Level 3 Study Notes

EO M331.01 – DESCRIBE AIRCRAFT STABILITY

CHARACTERISTICS OF STABILITY

Stability. The tendency of an aircraft in flight to remain in straight, level, upright flight and to return to this attitude, if displaced, without corrective action by the pilot.

Static Stability. The initial tendency of an aircraft to return to its original attitude, if displaced.

Dynamic Stability. The overall tendency of an aircraft to return to its original attitude.

Positive Stability. The aircraft is able to return to its original attitude without any corrective measure.

Neutral Stability. The aircraft will remain in the new attitude of flight after being displaced, neither returning to its original attitude, nor continuing to move away.

Negative Stability. The aircraft will continue moving away from its original attitude after being displaced.

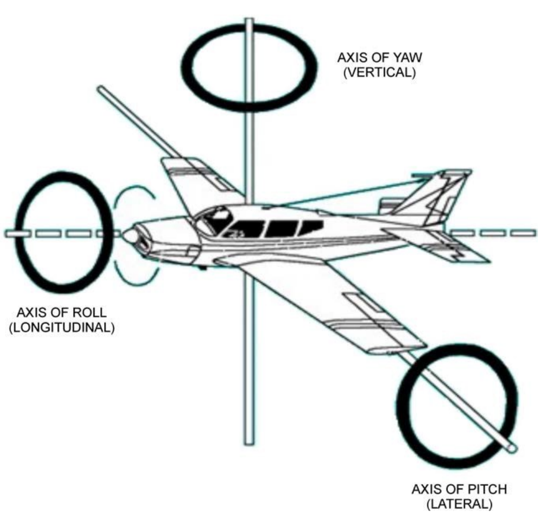
AXES OF THE AIRCRAFT

Each axis is an imaginary straight line which runs through the aircraft in a particular direction. All three axes intersect at the centre of gravity.

Longitudinal Axis and Roll: This axis runs the length of the aircraft from the tip of the nose to the end of the empennage. Movement around this axis is roll.

Lateral Axis and Pitch: This axis runs through the aircrafts' wings, from wing tip to wing tip. Movement around this axis is pitch.

Normal (Vertical) Axis and Yaw: This axis runs through the aircraft vertically top to bottom. Movement about this axis is yaw.



Level 3 Study Notes

LONGITUDINAL STABILITY

Longitudinal stability is stability around the lateral axis and is known as pitch stability. To achieve longitudinal stability, aircraft are designed to be nose heavy if loaded correctly.

Two principle factors influence longitudinal stability:

- the horizontal stabilizer, and
- the centre of gravity

The Effects of the Horizontal Stabilizer

The horizontal stabilizer is located at the tail end of the aircraft. Its function is similar to a counterweight at the end of a lever. When the nose of the aircraft is pushed up, this will force the tail down. Since the stabilizer now meets the airflow at a higher angle of attack, it will now produce more lift. This extra lift will counter the initial disturbance.

The Effects of the Centre of Gravity

The centre of gravity is an important factor in aircraft stability. Every aircraft has a naturally occurring centre of gravity which is inherent in its design. As the aircraft is loaded, the position of the centre of gravity can change. If this change is drastic, it can have an adverse affect on the stability of an aircraft.

If the centre of gravity is too far forward, it will produce a nose-down tendency. This will force the pilot to use excessive back pressure on the controls to maintain normal flight. If left uncorrected, the aircraft will speed up and lose altitude.

If the centre of gravity is too far aft, it will produce a nose-up tendency. This will force the pilot to use excessive forward pressure on the controls to maintain normal flight. Uncorrected, the aircraft will slow down and eventually stall.

The Effects of Dihedral and Anhedral

Dihedral is the angle that the wings make with the horizontal plane. As one looks at an aircraft from the front,
the wings will slowly angle away from the ground so that the wing tip is higher than the wing root.
This assists the aircraft in maintaining lateral stability by changing the angle that the leading edge makes with the airflow.
When an aircraft with dihedral wings is forced in to a side-slipping motion, the down-going wing will meet the airflow at a right angle. This will increase the lift produced on that wing, forcing it back into place.

The Effects of Sweepback

Similar to the dihedral, sweepback is a design feature where the wings sweep back instead of protruding straight out from the fuselage.
This assists the aircraft in maintaining lateral stability by changing the angle that the leading edge makes with the airflow.
When an aircraft with sweepback is forced into a slipping motion, the down going wing will meet the airflow at a right angle. This will increase the lift produced by that wing forcing it back into place.

Keel Effect

While dihedral and sweepback are usually found on low-wing aircraft, high-wing aircraft have stability built-in. Since the bulk of the aircraft is below the plane of the wings, it acts as a keel. When a wing is forced up by a disturbance, the fuselage acts like a pendulum swinging the aircraft back into position.

DIRECTIONAL STABILITY

Directional stability is stability around the vertical or normal axis. The principle factor influencing directional stability is the vertical tail surface, or fin.

The Effects of the Fin

called weather vaning, is a direct result of the vertical tail fin. If the aircraft yaws away from its course, the airflow strikes the fin from the side, forcing it back into position.
This will only work if the side area of the aircraft is greater aft of the centre of gravity than the area forward of the centre of gravity.

Level 3 Study Notes

EO C331.02 – READ PITOT STATIC INSTRUMENTS

BASIC INSTRUMENTS OF AN AIRCRAFT

There are two main sources from which the pitot static instruments receive information. The first of these is the pitot source and the second is the static source.

Pitot and Static Sources Provide Information for the ASI

The pitot source on a light aircraft is usually a pitot tube which is attached to the nose or wing of the aircraft. The information from the pitot source goes directly to the ASI, which then translates the pressure into airspeed. Since the pitot source is facing forward, it acts as an intake for air. Therefore the faster the aircraft is moving, the greater the pressure at the pitot source, which in turn means the higher the reading on the ASI.

The ASI also receives information from the static source. This information will allow the ASI to compensate for changes in the air pressure when at different altitudes.

Static Port Provides Information for the Altimeter

The static port is a small vent on the side of the aircraft. This senses the surrounding pressure of the air and feeds it to the altimeter. The static port relies on changes in air pressure to work. For example, as the aircraft increases in altitude, the air pressure decreases. This causes the altimeter to indicate a higher altitude.

Static Port Provides Information for the VSI

The static port also provides information to the VSI. As the aircraft changes its altitude, the VSI will indicate the rate of change. This reading is based on the rate at which the surrounding air pressure is changing.

READ THE AIRSPEED INDICATOR (ASI)

Reading the ASI is straightforward, and is nearly the same as reading a speedometer in a car. There is one needle and it points to the speed at which the aircraft is travelling. The biggest difference between the speedometer and the ASI is that the ASI has a colour code lining the speed scale.

Each of these arcs represent a speed range for certain flying conditions. The three colours common to all ASIs are:

- green,
- yellow, and
- red

Level 3 Study Notes

. Normal Operating Range

The green arc indicates safe and normal flying speeds. During normal flying the pilot will modify engine power and pitch attitude so that the airspeed flown is somewhere within the green arc. This does not apply for the early part of takeoff or the last part of landing, and may not apply during aerobatic manoeuvres.

Cautionary Range

The yellow arc indicates the cautionary speed range. The aircraft can fly safely at speeds in the yellow arc range, but only if manoeuvres are kept small and gentle. Aggressive manoeuvres at speeds in the yellow arc can cause structural damage to the aircraft.

Never Exceed Speed

The red line indicates the maximum speed that the aircraft should be flown at under any circumstances. If the airspeed exceeds the red line speed, then the aircraft has to be grounded and undergo a structural inspection. Exceeding the red line may cause structural damage.

Units of Measurement

When reading the ASI, it is very important to know what units of measurement are used. In most ASIs, the unit of measurement is knots indicated airspeed (KIAS). In slower aircraft ASIs may use miles per hour (mph) as the unit of measurement. The difference between the two units is that one nautical mile (used for KIAS) is 6 080 feet, whereas one statute mile is 5 280 feet.

READ AN ALTIMETER

Units of Measurement

Every altimeter has at least three hands: one long, one short and stubby, and one long and thin with a triangle on the end.

The long hand measures altitude in hundreds of feet ASL. This is the fastest moving hand of the three and a change in altitude will make it move.

The short hand measures altitude in thousands of feet ASL. This hand moves slowly as the altitude changes.

Every time the long hand goes through a 360-degree rotation, the short hand will move to the next number on the dial.

The third hand is the thinnest and the slowest moving. It measures altitude in tens of thousands of feet ASL.

As the short hand goes through a 360-degree rotation the short hand will move to the next number indicating ten thousand, twenty thousand, thirty thousand feet ASL and so on.

Pressure Sub-Scale

On the right hand side of the altimeter, there is a sub-scale. This sub-scale is used to adjust the altimeter to account for differences in the pressure of the surrounding air. The altimeter is sensitive to air pressure, and readings will change as pressure changes. Pilots have to be diligent and ensure that the sub-scale is set properly.

Field Elevation Versus Pressure Altitude

The sub-scale relies on pressure altitude to calibrate the altimeter. Pressure altitude is the perceived altitude based on the current air pressure. If this information is not available, pilots can set their altimeter to the elevation of the airfield, called field elevation. This will set the altimeter sub-scale to the proper reading.

Height Above Sea Level (ASL)/Above Ground Level (AGL)

The altimeter is designed to be used relative to sea level and is used on long flights where the ground changes in elevation. When arriving and departing an airport, all procedures are followed relative to the height above the ground. This is known as height AGL.

READ A VERTICAL SPEED INDICATOR (VSI)

The VSI is an instrument, which measures the rate at which the aircraft is changing altitude.

Units of Measurement

The VSI is different than the altimeter in that the altimeter measures the exact height ASL, whereas the VSI measures how fast the aircraft is gaining or losing altitude in feet per minute.

Positive/Negative Rates of Climb

The VSI is divided in half, top and bottom. Both halves are measured in increments of 100 feet, represented by the numbers 1–10 or 1–20. When the needle on the VSI is pointed to the number 1, it means 100 feet per minute. The top half is a positive rate of change in altitude or rate of climb, while the bottom half is a negative rate of change in altitude or rate of descent.

EO C331.03 – IDENTIFY ASPECTS OF HELICOPTER AERODYNAMICS

THE MAIN ROTOR OF A HELICOPTER

Helicopters, like airplanes, have airfoils. Unlike airplanes, which have fixed airfoils (wings), the airfoils of a helicopter are not in a fixed position. The airfoils on a helicopter are called rotor blades, which are attached to a rotating point on the top of the helicopter's airframe. The whole assembly is referred to as the main rotor or rotor system.
The terms "fixed wing" (airplane) and "rotary wing" (helicopter) are derived from the physical differences between airplane and helicopter airfoils.

Rotor Systems

The rotor systems of a helicopter incorporate many parts. Three of the basic parts are:

- the rotor blades,
- the rotor head, and
- the drive shaft.

The rotor blades are attached to the rotor head. The rotor head sits on top of the drive shaft. As the drive shaft spins, it moves the blades through the air.

As the blades spin, they act like the wings of an airplane. The shape of the rotor blade is symmetrical, meaning that the top of the blade is shaped the same as the bottom of the blade. As each blade passes through the air, the airflow over the blade creates lift using the same principles of a wing.

In order for a helicopter to move in a horizontal direction, the rotor system must be angled in the direction of travel. This changes the angle of the plane in which the blades rotate, and the rotor blades act the same as propellers.

Flying a helicopter is complicated. Once the angle of the plane of rotation has been changed, the amount of lift being produced will no longer be enough to maintain the helicopter's altitude. The pilot must apply more power in order to counteract this. The total lift force required to maintain the helicopter's altitude and forward motion is referred to as total rotor thrust.

Rotor Drag

Rotor drag is the opposite of rotor thrust. It is commonly known as torque, and acts opposite to the direction that each blade travels. Rotor drag attempts to slow down the rotation of the blades and an increase in engine power is required to maintain the speed of the blades. If the force of rotor drag is stronger than the rotor thrust, then the torque causes the body of the helicopter to rotate instead of the blades.

Rotor drag should not be confused with aerodynamic drag.

Factors Influencing Rotor Thrust

There are four factors that influence rotor thrust, including:

- **Air Density.** As the rotor blades pass through the air, the reaction between the air molecules and the surface of the blade produces lift. More air molecules will create a stronger reaction. One may state that more lift is produced in higher density air vice lower density air because dense air has more molecules.
Air density can decrease with increases in temperature or decreases in pressure.
- **Rotor Revolutions per Minute (rpm).** An increase in rotor rpm increases the total rotor thrust, while a decrease in rotor rpm decreases the total rotor thrust.
- **Blade (Pitch) Angle.** An increase in the blade angle increases the total rotor thrust, while a decrease in the blade angle decreases the total rotor thrust. This is similar to the effects of pitch on an airplane's wings.
- **Disc Area.** Disc area is the total area in which the rotor blades rotate and is determined by the length of the rotor blades. The larger the disc area is, the higher the total rotor thrust will be. This follows the same principle with airplanes, where the larger the wing area, the more lift is produced.

THE ANTI-TORQUE ROTOR

Location on the Airframe

The anti-torque rotor is a smaller version of the main rotor. It is mounted vertically at the end of the tail. Most helicopters have an anti-torque rotor that sits in the right side of the tail, although some designs have the antitorque rotor mounted on the left side or built into the tail assembly.

Function

The function of the anti-torque rotor is to counteract the torque produced by the main rotor. Without the antitorque rotor, the rotation of the main rotor would transfer to the airframe and rotate the airframe instead of the rotor blades. By installing the anti-torque rotor, the airframe stays relatively still while the rotor blades rotate above the airframe. The anti-torque rotor serves to control movement around the vertical axis of the helicopter.

Power Source

The anti-torque rotor receives power from the main engine through a drive shaft which runs the length of the tail assembly.

CONTROL INPUTS OF A HELICOPTER

There are three primary control inputs of a helicopter. They differ from the control inputs of an airplane in some ways, but are similar in others. The three primary control inputs are:

- collective,
- cyclic, and
- pedals.

Collective

The collective is an arm lever located on the left side of the pilot's seat (in most helicopters the pilot sits on the right side of the cockpit). The collective controls the angle of attack of the rotor blades which will affect the amount of lift produced. Pulling up on the collective will increase the angle of attack, producing more lift.

Pushing down on the collective will decrease the angle of attack, producing less lift.

At the end of the collective is a throttle. The throttle on a helicopter is a twist-style grip. The throttle controls the rpm of the blades. An increase in rpm will increase the amount of lift produced and the speed at which the helicopter travels.

It is important to remember that the rotors act in the same way as both the wings and the propeller of an airplane. They produce the lift and the thrust. The same happens for movements forward, backward and to the right.

Cyclic

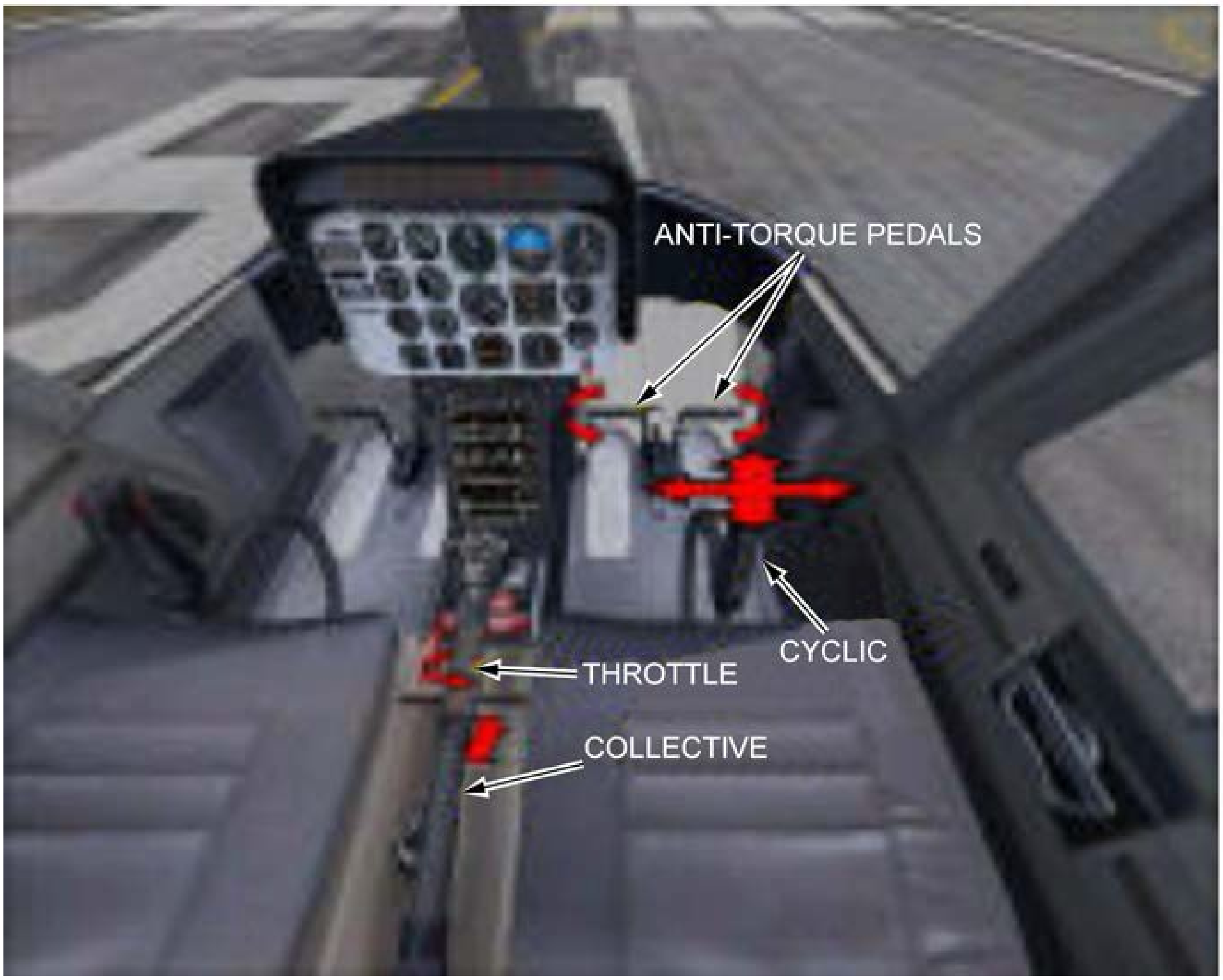
In a helicopter, the control column is known as the cyclic. The cyclic controls the angle of the plane in which the rotor blades move. Moving the cyclic left will angle the rotation of the blades left. Maintaining that angle long enough will move the helicopter to the left.

Pedals

The pedals in a helicopter cockpit are similar to rudder pedals. They control the anti-torque rotor, providing directional stability. They also control which direction the nose of the helicopter is pointed. One of the unique capabilities of a helicopter is that the nose can be pointed in a different direction than the direction of travel.

This provides the helicopter increased manoeuvrability.

Level 3 Study Notes



Level 3 Study Notes

EO C331.04 – DEMONSTRATE ATTITUDES AND MOVEMENTS IN A FLIGHT SIMULATOR

CONTROL COLUMN OR YOKE

The control yoke is located directly in front of the pilot in the centre of the pilot's side of the instrument panel.

The control yoke is very much like the steering wheel of a car, both in look and function. The yoke is designed to move on two planes of motion.

The first plane of motion is left and right. The standard yoke will usually move to approximately 45 degrees left or right of centre when moved like a steering wheel. This motion is what controls the ailerons of the simulated airplane. To roll left, turn the wheel left. To roll right, turn the wheel right.

Remember, this must be used as well as the rudder in order to properly turn the aircraft.
The control yoke also moves back and forth. The steering column of the yoke moves in and out of the main assembly. This controls the elevator of the simulated aircraft. To pitch up, pull back (towards the pilot). To pitch down, push forward (away from the pilot).

RUDDER PEDALS

On the floor of the simulator there are two pedals. If you push forward on the left pedal, the right one movesback and vice versa. These pedals control the rudder of the simulated aircraft. To yaw left, push on the left pedal. To yaw right, push on the right pedal.

LOCATION OF INSTRUMENTS

The instruments of the simulated aircraft will be displayed in front of the pilot, laid out on what is called an instrument panel. The three instruments that are of significance are the pitot static instruments: the airspeed indicator (ASI), vertical speed indicator (VSI), and altimeter. They are usually located just above the control yoke in a cluster of six instruments.

ASI. The ASI is located on the top row of the instrument panel on the far left.

VSI. The VSI is located on the bottom row of the instrument panel on the far right.

Altimeter. The altimeter is located on the top row of the instrument panel on the far right, just above the VSI.

Level 3 Study Notes

PO 336 – IDENTIFY METEOROLOGICAL CONDITIONS

EO M336.01 – DESCRIBE PROPERTIES OF THE ATMOSPHERE

COMPOSITION OF THE ATMOSPHERE

The atmosphere is composed of a mixture of invisible gases. These gases make up the majority of theatmosphere. There are also small particles of dust and debris in the lower levels of the atmosphere.

The Breakdown of the Major Gases

At altitudes of up to 250 000 feet above sea level (ASL), the atmosphere is composed primarily of nitrogen, oxygen, argon, carbon dioxide, hydrogen, water vapour, and several other gases. Each of these gases comprises a certain percentage of the atmosphere.

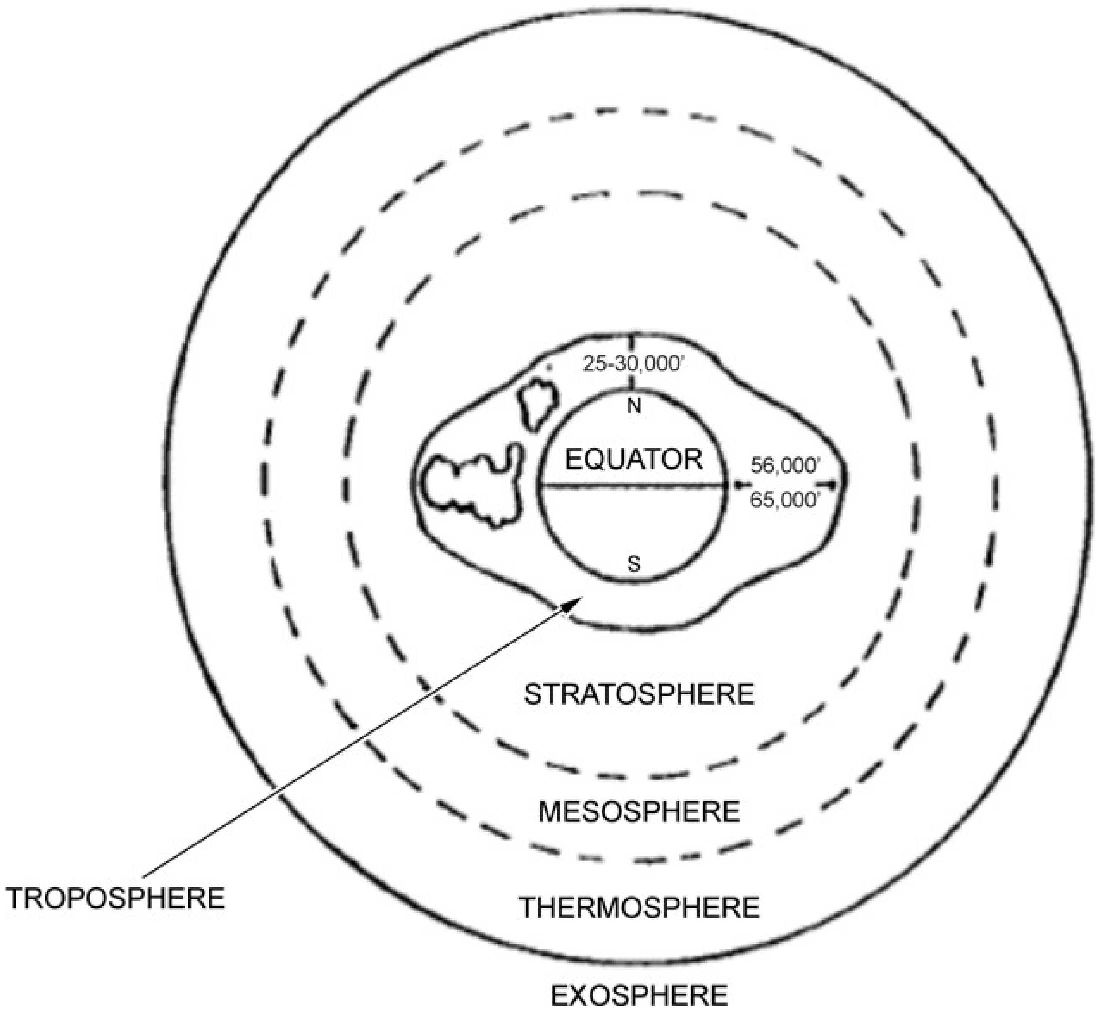
- **Nitrogen.** Nitrogen is the most abundant gas by percentage of the atmosphere at 78 percent.
- **Oxygen.** Oxygen is the second most abundant gas by percentage of the atmosphere at 21 percent.
- **Other.** The rest of the gases make up approximately 1 percent of the atmosphere.

The Importance of Water Vapour

Water vapour is found only in the lower layers of the atmosphere. The amount of water in the atmosphere is never constant, but it is the most important of the gases from the standpoint of weather. It can change from a gas into water droplets or ice crystals and is responsible for the formation of clouds.

Level 3 Study Notes

DIVISIONS OF THE ATMOSPHERE



The atmosphere is divided into four distinct layers which surround the earth for many hundreds of miles. These layers are the:

- troposphere,
- stratosphere,
- mesospehere, and
- thermosphere.

The exosphere is not actually a layer of the atmosphere; it is actually the first vestiges of outer space.

Level 3 Study Notes

The Troposphere

The troposphere is the lowest layer of the atmosphere. The troposphere starts at ground level and extends to varying heights ASL (see Figure 13-1-1). Within the troposphere air pressure, density and temperature decrease with altitude. Temperature will drop to a low of -56 degrees Celsius. Most weather occurs in this laye of the atmosphere due to the presence of water vapour as well as strong vertical currents caused by terrestrial radiation. Terrestrial radiation causes the troposphere to extend to varying altitudes. There is more radiation at the equator than at the poles.

The phenomenon known as the jet stream exists in the upper parts of the troposphere.
The top of the troposphere is known as the tropopause, which acts as a boundary between the troposphere and the stratosphere.

The Stratosphere

The stratosphere extends 50 000 feet upwards from the tropopause. The pressure continues to decrease in the stratosphere. The temperature will gradually rise to 0 degrees Celsius. It is in the stratosphere that the bulk of the ozone layer exists. This prevents the more harmful solar radiation from reaching the earth's surface, which explains the rise in temperature.

The top of the stratosphere is called the stratopause, which acts as a boundary between the stratosphere and the mesosphere.

The Mesosphere

The mesosphere is characterized by a decrease in temperature. The temperature will reach a low of -100 degrees Celsius at 275 000 feet ASL. It is in the mesosphere that meteorites will usually burn up.

The top of the mesosphere is known as the mesopause, which acts as a boundary between the mesosphere and the thermosphere.

The Thermosphere

The highest of the four layers, the thermosphere is so named due to its intense temperatures. This is the first layer to be affected by solar radiation and what few oxygen molecules there are in this layer will absorb a high amount of that radiation. The actual temperature will vary depending on solar activity, but it can exceed 15 000 degrees Celsius.

ICAO STANDARD ATMOSPHERE

The decrease in temperature, pressure and density with altitude is not constant, but varies with local conditions.

For the purposes of aviation, it is required that an international standard be set. Different regions have different standards.

The Basis of ICAO Standards in North America

The ICAO standard for North America is based on the summer and winter averages for 40 degrees north latitude. These averages include air pressure, air density and air temperature.

Level 3 Study Notes

The Assumptions for Standard Atmosphere in North America

ICAO standards for North America assume the following conditions:

- the air is a perfectly dry gas;
- a mean sea level pressure of 29.92 inches of mercury;
- a mean sea level temperature of 15 degrees Celsius; and
- temperature decreases with altitude at a rate of 1.98 degrees Celsius per 1 000 feet.

PROPERTIES OF THE ATMOSPHERE

The properties of the atmosphere allow for various weather conditions. There are three principle properties:

- **Mobility.** This property is the ability of the air to move from one place to another. This is especially important as it explains why an air mass that forms over the arctic may affect places in the south.

- **Capacity for Expansion.** The most important of the three properties. Air is forced to rise for various reasons. As the air pressure decreases, the air will expand and cool. This cooling may be enough for condensation to occur and clouds to form, creating precipitation.

- **Capacity for Compression.** The opposite of expansion, compression occurs when the air has cooled and becomes denser. The air will sink, decreasing in volume and increasing in temperature.

Factors Affecting the Properties of the Atmosphere

There are three factors which affect the properties of the atmosphere: temperature, density and pressure.
Temperature changes air density which creates the vertical movement of the air, causing expansion and compression. The vertical movement creates pressure differences, which causes mobility across the surface as the air moves horizontally to fill gaps left by air that has moved vertically.

Level 3 Study Notes

EO M336.02 – EXPLAIN THE FORMATION OF CLOUDS

CLOUD CLASSIFICATION

Clouds are classified based on type of formation and cloud height.

Types of Formation

There are two main types of cloud formations:

- **Cumulus.** Cumulus clouds are formed by air that is unstable. They are cottony or puffy, and are seen mostly during warmer seasons. Cumulus clouds may develop into storm clouds.

• **Stratus.** Stratus clouds are formed in air that is stable. They are flat and can be seen year round, but are associated with colder temperatures.

Cloud Height

Clouds are also classified based on their height above ground level (AGL). There are four main categories:

• **Low Clouds.** The bases of low clouds range from the surface to a height of 6 500 feet AGL. Low clouds are composed of water droplets and sometimes ice crystals. Low clouds use the word stratus as either a prefix (eg, stratocumulus) or a suffix (eg, nimbostratus).

• **Middle Clouds.** The bases of middle clouds range from 6 500 to 23 000 feet AGL. They are composed of ice crystals or water droplets, which may be at temperatures above 0 degrees Celsius. Middle clouds use the prefix of "alto" (eg, altocumulus).\

• **High Clouds.** The bases of high clouds range from 16 500 to 45 000 feet, with an average of 25 000 feet in the temperate regions of the earth. High clouds are composed of ice crystals. High clouds use the prefix of "cirrus" or "cirro" (eg, cirrocumulus).

• **Clouds of Vertical Development.** The base of these clouds may be as low as 1 500 feet AGL and may rise as high as the lower reaches of the stratosphere. They may appear as isolated clouds or may be seen embedded in layers of clouds. Clouds of vertical development are associated with thunderstorms and other phenomena which occur during the summer months.

Level 3 Study Notes

Cloud Name	Cloud Family	Cloud Description
Cirrus	High	High, thin, wispy clouds blown by high winds into long streamers. Cirrus clouds usually move across the sky from west to east. They generally indicate pleasant weather.
Cirrocumulus	High	Appear as small, round white puffs. The small ripples in the cirrocumulus sometimes resemble the scales of a fish. A sky with cirrocumulus clouds is sometimes referred to as a "mackerel sky."
Altocumulus	Middle	Appear as grey, puffy masses, sometimes in parallel waves or bands. The appearance of these clouds on a warm, humid summer morning often means thunderstorms will occur by late afternoon.
Altostratus	Middle	A grey or blue-grey layer cloud that typically covers the entire sky. In the thinner areas of the cloud, the sun may be dimly visible as a round disk. This cloud appears lighter than stratus clouds.
Stratus	Low	Uniform grey layer cloud that often covers the entire sky. They resemble fog that does not reach the ground. Usually no precipitation falls from stratus clouds, but sometimes they may drizzle.
Nimbostratus	Low	Dark grey layer clouds associated with continuously falling rain or snow. They often produce precipitation that is usually light to moderate.
Stratocumulus	Low	A series of rounded masses that form a layer cloud. This type of cloud is usually thin enough for the sky to be seen through breaks.
Cumulus	Vertical Development	Puffy clouds, which are thick, round, and lumpy. They sometimes look like pieces of floating cotton. They usually have flat bases and round tops.
Cumulonimbus	Vertical Development	Thunderstorm clouds that form if cumulus clouds continue to build. Violent vertical air currents, hail, lightning, and thunder are associated with the cumulonimbus clouds.

Level 3 Study Notes

AIR STABILITY

At the surface, the normal flow of air is horizontal. Disturbances may occur, which will cause vertical currents of air to develop. This is normally caused by a change in temperature. If the air that is displaced resists the change, then it is said to be stable. If it does not resist the change then it is unstable. When air rises, it expands and cools.

Stable Air. If a mass of rising air is cooler than the air that it comes in contact with, then it will sink back to its original position. Stable air may have the following affects on flight characteristics:

- poor low-level visibility (fog may occur),
- stratus type cloud,
- steady precipitation,
- steady winds, which can change greatly with height, and
- smooth flying conditions.

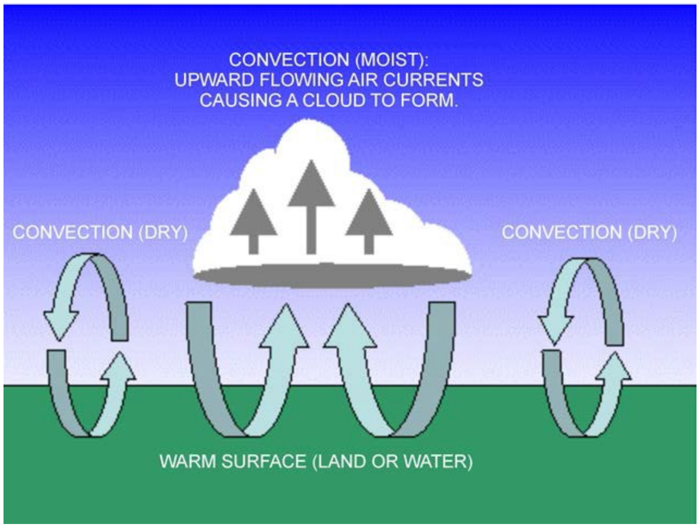
Unstable Air. If a mass of rising air is still warmer than the new air around it, then the air mass will continue to rise. Unstable air may have the following affects on flight characteristics:

- good visibility (except in precipitation),
- cumulus type cloud,
- showery precipitation,
- gusty winds, and
- moderate to severe turbulence.

LIFTING AGENTS

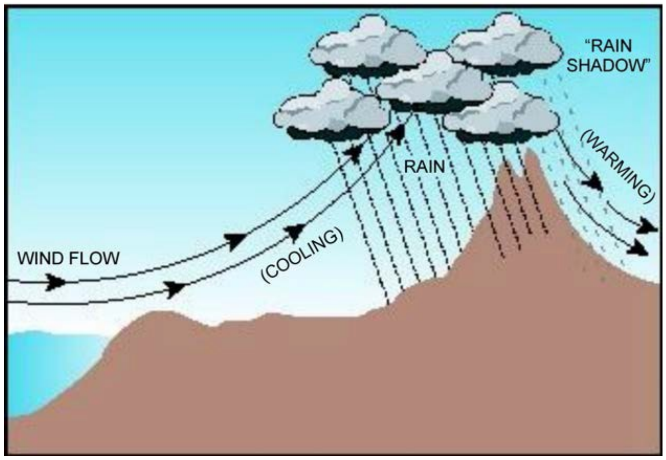
Rising currents of air affect many weather conditions. There are five conditions that provide the lift required to initiate rising currents of air.

Convection. The air is heated through contact with the earth's surface. As the sun heats the surface of the earth, the air in contact with the surface warms up, rises, and expands. Convection may also occur when air moves over a warmer surface and is heated by advection.

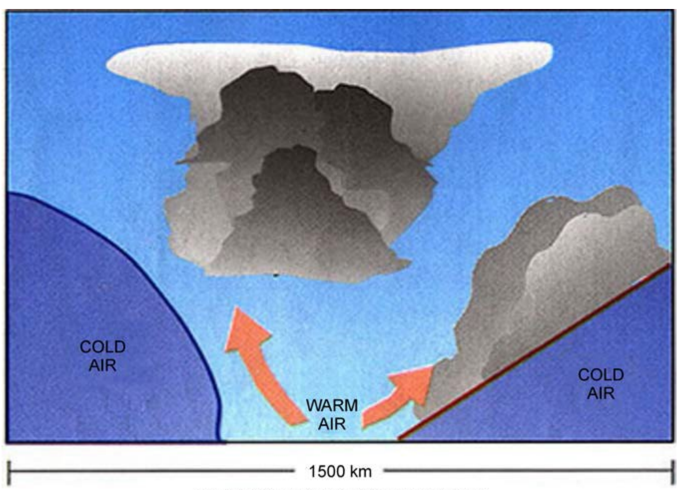


Level 3 Study Notes

Orographic Lift. Orographic lift occurs when the sloping terrain forces the air upward. This process can be exaggerated if the air mass is already.

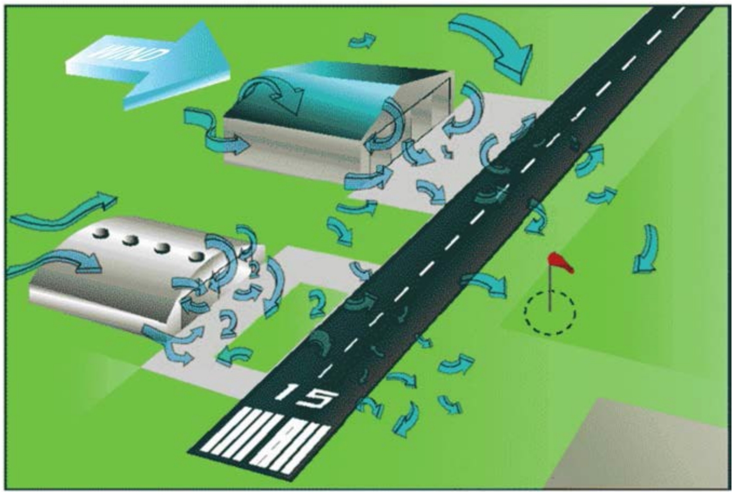


Frontal Lift. When different air masses meet, the warmer air is forced upwards by the denser cold air. This process may be exaggerated if the warm air mass becomes unstable.

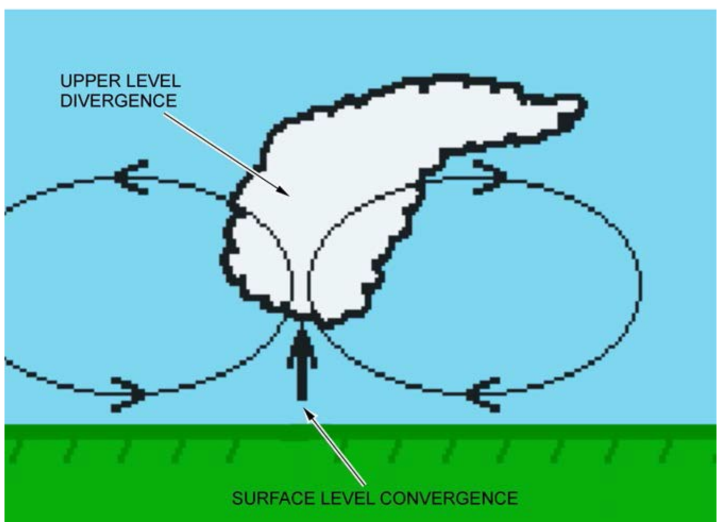


LIFTING ALONG WEATHER FRONTS

Mechanical Turbulence. Air moving over the ground may be affected by terrain that is not as pronounced as mountains. Forests, buildings, large ditches and quarries also affect the air through friction. This friction causes eddies, which are usually confined to the first few thousand feet of the troposphere. This process may be exaggerated if the air mass becomes or is already unstable.



Convergence. In a low pressure system, the wind blows toward the centre of the system. The excess air that collects here is forced upward to higher altitudes.



Level 3 Study Notes

EO M336.03 – EXPLAIN THE EFFECTS OF AIR PRESSURE ON WEATHER

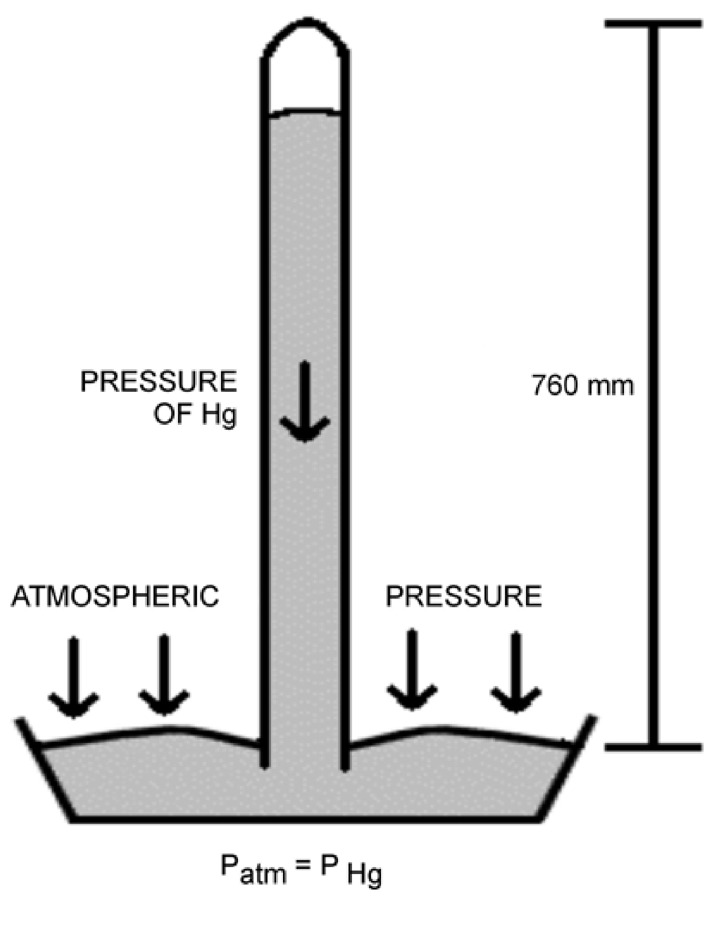
POLAR FRONT THEORY

The Polar Front theory was conceived by Norwegian meteorologists, who claimed that the interaction between the consistently high pressure area over the Arctic (and Antarctic) and the relatively lower pressure areas over the lower latitudes may provide force to the movement of air.

Definition of Atmospheric Pressure

Atmospheric Pressure. The pressure of the atmosphere at any point due to the weight of the overlying air. Pressure at the surface of the earth is normally measured using a mercury barometer and is expressed in mm of mercury (mm Hg) or inches of mercury ("Hg). The barometer is essentially an upside-down graduated, test tube that is partially immersed in a bowl of mercury. As the pressure of the air over the bowl increases, the mercury is forced further up the test tube, providing a higher reading. Pressure is a force and, in meteorological work, it is common to use hectopascals (hPa) to measure pressure.

One hectopascal is 1 000 dynes (a unit of force) of force exerted on a 1 cm^2 area.
The average pressure of the atmosphere at sea level is normally expressed as 760 mm Hg (29.92 "Hg), which is the same as 1013.2 hPa. Public radio and television weather broadcasts (such as the Weather Network or Environment Canada) will express pressure in kilopascals (kPa). One kPa is equal to 10 hPa, so that 1013.2 hPa would be equal 101.32 kPa.

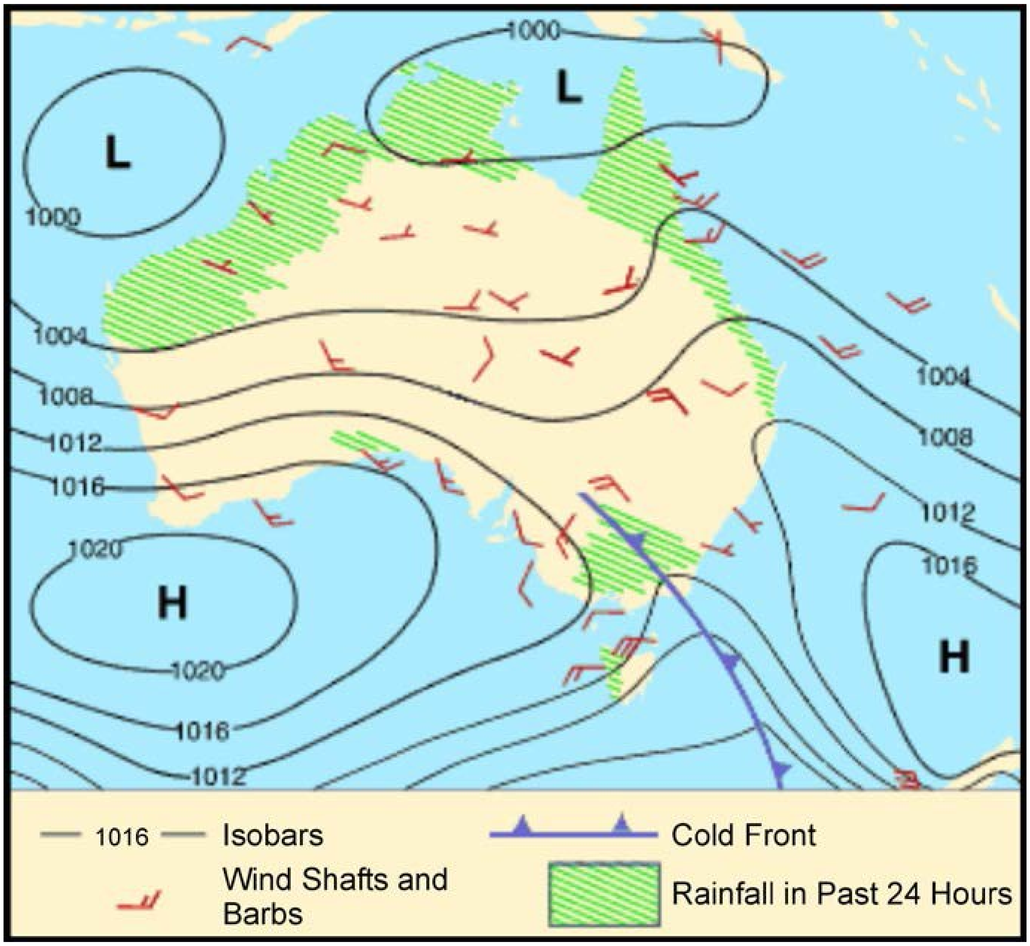


Level 3 Study Notes

Pressure Systems

There are pressure reading stations all over North America. Each station will send its readings to a main forecasting office, which will plot the information on a weather map.

• **Isobars.** Areas of like pressure are joined by lines called isobars (from Greek *isos* [same] and *baros* [weight]). On a weather map, isobars will look similar to contour lines found on a topographical map. The isobars form roughly concentric circles, each circle being four hPa different than the circles before and after it. Groups of isobars will indicate areas of relatively high pressure, or relatively low pressure.



Low Pressure Areas. Low pressure areas (often called lows, cyclones, or depressions) are areas of relatively lower pressure, with the lowest pressure in the centre. Lows will normally move in an easterly direction at an average rate of 800 km per day during the summer and 1 100 km per day in the winter.
Lows are associated with thunderstorms and tornadoes, and do not stay in one place for very long. In the northern hemisphere, air moves around a low pressure in a counter-clockwise direction.

• **High Pressure Areas.** High pressure areas (often called anti-cyclones) are areas of relatively higher pressure, with the highest pressure in the centre. Winds are usually light and variable. High pressure areas move very slowly, sometimes staying stationary for days at a time. In the northern hemisphere, air moves around a high in a clockwise direction.\

Level 3 Study Notes

An Air Mass Over the Polar Regions

Polar air is typically cold and dry.

An Air Mass Over the Equatorial Regions

The air over the equator is tropical, therefore warm and moist.

Movement at the Polar Front

The transition zone between the polar air and the equatorial air is known as the polar front. Due to the differences in the properties of the two air masses, many depressions (low pressure areas) form along the polar front. The cold air moves from north-east to south-west in the northern hemisphere, while the warm air moves in the opposite direction. The result is constant instability as the cold air bulges south and the warm air bulges north. The cold air moves faster than the warm air and eventually envelopes it. The movement of the air at the polar front is thought to be a cause for the circulation of air in the troposphere.

PROPERTIES OF AN AIR MASS

Weather forecasts used to be based solely on the existence and movement of pressure systems. Meteorologists currently base their predictions on the properties of air masses, of which pressure is only one factor.

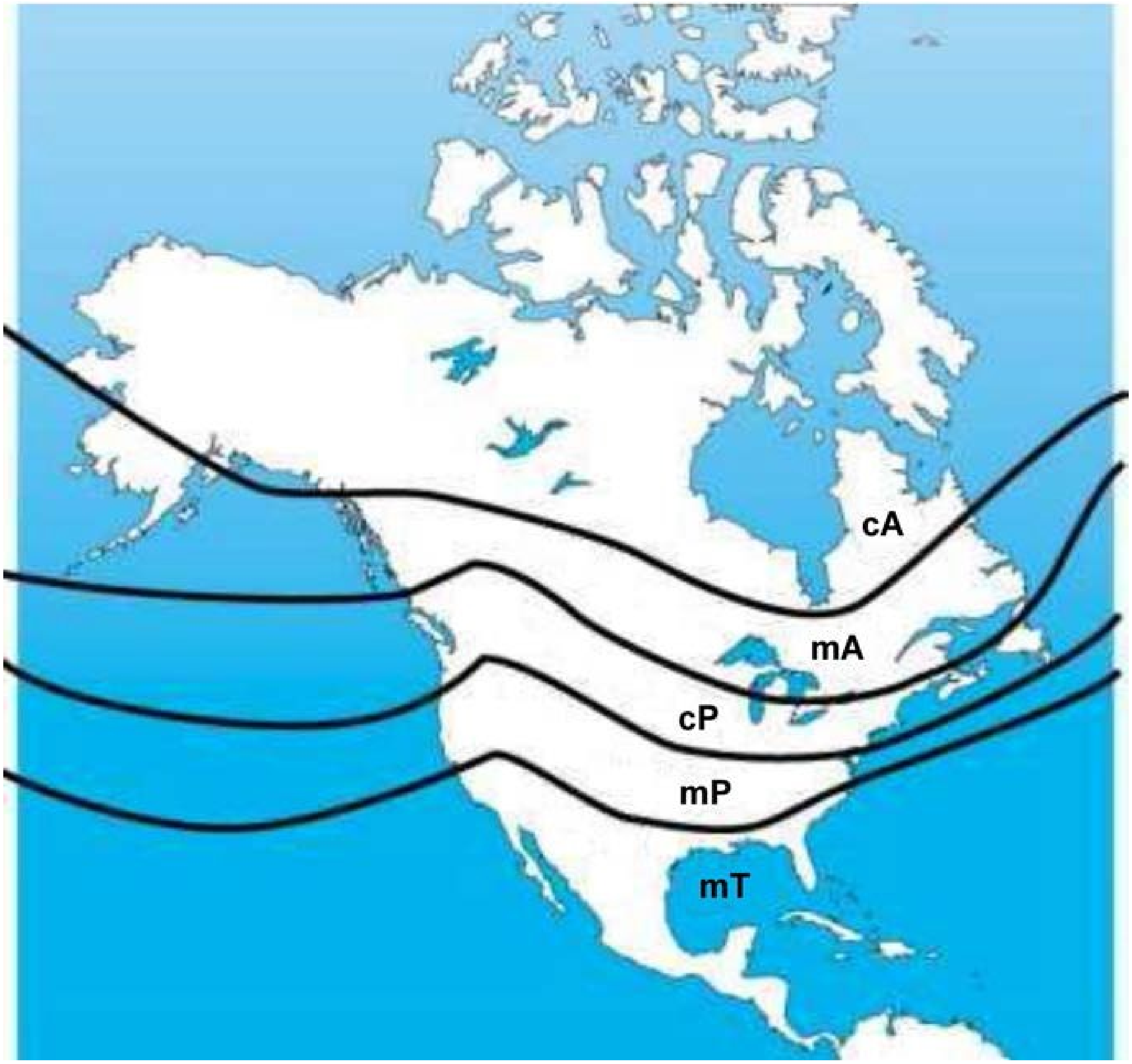
An air mass may be defined as a large section of the troposphere with uniform properties of temperature and moisture along the horizontal plane. This means that if a horizontal cross-section was taken of an air mass, one would see layers within the air mass where the temperature and the amount of moisture would be the same throughout.

An air mass will take on the properties of the surface over which it has formed. An air mass, which has formed over the Arctic would be cold and dry, while one, which formed over the Gulf of Mexico would be warm and moist.

Air masses may be described as:

- **Continental Air Mass.** Since the air mass formed over land, this will be a dry air mass.
- **Maritime Air Mass.** Since the air mass formed over water, this will be a moist air mass.
- **Arctic Air Mass.** Since the air mass formed over the Arctic, this will be a cold air mass.
- **Polar Air Mass.** Since the air mass formed over the Polar region, this will be a cool air mass.
- **Tropical Air Mass.** Since the air mass formed over the Tropical region, this will be a warm air mass.

Level 3 Study Notes



These types of air masses are usually combined to describe the properties of temperature and moisture.

For example, over Atlantic Canada one might find a maritime polar air mass, which will be cool and moist.

Meanwhile prairie winters usually see continental polar or continental arctic, which will be either cool and dry or cold and dry. The five air masses in North America indicated in Figure 13-3-3 include:

- Continental Arctic (cA),
- Maritime Arctic (mA),
- Continental Polar (cP),
- Maritime Polar (mP), and
- Maritime Tropical (mT).

Level 3 Study Notes

WIND

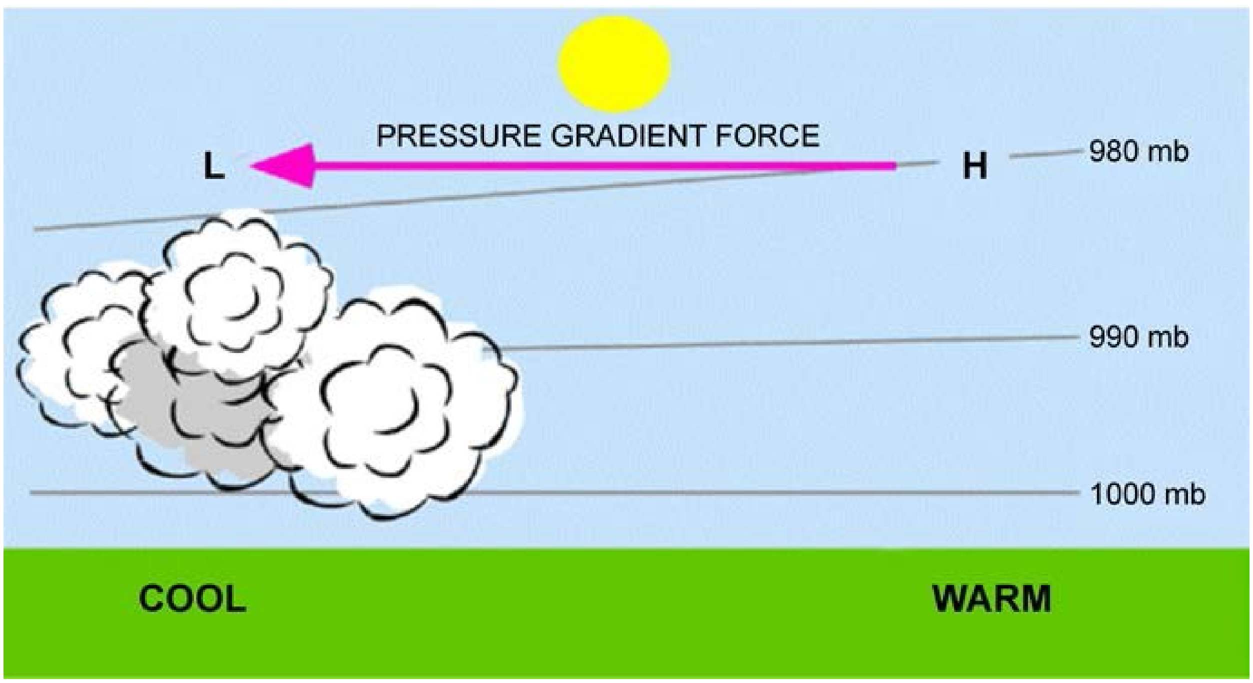
Wind is a major factor in flight planning and flight characteristics. Pilots must constantly be aware of the direction and speed of wind during all parts of the flight, but especially during the landing sequence.

The Definition of Wind

Wind. The horizontal movement of air within the atmosphere. Wind normally moves parallel to the isobars of a pressure system. Since isobars are not straight lines, this means that the wind direction will vary at different locations along the pressure system. Wind also moves in different directions based on whether the pressure is a low or high system.

Pressure Gradient

The pressure gradient is the rate of change of pressure over a given distance measured at right angles to the isobars. If the isobars are very close together, the rate of change will be steep and the wind speed will be strong. If the isobars are far apart, the rate of change will be shallow and the wind speed will be weak.

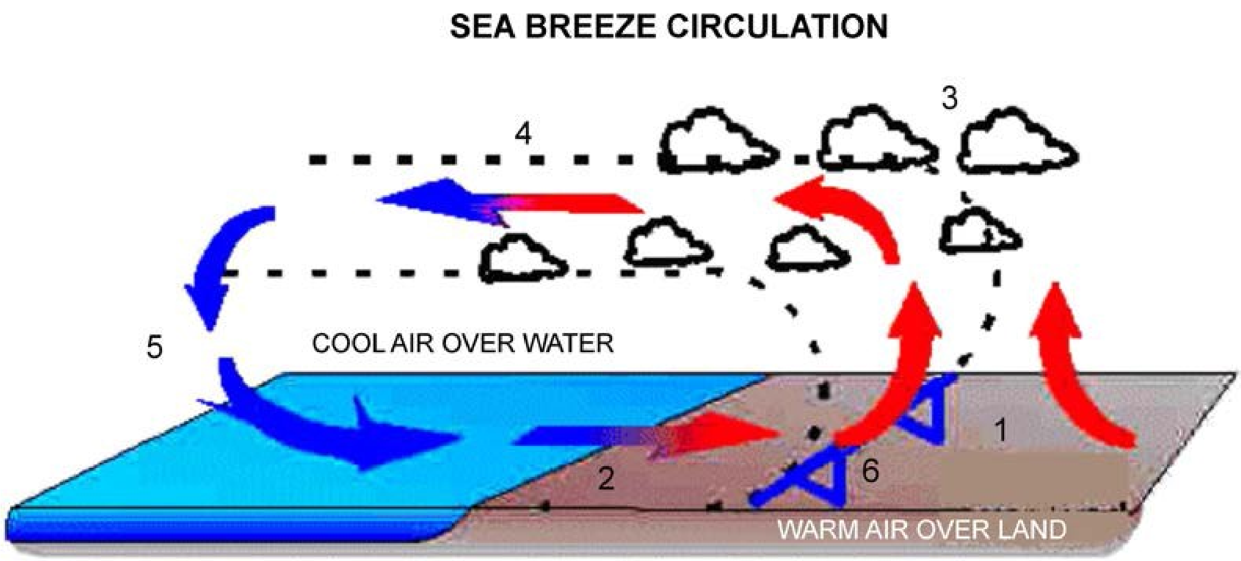


Level 3 Study Notes

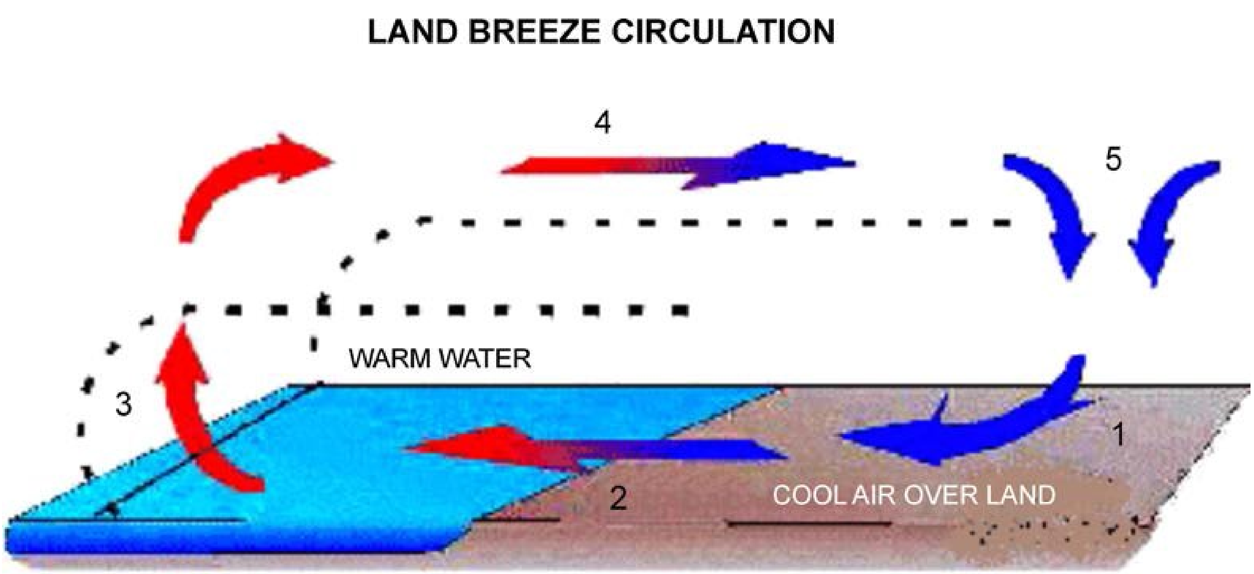
Land and Sea Breezes

Land and sea breezes are caused by the differences in temperature over land and water.

The sea breeze occurs during the day when the land heats up more rapidly than the water. This creates a lower pressure area over the land. The pressure gradient caused by this change is usually steep enough to create a wind from the water.



The land breeze occurs at night when the land cools down faster than the water. This creates a higher pressureover the land. The pressure gradient now moves the air from the land to the water.



Land and sea breezes are local and affect a small area only.

Diurnal Variation

Surface winds are generally stronger during the day than at night. This is due to the heating processes, which occur during the day, creating vertical currents and pressure gradients. At night, when the heating processes cease, the vertical currents diminish and the pressure gradients become shallower.

Coriolis Force

As air moves from a high pressure system to a low pressure system, the air will not flow directly from one to the other. The rotation of the earth causes a deflection to the right (in the northern hemisphere). This force is known as Coriolis Force. Coriolis Force also explains why air moves clockwise around a high, and counterclockwise around a low pressure system.

Veering and Backing

Veering is a change in wind direction clockwise relative to the cardinal points of a compass while backing is a change in wind direction counter-clockwise. For example, when the wind veers it will increase in direction from 090 degrees to 100 degrees; when it backs it will decrease in direction from 100 degrees to 090 degrees.

Veering and backing normally occur with changes in altitude. An increase in altitude will normally see a veer in wind direction and an increase in wind speed. A decrease in altitude will normally see a backing in wind direction and a decrease in wind speed. These changes are due to an increase in friction with the surface of the earth in the lower altitudes, and a decrease is friction in the higher altitudes.

RELATIONSHIP BETWEEN PRESSURE SYSTEMS AND WIND

Pressure and wind are interrelated, with one being the cause of the other.

Low Pressure Areas

Low pressure areas are the cause of all air movement as described by the Polar Front theory. Wind blows in a counter-clockwise direction around the low, and inwards to the centre of the system. Wind tends to be strong in a low as the pressure gradient is relatively steep causing the system to move fast over the ground.

Low pressure systems are generally associated with brief periods of poor weather, as the inward flow of air acts as a vacuum.

High Pressure Areas

The wind in a high pressure areas blows in a clockwise direction around the high and outwards from the centre of the system. Wind tends to be weak in a high as the pressure gradient is normally relatively shallow causing the system to move slowly over the ground. High pressure systems are usually associated with fair weather, as the outward flow of air acts as a shield against bad weather.

EO M336.04 – EXPLAIN THE EFFECTS OF HUMIDITY AND TEMPERATURE ON WEATHER

HUMIDITY

Humidity is a representation of the moisture or water vapour, which is present in an air mass. While water vapour is a small percentage of the overall atmosphere, it is the only gas which can change into a solid or a liquid in ordinary atmospheric conditions. It is this characteristic which causes most weather to develop.

The moisture in an air mass originates from a body of water over which the air mass forms or passes. This body of water may be a pond or an ocean. The size of the body of water determines how much water is available for the air mass to collect, while the rate of evaporation will determine how much of that water is collected by the air mass. Water may exist in the atmosphere in two forms: invisible (gaseous) or visible (water droplets [liquid] or ice crystals [solid]).

Condensation

Condensation is a process by which a gas changes into a liquid by becoming denser. This is usually caused by a cooling process. The air is cooled to a certain temperature at which the water vapour will condense into water.

Sublimation

Sublimation is a process by which a gas changes into a solid without first becoming a liquid. This is usually caused by freezing. Sublimation occurs whenever snow, ice or hail fall from the sky. This process usually occurs in the winter, but may occur during exceptional summer storms.

Dew Point

Dew point is the temperature to which unsaturated air must be cooled, at a constant pressure, in order to become saturated. The temperature and dew point are responsible for the creation of clouds and precipitation. If the difference between the temperature and the dew point is small, then the air is considered to be nearly saturated and a small drop in temperature will see the formation of clouds or precipitation.

Relative Humidity

Relative humidity is the ratio of the actual amount of water present in the air compared to the amount of water which the same volume of air would hold if it were saturated. Temperature and pressure must remain the same, otherwise the relative humidity will change. Saturated air will have a relative humidity of 100 percent, while perfectly dry air will have a relative humidity of zero percent.

Level 3 Study Notes

TEMPERATURE

Temperature represents the amount of heat in a given object, such as the human body or air. Temperature is measured using a thermometer. In aviation weather reports, temperature is normally expressed in degrees Celsius.

The Source

The source of the energy which warms the earth and its atmosphere is the sun. Solar radiation is transmitted to the earth and its atmosphere. Some of the solar radiation is absorbed by the stratosphere, while the rest passes through to be absorbed by the earth's surface. The earth then radiates heat into the troposphere through terrestrial radiation. It is terrestrial radiation that heats the troposphere, and is why the further one gets from the surface of the earth, the lower the temperature will be in the troposphere.

The atmosphere is heated from below not from above.

Diurnal Variation

During the day, the solar radiation exceeds the terrestrial radiation and the surface of the earth becomes warmer. At night, solar radiation ceases, and the terrestrial radiation causes the surface of the earth to cool.

This is called diurnal variation and causes the heating and cooling of the atmosphere.

Seasonal Variation

The axis around which the earth rotates is tilted compared to the plane of orbit around the sun. The result is that the amount of solar radiation that strikes the surface of the earth varies from season to season. In the northern hemisphere, the months of June, July, and August are warm, while the months of December, January, and February are cold.

The Heating Process

Air is a poor conductor of heat. The following are four processes which assist in getting warm air into the higher levels of the atmosphere:

- **Convection.** Air over a warm surface becomes buoyant and rises, allowing cooler air to move into the vacant location. This vertical current of air distributes the heat to the higher levels.
- **Advection.** Horizontal movement of cool air over a warm surface allows the cool air to be heated from below.
- **Turbulence.** Turbulence created as the result of friction with the surface of the earth causes a mixing process which moves the heated air to other areas of the atmosphere.
- **Compression.** There are instances where air masses are forced down, such as air moving down the leeward side of a mountain. The air pressure increases as the air mass moves further down, compressing the air mass. This compression forces the particles together, creating heat. This phenomenon is also called subsidence.

Level 3 Study Notes

The Cooling Process

Since the atmosphere is heated from below, the temperature usually decreases with altitude. The rate of temperature change is known as a lapse rate. The lapse rate is only a guideline as there is a variation in air masses and cooling processes. The following are three main cooling processes:

- **Radiation Cooling.** At night the temperature of the earth decreases with terrestrial radiation and cools the air in contact with the ground. Radiation cooling only affects the lower few thousand feet of the atmosphere.
- **Advection Cooling.** Air from a warm region moves over a cold region and cools the air.
- **Adiabatic Process.** As air is warmed it will begin to rise and as it rises it will expand and cool. In a rising current of air, the temperature decreases at a rate that is entirely independent of the surrounding, nonrising air.

THE EFFECTS OF TEMPERATURE AND HUMIDITY ON WEATHER

Temperature and humidity have a major effect on the weather. Together they will determine cloud formation and precipitation.

Dew Point

The temperature of the air mass will change during the heating and cooling processes. As the temperature nears the dew point, the air will become more saturated. This increases the relative humidity and allows clouds to form.

Relative Humidity

As the relative humidity increases, the weight of the air mass also increases. When the dew point is reached, the air will become saturated, and clouds will form. Once the air mass has reached 100 percent relative humidity, any addition of water or drop in temperature will cause precipitation.

Precipitation

Precipitation may be solid or liquid, depending on the temperature of the air mass. Snow will occur if the air mass has a temperature below freezing. Rain will occur in an air mass which has a temperature above freezing.

The temperature in the air mass will change with altitude, so that the water may freeze at higher levels of the air mass. Frozen precipitation such as hail and even snow has been seen in the summer months.

Level 3 Study Notes

TYPES OF PRECIPITATION

There are seven main categories of precipitation listed by the World Meteorological Organization (WMO). Each one is created depending on temperature and cloud type. Types of precipitation include:

- **Drizzle.** Precipitation in the form of small water droplets which appear to float. In temperatures near freezing, water droplets may freeze on contact with objects. This is known as freezing drizzle.
- **Rain.** Precipitation in the form of large water droplets. Freezing rain will occur when water droplets, which have retained their liquid form in freezing conditions, make contact with an object and freeze.
- **Hail.** Formed in clouds, which have strong vertical currents (such as thunderstorms), hail is the result of a water droplet which has been prevented from exiting the cloud by the vertical currents, until it has reached a particular mass. The stronger the vertical currents, the larger the hailstones. Softball-sized hailstones have been seen in the Prairies and tropical areas, where large thunderstorms commonly occur.
- **Snow Pellets.** If the water region where the cloud is receiving water from is shallow, then the droplet will not form the hard shell that a hailstone would have. The pellet falls as a soft pellet of snow.
- **Snow.** Snow is the result of sublimation. Flakes are an agglomeration of ice crystals and are usually in the shape of a hexagon or star.
- **Ice Prisms.** Created in stable air masses at very low temperatures. Ice prisms are tiny ice crystals in the form of needles. They can form with or without clouds. Sometimes confused with ice fog.
- **Ice Pellets.** Ice pellets are raindrops, which are frozen before contacting an object (as opposed to freezing rain, which freezes after contact with an object). They generally rebound after striking the ground

Level 3 Study Notes

EO C336.01 – READ AN AVIATION ROUTINE WEATHER REPORT (METAR)

METAR is the name given to the international meteorological code used in aviation routine weather reports.

These reports describe the existing weather conditions at a specific time and location. In other words, the **METAR** is a snapshot of the current weather; it is not a forecast..

FREQUENCY OF REPORTS

Normally, METAR observations are taken and disseminated on an hourly basis. METARs are only valid for the time that they are issued, not for the hour in between reports. METARS are normally issued every hour, on the hour as weather does not normally change much in an hour.

SPECIAL WEATHER REPORTS (SPECI)

There are times when the weather may change drastically in a short period of time. When this happens a **SPECI** is issued. **SPECIs** can be issued at any time. They will normally follow the last **METAR** issued and in sequence from oldest to newest as more **SPECIs** are issued. **SPECIs** use the same code as a **METAR**, but will start with **SPECI**.

WHERE METARS ARE AVAILABLE

METARs can be found at several locations. The three most common locations are:

- NavCanada's aviation weather website,
- a Flight Services Station (FSS),
- a Flight Information Centre (normally accessed by phone).

TERMINOLOGY USED IN METARS

Organization's (WMO) standards and conventions. A **METAR** is organized into sections with each section always showing in the same order.

Report Type
The report name is given in the first line of the text. The name will show as either **METAR** or **SPECI**.

Station Indicator
Each weather reporting station in Canada is assigned a four letter identifier, starting with the letter C. The remaining three letters are an abbreviation of the reporting station, where the first letter identifies what type of station it is.

An example would be CYOW for the reporting station at Ottawa/MacDonald-Cartier International Airport. The C means the station is Canadian, the Y means the station is co-located with an airport, and OW is the airport identifier.

Date and Time of Observation
The date and time of the observation are given in a six-digit grouping, based on universal coordinated time (UTC). The first two digits signify the day of the current month, while the last four digits signify the time of the day. The official time of the observation is given for all METAR reports that do not deviate more than 10 minutes from the top of the hour. SPECIs will have the time reported to the exact minute.

For example, a **METAR** will show as: 091000Z, which means that the observation was taken on the ninth day of the month at 1000 hrs UTC (or within 10 minutes of that hour).
For example, a **SPECI** will show as: 091036Z, which means that a significant change in weather was observed on the ninth day of the month at 1036 hrs UTC.

Report Modifier
This field may contain two possible codes: AUTO or CCA. AUTO indicates that the report is primarily based on observations from an automated weather observation station (AWOS). CCA is used to indicate corrected reports, where the first correction is CCA, the second is CCB, and so on. Both AUTO and CCA may be found in the same report.

Wind
This group reports the two-minute average wind direction and speed. Direction is always three digits, given degrees true but rounded off to the nearest 10 degrees. Speed is normally two digits, and is given in knots (nautical miles per hour or kt). A reading of 00000 kt indicates calm winds.
For example, 35016 will read as: winds are 350 degrees true (rounded off) at 16 kts.

If gust conditions exist, the direction and speed will be followed by a G and the maximum gust strength. A gust must be 5 knots stronger than the 10-minute average wind speed.

For example, **35016G25** will read as: winds are 350 degrees true at 16 kts gusting to 25 kts.

Prevailing Visibility
Prevailing visibility is the average visibility at the reporting station. The prevailing visibility is reported in statute miles (sm) or fractions of a statute mile.

Runway Visual Range
This is only included if the prevailing visibility is less than 1 sm, or the runway visual range is less than 6 000 feet.

This group will start with an R, then the runway number (eg, 06) and position (eg, L for left, R for right, C for centre), followed by the runway visual range in hundreds of feet. This is based on a 10-minute average.

For example, **R06L/1000V2400FT/U** will read as: the minimum runway visual range for runway 06 left is 1 000 feet and the maximum is 2 400 feet with an upward trend.

Present Weather
This section indicates the current weather phenomena at the reporting station. This may include precipitation, obscuration, or other phenomena. This section will include all phenomena that exist, varying the length of the section between reports.

Each phenomenon is represented by a code, which may be two to nine characters in length. Each code may include one or both of the following prefixes:

- **Intensity.** (-) indicates light, (+) indicates heavy, and no symbol indicates moderate.
- **Proximity.** Used primarily with precipitation or tornadoes, VC will precede certain phenomena meaning that they are in the vicinity (5 sm) of the station, but not actually at the station.

For example, **VCFZRABLSN+SNVA** would translate to: In the vicinity of the airport there is freezing rain, blowing snow, heavy snow, and volcanic ash.

Level 3 Study Notes

Sky Conditions
This group reports the sky condition for layers aloft. The group will include how much of the sky is covered measured in oktas (eighth of the sky) and the height of the clouds in hundreds of feet above ground level (AGL).

The sky cover is represented by an abbreviation related to how many oktas of the sky are covered.

- **SKC** = sky clear, no cloud present.
- **FEW** = few, greater than zero to two eighths cloud cover.
- **SCT** = scattered, three eighths to four eighths cloud cover.
- **BKN** = broken, five eighths to less than eight eighths cloud cover.
- **OVC** = overcast, eight eighths cloud cover.
- **CLR** = clear, clear below 10 000 feet AGL.

Cloud height is represented by a three digit number, which when multiplied by one hundred equals the actual height AGL. There will be one entry for every layer of cloud.

For example, **SCT025** would translate to: scattered cloud at 2 500 feet AGL.

Temperature and Dewpoint
This group reports the air temperature and dewpoint temperature, rounded to the nearest whole degree Celsius. A negative value will be preceded by (M). A (/) will separate the two values.

Altimeter Setting
This group reports the altimeter setting at the reporting station in inches of mercury. The group starts with (A), which will be followed by four digits, which directly relate to the actual value of the altimeter setting. Place a decimal after the second digit in order to read this group.

For example, **A3006** would translate to: altimeter setting is 30.06 inches of mercury.

Remarks
This group will usually include cloud types in each layer as well as opacity, general weather remarks, and sea level pressure measured in hectopascals. The sea level pressure will always be the last entry in a **METAR**, prefaced by **SLP**. Sea level pressure is translated by either adding a 9 or a 10 in front of the value given. The goal is to make the number as close to 1 000 as possible.

For example, **SLP 123** would translate to: sea level pressure is 1012.3 hPa.
For example, **SLP 998** would translate to: sea level pressure is 999.8 hPa.

SAMPLE METAR AND SPECI

METAR CYHZ 111700Z 28009G16KT 15SM FEW250 00/M11 A2990 RMK CS0 SLP134=

METAR CYHZ 111800Z 29015KT 15SM FEW250 01/M10 A2989 RMK CI0 SLP128=

METAR CYHZ 111900Z 30008KT 15SM FEW250 02/M12 A2987 RMK CI0 SLP123=

SPECI CYYJ 111744Z CCA 23019G24KT 20SM -SHRA BKN014 BKN030 BKN120 09/07 RMK SC5SC1AC1=

SPECI CYYJ 111744Z 23019G24KT 20SM -RA BKN014 BKN030 BKN120 09/07 RMK SC5SC1AC1=

Level 3 Study Notes

WORLD METEOROLOGICAL ORGANIZATION CODE FOR PRESENT WEATHER

QUALIFIER					WEATHER PHENOMENA			
INTENSITY or PROXIMITY 1	**DESCRIPTOR 2**		**PRECIPITATION 3**		**OBSCURATION 4**		**OTHER 5**	
Note: Precipitation intensity refers to all forms combined.	**MI**	Shallow	**DZ**	Drizzle	**BR**	Mist (Vis ≥ 5/8 SM)	**PO**	Dust/sand Whirls (Dust Devils)
	BC	Patches	**RA**	Rain	**FG**	Fog (Vis < 5/8 SM)	**SQ**	Squalls
	PR	Partial	**SN**	Snow	**FU**	Smoke (Vis ≤ 6 SM)	**+FC**	Tornado or Waterspout
	DR	Drifting	**SG**	Snow Grains				
- Light	**BL**	Blowing	**IC**	Ice Crystals (Vis = 6 SM)	**DU**	Dust (Vis ≤ 6 SM)	**FC**	Funnel Cloud
	SH	Shower(s)						
Moderate (no qualifier)	**TS**	Thunderstorm	**PL**	Ice Pellets	**SA**	Sand (Vis ≤ 6 SM)	**SS**	Sandstorm (Vis < 5/8 SM) (+SS Vis < 516 SM)
			GR	Hail				
+Heavy	**FZ**	Freezing	**GS**	Snow Pellets	**HZ**	Haze (Vis ≤ 6 SM)	**DS**	Dust storm (Vis < 5/8 SM) (+DS Vis < 516 SM)
VC In the vicinity			**UP**	Unknown precipitation (AWOS only)	**VA**	Volcanic Ash (with any visibility)		

Level 3 Study Notes

PO 337 – DEMONSTRATE AIR NAVIGATION SKILLS

EO M337.01 – MEASURE DISTANCE ALONG A ROUTE

AIR NAVIGATION TERMS

There are several key terms that must be understood.

Graticule. A three-dimensional geometrical pattern of intersecting circles. Envision the black lines on a basketball, or a globe with only the black lines.

Latitude. Parallels of latitude are imaginary circles on the earth's surface, which lie parallel to the equator.
Latitude measures 90 degrees north and 90 degrees south of the equator. Parallels of latitude make up half of the earth's graticule. Latitude is measured in degrees (°), minutes ('), and seconds (").

Longitude. Meridians of longitude are imaginary circles on the earth's surface, which intersect at the true or geographic poles, and join the poles of the earth together. Longitude measures 180 degrees west and 180 degrees east of the prime meridian (0 degrees), which passes through Greenwich, England. Meridians of longitude make up the other half of the earth's graticule. Longitude is measured in degrees (°), minutes ('), and seconds (").

Nautical Miles. A nautical mile (nm) is 6 080 feet and is the average length of one minute of latitude.

Statute Miles. A statute mile is 5 280 feet.

Scale. Scale on a map is the relationship between a unit of distance on the chart to the distance on the earth that the unit represents. For example, a scale of 1 : 250 means that one inch on the map is equal to 250 inches on the ground.

VNC. A visual flight rules (VFR) navigation chart (VNC) is a chart used primarily for visual navigation, at low altitudes (below 18 000 feet) and slower speeds (less than 300 knots). A VNC has a scale of 1 : 500 000, or one inch to eight miles.

TYPES OF NAVIGATION

There are several methods of navigation used by pilots to find their way from place to place. Four of the more common methods used include:

- pilotage,
- dead reckoning,
- inertial navigation, and
- satellite navigation.

Pilotage. This method of navigation is by reference to landmarks only. This is similar to orienteering.

Dead Reckoning. This method of navigation uses predetermined vectors of wind and true airspeed, precalculated heading and groundspeed, and estimated time of arrival. This is the most common method used by private pilots.

Inertial Navigation. This method of navigation is through use of gyroscopic equipment and electronic computers to provide a continuous display of position. This equipment is built into the aircraft.

Satellite Navigation. This method uses position and guidance systems, which transmit to and receive information from orbiting satellites. The global positioning system (GPS) is the most commonly used satellite system with many new aircraft having complex units built into the instrument panel.

MEASURING DISTANCE

International Civil Aviation Organization (ICAO) Ruler

The ICAO ruler is a simple straight edge with four measuring scales embossed into it. The scale used depends on the type of map and unit of measurement desired. For a VNC, the scale would be 1 : 500 000. Since all distances in aviation are given in nm, this is the measurement used when determining distance.
Place the ruler on the map, with the starting point at zero. Be sure to use the 1 : 500 000 side and the nm scale. Adjust the ruler so that the destination point is on the same edge as the start point, and measure across. The value found on the nm scale is the distance between the two points.

Map Scale

The distance can also be measured using the map scale. On the reverse side of the map legend there is a graduated scale for that map. It will show nm, statute miles, and km. Take a piece of paper and line it up on the map between the two points. Use a pencil to mark where the two points are on the paper. Line the paper up with the graduated scale, on the nm line, and determine the distance. If the distance on the map is greater than the graduated scale, simply mark off the end of the graduated scale on the paper, shift the paper down so that the new mark is set to zero and remeasure. Depending on the length of the route, some basic math may be required as the paper may have to be readjusted.

Level 3 Study Notes

EO M337.02 – DETERMINE A POSITION ON A VISUAL FLIGHT RULES (VFR) NAVIGATIONAL CHART (VNC)

GRATICULE

A graticule is a three-dimensional geometrical pattern of intersecting circles. Envision the black lines on a basketball, or a globe with only the black lines. When applied to the earth, either on a globe or a map, we refer to these intersecting lines as parallels of latitude and meridians of longitude.

Parallels of Latitude

Parallels of latitude are a series of concentric circles, which measure north and south. The baseline for measuring is the equator, which is 0 degrees of latitude. As one travels away from the equator the degree of latitude becomes larger, to a maximum of 90 degrees north or south. The southern borders of Canada's Prairie Provinces lie on the 49th parallel of latitude, and are therefore at 49 degrees north latitude. Latitude is expressed in degrees (°), minutes ('), and seconds ("). Though the terms are similar, latitude is not a measurement of time and is actually related to distance. One minute of latitude is equal to one nautical mile (nm).

Meridians of Longitude

Meridians of longitude are a series of circles, which measure east and west. The baseline for measuring is the prime meridian, which runs north to south through Greenwich, England. The prime meridian is 0 degrees of longitude. As one travels away from the prime meridian the degree of longitude becomes larger, to a maximum of 180 degrees east or west. Many meridians of longitude pass through Canada, with one being made famous by the Tragically Hip song "Hundredth Meridian". Longitude is expressed in degrees (°), minutes ('), and seconds ("). Longitude is not a measurement of time, but there is a relationship between time and longitude.

The Equator

The equator is the only parallel of latitude, which divides the earth into two equal halves. It is expressed as 0 degrees of latitude and is the dividing line between the northern and southern hemispheres.

The Prime Meridian

The prime meridian is one half of a circle, which will divide the earth into two equal halves. The other half is the International Date Line. The prime meridian is expressed as 0 degrees of longitude, while the International Date Line is expressed as 180 degrees of longitude. Both lines divide the earth into the western and eastern hemispheres.

GEOGRAPHICAL COORDINATES

The locations of cities, towns, and airports may be designated by their geographical coordinates. These coordinates express where a parallel of latitude intersects with a meridian of longitude. This is similar in principle to the X-and Y-axis on a graph.

Units of Measurement

Both latitude and longitude use the same units of measurement: degrees, minutes, and seconds. There are 60 seconds in a minute and 60 minutes in a degree. For latitude, this means that one degree is equal to 60 nm.

Sequencing

When expressing geographical coordinates, latitude is always shown first and longitude second. Whenever possible, coordinates should be given in the greatest detail. This means using degrees, minutes and seconds of latitude and longitude. The more precise the coordinates, the easier it will be to find a location.

Examples of coordinates include:

- Penticton Airport: N 49° 27' 47" W 119° 36' 08"
- Red Deer Airport: N 52° 10' 43" W 113° 53' 35"
- St. Jean Airport: N 45° 17' 40" W 73° 16' 52"
- Debert Airport: N 45° 25' 07" W 63° 27' 28"

Level 3 Study Notes

EO C337.01 – OPERATE A RADIO FOR AVIATION TRANSMISSION

Arrival messages are transmitted in order to communicate intentions, clearances and instructions. An airport can be a busy place, with many aircraft arriving and departing in short spans of time. This can cause confusion if proper communication is not practiced.

There are normally four parts to a radio message, including:
1. the **call-up**,
2. the **reply**,
3. the **message**, and
4. the **acknowledgement** or ending.

All parts of the message should be clear, concise and in phonetics where appropriate.

EXAMPLES OF ARRIVAL AND DEPARTURE COMMUNICATIONS

Arrival

1. The **call-up**:	Schefferville Radio This is Piper Foxtrot Alfa Bravo Charlie Over
2. The **reply**:	Piper Foxtrot Alfa Bravo Charlie This is Schefferville Radio Go ahead Over
3. The **message**:	Schefferville Radio This is Piper Foxtrot Alfa Bravo Charlie Four miles at one thousand Landing Schefferville Over
	Piper Foxtrot Alfa Bravo Charlie This is Schefferville Radio Roger Wind – one six zero at one five Altimeter – two niner niner seven Over
4. The **acknowledgement**:	Schefferville Radio This is Piper Foxtrot Alfa Bravo Charlie Roger

Level 3 Study Notes

Departure

1. The **call-up**: Schefferville Radio
This is
Piper Foxtrot Alfa Bravo Charlie
Over

2. The **reply**: Piper Foxtrot Alfa Bravo Charlie
This is
Schefferville Radio
Go ahead
Over

3. The **message**: Schefferville Radio
This is
Piper Foxtrot Alfa Bravo Charlie
Holding short of runway Tree Tree on Alfa
Ready for takeoff
Over

Piper Foxtrot Alfa Bravo Charlie
This is
Schefferville Radio
Proceed at your discretion
Wind – three two zero at one zero
Over

4. The **acknowledgement**: Schefferville Radio
Piper Foxtrot Alfa Bravo Charlie
Roger