Navigation Agenda for 2019

• Day 1: Navigation Topics Overview (90 min)
  – Key Learning Objectives
  – Wind and Weather
  – Tides and Currents
  – Washington Coastal Atlas
  – Moving Water
  – Charts
  – Group course plotting exercise

• Day 2: Planning for Tides & Currents (90 min)
  – Tides Stations and Tide Tables
  – Tide Exercise – filling in tide worksheet
  – Current Stations and Current Tables
  – Current Exercise (fill in worksheet for Blake Island)
  – Hope/Skagit Islands Homework Assignment

• Day 3: (100 min)
  – Review Homework
  – Elementary navigation
    – pilotage, dead reckoning, range finding, current compensation strategies
  – 50/90 Rule (Rule of thirds)
  – Homework Assignment

• Day 4: (20 min)
  – Review Homework
  – Weather – NOAA site
  – Wind Terrain Effects
  – Wind Shadow
Key Learning Objectives

• Understand weather’s effects on paddling

• Understand and interpret basic water dynamics and their impact on paddling

• Read and interpret Tide and Current tables

• Become familiar with and recognize importance of key elements of a navigational chart

• Perform basic navigation using pilotage

• Be able to make intelligent choices regarding paddling trips based on your own interpretation of the trip conditions and your skills.
What happens when the wind is blowing?

- Wind waves
- Slows you down or speeds you up
- Can push you over
- Pulls on your paddle
- Makes it hard to keep your boat going straight (tracking)

How can you anticipate what the wind and weather is going to do?

- NOAA Marine Forecast
- Weather sites (e.g. Windy.com, Wunderground…)
- Wind surfing sites (e.g. Windfinder, WindAlert…)
- Sharp changes in barometric pressure
- Count on an afternoon wind (sea breeze).
Wind

Atmospheric pressure at the Earth's surface is one of the keys to weather.

High and low pressure areas are important because they affect the weather.

A "high" is an area where the air's pressure is higher than the pressure of the surrounding air.

A "low" is where the air pressure is lower.

Meteorologists don't have any particular number that divides high from low pressure; it's the relative differences that count.
A sea breeze (or onshore breeze) is a wind from the sea that develops over land near coasts. It is formed by increasing temperature differences between the land and water which create a pressure minimum over the land due to its relative warmth and forces higher pressure, cooler air from the sea to move inland.
A wind blowing from land to sea (an offshore wind) which develops in coastal districts towards nightfall and is called a **land breeze**. Pressure is relatively higher above the land than above the sea as the land cools more rapidly in the evening, and air therefore moves seawards in order to even up the pressure difference.
Fetch is the distance the wind is able to move unobstructed over the water:

- As the wind blows over the water it causes friction and the water starts to ripple.
- Given an unobstructed fetch, and time, the wind will generate enough friction to develop (wind) waves.
- Combine that with an opposing current and the waves will get steeper.
- Fetch is an important factor in sea kayak (SK) trip ratings.
- Always consider fetch!
### Beaufort Wind Scale

**Estimating wind speed by direct observation**

<table>
<thead>
<tr>
<th>Beaufort number (force)</th>
<th>Wind speed Knots</th>
<th>Wind speed MPH</th>
<th>Wave height (feet)</th>
<th>WMO* description</th>
<th>Effects observed on the sea</th>
<th>Effects observed on the land</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>Under 1</td>
<td>Under 1</td>
<td>-</td>
<td>Calm</td>
<td>Sea is like a mirror</td>
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<tr>
<td>1</td>
<td>1 – 3</td>
<td>1 – 3</td>
<td>0.25</td>
<td>Light Air</td>
<td>Ripples with appearance of scales; no foam crests</td>
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<td>2</td>
<td>4 – 6</td>
<td>4 – 7</td>
<td>0.5 – 1</td>
<td>Light Breeze</td>
<td>Small wavelets; crests of glassy appearance, not breaking</td>
<td></td>
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<td>3</td>
<td>7 – 10</td>
<td>8 – 12</td>
<td>2 – 3</td>
<td>Gentle Breeze</td>
<td>Large wavelets; crests begin to break; scattered whitecaps</td>
<td></td>
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<tr>
<td>4</td>
<td>11 – 16</td>
<td>13 – 18</td>
<td>3 ½ - 5</td>
<td>Moderate Breeze</td>
<td>Small waves, becoming longer; numerous whitecaps</td>
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<tr>
<td>5</td>
<td>17 – 21</td>
<td>19 – 24</td>
<td>6-8</td>
<td>Fresh Breeze</td>
<td>Moderate waves, taking longer form; many whitecaps, some spray</td>
<td></td>
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<tr>
<td>6</td>
<td>22 – 27</td>
<td>25 – 31</td>
<td>9 ½ - 13</td>
<td>Strong Breeze</td>
<td>Larger waves forming; whitecaps everywhere; more spray</td>
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<tr>
<td>7</td>
<td>28 – 33</td>
<td>32 – 38</td>
<td>13 ½ - 19</td>
<td>Near Gale/Moderate Gale</td>
<td>Sea heaps up; white foam from breaking waves begins to be blown in streaks</td>
<td></td>
</tr>
<tr>
<td>Beaufort number (force)</td>
<td>Wind speed</td>
<td>Wave height (feet)</td>
<td>WMO* description</td>
<td>Effects observed on the sea</td>
<td>Effects observed on the land</td>
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<td>8</td>
<td>34 – 40</td>
<td>39 – 46</td>
<td>18 – 25</td>
<td>Fresh Gale/Gale</td>
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<td></td>
<td>9</td>
<td>41 – 47</td>
<td>23 – 32</td>
<td>Strong Gale</td>
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<tr>
<td></td>
<td>10</td>
<td>48 – 55</td>
<td>29 – 41</td>
<td>Whole Gale/Storm</td>
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<tr>
<td></td>
<td>11</td>
<td>56 – 63</td>
<td>37 – 52</td>
<td>Violent storm</td>
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<tr>
<td></td>
<td>12</td>
<td>64 and over</td>
<td>45 and over</td>
<td>Hurricane</td>
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<td>Moderate high waves of greater length; edges of crests begin to break into spindrift; foam is blown in well-marked streaks</td>
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<td>High waves; sea begins to roll; dense streaks of foam; spray may begin to reduce visibility</td>
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<td></td>
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<td>Very high waves with overhanging crests; sea takes white appearance as foam is blown in very dense streaks; tolling is heavy and visibility is reduced</td>
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<td>Exceptionally high waves; sea covered with white foam patches visibility further reduced</td>
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<td>Air filled with foam; sea completely white with driving spray; visibility greatly reduced</td>
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</tbody>
</table>

* World Meteorological Organization

Small Craft Advisory – 21 to 33 Kt (24 to 38 MPH) winds and/or wave heights exceeding 10 feet.

Gale Force Winds – 34 to 47 Kt (39 to 54 MPH) winds
Tides & Currents
Tides and Currents

Why do I need to know???
Tides & Currents

**Tides**

measured by height, tides are the vertical movement of water caused by the gravitational influences of other celestial bodies and the centrifugal forces as the earth rotates.

**Currents**

measured by speed and direction, currents are the horizontal movement of water caused when it moves from one area to another.
**Diurnal Tide:** Only a single high and a single low during each tidal day; successive high and low waters do not vary by a great deal. Such tides occur, for example, in the Gulf of Mexico, Java Sea and in the Tonkin Gulf.

**Semi-diurnal Tide:** The most common tidal pattern, featuring two highs and two lows each day, with minimal variation in the height of successive high or low waters. Such tides occur, for example on the east coast of North America, Central and South America.

**Mixed Semi-diurnal Tide:** Characterized by wide variation in heights of successive high and low waters, and by longer tide cycles than those of the semidiurnal cycle. Such tides occur, for example, in the U.S. Pacific coast and many Pacific islands.
Tides

Kayakers need very little water depth to paddle. Why worry about tides at all?

- Put in/Take out
- Lunch breaks (are you going to have to muck through mud to reach a beach?)
- Navigating in/around mudflats – who wants to wait for the tide to come back in while beached in their boat on a mudflat?

How are Mixed Semi Diurnal Tides different from Semi Diurnal Tides?

- Mixed Semi Diurnal Tides not only have two high tides and two low tides during a 25 hour period, the highs and lows are at different heights.

Why is that important?

- Suppose you pull your kayak onto the beach just above the lower high tide of the day. What will happen when the higher high tide of the day comes along?

“Hey! Where did our boats go?”
Tides

Spring tides - Moon is Full or New and gravitational + centrifugal forces aligned…

Result: Tides will be higher and lower (and currents faster)
Neap tides: Quarter moon. Sun and moon not in alignment…

Result: Tidal highs and lows will be less than average (and currents slower than average).
SOURCES OF TIDE INFORMATION

NOAA TIDE PREDICTIONS
https://tidesandcurrents.noaa.gov/tide_predictions.html

THE TIDEBOOK COMPANY
https://www.tidebookcompany.com/

TIDE & CURRENT APPS & LINKS

Always make sure to check the correct dates and relevant tide stations for your trip!

CAUTION: tide and current tables DO NOT factor in effects of wind and weather! Never depend on a single source of information when making travel decisions!!
Tides

Here is a handy way to check out Washington shorelines: the Coastal Atlas...
Use the Coastal Atlas to see aerial shore photos, beach access, and other info…
Tides

Let’s check out a put-in/take-out location: Fern Cove...
Tides

Fern Cove near low tide...check out that mudflat!
Tides

Now compare the date on the aerial photo with the NOAA tide data for Fern Cove on 8/8/2006...
Currents Overview

Currents are the horizontal movement of water caused when it moves from one area to another.

Current speed, direction, and behavior is influenced by tides, geographic features, and weather/wind.

Currents are measured in units of speed and direction.

Current prediction graphs and tables are different from tide prediction graphs and tables.

Currents are affected by the same moon/sun alignments as tides:

- When the sun and moon are aligned (spring tide), currents will typically move faster than average.
- When the sun and moon are not in alignment (neap tide), currents will typically move slower than average.

In what circumstances can this knowledge help you?
SOURCES OF CURRENT INFORMATION

NOAA CURRENT PREDICTIONS
https://tidesandcurrents.noaa.gov/noaacurrents/Regions

THE TIDEBOOK COMPANY
https://www.tidebookcompany.com/

TIDE & CURRENT APPS & LINKS

Always make sure to check the correct dates and relevant current stations for your trip!

CAUTION: tide and current tables DO NOT factor in effects of wind and weather! Never depend on a single source of information when making travel decisions!!
Moving Water Dynamics
Water Dynamics

Back Eddys
Water Dynamics

Tide Rips
Introduction to Charts
Charts vs. Maps … What’s the difference?
Charts

Charts vs. Maps ... What's the difference?

Charts

Have special unique characteristics including a very detailed and accurate representation of the coastline, which takes into account varying tidal levels and water forms, critical to a navigator.

• Working document used to plot courses for navigators.

• Way points are identified to indicate relative position and points at which specific maneuvers, such as changing courses, must be performed.

• Takes into account special conditions and risks such as tide rips; submerged rocks, wrecks and other hazards; aids to navigation; restricted areas; vessel traffic management systems; natural and artificial features on land visible from the water.
Charts
Charts vs. Maps ... What's the difference?

Maps

Emphasize land forms, including the representation of relief, with shoreline represented as an approximate delineation usually at mean sea level.

- Static document used as a reference guide; can not be used to plot a course.

- Provides a predetermined course, usually a road, path, etc., to be followed. Special consideration for the type of vehicle is rarely a consideration.

- Provide predetermined points-road intersections-to allow one a choice to change to another predetermined direction.
Charts
What do I need to know about nautical charts?

- Scale
- Features
- Soundings
- Latitude & Longitude
- Chart date & update info
Charts: Scale

Scale: an expressed **ratio of the size of a feature** on the chart to the actual size of the feature

Example

1 : 10,000 scale

1 inch on the chart = 10,000 inches in real life
Charts: Scale
LARGE scale vs. small scale

The terms large and small scale refer to the fraction !

Example

\[
\frac{1}{1} \gg \frac{1}{10,000} \gg \frac{1}{40,000} \gg \frac{1}{80,000}
\]

Bottom line:

A given feature will appear bigger on a large scale chart than on a small scale chart.
Chart No. 1 is not really a chart at all. It is a manual over 100 pages containing the meaning of all the symbols nautical charts. These include:

- Natural and cultural features
- Landmarks and ports
- Hydrology features
- Aids and services
- Hazards to navigation
- Safety notices
- https://www.nauticalcharts.noaa.gov/mcd/chartno1.htm

Printed version now $11.36 at Amazon.com
<table>
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<tr>
<th>Section Key</th>
<th>Chart Number, Title and Marginal Notes</th>
<th>INT 500 412</th>
<th>Mercator Projection</th>
<th>7th Ed., Mar. 9/09</th>
<th>DEPTHS IN METERS</th>
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<tr>
<td>A</td>
<td>Positions, Distances, Directions and Compass</td>
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<tr>
<td>B</td>
<td>Natural Features</td>
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<td>Cultural Features</td>
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<td>Landmarks</td>
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<td>Tides and Currents</td>
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<td>Nature of the Seabed</td>
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<td>I</td>
<td>Rocks, Wrecks and Obstructions</td>
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<td>Buoys and Beacons</td>
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<td>R</td>
<td>Small Craft (Leisure) Facilities</td>
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</table>

Charts: Features

Chart No. 1 Alternative

Contains all the information as in Chart No. 1 published by the government, but adds much more such as:

- The history of chart making
- Chart accuracy
- GPS and Electronic charts
- More detailed explanations of the symbols

Currently $18.70 at Amazon.com
Charts: Features

Some general notes...

Coloring

- Tan ➔ Land masses
- Greenish ➔ Mud at low tide
- Blue ➔ Water, depth down to 60 feet
- White ➔ Water, depth deeper than 60 feet

Italicized lettering ➔ object is subject to tidal changes

Standard lettering ➔ Object is fixed

Natural features

- Cliffs ➔
- Foreshore/mudflats ➔
- Rocks ➔

Charts: Soundings

**Soundings are depth measures** at specific points as indicated on the chart. The number given is the measure as it would be at the published low water datum for the chart (usually mean low low water [MLLW] for NOAA charts).

The unit represented by the number is in the chart notes. It is one of the following:

- Meters
- Feet
- Fathoms (units of 6 feet)

Key point to remember about soundings is that they are all relative to a particular low water datum, also known as the *Chart Datum* or *Sounding Datum*.

Always check your chart notes for the sounding datum and determine if the water is ever likely to be less than what is shown, and if so **WHEN!**
Mercator Projection

Scale 1:25,000 at Lat. 48°26'
North American Datum of 1983
(World Geodetic System 1984)

**SOUNDINGS IN FATHOMS**
**AT MEAN LOWER LOW WATER**

**SUPPLEMENTAL INFORMATION**
Consult U.S. Coast Pilot 7 for important supplemental information.

**TIDAL INFORMATION**

<table>
<thead>
<tr>
<th>Place</th>
<th>Height referred to datum of soundings (MLLW)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean High Water</td>
</tr>
<tr>
<td>Yokeko Point Deception Pass</td>
<td>10.5</td>
</tr>
<tr>
<td>(48°25′N/122°37′W)</td>
<td></td>
</tr>
<tr>
<td>Deception Pass St. Park, Bowman Bay</td>
<td>7.7</td>
</tr>
<tr>
<td>(48°25′N/122°40′W)</td>
<td></td>
</tr>
<tr>
<td>Anacortes, Guemes Channel</td>
<td>8.2</td>
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<tr>
<td>(48°31′N/122°37′W)</td>
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<tr>
<td>Swinomish Channel Ent., Padilla Bay</td>
<td>8.4</td>
</tr>
<tr>
<td>(48°28′N/122°31′W)</td>
<td></td>
</tr>
</tbody>
</table>
Charts: Latitude & Longitude

Latitude

Longitude
Charts: Latitude & Longitude

Latitude

180°
From pole to pole

1° = 60’ (minutes)

1’ = 1 nautical mile (nm)
Charts: Latitude

1 nm = 1 nautical mile (nm)
1 nm = 1.15 statue miles
Degrees of Longitude?

Because longitude is measured laterally (east to west), degrees of longitude must not be used for measuring distance.

Why?
Charts: Date and Updates


Make sure your charts are up-to-date!

Check the U.S. Coast Guard’s Navigation Center for more information on Notice to Mariners, Local Notice to Mariners, Coastal Pilot, and other update information.

[https://www.navcen.uscg.gov/](https://www.navcen.uscg.gov/)
And now, let’s play with charts!
Group Exercise
Plot a Course Using a Chart

Objectives:
- Identify important chart details and symbols along your planned course.
- Determine when and where tide and current might affect the trip.
- Identify areas where long fetch could be an issue and when.
- Plot waypoints and draw course legs.
- Determine compass readings (magnetic) for each leg.
- Determine distances traveled for each leg.
- Determine travel time for each leg.
- Estimate total trip time, including breaks.
NOTE: sea kayak compasses don’t have an adjustment for magnetic variation! The number you read off the compass is in degrees magnetic.
Group Exercise
Plot a Course Using a Chart

Plot a clockwise trip around Indian Island for 8/28/2016: Trip rating SK III/III+, challenging due to distance, fetch, current in excess of 2 kts, portage, boat traffic.

1) Assume sunny 70°F weather with 3-5kt winds from the south increasing to 8-10 kts after 2pm. Average group paddling speed 2.5 kts. On this day the tide is estimated to be at about 7 feet at Mystery Bay at 2:45pm and the current in the Port Towsnend Canal is estimated to be ebbing northward at about 2.5 kts by 4:00pm, toward a maximum of about 3 kts by 5:30pm.

2) Put-in and take-out at Port Hadlock.
3) Five minute rest stop off Kala Point.
4) Stay well away from the restricted area at Walan Point and other Navy facilities.
5) Thirty minute rest break at Fort Flagler boat launch.
6) Sixty minute lunch break at Mystery Bay State Park boat ramp.
7) Thirty minute rest break and portage at the isthmus between Indian and Marrowstone Islands at the 7 foot tide.
8) Paddle Port Townsend Canal before the current reaches 2.5 kt.
9) Mark way points in pencil on the chart.
10) Draw trip legs connecting waypoints then write down direction, distance, and time next to each leg. Assuming 2.5 kts paddling speed and magnetic variation 16° E
11) Travel time (minutes) = Distance (nm) / speed (knots) x 60

For classroom use only – not intended for navigation
What else should you know or do when planning this trip?

- Complete tide and current information for the date and locations planned, and the impacts they will have on the trip.
- Determine trip length, trip duration, launch time, and approximate ending time.
- Latest NOAA marine weather, wind, and zone forecasts for the area.
- Ability of participants to handle potentially challenging conditions and a long trip.
- Alternate take-out options should conditions warrant.
- Plan “B” in case weather and water conditions don’t work out.
- Local emergency contact info and procedures.
Many thanks to Frugal Navigator for the donation of the Small Craft charts used in tonight’s class!

www.frugalnavigator.com
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- Alternate take-out options should conditions warrant.
NOAA/NOS/CO-OPS
Tide Predictions at 9444971, Mystery Bay, Marrowstone Island WA
From 2016/08/28 12:00 AM LST/LDT to 2016/08/29 11:59 PM LST/LDT
Subordinate Station | Ref. Station (Port Townsend 9444900) | Time offsets (high: 15 min. low: 52 min.) | Height offsets (high: *0.95 ft. low: *0.99 ft.)

Data Listing

<table>
<thead>
<tr>
<th>Date</th>
<th>Day of the Week</th>
<th>Time (LST/LDT)</th>
<th>Predicted (ft)</th>
<th>High/Low</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016/08/28</td>
<td>Sun</td>
<td>12:40 AM</td>
<td>7.19</td>
<td>H</td>
</tr>
<tr>
<td>2016/08/28</td>
<td>Sun</td>
<td>08:24 AM</td>
<td>-0.43</td>
<td>L</td>
</tr>
<tr>
<td>2016/08/28</td>
<td>Sun</td>
<td>3:56 PM</td>
<td>7.60</td>
<td>H</td>
</tr>
<tr>
<td>2016/08/28</td>
<td>Sun</td>
<td>9:08 PM</td>
<td>5.36</td>
<td>L</td>
</tr>
</tbody>
</table>
Port Townsend Canal (PCT1561)
LAT/LON: 48.0333° N 122.7333° W

Note: Depth source is unknown. Subordinate station: only max/slack predictions available.


For predictions of Subordinate stations, the solid red line depicts a curve fit between the flood, ebb and slack values and approximates the segments between.

<table>
<thead>
<tr>
<th>Time (LST/LDT)</th>
<th>Event</th>
<th>Speed (knots)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2016-08-28 02:41 AM</td>
<td>ebb</td>
<td>2.02</td>
</tr>
<tr>
<td>2016-08-28 07:00 AM</td>
<td>slack</td>
<td>-</td>
</tr>
<tr>
<td>2016-08-28 09:20 AM</td>
<td>flood</td>
<td>2.68</td>
</tr>
<tr>
<td>2016-08-28 01:02 PM</td>
<td>slack</td>
<td>-</td>
</tr>
<tr>
<td>2016-08-28 03:47 PM</td>
<td>ebb</td>
<td>2.42</td>
</tr>
<tr>
<td>2016-08-28 08:12 PM</td>
<td>slack</td>
<td>-</td>
</tr>
</tbody>
</table>

Disclaimer: These data are based upon the latest information available as of the date of your request, and may differ from the published tidal current tables.
Determining Travel Time

Travel Time (minutes) = Distance (nautical miles) ÷ Speed (knots) × 60

Example:

How many minutes will it take you to paddle four nautical miles if your paddling speed is two and a half knots (nautical miles per hour)?

Travel Time (minutes) = 4 nm ÷ 2.5 knots × 60 = 96 minutes
Using a Weems & Plath “Compute-A-Course” Course Plotter for Class Exercises

1) The class plotters are already adjusted for local magnetic variance so please leave them as set. Normally, the device would need to be adjusted for local magnetic variance before it could be used.

2) Mark two waypoints on a chart and draw a course line between them.

3) Place the course plotter right side up on the chart and position the “eye” of the plotter over the center of the course line.

5) Keeping the “eye” on center of the course line, align a red grid line on the plotter with either a latitude or a longitude line on the chart.

6) Turn the red arrow of the course plotter to align with the course line, with the arrowhead pointing in the direction of travel.

7) At the red arrowhead, read the magnetic direction from the outer ring of the course plotter.

8) On the chart, write the magnetic direction next to the middle of the course line and follow the number with the letter M. For example: 247º M.

Distances for 1/40,000 and 1/80,000 scale charts can be read off the bottom of the course plotter. Divide the 1/40,000 figures in half to get 1:20,000 results. For example: 1 nm on the 1/40,000 scale is .5 nm on the 1:20,000 scale.