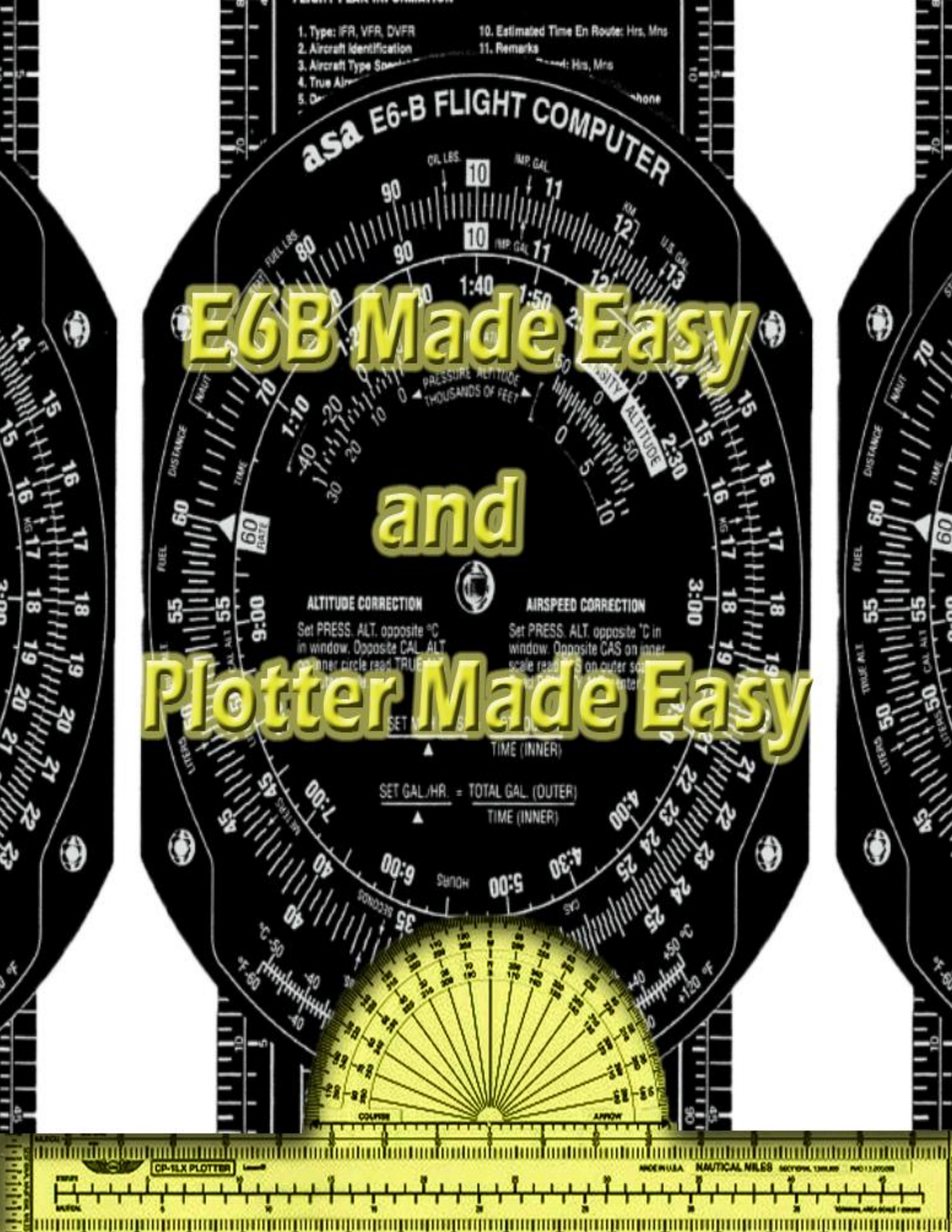
# E6B Made Easy and Plotter Made Easy



## Contents

# About the Author
# Brian Johnson

Hi, my name is Brian Johnson and flying on a Professional level has always been a dream of mine since childhood. I attended North Carolina Central University where I double majored in History and Geography. I have been proudly serving in the military for over 13 years. I got my start in aviation at a small FBO in Durham, NC at the age of 17. In April of 2008, I earned the opportunity to attend Airline Transport Professionals flight school in Panama City, FL. During my stay in Florida, I received the best flight instruction and gained valuable flight experience, which provided me with a solid foundation for my start as a Professional Pilot. After flight school, I felt compelled to impart my knowledge of flying to the masses, and so Pilot Up Gear & Apparel was founded to take on the mission of helping pilots become better pilots by giving them the information and tools they need to succeed. "We Are Here For Your Success!"

# Introduction

It's almost hard to believe that E6B flight computers and navigational plotters have existed for almost a century now. Even with the advent of software and GPS, they still prove to be an essential component in a pilots gear.

They are perhaps more dominantly employed in flight training programs and flight planning; nonetheless, some pilots choose to travel with them just in case a dreaded mishap with the modern computers might occur. A pilot can always count on the E6Bs to manually navigate his/hers way throughout the journey.

The E6Bs and plotters might seem a little complicated and quite disheartening to work with but this eBook is here to simplify everything for you. A reservoir of essential instructions, the book will dissect each component of these devices and show you how to use them to determine your ground speed, true course, true airspeed, the distance between each check point, and the total distance of your flight and much besides.

## What are E6Bs and their functions

E6B flight computers, otherwise known as, Whiz Wheels are compact gears that are easily carried in the cockpit of a plane. You can find aluminum, cardboard or plastic models—they are waterproof and don't require batteries to function, which makes them a very resilient and reliable accessory for the pilot. There are also electronic versions of E6Bs resembling calculators. The flight computers are circular slide rules which perform multiple functions in helping calculate wind correction, ground speed, time en route, and much besides.

These devices are now becoming less dominant in the aviation spectrum as they are becoming supplanted by various navigational systems where websites and electronic planning equipments or software are now automatically performing the calculations for pilots . Nevertheless, E6Bs are still predominant in flight training; they are also essential in the computation of fundamental variables such as wind direction and fuel burn before takeoff—this is known as flight planning. Some pilots still carry their whiz wheel in fear of a malfunction with the computer system or a change of plan. Bottom line, the E6B is NOT a redundant article.

At first glance, the E6B might come off looking complicated, even nauseating, with its unending set of wheels and markings, but bear with me now. By the end of this eBook, I will demystify the functions of this puzzling object, having you operate it like that watch on your wrist—well that is of course, if iPhones haven't made watches redundant yet.

## History of E6Bs

The architect of the E6B was a U.S Naval Lt. Philip Dalton. Originally known as the E-6B, the device was created by Dalton in the early 30s and was largely applied in WWII. In partnership with P.V.H Weems, he produced and sold a legion of flight computers.

Dalton's first flight computer was crafted in 1930. It was known as Model B and had the features of computing true airspeed (TAS) and altitude corrections. He made multiple versions of the device and formally had the versions Model C, D and G copyrighted in 1936. These computers were then extensively applied in WWII by the U.S. Navy and the British Common Wealth—known to them as "Dalton Dead Reckoning Computer". They were duplicated by the Japanese and advanced by the Germans through Siegfried Knemeyer where he invented a version of the device with a disc—much like the back of the current E6B.

The advent of the E-6B wasn't until the 1940s when it was first introduced to the U.S. army. The Pearl Harbor attack led to the mass demand of the devices by the army. There was a production of over 400,000 E6Bs during the Second World War.

## Breaking down the Components

There are two sides of the E6B— the front and the back. They are known as:


#### I. The Computer side

This is the preeminent side of the E6B which helps in the heavy-duty computations of:

- Distance, Speed and Time Enroute
- True Airspeed
- Consumption of fuel and Duration
- Density altitude
- True Altitude, Interpellation techniques for interpreting temp/alt data

#### II.The wind side

Unfortunately, the advent of GPS has reduced the significance of this feature, but it's still used to determine:

- Wind correction Angle
- True Heading
- Magnetic heading
- Ground Speed
- Compass heading

## I. How to Use the Computer Side

As mentioned earlier, the computer side of the E6B is used to compute distance, time enroute, fuel consumption and duration, altitude, air temperature, true airspeed and pressure pattern.

The device itself looks a bit too complicated and that certainly makes the task seem more complicated and difficult to understand. This is a common impression the E6B leaves on most people. The truth though is that with a little effort, operating this flight computer is fairly simple. And with the following guides at your disposal, understanding the ways and hows of the computer side should be a breeze.

## The Basics

The computer side of the E6B is composed of two scales: The fixed scale (outer scale) and the movable scale (inner scale). Time is always on the inner scale. Speed and distance are always on the outer scale.

On the inner scale you will find the number 60 highlighted in black—this is also known as the "rate arrow". This number is one of the most salient components of the flight computer, as most of the problems you would be dealing with are in one way or another related to time. It is used to indicate a 'value per hour' on the outer scale. And right above this number you will see a discernable arrow, which will be pointing at the speed on the outer wheel. The middle scale represents the minutes/decimal points.

The numbers on the computer side of the E6B are from 10-99, no more or less. But they are of infinite decimal points which means that you can use the number 40 to represent 4, 40, 400, .4, 4000 etc. If for instance you are solving a problem involving 300 gallons of fuel, then you would have to use the number 30 to represent 300. And if numbers are out of range like 107, then by moving the decimal point you can use 10.7 to represent the desired number 107. It is all a matter of common sense.

# Distance, Speed, and Time Enroute Calculation

Now here comes the fun part: the time-speed-distance problem.

## Calculating Distance

If you already know the value of the time and speed of your travel then determining the distance is fairly simple.

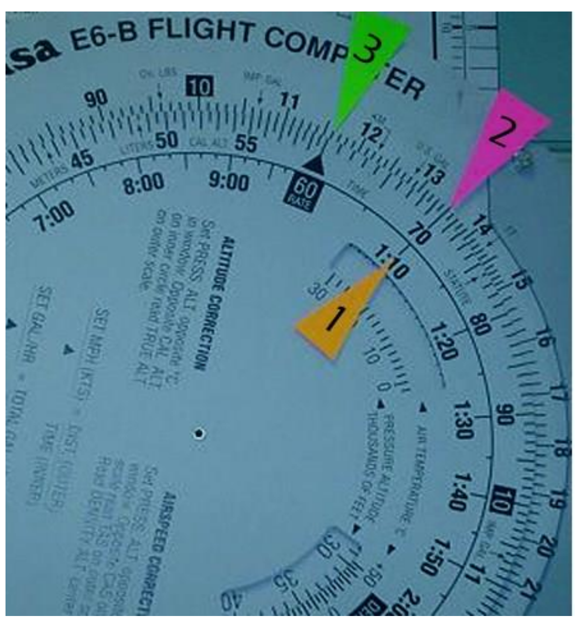
As previously mentioned, the arrow above the number 60, "rate arrow", indicates the speed on the outer wheel. So if your speed is 120 knots, then simply configure the rate arrow to 12. Once you're done setting this one up, find the time value which for the sake of illustration I have chosen 2:00. Opposite to 2:00 on the outer wheel you will then read the number 24, which denotes the distance and should be read as 240.

So there you have it, in 2 hours you will be able to travel 240 miles at 120 knots.


## Calculating speed

Determining the speed at which you would be travelling using the E6B is by far the easiest task to complete. As long as you have the value of time and distance, let's just say that the value of the speed is sitting right above the black arrow (rate arrow).

For instance, if the distance is135 miles and time is 1:10, then set 1:10 opposite to 135 miles which is between 13 and 14. Then find the arrow rate and the value at which it's pointing and you have your answer—116 knots which is between 11 and 12.



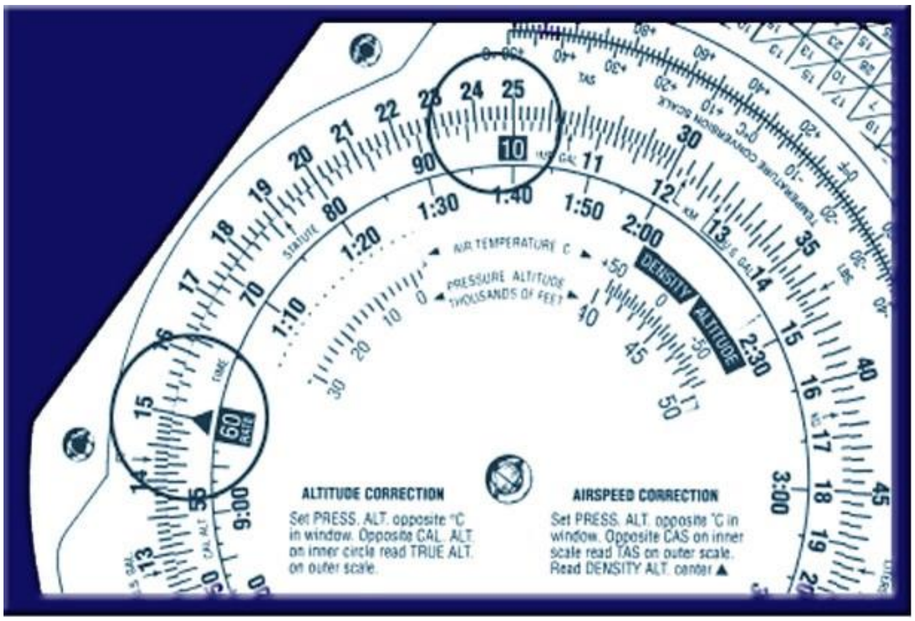
## Calculating Time

So far we have found the way to determine how far and how fast we can travel, and now we shall discuss the way we can realize the amount of time it will take us to reach a certain destination.

*Say you plan on traveling 245 nautical miles at 150 knots: How long will it take you to get there?*

First, configure the arrow rate at 15, and then find 245 on the outer wheel which is set between 24 and 25.

Opposite the value of the distance, you will find the Time Enroute on the inner scale, which should be set at 1:38.




***<u>Here are some Speed-Time-Distance problems for you to solve:</u>***

| Speed | Time | Distance |
|---|---|---|
| 1. 105kts. | 43 min. | |
| 2. | 9 min. | 15NM |
| 3. 107 | 3hr. 27 min. | |
| 4. 125kts. | | 524NM |
| 5. 110kts. | 1 hr. 40 min. | |
| 6. | 2 hr. 30 min. | 345NM |

**Answers are on page 19**

## Fuel Consumption

The computer side of the E6B doesn't have to change its form or numbers to solve problems related to fuel consumption, fuel endurance and fuel capacity. The only difference here is the name.

Time remains unaltered but the number the rate arrow represents will be referred to as Gallons per hour instead of Speed per hour. And the numbers on the outer scale will be referred to as fuel capacity instead of distance.

### Fuel Endurance

Say that you are burning 8.4 gallons of fuel per hour and that you have a fuel capacity of 64 gallons. How long could that last you?

1. Configure the rate arrow to 8.4, which is between 80 and 90.
2. On the outer wheel, find 64.
3. Look opposite 64 and on the inner wheel you will find the value of fuel endurance in hours, which in this instance is 7:37.

### Fuel Capacity

If you plan on taking a 2:30 flight and your fuel consumption rate is 8.2 gallons per hour (GPH), how much fuel would you need?

Well, this would be an easy one. Configure the rate arrow to 82. Find 2:30 on the inner scale or 150 minutes on the middle scale, and look to the opposite of the time value. On the outer scale you will then find the value of the fuel capacity at 20.5—between 20 and 21.

**Questions:**

| Gallon Per Hour | Time | Total Fuel Used |
|---|---|---|
| 1. 7.8 GPH | 3 hr. 20 min. | |
| 2. | 4 hr. 50 min. | 62 Gallons |
| 3. 10 GPH | 2 hr. 30 min. | |
| 4. 7.0 GPH | | 3.5 Gallons |
| 5. 16.3 GPH | | 62 Gallons |

**Answers are on page 19**

## Conversion

There is but very little reason for pilots not to be flustered by this device, right? But here's the thing, knowing how many functions it has and knowing how to function it are two different things. The latter is pretty easy but the former can surely leave you breathless.

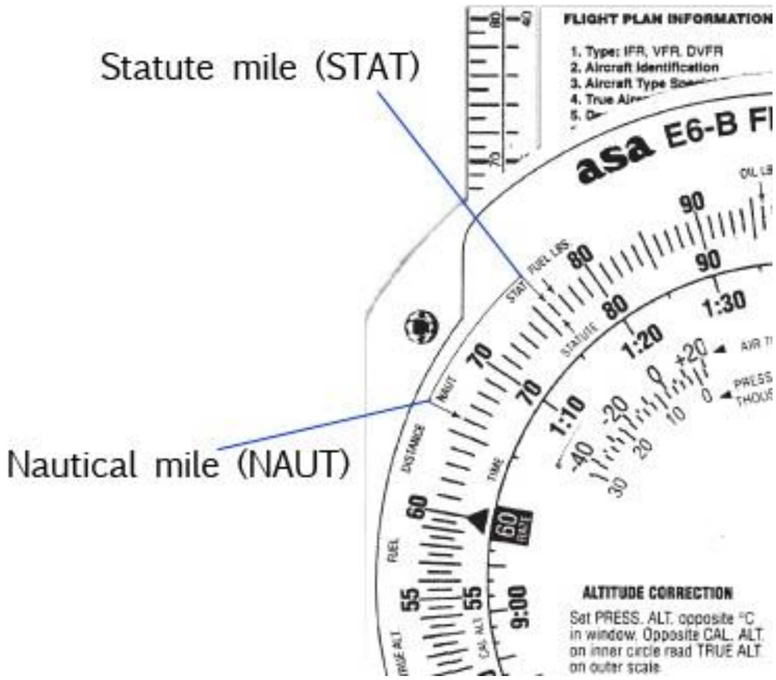
Now, on most occasions a pilot would have to convert nautical miles (NM) to statute miles (SM), gallons to liters, knots (KT) to miles per hour (MPH). The computer side of the E6B provides you with all that's needed to conduct these conversions, and here's how you figure it out.

## Nautical Miles to Statute Miles

The distance on sectional and world aeronautical charts is in statute miles. So it's quite often demanded for a pilot to convert Nautical miles to Statute miles.

On the outer scale near '65' you will find an arrow labeled 'NAUT' (nautical miles) and near '75', an arrow labeled 'STAT' (Statute mile).

So if you plan on converting say 90 nautical miles per hour (knots) to statute miles per hour (MPH), then simply configure the number 90 on the middle scale opposite the arrow marked NAUT. Then look to the arrow marked STAT. Under the STAT arrow you will be able to read the converted value which, in this case, is 103.




## U.S Gallons to Imperial Gallons

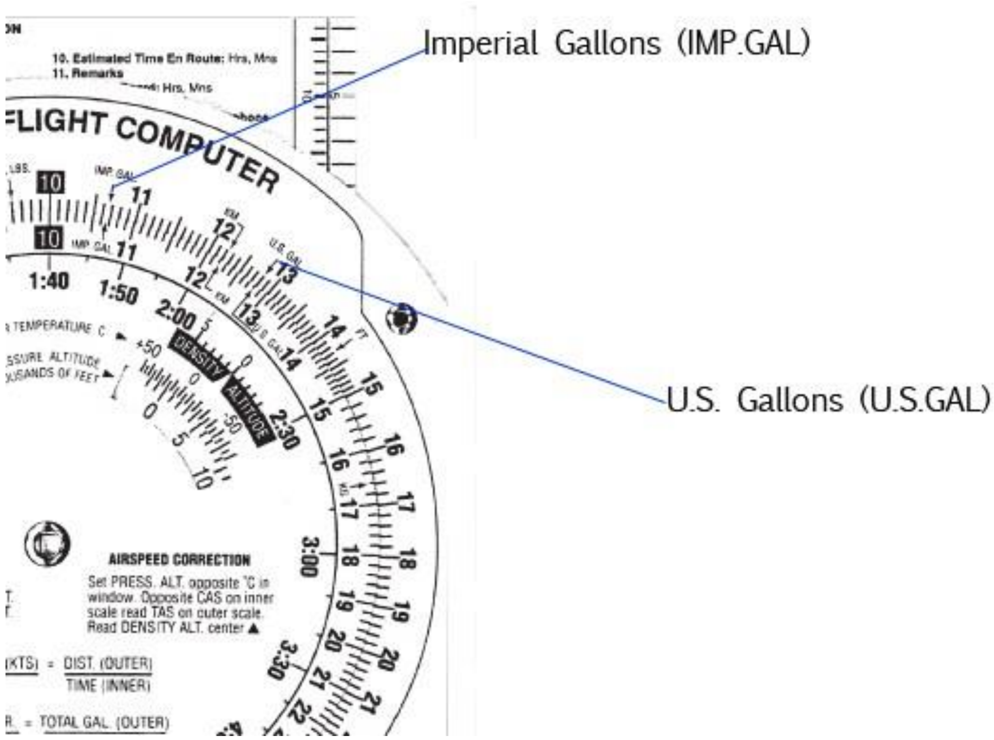
In many countries fuel is delivered in Imperial Gallons. So it's mandatory for a pilot to always be prepared to convert U.S GAL to IMP. GAL.

On both the outer and middle scale near the number '13' and '11' you will find arrows marked U.S. GAL and IMP. GAL.

To convert Imperial to U.S. gallons or vice-versa, all you have to do is line up the arrow labeled U.S. GAL on one scale opposite the arrow labeled IMP.GAL on the outer scale.

If for instance you want to convert 64 U.S. gallons to IMP.GAL, you will have to first line up the arrow labeled U.S. GAL on the middle scale opposite the arrow labeled IMP.GAL on the outer scale. Then look for the number 64 on the middle scale. Opposite the number 60 you will read 53 on the outer scale.

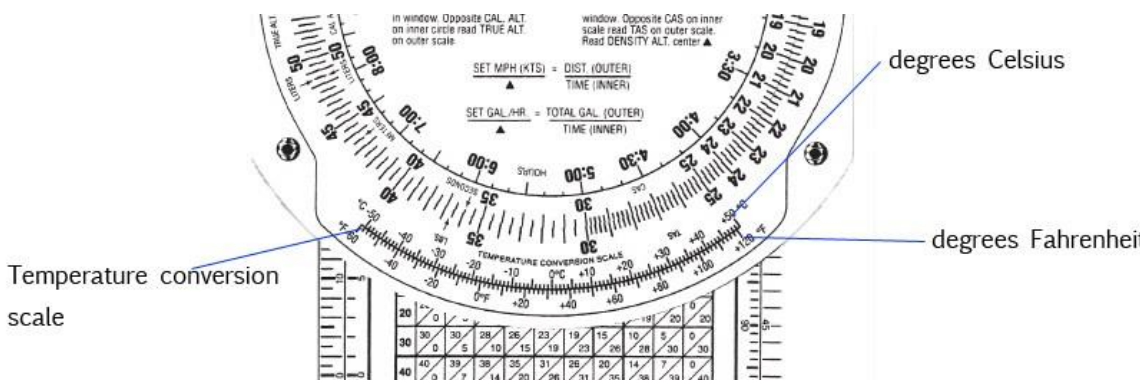
So there you have it, 64 U.S.GAL is equivalent to 53 IMP.GAL.




## Temperature Conversion

At the bottom of the computer side of the E6B there is a temperature conversion scale.

The top scale is degrees Celsius and the bottom scale is degrees Fahrenheit. So if you want to convert 70°F to Celsius, locate 70°F on the bottom scale, then read the value right above it, which is 21°C.




## True Airspeed and Density Altitude

There are distinct windows on the inner scale of the E6B. These windows are used to determine True Airspeed and Density altitude.

True Airspeed (TAS) is the actual speed of an airplane when it travels through the air. It is the indicated airspeed that's adjusted for calibration errors, nonstandard altitude, and nonstandard pressure.

The TAS is determined by adjusting the Calibrated airspeed (CAS) for density altitude.

The CAS can be obtained from the Pilot's Operating Handbook (POH).

Density altitude is the altitude in standard atmosphere, and it is determined by adjusting the pressure altitude for nonstandard temperature.

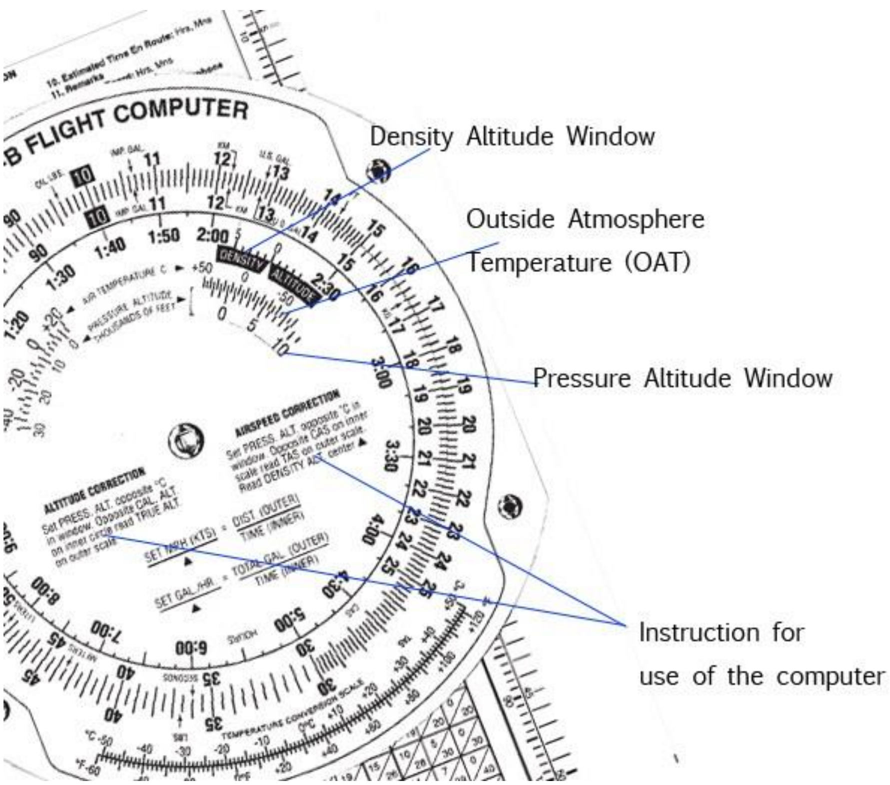
To determine the pressure altitude, set the airplane's altimeter to 29.92 and read the altitude. You can't solve the TAS without knowing the pressure altitude first.

## Determining True Airspeed and Density Altitude

The numbers in the window labeled 'DENSITY ALTITUDE' range from -10 to 45. But they are in thousands of feet, so -10 is -10,000ft and 45 is 45,000ft.

The numbers above the second window are of the Outside Atmosphere Temperature (OAT). The numbers of the OAT are in degrees Celsius and they range from +50°c to -70°c.

And the numbers in the window under the OAT represent the pressure altitude, and they too are in thousands of feet. They range from -2 (-2,000 ft) to 50 (50,000).



If you understand the mechanism of these components, determining the TAS and density altitude is fairly simple.

For instance, if the value of the IAS is 130 knots, the OAT is -15°c and the pressure altitude is 5,000 (5), you would have to first locate -15°c on the OAT then rotate the inner wheel until the pressure altitude of 5,000 (5) is under -15°c. Over the arrow in the 'DENSITY ALTITUDE' window, you will then be able to read the value of the density altitude, which is 2,500ft (25).

To determine the TAS, locate 130 knots (13) on the middle scale without moving the wheel. Then on the outer scale, opposite 13, you will read the value of the TAS, which is 135 knots.

NOTE: The outer scale of the E6B is marked TAS (True Airspeed) and the middle scale is marked CAS (Calibrated Airspeed).

**Questions:**

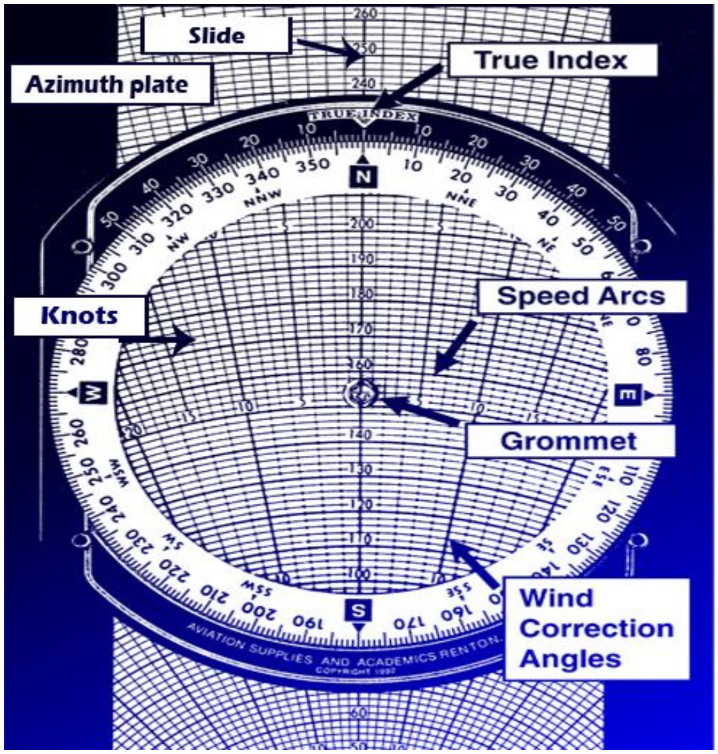
| Pressure Altitude | Temp | CAS | Density Altitude | TAS |
|---|---|---|---|---|
| 1. 7,000 | 0° C | 130kts. | | |
| 2. 20,000 | -20°C | 200kts. | | |
| 3. 9,500 | -10°C | 115kts. | | |
| 4. 4,500 | +10°C | 95kts. | | |
| 5. 8,000 | 15°C | 150kts. | | |

**Answers are on page 19**

## II.How to use the wind side

The main use of the wind side of the flight computer is to help you determine how much your plane will be pushed off course by the wind, so you can calculate the course correction needed to compensate for it.

Below is a figure to help you recognize the various components of the wind side. The lines of the knots may vary in different E6B models. For instance 1 line is equivalent to 2 knots on the micro E6B-1 and paper E6B-P models; for E6-B models, each line is equivalent to 1 knot. Just be sure to count the lines to avoid any errors.




**Note: Speed is provided in knots and Direction is represented as True.**

To carry out the task of determining ground speed, wind correction angle, true heading and compass heading, you must first have the following information: True Course, True airspeed (TAS), True wind direction, Wind velocity.

> **True wind direction and wind velocity should be supplied by the winds aloft forecast.TAS is taken during the flight planning from the plane's performance charts and true course can be determined from either your WAC or sectional chart.**

Here are simple steps to help you determine ground speed, wind correction angle, true heading and compass heading. Let's work with this given information:

**True Course (TR): 340°**

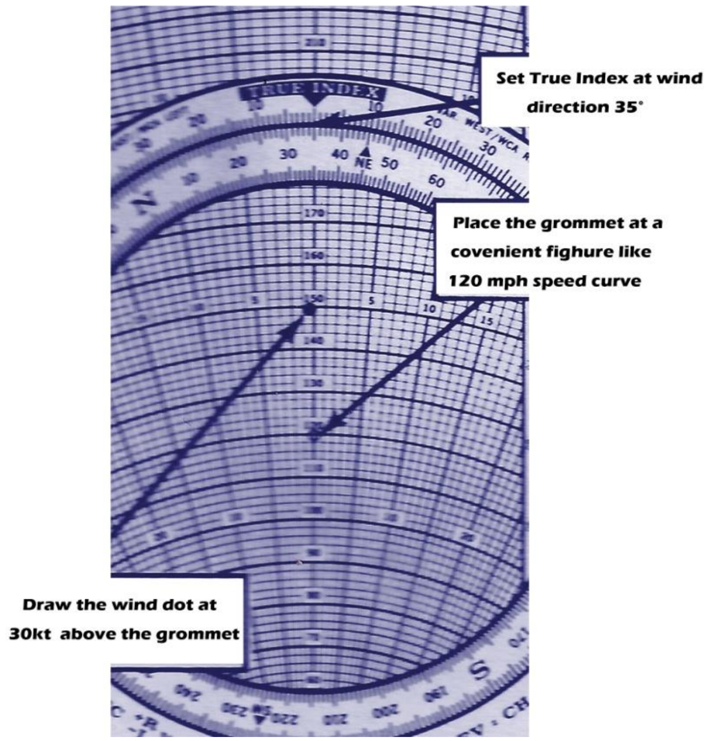
**True airspeed (TAS): 140 knot**

**Wind velocity: 035° at 30 knot**

## Step 1

Provided you already have the aforementioned information, align the 'True Index' mark to the given wind direction. You can do this by turning the azimuth plate until it points to the right figure. In this case it is 035° to 30kt. Have the True Index mark pointing at 35°.

## Step 2
Then move the slide until the grommet is away from the center and above any of the speed arcs (the dark lines). To show the wind speed, count 30 knots up from where you have currently positioned the grommet and mark the area with a circle or an X using a pencil. (Be sure to know how many knots each line represents.)The mark would be known as your wind dot.



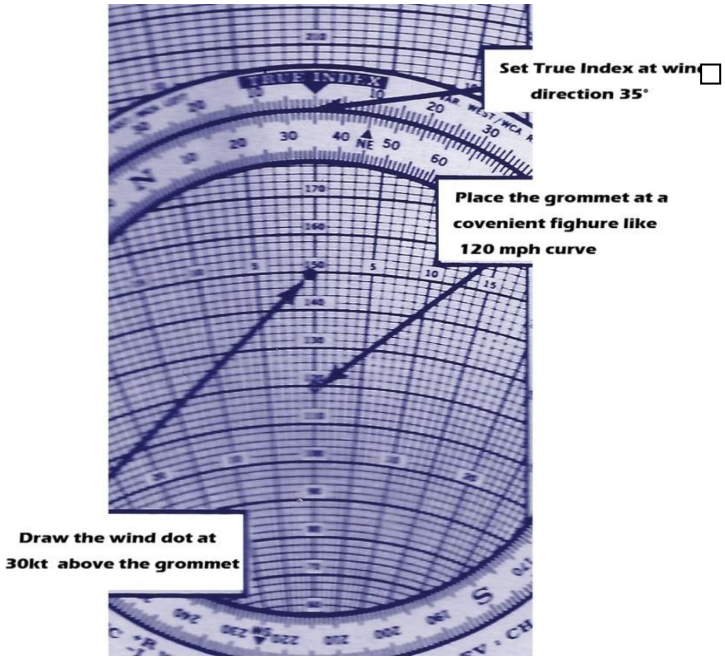

## Step 3
Your next step would be to rotate the azimuth plate until the True Index mark is at the True Course. In this case it would be 340°.

## Step 4
Move the slide up or down until the wind dot—which you have either marked with a circle or an X earlier— is over the true airspeed; in this case it is 140knots.

## Step 4
Now you are ready to make your assessments. Look right below the grommet and you will find your ground speed. In this example it is 120mph.The **ground speed** being below the grommet signals a tailwind.

## Step 5
To determine your **wind correction angle (WCA),** count the number of degrees between the wind dot and the grommet. Depending on the weather, the wind dot might be situated either on the right side of

the grommet or the left. The WCA will be negative if the wind dot is on the right and positive if it's on the left. As you can see, in this case it is +10° right of the grommet.



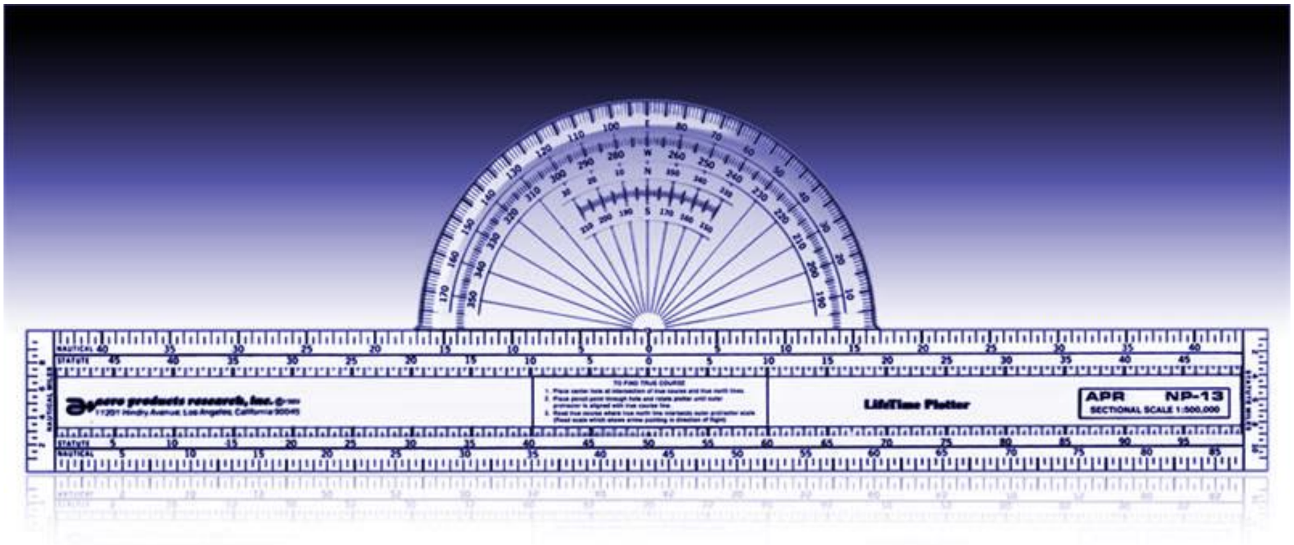

## Step 6

Your **true heading** can be determined by adding or subtracting (depending on whether you have a positive or negative figure) the WCA to the true course. In this case we add 340° to +10° thus, the true heading is 350°.

TH = TC +/- WCA

## What is a plotter?

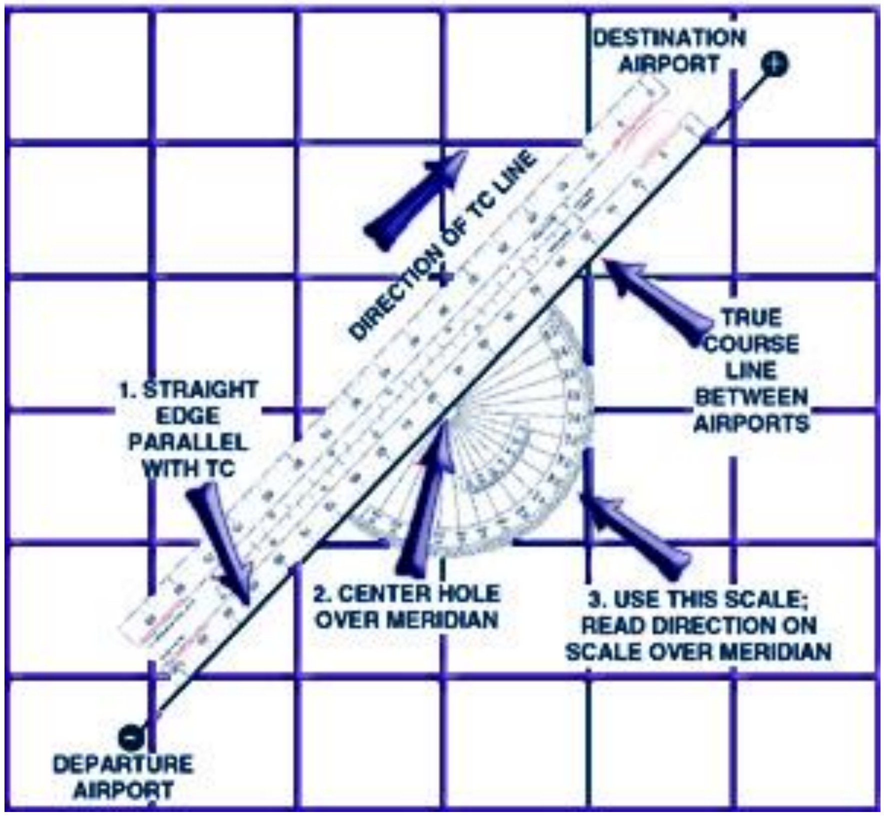
A plotter is a navigational tool that has a translucent scale with an inbuilt protractor. It is used to determine the true course (TC), the distance between each check point, and the total distance of your flight. Both sides of the plotter are calibrated: one side is in nautical miles and the other is in statue miles. Each side, moreover, has two scales: one for sectional charts, 1:500,000, and one for the world aeronautical charts, 1:1,000,000.




## How to Use a Plotter

Planning a cross-county flight for the first time is certainly thrilling. But to plan the course, you'll need to first know how to use a plotter. This device might seem a bit peculiar and difficult to manage at first; however, with little guidance you'll understand how simple it is to use this aviation plotter. To get you started, below are some easy instructions on how to use this tool.

1. Once you've decided the destination of your first cross-country, draw a course line using your plotter's straightedge on the open sectional map. The course line should begin from the center of the departure airport to the center of the destination airport. Make sure you use a light pencil so that you can easily erase it for the next flight planning and to avoid confusion.
2. Now, measure the distance along the course-line between your departure and destination airport marks. Ascertain that the nautical-mile side of the plotter is up, if the nautical-mile is what you will be using to conduct your calculation with. A plotter's scale on each side is distinctly marked, but it's extremely crucial to check if the correct side is up before measuring any distances.
3. You will find the meridian line (otherwise known as the **line of longitude**) intersecting the course line about half way. **(A meridian line is one of the north-south gridlines.**) Position the top-edge of the plotter along your course line and rotate it until the grommet, the center-point of the protractor, lies exactly on the meridian line.




Since meridians are not parallel lines and converge at poles, the course measurements should be formed near the midpoint of each segment.

4. Now use the scale to determine your true course and write it down on your flight planning.
5. If the protractor doesn't fall on a meridian line because the flight is too northerly or southerly, use the smaller protractor from the inner main protractor to read the angle. Again, place the plotter on the course line and rotate it until the grommet falls exactly on the horizontal grid line.

# ANSWERS

**Speed-Time-Distance Questions, Page 8**

1. 75NM
2. 100kts.
3. 370NM
4. 4 hr. 12 min.
5. 183NM
6. 138kts.

**Fuel consumption Questions, Page 9**

1. 26 Gallons
2. 12.8 GPH
3. 25 Gallons
4. 30 min.
5. 3 hr. 48 min.

**True Airspeed and Density Altitude Questions, Page 13**

1. 144kts., 6,800 ft
2. 273kts., 20,500 ft
3. 131kts., 8,900 ft
4. 102kts., 4,900 ft
5. 174kts., 9,800 ft