Course Outline for Ordinary Requirement 10: Piloting and Navigation

By Douglas D. Love, Mate, SSS Chaser, Napa, California
September 2013

Acknowledgements

The author would like to gratefully acknowledge the following people for their help and input:

Joshua Gilliland, Western Regional Commodore, Sea Scouts, Boy Scouts of America for assigning this project to me and a generous and kindly ear and timeline for completion

Glenn Draper, Assistant District Commissioner for Sea Scouts, Long Beach Council for his input and encouragement, and finally:

Charles Riedmuller, USCG (ret), USCG Unlimited Master, former navigation instructor at California Maritime Academy, fellow Mate aboard the SSS Chaser, mentor, shipmate and friend for his support, input and editing skills.

This work is my own and is to be used solely as a guide for the teaching of Ordinary Requirement #10: Piloting and Navigation. It is the result of over twenty years of teaching basic piloting and navigation and twenty five years of experience as a public school teacher. It is by no means comprehensive and may be modified to fit the needs of the individual Ship. I hope that this modest effort is of some use.

This course outline is NOT an official publication of the Boy Scouts of America and should only be used as a general reference and outline.

In Service to Scouting,

Douglas D. Love
Benicia, California
September, 2013

Ordinary Requirement 10: Piloting and Navigation

Objective: To acquaint the student with the rudiments of piloting and position determination.

Materials: Nautical Charts (Can either be local charts or NOAA Training Charts)
Dividers
Navigator's Triangles
Parallel Rules
Course Plotter
Stopwatch
Calculator
Nautical Slide Rule
0.5 #2 Mechanical Pencils
Staedler/Mars white eraser or equivalent
Scratch paper
Note Pad
Ball point pen
Magnetic Compass
NOAA Chart #1
Light List for the local Coast Guard District (For Reference)
Sea Scout Manual
Chapman Piloting & Seamanship (For reference)
Dutton's Navigation and Piloting (Optional, for reference)
Pub No. 9: The American Practical Navigator: Bowditch (Optional, for reference)

Section a. Latitude and Longitude: For this section the student must be able to demonstrate an understanding of latitude and longitude by completing the following tasks:

1. Determine their position on a nautical chart using a set of given coordinates.
2. Determine the latitude and longitude of five different aids to navigation

Materials: Dividers
Parallel Rules, Navigator's Triangles or Course Plotter
0.5 #2 Mechanical Pencil
Ball Point Pen
Scratch Paper
NOAA Chart #1
Nautical Chart

Procedure: The instructor should have a working knowledge of how to determine latitude and longitude on a nautical chart and how latitude and longitude are derived. If not, the instructor should familiarize him or herself with Chapter 15 of Chapman, Chapter 2 of Dutton's , Chapter 1 of Bowditch or pages 172-175 of the Sea Scout Manual. Latitude is measured in degrees, minutes and seconds of arc starting at 0 degrees at the Equator and ending at 90 degrees North or South at the respective poles. Longitude is measured East or West of the Prime Meridian

running through Greenwich, England and ending at 180 degrees at the International Date Line running roughly through the middle of the Pacific Ocean. The instructor should tell the scouts that every degree is composed of 60 minutes of arc and that every minute of arc is divided into sixty seconds of arc. Furthermore the instructor should teach the Scouts that every minute of latitude is equal to one nautical mile (≈ 6080 feet/6076.12 feet exact.) and every second of latitude is roughly equal to 100 feet. (6000/60=100/101.286 feet exact.)

The instructor should demonstrate to the Scouts how to determine the position of some objects on the chart using dividers, parallel rules, triangles or a plotter and then allow the students to practice with guidance. The instructor should make it clear that for Sea Scouts in the United States latitude will be North of the Equator and longitude West of the Prime Meridian. The instructor should also introduce the Scouts to the standard notation of DDDºMM'ss"N/S Lat. DDDºMM'ss" E/W Long or DDDºMM.dd' N/S Lat and DDD ºMM.dd' E/W Long where the uppercase D is the whole number of degrees, MM is minutes and ss is seconds. The lower case d is the decimal minutes rounded to the nearest 1/100.To convert seconds into decimal minutes the Scouts must divide the number of seconds by 6 so that 54 seconds becomes 0.9 minutes. To convert the decimal back into seconds one has to multiply by 6 so that 0.9' becomes 54".

Once the Scouts are familiar with this, the instructor should provide the Scouts with a set of latitude and longitude coordinates and have the Scouts find the location on the chart. The instructor should also pick at least five aids to navigation and have the Scouts determine their position in either degrees minutes and seconds or decimal degrees. (The instructor can determine the position of the aids beforehand by finding the latitude and longitude from the chart or looking up the position of the aids in the USCG Light List.) Once the Scouts can do this and repeat the task without help, they have completed this part of the requirement.

Section b. Compass: For this section the student must be able to demonstrate an understanding of a ship's compass and direction by completing the following tasks:
1. Be able to explain the degree system of compass direction.
2. Explain Variation and Deviation
3. Convert between True and Compass direction and bearing using Variation and Deviation.

Materials:
Magnetic Compass
0.5 Mechanical Pencils
Scratch Paper
Nautical Chart (For determining Variation)
Sample Deviation Table (There is one in the Sea Scout Manual)

Procedure: The instructor should have a working understanding of the degree system and be comfortable converting true to compass direction and compass direction to true direction. If not, the instructor should familiarize him or herself with Chapter 13 of Chapman, pages 175-177 of the Sea Scout Manual, Chapter 4 of Dutton's or Chapter 6 of Bowditch.

The instructor should teach the Scouts that a compass is divided into 360 degrees with 000 degrees being North and proceeding clockwise around the compass card with 090 degrees being East, 180 degrees being South and 270 degrees being West. This progression, NESW, is easily remembered by the mnemonic **N**ever **E**at **S**hredded **W**heat. All courses are expressed in degrees

and in the following format: XXX degrees; so East is expressed as 090 degrees and West is expressed as 270 degrees. The labeling of courses on a chart follows the same format.

Variation is the difference between geographic True North and Magnetic North. The Magnetic North pole is not in the same location as the geographic North Pole and this difference is Variation. Variation can differ from year to year and from location to location depending on the location of the Magnetic North Pole, local magnetic anomalies and your longitude. Deviation is the difference between Magnetic North and North as indicated on your compass due to errors created by metals and electrical fields in your boat. Courses are typically laid out using True bearings and converted to Compass by adding or subtracting Variation and Deviation. Conversely, Compass bearings can be converted to True bearings by reversing the process. The formulas are as follows:

T=True Bearing	C=Compass Bearing
V=Variation	D= Deviation
M= Magnetic Bearing	M= Magnetic Bearing
D= Deviation	V= Variation
C= Compass Bearing	T= True Bearing
add West (subtract East)	add East. (subtract West)

Both Variation and Deviation can be expressed as degrees, minutes or seconds East or West of True North. The mnemonics for these formulae are: Turquoise Violates My Dress Code at Weddings and Can Dead Men Vote Twice at Elections.

Variation can be found by looking at the Compass Rose of a Nautical Chart and applying the annual correction always adding West and subtracting East since the Earth rotates in a counterclockwise direction. Deviation is determined by several processes and there is usually a Deviation table for a vessel mounted near the compass or kept in the log book. You can demonstrate Deviation by holding a small magnetic object near the compass and having the Scouts watching it move.

Give the Scouts several sample problems and have them correct True courses and bearings to Compass courses and Compass courses to True. Once they are able to explain Variation and Deviation to the instructor, express various directions in degrees and can correct Compass to True bearings and True to Compass bearings finding variation and using a deviation table without help, they have completed this part of the requirement. The instructor may want to devise a written test for this portion of the requirement.

Section c. Speed Determination: For this section, the student must be able to name three devices for determining speed and distances travelled and, if possible, demonstrate their use.

Materials: Various, depending on the equipment with which the Unit's vessel is fitted but may include a chip log, a patent log, a speedometer, GPS or Radar. **Optional:** Nautical Chart, Dividers, stopwatch, calculator or a nautical slide rule.

Procedure: The instructor should be familiar with the devices used to determine speed and distance travelled commonly used on their vessel and their limitations. The instructor should be comfortable with computing speed and distance using the formula 60D=ST. If not, the instructor should familiarize him or herself with pages 177-179 of the Sea Scout Manual, Chapter 16 of Chapman, Chapter 7 of Dutton's or Chapter 4 of Bowditch. If the Scout can name a chip log, a

patent log and GPS or Radar as a way to measure speed, they have completed this part of the requirement.

Optional: The instructor may teach the Scouts how to determine speed by measuring distance travelled and time elapsed between two points on a chart and using the formula 60D=ST. A nautical slide rule or calculator may be used as an aid to computation. The instructor may want to teach the Scouts how to determine speed by taking radar ranges on a fixed point 6 minutes apart, determining the distance travelled and multiplying by 10 to determine the vessel's speed, if radar is available, or by taking relative bearings on a prominent land mark six minutes apart, plotting them and doing the same calculation.

Section d. Coordinated Universal Time: The student must demonstrate an understanding of Coordinated Universal Time (UTC or Zulu Time) and local zone time (ZT) and be able to convert between the two.

Materials: Sea Scout Manual
Pencils
Paper

Procedure: The instructor should be familiar with UTC and local time zones. If not, the instructor should familiarize him or herself with page 179 of the Sea Scout Manual, Chapter 16 of Chapman, Chapter 22 of Dutton's or Chapter 18 of Bowditch. The instructor should teach the Scouts that time is derived from the time at the Prime Meridian (0 degrees longitude) and that this time was originally called Greenwich Mean Time but is now called Coordinated Universal Time (UTC or Zulu time) and that hours are added or subtracted depending on your longitude to get local zone time (ZT or zone time). All time zones are about 15 degrees of longitude because the Earth rotates 15 degrees every hour. (360/24=15) On land, the time zones may vary due to political boundaries. In the United States the standard time zones are:

Atlantic daylight time (ADT)	subtract 3 hours from UTC
Atlantic standard time (AST)	subtract 4 hours from UTC
Eastern daylight time (EDT)	subtract 4 hours from UTC
Eastern standard time (EST)	subtract 5 hours from UTC
Central daylight time (CDT)	subtract 5 hours from UTC
Central standard time (CST)	subtract 6 hours from UTC
Mountain daylight time (MDT)	subtract 6 hours from UTC
Mountain standard time (MST)	subtract 7 hours from UTC
Pacific daylight time (PDT)	subtract 7 hours from UTC
Pacific standard time (PST)	subtract 8 hours from UTC
Alaska daylight time (AKDT)	subtract 8 hours from UTC
Alaska standard time (AKST)	subtract 9 hours from UTC
Hawaii-Aleutian daylight time (HADT)	subtract 9 hours from UTC
Hawaii-Aleutian standard time (HAST)	subtract 10 hours from UTC
Samoa standard time (SST)	subtract 11 hours from UTC
Chamorro standard time (ChST)	add 10 hours to UTC

(Note: There may be states or localities that do not observe Daylight Savings Time. Namely Arizona, except the Navajo Nation, Puerto Rico, Hawaii, Virgin Islands, American Samoa and Guam) The instructor should do several time conversions from UTC to local and back and then allow the Scouts to practice on their own. The instructor should then give the Scouts several problems to work on their own. The instructor should also teach the Scouts that UTC is **ALWAYS** written with the notation UTC or Z after the time and that the local time may be written with no notation, the three letter abbreviation of the time zone or the designation ZT, for instance 1300UTC=1300Z=0500PST, 0500ZT or 0500 if correcting for Pacific Standard Time. 1300Z would be 0800EST, 0800 or 0800ZT if one was correcting for the Eastern Standard Time. Once the Scouts have successfully converted several local times to UTC and several UTC times to local they have completed this part of the requirement. **(Please note that Coordinated Universal Time is abbreviated UTC for Universal Time Coordinated, not UCT as used in the Sea Scout Manual and that the uppercase Z is the designation for UTC not for local zone time. Local time is either designated with no notation at all, the zone abbreviation or the uppercase letters ZT**

Section e. 24 Hour Time: The student must be able to explain the 24 hour time system and be able to convert between 12 hour time and 24 hour time. The student should also be able to add and subtract minutes and hours in 24 hour system.

Materials: Sea Scout Manual
Paper
Pens/Pencils.

Procedure: The instructor should be thoroughly familiar with the 24 hour time system and its conventions and notation. If not, the instructor should familiarize him or herself with pages 179-180 of the Sea Scout Manual, Chapter 16 of Chapman, Chapter 22 of Dutton's or Chapter 18 of Bowditch. The instructor should explain to the Scouts that it is standard practice to note all time aboard all vessels in the 24 hour system. The 24 hour system is very easy to explain: Midnight is written as 0000 and the hours of the day proceed to 2359 and begin again at 0000. To convert from 24 hour time to 12 hour time, one merely subtracts 12 from the hours in the afternoon; so that 1330 becomes 1:30 pm. The instructor should also explain that 24 hour time is **ALWAYS** written with four digits (8:00 am is 0800) and without a colon dividing hours and minutes. 24 hour times are always spoken as units of 100, for instance 0800 is spoken as Zero Eight Hundred and 2300 is spoken as Twenty Three Hundred. 1530 is spoken as Fifteen Thirty. The word hours is never used as it denotes the number of hours that have elapsed between two events, not the actual time. 1530 is Fifteen Thirty **NOT** Fifteen Thirty hours. The instructor should work several examples of converting 12 hour to 24 hour time and then allow the Scouts to work several problems themselves.

One of the most common problems is the addition and subtraction of hours and minutes in 24 hour time. Quite often the Scouts will make the mistake of thinking that they are adding and subtracting in decimal units, not units of sixty. The instructor should make it clear that when working with time calculations one always works in units of sixty as there are sixty seconds in a minute and sixty minutes in an hour. When adding minutes in 24 hour time one **MUST** add an hour if the number of minutes exceeds fifty nine, 0830 + 45 minutes = 0915 **NOT** 0875. The instructor should work several addition and subtraction problems with the Scouts and then give

the Scouts several problems to work on their own. Once the Scouts can explain the 24 hour system, convert 12 hour time to 24 hour time and 24 hour time to 12 hour time and add and subtract minutes and hours using the 24 hour system independently, they have fulfilled this portion of the requirement.

Section f. Dead Reckoning and Plotting: The student must plot a properly labeled course between two points with a minimum of three legs, construct a table of courses and distances and determine the final position of the vessel. Ideally, this should be completed while underway, but if this is not possible, this part of the requirement can be fulfilled by chart work alone.

Materials: Nautical Chart (Either a local chart or a Training Chart will suffice)
Parallel Rules/Course Plotter/Navigator's Triangles
Dividers
0.5 #2 Mechanical Pencils
White Erasers
Ball Point Pens
Paper
Calculator or Nautical Slide Rule to aid in calculation (Optional)
Deviation Table

Procedure: The instructor should be thoroughly familiar with the practice and standards of plotting and dead reckoning. If not, the instructor should familiarize him or herself with pages 181-184 of the Sea Scout Manual, Chapters 16 and 18 of Chapman, Chapter 8 of Dutton's or Chapter 7 of Bowditch. The instructor should demonstrate the proper plotting and labeling of course lines, measuring of distances, plotting and labeling of DR positions and determining the latitude and longitude of the departure and arrival points. It is standard practice to begin a DR plot at a fix. Fixes are marked with a circle with a dot in the center and labeled with the time written horizontally. It is standard US practice to mark electronic fixes with a triangle with a dot in the center labeled with the time written horizontally and the source written in uppercase under the time, for instance, GPS or RADAR. International practice differs, GPS fixes are marked with a circle and a dot, labeled with the time written horizontally and the label GFix. Radar fixes are marked as a circle with a vertical line, the time written horizontally and the label RaFix. This can be confused with a running fix. DR positions are marked as a semicircle and a dot on the course line and labeled with the time written diagonally.

Course lines are labeled with the direction above the course line preceded by the uppercase letter C. (C 097) Courses are usually marked in True directions but can be marked in magnetic direction marked with an uppercase M (C 080M) or Compass direction marked with an uppercase C (C 083C) The navigator may want to mark the course on both True and Compass direction separating them with a dash (C 097T- 083C), but it is not necessary. Speeds and distances are written under the course line, speed being designated by an uppercase S (S 6.5) and distance designated by an uppercase D. (D 12.5) The Scout needs to create a dead reckoning table of courses and times to each turning point and the latitude and longitude of each turn point. The following table may be used:

Date:	Cruise from	to	Navigator:

Time	LAT	LONG	True	Var.	Mag.	Dev.	Comp.	Spd.	Dist.	ETA

The instructor needs to provide the Scout with the point of departure, a time of departure, a deviation table and a speed. The instructor must also make sure that the Scout follows the rules of dead reckoning:

1. A DR position must be plotted every hour on the hour.
2. A DR position must be plotted at every change of course or speed.
3. A DR position must be plotted after every fix or running fix.
4. A DR position must be plotted after plotting a single line of position. (LOP)

(Note: While it is standard practice to plot a DR position every hour, when operating in congested, inland or unfamiliar waters, a prudent navigator should plot a position more frequently, as often as every 12 minutes or half hour.)

A Scout has passed the requirement of all courses are correctly plotted and labeled, the courses are within one degree of error, the positions are within $1/10^{th}$ of a minute of latitude and longitude and all times are within plus or minus five minutes. (Note: If completed underway, the times may be within plus or minus 10 minutes and positions may be within ½ of a minute of latitude and longitude to account for set and drift.)

Annotated Bibliography

Maloney, Elbert S. and Charles F. Chapman Chapman Piloting and Seamanship. 65th ed. New York: Hearst, 2006

Chapman is by far the most used reference on piloting and seamanship in use in the United States today. It contains information on piloting, seamanship, boat handling, safety and has a number of useful appendices.

Maloney, Elbert S. Dutton's Navigation and Piloting. 13th ed. Annapolis: Naval Institute Press, 1978

Dutton's is the standard textbook on piloting and navigation used in the United States Naval, Coast Guard and Merchant Marine academies. Often the explanations in Dutton's are more detailed, yet clearer than those in Chapman.

Bowditch, Nathaniel. Pub. No. 9: The American Practical Navigator: An epitome of navigation. Bethesda, MD: National Imaging and Mapping Agency, 2002

Bowditch is THE BIBLE when it comes to piloting and navigation in the United States. It is the standard reference from which all others are drawn. A copy is carried on every vessel in the United States Navy, Coast Guard and Merchant Marine and it should be on your bookshelf as well. Besides the basics of piloting and navigation, Bowditch contains information on celestial and electronic navigation, gyrocompasses, magnetic compass compensation, buoyage, charting and a host of other subjects.

Sea Scout Manual. 11th ed. Irving, TX: Boy Scouts of America, 2010.

The Sea Scout Manual is the reference for the Sea Scout program in the United States. While it outlines requirements, advancement and program, it is far from complete or accurate. There are non-standard abbreviations and practices used throughout. While it is a good starting point, I highly suggest that it be supplemented by one of the above cited references.

Sources for Materials

Below is a list of suggested sources for materials. It is by no means exhaustive or comprehensive but should serve as a starting point for those wishing to assemble, update or replenish their navigational references and materials.

Basic piloting tools: plotters, triangles, dividers, nautical slide rules etc: I usually go to West Marine, Celestaire Landfall Navigation, Safe Navigation Way Point or Maryland Nautical.

West Marine: www.westmarine.com
Celestaire: www.celestaire.com
Way Point: www.waypoints.com
Maryland Nautical: www.mdnautical.com
Landfall Navigation: www.landfallnavigation.com
Safe Navigation: www.safenavigation.com

Maryland Nautical and Way Point have print on demand charts and Maryland Nautical carries the NOAA Training charts.

Chart No. 1 is available for free download at:
http://www.nauticalcharts.noaa.gov/mcd/chartno1.htm

Light Lists are available for free download at:
http://www.navcen.uscg.gov/?pageName=lightLists

US Coast Pilots and updated electronic charts are available for free download at:
http://www.nauticalcharts.noaa.gov/staff/charts.htm

Chapman, Dutton's and Bowditch are available at www.amazon.com but they may not always be in stock or be available at the best prices.

An online copy of Bowditch can be found here:
http://en.wikisource.org/wiki/The_American_Practical_Navigator

International charting symbols and standards can be found at:
http://www.sailingissues.com/navcourse4.html

0.5 #2 mechanical pencils, pens, white erasers and paper can be purchased at www.amazon.com, www.officemax.com, www.staples.com or www.officedepot.com. For teaching and practical piloting on the boat, I prefer the Bic 0.5 disposable pencils and Bic Stick pens. They are inexpensive and can be purchased in large quantity.

A Navigator's Toolkit

Often I have been asked to provide a list of tools which I carry when I board a boat to teach or perform piloting duties. Below is a list of what is in my personal took kit:

1 pair Weems and Plath Protractor Triangles. #1011. The preferred tool for laying down courses and determining true direction.

1 Weems and Plath Nautical Slide Rule. #105. This tool makes computing speed and distance extremely fast and easy. With practice it is faster than a calculator.

1 C-Thru Protractor Plotter P-72. In rough seas, this tool is indispensable for plotting positions and laying down course lines.

1 pair Weems and Plath 15 inch Parallel Rules. #145. The traditional tool for plotting and determining direction on a chart. Many find them slow and cumbersome, but with practice, they can be extremely accurate.

1 Weems and Plath Parallel Plotter. #120. Also called a roller plotter. The tool I personally use most. It is quick and accurate provided that the seas are not rough.

1 pair Weems and Plath Ultralight Dividers. #176 The BEST tool for measuring distance on a chart. The thumbwheel adjustment makes them very accurate and easy to use, even one handed.

1 6 inch Helix Drafting Compass. While the Ultralight dividers come with pencil points and can be used as a compass, nothing, and I mean nothing can beat a good quality drafting compass when plotting range arcs on a chart.

1 Staedler/ Mars White plastic eraser. Erases cleanly without wearing holes in charts.

1. Pentel P205 0.5mm #2 Mechanical pencil. These pencils are relatively inexpensive, refillable and lay down a clear, consistent, legible line.

1 Parker Jotter medium ball point pen (Blue Ink) The Parker Jotter is an inexpensive, refillable, smooth writing, dependable pen which can be used for log entries and other tasks.

All of these tools fit into a Weems and Plath Navitote #325, which has plenty of pockets for all of your gear.

I also carry a Plastimo Iris 50 hand bearing compass for taking quick magnetic bearings, a pair of Steiner 7x50 binoculars and a Garmin hand held GPS. All of these tools have been used and are in use every time I teach, demonstrate or practice piloting.