AS Aviation Services

A Pilots guide on How to Use the E6B Flight Computer

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A Pilots guide to the E6B Flight Computer

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Introduction

The basic E6B is an amazing tool for any pilot to have. With a little practice, it is extremely easy to use, and it never runs out of battery! It is essentially a circular slide rule. One important heads up about the E6B Flight Computer is that, it does not know decimals. It is up to the user to determine how to place the decimal point after a calculation. Although the E6B flight computer spells out several calculations on the computer itself, there are many little tricks and secrets that are often forgot about.

The E6B Flight Computer can:

- Calculate Wind Correction Angle
- Calculate Ground Speed
- Calculate True Airspeed
- Calculate Density Altitude
- Calculate Time Enroute
- Calculate Fuel Consumption
- Do basic division
- Do basic multiplication
- Do unit conversions
- Much More!

Flight Planning

The first thing you are usually taught to do on the E6B is Flight Planning. This typically includes calculating wind correction angles, flight time per leg, and fuel burn per leg.

Wind Correction Angle and Ground Speed

Wind is given relative to True North. Courses are measured off a sectional chart relative to true north. One step in determining the correct heading to fly so that you can track that measured course, is to calculate a wind correction angle.

1. Rotate the dial such that the direction the wind is from is under the “True Index.”
2. Slide the cardboard such that an easy reference, such as “100” is under the center grommet.
3. With a pencil, mark wind straight up from the center grommet. Example: If the wind is 20 knots, and the “100” is under the center grommet, place a mark near the “120” knot line.
4. Rotate the dial such that the true course is now under the “True Index.”
5. Slide the wind marking such that it lines up with your planned True Airspeed Line.
6. Read ground speed from under center grommet.
7. Read the angle by looking at the angle markings under the wind mark. If it’s on the left side, it is a negative correction angle. If it’s on the right side, it is a positive correction angle.

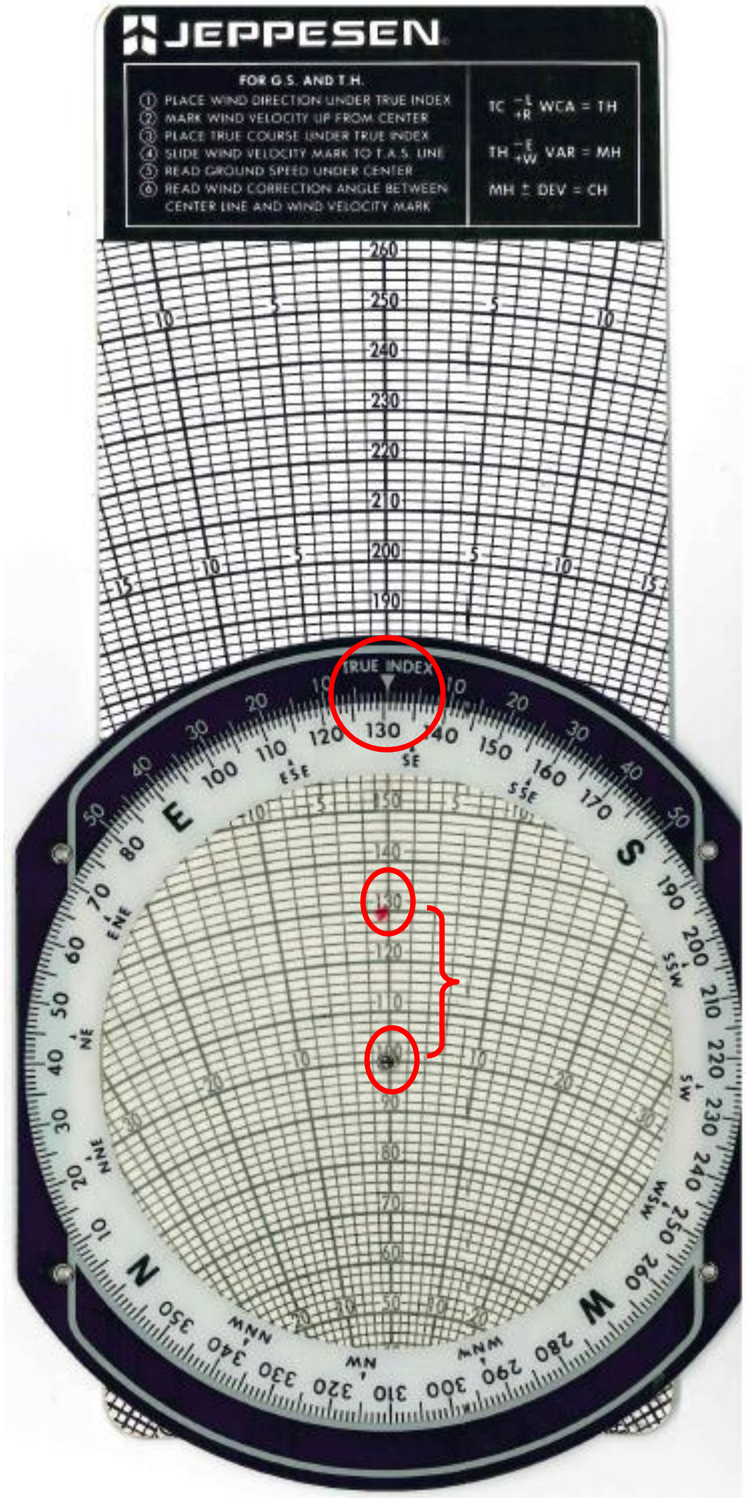
True Course -Left Wind Correction/+Right Wind Correction = True Heading

Example:

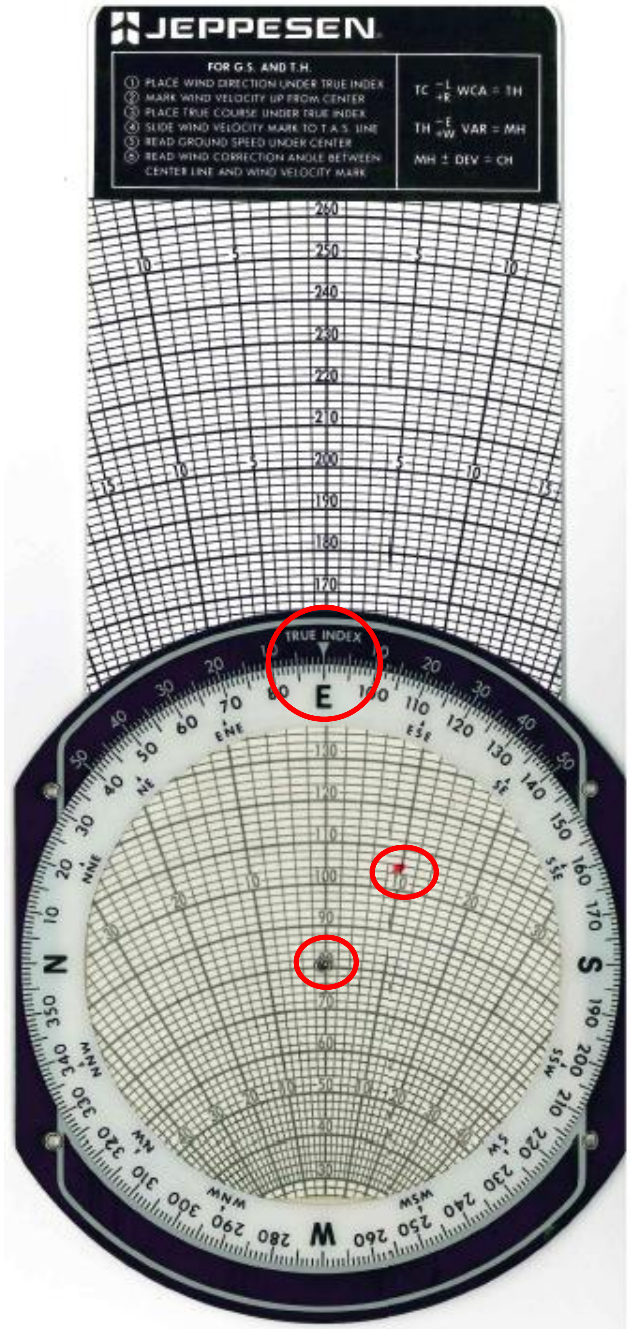
True Course = 90 degrees
True Airspeed = 105 knots
Wind = 130 at 30 knots

→

Wind Correction Angle = +10 degrees
Ground Speed = 80 knots
True Course +R WCA = True Heading
90 deg + 10 deg = 100 deg
True Heading = 100 deg



On the above image, you can see that the Wind direction has been placed under the “True Index”, and the wind speed was marked up from the center grommet. 30 knots starting with 100 knots as a reference places the dot over the 130 knot line.



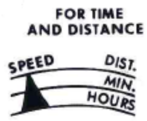
The dial was turned such that the "True Course" was now under the "True Index", and the inner part was slid until the mark you made for the wind, was now aligned with the Airspeed line corresponding to your True Airspeed. Our true Airspeed was 105 knots in this example. This now puts the wind mark over the +10 deg line, meaning a +10 degree wind correction angle. The ground speed is read under the center grommet, which in this example is 80 knots. The "True Heading" = 90 degree + 10 Degree = 100 degrees. The equation used was TC $^{-L}_{+R}$ WCA = TH. This angle corrected for "Magnetic Variation" using TH $^{-E}_{+W}$ VAR = MH, gives you "Magnetic Heading". The "Magnetic Heading" is the compass heading you would fly, to track your course and not drift due to wind. The amount of "Magnetic Variation" is read off your Sectional Chart using "Isogonic Lines".

Flight Time per Leg

Flight time per leg involves knowing your ground speed, which was determined when calculating a wind correction angle, and the total distance of the flight leg.

Example:

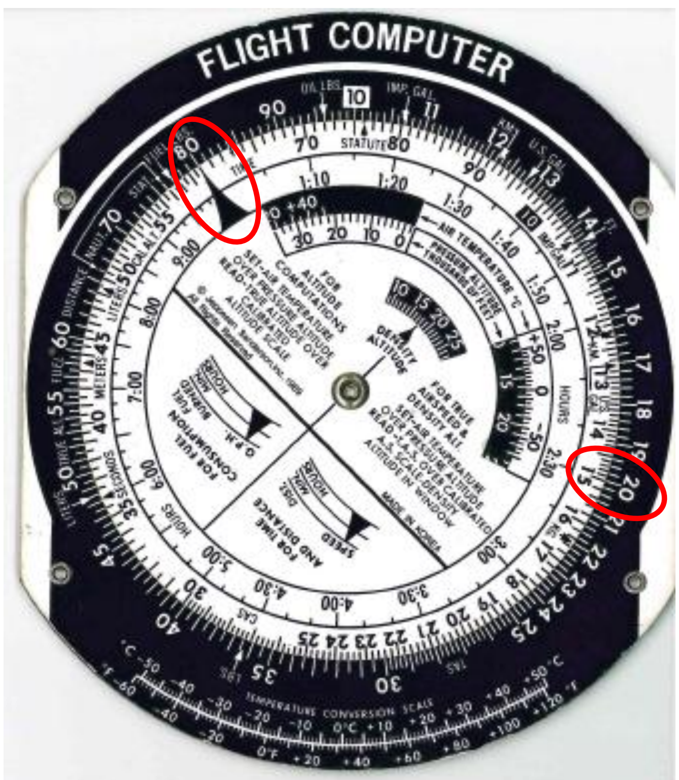
Ground Speed = 80 knots
Leg Distance = 20 nautical miles → Flight Time = approximately 15 minutes



To calculate flight time per leg:

1) Rotate the dial such that the black triangle/arrow on the inner ring points to your ground speed on the outer ring. The black triangle/arrow is located where the "60" would be. In the picture below, you can see that it points to "80".

2) Read "Distance over Time" with "Outer Ring over Inner Ring". This is illustrated in the above picture "For Time and Distance". On the outer ring, find the number that corresponds to your legs distance, and see what the number on the inner ring is. You will see 20 nm is over 15. It is up to the user to determine decimal points. "15" in this example is 15 minutes.

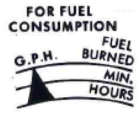


Fuel Burn per Leg

Calculating fuel burn per leg involves knowing a fuel burn rate, typically expressed in gallons per hour, and knowing the total time spent on the leg.

Example:

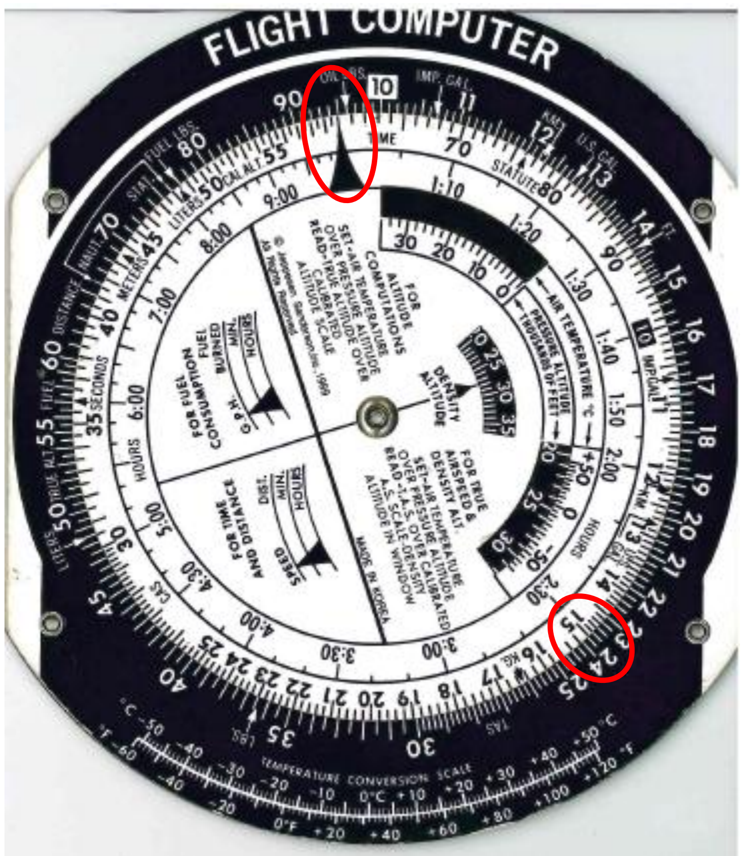
Burn Rate = 9.5 Gallons per hour
Leg Flight Time: 15 minutes → Approximately 2.38 Gallons burned



To calculate fuel burn per leg:

1) Rotate the dial such that the black triangle/arrow on the inner ring points to your burn rate on the outer ring. The black triangle/arrow is located where the "60" would be. In the picture below, you can see that it points to "9.5".

2) Read "Fuel Burned Over Time" with "Outer Ring over Inner Ring". This is illustrated in the above picture "For Fuel Consumption". That is, on the inner ring, find the number that corresponds to your legs flight time, and see what the number on the outer ring is. You will see "23.8" is over "15". It is up to the user to determine decimal points. "23.8" could be "2.38" as in this example. You can tell this by common sense. It wouldn't make sense for almost 24 gallons to be burned in 15 minutes, if you only burn 9.5 gallons per hour.



Calculating Density Altitude

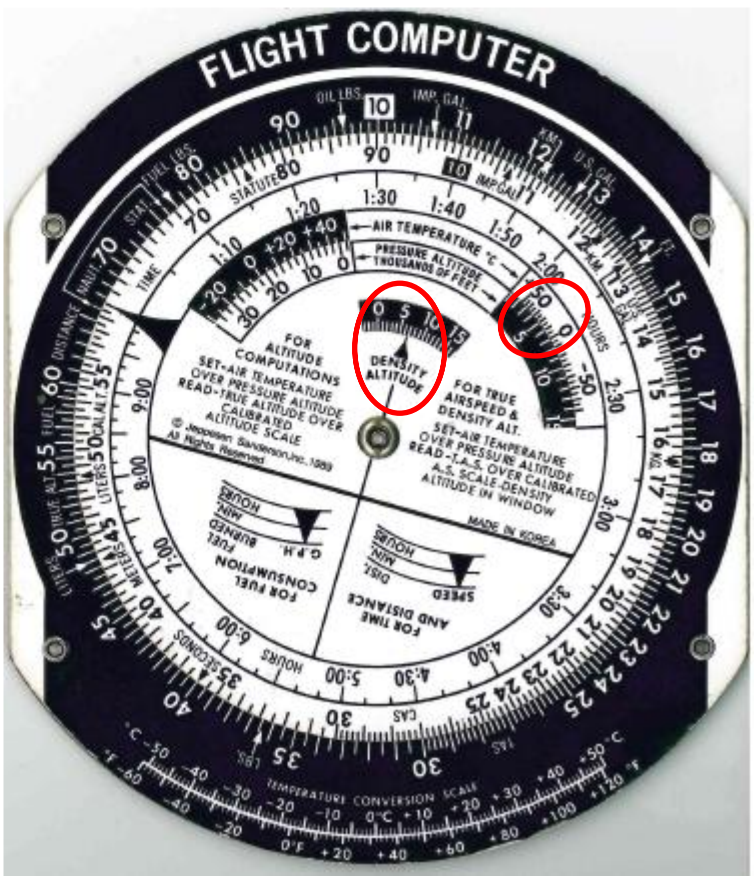
Your airplanes performance will change greatly with change in density altitude. To calculate density altitude, you must know the pressure altitude and outside air temperature (OAT). Density altitude is pressure altitude corrected for non-standard temperature. Pressure altitude can be found by adjusting the barometric pressure setting on your altimeter to 29.92. On the inner wheel toward the right side, you will see a place for Air Temperature, a window for Pressure Altitude, and a window for Density Altitude.

Example:

Outside Air Temperature = 20 deg C
Pressure Altitude = 5,000 Feet → Density Altitude is approximately 7,000 feet

To determine density altitude:

1) Rotate dial to place 20 deg C over 5,000 feet. Read the density altitude in the window.



Simple Math

Your E6B is capable of doing a lot of simple math. This simple math includes multiplication, division and basic unit conversion.

Division

Division is simple. It is simply the same as it would appear written out on paper. Number1 Divided by Number2 is written as: $\frac{\text{Number 1}}{\text{Number 2}}$

This is how it should be input on the flight computer; Outer ring over inner ring.

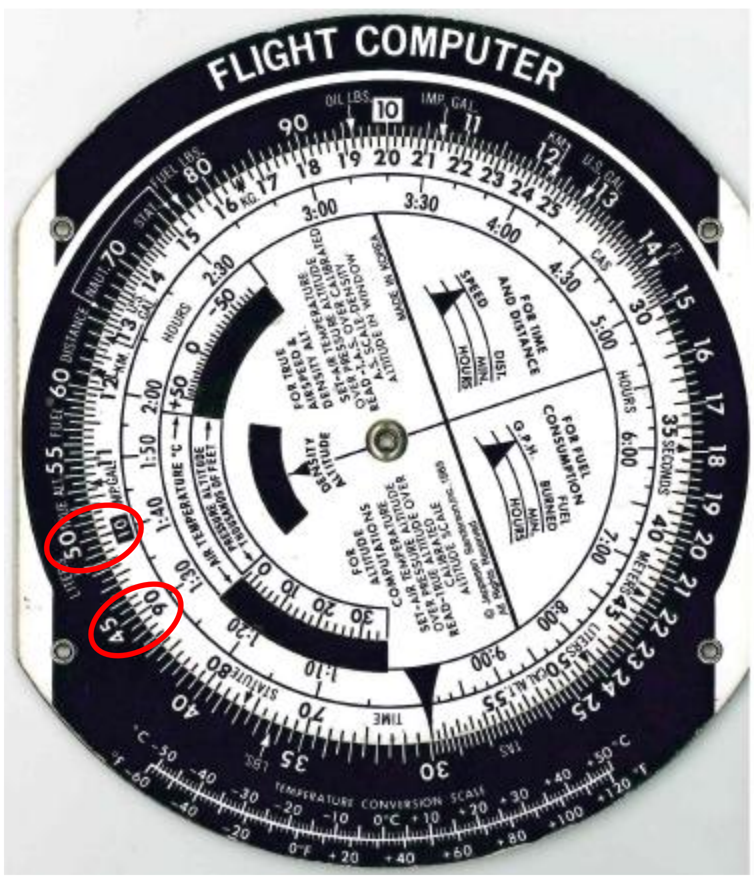
$$\frac{\text{Outer Ring}}{\text{Inner Ring}} \text{ as } \frac{\text{Number 1}}{\text{Number 2}}.$$

Example:

What is 450 divided by 9? (450 / 9) → 50

To do this division problem:

1) Rotate the inner ring such that the “45” is over the “9”. Read the value that is above the inner ring’s “10”. Remember, Decimal point placement is up to the user, and can be determined with basic common sense.



Multiplication

Multiplication may not look as straight forward as division, but it is the same process, almost in reverse.

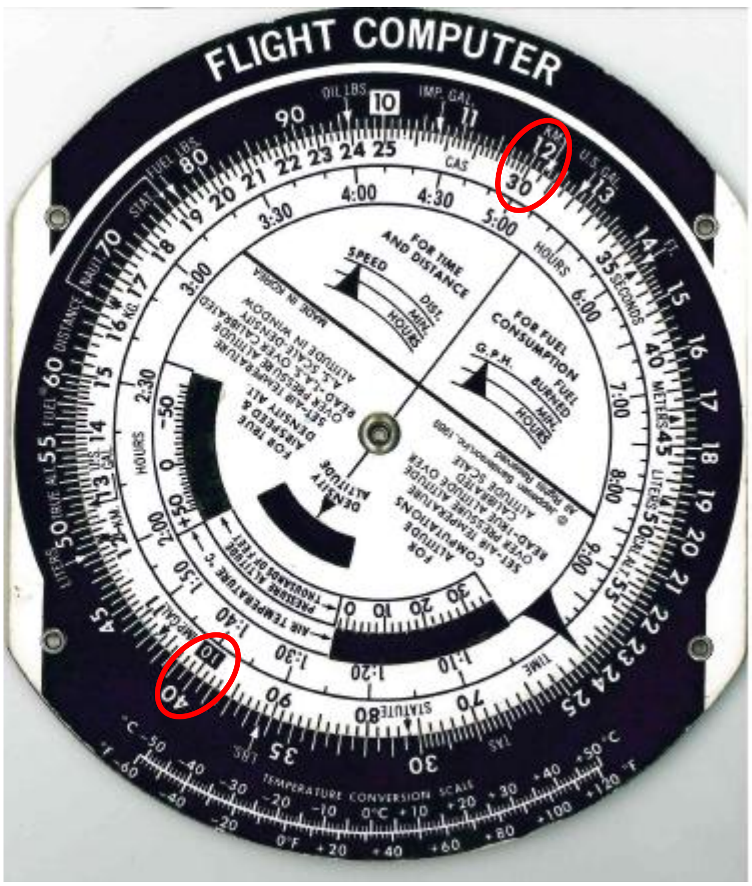
Example:

What is 40 times 3? (40 x 3) → 120

To do this multiplication:

1) Rotate the inner ring such that the inner ring's "10" is below one of the numbers you are multiplying together.

2) Find the other number you are multiplying also on the inner ring. Your answer is above this number. Here, we placed the "40" over the "10" and see that "12" is over the "30". The "12" represents your answer. Don't forget the decimal point is up to the user to place. You know 40 times 3 has to be larger than "12"; Therefore, the correct answer must be 120.



Compound/Complex Math

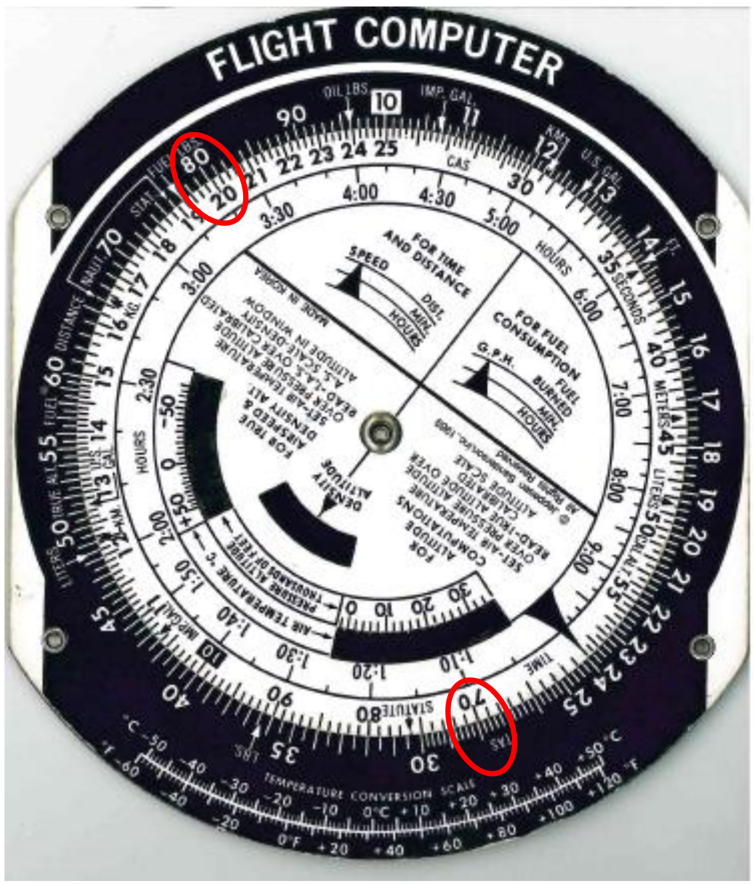
You can also do a combination of multiplication and division in one step. This comes in handy later when determining climb gradients, and time and distance to a VOR station.

Example:

What is 80/20 * 7 → 28

To do this:

1) Rotate the inner ring such that the “80” (on the outer ring) is over the “20” (on the inner ring) as you would for the division. Your answer is over the “70” (“70” here represents 7). In our example, “28” is over the “80”. The answer is 28.



Unit Conversions

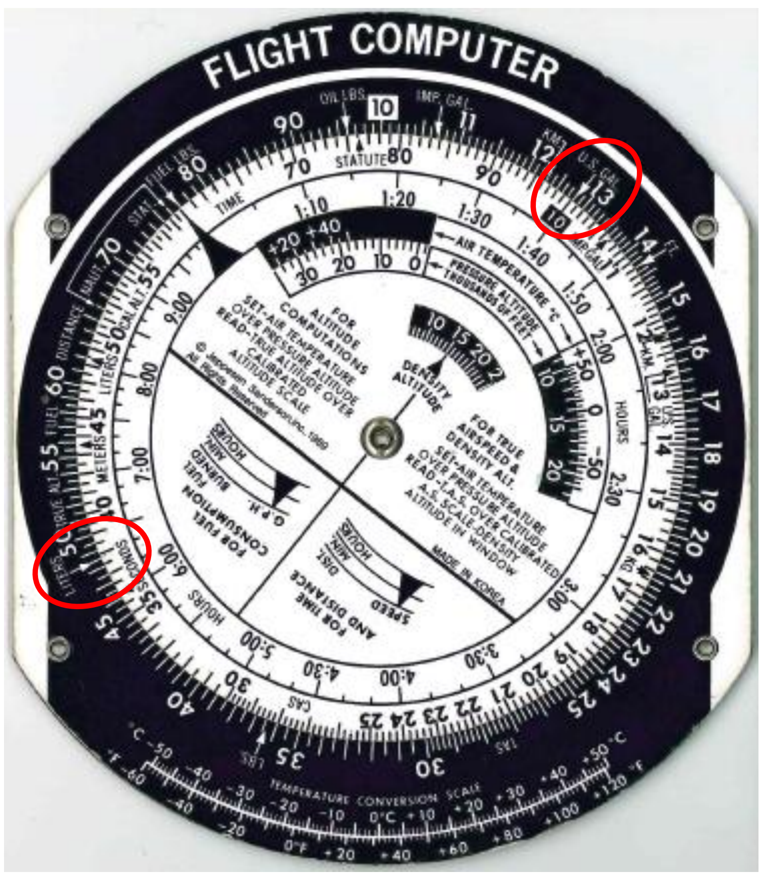
The E6B has several unit conversions built-in which makes unit conversions a snap. Here are a few examples. There are several others on the wheel which are not mentioned here but are relatively easy to figure out.

Example: Liters to Gallons

There are approximately 3.79 Liters in 1.0 U.S. Gallon. You can convert from Liters to Gallons with the E6B and can verify that conversion. The Outer wheel has “Liter” and “U.S. Gallon” Marked.

Method 1

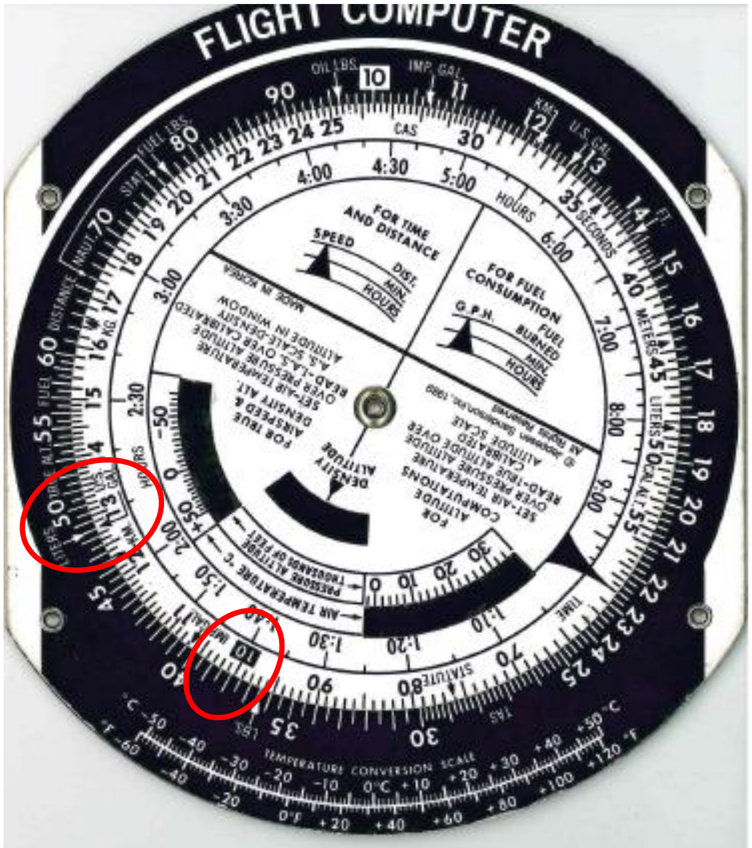
Rotate the inner wheel such that 37.9 (User determines decimal point, and 37.9 will represent 3.79) is under the “Liter” marking. This will convert 3.79 Liters into another unit. Look around the outer wheel between the 12 and 13 and you will use an arrow for “U.S. Gal” pointing to “10”. The user of the E6B is left to determine the proper location of the decimal point. With that said, “10” could be “1” or “100” as well, but common sense says that for 3.79 Liters, it would be 1 U.S. Gallon. As a quick sanity check, think about 2 two liter soda bottles compared to a 1 gallon jug of milk.



Method 2

This conversion can also be done by turning the inner ring such that “Liters” on the outer ring is over “U.S. Gal” on the inner dial. Then simply find your liter value on the outer ring, and read the value under it on the inner ring.

Again, “37.9” (Corresponding to 3.79 L) is over the “10” (Corresponding to 1.0 U.S. Gal).



Example: Temperature

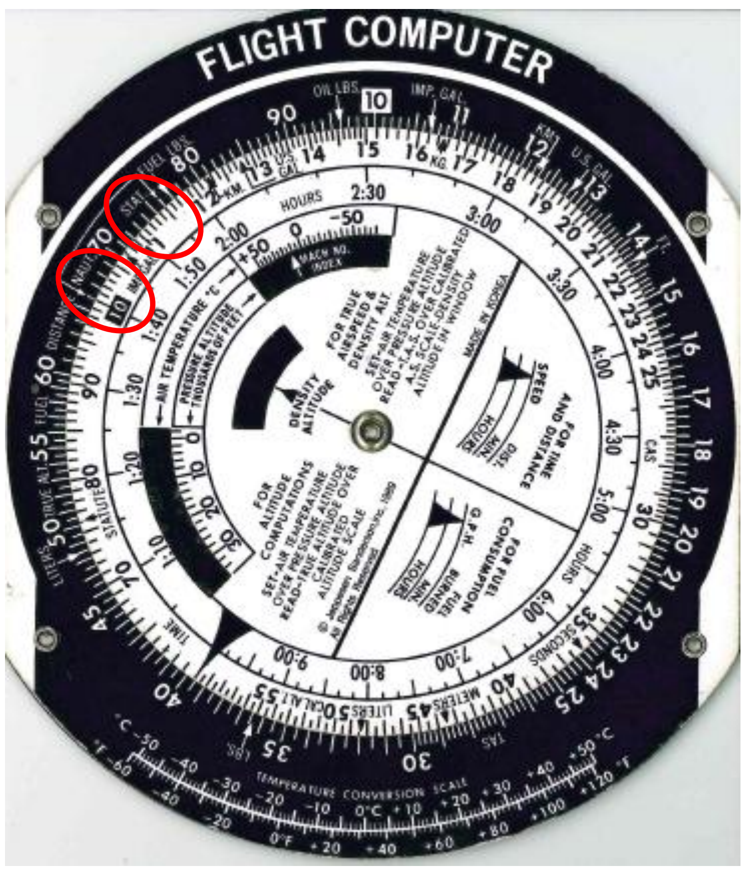
Temperature conversions are easy. Simply look at the bottom and see how the Celsius Scale lines up with the Fahrenheit scale. You will see that Freezing, 0 deg C lines up with 32 deg F.

Example: Nautical Miles to Statute Miles

Converting from Nautical Miles to Statute Miles is very similar to the Liter to Gallon conversion.

Method 1

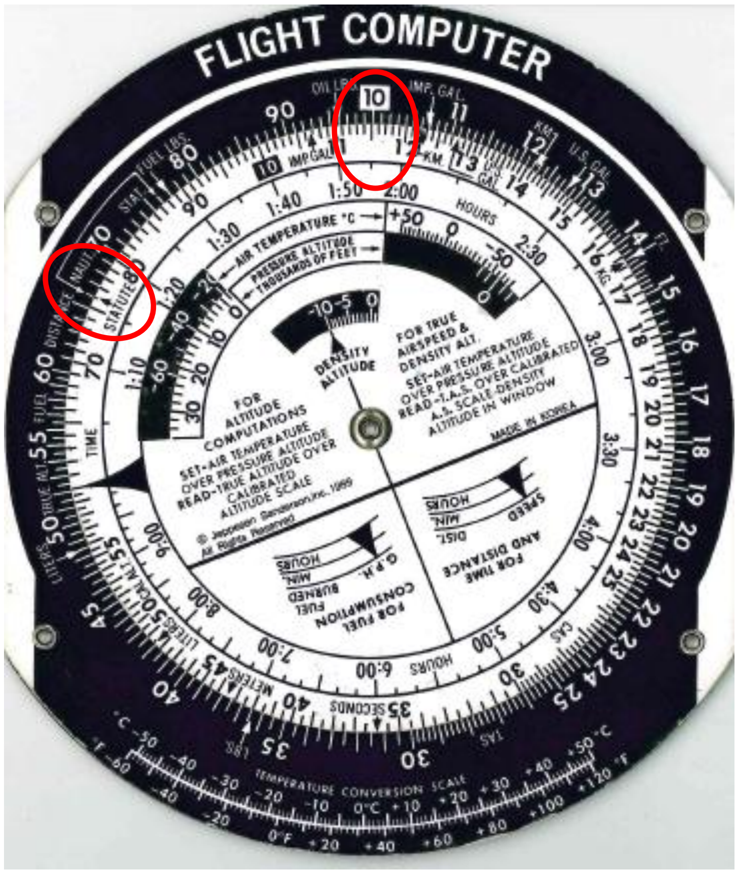
On the outer ring between the 6 and 8 are the “Naut” and “Stat” labels. The value of statute miles is 15% higher than nautical miles. In other words, 100 Nautical miles = 115 Statute Miles. To verify that conversion, place the “10” (“10” represents the value of ”100”) under the “Naut” mark, and read the value under the “Stat” mark. You will notice the value “11.5” is under the “Stat” mark. Keep in mind; it is up to the user to determine the proper placement of the decimal point. “10” can be “100” just like “11.5” can be “115”.



Method 2

This can also be done by turning the inner ring such that “Naut” on the outer ring is over “Stat” on the inner ring. Then simply find your Nautical Mile value on the outer ring, and read the value under it on the inner ring.

Again, you will see that the “10” on the outer ring (Corresponding to 100 Nautical Miles) is over the “11.5” on the inner ring (Corresponding to 115 Statute miles).



Enroute Calculations

True Airspeed

To calculate true airspeed, you would set up the flight computer as if you were calcuating density altitude. True airspeed is the same as your ground speed in zero wind conditions. It is your calibrated airspeed corrected for density altitude.

You must know the pressure altitude and outside air temperature (OAT). Pressure altitude can be found by adjusting the barometric pressure setting on your altimeter to 29.92. On the flight computer on the upper right side, you will see the note that says: “READ – T.A.S. Over Calibrated A.S.” This is saying that the true airspeed is on the outer ring and the calibrated airspeed is on the inner ring. For practical purposes, you can assume your calibrated airspeed is equal to your indicated airspeed.

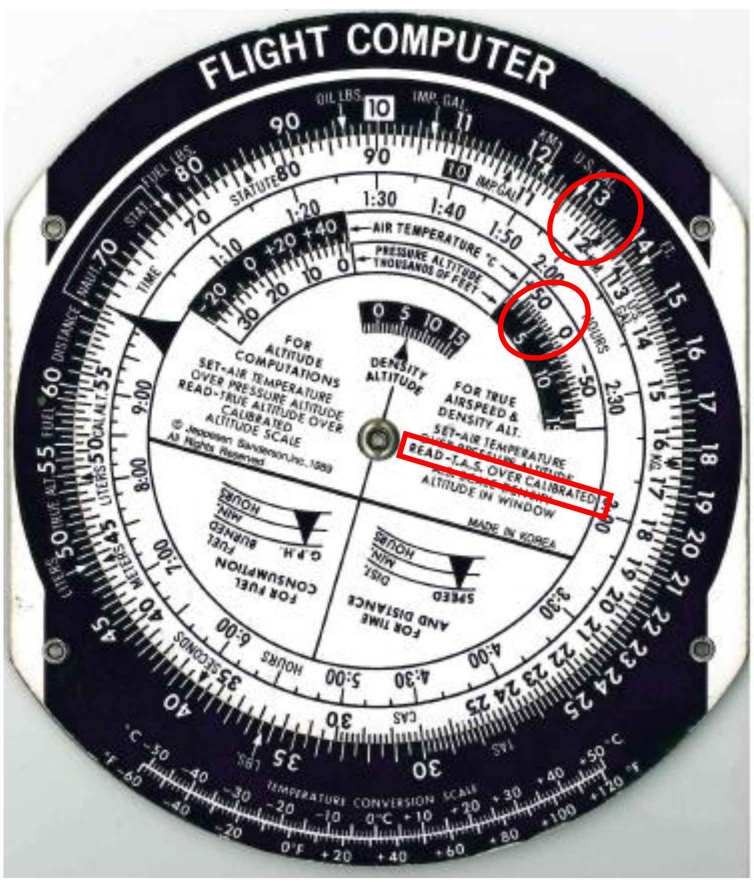
Example:

Outside Air Temperature = 20 deg C
Pressure Altitude = 5,000 Feet
Indicated Airspeed = 120 knots

→ True Airspeed = 133 knots

To determine True Airspeed:

1) Rotate dial to place 20 deg C over 5,000 feet. Read the True Airspeed over your Indicated Airspeed.



Off Course Problem – Correcting for Wind Drift

Suppose you are flying along assuming the wind is calm (you do not have a wind correction angle) and suddenly you realize you are off course. You understand this to mean that the wind was different than you expected. Using the basic techniques described above, in a more advanced manner, you can determine the proper correction angle to still arrive at your planned destination. To calculate a wind drift correction angle, you need to know how far you've flown, how far off course you are, and how far you have to fly to your destination from your current position.

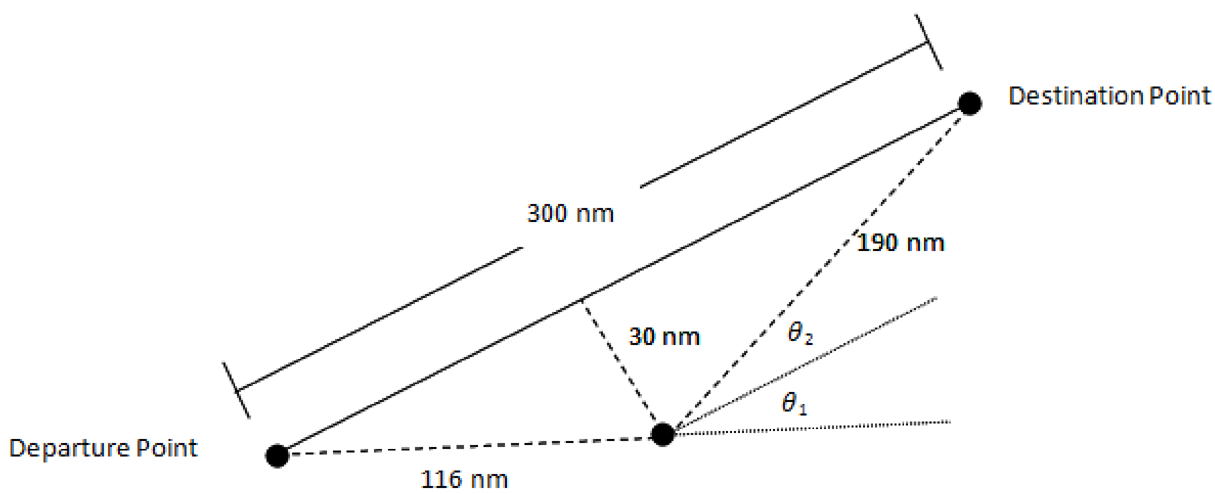
This problem is shown in the following figure. In a straight line, it is 300 nm from your point of departure to your destination. Along the way, you realize you are 30 nm off course. The E6B can be used to determine the heading change to arrive at your destination. Keep in mind though, this does not account for the fact that a wind caused you to drift. A wind correction angle should also be considered to avoid drifting further.

The following equations describe the process:

$$\theta_1 = \frac{\text{Mile Off Course}}{\text{Miles Flown}} * 60 = \text{Heading Change to Parallel Initial Course}$$

$$\theta_2 = \frac{\text{Mile Off Course}}{\text{Miles To Go}} * 60 = \text{Additional Heading Change to turn from a Parallel Course and Converge with Initial Course at Destination}$$

$$\theta_1 + \theta_2 = \text{Total Required Heading Change to Correct Course and arrive at Destination}$$



Example:

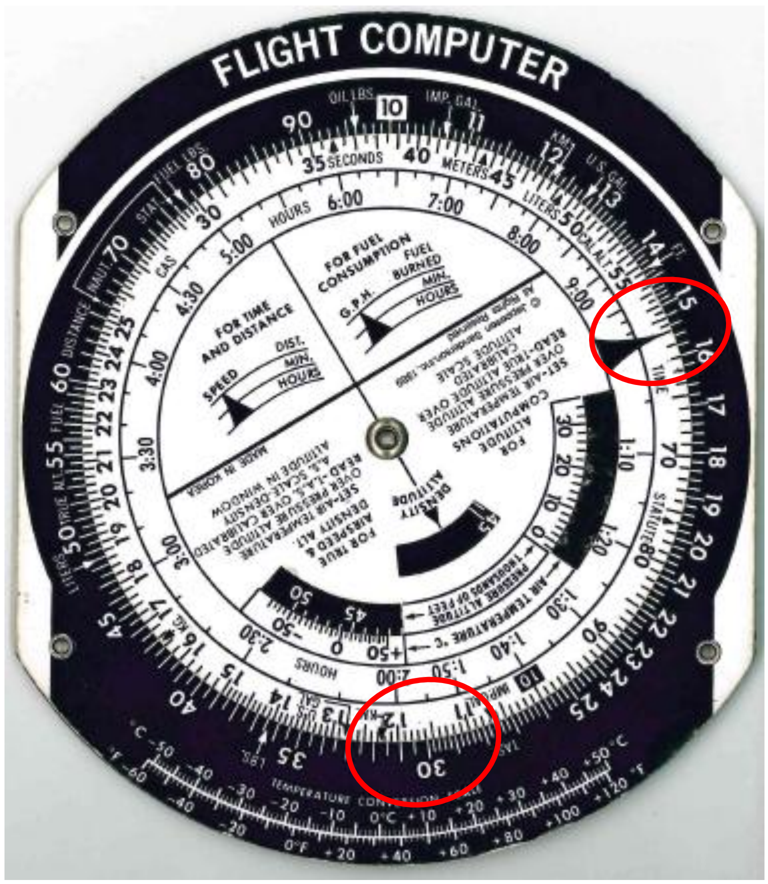
Off Course: 30 nm
Miles Flown: 116 nm
Miles to Go: 190 nm

→ $\theta_1 = 15.5$ deg
$\theta_2 = 9.5$ deg
$\theta_1 + \theta_2 = 25$ deg

To determine the total heading change to arrive at destination:

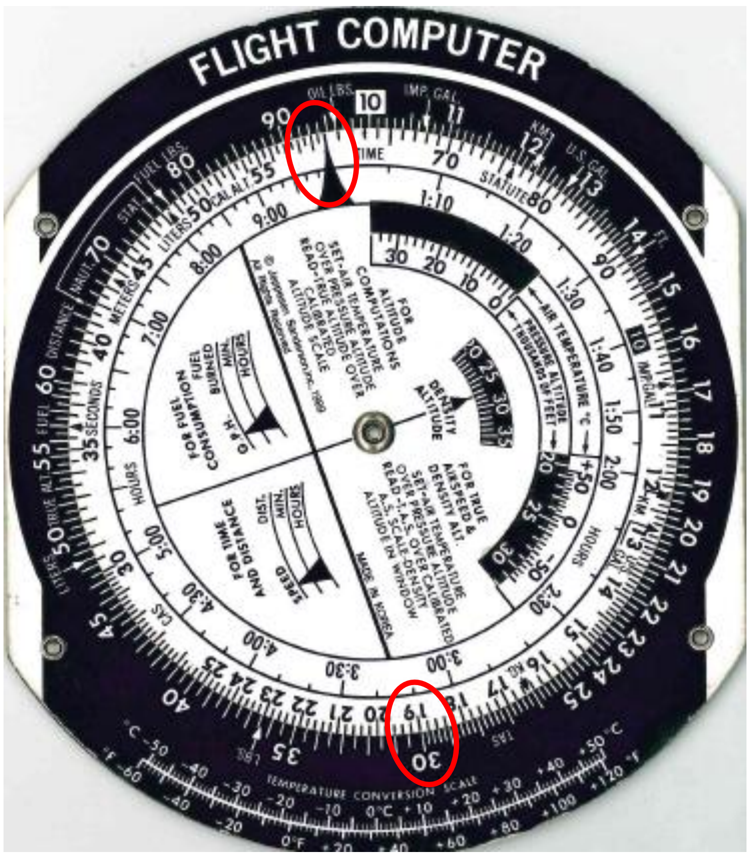
1) To determine the first part of the heading change, θ_1, rotate the inner ring such that the distance off course (on the outer ring) is over the distance flown (on the inner ring). In our example, “30” (Corresponding to 30 miles off course) is over the “11.6” (Corresponding to 116 miles flown). Our answer is above the inner ring’s “60” (the black triangle) on the outer ring. We see that “15.5” is over the “60”. Our answer to the first part of the problem is 15.5 degrees. A heading change of 15.5 degrees is required to parallel your initial course.

$$\theta_1 = \frac{30}{116} * 60 = 15.5$$



2) To determine the second part of the heading change, θ_2, rotate the inner ring such that the distance off course (on the outer ring) is over the distance to go (on the inner ring). In our example, the "30" (Corresponding to 30 miles off course) is placed over the "19" (Corresponding to 190 miles to go). Our answer is above the inner ring's "60" (the black triangle) on the outer ring. We see that "95" is over the "60". Our answer to the second part of the problem is 9.5 degrees. An additional heading change of 9.5 degrees is required to converge with your initial course at the destination.

$$\theta_2 = \frac{30}{190} * 60 = 9.5$$



3) Add the answers from steps 1 and 2 together for the total new heading change.

$\theta_1 + \theta_2 = 15.5 + 9.5 = 25$ degrees.

A total heading change of 25 degrees is required to converge on your final destination. Again, this does not account for a wind correction angle (keep in mind, an unknown wind might have caused your course deviation).

Time and Distance to VOR

You can quickly determine how far away from a VOR you are and how long it will take you to get there using a few basic procedures and equations.

First, determine how long it takes for a given bearing change.

1) While tracking towards a station with the CDI needle on the omni-bearing indicator centered, change the OBS setting by 5 or 10 degrees.

2) Turn perpendicular to your previous course, in the direction towards the CDI needle, and time how long it takes for the needle to re-center.

To find time and distance to a station, fly perpindicular to the radial at which the aircraft is currently located, and note the time it takes for a given change in radial.

Time to Station

$$\text{Time to Station(minutes)} = \frac{60 * \text{Time Between Bearings (minutes)}}{\text{Degrees of Bearing Change}}$$

Distance to Station

$$\text{Distance to Station(nm)} = \frac{\text{TAS} * \text{Time Between Bearings(minutes)}}{\text{Degrees of Bearing Change}}$$

Time to the VOR Station

Using the above procedure, you should now know how long it will take to change a given number of degrees. This equation assumes no wind. Use the first equation above:

$$\text{Time to Station (minutes)} = \frac{60 * \text{Time Between Bearings (minutes)}}{\text{Degrees of Bearing Change}}$$

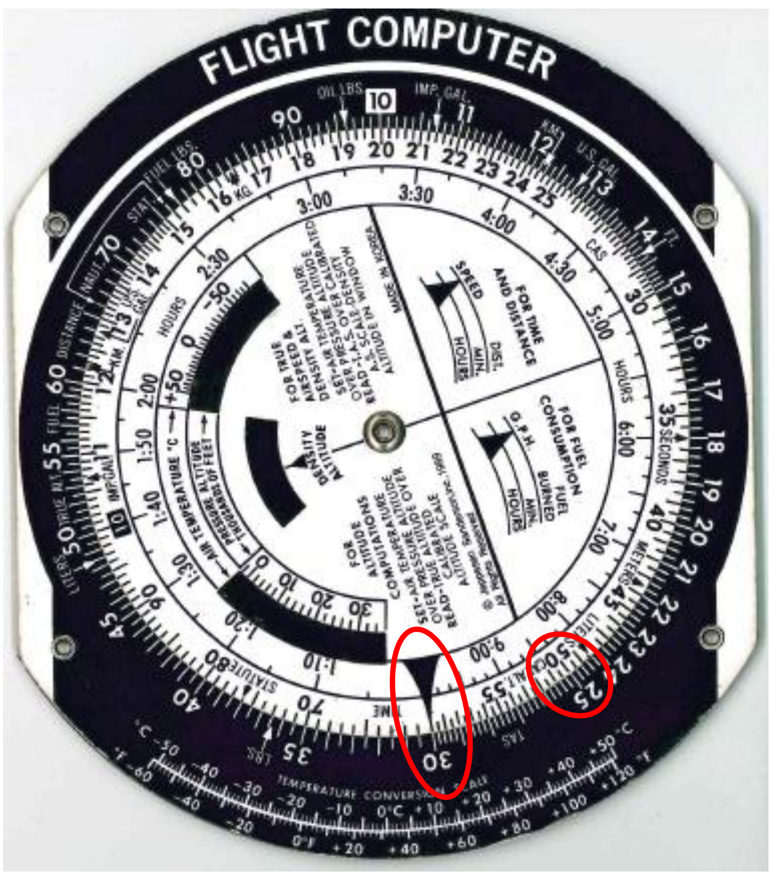
Example:

Time Between Bearings: 2 ½ minutes
Degree of Bearing Change: 5 degrees → Time to Station = 30 minutes

To solve for Time to the Station:

1) Turn the inner ring such that the "Time between Bearings" on the outer ring is over the "Degree of Bearing" change on the inner ring. In our example, the "25" (Corresponding to 2.5 minutes) should be over the "50" (Corresponding to 5 degrees change).

2) The "Time to Station" will be indicated on the outer ring above the "60" (or the black triangle). The answer is 30 minutes.



Distance to the VOR Station

The steps for determining the Distance to the Station are almost identical to the procedure for determining the Time to the Station. This equation assumes no wind. Use the first equation above:

$$\text{Distance to Station(nm)} = \frac{\text{TAS* Time Between Bearings(minutes)}}{\text{Degrees of Bearing Change}}$$

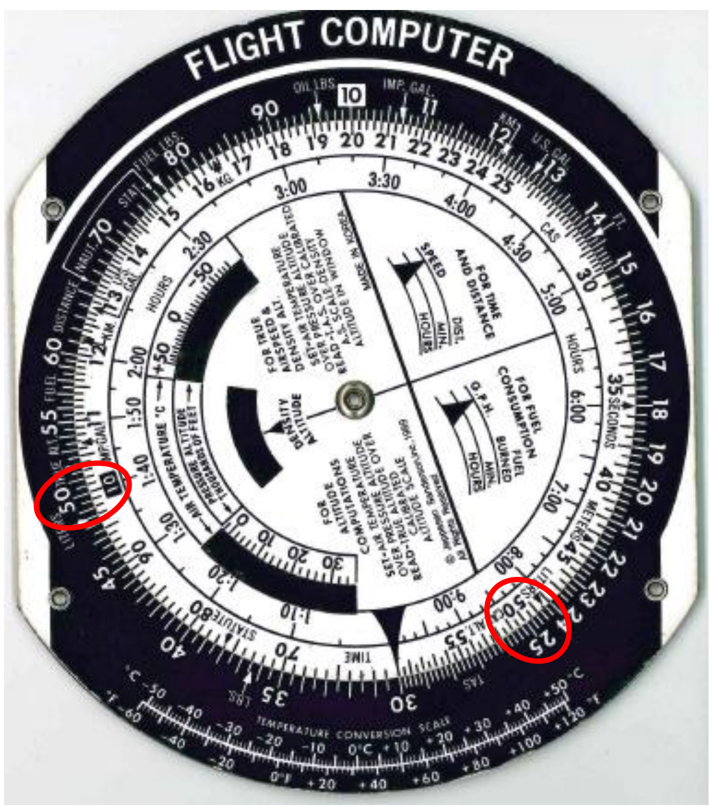
Example:

Time Between Bearings: 2 ½ minutes
Degree of Bearing Change: 5 degrees → Time to Station = 30 minutes
TAS = 100 knots

To solve for Time to the Station:

1) Turn the inner ring such that the "Time between Bearings" on the outer ring is over the "Degree of Bearing" change on the inner ring. In our example, the "25" (Corresponding to 2.5 minutes) should be over the "50" (Corresponding to 5 degrees change).

2) The "Distance to Station" will be indicated on the outer ring above the number corresponding to your TAS on the inner ring. In our example, our TAS was 100 knots. This means the distance to the station will be indicated above the inner ring number "10". The answer is 50 nautical miles. This makes sense when you compare time to station with the true airspeed.



Climb Rate for a Given Climb Gradient

Climb gradients expressed in feet per nautical mile are often specified on instrument departure procedures. It takes a few extra steps though to determine what climb rate you need to climb at to achieve that. You must know the required climb gradient and your ground speed to determine the required climb rate.

$$\text{Climb Rate (feet per minute)} = \frac{\text{TAS}}{60} * \text{Climb Gradient (feet per nm)}$$

Example:

Climb Gradient = 400 feet per nautical mile
TAS = 100 knots → Climb Rate = 667 feet per minute

This is often expressed in a table such as the following:

INSTRUMENT TAKEOFF PROCEDURE CHARTS
RATE-OF-CLIMB TABLE
(ft. per min.)

A rate-of-climb table is provided for use in planning and executing takeoff procedures under known or approximate ground speed conditions.

REQUIRED CLIMB RATE (ft. per NM)	GROUND SPEED (KNOTS)						
	30	60	80	90	100	120	140
200	100	200	267	300	333	400	467
250	125	250	333	375	417	500	583
300	150	300	400	450	500	600	700
350	175	350	467	525	583	700	816
400	200	400	533	600	667	800	933
450	225	450	600	675	750	900	1050
500	250	500	667	750	833	1000	1167
550	275	550	733	825	917	1100	1283
600	300	600	800	900	1000	1200	1400
650	325	650	867	975	1083	1300	1516
700	350	700	933	1050	1167	1400	1633

REQUIRED CLIMB RATE (ft. per NM)	GROUND SPEED (KNOTS)					
	150	180	210	240	270	300
200	500	600	700	800	900	1000
250	625	750	875	1000	1125	1250
300	750	900	1050	1200	1350	1500
350	875	1050	1225	1400	1575	1750
400	1000	1200	1400	1600	1700	2000
450	1125	1350	1575	1800	2025	2250
500	1250	1500	1750	2000	2250	2500
550	1375	1650	1925	2200	2475	2750
600	1500	1800	2100	2400	2700	3000
650	1625	1950	2275	2600	2925	3250
700	1750	2100	2450	2800	3150	3500

There is a simple and quick way to calculate this value with the E6B without having to look for the appropriate book and look it up.

To determine required climb rate:

1) Rotate the inner dial such that the TAS on the outer ring is over the “60” (black diamond) on the inner ring. In our example, the “10” should be over the “60”.

2) The required climb rate (on the outer ring) will be over the required climb gradient (on the inner ring). In our example, the “66” (Corresponding to 660 feet per minute climb rate) is over the “40” (Corresponding to 400 feet per nautical mile climb gradient). The answer is 660 feet per minute.