

**121 Red Arrows Accelerated Training Program**

**For Advancement to Level Three**



**PO 201 – IDENTIFY THE ROLE OF AN ENVIRONMENTALLY CONSCIOUS CITIZEN**

**M201.01 – DISCUSS THE RIGHTS AND RESPONSIBILITIES OF A CANADIAN CITIZEN**

**OBJECTIVES**

By the end of this lesson the cadet shall be expected to identify the rights and responsibilities of a Canadian citizen.

**IMPORTANCE**

Cadets are valued members of their community and they have the ability to make positive contributions to society. Recognizing and understanding the rights and responsibilities of a Canadian citizen may assist cadets in positively impacting their community.

**TEACHING POINTS**

Every Canadian citizen is granted certain rights based on Canada’s tradition of democracy and respect for human dignity and freedom. These rights are found in Canada’s *Human Rights Codes* and in the Canadian - *Charter of Rights and Freedoms*.

All Canadians have the following rights:

* **Equality Rights.** Every citizen is entitled to equal treatment before and under the law, and equal protection and benefit of the law without discrimination.
* **Democratic Rights.** Every citizen has the right to participate in political activities including voting and being elected to political office.
* **Legal Rights.** Every citizen has the right to be presumed innocent until proven guilty, the right to retain a lawyer and to be informed of that right and the right to an interpreter in court proceedings.
* **Mobility Rights.** Every citizen has the right to enter and leave Canada, and to move to and take up residence in any province.
* **Language Rights.** Every citizen has the right to use either the English or French language in communications with the federal government and certain provincial governments.
* **Minority Language Education Rights.** In general, English and French minorities in every province and territory have the right to be educated in their own language. Canadians also enjoy fundamental freedoms of religion, thought, expression, peaceful assembly and association.

If Canadian citizens have their rights violated by the federal, provincial or territorial governments or their rights are violated by others, Canadian citizens can challenge that action in court.

English and French are the two official languages of Canada. They are an important part of our national heritage and national identity.

Canadian citizens share certain common responsibilities.

These responsibilities are:

* understanding and obeying Canadian laws;
* participating in Canada’s democratic political system;
* voting in elections;
* allowing other Canadians to enjoy their rights and freedoms; and
* appreciating and helping to preserve Canada’s multicultural heritage.

All Canadians are encouraged to become informed about political activities and to help better their communities and the country by reading a newspaper, watching news programs, etc.

**PO 203 – DEMONSTRATE LEADERSHIP ATTRIBUTES WITHIN A PEER SETTING**

**M203.01 – DISCUSS THE PRINCIPLES OF LEADERSHIP**

**OBJECTIVES**

By the end of this lesson the cadet shall be expected to discuss leadership within a peer setting.

**IMPORTANCE**

It is important for cadets to learn about leadership within a peer setting because there are responsibilities for second year cadets. Being aware of the responsibilities second year cadets perform will assist them in setting achievable goals and adapting to their new role as leaders in the squadron.

**TEACHING POINTS**

Within junior leadership, there are responsibilities for a Proficiency Level Two cadet at the squadron. To make the second year of cadets a fun, challenging and dynamic experience, second year cadets should know their responsibilities.

There are some responsibilities common to every Proficiency Level Two cadet in the squadron. They are:

* **Following the Chain of Command.** Following the chain of command ensures that all information that must be passed up and down the chain is delivered. Following the chain of command prevents gaps in the information flow.
* **Setting the Example.** A Proficiency Level Two cadet must set a personal example in dress and deportment. A good leader will never ask more of their followers and teammates than they are willing to give themselves.
* **Being Firm, Fair and Friendly With Everyone, Especially New Recruits.** No one is impressed with a Proficiency Level Two cadet who yells, least of all new cadets. A highly influential and respected Proficiency Level Two cadet is one who is consistent in their approach to people and each situation. Being approachable at all times should enable the cadet to fulfill all duties and responsibilities in an effective manner.
* **Being Respectful to Superiors and Subordinates.** Using a proper tone of voice, looking people in the eyes when they speak and standing up straight is a physical way to show respect. If the Proficiency Level Two cadet wishes to be treated with respect, they must display respect toward others.
* **Being Aware of Safety Hazards.**
* **Displaying Initiative.** Undertaking small matters, like cleaning up, before being told to do so is an example of using initiative. Superiors notice when small tasks are completed without any request to do so.
* **Setting Goals.** Every leader needs to set goals. Goals allow people the opportunity to turn ideas into results. A goal is a glimpse of the future. Setting goals like improving their drill, dress and deportment, gives Proficiency Level Two cadets something to strive for. By setting goals, and working towards them, a Proficiency Level Two cadet will show commitment.

M203.02 DISCUSS THE PRINCIPLES OF LEADERSHIP

**OBJECTIVES**

By the end of this lesson the cadet shall be expected to discuss the principles of leadership.

**IMPORTANCE**

It is important for cadets to learn the principles of leadership because they are fundamentals of leadership theory. As listed in CATO 11-03, *Cadet Program Mandate*, leadership is inherent in the participant outcomes of social competence and it is one of the three aims of the Cadet Program.

Leadership is a demonstrable skill. This means it can be displayed and observed. Leadership can be learned and the skills involved can be improved with practice. Within leadership there are set of principles that may be used to improve leadership ability.

**PRINCIPLES OF LEADERSHIP**

**Leadership is influence.**

The ability to influence others is fundamental within the leadership process. Everyone influences someone. People are influenced by those around them on a daily basis: friends, family, teachers, newsmakers, athletes, etc. all influence others. In turn, those same people are influenced.

**Influence can be positive or negative.**

There are many people who use their influence in a positive manner and while doing so help their community, their school, their family, and the world around them. There are some people who use their influence in a negative manner and while doing so do not help anyone including themselves.

**Leadership can create opportunities in life.**

Qualities of leadership are learned and practiced, therefore improving your ability to lead may create opportunities in life. Throughout the Cadet Program, cadets may be given many occasions to lead. Success in a leadership role may lead to greater leadership opportunities with bigger challenges, more responsibility, rewards, etc.

**M203.03 – DISCUSS EFFECTIVE COMMUNICATION IN A PEER SETTING**

**OBJECTIVES**

By the end of this lesson the cadet shall discuss effective communication in a peer setting.

**IMPORTANCE**

It is important for cadets to learn effective communication in a peer setting to continue to improve their leadership skills. Effectively communicating in a peer setting may improve the leadership skills of cadets because communication is the most basic way to influence others. Effective communication may be used to resolve and/or reduce problems and conflict. By experiencing the benefits of effective communication in a peer setting, cadets may enhance their self-confidence and self-esteem.

**TEACHING POINTS**

Effective communication is a critical skill for leaders in a peer setting. Communication is the exchange of thoughts, messages and information. It is the process of sharing knowledge, interests, attitudes, opinions, feelings and ideas with others. Through communication one person can influence others. Effective communication may also be used to resolve and/or reduce problems and conflict.

**COMMUNICATION IS A SKILL**

Like any skill, the ability to communicate with competence must be learned and developed over a lifetime. Communication skills permit the flow of ideas from one individual to another or to a group, and vice versa. The process of communication can include both verbal and non-verbal messages.

**NON-VERBAL COMMUNICATION**

Non-verbal communication uses many channels for sending and receiving information. Information is received through all our senses (taste, sight, smell, touch and sound). Some aspects of non-verbal communication include:

* **Eye Contact.** Looking directly at another person when speaking is an effective way of indicating sincerity and getting someone’s attention.
* **Body Posture.** The weight of the message being sent will be increased when facing the person being spoken to, standing or sitting closer to them and leaning forward. Using correct body posture when listening is also an effective way of indicating interest in the conversation.
* **Gestures.** A message that has a body gesture attached to it takes on added emphasis.
* **Facial Expressions.** When making a statement, make sure facial expressions agree with the message.
* **Voice Tone, Volume Changes.** Shouting may cause people to become defensive, just a whispering may cause people to tune out the message. Make sure voice levels are correct for the space and that statements are convincing without being intimidating. Being able to read non-verbal responses to communication, while leading in a peer setting, may help cadets understand how they are being perceived.

**SENDING, RECEIVING AND RESPONDING TO A MESSAGE**

Communication consists of three things: sending, receiving and responding to a message.

The sender must deliver a clear message, taking into consideration the characteristics of the individual(s) receiving the message. Is the person a child or an adult? Is there one person, or are there 20? These and similar factors all determine how the message should be sent.

Next, the message is received. It is important to remember that receivers translate what they have heard based on their own set of definitions, which may differ greatly for those of the sender.

The final component of communication is response. A response lets the sender know the message has been received. All three parts are necessary for effective communication.

**THREE STYLES OF COMMUNICATION**

**Aggressive Communication.** A person who is an aggressive communicator puts their own wants and needs ahead of everyone else and they often ignore or belittle other people’s concerns.

Aggressive communicators often:

* talk over people and interrupt;
* make sarcastic, demeaning or threatening remarks;
* consider only their own point of view; or
* stand too close, lean over you or in some other way make you feel physically uncomfortable.

Aggressive communication usually leads to hostility, anger and resentment.

**Passive Communication.** A person who is a passive communicator puts other people’s wants and needs ahead of their own and often denies what they want or need. Passive communicators often:

* hardly ever say what they want or need;
* let others make decisions for them;
* avoid conflict and disagreement at all costs; and
* drop hints rather than directly request that something gets done.

Passive communication usually leads to bad feelings and damages relationships.

**Assertive Communication.** A person who is an assertive communicator uses skills based on mutual respect. Assertive communicators can say how they see things and hear how others see things. They work towards outcomes that satisfy everyone.

Assertive communicators often:

* are open and honest about what they are thinking and feeling;
* make direct requests if they want something done, leaving the option to say “no”;
* respect themselves and show respect to others; and
* are able to disagree without creating bad feelings.

Assertive communication usually results in clear and open communication.

Assertive people use a number of important communication skills. They ask questions to gather information and check that they have understood correctly. Assertive people say what is on their mind in a direct yet courteous way so there is no hidden message.

**USING “I” STATEMENTS**

One of the most important skills that an assertive communicator uses is making “I” statements. Assertive people use “I” language. An assertive communicator uses statements like “I’d like…”, “I’d appreciate…”, “I think….” and “I feel”… etc. They own their own messages and speak for themselves. Their suggestions are not weighted with advice, commands, and “shoulds” or “oughts”. Their feedback is constructive and free from blame.

* Non-verbally assertive people:
* make appropriate eye contact;
* sit or stand comfortably erect;
* use open gestures to support their comments;
* speak in a clear, steady, firm tone of voice; and

maintain open, unchanging and relaxed facial expressions that accurately reflect their thoughts.

**ACTIVE LISTENING SKILLS**

Assertive people also use active listening skills. These skills include:

* repeating the conversation back to the speaker, in their own words, to understand the speakers meaning;
* not talking about themselves;
* letting the speaker take the lead by encouraging them back to the issue if the speaker digresses;
* concentrating fully on what the speaker is saying;
* asking for clarification if it is needed;
* acknowledging the speaker’s feelings; and
* allowing for silence.

EO M203.07 – DISCUSS PERSONAL INTEGRITY AS A QUALITY OF LEADERSHIP

**IMPORTANCE**

It is important for cadets to learn that personal integrity is a fundamental quality of leadership. Without personal integrity, a leader may never build the trust of his followers or his teammates. As listed in CATO 11-03, Cadet Program Mandate, leadership is one of the three aims of the Cadet Program.

Integrity means moral uprightness; honesty. Personal integrity means doing the right thing, even if nobody is watching. People struggle daily with situations that demand decisions between what they want to do and what they ought to do.

According to John C. Maxwell, the author of a number of best-selling books on leadership, if a leader uses personal integrity, a leader should be consistent. If what the leader says and what the leader does is the same, the results by the team will be consistent. For example,

The leader says to their team: “Be on time.” The leader arrives on time. The team will be on time. The leader says to their team: “Be positive.”

The leader exhibits a positive attitude. The team will be positive. The leader says to their team: “Put others first.”

The leader puts others first. The team puts others first. If what the leader says and what the leader does is not the same, the results by the team will be inconsistent. The leader says to their team: “Be on time.”

The leader arrives late regularly. Some of the team will be on time, some will not.

The leader says to their team: “Be positive.” The leader exhibits a negative attitude regularly. Some of the team will be positive, some will not.

The leader says to their team: “Put others first.” The leader puts themselves first. Some of the team will put others first, some will not.

Aristotle, the Greek philosopher, once said, “We are what we repeatedly do. Excellence, then, is not an act but a habit.”

Personal integrity builds trust. To earn the trust of others, a leader should lead by example. If the leader’s words and actions match, teammates and followers should have trust and confidence in the group. Personal integrity usually results in a solid reputation, not just an image.

Personal integrity builds trust. Trust builds confidence. Confidence builds relationships. Relationships build leadership.

Personal integrity is the foundation of leadership. When cadets display this quality, it is the first step in their

role as leaders within a peer setting.

**PO 204 – UPDATE PERSONAL ACTIVITY PLAN**

**M204.02 – IDENTIFY HEALTHY FOOD CHOICES**

**OBJECTIVES**

By the end of this lesson the cadet shall be expected to identify healthy food choices.

**IMPORTANCE**

It is important for cadets to identify healthy food choices because it is a significant component of living a healthy lifestyle. Choosing healthy foods may help the body to grow strong and help to prevent illnesses.

**TEACHING POINTS**

**CANADA’S FOOD GUIDE**

Health Canada, *Canada’s Food Guide*, Her Majesty the Queen in Right of Canada, describes how much of each type of food is required as part of a healthy eating pattern. There are four food groups in the guide; vegetables and fruit, grain products, milk and alternatives, and meat and alternatives. The front page of the guide shows a rainbow with samples of the type of foods that fit in these four categories. The size of the arcs in the rainbow represents the proportion of each food group that makes up a healthy eating pattern.

**Vegetables and Fruit**

Consuming plenty of vegetables and fruit may help reduce the risk of cardiovascular disease and certain types of cancer. This food group provides nutrients such as carbohydrates, vitamin A, vitamin C, potassium, magnesium, and B vitamins. Vegetables and fruit are the most prominent food group in the guide because of the important role these foods play in healthy eating. Examples of foods from the vegetable and fruit group include:

* fresh vegetables/fruit,
* frozen vegetables/fruit,
* canned vegetables/fruit,
* dried vegetables/fruit, and
* vegetables/fruit juices.

**Grain Products**

Consuming the required amount of grain products may help to reduce the risk of cardiovascular disease. Grain products, particularly whole grains, are a source of fibre and are usually low in fat. Whole grains contain all three edible layers of the grain seed or kernel, which provides a greater combination of nutrients. This food group provides nutrients such as carbohydrates, B vitamins (e.g. thiamin, riboflavin, niacin and folate), iron, zinc, and magnesium. The grain products food group is the second most prominent food group in the guide. Examples of foods from the grain products group include:

* grain,
* cereal,
* pasta,
* rice, and
* products made with grain flour (including corn flour).

**Milk and Alternatives**

Consuming the required amount of milk and alternatives may help to develop strong bones and reduce the risk of osteoporosis. This food group provides nutrients such as calcium, vitamin A, vitamin D, vitamin B12, riboflavin, zinc, magnesium, potassium, protein and fat. Examples of foods from the milk and alternatives group include:

* milk products, such as:
  + canned milk (evaporated milk),
  + powdered milk,
  + cheese, and
  + yogurt; and
* alternative milk products, such as fortified soy beverage.

**Meat and Alternatives**

Consuming the required amount of meat and alternatives food group provides nutrients such as iron, zinc, magnesium, B vitamins (e.g. thiamin, riboflavin, niacin, vitamin B6, and vitamin B12), protein, and fat. Examples of foods from the meat and alternatives group include:

* meat products, such as:
  + eggs,
  + fish,
  + meat,
  + poultry, and
  + shellfish; and
* alternative meat products, such as:
* legumes (e.g. chick peas),
* kidney beans,
* lentils, nuts/seeds, and
* tofu.

**FOOD GUIDE SERVINGS**

A food guide serving is a specified quantity of food from each of the food groups. It is used to help people understand how much food is recommended every day from each of these groups. This is generally close to what a person would eat in one sitting (e.g. one apple). When eating out, food portions are often large and contain more than one serving of a food group. It is important to recognize the food groups that make up a meal and how much food is on the plate, in order to count the food guide servings in a meal.

**RECOMMENDED DAILY INTAKE**

The recommended daily intake outlined in Health Canada, *Canada’s Food Guide*, Her Majesty the Queen in Right of Canada (p. 2), describes what amount of food people should eat based on age and gender. The recommended number of servings a child (male and female) between the ages of 9 to 13 should eat in one day is as follows

* six servings of vegetables and fruit,
* six servings of grain products,
* three to four servings of milk and alternatives, and
* one to two servings of meat and alternatives.

Following the recommended daily intake in Health Canada, *Canada’s Food Guide*, Her Majesty the Queen in

Right of Canada, will help people to:

* take in the required vitamins, minerals and other nutrients;
* reduce the risk of obesity, type two diabetes, heart disease, certain types of cancer and osteoporosis; and achieve overall health and vitality.

**M204.03 – IDENTIFY THE BENEFITS OF A HEALTHY LIFESTYLE**

**OBJECTIVES**

By the end of this lesson the cadet shall be expected to identify the benefits of a healthy lifestyle.

**IMPORTANCE**

It is important for cadets to identify the benefits of a healthy lifestyle because it is key to becoming physically fit, which is one of the aims of the Cadet Program.

**TEACHING POINTS**

**SMOKING**

Known facts about smoking include:

* adolescence is the usual time a person will start smoking;
* youth in grades six and seven are considered to be at the critical stage for deciding whether to experiment with smoking; and
* cigarette smoking is more addictive and harder to quit than some other substances such as heroin and cocaine.

Known physical effects of smoking include:

* dry skin and premature wrinkling;
* a longer healing time for a smoker’s acne;
* hair loss in some teenagers;
* yellow teeth and tooth decay; and
* an increased occurrence of oral cancer in some people.

Statistics about smoking:

* It is estimated that 55% of young men and 51% of young women who start smoking by the age of 15 will die before age 70 if they continue to smoke.
* Tobacco kills more than 40 000 Canadians every year.

Consequences of smoking may include:

* cancer of the lungs, mouth, sinuses, throat, brain, breast, uterus, bladder, kidney, thyroid, lymph glands, and blood;
* serious ailments such as bronchitis, pneumonia, emphysema, strokes, heart attacks, ulcers, cataracts, gum disease, tooth decay, ear infections, dry skin, early aging, and impotence;
* respiratory problems such as increased coughing, phlegm, wheezing, chest colds, and shortness of breath;
* asthma attacks or increased asthma symptoms;
* cold fingers and toes due to poor circulation; and
* a dulled sense of smell and taste.

**NUTRITION CHOICES**

Following Health Canada, *Canada’s Food Guide*, Her Majesty the Queen in Right of Canada, will ensure a person eats the amount and type of food that is recommended to help achieve a healthy lifestyle. Eating the amount and type of food recommended and following the tips in Health Canada,

*Canada’s Food Guide*, Her Majesty the Queen in Right of Canada, will help:

* meet the body’s needs for vitamins, minerals, and other nutrients;
* reduce the risk of obesity, type 2 diabetes, heart disease, certain types of cancer, and osteoporosis;
* and contribute to overall health and vitality.

Just as important as eating the right amount of food is eating the right types of foods. People should be encouraged to eat foods that are lower in fat, sugar, and salt.

The benefits of eating well include:

* better overall health,
* lower risk of disease,
* healthy body weight,
* feeling and looking better,
* more energy, and
* stronger muscles and bones.

**REGULAR PHYSICAL ACTIVITY**

Benefits of regular physical activity contribute to the following:

* overall health,
* improved fitness,
* better posture and balance,
* weight control,
* stronger bones and muscles,
* energy level, and
* an increase in relaxation and reduction in stress.

Health risks that may result from inactivity include:

* premature death,
* heart disease,
* obesity,
* high blood pressure,
* adult-onset diabetes (type 2),
* osteoporosis,
* stroke,
* depression, and
* various forms of cancer.

**Healthy Growth and Development**

Studies, in recent years, have shown that over half of young people are not active enough for healthy growth and development. According to the Canadian Community Health Survey in 2000-2001, 56% of Canadian’s aged 12 to 19 were physically inactive and as many as 82% may not have been active enough to meet international guidelines for optimal growth and development.

**Healthy Heart**

Eating more nutritious foods, not smoking, and being physically active can help maintain a healthy heart. A healthy body weight, for example, can help to lower risk factors for heart disease by decreasing blood cholesterol, fat levels, and high blood pressure. Cardiovascular disease, such as heart disease, stroke, and atherosclerosis (ather-o-skleh-ro-sis) – hardening and narrowing of the arteries, is the number one cause of premature death in Canada.

**Stronger Bones and Muscles**

Physical activity, especially strength activities, can contribute to the maintenance of bone mass through adulthood, by helping develop the bony and muscular tissue during childhood. Daily physical activity in adolescence and early adulthood is positively correlated to mineral density and the skeleton’s bone density. This development of mineral density and bone mass may help reduce the risk of osteoporosis later in life. Strength activities will lead to stronger muscles and help them stay strong over time. Stronger bones and muscles can also lead to better posture and balance among people of all ages.

**Weight Control**

Physical activity affects body composition and helps weight loss. Active individuals are at less risk of becoming overweight. Having a healthy body means maintaining a healthy body weight. Having a healthy weight does not necessarily mean being extremely slim and having a low body weight. A healthy body weight should encourage physical, social, and psychological well-being. In 1988, Health and Welfare Canada introduced the “healthy weights strategy”. This strategy promotes healthy eating opposed to dieting and regular physical activity versus intense exercise. For adults, healthy body weight can be determined by the Body Mass Index (BMI) and the waist-hip ratio (WHR).

According to the World Health Organization (WHO) in 2002, there were approximately one billion people in the world who were overweight or obese and only 800 million who were hungry/starving or underweight. According to the Canadian Community Health Survey conducted in 2004, obesity rates in adolescents aged 12 to 17 have tripled from 3% to 9% in the past 25 years. Being inactive and/or overweight increases the risk of heart disease, osteoarthritis, diabetes, various cancers, and back injuries.

**Lower Health Risks**

Regular participation in at least 30 minutes of moderate physical activity can help prevent some chronic conditions, such as:

**Cardiovascular Disease (CVD).** Regular physical activity can reduce the risk of heart disease by as much as 50%.

**Osteoporosis.** In Canada, about one out of four women and one out of eight men over 50 years of age, develops osteoporosis. The risk of osteoporosis may be reduced through regular physical activity during childhood and adolescence.

**Cancer.** Regular physical activity can help in the prevention of certain types of cancer, such as breast and colon cancer. Research shows that overall 30% to 35% of all cancers can be prevented by eating well, maintaining a healthy weight, and by including physical activity into one’s lifestyle.

**Type 2 Diabetes.** Physical activity, together with decreased fat intake, can help in the prevention of type 2 diabetes by as much as 58%.

**PSYCHOLOGICAL BENEFITS OF A HEALTHY LIFESTYLE**

**Positive Self-esteem**

Positive self-esteem requires a person to have a good opinion of their own character and abilities. Self-esteem can be measured by how worthy individuals feel in various social, physical, and academic situations. Individuals with high self-esteem generally view themselves in a positive manner and can appreciate their abilities, as well as their potential and limitations. Those with low self-esteem generally tend to be more passive and dependent in reacting to stress and demands and are more likely to conform to social pressures, while also being pessimistic about their abilities.

Making new friends is easier when a youth participates in activities involving other youth. For example, if an individual participates in a sports team or a recreational club, there are more opportunities to meet new people. As well, an individual who is living a healthy lifestyle, is often more self-confident, making it easier to meet new people and make friends. According to the Canadian Fitness and Lifestyle Research Institute, physical activity appears to have a positive influence on youth’s social lives and the number of same-gender and opposite gender friends they have.

**Positive Self/Body Image**

Self/body image is how an individual perceives their own physical characteristics and how they evaluate themselves based on this perception of self. This is then formulated into a self/body image as an individual perceives their own body, how it looks to them, and how they think it looks to others. Having a positive self/body image comes with the idea that a wider range of body weights, shapes, and sizes are healthy and normal. The reality of genetics encompasses the fact that not all people can be the same shape and size and that not everyone can or should meet the body type seen often in the media.

**Higher Energy**

Nutrition choices have a direct effect on the amount of energy the body produces. Although the body

requires foods from all four food groups, Health Canada recommends that 55% of calories should come from carbohydrates, which should be in the form of starches and natural sugars. These starches and sugars are digested and changed into glucose and are burned during regular physical activity.

Physical activity can also lead to high energy as it determines the amount of energy expended and therefore leads to energy balance (the amount of energy ingested in the forms of carbohydrates, fat, protein and alcohol, should equal the amount expended). Physical activity increases oxygen throughout the body. Endorphins are also increased, therefore, leading to higher levels of energy. Many studies show that physically active youth tend to sleep and eat better than those who are more sedentary or less active.

**Reduced Stress/Increased Relaxation**

Regular physical activity appears to be associated with better self-esteem and a decrease in anxiety and depression symptoms in normal situations. Flexibility activities are especially effective in ensuring the muscles are relaxed. Individuals who are more physically active and eat balanced, nutritious meals are more likely to have positive self-esteem and self/body image, leading to a reduction in anxiety and negative feelings about their sense of self.

**EO C207.01 – IDENTIFY THE RANK STRUCTURE OF**

**THE ROYAL CANADIAN SEA AND ARMY CADETS**

**IMPORTANCE**

It is important for cadets to identify the rank structure of the Sea and Army Cadets to better understand the structure of other elements. Knowing the rank structure and insignia will help cadets address other cadets and gain an appreciation for the differences and similarities between Sea, Army and Air Cadets.



**CHAPTER 11**

**PO 231 – EXPLAIN PRINCIPLES OF FLIGHT**

**EO M231.01 – IDENTIFY THE FOUR FORCES THAT ACT UPON AN AIRCRAFT**

**IMPORTANCE**

It is important for cadets to learn and identify the four forces that act upon an aircraft so that they will understand the principles of flight by which an aircraft operates

**TEACHING POINTS**

**WEIGHT**

Every aircraft has weight, which influences the design and performance of the aircraft.

The weight of an aircraft is the force that acts vertically downward toward the centre of the Earth and is the result of gravity.

The gliders used in the Air Cadet gliding program are towed to their determined altitude by a tow-plane. There are other methods of getting altitude, such as using a winch to get up to speed on the ground.

An aircraft gains energy as it gains altitude. The energy that the glider gains as it is taken to its determined altitude can be spent quickly in a rapid descent to Earth or it can be spent slowly in a long descent.

**DRAG**

Drag is the resistance that any object experiences as it moves through the air. Cadets will have experienced the resistance of air on their bicycles or just walking on a windy day. Effort is put into aircraft design to minimize drag. Cadets avoid drag when they lower their head and shoulders on a bicycle to gain speed.

The design of an aircraft can minimize drag but cannot avoid it entirely. The faster an aircraft is designed to fly, the more sleek and streamlined its design is likely to be.

A parachute is designed to maximize drag by catching air and using it to slow descent.

**THRUST**

A glider is always gliding downwards through the air, but by locating atmospheric lift (rising air) to offset the

downward motion of the aircraft due to gravity, the pilot can actually gain altitude and fly great distances without needing to use artificial lift again.

Thrust is a force that moves an aircraft forward. A glider spends the energy it has gained and moves forward by trading the speed of descent for forward motion. It gets this control by using its weight to push upon the air below. With its nose lowered, it slides forward over the air below.

**LIFT**

A glider’s wings are designed to project out into the passing air. Glider’s wings are usually very large for the

size of aircraft because a glider depends on its wings to develop lift without help from an engine or a propeller.

As air moves over and under the wing, the air is used by the wing to generate lift.

The purpose of a glider’s wings is not to go fast to minimize descent. The object of soaring is to get as much

forward distance as possible, while losing as little altitude as possible for each unit of energy that the glider

loses in descent. The distance travelled forward compared to the altitude lost is referred to as glide ratio. This

should be a very large number such as 30 metres forward for each metre of descent.

The glider’s wing is designed to develop lift because lift reduces the rate of descent while allowing forward

motion. The lift of the aircraft’s wing will counteract the aircraft’s weight, to a degree, and this will improve the aircraft’s glide ratio. Generally, the larger the wing, the more lift can be developed.

A wing generates lift by acting upon the passing air in a highly sophisticated manner that will be explored in

the next lesson.

**POWERED AIRCRAFT**

A powered aircraft also experiences weight, drag and lift as does a glider. However, while a glider can gain

forward motion only by trading the energy of its descent for thrust, a powered aircraft can generate thrust by

running its engine. In this case, thrust is provided to the aircraft via a driven propeller or a high-speed jet exhaust.

On the other hand, the engine adds weight to the aircraft and both the propeller and engine body add to the drag that the aircraft experiences. A powered aircraft, therefore, will usually not have the high glide ratio of a glider.

A powered aircraft, though, can attain equilibrium, which is something a glider cannot do. Equilibrium is a

condition where lift equals weight or thrust equals drag. Pilots often refer to this as flying straight and level.

If lift is greater than weight, the aircraft will climb higher.

If weight is greater than lift, the aircraft will descend.

If thrust is greater than drag, the aircraft’s forward speed will increase.

If drag is greater than thrust, the aircraft’s speed will decrease.

A glider can fly even though it does not produce its own thrust. It can fly even though its weight is greater than

its lift. However, in the Earth’s gravity, its flight is limited by atmospheric conditions and the pilot’s skill. On a

day without wind, even the most skilful pilot will soon return to Earth after being released.

With a powered aircraft, descent can be delayed by turning the energy of burning fuel into

thrust because thrust can then be turned into lift by the aircraft’s wings.

**EO M231.02 – DESCRIBE THE PRODUCTION OF LIFT BY AN AIRCRAFT WING**

**IMPORTANCE**

It is important for cadets to learn about the production of lift by an aircraft wing so that they can develop an

understanding of subsequent and related principles of flight.

**TEACHING POINTS**

*Air follows Newton’s laws of motion:*

Newton’s first law predicts that air, being a gaseous fluid, tends to remain in motion when it is moving.

Newton’s second law of motion requires that a force must be applied to change the air’s motion.

Newton’s third law of motion allows the aircraft wing, by applying a force that changes the motion of air,

to develop lift through an opposite and equal reaction.

The fact that air has mass is very important in aviation. Even though air’s mass is less than the mass of most solids, its mass is still great enough to allow an aircraft to fly and to allow the aircraft to control its own flight.

*Bernoulli’s Principle:*

To develop the equal and opposite reaction described by Newton’s third law of motion, the wing is given a

shape that takes advantage of Bernoulli’s Principle to make the air change direction. Air behaves like a fluid

since it has pressure and speed. As airspeed increases, its pressure drops. A wing uses Bernoulli’s Principle

to deflect air, which causes an equal and opposite reaction.

One part of Bernoulli’s Principle that is very useful to remember is that if air speed increases, pressure decreases and if speed decreases, pressure increases. This is an inverse relationship between airspeed and air pressure. This part of Bernoulli’s Principle is often referred to as the venturi principle. The shape of the wing is carefully calculated to decrease pressure above while increasing pressure below.

The pressure of moving air can be examined by blowing gently over a small piece of curved paper. The air does not push the paper down as might be intuitively assumed. Instead, the paper behind the curve rises toward the moving air. This happens because the air pressure drops over the paper due to the air’s increased speed –

this would seem to match the description of speed/pressure relationship. The curvature in the paper enhances

the effect of the lowered air pressure.

A similar effect can be observed when air moves past any object that is light enough to be affected by the drop

in air pressure associated with movement. A balloon is light enough to show this effect clearly.

*Angle of Attack*

An aircraft wing is an airfoil because of its cross-sectional shape. The top surface is curved outward (convex curvature). Therefore, the air flowing over the top has further to go, over the curve, and so it must move faster which, as we know, will result in lower pressure. This happens above the wing.

Below the wing, the air is deliberately slowed to increase its pressure. This is done by curving the surface slightly inward (concave curvature) and by sloping the wing so that it is slightly higher at the front (leading edge) than it is at the back (trailing edge). This angle of the wing’s under-surface, which encounters the moving air, is called the wing’s angle of attack.

The greater the wing’s angle of attack, the more air the under-surface of the wing will encounter, thereby generating more lift. This is a direct relationship between angle of attack and lift.

Increasing the wing’s speed will also cause it to encounter more air, thereby generating more lift. This is also a direct relationship between speed and lift.

There is a limit to the amount of lift that can be produced by merely increasing the angle of attack. Long before

the wing becomes vertical, it stops generating lift above and this often happens abruptly. The wing “stalls” and

stops generating lift when this happens.

**EO M231.03 – DESCRIBE THE TYPES OF DRAG THAT ACT UPON AN AIRCRAFT**

**IMPORTANCE**

It is important for cadets to know the types of drag that act upon an aircraft so that they will understand

subsequent and related principles of flight.

**TEACHING POINTS**

Drag is the force that opposes the forward motion of an aircraft. The two main types of drag are parasite drag

and induced drag.

Parasite drag is caused by those parts of the aircraft that do not generate lift such as the fuselage, landing gear, struts, antennas, wing tip fuel tanks, etc. Any drag caused by openings, such as those in the cowling and those between the wing and the ailerons and flaps, add to parasite drag.

Induced drag is produced by those parts of an aircraft that are active in producing lift, such as the wings. Induced drag is the result of the wing and is therefore a part of lift and can never be eliminated.

It is true that drag does limit an aircraft’s performance. However, drag also allows the pilot to control flight because an aircraft turns by increasing the drag in certain areas using control surfaces that push on the passing

air. Without drag, an aircraft could not fly in a controlled manner.

Parasite drag is broken down into two components; form drag and skin friction:

- Form drag refers to the drag created by the form or shape of a body as it resists motion through the air.

- Skin friction refers to the tendency of air flowing over a body to cling to its surface.

Although parasite drag can never be eliminated, it can be reduced. One method is to remove parts of the aircraft that cause it. For this reason, retractable landing gears have been developed. Another method is to streamline those parts that cannot be eliminated. Skin friction can be reduced substantially by the removal of dust, dirt, mud or ice that has collected on the aircraft.

Induced drag is another force that opposes the forward motion of the aircraft, but it is produced by those parts of an aircraft that are active in producing lift. Induced drag results from the wing and is therefore a part of lift that can never be eliminated.

Induced drag increases as the angle of attack increases and decreases as the angle of

attack decreases.

Induced drag can only be reduced during the initial designing of the aircraft. The phenomenon known as wing

tip vortices seen in Figure 11J-1 is testimony to the existence of induced drag.

Aircraft are often fixed with upwardly swept wing tip “winglets” to reduce wing tip vortices and their associated induced drag as shown in Figure 11J-2.

The various forms of drag change with different flying conditions and, in general, they increase with speed. As well, when the pilot uses control surfaces, they produce both form drag and induced drag.

**EO M231.04 – DESCRIBE THE AXIAL MOVEMENTS OF AN AIRCRAFT**

**IMPORTANCE**

It is important for cadets to learn about aircraft axes and axial movement so that they can understand subsequent and related principles of flight.

Aircraft operate in a three-dimensional space so there are three corresponding ways they can turn. Each of the

three possibilities has an associated axis of motion:

- the longitudinal axis,

- the lateral axis, and

- the vertical axis.

When an aircraft is airborne, it can move in almost any direction. All movement of the aircraft takes place around the centre of gravity. This is the aircraft’s balance point, or point through which all weight acts downwards.

The centre of gravity is the point where the three axes intersect.

To clarify the ways that aircraft can move in flight, the aircraft is said to move around an axis. This is an imaginary line running through the centre of gravity of the aircraft and around which the aircraft rotates.

There are three such axes and the aircraft may rotate around one, two or all three axes at the same time. They

are the longitudinal axis, the lateral axis, and the vertical axis:

- The longitudinal axis runs lengthwise through the fuselage from the nose to the tail and passes through

the centre of gravity.

- The lateral axis runs from wingtip to wingtip through the centre of gravity.

- The vertical axis runs vertically through the centre of gravity. It is situated at right angles to the other axes.

Rolling. Movement of an aircraft about the longitudinal axis is called roll.

Pitching. Movement of an aircraft about the lateral axis is called pitch.

Yawing. Movement of an aircraft about the vertical axis is called yaw.

It is possible for an aircraft to move in only one axis at a time but it is not necessary. Although an aircraft can climb or descend using only pitch around the lateral axis, movement around all three axes simultaneously is necessary for efficient flight.

When riding a bicycle around a high-speed turn, it is necessary to not only yaw to make the turn, but efficient cycling requires the cyclist to lean into the turn, (or roll) slightly as the turn is made. A turn without leaning would be very slow and inefficient and would be the mark of a beginner cyclist.

Similarly, an aircraft normally makes a “bank” manoeuvre in a level turn, involving movement about the longitudinal as well as the vertical axis. A climbing or descending turn requires that movement around the lateral axis be included as well.

**EO M231.05 – DESCRIBE AIRCRAFT CONTROL SURFACES**

**IMPORTANCE**

It is important for cadets to learn about aircraft control surfaces so they can understand subsequent and related

principles of flight.

**TEACHING POINTS**

An aircraft’s empennage is very often called the tail section. Its most obvious parts are the vertical and horizontal stabilizers, each of which has other names as well. The vertical stabilizer is sometimes referred to as the fin and the horizontal stabilizer is sometimes referred to as the tailplane.

The rudder is hinged to the back of the vertical stabilizer or fin. It is used to steer (yaw) the aircraft around

the vertical axis.

The elevator is hinged to the back of the horizontal stabilizer or tailplane. It is used to climb or descend by

changing pitch around the lateral axis.

*Stabilizers*

The horizontal and vertical stabilizers reduce unwanted pitch and yaw. The control surfaces are held straight by the passing wind. This is because the air moving past the flat surfaces of the stabilizers tends to resist a change of direction as predicted by Newton’s second law (a force must be applied to alter the motion of the air).

The vertical stabilizer, or fin, provides the aircraft with directional stability. Air moving past the fin resists any unwanted yaw around the vertical axis.

The horizontal stabilizer, or tailplane, provides the aircraft with longitudinal stability. That is, air moving past the tailplane resists unwanted roll around the longitudinal axis and unwanted pitch around the lateral axis.

*Rudder*

The rudder is located at the very back of the aircraft, hinged to the trailing edge of the vertical stabilizer, or fin.

The rudder can be turned left and right to give the pilot directional control. The rudder rotates the aircraft about its vertical (yaw) axis by pushing the tail to the left or to the right.

The rudder operated by itself causes the aircraft to yaw around its vertical axis.

When the rudder is turned to the right side of the fin, the moving air will push the empennage to the left, causing the aircraft to yaw to the right around its vertical axis.

When the rudder is turned to the left side of the fin, the moving air will push the empennage to the right, causing the aircraft to yaw to the left around its vertical axis.

The rudder is operated by the rudder bar or pedals in the cockpit. The pedals work together. When the bar or pedals are level the rudder is straight. Pressure applied to the right pedal moves the left pedal upwards and vice versa.

Pressure on the left rudder pedal displaces the rudder to the left into the airflow. This increases pressure on the left side and forces the tail to move to the right. This moves the nose of the aircraft to the left. Conversely, pressure applied to the right pedal moves the rudder to the right. The tail moves to the left and the aircraft yaws to the right.

*Elevators*

Both the left and right portions of the horizontal stabilizer, or tailplane, have a moveable control surface known

as an elevator.

The elevator rotates the aircraft about its lateral (pitch) axis by pushing the empennage, or

tail-section, up or down.

The elevator, of which there is normally a left and a right section, is located on the trailing edge of the horizontal stabilizer. It is used to give the pilot lateral control. Raising the elevator into the moving air above the tailplane will push the empennage down, thus raising the aircraft’s nose. Alternately, lowering the elevator down into the air moving below the tailplane will push the empennage up, thus lowering the aircraft’s nose. These pitch movements take place around the lateral axis.

The pilot controls the elevator by pushing or pulling on the control column.

Pushing the control column forward lowers the elevator into the wind passing under the tailplane, pushing the empennage up. This causes the aircraft’s nose to drop and the aircraft will descend.

Pulling the control column back raises the elevator into the wind passing over the tailplane, pushing the empennage down. This causes the aircrafts nose to rise and the aircraft will climb.

*Ailerons*

The surfaces that control roll are located near the ends of the wings on the trailing edge. They are called ailerons.

Ailerons operate simultaneously, but in opposite directions. When the right aileron rises to push the right wing down, the left aileron lowers to push the left wing up.

The down-going aileron increases the wing’s lift and the up-going aileron decreases the wing’s lift. Therefore, the left wing’s lift increases and the right wing’s lift decreases. The left wing lifts and the right wing descends, so the aircraft rolls to the right and keeps rolling until the ailerons are retracted.

To recover from the roll, the ailerons must be applied in the opposite direction until the aircraft is level and the ailerons are then again neutralized for level flight.

*Flaps*

Flaps are located nearer the fuselage on the trailing edge of the wing.

Both flaps operate together. They are raised together and they are lowered together with one control mechanism.

Flaps are lowered to create lift and to slow the aircraft. When they are lowered into the air moving past the under-surface of the wing, they slow the air and the air pushes them up, creating lift while simultaneously slowing the aircraft by creating both form drag and induced drag. When fully lowered, the drag created exceeds the lift generated.

Flaps allow for shorter landings.

**EO M232.02 – IDENTIFY THE COMPONENTS OF PISTONPOWERED**

**INTERNAL COMBUSTION ENGINES**

**IMPORTANCE**

It is important for cadets to learn about the components of piston-powered internal combustion engines so that

they can develop an understanding of subsequent and related principles of aviation.

**MAJOR COMPONENTS OF A PISTON-POWERED ENGINE**

Cylinder. In order to understand how an engine works, it is necessary to first know what parts make up an

engine. The cylinder is the main component. This is where the combustion of a gasoline and air mixture takes

place. Piston. The piston is found in the cylinder and is driven up and down by the exploding air and fuel mixture.

Connecting Rod. The piston is attached by a connecting rod to the crankshaft. The connecting rod is joined to

the piston and to the crankshaft with bearings which allow movement so that the reciprocating (up-and-down)

motion of the piston can be transformed into rotary (spinning) motion of the crankshaft.

Crankshaft. As the piston drives up and down, the connecting rod rotates around the crankshaft, turning it.

The crankshaft can rotate while the piston goes up and down.

Camshaft. The crankshaft often turns a second shaft called a camshaft. The cams are bumps on the camshaft

that open and close the intake and exhaust valves at the correct time. Of course, the crankshaft also powers

the aircraft’s propeller. Each cylinder has at least one set of valves operated by the cams on the camshaft. The

intake valve opens to let the mixture of gasoline and air into the cylinder and then it closes. Once this is done

and the mixture is burnt, the exhaust valve opens to release the exhaust and then closes.

Distributor. The gasoline and air mixture is ignited by a spark plug. Most aircraft have two spark plugs in every cylinder. The fuel takes time to burn completely. Because of this time delay, the spark must happen at just the right time; a fraction of a second before the piston has reached the top of its stroke. In a multi-cylinder engine such as aircraft use, an electrical signal must be sent to each cylinder’s spark plug at exactly the right time. The timing and distribution of spark sometimes relies on a central distributor, which is worked by gears from the crankshaft. Should this distributor fail, the engine will stop. A better, though more expensive method, is to equip each cylinder with its own spark timing and delivery system.

Carburetor. Before fuel is delivered to the cylinder for detonation, it is mixed with air in exact proportion. A

fuel injector or a carburetor does this. For effective detonation and clean burning, the fuel must be broken into

tiny droplets and mixed with air.

Oil Sump. The moving parts of the engine all need to be coated with engine oil. Oil is provided under pressure

to make sure that all moving parts are coated. A wet sump stores the oil supply in the crankcase with the

crankshaft, while a dry sump stores the oil in a separate tank and delivers it to the engine via piping.

The oil is circulated and re-used, serving other purposes in addition to lubrication. As the oil circulates, it cleans the engine by flushing dirt out of the engine. It also cools the engine by carrying heat away and it improves the pressure seal to keep the combustion chamber airtight.

**ROTARY VS. RADIAL ENGINES**

Some early aircraft engines used rotary engines in which the cylinders themselves rotated around the stationary central crankshaft. These were different than the later radial engines in which the stationary cylinders were arranged around the rotating crankshaft.

Many larger older aircraft had radial engines. In this design the cylinders were arranged in a circle at the front of the engine with the cylinder tops pointed outwards. The crankshaft ran through the middle of the cylinders to the front of the aircraft. Radial engines had many cylinders; some aircraft from World War II had 13 cylinders.

Even older aircraft, before and during World War I, had rotary engines that were different but were often confused with the later radial types. In the rotary engine, the crankshaft was stationary and the cylinders rotated around the crankshaft. This is the opposite of the radial engine, which had stationary cylinders and rotating crankshaft. Rotary engine design was abandoned because the great weight of the spinning cylinders was found to interfere with turning the aircraft in flight.

*Internal Combustion Engines*

Internal combustion engines come in a variety of styles that are described by how the cylinders are configured.

The horizontally opposed engine is most commonly used in general aviation airplanes. This engine has two banks of cylinders lying flat, directly opposite each other and working on the same crankshaft. There may be four, six or eight cylinders. The advantage of this engine type is its flat shape that generates less form drag. Form drag is a force that opposes the aircraft’s movement through the air.

Some older aircraft have in-line engines. This was the first type of aircraft engine used in great numbers. In an in-line engine, the cylinders are lined up in a row from the front of the engine to the back, with the tops pointed up. The crankshaft runs under the cylinders to the front of the aircraft.

**EO M232.03 – EXPLAIN THE CYCLES OF A FOUR-STROKE PISTON-POWERED ENGINE**

**IMPORTANCE**

It is important for cadets to learn about the cycles of a four-stroke piston-powered engine so that they will

understand the process by which an aircraft operates.

**TEACHING POINTS**

**CYCLES OF A FOUR-STROKE PISTON-POWERED ENGINE**

The parts of an engine work together in a cycle to turn the aircraft’s propeller. In most aircraft engines, this cycle has four distinct stages called strokes:

- the intake stroke draws fuel and air into the cylinder;

- the compression stroke forces the fuel and air into the combustion chamber;

- the power stroke transmits the energy of the exploding fuel to the crankshaft; and

- the exhaust stroke cleans the cylinder of exhaust fumes and prepares it for the next intake stroke.

The piston travels four strokes (two up and two down) to complete one cycle. During this operation, the crankshaft goes through two complete revolutions.

*The Intake (Induction) Stroke*

During the first (intake) stroke, the intake valve opens to let the gasoline and air mixture into the cylinder and

the piston moves down to draw the mixture into the cylinder. The exhaust valve is closed during this stroke.

*The Compression Stroke*

In the second (compression) stroke, both valves are closed while the piston moves up to compress the mixture.

*The Power (Combustion) Stroke*

In the third (power) stroke, both valves remain closed while the spark plug ignites the gas, which burns, expands and forces the piston down again.

*The Exhaust Stroke*

In the fourth (exhaust) stroke, the exhaust valve is open to let the burnt gases out while the intake valve is

closed. The piston moves up again to force the burned gases out through the open exhaust valve.

After the exhaust stroke, the whole process repeats itself thousands of times per minute, causing the crankshaft

to turn the propeller on the aircraft.

*Valves*

Other important components of piston-powered four-stroke internal combustion engines are the cam systems,

which operate the valves.

*Crankshaft*

Since the crankshaft rotates in time with the piston movements, its rotation is used to provide signals to the valves, telling them when to open. The usual method is to arrange for the crankshaft to turn a secondary shaft (camshaft) that has lobes, or cams, raised on its surface. The shape of the cam is such that it mechanically pushes its associated valve open – there are many ways to mechanically arrange this – just the right amount at just the right time.

The crankshaft provides the timing information to the valves by using cams on a camshaft to push the valves open. The camshaft is usually connected to the crankshaft through gears.

*Electrical Ignition Spark Plug Distribution*

Efficient, complete burning takes time. Even though an explosive detonation like that found in a piston-powered engine cylinder seems to happen in an instant, time is actually required. The engine turns very fast, thousands of revolutions per minute, so time is short. To ensure that the fuel is burned completely and that all energy is recovered from the fuel, the spark that sets off the detonation must be delivered while the piston is still rising on the compression stroke. If the spark arrives during the power stroke there is not enough time to burn the fuel completely and unburned fuel is exhausted. This would be an inefficient waste of fuel and it would contribute to environmental pollution in the form of blue smoke. Therefore, the timing of the spark plug’s electrical signal must be exact.

Each spark plug of each cylinder must get its electrical signal as the piston is rising, before the end of the compression stroke.

The timing for spark distribution also originates from the crankshaft through a system of gears, which provide coarse, or rough, timing. The need for precision timing is so great that a technician usually measures spark timing with electronic tools to ensure precision during engine tune-ups.

**IMPORTANT**

Engine operations must proceed precisely in order. Often, more than one operation must happen simultaneously. For example, the spark must be delivered to the cylinder while both valves are closed. A spark delivered to a charged cylinder when a valve is open results in a “backfire”. Power is lost and a valve will be burned – or perhaps even broken.

The engine operation must proceed as follows:

- Fuel and air mixture must be available for all cylinders, all the time, in a multi-cylinder engine.

- The intake stroke of the piston must take place with the intake valve open and the exhaust valve closed.

- The compression stroke of the piston must take place with both valves closed.

- Electrical signals must be delivered to spark plugs just before the piston completes the power stroke, when

both valves are closed.

- The power stroke of the piston must take place with both valves closed.

- The exhaust stroke of the piston must take place with the exhaust valve open and the intake valve closed.

- The camshaft must push each valve open and closed at the right times.

**EO M232.04 – RECOGNIZE THE FUNCTIONS OF OIL IN A FOUR-STROKE PISTON-POWERED ENGINE**

**IMPORTANCE**

It is important for cadets to learn about the four functions of oil because specific oil is required for the efficient

operation and maintenance of engines that are so critical to aviation.

**TEACHING POINTS**

Oil plays an important role in the functioning of an aircraft engine. Oil fulfills four important functions:

- Lubricating,

- Sealing,

- Cooling, and

- Flushing.

**LUBRICATING**

Oil lubricates the engine by creating a smooth surface between parts that rub together, such as the piston when it moves up and down in the cylinder.

Oil is manufactured in different grades and viscosities. The grade of a particular sample of oil is a measure of

its ability to maintain its viscosity, or resistance to flow, under extreme temperatures.

The viscosity, or resistance to flow, affects the oil’s stickiness. Low-viscosity oil flows more easily than high viscosity oil. Oil thins as its temperature is raised so the correct grade of oil must be selected for the intended condition when the engine is at operating temperature. Oil that is too thin (too low a viscosity number) at operating temperature will result in low oil pressure and will not protect the engine component surfaces adequately. Oil that is too thick will result in too high an oil pressure and will not be delivered in sufficient quantity when the engine is cold.

A good grade of oil is one in which the changes in viscosity, due to widely varying operating temperatures, are small.

The engine manufacturer specifies what oil to use and this direction must be followed to avoid engine wear.

Cold oil is often too thick to be delivered to the engine component’s metal surfaces in sufficient quantity so when an engine is cold it should not be run fast or given a load. An aircraft will often be seen sitting still with the engine and propeller running while the engine oil comes up to temperature, just like a car in the winter.

**SEALING**

Oil seals the combustion chamber by preventing the expanding gases from leaking out during the power stroke. It does this by creating a barrier between the engine components so that air and other gases cannot get through. This is especially important in the cylinder, so that the exploding gasoline and air mixture does not escape.

Oil has conflicting demands to meet. A high viscosity (resistance to flow) provides the best seal for the combustion chamber but a low viscosity enables the oil to be delivered in greater quantity to bearing surfaces. The same oil must do both jobs and so the engine manufacturer must consider both of these competing requirements when specifying the viscosity and grade of oil to be used.

**COOLING**

Some parts of the engine get hotter than other parts. Areas near the combustion chamber get particularly hot and need to be cooled. Oil cools hot spots in the engine by carrying heat away and equalizing temperature within the engine. This equalization of temperature also helps to bring a cold engine up to operating temperature quickly.

Oil must maintain its viscosity while near the heat of the combustion chamber and so manufacturers of oil have developed viscosity modifiers that lessen the change of viscosity that results from temperature change. Engine manufacturers take this into consideration when specifying what oil to use.

**FLUSHING**

Oil flushes the engine. It removes and holds tiny particles and grit, which are harmful to the engine. This means the oil carries away dirt and debris from the engine as it flows through. This is why it is important to change oil at frequent intervals as specified by the engine manufacturer.

As the oil is continuously circulated around the engine it passes through an oil filter. This filter fills with debris and must also be changed at regular intervals to remain effective, just as in a car.

**EO C232.01 – IDENTIFY THE CHARACTERISTICS OF GAS TURBINE ENGINES**

**IMPORTANCE**

It is important for cadets to know about the characteristics of gas turbine engines because this knowledge will

enable them to recognize a variety of propulsion applications and to recognize reasons for the performance

differences between various classes of aircraft.

**TEACHING POINTS**

A jet engine is a reactive engine, which propels itself by ejecting material to create a force, as described by Newton’s third law of motion.

Newton’s third law states that for every action there is an equal and opposite reaction. All propulsion systems rely on this fact in some way. A jet engine propels itself in one direction by ejecting a fluid (hot gas) in the opposite direction.

The amount of thrust developed by ejecting hot gas depends on the mass and velocity of the material ejected.

To develop a lot of thrust, a lot of material must be ejected or else it must be ejected at high velocity. Most of the mass ejected by a jet engine comes from the air, which is scooped up from the atmosphere that the jet is passing through. That scooped air is raised to a high velocity by burning fuel.

Since the jet engine can always get more air, its thrust duration is limited only by the amount of fuel that it has available.

**A SHORT HISTORY OF TURBINE ENGINES**

150 BC – Hero. An Egyptian philosopher and mathematician, invented a toy (Aeolipile) that used steam to rotate on top of a boiling pot of water. The escaping steam caused a reaction that moved several nozzles arranged on a wheel.

1232 – Battle of Kai-Keng. Chinese soldiers used rockets as weapons to repel the Mongols at the Battle of

Kai-Keng. Burning gunpowder and the reaction principle were used to propel the rockets. After Kai-Keng, the

Mongols used rockets and it is believed that they brought the technology to Europe.

1500 – Leonardo da Vinci. He drew a sketch of a device, the chimney jack, which rotated due to the movement of smoke and hot gases flowing up a chimney. This device used hot air to rotate a shaft, which turned a spit.

The hot air from the fire rose upward to pass through a series of fanlike blades that turned a shaft, which turned the roasting spit.

1629 – Giovanni Branca. He developed a stamping mill for bending metal. His stamping mill used jets of steam to spin a turbine, which rotated a shaft to operate the machinery.

1872 – Dr. F. Stolze. He designed the first true gas turbine engine. His engine used a multi-stage turbine section and a flow compressor. This engine never ran under its own power.

1930 – Sir Frank Whittle. He designed a gas turbine for jet propulsion in England. The first successful use of this engine was in April, 1937. His early work on the theory of gas propulsion was based on the contributions of most of the earlier pioneers of this field.

1939 – Heinkel Aircraft Company. This company flew the first gas turbine jet, the HE178.

1941 – Sir Frank Whittle. He designed the first successful turbojet airplane, the Gloster Meteor. Whittle improved his jet engine during World War II and in 1942, he shipped an engine prototype to General Electric in the United States. America’s first jet aircraft was built the following year.

1942 – Dr. Franz Anslem. He developed the axial-flow turbojet, which was used in the Messerschmitt Me 262, the world’s first operational jet fighter.

After World War II, the development of jet engines was directed by a number of commercial companies. Jet engines soon became the most popular method of powering high-performance aircraft.

The earliest jet to fly was a ramjet, the simplest jet engine, which has no moving parts. The speed of the aircraft forces air into the small volume of the engine, increasing air pressure and density. Ramjet application is restricted by the fact that its air compression depends on forward speed. The ramjet develops no static (stationary) thrust and very little thrust in general when travelling below the speed of sound. As a consequence, a ramjet vehicle requires some form of assisted takeoff, such as another aircraft, and so it has been used primarily in guided-missile systems.

In 1930, Sir Frank Whittle’s ingenious idea of placing a turbine into the stream of hot exhaust gases allowed the operation of a compressor to solve the problem of running the engine at low speeds or static conditions. This is the secret of the turbojet engine and of all other refinements of the design, such as turboprops, turbofans and turboshafts.

Another benefit of turbines in jet engines is that they provide power for all sorts of ancillary flight instruments and other systems. In a modern airliner, turbine power provides everything from radio communications with the air traffic control tower to hot water for the passengers.

The four basic parts of any gas turbine jet engine are the compressor, combustor, turbine, and nozzle, all of which process air, or core air, which travels through the engine. In the most common gas turbine aircraft engine, the turbofan, there is also the fan, which provides bypass air as well as core air, and a mixer, which combines the core airflow with the bypass airflow. The reduced engine noise levels and the excellent fuel efficiency of the turbofan engine have made it the engine design of choice for most modern commercial applications. Examples of varied turbofan applications are the CF-18’s two GE F404 low bypass turbofan engines and the A380 Airbus’s four Rolls-Royce Trent 900 high bypass turbofan engines; two dissimilar applications that both favour turbofan technology.

**PARTS OF A TURBOFAN ENGINE**

Fan. The fan is the first component in a turbofan. The fan pulls air into the engine. The air then splits it into two parts. One part continues through the “core” or centre of the engine, where it is acted upon by the other engine components. The second part “bypasses” the core of the engine, travelling through a duct to the back of the engine where it produces much of the force that propels the aircraft forward.

Compressor. The compressor is the first component in the engine core. The compressor squeezes the air into a smaller volume, increasing its pressure. The air is then forced into the combustor.

Combustor. In the combustor the air is mixed with fuel and ignited, producing high temperature, expanding gases.

Turbine. The high-energy airflow coming out of the combustor goes through the turbine, causing the turbine blades to rotate. The task of the turbine is to convert the linear gas motion into rotary mechanical work to drive the compressor, which then feeds the combustor with high-pressure air.

Nozzle. The nozzle is the engine’s exhaust outlet. The hot, high-pressure gases that have passed through the turbine, combined with the colder air that bypassed the engine core, produce a force when exiting the nozzle that acts to propel the engine, and therefore the aircraft, forward. The nozzle may be preceded by a mixer, which combines the high temperature air coming from the engine core with the lower temperature air that was bypassed in the fan. The mixer results in a quieter engine.

Afterburner. In addition to the basic components of a gas turbine jet engine, one other process is occasionally employed to increase the thrust of a given engine. Afterburning consists of the introduction and burning of raw fuel between the engine turbine and the jet nozzle, utilizing the unburned oxygen in the exhaust gas to support combustion. The increase in the temperature of the exhaust gases further increases their velocity as they leave the propelling nozzle, which thereby increases the engine thrust. This increased thrust could be obtained by the use of a larger engine, but this would increase the weight and overall fuel consumption.

**EO C232.02 – IDENTIFY THE CHARACTERISTICS OF ROCKET ENGINES**

**IMPORTANCE**

It is important for cadets to know about the characteristics of rockets so that they can understand the Canadian

Space Agency’s mission to promote the peaceful use and development of space, to advance the knowledge of

space through science and to ensure that space science and technology provide social and economic benefits

for Canadians.

**TEACHING POINTS**

Every method of propulsion relies on Newton’s third law, which states that for every action there is an equal

and opposite reaction. This is most obvious when the original action affects an object that is close in size to the object that the reaction affects, such as when a swimmer pushes a floating object. In that case, the swimmer is pushed backward when the object is pushed forward.

However, when the object to be pushed is as large as the Earth, as in the case of a person taking a step forward, it is not so obvious that the Earth moves in the opposite direction when the step is taken. Yet the tiny motion of the Earth is in the opposite direction. The difference in the amount moved is proportional to the difference in weight between the Earth and the walker, so that the reaction is equal, as well as opposite.

In that same way, a wheeled vehicle such as an automobile pushes on the Earth when it begins its journey.

Since the automobile is much smaller than the Earth, the smaller mass of the automobile moves much more than the great mass of the Earth. The swimmer, the person walking and the wheeled automobile are all relying on traction to propel them forward.

Newton’s third law of motion also dictates the movement of propeller-driven aircraft and jet aircraft. The forward motion of aircraft depends on pushing gases backward instead of pushing the Earth backward. A propeller pushes air backwards and this is called prop wash. A jet engine ejects hot exhaust gases backwards. To move in any direction, all objects and all creatures, whether living or artificial, must push matter of some sort in the opposite direction.

Newton’s third law of motion states that for every action there is an equal and opposite reaction. The third law can be correctly interpreted to mean that for every desired reaction there must be an equal and opposite action.

*Rocket Systems in Space*

A balloon rocket would work in outer space. The air that is ejected from the balloon would produce the same

opposite and equal reaction in space that it does in the Earth’s atmosphere, except that form drag from the

atmosphere would not slow the balloon’s travel. The balloon rocket’s performance would be improved in space, without the form drag of air.

A reactive propulsion system can operate by ejecting any material. However, the higher the speed of the ejected material, the greater the resulting propulsive force will be. To raise the velocity of ejection, material is most often heated to create pressure. This has been the preferred solution since Hero used steam to operate his toy Aeolipile (pronounced A – O – lipile).

Hero of Alexandria invented a rocket-like sphere called an Aeolipile, in about 150 BC, which used steam as a propulsive gas. Hero mounted it on top of a water kettle. A fire below the kettle turned the water into steam, which travelled through pipes to the Aeolipile. Two L-shaped tubes on opposite sides of the sphere allowed the steam to escape and so gave thrust to the sphere that caused it to rotate.

Heating of the material to be ejected most often involves combustion in contemporary rockets although other methods could be used. Rocket combustion systems operate in space because they are self-contained and require no atmospheric oxygen.

Combustion in a rocket engine or a jet engine requires the rapid oxidization of fuel. A jet engine gets access to oxygen by drawing it from the surrounding air, so that a jet’s range is limited to the atmosphere. A rocket develops thrust in much the same way as a jet, but a rocket carries its own oxygen supply. Rocket engines and jet engines both have nozzles to generate thrust

A rocket engine uses a nozzle to accelerate hot exhaust to produce thrust as described by Newton’s third law of motion. The amount of thrust produced by the engine at any given moment depends on both the amount of gas ejected each second and its velocity. These are determined by the rocket nozzle design.

A rocket works in outer space because it brings everything it needs with it.

The Earth’s atmosphere is mostly nitrogen. Oxygen is only a fifth of the atmosphere’s composition. Therefore, simply storing air for combustion would waste most of the storage space on unreactive nitrogen. To make good use of storage space, oxygen is stored in more pure forms, including liquid oxygen, or LOX. This gives the rocket engine the ability to operate for a longer period in outer space.

**CONSTRUCTION**

There are three main categories of rocket engines; liquid rockets and solid rockets.

Liquid rocket propellants, the fuel and the oxidizer, are stored separately as liquids and are pumped into the combustion chamber of the nozzle where burning occurs.

Solid rocket propellants, both fuel and oxidizer, are mixed together to form a composite fuel and then packed into a solid cylinder. Under normal temperature conditions the solid rocket propellants do not burn until exposed to a source of heat provided by an igniter. Once the burning in a solid rocket starts, it proceeds until all the propellant is exhausted.

With a liquid rocket the pilot can stop or modify the thrust by turning off the flow of propellants; but with a solid rocket, the casing must be destroyed to stop the engine.

Liquid rockets tend to be heavier and more complex because of the pumps and storage tanks. The propellants are loaded onto the rocket just before launch. A solid rocket is much easier to handle and can sit for years before firing.

**VEHICLE APPLICATIONS**

Solid rocket engines are used on air-to-air and air-to-ground missiles, on model rockets and as boosters for satellite launchers, including the space shuttle’s two solid rocket boosters (SRBs).

Liquid rocket engines are used in the Space Shuttle’s main engines to place humans in orbit, on many robot missiles to place satellites in orbit and on several high-speed research aircraft.

**FUELS AND OXIDIZATION**

In a solid rocket, the fuel and oxidizer are mixed together into a solid propellant, which is packed into a solid cylinder. A hole through the cylinder serves as a combustion chamber. When the mixture is ignited, combustion takes place on the surface of the propellant. A flame front is generated which burns into the mixture. The combustion produces great amounts of exhaust gas at a high temperature and pressure. The amount of exhaust gas that is produced depends on the area of the flame front and engine designers use a variety of hole shapes to control the change in thrust for a particular engine. The hot exhaust gas is passed through a nozzle, which accelerates the flow. Thrust is then produced according to Newton’s third law of motion.

In a liquid rocket, stored fuel and stored oxidizer are pumped into a combustion chamber where they are mixed and burned. The combustion produces great amounts of exhaust gas at high temperature and pressure. The hot exhaust is passed through a nozzle, which accelerates the flow. Thrust is produced according to Newton’s third law of motion.

There are many parts that make up a liquid-fuelled rocket. For design and analysis, engineers group parts which have the same function into systems. There are four major systems in a full scale rocket: the structural system, the payload system, the guidance system and the propulsion system.

**AMERICAN, RUSSIAN, EUROPEAN and CHINESE LAUNCH VEHICLES**

Although space-age rocketry is often considered to be in its early stages, there are many launch vehicles to explore. One example each of American, Russian, European and Chinese launchers follow:

*American Launch Vehicle – Ares*

NASA currently has many launchers that they can match to particular missions. For manned space flight after the space shuttle program, the Ares series of rockets has been developed

Ares I is an in-line, two-stage rocket configuration topped by the Orion crew vehicle and its launch abort system.

In addition to the vehicle’s primary mission – carrying crews of four to six astronauts to Low Earth Orbit (LEO) – Ares I may also use its 22.5-tonne payload capacity to deliver resources and supplies to the International Space Station, or to “park” payloads in orbit for retrieval by other spacecraft bound for the Moon or other destinations.

The Ares I first stage is a single, five-segment Reusable Solid Rocket Booster (RSRB) derived from the Space

Shuttle Program’s reusable solid rocket motor, which burns a specially formulated and shaped solid propellant.

The Ares I second, or upper, stage is propelled by a J-2X main engine fuelled with liquid oxygen and liquid hydrogen.

The first stage of the Ares V vehicle relies on two, five-segment reusable solid rocket boosters for lift-off. The

twin solid rocket boosters of the first stage flank a single, liquid-fuelled central booster element.

The central booster tank delivers liquid oxygen and liquid hydrogen fuel to five RS-68 rocket engines. The RS-

68 engines serve as the core stage propulsion for Ares.

Atop the central booster element is an interstage cylinder, which includes booster separation motors and a newly designed forward adapter that mates the first stage with the Earth Departure Stage. A J-2X main engine fuelled with liquid oxygen and liquid hydrogen propels the Earth Departure Stage, the same J-2X engine as is used in the Ares I upper stage.

*Russian Launch Vehicle – Proton*

The Proton engines burn a liquid fuel called hydrazine (UDMH) with an oxidizer called Nitrogen Tetroxide.

Nitrogen Tetroxide and UDMH burn when they come in contact, without any ignition, so they are said to be hypergolic. The Proton launch vehicle is currently used for national programs and commercial launches of foreign satellites.

Proton is designed as a tandem launch vehicle available in three-stage and four-stage options.

*European Launch Vehicle – Ariane 5*

Ariane 5’s cryogenic main stage is referred to as the EPC from its title in French, Etage Principal Cryotechnique. The EPC is essentially composed of an aluminum tank with two compartments: one for liquid oxygen and one for liquid hydrogen. Both propellants are produced at plants located inside Europe’s Spaceport in French Guiana.

Weighing 37 tonnes each when empty, the SRBs (Solid-Rocket Boosters) provide 1100 tonnes of thrust, roughly 92% of the total thrust at liftoff.

*Chinese Launch Vehicles – Changzheng (Long March) Rockets*

The main stages and the booster rockets of Long March rockets use liquid storable propellants with hydrazine

(UDMH) as fuel and nitrogen tetroxide as the oxidizing agent—the same hypergolic system used by the Proton rocket discussed above. The upper stages of Long March CZ-3A and CZ-3B use liquid hydrogen (LH2) as fuel and liquid oxygen (LOX) as oxidizer.

**EO C232.03 – IDENTIFY THE CHARACTERISTICS OF HELICOPTER ENGINES**

**IMPORTANCE**

It is important for cadets to know about the characteristics of helicopter engines because helicopters form a

significant part of the Canadian Forces’ lift, tactical manoeuvring and Search and Rescue capabilities

**TEACHING POINTS**

Important challenges limited early experiments with helicopters. In particular, suitable engines did not exist in the early years. This was a problem that was not to be overcome until the beginning of the 20th century by the development of internal combustion (gasoline) powered engines. Even then, it was not until the mid-1920s that engines with sufficient power, and with the high power-to-weight ratios suitable for vertical flight became more widely available.

Early engines were made of cast iron and were too heavy for helicopters. Aluminum, a common material used

on modern aircraft, was available commercially around 1890, but was extremely expensive. Aluminum was not widely used in aeronautical applications until 1920.

While many additional factors contributed in some way to the lack of progress in achieving successful vertical flight, the development of a practical helicopter had to wait until engine technology could be refined to the point that lightweight engines with considerable power could be built. By 1920, gasoline powered piston engines with higher power-to-weight ratios were more widely available. It then became possible to begin to solve the control problems of vertical flight. The era after 1920 is marked by the development of a vast number of prototype helicopters throughout the world.

When a helicopter engine loses power under flight, the pilot can auto-rotate the aircraft to the ground

Auto-rotation is the state of flight where the main rotor is being turned by the action of the wind passing up through the rotor disc instead of being turned by engine power.

To do this the rotor must be released from the engine. This release is provided by a free-wheeling device which allows the rotor to turn even if the engine is not running.

To successfully change the downward flow of air to an effective upward flow during auto-rotation, the pitch angle of the main rotor blades must be reduced. This can be compared to lowering the nose and changing the pitch attitude of a fixed-wing aircraft in order to establish a glide.

The most defining characteristic of a helicopter engine is the need to maintain constant rotor speed, or a constant number of revolutions per minute (RPM), as specified by the manufacturer.

If the rotor goes too fast, lift will be lost and damage will result as the blade tips approach the speed of sound and shock waves develop. This is more significant with the long blades associated with rotary wings than it is with the shorter blades of fixed-wing aircraft propellers.

On the other hand, a rotor under load cannot be allowed to slow below the design speed because the blades rely on centrifugal force to stay horizontally extended. Because they are wings, rotor blades experience lift.

The lift will cause the rotors to rise to form a “cone” if centrifugal force is insufficient to keep them horizontally extended. As the dangerously slowing rotor blades “cone” upward, lift is lost and a crash becomes imminent

When the helicopter is at rest, the outer tips of the rotor travel at a speed determined by the length of the blade and the RPM. In a moving helicopter, however, the speed of the blades relative to the air depends on the speed of the helicopter as well as on their rotational velocity. The airspeed of the rotor blade in the forward moving, or advancing, part of its rotation is much higher than that of the helicopter itself. It is possible for this blade tip to exceed the speed of sound, and thus produce vastly increased drag and vibration.

In a moving helicopter, the velocity of the blade tips relative to the air depends on the speed of the helicopter itself, as well as the speed of the blade.

Why the Rotor Can Never Be Allowed To Go Too Fast. If the rotor goes too fast, the tips of the long blades will approach the speed of sound and sonic shock waves will cause both equipment damage and loss of lift.

Why the Rotor Under Load Can Never Be Allowed To Go Too Slow. A rotor under load cannot be allowed to drop below the design speed because the blades rely on centrifugal force to stay horizontally extended. Rotor blades under load are experiencing lift and will rise to form a “cone” if centrifugal force is insufficient to keep them horizontally extended. As the dangerously slowing rotor blades “cone” upward, lift is lost and a crash becomes imminent.

Why a Helicopter Has a Never-Exceed Velocity (VNE). As the helicopter flies faster, the true airspeed of the advancing blade’s tip will increase toward the speed of sound and sonic shock waves will cause both equipment damage and loss of lift.

Changing the pitch angle on the blades changes the blade angle and lift. With a change in angle of attack and lift comes a change in drag and, therefore, the speed or RPM of the rotors could be affected. As the blades’ angle of attack is increased, drag increases and so the rotor speed would decrease if it were allowed. Decreasing the blades’ angle of attack decreases drag, and so rotor speed would increase if it were allowed.

To maintain a constant rotor speed, which is essential in helicopter operation, a proportionate change in power is required to compensate for the change in drag. A correlator and/or governor is the most common way to accomplish this. The engine is allowed to speed up or slow down according to the load on the rotor, but the rotor speed remains unchanged.

This feature of rotary-wing flight imposes requirements on helicopter engine design. In the turboshaft engines used on most helicopters, the turbine powering the engine’s compressor is separate from the turbine powering the shaft that drives the main rotor.

Although piston-powered engines are still used in some general-aviation helicopters, most helicopters produced are for military or commercial use and feature gas turbine engines, which have high power-to-weight ratios

Gas turbines can maintain constant rotor speed separate from the speed of the engine itself and in this configuration they are referred to as turboshaft engines. In particular, an engine designed for turboshaft use will generally have one turbine for the engine’s own air compressor and a second, separate turbine for powering the drive shaft, which turns the main rotor. The engine itself, because it has a separate compressor turbine, can speed up or slow down as necessary to provide the right amount of high-velocity exhaust gases for the second turbine, keeping the rotor speed constant.

Turboshaft engines are also used to power tanks and ships as well as having stationary applications

CF HELICOPTERS

CH-149 CORMORANT

The Cormorant has been chosen as Canada’s new Search and Rescue (SAR) helicopter. The first of these aircraft entered squadron service in 2002 at 19 Wing Comox, and by Spring of 2004, the entire fleet of 15

Cormorants became fully operational. It has three powerful engines, long-range capability and a large cargo area. Its ice protection system, allowing it to operate in continuous icing conditions, and its ability to withstand high winds, make it ideal for Canada’s demanding geography and climate.

The Agusta-Westland CH-149 Cormorant is a fully certified off-the-shelf civilian utility helicopter. It includes search and rescue-specific equipment and physical characteristics and performance requirements to meet Canada’s SAR responsibilities. This modification provided reduced procurement costs, a rear-fuselage ramp, a single rescue door with both hoists on one side, and eliminated unnecessary military equipment. Shaped rotor blades, strengthened by titanium strips along the leading edge, allow the CH-149 to improve lift and increase speed, lowering the stall speed and reducing vibration. This enables it to withstand high winds (exceeding 50 knots) and provide superior gust response while carrying out routine tasks of hoisting, starting and stopping.

Quantity in the CF: 15

Locations:

9 Wing Gander, NF,

8 Wing Trenton, ON,

14 Wing Greenwood, NS, and

19 Wing Comox, BC.

CH-148 CYCLONE

After a thorough pre-qualification and bid evaluation process, the Government of Canada has selected the H92 proposed by Sikorsky as the winner of the Maritime Helicopter Project. Sikorsky will be awarded two separate, but interrelated contracts. The first contract will cover the acquisition of 28 fully integrated, certified and qualified helicopters with their mission systems installed, and will also include modifications to the 12 Halifax Class ships. The second contract will be for a 20-year in-service support contract that includes a training building, and a simulation and training service.

CH-146 GRIFFON

As Canada’s Utility Transport Tactical Helicopter (UTTH), the Griffon provides a robust, reliable and costeffective capability to conduct: airlift of equipment and personnel, command and liaison flights, surveillance and reconnaissance, casualty evacuation, logistic transport, search and rescue, counter-drug operations, and domestic relief operations.

Griffons are used by Combat Support Squadrons at 3, 4 and 5 Wings to support fighter operations by providing a search and rescue capability and utility transportation support to fighter training and operations.

Quantity in the CF: 85

Locations:

Bagotville, QC,

Cold Lake, AB,

Gagetown, NB,

Valcartier, QC,

Goose Bay, NL,

Edmonton, AB,

Petawawa, ON, and

Borden, ON.

CH-139 JET RANGER

The 14 CH-139 Jet Rangers were purchased in 1981 for use by 3 Canadian Forces Flying Training School at

CFB Portage la Prairie, in southern Manitoba, now the Southport Aerospace Centre. They are still in use today by 3 Canadian Forces Flying Training School (3 CFFTS), with upgraded avionics and air conditioning, and are maintained by the Allied Wings consortium which provides the aircraft used by 3 CFFTS.

The CH-139 Jet Ranger is a single-engine, five-seat light helicopter. It is configured with a two-bladed, semirigid main rotor and a two-bladed anti-torque tail-rotor. The Jet Ranger is powered by an Allison Model 250- C20B gas-turbine engine de-rated to deliver 317 shaft horsepower at sea-level.

Quantity in the CF: 14

Locations: 3 CFFTS Portage la Prairie

CH-124 SEA KING

The Sea King is a ship-based helicopter with both day and night flight capabilities, and is carried aboard many Canadian Maritime Command destroyers, frigates and replenishment ships. The Sea King carries detection, navigation and weapons systems as part of its primary mandate of searching for, locating and destroying submarines. With its subsurface acoustic detection equipment and homing torpedoes, it is also a versatile surveillance helicopter.

Domestically, Sea Kings have increasingly become responsible for search and rescue operations, disaster relief, and assisting other government departments in carrying out counter-narcotic operations, fisheries and pollution patrols.

The Sea King has also been instrumental in peacekeeping operations. For example, during the deployment of forces to Somalia, the CH-124 provided troops with logistical, medical and ammunition support along with flying overland reconnaissance and convoys. It was, in effect, the only link soldiers had with the ships especially during the initial stages of the deployment.

The Sea King fleet has been heavily committed to the campaign against terrorism, deploying aboard Canadian

Navy ships to the Persian Gulf since the autumn of 2001. Sea Kings have conducted hundreds of missions ranging from logistics flights to move personnel and cargo to hailing and boarding suspicious vessels.

Quantity in the CF: 27

Locations:

12 Wing Shearwater, NS, and

Patricia Bay, BC.

**PO 260 – PARTICIPATE IN AERODROME OPERATIONS ACTIVITIES**

**EO M260.01 – EXPLAIN ASPECTS OF AIR TRAFFIC CONTROL (ATC)**

**IMPORTANCE**

It is important for cadets to understand the role of ATC at an aerodrome. This lesson will assist in stimulating

the cadets’ interest in aerospace activities which may lead to future summer training opportunities in the Air

Cadet Program.

*The Role of the Air Traffic Controller*

The ATC system is a vast network of people and equipment that ensures the safe operation of commercial

and private aircraft.

The air traffic controller’s’ immediate concern is safety, but controllers must also direct planes efficiently to

minimize delays. Their main responsibility is to organize the flow of aircraft into and out of the aerodrome.

Air traffic controllers coordinate the movement of air traffic to make certain that planes stay a safe distance

apart. They prevent collisions between:

- aircraft,

- aircraft and obstructions, and

- aircraft and vehicles on the manoeuvring area.

In addition, air traffic controllers keep pilots informed about changes in weather conditions such as wind shear,

a sudden change in the velocity or direction of the wind that can cause the pilot to lose control of the aircraft.

*ATC Authorization*

An ATC clearance is an authorization from an ATC unit for an aircraft to proceed within controlled airspace under specific conditions. Some air traffic controllers regulate traffic through designated airspaces; others regulate airport arrivals and departures.

**RADAR**

The name “RADAR” is an abbreviation for “radio detection and ranging”. To operate, radar requires a highly directional radio transmitter/antenna and a scope, or screen, to display the information received by the antenna.

The principle uses of radar in aviation are:

ATC;

fixing positions of airplanes in flight;

detecting thunderstorm activity; and

approaching and landing guidance to airplanes.

The use of radar in ATC greatly increases the utilization of the airspace and permits expansion of flight

information services such as traffic and weather information and navigational assistance

**NORDO**

Aircraft without radio (NORDO) are not permitted to operate at most large controlled airports served by the

scheduled air carriers. Where they are permitted to operate (less busy controlled airports), they are directed by

visual signals. A pilot must be alert to the light signals from the tower letting you know what to do.

Prior to initiating a NORDO flight, the pilot should contact the control tower to inform the controllers of their

intentions and to secure a clearance for operation within the airspace. The tower will then be expecting the pilot and will be prepared to give the pilot light signals.

**AUTHORIZED LIGHT SIGNALS (DEPARTING AIRCRAFT)**

- Flashing Green. Cleared to taxi.

- Steady Green. Cleared for take-off.

- Flashing Red. Taxi clear of runway in use.

- Steady Red Light. Stop.

- Flashing White. Return to starting point on airport.

- Blinking Runway Lights. Vehicle and pedestrians are to vacate the runway immediately.

**AUTHORIZED LIGHT SIGNALS (ARRIVING AIRCRAFT)**

- Steady Green Light. Clear to land.

- Steady Red Light or Red Flare. Do not land. Continue in circuit. Avoid making sharp turns, climbing or diving after you receive the signal.

- Flashing Green Light. Recall signal. Return for landing (usually to recall an airplane which has taken off or has been previously waved off with a red light). This will be followed by a steady green light when the approach path and landing area is clear.

- Alternating Red and Green Light (U.S.). Danger. Be on alert. This signal may be used to warn you of such hazards as danger of collision, obstruction, soft field, ice on runways, mechanical failure of your undercarriage, etc. The danger signal is not a prohibitive signal and will be followed by a red or green light as circumstances warrant.

- Flashing Red Light. Airport unsafe. Do not land.

- Red Pyrotechnical Light. The firing of a red pyrotechnical light, whether by day or night and notwithstanding any previous instruction means “Do not land for the time being”.

**EO M260.02 – IDENTIFY ASPECTS OF BASIC AERODROME OPERATIONS**

**IMPORTANCE**

It is important for cadets to discuss basic aerodrome operations at a civilian airport to gain an awareness of the

services and facilities present at an aerodrome. This may generate an interest in aerodrome operations and

may lead to future opportunities in the Air Cadet Program.

**TEACHING POINTS**

Basic operations at a civilian aerodrome are generally divided into three categories. They are air traffic control,

ground control and airport maintenance.

**AIR TRAFFIC CONTROL**

Most people do not give second thought to who is actually in control of the aircraft when it is flying. Most people would say that the pilot has control of the direction and course of the aircraft but they would be mistaken.

The task of ensuring safe operations of commercial and private aircraft falls on air traffic controllers. They must coordinate the movements of thousands of aircraft, keep them at safe distances from each other, direct them during takeoff and landing, direct them around bad weather and ensure that traffic flows smoothly with minimal delays.

**GROUND CONTROL**

Ground control, sometimes known as Ground Movement Control (GMC) or Surface Movement Control (SMC) is responsible for the airport “manoeuvering” areas, or areas not released to the airlines or other users. This generally includes all taxiways, holding areas, and some transitional aprons or intersections where aircraft have arrived and vacated the runways and departure gates.

**AIRPORT MAINTENANCE**

Airport maintenance is responsible for a variety of airport field maintenance work, including general maintenance and construction work. They operate equipment and service a variety of power and general maintenance equipment in the upkeep of runways, taxiways, and aprons as well as perform other related duties.

**THE ROLE OF GROUND CONTROLLERS**

Once an aircraft has landed, ground controllers provide the pilot with precise taxi information to passenger

gates and jetways.

From the cockpit, it is difficult to assure that there is sufficient clearance between the aircraft structure and any

buildings or other aircraft. Marshalling personnel are provided to assist aircraft when arriving at and departing

from passenger gates and jetways.

While the goal of ground controllers is to maintain aircraft in such a manner as to assure safe flight, they must

provide clearance for aircraft-to-taxi on the ground at the aerodrome while creating a safe environment while

an aircraft is on the ground.

**GROUND FACILITIES**

Ground facilities and services assist with aircraft arrivals and departures. The following are some of the ground

services and facilities that can be found at a basic aerodrome.

**RUNWAY MAINTENANCE**

Runway maintenance is responsible for the runway upkeep within the airport grounds. Duties range from tarmac servicing to keeping the runways in good condition. During the winter, the main focus of the work is on runway and taxiing area maintenance.

**RUNWAY LIGHTING**

Runway lighting is used at airports which allow night landings. Seen from the air, runway lights form an outline of the runway. A particular runway may have some or all of the following:

- Runway End Identification Lights (REIL). Unidirectional (facing approach direction) or omni-directional

are a pair of synchronized flashing lights installed at the runway threshold, one on each side.

- Runway End Lights. Rows of lights on each side of the runway on precision instrument runways, these lights extend along the full width of the runway. These lights show green when viewed by approaching aircraft and red when seen from the runway.

- Runway Edge Lights. These are white elevated lights that run the length of the runway on either side.

- Taxiways are differentiated by being bordered by blue lights. On precision instrument runways, the edge lighting becomes yellow in the last 2000 feet of the runway.

- Runway Centreline Lighting System (RCLS). These are lights embedded into the surface of the runway at 50 foot intervals along the runway centreline on some precision instrument runways. The lights are white except for the last 3000 feet. For the last 3000 feet, the lights alternate white and red for 2000 feet and red for the last 1000 feet.

- Touchdown Zone Lights (TDZL). This consists of rows of white light bars (with three in each row) on either side of the centreline over the first 3000 feet (or to the midpoint, whichever is less) of the runway.

- Taxiway Centreline Lead-off Lights. These are installed along lead-off markings. They are alternating green and yellow lights that are embedded into the runway pavement. They start with green lights branching off the runway centreline to the position of the first centreline light beyond the holding position on the taxiway.

- Taxiway Centreline Lead-on Lights. These are installed the same way as the taxiway centreline leadoff lights.

- Land and Hold Short Lights. These are a row of white pulsating lights installed across the runway to indicate the hold short position on some runways.

- Approach Lighting System (ALS). A lighting system installed on the approach end of an airport runway, it consists of a series of light bars, strobe lights, or a combination of the two that extend outward from the end of the runway.

**BAGGAGE HANDLING**

Baggage handlers work both indoors and outdoors at an aerodrome. They are responsible for making sure that

not only does the mail, freight and luggage get onto the right aircraft but also that it gets there on time.

**FUEL STORAGE SYSTEMS**

Most of the large airports that service transport category aircraft have underground storage tanks and buried

fuel lines. This arrangement allows the aircraft to be fuelled without having to carry the fuel to the aircraft in fuel trucks. Most aircraft that are fuelled from this type of system use under wing fuelling.

**DE-ICING/ANTI-ICING**

The successful treatment of ice and snow deposits on airplanes on the ground is an absolute necessity for

safe winter operations. A flight that is expected to operate in known ground icing conditions shall not takeoff

unless the aircraft has been inspected for icing and, if necessary, has been given the appropriate de-icing/antiicing treatment. Accumulation of ice or other contaminants shall be removed so that the aircraft is kept in an airworthy condition prior to takeoff.

**CANADIAN AIR TRANSPORT SECURITY AUTHORITY (CATSA)**

CATSA is a crown corporation based in the national capital region and it reports to Parliament through the

Minister of Transport. It works with ground control to protect the public by securing critical elements of the

air transportation system as assigned by the government. CATSA ensures passengers are aware of packing

restrictions.

**CATSA DUTIES AND RESPONSIBILITIES**

CATSA is responsible for the following:

- Pre-Board Screening (PBS) of passengers and their belongings at Canada’s major airports must be conducted before every flight.

- Acquiring, deploying, operating, and maintaining Explosive Detection Systems (EDS) equipment at designated airports which covers 99 percent of air travellers in Canada.

- Contracting for RCMP policing services and implementation of the Canadian Air Carrier Protective

Program. Working with the RCMP for the provision of on-board security services under the Canadian Air Carrier Protective Program. This program covers selected domestic, trans-border and international flights, and all flights to Reagan National Airport in Washington, DC.

- The implementation of a restricted area identification card. CATSA has implemented an enhanced restricted area identification card for non-passengers which includes the use of biometric identifiers. This card is issued by the airport authority and enhances the security of restricted areas at major Canadian airports. The program includes a national database authenticating the validity of the identification card.

- Non-Passenger Screening (NPS) entering airport restricted areas. NPS has been regulated by Transport

Canada since February 2004 in order to add another layer of security to Canada’s air transport security system. The purpose of NPS is to enhance both airport and civil aviation security by operating random and unpredictable security screening checkpoints at entry points to or within airport restricted areas.

- Supplemental airport policing service contributions. Contributions toward airport policing costs: in the aftermath of September 11, 2001, new measures were implemented at airports to increase police presence. The Government of Canada, through CATSA, has committed to assisting selected airports with these additional costs.

Note: Refer to the CATSA Website at www.catsa-acsta.gc.ca for an up-to-date list of baggage packing

restrictions for air travellers.

**EO C260.04 – PERFORM MARSHALLING**

**IMPORTANCE**

It is important for the cadet to be familiar with marshalling signals as an orientation to aerodrome activities.

Marshalling aircraft is one of the many duties performed by ground crew/maintenance staff at an aerodrome.

Familiarizing the cadets with these tasks will expand their awareness of different roles in aerodrome operations.

**WHY IS AIRCRAFT MARSHALLING USED?**

Aircraft marshalling ensures the safety of all aircraft and personnel on the ground. Marshalling is used

to direct aircraft. The marshaller uses hand-held lighted wands to give signals to a pilot; the pilot then

manoeuvres the aircraft into the correct position.

**WHEN IS AIRCRAFT MARSHALLING USED?**

Aircraft marshalling is used when there are multiple aircraft moving on the ground, or a large aircraft is

moving under its own power.

**WHERE IS AIRCRAFT MARSHALLING USED?**

Aircraft marshalling is used when aircraft enter, depart or manoeuvre on the apron of an aerodrome



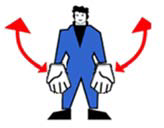
*Marshalling Stop*

Raise arms straight above the head. Move arms back and forth, crossing arms over the head.



*Marshalling Move Ahead*

Arms are in the prove position, bent at the elbow, in front of the body with the upper arm parallel to the ground. Move the hands from in front of the body toward the head.



*Marshalling Move Back*

Starting with the arms straight at the sides of the body, move arms from the waist toward the shoulders, out and away from the body.



*Marshalling Turn to Your Left*

The right arm points to the right. The left arm is in the prove position, bent at the elbow, away from the body with the left hand above the head. Move the left arm back and forth from the shoulder to above the head.



*Marshalling Turn to Your Right*

The right arm points to the right. The left arm is in the prove position, bent at the elbow, away from the body with the left hand above the head. Move the left arm back and forth from the shoulder to above the head.



*Marshalling Slow Down*

With the arms out in front of the body, move the arms up and down from the waist to the shoulders.



*Marshalling All Clear*

The left arm remains at the side of the body. The right arm is in the prove position, bent at the elbow, in front of the body with the upper arm parallel to the ground. Give the thumbs up signal with the right hand.



*Marshalling Cut Engines*

The left arm remains at the side of the body. Position the right arm out from the shoulder, parallel

to the tarmac. The right arm should be bent at the elbow. With the right hand, make a cutting motion in front of the throat.



*Marshalling Start Engine(s)*

With the left arm straight above the head, form a “V” with the index and middle fingers. With the right arm bent and the upper arm parallel to the tarmac, point the index finger up and curl the fingers. Make a circular, counterclockwise motion with the right hand.