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ABSTRACT

This curriculum guide for a beginning course on marine navigation describes marine navigation (the art of and science of determining position of a ship and its movement from one position to another in order to keep track of where the ship is and where it is going) and defines dead reckoning, piloting, electronic navigation, and celestial navigation. It goes on to address such topics as: plotting tools; other navigation instruments; duties of the coastal navigator; mercator projection charts; charting; magnetic compass; reading direction from a triangle; using dividers; measuring speed; knotmeter; measuring depth; and the global positioning system. It includes quizzes on topics such as uncorrecting the compass; correcting the compass; finding compass error; deviation from a range; geographic coordinates; plotting positions; laying out a course; estimated time of arrival; finding speed; and determining course to steer for a known set and drift. Quiz answers are included. (SM)

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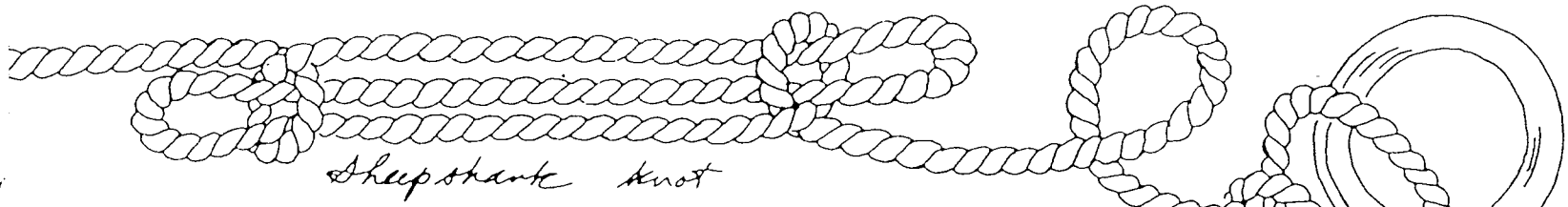

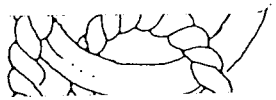

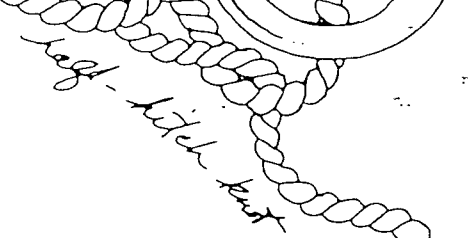

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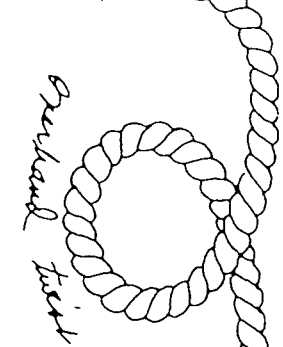
Navigation 101



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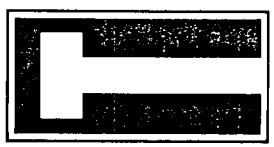

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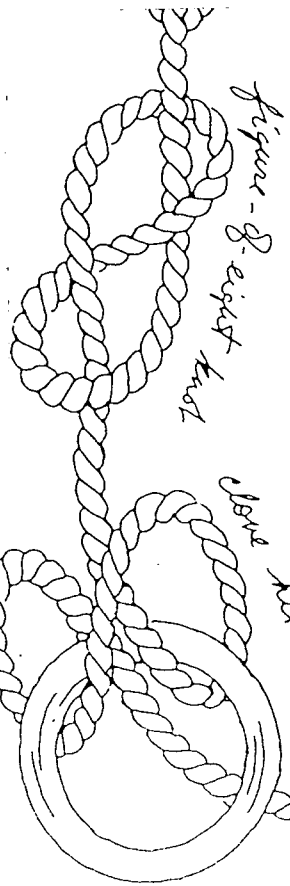

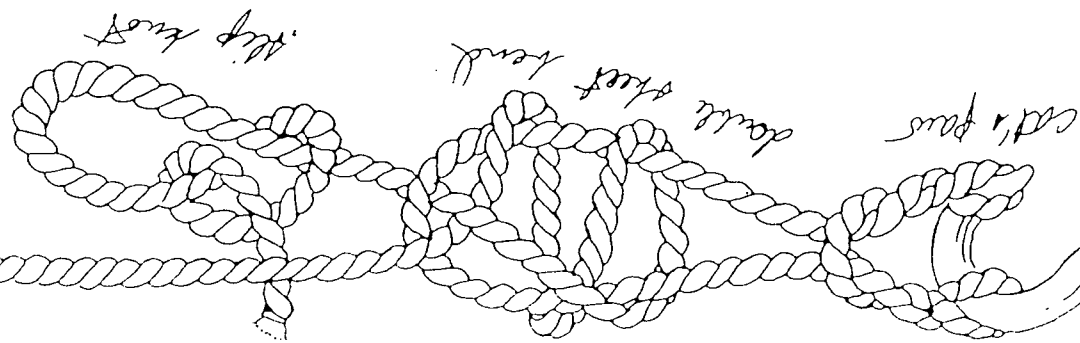

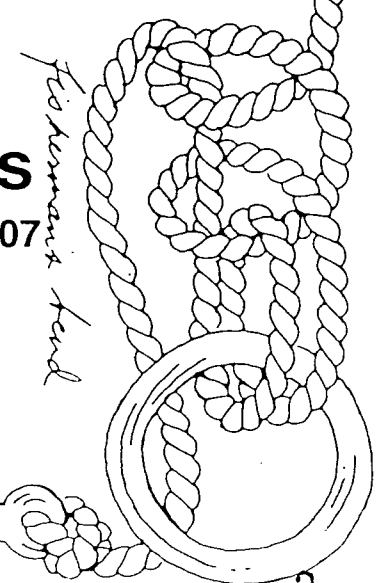

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Coastal Piloting & Charting
Navigation 101

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Marine Navigation

- Art and science of determining position of a ship and its movement from one position to another
- Purpose: To keep track of where you are and where you are heading
- Dead reckoning - Position is determined from a fix or last known position, and the vessel's direction and speed through water
- Piloting - Position is determined near shore using landmarks, soundings, and navigational aids
- Electronic navigation - Electronic devices are used to collect information on position
- Celestial navigation - Position is determined by observing celestial objects such as the sun, moon, stars and planets, and using celestial computations

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"If you don't care where you are, then you aren't lost"

- But, most boaters want to know where they are when they are on the water.
- Navigation helps you find the answers to questions:
  - Where am I starting from?
  - Where do I want to go?
  - How do I get from here to there?
  - Am I where I'm supposed to be? If not, how do I get back on course?
  - Are there any hazards along the way that I should avoid?

3

- How far away is my destination?
- How long will the trip take?
- Will anything slow my progress or take me out of the way?
- When will I get there?
- How fast do I need to travel in order to get there by a certain time?
- What tools, "road signs" & "maps" are available to help me find the way?

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Plotting Tools

- Parallel rulers or course plotter
- Triangle
- Dividers
- Pencil and eraser
- Charts
- Magnetic compass and hand bearing compass
- Depth sounder
- Knot meter
- Clock
- Other: Magnifying lens, Binoculars, Calculator, GPS
- Books: GPS waypoints, Coast Pilot, tide tables, light list, cruising guide, Chart #1, Navigation Rules, Local Notice to Mariners

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Other Navigation Instruments

- Electronic instruments
  - Global positioning system (GPS)
  - Radio direction finder (RDF)
  - Radio detecting and ranging (RADAR)
  - Sonic ranging (SONAR)
  - Long range navigation (LORAN)
  - Computer with navigation software and raster charts
- Celestial navigation instruments
  - Sextant

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Duties of the Coastal Navigator

- Collects and records data when getting underway, leaving port, before losing sight of land, upon sighting land, when entering port, and after anchoring, docking or mooring
- Identifies all aids to navigation
- Witness all course changes from on deck because of the close proximity of danger in near coastal areas
- Keeping a log

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Mercator Projection Charts

- Mercator projection charts are most commonly used for coastal navigation.
- Flemish geographer, astronomer, theologian and cartographer Gerhard Kramer (AKA: Gerhardus Mercator) published his, very accurate for its time, worldwide ocean navigation chart in 1569.
- Mercator charts are cylindrical projections tangent to the earth at the equator then flattened out.
- Allow latitude and longitude from a spherical earth to appear as horizontal and vertical lines on a flat chart.
- Relative size of features on the chart are distorted, but correct angular relationships between points on the chart is maintained.
- Permits sailing from point to point on a straight course.

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Charts

- Maps designed for navigating on the water
- Published by the National Ocean Service (NOS), a division of the National Oceanic & Atmospheric Organization (NOAA), an agency of the U.S. Government
- Show: soundings, fathom curves that connect points of equal depth, shoreline, landmarks, buoys, light visibility range, positioning of aids to navigation, heights, traffic separation schemes, hazards
- Correction date of the last weekly Notice to Mariners applied to the chart is shown on the lower left border of the chart
- Paper charts, waterproof paper charts, spiral bound chart books, and computerized charts are also available

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Chart Scale

- Large scale charts cover a small geographic area
- Small scale charts cover a large area in great detail
- Scale is written as a ratio
- 1: 50,000 scale means 1" on the chart is equal to 50,000 real inches
- Chart types
  - General - small scale
  - Coast - medium scale
  - Harbor - large scale

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Chart #1:

Nautical Chart Symbols, Abbreviations and Terms, USA

General

A Chart Number, Title, Margin Notes
B Positions, Distances, Directions, Compass

Topography

C Natural Features
D Cultural Features
E Landmarks
F Ports
G Topographical Terms

Hydrography

H Tides, Currents
I Depths

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Chart #1:

Nautical Chart Symbols, Abbreviations and Terms, USA

J Nature of the Seabed
K Rocks, Wrecks, Obstructions
L Offshore Installations
M Tracks, Routes
N Areas, Limits
O Hydrographic Terms

Aids and Services

P Lights
Q Buoys, Beacons
R Fog Signals
S Radar, Radio, Electronic Position-Fixing Systems
T Services
U Small Craft Facilities

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Chart #1:

Nautical Chart Symbols, Abbreviations and Terms, USA

Alphabetical Indexes

V Index of Abbreviations

W International Abbreviations

X List of Descriptors

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Magnetic Compass

- A magnetic compass uses the earth's magnetic force to determine direction
- Simple and reliable
- A magnetic compass will usually continue to operate even if there is a power failure, fire, collision, or grounding
- Use the compass card for reading direction while looking at the lubbers line
- Lubbers line is a reference mark on the inside of the compass bowl that is aligned with the ships keel
- Binnacle – non magnetic housing which supports the compass

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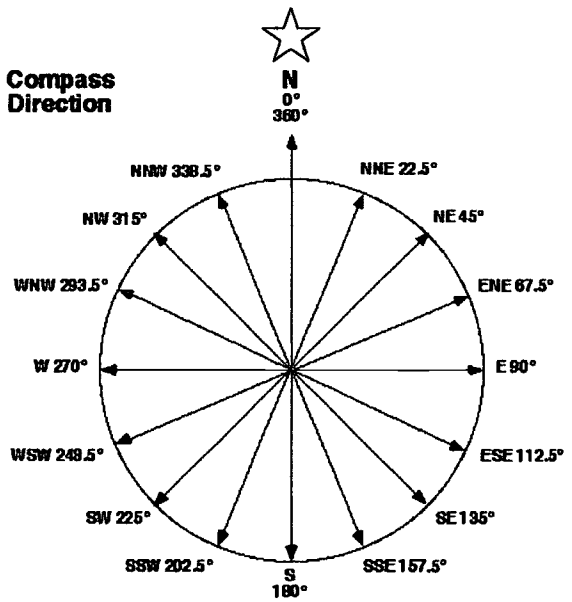
Compass Direction



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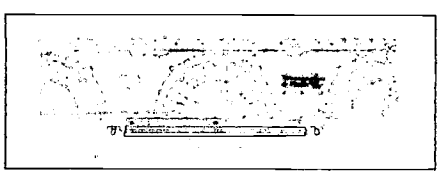
Using a Plotter

- Place the plotter on the chart and align the straight (top) edge along the course
- Roll or slide the plotter across the chart by applying pressure with one hand, so the center point on the compass printed on the plotter is on any meridian. Read the course at the point on the edge of the compass that lies on the meridian to determine direction.
- Or, walk parallel rules across the chart from the DR to a compass rose printed on the chart



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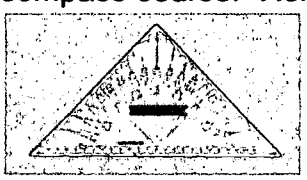
Reading Direction from a Triangle

- Keeping aligned with your parallel plotter, move the triangle to a meridian
- When 0 touches a meridian, read the edge of the compass to determine direction
- East is least (less than 180°)
- West is best (greater than 180°)
- Triangle can be used instead of a compass rose
- Chart lines are always drawn in relation to true north, but you steer a compass course. Remember to convert



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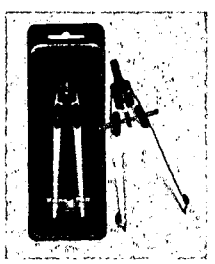
Using Dividers



- Tool used for measuring distance
- Open and close dividers with one hand
- For accurate measurements, make sure the leg points are sharp
- Extend the legs and place one leg of the dividers on location A and the other leg of the dividers on location B
- Take the extended dividers, without changing their spacing, to the nearest latitude scale on the side of the chart and count the distance. Remember 1 minute of latitude equals 1 nautical mile.
- Or, extend the dividers to a known distance using the bar scales, then walk the dividers along the course
- Dividers can also be used to measure the location of a point using the closest line of latitude and longitude

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Measuring Speed

- Olden days – Speed was measured with a chip log. A chip log was a piece of wood attached to a line with evenly spaced knots. The knots were counted as they paid out behind the stern of the ship over a certain amount of time.
- Today – Boat speed, a measure of boat movement through the water, is measured with a knotmeter.
- Speed over ground is affected by current and wind, so boat speed through the water, and speed over ground are not necessarily the same
- A GPS tells you speed over ground

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Knotmeter

- An impeller type underwater log uses a propeller which spins as the boat moves through the water. This produces an electrical impulse which is converted to a digital reading used to measure speed through the water.
- Remove the through hull paddlewheel for cleaning, and temporarily replace it with the blank plug. Remember to replace the paddlewheel facing the bow and in line with the keel from bow to stern.

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Measuring Depth

- Olden days – Depth measured using a hand lead
- Today – A fathometer (AKA depthfinder or depth sounder) transmits a sound signal vertically and measures the time between the transmission of the signal and the return of the echo after bouncing off the bottom. Depth is half the distance traveled.
- Average speed of sound waves is 800 fathoms per second.
- Signal is sent from the bottom of the keel. Depths recorded by the fathometer should be depth below the keel, not from below the waterline.

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Depthfinder

- Shows present depth on a digital display
- Depthfinders that provide a graphic display of the boat's path through the water are also available
- Many depthfinders have shallow water alarms that you can set at a specific depth to warn you that you are entering shallow water, prior to running aground

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GPS

- Global Positioning System
- Conceived in 1960
- Consolidation of navigation projects -- started by U.S. Air Force but joined by other military branches in 1974
- Project was named NAVSTAR Global Positioning System, but commonly called GPS
- Cost $10 billion to develop
- Became fully operational in April 1995
- Project is monitored and administered by the U.S. Defense Department

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GPS

- Satellite navigation system
- 24 satellites, each orbiting 12,552 miles above the earth, circle the globe every 12 hours and beam radio signals toward earth
- Can determine position 24 hours per day, anywhere, any kind of weather, or at night
- Most advanced navigation system ever to exist
- GPS can:
  - Lead you to a specific position
  - Calculate your present position
  - Store a position in memory so you can return at a later time

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GPS Limitations

- GPS receiver may not work when you need it most
- Signals can be blocked: radio signals cannot penetrate buildings, landforms, dense vegetation, rocks, or caves
- Remote areas may not be covered by the minimum number of satellites to get a fix
- Signals may be too weak, or broken up,
- Batteries can go dead
- GPS receiver antenna may not be not sensitive enough to pick up the satellites
- Should not depend on GPS as a single method of navigation, should always have a back-up and verify measurements from other navigational methods

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GPS Satellites

- Uses radio waves
- Satellite sends a sequence of numbers not repeated for a millisecond that enable the receiver to measure distance from each satellite
- GPS receiver has the same sequence stored in its memory and knows the exact time the satellite started sending the numbers, and time segments for the radio wave to get from the satellite to the receiver
- This technique is called ranging
- Each satellite knows its own position and the position of all the other satellites and sends the orbital information to the receiver

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GPS Receiver

- Small, portable, electronic device used to pick up signals from satellites
- Used in conjunction with map and compass
- Finding position by GPS is done by triangulation, using intersecting spheres to determine latitude, longitude and altitude
- In order to get 3 dimensions, the GPS receiver needs to lock onto 4 satellites
- 4th satellite is used to synchronize the time between satellite's atomic clocks and receiver's quartz clock
- GPS receivers only listen to satellite transmission but do not interact, so the number of simultaneous users is unlimited

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GPS TTFF

- When turned on the first time or after being moved more than 300 miles
  - Receivers download an almanac of orbital information of all the satellites
  - Each satellite has the information for all the satellites
  - Time it takes to do this is called Time To First Fix or TTFF
  - TTFF may take up to 12 minutes
  - After the TTFF, the almanac is stored in the receiver's memory, and locking in takes less time

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GPS Accuracy

- Accuracy 1 – 15 meters (3.3' – 49.2')
- Concern about U.S. enemies using it against us, so two tiers of accuracy were originally developed
- In May 2000, the Selective Availability was eliminated so civilian receivers are now more accurate
- Concern that Department of Defense could turn off GPS codes for civilian receivers in time of war are unlikely because so many industries (airlines, maritime industry, shipping, trucking, as well as many military units) now depend on GPS
- More likely that your GPS won't work because the batteries go dead, you drop it, or it gets wet

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GPS Accuracy

- External antennas (usually more sensitive than internal antennas) are required if the GPS receiver is inside an enclosure like a boat, -- the antenna must be open to outside
- Receivers can detect satellite signals through plastic bags
- Reduce a receiver's accuracy:
  - Atmospheric interference
  - Satellite geometry or position in the sky relative to your position
  - Reflected or multi-path signals
  - Altitude accuracy is not as good as horizontal position accuracy

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GPS Datum

- Charts are drawn so every point is known from a standard reference point or datum
- A chart can have only one datum
- Most common datum for use by GPS receivers:
  - North American Datum 1927 (NAD 27
  - World Geodetic System 1984 (WGS 84)
- Receiver must be set to correct datum before entering data

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GPS Computer Interface

- Connect to a personal computer to add capabilities
- Use with digitized map databases stored on CD-ROM
- Can print out paper copy
- GPS communicates with a computer through an input/output port and cable using NMEA standards (National Marine Electronics Association)
- GPS receives position and sends coordinates to the computer
- Computer then displays information on charts
- As you move the chart shows and updates your position
- Some portable receivers have permanent charts stored in memory

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GPS Common Functions

- Waypoints
  - Coordinates that mark a specific location
  - Can be given a 6 letter/number name, or will be automatically named, can change the name later
  - Can be stored in memory which is not lost when the GPS receiver is turned off or the batteries are dead
- Goto
  - Function that helps you find the coordinates of a particular location
  - Waypoints can tell the receiver to guide you using a steering screen to a location
  - Tells you if you are off course, speed, how far you are off course, ETA

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GPS Common Functions

- Navigational statistics
  - Odometer, average or maximum speed, speed over ground, velocity made good, course made good, bearing, track, heading, cross track error, course deviation, course to steer, ETA, elapse time...
- Data entry keys, buttons and entry keys
- Backlighting of data screens
  - So receiver can be read in the dark
  - Uses a lot of power
- Multiple power sources
  - Batteries
  - External power
- Times of sunrise / sunset

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GPS Common Functions

- Routes
  - Route is a list of waypoints that describe the path you need to travel,
  - Routes lead you to your location sequentially
  - Waypoints have to already be in the receiver's memory and in a list in the order they need to be traveled
  - Automatic route reversal – can put the waypoints in a reverse order list
- Man Overboard
  - Function used to quickly mark a point for return
  - Immediately records present position and directs you back using the navigation screen

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GPS Common Functions

- Compass
  - Cannot measure distance if you are sitting still
  - Can only measure direction of movement
  - Most receivers are not electronic compasses
- Bearing
  - Compass position between your present position and your destination, or between any two waypoints
- Modes
  - Can set receiver to read: True or magnetic north
  - Can set receiver to read: Nautical or statute miles

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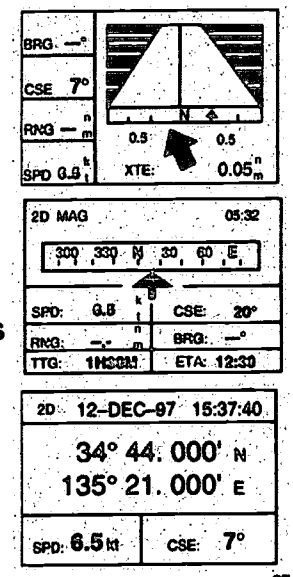
GPS Navigation Screens

- Steering screens:
  - Compass
  - Highway (if the highway veers left, steer left)
- Map screen:
  - Visually show the waypoints, and track lines at different scales
- Position screen:
  - Shows position and altitude
  - Uses the position grid you select (latitude and longitude)



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Course Correction

- Variation
- Deviation
- Correcting the Compass
- Uncorrecting the Compass
- Finding Compass Error
- Deviation from a Range

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Magnetic North & True North

- The magnetic north pole moves
- Currently the magnetic north pole is at 74°N 101° W in Canada below the true north pole
- The true north pole is at 90° north latitude
- True and magnetic poles do not coincide, nor do true and magnetic meridians
- The difference between the true and magnetic meridians is variation
- Read true course on a chart, but steer the compass course

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Variation

- Angular difference between magnetic north and true north
- Nautical charts are drawn using true north
- To find variation in the area where you are sailing, look at the compass rose on a chart
- Add westerly variation and subtract easterly variation when converting from true to magnetic
- Remember the memory aid "True Virgins Make Dull Company add Whisky" when converting from true to magnetic or compass courses

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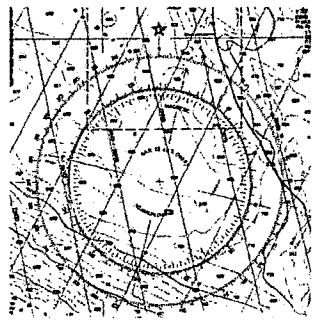
Compass Rose



- Concentric circles
- Outer circle has 0 at true north and is marked with a star
- Inner circle shows magnetic north and is marked with an arrow
- The difference between the 0 on both circles is the magnetic variation at the location where the compass rose is positioned
- The variation east or west is labeled in the center of the compass rose along with the annual rate of change in variation
- Always use the compass rose closest to the area where you are plotting on the chart

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Deviation

- Onboard electrical or magnetic variation
- Magnetic error caused by the vessel and its mechanical and electrical equipment
- Deviation changes as equipment is moved or brought aboard
- Must be corrected for each heading
- Swing a compass to determine deviation at each point

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Deviation Chart (Example)

Magnetic Heading	Deviation	Magnetic Heading	Deviation
000	2° E	180	2° W
015	2° E	195	2° W
030	2° E	210	3° W
045	3° E	225	3° W
060	3° E	240	3° W
075	4° E	255	2° W
090	3° E	270	2° W
105	2° E	285	1° W
120	2° E	300	0°
135	0°	315	1° W
150	1° W	330	2° W
165	1° W	345	1° W

TVMDC

- Uncorrecting the compass
- Determining the compass course to steer
- True Variation Magnetic Compass add West
- When converting from true course to compass course use the memory aid "True Virgins Make Dull Company add Whiskey"
- Add westerly variation and subtract easterly variation when converting from true to magnetic

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CDMVT

- Correcting the compass
- Determining the true course to plot
- Compass Deviation Magnetic Variation True add East
- When converting from compass course to true course use the memory aid "Can Dead Men Vote Twice at Elections"
- Add easterly variation and subtract westerly variation when converting from magnetic to true

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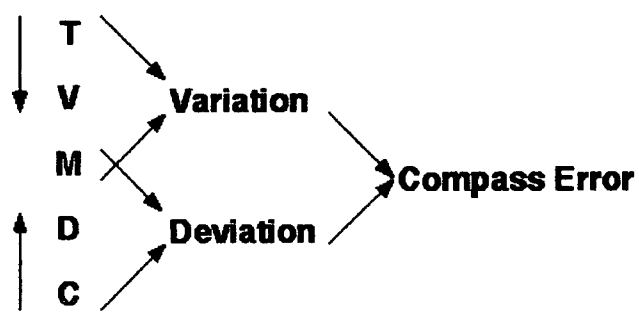
Compass Correcting & Uncorrecting



If compass is best, error is west
If compass is least, error is east

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Quiz: Uncorrecting the Compass

1. What is the compass course to steer from the Dana Point harbor entrance to Avalon?
   T
   V
   M
   D 2° W
   C ___

2. What is the compass course to steer from San Diego's Mission Bay to Dana Point?
   T
   V
   M
   D 1° W
   C ___

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Quiz: Correcting the Compass

3. You depart from Avalon on a compass course of 084°. What is the true course to plot?
   T
   V
   M
   D 2° E
   C 84°

4. You are steering a course of 210° per your magnetic compass. What is the true course to be plotted on the chart?
   T
   V
   M
   D 3° W
   C 210°

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Finding Compass Error

- Compass error is the sum of variation and deviation
- Difference between true and compass readings

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Quiz: Finding Compass Error

5. If variation is 13° E and Deviation is 2° W, what is the compass error?

   13° E
   +2° W

6. The compass course between two points is 350°. Variation is 13° E and Deviation is 1° W. What is the true course to plot? What is the compass error?

T			X
V	13° E		- 350°
M			
D	1° W		
C	350°		

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Quiz: Finding Missing Values & Compass Error

		A	B	C
+W	T	270°	___	175°
-E	V	14° E	12° W	5° E
	M	___	102°	___
+E	D	___	___	___
-W	C	258°	100°	171°
Compass Error		___	___	___

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Range

- A range is two objects identified on a chart which line up with the bow (or beam or stern) of the vessel.

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Deviation from a Range

- To find deviation from a range:
- Find the true direction from one charted object to the other
- Uncorrect from true to compass using TVMDC
- Fill in true direction and magnetic variation from the chart to find the magnetic bearing
- Fill in the compass bearing from your handheld compass
- The difference between the magnetic and compass bearing is the deviation
- Find direction of the error using the memory aid:
  If the compass is best, the error is west.
  If the compass is least, the error is least.

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Question: Deviation from a Range

8. The north jetty light at the entrance to Mission Bay (characteristics Fl G 6s 22ft 7m "1") is sighted over the bow in line with the Sea World sky tower (characteristics 338ft Fl R). The compass bearing is 059°. What is the deviation of the compass while on that heading?

T	___	___° M
V	___	- 059° C
M	___	°
D	___	Compass is _____, error is _____
C	059°	___° ___

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Geographic Coordinates

- Finding Latitude and Longitude
- Plotting Positions
- Laying Out a Course
- Determining Position by Visual Bearings and a 3 LOP Fix

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Geographic Coordinates

- Geographic coordinates are measured in degrees, minutes and tenths of a minute (or seconds)
- 1 degree is 1/360th of a circle
- 1 minute is 1/60th of a degree
- 1 second is 1/60th of a minute
- More commonly today, 1/10th of a minute is used instead of seconds
- Parallels of latitude are equally spaced
- 1 minute of latitude is equal to 1 nautical mile

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Latitude

- 1 nautical mile equals 6,076 feet or 1.15 statute miles
- 1° (degree) of latitude equals 60 nautical miles
- 1' (minute) of latitude equals 1 nautical mile
- Each minute of latitude can be broken into seconds (''), or tenths of a minute
- Parallels of latitude run parallel to the equator and are measured north or south of the equator up to 90°
- The equator is 0° latitude
- The poles are 90° latitude (north or south)

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Longitude

- Meridians of longitude run north and south
- The prime meridians (0° longitude) runs through Greenwich, England
- Longitude is measured east and west of the prime meridian from 0° to 180°
- The International Date Line is at 180°
- At the equator, each 1° of longitude is about 60 nautical miles apart, but degrees get closer together until they meet at the poles

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Definitions

- Distance — Expressed in nautical miles
- Speed — Velocity of travel expressed in knots
- Depth — Expressed in feet, fathoms or meters
- Course — Direction of travel
- Heading — Direction a vessel is pointing
- Bearing — Direction of an object from the observer
- Relative bearing is measured with reference to the fore and aft axis of the vessel
- All bearings are converted to true bearings for plotting on a chart

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Quiz: Plotting Positions

What is located at each of the following positions?

9. _____ 33° 22.3' N, 117° 33.5' W

10. _____ 32° 49.4' N, 118° 21.3' W

11. _____ 33° 35.8' N, 118° 08.6' W

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Quiz: Finding Latitude and Longitude

Determine the latitude and longitude for each of the following positions.

12. Point Loma lighthouse (new)

13. Ship Rock (Isthmus Cove on Santa Catalina Island)

14. Lighted red & white safe water mark at the entrance to Newport Harbor

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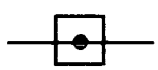
Charting Symbols


Dead reckoning position


Visual fix


Electronic fix


Estimated position from incomplete data

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Dead Reckoning

- Dead (deduced) reckoning track - Line showing the route you plan to follow to get from point A to point B
- Plotting a DR allows you to graphically see where you are and where you are going
- Lets you estimate your position based on speed at time intervals
- Used as a back-up in case other methods of navigation fail

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Dead Reckoning

- Write your course above the DR line (C 002)
- Use your dividers and the latitude scale to measure the leg (1 minute of latitude equals 1 nautical mile)
- Write the distance of the leg below the DR line (D 5.8)
- Determine and write speed on the chart below the DR line nest to distance (S 6.1)
- Mark your dead reckoning position on the DR track as a dot inside a half circle
- Always start a DR track at a known point (fix) and plot your position every hour

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Quiz: Laying Out a Course

Lay out the following courses. Remember all course lines drawn on a chart should be true courses.

15. Determine the true course from Dana Point harbor entrance to Avalon.

16. What is the compass course you would steer from Dana Point to Avalon? Use the deviation chart provided and information from the chart compass rose.

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Fix

- Fix is a known position determined from the intersection of at least 2 LOPs (3 LOPs is better)
- Fix by soundings - A fix can be obtained using a depthfinder by noting when you pass charted bottom contour lines and using them as lines of position
- Mark a fix on the track line as a point inside a circle distance from the object

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Running Fix

- A running fix can be used when only one object is available using bow and beam bearings
  - Take the first bearing using a hand bearing compass when the object is 45° from the bow
  - Take the second bearing when the object is 90° abeam
  - Use elapsed time, speed and 60 D ST to find distance
  - The distance the boat travels (distance run) in the time between the bow and beam bearings is equal to your

67

3 Line of Position Fix

- You can find where you are (get a fix) by using visual bearings and lines of position
- Uses points of land, aids or landmarks identifiable on a chart and which can be easily seen
- Use a hand bearing compass to obtain 3 bearings from your position on objects on shore that are widely spaced
- Ideally the 3 objects should be equally spaced about 120° apart from each other
- Assume deviation of a hand bearing compass is zero since it can be moved about the vessel
- Since all 3 bearings are taken from the same geographic location, they will all have the same variation

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3 Line of Position Fix

- Correct the 3 compass bearings to true using the CDMVT memory aid
- Plot the true bearings, now called lines of position (LOPs) from the vessel on the chart
- The center of the small triangle (cocked hat) where the 3 LOPs converge (or if very accurate, at the point where they intersect) is the fix.
- A 3 LOP fix will be more accurate if you are not moving and dead in the water
- If you are moving, take the reading off the beam first

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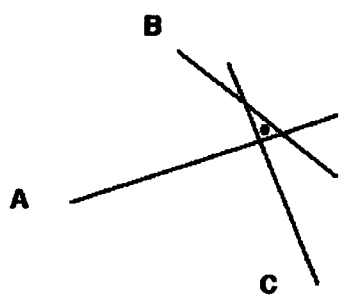
3 Line of Position Fix



		A	B	C
+ W / - E	T	240	320	170
	V	14E	14E	14E
	M	226	306	156
	D	2W	2W	2W
+ E / - W	C	228	308	158

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Quiz: 3 Line of Position Fix

17. You are anchored in Pyramid Cove and want to make sure you are not dragging your anchor. You take 3 bearings with your handheld compass on Pyramid Head Light, a Navy building on shore, and a light on the cliff. What is your position.

	Position	Bearing
Pyramid Head light	_____ N, _____ W	075° C
Navy building	32° 50.0' N, 118° 23.5' W	326° C
Cliff light	32° 48.9' N, 118° 24.3' W	237° C

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Distance

- Measuring Distance Between Two Points
- Determining Distance from the Equator

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Measuring Distance

- Distance is measured in nautical miles
- A nautical mile is equal to:
  - 1 minute of latitude
  - 6,076 feet
  - 1.15 statute miles
- Set the dividers to a known distance and walk them along the course
- Or, for short distances, extended dividers, without changing their spacing, to the nearest latitude scale and count the distance

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Quiz: Measuring Distance

What is the distance between the two points?

18. The Casino building in Avalon to Oceanside Harbor entrance?
19. Marina del Rey to Bird Rock at the entrance to Isthmus Cove (Santa Catalina Island)?
20. Safe water mark at the entrance to Newport Harbor to the Huntington Beach Pier?

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Distance from the Equator

- Distance from the equator can be found using latitude
- Multiply degrees latitude by 60 nautical miles
- To that sum, add the minutes of latitude

Example:
32° 45' N is (32° x 60 nm) + (45' x 1 nm) =
1,965 north of the equator

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Time

- Converting Time in Hours and Minutes to Minutes
- Converting Time in Minutes to Hours and Minutes
- Determining Elapsed Time
- Estimated Time of Arrival

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Converting Time

- Use the military time 24 hour clock
- Always work 60 D Street problems in minutes
- Converting hours & minutes to minutes: Multiply the number of hours by 60 and add the minutes
- Converting minutes to hours & minutes: Divide minutes by 60 to obtain hours. Multiply the dividend by 60 and subtract from the minutes. The remainder is the minutes.

Change hours into minutes
3:42 = (3 x 60) + 42 = 222 minutes

Change minutes into hours and minutes

```
      3:42
60 | 222
    -180
     42
```

Quiz: Converting Time

21. Convert 537 minute to hours and minutes.

22. Convert 305 minutes to hours and minutes.

23. Convert 2:35 into minutes.

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Determining Elapsed Time

- Use military time (24 hour clock)
- Subtract starting time (time of departure) from ending time (time of arrival)
- If you "borrow" an hour, add 60 minutes

19	
~~20~~	13 + 60 = 73
- 15	42
4	31

79

Quiz: Determining Elapsed Time

24. You left Mission Bay at 0615 hours and arrived at the entrance to Oceanside Harbor at 0940. How long did the trip take?

25. You spotted Anacapa's West Island at 0740 after sailing all night from Newport Beach. You departed from Newport at 1510. How long were you underway?

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Estimated Time of Arrival

- Plot point A (your point of departure or your current starting position) and point B (your destination)
- Draw a line between and measure the distance between the two points
- Find your boat speed from your knotmeter
- Enter speed and distance and use 60 D Street to find time to determine how long the trip will take
- Convert time in minutes to hours and minutes, and add to your time of departure.

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Quiz: Estimated Time of Arrival

26. Your 0900 position is off LaJolla at 32° 50' N, 117° 20' W and you are enroute to Dana Point at a speed of 6.2 knots. What is your estimated time of arrival?

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60 D ST

- Determining Speed
- Determining Time
- Determining Distance

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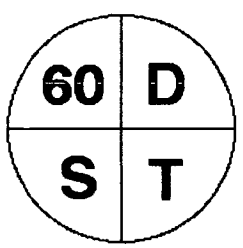
60 D Street

- 60 D Street is used to find speed, distance or time when 2 of the 3 factors are known

- Speed = (60 x Distance) ÷ Time
- Distance = (Speed x Time) ÷ 60
- Time = (60 x Distance) ÷ Speed



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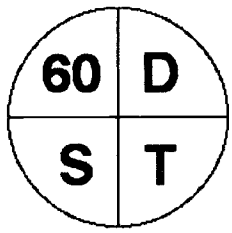
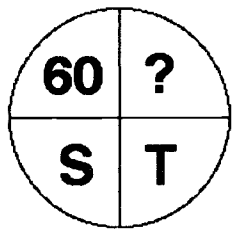
Finding Distance





Time: 3:50
Speed: 6.3 knots
Distance: ?

$$D = \frac{6.3 \times 230}{60} = 24.15 \text{ nm}$$

Convert time to minutes
Multiply speed x time
Divide by 60

85

Quiz: Finding Distance

27. Cruising at 6.3 knots, it took 7:05 to cross the Outer Santa Barbara Passage from Cat Harbor (Santa Catalina Island) to Pyramid Cove (San Clemente Island). What was the distance?

28. You got underway at 0635 at a speed of 7.2 knots, and arrived at your destination at 1715. How far did you travel?

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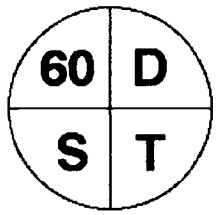
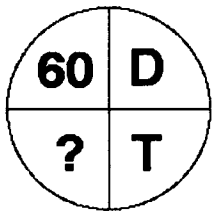
Finding Speed





Time: **Departed 0638**
Arrived 0818
Speed: **?**
Distance: **11.5 nm**

Find time in minutes
Multiply 60 x distance
Divide by time in minutes

07	
~~08~~	18 + 60 = 78
- 06	38
1	40

Change hours into minutes
1:40 = (1 x 60) + 40 = 100 minutes

$$S = \frac{60 \times 11.5}{100} = 6.9 \text{ knots}$$

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Quiz: Finding Speed

29. It took 55 minutes to travel 6 nautical miles from Mission Bay to the LaJolla kelp beds. What was your speed?

30. You depart from Avalon at 0800 and must travel 72 nautical miles back to your marina at Shelter Island in San Diego Bay. You want to arrive before sunset at 2015. What speed must be made?

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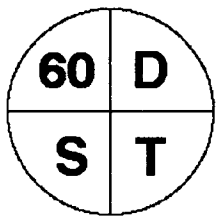
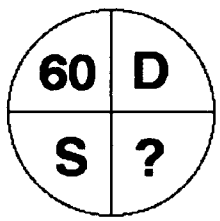
Finding Time





Time: ?
Speed: 5.8 knots
Distance: 78 nm

Multiply 60 x distance
Divide by speed
Convert minutes to hours

$$T = \frac{60 \times 78}{5.8} = 806 \text{ minutes}$$

$$\begin{array}{r} 13{:}26 \\ 60 \overline{)806} \\ -60 \\ \hline 206 \\ -180 \\ \hline 26 \end{array}$$

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Quiz: Finding Time

31. Your vessel's top speed is 6.3 knots. You plan to sail a total distance of 275 nautical miles during your upcoming trip. How many hours will you be underway?

32. The distance from Dana Point to Avalon is 33 miles. Your vessel's average speed is 8.1 knots. How long will the trip take?

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Course & Speed Made Good

- Course Made Good
- Speed Made Good

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Course Made Good

- Course made good AKA: track
- Direction from the point departure to the point of arrival
- Always plot as true course (not magnetic course)
- Plot your starting and ending points on a chart
- Draw a line between the two points
- Determine the direction from the starting point toward the ending point
- Use your plotter and triangle (or compass rose) to find your true course in degrees
- Course made good is always a true bearing
- You don't need to know speed, time, distance or heading in order to find the course made good

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Quiz: Course Made Good

33. You depart from a position 3 miles directly west of Batiquitos Lagoon at a speed of 6 knots. Forty-five minutes later, you are at position 33° 09.5' N, 117° 25.9' W and stop to fish. What was the course made good?

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Speed Made Good

- Plot your starting point and ending position on a chart and measure the distance between the two points
- Calculate the time interval from start to finish by subtracting the starting time from the ending time
- Use 60 D Street and solve for speed using 2 fixes and a time interval
- Speed over ground is speed made good
- You don't need to know course or the vessel's speed in order to find speed made good

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Quiz: Speed Made Good

34. At 1350 you are at position 32° 34.8' N, 117° 24.4' W on a compass course of 018° at a speed of 5.2 knots. At 1620, you are at the entrance to the Mission Bay Channel. What was the speed made good?

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Set & Drift

- Determining Course to Steer for a Known Set & Drift
- Determining Set & Drift

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Set & Drift

- Set - Direction of the current
- Drift - Speed of the current
- Current causes a discrepancy between your actual and predicted positions
- In addition to current, wind, variations in engine speed, and helmsmanship cause you to waiver from your course

97

Determining Course to Steer for a Known Set & Drift

- Plot your starting position point A and draw your track line
- Plot the direction of the current (set) starting from point A
- Using your dividers, measure a distance equal to 1 hour of current (drift) starting at point A down the set line
- Mark the point where the dividers touch the set line as B
- Measure a distance equal to 1 hour of boat speed with your dividers
- Place one leg of your dividers on point B on the set line, and the other leg of the dividers on the track line
- Mark the point on the track line as point C
- Draw a line to connect points B and C, and find the course
- This is the true course to steer to compensate for set & drift

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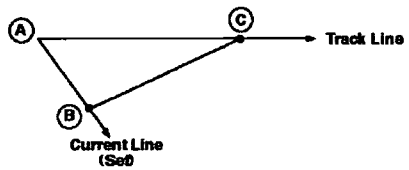
Determining Course to Steer for a Known Set & Drift



1. Plot your starting position (A)
2. Draw your intended track line. Correct course to true (if necessary).
3. Draw the current line (Set) starting from (A)
4. Measure distance equal to 1 hour of current (Drift) on the set line
5. Plot the point on the set line as (B)
6. Using your dividers, measure distance equal to 1 hour of boat speed
7. Place the dividers on (B) and mark the point where they touch the track line as (C)
8. Draw a line from (B) to (C)
9. Determine the direction from (B) to (C)

This is the true course to steer corrected for set & drift.

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Quiz: Determining Course to Steer for a Known Set & Drift

35. Your position at 0700 is 32° 53.3' N, 117° 28.1' W. The current is 162° at 2 knots. Your vessel's course is 126° true and your speed is 6.3 knots. What compass course must you steer to correct for the current (set & drift) and stay on course for your destination?

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Determining Set & Drift

- To find set and drift, compare the intended course with the course made good
- Determining set & drift means finding the direction & speed of the current
- Plot your starting position and indicate the time
- Draw the track line, correcting for true bearing if necessary
- Use 60 D St to find the distance down the track line where you should be at the time of your 2nd fix (DR)
- Plot your 2nd fix
- Find direction from the DR to the 2nd fix. This is the set.
- Measure distance from the DR to the 2nd fix. Use 60 D ST to find speed. This is the drift.

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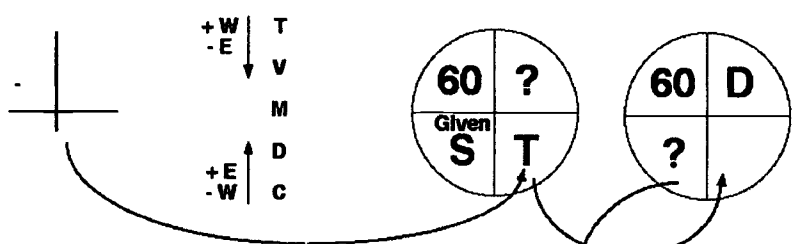
Determining Set & Drift



1. Plot your starting position
2. Correct course to true (if necessary)
3. Draw a track line on the chart
4. Find time and convert to minutes
5. Do a 60 D Street problem to find distance (DR)
6. Measure distance on the chart using the latitude scale
7. Mark the DR point on the track line indicating where you should be
8. Plot the second fix
9. Draw a line from the DR point to the second fix
10. Find the true course from the DR to the second fix (This is the Set)
11. Measure the distance from the DR to the second fix. Place this distance in the second 60 D Street calculation and solve for speed (This is the Drift)

Set _____° T

Drift _____ knots

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Quiz: Determining Set & Drift

36. You depart from the Isthmus on Santa Catalina Island at 1245 enroute to Newport Harbor. Your vessel's speed is 9.4 knots. At 1400, your vessel's position is 33° 27.6' N, 118° 17.4' W. What was the set and drift?

103

Aids to Navigation

- Buoys, marks
- Ranges
- Lights
- Publications

104

Aids to Navigation

- Lateral marks
- Beacons - fixed
- Buoys - float and move
- Nuns
- Cans
- Day marks
- Mid channel buoys
- Preferred channel marks
- Junctions
- Bifurcations
- Safe water marks
- Isolated danger marks
- Special marks
- Information and regulatory marks
- Ranges

105

Lights

- Light color
- Light rhythms
- Characteristics of lights
- Lighthouses
- Light ships
- LNBs (Large Navigational Buoys)

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Buoys

- Consist of a float, mooring chain and anchor
- May be equipped with lights and/or sound signals (bells, gongs, whistles)
- Lateral System as seen as entering from seaward (except on Western Rivers and Intracoastal Waterway)
- Numbers increase as you head in from the sea
- Consistent in IALA region B (all of the Americas)
- Junctions come together
- Bifurcations split

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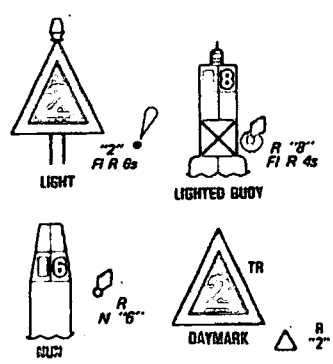
Starboard Side Aids

- Red buoys are found on the starboard side of a channel when entering from seaward
- Lit with red or white lights
- Evenly numbered
- Use the memory aid "Red Right Returning" to keep buoy on your starboard side when entering from seaward
- Lighted buoys, nuns, triangular daymarks
- Light can be: fixed, flashing, occulting, quick-flashing, or equal intervals



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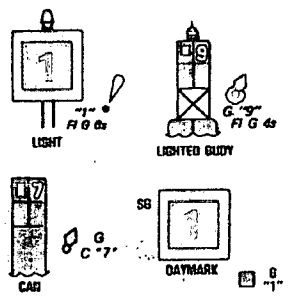
Port Side Aids

- Green buoys
- Found on the port side of a channel when entering from seaward
- Lighted buoys, cans, square daymarks
- Odd numbered
- Lights can be: fixed, flashing (most common), occulting, quick-flashing, or equal intervals
- Under the old buoyage system (pre 1989 IALA-B), green buoys were black, and if lit, were lit with white lights



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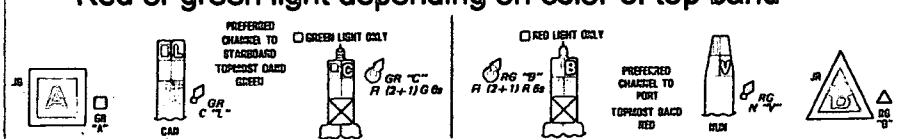
Horizontally Striped Aids

- Preferred Channel marks
- Red and green horizontally banded
- Mark junctions, bifurcations, or obstructions that can be passed on either side
- Preferred channel is to starboard when entering from seaward if the top band is green
- Preferred channel is to port if the topmost band is red
- Lighted buoys, cans or nuns depending on topmost color band, and square or triangular daymarks depending on the topmost color band
- Red or green light depending on color of top band



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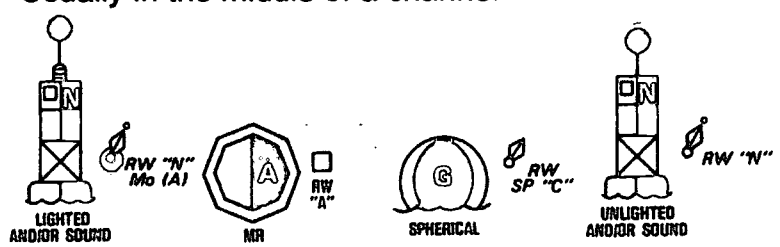
Vertically Striped Aids

- Mark Safe Water
- Red and white vertically striped
- No numbers, but may be lettered
- White light only
- Morse code A (dot dash, dot dash, dot dash)
- Sphere, lighted and/or sound buoy, octagonal mark
- Usually in the middle of a channel



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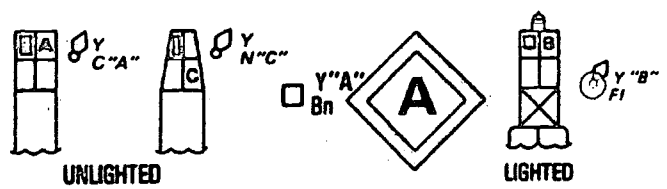
Special Marks

- Yellow buoys, cans, nuns or daymarks depending on the position of the mark in relation to the direction of buoyage
- Yellow lights if lit, fixed or flashing only
- Lettered rather than numbered
- Used to mark anchorages, military exercise areas, scientific data collection areas, traffic separation schemes, cables



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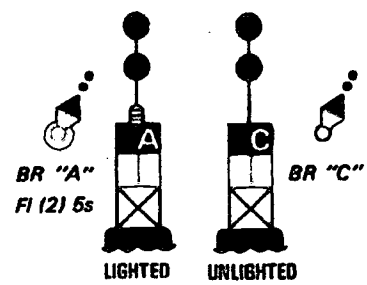
Isolated Dangers

- Mark hazards
- Horizontally banded - black, red, black
- Two black, spherical topmarks placed one on top of each other
- White lights
- Light characteristic is Fl (2) 5 sec - two flashes then an eclipse period
- Not numbered, but may be lettered



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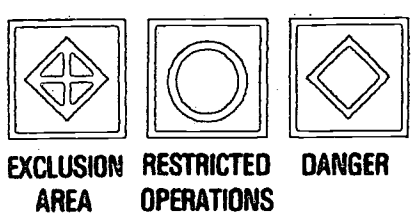
Information & Regulatory Markers

- Provide information or instructions, notify boaters of dangers, exclusion areas, regulations or operating restrictions
- White buoys with orange crossed diamonds (exclusion areas), circles (restricted operations) or open diamonds (danger)
- Ex. swimming areas, speed limits
- White lights if lit, using any rhythm except flashing or quick flashing



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Quiz: Aids to Navigation

37. The letters "Fl 4s 75ft 6M" are located next to an aid to navigation on the chart. What information is being provided?

38. A buoy located at the entrance to Newport Harbor is labeled RW "NWP" Mo (A) on the chart. What type of aid to navigation is this?

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Beacons

- Beacons
- Fixed, usually erected in shallow water, more reliable than buoys, colors match buoys that could be placed in the same locations

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Lights

- Lighted buoys, lighted beacons, lightships, lighthouses
- Light colors red, green, white, yellow
- Period is the time in seconds required to complete a light cycle
- Light sectors
  - Colored glass panels may be used to obscure or shield a sector of light or show light in another color (usually red)
  - Often used to indicate safe passage (white) or danger areas (red)

117

Visibility of Lights

- Geographic
  - Distance in nautical miles that a light can be seen by an observer under prefect visibility at a height 15 feet above sea level
  - Higher the light is, farther the distance it should be able to be seen
- Nominal
  - Maximum distance a light can be seen in clear weather
- Luminous
  - Maximum distance a light can be seen in existing conditions of visibility

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Publications

Helpful to Have Onboard to Assist with Navigation

- Charts (current and corrected)
- Coast Pilots (or Sailing Directions) for areas in which you are operating
- Light Lists
- Tide Tables
- Current Tables
- Navigation Rules (> 12 meters)
- Notice to Mariners (recommended)

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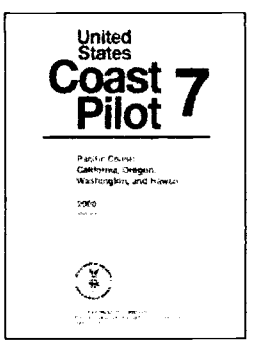
Coast Pilot



- Information about areas in which you are operating
- Like a cruising guide
- Published by NOAA by region
- Contains descriptive information about routes, applicable charts, approaches, aids to navigation, distances, weather information, anchorages, restricted areas, hazards
- Also includes Navigation Regulations, and useful General Information (Ex. pollution prevention, submarine ID signals, destructive waves, distress procedures, towing preparation, helicopter rescue...)

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Light List

- Describes lights and buoys
- Geographic range - how far you can see an object from a particular height
- Chart acronyms
- Chart symbols
- Glossary of terms
- Index of light names
- Should be corrected weekly from the Local Notice to Mariners

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Local Notice to Mariners

- Published monthly and weekly by each Coast Guard District, free of charge
- Available on the web at www.navcen.uscg.gov/lnm/d11
- Lists special notices
- Provides information about the status of GPS and LORAN
- Lists discrepancies or temporary changes (missing, inoperative, reduced intensity, damaged) to aids to navigation, chart corrections, proposed changes in aids to navigation,and hazards to navigation
- The "Notice to Mariners" is also published weekly, by the National Imagery and Mapping Agency (NIMA), and provides information primarily for large vessels

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Tide Tables

- Provide times and height differences for high and low water
- To find the depth at a location, add the height from the Tide Tables to the charted depth
- Use information for the reference station or correct for the subordinate station nearest where you are sailing
- Remember to add an hour for Daylight Savings Time
- Also provide sunrise/sunset and moon rise moon set times
- Published by International Marine for NOS of NOAA
- Privately published almanacs and commercial tide tables are also available

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Tides

- Tide is the vertical rise and fall of the ocean level resulting from forces of gravitation
- The moon exerts the primary force on tides
- Sun also exerts a force on tides but less than the moon, because although the sun is larger, it's further away
- High tide is the highest water level in a cycle
- Low tide is the lowest water level in a cycle
- Stand of a tide is the period in the tidal cycle in which the level appears not to change
- Range is the difference between the height of high tide and low tide
- Time difference between one high tide and one low tide is approximately 6:12

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Tides

- Mean low water is the average of all low tides
- Mean lower low water is the average of the lower of two low tides occurring within a day
- Actual depth of water equals the depth on the chart plus the height of the tide
- Spring tide
  - Occurs when the sun and moon act together at times of new or full moon
  - High tides are higher and low tides are lower than normal
- Neap tides
  - Occur when the sun and moon act in opposition
  - Smallest tide range

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Current Tables

- Provides predictions on:
  - Slack time (minimum current flow) and times of maximum flood for both ebbs and both floods
  - Speed of current in knots for flood and ebb
  - Approximate true direction of currents
- Use information for the 34 primary reference stations on the N. American Pacific Coast or correct for one of the 1,500 subordinate station nearest where you are sailing
- Current cannot be determined from Tide Tables
- North American Pacific Coast: Typically diurnal inequality (difference in two consecutive ebb or floor maximums) due to the effect of the moon

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Current Tables

- Usually 4 slack currents and 4 maximum currents each day
- Currents can be altered by wind, weather, river discharge, so actual speeds and times may vary from what is published
- Published by International Marine for NOS of NOAA, and by the Canadian Hydrographic Service
- Privately published almanacs and commercial current tables are also available

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Currents

- Currents are the horizontal movement or flow of water between the ocean and coastal waters
- Two types of currents: ocean currents and tidal currents
  - Ocean currents result from effects of winds, salinity and temperature differences in the water (example: Gulf Stream, California Current)
  - Tidal currents result from tidal changes
- Strength of the current depends on the point in the tidal cycle and land configuration
- Strong currents are predicted when a large amount of water has to move through a small land opening

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Currents

- Flooding means the current is moving toward shore and the tide is rising
- Ebbing means the current is moving away from shore
- At slack water no detectable horizontal movement of water

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Navigation Rules

- Inland Rules
  - Replaces the old Inland Rules, Western Rivers Rules, Great Lakes Rules and parts of the Motorboat Act of 1940
  - Adopted by Congress as the Inland Navigational Rules Act of 1980
  - Became effective December 24, 1981 (except on the Great Lakes -- March 1, 1983)
  - International and Inland Navigational Rules and Annexes are similar in content and format

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Navigation Rules

- International Rules
  - Formalized at the Convention on the International Regulations for Prevention of Collisions at Sea
  - Became effective on July 15, 1977
  - Commonly referred to as the 72 COLREGS
  - Adopted by Congress as the International Navigational Rules Act of 1977
  - International Maritime Organization (IMO) adopted 55 amendments (effective in 1983), and 8 more amendments (effective in 1989)
  - Applicable on waters outside demarcation lines

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Navigational Errors

- Incorrectly identifying aids to navigation
- Not using charts, tables, lists, coastal pilots and other reference publications
- Using out-of-date or uncorrected charts
- Failing to apply variation or deviation
- Not keeping a DR plot
- Ignoring or incorrectly evaluating available information
- Depending on only one source of information
- Forgetting to note depths and hazards
- Using impaired or poor judgment

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Quiz Answers

133

Answer: Uncorrecting the Compass

1. What is the compass course to steer from the Dana Point harbor entrance to Avalon?
   T 259°
   V -13° E
   M 246°
   D + 2° W
   C 248°

2. What is the compass course to steer from San Diego's Mission Bay to Dana Point?
   T 332°
   V -13° E
   M 319°
   D + 1° W
   C 320°

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Answer: Correcting the Compass

3. You depart from Avalon on a compass course of 084°. What is the true course to plot?

T	99°
V	+ 13° E
M	86°
D	+ 2° E
C	84°

4. You are steering a course of 210° per your magnetic compass. What is the true course to be plotted on the chart?

T	220°
V	+ 13° E
M	207°
D	- 3° W
C	210°

135

Answer: Finding Compass Error

5. If variation is 13° E and Deviation is 2° W, what is the compass error?

13° E
+2° W
11°

6. The compass course between two points is 350°. Variation is 13° E and Deviation is 1° W. What is the true course to plot? What is the compass error?

T	002°
V	+ 13° E
M	349°
D	- 1° W
C	350°

002° = 362°
- 350°
12° E

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Answer: Finding Missing Values & Compass Error

		A	B	C
+W	T	270°	090°	175°
-E	V	14° E	12° W	5° E
	M	256°	102°	170°
+E	D	2° W	2° E	1° W
-W	C	258°	100°	171°
Compass Error		12° E	10° W	4° E

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Answer: Deviation from a Range

8. The north jetty light at the entrance to Mission Bay (characteristics Fl G 6s 22ft 7m "1") is sighted over the bow in line with the Sea World sky tower (characteristics 338ft Fl R). The compass bearing is 059°. What is the deviation of the compass while on that heading?

T	076°	063° M
V	- 13° E	- 059° C
M	063°	4°
D	___	Compass is least, error is east
C	059°	4° E

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Answer: Plotting Positions

What is located at each of the following positions?

9. San Onofre Nuclear Power Plant

10. Pyramid Head Light on San Clemente Island

11. Offshore Oil Platform Edith

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Answer: Finding Latitude and Longitude

Determine the latitude and longitude for each of the following positions.

12. Point Loma lighthouse (new)

    Latitude 32° 39.9' N
    Longitude 117° 14.5' W

13. Ship Rock (Isthmus Cove on Santa Catalina Island)

    Latitude 33° 27.7' N
    Longitude 118° 29.5' W

14. Lighted red & white safe water mark at the entrance to Newport Harbor

    Latitude 33° 35.0' N
    Longitude 117° 52.7' W

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Answer: Laying Out a Course

Lay out the following courses. Remember all course lines drawn on a chart should be true courses.

15. Determine the true course from Dana Point harbor entrance to Avalon.
    258° T

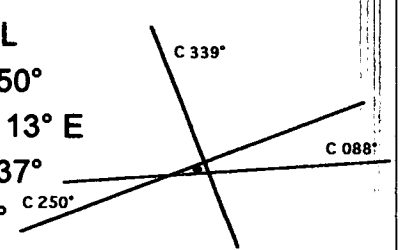
16. What is the compass course you would steer from Dana Point to Avalon? Use the deviation chart provided and information from the chart compass rose.
    T 258°
    V - 13° E
    M 245°
    D + 3° W
    C 248°

141

Answer: 3 Line of Position Fix

	Position	Bearing	
Pyramid Head light	32° 49.3' N,	118° 21.4' W	075° C
Navy building	32° 50.0' N,	118° 23.5' W	326° C
Cliff light	32° 48.9' N,	118° 24.3' W	237° C

	PHL	NB	CL
T	088°	339°	250°
V	+ 13° E	+ 13° E	+ 13° E
M	075°	326°	237°
D	0°	0°	0°
C	075°	326°	237°



Position: 32° 49.0' N, 118° 23.4' W

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Answer: Measuring Distance

What is the distance between the two points?

18. The Casino building in Avalon to Oceanside Harbor entrance?
    47 nautical miles

19. Marina del Rey to Bird Rock at the entrance to Isthmus Cove (Santa Catalina Island)?
    31 nautical miles

20. Safe water mark at the entrance to Newport Harbor to the Huntington Beach Pier?
    7.3 nautical miles

143

Answer: Converting Time

21. Convert 537 minute to hours and minutes.

```
      8
60 | 537 minutes
   - 480
     57
```

8:57

22. Convert 305 minutes to hours and minutes.

```
      5
60 | 305 minutes
   - 300
     05
```

5:05

23. Convert 2:35 to minutes.
    2:25 = (2 hours x 60 minutes) + 35 minutes = 155 minutes

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Answer: Determining Elapsed Time

24. You left Mission Bay at 0615 hours and arrived at the entrance to Oceanside Harbor at 0940. How long did the trip take?

```
  09 | 40
- 06 | 15
  3  | 25   3:25 = (3 x 60) + 25 = 205 minutes
```

25. You spotted Anacapa's West Island at 0740 after sailing all night from Newport Beach. You departed from Newport at 1510. How long were you underway?

```
  14
  ~~15~~ | 10 + 60 = 70
- 07 | 40
  7  | 30   7:30 = (7 x 60) + 30 = 450 minutes
```

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Answer: Estimated Time of Arrival

26. Your 0900 position is off LaJolla at 32° 50' N, 117° 20' W and you are enroute to Dana Point at a speed of 6.2 knots. What is your estimated time of arrival?

Distance = 41.3 miles

60	41.3
6.2	?

$$\frac{60 \times 41.3}{6.2} = 399 \text{ minutes}$$

```
      6
60 | 399 minutes
   - 360
     39
```

6:39

```
  09 | 00
+ 06 | 39
  15 | 39
```

ETA 15:39

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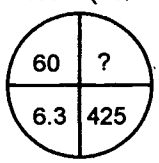
Answer: Finding Distance

27. Cruising at 6.3 knots, it took 7:05 to cross the Outer Santa Barbara Passage from Cat Harbor (Santa Catalina Island) to Pyramid Cove (San Clemente Island). What was the distance?

7:05 = (7 x 60) +05 = 425 minutes

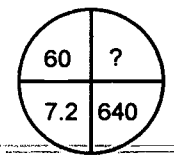


$$\frac{6.3 \times 425}{60} = 44.6 \text{ nautical miles}$$

28. You got underway at 0635 at a speed of 7.2 knots, and arrived at your destination at 1715. How far did you travel?

10:40 = (10 x 60) + 40 = 640 minutes

16	
~~17~~	15 + 60 = 75
- 06	35
10	40



$$\frac{7.2 \times 640}{60} = 76.8 \text{ nautical miles}$$

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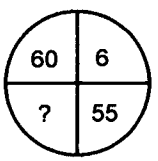
Answer: Finding Speed

29. It took 55 minutes to travel 6 nautical miles from Mission Bay to the LaJolla kelp beds. What was your speed?

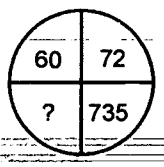


$$\frac{60 \times 6}{55} = 6.5 \text{ knots}$$

30. You depart from Avalon at 0800 and must travel 72 nautical miles back to your marina at Shelter Island in San Diego Bay. You want to arrive before sunset at 2015. What speed must be made?

12:15 = (12 x 60) + 15 = 735 minutes

20	15
- 08	00
12	15



$$\frac{60 \times 72}{735} = 5.8 \text{ knots}$$

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Answer: Finding Time

31. Your vessel's top speed is 6.3 knots. You plan to sail a total distance of 275 nautical miles during your upcoming trip. How many hours will you be underway?

60	275
6.3	?

$$\frac{60 \times 275}{6.3} = 2619 \text{ minutes}$$

```
      4 3
60 ) 2619 minutes
     - 240
       219
     - 180
        39
```

43:39

32. The distance from Dana Point to Avalon is 33 miles. Your vessel's average speed is 8.1 knots. How long will the trip take?

4:04

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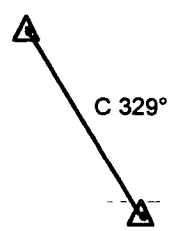
Answer: Course Made Good

33. You depart from a position 3 miles directly west of Batiquitos Lagoon at a speed of 6 knots. Forty-five minutes later, you are at position 33° 09.5' N, 117° 25.9' W and stop to fish. What was the course made good?



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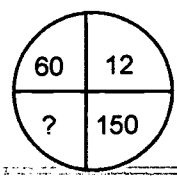
Answer: Speed Made Good

34. At 1350 you are at position 32° 34.8' N, 117° 24.4' W on a compass course of 018° at a speed of 5.2 knots. At 1620, you are at the entrance to the Mission Bay Channel. What was the speed made good?

Distance = 12 nautical miles

```
  15
 ~~16~~ | 20 + 60 = 80
- 13 | 50
   2 | 30
```

2:30 = (2 x 60) + 30 = 150 minutes



$$\frac{60 \times 12}{150} = 4.8 \text{ knots}$$

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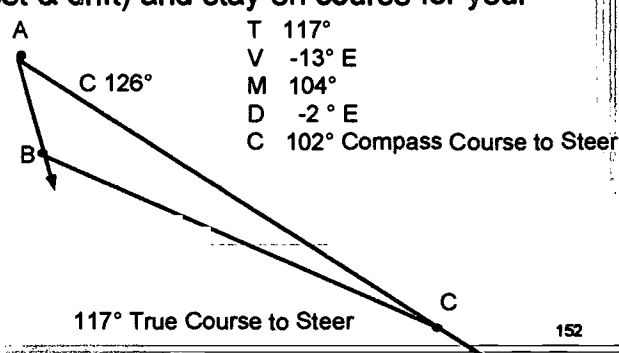
Answer: Determining Course to Steer for a Known Set & Drift

35. Your position at 0700 is 32° 53.3' N, 117° 28.1' W. The current is 162° at 2 knots. Your vessel's course is 126° true and your speed is 6.3 knots. What compass course must you steer to correct for the current (set & drift) and stay on course for your destination?



T 117°
V -13° E
M 104°
D -2 ° E
C 102° Compass Course to Steer

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Answer: Determining Set & Drift

36. You depart from the Isthmus on Santa Catalina Island at 1245 enroute to Newport Harbor. Your vessel's speed is 9.4 knots. At 1400, your vessel's position is 33° 27.6' N, 118° 17.4' W. What was the set and drift?

T course = 074°

```
 13
 ~~14~~ 00 + 60 = 60
-  12 45
   1  15
```

1:15 = (1 x 60) + 15 = 75 minutes

Find D

60	?
9.4	75

$$\frac{9.4 \times 75}{60} = 11.75 \text{ miles}$$

Find S

60	2.6
?	75

$$\frac{60 \times 2.6}{75} = 2.08 \text{ knots (Drift)}$$

Set 210° (Direction of current)
Drift 2.08 knots (Speed of current)

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Answer: Aids to Navigation

37. Fl 4s 75ft 6M means the light is located 75 feet above the water, is flashing at 4 second intervals and has a light range of 6 nautical miles

38. Safe water mark

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