PROFICIENCY LEVEL 3

TRAINING HANDBOOK

CREATED BY: Lt Jarrell, TrgO, 126RCACS

Table of Contents

INTRODUCTION

This handbook was created to assist Level 3 cadets to study for the Aviation related courses. It is expected that the cadets bring this handbook with them to all regular training nights and take notes where required.

Any issues with the handbook should be directed to your Senior Level Instructor.

PO331 – DESCRIBE PRINCIPLES OF FLIGHT

EO M331.01 – DESCRIBE AIRCRAFT STABILITY

CHARACTERISTICS OF STABILITY

Stability is 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 is the initial tendency of an aircraft to return to its original attitude, if displaced.

Dynamic Stability is 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

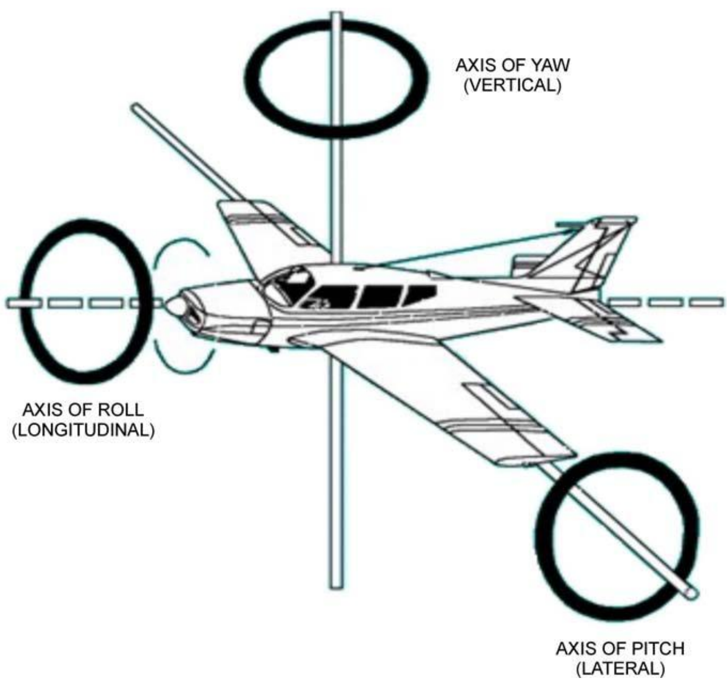

Figure 1 - Axes of Rotation

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 (tail assembly). Movement around this axis is roll. The ailerons control roll.

Lateral Axis and Pitch

This axis runs through the aircrafts' wings, from wing tip to wing tip. Movement around this axis is pitch. The elevator controls roll.

Normal (Vertical) Axis and Yaw

This axis runs through the aircraft vertically top to bottom. Movement about this axis is yaw. The rudder controls yaw.

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 effect 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 backpressure 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.

What is longitudinal stability?

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What does the horizontal stabilizer act like?

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What is the danger of an aft centre of gravity?

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LATERAL STABILITY

Lateral stability is stability around the longitudinal axis and is called roll stability. To achieve lateral stability certain design features are built into the aircraft. Three of these design features are:

- Dihedral;
- Sweepback; and
- Keel effect.

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 forces into 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.

Anhedral 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 towards the ground so that the wing tip is lower than the wing root. Anhedral works in the same manner as dihedral.

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.

What is lateral stability?

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What are three design features which provide lateral stability?

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How does keel effect work?

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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

Aircraft, specifically airplanes, have a tendency of always flying head-on into the relative airflow. This tendency, 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.

What is directional stability?

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What is the principle factor influencing directional stability?

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What is the effect of the fin?

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End of EO

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 the atmosphere. There are also small particles of dust and debris in the lower levels of the atmosphere.

The Breakdown of the Major Gasses

At altitudes 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%.
- **Oxygen.** Oxygen is the second most abundant gas by percentage of the atmosphere at 21%.
- **Other.** The rest of the gasses make up approximately 1% 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 a water droplets or ice crystals and is responsible for the formation of clouds.

How much of the atmosphere is composed of nitrogen?

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How much of the atmosphere is composed of nitrogen?

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From the standpoint of weather, which gas is the most important?

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;
- Mesosphere; and
- Thermosphere.

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

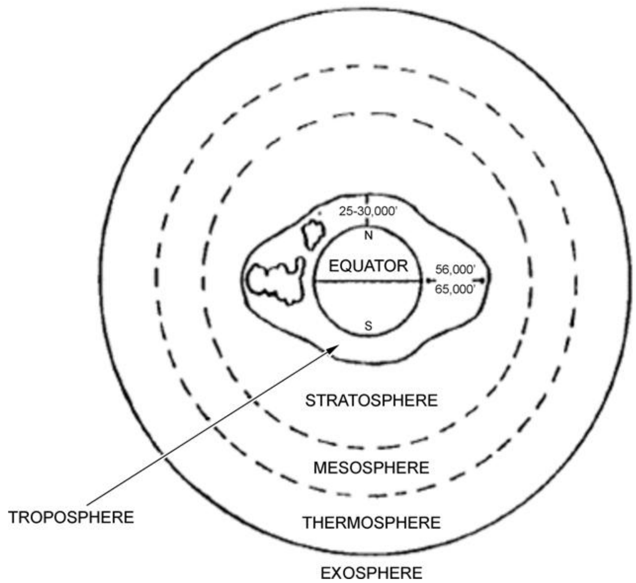

Figure 2 - The Four Layers of the Atmosphere

The Troposphere

The troposphere is the lowest layer of the atmosphere. The troposphere starts at ground level and extends to varying heights Above Sea Level (ASL). 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 layer 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 50000 feet upward 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 andthe 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 mesosphereand 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.

Name the four layers of the atmosphere?

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In which layer does most weather occur?

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In which layer is the ozone layer found?

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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.

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.

What are the three properties of the atmosphere?

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Which is the most important property of the atmosphere?

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What are the three factors affecting the properties of the atmosphere?

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Why is there an international standard atmosphere?

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Which is the most important property of the atmosphere?

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End of EO

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.

Figure 3 - Cumulus Cloud

- **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.

Figure 4 - Stratus Cloud

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.

The chart on the next page includes a brief description of the more common cloud types.

How are clouds classified?

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What are the two types of cloud formations?

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What are the four categories of cloud height?

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Cloud Name	Cloud Family	Cloud Description
Cirrus	High	High, thin, wispy clouds blown by high winds into long streamers. Cirrus clouds usually mode 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 cumulonimbus clouds.

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 effects 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 effects on flight characteristics:

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

What may create vertical currents?

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What is stable air?

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What is unstable air?

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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.

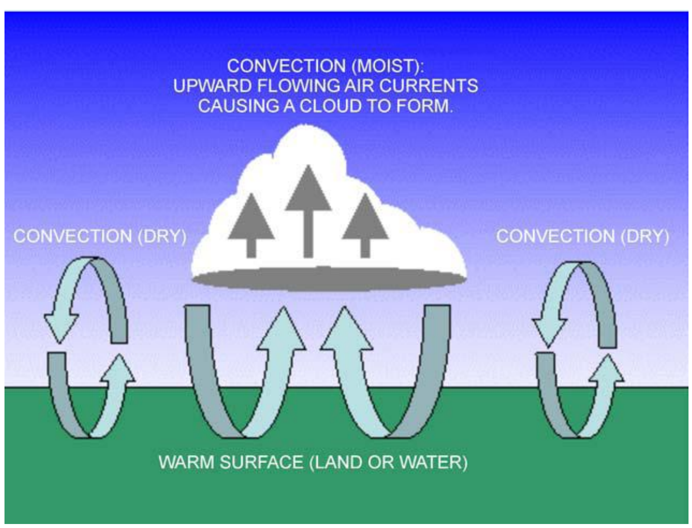

Figure 5 – Convection

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

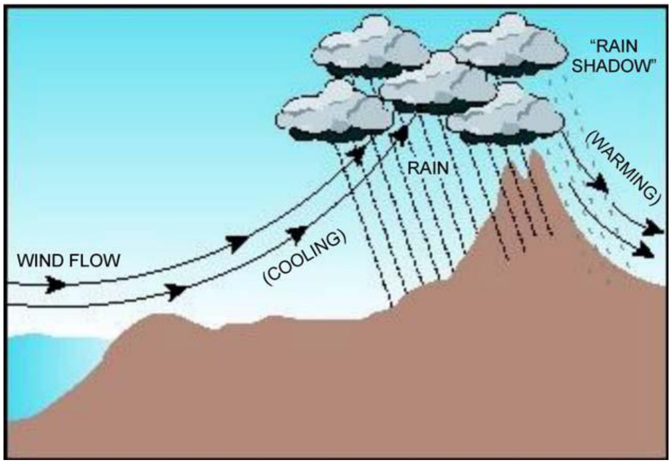

Figure 6 - Orographic Lift

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

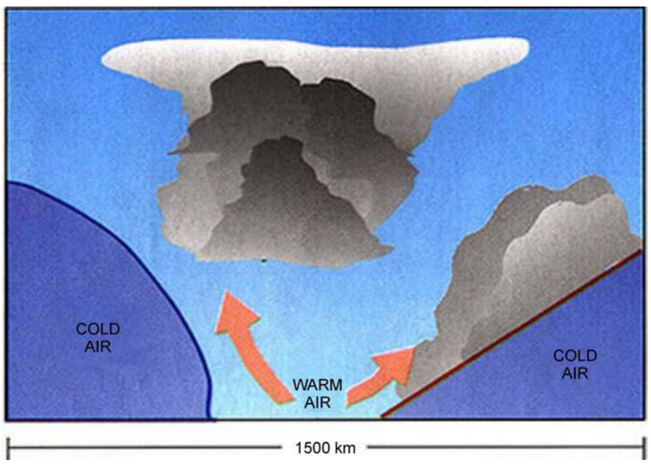

Figure 7 - Frontal Lift

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.

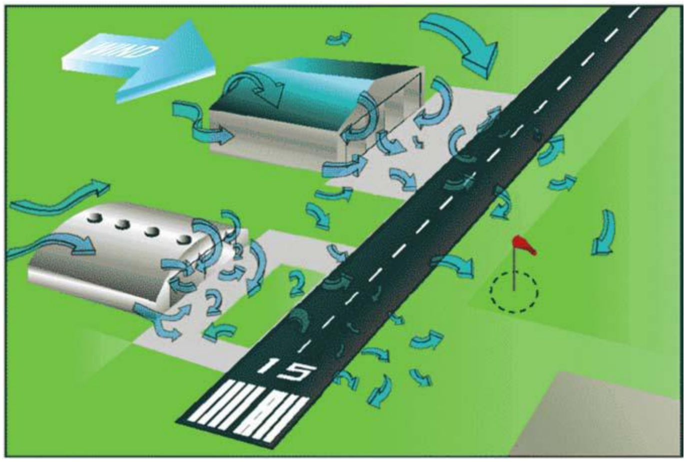

Figure 8 - Mechanical Turbulence

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

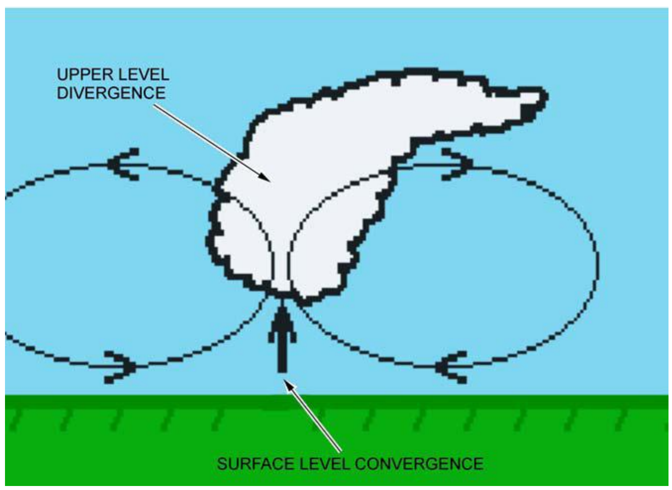

Figure 9 – Convergence

Explain how convection (as a source of lift) occurs.

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Explain orographic lift.

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Explain frontal lift.

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CLOUD FORMATION

Clouds are formed by the lifting agents and air stability.

Clouds are formed in two ways. Either the temperature drops to the saturation point of the air or the temperature is constant but the amount of water in the air increases.

Relating Lifting Agents to Air Stability

Each of the lifting agents described have an effect on, or is affected by, air stability. Convection, for example, is normally associated with unstable air since heat causes the convection, and is also a source of instability in the air.

Another example would be orographic lift, which is usually associated with stable air. After the air has been forced up by the terrain, it cools and becomes dense. The effect is similar to positive stability in an airplane.

Relating Air Stability to Types of Formation

Air stability will have a direct effect on cloud formation. Clouds created in stable air will form as stratus-type clouds. Clouds formed in unstable air will form as cumulus-type clouds.

What are the two ways in which a cloud forms?

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How does orographic lift relate to air stability?

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What cloud type will form in stable air?

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End of EO

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

Note: Certain terms used in this document are meant to be relative; they may not necessarily have a fixed value. For example, low pressure system does not necessarily mean that the pressure of the air is lower than mean sea level. It means that the air pressure in that system is lower than the air pressure around the system.

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

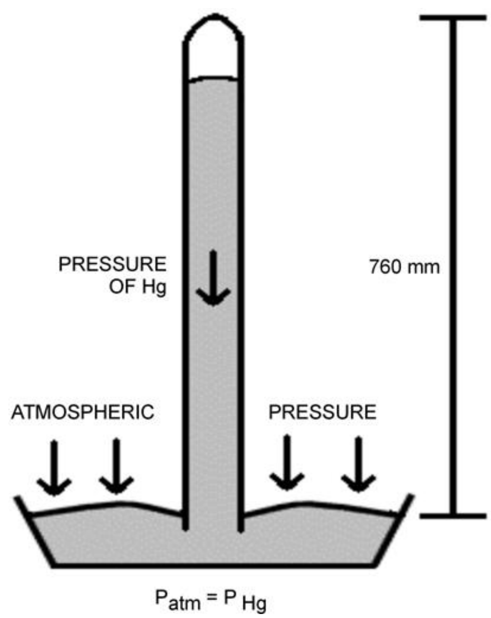

Figure 10 - Barometer

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 over an area 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.

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.

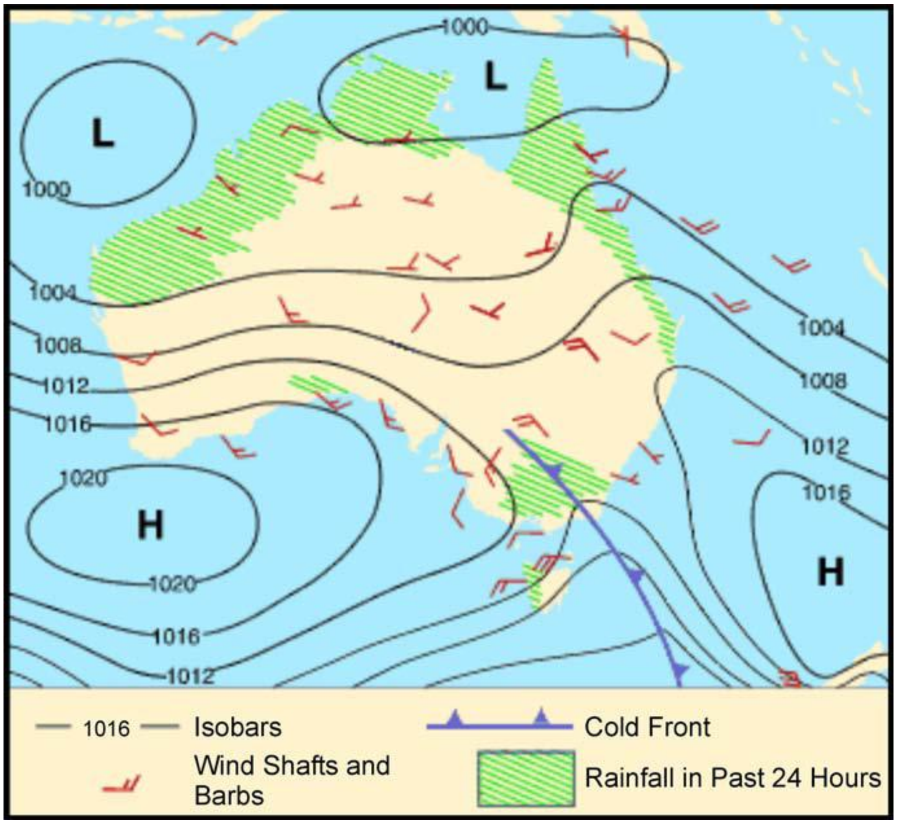

Figure 11 - Isobars on a Weather Map

- **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.

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.

What is a hectopascal?

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Which direction does the air move around a low pressure in the northern hemisphere?

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What is the transition zone between the polar air and the tropical air known as?

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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.

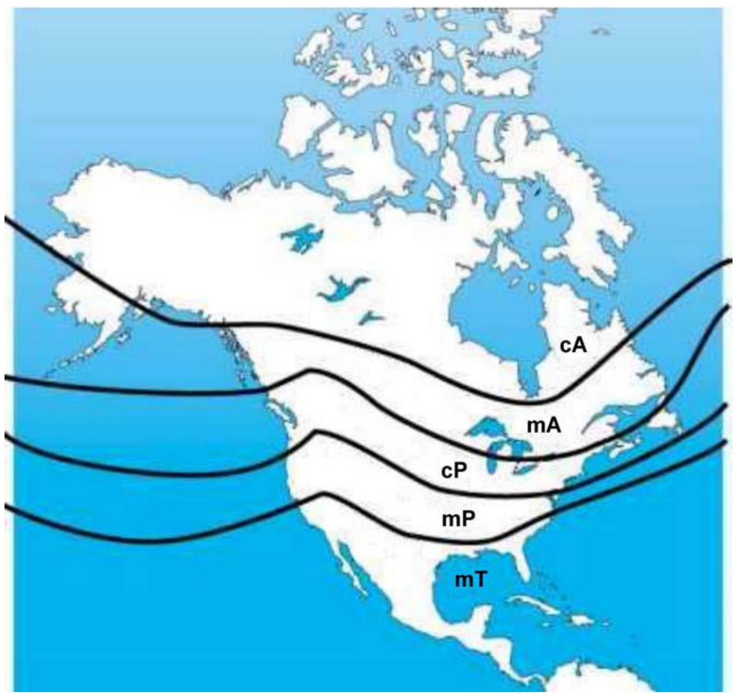

Figure 12 - North American Air Masses

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 12include:

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

What is the definition of an air mass?

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Where does an air mass obtain its properties from?

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What are five air masses in North America?

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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.

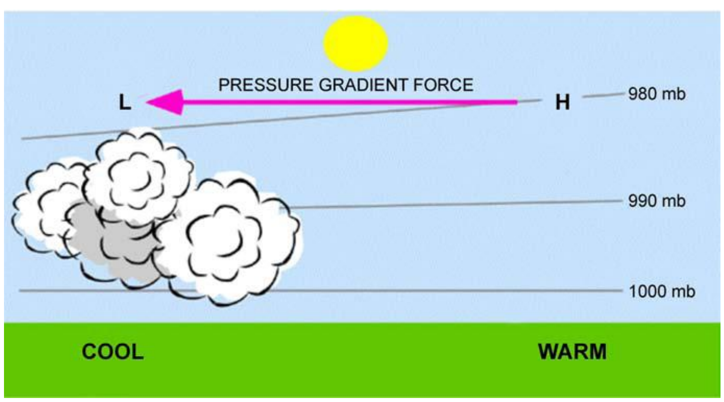

Figure 13 - Pressure Gradient

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.

Land and Sea Breezes

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

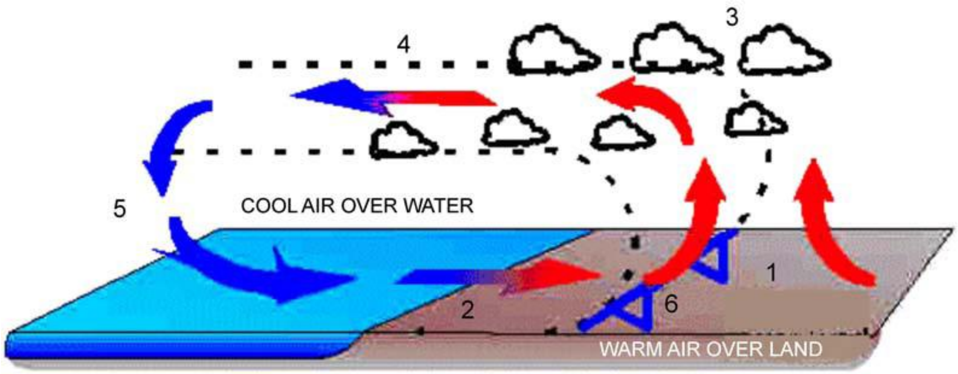

Figure 14 - Sea Breeze

Note that the term breeze is used here as a technical term and has no bearing on wind strength. 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 pressure over the land. The pressure gradient now moves the air from the land to the water.

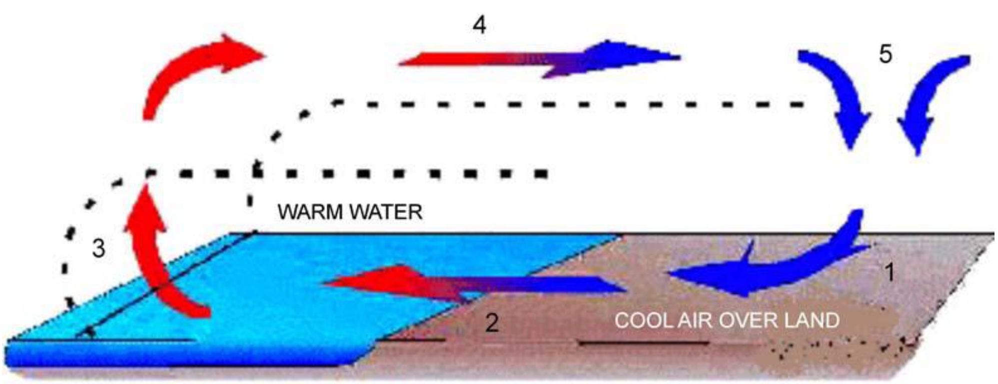

Figure 15 - Land Breeze

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 counter-clockwise 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

Define pressure gradient.

____

Why do sea breezes occur?

____

What is veering?

____

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.

What direction does the wind blow around a low pressure system in the northern hemisphere?

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What direction does the wind blow around a high pressure system in the northern hemisphere?

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End of EO

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.

Define condensation.

____

Define dew point.

____

Define relative humidity.

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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.

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, non-rising air.

How is the atmosphere heated?

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Identify the four heating processes.

____

Identify the three cooling processes.

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THE EFFECTS OF TEMPERATURE ON RELATIVE HUMIDITY

Temperature will affect the relative humidity of an air mass by changing the volume of the air mass.

As the temperature of the air mass increases, the air mass will expand increasing the volume of the mass. The result is that the relative humidity will decrease, as the air mass has a higher capacity for water. This assumes that there is no change in the amount of water in the air mass.

As the temperature of the air mass decreases, the air mass will contract, decreasing the volume of the mass. The result is that the relative humidity will increase, as the air mass has a lower capacity for water. This assumes that there is no change in the amount of water in the air mass.

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.

What is the effect of dew point on weather?

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How does relative humidity affect the creation of precipitation?

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How is it possible for hail or snow to occur in the summer months?

____

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. The hailstone in Figure 16 has a circumference of 47.63 cm (18.75 inches) and weighs almost 1 kg (2 pounds).

Figure 16 - Hailstone

- **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.

Figure 17 - Snow Pellets

- **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.

Figure 18 - Snow Doughnut

- **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 it is confused with ice fog.

Figure 19 - Ice Prisms

- **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.

What are the seven types of precipitation?

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What process creates snow?

____

What is the difference between ice pellets and freezing rain?

____

End of EO

End of PO

PO 337 – DEMONSTRATE AIR NAVIGATION SKILLS

EO M337.01 – MEASURE DISTANCE ALONG A ROUTE

AIR NAVIGATION TERMS

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

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 (^{o}), minutes ('), and seconds (").

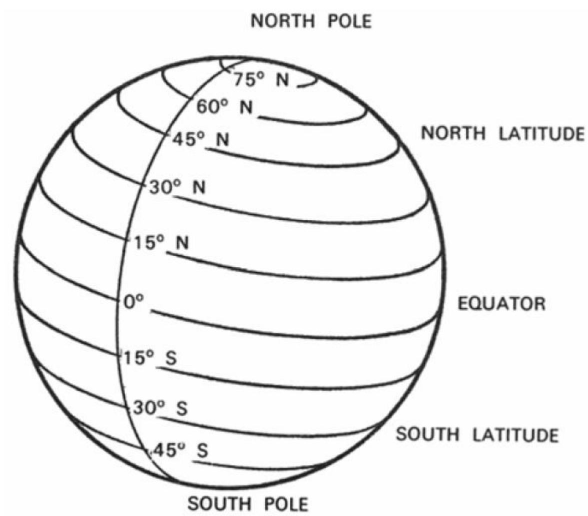

Figure 20 - Parallels of Latitude

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 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 (^{o}), minutes ('), and seconds (").

A **nautical mile (nm)** is 6080 feet and is the average length of one minute of latitude.

A **statute mile (mi)** is 5280 feet.

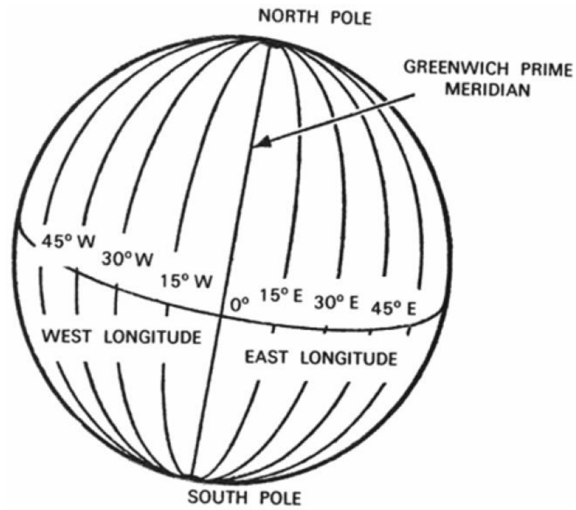

Figure 21 - Meridians of Longitude

The **scale** on a map is the relationship between units 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.

A **Visual Flight Rules (VFR) Navigation Chart (VNC)** is a chart used primarily for visual navigation, at low altitudes (below 18000 feet) and slower speeds (less than 300 knots). A VNC has a scale of 1: 500 000 or one inch to eight miles.

What is a graticule?

____

How many nautical miles are in one minute of latitude?

____

How many feet are in a statute mile?

____

TYPES OF NAVIGATION

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

- Pilotage;
- Dead reckoning;
- Inertial Navigation;
- Satellite Navigation;

Navigation by reference to landmarks only is known as **pilotage**. This is similar to orienteering.

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

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

Satellite navigation 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 1:500000. 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 1:500000 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.

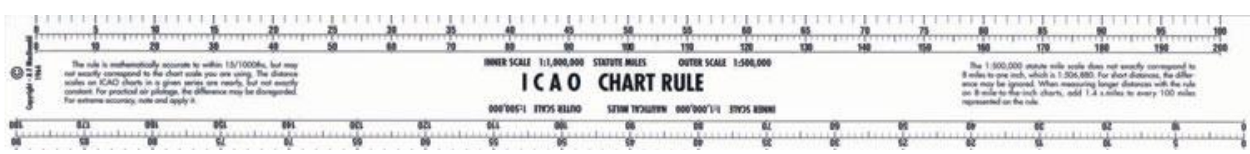

Figure 22 - ICAO Ruler

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 sale, 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 re-measure. Depending on the length of the route, some basic math may be required as the paper may have to be readjusted.

Remember that the distance between minutes of latitude is one nm. This means that if two points are directly north of each other, count up the number of minutes of latitude between them and this equals the distance.

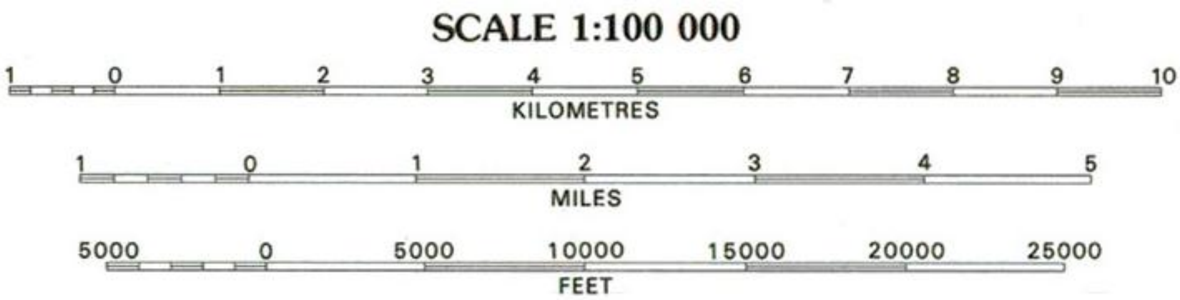

Figure 23 - Map Scale

End of EO

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

Meridians of longitude are semicircles joining the true/geographic poles of the Earth.

Longitude is measured from 0 to 180 degrees east and west of the prime meridian. The prime meridian is the meridian which passes though Greenwich, England and is numbered zero degrees. The meridian on the opposite side of the Earth to the prime meridian is the 180th and is called the International Date Line (the time changes a day).

Longitude is measured in degrees (º), minutes (’), and seconds (”). There are 60 minutes in a degree and 60 seconds in a minute.

When dealing with longitude and latitude, seconds and minutes are not measurements of time, but rather divisions of a degree. This can be compared to the way that a metre is divided into 100 cm, and each centimetre is divided into 10 mm.

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, and are therefore at 49 degrees north latitude. Latitude is also measured in degrees, minutes, and seconds. One minute of latitude is equal to one nautical mile (nm).

The Equator is the only parallel of latitude that 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 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: 49°27'47" N 119°36'08"W
- Red Deer Airport: 52°10'43" N 113°53'35"W
- St. Jean Airport: 45°17'40" N 73°16'52"W
- Debert Airport: 45°25'07" N 63°27'28"W

For example, the geographical coordinates of the military airport at Trenton, ON are 44°07'N, 77°32'W. Try it using Figure 24.

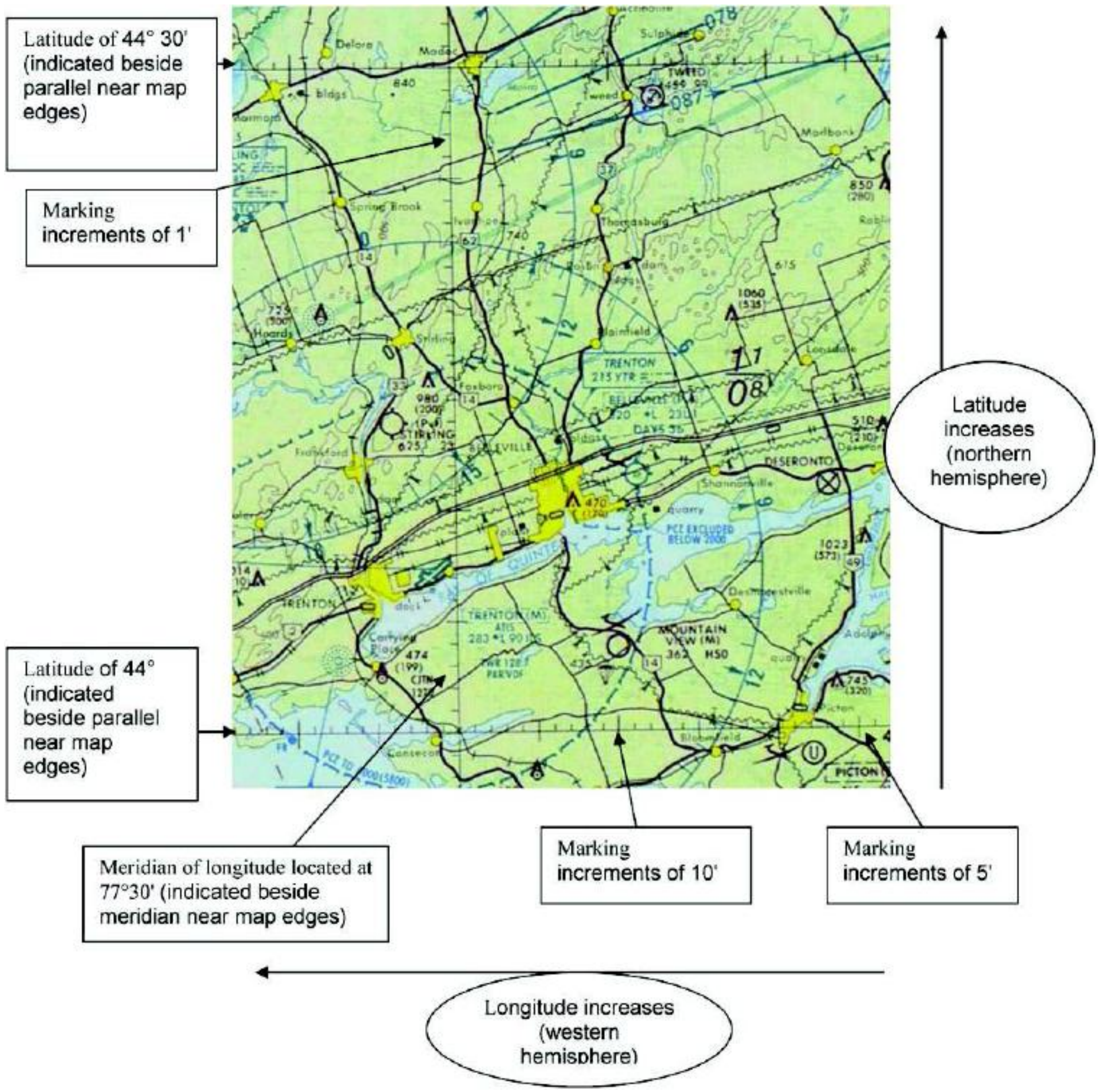

Figure 24 - VNC Chart showing CFB Trenton

End of EO

End of PO