



**ROYAL CANADIAN AIR CADETS  
PROFICIENCY LEVEL FOUR  
INSTRUCTIONAL GUIDE**



**SECTION 1**

**EO M437.01 – DEFINE AIR NAVIGATION TERMS**

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Total Time:	60 min
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**PREPARATION**

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**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.

Photocopy the handout located at Attachment A for each cadet.

Prepare slides of the figures located at Attachment B.

Photocopy the Headings and Bearings Worksheet located at Attachment C for each cadet.

**PRE-LESSON ASSIGNMENT**

Nil.

**APPROACH**

An interactive lecture was chosen for TPs 1–3 to clarify, emphasize, and summarize navigation terms.

An in-class activity was chosen for TP 4 as it is an interactive way to reinforce bearings and headings, and confirm the cadets' comprehension of navigation terms.

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**INTRODUCTION**

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**REVIEW**

Nil.

**OBJECTIVES**

By the end of this lesson the cadet shall be expected to define air navigation terms.

**IMPORTANCE**

It is important for cadets to define air navigation terms to ensure a firm foundation in navigation before learning more advanced material. Knowledge of air navigation terms is essential for future aviation training and potential instructional duties at the squadron.

**Teaching Point 1**

**Define meridians of longitude, parallels of latitude, geographical co-ordinates, and the relationship between time and longitude.**

Time: 25 min

Method: Interactive Lecture



Use a large globe to point out the meridians of longitude and parallels of latitude.

**MERIDIANS OF LONGITUDE**

**Meridians of longitude.** Semicircles joining the true / geographic poles of the Earth.

Longitude is measured from 0–180 degrees east and west of the prime meridian. The prime meridian is the meridian which passes through Greenwich, England and is numbered zero degrees. The meridian on the opposite side of the Earth to the prime meridian is the 180<sup>th</sup> and is called the international date line (the time changes a day).

Longitude is measured in degrees ( ° ), minutes ( ' ), and seconds ( " ). There are 60 minutes in a degree and 60 seconds in a minute.



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

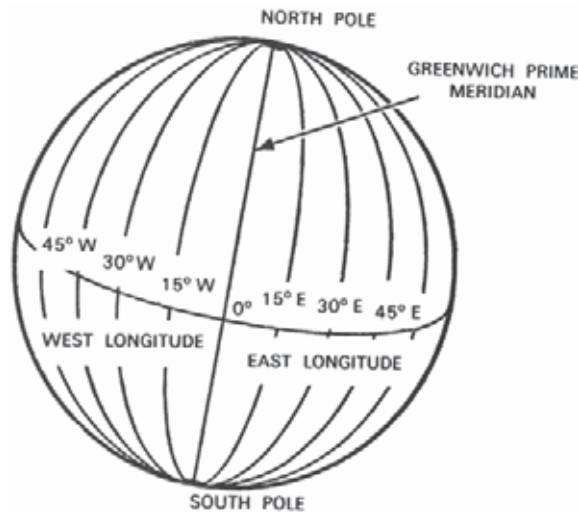


Figure 1 Meridians of Longitude

*Note.* From "Air Cadet Master Lesson Plans", 2007, *Cadets Canada: RCSU Pacific*. Retrieved November 14, 2007, from [http://www.regions.cadets.ca/pac/aircad/resources/mlp\\_air\\_e.asp](http://www.regions.cadets.ca/pac/aircad/resources/mlp_air_e.asp)

**PARALLELS OF LATITUDE**

**Parallels of latitude.** Circles on the Earth's surface that lie parallel to the equator.

**Equator.** An imaginary line on the surface of the Earth equidistant from the poles.

Latitude is measured from 0–90 degrees north and south of the equator, which is numbered zero degrees. Like longitude, latitude is measured in degrees, minutes, and seconds.

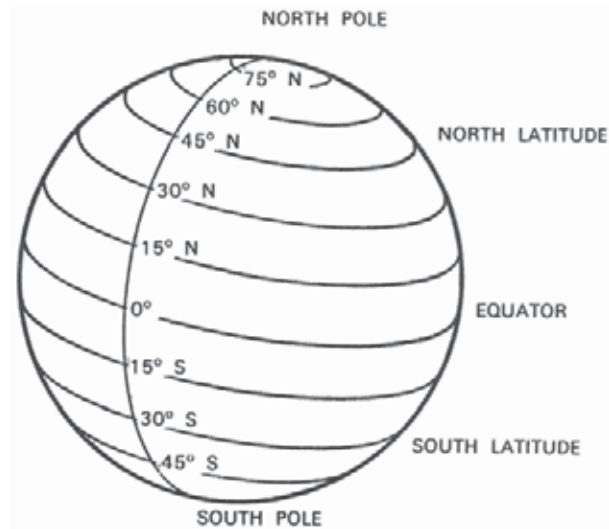


Figure 2 Parallels of Latitude

*Note.* From "Air Cadet Master Lesson Plans", 2007, *Cadets Canada: RCSU Pacific*. Retrieved November 14, 2007, from [http://www.regions.cadets.ca/pac/aircad/resources/mlp\\_air\\_e.asp](http://www.regions.cadets.ca/pac/aircad/resources/mlp_air_e.asp)



Remember the difference between latitude and longitude using one of the following mnemonics:

- Lat is flat / fat; longitude is long.
- Latitude is like climbing up a ladder because it is north / south; longitude is like swinging across because it is east / west.

## GEOGRAPHICAL CO-ORDINATES

**Geographical co-ordinates.** The intersection of lines of latitude and longitude. Geographical co-ordinates mark the position of places (eg, cities, towns, airports) on a chart.

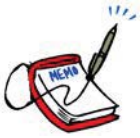
On a chart, there are black lines representing longitude and latitude, every 30 minutes. Small marks represent 1 minute. There are slightly larger marks for 5 minute and 10 minute increments.



Distribute the handout located at Attachment A to each cadet.

Have the cadets find markings on a line of latitude or longitude to represent 1 minute, 5 minutes, and 10 minutes using a local VFR Navigation Chart (VNC).

Co-ordinates express latitude first, in degrees north or south of the equator and longitude second, in degrees east or west of the prime meridian. For example, the geographical coordinates of the military airport at Trenton, Ont. are 44°07' N, 77°32' W.



The location of the military airport at Trenton, Ont. has been chosen as an example because it appears on the sample VNC provided in the back of *From The Ground Up: Millennium Edition*.

The grid surrounding this airport can be found at Attachment A.



Select a major airport in the area and have the cadets find the coordinates using a local VNC.

## THE RELATIONSHIP BETWEEN TIME AND LONGITUDE

The Earth rotates about its axis as it revolves in an elliptical orbit around the Sun. This creates the illusion that the Sun is revolving around the Earth. The time between one apparent passage of the Sun over a meridian of longitude is called an apparent solar day and varies throughout the year. To provide a convenient method of measuring time, it has been averaged to a mean solar day, divided into 24 hours. During the mean solar day, the Sun is assumed to travel once around the Earth, thereby travelling through 360 degrees of longitude. Hence, mean time can be expressed in terms of longitude and vice versa.

For example:

- 24 hours = 360 degrees of longitude
- 1 hour = 15 degrees of longitude
- 1 minute = 15 minutes of longitude
- 1 second = 15 seconds of longitude
- 360 degrees of longitude = 24 hours
- 1 degree of longitude = 4 minutes
- 1 minute of longitude = 4 seconds
- 1 second of longitude = 1/15 second

**Local mean time (LMT).** The mean time on any particular meridian.

**Co-ordinated universal time (UTC).** An atomically measured global standard time, calculated from midnight on the zero meridian. UTC is also referred to as Zulu (Z) time.



UTC replaced Greenwich mean time (GMT) which was the universally accepted standard for the measurement of time until December, 1985.

UTC is the LMT for the prime meridian.

The LMT of any place east of the prime meridian is ahead of UTC. For example, 1200 hours LMT in Cairo is 1000Z.

The LMT of any place west of the prime meridian is behind UTC. For example, 1200 hours LMT in Halifax is 1600Z.



Tell the cadets how many hours are added to LMT to find UTC in their location.



Use a large globe to indicate the time zones.

The world is divided into 24 time zones, each 15 degrees of longitude (one hour) wide. When travelling westward into a new time zone, time is turned back one hour. When travelling eastward into a new time zone, time is turned ahead one hour.



One exception to this is Newfoundland Standard Time, which is 1/2 hour ahead of Atlantic Standard Time.

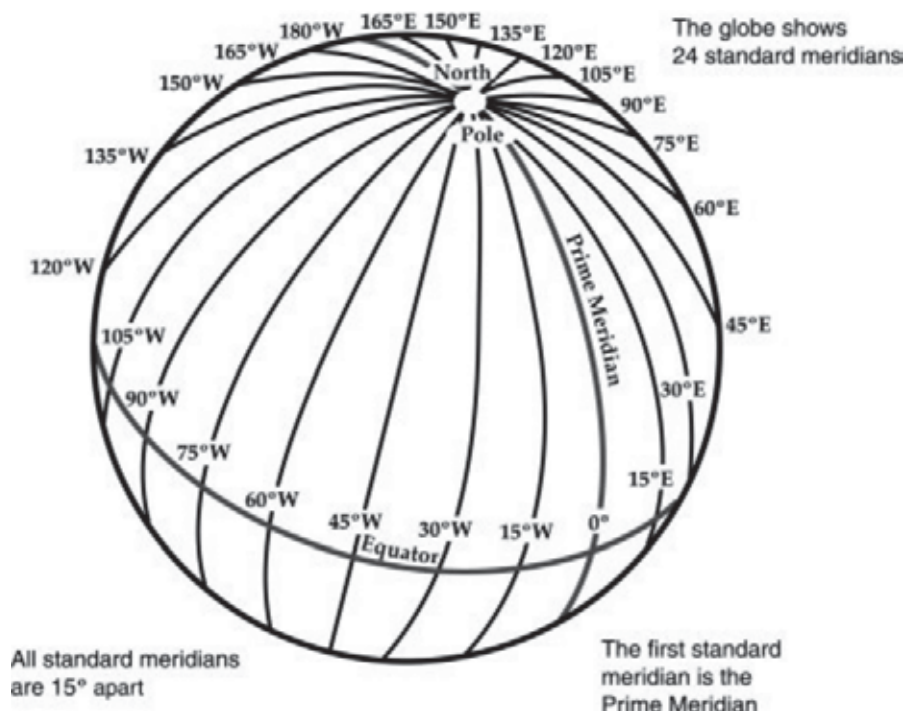


Figure 3 Meridians of Longitude

*Note.* From "Globe Lesson 12", *1-World Maps Online*, Copyright 2008 by 1-World Maps Online. Retrieved November 25, 2008, from <http://www.worldmapsonline.com/LESSON-PLANS/6-global-time-globe-lesson-12.htm>



Part of our heritage: Sir Sandford Fleming, a Canadian railway planner and engineer, outlined a plan for worldwide standard time in the late 1870s. Following this initiative, in 1884, delegates from 27 nations met in Washington, D.C. for the Meridian Conference and agreed on a system basically the same as that now in use.

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## CONFIRMATION OF TEACHING POINT 1

### QUESTIONS:

- Q1. What are meridians of longitude?
- Q2. How are parallels of latitude measured?
- Q3. What must be done to LMT in Canada to convert it to UTC?

### ANTICIPATED ANSWERS:

- A1. Semicircles joining the true / geographic poles of the Earth.
- A2. From 0–90 degrees north and south of the equator.
- A3. The appropriate number of hours must be added.

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## Teaching Point 2

Define great circles and rhumb lines.

Time: 10 min

Method: Interactive Lecture

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## GREAT CIRCLES



Show the slide of Figures B-1 and B-2 to the cadets.

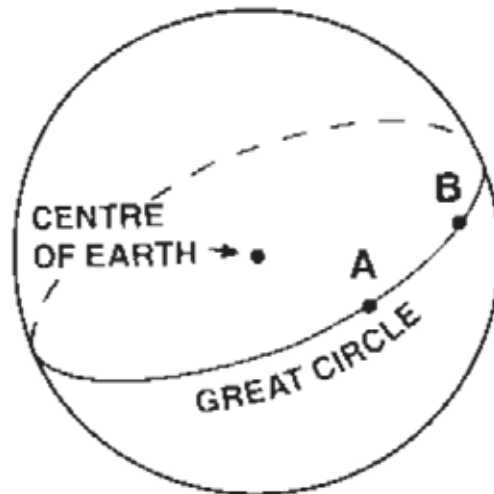


Figure 4 Great Circle

*Note. From From the Ground Up: Millennium Edition (p. 177), by A. F. MacDonald and I. L. Peppler, 2000, Ottawa, ON: Aviation Publishers Co. Limited. Copyright 2000 by Aviation Publishers Co. Limited.*

**Great circle.** A circle on the surface of a sphere that passes through the centre of the sphere, cutting it into two equal parts.

The equator is a great circle. The meridians of longitude are semi-great circles as they run from pole to pole and do not completely encircle the Earth.

Only one great circle can be drawn through two places that are not diametrically opposite each other. The shortest distance between these two points is the shorter arc of the great circle joining them. Therefore, most long-distance flights are flown over great circle routes.

A great circle does not cross the meridians it meets at the same angle. Therefore, the heading must be changed at frequent intervals to enable the airplane to maintain a great circle route.

## RHUMB LINES



Show the slide of Figures B-3 and B-4 to the cadets.

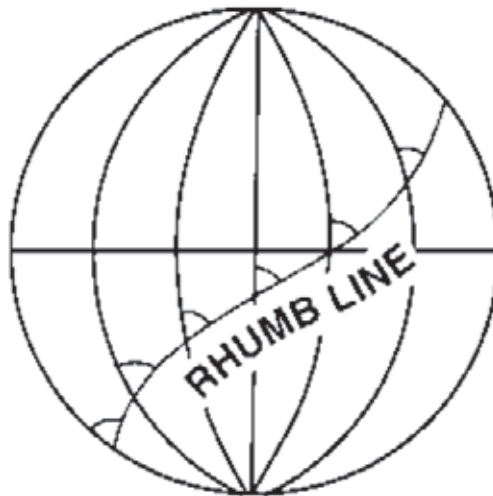


Figure 5 Rhumb Line

*Note.* From *From the Ground Up: Millennium Edition* (p. 177), by A. F. MacDonald and I. L. Pepler, 2000, Ottawa, ON: Aviation Publishers Co. Limited. Copyright 2000 by Aviation Publishers Co. Limited.

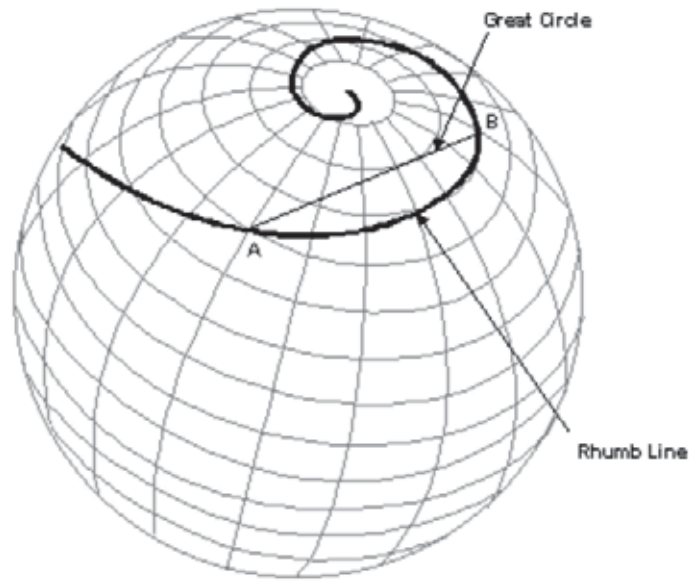
**Rhumb line.** A curved line on the surface of the Earth, cutting all the meridians it meets at the same angle.

All parallels of latitude are rhumb lines. The meridians of longitude and the equator are rhumb lines as well as great circles.



Show the slide of Figures B-5 and B-6 to the cadets.

When two places are not situated on the equator or on the same meridian of longitude, the distance measured along the rhumb lines joining them will not be the shortest distance between them. The advantage of the rhumb line route is that the direction is constant, allowing a navigator to follow a constant heading.



The great circle is a straight line and the Rhumb line is a spiral curve

Figure 6 Great Circle and Rhumb Line

Note. From "Flights", *Navworld*. Retrieved November 26, 2008, <http://www.navworld.com/navcerebrations/flights.htm>

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## CONFIRMATION OF TEACHING POINT 2

### QUESTIONS:

- Q1. What is a great circle?
- Q2. What is a rhumb line?
- Q3. What is the advantage of following a rhumb line route?

### ANTICIPATED ANSWERS:

- A1. A circle on the surface of a sphere that passes through the centre of the sphere, cutting it into two equal parts.
- A2. A curved line on the surface of the Earth, cutting all the meridians it meets at the same angle.
- A3. The direction is constant, allowing a navigator to follow a constant heading.

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## Teaching Point 3

Define headings and bearings.

Time: 5 min

Method: Interactive Lecture

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## HEADINGS AND BEARINGS

Direction is measured in degrees clockwise from north, which is zero degrees (or 360 degrees). East is 90 degrees, south is 180 degrees, and west is 270 degrees.





Show the slide of Figure B-7 to the cadets.



Figure 7 Heading

*Note.* From *From the Ground Up: Millennium Edition* (p. 177), by A. F. MacDonald and I. L. Peppler, 2000, Ottawa, ON: Aviation Publishers Co. Limited. Copyright 2000 by Aviation Publishers Co. Limited.

**True heading.** The angle between the meridian of longitude over which an airplane is flying and the line representing the direction the airplane's nose is pointing, measured clockwise from the meridian.



Show the slide of Figure B-8 to the cadets.

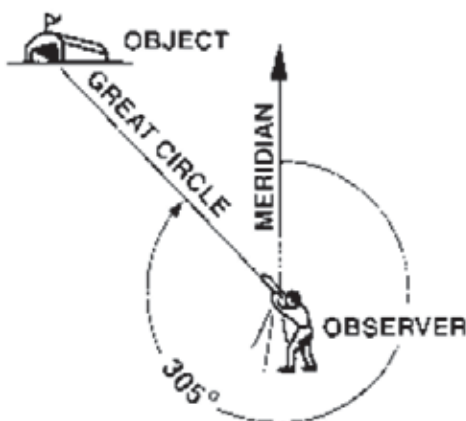


Figure 8 Bearing

*Note.* From *From the Ground Up: Millennium Edition* (p. 177), by A. F. MacDonald and I. L. Peppler, 2000, Ottawa, ON: Aviation Publishers Co. Limited. Copyright 2000 by Aviation Publishers Co. Limited.

The direction of any point on the surface of the Earth from an observer is known by measuring the bearing.

**Bearing.** The angle between the meridian of longitude passing through the observer and the great circle that joins the observer to the object, measured clockwise from the meridian.

Headings and bearings are found using a compass.

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### CONFIRMATION OF TEACHING POINT 3

#### QUESTIONS:

- Q1. How is direction measured?
- Q2. Define true heading.
- Q3. Define bearing.

#### ANTICIPATED ANSWERS:

- A1. In degrees clockwise from north.
- A2. The angle between the meridian of longitude over which an airplane is flying and the line representing the direction the airplane's nose is pointing, measured clockwise from the meridian.
- A3. The angle between the meridian of longitude passing through the observer and the great circle that joins the observer to the object, measured clockwise from the meridian.

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### Teaching Point 4

**Have the cadets take headings and bearings.**

Time: 10 min

Method: In-Class Activity

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## ACTIVITY

### OBJECTIVE

The objective of this activity is to have the cadets take headings and bearings.

### RESOURCES

- Douglas Protractor,
- Pen / Pencil, and
- Headings and Bearings Worksheet located at Attachment C.

### ACTIVITY LAYOUT

Nil.

### ACTIVITY INSTRUCTIONS

1. Distribute a Douglas protractor to each cadet.
2. Distribute a Headings and Bearings Worksheet to each cadet.
3. Designate an object in the room as representing magnetic north.
4. Have the cadets take the magnetic headings of the aircraft in Section 1 of the worksheet.

5. Review and correct the answers.
6. Designate a different object in the room as representing true north.
7. Have the cadets take the bearing of the tower from the aircraft in Section 2 of the worksheet.
8. Review and correct the answers.

### **SAFETY**

Nil.

### **CONFIRMATION OF TEACHING POINT 4**

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

### **END OF LESSON CONFIRMATION**

#### **QUESTIONS:**

- Q1. How many degrees of longitude are equal to one hour?
- Q2. What is the shortest distance between two places on the surface of the Earth?
- Q3. How are headings and bearings found?

#### **ANTICIPATED ANSWERS:**

- A1. Fifteen.
- A2. The shorter arc of the great circle joining them.
- A3. Using a compass.

### **CONCLUSION**

### **HOMEWORK / READING / PRACTICE**

Nil.

### **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**

Future aviation training and instructional duties require knowledge of air navigation terms.

### **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., & Pepler, I. L. (2000). *From the ground up: Millennium edition*. Ottawa, ON: Aviation Publishers Co. Limited.

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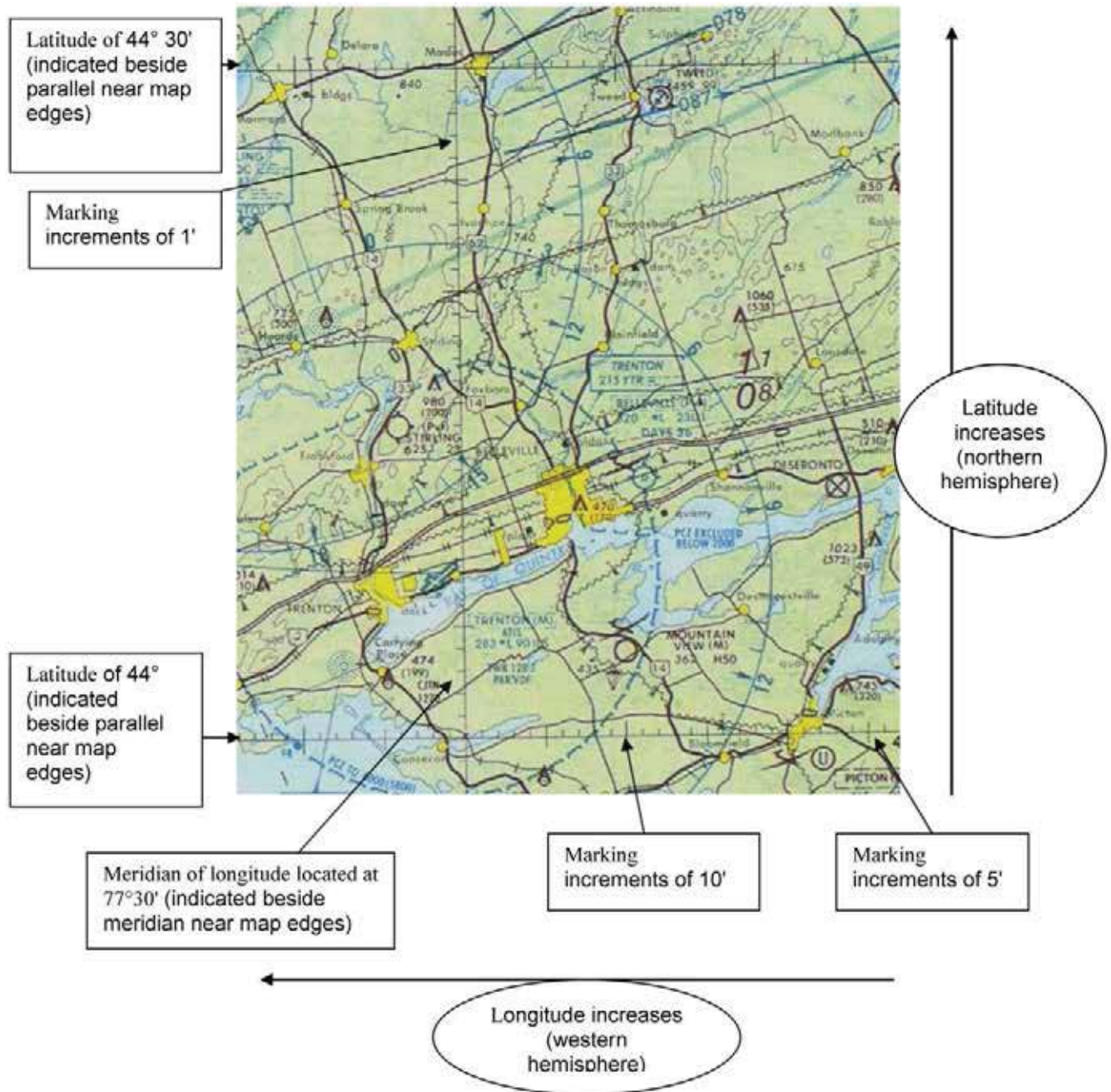


Figure A-1 Example of a VNC

Note. From *Toronto VFR Navigation Chart*, by Geomatics Canada, 2001, Ottawa, ON: Geomatics Canada Department of Natural Resources. Copyright 2001 by NAV CANADA and Her Majesty the Queen in Right of Canada.

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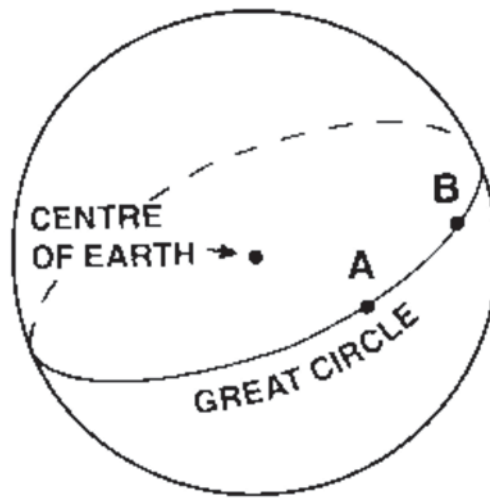


Figure B-1 Great Circle

*Note.* From *From the Ground Up: Millennium Edition* (p. 177), by A. F. MacDonald and I. L. Pepler, 2000, Ottawa, ON: Aviation Publishers Co. Limited. Copyright 2000 by Aviation Publishers Co. Limited.

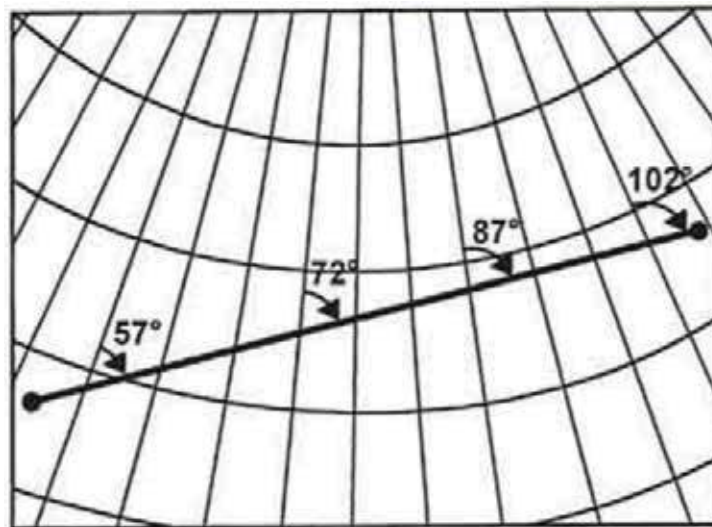


Figure B-2 Great Circle

*Note.* From "Navigation Basics", *Free Online Private Pilot Ground School*. Retrieved November 26, 2008, <http://www.free-online-private-pilot-ground-school.com/navigation-basics.html>

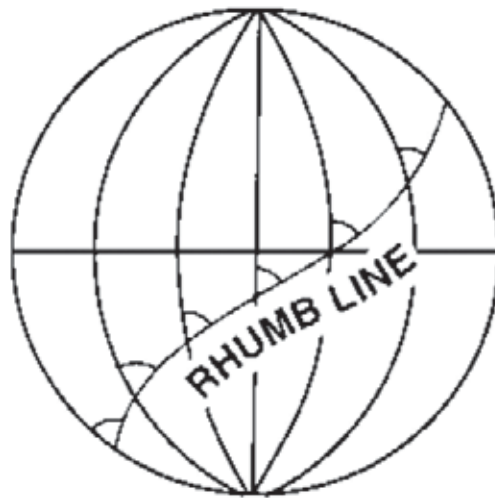


Figure B-3 Rhumb Line

*Note.* From *From the Ground Up: Millennium Edition* (p. 177), by A. F. MacDonald and I. L. Peppler, 2000, Ottawa, ON: Aviation Publishers Co. Limited. Copyright 2000 by Aviation Publishers Co. Limited.

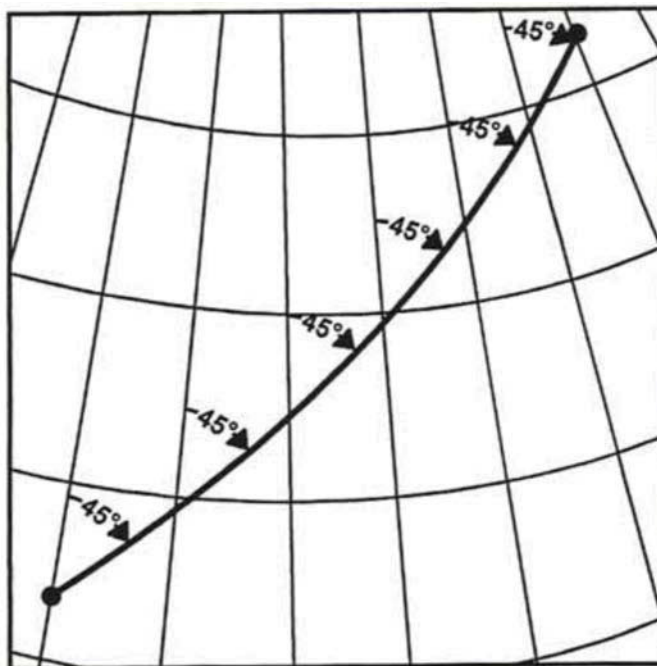


Figure B-4 Rhumb Line

*Note.* From "Navigation Basics", *Free Online Private Pilot Ground School*. Retrieved November 26, 2008, <http://www.free-online-private-pilot-ground-school.com/navigation-basics.html>





Figure B-5 Great Circle and Rhumb Line

Note. From "Flights", *Navworld*. Retrieved November 26, 2008, <http://www.navworld.com/navcerebrations/flights.htm>



Figure B-6 Great Circle and Rhumb Line

Note. From "Navigation Basics", *Free Online Private Pilot Ground School*. Retrieved November 26, 2008, <http://www.free-online-private-pilot-ground-school.com/navigation-basics.html>

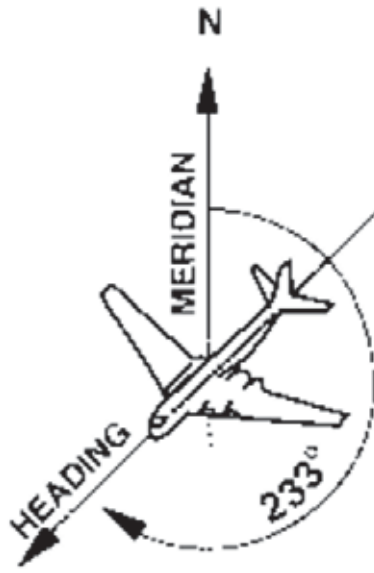


Figure B-7 Heading

*Note.* From *From the Ground Up: Millennium Edition* (p. 177), by A. F. MacDonald and I. L. Peppler, 2000, Ottawa, ON: Aviation Publishers Co. Limited. Copyright 2000 by Aviation Publishers Co. Limited.

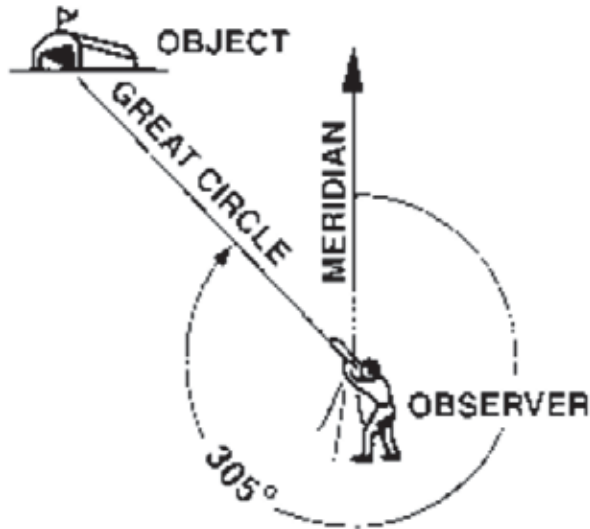


Figure B-8 Bearing

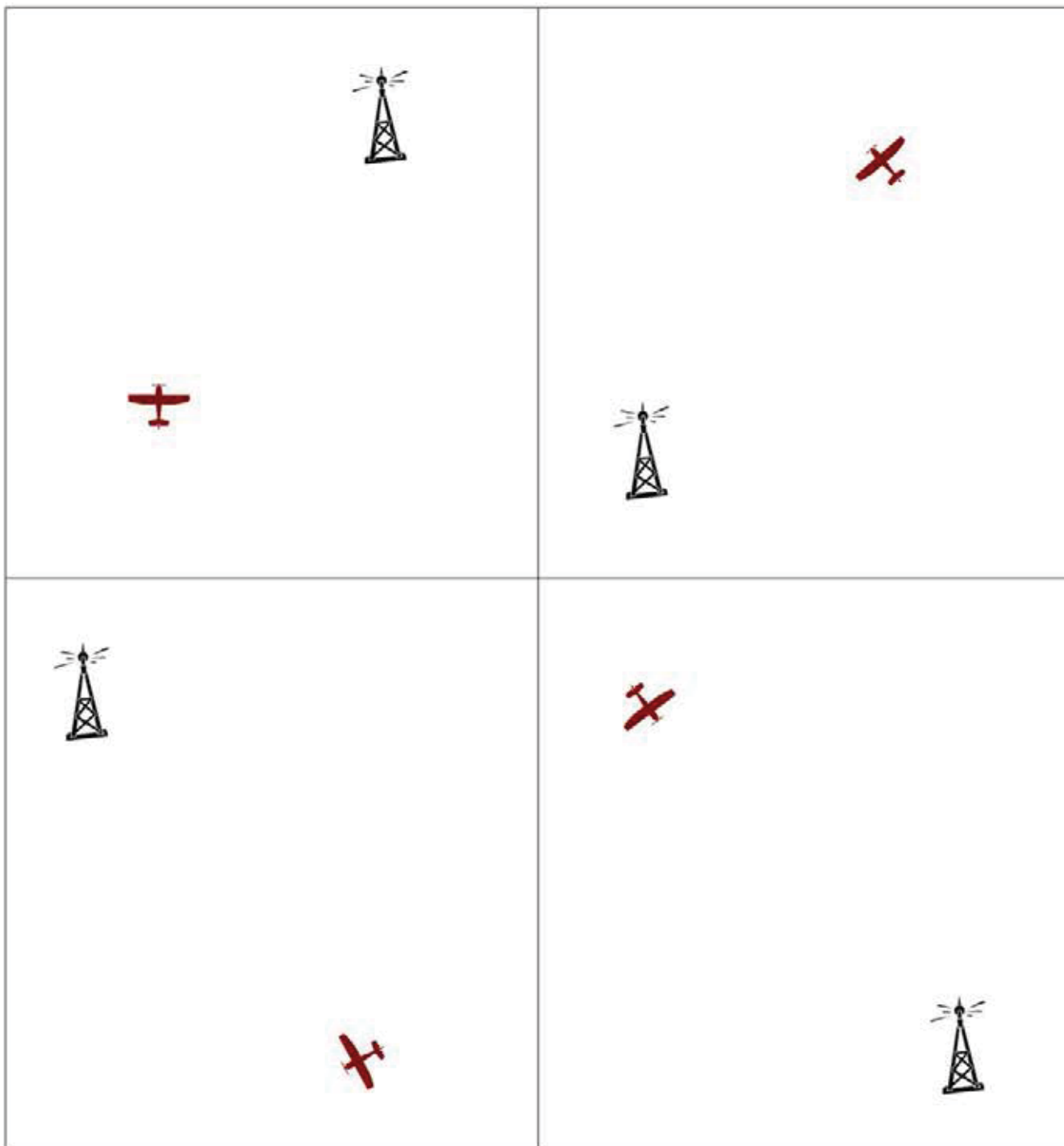
*Note.* From *From the Ground Up: Millennium Edition* (p. 177), by A. F. MacDonald and I. L. Peppler, 2000, Ottawa, ON: Aviation Publishers Co. Limited. Copyright 2000 by Aviation Publishers Co. Limited.

### Headings and Bearings Worksheet

#### Section 1 – Take the Heading of Each Aircraft



Section 2 – Take the Bearing of the Tower from the Aircraft





**ROYAL CANADIAN AIR CADETS  
PROFICIENCY LEVEL FOUR  
INSTRUCTIONAL GUIDE**



**SECTION 2**

**EO M437.02 – DESCRIBE THE MAGNETIC COMPASS**

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Total Time: 30 min

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**PREPARATION**

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**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.

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**INTRODUCTION**

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**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.**

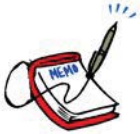
Time: 5 min

Method: Interactive Lecture

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**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

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**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.

**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.



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.

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### 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

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#### 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 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.

---

## 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.

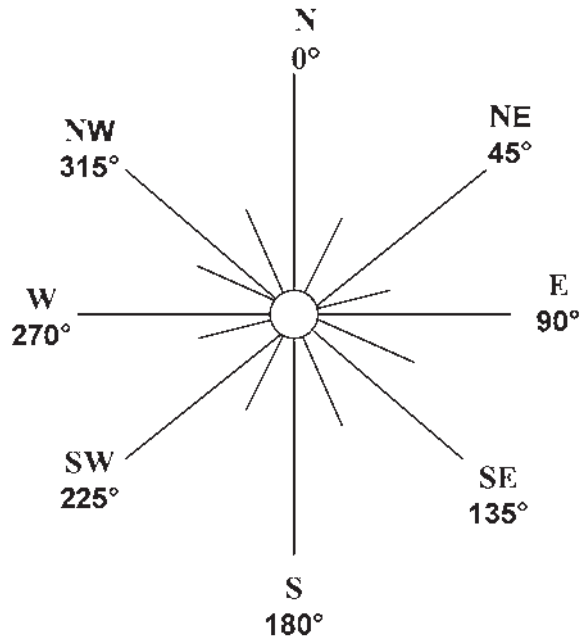


Figure A-1 Points on a Compass Rose

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



Figure A-2 Lubber Line

*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](http://www.nappf.com/nappf_flight_instruments_files/image008.jpg)

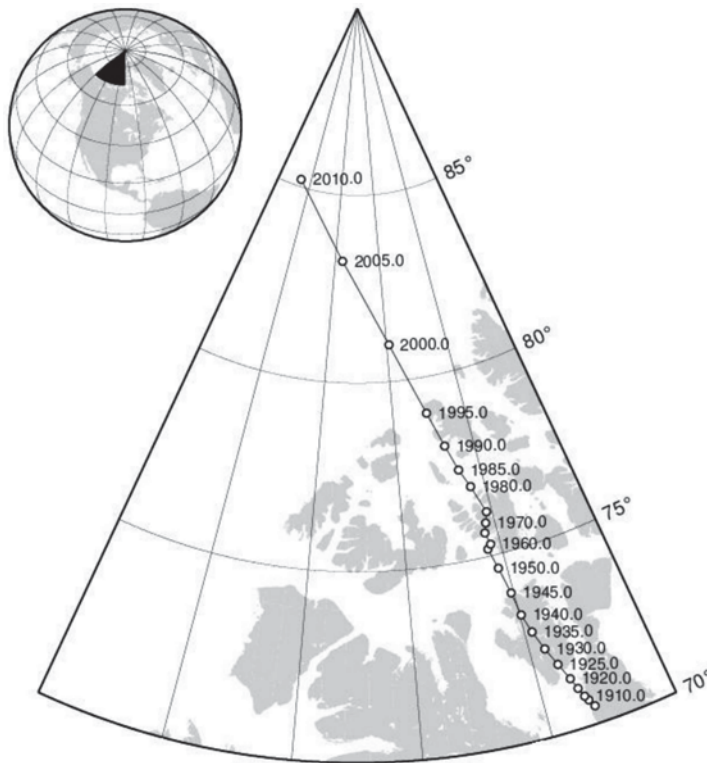


Figure A-3 Location of the Magnetic North Pole

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>

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°

Figure A-4 Compass Correction Card

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

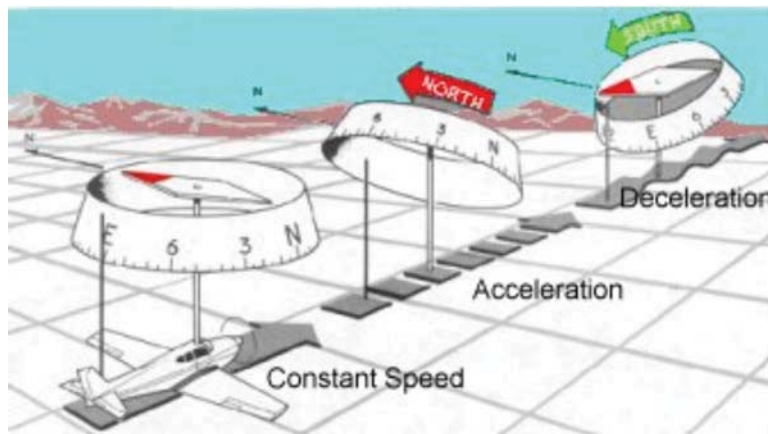


Figure A-5 Acceleration and Deceleration Errors

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

### 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°	<b>128°</b>
2.	2° east	270°	<b>268°</b>
3.	11° east	010°	<b>359°</b>
4.	15° west	350°	<b>005°</b>
5.	22° east	180°	<b>158°</b>
6.	<b>11° west</b>	090°	101°
7.	<b>5° east</b>	085°	080°
8.	<b>6° west</b>	359°	005°
9.	<b>12° west</b>	254°	266°
10.	<b>4° east</b>	122°	118°
11.	9° east	<b>122°</b>	113°
12.	3° west	<b>354°</b>	357°
13.	15° west	<b>330°</b>	345°
14.	12° east	<b>136°</b>	124°
15.	2° west	<b>178°</b>	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°	<b>020°</b>
2.	161°	<b>163°</b>
3.	345°	<b>344°</b>
4.	<b>082°</b>	080°
5.	<b>213°</b>	215°

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**ROYAL CANADIAN AIR CADETS**  
**PROFICIENCY LEVEL FOUR**  
**INSTRUCTIONAL GUIDE**



**SECTION 3**

**EO C437.01 – SOLVE NAVIGATION PROBLEMS WITH A MANUAL FLIGHT COMPUTER**

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Total Time:	60 min
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**PREPARATION**

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**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 Navigation Problems Worksheet located at Attachment B for each cadet.

Assistant instructors may be required for this lesson.

**PRE-LESSON ASSIGNMENT**

Nil.

**APPROACH**

A demonstration and performance was chosen for this lesson as it allows the instructor to explain and demonstrate solving navigation problems with a manual flight computer while providing an opportunity for the cadets to practice this skill under supervision.

---

**INTRODUCTION**

---

**REVIEW**

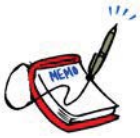
Nil.

**OBJECTIVES**

By the end of this lesson the cadet shall have solved navigation problems with a manual flight computer.

**IMPORTANCE**

It is important for cadets to be able to solve navigation problems with a manual flight computer as it is an important skill that is required for flight planning and en route navigation. Solving navigation problems provides skills for potential instructional duties and is part of the fundamentals that cadets pursuing future aviation training will require.



For this lesson, it is recommended that the instruction take the following format:

1. Explain and demonstrate the technique to use the manual flight computer while the cadets observe.
2. Explain and demonstrate each step required to complete the skill. Monitor cadets as they imitate each step.
3. Monitor the cadets' performance as they practice using the manual flight computer to solve navigation problems.

Note: Assistant instructors may be used to monitor the cadets' performance.

### Teaching Point 1

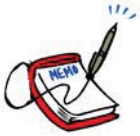
**Demonstrate how to use a manual flight computer to convert units of measure and have the cadets practice converting units of measure.**

Time: 25 min

Method: Demonstration and Performance

### MANUAL FLIGHT COMPUTER

Navigation calculations are simplified by the use of a flight computer. Most manual flight computers consist of two sides: a circular slide rule and a wind side.



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



The instructions for using a manual flight computer are often printed directly on the flight computer.

### Circular Slide Rule

The circular slide rule can be used to solve any problem of multiplication, division, or proportion. There are three scales printed on the circular slide rule. The outer scale is fixed to the computer. The two inner scales are printed together on a disc that may be rotated to any position opposite the outer scale.



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

The outer scale represents miles, gallons, true airspeed and corrected altitude. The inner scale represents time in minutes, calibrated airspeed, and calibrated altitude. The third scale represents time in hours and minutes.

The figures on the circular slide rule may represent any proportion or multiple of 10. For example, 10 on the outer scale may represent 1, 10, or 100; 45 may represent 4.5, 45, or 450.

## CONVERTING UNITS OF MEASURE


One of the most common types of calculations a pilot has to make is converting from one unit of measure to another. Fuel is sold by the litre, but fuel quantities and consumption are usually specified in the aircraft manual in gallons. Wind speeds are reported in knots, but the airspeed indicator (ASI) may be in statute miles per hour.

Using the circular slide rule for conversion calculations is a simple process. Rotate the inner scale to the correct position, locate the original quantity / measure on the outer scale, and read the converted quantity / measure from the inner scale, opposite to the appropriate marking.

### Convert Between Nautical and Statute Miles

To convert between nautical and statute miles:

1. Rotate the inner scale until the known number of miles is under the appropriate index (NAUT or STAT).
2. Read the converted number of miles under the other index.



For example, to convert 90 nautical miles to statute miles:

1. Rotate the inner scale until 90 is under the nautical miles index.
2. Read the number of statute miles under the statute miles index (104 statute miles).

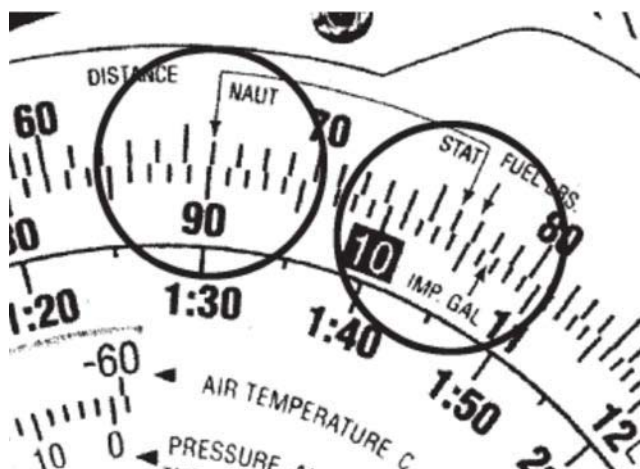



Figure 1 Nautical and Statute Mile Indexes

*Note.* From "Air Classics E6-B Flight Computer Instructions", *Aviation Supplies and Academics, Inc.* Retrieved November 26, 2008, from [http://www.asa2fly.com/files/support/E6B\\_Manual.pdf](http://www.asa2fly.com/files/support/E6B_Manual.pdf)

### Convert Between Miles and Kilometres

To convert between miles and kilometres:

1. Rotate the inner scale until the known number is under the appropriate index (NAUT, STAT, or KM).
2. Read the converted number under the desired index.



For example, to convert 115 statute miles to kilometres:

1. Rotate the inner scale until 115 is under the statute miles index.
2. Read the number of kilometres under the kilometres index (185 km).




Figure 2 Statute Mile and Kilometre Indexes

Note. From "Air Classics E6-B Flight Computer Instructions", Aviation Supplies and Academics, Inc. Retrieved November 26, 2008, from [http://www.asa2fly.com/files/support/E6B\\_Manual.pdf](http://www.asa2fly.com/files/support/E6B_Manual.pdf)

### Convert Between Imperial and US Gallons

To convert between imperial and US gallons:

1. Rotate the inner scale until the imperial and US gallon indexes are aligned.
2. Locate the known quantity (outer scale for imperial gallons and inner scale for US gallons) and read the desired quantity on the opposite scale.



For example, to convert 55 imperial gallons to US gallons:

1. Rotate the inner scale until the imperial and US gallon indexes are aligned.
2. Locate 55 on the outer scale and read the quantity of US gallons on the inner scale (66 US gallons).

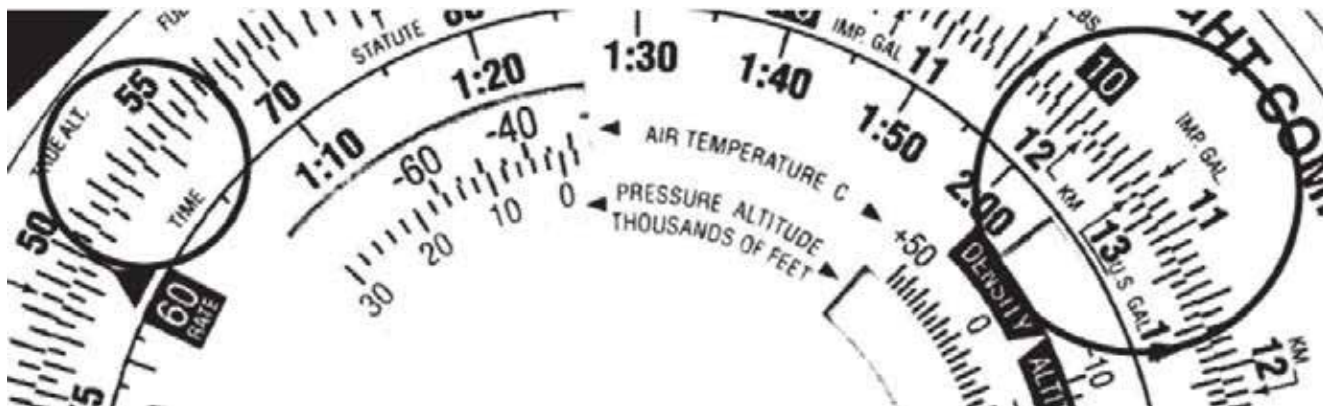


Figure 3 US and Imperial Gallon Indexes

Note. From "Air Classics E6-B Flight Computer Instructions", *Aviation Supplies and Academics, Inc.* Retrieved November 26, 2008, from [http://www.asa2fly.com/files/support/E6B\\_Manual.pdf](http://www.asa2fly.com/files/support/E6B_Manual.pdf)

### Convert Between Gallons and Litres

To convert between gallons and litres:

1. Rotate the inner scale until the litres index is aligned with the appropriate gallon index.
2. Locate the known quantity and read the desired quantity on the opposite scale.



For example, to convert 100 L to US gallons:

1. Rotate the inner scale until the litres index is aligned with the US gallon index.
2. Locate 100 on the outer scale and read the quantity of US gallons on the inner scale (26 US gallons).

### Convert Between Pounds and Kilograms

To convert between pounds and kilograms:

1. Rotate the inner scale until the pounds index is aligned with the kilograms index.
2. Locate the known quantity and read the desired quantity on the opposite scale.



For example, to convert 100 pounds to kilograms:

1. Rotate the inner scale until the pounds index is aligned with the kilograms index.
2. Locate 100 on the outer scale and read the quantity of kilograms on the inner scale (45 kg).

---

## ACTIVITY

Time: 10 min

### OBJECTIVE

The objective of this activity is to have the cadets practice converting units of measure using a manual flight computer.

### RESOURCES

- Pen / pencil,
- Manual flight computer,
- Navigation Problems Worksheet located at Attachment B, and
- Navigation Problems Answer Key located at Attachment C.

### ACTIVITY LAYOUT

Nil.

### ACTIVITY INSTRUCTIONS

1. Distribute a manual flight computer and a Navigation Problems Worksheet to each cadet.
2. Have the cadets complete Part 1 of the worksheet using the manual flight computer.
3. Review the answers using the answer key located at Attachment C.

### SAFETY

Nil.

---

### CONFIRMATION OF TEACHING POINT 1

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

---

### Teaching Point 2

**Demonstrate how to use a manual flight computer to calculate speed, distance, and time and have the cadets practice calculating speed, distance, and time.**

Time: 25 min

Method: Demonstration and Performance

---

### SPEED, DISTANCE, AND TIME PROBLEMS

The rate arrow on the disk is always set to indicate a value per hour on the outer scale. There are three basic types of speed-time-distance problems. In two types of problems the speed is known, in the third, the speed is the unknown.



When solving speed, distance, and time problems, the units have to agree. For example, if the speed is in knots, the distance has to be in nautical miles and the time in hours.

If the units do not agree, use the circular slide rule to perform the required conversions to make the units agree before attempting to solve the problem.

### Calculating Time (Speed and Distance are Known)

To calculate time when speed and distance are known:

1. Rotate the inner scale until the rate arrow is opposite the speed.
2. Locate the distance on the outer scale.
3. Read the time from the inner scale, opposite the distance.



For example, to calculate the time en route if the speed is 150 knots and the distance is 245 nautical miles:

1. Rotate the inner scale until the rate arrow is opposite 150.
2. Locate 245 on the outer scale.
3. Read the time en route from the inner scale, opposite 245 (1 hour and 38 minutes).

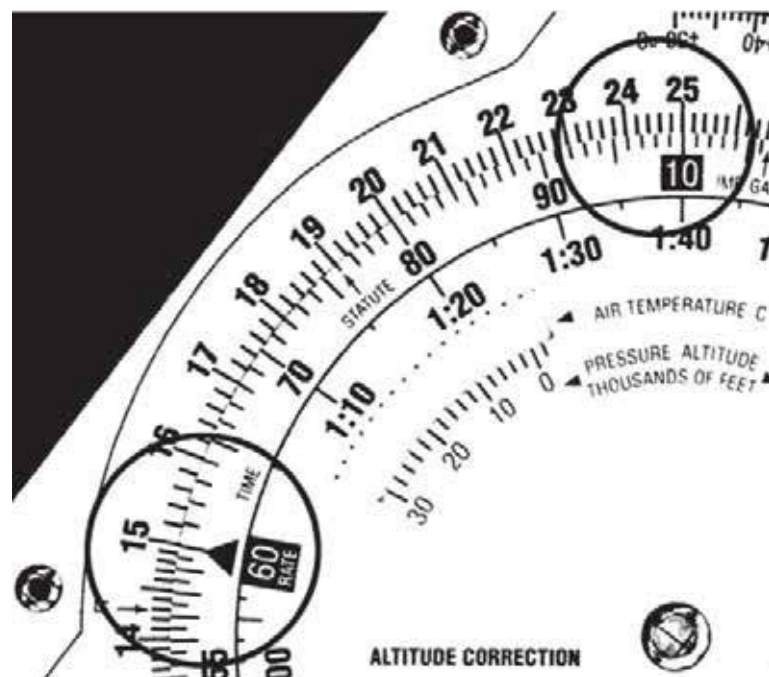



Figure 4 Rate Arrow, Speed, Distance, and Time

*Note.* From "Air Classics E6-B Flight Computer Instructions", *Aviation Supplies and Academics, Inc.* Retrieved November 26, 2008, from [http://www.asa2fly.com/files/support/E6B\\_Manual.pdf](http://www.asa2fly.com/files/support/E6B_Manual.pdf)



For example, to calculate the time en route if the speed is 120 knots and the distance is 100 statute miles:


1. Convert the distance to nautical miles (87).
2. Rotate the inner scale until the rate arrow is opposite 120.
3. Locate 87 on the outer scale.
4. Read the time en route from the inner scale, opposite 87 (44 minutes).

 When calculating time en route, use the aircraft's groundspeed, not the airspeed.

**Calculating Distance (Speed and Time are Known)**

To calculate distance when speed and time are known:

1. Rotate the inner scale until the rate arrow is opposite the speed.
2. Locate the time on the inner scale.
3. Read the distance from the outer scale, opposite the time.

 For example, to calculate the distance if the speed is 125 knots and the time en route is 4.5 hours:

1. Rotate the inner scale until the rate arrow is opposite 125.
2. Locate 4:30 on the inner scale.
3. Read the distance from the outer scale, opposite 4:30 (564 nautical miles).

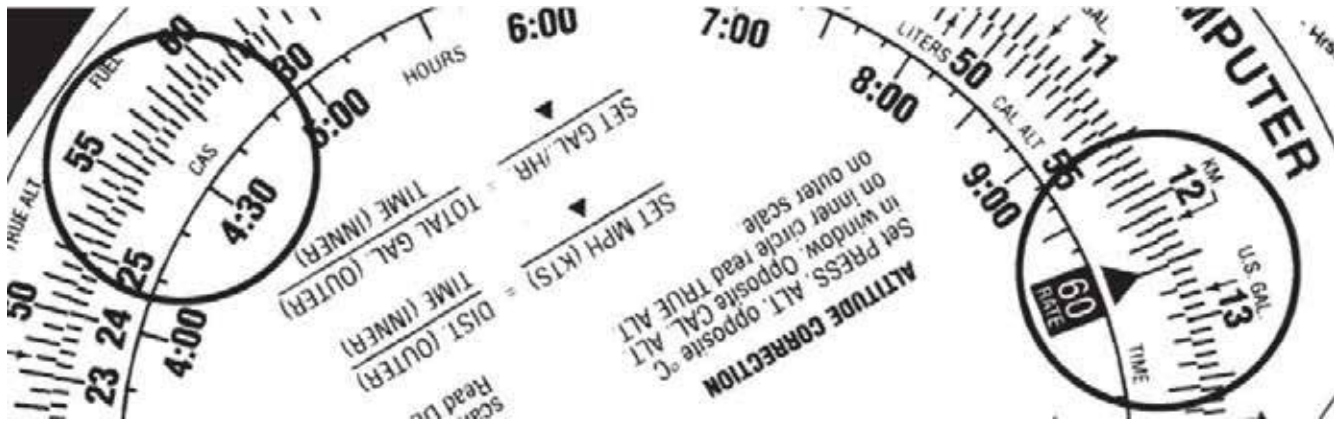



Figure 5 Rate Arrow, Speed, Distance, and Time

*Note.* From "Air Classics E6-B Flight Computer Instructions", *Aviation Supplies and Academics, Inc.* Retrieved November 26, 2008, from [http://www.asa2fly.com/files/support/E6B\\_Manual.pdf](http://www.asa2fly.com/files/support/E6B_Manual.pdf)

 When calculating distance, use the aircraft's groundspeed, not the airspeed.

**Calculating Speed (Distance and Time are Known)**

To calculate speed when distance and time are known:

1. Rotate the inner scale until the distance is opposite the time.
2. Locate the rate arrow.
3. Read the speed from the outer scale, opposite the rate arrow.





For example, to calculate the speed if the distance is 26 nautical miles and the time en route is 13 minutes:

1. Rotate the inner scale until 26 is opposite 13.
2. Locate the rate arrow.
3. Read the speed from the outer scale, opposite the rate arrow (120 knots).

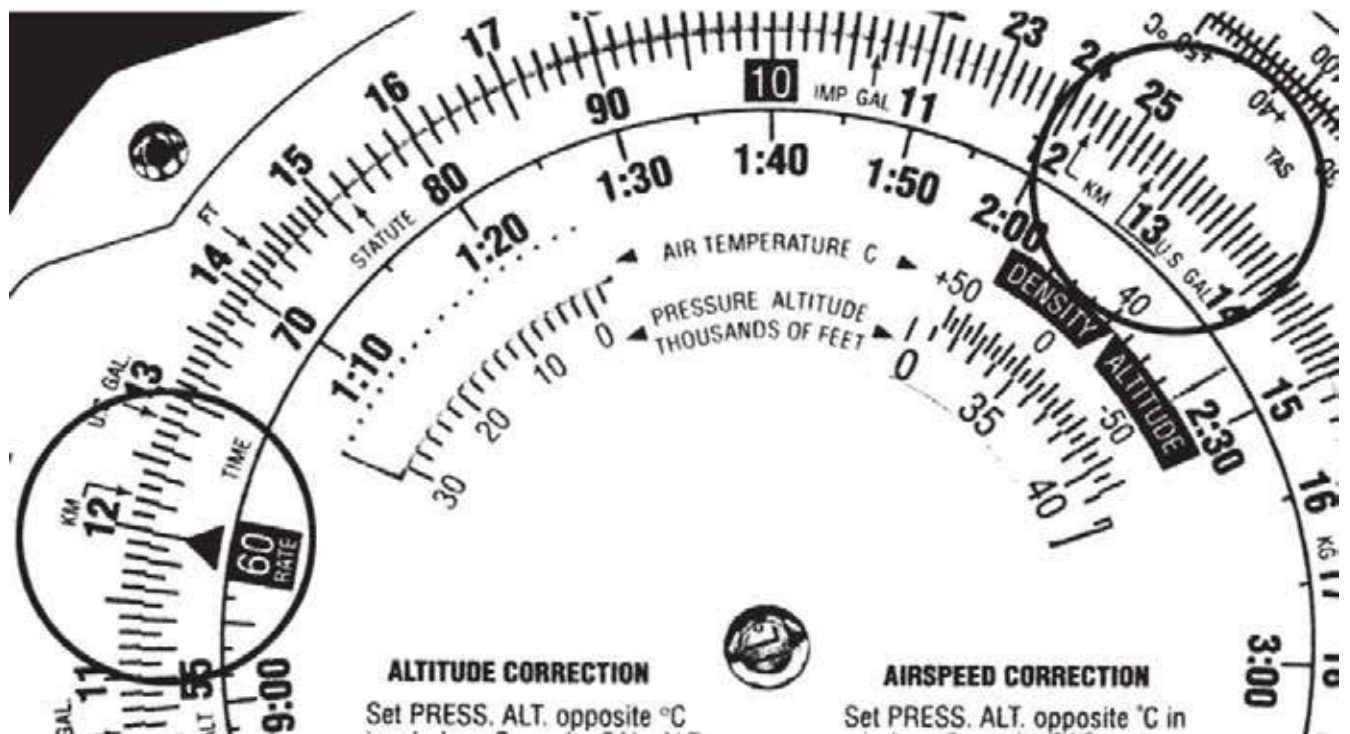


Figure 6 Rate Arrow, Speed, Distance, and Time

Note. From "Air Classics E6-B Flight Computer Instructions", *Aviation Supplies and Academics, Inc.* Retrieved November 26, 2008, from [http://www.asa2fly.com/files/support/E6B\\_Manual.pdf](http://www.asa2fly.com/files/support/E6B_Manual.pdf)



When calculating speed from distance and time, it is the groundspeed that is being calculated, not the airspeed.

## ACTIVITY

Time: 10 min

### OBJECTIVE

The objective of this activity is to have the cadets practice calculating speed, distance, and time using a manual flight computer.

### RESOURCES

- Pen / pencil,
- Manual flight computer,

- Navigation Problems Worksheet located at Attachment B, and
- Navigation Problems Answer Key located at Attachment C.

### **ACTIVITY LAYOUT**

Nil.

### **ACTIVITY INSTRUCTIONS**

1. Have the cadets complete Part 2 of the worksheet using the manual flight computer.
2. Review the answers using the answer key located at Attachment C.

### **SAFETY**

Nil.

---

### **CONFIRMATION OF TEACHING POINT 2**

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

---

### **END OF LESSON CONFIRMATION**

The cadets' completion of the Navigation Problems Worksheet will serve as the confirmation of this lesson.

---

### **CONCLUSION**

---

### **HOMEWORK / READING / PRACTICE**

Additional time may be required for the cadets to complete the worksheet.

### **METHOD OF EVALUATION**

Nil.

### **CLOSING STATEMENT**

Flight planning and navigation relies on being able to solve navigation problems. Being able to use a manual flight computer makes solving navigation problems faster and easier.

### **INSTRUCTOR NOTES / REMARKS**

Assistant instructors may be required for this lesson.

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

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### **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.

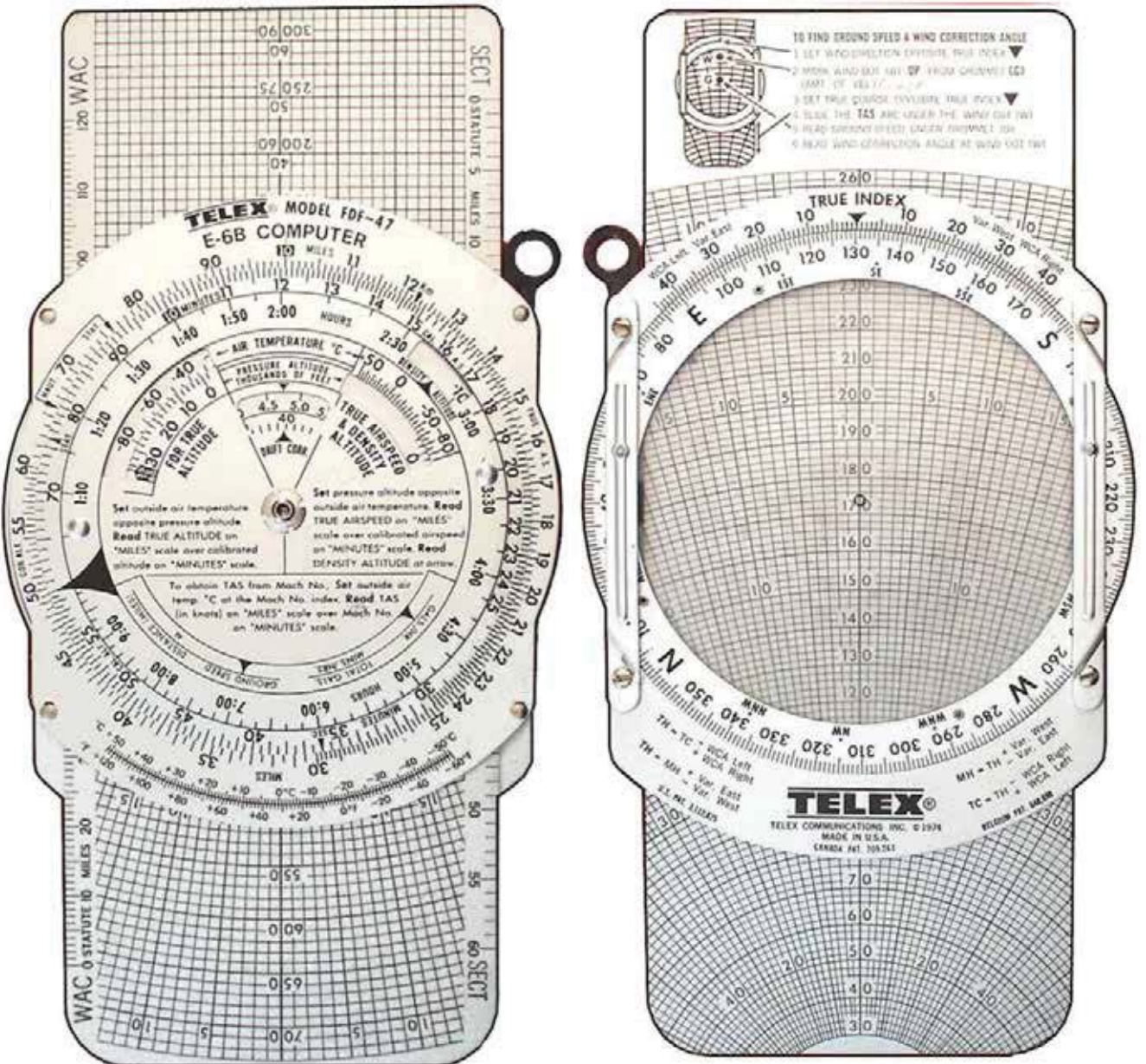


Figure A-1 E6B Manual Flight Computer

Note. From "Slide Rule Catalog", *Dutch Circle of Slide Rule Collectors*. Retrieved November 26, 2008, from <http://www.rekeninstrumenten.nl/pages%20and%20pictures/25261.jpg>

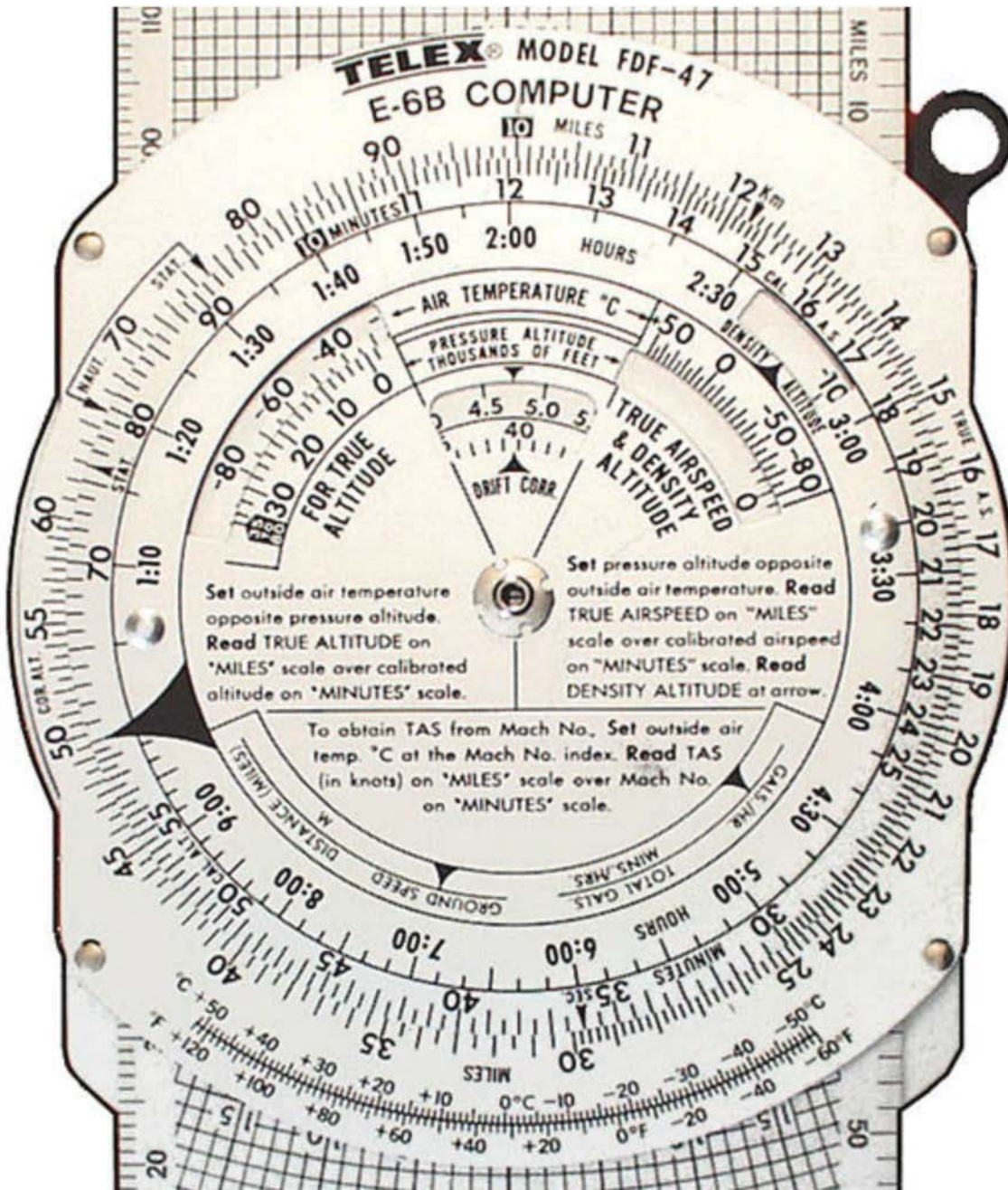


Figure A-2 E6B Circular Slide Rule

Note. From "Slide Rule Catalog", *Dutch Circle of Slide Rule Collectors*. Retrieved November 26, 2008, from <http://www.rekeninstrumenten.nl/pages%20and%20pictures/25261.jpg>

### Navigation Problems Worksheet

#### Part 1

Convert	To	Convert	To
123 nautical miles	_____ statute miles	23 nautical miles	_____ statute miles
99 statute miles	_____ nautical miles	1000 statute miles	_____ nautical miles
400 statute miles	_____ km	85 statute miles	_____ km
25 km	_____ statute miles	110 km	_____ statute miles
156 km	_____ nautical miles	93 km	_____ nautical miles
225 nautical miles	_____ km	48 nautical miles	_____ km
10 US gallons	_____ gallons	150 US gallons	_____ gallons
150 US gallons	_____ L	35 US gallons	_____ L
35 gallons	_____ US gallons	10 gallons	_____ US gallons
48 gallons	_____ L	225 gallons	_____ L
93 L	_____ gallons	156 L	_____ gallons
110 L	_____ US gallons	25 L	_____ US gallons
55 pounds	_____ kg	400 pounds	_____ kg
85 kg	_____ pounds	99 kg	_____ pounds
1000 feet	_____ m	123 feet	_____ m
23 m	_____ feet	55 m	_____ feet

#### Part 2

Calculate the missing values.		
Speed	Distance	Time
130 knots	100 nautical miles	_____
85 knots	_____	2.5 hours
_____	250 nautical miles	4 hours 15 minutes
_____	25 nautical miles	5 minutes
65 knots	200 statute miles	_____
78 miles per hour	55 nautical miles	_____
330 km/h	300 km	_____
95 km/h	45 nautical miles	_____
_____	1000 km	320 minutes
_____	55 nautical miles	2 minutes
122 miles per hour	_____	1.3 hours
101 knots	_____	45 minutes
150 knots	5525 m	_____

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### Navigation Problems Answer Key

#### Part 1

Convert	To	Convert	To
123 nautical miles	<u>142</u> statute miles	23 nautical miles	<u>26</u> statute miles
99 statute miles	<u>86</u> nautical miles	1000 statute miles	<u>869</u> nautical miles
400 statute miles	<u>644</u> km	85 statute miles	<u>137</u> km
25 km	<u>16</u> statute miles	110 km	<u>68</u> statute miles
156 km	<u>84</u> nautical miles	93 km	<u>50</u> nautical miles
225 nautical miles	<u>417</u> km	48 nautical miles	<u>89</u> km
10 US gallons	<u>8</u> gallons	150 US gallons	<u>125</u> gallons
150 US gallons	<u>568</u> L	35 US gallons	<u>132</u> L
35 gallons	<u>42</u> US gallons	10 gallons	<u>12</u> US gallons
48 gallons	<u>218</u> L	225 gallons	<u>1023</u> L
93 L	<u>20</u> gallons	156 L	<u>34</u> gallons
110 L	<u>29</u> US gallons	25 L	<u>7</u> US gallons
55 pounds	<u>25</u> kg	400 pounds	<u>181</u> kg
85 kg	<u>187</u> pounds	99 kg	<u>218</u> pounds
1000 feet	<u>305</u> m	123 feet	<u>37</u> m
23 m	<u>75</u> feet	55 m	<u>180</u> feet

#### Part 2

Calculate the missing values.		
Speed	Distance	Time
130 knots	100 nautical miles	<b>46 minutes</b>
85 knots	<b>213 nautical miles</b>	2.5 hours
<b>59 knots</b>	250 nautical miles	4 hours 15 minutes
<b>300 knots</b>	25 nautical miles	5 minutes
65 knots	200 statute miles	<b>2 hours 41 minutes</b>
78 miles per hour	55 nautical miles	<b>48 minutes</b>
330 km/h	300 km	<b>55 minutes</b>
95 km/h	45 nautical miles	<b>52 minutes</b>
<b>188 km/h</b>	1000 km	320 minutes
<b>1650 knots</b>	55 nautical miles	2 minutes
122 miles per hour	<b>159 statute miles</b>	1.3 hours
101 knots	<b>76 nautical miles</b>	45 minutes
150 knots	5525 m	<b>1 minute</b>

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**ROYAL CANADIAN AIR CADETS  
PROFICIENCY LEVEL FOUR  
INSTRUCTIONAL GUIDE**



**SECTION 4**

**EO C437.02 – USE A VISUAL FLIGHT RULES (VFR) NAVIGATION CHART (VNC)**

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Total Time:	60 min
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**PREPARATION**

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**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.

Select coordinates of landmarks on a local VNC.

**PRE-LESSON ASSIGNMENT**

Nil.

**APPROACH**

An interactive lecture was chosen for TPs 1 and 2 to clarify, emphasize, and summarize types of projections and aeronautical charts.

A demonstration and performance was chosen for TPs 3–6 as it allows the instructor to explain and demonstrate using a VNC while providing an opportunity for the cadets to practice using a VNC under supervision.

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**INTRODUCTION**

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**REVIEW**

Nil.

**OBJECTIVES**

By the end of this lesson the cadet shall have used a VNC.

**IMPORTANCE**

It is important for cadets to use a VNC as it is a skill required for flight planning and en route navigation. The VNC is the principal chart used in flight at low altitudes and slow speeds. Many of the skills used with this chart are transferable to other types of maps both in the air and on the ground. Knowledge of this material is essential for future aviation training and potential instructional duties at the squadron.

**Teaching Point 1****Explain types of projections.**

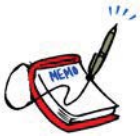
Time: 5 min

Method: Interactive Lecture

Earth is a sphere, so its surface cannot be represented accurately on a flat plane. Therefore, a map shows a portion of the Earth's surface with some distortion. There are four basic elements in map construction:

- areas,
- shapes,
- bearings, and
- distances.

Depending on the particular purpose of the map, one or more of these elements is preserved with minimal distortion, with the most distortion in the remaining elements.



Using the globe and the sheet of construction paper, demonstrate the impossibility of wrapping the sheet around the globe smoothly to create a chart.

The two principal types of chart projections used in air navigation charts are:

- the Lambert Conformal Conic Projection, and
- the Transverse Mercator Projection.

**THE LAMBERT CONFORMAL CONIC PROJECTION**

Using the globe and the sheet of construction paper, demonstrate superimposing a cone over the surface of the globe.

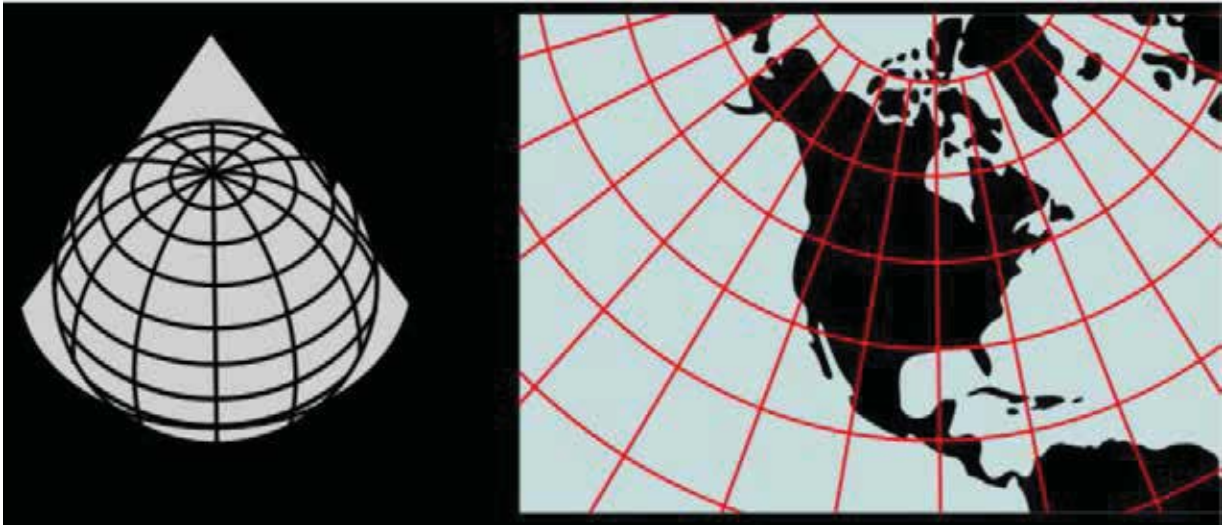


Figure 1 Lambert Conformal Conic Projection

*Note.* From "Image: Lambert Conformal Conic", *Wikimedia*. Retrieved November 27, 2008, from [http://commons.wikimedia.org/wiki/Image:Lambert\\_conformal\\_conic.svg](http://commons.wikimedia.org/wiki/Image:Lambert_conformal_conic.svg)

The properties of the Lambert Conformal Conic Projection are:

- Meridians of longitude are slight curves or straight lines converging toward the nearer pole.
- Parallels of latitude are curves which are concave toward the nearer pole.
- The scale of distance is uniform throughout the entire chart.
- A straight line drawn between any two points on the chart represents an arc of a great circle.

VNCs and World Aeronautical Charts (WACs) are examples of Lambert Conformal Conic Projections.

**The Transverse Mercator Projection.** Applies the Mercator technique by rotating the cylinder 90 degrees so the point of tangency is a meridian of longitude rather than the equator. This projection is accurate in depicting scale, especially on charts covering a relatively small geographical area. The VFR Terminal Area (VTA) Charts are examples of Transverse Mercator Projections.



Using the globe and the sheet of flip chart paper, demonstrate wrapping a cylinder around the globe with its point of tangency at a meridian of longitude.

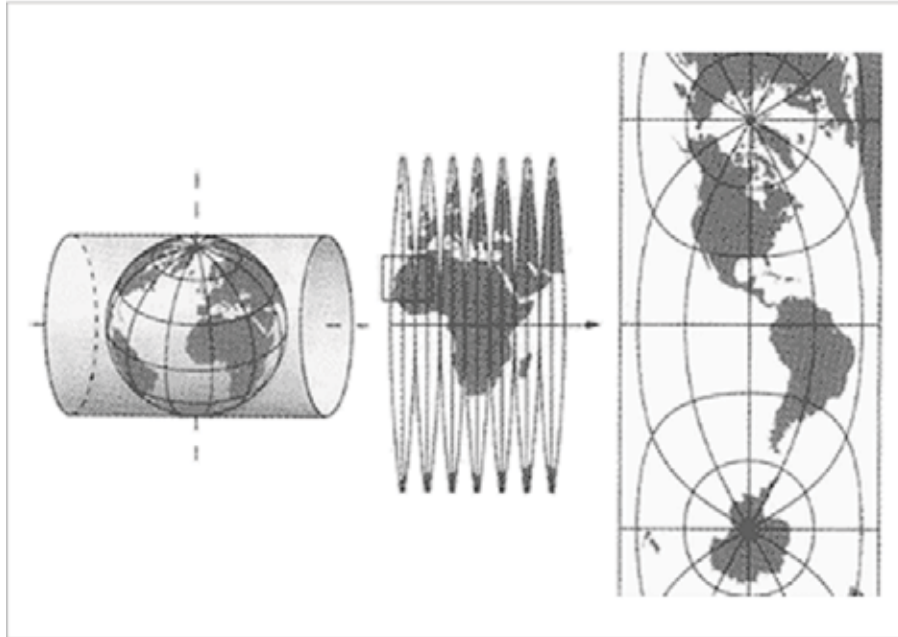


Figure 2 Transverse Mercator Projection

*Note.* From "Swiss Map Projections", 2008, *Federal Office of Topography Swisstopo*. Retrieved November 27, 2008, from <http://www.swisstopo.admin.ch/internet/swisstopo/en/home/topics/survey/sys/refsys/projections.html>

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## CONFIRMATION OF TEACHING POINT 1

### QUESTIONS:

- Q1. What does a straight line drawn between any two points on a Lambert Conformal Conic Projection represent?
- Q2. What are two examples of Lambert Conformal Conic Projections?
- Q3. What is an example of a Transverse Mercator Projection?

### ANTICIPATED ANSWERS:

- A1. An arc of a great circle.
- A2. VNCs and WACs.
- A3. A VTA Chart is an example of a Transverse Mercator Projection.

**Teaching Point 2****Describe types of aeronautical charts.**

Time: 5 min

Method: Interactive Lecture

**VFR NAVIGATION CHART (VNC)**

Show the cadets a VNC.

VNCs are designed primarily for visual navigation at low altitudes and slow speeds. Each chart is identified by the name of a principal landmark on the chart (eg, Toronto, Winnipeg, Gander). The scale of the chart is 1 : 500 000 or about one inch to eight miles.

**WORLD AERONAUTICAL CHART (WAC)**

Show the cadets a WAC.

WACs are designed primarily for visual navigation at higher altitudes and greater speeds. Each chart depicts a sizeable portion of the country's geographical area—eighteen charts cover Canada. Each chart is identified by a letter and a number. For example, E17 covers the area from Marathon, Ont., west to Brandon, Man., and from the 48<sup>th</sup> parallel north to Thompson, Man. The scale of the chart is 1 : 1 000 000 or about one inch to 16 miles.

**VFR TERMINAL AREA (VTA) CHART**

Show the cadets a VTA Chart.

VTA Charts are large scale charts (1 : 250 000) published for airports where there is a high volume of air traffic and where there is usually a mix of controlled airspace. Radio communication information and other information that is necessary for conducting flight through the area are given on the chart.

**ENROUTE CHART**

Show the cadets an Enroute Chart.

Enroute Charts provide information for radio navigation over designated airways systems. Enroute Charts do not portray any cities, towns, or topographical features. They depict all radio navigation aids, including airways, beacons, reporting points, and communication frequencies. Examples of Enroute Charts are Enroute Low Altitude Charts, Enroute High Altitude Charts, and Terminal Area Charts.



**Canada Flight Supplement (CFS).** A joint civil / military flight information publication and a supplement of the Aeronautical Information Publication (AIP). It contains information on Canadian and North Atlantic aerodromes. The CFS is designed to be used in conjunction with all Canadian charts and should be carried by every pilot departing on a flight. It is revised and reissued every 56 days.

## CONFIRMATION OF TEACHING POINT 2

### QUESTIONS:

- Q1. What is the scale of a VNC?  
 Q2. What are WACs primarily used for?  
 Q3. What are Enroute Charts used for?

### ANTICIPATED ANSWERS:

- A1. 1 : 500 000.  
 A2. Visual navigation at higher altitudes and greater speeds.  
 A3. Radio navigation.

## Teaching Point 3

**Explain, demonstrate and have the cadets practice locating landmarks on a VNC using latitude and longitude.**

Time: 15 min

Method: Demonstration and Performance



For this TP, it is recommended that the instructor take the following format:

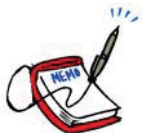
1. Explain and demonstrate the skill while the cadets observe.
2. Explain and demonstrate each step required to complete the skill. Monitor cadets as they imitate each step.
3. Monitor the cadets' performance as they practice the skill.

Note: Assistant instructors may be used to monitor the cadets' performance.

## USE LATITUDE AND LONGITUDE TO LOCATE LANDMARKS ON A VNC



The cadets were introduced to latitude and longitude in EO M437.01 (Define Air Navigation Terms). They were asked to find the coordinates of a major airport. In this TP, the cadets are given the coordinates and asked to find the landmarks. They should require minimal instruction as it is a review.



Give the cadets coordinates of several landmarks on a local VNC and have them identify the landmarks.

For example, 43°59'N, 80°17'W is a soaring site (Grand Valley).



Figure 3 Example of a VNC

*Note.* From *Toronto VFR Navigation Chart*, by Geomatics Canada, 2001, Ottawa, ON: Geomatics Canada Department of Natural Resources. Copyright 2001 by NAV CANADA and Her Majesty the Queen in Right of Canada.

### CONFIRMATION OF TEACHING POINT 3

The cadets' participation in locating landmarks on a VNC using latitude and longitude will serve as the confirmation of this TP.

### Teaching Point 4

**Explain, demonstrate and have the cadets practice plotting tracks between landmarks on a VNC.**

Time: 5 min

Method: Demonstration and Performance



For this TP, it is recommended that the instruction take the following format:

1. Explain and demonstrate the skill while the cadets observe.
2. Explain and demonstrate each step required to complete the skill. Monitor cadets as they imitate each step.
3. Monitor the cadets' performance as they practice the skill.

Note: Assistant instructors may be used to monitor the cadets' performance.

## PLOT A TRACK BETWEEN LANDMARKS ON A VNC

To plot a track between landmarks on a VNC:

1. Identify the landmarks.
2. Use a ruler to draw a straight line between the landmarks.



Give the cadets coordinates of a departure aerodrome and a destination aerodrome on a local VNC. Have them plot a track.



More advanced flight plan plotting (eg, 10-degree drift lines) will be taught during future aviation training.

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## CONFIRMATION OF TEACHING POINT 4

The cadets' participation in plotting tracks between landmarks on a VNC will serve as the confirmation of this TP.

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### Teaching Point 5

**Explain, demonstrate and have the cadets practice measuring distances on a VNC.**

Time: 10 min

Method: Demonstration and Performance



For this TP, it is recommended that the instruction take the following format:

1. Explain and demonstrate the skill while the cadets observe.
2. Explain and demonstrate each step required to complete the skill. Monitor cadets as they imitate each step.
3. Monitor the cadets' performance as they practice the skill.

Note: Assistant instructors may be used to monitor the cadets' performance.

## MEASURE DISTANCE ON A VNC

Measure distance on a VNC by:

- using a scale, or
- using an International Civil Aviation Organization (ICAO) ruler.

### Using a Scale

The scale of the chart is the relationship between a unit of distance (eg, one inch) on the chart to the distance that the unit represents on the surface of the Earth.



There are two scales found on a VNC:

- **Representative fraction.** A ratio representing the distance on a map in relation to the surface of the Earth. The representative fraction of a VNC is 1 : 500 000 (one inch on the map represents 500 000 inches or eight miles).
- **Graduated scale line.** Three scale lines printed on the border of the chart representing kilometres, statute miles, and nautical miles. The distance between two locations on a VNC can be compared to one of these lines to give the represented distance in any of the three units of distance.

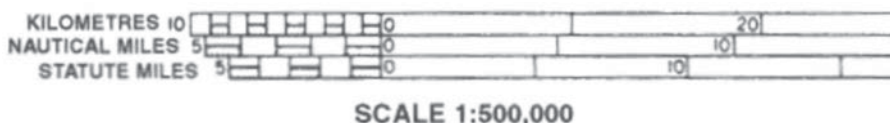


Figure 4 Graduated Scale Line

*Note.* From *From the Ground Up: Millennium Edition* (p. 123), by A. F. MacDonald and I. L. Peppler, 2000, Ottawa, ON: Aviation Publishers Co. Limited. Copyright 2000 by Aviation Publishers Co. Limited.

To measure distance on a VNC using the representative fraction:

1. Use a ruler to measure the distance between two landmarks in inches.
2. Multiply the number of inches by eight to determine the distance in statute miles.

To measure distance on a VNC using the graduated scale:

1. Use a straightedge to measure the distance between two landmarks.
2. Line the straightedge up with the graduated scale, starting at the zero mark, to determine the distance in kilometres, nautical miles, or statute miles.



Have the cadets practice measuring distance using each technique.

### Using an ICAO Ruler

**ICAO ruler.** A plastic straightedge graduated in both statute and nautical miles for use with 1 : 1 000 000 and 1 : 500 000 scale charts. On its reverse side, the ICAO ruler provides conversion factors, VHF reception distances, standard time conversions to Co-ordinated Universal Time (UTC), time equivalencies, flight plan sequences, and an aviation gasoline conversion table.

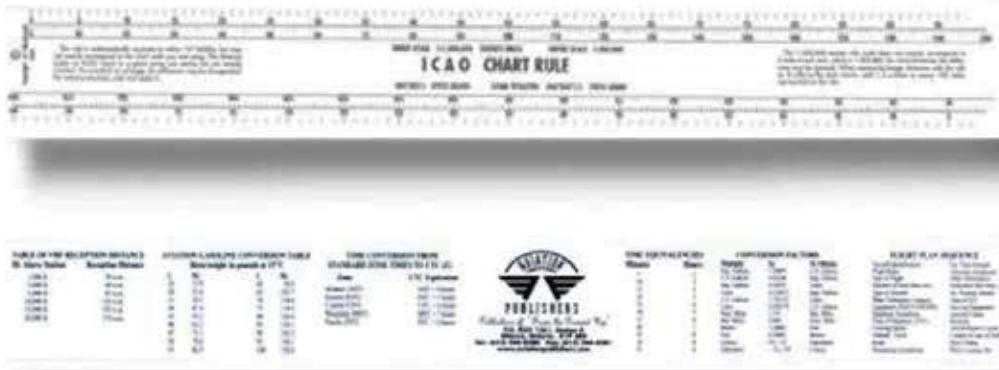



Figure 5 ICAO Ruler


Note. From "Other Publications", *Aviation Publishers*. Retrieved November 28, 2008, from <http://www.aviationpublishers.com/otherpub/icao.html>

To measure distance on a VNC using an ICAO ruler:

1. Align the edge of the ruler with the track. Ensure the zero mark is at one of the landmarks.
2. Read the desired scale (nautical miles or statute miles) where the ruler meets the other landmark.



Use the edge of the ICAO ruler meant for 1 : 500 000 scale charts.



Have the cadets practice measuring distance using this technique.

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**CONFIRMATION OF TEACHING POINT 5**

The cadets' participation in measuring distances on a VNC will serve as the confirmation of this TP.

**Teaching Point 6****Explain, demonstrate and have the cadets practice determining headings on a VNC.**

Time: 10 min

Method: Demonstration and Performance



For this TP, it is recommended that the instruction take the following format:

1. Explain and demonstrate the skill while the cadets observe.
2. Explain and demonstrate each step required to complete the skill. Monitor cadets as they imitate each step.
3. Monitor the cadets' performance as they practice the skill.

Note: Assistant instructors may be used to monitor the cadets' performance.

**DETERMINE A HEADING ON A VNC**

**Douglas protractor.** A tool used for determining headings and as a straightedge. It is transparent and has a compass rose graduated in 360 degrees marked around the outer edges.

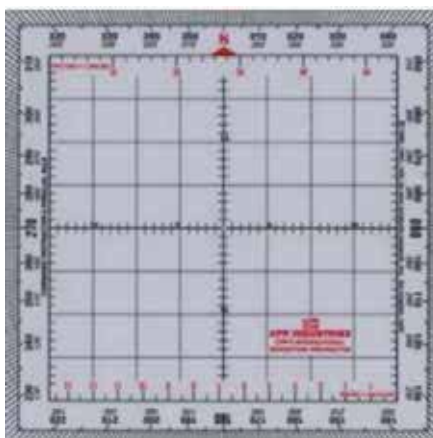


Figure 6 Douglas Protractor

*Note.* From "Douglas Protractor / Parallel Ruler", *VIP Pilot Centre*. Retrieved November 28, 2008, from <http://www.canada-shops.com/Magasin/vippilotcenter/c46907p95758.2.html>

To determine a heading on a VNC using a Douglas protractor:

1. Place the protractor on the chart with the hole in the centre lying on the track at a point where the north-south line on the protractor lies along the meridian of longitude. If this is not convenient, one of the vertical lines can be lined up parallel with the nearest meridian.
2. Read the heading where the track cuts the edge of the protractor.



Have the cadets determine the headings of the tracks previously plotted. Have them plot more tracks and determine the headings as time permits.

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**CONFIRMATION OF TEACHING POINT 6**

The cadets' participation in determining headings on a VNC will serve as the confirmation of this TP.

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**END OF LESSON CONFIRMATION**

The cadets' performance of locating landmarks, plotting tracks, measuring distances, and determining headings on a VNC will serve as the confirmation of this lesson.

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**CONCLUSION**

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**HOMEWORK / READING / PRACTICE**

Nil.

**METHOD OF EVALUATION**

Nil.

**CLOSING STATEMENT**

Flight planning and navigating at low altitudes and slow speeds relies on being able to use a VNC. Many of the skills used with this chart are transferable to other types of maps both in the air and on the ground.

**INSTRUCTOR NOTES / REMARKS**

Assistant instructors may be required for this lesson.

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

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**REFERENCES**

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