ROYAL CANADIAN AIR CADETS

PROFICIENCY LEVEL FOUR

INSTRUCTIONAL GUIDE

SECTION 10

EO C490.05 – NAVIGATE A ROUTE USING A MAP AND COMPASS

Total Time:	120 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.

Learning stations are a form of group work, where the cadets will be learning by demonstration and performance. When setting up learning stations, ensure that there is enough room for each cadet to be comfortable, and adequate space to work with the equipment. When cadets arrive at a learning station, all materials shall be available. These stations should be placed closely together to minimize time for movement; however far enough apart to avoid interruptions from other groups. For this lesson, four learning stations are required: one station for TPs 1 and 2 and one station each for TPs 3–5.

Based on the topographical map being used, create:

- a list of 10 conventional signs, to be used for TP 2;
- a list of 20 conventional signs for the cadets to determine four- and six-figure grid references (GRs), and a list of 20 four- and six-figure GRs for the cadets to determine the conventional signs, to be used for TP 3;
- two sets of GRs (one set for point-to-point and one set for along-a-route) for the cadets to measure distance on a map, to be used for TP 4;
- a set of GRs for the cadets to determine the bearing on a map, to be used for TP 4; and
- a 100-m straight flat course used to determine personal pace, to be used for TP 5.

A reconnaissance (recce) of the exercise area should be made to determine a site with several distinctive features to be used as prominent objects, to create a bearing course to be used for TP 5.

Create 4–6 three-leg map and compass courses to be used for TP 6. Each course will be listed as a set of four 6-figure GRs (the start point and the endpoint of each leg). Total length of each course should not exceed 2 km.

Determine a safety bearing in the event any groups become disoriented or lost.

PRE-LESSON ASSIGNMENT

Nil.

APPROACH

A practical activity was chosen for this lesson as it is an interactive way for the cadets to review the compass, topographical maps, GRs, distance on the map and on the ground, bearings on the map and on the ground, and to navigate a route using a map and compass in a safe and controlled environment. This activity contributes to the development of navigation skills and knowledge in a fun and challenging setting.

INTRODUCTION

REVIEW

Nil.

OBJECTIVES

By the end of this lesson the cadet shall navigate using a map and compass.

IMPORTANCE

It is important for cadets to navigate using a map and compass because it allows cadets another opportunity to practice skills learned in Proficiency Level Three.

Divide the cadets into four groups. Have the groups rotate between four learning stations: one station for TPs 1 and 2 and one station each for TPs 3–5. After the groups have been to all four stations, have them rendezvous at the designated location for TP 6.

Teaching Point 1 **Review the compass.**

Time: 10 min Method: Practical Activity

BACKGROUND KNOWLEDGE

PRINCIPLES BEHIND THE WORKINGS OF A COMPASS

Regardless of intended purpose or complexity of construction, most compasses operate on the same basic principle. A small, elongated, permanently magnetized needle is placed on a pivot so that it may rotate freely on the horizontal plane. The earth's magnetic field, which is shaped approximately like the field around a simple bar magnet, exerts forces on the compass needle causing it to rotate until it comes to rest in the same horizontal direction as the magnetic field. Over much of the earth this direction is roughly running between north and south, which accounts for the compass's importance in navigation.

The earth has a north and south magnetic pole. These magnetic poles correspond roughly with the actual geographical poles. The north magnetic pole is located (2005 estimate) at approximately 82.7 degrees N latitude and 114.4 degrees W longitude, which lies over 800 km from the north geographic pole.

The horizontal force of the magnetic field, responsible for the direction in which a compass needle is oriented, decreases in strength as one approaches the north magnetic pole. This decrease is due to the lines of force changing direction towards the vertical as they bend back into the earth at the north magnetic pole towards the south magnetic pole. The compass starts to behave erratically, and eventually as the horizontal force decreases even more, the compass becomes unusable.

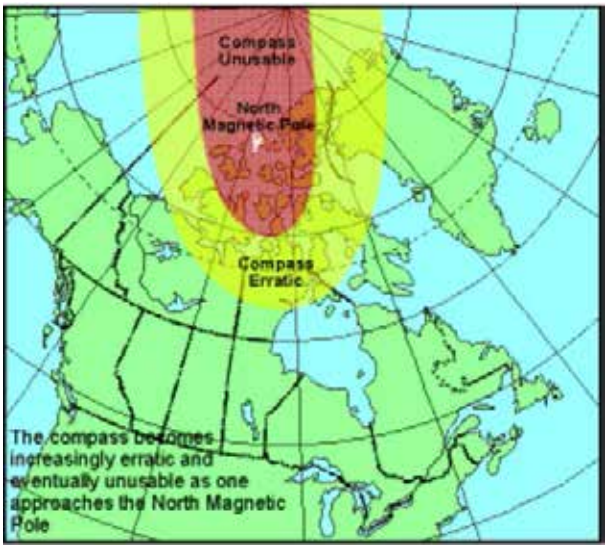


Figure 1 Earth's Magnetic Field

Note. From *Royal Canadian Army Cadet Reference Book* (p. 5-33), by Director Cadets 3, 2003, Ottawa, ON: Department of National Defence.

The nature of the earth's magnetic field is such that the magnetic north pole shifts geographic position about 5–10 km per year. Natural phenomena, like earthquakes, may also shift the magnetic field.

PARTS OF THE COMPASS

A - Sight. Located at the top of the compass cover. Used to align on an object when taking a bearing or to observe one along a given bearing.

B - Compass cover. Protects the compass dial and houses the sighting mirror.

C - Sighting mirror. Used to see the compass dial while taking a bearing.

D - Sighting line. Used when aligning an object or observing along a bearing.

E - Luminous index point. At the top of the compass dial and where a bearing is set or read from.

F - Compass dial. Houses the magnetic needle, the orienting arrow, the meridian lines, the declination scale (on the inside) and the dial graduations (on the outside).

G - Dial graduations. The compass dial is graduated in 2-degree divisions from 0 to 360 degrees. The dial is rotated by hand.

H - Orienting arrow. The black and red orienting arrow is located inside the compass dial and is used to line up with the magnetic needle when taking a bearing on the ground. The orienting arrow is what is adjusted when the magnetic declination is set.

I - Romer 1 : 25 000. Used to measure six-figure grid references (GRs) on maps with a 1 : 25 000 scale.

J - Compass base plate. A clear piece of flat plastic to which the cover, dial and lanyard are attached.

K - Declination scale. Used when adjusting the orienting arrow and while setting the magnetic declination for the map being used. It is graduated in 2-degree divisions.

L - Compass meridian lines. Black or red lines inside the compass dial. They are used to line up the compass dial with the grid lines (eastings) on a map.

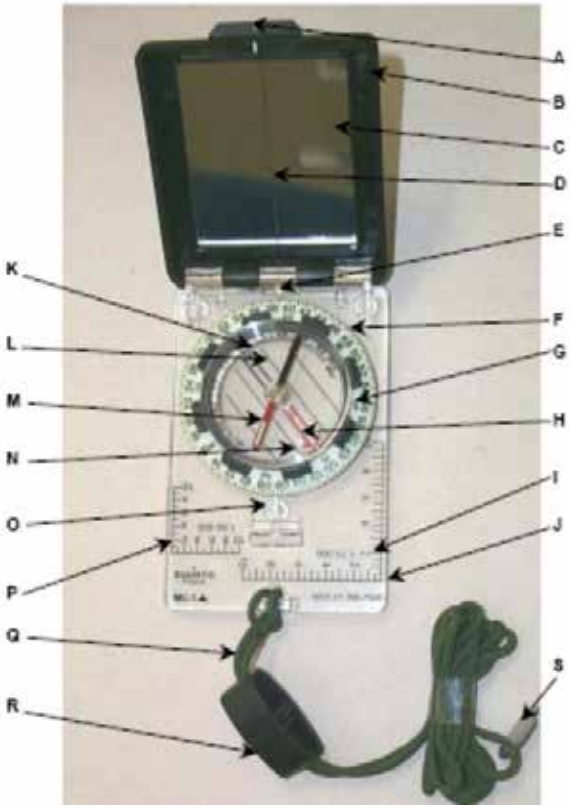


Figure 2 Compass

Note. From *Royal Canadian Army Cadet Reference Book* (p. 5-33), by Director Cadets 3, 2003, Ottawa, ON: Department of National Defence.

M - Magnetic needle. Spins freely and points towards magnetic north. The south end of the compass needle is black and the north end, with a luminous patch, is red.

When the magnetic needle is lined up in the red end of the orienting arrow, the mnemonic device "Red in the Bed" is used to remember that the red end of the needle belongs in the red end of the arrow.

N - Luminous orienting points. There are two luminous orienting points located on either side of the red end of the orienting arrow.

O - Luminous index point. At the bottom of the compass dial; where a back bearing is read from.

P - Romer 1 : 50 000. Used to measure six-figure GRs on maps with a 1 : 50 000 scale.

Q - Safety cord or lanyard. Used to fasten the compass to the wrist (never around the neck).

R - Adjustable wrist lock. Used to attach the compass to the wrist.

S - Screwdriver. Located at the end of the safety cord and is used to turn the screw to adjust the orienting arrow's position on the declination scale.

T - Declination adjusting screw. Located on the back side of the compass dial and is used to adjust the orienting arrow's position on the declination scale.

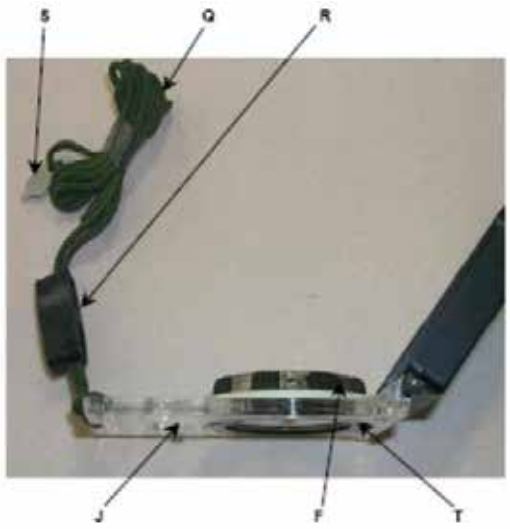


Figure 3 Compass

Note. From *Royal Canadian Army Cadet Reference Book* (p. 5-34), by Director Cadets 3, 2003, Ottawa, ON: Department of National Defence.

After being exposed to a strong light source, the luminous parts of the compass will glow in the dark making operating the compass at night possible.

HOW TO SET A PREDETERMINED DECLINATION

Declination

Magnetic declination is the difference in bearing either between grid north and magnetic north or between true north and magnetic north. Declination will change for each topographical map and it also changes annually due to the shifting north magnetic pole.

Cadets will almost always use the magnetic declination value between grid north and magnetic north (grid declination) when navigating using a map and compass. By setting the magnetic declination on the compass, magnetic bearings are converted to grid bearings which allow bearings taken from the map to be used on the ground and vice versa.

Declination is further described by stating whether the declination is east or west of magnetic north. The declination for the map being used is calculated using the information in the declination diagram (as illustrated in Figure 4) found in the marginal information of the map.

Declinations are stated in degrees and minutes. Each degree is subdivided into 60 minutes. This is important when setting the declination as the declination scale is graduated in 2-degree divisions.

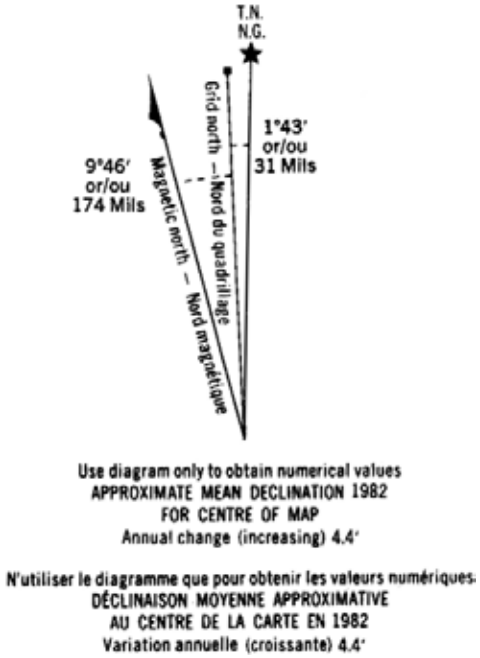


Figure 4 Declination Diagram

Note. From *Royal Canadian Army Cadet Reference Book* (p. 5-39), by Director Cadets 3, 2003, Ottawa, ON: Department of National Defence.

Adjusting the Declination on a Compass

The compass's declination scale must be set to compensate for the difference between grid north and magnetic north. To do this, first have the amount of declination in degrees east or west. Then, turn the compass over and look at the back of the dial.

From the zero point, using the screwdriver, turn the declination adjusting screw to the right for west and to the left for east declination (as illustrated in Figure 5). Each small black line represents two degrees of declination.

When setting declination on a compass, it is easier to hold the screwdriver and turn the compass, especially in cold weather. The declination shall never be turned past the last number of the declination scale.

Figure 5 Declination Scale and Screw

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

If a person were to follow a compass bearing for 1 km without first adjusting for declination, for every one degree of declination, that person would be over 17 m to the left or right of their plotted bearing. This is how important declination is.

ACTIVITY

Time: 5 min

OBJECTIVE

The objective of this activity is to have the cadets name a part of the compass and describe its purpose.

RESOURCES

Compasses.

ACTIVITY LAYOUT

Nil.

ACTIVITY INSTRUCTIONS

1. Hand out the compasses to the cadets.
2. Ask the cadets to describe how a compass works.
3. Point to a part of the compass and have a cadet name it and describe its purpose.
4. Rotate through all the cadets.

SAFETY

Nil.

ACTIVITY

Time: 5 min

OBJECTIVE

The objective of this activity is to have the cadets set four different magnetic declination values on a compass.

RESOURCES

- Compasses, and
- Predetermined declinations, to include:
  - 8 degrees W,
  - 15 degrees E,
  - 3 degrees 30 minutes E, and
  - 9 degrees 45 minutes W.

When verifying the declinations set by the cadets, the line at the end of the orienting arrow should be:

- 8 degrees W: directly over the fourth graduated line to the left of the zero mark.
- 15 degrees E: halfway between the seventh and eighth graduated line to the right of the zero mark.
- 3 degrees 30 minutes E: three quarters of the way from the first towards the second graduated line to the right of the zero mark.
- 9 degrees 45 minutes W: to the right of and beside the fifth graduated line to the left of the zero mark.

ACTIVITY LAYOUT

Nil.

ACTIVITY INSTRUCTIONS

1. Review magnetic declination.
2. Give the cadets a declination value.
3. Have the cadets turn the compass over (on its back with the declination adjusting screw facing up).
4. Have the cadets grasp the screwdriver attached to the safety cord / lanyard.
5. Using the screwdriver, have the cadets turn the declination adjusting screw to the right for west and to the left for east declination values and set the given declination.
6. Check the set declination.
7. Have the cadets repeat Steps 2–6 for each of the predetermined declinations.
8. Have the cadets set the declination to zero before returning the compasses.

SAFETY

Nil.

CONFIRMATION OF TEACHING POINT 1

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

Teaching Point 2 **Review topographical maps.**

Time: 10 min Method: Practical Activity

BACKGROUND KNOWLEDGE

MARGINAL INFORMATION

The margins provide information important to the understanding and use of the map. Before using an unfamiliar map, it is important to have a good look at the information contained in its margins. The layout and contents of the marginal information is normally in the same place for all topographical maps, but will always be found within the margins. This information includes:

Name of map sheet. For ease of reference, the name of the map is usually a major community or district located on the map (found at the bottom centre of the margin, as well as in the top or bottom right corner).

Number of the map and index of adjoining maps. A diagram showing the position of the map sheet in relation to adjoining sheets is shown near the lower right-hand margin. The diagram shows the sheet numbers of the adjoining sheets and accentuates the sheet in hand.

Date of map data. Helps to indicate the amount of change that may have occurred since the map was printed (found in the bottom left corner).

Map scale. Indicates the scale of the map, most commonly 1 : 25 000 or 1 : 50 000. Scale is used to represent distances on the map in direct relation to the ground. On a 1 : 50 000 scale map 1 cm on the map represents 50 000 cm (500 m) on the ground.

Scale bars. Used as a measuring aid for determining distance on the map (found bottom centre below the map name). The left end of the scale bars is divided into tenths for measuring distances more accurately.

Contour interval. Indicates the vertical (height) interval between contour lines and is given in metres or feet. The contour interval is found in the bottom margin.

Legend of conventional signs. A table showing the conventional signs used on the sheet in their correct colours with their descriptions is shown in the bottom or side margin, plus in a more complete list on the back of the map.

Military index number. The index is found in the top right corner of the map sheet and used for ordering additional maps.

Declination diagram. Contains the information for the map on how true, grid, and magnetic north relate to each other. This information is given in the form of a diagram with explanatory notes. The diagram is in the right side margin.

Universal Transverse Mercator grid system (UTM). The UTM grid system divides the earth's surface into zones, each covering six degrees of longitude and eight degrees of latitude. The 60 longitude bands are

numbered and the 20 latitude bands are lettered. Each grid zone is one rectangle of the grid pattern, established by the bands and designated by the figures of the longitude band followed by the letter of latitude band.

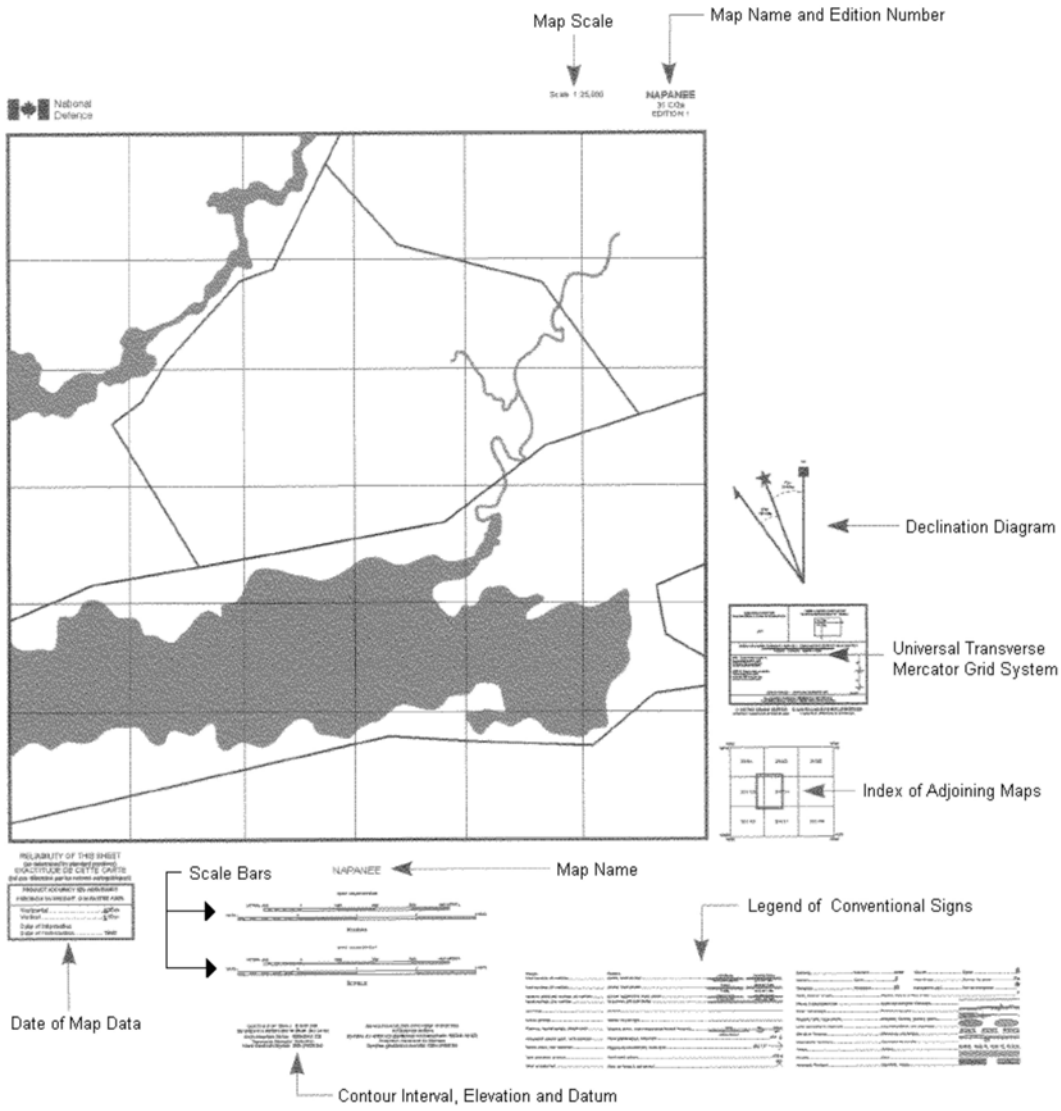


Figure 6 Marginal Information

Note. From *Maps, Field Sketching, Compasses and the Global Positioning System* (p. 11), by Directorate of Army Doctrine 8, 2006, Ottawa, ON: Copyright 2006 by Her Majesty the Queen in Right of Canada.

Military users, refer this map as:	SERIES **A901** MCE 320 EDITION 1

Figure 7 Military Index Number

Note. From *Maps, Field Sketching, Compasses and the Global Positioning System* (p. 12), by Directorate of Army Doctrine 8, 2006, Ottawa, ON: Copyright 2006 by Her Majesty the Queen in Right of Canada.

CONVENTIONAL SIGNS

A number of symbols are used to indicate an object or item of detail that cannot be shown either by outline or by a line symbol. Most have been established through long usage and standardization agreements. The meaning of most symbols is obvious. However, if there is doubt, consult the table of conventional symbols located on every map. Located on the back of most maps will be a chart listing many additional conventional signs.

Map-reading not only involves the ability to interpret the symbols shown on the map and to understand the information given in pictorial or written form, but it also involves a true understanding of the ground portrayed and an appreciation of the reliability and value of the particular map being used.

Where the symbol may have more than one meaning, the sign or symbol will be accompanied by a descriptive word (eg, tank or tower).

The use of colour aids in distinguishing details.

Red. Used to identify paved roads and highway numbers. Red is also used to shade in areas of urban development.

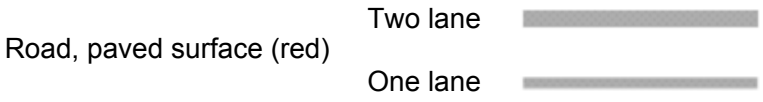


Figure 8 Red Conventional Signs

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

Orange. Used to represent unpaved roads.

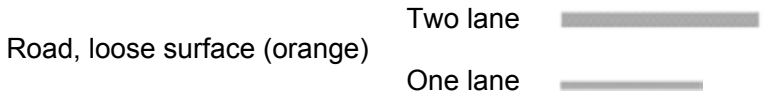
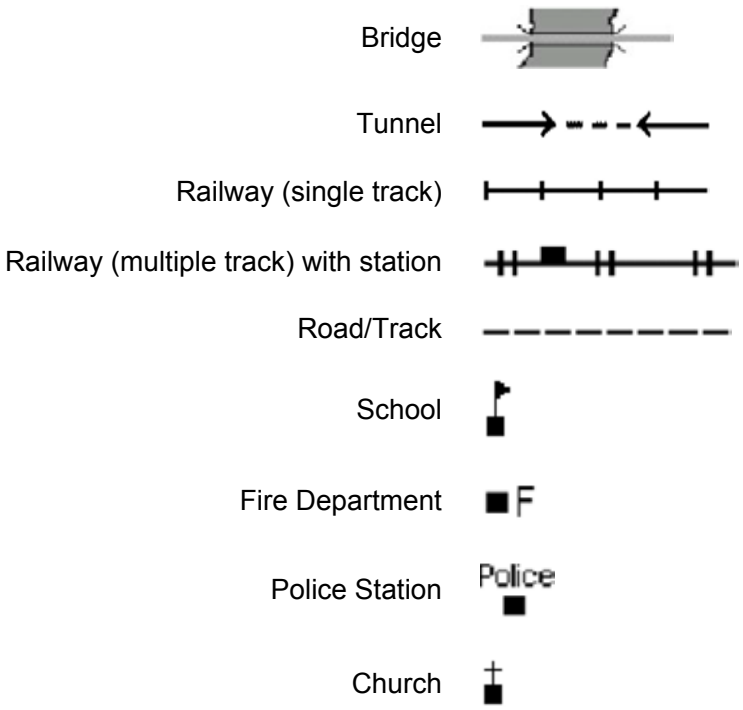


Figure 9 Orange Conventional Signs

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

Black. Used for cultural features, toponyms (place names), some symbols and precise elevations.



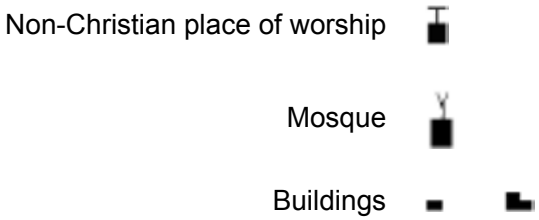


Figure 10 Black Conventional Signs

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

Brown. Used for contour lines, contour elevations, spot elevations, sand, cliffs, and other geographical features.

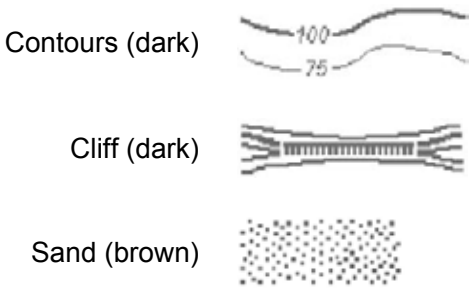


Figure 11 Brown Conventional Signs

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

Blue. Used for water or permanent ice features (eg, rivers, lakes, swamps and ice fields), names of water features and the grid lines.

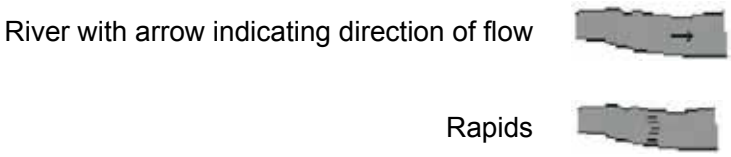


Figure 12 Blue Conventional Signs

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

Green. Used for vegetation features such as woods, orchards and vineyards.

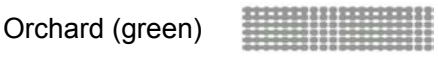


Figure 13 Green Conventional Signs

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

White. Used to represent open fields.

Grey. Used for the legend of conventional signs on the back of the map.

Purple. Used for updates that are made over top of the original map information.

ACTIVITY

Time: 10 min

OBJECTIVE

The objective of this activity is to have the cadets locate marginal information and identify conventional signs on a topographical map.

RESOURCES

- Topographical maps, and
- List of conventional signs (as per pre-lesson instructions).

ACTIVITY LAYOUT

Large flat areas, preferably tables. If outside, use paperweights to hold down the maps.

ACTIVITY INSTRUCTIONS

1. Review the purpose of marginal information.
2. Review the purpose of conventional signs.
3. Have the cadets study the topographical maps.
4. Have the cadets locate the following marginal information:
   a. declination diagram,
   b. date of map data,
   c. scale bars,
   d. map name, and
   e. contour interval.
5. Have the cadets locate conventional signs.

SAFETY

Nil.

CONFIRMATION OF TEACHING POINT 2

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

Send the group to their next learning station (only for the first three groups). If this is the last group, have them rendezvous at the designated location for TP 6.

Teaching Point 3 **Conduct an activity to have the cadets review GRs.**

Time: 20 min Method: Practical Activity

BACKGROUND KNOWLEDGE

FOUR-FIGURE GRs

Characteristics of a four-figure GR:

- Four-figure GRs will have four numerical digits derived from the numbers assigned to the eastings and northings on the map sheet.
- The numbers are listed by recording the two-digit easting followed by the two-digit northing.

The grid lines that intersect in the bottom left corner of the grid square are used to identify that grid square.

Steps to determine a four-figure GR:

1. Confirm the correct grid square.
2. Place a finger at the bottom left corner of the map.
3. Move that finger along the bottom of the map (left to right) up to the grid line (easting) before the grid square.
4. Record the two-digit easting.
5. Place a finger at the bottom left corner of the map.
6. Move that finger along the left side of the map (bottom to top) up to the grid line (northing) before the grid square.
7. Record the two-digit northing after the two-digit easting to create the four-figure GR.
8. Confirm the four-figure GR.

In Figure 14 Building A is located at GR 7433 and Building B at GR 7632.

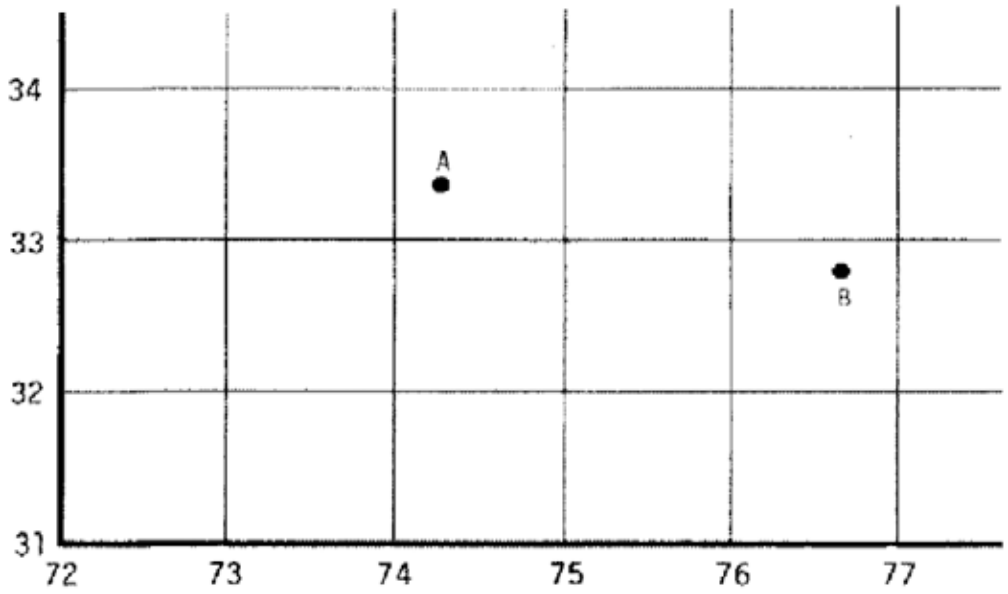


Figure 14 Four-Figure Grid References

Note. From *Maps, Field Sketching, Compasses and the Global Positioning System* (p. 37), Directorate of Army Doctrine 8, 2006, Ottawa, ON: Department of National Defence.

Steps to determine a grid square using a four-figure GR:

1. Confirm the four-figure GR.
2. Place a right-hand finger at the bottom left corner of the map.
3. Move that finger along the bottom of the map (left to right) up to the grid line (easting) numbered the same as the first two digits of the four-figure GR.
4. Place a left-hand finger at the bottom left corner of the map.
5. Move that finger along the left side of the map (bottom to top) up to the grid line (northing) numbered the same as the last two digits of the four-figure GR.
6. Move the right-hand finger up the grid line and the left-hand finger right along the grid line.
7. Where the two grid lines intersect is the bottom left corner of the grid square.
8. Confirm the correct grid square.

In Figure 14, GR 7532 represents the grid square southeast of Building A and west of Building B.

CONSTRUCTING A ROMER

Romer. A device used for measuring a point within a grid square to determine its six-figure GR.

Romers may be purchased or created. Purchased romers include compasses and protractors. Constructed romers use a small piece of paper and the scale bars of a topographical map.

Compass

Many compasses include romers already printed on the compass base plate. There are commonly two romers, for use with 1 : 25 000 and 1 : 50 000 scale topographical maps.

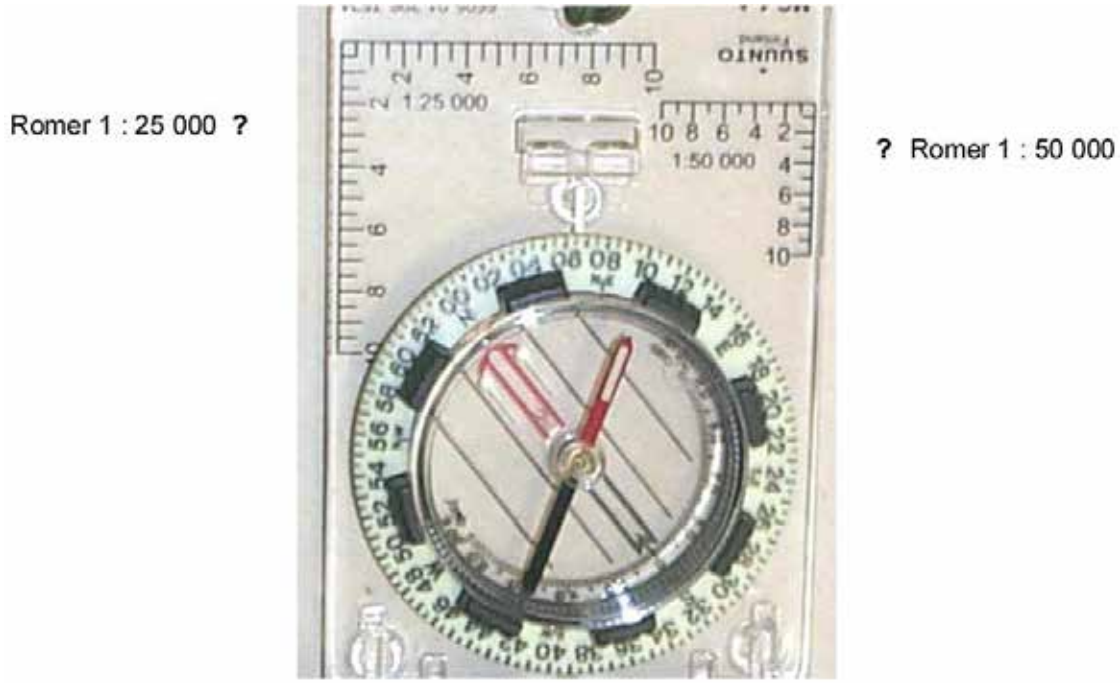


Figure 15 Compass

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

Protractor

All protractors may be used to determine a bearing on a map, however, few have romers already printed on them. The Canadian Forces has created the C2 protractor (as illustrated in Figure 16) specifically designed for use on topographical maps.

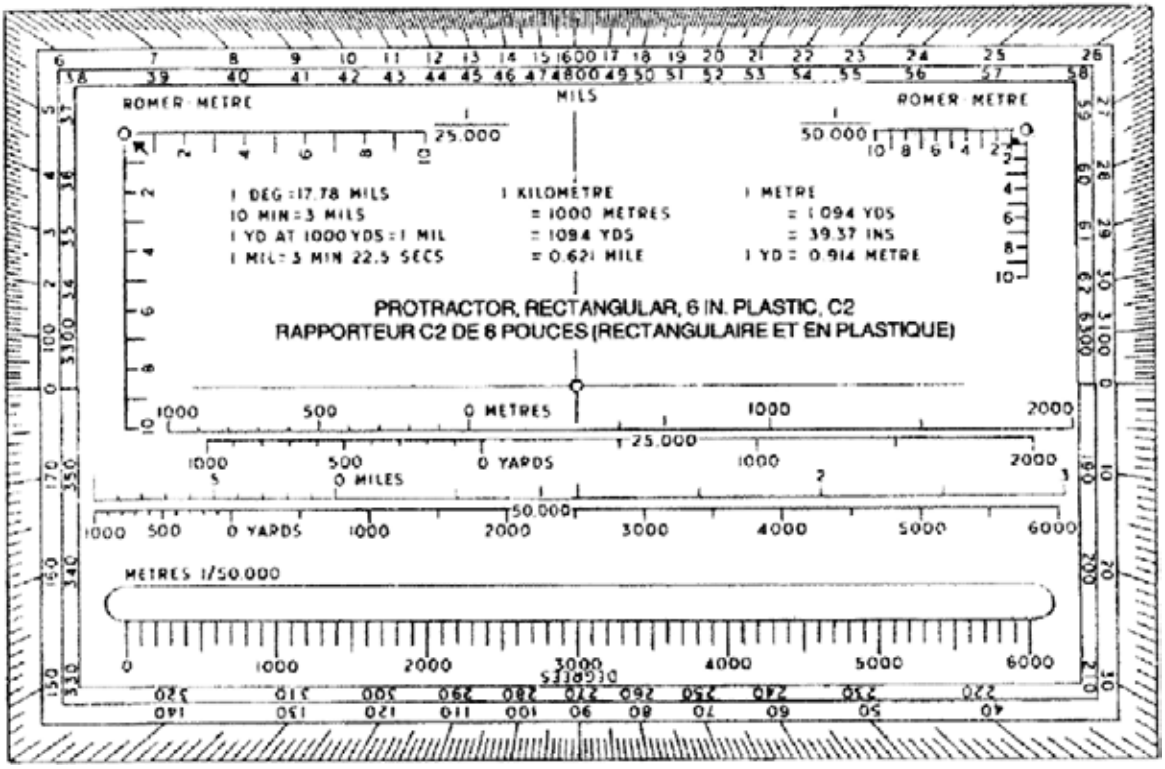


Figure 16 C2 Protractor

Note. From *Maps, Field Sketching, Compasses and the Global Positioning System* (p. 41), Directorate of Army Doctrine 8, 2006, Ottawa, ON: Department of National Defence.

Constructed

A constructed romer requires a piece of paper with at least one square corner and the scale bars of the topographical map. Using the scale bars of the topographical map, a romer can be constructed as illustrated in Figure 17.

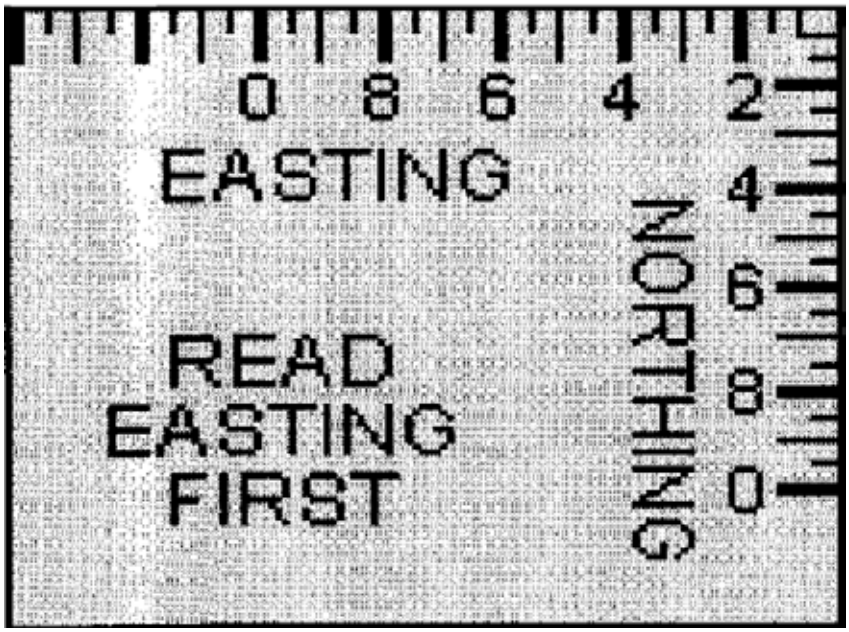


Figure 17 Constructed Romer

Note. From *Maps, Field Sketching, Compasses and the Global Positioning System* (p. 41), Directorate of Army Doctrine 8, 2006, Ottawa, ON: Department of National Defence.

Construct a romer for determining six-figure GRs by:

1. obtaining a blank piece of paper with a square edge;
2. placing one side of the square edge along the 100-m scale bars;
3. marking off 100-m segments beginning at the corner of the paper and working outward;
4. numbering these markings from zero (at the corner of the paper) to ten; and
5. repeating Steps 2–4 on the adjacent edge (eg, completed romer as illustrated in Figure 17).

It is important to use the correct scale bar. The constructed romer's markings should match the grid lines of the topographical map; the side of a grid square must be equal to ten 100-m marks on each of the romer's two edges.

SIX-FIGURE GRs

Determine a six-figure GR using a constructed romer by:

1. placing the corner of the constructed romer on the bottom left corner of the grid square, noting the four-figure GR;
2. moving the constructed romer to the right the number of tenths required to align the romer directly to or before (never past) the conventional sign or location for which the GR is being determined;

3. reading the value along the X-axis of the romer where it crosses the easting on the map sheet (the value at this intersection becomes the value for the third digit of the six-figure GR);
4. moving the constructed romer up the number of tenths required for the corner of the romer to be positioned on or before (never past) the conventional sign or location for which the GR is being determined;
5. reading the value along the Y-axis of the romer where it crosses the northing on the map sheet (the value at this intersection becomes the value for the sixth digit of the six-figure GR); and
6. combining the two sets of digits to create the six-figure GR.

Figure 18 Using a Constructed Romer

Note. From *Royal Canadian Army Cadet Reference Book* (p. 5-20), by Director Cadets 3, 2003, Ottawa, ON: Department of National Defence.

Determine what a six-figure GR represents using a constructed romer, by:

1. determining the four-figure GR, by removing the third and sixth digits from the six-figure GR, to identify and locate the correct grid square;
2. placing the corner of the constructed romer on the bottom left corner of the grid square;
3. moving the constructed romer to the right the number of tenths, as identified by the third digit;
4. moving the constructed romer up the number of tenths, as identified by the sixth digit; and
5. determining the object (that is up and to the right from the tip of the romer).

ACTIVITY

Time: 20 min

OBJECTIVE

The objective of this activity is to have the cadets determine four- and six-figure GRs and construct a romer.

RESOURCES

- Topographical maps,
- List of 20 conventional signs (as per pre-lesson instructions),
- Pens / pencils, and
- Paper.

ACTIVITY LAYOUT

Large flat areas, preferably tables. If outside, use paperweights to hold down the maps.

ACTIVITY INSTRUCTIONS

1. Have the cadets study the topographical maps.
2. Have the cadets determine the four-figure GR for each conventional sign.
3. Have the cadets determine the conventional sign of each four-figure GR.
4. Have the cadets construct a romer.
5. Have the cadets determine a six-figure GR for each grid square.
6. Have the cadets determine the conventional sign of each six-figure GR.

SAFETY

Nil.

CONFIRMATION OF TEACHING POINT 3

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

Send the group to their next learning station (only for the first three groups). If this is the last group, have them rendezvous at the designated location for TP 6.

Teaching Point 4 — **Conduct an activity to have the cadets review determining distance on a map and determining bearings on a map.**

Time: 20 min — Method: Practical Activity

BACKGROUND KNOWLEDGE

DETERMINING DISTANCE ON A MAP

Cadets can use a map to measure the distance between two points (eg, points A and B as illustrated at Figure 19) on the ground. All maps are drawn to scale; therefore, a specified distance on a map equals a specified distance on the ground. The scale of a map is printed at the top and bottom of each map (eg, scale 1 : 50 000). This means that 1 cm on the map equals 50 000 cm (500 m) on the ground.

There are two ways to determine distance on a topographical map—point-to-point and along-a-route.

Measuring Point-to-Point

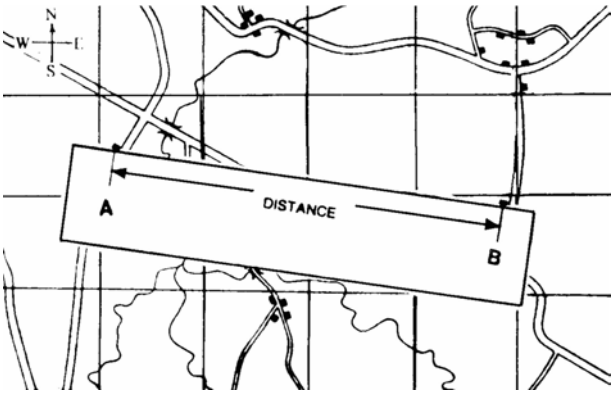


Figure 19 Measure Distance Point-to-Point

Note. From *Royal Canadian Army Cadet Reference Book* (p. 5-24), by Director Cadets 3, 2003, Ottawa, ON: Department of National Defence.

To measure a distance point-to-point:

1. Lay the straight edge of a piece of paper against the two points.
2. With a sharp pencil, mark the paper at the A (start) and B (end) points.
3. Lay the paper just under the metres scale bar with the B mark at the right end of the scale. Move the paper to the left, aligning the B mark with each thousand metre mark until the A mark falls within the subdivided thousands (hundreds) to the left of the zero.
4. To calculate the total distance, add the number of thousands where the B mark is, plus the number of subdivided thousands where the A mark is to the left of the zero.

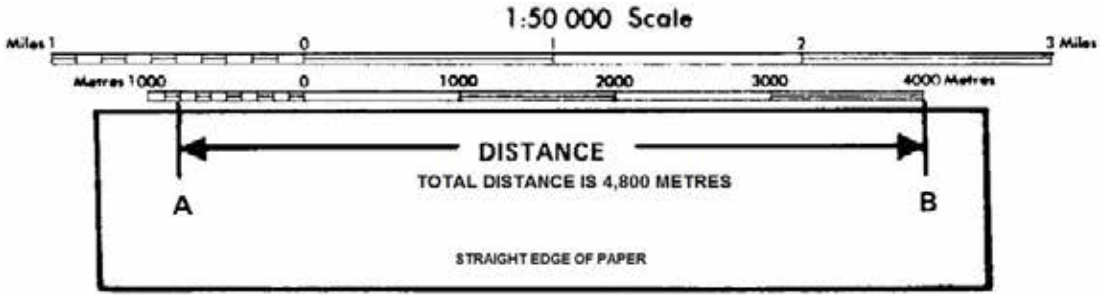


Figure 20 Calculate Distance

Note. From *Royal Canadian Army Cadet Reference Book* (p. 5-25), by Director Cadets 3, 2003, Ottawa, ON: Department of National Defence.

For a distance that is longer than 5 000 m, measure the first 5 000 m and mark the paper with a new line and label it ‘5 000 m’. Place the new mark at the zero or thousands mark until the A mark fits within the subdivided thousands (hundreds) bar. Add the total of that distance to the 5 000 m to create the total distance.

Measuring Along-a-Route Between Two Points

Sometimes cadets need to find the distance between A and B around the curves in a road along a planned route.

To measure a distance along a route between two points:

1. Lay the straight edge of a piece of paper against point A.
2. With a sharp pencil, mark point A on the paper and the map.
3. Line up the paper with the edge of the road until a curve is reached and make another mark on the paper and on the map.
4. Pivot the paper so that it continues to follow the road edge. Repeat until point B is reached.
5. Mark the paper and the map at point B.
6. Lay the paper just under the metres scale bar with the B mark at the right end of the scale. Move the paper to the left, aligning the B mark with each thousand metre mark until the A mark falls within the subdivided thousands (hundreds) to the left of the zero.
7. Add the number of thousands where the B mark is, plus the number of subdivided thousands (hundreds) where the A mark is to the left of the zero, to determine the total distance.

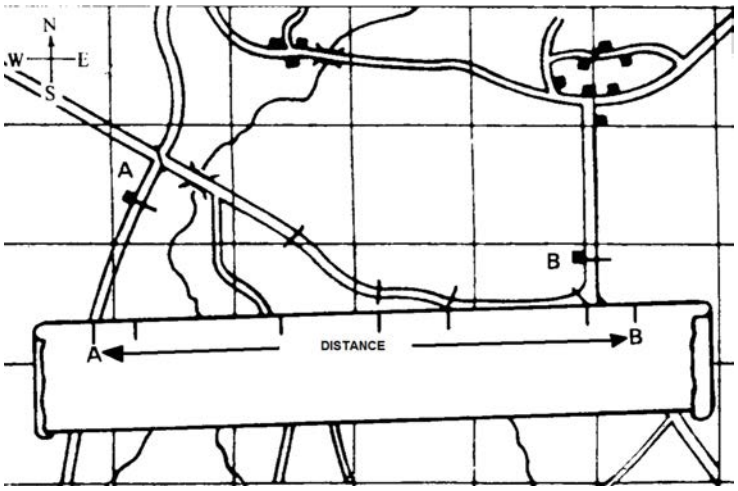


Figure 21 Measure Distance Along-a-Route

Note. From *Royal Canadian Army Cadet Reference Book* (p. 5-25), by Director Cadets 3, 2003, Ottawa, ON: Department of National Defence.

DETERMINING BEARINGS ON A MAP

In order to determine bearings on a map, the cadet needs to understand the points of a compass, the degree system, the three norths and types of bearings.

The 16 Points of a Compass

Figure 22 Compass Rose

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

The four cardinal points of the compass, measured at right angles clockwise from north are:

- north (N) at 0 and 360 degrees,
- east (E) at 90 degrees,
- south (S) at 180 degrees, and
- west (W) at 270 degrees.

The four inter-cardinal points are located halfway between each of the cardinal points. Measured clockwise from north, they are:

- northeast (NE) at 45 degrees,
- southeast (SE) at 135 degrees,
- southwest (SW) at 225 degrees, and
- northwest (NW) at 315 degrees.

The eight intermediate points are located halfway between each cardinal point and inter-cardinal point. Measured clockwise from north, they are:

- north-northeast (NNE) at 22.5 degrees,
- east-northeast (ENE) at 67.5 degrees,
- east-southeast (ESE) at 112.5 degrees,
- south-southeast (SSE) at 157.5 degrees,

- south-southwest (SSW) at 202.5 degrees,
- west-southwest (WSW) at 247.5 degrees,
- west-northwest (WNW) at 292.5 degrees, and
- north-northwest (NNW) at 237.5 degrees.

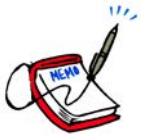
As an aid to remember the different types of points:

- cardinal points are designated by one letter,
- inter-cardinal points are designated by two letters, and
- intermediate points are designated by three letters.

The Degree System

The cardinal, inter-cardinal, and intermediate points describe directions only to within one-sixteenth of a full circle. For a more precise indication of direction, it is necessary to use the sub-divisions of the circle called degrees. This measurement starts and ends at north (top) and is measured in a clockwise rotation.

Degrees. The most common method of dividing a circle is by degrees. These degrees represent 360 equal angles in a complete circle and they are represented by the symbol "°" (eg, 222°).



It is important to emphasize that degrees should always be measured clockwise and always using north as the start point.

The Three Norths

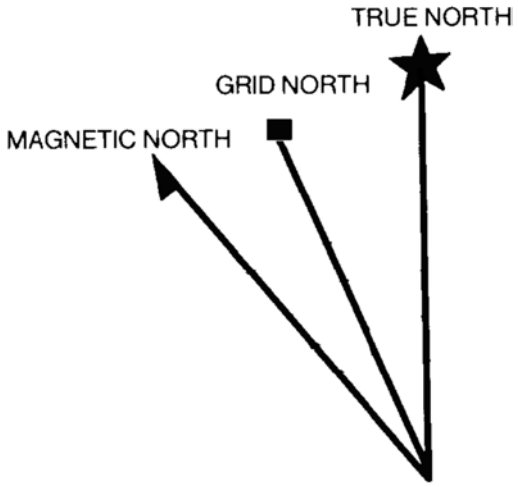


Figure 23 The Three Norths

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

The relationship between the three norths, especially grid and magnetic, is key to using a compass on both a map and on the ground.

True north. True north is located at the top of the earth where the geographic North Pole is located, where all lines of longitude meet. In the declination diagram on the map, true north is represented by the symbol of a star, which represents the North Star, Polaris.

Grid north. Grid north is the north indicated by the grid lines (eastings) on a topographical map. The easting lines run parallel to each other and will never meet at the geographic North Pole; because of this, grid north points off slightly from true north. In the declination diagram on the map, grid north is represented by a square, which represents a map grid.

Magnetic north. Magnetic north is the location of the north magnetic pole, where the Earth's magnetic field bends back into the Earth toward the south magnetic pole. It is located in the Canadian arctic and is different from true north. It is the direction in which the compass needle points. In the declination diagram on the map, magnetic north is represented by a needle as on a compass.

The differences between the three norths affect navigation for the map and compass user, in the form of magnetic declination. Magnetic declination is the difference in bearing either between true north and magnetic north or between grid north and magnetic north.

Cadets will normally use the magnetic declination value between grid north and magnetic north when navigating using a map and compass. By setting the magnetic declination on the compass, magnetic bearings are converted to grid bearings which allow bearings taken from the map to be used on the ground and vice versa.

Types of Bearings

Bearing. A bearing is an angle that is measured clockwise, from north. It is measured in degrees and is relative to the observer.

In geometry, an angle is based on three points; a vertex, and two points, each of which designates a ray. For a bearing, the vertex is the point where the bearing is taken from, another point is north, and the last point is where the bearing is directed to. The north (either true, grid or magnetic) used identifies the type of bearing.

In ground navigation, one ray of the angle points north (usually grid north) and the other ray, known as a plotting ray, points to the object / direction.

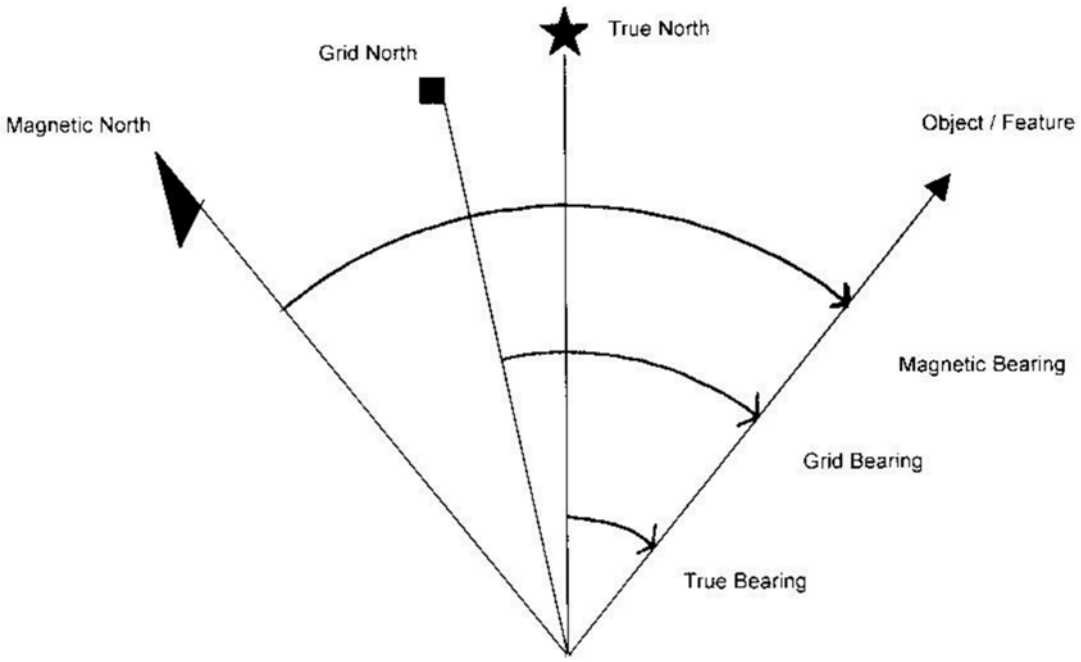


Figure 24 Types of Bearings

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

True bearings. A true bearing is a bearing measured from true north. While map users rarely use them, directions determined using the sun, moon and stars are true bearings. Global Positioning System (GPS) receivers also use true bearings.

Grid bearings. A grid bearing is a bearing measured from grid north. The ability to determine a bearing from a map allows a map user to plan routes or activities before going into the field, and allows an easy method of communicating information about movement or location.

Magnetic bearings. A magnetic bearing is measured from magnetic north and is measured using a compass, which either has no option of setting magnetic declination or has the magnetic declination set to zero. A magnetic bearing is a quick and efficient method of describing a route when a map is not being used.

If a compass has its declination set to zero, bearings to objects on the ground determined by that compass are magnetic bearings. Setting the magnetic declination on a compass converts the magnetic bearings determined by that compass into grid bearings for the map being used.

Back bearing. A back bearing is a bearing that is in exactly the opposite direction of the bearing that has been measured. A back bearing can be useful for different reasons: to return to the start location after a hike, or to calculate the bearing from an object to one's current location. The steps to calculate a back bearing are:

- if the bearing is less than 180 degrees, add 180 degrees; and
- if the bearing is greater than 180 degrees, subtract 180 degrees.

ACTIVITY

Time: 20 min

OBJECTIVE

The objective of this activity is to have the cadets determine distances and bearings on a map.

RESOURCES

- Topographical maps,
- Sets of GRs for distances (as per pre-lesson instructions),
- Sets of GRs for bearings (as per pre-lesson instructions),
- Pens / pencils, and
- Paper.

ACTIVITY LAYOUT

Large flat areas, preferably tables. If outside, use paperweights to hold down the maps.

ACTIVITY INSTRUCTIONS

1. Have the cadets study the topographical maps.
2. Have the cadets determine the distance point-to-point on a map.
3. Have the cadets determine the distance along-a-route on a map.
4. Have the cadets identify the 16 points of a compass.
5. Have the cadets describe the degree system.
6. Have the cadets identify the three norths.
7. Have the cadets describe types of bearings.
8. Have the cadets determine a bearing on a map (as per created list).

SAFETY

Nil.

CONFIRMATION OF TEACHING POINT 4

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

Send the group to their next learning station (only for the first three groups). If this is the last group, have them rendezvous at the designated location for TP 6.

Teaching Point 5 **Conduct an activity to have the cadets review determining distance on the ground and determining bearings on the ground.**

Time: 20 min Method: Practical Activity

BACKGROUND KNOWLEDGE

DETERMINING DISTANCE ON THE GROUND

Before distance can be determined on the ground, a method of measuring distance needs to be found. One such method is by determining one's own personal pace.

Determining a Personal Pace for 100 m

Being able to determine distance is a key skill for ground navigation. By learning how to determine distance using a personal pace, a cadet will have the skill to determine how far they have travelled, and how far they have to travel to reach their destination.

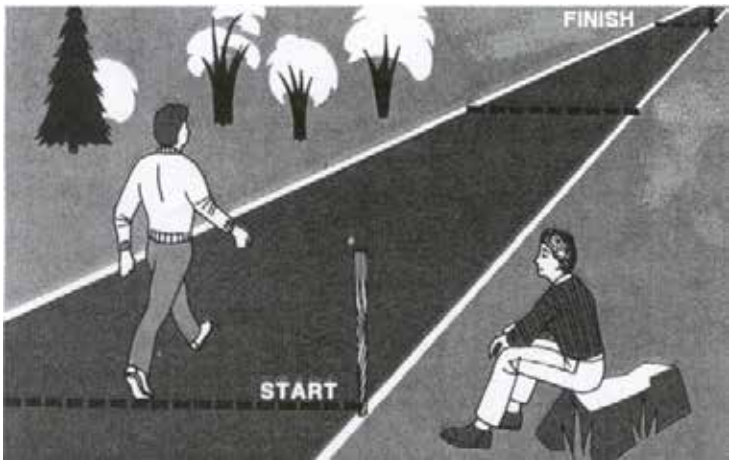


Figure 25 Determining Distance Using Pacing

Note. From *Be Expert With Map & Compass* (p. 53), by B. Kjellstrom, 1994, New York: Hungry Minds, Inc. Copyright 1994 by Bjorn Kjellstrom.

Personal pace. The number of paces a person walks over a distance of 100 m.

Counting Paces

There are two basic methods to count pace:

- count every pace (count every step); or
- count every other pace (count every left or every right step).

For example:

- count every pace: 140 paces = 100 m; or
- count every other pace: 70 paces = 100 m.

Calculating Distance

In order to determine distance travelled, the total number of paces travelled is divided by the personal pace and multiplied by 100 m to calculate the number of metres travelled.

Formula:

$$\frac{\text{total number of paces}}{\text{personal pace}} \times 100 \text{ m} = \text{total distance travelled (m)}$$

Example:

$$\frac{140 \text{ paces}}{70} \times 100 \text{ m} = 200 \text{ m}$$

Common methods of keeping track of the number of paces travelled include:

- transferring pebbles from one pocket to another: one pebble for each 100 paces;
- using a length of cord with knots—the knotted cord is held with the hand gripping a knot and the hand is advanced one knot down the cord for every 100 paces; and
- combining the knotted cord and pebbles (eg, cord with 10 knots, pebbles transferred for each completed cord [10 knots x 100 paces each = 1000 paces / pebble]).

Identifying Factors That Affect Pace

Factors that will affect personal pace include:

Terrain. The rougher the ground, the shorter the pace.

Slopes. Pace is shorter going uphill and longer going downhill.

Fatigue. Will shorten a person's pace.

Equipment. Footwear with poor traction will shorten a person's pace. Carrying a heavy load will also shorten a person's pace.

Weather. Snow and rain will shorten a person's pace. The wind will increase / decrease pace length if a person is travelling with / against the wind.

Obstacles. Going around small features (eg, trees, bushes) will affect pace count unless compensated for. Compensation methods include:

- **Sidestepping.** Stepping to the side (left / right) enough paces to bypass the obstacle, pacing forward past the obstacle and sidestepping back (right / left) to return to the original line of travel. This method maintains pace accuracy, but takes time.

The paces that the cadets sidestep are not added to their total pace count.

- **Alternating sides.** In this method, the cadet alternates which side (left / right) of the obstacle they pass (eg, last obstacle was passed on the left, next will be on the right). This method is less accurate, but faster.

If obstacles are always bypassed on the same side, the line of travel will veer off in that direction unless a distant steering point (eg, tall tree, hill top, building) is used as a guide.

DETERMINING BEARINGS ON THE GROUND

A compass can be used to determine the bearing for a direction of travel and from one's current location to a prominent object. The ability to take a bearing of a prominent object also allows the cadet to look for a prominent object as a steering point when they need to follow a given bearing. A bearing is a quick and accurate method for describing the direction of travel.

A prominent object is something that is usually tall and easily recognizable (eg, church steeple, tall tree or hilltop).

Figure 26 Determining a Bearing

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

After the cadets have demonstrated the skill, have them practice determining the bearings of other prominent objects. This location should be predetermined by the recce IAW the pre-lesson instructions.

To determine the bearing of a prominent object:

1. Set the predetermined declination on the compass.
2. Hold the compass at eye level and at arm's length, and turn to face the prominent object (as illustrated in Figure 26).
3. Aim at the object using the compass sight, ensuring the sighting line is in line with the index pointer.
4. Adjust the compass cover so the compass dial is seen in the sighting mirror.

5. Look in the mirror and turn the compass dial until the magnetic needle is over the orienting arrow (put the red in the bed).

6. Read the number on the compass dial at the luminous index pointer.

Inform the cadets that when taking a bearing of a prominent object they will get different readings than other cadets unless they are all using the same line of sight to that prominent object (eg, standing in the same spot).

ACTIVITY

Time: 20 min

OBJECTIVE

The objective of this activity is to have the cadets determine distance on the ground and to determine bearings on the ground.

RESOURCES

- Compass, and
- Bearing course.

ACTIVITY LAYOUT

Pace course set up as per pre-lesson instructions. A bearing course with locations identified (spot to take bearing from and the prominent object / feature for which to take the bearing).

ACTIVITY INSTRUCTIONS

1. Have the cadets determine their personal pace using the pace course.

2. Have the cadets identify factors that affect pace.

3. Have the cadets determine bearings on the ground using the bearings course.

SAFETY

Nil.

CONFIRMATION OF TEACHING POINT 5

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

Send the group to their next learning station (only for the first three groups). If this is the last group, have them rendezvous at the designated location for TP 6.

Teaching Point 6 **Have the cadets navigate a route using a map and compass.**

Time: 30 min Method: Practical Activity

ACTIVITY

OBJECTIVE

The objective of this activity is to have the cadets navigate a route using a map and compass.

RESOURCES

- Topographical map of the area,
- Predetermined magnetic declination,
- Set of four 6-figure GRs (the start point and the endpoint of each leg),
- Compass,
- Pencil, and
- Paper.

ACTIVITY LAYOUT

Four to six 3-leg map and compass courses, with the starting point for each course designated with a stake / marker.

ACTIVITY INSTRUCTIONS

1. Divide the cadets into groups of two.
2. Distribute a map, a compass, the predetermined magnetic declination, safety bearing, a set of four 6-figure GRs, a pencil and a sheet of paper to each group.
3. Brief the cadets on the activity, to include:
   a. the purpose of the activity, and
   b. safety.
4. Move the cadets to their start points.
5. Have the cadets complete their navigation exercise.
6. Have the cadets return their maps and compasses.

SAFETY

Nil.

CONFIRMATION OF TEACHING POINT 6

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

END OF LESSON CONFIRMATION

The cadets' navigating a route using a map and compass will serve as the confirmation of this lesson.

CONCLUSION

HOMEWORK / READING / PRACTICE

Nil.

METHOD OF EVALUATION

Nil.

CLOSING STATEMENT

Map and compass skills are important when training in a field setting. It allows groups to navigate within the training area in a safe manner. Survival training usually requires working within the bush away from the main exercise site. Understanding and practicing these skills allows the cadets to help plan survival training and organize routes between the main exercise site and the aircrew survival training areas.

INSTRUCTOR NOTES / REMARKS

TPs 1–5 are taught by learning stations. Divide the cadets into four groups and have the groups rotate between four learning stations: one station for TPs 1 and 2 and one station each for TPs 3–5.

To preserve and reuse the maps, they should be covered or coated with mac tac to allow the use of dry-erase markers instead of pencils or pens.

Assistant instructors and cadets who are qualified Survival Instructor may assist with this instruction.

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