ROYAL CANADIAN ARMY CADETS

GOLD STAR

INSTRUCTIONAL GUIDE

SECTION 7

EO C422.04 – MEASURE A GRID BEARING WITH A PROTRACTOR

Total Time: 90 min

PREPARATION

PRE-LESSON INSTRUCTIONS

Resources needed for the delivery of this lesson are listed in the lesson specification located in A-CR-CCP-704/PG-001, *Gold Star 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 Steps to Measure a Grid Bearing With a Protractor handout located at Attachment A for each cadet.

Photocopy the Steps to Converting Bearings located at Attachment B for each cadet.

Prepare the topographical map of the area being used. A minimum of four sets of six-figure grid references (GRs) for the start and finish points.

Identify a minimum of four grid bearings and four magnetic bearings to convert.

For the activity in TP 3, select a location, such as a sports field or park, where cadets can march on a bearing for at least 100 paces. From the start point, take a bearing that will allow cadets to march no less than 100 paces in a straight line with the magnetic declination of the compass set at zero, 10° mils west and 10° mils east, safely and within visibility of the start point.

Assistant instructors may be required for this lesson.

PRE-LESSON ASSIGNMENT

Nil.

APPROACH

An interactive lecture was chosen for TP 1 to introduce the cadet to the features of a protractor.

A demonstration and performance was chosen for TPs 2 and 3 as it allows the instructor to explain and demonstrate the skill of measuring grid bearings with a protractor and converting bearings while providing an opportunity for the cadet to practice the skill under supervision.

A practical activity was chosen for TP 4 as it is an interactive way to allow cadets to experience following a magnetic bearing in a safe and controlled environment.

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INTRODUCTION

REVIEW

Nil.

OBJECTIVES

By the end of this lesson the cadet shall have measured a grid bearing with a protractor.

IMPORTANCE

It is important for cadets to know how to measure a grid bearing with a protractor as it is much more accurate than the compass when measuring grid bearings and it provides the cadet an opportunity to enhance their map and compass skills by using another useful navigation tool.

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Teaching point 1 **Describe the features of a protractor.**

Time: 10 min Method: Interactive Lecture



This TP is to describe the features of the protractor to the cadets. Distribute a protractor to every cadet so they can clearly see each feature and point to each feature as it is described.

Refer to Figure 1 to aid in locating and describing the features of the protractor.

FEATURES OF A PROTRACTOR

The protractor is made of flexible plastic. Its features include:

1. 1 : 50 000 scale romer,
2. 1 : 25 000 scale romer,
3. a hole in each romer for plotting GRs,
4. conversion scale for converting between mils and degrees,
5. graduations in mils (outside edge),
6. graduations in degrees (outside edge),
7. 1 : 50 000 scale for measuring distance,
8. 1 : 25 000 scale for measuring distance,
9. centre lines (vertical and horizontal),
10. a centre hole, and
11. conversion scales for converting units of distance.



The outside of the protractor indicates both degrees and mils.

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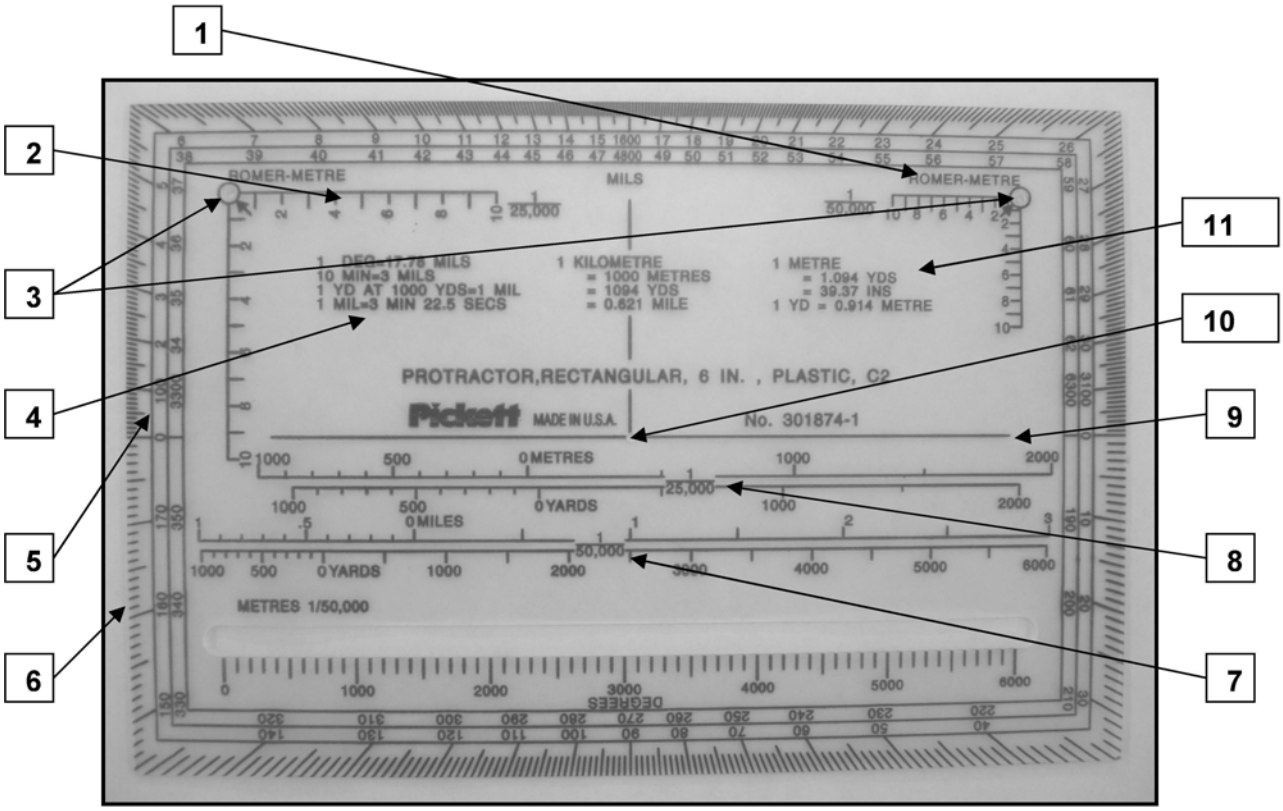

Note. Created by Director Cadets 3, 2009, Ottawa, ON: Department of National Defence.

Figure 1 Protractor

CONFIRMATION OF TEACHING POINT 1

QUESTIONS:

Q1. What is the protractor made of?

Q2. How many romers are there on the protractor and where are they located?

Q3. What do the graduations around the outside edge of the protractor show?

ANTICIPATED ANSWERS:

A1. The protractor is made of flexible plastic.

A2. There are two romers: 1 : 25 000 and 1 : 50 000 scale, located at the top left and right hand corners.

A3. The graduations are in mils and degrees.

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Teaching point 2 **Explain, demonstrate and have the cadets measure a grid bearing with a protractor.**

Time: 20 min Method: Demonstration and Performance



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

(1) Explain and demonstrate the complete skill of how to measure a grid bearing with a protractor while cadets observe, to include:

a. plotting the six-figure GR start and finish points;

b. placing the protractor on the map;

c. aligning the protractor parallel to the eastings; and

d. reading the grid bearing at the point where the plotting ray crosses the edge of the protractor.

(2) Explain and demonstrate each step required to measure a grid bearing with a protractor.

(3) Have each cadet practice each step.

(4) Have each cadet perform the complete skill.

Distribute a copy of the Steps to Measure a Grid Bearing with a Protractor handout located at Attachment A for each cadet, as a reference.

MEASURE A GRID BEARING WITH A PROTRACTOR

The steps to measuring a grid bearing with a protractor are:

Step 1. Plot the six-figure GR start and finish points by:

- sharpening the pencil that is being used, as this will allow for a more accurate plotting of a bearing;



The line of the plotting ray that is created must be accurate and thin. If the plotting ray is slightly off or thick, it can cause the bearing reading to be off, which can cause the final location to be missed by the navigator.

- identifying, using a romer to create a precise dot, the start GR and marking it as Point A on the map;
- identifying, using a romer to create a precise dot, the finish GR and marking it as Point B on the map;
- drawing a straight line, using the edge of the protractor, starting from Point A and continuing to Point B (This line is called the plotting ray); and
- extending the plotting ray past Point A and B and mark the line with an arrow to indicate the direction of travel. This will make it easier to read the bearing.



The plotting and reading of grid bearings on a map can be done by using either a protractor or a compass; however, the protractor is a more accurate measure.

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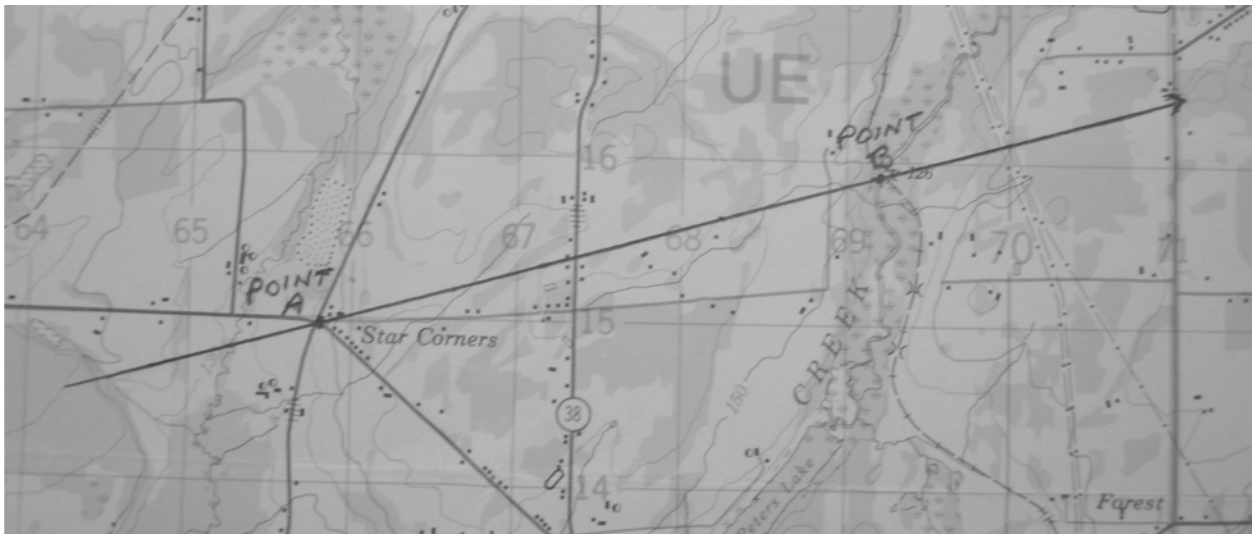

Note. Created by Director Cadets 3, 2009, Ottawa, ON: Department of National Defence.

Figure 2 Step 1 to Measuring a Grid Bearing With a Protractor

Step 2. Place the protractor on the map by:

- ensuring the centre hole is on the plotting ray and the centre line is over an easting line on the map;
- orienting zero mils to the top of the map (north); and
- ensuring the mils scale is placed east or west of the grid lines, as required.



If the bearing to be plotted is estimated to be between 0 and 3 200 mils, the protractor must be placed so that the mils scale is to the east of the easting line.

If the bearing to be plotted is estimated to be between 3 200 mils and 6 400 mils, the protractor must be placed so that the mils scale is to the west of the easting line.

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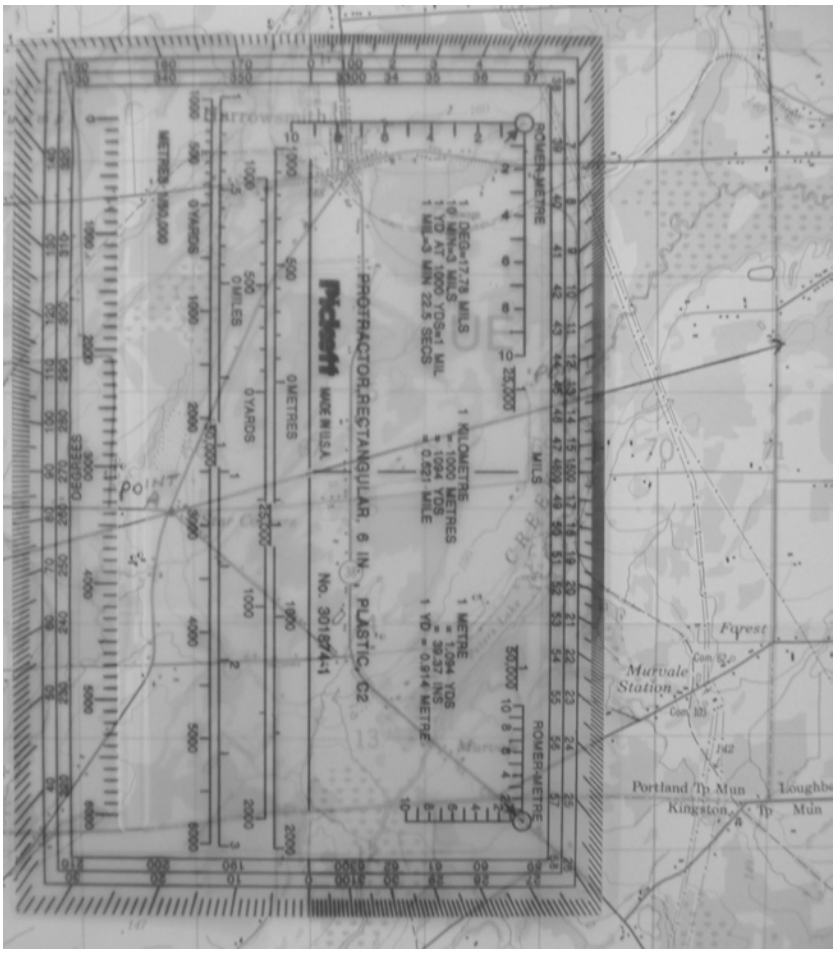

Note. Created by Director Cadets 3, 2009, Ottawa, ON: Department of National Defence.

Figure 3 Step 2 to Measuring a Grid Bearing With a Protractor

Step 3. Align the protractor parallel to the eastings by:

- sliding the centre hole along the plotting ray; and
- matching the vertical line on the protractor with an easting line.

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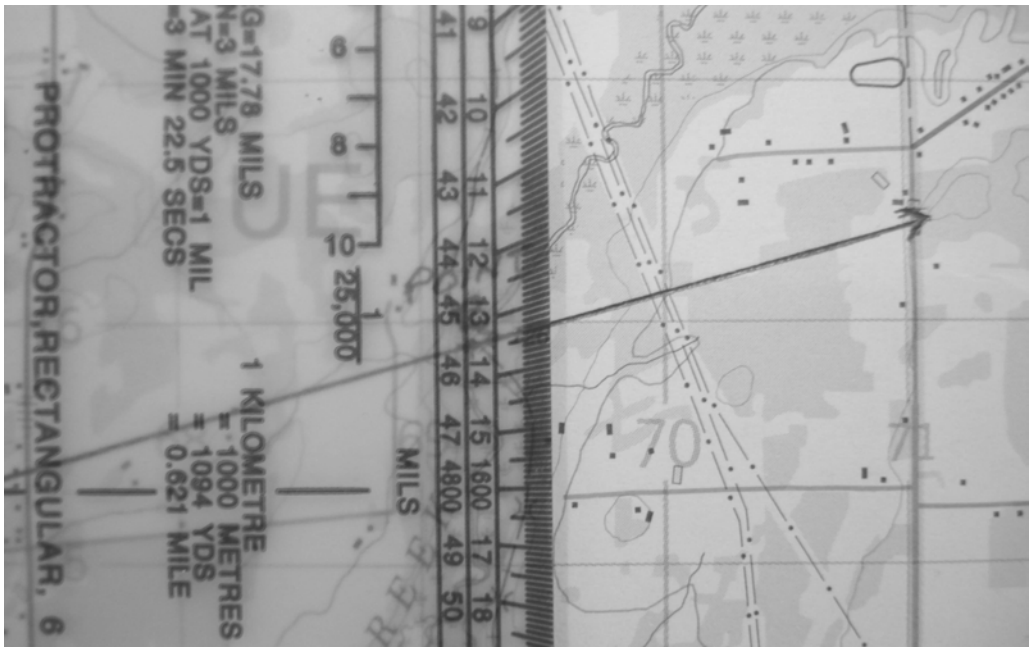

Note. Created by Director Cadets 3, 2009, Ottawa, ON: Department of National Defence.

Figure 4 Step 3 to Measuring a Grid Bearing With a Protractor

Step 4. Read the grid bearing at the point where the plotting ray crosses through the mils graduations on the side of the protractor by:

- finding and reading the grid bearing off the protractor on the mils scale;
- determining which bearing is the correct one; and
- recording the bearing.



By referring to basic knowledge of cardinal points and their mils equivalents, a close estimate of the bearing can be determined prior to plotting and reading the grid bearing.

CONFIRMATION OF TEACHING POINT 2

The cadets' measuring a grid bearing with a protractor will serve as the confirmation of this TP.

Teaching point 3 **Conduct an activity where the cadets will demonstrate the effects of magnetic declination adjustment.**

Time: 30 min Method: Practical Activity

The magnetic declination correctly set on a compass will help to identify the bearing from one's current location to a prominent object, which will save hours when in the wilderness.

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The term magnetic declination is correctly used to identify the difference between true north (axis of the earth) and magnetic north (compass). Because the army rarely uses true north for land navigation, it is common to refer to the difference between grid north (map) and magnetic north (compass), the grid magnetic angle, as magnetic declination.

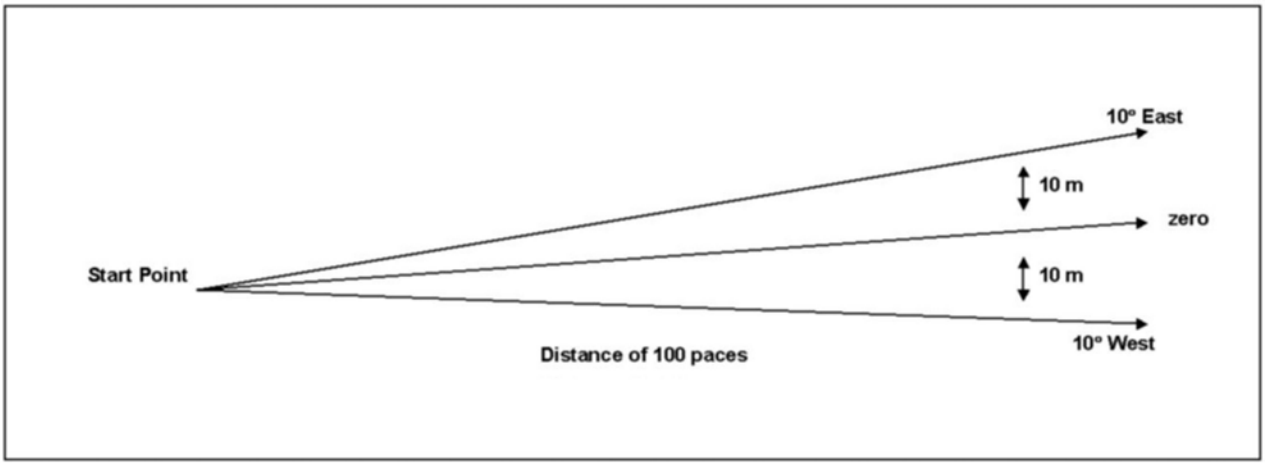
Magnetic declination is the difference between grid north (map) and magnetic north (compass). It is caused by the different locations of the north of the eastings and the magnetic north pole.

Declination changes due to the constantly shifting magnetic pole. Although this change is ongoing, the variation is minor, therefore only the annual change (change over the course of one calendar year) is calculated.



Where it is necessary to convert from degrees to mils or vice versa when following a bearing, the following conversion factors may be useful.

- 1° = 17.8 mils;
- 1' = 0.3 mils;
- 1 mil = 3.4'



Note. Created by Director Cadets 3, 2009, Ottawa, ON: Department of National Defence.

Figure 5 Following a Magnetic Bearing Description

ACTIVITY

Time: 25 min

OBJECTIVE

The objective of this activity is to have the cadets demonstrate the effects of magnetic declination by following three different magnetic bearings to determine the importance of calculating the correct magnetic declination on a compass.

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RESOURCES

- Topographical map (one per cadet),
- Compass (one per cadet),
- Marker, with flag (one per cadet),
- A predetermined distance, and
- Predetermined magnetic declinations.

ACTIVITY LAYOUT

Nil.

ACTIVITY INSTRUCTIONS

1. Conduct a safety briefing.

2. Select three cadets to march on the bearings.

3. Issue each cadet the required resources.

4. Have one cadet follow a bearing for 100 paces with the magnetic declination on the compass set to zero.

5. Have a cadet follow a bearing for 100 paces with the magnetic declination on the compass set to 10 degrees east.

6. Have a cadet follow a bearing for 100 paces with the magnetic declination on the compass set to 10 degrees west.

7. Once the three cadets have marched 100 paces, have them stop and mark the spot with a flagged marker that is visible from a distance and return to the start point.

8. From the start point, have the cadets observe the three points and note the difference. Also inform them that if the cadets were to keep walking, the further they are from the start point, the further apart they would become.



This activity demonstrates that an incorrect magnetic declination set on a compass can affect the final destination when following a bearing.

9. Conduct a debriefing.

SAFETY

Cadets shall be briefed on boundaries.

CONFIRMATION OF TEACHING POINT 3

The cadets' participation in demonstrating the effects of magnetic declination when following a magnetic bearing will serve as the confirmation of this TP.

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Teaching point 4 **Explain, demonstrate and have the cadets convert bearings.**

Time: 20 min Method: Demonstration and Performance



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

(1) Explain and demonstrate the complete skill of how to measure a grid bearing with a protractor while cadets observe, to include:

a. identifying the grid or magnetic bearing;

b. converting the bearing; and

c. listing the magnetic or grid bearing.

(2) Explain and demonstrate each step required to convert bearings.

(3) Have each cadet practice each step.

(4) Have each cadet practice the complete skill.

Distribute a copy of the Steps to Converting Bearings handout located at Attachment B for each cadet, as a reference. Refer to A-CR-CCP-703/PF-

Refer to A-CR-CCP-703/PF-001, Silver Star Instructional Guides, EO M322.02 (Calculate Magnetic Declination), if further information is required.

Use the pre-determined grid bearings and magnetic bearings when converting.

CONVERT BEARINGS

Bearings taken on a map are grid bearings and bearings taken using a compass to an object on the ground are magnetic bearings. Given the fixed point of reference for these two types of bearings, north, is not the same for grid bearings (map north located at the top of the eastings) and magnetic bearings (magnetic north), there is a requirement to convert the bearings when switching from using a map to using a compass. Some compasses will do this automatically when the magnetic declination is set on the compass. When using compasses without the magnetic declination set or a protractor the bearing will have to be manually converted.

Map users will identify the declination in the marginal information through a declination diagram depicting the true, grid, and magnetic bearing of any line within the area of the map sheet.

The steps to converting a grid bearing to a magnetic bearing are:

1. Calculate the current magnetic declination.

2. Adjust for the magnetic bearing by either adding or subtracting the appropriate angle, which is called the grid magnetic angle (GMA), to / from the grid bearing.

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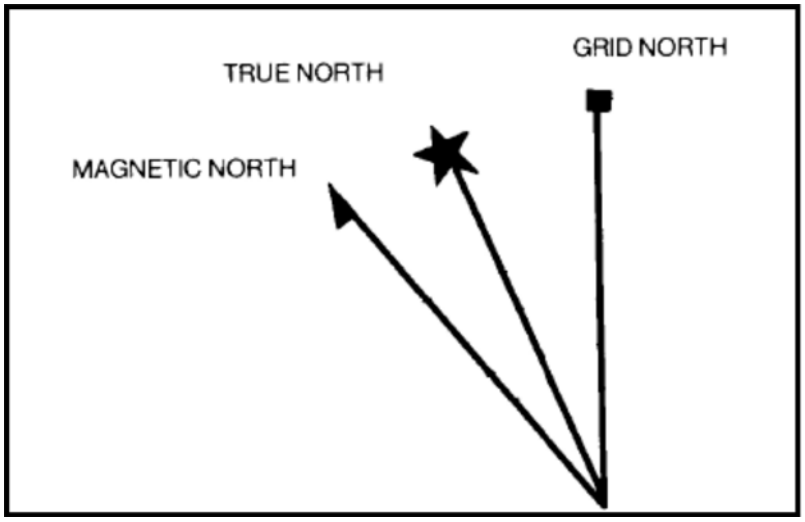
When converting grid bearings to magnetic bearings, the following mathematical formulas are used:

- When the GMA is **west** of Grid North, **add** the magnetic declination to the grid bearing (west is best).
- When the GMA is **east** of Grid North, **subtract** the magnetic declination from the grid bearing (east is least).

Grid magnetic angle is the horizontal angular difference between grid north and magnetic north. This is the number that is applied when converting from magnetic to grid bearings.



Note. From Maps, Field Sketching, Compasses and the Global Positioning System (p. 51), by Canadian Forces, 2006, Ottawa, ON: Department of National Defence.

Figure 6 Three Norths

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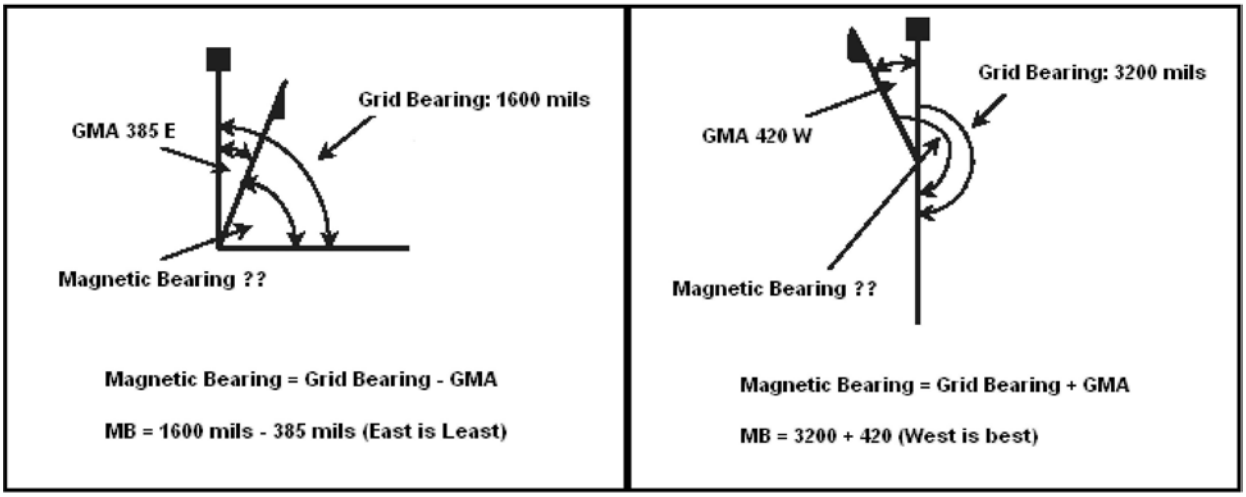
3. List the magnetic bearing.



Note. From Land Environmental Training, by Director Cadets 6 (Personnel, Policy and Training), 2009, Ottawa, ON: Department of National Defence.

Figure 7 Examples of Converting Grid Bearings to Magnetic Bearings Diagram

The steps to converting a magnetic bearing to a grid bearing are:

4. Calculate the current magnetic declination.

5. Adjust for the magnetic bearing by either adding or subtracting the GMA from the magnetic bearing.



When converting magnetic bearings to grid bearings, the following mathematical formulas are:

- When the GMA is **west** of Grid North, **subtract** the magnetic declination from the magnetic bearing (west is least).
- When the GMA is **east** of Grid North, **add** the magnetic declination to the magnetic bearing (east is best).

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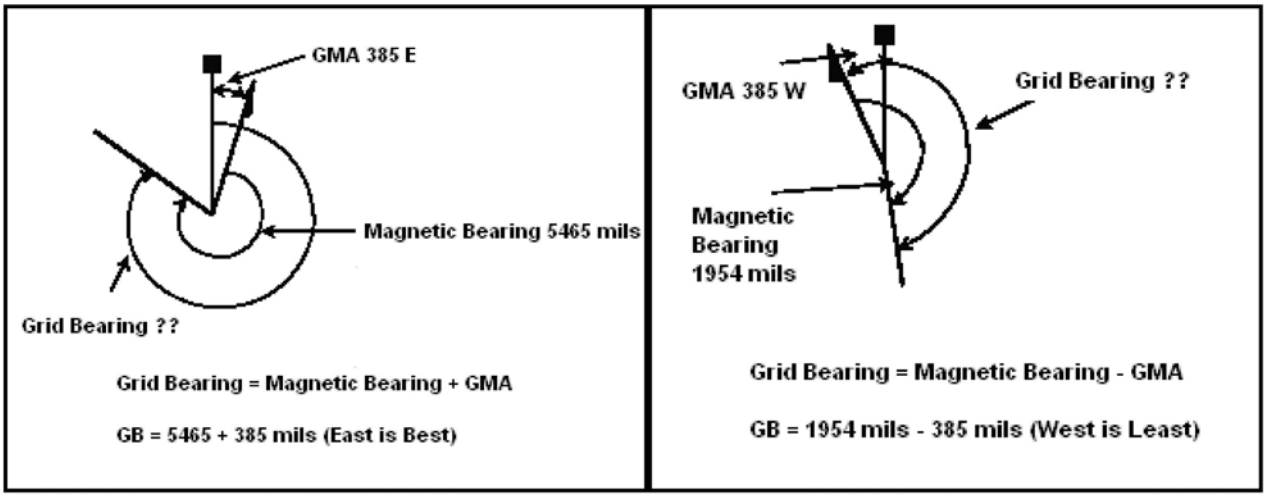
6. List the grid bearing.



Note. From Land Environmental Training, by Director Cadets 6 (Personnel, Policy and Training), 2009, Ottawa, ON: Department of National Defence.

Figure 8 Examples of Converting Magnetic Bearings to Grid Bearings Diagram



Figures 7 and 8 show the relative positions and values of the angles from the information supplied.

It is important to place the bearings in their correct positions relative to each other in accordance with the map information supplied. Once a correct and relative diagram has been made, with the values inserted, the conversion of bearings is straightforward.

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Another useful tool is to create a table, Magnetic–Declination–Grid, then add or subtract in the direction referred to by the declination.

Example 1, with all the required information.

Magnetic	Declination	Grid
1725 mils	W 125 mils	1600 mils
For West declination, going west, the mathematical formula for finding the magnetic bearing: 1600 mils + 125 mils = 1725 mils.		

Example 2, the grid bearing is missing.

Magnetic	Declination	Grid
3200 mils	W 250 mils	**?**
If **?** + 250 mils = 3200 mils, then 3200 mils - 250 mils = 2950 mils. The answer is 2950 mils.		

Example 3, the magnetic bearing is missing.

Magnetic	Declination	Grid
?	W 300 mils	6050 mils
If **?** - 300 mils = 6050 mils, then 6050 mils + 300 mils = 6350 mils. The answer is 6350 mils.		



All bearings are measured clockwise from their north point. The magnetic bearing will be greater than the corresponding grid bearing by the amount of the GMA.

CONFIRMATION OF TEACHING POINT 4

The cadets' performance of converting bearings will serve as the confirmation of this TP.

END OF LESSON CONFIRMATION

The cadets' measuring of a grid bearing with a protractor will serve as the confirmation of this lesson.

CONCLUSION

HOMEWORK / READING / PRACTICE

Nil.

METHOD OF EVALUATION

Nil.

CLOSING STATEMENT

Knowing how to measure a grid bearing with a protractor enhances map and compass skills and allows cadets to plot bearings by using another useful tool, while navigating confidently during field training exercises.

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INSTRUCTOR NOTES / REMARKS

Topographical maps can be requested through RCSU.

REFERENCES

A2-041 B-GL-382-005/PT-001 Directorate of Army Doctrine 8. (2006). *Maps, field sketching, compasses and the global positioning system*. Ottawa, ON: Department of National Defence.

C2-041 ISBN 0-07-136110-3 Seidman, D., & Cleveland, P. (1995). *The essential wilderness navigator*. Camden, ME: Ragged Mountain Press.

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STEPS TO MEASURE A GRID BEARING WITH A PROTRACTOR

The steps to measuring a grid bearing with a protractor are:

Step 1. Plot the six-figure GR start and finish points by:

1. sharpening the pencil that is being used, as this will allow for a more accurate plotting of a bearing;

2. identifying, using a romer to create a precise dot, the start GR and marking it as Point A on the map;

3. identifying, using a romer to create a precise dot, the finish GR and marking it as Point B on the map;

4. drawing a straight line, using the edge of the protractor, starting from Point A and continuing to Point B (This line is called the plotting ray); and

5. extending the plotting ray past Point A and B and mark the line with an arrow to indicate the direction of travel. This will make it easier to read the bearing.

Step 2. Place the protractor on the map by:

1. ensuring the centre hole is on the plotting ray and the centre line is over an easting line on the map;

2. orienting zero mils to the top of the map (north); and

3. ensuring the mils scale is placed east or west of the grid lines, as required.

Step 3. Align the protractor parallel to the eastings by:

1. sliding the centre hole along the plotting ray; and

2. matching the vertical line on the protractor with an easting line.

Step 4. Read the grid bearing at the point where the plotting ray crosses through the mils graduations on the side of the protractor by:

1. finding and reading the grid bearing off the protractor on the mils scale;

2. determining which bearing is the correct one; and

3. recording the bearing.

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STEPS TO CONVERTING BEARINGS

The steps to converting a grid bearing to a magnetic bearing are:

1. Calculate magnetic declination.

2. Adjust for the magnetic bearing by either adding or subtracting the appropriate angle, which is called the grid magnetic angle (GMA), to / from the grid bearing.



When converting grid bearings to magnetic bearings, the following mathematical formulas are:

- When the GMA is **west** of Grid North, **add** it to the grid bearing (west is best).
- When the GMA is **east** of Grid North, **subtract** it from the grid bearing (east is least).

3. List the magnetic bearing.

The steps to converting a magnetic bearing to a grid bearing are:

4. Calculate magnetic declination.

5. Adjust for the magnetic bearing by either adding or subtracting the GMA from the magnetic bearing.



When converting magnetic bearings to grid bearings, the following mathematical formulas are:

- When the GMA is **west** of Grid North, **subtract** it from the magnetic bearing (west is least).
- When the GMA is **east** of Grid North, **add** it to the magnetic bearing (east is best).

6. List the grid bearing.

The Magnetic–Declination–Grid table. Add or subtract in the direction referred to by the declination.

Magnetic	Declination	Grid
1725 mils	W 125 mils	1600 mils
For West declination, going west, the mathematical formula for finding the magnetic bearing: 1600 mils + 125 mils = 1725 mils.		

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