The Cutterman's Guide to Maneuvering Boards

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www.practicalnavigator.org

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The Cutterman's Guide to Maneuvering Boards

Preface

Maneuvering boards are a tool that must be mastered to achieve proficiency as a deck watch officer or officer-in-charge of a navigational watch. Although an older technique, it is not outdated. A mastery of maneuvering board techniques demonstrates a true understanding of relative motion, the most critical aspect in making collision avoidance decisions at sea.

How to Use This Guide

The Cutterman's Guide series of books assumes that readers want to either refresh or master certain navigation techniques in order to pass an exam or meet other qualification requirements, and is therefore written in a "no-nonsense" fashion.

Pub 1310: *The Radar Navigation and Maneuvering Board Manual,* published by the National Imagery and Mapping Agency is an excellent and comprehensive guide to radar navigation and maneuvering board theory. However, it is often difficult to learn on-the-job. *The Cutterman's Guide to Maneuvering Boards* attempts to fill the void of a basic text specifically for Coast Guard Deck Watch Officers, Boatswain's Mates, and Operations Specialist ratings, as well as other mariners in need of a refresher or basic text on maneuvering boards.

This guide is specifically written to dovetail with the online course "**Fundamentals of the Maneuvering Board**," available at www.practicalnavigator.org. Many of the example problems solved in this guide are also solved in short videos located on the website. Additionally, students who complete the end-of-course practical exam located on the website obtain a certificate of completion. This certificate can often be used in lieu of, or in addition to, on-the-job training at US Coast Guard units. For questions regarding this course or this guide, please contact navigation.training.videos@gmail.com or chris.d.nolan@gmail.com.

About

The Practical Navigator website: www.practicalnavigator.org was originally created for Coast Guard Deck Watch Officers, Boatswains Mates, and Operations Specialists to have free access to videos and texts which would increase their proficiency in navigation and radar tasks. Since then, it has found a following with merchant mariners, sailors, and naval personnel around the world.

Christopher D. Nolan graduated with honors from the US Coast Guard Academy in 2002. He has over 8 years of sea-time aboard the cutters:

ALEX HALEY (WMEC-39) – Kodiak, AK. First Lieutenant (3rd Mate)
DORADO (WPB-87306) – Crescent City, CA. Commanding Officer (Master)
EAGLE (WIX-327) – New London, CT. Navigator/Operations Officer (2nd Mate)
JEFFERSON ISLAND (WPB-1340) – Portland, ME. Commanding Officer (Master)

After completing service in the USCG, he sailed as a master of the sailing school vessels CORWITH CRAMER and ROBERT C. SEAMANS and taught as an assistant professor of Nautical Science with Sea Education Association in Woods Hole, MA.

After obtaining his original mariner's license in 2006, he now holds an STCW license as Master, less than 3000 GT and a domestic license as Master up to 1600 GRT upon oceans. He holds a B.S. in Marine Science from the USCG Academy and a P.S.M. in Fisheries and Wildlife Administration from Oregon State University.

He is the co-author of "Eagle Seamanship – A Manual for Square Rigger Sailing" and the author of "The Bridge Navigation and Seamanship Refresher Guidebook," "The Cutterman's Guide to Basic Celestial Navigation," and "The Cutterman's Guide to Navigation Problems." Additionally, he maintains the training program website www.practicalnavigator.org and a YouTube channel dedicated to Navigation Training.

The Cutterman's Guide to Maneuvering Boards

Part One: Plotting on the Maneuvering Board

The Basics

The maneuvering board is primarily a tool used to assist mariners in making collision avoidance decisions.

In its simplest form, the maneuvering board is used to represent a radar screen, with your "own ship" at the center. In more complex terms, it is a **polar-coordinate** plotting sheet designed for solving **relative motion** problems.

Even when a ship's engines are disengaged, it is always in motion. In relation to the Earth, that motion is called **true motion**. In relation to another ship, or another observer, the motion is called relative motion.

True motion can be represented by the ship's true course and speed.

Relative motion - the motion of one ship relative to another ship (e.g. your ship!) is represented by the terms **direction of relative motion (DRM)**, and **speed of relative motion (SRM).**

Both true motion and relative motion are represented on the maneuvering board as **vectors.** A vector is a line segment representing both direction and magnitude.

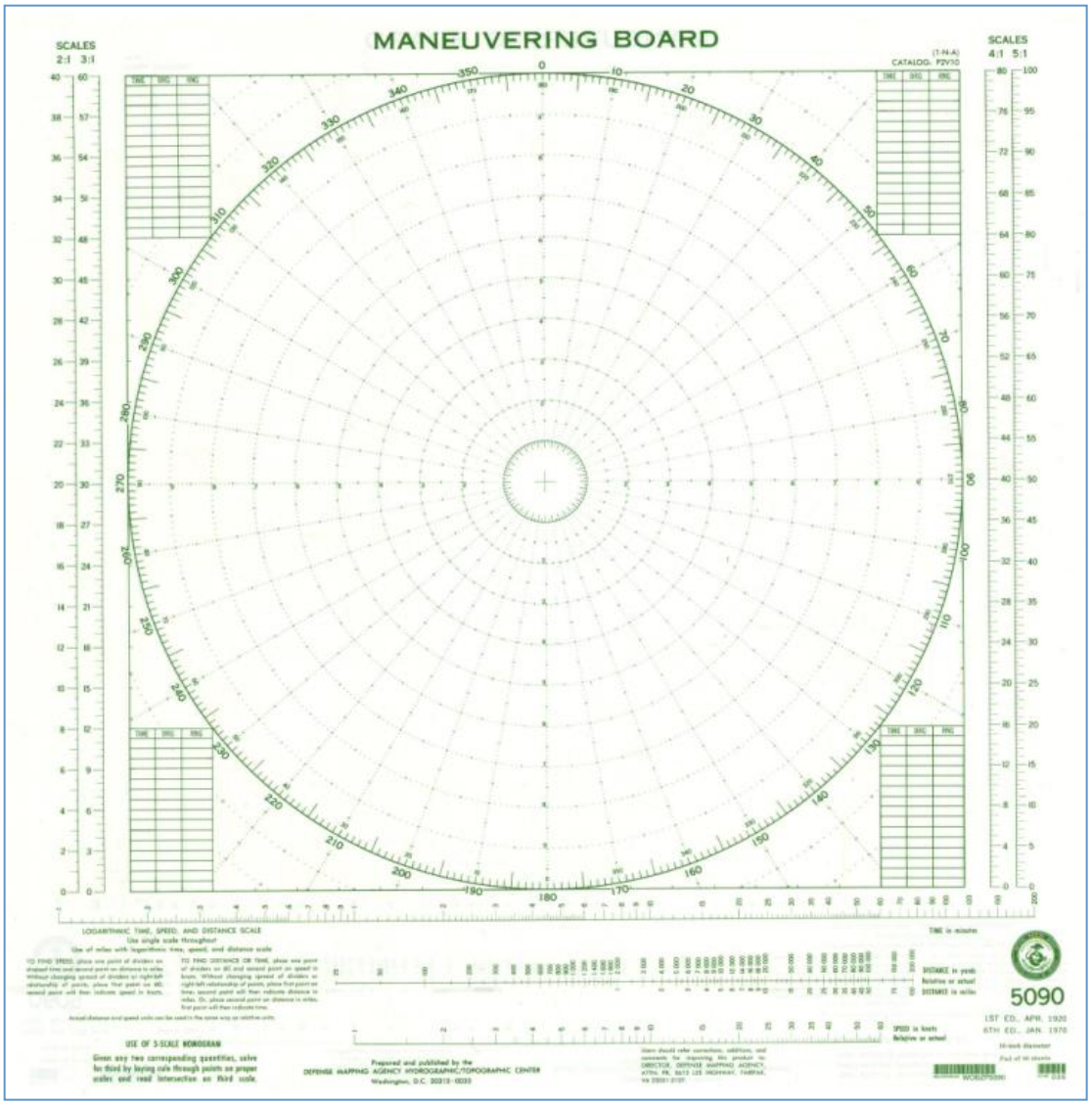
Modern radar units have the ability to plot contacts in true motion or relative motion mode. Most seasoned mariners rely on relative mode…this enables rapid determination of **risk of collision**.

The maneuvering board is a manual method for making the same calculations that a radar unit's **automatic radar plotting aid (ARPA)** can make. Aside from being a training requirement for USCG deck watch officers, boatswain's mates, and operations specialists, the maneuvering board enables a deeper understanding of how a ship's ARPA works.

Layout of the Maneuvering Board

The three main feature of the maneuvering board are:

1. **Plotting surface** – the polar coordinate nature of the board means that your own-ship is in the center, and radar contacts are transferred to the plotting sheet by measuring true bearing and range.
2. **Scales** – the maneuvering board can be re-scaled to suit a variety of speeds. The normal scale is 1:1. This means that 1 mile on the board equates to 1 mile of distance between your vessel and the radar contact. Later, we will learn that it is possible to use one scale for distance and another for speed. However, it is generally easier to use a single scale for all calculations for each contact.
3. **Nomogram** – this is a logarithmic speed-distance-time calculator at the bottom of the maneuvering board. Knowing two values, the third value is rapidly calculated by connecting the points in a line.

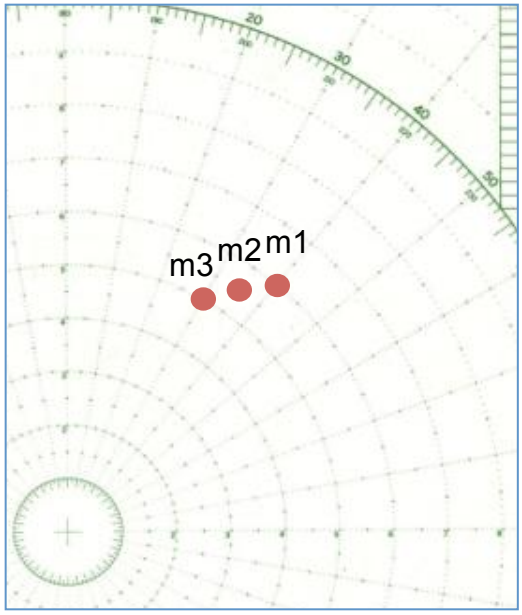


Plotting a Radar Contact

Problem 1-1. *Using a maneuvering board, plot the following contact.*

Time: 0100. Bearing 040°T. Range 6.0nm.
Time: 0106. Bearing 035°T. Range 5.5nm.
Time: 0112. Bearing 030°T. Range 5.0nm.

What is the direction of relative motion (DRM) for this contact?
Answer: 262°T



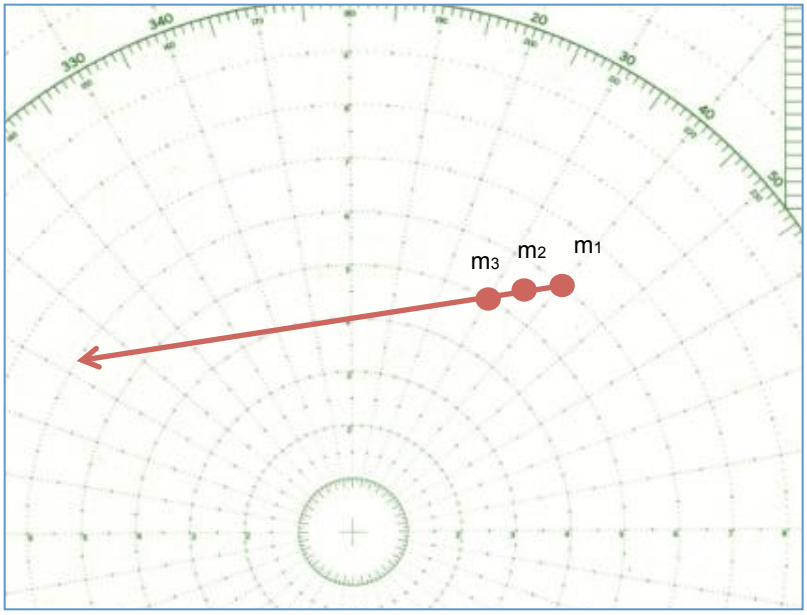
Step 1: Plot the contact.

Radar contacts are typically plotted with the designator "M."

Be sure to plot carefully, and label each point as "M1," "M2," and "M3." You may alternatively plot the times of each point if you wish.

Step 2: Draw the Relative Motion Line (RML).

Often, the three plotted points do not exactly align in a straight line. Unless a specific point is clearly incorrect, draw a line of best fit through the three points, from M1 towards M3 and beyond, until it clearly has passed the center of the maneuvering board.

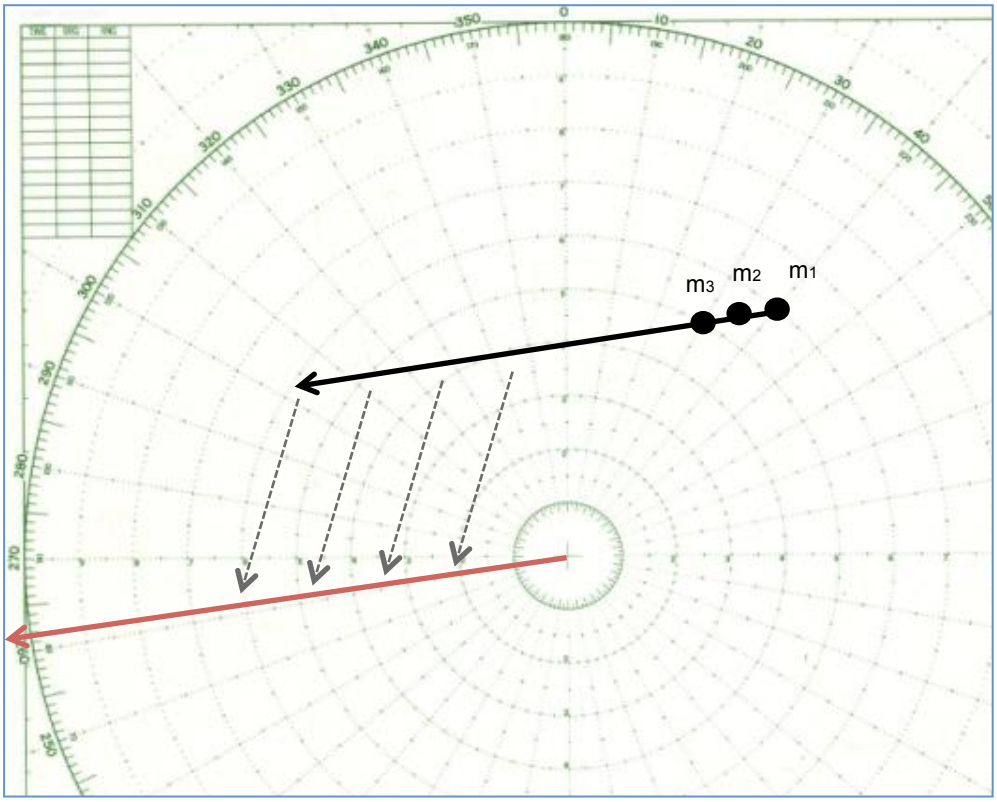


This line is called the **relative motion line (RML)**. Unless one of the two ships involved changes its vector, the contact will appear to continue to travel down the RML indefinitely.

Step 3: Determine the direction of relative motion (DRM).

The direction of relative motion (DRM) is not the true course of the radar contact. Rather, it is a direction in which the contact will *appear* to travel on your radar screen. When rapidly solving maneuvering boards, this step is merely an intermediate step which may be skipped. However, it is beneficial to learn the correct process.

To determine the DRM, parallel the relative motion line to the origin and note the bearing (in the proper direction – from M1 to M3). In this case, the direction of relative motion is 262°T.



Additional Problems and Answers

Problem B-1. Using a maneuvering board, plot the following contact.

Time: 1430. Bearing 355°T. Range 8.0nm.

Time: 1436. Bearing 350°T. Range 7.0nm.

Time: 1442. Bearing 344°T. Range 6.2nm.

What is the direction of relative motion (DRM) for this contact?

Answer: 206°T. An acceptable answer is within 5° in either direction (e.g. 201-211°T).

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Part Two: Vectors and the Speed Triangle

Vectors

The terms "speed" and "velocity" are often used interchangeably, but they are not the same thing. In addition to the rate of travel, "velocity" refers to the direction of travel. If CGC WAESCHE is travelling at 18 knots on course 330°T, her speed is 18 knots, but her velocity is 330°T at 18 knots. A subtle difference, but important.

When completing maneuvering board calculations, using standard notation allows other watchstanders to follow your work. For most maneuvering board situations, the following symbols and vectors are standard:

e – point "e" represents your own-ship position. It is most often located at the origin (center) of the maneuvering board.

m – point "m" represents the location of the radar contact. Subsequent positions are designated "m1," "m2," etc. For situations involving changes in course or speed, the point "mx" represents the point at which a course/speed change is made.

r – point "r" represents the end of the vector describing your own-ship, as well as the beginning of the vector representing the relative motion line.

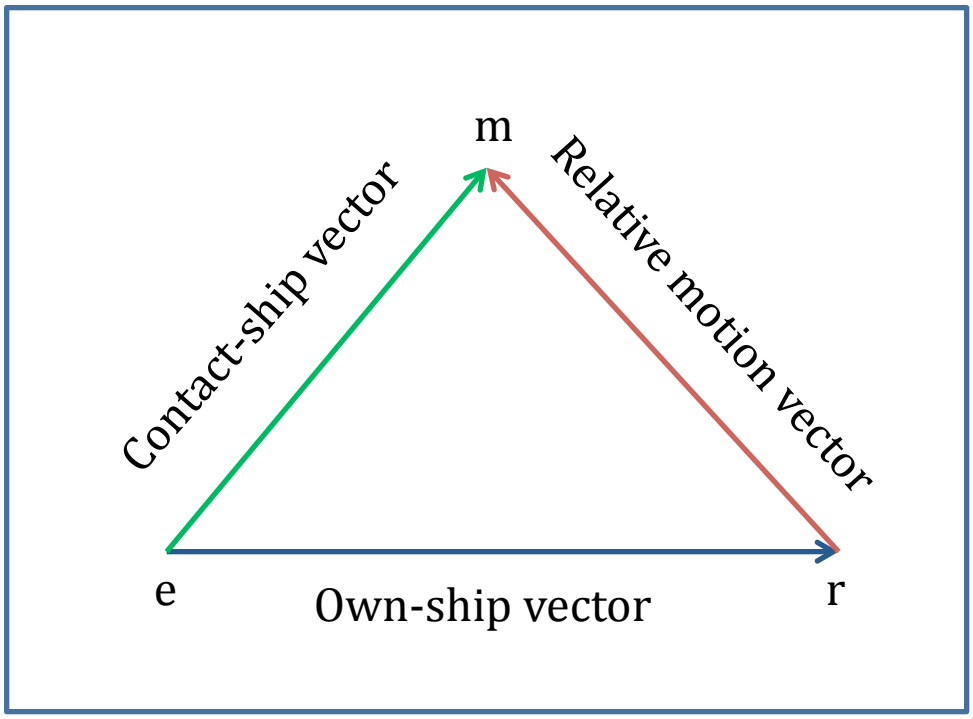
e-r – vector "e->r" represents your own-ship vector (i.e. your own-ship course and speed). It is always drawn from point "e" to point "r."

r-m – vector "r->m" represents the relative motion line (RML). Its direction is equal to the direction of relative motion (DRM), and its length is equal to the speed of relative motion (SRM).

e-m – vector "e->m" represents the contact ship vector (i.e. the contact's true course and speed). It is always drawn from point "e" to point "m."

The Speed Triangle

When solving maneuvering board problems, the above mentioned vectors will "fit" together in a triangular shape. This **speed triangle** can take many shapes, sometimes even forming a line! As a general principle, the vectors described above can be reduced to the principle illustrated below:



It is very important to keep the orientation of each vector in mind – for instance plotting the vector "m->e" would lead to an incorrect calculation of a contact's true course.

Often, it helps if beginning students draw this triangle in the margin of the maneuvering board to remind themselves of what they are looking for.

Risk of Collision

Rule seven in the International Regulations for Preventing Collisions at Sea, more commonly known as the "Rules of the Road," states:

> "*Every vessel shall use all available means appropriate to the prevailing circumstances and conditions to determine if risk of collision exists. If there is any doubt, such risk shall be deemed to exist.*
>
> *Proper use shall be made of radar equipment if fitted and operational, including long range scanning to obtain early warning of risk of collision and radar plotting or equivalent systematic observation of detected objects.*
>
> *Assumptions shall not be made on the basis of scanty information, especially scanty radar information.*
>
> *In determining if risk of collision exists, the following considerations shall be among those taken into account:*
>
> > *Such risk shall be deemed to exist if the compass bearing of an approaching vessel does not appreciably change.*
> >
> > *Such risk may sometimes exist even when an appreciable bearing change is evident, particularly when approaching a very large vessel or a tow or when approaching a vessel at close range.*"

As applied to this publication, the underlined phrase indicates that systematic observation of a contact using a maneuvering board (as well as other means) meets the requirements of the law.

The main purpose of marine radar, and the maneuvering board, is to aid the mariner in making collision avoidance decisions at sea.

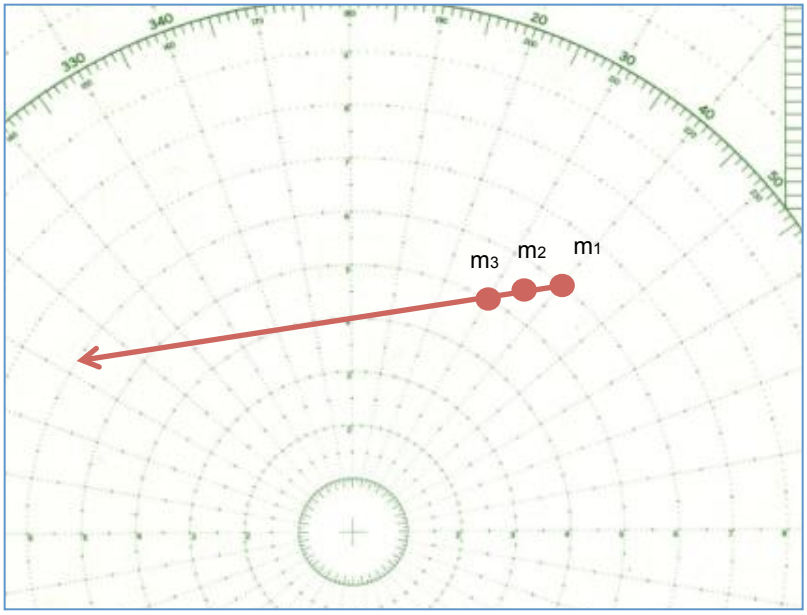
The best way to avoid collisions is to check the **closest point of approach**, or CPA, for each radar contact encountered.

Closest Point of Approach

The CPA of a radar contact is simply the point at which it is closest to your vessel. This point has a bearing (BCPA), range (RCPA), and time (TCPA) associated with it, and obtaining this data will help you decide if the contact is a risk of collision.

Problem 3-1. *Using a maneuvering board, determine the BCPA, RCPA, and TCPA for the following contact.*

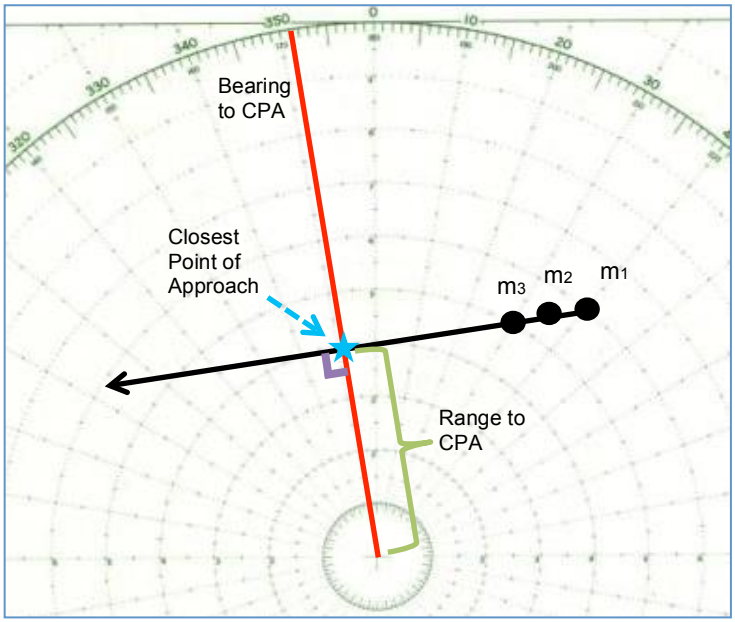
Time: 0100. Bearing 040°T. Range 6.0nm.
Time: 0106. Bearing 035°T. Range 5.5nm.
Time: 0112. Bearing 030°T. Range 5.0nm.



Step 1: Plot the contact.

This is the same contact plotted in Part 1, Problem 1-1.

Step 2: Determine the bearing to CPA (BCPA) and range to CPA (RCPA).

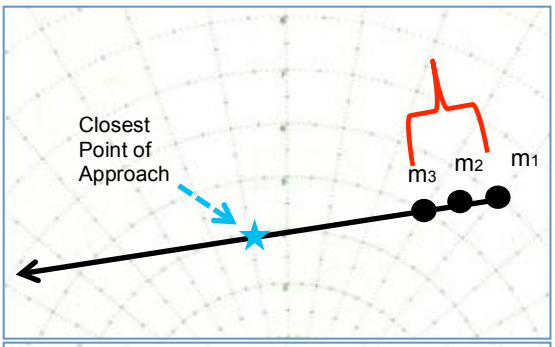


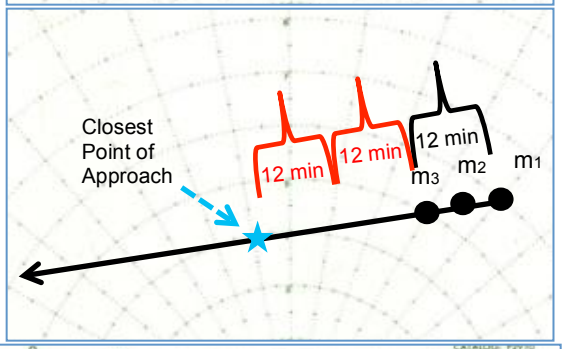
The bearing and range to closest point of approach are located at the point where the relative motion line (RML) is closest to the origin of the maneuvering board. To determine this position, use a parallel ruler to draw a perpendicular line from the relative motion line to the origin. Measure the bearing and range to CPA (BCPA and RCPA). The values are 351°T and 3.8 nm in this case.

Step 3: Determine the time to CPA (TCPA).

Depending on the level of detail required in the problem, there are two ways to accomplish this task.

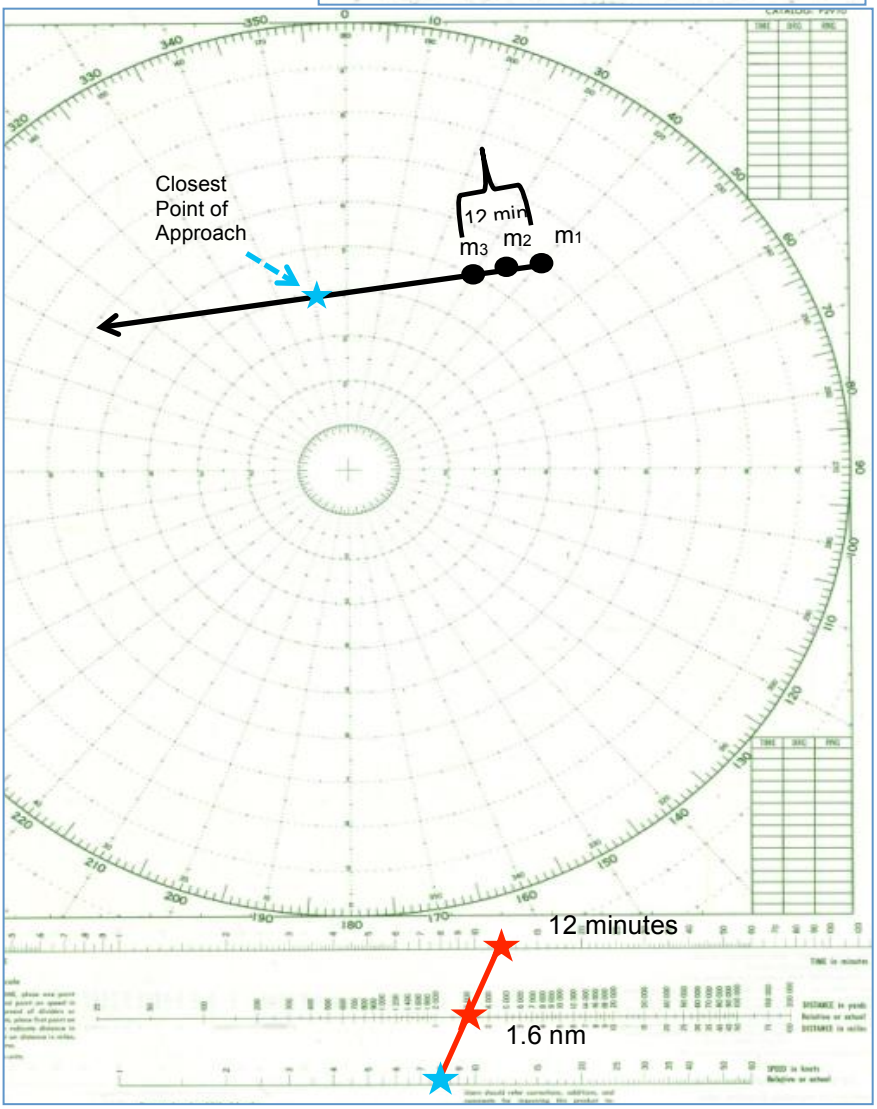
For non-critical problems (e.g. just checking the approximate time to CPA for a contact with no risk of collision), you can "walk" down the relative motion line with a pair of dividers. Assuming the contact covered a certain distance from M1 to M3 in 12 minutes, you can set the dividers to this distance, and walk from M3 to the CPA point, counting each gap as 12 more minutes (e.g. "12 minutes, 24 minutes, 36 minutes etc") until you can approximate the TCPA.





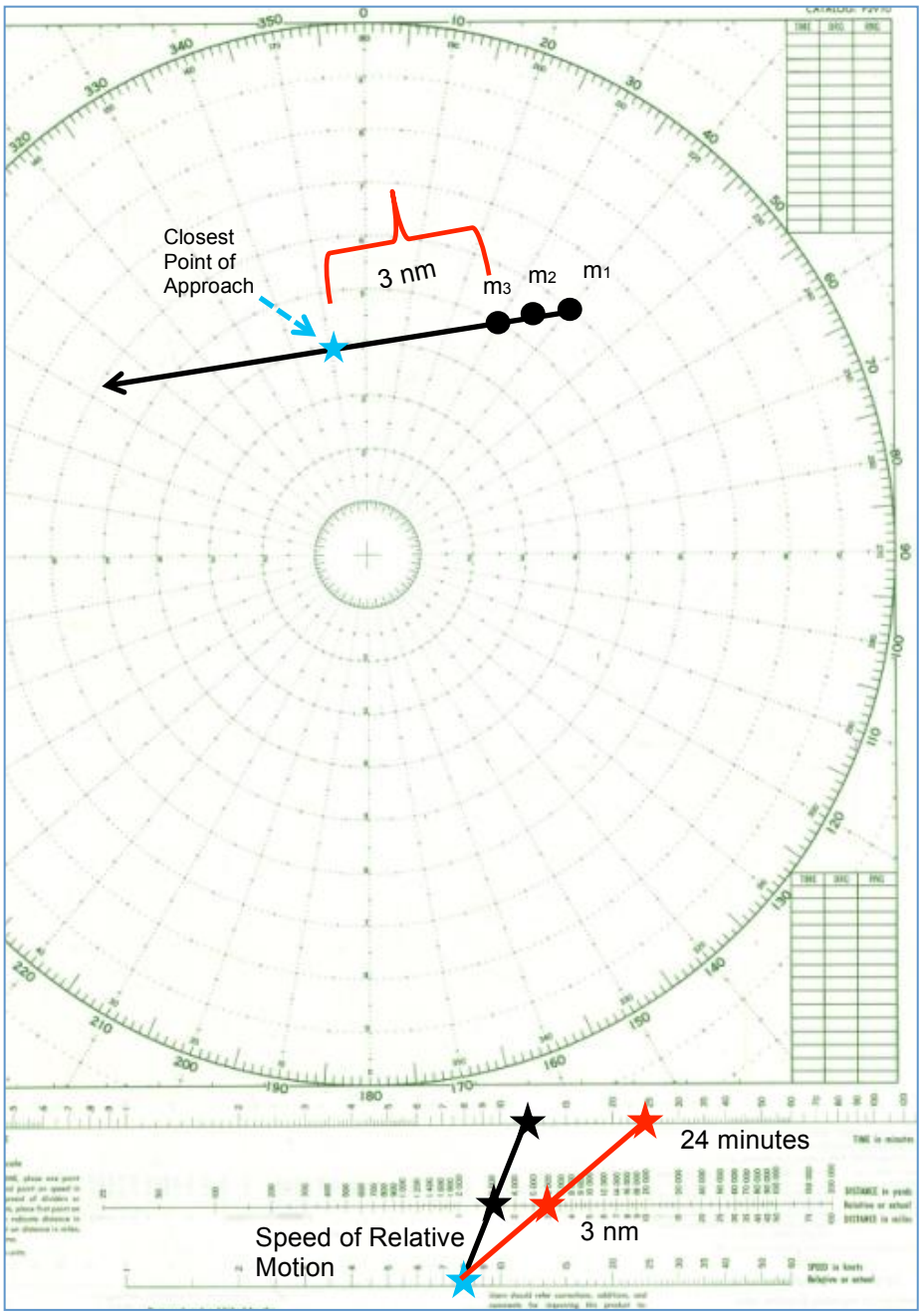
For critical problems (e.g. exam problems, qualification problems, or contacts which may have risk of collision), the answer should be obtained using the speed-distance-time **nomogram** at the bottom of the maneuvering board.

To use the nomogram, mark the distance the contact covered from M1 to M3 (1.6 nautical miles in this case).



Next, mark the time interval from M1 to M3 (12 minutes in this case).

Finally, draw a line through the distance and time marks to obtain the contact's **speed of relative motion (SRM).** The speed of relative motion is an abstract concept which indicates how quickly the contact moves down the relative motion line. It is not the same as the contact's true speed. Instead, it indicates how quickly the two ships are closing together.



Imagine two cars each driving north. If you are moving 60mph and the car ahead of you is moving 50 mph, the speed of relative motion is 10mph. If the two cars are driving in opposite directions (but with the same individual speeds), the speed of relative motion would be 110 mph. At sea, contact's individual vectors combine to produce a speed of relative motion.

Using the speed of relative motion, you next proceed in the opposite direction on the nomogram. Measure the distance along the relative motion line from M3 to the CPA (3 nm in this case), and place a mark on the distance scale of the nomogram. By connecting the speed of relative motion mark with the distance mark, a new time value is obtained. This is the amount of time from M3 to CPA (24 minutes in this

case). However, since the measurement was from M3 (0112), the actual time of CPA is 0112 + 24m, so **the time of CPA is 0136.**

Accuracy in Measurement

Obviously one should be as accurate as possible when completing maneuvering board problems. However, since ships are always in motion, and individual measurements may vary, the following parameters are generally considered acceptable, particularly in academic problems:

Bearing to CPA: **± 10° to the given solution.**
Range to CPA: **± 0.5 nm or 1000 yards to the given solution.**
Time to CPA: **± 5 minutes to the given solution.**

Additional Problems and Answers

Problem B-2. Using a maneuvering board, determine the bearing, range, and time to CPA.

Time: 1430. Bearing 355°T. Range 8.0 nm.

Time: 1436. Bearing 350°T. Range 7.0 nm.

Time: 1442. Bearing 344°T. Range 6.2 nm.

Answer:

BCPA: 299°T

RCPA: 4.4 nm

TCPA: 1448

Problem B-3. Using a maneuvering board, determine the bearing, range, and time to CPA.

Time: 0230. Bearing 120°T. Range 5 nm.

Time: 0233. Bearing 120°T. Range 4.5 nm.

Time: 0236. Bearing 120°T. Range 4 nm.

Answer:

BCPA: 120°T - CBDR

RCPA: CBDR

TCPA: 0300

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Part Four: Course and Speed Determination

Two Worlds

In the previous Part, we learned how to calculate the closest point of approach (CPA) of a contact using the direction of relative motion and the speed of relative motion.

Moving forward, it is important to note that there are two "worlds" on the maneuvering board. So far, we've dealt with the relative motion line world. Always remember that the relative motion line indicates where the contact actually is. If neither ship changes its vector, the contact will continue to move down the relative motion line, regardless of any other vectors you happen to draw.

The second "world" of the maneuvering board is more theoretical, and allows us to calculate the true course and speed of the contact in question. To do this, we utilize the speed triangle (Part 2) to combine vectors to determine the true vector for the contact.

It is important to note that these two "worlds" should be kept mentally separate – even if they are both plotted on the same maneuvering board. Although you can use different scales for each "world," beginners can be easily confused by the length of each vector – so pay careful attention to measurements!

True Course and Speed Determination

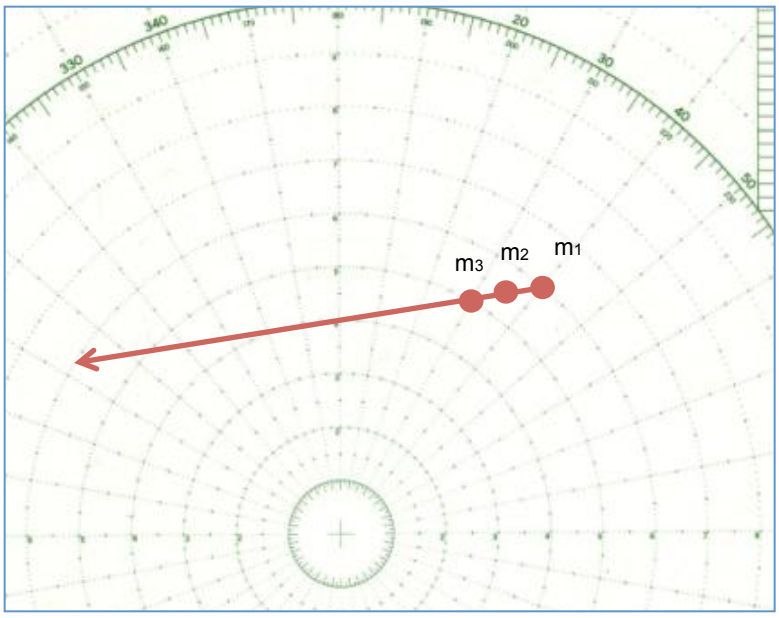
Determining the true course and speed of a contact is relatively easy once the speed of relative motion has been determined (Part 3).

Problem 4-1. *You are on course 050°T at 5 knots. Using a maneuvering board, determine the true course and speed for the following contact:*

Time: 0100. Bearing 040°T. Range 6.0nm.
Time: 0106. Bearing 035°T. Range 5.5nm.
Time: 0112. Bearing 030°T. Range 5.0nm.

Step 1: Plot the contact.

This is the same contact potted in Part 1, Problem 1-1.

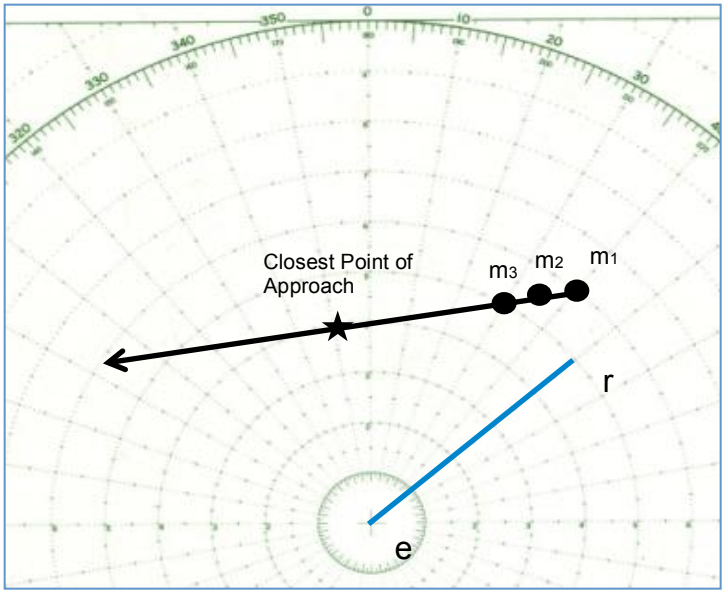


Step 2: Determine the speed of relative motion.

This step was completed in Part 3, Problem 3-1. The speed of relative motion is 8kts.

Step 3: Draw your own-ship vector, E to R.

Your ship is on course 050°T at 5 knots. Use a 1:1 scale in this case, by plotting directly on the board.

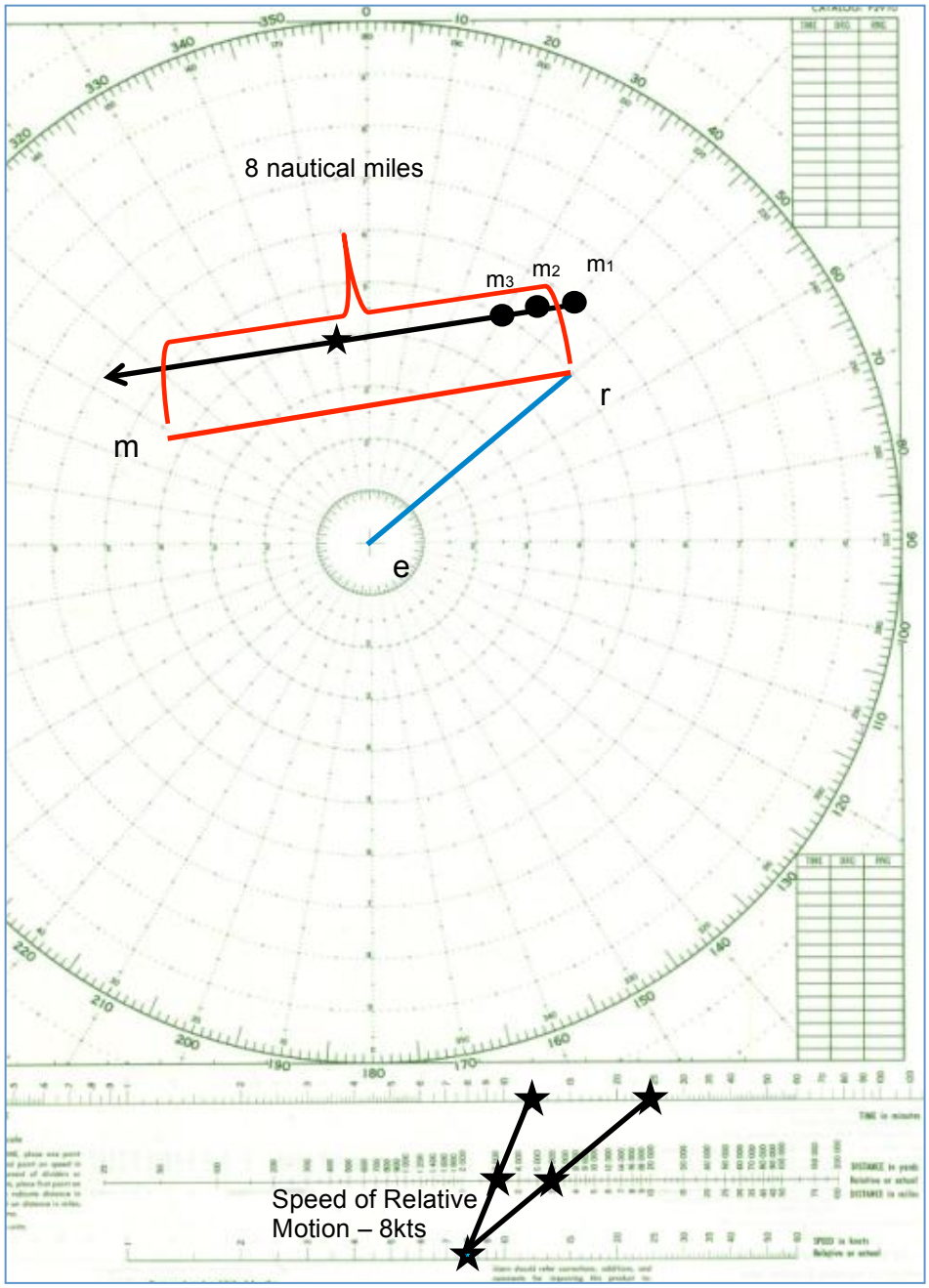


Step 4: Draw the relative motion vector from R to M.

There are two ways to accomplish this. First, you could set up a parallel ruler using the direction of relative motion obtained earlier (262°T in this case), and then parallel the line to point "r."

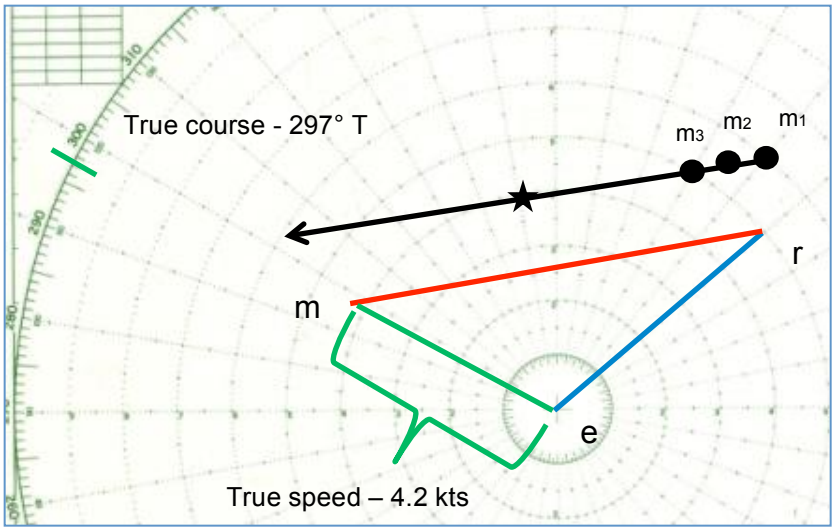
The more common way to draw the R-M vector is to simply parallel the actual relative motion line (where the contact positions are labeled) to point "r."

The length of the relative motion vector (R-M) is equal to the speed of relative motion (determined earlier to be 8 knots, or 8 nautical miles).



Step 5: Determine the true course and speed of the contact using the E-M vector.

The remaining vector, from "e" to "m" represents the contact's true course and speed.



The true course is equal to the bearing of the E-M vector, and the true speed is equal to the length of the E-M vector.

Your answers may vary slightly based on the intricacies of plotting and measurement.

In this example, the contact's true course is **297°T** and its true speed is **4.2 knots**.

Problem 4-2. *You are on course 060°T at 20 knots. Using a maneuvering board, determine the true course and speed for the following contact:*

Time: 0000. Bearing 090°T. Range 11 nm.
Time: 0003. Bearing 088.5°T. Range 10 nm.
Time: 0006. Bearing 087°T. Range 9 nm.

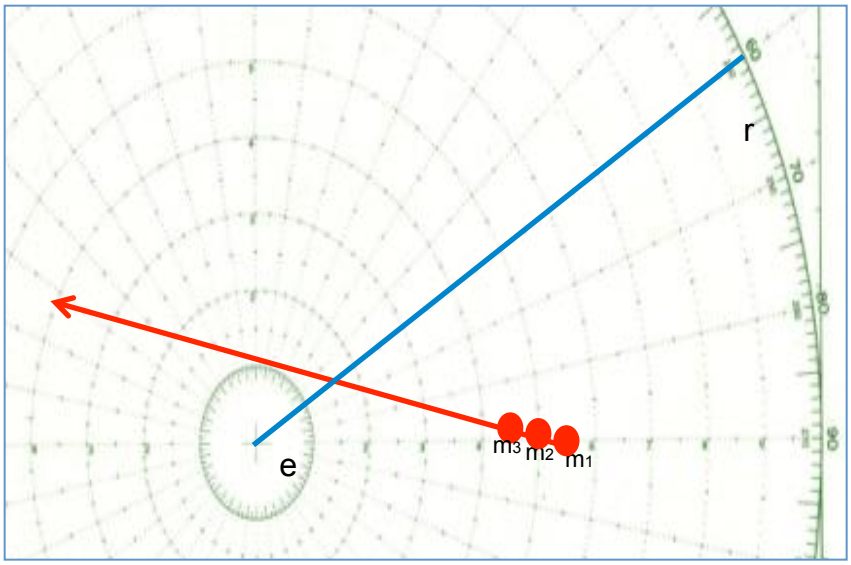
In this example, we'll proceed from beginning to end, as if you were completing this calculation on watch.

Step 1: Draw your own-ship vector E to R.

Your ship is on course 060°T at 20 knots. Use a 2:1 scale in this case, by making all measurements on the 2:1 scale on the left side of the maneuvering board.

Step 2: Plot the contact.

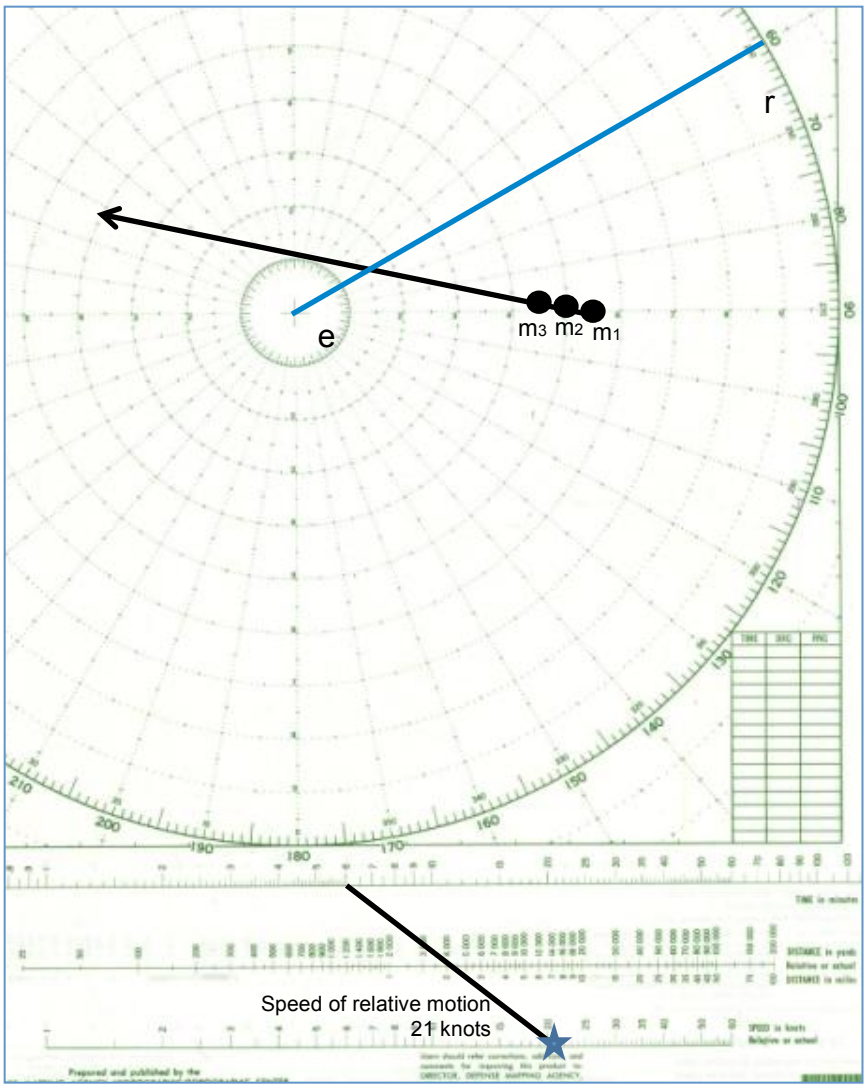
Plot three positions for the contact and draw the relative motion line.



Step 3: Determine the speed of relative motion.

By noting the distance the contact travelled (2.2 nm) in the elapsed time (6 minutes), we can determine the speed of relative motion using the speed-distance-time nomogram. The SRM is 21 knots.

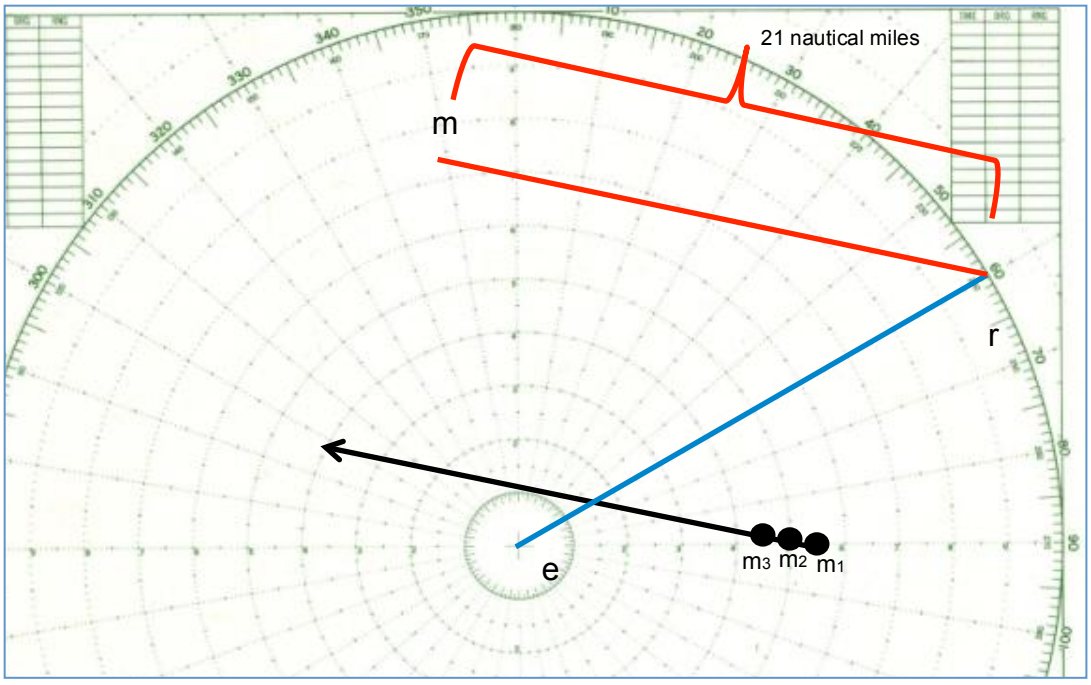
At this point, you could determine the CPA bearing, range, and time if desired (Part 3). However, since we can clearly see the CPA is 2 nm, we'll skip the calculations in this case and focus on true course and speed determination.



Step 4: Draw the relative motion vector from R to M.

Parallel the actual relative motion line to point "r."

The length of the relative motion vector (R-M) is equal to the speed of relative motion (determined earlier to be 21 knots, or 21 nautical miles). Remember we are using a 2:1 scale.



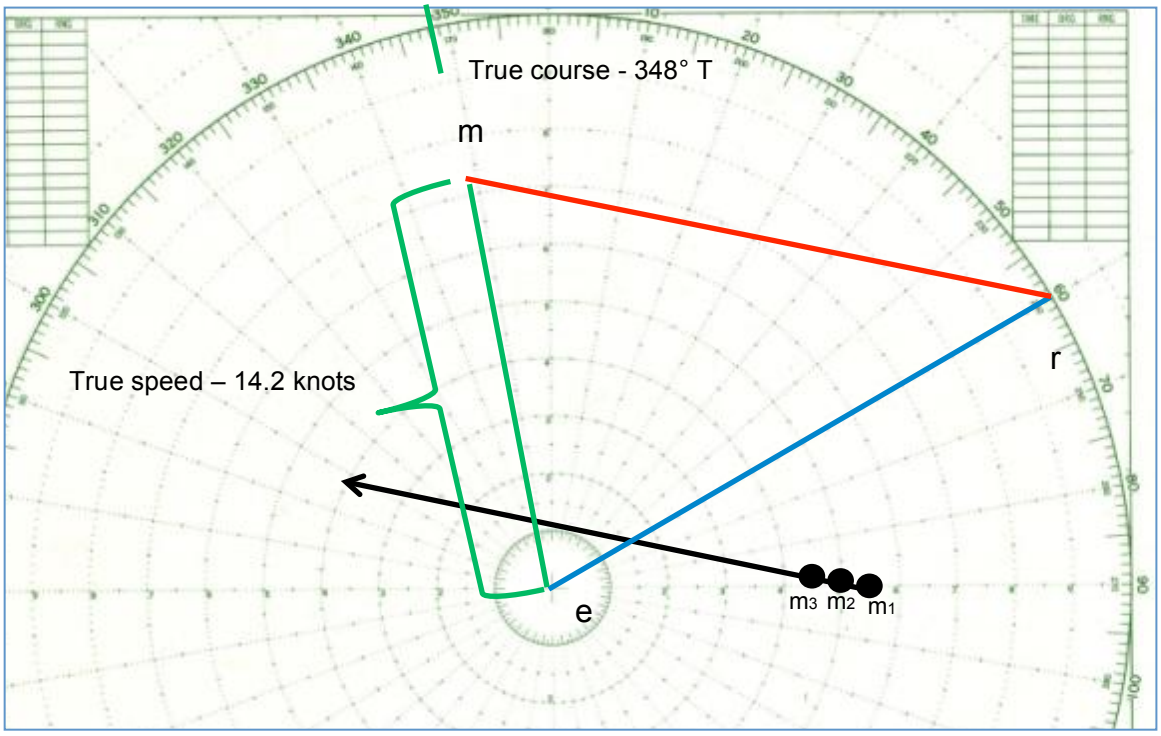
Step 5: Determine the true course and speed of the contact using the E-M vector.

The remaining vector, from "e" to "m" represents the contact's true course and speed.

The true course is equal to the bearing of the E-M vector, and the true speed is equal to the length of the E-M vector.

Your answers may vary slightly based on the intricacies of plotting and measurement.

In this example, the contact's true course is **348°T** and its true speed is **14.2 knots**.



Additional Problems and Answers

Problem B-4. You are on course 000°T at 5 knots. Determine the true course and speed for the following radar contact:

Time: 0000. Bearing 090°T. Range 5 nm.

Time: 0006. Bearing 087°T. Range 4.5 nm.

Time: 0012. Bearing 084°T. Range 4 nm.

Answer: True course 325°T, True speed 9 knots

Problem B-5. You are on course 180°T at 6 knots. Determine the true course and speed for the following radar contact:

Time: 0000. Bearing 165°T. Range 5 nm.

Time: 0006. Bearing 168°T. Range 4.5 nm.

Time: 0012. Bearing 171°T. Range 4 nm.

Answer: True course 245°T, True speed 3.5 knots

Problem B-6. You are on course 300°T at 12 knots. Determine the true course and speed, as well as CPA bearing, range, and time for the following radar contact:

Time: 1830. Bearing 285°T. Range 10 nm.

Time: 1833. Bearing 288°T. Range 9 nm.

Time: 1836. Bearing 292°T. Range 8 nm.

Answer: True course 050°T, True speed 15 knots.

BCPA: 350°T, RCPA: 4.2nm, TCPA: 1854

Problem B-7. You are on course 045°T at 18 knots. Determine the true course and speed, as well as CPA bearing, range, and time for the following radar contact:

Time: 2245. Bearing 060°T. Range 4.5 nm.

Time: 2248. Bearing 059°T. Range 4 nm.

Time: 2251. Bearing 058°T. Range 3.5 nm.

Answer: True course 020°T, True speed 9.5 knots.

BCPA: 338°T, RCPA: 1200 yards, TCPA: 2311

Problem B-8. You are on course 195°T at 8 knots. Determine the true course and speed, as well as CPA bearing, range, and time for the following radar contact:

Time: 0300. Bearing 195°T. Range 4 nm.

Time: 0303. Bearing 195°T. Range 3.25 nm.

Time: 0306. Bearing 195°T. Range 2.5 nm.

Answer: True course 015°T, True speed 7 knots.

BCPA: CBDR, RCPA: CBDR, TCPA: 0316

Accuracy in Measurement

Obviously one should be as accurate as possible when completing maneuvering board problems. However, since ships are always in motion, and individual measurements may vary, the following parameters are generally considered acceptable, particularly in academic problems:

Bearing to CPA: ± 10° to the given solution.
Range to CPA:± 0.5 nm or 1000 yards to the given solution.
Time to CPA: ± 5 minutes to the given solution.

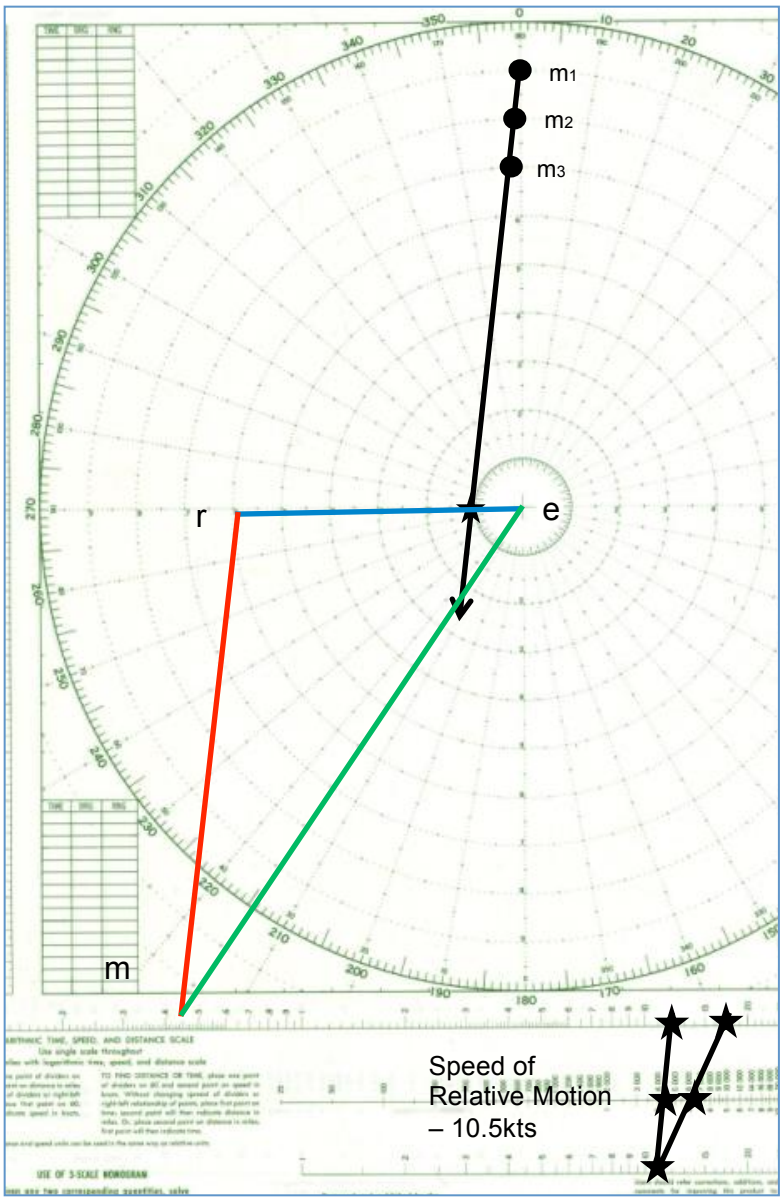
Risk of Collision

As described in Part 1 and Part 3, the maneuvering board enables rapid determination of **risk of collision**. Once risk of collision has been determined, and the rules of the road have been considered, the maneuvering board can also help you determine what changes in course or speed (if any) are necessary to obtain a desired **closest point of approach (CPA)**.

Avoidance Calculation

The first step in any avoidance calculation is to determine the true course and speed of the contact in question, using the steps outlined in Part 4. Once the true course and speed are indentified, and the rules of the road have been considered, you must determine a change in course or speed from the own-ship vector to enable a desired CPA.

The fundamental principle to know is that the contact vector does not change – instead, you create a new relative motion vector in order to obtain a desired CPA, then calculate "backwards" to determine what course or speed you must use to enable the desired CPA.



Problem 5-1. *You are on course 270°T at 6 knots. A contact on true course 215°T and speed 12.5 knots has the following bearings:*

Time: 0100. Bearing 000°T. Range 9 nm.
Time: 0106. Bearing 359°T. Range 8 nm.
Time: 0112. Bearing 358°T. Range 7 nm.

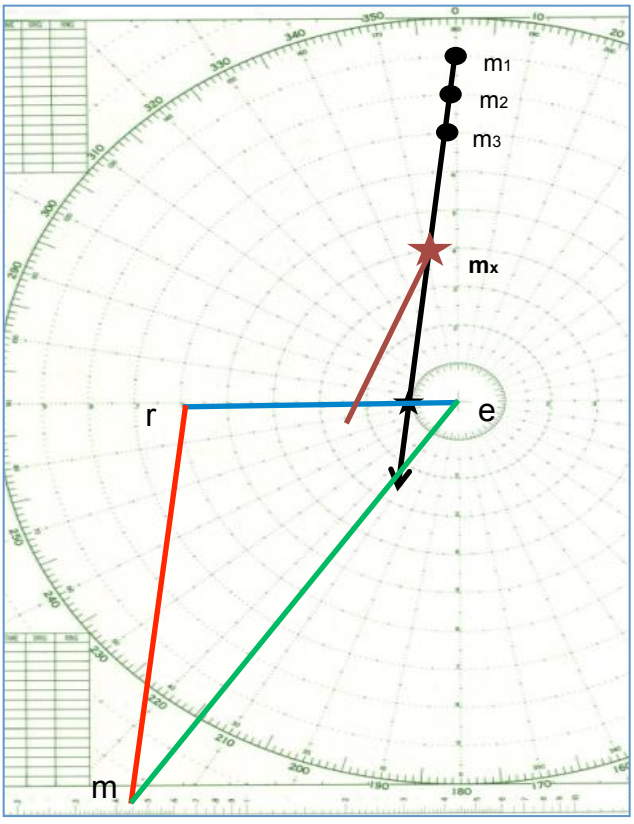
The current CPA of this contact is 1nm. You desire a CPA of 2 nm. First, verify the true course and speed of the contact. Then, when the contact reaches a point 4 nm away from your ship, alter course or speed such that the contact's new CPA opens to 2 nm.

Step 1: Plot the contact and determine true course and speed.

For a description of how to determine true course and speed, see Part 4. In this example, the true course and speed are given – verify your answer matches the given answer (within reasonable tolerances) before proceeding.

Step 2: Mark the moment of execution and draw the new relative motion line.

In this example, your own-ship desires to make a maneuver when the contact reaches 4nm. Find the point of the relative motion line which is 4nm away from the origin and mark it "Mx" for "moment of execution." This is the moment when your own-ship vector will change. Always remember that the contact will continue to travel down the relative motion line until one of the two ships changes it's vector. Therefore, leave enough time between M3 and Mx in order to make your calculations. There is nothing worse than altering course too late, and having to do the calculations again!

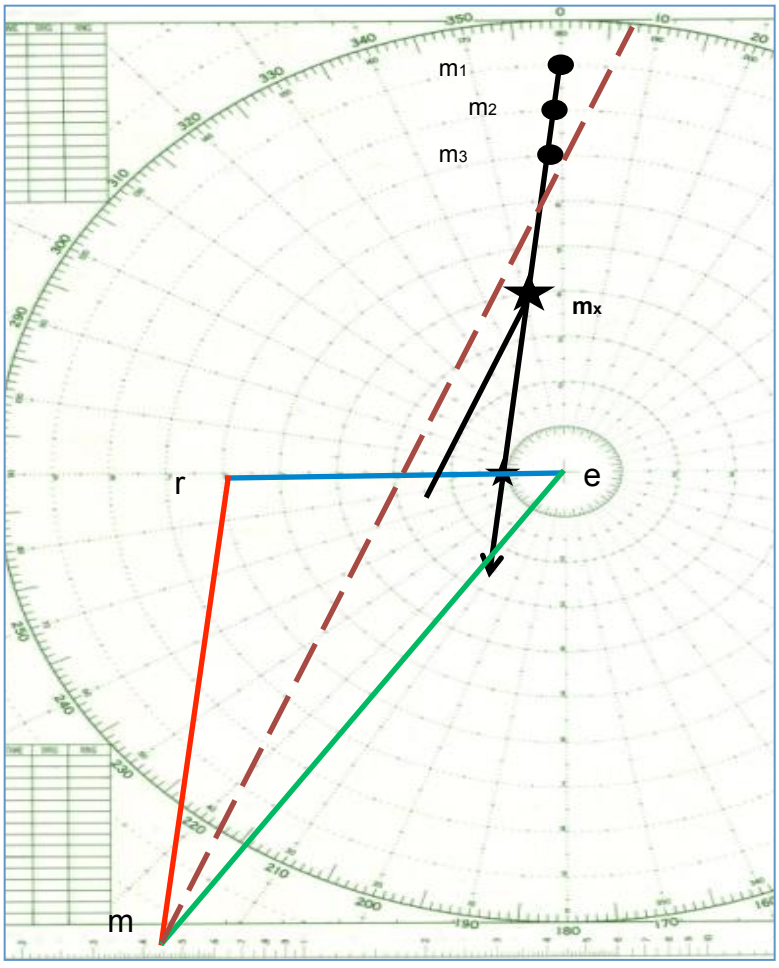


From the moment of execution, draw the new desired relative motion line. In this case we desire a CPA of 2nm, so draw a new relative motion line with a CPA of 2nm.

Step 3: Parallel the new relative motion line to point M, and draw the new relative motion vector.

Remembering that the contact vector (E-M) does not change, we must create a new relative motion vector. Be sure to draw the vector in the correct direction; generally it is opposite the direction you drew the original relative motion vector. For instance, you typically draw a relative motion vector in the direction from M1 to M3, which becomes R to M.

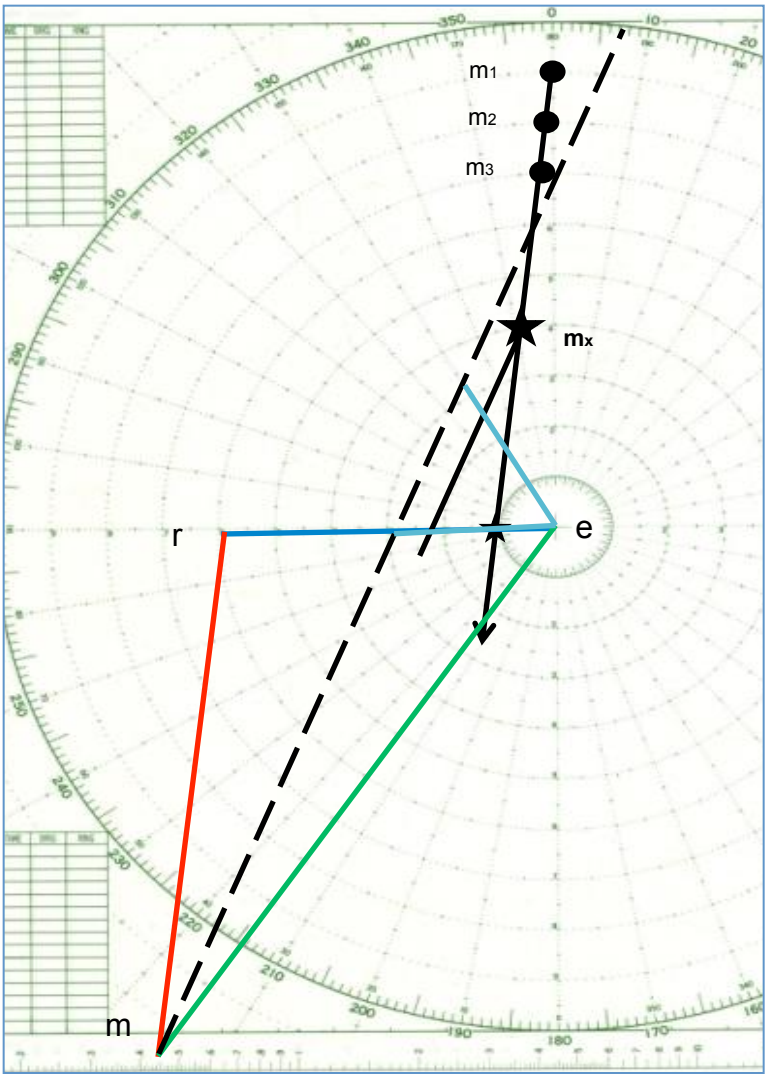
In the case of desired CPA problems, since we are drawing the new relative motion line from point M instead of point R, the line should be drawn backwards. Carefully consider your plot, and you will have no problem determining the correct direction.



Step 4: Determine the new course or speed required to obtain desired CPA.

Since the contact vector does not change, and we have drawn a new relative motion vector, a vector from the origin to *any* point along the new relative motion vector will yield a correct solution to provide a 2nm CPA.

So it is a matter of preference if your own-ship vector changes course or speed. In this case, we can simply keep our own course, but reduce speed to 3 knots. For clarity, another acceptable solution would be to alter course to 330°T and alter speed to 3.5 knots. This would also result in a 2nm CPA.

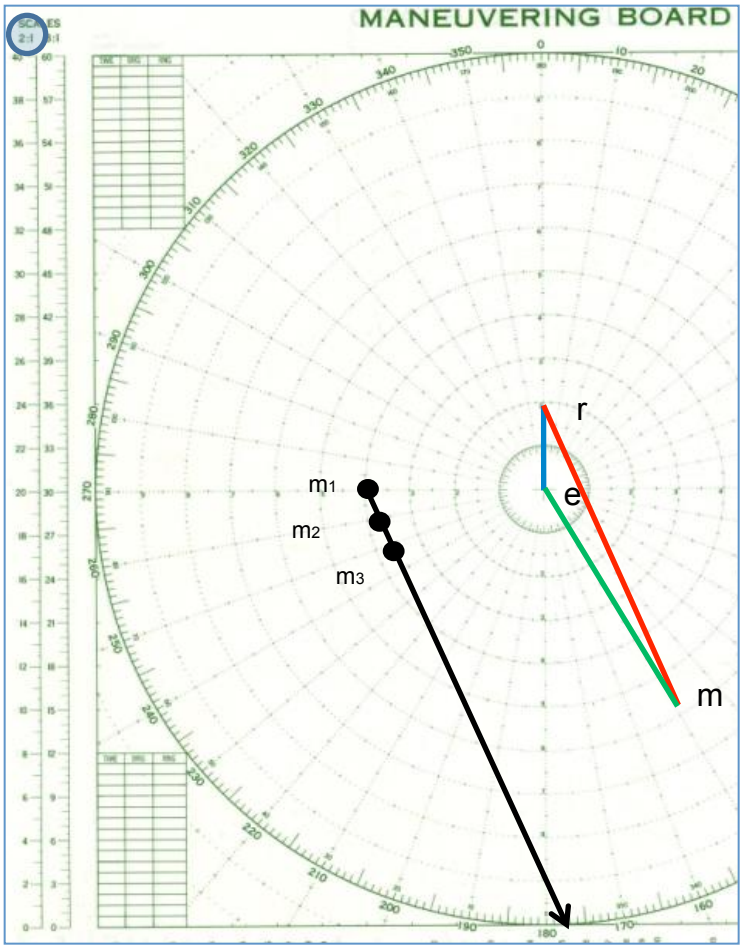


Intercept

Most often, the maneuvering board is used to aid in collision *avoidance* decisions – however it can also be used to calculate the course or speed to steer to intercept a contact, either for search & rescue, law enforcement, or logistical purposes.

Intercept Calculations

Intercept calculations are completed exactly like avoidance problems, with the desired CPA simply set to zero. As with avoidance problems, the first step is to calculate the true course and speed of the contact in question, using the steps outlined in Part 4.



Always keep in mind the fundamental principle of intercept and avoidance problems: the contact vector does not change – instead, you create a new relative motion vector in order to obtain a desired CPA, then calculate "backwards" to determine what course or speed you must use to enable the desired CPA.

Problem 6-1*. You are on course 000°T at 4 knots, patrolling several miles east of a closed fishing area. By radar, you spot a vessel which fits the profile of a vessel engaged in fishing inside the closed area. After calling the case in to higher authority and awaiting their response, you are directed to intercept the vessel and conduct a boarding to determine if any illegal activity occurred.*

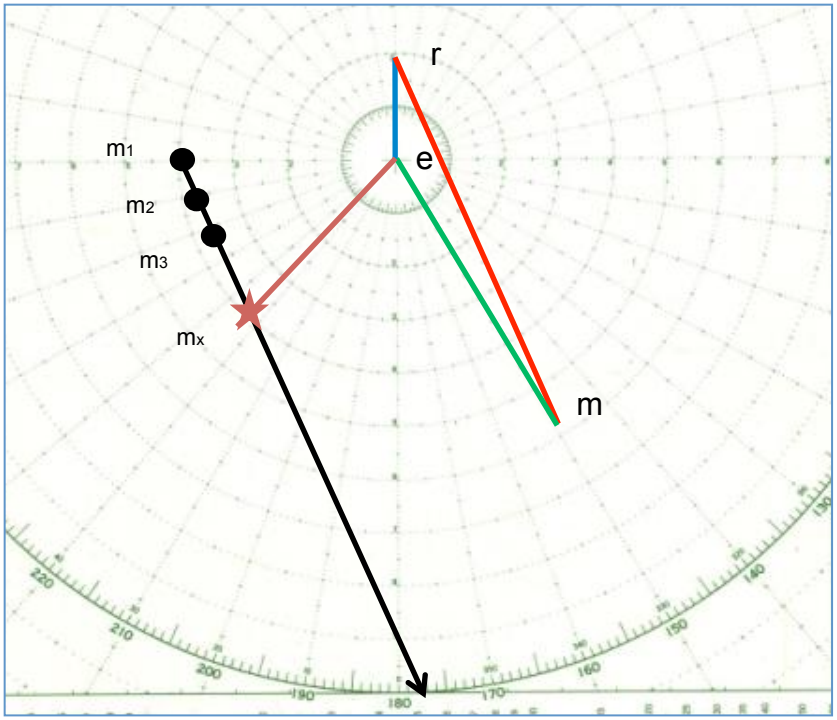
Time: 1300. Bearing 270°T. Range 8 nm.
Time: 1306. Bearing 259°T. Range 7.7 nm.
Time: 1312. Bearing 248°T. Range 7.5 nm.

The current CPA of this contact is past and opening. When the vessel is 8 nm away (again) and opening, alter course to intercept the contact using a speed of 18 knots.

Step 1: Plot the contact and determine true course and speed.

For a description of how to determine true course and speed, see Part 4. In this example, the true course and speed of the contact is 150°T at 11.5 knots. Your answer may vary slightly. We will also use a 2:1 scale in this example.

Step 2: Mark the moment of execution and draw the new relative motion line.

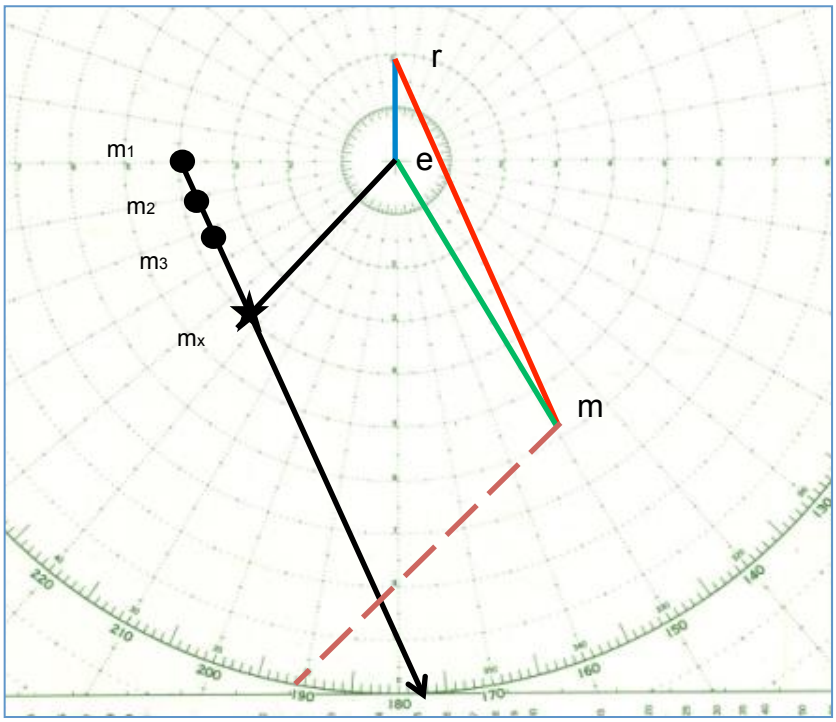


In this example, your own-ship desires to make a maneuver when the contact reaches 8 nm and opening. Find the point of the relative motion line which is 8 nm away from the origin and mark it "Mx" for "moment of execution." This is the moment when your own-ship vector will change. Always remember that the contact will continue to travel down the relative motion line until one of the two ships changes it's vector. Therefore, leave enough time between M3 and Mx in order to make your calculations. There is nothing worse than altering course too late, and having to do the calculations again! In this case, the moment of execution was given to you.

From the moment of execution, draw the new desired relative motion line. In this case we desire a CPA of zero (in order to intercept the contact), so draw a new relative motion line right to the origin.

Step 3: Parallel the new relative motion line to point M, and draw the new relative motion vector.

Remembering that the contact vector (E-M) does not change, we must create a new relative motion vector. Be sure to draw the vector in the correct direction; generally it is opposite the direction you drew the original relative motion vector. For instance, you typically draw a relative motion vector in the direction from M1 to M3, which becomes R to M.

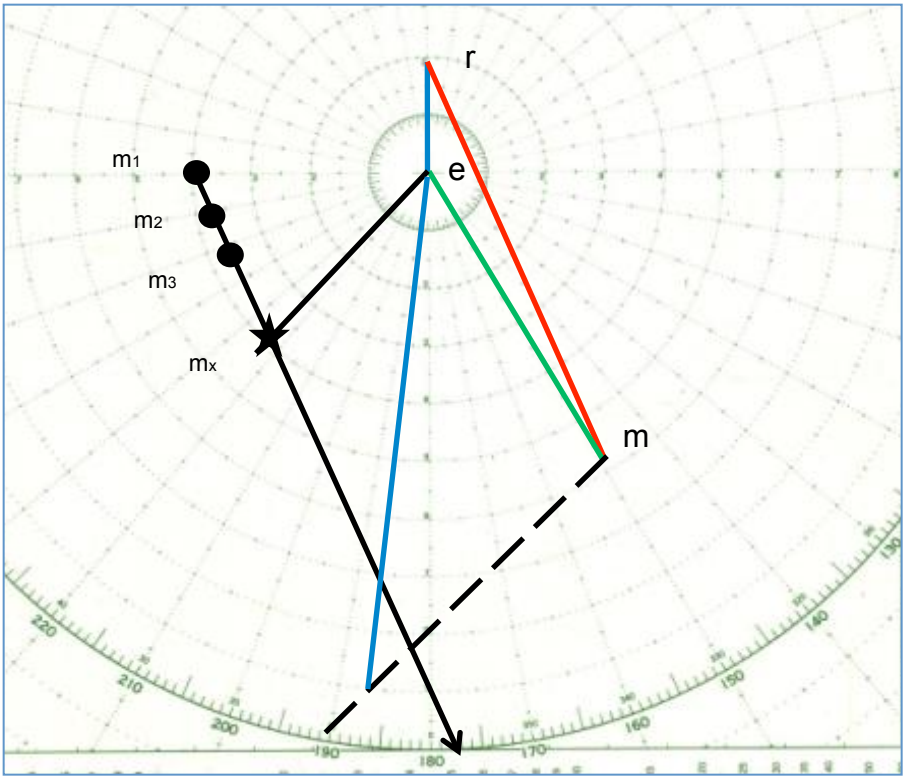


In the case of desired CPA problems, since we are drawing the new relative motion line from point M instead of point R, the line should be drawn backwards. Carefully consider your plot, and you will have no problem determining the correct direction.

Step 4: Determine the new course or speed required to obtain desired CPA.

Since the contact vector does not change, and we have drawn a new relative motion vector, a vector from the origin to *any* point along the new relative motion vector will yield a correct solution to provide a CBDR (constant bearing, decreasing range) situation – which is what we want in order to intercept the contact.

However, our direction was to intercept at 18 knots – so we set our dividers to 18 knots (remember we are using a 2:1 scale), and find the course that matches. In this case, the course to steer is approximately 188°T (your answer may vary slightly).



The Cutterman's Guide to Maneuvering Boards

Part Seven: True Wind Problems

Utility

The easiest use of the maneuvering board is for calculations of true wind speed and direction. With practice, this can be accomplished in a matter of seconds.

Relative Wind vs. Apparent Wind

When completing wind calculations on the maneuvering board, we will be using the board in a similar manner to determining CPA of a contact. The only concept we need to discuss is the difference between relative wind and apparent wind.

Relative Wind is the wind read off the anemometer on the bridge. If you were steaming on course 090° T and the anemometer read 030° at 10 knots, the relative wind would be 030° at 10 knots, or 30 degrees off the ship's starboard bow.

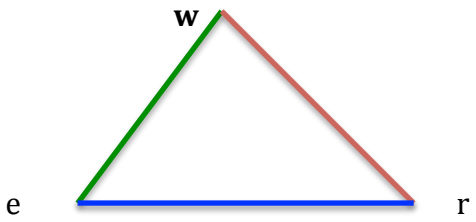
Apparent Wind is the compass direction of the relative wind, and can be determined by mathematically summing the course and the relative wind direction. If you were steaming on course 090° T and the anemometer read 030° at 10 knots, the **relative wind** would be 030° at 10 knots, or 30 degrees off the ship's starboard bow, but the **apparent wind** would be equal to the ship's heading (090° T) plus the relative wind direction (030° relative), for a total of 120° T.

A second example, because this is a critical point: if the own ship course was 090° and the anemometer read 010° relative, the apparent wind would be 100° True.

As a third example, sometimes this addition technique leads to nonsensical results…you must use common sense. If the relative wind was 330° (or 30 degrees off the port bow), the apparent wind would be equal to the ship's heading (090° T) plus the relative wind direction (330° relative), for a total of 420° T. Since this is greater than 360 degrees, you would subtract 360 degrees for a final answer of 060° T. Alternatively, you could simply subtract 30 degrees from the course to get the same answer.

The Relative Wind Triangle

To complete the true wind calculation on the maneuvering board, simply note the ship's vector (e-r), and note the apparent wind. Draw a vector from point r in the direction of the apparent wind equal to the distance of the apparent wind speed. The remaining vector (e-w), represents the true wind. It is important to note the vector is read from "e" to "w." A common error is to interpret the vector backwards.



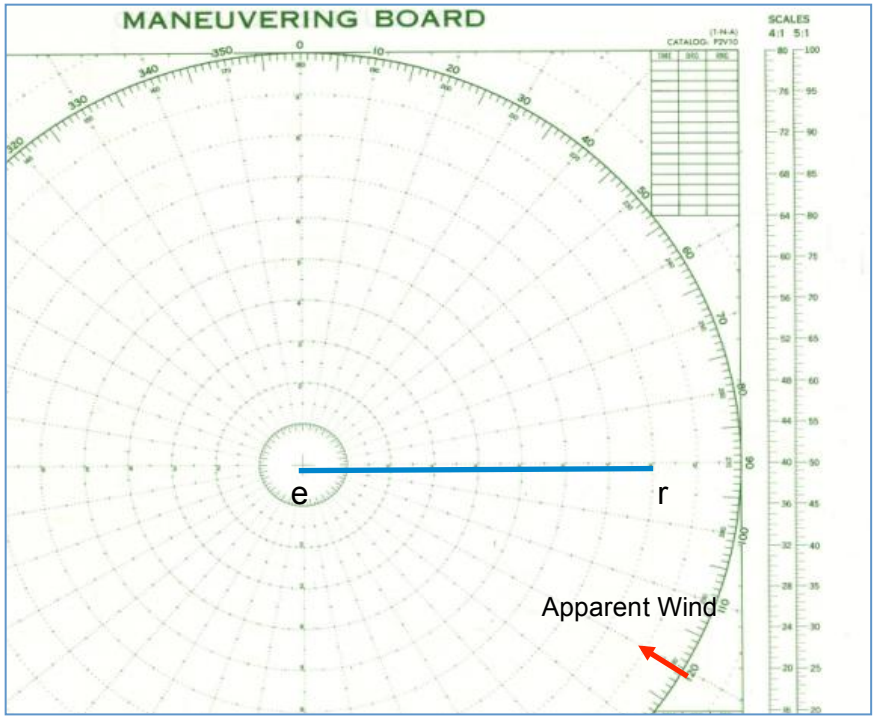
Solving for the True Wind

Problem 7-1. *You are steaming on course 090° T at 8 knots. The relative winds is 30° off the starboard bow at 11.5 knots. What is the true wind?*

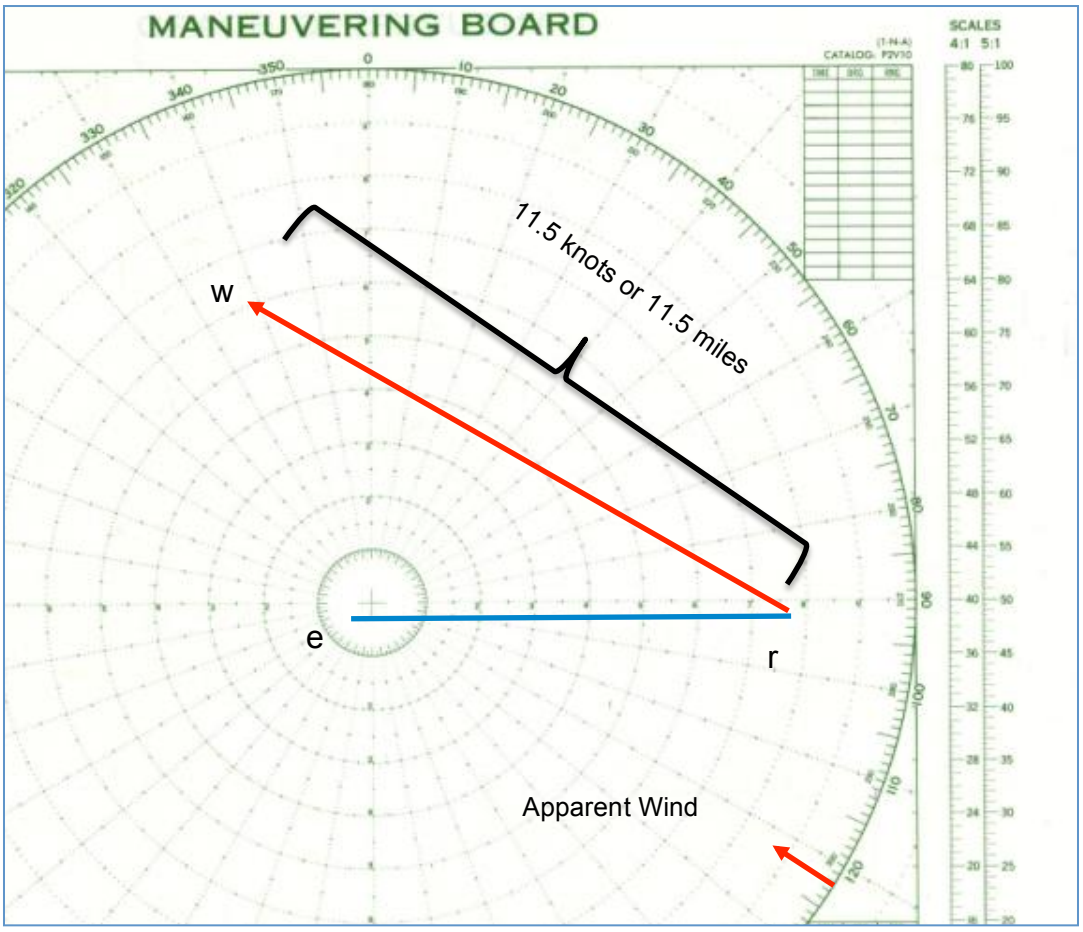
Step 1: Plot own ship's vector, and determine the apparent wind.

Plot the e-r vector as 090° and 8 knots.

If the relative wind is 30° off the starboard bow, the apparent wind is therefore 090° T + 30° R = 120° True.



Step 2: Plot the relative wind vector, "r-w."

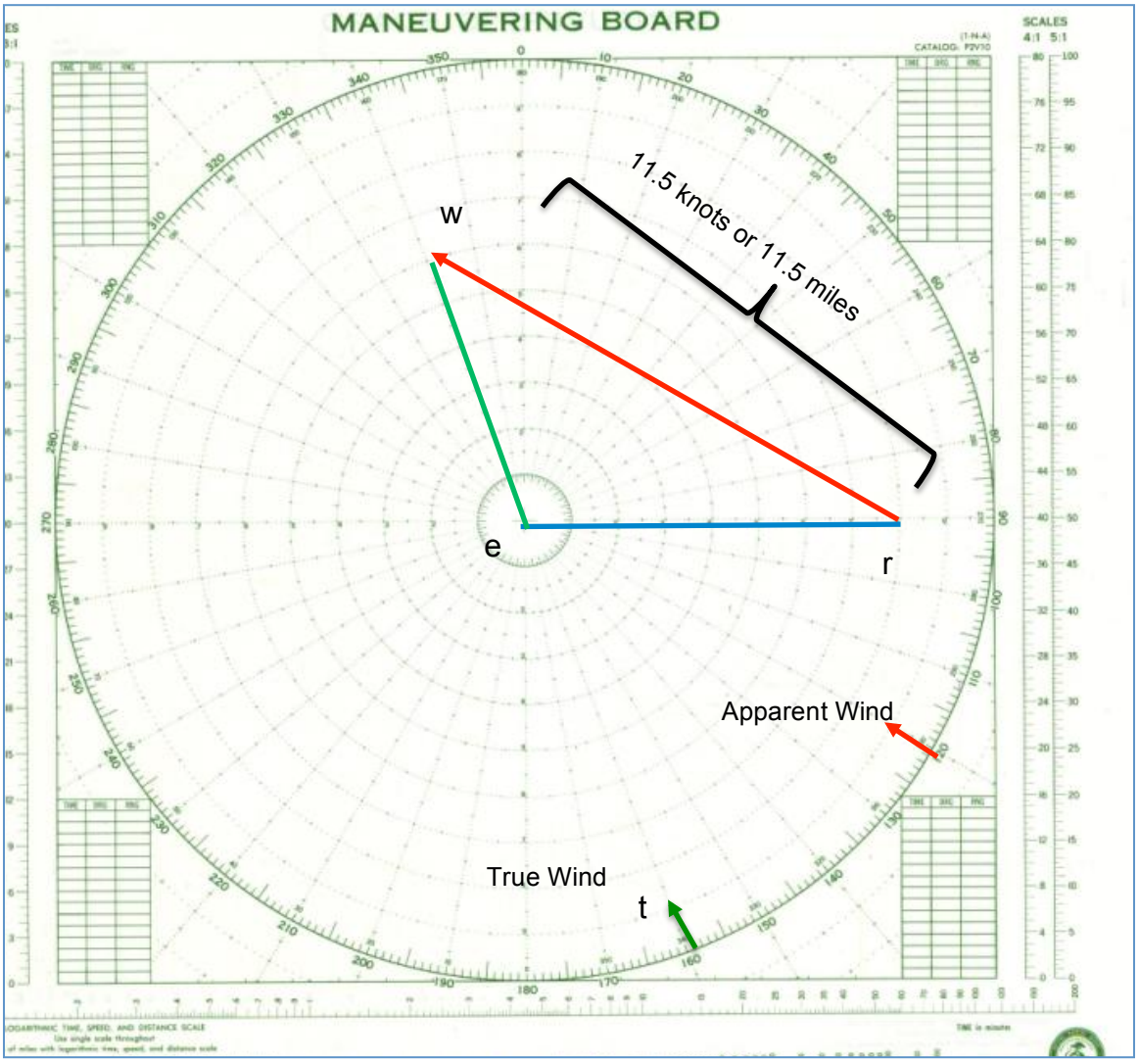


In order to perform this step, parallel the apparent wind vector to point "r" and extend it for 11.5 knots/miles. The vector is labeled "r-w."

Step 3: Determine the true wind.

The true wind is the resultant vector "e-w." It is critical to remember that the true wind is **FROM** "e" and extends **TO** "w."

A good way to remember this is the acronym WET…when plotting this final step, remember that if you read the labels in the order w, e, t, then the true wind will be clear to you. Another good thing to remember is that <u>the true wind is always on the same side, and aft, of the relative wind</u> on a moving vessel.



Additional Problem and Answer

Problem B-9. You are on course 055° T at 15 knots. The relative wind is 135° R at 5 knots. What is the true wind?

Answer:

224° T at 19 knots (+/- 10° and 2 knots is acceptable).

Utility

If your ship needs a certain wind speed and direction over the deck, for instance if conducting helicopter operations, the desired wind calculation can provide a quick answer.

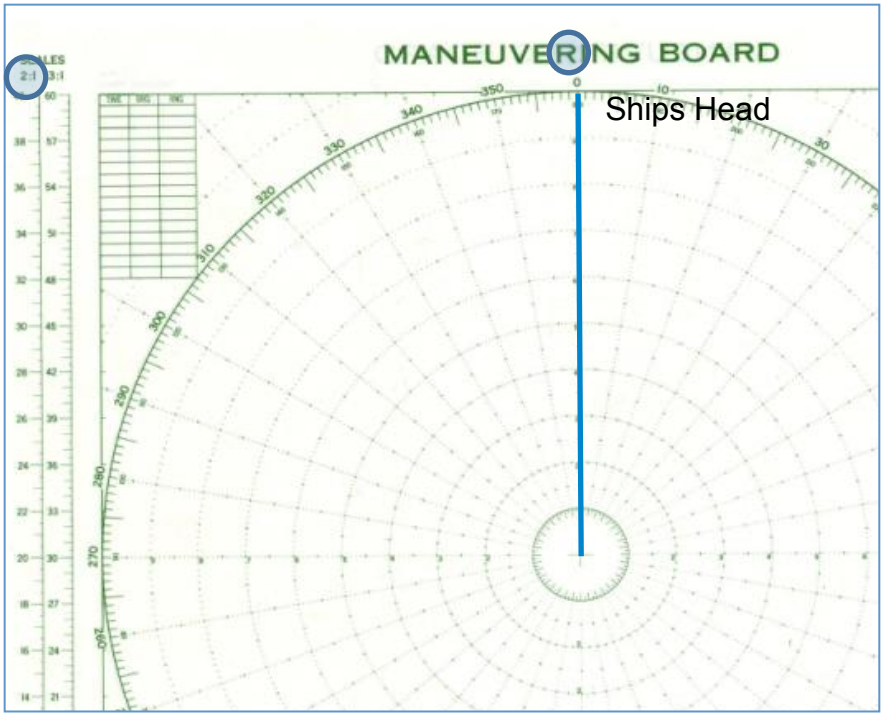
Desired Wind

There are at least three methods of determining desired wind. The method presented here is the quickest and easiest.

Problem 8-1. *The true wind is from 160° True at 6.5 knots. You desire a wind across your deck from 30° off the port bow at 12 knots for helicopter operations. What course and speed do you steer?*

Step 1: Set up the maneuvering board.

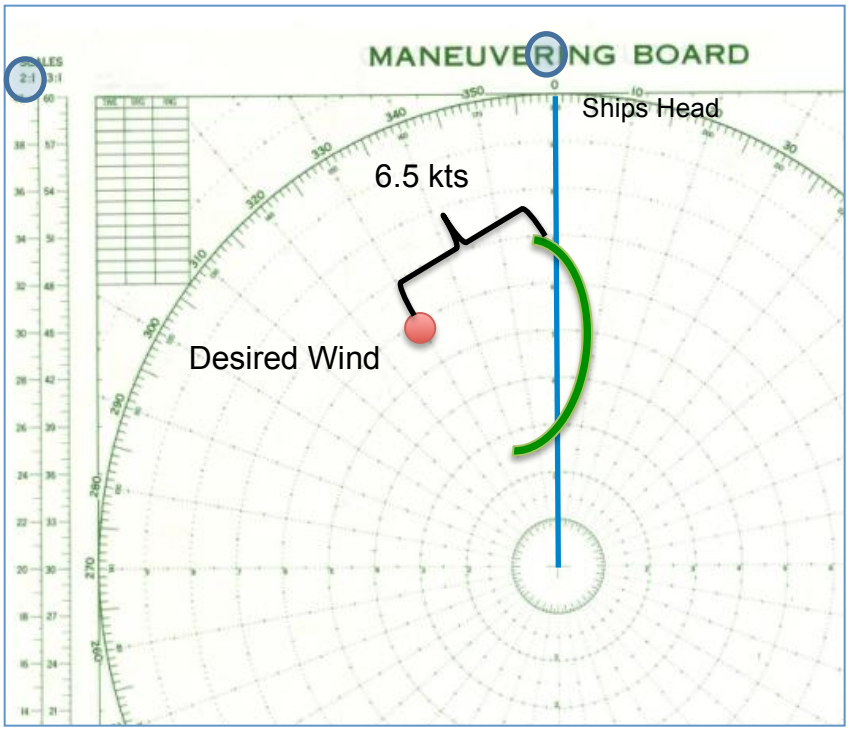
For these problems, we will use the maneuvering board in "relative mode." That is to say that the ship's head will be 000° on the maneuvering board, regardless of our course. Also, since the desired wind is 12 knots, we'll use the 2:1 scale.



Step 2: Plot the desired wind.

Given the desired wind of 30° off the port bow at 12 knots, use the 2:1 scale and plot a point at 330° and 6 miles.





Step 3: Plot the true wind speed.

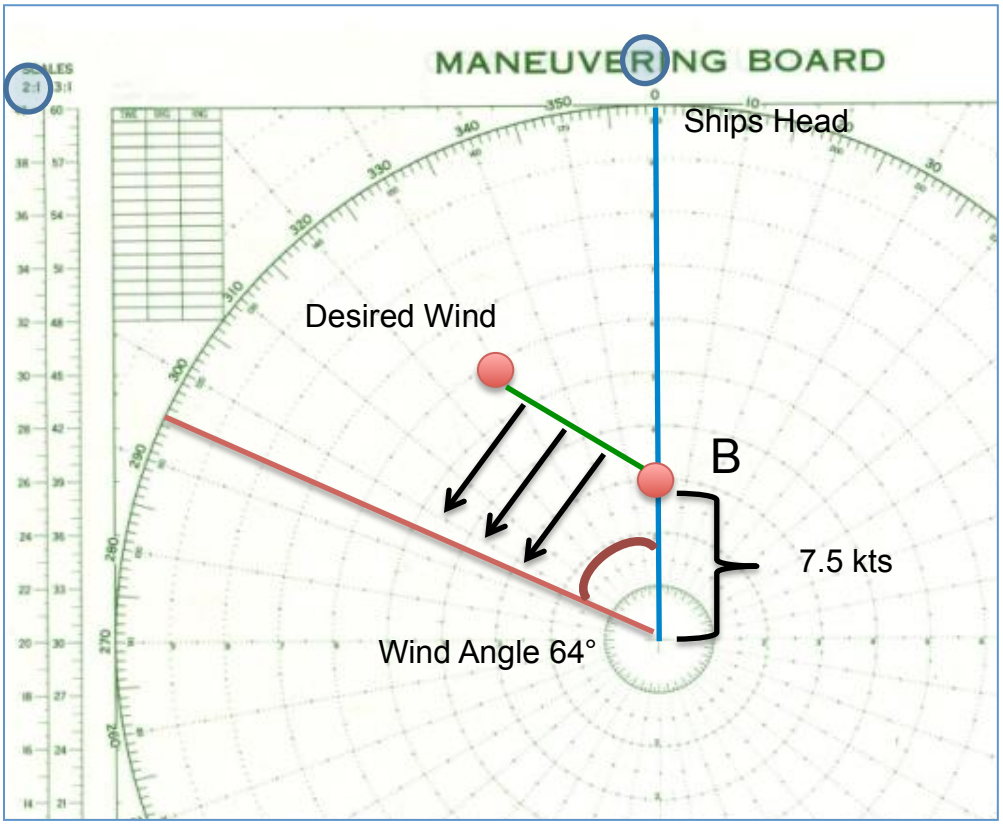
Set your dividers to the true wind speed (6.5 knots) on the 2:1 scale, and swing and arc from the desired wind point across the ships head. Be sure to extend the arc at least 180°, because there could be more than one solution.

Step 4: Determine the wind angle.

Either of the two points on the arc that cross the ships heading line will work for your desired wind. However, most often we choose the closest point to the origin because it will result in a lower ships speed. Label this point "B" and parallel it to the origin.

The **angle** between the heading line and this solution (64° in this case) represents the "bow angle." The bow angle is the number of degrees off of the true wind you must steer in order to obtain the desired wind.

In this case, we already knew that the true wind was from 160° at 6.5 knots. Since the maneuvering board is in "relative" mode, if we want our desired wind, we simply point our ship 64° away from the true wind, or 224° true.



True Wind: 160° T
Wind Angle: 64°
Course to Steer: 160+64 = **224° T**

The necessary ship speed is then measured from the origin to point "B", or **7.5 knots** in this case.

Additional Problem and Answer

Problem B-10. The true wind is from 030° T at 19.5 knots. The captain desires a wind from 30° off the port bow at 30 knots. What is the required course to steer?

Answer:

080° T (+/- 10° is acceptable).

Student Notes

Student Notes

Student Notes