ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL FOUR

INSTRUCTIONAL GUIDE

SECTION 2

EO M437.02 – DESCRIBE THE MAGNETIC COMPASS

Total Time: 30 min

PREPARATION

PRE-LESSON INSTRUCTIONS

Resources needed for the delivery of this lesson are listed in the lesson specification located in A-CR-CCP-804/PG-001, *Proficiency Level Four Qualification Standard and Plan*, Chapter 4. Specific uses for said resources are identified throughout the instructional guide within the TP for which they are required.

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

Prepare slides of the figures located at Attachment A.

Photocopy the homework assignment located at Attachment B for each cadet.

PRE-LESSON ASSIGNMENT

Nil.

APPROACH

An interactive lecture was chosen for this lesson to clarify, emphasize, and summarize the magnetic compass.

INTRODUCTION

REVIEW

Nil.

OBJECTIVES

By the end of this lesson the cadet shall be expected to describe the magnetic compass.

IMPORTANCE

It is important for the cadets to learn about the magnetic compass because the compass is a vital instrument used for navigation. The compass is often used as a reference for other instruments used in direction finding (such as the heading indicator). The cadets can apply this knowledge in a flight simulator and on a demonstration flight.

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Teaching point 1 **Describe the Earth's magnetism.**

Time: 5 min Method: Interactive Lecture

THE EARTH'S MAGNETISM

The Earth is a giant magnet that has a north and south pole. There are lines of force generated by currents of molten iron that flow within the Earth. The lines of force flow between the poles, creating a magnetic field that surrounds the Earth. The compass needle is affected by the lines of force, causing the magnetic needle to point to magnetic north.

Points of a Compass Rose



Show the slide of Figure A-1 to the cadets.

The main cardinal points are north, south, east, and west. The inter-cardinal points are northeast, southeast, southwest, and northwest.

CONFIRMATION OF TEACHING POINT 1

QUESTIONS:

Q1. Where does the magnetic needle point?

Q2. What cardinal point does a bearing of 270 degrees represent?

Q3. What is your heading (in degrees) if you are flying northeast?

ANTICIPATED ANSWERS:

A1. Magnetic north.

A2. West.

A3. 45 degrees.

Teaching point 2 **Describe the main parts of the magnetic compass.**

Time: 5 min Method: Interactive Lecture

MAIN PARTS OF THE MAGNETIC COMPASS



Show the slide of Figure A-2 to the cadets.

Point out the parts of a magnetic compass using the examples of magnetic compasses.

Lubber line. The lubber line is a painted white line that indicates the direction the airplane is heading. It is in line with or parallel to the longitudinal axis of the airplane. It is at this location that the compass card is read.

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Compass card. The compass card contains the numbers. It is attached to the pivot and moves within the compass bowl. The compass card is read at the lubber line through a window.

Compass bowl. The compass bowl encompasses the entire compass assembly, including the liquid. The compass bowl is made of brass which is a non-magnetic material.

Pivot. The pivot allows the compass card to rotate freely.

Magnetic needle. The magnetic needle always points to magnetic north.

Liquid. The compass bowl is filled with liquid to lubricate the pivot, reduce the weight of the compass card and magnets, and limit movement that may be caused by turbulence. The liquid is either alcohol or white kerosene because they are transparent and have a low freezing point and a high boiling point.

CONFIRMATION OF TEACHING POINT 2

QUESTIONS:

Q1. What does the lubber line indicate?

Q2. What part of the compass contains the numbers that are read?

Q3. What liquids are used in the compass bowl?

ANTICIPATED ANSWERS:

A1. The direction the airplane is heading.

A2. The compass card.

A3. Alcohol or white kerosene.

Teaching point 3 **Describe variation.**

Time: 5 min Method: Interactive Lecture

VARIATION

True north and magnetic north do not have the same location. The two poles can be located far apart because magnetic north is continuously moving at a very slow rate. This is a significant concern for navigation because geographical coordinates are based on true or geographic north whereas a magnetic compass points to magnetic north.



Show the slide of Figure A-3 to the cadets.

Variation. Variation is the angle between true north and magnetic north. It is also known as magnetic declination. This angle is taken into consideration during flight planning.

Agonic lines. Agonic lines join places of zero magnetic variation. This is to say that both the true north and magnetic north lie in a straight line relative to these places.

Isogonic lines. Isogonic lines join places of equal magnetic variation. If an observer were to move along this invisible line, the angle between true and magnetic north would remain the same.

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Aeronautical navigation charts use true north and display variation information. Pilots must convert the true headings to magnetic headings in order to navigate using the charts and magnetic compass.

The following rhymes can help pilots remember how to apply variation to true headings:

- "Variation West, Magnetic Best", and
- "Variation East, Magnetic Least".

In other words, ADD westerly variation to a true heading to calculate the magnetic heading. SUBTRACT easterly variation from a true heading to calculate the magnetic heading.

CONFIRMATION OF TEACHING POINT 3

QUESTIONS:

Q1. What is variation?

Q2. What are isogonic lines?

Q3. How is a magnetic heading calculated?

ANTICIPATED ANSWERS:

A1. The angle between true north and magnetic north.

A2. Isogonic lines join places of equal magnetic variation.

A3. By adding westerly variation (subtracting easterly variation) to (from) the true heading.

Teaching point 4 **Describe compass errors.**

Time: 10 min Method: Interactive Lecture

DEVIATION

The magnetic compass is affected by anything metal that is in close proximity to it. When mounted in an aircraft, it is affected by the surrounding metal in the aircraft's frame and engine, as well as electrical equipment. The compass does not point to magnetic north, but is deflected slightly by the magnetic fields associated with the surrounding metal. The direction that the magnetic needle will point when affected by the running engine and working electrical equipment is unique to the aircraft. It is referred to as compass north. The angle between magnetic north and compass north is deviation.



Demonstrate deviation by placing a compass near a laptop computer or other electrical device.

Since deviation cannot be eliminated, the amount of deviation on a given heading is determined so that a pilot can compensate for this compass error. This occurs by swinging the compass. The aircraft is lined up on a known magnetic heading with its engine running and all electrical equipment working. The direction is read

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from the compass and compared to the known magnetic heading. After this is taken on many headings, a compass correction card is prepared and placed in the aircraft.



Show the slide of Figure A-4 to the cadets.



Deviation must be added to or subtracted from the magnetic heading to calculate the compass heading.

When the magnetic heading is between the headings listed on the compass correction card, interpolate (estimate) the amount of deviation by using the two nearest magnetic headings that are listed.

Magnetic Dip

The magnetic lines of force of the Earth's magnetic field are horizontal at the equator, but bend down into the poles. This causes the north-seeking end of the needle to dip towards the ground. This error is more pronounced the closer the compass is to the poles.

Magnetic dip can be reduced, but not eliminated, by the design of the compass.

Northerly Turning Error

During a turn, centripetal and centrifugal forces combine with the inertial influence of the liquid in the compass bowl to affect the movement of the compass needle. This error is most apparent on north and south headings. The amount of the error is greatest over the poles and the least over the equator.



On turns from north, northerly turning error causes the compass to lag.

On turns from south, northerly turning error causes the compass to lead.

Acceleration and Deceleration Errors

Acceleration or deceleration of the aircraft affects the magnetic compass and the inertia causes a turning moment when the aircraft is on an east or west heading. Once the airspeed has stabilized, the compass will again read correctly.



Show the slide of Figure A-5 to the cadets.



On east and west headings:

- acceleration causes the compass to register a turn toward north, and
- deceleration causes the compass to register a turn toward south.

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CONFIRMATION OF TEACHING POINT 4

QUESTIONS:

Q1. For what does a compass card indicate corrections?

Q2. What does a turn from the north cause a compass to do?

Q3. On what headings do acceleration and deceleration cause the compass to register a turn?

ANTICIPATED ANSWERS:

A1. Deviation.

A2. Lag.

A3. East and west.

END OF LESSON CONFIRMATION

The cadets' completion of the homework assignment will serve as the confirmation of this lesson.

CONCLUSION

HOMEWORK / READING / PRACTICE

Have the cadets complete the Magnetic Headings Worksheet located at Attachment B. Use the answer key located at Attachment C to review their answers.

METHOD OF EVALUATION

This EO is assessed IAW A-CR-CCP-804/PG-001, *Proficiency Level Four Qualification Standard and Plan*, Chapter 3, Annex B, Aviation Subjects–Combined Assessment PC.

CLOSING STATEMENT

To use a magnetic compass, the underlying principles must be understood. A compass is a common instrument in aviation and can act as a reference for setting other instruments. Magnetic compasses are useful not only in aviation but also on the ground and on the water.

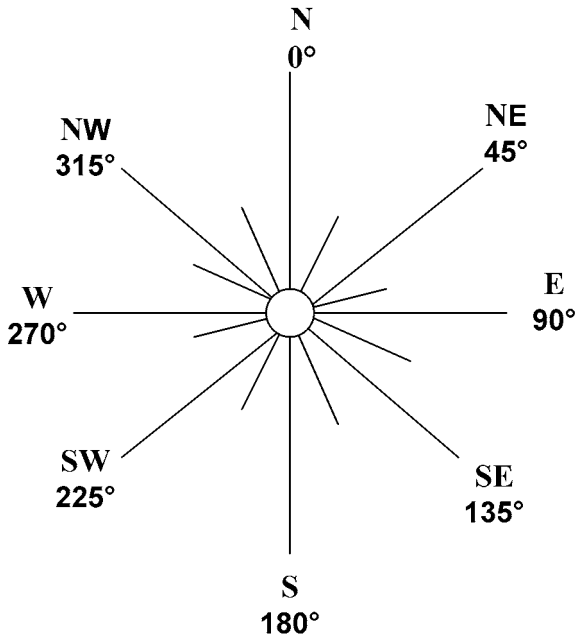
INSTRUCTOR NOTES / REMARKS

Cadets who are qualified Advanced Aviation may assist with this instruction.

REFERENCES

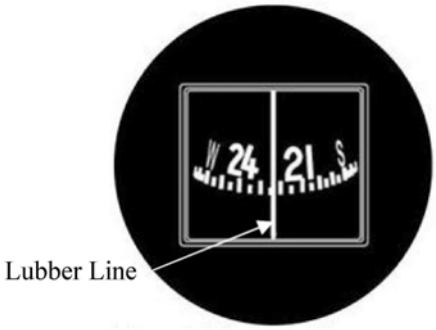
C3-116 ISBN 0-9680390-5-7 MacDonald, A. F., & Peppler, I. L. (2000). *From the ground up: Millennium edition*. Ottawa, ON: Aviation Publishers Co. Limited.

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Note. Created by Director Cadets 3, 2007, Ottawa, ON: Department of National Defence.

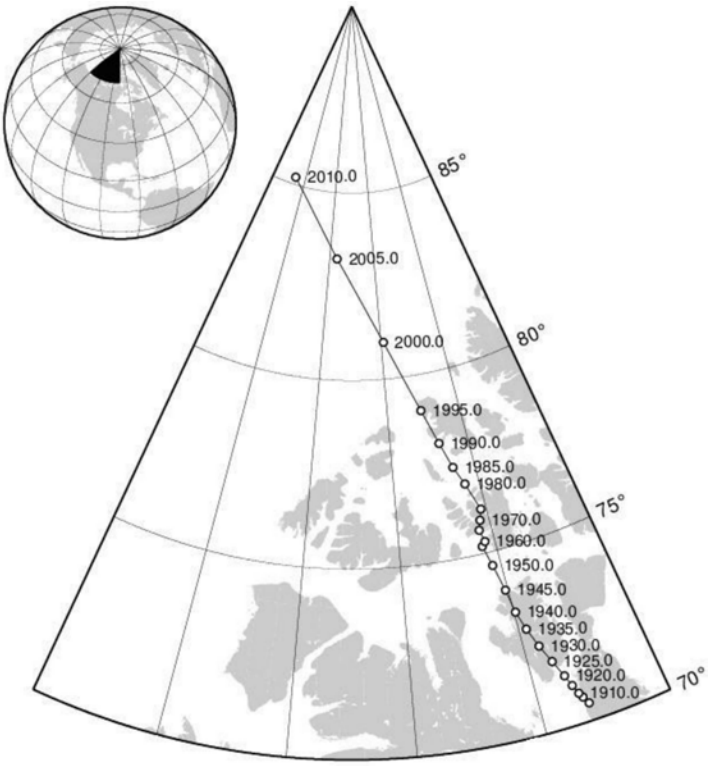
Figure A-1 Points on a Compass Rose



Note. From "Magnetic Compass", by North American Powered Parachute Federation, 2001, Flight Instruments, Copyright 2001 by North American Powered Parachute Federation. Retrieved November 8, 2007, from http://www.nappf.com/nappf_flight_instruments_files/image008.jpg

Figure A-2 Lubber Line

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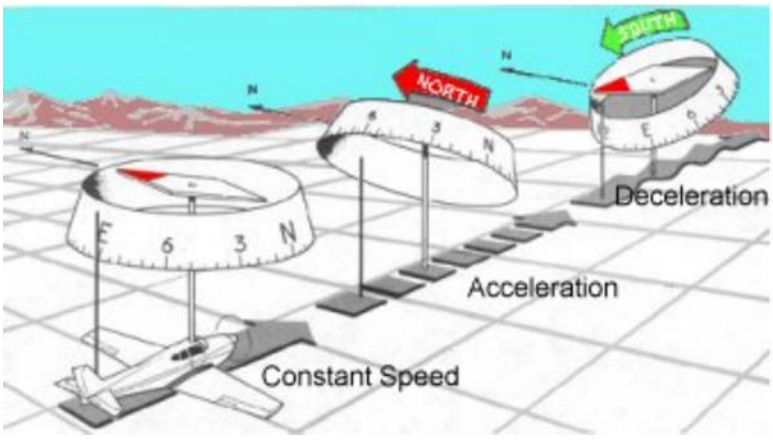
Note. From "Locations of the North Magnetic Pole from IGRF-10", by K. Korhonen, Helsinki University of Technology. Retrieved November 8, 2007, from http://users.tkk.fi/~kkorhon1/nmplocs.png

Figure A-3 Location of the Magnetic North Pole

For	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
Steer	359°	30°	60°	88°	120°	152°	183°	212°	240°	268°	300°	329°

Note. Created by Director Cadets 3, 2008, Ottawa, ON: Department of National Defence.

Figure A-4 Compass Correction Card



Note. From "Magnetism and the Magnetic Compass ", by Pilot's Web. Retrieved November 8, 2007, from http://pilotsweb.com/navigate/art/accel.jpg

Figure A-5 Acceleration and Deceleration Errors

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MAGNETIC HEADINGS WORKSHEET

Fill in the missing values.

	Variation	True Heading	Magnetic Heading
1.	8° west	120°	
2.	2° east	270°	
3.	11° east	010°	
4.	15° west	350°	
5.	22° east	180°	
6.		090°	101°
7.		085°	080°
8.		359°	005°
9.		254°	266°
10.		122°	118°
11.	9° east		113°
12.	3° west		357°
13.	15° west		345°
14.	12° east		124°
15.	2° west		180°

Sample Compass Correction Card

For	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
Steer	359°	30°	60°	88°	120°	152°	183°	212°	240°	268°	300°	329°

Fill in the missing values.

	Magnetic Heading	Compass Heading
1.	020°	
2.	161°	
3.	345°	
4.		080°
5.		215°

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MAGNETIC HEADINGS ANSWER KEY

Fill in the missing values.

	Variation	True Heading	Magnetic Heading
1.	8° west	120°	**128°**
2.	2° east	270°	**268°**
3.	11° east	010°	**359°**
4.	15° west	350°	**005°**
5.	22° east	180°	**158°**
6.	**11° west**	090°	101°
7.	**5° east**	085°	080°
8.	**6° west**	359°	005°
9.	**12° west**	254°	266°
10.	**4° east**	122°	118°
11.	9° east	**122°**	113°
12.	3° west	**354°**	357°
13.	15° west	**330°**	345°
14.	12° east	**136°**	124°
15.	2° west	**178°**	180°

Sample Compass Correction Card

For	0°	30°	60°	90°	120°	150°	180°	210°	240°	270°	300°	330°
Steer	359°	30°	60°	88°	120°	152°	183°	212°	240°	268°	300°	329°

Fill in the missing values.

	Magnetic Heading	Compass Heading
1.	020°	**020°**
2.	161°	**163°**
3.	345°	**344°**
4.	**082°**	080°
5.	**213°**	215°

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