INDEX toggles the Bookmarks for quick navigation

STARPATH®

TrueWind

User's Guide

by

David Burch

About Starpath TrueWind

Starpath TrueWind is a Windows program designed to compute very conveniently true wind from apparent wind for use in maneuvering and weather analysis. It is also graphically enhanced for studying the vector solution in general to learm more about how the individual components of the solution are interdependent. A general discussion of wind analysis is included for background.

The program has been produced and copyrighted by Starpath School of Navigation which retains all rights to the product. We do, however, distribute it free of charge as a service to mariners and as a means of promoting our other products and services which can be seen at www.starpath.com.

The program may be distributed freely provided it is not modified and it is presented in full with its original install file which includes the discussion document (truewind.pdf) and so long as it is not part of any commercial product or service, directly or indirectly.

A valid legal edition of this program is called "Starpath TrueWind" and the file name for distribution of the self extracting zip file is sp-tw101.exe.

Starpath School of Navigation
3050 NW 63rd St.
Seattle, WA 98107-2521, USA
206-783-1414, fax 206-783-9209

info@starpath.com
www.starpath.com

How to Use StarPath TrueWind

You can compute true wind two ways, either enter the apparent wind data numerically and then press "Compute True Wind" or drag the yellow dots in the diagram with the mouse to create the appropriate vector diagram. The computations will execute when you release a dot. The apparent wind angle and apparent wind speed are shown in green. True wind values are shown in blue.

All wind speeds are intended to be in knots, but any unit can be used so long as the boat speed and the wind speeds are in the same units, ie miles per hour, km per hour, or meters per second.

To drag yellow dots, left click a dot and hold down the left mouse button as you move the dot to the desired location, then release the mouse button. You can move the wind from port to starboard side or vice versa.

Adjust the scale as needed with the set of radio buttons, which determine the scale of the full picture. The scale values will apply to the speed units you choose, even though still marked in kts.

To move the entire diagram on the page, right click anywhere on the diagram and then drag it into position and release the right mouse button.

Quick help buttons are available on the screen itself.

Definitions of the various terms are given below, as well as discussion of a few general issues of true wind versus apparent. Note restrictions mentioned in definitions of speed and heading.

Definitions

Wind direction

This name generally refers to the true wind blowing across the land or across the water. In this case, it is always the direction from which the wind is blowing. A north wind blows from the north, toward the south. Unless otherwise specified, these directions are assumed to be true directions. Usually it is best to specify wind direction numerically as, say, 280 for a wind from 10° north of west. In particular, for careful weather analysis, we do not want to refer to, or to log a wind direction as just "west" or "westerly." when we know it to be, say, 275. When less than 100, it is best to add a leading zero, i.e., "the wind is from 050," said as "oh-five-oh" rather than from 50 (five-oh or fifty). A southerly wind is from 180, if asked the wind direction the answer would be one-eight-oh. "Wind direction" is distinguished from "wind angle."

Note that although the final goal is to have wind direction in terms of true bearings, we often keep track of directions with compass headings, and in these cases at some point we have to apply the local magnetic variation to get the desired result. Once we find the true wind angle, we have to either apply it to a corrected compass heading (ie the true heading of the vessel), to get true wind direction, or we apply it to the compass heading itself to get the compass bearing of the true wind direction. In this latter case, it would be best to then immediately correct this to get the true bearing of the true wind.

Apparent wind

The wind we actually feel or the vessel feels when moving. It is a combination of the true wind and the effective wind created by our motion. If our speed is zero, the apparent wind is the same as the true wind. The apparent wind is described by the apparent wind speed and the apparent wind angle.

Apparent wind angle (AWA)

The direction of the apparent wind relative to the head of the vessel, usually listed as port or starboard. It varies from 0° (wind on the bow), through 90° (wind on the beam), on around to 180° (wind on the stern). The apparent wind angle is always smaller (forward of) the true wind. The faster you go, the more the apparent wind moves forward on the vessel. The apparent wind is the actual wind you feel on your face. If you are facing 30° to the right of the bow, and the wind is in your face, then the apparent wind angle is 30°. Note that unlike wind direction, leading zeros are not used for wind angles. It is AWA = 30°, not 030. Since apparent wind angles are relative angles, it does not make sense to refer to them as "true" or "magnetic."

Apparent wind speed (AWS)
The speed of the wind in knots that we measure from a moving vessel. It is a combination of the true wind speed and the effective wind we create with our motion. Motoring at 8 kts straight into a 12-kt true wind, we would experience an apparent wind speed of 20 kts. Sailing dead downwind at 7 kts in a true wind of 12 kt, the apparent wind would be reduced to 5 kt. When sailing diagonal to the true wind direction, up or down wind, the resulting apparent wind speed cannot be determined from simple arithmetic, but instead vectors must be solved as done by this computer program. In general, though, sailing into the wind, the apparent wind speed is always higher than the true wind speed and sailing downwind it is always lower.

True wind angle (TWA)
The direction of the true wind relative to the head of the vessel, usually listed as port or starboard. It varies from 0° (wind on the bow), through 90° (wind on the beam), on around to 180° (wind on the stern). The true wind angle is always larger (aft of) the apparent wind. If the apparent wind is on the bow, the true wind is more toward the beam. If the appraent wind is on the beam, the true wind is more toward the quarter, and if the apparent wind is on the quarter, the true wind is more toward the stern.

True wind speed (TWS)
This is the actual speed of the wind over the water. Generally it is expressed in knots. 1 knot = 1.15 miles per hour = 1.85 km/hr = 0.514 meters per second.

Speed (S)

This is usually just your boat speed through the water as measured by a knotmeter, when in strong current parallel to your heading, however, it could be more accurate to use speed over ground (SOG) as measured with the GPS. (On the other hand, if your course over ground (COG) is significantly different from your heading, you cannot figure accurate true wind from a single simple computation as done here.)

Heading

The best thing to enter here is the true heading of the vessel, that is, if steering a compass course, correct the compass course first with the variation so you can input here your actual true heading at the time the wind data was collected. This way you get out directly the true wind direction in true bearings. If, instead, you input here your compass heading, you end up with the compass bearing of the true wind, which is a rather awkward concept. It is best to compute and log the true direction of the true wind.

Note that if you are being set significantly by the current at the time of the wind measurement, which would be the case if your COG from the GPS does not agree with your heading, then this method of determining true wind from apparent will not work. The vector solution needed then is more complex. You could perhaps remedy this by altering course to align with the set at least long enough to get an accurate wind measurement.

Discussion

Telltales
To watch the wind direction without proper wind instruments, it is extremely helpful to rig a telltale, a piece of string or strip of light cloth tied high in the rigging, out of the way of other structures on the boat. Strips of plastic bag or cassette tape also make good telltales. Telltales show the apparent wind angle instantaneously. It is always better to use them than to guess the wind direction from the feel of it. Telltales are commonplace on sailboats, less so on powerboats. But on any boat, if you must watch the wind direction carefully, the first thing to do is rig a telltale. Its an "instrument" you can rely on.

A mechanical windvane generically called a "windex" (in honor of the Davis Instruments version, a very popular brand of the tool) is effectively a calibrated telltale, with the apparent wind angles of 30 and 150 clearly marked as reference points (the user can adjust these two points to best match the sailing characteristics of the boat).

Electronic wind instruments
Electromechanical windvanes and anemometers at the masthead measure and display digitally the apparent wind speed and apparent wind angle. These simple apparent wind instruments are extremely valuable additions to any vessel, power or sail. This data can then be converted to true wind as explained below.

Alternatively, more expensive electronic options can accept input of vessel speed and compass course, and from these automatically compute and display real time values of the actual true wind speed and direction. Note, though, that for these automatic true-wind computations to be of most use, all inputs must be very carefully calibrated and maintained. For some vector solutions, slight errors in the input can yield rather large errors in the true wind solutions. Unless adequate time can be devoted to the monitoring of these calibrations, the simpler approach of measuring apparent values and then hand computing true winds might be the better solution in the long run.... needless to say, the Starpath TrueWind program will do that job nicely.

True wind versus apparent wind

In reading a telltale, we need to keep in mind that it shows the direction of the apparent wind as distinguished from the true wind. The apparent wind is the combination of the true wind and the effective wind generated by the motion of the boat. The difference between the directions of the true wind and the apparent wind depends on how fast you are moving relative to the true wind speed. For boat speeds less than 10 or 20 percent of the true wind speed, the difference is negligible, and you can read the true wind direction directly from the telltale.

When you are moving, the direction of the true wind is always aft of the apparent wind. If the apparent wind is on the beam, you must face this apparent wind and turn aft to be looking in the direction the true wind comes from. This is true regardless of your point of sail. If the apparent wind is 45° on the bow, the true wind is closer to the beam. If the apparent wind is on the quarter, the true wind is closer to the stern.

The exact number of degrees the true wind is aft of the apparent wind depends on your speed relative to the wind and on your point of sail. At any relative speed, the difference between the two is largest when you are sailing with the apparent wind on the beam. The difference is typically somewhere between 10° and 40°, where, generally speaking, the higher the performance of the sailboat, the bigger the shift can be.

When relying on wind shifts to tell us something about the weather, it is ultimately the true wind direction you care about. Apparent and true wind directions will not always be different enough to matter, but in order to read the wind — for maneuvering or for weather analysis — we must keep their potential differences in mind.

Tips, tricks, and special cases

(1) With the wind on the beam, the true wind can be well aft of the apparent wind. For example, in 5 to 10 knots of true wind, a typical sailboat travels at some 0.6 to 0.7 times the true wind speed. At speeds of 0.65 times the true wind, when the apparent wind is on the beam, the true wind is 41° aft of the apparent wind.

(2) If the true wind speed changes and your boat speed doesn't, the apparent wind will shift even though the true wind has not. For example, with the apparent wind on the beam, traveling at a hull speed of 7 knots in 10 knots of true wind, if the true wind increases to 15 knots but the boat speed stays at 7 knots, the apparent wind will shift aft some 20°, even though the true wind did not shift at all.

(3) Sailing downward with the true wind well aft, a small change in true wind can result in a large shift in apparent wind direction. For example, at a boat speed of 6 knots in 12 knots of true wind at 170°, if the true wind shifts forward 20° and drops to 10 knots, the boat speed would likely remain about the same, but the apparent wind would shift forward some 40°. With only the apparent wind shift to go by, we could easily misinterpret this wind shift.

(4) When we tack, the bow crosses the true wind direction and moves through two times the true wind angle.

(5) When we gybe, the stern crosses the true wind direction and the bow moves through two times the supplement of the true wind angle (180° - TWA).

How to find true wind from apparent

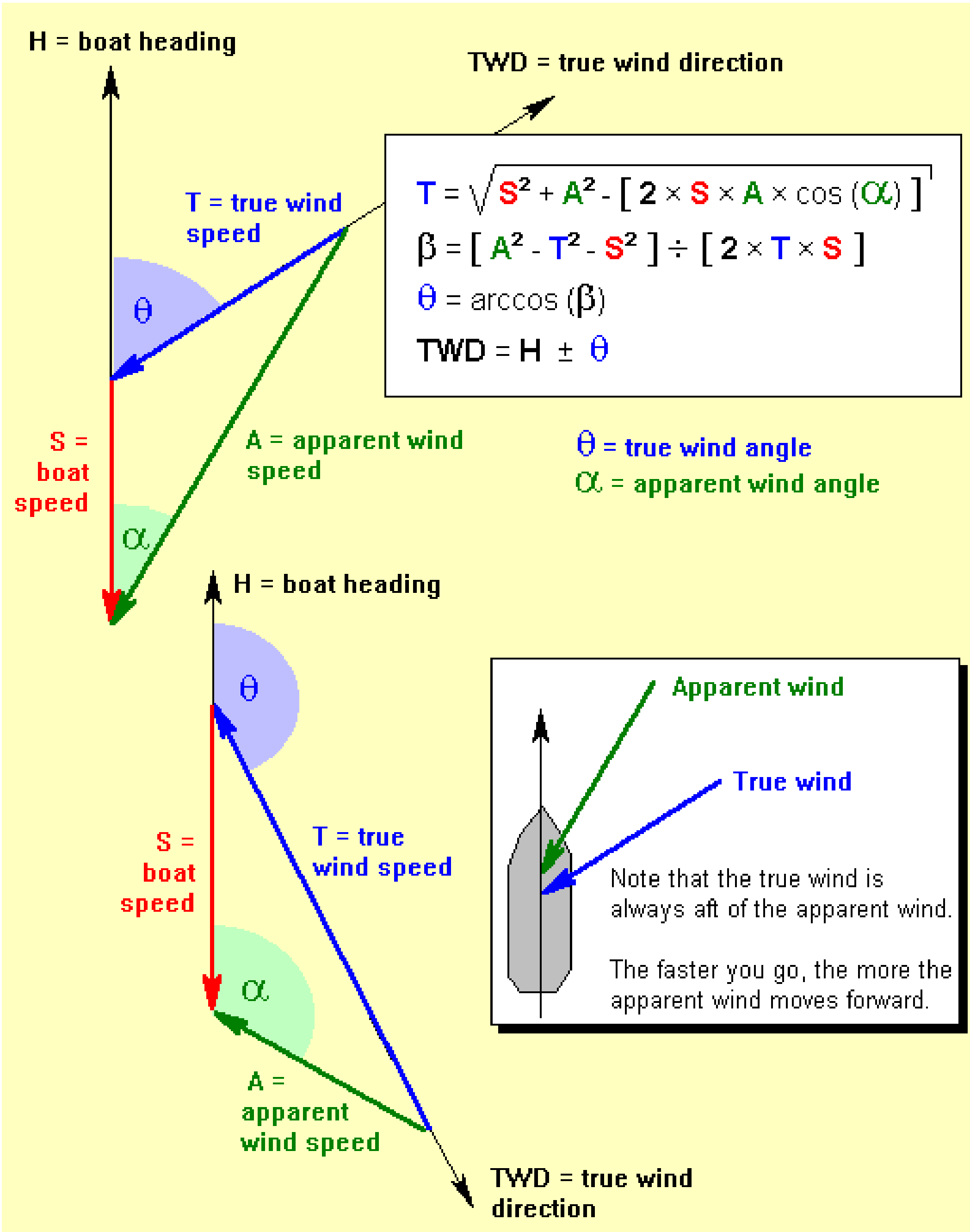
Reading the water

An obvious way to read the true wind direction is to stop the boat. This would automatically give you accurate true wind data provided you are not being set significantly by a strong current. Typically, though, you don't have to go to this extreme; you can usually read the true wind direction from the wave direction or from ripples on the water. These cats paws, as they are sometimes called, are the scalloped ripples that look like fish scales on the surface of the waves. The bigger waves do move in the direction of the wind if it is stable, but when the wind shifts, the wave direction does not follow immediately. Surface ripples, on the other hand, respond instantly to the wind, as if the wind were stroking the surface with a paint brush. Sometimes you have to stare at the water for a while to see them, but in any wind over a few knots they are there, and you can spot the wind direction from them.

Formulas and diagrams

That is what this program does — calculates the solution directly using the formulas — as does other software and hand held calculators such as the Starpath StarPilot, which in addition to wind and other navigation calculations also performs all celestial navigation functions.

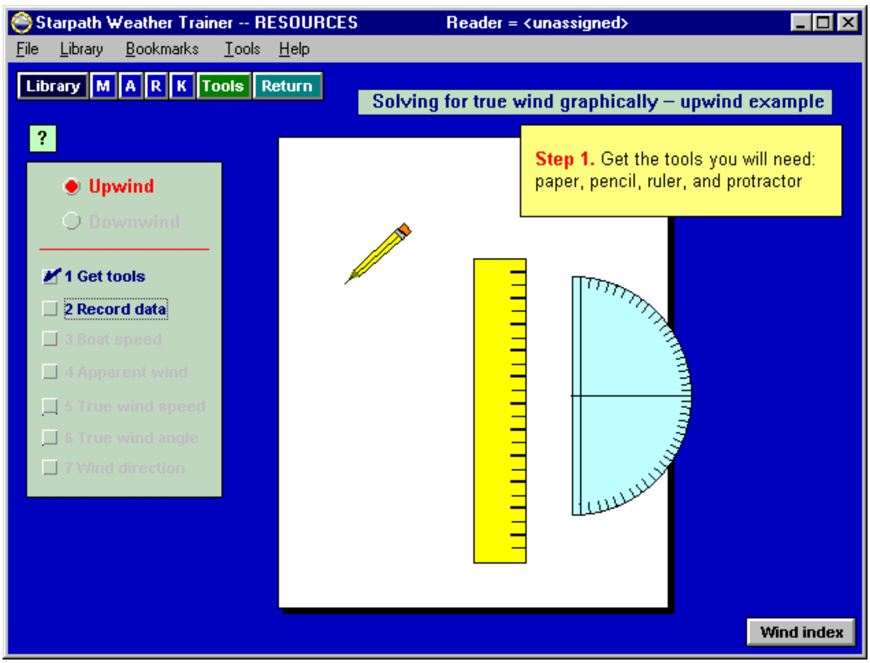
If you wish to do this directly from the trig equations, they are listed on the following page along with a diagram which defines the terms. These graphics are from the Starpath Weather Trainer program which includes a section that shows, step by step, how to solve these formulas with a simple trig calculator.



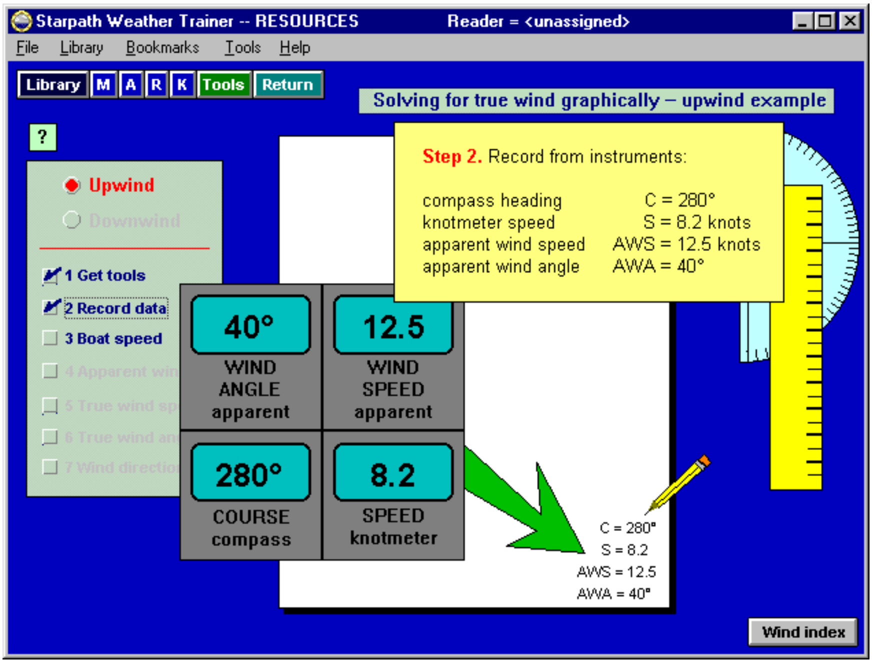
H = boat heading
TWD = true wind direction
T = √ S² + A² - [2 × S × A × cos (α)]
β = [A² - T² - S²] ÷ [2 × T × S]
θ = arccos (β)
TWD = H ± θ
T = true wind speed
θ
S = boat speed
α
A = apparent wind speed
θ = true wind angle
α = apparent wind angle
H = boat heading
θ
S = boat speed
T = true wind speed
α
A = apparent wind speed
TWD = true wind direction
Apparent wind
True wind
Note that the true wind is always aft of the apparent wind.
The faster you go, the more the apparent wind moves forward.

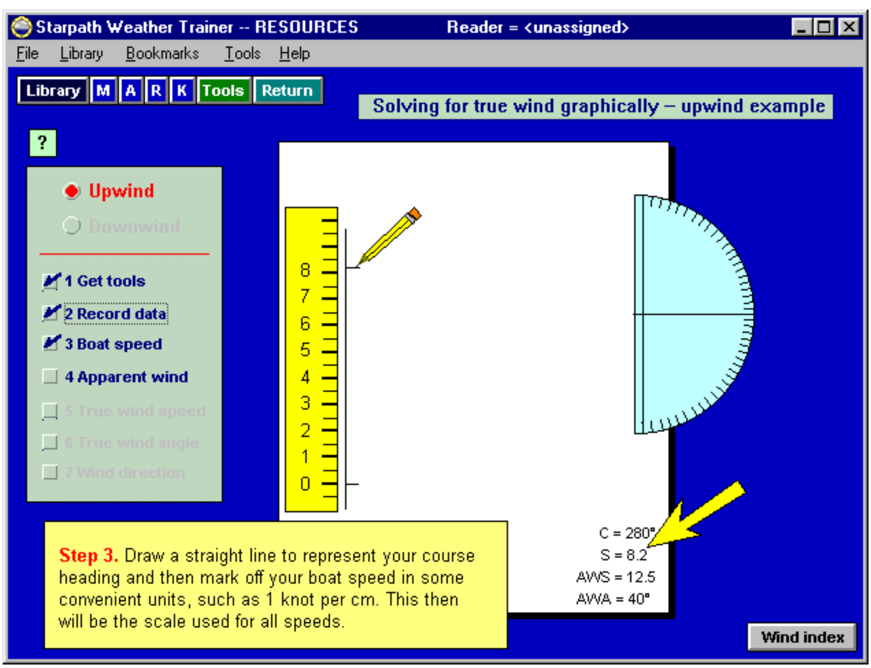
Graphical method

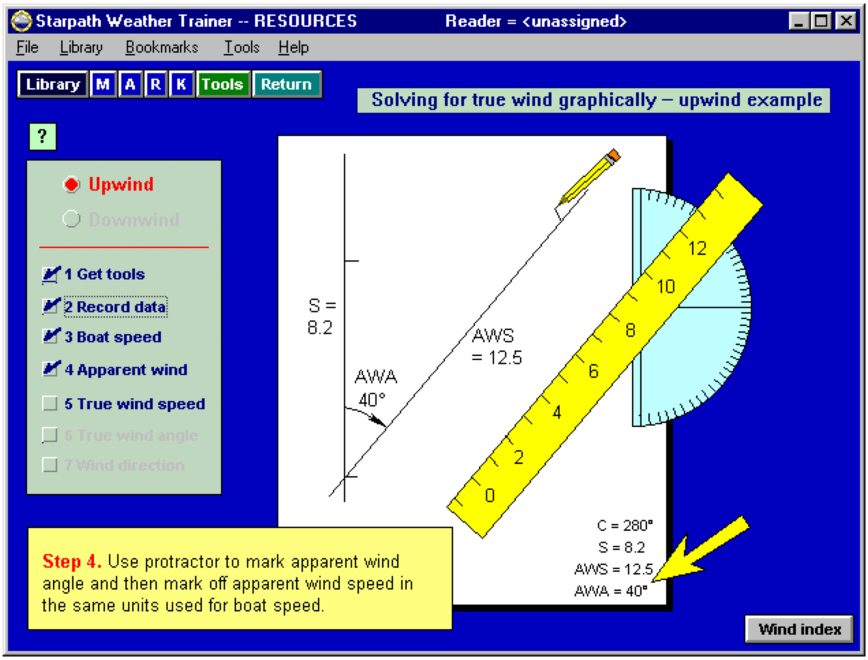
It is useful to understand and practice direction solution by vecotrs for the event that all convenient computers and calculators are not available. It is the same procedures used in solving current sailing problems. The steps for plotting the solution are outlined in the next sevral pages. These graphics are from the Starpath Weather Trainer program.



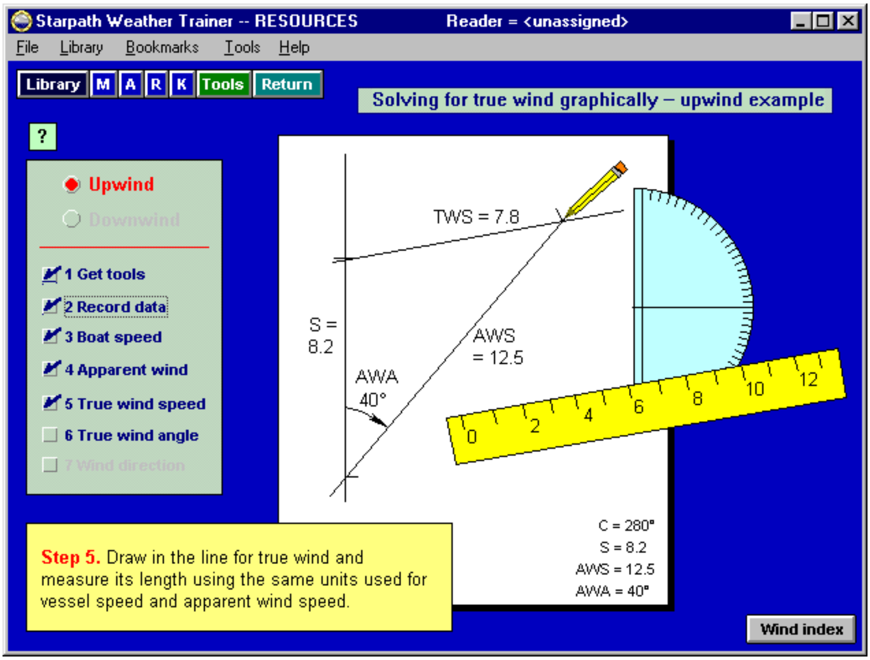
Each of the graphics shown is a screen capture of the last image in a series of animations that explain the procedure. The full animations along with practice problems are in the Starpath Weather Trainer program.


Starpath Weather Trainer -- RESOURCES
Reader = <unassigned>
File Library Bookmarks Tools Help
Library M A R K Tools Return
Solving for true wind graphically – upwind example
?
Upwind
Downwind
1 Get tools
2 Record data
3 Boat speed
Step 2. Record from instruments:
compass heading C = 280°
knotmeter speed S = 8.2 knots
apparent wind speed AWS = 12.5 knots
apparent wind angle AWA = 40°
40° WIND ANGLE apparent
12.5 WIND SPEED apparent
280° COURSE compass
8.2 SPEED knotmeter
C = 280°
S = 8.2
AWS = 12.5
AWA = 40°
Wind index

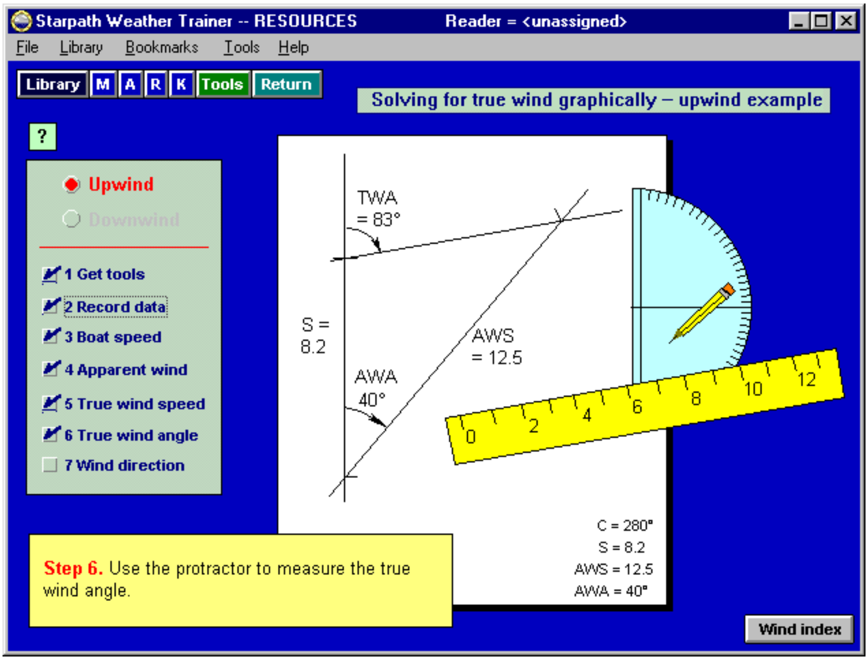

Starpath Weather Trainer -- RESOURCES
Reader = <unassigned>
File Library Bookmarks Tools Help
Library M A R K Tools Return
Solving for true wind graphically – upwind example
?
Upwind
Downwind
1 Get tools
2 Record data
3 Boat speed
4 Apparent wind
5 True wind speed
6 True wind angle
7 Wind direction
8
7
6
5
4
3
2
1
0
Step 3. Draw a straight line to represent your course heading and then mark off your boat speed in some convenient units, such as 1 knot per cm. This then will be the scale used for all speeds.
C = 280°
S = 8.2
AWS = 12.5
AWA = 40°
Wind index

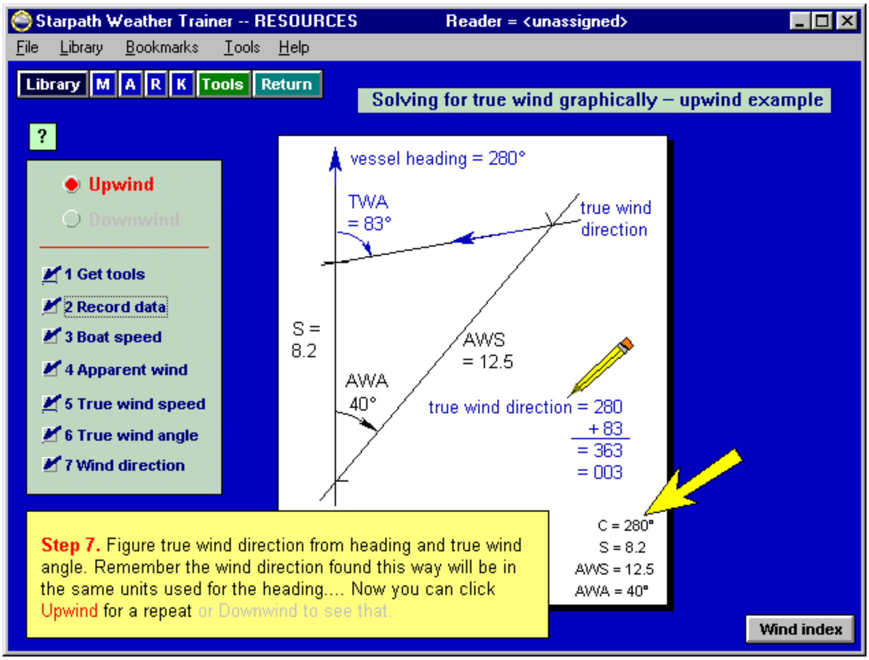


Starpath Weather Trainer -- RESOURCES
Reader = <unassigned>
File Library Bookmarks Tools Help
Library M A R K Tools Return
Solving for true wind graphically – upwind example
?
Upwind
Downwind
1 Get tools
2 Record data
3 Boat speed
4 Apparent wind
5 True wind speed
6 True wind angle
7 Wind direction
S = 8.2
AWS = 12.5
AWA 40°
C = 280°
S = 8.2
AWS = 12.5
AWA = 40°
Step 4. Use protractor to mark apparent wind angle and then mark off apparent wind speed in the same units used for boat speed.
Wind index



Starpath Weather Trainer -- RESOURCES
Reader = <unassigned>
File Library Bookmarks Tools Help
Library M A R K Tools Return
Solving for true wind graphically – upwind example
?
Upwind
Downwind
1 Get tools
2 Record data
3 Boat speed
4 Apparent wind
5 True wind speed
6 True wind angle
7 Wind direction
TWS = 7.8
S = 8.2
AWS = 12.5
AWA 40°
C = 280°
S = 8.2
AWS = 12.5
AWA = 40°
Step 5. Draw in the line for true wind and measure its length using the same units used for vessel speed and apparent wind speed.
Wind index


Starpath Weather Trainer -- RESOURCES
Reader = <unassigned>
File Library Bookmarks Tools Help
Library M A R K Tools Return
Solving for true wind graphically – upwind example
?
Upwind
Downwind
1 Get tools
2 Record data
3 Boat speed
4 Apparent wind
5 True wind speed
6 True wind angle
7 Wind direction
TWA = 83°
S = 8.2
AWS = 12.5
AWA 40°
0 2 4 6 8 10 12
C = 280°
S = 8.2
AWS = 12.5
AWA = 40°
Step 6. Use the protractor to measure the true wind angle.
Wind index


Starpath Weather Trainer -- RESOURCES
Reader = <unassigned>
File Library Bookmarks Tools Help
Library M A R K Tools Return
Solving for true wind graphically – upwind example
?
Upwind
Downwind
1 Get tools
2 Record data
3 Boat speed
4 Apparent wind
5 True wind speed
6 True wind angle
7 Wind direction
vessel heading = 280°
TWA = 83°
true wind direction
S = 8.2
AWS = 12.5
AWA 40°
true wind direction = 280
+ 83
= 363
= 003
C = 280°
S = 8.2
AWS = 12.5
AWA = 40°
Step 7. Figure true wind direction from heading and true wind angle. Remember the wind direction found this way will be in the same units used for the heading.... Now you can click Upwind for a repeat or Downwind to see that.
Wind index