



AIRCLASSICS<sup>TM</sup>

**E6-B**

Circular Flight  
Computer

**Instructions**

## *E6-B Circular Flight Computer Instructions*

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**ASA-E6B-CIRC**

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# Instructions for Using ASA E6-B Circular Flight Computer

Your ASA E6-B Circular Flight Computer has two main parts: a circular slide rule side for making quick calculations (Figure 1), and a wind side for computing ground speed and wind correction angle (Figure 2).

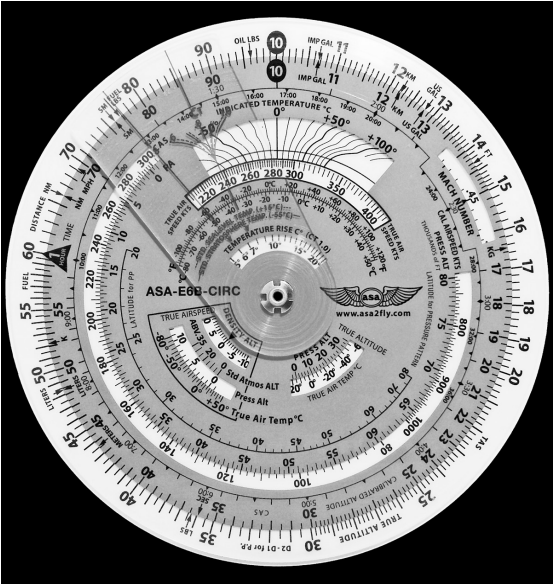


Figure 1. The calculator side.

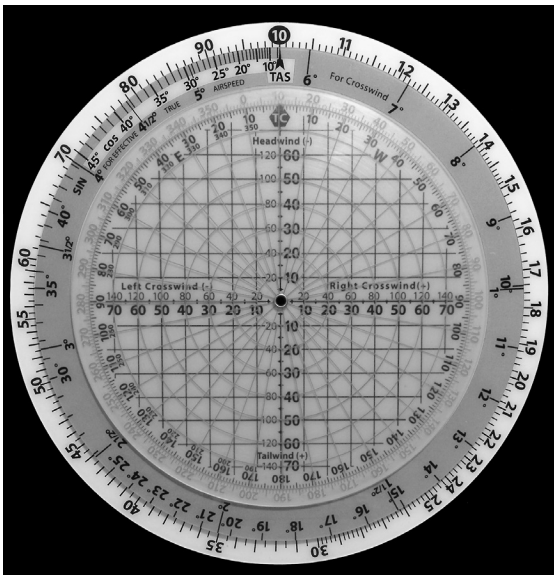


Figure 2. The wind side.

## The Calculator Side

The calculator side of the E6-B circular flight computer uses conventional slide rule procedures. This side of your computer consists of a rotating disk with numbers on the middle scale, which when set against similar numbers on the fixed portion (*outer scale*), allows you to solve problems of **time, speed, distance**, calculate **fuel consumption**, and make conversions between measurements such as statute and nautical miles. The inner scale on the rotating disk is graduated in hours. The calculator side also has “windows” that you will use to solve airspeed and altitude problems. In addition, the tab with red lettering provides

the ability to solve problems associated with temperature rise allowing you to find true air temperature, Mach number and true airspeed.

The **1 Hour** triangle on the rotating disk is marked differently than the other numbers. That is because most of your problems will be concerned with time—"something" per hour, either miles or gallons. Before you get to that, you should learn how to read and interpret the numbers on both portions of the slide rule side.

Rotate the disk until all of the numbers on the middle scale match up with the numbers on the outer scale—10 will be at the top. However, that number "10" may be read as ".1," "1," "100," or "1,000" depending upon the context of the problem. For now, read it as 10. The next number to the right is 11, so each line (or mark) of calibration between the two numbers is equal to .1, and you would read them as 10.1, 10.2, 10.3, etc. If you were solving a problem involving 1,000 pounds of fuel, the number 10 would be read as 1,000, and each calibration would be equal to 10 pounds, and the 11 would be read as 1,100 pounds (see Figure 1).

Now look at the number 15 on the outer scale. Between 15 and 16 each calibration mark is equal to .2 and would be read as 15.2, 15.4, etc. If you were solving a problem with an airspeed of 150 knots, the first calibration past 15 (150 in this case) would be 152. The spacing changes again at the number 30, where each calibration becomes .5, and at 60, where each calibration equals 1. Before you read a value from the disks, be sure you understand what each line of calibration is equal to.

You will use the calculator side to establish **ratios**. With the numbers matched, the ratio is 1 to 1 (see Figure 3). Set the number 1 (the rate arrow) directly opposite to (or, "lined-up" with) 12 on the outer disk. Notice that all of the numbers on the outer disk are exactly twice the value

The image shows a circular E6B flight computer with the following scales and highlighted values:

- Distance Scale (Outer):** Miles (0 to 100), Kilometers (0 to 160), Nautical Miles (0 to 110). A red circle highlights **70** on the Miles scale.
- Fuel Scale (Inner):** Gallons (0 to 100), Liters (0 to 400). A red circle highlights **30** on the Gallons scale.
- Speed Scale (Outer):** Knots (0 to 200), Miles per Hour (0 to 200), Kilometers per Hour (0 to 300). A red circle highlights **12** on the Knots scale.
- Temperature Scale (Inner):** Fahrenheit (0 to 100), Celsius (0 to 40). A red circle highlights **18** on the Fahrenheit scale.
- Altitude Scale (Inner):** Feet (0 to 10,000), Meters (0 to 3,000). A red circle highlights **40** on the Feet scale.

Other scales include True Airspeed (0 to 200), Indicated Airspeed (0 to 200), and Mach Number (0.2 to 1.5). The center of the computer features a small window for the current time and date.

Look at the inside scale on the disk, where the lines of calibration look like clock times: 9:00, 6:00, etc.—these express hours. The inner scale is in hours and the middle scale is in minutes. 1:30 is directly below 90; one hour and thirty minutes is the same as ninety minutes. 5:00 is printed below 30, indicating five hours is the same as 300

minutes. To convert minutes to seconds, place the rate arrow opposite to the number of minutes on the **outer** scale and read equivalent seconds opposite to the “seconds” arrow, just to the right of 35 on the inner scale.

## Basic Arithmetic

### *Multiplication*

Set unit index (10) beneath the multiplicand and read the product above the multiplier. For example:  
 $7 \text{ (multiplier)} \times 12 \text{ (multiplicand)} = 84 \text{ (product)}$

1. Rotate so the unit index (10) on the blue disk is opposite the multiplicand (12) on the white disk.
2. Read the product (84) on the white disk above the multiplier (7)

Remember that a given number on the computer such as 25 can also represent 2.5, 250, 250,000, etc. Select the value appropriate to the given problem. For example:  
 $17 \times 250 = ?$

1. Rotate so the unit index (10) on the blue disk is opposite the multiplicand (250) on the white disk.
2. Read the product on the white disk above the multiplier (17)—the answer is 4,250.

### *Division*

Set the dividend above the divisor and read the quotient above the unit index (10). For example:  
 $20 \text{ (dividend)} / 4 \text{ (divisor)} = 5 \text{ (quotient)}$

1. Rotate so the divisor (4) on the blue disk is opposite the dividend (20) on the white disk.
2. Read the quotient (5) on the white disk opposite the unit index (10) on the blue disk.

Remember that a given number on the computer such as 350 can also represent 3.5, 35, 350,000, etc. Select the value appropriate to the given problem. For example:



$$740 / 37 = ?$$

1. Rotate so the divisor (37) on the blue disk is opposite the dividend (740) on the white disk.
2. Read the quotient on the white disk opposite the unit index (10) on the blue disk—the answer is 20.

Try these arithmetic problems:

*(Answers are on Page 45)*

1.  $17 \times 5 = ?$
2.  $12 \times 60 = ?$
3.  $270 / 20 = ?$
4.  $180 / 3 = ?$

## Conversions

You can't solve a problem unless the values agree. You can't mix statute and nautical miles, gallons and liters, or Fahrenheit and Celsius. Your ASA E6-B Circular Flight Computer makes it possible for you to convert between values. To do this, place the converting arrow for one scale opposite the corresponding arrow on the other scale and read the value opposite each other on corresponding scales. Align 10 on the inner scale with 10 on the outer scale. Labeled arrows can be found on the inner and/or outer scales for the following items:

- Nautical Miles, NM (near 66 on both scales)
- Statute Miles, SM (near 76 on both scales)
- Feet, FT (near 14 on the outer scale)
- Meters, M (near 44 on the inner scale)
- Kilometers, KM (near 12 on both scales)
- Imperial Gallons, IMP GAL (near 11 on both scales)
- U.S. Gallons, US GAL (near 13 on both scales)
- Liters, L (near 48 on both scales)
- Pounds, LBS (near 36 on the outer scale)
- Kilograms, KG (near 17 on the inner scale)

### Nautical to Statute Miles

Distances on some maps and charts are in statute miles. Your airspeed indicator usually reads in knots, or nautical miles per hour. It is easy to convert between the two values by using special markings on the slide rule side of your flight computer. Knots can be converted to miles per hour in two ways: (1) aligning the NM and SM arrows or (2) using the NM and SM arrows on the outer disc. Look on the outside scale on either side of 70 for markings labeled NM and SM. Set the known value under the appropriate arrow and read the converted value under the other (see Figure 4). To convert 90 knots to statute miles per hour:

1. Set the arrow marked NM on the outer scale opposite of 90 on the middle scale.
2. Read 103.5 under the SM arrow.

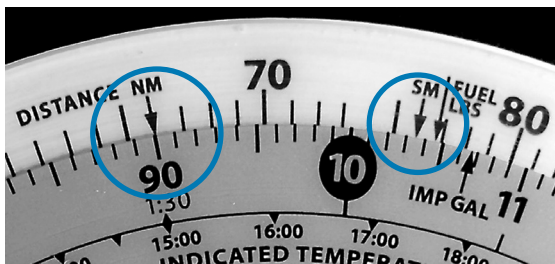


Figure 4. Place the nautical value (90) under the NM arrow and read the corresponding statute value under the SM arrow.

You can convert either **nautical or statute miles to kilometers**. Find the KM marking on the outer scale (near the 12). Set the known value beneath the NM or SM arrow as before, and read kilometers under the KM marking (see Figure 5). To convert 115 statute miles to kilometers:

1. Set 115 opposite of the STATUTE arrow.
2. Read 185 under the KM marking.



Figure 5. Set the SM value under the SM arrow and read the corresponding KM value under the KM arrow.

Try these sample problems:  
(Answers are on Page 45)

	NAUT	STAT	KM
1.	20	---	---
2.	---	48	---
3.	---	---	110

## U.S. Gallons to Imperial Gallons

Your Approved Flight Manual lists fuel capacity in U.S. gallons, but in many countries fuel is delivered in Imperial gallons. Arrows marked US GAL and IMP GAL are provided on both middle and outer scales to help you convert between these quantities. For example, assume your tanks are placarded to hold 64 U.S. gallons. How many Imperial gallons will they hold (see Figure 6)?

1. Line up the US GAL arrow on the middle scale (near 13) opposite the IMP GAL (near 11) arrow on the outer scale.
2. Find 64 on the middle scale.

3. Read 53.3 Imperial gallons on the outer scale. Because Imperial gallons are larger than U.S. gallons, the number of U.S. gallons will always be larger.



Figure 6. Align the US GAL and IMP GAL arrows to convert between these units.

You have purchased fuel in Canada and the delivery slip says 32 Imperial gallons. How many U.S. gallons have you purchased? Line up the IMP GAL arrow on the middle scale (near 11) with the US GAL arrow on the outer scale (near 13). Find 32 on the middle scale and read 38.4 U.S. gallons on the outer scale.

## Quantity/Weight Conversions

Aviation gasoline weighs 6 pounds per U.S. gallon (see Figure 7). For weight and balance calculations, aviation gasoline weight-per-gallon can be determined by aligning the US GAL arrow on the middle scale (near 13) with the FUEL LBS arrow on the outer scale (near 80). Fuel gallons are read on the middle scale and fuel weight on the outer scale. To find the weight of 32 U.S. gallons:

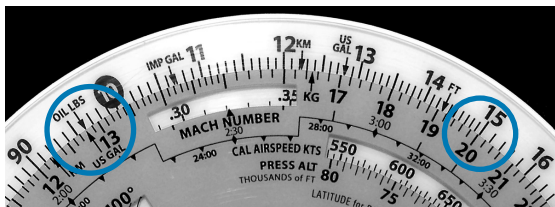
1. Align the arrows.
2. Read 192 pounds on the outer scale opposite of 32 gallons on the middle scale.



Figure 7. Place Fuel LBS arrow above US GAL arrow and read the weight of fuel above total gallons.

Similarly, oil weight may be determined by lining the **US GAL** arrow on the middle scale (near 13) with the **OIL LBS** arrow on the outer scale (near 10). Oil gallons are read on the middle scale and oil weight is read on the outer scale (see Figure 8). To find the weight of 2 gallons (8 quarts) of oil:

1. Align the arrows.
2. Read 15 pounds on the outer scale opposite of 2 gallons on the middle scale.



*Figure 8. Place Oil LBS arrow above US GAL arrow then read weight of oil above total gallons.*

**Imperial gallon weight** of fuel and oil may also be determined in the same manner by lining up the IMP GAL arrow on the middle scale (near 11) with the FUEL LBS (near 80) or OIL LBS arrow (near 10) on the outer scale.

You can convert **liters to U.S. gallons**, **pounds to kilograms**, or **feet to meters** by aligning the appropriate arrows on the middle and outer scales. For example, to convert pounds to kilograms:

1. Find the arrows marked LBS (near 35 outer on the scale) and KG (near 17 on the inner scale), and line them up.
2. Any value in pounds on the outer scale will be opposite of its converted value in kilograms on the middle scale: 2,000 lbs is 907 kg, and 160 kg is 352 lbs.

3. The same procedure is followed for the other conversions.

## Time, Speed, and Distance Problems

The rate arrow (1 HOUR triangle) is always set to indicate a value per hour on the outer scale. There are three basic time-speed-distance problems. In two of these problems you know the rate, while in the third problem, the rate is part of the answer you are looking for.

To find the **Time En Route**, let's assume you know your ground speed is 150 knots (nautical miles per hour) and the distance to your destination is 245 nautical miles (see Figure 9):

1. Set the rate arrow (1 HOUR triangle) to 150.
2. Speed and distance are always on the outer scale; 245 is halfway between 24 and 25.
3. Look directly opposite to that value on the inner time scale to find the Time En Route of 98 minutes or 1:38.



Figure 9. Place time index under ground speed then read time en route under distance.

To find out how far you can go if your **fuel endurance** is 4.5 hours and your ground speed is known to be 125 knots (see Figure 10):

1. Set the rate arrow to 125 on the outer scale.
2. Find 4:30 on the blue scale between 4:00 and 5:00.
3. The value on the outer scale is slightly more than 56. You know that 4 hours at 125 knots should cov-

er 500 miles, so the outer scale is read as 500, not 50 or 5,000, which makes each large calibration mark worth 10 nautical miles. The answer is 563 nautical miles.

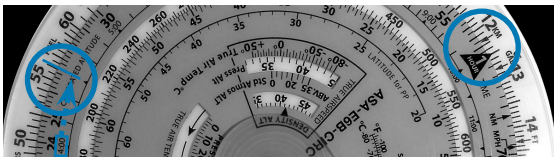


Figure 10. Place the time index under ground speed, find fuel endurance on inner scale, then read distance opposite this number on the outer scale.

In the final and most common type of time-speed-distance problem, the time and distance are known, and you need to solve for **unknown speed**. The rate arrow represents the answer. You will have flown between two known ground reference points 26 NM apart and checked the time between them to be: 13 (thirteen minutes, that is, not thirteen hours) (see Figure 11).

1. Set 13 minutes on the middle scale opposite to 26 on the outer scale.
2. The rate arrow points to your ground speed, 120 knots.



Figure 11. Set elapsed time under distance then read ground speed above the time index.

Try these time-speed-distance problems:  
(Answers are on Page 45)

	<b>SPEED</b>	<b>TIME</b>	<b>DISTANCE</b>
1.	125 KTS	---	524 NM
2.	---	2:30	345
3.	110 KTS	1:40	---
4.	---	0:24	44
5.	95	1:24	---

## Feet Per Mile vs. Feet Per Minute

Because aircraft performance characteristics vary dramatically between types, the FAA establishes climb and descent requirements in feet per mile, rather than in feet per minute. A climb of 300 feet per mile will result in a 3° climb angle for any aircraft; a light trainer climbing at that angle at 90 knots ground speed will indicate 450 feet per minute, while a jet following that same gradient at 240 knots ground speed will show a vertical speed of 1,200 feet per minute.

You can convert feet per mile to feet per minute by placing the rate arrow opposite to the ground speed, finding the feet per minute value on the outer scale opposite the feet per mile value on the middle scale. For example, to find feet per minute:

1. Set the rate (1 HOUR) arrow to 90 kts.
2. Find 300 feet per mile on the middle scale to read a climb rate of 450 feet per minute on the outer scale.

Another example:

1. Set the rate arrow at 240 knots.
2. Look above 300 on the middle scale.
3. You should find a vertical speed of 1,200 feet per minute.



Try these rate of climb problems:  
(Answers are on Page 45)

	GROUND SPEED REQUIRED	FEET PER MILE	FEET PER MINUTE
1.	120	350	---
2.	100	250	---
3.	150	300	---

## Fuel Consumption Problems

Problems involving fuel consumption, fuel endurance, and fuel capacity are solved using the same numbers you used in the time-speed-distance problems. With the exception of time values, only the names change.

Assume that your airplane's Approved Flight Manual indicates fuel consumption of 8.4 gallons per hour at a given power setting and that the usable fuel capacity is 64 gallons. How many hours **endurance** do you have in the tanks (see Figure 12)?

1. Line up the rate arrow (1 HOUR) with 8.4 on the outer scale.
2. Now find 64 on the outer scale.
3. Opposite of 64, read fuel endurance in hours: 7:37 on the inner scale. The outer scale, which was used for speed and distance, is now used to indicate gallons per hour and fuel capacity.



Figure 12. Point rate index to fuel consumption, find fuel capacity on outer scale and read fuel endurance below.

When you paid for your fuel you noted on the delivery ticket that it took 32 gallons to top the tanks. You flew four hours and twenty minutes before stopping for fuel. What was the **average fuel consumption**? This time the rate arrow provides the answer (see Figure 13).

1. Set 4:20 on the inner scale—opposite of 32 on the outer scale.
2. The rate arrow indicates the average fuel burn rate: 7.4 gallons per hour.

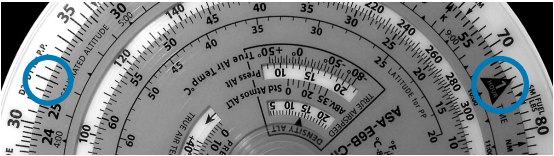


Figure 13. Set time flown opposite gallons and read fuel rate above the rate arrow.

Remember that fuel consumption is greater during the climb to altitude, so this average value does not accurately reflect fuel consumption in cruising flight.

Try these examples:  
(Answers are on Page 45)

	<b>GALLONS PER HOUR</b>	<b>TIME</b>	<b>TOTAL USED</b>
1.	7.8	3:20	---
2.	---	4:50	62
3.	8.5	---	38
4.	10	2:30	---
5.	12	---	22

## Using the Altitude and Speed Correction Windows

Altimeters and airspeed indicators are designed to give correct indications under standard conditions at sea level. The consistency of the earth's atmosphere does not change linearly as you gain altitude; its density is affected by variations in temperature and pressure. The E6-B Circular provides windows on the slide rule side so you can allow for these variations when converting calibrated airspeed to true airspeed or indicated altitude to true altitude.

## True Airspeed and Density Altitude

Note that the outer scale of your flight computer is marked TAS (true airspeed) and the middle scale is marked CAS (calibrated airspeed).

The Approved Flight Manual for your airplane contains a conversion table that allows you to convert indicated airspeed to CAS. The difference is greatest at low speeds and becomes negligible at cruise speeds. To determine true airspeed you must first know the pressure altitude. Set your altimeter to 29.92 and read the altitude indicated; that is the pressure altitude. Note the outside air temperature and convert it to Celsius using the conversion scale above the Temperature Rise window.

Find true airspeed and density altitude when pressure altitude is 15,000, air temperature is  $-15^{\circ}$ , calibrated airspeed is 145 knots (see Figure 14).

1. Find 45 on the outer blue scale and move inward towards the center of the disk to find the Pressure Altitude and Density Altitude windows.
2. Set the pressure altitude (15,000) in the window opposite the outside air temperature ( $-15^{\circ}$  C).
3. Without moving the scale, find CAS (145) on the outer blue scale, and read true airspeed 182 knots opposite on the outer white scale.

- Read the density altitude under the arrow in the DENSITY ALTITUDE window.

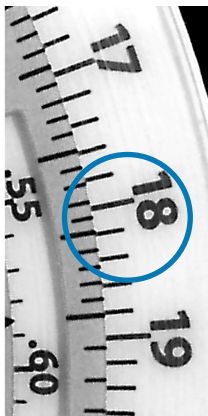
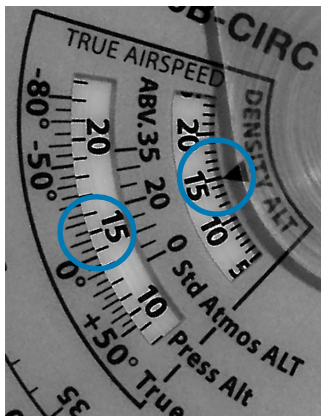


Figure 14. Align outside air temperature opposite the pressure altitude then read density altitude over the arrow.

At a pressure altitude of 15,000 feet and an air temperature of  $-15^{\circ}\text{C}$ , a calibrated airspeed of 145 knots converts to a true airspeed of 182 knots and a density altitude of 15,000 feet.

Here are some sample problems:  
(Answers are on Page 45)

	<b>PRESSURE ALTITUDE</b>	<b>TEMP</b>	<b>CAS</b>	<b>TAS</b>	<b>DENSITY ALTITUDE</b>
1.	14,000	$5^{\circ}\text{C}$	160	---	---
2.	20,000	$-20^{\circ}\text{C}$	200	---	---
3.	8,000	$15^{\circ}\text{C}$	150	---	---

## True Altitude

True altitude is the exact height of an aircraft above mean sea level (MSL). To find true altitude, use calibrated altitude (or indicated altitude if calibrated is not available) and true air temperature. True altitude can be read directly above calibrated altitude if the station altitude is unknown or at sea level.

There is a pressure altitude of 15,000 feet, calibrated altitude of 13,500 feet, true air temperature of  $-20^{\circ}\text{C}$ , and ground station altitude of 1,200 feet. Find the true altitude above ground and sea level.

1. Find 22 on the outer blue scale and move inward towards the center of the disk to find the True Altitude Window.
1. Align pressure altitude (15,000) with true air temperature ( $-20^{\circ}\text{C}$ )
2. Subtract station altitude from calibrated altitude to find calibrated altitude above ground:  $13,500 - 1,200 = 12,300$  feet.
3. Find calibrated altitude above ground (12,300) on the outer blue scale and read true altitude above ground (12,000) on the outer white scale
4. Add station altitude to true altitude above ground to get true altitude above sea level:  $1,200 + 12,000 = 13,200$  feet.

## True Air Temperature

True air temperature (TAT) is indicated air temperature (IAT) corrected for the heat of compression caused by high-speed flight. True airspeed calculations are affected by a temperature recovery coefficient  $C_t$ , which varies with installation and design of the temperature probe on the particular airplane. Once  $C_t$  is determined for a particular airplane, the coefficient will not vary greatly with speed or altitude.

The Ct tab is marked with a straight hairline for .8 and a curved line with the Ct plotted for values between .6 and 1.0. The .8 Ct is the most common coefficient. The dashed lines apply to the standard sea level temperature of +15°C. The solid lines apply to the standard stratosphere temperature of -55°C. When flying between sea level and 35,000 feet you need to interpolate between the two lines. True air temperature can be computed by subtracting temperature rise from the indicated air temperature.

This function will also display the Mach number and true airspeed.

With a calibrated airspeed of 500 knots, pressure altitude of 15,000, and indicated air temperature of 30°C, find true air temperature (see Figure 15).

1. Using the Cal Airspeed Kts window (below the 1 hour rate index), align pressure altitude (15,000) below calibrated airspeed (500).
2. Using the Ct tab, place hairline at intersection of indicated air temperature (30) and rising line in the Indicated Temperature window.
3. Read temperature rise indicated by arrow (49) and subtract from indicated air temperature ( $30 - 49 = -19^{\circ}\text{C}$ ).

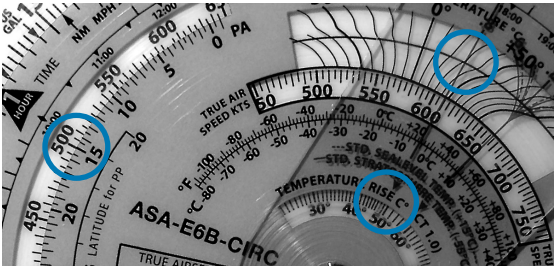


Figure 15. Find temperature rise to determine true air temperature.

At a calibrated airspeed of 400 knots, pressure altitude of 20,000 feet, indicated air temperature of  $10^{\circ}\text{C}$ , and coefficient of .6, find the true airspeed and Mach number.

1. Place calibrated airspeed (400) above pressure altitude (20,000).
2. Rotate Ct tab so .6 intersects the indicated air temperature ( $10^{\circ}\text{C}$ ).
3. Read true airspeed (535) and Mach number (.85).

## **Mach Index Arrow**

Set the 10 index on the blue disk opposite the 60 on the white disk. This setting will help you find the double-ended Mach index arrow in the small Press Alt window in the lower left portion of the disk. This double-ended Mach Index relates a “standard atmosphere” altitude with the standard temperature for that altitude. The temperature of the “standard atmosphere” can be used to help you estimate outside air temperature.

For example, with a pressure altitude of 28,000 find the estimated free air temperature.

1. Set the Mach Index arrow to the pressure altitude (28,000 feet) on the Std. Atmos. scale.
2. At the bottom of the arrow read the Std. Atmos. temperature below pressure altitude (28,000 feet), which is  $-40^{\circ}\text{C}$ .

## **Converting Mach Number to True Airspeed**

To convert Mach Number to True Airspeed (or vice versa), use the double-ended Mach index arrow in the small Press Alt window in the lower left portion of the disk. Line up the true Air Temp (do not use Indicated Air Temperature) opposite this Mach Number Index. Mach Number on the inner scale reads opposite True Airspeed (in nautical miles per hour) on the outer scale.

In Figure 16, at an outside air temperature of  $+15^{\circ}\text{C}$  and Mach 1 (10 on the outer blue scale), read 645 knots on the outer scale.



Figure 16. Set double-pointed MACH INDEX at outside air temperature and read true airspeed on the white disk above the Mach Number on the blue disk.

## True Airspeed from Mach Number and Indicated Air Temperature

Mach Number is a measurement of speed based on the ratio of the speed of the aircraft to the speed of sound under the same atmospheric conditions. An airplane flying at Mach 1 is flying at the speed of sound. Mach Number is affected by temperature; for example, Mach 1 is 669.6 MPH at  $-50^{\circ}\text{C}$  and 806.9 MPH at  $+50^{\circ}\text{C}$ . In aircraft with a Mach indicator, it is possible to find true airspeed from Mach Number and temperature (see Figure 17).

At a Mach number of .5, indicated air temperature of  $+15^{\circ}\text{C}$ , and coefficient of .8, what is the true airspeed?

1. Set Mach number arrow (on the outer blue disk) at Mach number (.5).
2. Set Ct tab so .8 cursor hairline intersects rising line at  $+15^{\circ}\text{C}$ .
3. Read true airspeed 322 knots.



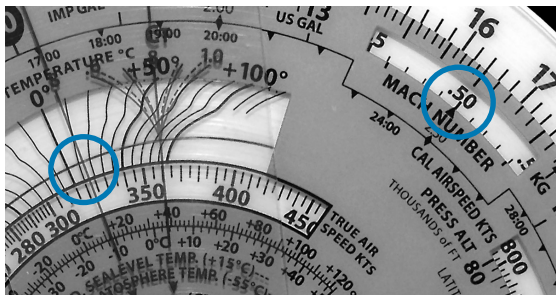


Figure 17. Find true airspeed with Mach number and indicated air temperature.

## True Altitude

When the air is colder than standard your altimeter can mislead you into thinking you are higher than you actually are. Determine true altitude by the following steps:

1. Determine pressure altitude by setting 29.92 momentarily on the altimeter.
2. Set pressure altitude next to outside air temperature in the altitude correction window.
3. Subtract station altitude from indicated/calibrated altitude to determine calibrated altitude AGL.
4. Find calibrated altitude AGL on the middle scale and read the correction to station altitude on the outer scale.
5. Add the correction to station altitude to get true altitude MSL.

If the station altitude is unknown, read calibrated altitude MSL on the middle scale and true altitude MSL on the outer scale.

In Figure 18 the pressure altitude is 10,000 feet, station altitude is 5,000 feet, outside air temperature is  $-19^{\circ}\text{C}$ ,

and your indicated (calibrated) altitude is 12,000 feet. The difference between 5,000 feet station altitude and 12,000 feet indicated altitude is 7,000 feet. Opposite 7,000 feet on the middle scale read correction to station altitude (6,600 feet) on the outer scale—5,000 feet plus 6,600 feet equals 11,600 feet true altitude.

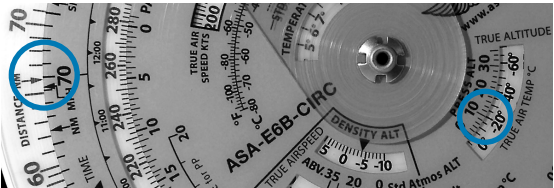


Figure 18.

*CAUTION: If the temperature between the surface and the aircraft does not decrease at the standard rate of 2°C per 1,000 feet or if the pressure at flight level is nonstandard, reliance on a computer solution to determine obstruction clearance can be very hazardous.*

Find True Altitude:  
(Answers are on Page 46)

	INDICATED/ PRESSURE ALTITUDE	CALIBRATED ALTITUDE	TEMP	STATION ALTITUDE	TRUE ALTITUDE
1.	10,500	10,000	-20°C	5,000	---
2.	12,000	11,000	-30°C	3,000	---
3.	8,000	7,600	-15°C	2,000	---

## Pressure Pattern

The shortest route may not be a straight line when you cross a weather system. This rule of thumb is most useful for trips longer than 300 NM and when crossing a high or low system. Flying south of the straight line gets bet-

ter winds. For efficiencies, you will want to fly a constant heading rather than crabbing left then right. To do this, you need to apply a crosswind component. Knowing your groundspeed and pressure along your route you can plot the offset of the minimum crab path.

To calculate the crosswind component using the E6-B Circular computer:

- $D$  = radio altimeter reading minus pressure altimeter reading.
- $D1$  and  $D2$  designate first and second readings respectively, taken with an intervening time interval.
- In the northern hemisphere if  $D2 - D1$  is positive, wind is from the right. If  $D2 - D1$  is negative, wind is from the left. In the southern hemisphere this rule is reversed.

Given  $D1$  is 520 feet and  $D2$  is 200 feet, the distance traveled between readings is 320 NM and mid-latitude is  $43^\circ$  N. Find the crosswind component:

1.  $D2 - D1 = 200 - 520 = -320$  feet. Place 320 on the outside disk opposite the distance traveled (340) on the blue scale.
2. Rotate the  $Ct$  index tab until hairline passes through 43 degrees on latitude scale. At the end of the hairline read the crosswind on the outside scale (29.5 knots). Since  $D2 - D1$  is negative and flight is in the northern hemisphere, the wind is from the left.

## Off-Course Problems

When you navigate by pilotage, you will occasionally find your airplane has drifted off the planned course due to the wind. If you find yourself over a landmark to one side of the course line you should be able to estimate the distance you have drifted off course (the scale of sectional charts is 8 statute miles to the inch), and your flight log should help determine how far you have flown and how far it is to your destination.

Two computer setups are required. The first will give you the heading correction necessary to offset wind drift, or “course to parallel.” On the middle scale, set the distance flown opposite of the distance off course on the outer scale; the rate arrow points to the degrees of heading change to parallel the course.

Example: After flying 125 miles, you note that you are 8 miles off course (see Figure 19).

1. Set 125 on the outer blue scale to line up with 8 on the outer white scale.
2. Read approximately  $3.8^\circ$  at the rate arrow.



*Figure 19. Set distance flown on middle scale opposite off-course distance and read correction above the rate arrow.*

The second setup will give you the additional heading change required to fly back to the original course line. On the middle scale, set distance remaining opposite of the distance off course; read additional degrees of heading change opposite of the rate arrow. Add the two answers and apply the result to your heading.

Example: Your destination is 235 miles ahead (see Figure 20).

1. Set 235 on the middle scale opposite 8 on the outer scale.
2. Read approximately  $2^\circ$  at the rate arrow.
3. Change course  $\approx 6^\circ$  ( $3.8 + 2$ ) toward the course line and, if the wind doesn't change, you will rejoin the original course line as you approach the destination.



Figure 20.

## The Wind Side of the E6-B Circular

The wind side of the E6-B Circular provides a graphic method of solving problems in trigonometry and displaying the answers in a useful form as well as can be used for basic arithmetic. The surface of the top disk is suitable for marking with a No. 2 pencil, which can be easily removed with eraser or by lightly scrubbing with water.

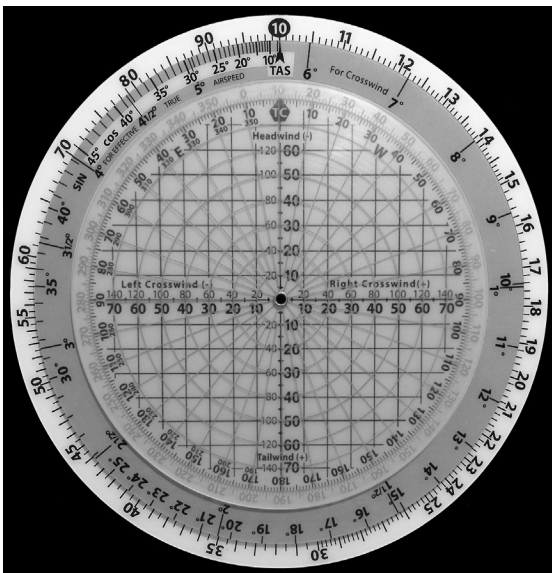


Figure 21.

## Addition and Subtraction

Addition and subtraction can be done on the wind side of the E6-B Circular for numbers up to 360, using the outside scale of the top disc and the curving scale either side of the TC index on the middle scale. This curving scale can be read as high as 180 to the left and 360 to the right.

For example, add 27 and 48:

1. Align 27 (on the blue scale on the transparent inner disk) with TC index.
2. Since you are adding, move right of the TC index along the black scale to 48 and find the answer above (75).

Another example, subtract 27 from 48.

1. Align 48 (on the blue scale on the transparent inner disk) with TC index.
2. Since you are subtracting, move left of the TC index along the black scale to 27 and find the answer above (21).

## Magnetic vs. True Winds

Winds are given in True, while airport towers report winds in Magnetic. It's important not to mix units when calculating wind problems. To convert between these units, set the magnetic course on the blue scale opposite the applicable variation and your true course can be read opposite the true course outline.

For example, if magnetic course is 275 and variation is 14° E, what is the true course?

1. Place MC (275) on blue scale over 14 on black scale to left of TC indicator.
2. Read TC on blue scale above TC arrow (289).

## Wind Triangle

The E6-B Circular wind side uses a variation of the conventional wind triangle to compute wind correction angle (WCA) and groundspeed (GS). The E6-B Circular applies headwind or tailwind to the true airspeed line to compute ground speed. As the WCA increases to  $10^\circ$  or more, the effective true airspeed scale (located left of the TAS index) must be used rather than true airspeed to find accurate ground speed.

Two wind scales on the horizontal and vertical lines radiate from the center of the computer for low speed (0-80) or high speed (0-160) computations. Use only one scale at a time; they may not be used interchangeably for a single computation. Use the large scale (0-80) if the wind is less than 80 knots or MPH. Use the small scale (0-160) if the wind is more than 80.

On the middle blue disc there are 2 crosswind scales with units of 1, 1-1/2, 2, 2-1/2, etc. and larger units of 10, 11, 12, etc. Use the scale applicable to your airspeed. If the crosswind component is less than 10% of the true airspeed, the WCA should be read on the lower scale.

## Preflight Planning

Remember: Two wind scales on the horizontal and vertical lines radiate from the center of the computer for low speed (0-80) or high speed (0-160) computations. Use only one scale at a time; they may not be used interchangeably for a single computation. Use the large scale (0-80) if the wind is less than 80 knots or MPH. Use the small scale (0-160) if the wind is more than 80.

To determine **ground speed** and **wind correction** angle you must know four things: true course (or magnetic course and variation), true airspeed, true wind direction, and wind velocity. The winds aloft forecast provides the latter two; true course is measured directly on your sec-

tional or WAC chart, and TAS is either converted from indicated airspeed in flight or taken from the airplane's performance charts during preflight planning.

For example: You have laid out a course on a sectional chart and measured it to be  $130^{\circ}$  true using your plotter (140 magnetic,  $10^{\circ}$  W variation). The winds aloft forecast calls for the wind at your chosen altitude to be  $100^{\circ}$  at 40 knots, and the performance data for the airplane says that you can expect a true airspeed of 180 knots at that altitude (see Figure 22).

1. Rotate the blue disc to set the TAS INDEX to 18 (180 knots).
2. Rotate the top disk to set true course (130) at the TC INDEX.
3. Place wind dot at intersection of wind direction (100) and wind velocity circle (40 knots).
4. Read crosswind component on scale below dot (20 knots left crosswind).
5. Find crosswind component (20 knots) on outer scale and note WCA below (6+).
6. The wind dot shows a left crosswind therefore a left crab so we subtract crab angle from magnetic course to get magnetic heading:  $140 - 6 = 134$  degrees magnetic heading.
7. Return to the wind dot and read directly to the right of it to find a headwind of 35 knots. Subtract headwind from TAS to find ground speed:  $180 - 35 = 145$  knots ground speed.



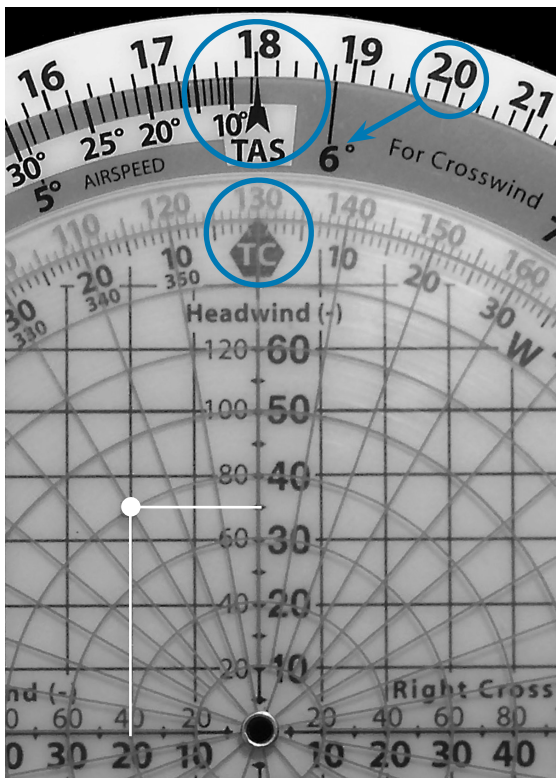


Figure 22. Set TAS, TC, and wind to find crab, MH and ground speed.

If the upper winds forecast applies to your entire trip, simply use the wind dot in this manner with the true course for each leg.

Here are some sample problems:  
*(Answers are on Page 46)*

	<b>TRUE WIND DIREC.</b>	<b>WIND VELOCITY</b>	<b>TRUE COURSE</b>	<b>TAS</b>	<b>TRUE HDG</b>	<b>GROUND SPEED</b>
1.	240	38	300	165	---	---
2.	040	43	150	140	---	---
3.	330	25	020	180	---	---
4.	110	18	260	225	---	---

## Determining Winds in Flight

Winds aloft forecasts are frequently in error. If you have an autopilot, and some free time, you can calculate the actual winds at your location and altitude. It helps if you have GPS, too.

To solve an in-flight wind problem you need your ground speed, true heading, true course, and true airspeed. Let's assume your true course is 180°, your true heading is 160°, your last ground speed check came out to be 120 knots, and you calculate the true airspeed at your altitude to be 140 knots. Find the actual wind direction and velocity (see Figure 23):

1. Set 140 knots at the TAS on the wind side of the computer.
2. Set 180° at the TC index.
3. Subtract the true heading from the true course to find the crab angle:  $180 - 160 = 20^\circ$  crab. A true heading less than the true course indicates a left crab; therefore the wind is from the left.
4. The crab angle (20) is fairly high; therefore, use "effective" true airspeed. Find 20 on the effective scale and read directly above (132).
5. Determine the difference between effective true airspeed and actual ground speed, which will be

the headwind or tailwind component you will spot on the computer. In this example,  $132 \text{ (ETAS)} - 120 \text{ (GS)} = 12 \text{ headwind}$ .

6. From the 12 headwind figure, draw a line to the left (left crab indicates wind from the left).
7. Determine the crosswind component. Read the crosswind scale on the middle disk at 20 to find a 48 knot crosswind component. From the horizontal crosswind line at the 48 position draw a line upward.
8. Find the point of intersection of the two lines to determine the wind dot. Its position indicates we have an actual wind from 104 true at 48 knots (see Figure 24).

If you have GPS, the direct track readout is used instead of true heading. Correct for variation, because the direct track information is magnetic.

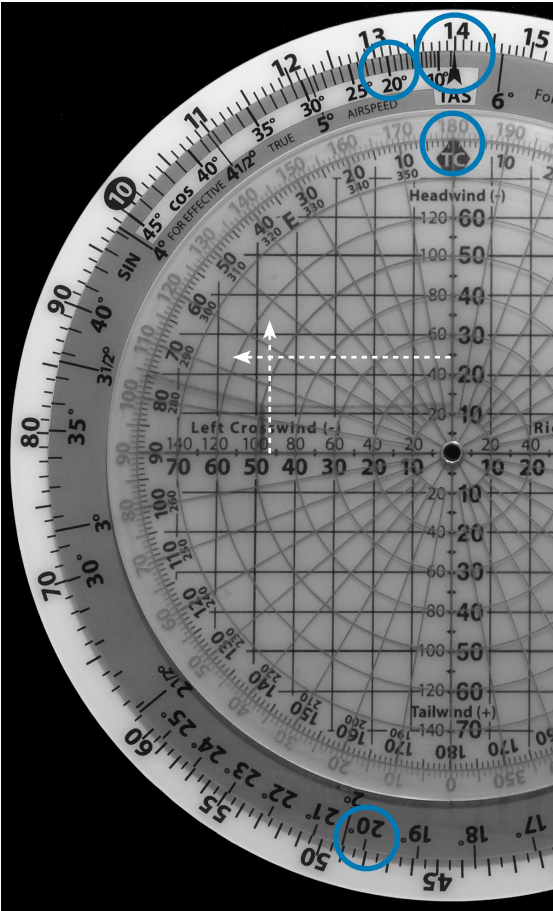


Figure 23.

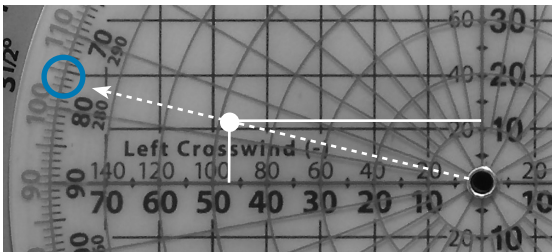


Figure 24.

Sample problems:

(Answers are on Page 46)

	TRUE HDG	TRUE COURSE	TAS	GROUND SPEED	WIND DIREC.	WIND VELOCITY
1.	320	315	140	128	---	---
2.	175	160	150	115	---	---

## True Course and Ground Speed

True course (track) and ground speed may be found with airspeed, heading and wind information.

For example, given true airspeed 220 knots, magnetic heading 230°, variation 8° west, and wind at 120° true and 25 knots, find true course and ground speed (see Figure 25):

1. Place 220 above TAS index.
2. Place magnetic heading (230) above variation (8) on + side.
3. Place wind dot at intersection of 120 wind direction radial and 25 knot wind velocity circle. Read up to find 25 knot crosswind.
4. Find 25 knot crosswind component on outer scale. Note  $\approx 7^\circ$  WCA below. Since wind is from the left, true heading must be left of true course.

5. Rotate wind disc  $7^\circ$  (WCA) to the left and note new crosswind component of 24 knots (see Figure 26).
6. Note 24 knot crosswind component on outer scale, use  $6^\circ$  correction on inner scale.
7. Correct for  $1^\circ$  error in alignment of TC index and read TC now at true index ( $228^\circ$ ).
8. Look to the right of the wind dot to find a 7 knot tailwind component.
8. Add 7 knot tailwind to 220 knot TAS for 227 knot ground speed. (If WCA had been  $10^\circ$  or more the tailwind would be applied to the ETAS scale for an accurate ground speed.)

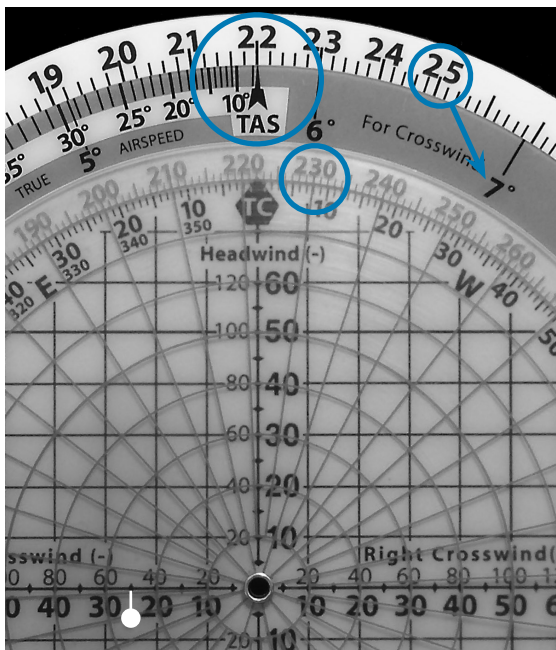


Figure 25.



Figure 26.

## True Heading and True Airspeed

Find true airspeed and true heading when you know your true course, intended ground speed and wind information.

For example, true course is  $160^{\circ}$ , intended ground speed is 180 knots, and wind is  $190^{\circ}$  at 30 knots. Find true airspeed and true heading:

1. Place true course (160) above TC index.
2. Place wind dot on  $190^{\circ}$  radial at wind velocity circle for 30 knots.
3. Read 26 knot headwind on scale left of wind dot. Add headwind to intended ground speed for true airspeed of 206 knots.
4. Place 206 knots above TAS index. (Note: if the WCA is 10 or greater, the TAS must be positioned above the WCA on the effective true airspeed scale rather than the TAS index; then the crosswind component on the outer scale must be checked to make sure it wasn't changed in the move. If it has changed, the ETAS must be set above the correct WCA. In this example, the TAS index will indicate the correct TAS when the ETAS is set above WCA.)
5. Read 16 knots right crosswind giving a  $4^{\circ}$  WCA.
6. Add right crosswind (4) to true course (160) for  $164^{\circ}$  true heading. TH may also be read above  $4^{\circ}$  on the west variation scale.



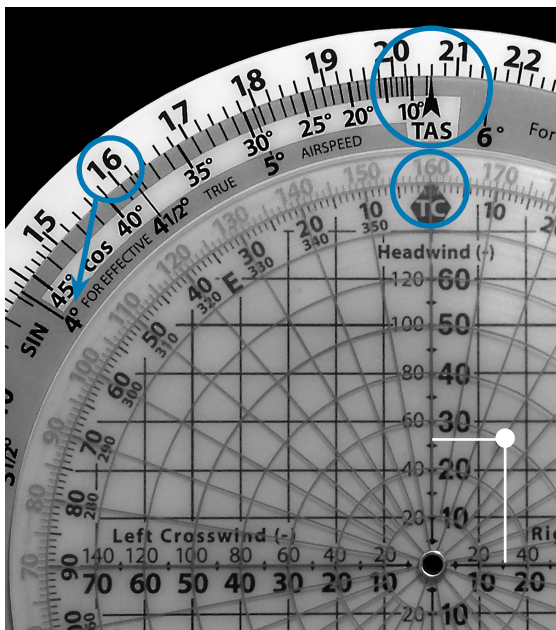


Figure 27.

## Off-Course Correction

You can determine the correction needed to reach a destination if you know your miles flown, miles off course and the miles to the destination.

For example, 40 miles flown, 5 miles off course, with 160 miles to the destination. Find the amount of correction you need to the heading:

1. Set the miles flown (40) opposite the TAS index (see Figure 28).

2. Find the miles off course (5 depicted as 50 on the computer) on the outer scale and read the correction needed ( $7^\circ$ ). This is the number of degrees you must correct your heading to parallel your intended course.
3. Find the number of additional correction needed to reach your destination; place the miles to destination (160 depicted by 16 on the computer) opposite the TAS index (see Figure 29).
4. Find the miles off course (5 depicted as 50 on the computer) on the outer scale and read 18 on the inner scale. Additionally, it is also opposite a point between  $1\text{-}1/2$  and  $2^\circ$  on the scale containing the 18 (use 2).
5. Add the degrees correction necessary to parallel your course and the additional correction necessary to reach your destination to get the total correction needed:  $7 + 2 = 9^\circ$ .

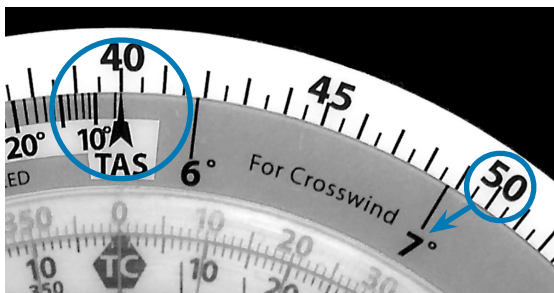


Figure 28.

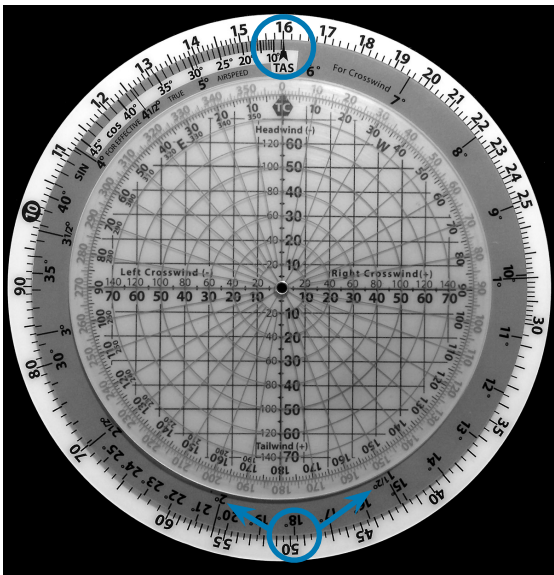


Figure 29.

*Note: If you are off course to the right, correct to the left by subtracting the correction to your compass heading. If you are off course to the left, correct to the right by adding the correction to your compass heading.*



## **Answers to Sample Problems**

### **Basic Arithmetic, Page 9**

1. 85
2. 720
3. 13.5
4. 60

### **Conversions, Page 11**

1. 23 Statute Miles, 37 Kilometers
2. 41.7 Nautical Miles, 77.2 Kilometers
3. 59.4 Nautical Miles, 68.4 Statute Miles

### **Time, Speed, and Distance Problems, Page 16**

1. 4 Hours and 12 Minutes
2. 138 Knots
3. 183 Nautical Miles
4. 110 Knots
5. 133 Nautical Miles

### **Feet Per Mile vs. Feet Per Minute, Page 17**

1. 700 FPM
2. 415 FPM
3. 750 FPM

### **Fuel Consumption Problems, Page 18**

1. 26 Gallons
2. 12.8 GPH
3. 4 Hours and 28 Minutes
4. 25 Gallons
5. 1 Hour and 50 Minutes

### **True Airspeed and Density Altitude, Page 20**

1. 204 Knots TAS, 16,000' DA
2. 276 Knots TAS, 20,500' DA
3. 174 Knots TAS, 9,800' DA

### **True Altitude, Page 26**

1. 4,750' above ground, 9,750' True Altitude above sea level
2. 7,300' above ground, 10,300' True Altitude above sea level
3. 7,200' True Altitude

### **Preflight Planning, Page 34**

1. 288, 143
2. 133, 149
3. 014, 163
4. 258, 240

### **Determining Winds in Flight, Page 37**

1. 002, 17
2. 212, 49



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