ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL THREE

INSTRUCTIONAL GUIDE

SECTION 4

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

Total Time: 60 min

PREPARATION

PRE-LESSON INSTRUCTIONS

Resources needed for the delivery of this lesson are listed in the lesson specification located in A-CR-CCP-803/PG-001, Chapter 4. Specific uses for said resources are identified throughout the instructional guide within the TP for which they are required.

Review the lesson content and become familiar with the material prior to delivering the lesson.

Gather the resources required for the in-class activity in TP 3.

Create slides of Annex Q.

PRE-LESSON ASSIGNMENT

N/A.

APPROACH

An interactive lecture was chosen for TPs 1, 2, 4, and 5 to introduce temperature, humidity and precipitation to the cadets.

An in-class activity was chosen for TP 3 as an interactive way to provoke thought about temperature and humidity.

INTRODUCTION

REVIEW

N/A.

OBJECTIVES

By the end of this lesson the cadet shall be expected to explain the effects of temperature and humidity on weather.

IMPORTANCE

It is important for cadets to be able to explain the effects of temperature and humidity on weather as it will allow the cadet to make more informed decisions about activities in the field, in aviation or whether to wear a raincoat.

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Teaching point 1 **Explain Humidity**

Time: 10 min Method: Interactive Lecture

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.

CONFIRMATION OF TEACHING POINT 1

QUESTIONS

Q1. Define condensation.

Q2. Define dew point.

Q3. Define relative humidity.

ANTICIPATED ANSWERS

A1. Condensation is a process by which a gas changes into a liquid by becoming denser.

A2. Dew point is the temperature to which unsaturated air must be cooled, at a constant pressure, in order to become saturated.

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A3. 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.

Teaching point 2 **Explain Temperature**

Time: 15 min Method: Interactive Lecture

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.

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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.

CONFIRMATION OF TEACHING POINT 2

QUESTIONS

Q1. How is the atmosphere heated?

Q2. Identify the four heating processes.

Q3. Identify the three cooling processes.

ANTICIPATED ANSWERS

A1. The atmosphere is heated from below not from above.

A2. Convection, advection, turbulence, and compression.

A3. Radiation cooling, advection cooling, and adiabatic process.

Teaching point 3 **Describe the Effects of Temperature on Relative Humidity**

Time: 10 min Method: In-Class Activity

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.

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ACTIVITY

OBJECTIVE

The objective of this activity is to illustrate the effects of temperature on relative humidity.

RESOURCES

- Water,
- Paper towel,
- One small plastic cup per cadet, and
- One large plastic cup per cadet.

ACTIVITY LAYOUT

N/A.

ACTIVITY INSTRUCTIONS

1. Distribute one small cup and one large cup to each cadet.

2. Fill each small cup three quarters full of water. This will represent an air mass with a relative humidity of 75 percent.

3. Have the cadet pour the water from the small cup into the large cup. The large cup represents the results of increasing the temperature of the air mass.

4. Have the cadets estimate the percentage of the large cup which now contains water.

5. Fill the large cup of water to 80 percent. This will represent the continued evaporation of water from all sources into the air mass.

6. Have the cadets pour the large cup into the small cup. This will represent the results of cooling the air mass to the dew point. The water that does not fit into the small cup is the precipitation.

7. Have the cadets clean up the water.

SAFETY

N/A.

CONFIRMATION OF TEACHING POINT 3

The cadets' participation in the relative humidity activity will serve as the confirmation of this TP.

Teaching point 4 **Explain the Effects of Temperature and Humidity on Weather**

Time: 5 min Method: Interactive Lecture

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.

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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.

CONFIRMATION OF TEACHING POINT 4

QUESTIONS

Q1. What is the effect of dew point on weather?

Q2. How does relative humidity affect the creation of precipitation?

Q3. How is it possible for hail or snow to occur in the summer months?

ANTICIPATED ANSWERS

A1. As the temperature nears the dew point, the air will become more saturated.

A2. Once the air mass has reached 100 percent relative humidity, any addition of water or drop in temperature will cause precipitation.

A3. The temperature in the air mass will change with altitude, so water may freeze at higher levels of the air mass.

Teaching point 5 **Explain Types of Precipitation**

Time: 10 min Method: Interactive Lecture

TYPES OF PRECIPITATION



Show slides of figures located at Annex Q.

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.

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- **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 13-4-1 has a circumference of 47.63 cm (18.75 inches) and weighs almost 1 kg (2 pounds).



UCAR Communications, Staff Notes Monthly, 2003, One Hail of a Storm, Copyright 2003 by University of Carolina. Retrieved April 2, 2008, from http://www.ucar.edu/communications/staffnotes/0308/hail.html

Figure 1 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.

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Climber.org, by S. Eckert, 2006. Graupel–Snow Pellets, Lighter and Smaller Than Hail, Copyright 2006 by Climber.org. Retrieved April 2, 2008, from http://www.climber.org/TripReports/2006/1473.html

Figure 2 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.

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Neatorama, 2007, Snow-donut. Copyright 2007 by Neatorama. Retrieved April 2, 2008, from http://www.neatorama.cachefly.net/images/2007-03/snow-donut.jpg

Figure 3 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 confused with ice fog.



Ohio Weather Library, by B. Plonka, 2008, Unusual Weather. Copyright 2008 by Ohio Weather Library. Retrieved April 2, 2008, from http://www.owlinc.org/unusualweatherpg7.html

Figure 4 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.

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CONFIRMATION OF TEACHING POINT 5

QUESTIONS

Q1. What are the seven types of precipitation?

Q2. What process creates snow?

Q3. What is the difference between ice pellets and freezing rain?

ANTICIPATED ANSWERS

A1. Drizzle, rain, hail, snow pellets, snow, ice prisms and ice pellets.

A2. Sublimation.

A3. Ice pellets freeze before contacting an object while freezing rain freezes after contact.

END OF LESSON CONFIRMATION

QUESTIONS

Q1. Define dew point.

Q2. Explain how the atmosphere is heated.

Q3. Explain the effect of dew point on weather.

ANTICIPATED ANSWERS

A1. Dew point is the temperature to which unsaturated air must be cooled, at a constant pressure, in order for it to become saturated.

A2. The atmosphere is heated from below not from above.

A3. As the temperature nears the dew point, the air will become more saturated.

CONCLUSION

HOMEWORK/READING/PRACTICE

N/A.

METHOD OF EVALUATION

This EO is assessed IAW A-CR-CCP-803/PG-001, Chapter 3, Annex B, Aviation Subjects – Combined Assessment PC.

CLOSING STATEMENT

Weather is an amazing aspect of nature, which has a great impact on how we live our lives. Being aware of what causes weather will assist cadets in making decisions about outdoors activities.

INSTRUCTOR NOTES/REMARKS

Video resources are available for purchase through flight training centres or aviation supply websites. These videos may be used to augment instruction.

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C3-116 (ISBN 0-9680390-5-7) MacDonald, A. F., & Peppler, I. L. (2000). *From the Ground Up: Millennium Edition*. Ottawa, ON: Aviation Publishers Co. Limited.

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