


Pointer shows 100s of feet of rate of change

Maximum that can be shown

INSTRUMENTS: VERTICAL SPEED INDICATOR

GROUND SCHOOL



Effectively 2 static inputs – one is direct and one is delayed (or leaked)

AIRCRAFT CLIMBS

New lower pressure is fed immediately into capsule

Lower pressure into case is fed in with a slight delay

Difference in time forces capsule to contract which shows on the dial as a rate of climb and vice versa

INSTRUMENTS: VERTICAL SPEED INDICATOR: ERRORS

GROUND SCHOOL

INSTRUMENT ERROR

Known errors caused by manufacture of the instrument

POSITION ERROR

Caused by poor siting of the static port (reduced in aircraft with two static ports)

BLOCKAGES

If static vent or line becomes blocked, the instrument will sense no pressure differential and so will always indicate zero

INSTRUMENTS: AIRSPEED INDICATOR

GROUND SCHOOL

Displays Indicated Airspeed (IAS)

Uses input from Pitot tube (total pressure)

Uses input from Static Vent (static pressure)

Pitot – Static = Dynamic Pressure

INSTRUMENTS: AIRSPEED INDICATOR

GROUND SCHOOL

VS_0

Stall speed in landing configuration

VS_1

Stall speed in clean configuration

GREEN ARC

Normal operating speed range

WHITE ARC

Flap operation speed range

V_{FE}

Maximum flap extension speed

V_{NE}

Never exceed speed

YELLOW ARC

Cautionary speed range

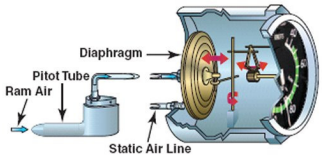
V_{NO}

Maximum structural cruising speed

INSTRUMENTS: AIRSPEED INDICATOR

GROUND SCHOOL

Static pressure is fed into the case of the instrument



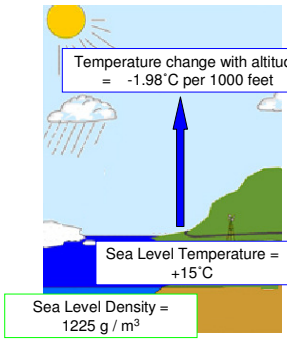
Pitot pressure is fed into the expandable diaphragm

Because the diaphragm has to push against the air inside the case, the 2 static pressures cancel each other out

A series of linkages then transfer this information onto the face of the instrument

INSTRUMENTS: AIRSPEED INDICATOR

GROUND SCHOOL



All airspeed indicators are calibrated to the International Standard Atmosphere (ISA)

More details in the Meterorology lectures!

INSTRUMENTS: AIRSPEED INDICATOR: ERRORS

GROUND SCHOOL

Indicated Airspeed (IAS)

INSTRUMENT ERROR

POSITION ERROR

Calibrated / Rectified Airspeed (CAS / RAS)

DENSITY ERROR

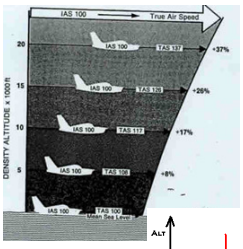
Found in the POH

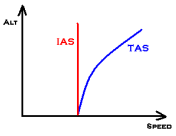
True Airspeed (TAS)

Used for navigation calculations

INSTRUMENTS: AIRSPEED INDICATOR: IAS / TAS

GROUND SCHOOL



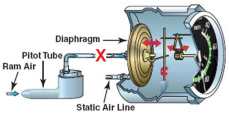


As the aircraft climbs (density decreases) IAS under-reads in relation to TAS

This can be worked out using the CRP 1/5 or on some airspeed indicators

INSTRUMENTS: AIRSPEED INDICATOR: ERRORS

GROUND SCHOOL



BLOCKED PITOT TUBE

No input of pitot pressure so ASI will read zero (or reduce to zero)

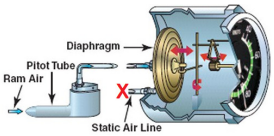
BLOCKED STATIC PORT

Climb

pressure trapped in case will be higher than it should be – difference in pressures is less than it should be – ASI under-reads

Descent

The opposite!



INSTRUMENTS: CHECKS

GROUND SCHOOL

It is VERY important to check the pitot static system instruments prior to flight:

ALTIMETER

Glass should be clear & unbroken
Zero the altimeter
Add on 10 hPa
Altimeter should increase by 280 feet
Subtract 10 hPa from original setting
Altimeter should decrease by 280 feet

VERTICAL SPEED INDICATOR

Glass should be clear & unbroken
Should be indicating zero
As soon as possible after getting airborne, check showing rate of climb

INSTRUMENTS: CHECKS

GROUND SCHOOL

AIRSPEED INDICATOR

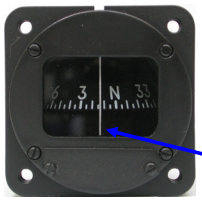
Glass should be clear & unbroken
Should be reading zero
During take-off roll, ensure that indication is being seen

Also ensure on the walk-round that you have checked:

1. Static port is clear and unobstructed
2. Pitot tube is clear and unobstructed
3. Pitot heat works (do not leave heat on for too long on ground – may burn out the element)

INSTRUMENTS: MAGNETIC COMPASS

GROUND SCHOOL



Displays magnetic heading information

Also known as a "direct reading compass"

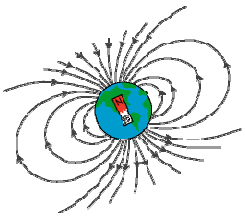
"Lubber" line reads the magnetic heading of the aircraft

Directions are always expressed as a 3-digit grouping to avoid confusion (030°, 300°, 330°, etc."

"north", "south", "east" and "west" also used but now not terms such as "north north west", etc.

INSTRUMENTS: MAGNETIC COMPASS

GROUND SCHOOL



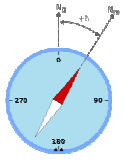
The earth has a magnetic field and acts like a weak magnet

The poles of a magnet are either "north seeking" or "south seeking" – more usually known as north and south poles

A bar magnet which is allowed to float free will automatically align itself with the earth's magnetic field

INSTRUMENTS: MAGNETIC COMPASS

GROUND SCHOOL



The compass shows MAGNETIC north

Maps and charts are aligned to TRUE north

The difference between the two is known as VARIATION

Lines of equal variation are known as ISOGONALS

INSTRUMENTS: MAGNETIC COMPASS

GROUND SCHOOL

The aircraft is made of metal and has lots of radio equipment and so the compass is not very accurate!

The inaccuracies are know and are displayed in the aircraft on a DEVIATION card

Compass Heading +/- Deviation = Magnetic Heading +/- Variation = True Heading

or CDMVT

or "Cadburys dairy milk is very tasty"

or "true virgins make dull companions"

INSTRUMENTS: MAGNETIC COMPASS

GROUND SCHOOL

Every compass is "swung" so that amount of deviation indicated can be noted.

Must be done when:

New compass fitted

New radio / electrical equipment fitted

After aircraft has changed location north/south by over 1000 miles

After a heavy landing

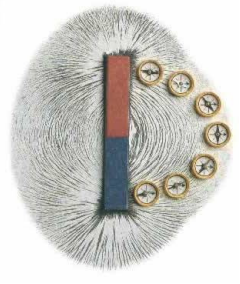
After flight through a magnetic storm

After any lightning strike

Whenever the pilot believes it is necessary to ensure accuracy

INSTRUMENTS: MAGNETIC COMPASS: ERRORS

GROUND SCHOOL



MAGNETIC DIP

The compass aligns to the earth's magnetic field

At latitudes near the poles, the magnetic field dips in so that it enters the ground nearly vertical

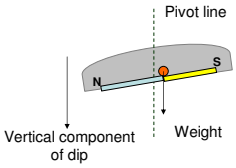
The compass will try to follow this!

The compass will indicate poorly and is generally useless in latitudes above 60° north or south

To counter this, compasses are pivoted slightly off-centre but this causes other errors:

INSTRUMENTS: MAGNETIC COMPASS: ERRORS

GROUND SCHOOL



In northern hemisphere, centre of gravity is arranged so that it is placed south of the pivot point

This reduces errors due to dip but causes errors during turns or during accelerations / decelerations

INSTRUMENTS: MAGNETIC COMPASS: ERRORS

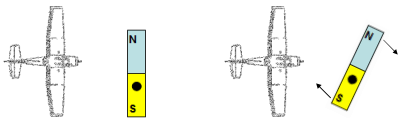
GROUND SCHOOL

ACCELERATION ERRORS

Acceleration on easterly & westerly headings

Compass gets "left behind" due to inertia and the offset pivot causes the compass to swing away from the correct direction.

In the northern hemisphere this is a swing to the north (the nearer pole)



Steady speed

Aircraft accelerates

INSTRUMENTS: MAGNETIC COMPASS: ERRORS

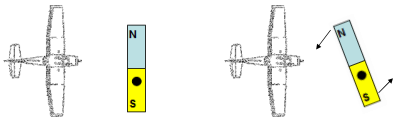
GROUND SCHOOL

DECELERATION ERRORS

Deceleration on easterly & westerly headings

Pivot slows with aircraft but magnetic tries to continue at same speed due to inertia

In the northern hemisphere this is a swing to the south (the nearer pole)



Steady speed

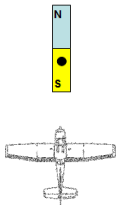
Aircraft accelerates

INSTRUMENTS: MAGNETIC COMPASS: ERRORS

GROUND SCHOOL

ACCELERATION & DECELERATION ERRORS

Changes of speed on northerly / southerly directions



Aircraft is accelerating in line with the compass so no swing occurs

This means no compass errors due to acceleration or deceleration

INSTRUMENTS: MAGNETIC COMPASS: ERRORS

GROUND SCHOOL

Easy way to remember compass acceleration & deceleration errors

"Accelerate North, Decelerate South"

"ANDS"

GROUND SCHOOL

INSTRUMENTS: MAGNETIC COMPASS: ERRORS

TURNING ERRORS

During a turn the aircraft experiences centripetal force acting towards the centre of the turn

This force is essentially an acceleration

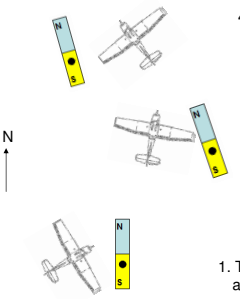
The force acts on the compass pivot and accelerates it towards the centre of the turn

The compass is left behind due to inertia

GROUND SCHOOL

INSTRUMENTS: MAGNETIC COMPASS: ERRORS

TURNING ERRORS – through northerly headings



4. For example, if a heading of north (360°) is required, pilot must roll out when 030° is indicated and wait – the compass will indicate 360° after a short interval

3. Pilot must undershoot when using the compass because it has to "catch up" with the actual heading

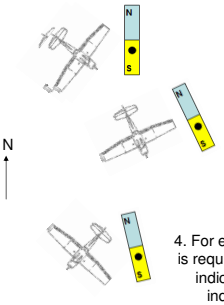
2. Centre of gravity gets left behind due to inertia

1. Turning left through north – acceleration is to the east

GROUND SCHOOL

INSTRUMENTS: MAGNETIC COMPASS: ERRORS

TURNING ERRORS – through southerly headings



1. Turning right through south – acceleration is to the west

2. Centre of gravity gets left behind due to inertia

3. Pilot must overshoot when using the compass because it has to "slow back" to the actual heading

4. For example, if a heading of south (180°) is required, pilot must roll out when 210° is indicated and wait – the compass will indicate 180° after a short interval

GROUND SCHOOL

INSTRUMENTS: MAGNETIC COMPASS: ERRORS

Easy way to remember compass turning errors

"Undershoot North, Overshoot South"

"UNOS"

GROUND SCHOOL

INSTRUMENTS: MAGNETIC COMPASS: CHECKS

Before taxy check:

no leaks and no bubbles

Glass clear and unobstructed

During taxy check:

Right turn – compass shows increase in heading

Left turn – compass shows decrease in heading

On runway check:

Compass is reading correctly in relation to runway heading

In flight check:

When aligning DI to compass, the aircraft must not be turning or accelerating or decelerating

GROUND SCHOOL

Lecture complete

Any Questions?