NAVAL AVIATION SCHOOLS COMMAND

NAS PENSACOLA, FLORIDA **NAVAVSCOLSCOM-SG-141**

INTRODUCTION TO AIR NAVIGATION

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DEPARTMENT OF THE NAVY
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Subj: INTRODUCTION TO AIR NAVIGATION STUDENT GUIDE

1. NAVAVSCOLSCOM-SG-141 Introduction to Air Navigation is issued for information, standardization of instruction, and guidance to instructors and student in Naval Aviation Schools Command (NAVAVSCOLSCOM), as well as for reference during Naval Aviation Training Commands.

2. This publication will be used to supplement the Preflight Syllabus (Course Identification Number Q-9B-0020) in the Aviation Training School Department (N3B) of NAVAVSCOLSCOM.

3. Recommendations for changes to any NAVAVSCOLSCOM-SG-141, student guide, shall be submitted to the Commanding Officer, Naval Aviation Schools Command, Code N3A, Learning Management Office(LMO), via the Training Improvement Plan. Point of Contact is in LMO at 850-452-4210 or DSN 922-4210.

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5. NAVAVSCOLSCOM-SG-141 replaces CNATRA P-203 (Rev ~~12-02~~ 09-06 JCH) under the realignment of NAVAVSCOLSCOM under Commander, Center for Naval Aviation Technical Training.

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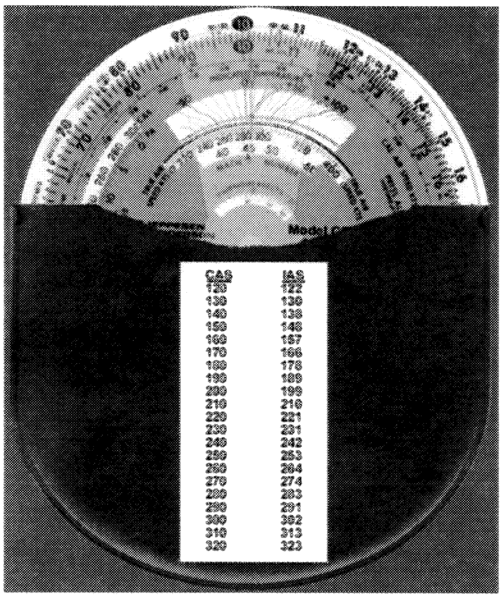
STUDENT GUIDE

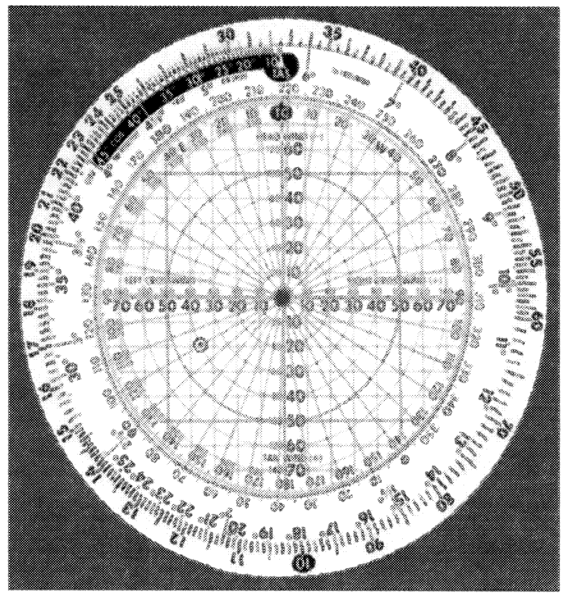
FOR

PREFLIGHT

Q-9B-0020

UNIT 4





Navigation

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CHANGE RECORD

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SECURITY AWARENESS NOTICE

This course does not contain any classified material.

SAFETY NOTICE

All personnel must be reminded that personal injury, death or equipment damage can result from carelessness, failure to comply with approved procedures, or violations of warnings, cautions, and safety regulations.

SAFETY/HAZARD AWARENESS NOTICE

a. Safe training is the number one goal. Each year at training commands, lives are lost and thousands of man-hours and millions of dollars are wasted as the result of accidents. Most of these accidents could have been prevented. They are the result of actions performed incorrectly, either knowingly or unknowingly, by people who fail to exercise sufficient foresight, lack the requisite training, knowledge, or motivation, or who fail to recognize and report hazards.

b. A mishap is any unplanned or unexpected event causing personnel injury, occupational illness, death, material loss or damage or an explosion whether damage occurs or not.

c. A near miss or hazardous condition is any situation where, if allowed to go unchecked or uncorrected, has the potential to cause a mishap.

d. It is the responsibility of all Department of Defense personnel to report all mishaps and near misses. If a mishap, hazardous condition or near miss occurs let your instructor know immediately.

e. Students will report all hazardous conditions and near misses to the command high-risk safety officer via their divisional/departmental high-risk safety officer. Reports can be hand written on the appropriate form. Injuries shall be reported on the appropriate form.

HOW TO USE THIS STUDENT GUIDE

This publication is for your use while studying the Navigation unit of Preflight. You may mark any pages in this book, including information sheets and assignment sheets. When filled in, this guide will become a useful reference. It <u>may not</u> be used during testing.

The Navigation Unit is divided into Lesson Topics 1 through 7 covering all the phases of preflight planning that involve charts and use of the CR-3 computer. The final chapter is a comprehensive review of the previous six chapters introducing and explaining the use of the jet log.

The knowledge to be acquired is stated for each topic so that you can check your progress. It is to your advantage to review the learning objectives prior to the class presentation.

Assignments in this guide are given for study. The effectiveness of the guide depends upon the conscientious accomplishment of the reading and study assignments.

Participation in a study group is highly recommended. Statistical analysis suggests that a study group of four members is optimum.

A written examination will be administered on the material following the completion of Navigation.

Page numbers in this student guide consist of three parts: the unit number (4 for Navigation), followed by a decimal point, the lesson topic number (1 through 7), followed by a dash (-), and finally, the page number within the lesson topic.

CLASS SCHEDULE

Topic No.	Type	Hours	Topic
4.1	Class	1.0	Introduction to Air Navigation
4.2	Class	3.0	Chart Projections, Plotting and Global Time Keeping
4.3	Class	2.0	CR-3 Air Navigation Computer (Calculator Side)
4.4	Class	1.0	Airspeeds
4.5	Class	2.0	Preflight Winds
4.6	Class	1.0	In Flight Winds
4.7	Class	4.0	Flight Planning and Conduct
	Review	1.0	In Class Review
	Exam	2.2	Final Examination

ASSIGNMENT SHEET

Introduction to Air Navigation
Assignment Sheet No. 4.l.l A

INTRODUCTION

The purpose of this assignment sheet is to aid the student in understanding the basic knowledge of air navigation concepts, principles, and terminology.

LESSON TOPIC LEARNING OBJECTIVES

TERMINAL OBJECTIVE:
Partially supported by this lesson topic:

4.0 Upon completion of this unit of instruction, the student will demonstrate, per NAVAVSCOLSCOMINST 1610.7 series, knowledge of the fundamentals of air navigation skills necessary for pilot or naval flight officer training.

ENABLING OBJECTIVES:
Completely supported by this lesson topic:

4.1 State the basic concepts, principles, and terminology used in air navigation.

4.2 Name the concept that is the basis for all types of air navigation.

4.3 Define the four basic elements of DR navigation.

4.4 Name the three primary flight instruments essential to dead reckoning (DR) navigation.

4.5 Name the two secondary flight instruments used to correct for density in DR navigation.

4.6 Define the three major types of navigation.

STUDY ASSIGNMENT

Study Information Sheet 4.1.1I, and solve the practice problems at the end of the lesson topic.

INFORMATION SHEET

Introduction to Air Navigation
Information Sheet No. 4.1.1I

INTRODUCTION

Air navigation is defined as "the process of determining the geographic position and maintaining the desired direction of an aircraft relative to the surface of the earth."

REFERENCE

INFORMATION

There are three types of navigation: Dead Reckoning Navigation, Visual Navigation, and Electronic Navigation. Visual and electronic navigation are back-up techniques to dead reckoning.

DEAD RECKONING NAVIGATION

Dead Reckoning is defined as directing an aircraft and determining its position by the application of direction and speed data from a previous position. It is the basis for all types of air navigation. Navigation is both the history and prediction of an aircraft's flight path. At the heart of DR are its four components: position, direction, time, and speed. Position is a set of coordinates that define the specific location of the aircraft above the earth's surface. Direction is an angular measurement from a reference, which determines the actual flight path from a known starting point. Speed multiplied by time will produce the distance flown (or to be flown). The combination of these four components will allow the aircrew to determine the aircraft's current position or to predict its future position. As with any mathematical relationship, if three of the four components are known, the fourth can be determined.

Position is a geographic point defined by coordinates. There are several coordinate systems available to determine a specific location on the earth's surface. The primary system used in aviation is the latitude/longitude system.

Every point on the surface of the earth can be defined by a specific **latitude** (angular distance north or south of the equator) and by a specific **longitude** (angular distance east or west of the Prime Meridian) (Figure 4.1-1). Lines of latitude are also called parallels, while lines of longitude can be referred to as meridians.

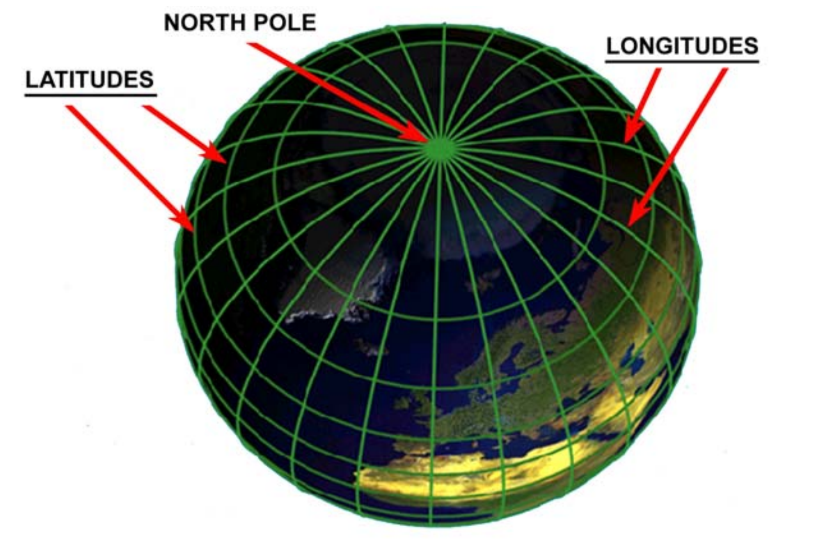

Figure 4.1-1 The Polar Perspective

Since they are angular distances, latitude and longitude are measured in degrees and minutes. There are 60 minutes in each degree. Latitude, starting at the equator, is measured from 0 to 90 degrees and labeled North or South. Longitude, starting at the prime meridian (0° Longitude), is measured from 0 to 180 degrees and labeled East or West, and ends at the International Date Line (180° Longitude).

In Figure 4.1-2, NAS Pensacola is located at 30 degrees, 21 minutes north latitude; and 087 degrees, 19 minutes west longitude. This position would be written as: 30° 22'N, 087° 19'W. (Note: Always read latitude first and use 3 digits for longitude to avoid confusion)

Figure 4.1-2 Latitude Longitude Coordinates

Direction is an angular distance from a reference. Direction, stated in whole numbers, is measured from 0° to a maximum of 359°. The reference for the angle can be either True North or Magnetic North. True North is the top of the earth whereas Magnetic North is the point from which all of the Earth's magnetic lines of force emanate. Magnetic North is currently located near Hudson Bay in Canada. A magnetic compass system converts the energy from these lines of force to a cockpit indicator reading. Typical military aircraft have two compass systems: a primary and a secondary/back-up.

The aircrew's primary instrument for determining direction in the cockpit is the Remote Gyro Vertical Compass Card**.** This compass uses a remotely located detection element (called a flux detector) to sense the magnetic field at a point where interference is at a minimum (such as a wing tip). This sensor converts magnetic energy to an electrical voltage, which then drives electrical motors that turn the compass card to reflect changes in aircraft heading (see Figure 4.1-3).

Figure 4.1-3 Remote Gyro Vertical Compass Card

Because the compass is gyro-stabilized, it is not subject to "G-loading" and continues to function in high-G environments. The aircraft's magnetic heading is found under the white triangle at the top of the card.

As a backup to the primary system, all aircraft have a Stand-by Compass (see Figure 4.1-4). This is a direct reading compass in which the measurement of direction is taken directly from a balanced/pivoted magnetic needle. The stand-by compass is sometimes called the "wet" compass because it is filled with a fluid to dampen needle movement. This compass is unstable during maneuvering, but it has the advantage of reliability and is independent of the aircraft's electrical


Figure 4.1-4 Stand-by Compass

system.

Discussion of direction will continue in Lesson Topic 4.2 when charts and plotting techniques are introduced.

Time can be expressed in two ways: as the time of day (0815, 1400, etc.) or elapsed time. Elapsed time is written as hours and minutes or minutes and seconds. With elapsed time, the units are separated with a “+” sign (2+30, 3+15, etc.).

Estimated time of departure (ETD) and estimated time of arrival (ETA) will be expressed in four-digit time of day format, while elapsed time, such as estimated time en route (ETE), will be expressed in hours and minutes (or for short distances, minutes and seconds). All aircrew must be able to convert from local time to Greenwich Mean Time (Zulu time) and vice versa. This will be covered in greater detail in Lesson Topic 4.2.

Speed is the magnitude of the velocity of an aircraft. It is the distance traveled with respect to time and is stated in nautical miles per hour (knots). Lesson Topics 4.3 and 4.4 will cover speed in greater detail and explain how atmospheric conditions (altitude, temperature) affect it.

$$\text{Speed} = \frac{\text{Distance}}{\text{Time}}$$

ADDITIONAL TYPES OF NAVIGATION

To assist the aviator in the DR process, there are two additional types of navigation: visual and electronic. It is important to understand that these are aids available to the aviator in the DR process and does not relieve an aviator of the responsibility to keep a good DR plot.

Visual Navigation requires maintaining direct visual contact with the earth's surface. Visual navigation supports DR by using ground references to determine current position or to provide steering cues to a destination. Visual navigation is most commonly used for helicopter operations and for high speed/low level flight by tactical aircraft. Its obvious limitation is that it requires sufficient visibility and visual references. Visual navigation is not a stand-alone form of navigation. Without DR, the aviator is likely to misidentify ground references and become lost.

Electronic Navigation requires the use of electronic devices to determine position. They can be grouped into three general categories. In the first category, electronic signals are received from ground stations (VOR, TACAN, ADF, OMEGA/VLF). The second category of electronic devices will transmit their own signals (RADAR, DOPPLER). The last group is self-contained and requires the aviator to input the starting location (INERTIAL NAVIGATION SYSTEM or INS). The INS is a high speed DR computer that does the same thing the aviator does but faster and with greater accuracy. The newest addition to the electronic navigation family is the Global Positioning System (GPS). This system is similar to OMEGA but receives its input from space-based satellites. The discussion of electronic navigation for this class will be limited to TACAN.

TACTICAL AIR NAVIGATION (TACAN)

A **TACAN** is a ground-based system that provides the aviator with precise position information. Position is determined by providing the distance (in NM) away and by giving the magnetic bearing (radial) from the station. Since the TACAN station is at a known geographic location, the aircrew will be able to determine their position above the earth's surface via their relationship to the station. The procedures for this are covered in detail in Lesson Topic 4.2.

A TACAN station operates in the 962 to 1213 MHz frequency range with the individual UHF frequencies being assigned to a channel. These channels number 1 to 126 with a sub-designation of "X" or "Y". Each TACAN emits 360 unique signals that are carefully calibrated to magnetic north and radiate out from the station. These radials look similar to the spokes of a wheel (Figure 4.1-5). The radial that the aircraft is currently on and the distance from the station are displayed in the cockpit allowing the aircrew to "fix" their position.

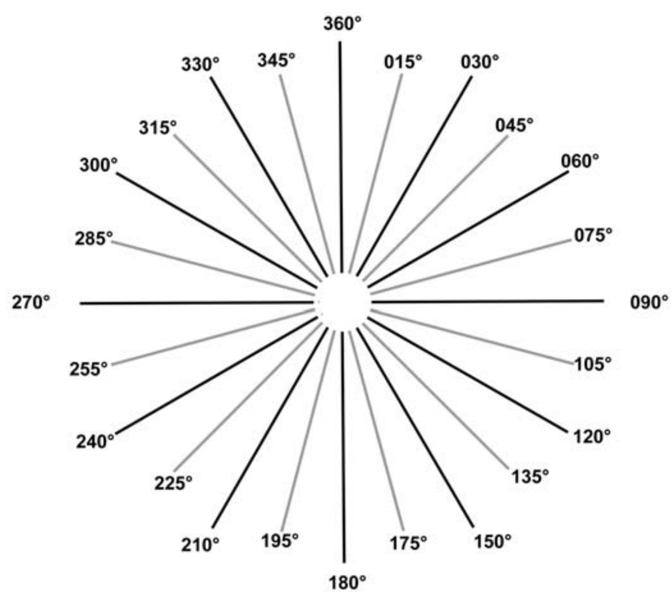

Figure 4.1-5 Station Magnetic Radials

AIRCRAFT INSTRUMENTS FOR DR

There are three primary aircraft instruments essential for DR navigation (Figure 4.1-6). The combination of these instruments provides the information required to determine and track an aircraft's position and movements.

Instrument	Function
BDHI	Direction and Position
Clock	Time
Airspeed indicator	Speed

Figure 4.1-6 Primary DR Instruments

Two secondary instruments (Figure 4.1-7), the altimeter and outside air temperature (OAT) gauge, provide altitude and temperature information. This information is used to calculate the effects of the air’s density. The density of the air affects the aircraft’s true airspeed. Position information is provided through visual or electronic means.

Figure 4.1-7 Secondary DR Instruments

PRACTICE PROBLEMS

1. Which of the following is NOT a basic type of air navigation?

    a. Dead reckoning
    b. Autopilot
    c. Visual
    d. Electronic

2. Which of the following navigation methods relies on adequate visibility?

    a. Dead reckoning
    b. Visual
    c. Electronic
    d. Radar

3. The four major components of DR navigation are position, direction (heading), time and __________.

    a. altitude
    b. temperature
    c. chart work
    d. speed

Match the three primary aircraft navigation instruments with the information they provide:

	INSTRUMENT		FUNCTION
4.	Compass	A.	Speed
5.	Clock	B.	Direction
6.	Airspeed	C.	Time

7. Parallels are also called lines of latitude and run generally horizontal (left/right) on the chart.

    a. True
    b. False

8. Latitude is divided up into minutes. Each minute has 60 degrees.

    a. True
    b. False

9. The standby compass is stabilized by gyroscopes to dampen needle movements.

   a. True
   b. False

10. The Remote Gyro Vertical Compass Card is the primary instrument for determining direction.

   a. True
   b. False

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ASSIGNMENT SHEET

Chart Projections, Plotting and Global Time Keeping
Assignment Sheet No. 4.2.1A

INTRODUCTION

The purpose of this assignment sheet is to familiarize the student with chart projections and plotting techniques. It is also necessary for navigation and coordination purposes that time be expressed in a standardized form. To achieve this, an understanding of the global timekeeping system is required.

LESSON TOPIC LEARNING OBJECTIVES

TERMINAL OBJECTIVE:
Partially supported by this lesson topic:

4.0 Upon completion of this unit of instruction, the student will demonstrate, per NAVAVSCOLSCOMINST 1610.7 series, knowledge of the fundamentals of air navigation skills necessary for pilot or naval flight officer training.

ENABLING OBJECTIVES:
Completely supported by this lesson topic:

4.7 Define a great circle.

4.8 State why a great circle route is desirable for aircraft navigation.

4.9 Name the two main types of Lambert conformal charts.

4.10 Describe the characteristics of the two main types of Lambert Conformal charts.

4.11 Define heading, course, and track.

4.12 Describe the relationship between heading, course, and track.

4.13 Define magnetic variation.

4.14 Using magnetic variation, convert between true directions and magnetic directions.

4.15 Explain the global timekeeping system.

4.16 State where a particular location's zone description can be obtained.

4.17 Apply standard zone description to convert between Greenwich Mean Time and local mean time.

4.18 Using a navigation plotter and chart, locate geographic points, and plot the positions to within +/- 1/2 nautical mile using degrees and minutes of latitude and longitude.

4.19 Using the navigation plotter and dividers, plot courses and measure directions to a tolerance of +/- one degree and a distance to within +/- 1/2 nautical mile.

4.20 Plot an aircraft's geographical position based on its relationship to a TACAN station.

STUDY ASSIGNMENT

Study Information Sheet 4.2.1I, and solve the practice problems at the end of the lesson topic.

INFORMATION SHEET

Chart Projections, Plotting and Global Time Keeping
Information Sheet No. 4.2.1I

INTRODUCTION

This information sheet introduces the student to the most widely used air navigation charts, and explains that these charts are essential tools for effective air navigation. This information sheet will also introduce the student to the global timekeeping system that will aid in understanding and coordinating navigation problems.

REFERENCE

INFORMATION

CHART PROJECTIONS

Because the earth is a sphere, it cannot be flattened and still maintain the integrity of the surface. Therefore, a sphere is an undevelopable surface. Figure 4.2-1 shows the results of such an attempt.

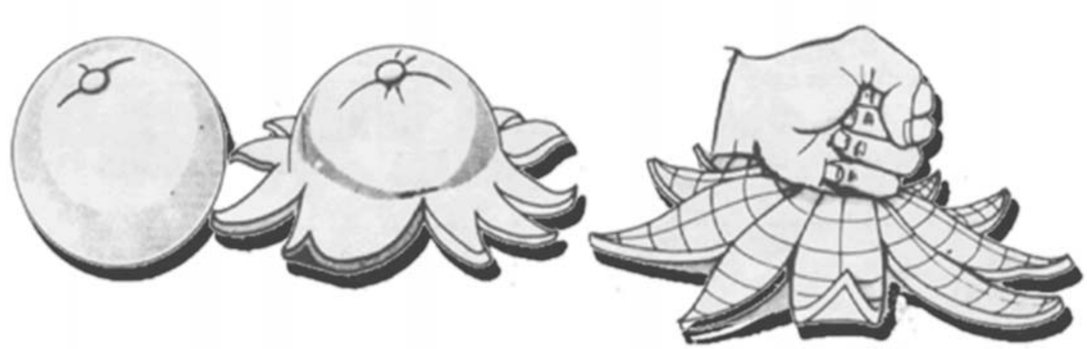


Figure 4.2-1 Undevelopable Surface

A chart is a small-scale representation of the earth's surface. No chart can be entirely accurate in its representation since it is a two-dimensional piece of paper and the earth is a three-dimensional sphere. Some distortion is always present, but it can be minimized. Charts are projected on surfaces that can be flattened without stretching or tearing, such as a cone. This surface is called a developable surface.

The problem in creating a chart projection lies in developing a method for transferring the meridians and parallels to a developable surface that will preserve certain desired characteristics.

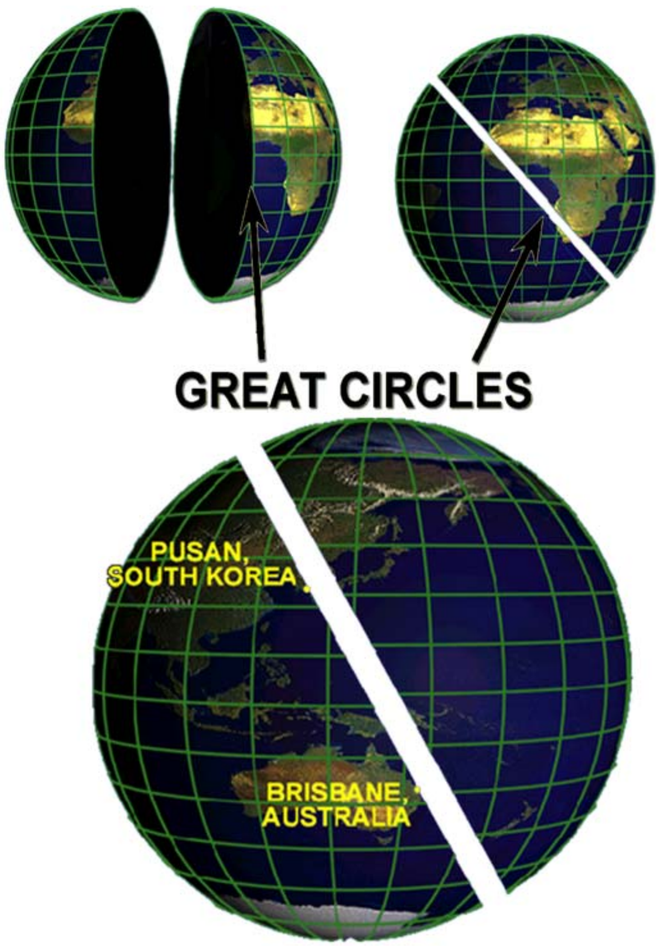


Figure 4.2-2 Great Circles

Constant Scale: If the chart scale is, for example, "one inch equals one hundred miles," then it is desirable that the scale be constant and accurate in every direction for the entire area covered by the chart.

Course Lines are Great Circles: A great circle is a circle formed by continuing the arc inscribed by connecting the shortest distance between two points on a sphere. Further defined, it is a circle whose plane passes through the earth's center, dividing the earth into two equal halves. Several great circles are shown in Figure 4.2-2.

Notice that great circles are not limited to being horizontal or vertical. They can be at any angle that divides the sphere into two equal halves. A great circle route is important because it is the shortest distance between two points, saving both time and fuel. Only one parallel, the equator, forms a great circle. However, all meridians are great circles since they vertically bisect the earth.

Simply stated, the intersection of a sphere and a plane is a circle - a great circle if the plane passes through the center of the sphere and a small circle if it does not.

LAMBERT CONFORMAL PROJECTION

The most widely used projection is the Lambert Conformal Projection. It is referred to as a "conic" projection because it is developed by placing a secant cone over the earth, intersecting the earth at two lines of latitude called "standard parallels." The development of a Lambert Conformal chart projection is illustrated in Figure 4.2-3.

Characteristics of a Lambert Conformal Projection

- Parallels - equally spaced concentric circles
- Meridians - straight lines converging at the poles
- Scale - constant distance scale
- Great circle – plot as straight lines

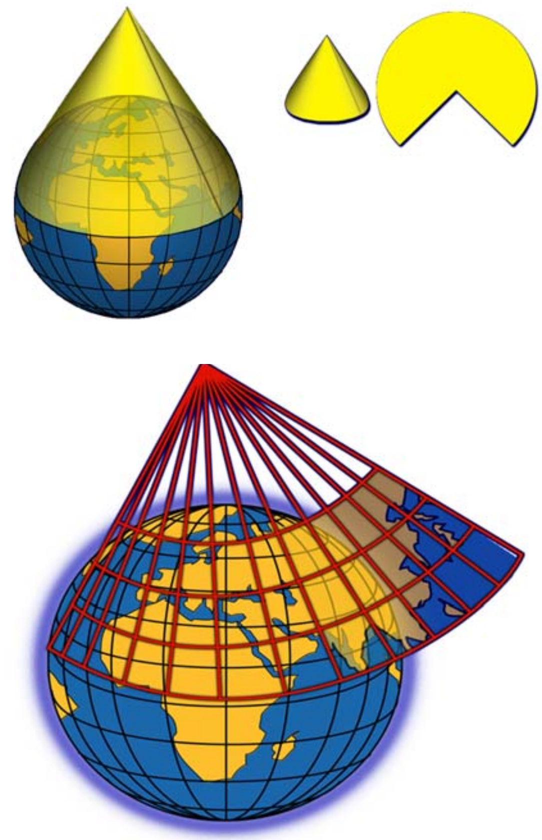


Figure 4.2-3 Lambert Conformal Projection

TYPES OF LAMBERT CONFORMAL CHARTS

The main types of Lambert Conformal charts available for navigation are the Operational Navigation Chart (ONC) and the Tactical Pilotage Chart (TPC). A legend that explains chart symbology is located in the left margin. It is important to mention that the meridians of all Lambert conformal charts (such as the ONC and TPC) are oriented toward the geographic (true) North Pole.

The ONC provides worldwide coverage at a scale of 1:1,000,000. It contains multicolor hydrographic and cultural features and is used for planning long-range navigation. You will be exposed to the ONC chart at your follow-on squadrons.

The TPC provides worldwide coverage at a scale of 1:500,000. It provides increased details of ground features significant for visual and low-level radar navigation. The TPC is the most commonly used chart for route and checkpoint determination. A section of a TPC chart covering NAS Pensacola is depicted in Figure 4.2-4.

There are other chart projections available such as the Mercator, a cylindrical chart projection which uses a cylinder rather than a cone as its developable surface. However, the disadvantages of this projection (such as variable distance scales and curved great circle routes) make it awkward for aviation navigation purposes; therefore, it is used less frequently.

Figure 4.2-4 TPC Chart

COURSE / HEADING / TRACK

Lesson Topic 4.1 introduced direction as one of the four components of DR navigation. Direction can be further defined by three related terms: <u>course</u>, <u>heading</u>, and <u>track</u>. Additionally, course and heading can be expressed as true or magnetic, depending on whether True North or Magnetic North is used as the reference.

Figure 4.2-5 Course

Course is the aircraft's intended flight path. When a straight line is drawn from departure point to destination on a Lambert conformal chart (oriented to True North), the "True Course" (abbreviated TC), is plotted. Figure 4.2-5 shows and intended flight from the Mobile TACAN to the Whiting Field TACAN.

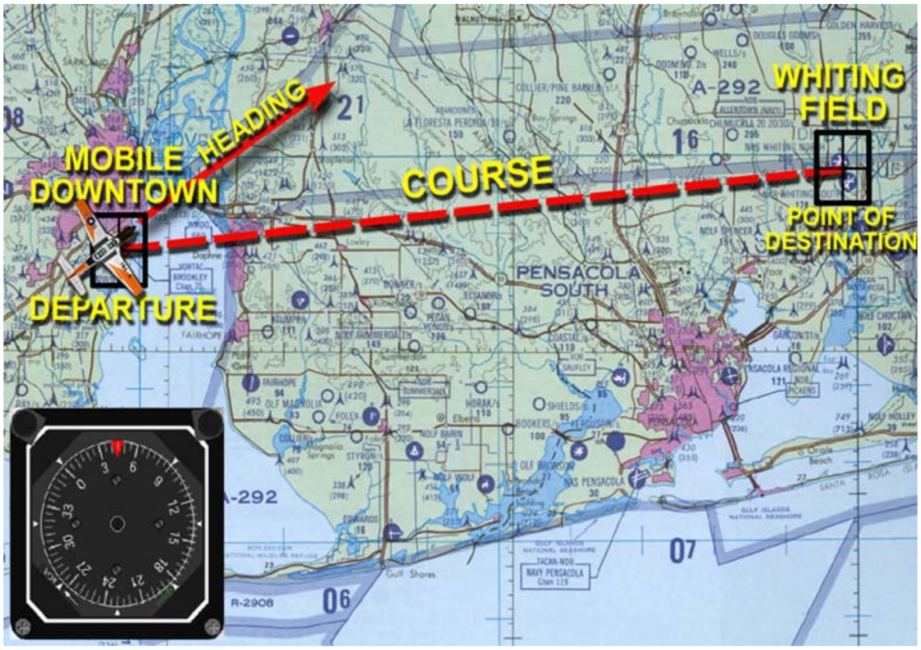


Figure 4.2-6 Heading

Technically, **heading** is the angular distance of the aircraft's longitudinal axis from a reference (typically True North or Magnetic North). Generally speaking, heading is the direction the nose of the aircraft is pointed. Figure 4.2-6 shows how True Heading is determined. <u>The heading of the aircraft will differ from the course in order to compensate for crosswinds.</u> Lesson Topic 4.5 covers wind in detail.

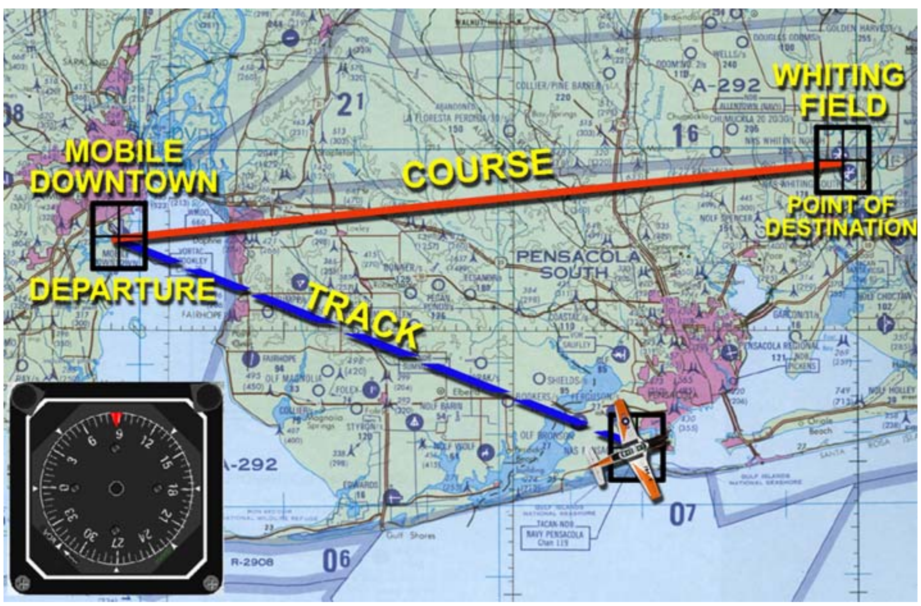


Figure 4.2-7 Track

Track is the aircraft's actual flight path over the ground. Suppose an aircraft took off from Mobile and underestimated the northerly wind. A line drawn from the departure point to the aircraft's present location ("fix" position) shows the track, or actual flight path, of the aircraft (see Figure 4.2-7). The aircraft's actual path over the ground is shown as a dashed line.

CONVERTING FROM TRUE TO MAGNETIC

Because the Lambert conformal chart is referenced (via the meridians) to True north lines drawn on them are True directions. The heading systems in all aircraft are referenced to Magnetic North. In order to fly the course, it must be converted from a true course to a magnetic course. This is accomplished through the use of magnetic variation.

VARIATION

Lesson Topic 4.1 discussed how cockpit compass systems are referenced to the magnetic lines of force (Magnetic North). The Magnetic North Pole is located in northern Canada near the Hudson Bay, far from the geographic True North Pole (Figure 4.2-8).

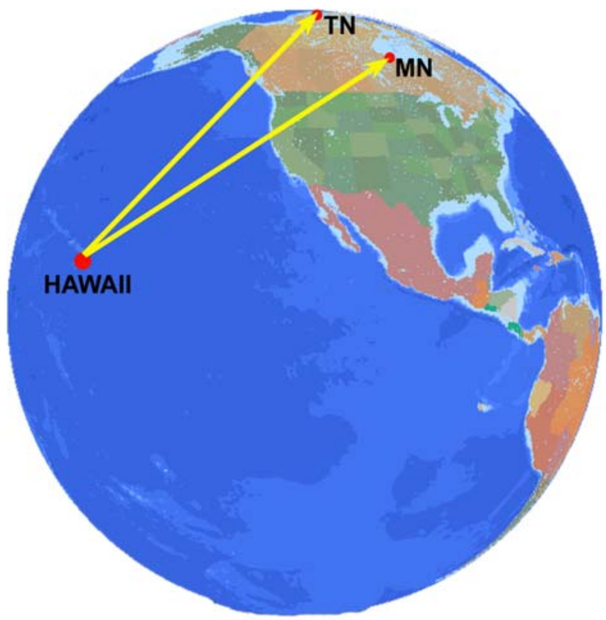


Figure 4.2-8 True / Magnetic North Poles

Variation is the angular difference between True North and Magnetic North from any given position on the earth's surface. Variation is expressed in degrees east or west.

Figure 4.2-9 Easterly Variation

If a line is drawn from Hawaii to True North and another line from the Hawaii to Magnetic North, the angular difference from True to Magnetic North is the variation. In this example, variation is easterly, since Magnetic North is to the east of True North from this particular position (Figure 4.2-9).

Plotting lines to the poles to determine variation is not necessary. Charts contain isogonic lines that depict variation for the area covered by the chart. An **isogonic line** connects points of equal variation. A world chart showing all isogonic lines is depicted in Figure 4.2-10. On TPC and ONC charts, isogonic lines appear as dashed blue lines with the variation stated in degrees.

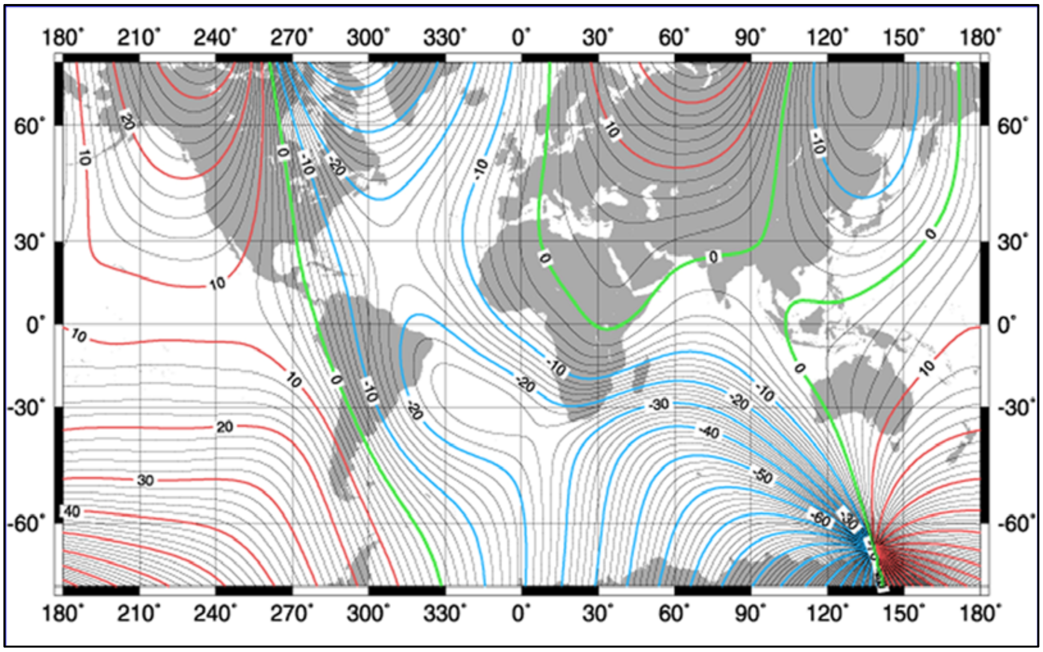


Figure 4.2-10 Isogonic Lines

In order to convert a True Course to a Magnetic Course we use the following formulas:

MC = TC - East Variation

MC = TC + West Variation

To convert a True Course to a Magnetic Course, we use the memory aid, "East is least, and West is best". This is a reminder to subtract easterly variation and add westerly variation to determine the Magnetic Course. Example: In the vicinity of Pensacola, the variation is 2º east. If True Course measures 045º, subtract 2º to yield a Magnetic Course of 043º.

<u>GLOBAL TIMEKEEPING SYSTEM</u>

Due to the large distances covered in air travel, it is necessary to use a common time standard to allow for coordination of assets on a global basis. The Local Mean Time (LMT) must be converted to a common reference. This reference is the time at the prime meridian (which passes through Greenwich, England) called Greenwich Mean Time or GMT, and it's also referred to as "ZULU" (Z) time.

TIME ZONES

Time is measured in terms of the rotation of the earth. Since the earth rotates 360º in a 24-hour period, we divide 360 by 24 to yield 15º of rotation in one hour. This divides the earth into 24 time zones; each 15º of longitude in width, making the time between each zone differ by one hour. Each time zone is centered on a meridian that is a multiple of 15º. The time within each zone is called **Local Mean Time (LMT)**.

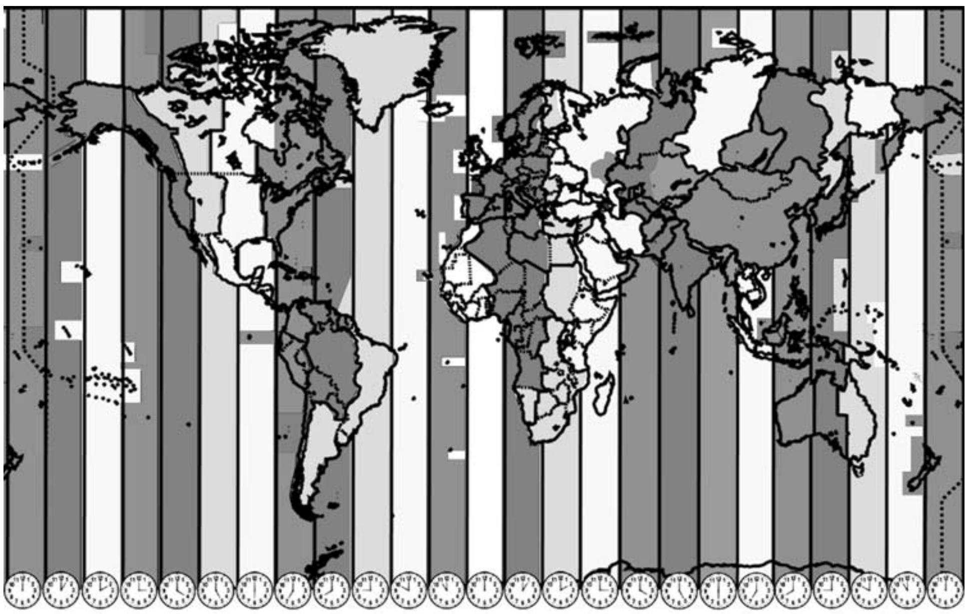


Figure 4.2-11 Time Zones

Each time zone has been given both alphabetic and numeric designators. The alphabetic designator for the time zone centered on the zero-degree meridian (the prime meridian) is **"Z" (Zulu)**. The time within the Zulu time zone is called Greenwich Mean Time (GMT). Greenwich Mean Time is used as the reference for each of the remaining zones. The **zone description (ZD),** numeric designator for any zone, indicates the difference in hours from local time to GMT.

In air travel, where great distances can be covered in a short time, it is inconvenient to keep track of time zones being crossed. To avoid confusion, Greenwich Mean Time is the standard used for aviation since GMT is the same all over the world at any particular instant in time. For example, weather briefs and flight plans are filed using GMT. Therefore, you must be able to convert any local time to GMT and GMT to local time.

ZONE DESCRIPTIONS (ZD)

The first step in time conversions is determining the zone description. Theoretically, the zone description could be found by dividing the local longitude by 15, since each zone is 15º wide, but problems arise because the zone boundaries have been modified (for greater convenience) along geographical and political boundaries. Cities and other populated areas are not split between two time zones. In some countries that overlap two or three zones, one zone is used throughout. Also, zone descriptions are influenced by daylight savings time.

The most common source for Zone Descriptions is the IFR Enroute Supplement. The ZD is found by looking up the departure or arrival airport and locating the ZD after the latitude and longitude coordinates in the first paragraph.

PENSACOLA NAS, (FORREST SHERMAN FLD) FL ◇ **KNPA** N 30°21.2'N 87°19.2'W 30
UTC-6(-5DT) **H-5D, L-18E**
(B) **RWY-01** L6 ——(7137x200 ASP S114 T206 ST175 TT382 TDT850)—— L6 **RWY-19**
←E5 (33' OVRN) E-28(B) (1544')—— E-28(B) (1100') E5→ (126' OVRN)
RWY-07L L6 ——(8002x200 ASP S114 T206 ST175 TT382 TDT850)—— L6 **RWY-25R**
←E5 (149' OVRN) E-28(B) (1200')—— E-28(B) (1300') E5→ (149' OVRN)
RWY-07R L6,7,8 ——(8001x200 ASP S114 T206 ST175 TT382 TDT850)—— L6 **RWY-25L**
←E5 (123' OVRN) E-28(B) (1300')—— E-28(B) (1450') E5→ (123' OVRN)
SERVICE - LGT - Mobile OLS 3.25° avbl all rwy. **A-GEAR -** 15 min PN rqr to remove A-GEAR. E5 RATING - 01 370 HW (DRY), 07R 475 HW (DRY), 07L-25R-25L 475 HW (DRY/WET), 19 540 HW (DRY) 330 HW (WET). **JASU -** 3(NC-8) 4(GTC-85 Navy F4 emerg start only) 1(NCPP-105) **FUEL -** Acft nitrogen and oxygen svcg avbl 1400-2200Z++ wkends and hol. 100LL, J5 O-128-148-156 SP LHOX LOX OXRB **TRAN ALERT -** Tran svc avbl 1300-0500Z++ Mon-Fri; 1400-0400Z++ Sat, Sun, hol; ltd tran maint avbl 1400-2200Z++ Mon-Fri only. Tran acft exp extv svcg delays.
REMARKS - Opr 1200-0600Z++ Mon-Fri; 1400-0400Z++ Sat, Sun, hol. **RSTD -** PPR all acft, exc CNATRA/NALO/AIREVAC, ctc Base OPS DSN 922-2431, C904-452-2431. Crs rule brief rqr for tran acft or lcl/round-robin flt. **CAUTION -** Ints VFR trng tfc. Vcnty OLF Saufley extv flt trng. **TFC PAT -** Ldg/taxi lgt rqr all ldg when wx cond permit. SID recommended for IFR dep. See Mandatory IFR Arr Pro-FLIP AP/1 Supplementary Arpt Rmk. Reduced rwy separation std in eff USN/USMC acft. Multiple apch severely ltd dur single rwy opr. **CSTMS/AG/IMG -** CSTMS, AG avbl if prior arng made 24 hr in advance. **MISC -** Class G Airspace eff 0600-1200Z++ Mon-Fri; 0400-1400Z++ Sat, Sun, hol. Class E 700' AGL and abv.

Figure 4.2-12 Enroute Supplement

For Sherman Field the ZD is -6 except in daylight savings time when it is -5. (Figure 4.2-12) An additional source for ZD is the TPC that covers the area of interest. For this navigation course, the zone description will always be given to you.

CONVERSION FORMULAS

Once the zone description has been determined, it can be applied to local mean time to obtain GMT. Using the ZD from the enroute supplement, the formula is:

GMT (Z) = LMT - ZD

If given Greenwich Mean Time and the zone description, the formula for finding local mean time would be:

LMT = GMT (Z) + ZD

Example #1

If LMT is 0700 and the zone description is -6, what will the Greenwich Mean Time be?

GMT (Z) = LMT - ZD
GMT (Z) = 0700 – (-6)
GMT (Z) = 1300z

NOTE: Remember that to subtract a negative number, you actually add.

NOTE: You will usually see a "z" after Zulu time.

Now, try some conversions with flight time figured in.

Example #2

If you are given an arrival time into Manama, Bahrain (+3) of 1200 Z, what is your local arrival time?

LMT = GMT + ZD
LMT = 1200 Z + (+3)
LMT = 1500

Example #3

You are leaving Navy North Island (ZD - 8) at 1100L with a flight time of 4+00. Will you arrive at NAS Pensacola (ZD - 6) in time for Happy Hour (1600-1800)?

Step 1 - Convert take off time to ZULU
GMT = LMT - ZD
= 1100 - (-8)
GMT = 1900Z Take Off

Step2 - "Fly in ZULU"
1900Z + 4+00 = 2300Z Land

Step 3 - Convert landing time to local
LMT = GMT + ZD
= 2300Z + (-6)
= 1700L

PLOTTING

This section discusses the equipment and techniques used in plotting.

Figure 4.2-13 Dividers

PLOTTING EQUIPMENT

The dividers (Figure 4.2-13) are used primarily for measuring distances. A secondary use (when combined with the plotter) is to measure courses.

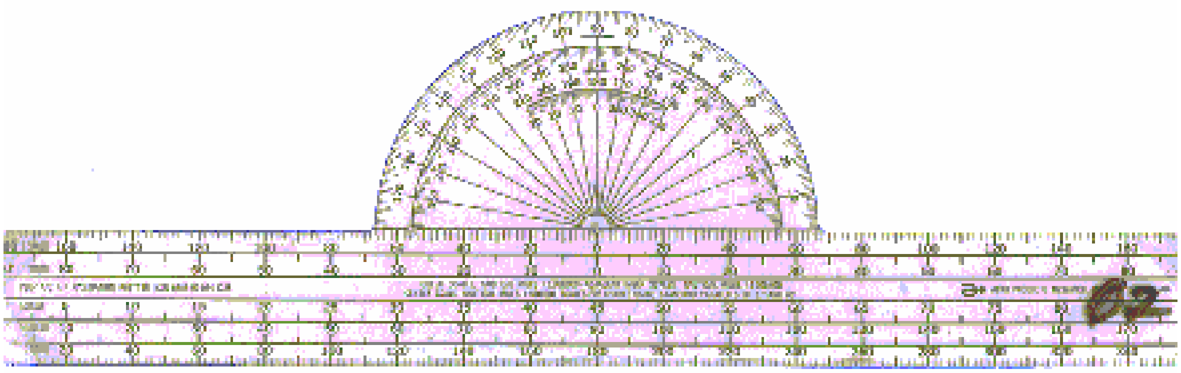


Figure 4.2-14 Plotter

The plotter (Figure 4.2-14) is a combination protractor and straightedge. It is used to aid in drawing course lines and measuring direction. The parts of the plotter include the straightedge itself, the grommet (center hole of the protractor section), and the scales on the protractor outer edge. The scales run from 0º to 180º on the top of the outer scale, and from 180º to 360º on the bottom of the outer scale. The number line on the plotter is reversed (i.e. the numbers increase to the left and decrease to the right). There is also an inner scale (called the north/south scale), which will be helpful in measuring course lines that run close to the north-south axis of the chart. Do not use the distance scales on the straightedge, as they are not accurate. The dividers will be used to measure distances.

LATITUDE/LONGITUDE COORDINATES

If you do not know the Latitude/Longitude coordinates, you need to pull them. If you know the Latitude/Longitude coordinates, then you will plot them.

PULLING COORDINATES:

1. Find the point to be measured on the chart.

2. Position the plotter so that the desired point is slightly below the straightedge. Carefully align the grommet and 90º mark on the outer scale so that they lie along the same meridian (any meridian). Slide the plotter down until the straightedge touches the point of interest. Check to make sure that the grommet and the 90º mark are still aligned with the meridian and, if necessary, adjust the plotter so they do (Figure 4.2-15).

3. Mark the point on the meridian where the straightedge of the plotter crosses the meridian. Remove the plotter. Locate the nearest whole degree of Latitude and count up the meridian. There are speed marks on the meridian to avoid the need to count each tick mark. Starting at a printed parallel, every 5 minutes, is a larger mark that is still on the left side of the meridian. At 10 minutes, the mark is even larger and extends on either side of the meridian. Round to the nearest tenth of a minute.

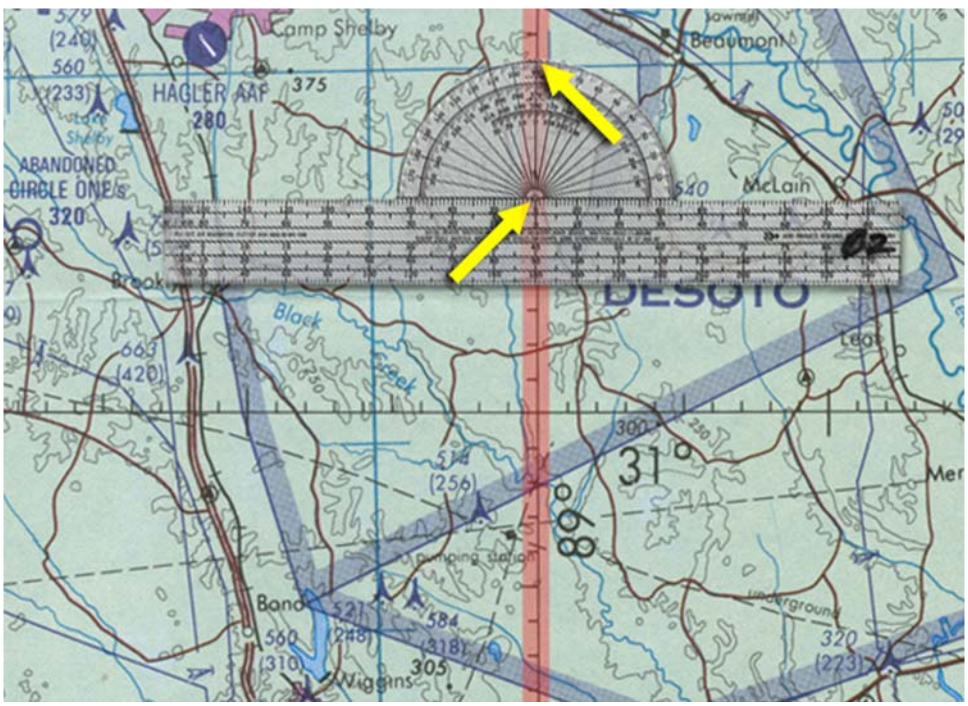


Figure 4.2.15 Latitude

4. To determine the Longitude coordinate, repeat steps 1 through 3 above aligning the plotter to a parallel instead of a meridian (Figure 4.2-16).

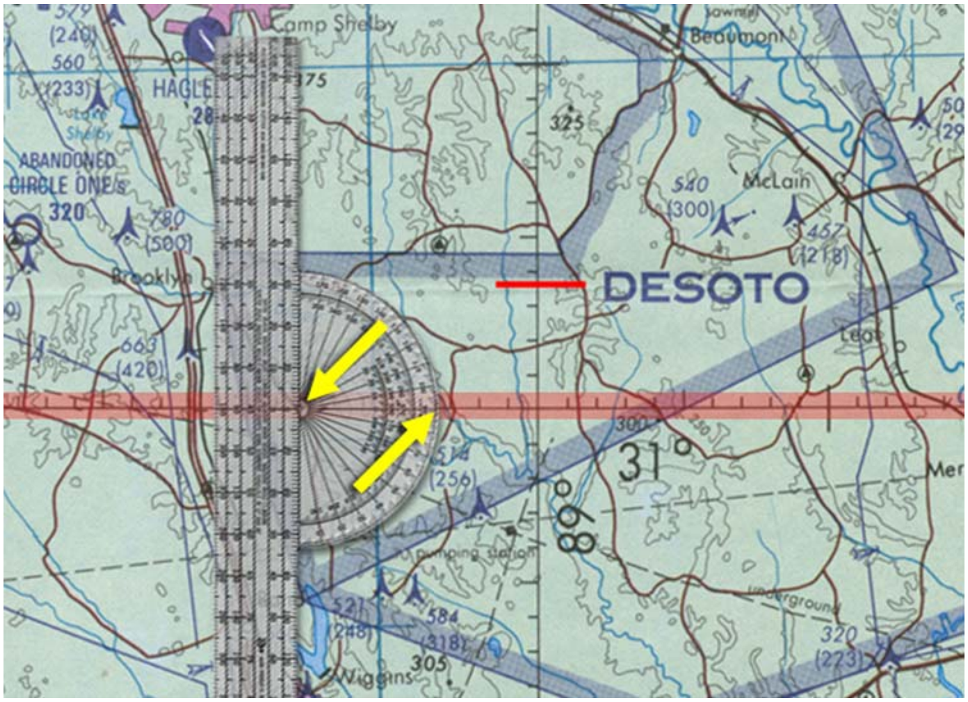


Figure 4.2-16 Longitude

PLOTTING COORDINATES

Any given set of coordinates can be plotted using the same principles.

1. Position the plotter horizontally with the grommet and the 90º mark of the outer scale along the same meridian. Move the plotter vertically until the straightedge rests along the desired parallel (Latitude coordinate). Draw a line along the straightedge.

2. Rotate the plotter 90º, aligning the straightedge vertically, and place the grommet and the 90º mark along the same parallel. Move it horizontally until the desired Longitude coordinate is under the straightedge. Again, draw a line along the straightedge.

3. The intersection of these two lines is the location of the coordinates.

MEASURING DIRECTION

1. Locate the two points of interest.

2. Connect the two points with a straight line using the straightedge of the plotter. Draw a single arrow depicting the direction of travel.

   Next, always estimate the approximate direction of travel to avoid choosing a reciprocal course direction (180º error). In Fig 4.2-17, the course is generally heading northwest; therefore, the True Course should be between 270º and 360º.

3. Spread the dividers and place the tips on the courseline. If they will reach, place the tips of the dividers on the two points (Figure 4.2-18).

Figure 4.2-17 Measuring Direction

4. Place the straightedge of the plotter against the two points of the dividers (Figure 4.2-18).

5. While keeping the straightedge against the dividers' points, slide the plotter along the course line until the plotter's grommet is over a <u>meridian</u> (Figure 4.2-18).

NOTE: Greatest accuracy can be obtained by using a meridian exactly halfway along your course, but using nearby meridians for convenience will still provide satisfactory results.

6. In conclusion, go to the outer two scales and note where the meridian (the one under the grommet) intersects the scales. There will be a choice of two answers, choose the one that is nearest the estimate. Be sure to count the marks carefully and remember the scale increases in a <u>counterclockwise</u> direction (Figure 4.2-18).

CAUTION: Be careful to interpret the scales of the plotter correctly. Always look at the scale numbers to both the left and the right of the meridian being used. This is known as bracketing and eliminates erroneous answers that could be off by as much as ten degrees.

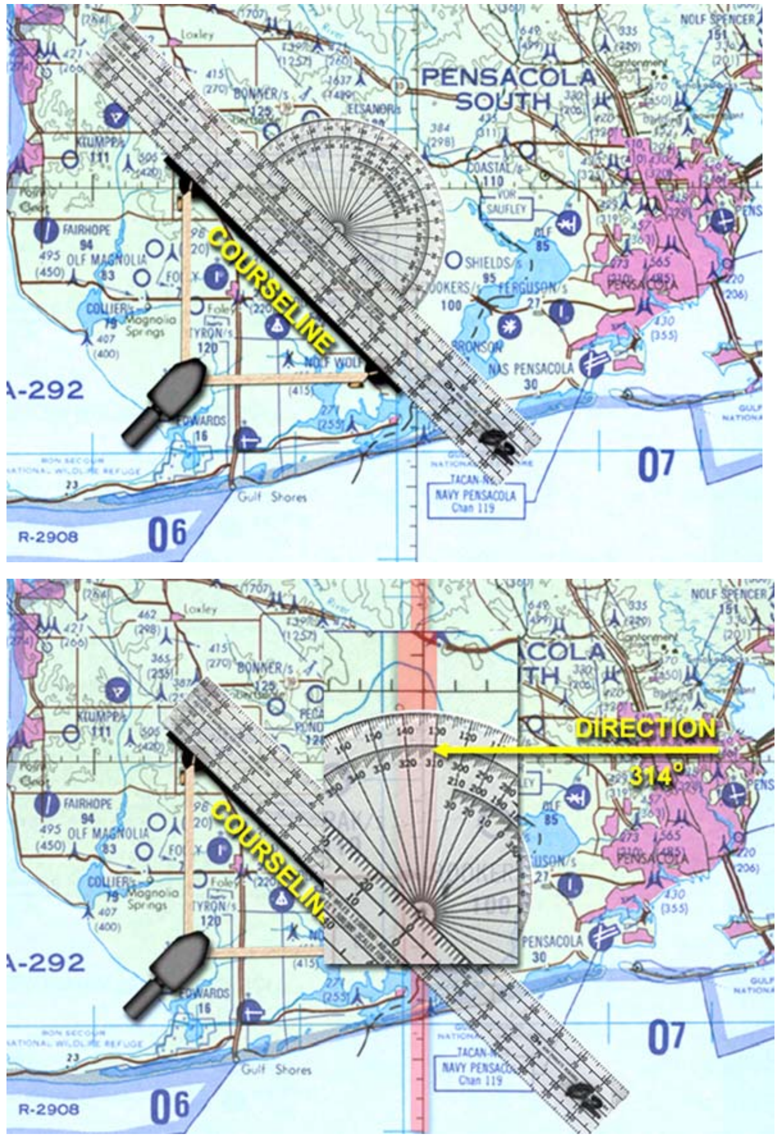


Figure 4.2-18 Measuring East/West Direction

If a course line runs generally north and south, it may be difficult, if not impossible, to slide the plotter along the course line until a meridian falls under the plotter's grommet. The north/south scale (the innermost scale on the plotter) can be used in this situation.

The procedures are the same in that the plotter's straight edge is kept on the course line, but now a parallel is placed under the plotter's grommet. Then, follow that parallel out to the inner north/south scale to read the answer (Figure 4.2-19). Again, there is a choice of two answers, so it is imperative to estimate the general course direction before beginning.

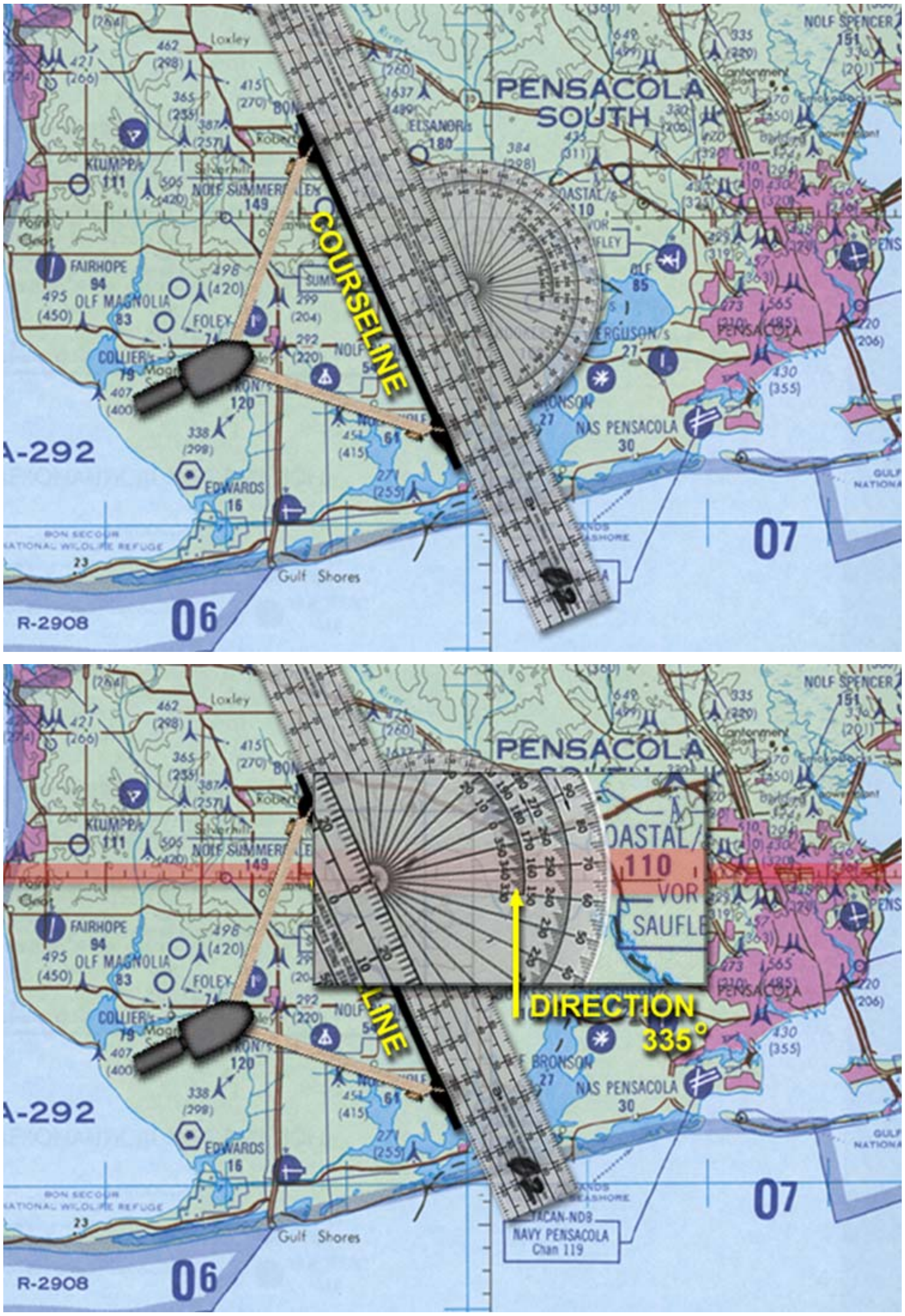


Figure 4.2-19 North/South Course Measurement

Measuring Courses Summary

1. Always estimate the answer first.

2. Span dividers along the course line.

3. Place the straightedge against the dividers and slide it until the grommet is over a meridian or parallel. (Figure 4.2-18)

4. When placing a <u>meridian</u> under the grommet, read the course from the outer scales. (Figure 4.2-19)

5. When placing a parallel under the grommet, read the course from the inner north/south scale.

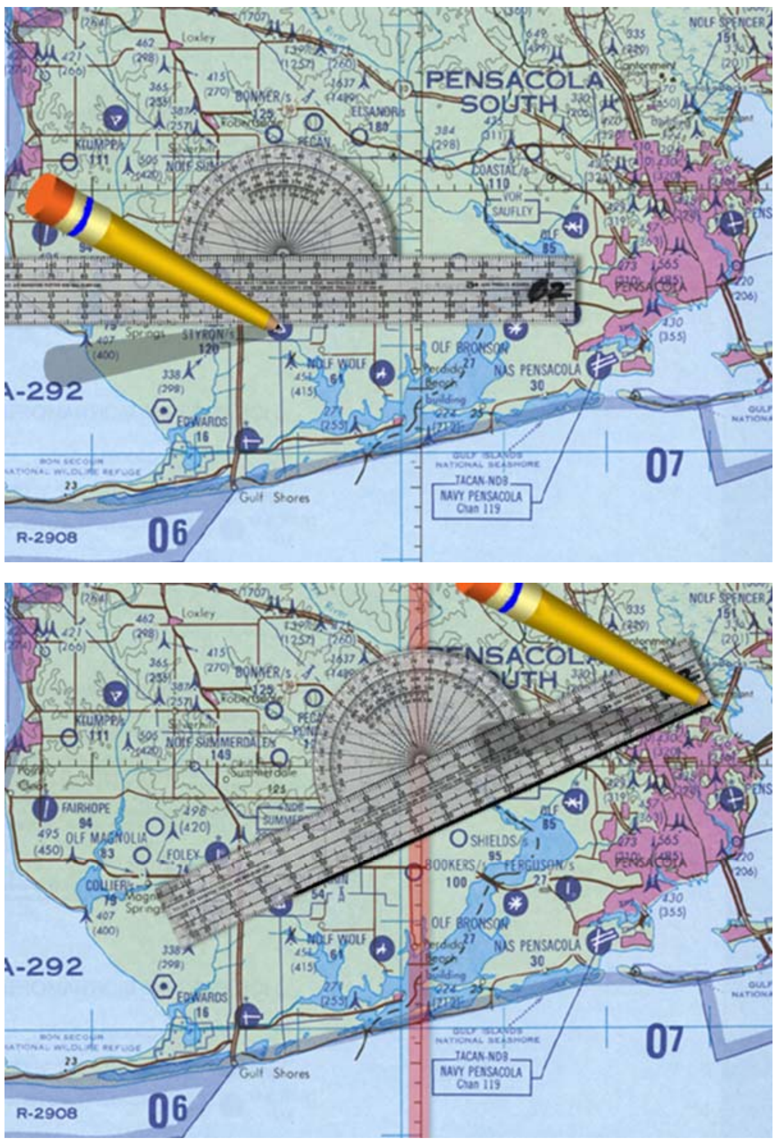


Figure 4.2-20 Plotting East/West Direction

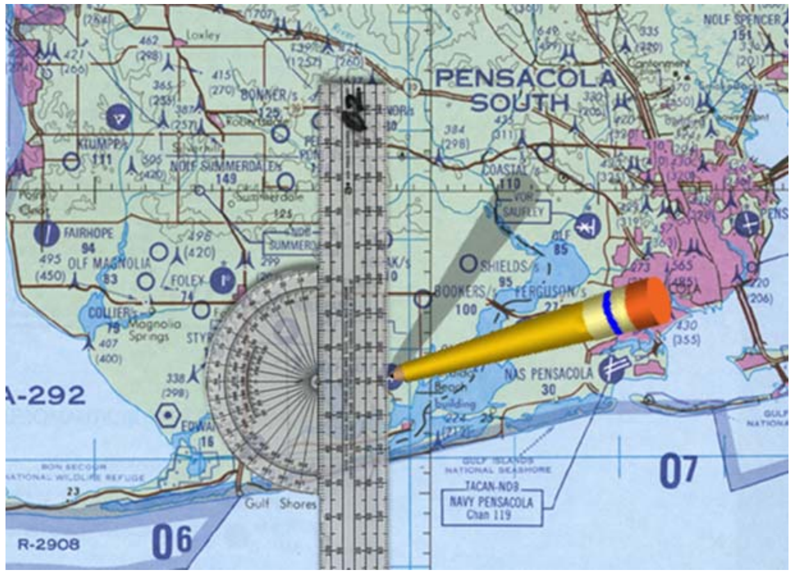
Plotting Direction

1. Locate the point of interest.

2. Estimate the Direction

3. Place a pencil on the point of interest and slide the straightedge of the plotter up against the pencil.

4. Place the grommet of the plotter over the nearest meridian sliding the grommet up and down the meridian until the desired direction is read under the outer scale. (Figure 4.2-20)



Note: Estimating the direction first will maintain individual focus when selecting the angle from the proper plotter scale.

If a direction line runs generally north and south, it may be difficult, if not impossible, to slide the plotter along the direction line until a meridian falls under the plotter's grommet. The north/south scale (the innermost scale on the plotter) can be used in this situation. (Figure 4.2-21)

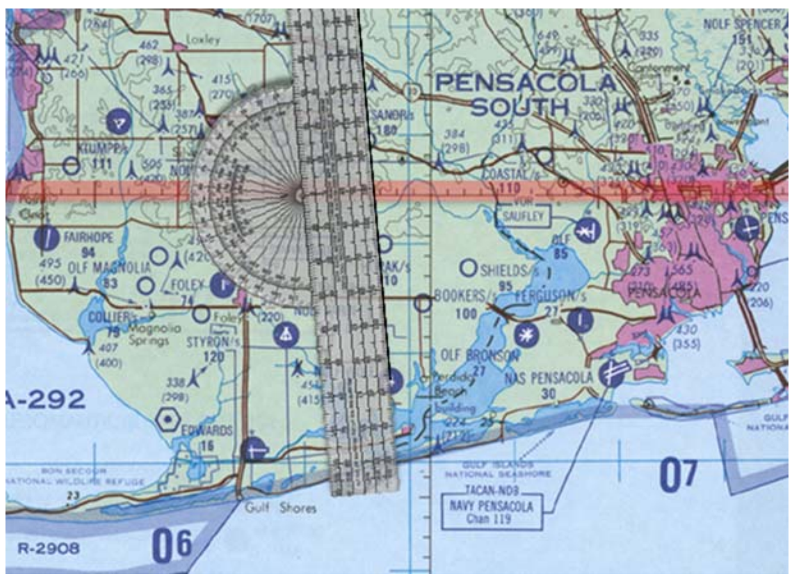


Figure 4.2-21 Plotting North/South Direction

The procedures are the same in that the plotter's straight edge is kept on the point of interest, but now a parallel is placed under the plotter's grommet. Next, slide the grommet along the parallel until the desired direction is read under the inner north/south scale (Figure 4.2-21). Again, it is imperative to estimate the general course direction before beginning.

Note: The plotter outer scale is applicable when using meridians whereas the inner scale is applicable when using parallels.

Measuring Distances

In navigation, the standard for distance measurement is the nautical mile. On Lambert conformal projections one **nautical mile** equals one minute of arc measured along any great circle. All lines of longitude (meridians) are great circles; therefore, one-degree (60 minutes) measured along a meridian equals 60 nautical miles. It is important to understand that this is NOT a degree of longitude, but actually a degree of latitude. Degrees of latitude are marked on the longitude lines. **Never** measure distance along a parallel. On Lambert Conformal charts a course line is a segment of a great circle. To find the distance of the course, compare it's length to an equal length of another great circle (any meridian). (Figure 4.2-22)

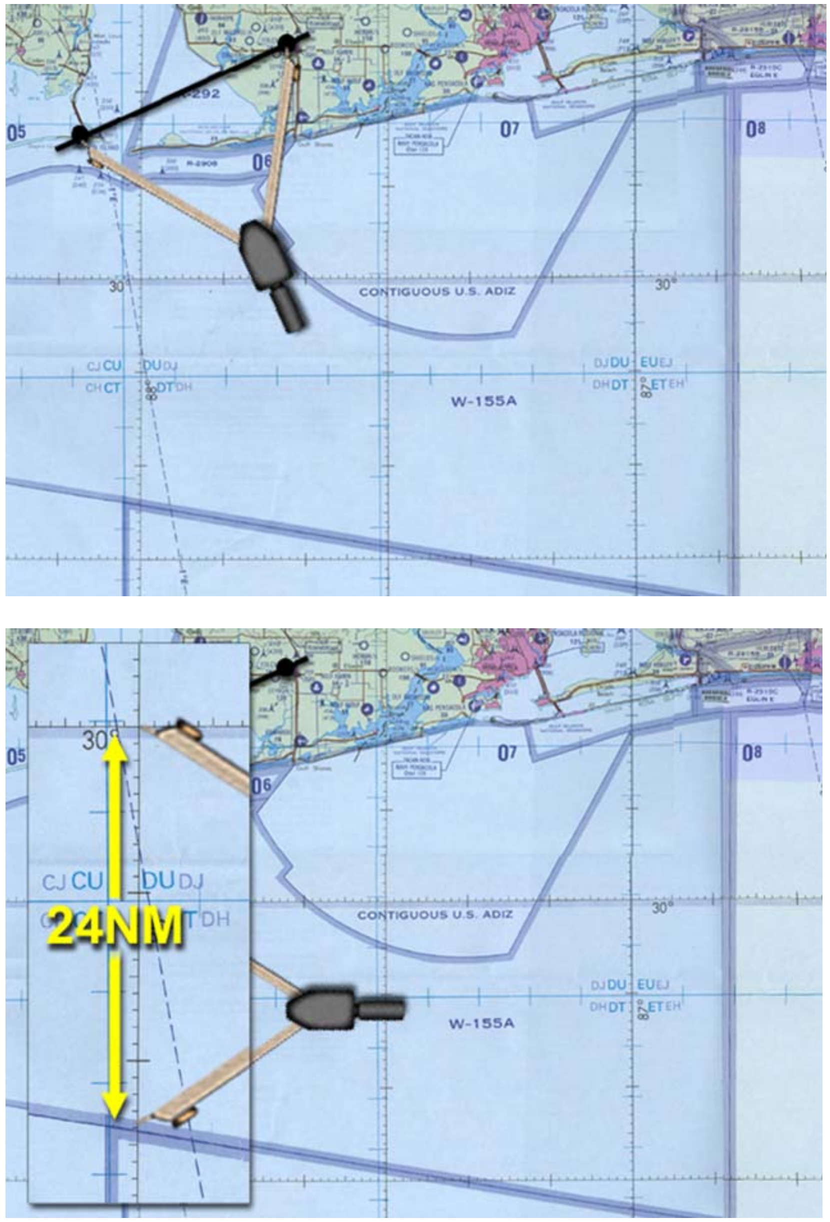


Figure 4.2-22 Measuring Distance

1. Spread the dividers, putting a tip on each point.

2. Being careful not to move the divider setting, transfer the divider to the nearest meridian with one leg on the intersection of meridian and parallel.

3. Use the speed marks to help count the tick marks along the **meridian**. On a TPC, each tick mark is 1 nautical mile (NM).

If the dividers will not reach between the two points, set the dividers at a fixed distance (30 NM is a good distance), and "walk off" this fixed distance along the course.

1. Set the dividers for 30 NM using any meridian.

2. Place the dividers along the course line with one tip on the departure point. Rotate the dividers by lifting one point off the departure and keeping the other point on the course line. Lay the first tip on the course ahead of the other. Continue “walking” the dividers in this manner until the point of the dividers ends up past the destination point. Count each “step” of the walk in multiples of 30 (30, 60, 90, etc.). Now squeeze the dividers closed to measure off this remaining distance and add it to the multiples of 30.

TACAN POSITION FIXING

Recall the discussion in lesson 4.1 concerning the operation of the TACAN. If the aircrew knows what radial of the TACAN the aircraft is currently on and the distance from the station, then the position of the aircraft relative to the station can be determined. This ultimately determines the aircraft’s position over the earth. The information relative to the station is displayed in the cockpit on an instrument called the Bearing Distance Heading Indicator (BDHI). Figure 4.2-23 contains a typical BDHI found in most military aircraft.

The information concerning the TACAN is displayed on the #2 needle. The point of the needle (called the head) gives a magnetic bearing to the station. The tail displays the current radial. In figure 4.2-23, the aircraft is on the 135 radial and is 7.5 nm from the station. The distance displayed is actually a slant range. For purposes of this course the slant range is equal to the ground range.

To determine our position we must first determine the magnetic variation of the station. This is found in the enroute supplement under the name of the TACAN or under the NAVAID section of an airfield (for a TACAN located on an airfield). If the aircrew had selected the Lake Charles TACAN to fix their position, they would have had to look under Lake Charles to find that the magnetic variation is 7º east.

Figure 4.2-23 BDHI

This 7º must be ADDED to the 135º radial in order to plot the true radial (Refer back to the section in this unit on variation. <u>Because we are going from magnetic to true, the formula is reversed</u>. This produces a True radial of 142º. This is plotted from the station using the techniques described previously in the plotting section. The last thing to do, is measure the distance from the station, and mark the point on the radial drawn. The circle in Figure 4.2-24 is the TACAN position fix. Note: For this course, use the magnetic variation from the nearest isogonic line to the NAVAID.

Figure 4.2-24 TACAN Position Fixing

PRACTICE PROBLEMS

1. The shortest distance between any two points on the earth's surface is a ________.

   a. route over the north pole
   b. concentric circle
   c. constant heading
   d. great circle route

2. A great circle route is desirable because ________.

   a. it is the shortest distance
   b. it saves time
   c. it saves fuel
   d. All of the above

3. On a Lambert conformal chart, every ________ is a great circle, but only one ________, the ________ is a great circle.

   a. meridian, parallel, equator
   b. parallel, meridian, the prime meridian
   c. curved line, parallel, equator
   d. straight line, meridian, the international date line

4. On a Lambert conformal chart, parallels appear as ________ lines, and meridians appear as ________ lines.

   a. straight, curved
   b. curved, straight
   c. straight, straight
   d. curved, curved

5. The ONC is a 1:1,000,000 scale Lambert conformal chart and the TPC is a 1:500,000 scale Lambert conformal chart.

   a. True
   b. False

6. The meridians of both the ONC and the TPC charts are oriented to the magnetic north pole, so course lines plotted on these charts are magnetic courses.

   a. True
   b. False

7. The angular difference from true north to magnetic north from any given position is called ________.

   a. deviation
   b. isolation
   c. magnetic variation
   d. strangulation

8. A line connecting points of equal variation which can be found on most Lambert conformal charts is called a(n) ________.

   a. Prime Meridian
   b. International Date Line
   c. line of demarcation
   d. isogonic line

Match the following:

9.	____ Course	A.	Direction in which the aircraft is pointed
10.	____ Heading	B.	Intended flight path
11.	____ Track	C.	Actual flight path

12. Latitude is measured along ________ and longitude is measured along ________.

   a. a parallel, a meridian
   b. a meridian, a parallel
   c. a line of latitude, a line of longitude
   d. None of the above

13. Locate the 223' tower at N 28° 42'.0, W 091° 14.0': Draw a True Course of 235° FROM the tower. Measure 25 nm. What are the coordinates of this point?

   N ________ W

14. Plot the following coordinates: N 28°16.0', W 091°28.0'. Measure the Magnetic Course and distance from the previous point (answer from problem 13) to this point.

   MC = ________°
   Dist= ________nm

15. Plot the following coordinates: N 29°06.0’, W 091°08.0’. Plot a Magnetic Course of 315°,and a distance of 41 nm. What are the coordinates of this point?

N ________ W

16. Plot the following coordinates: N 28°56.0’, W 091°01.0’. Plot a Magnetic Course of 185°,and a distance of 49 nm. What are the coordinates of this point?

N ________ W

17. Plot the following coordinates: N 28°36.0’, W 091°38.0’. A 290’ tower lies on an approximate Magnetic Course of 228° at 32 nm. What are the coordinates of this tower?

N ________ W

18. From the tower in problem #17, measure the Magnetic Course and distance to: N 29°06.0’, W 092°08.0’

MC = ________°
Dist= ________nm

19. Measure the Magnetic Course and distance between: N 29°14.0’, W 090°58.0’, and N 29°06.0’, W 092°08.0’

MC = ________°
Dist= ________nm

20. Plot the following coordinates: N 28°42.0’, W 091°22.0’. A small island (Eugene Island) lies approximately 40 nm due north from this point. Find the coordinates of Eugene Island, then measure the Magnetic Course and exact distance from the given point to the island.

N ________ W
MC = ________°
Dist= ________nm

21. Measure the Magnetic Course and distance between: N 29°14.0’, W 090°58.0’, and N 28°36.0’, W 091°08.0’

MC = ________°
Dist= ________nm

22. Measure the Magnetic Course and distance between: N 28°36.0', W 091°08.0', and N 28°59.0', W 091°31.0'

MC = ________°
Dist= ________nm

23. Measure the Magnetic Course and distance between: N 28°59.0', W 091°31.0', and N 28°25.0', W 091°28.0'

MC = ________°
Dist= ________nm

24. Measure the Magnetic Course and distance between: N 28°25.0', W 091°28.0', and N 29°30.0', W 092°00.0'

MC = ________°
Dist= ________nm

Plot the following TACAN position fixes from the Lufkin TACAN (CH 58) (31º10.0'N/ 094º42.8'W). Measure the latitude and longitude and describe the given target..

25. 074 Radial/ 31.5 DME

26. 060 Radial/ 52 DME

27. 306 Radial/ 35 DME

Plot the following TACAN position fixes from the Esler TACAN (CH 126) (31º26.8'N/ 092º19.2'W). Measure the latitude and longitude and describe the given target

28. 144 Radial/ 25 DME

29. 064 Radial/ 43 DME

Calculate the missing value.

	ZD	GMT	LMT
30.	+ 9	1320	___
31.	- 3	2130	___
32.	+ 4	___	1410

33.	- 6	___	1652
34.	- 11	0412	___
35.	+ 7	___	1815
36.	+ 4	0710	___
37.	- 10	1215	___
38.	+ 3	1730	___
39.	- 6	___	1920

40. An A-6 Intruder departs NAS Whidbey Island (where the ZD is -8) at 0900 local time for NAS Oceana (ZD is -5). What is the local time in Oceana at takeoff time?

____

41. An F-14 Tomcat departs NAS Pensacola (ZD is -6) at 1500 local time on a four hour flight to NAS Miramar (ZD is -8). Will the crew make happy hour at Miramar if happy hour ends at 1900 local time?

____

42. You plan a 1715z departure from MCAS Cherry Point (ZD is -5) for a flight to Tinker AFB (ZD is -6) with an estimated time enroute of 2 hours and 20 minutes. What is your local time of arrival?

____

43. If you wanted to place a phone call to a friend in Naples, Italy (ZD is +1), and you wanted the phone to ring at 1300 local Naples time, at what time in Pensacola (ZD is -6) would you have to place the call?

____

44. A P-3 Orion departs San Francisco at 1300 local time on 2 January where the ZD is -8. Sixteen hours (and three microwave dinners) later, it arrives in Tokyo where the ZD is +9. What is the aircraft's local time of arrival?

____

ASSIGNMENT SHEET

CR-3 Air Navigation Computer (Calculator Side)
Assignment Sheet No. 4.3-1A

INTRODUCTION

The purpose of this assignment sheet is to introduce the calculator side of the CR-3 computer and its uses in air navigation.

LESSON TOPIC LEARNING OBJECTIVES

TERMINAL OBJECTIVE:
Partially supported by this lesson topic:

4.0 Upon completion of this unit of instruction, the student will demonstrate, per NAVAVSCOLSCOMINST 1610.7 series, knowledge of the fundamentals of air navigation skills necessary for pilot or naval flight officer training.

ENABLING OBJECTIVES:
Completely supported by this lesson topic:

4.21 Use the components, scales, and indexes of the CR-3 air navigation computer.

4.22 Solve rate problems involving speed, distance, and time using the CR-3 computer.

4.23 Solve fuel rate problems involving fuel flow, fuel quantity, and time.

4.24 Solve fuel problems involving conversions between pounds and gallons.

STUDY ASSIGNMENT

Read Information Sheet 4.3.1I and solve the practice problems at the end of the lesson topic.

INFORMATION SHEET

CR-3 Air Navigation Computer (Calculator Side)
Information Sheet No. 4.3.1I

INTRODUCTION

To be proficient at air navigation, all aviators must possess some basic mathematical skills. Using specialized, handheld electronic calculators could solve all problems associated with air navigation; however, these problems can be solved quickly and accurately with the CR-3 air navigation computer. The advantages of the CR-3 over electronic calculators are twofold: reliability and cost.

REFERENCE

<u>CARE AND COMPONENTS OF CR-3</u>

CARE

The plastic CR-3 computer is fragile and must be cared for properly by observing the following guidelines:

1. Do not leave the computer in direct sunlight such as on the dashboard of a car or a windowsill. Heat will cause the computer to warp.

2. Use only a soft lead pencil or a felt tip pen on the wind side of the computer.

3. Keep the computer clean - avoid getting dirt between the discs of the computer.

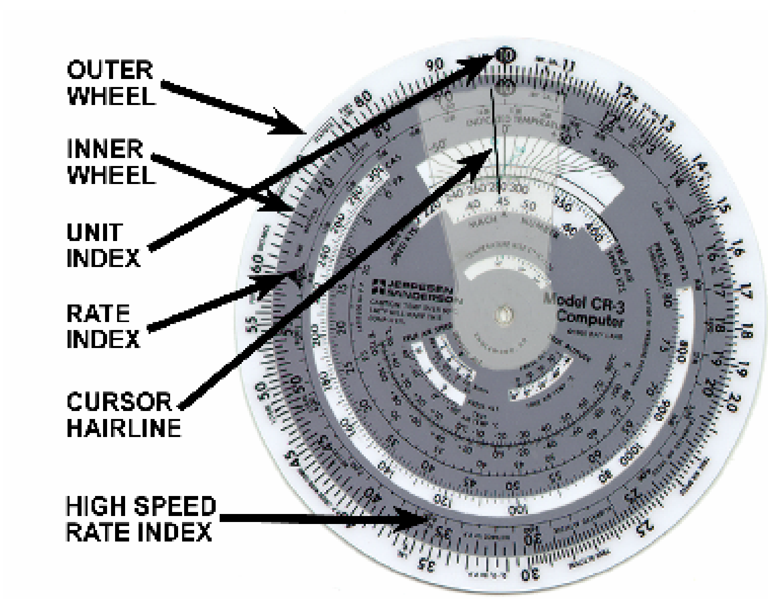


Figure 4.3-1 CR-3 Calculator Side

COMPONENTS

Figure 4.3-1 shows the major components of the calculator side of the CR-3. The warrior-aviator must become familiar with this computer in order to be proficient at air navigation. The CR-3 is a two-sided disk with a circular slide rule, or calculator, on the front and a graphic display for wind calculations on the back.

OUTER AND INNER WHEELS

The circular slide rule side includes a rotatable disc attached to a base. Both the base and the rotatable disc have graduated logarithmic scales. The scale on the base is most often used to represent distance and fuel and is referred to as the OUTER wheel (white scale). (Figure 4.3-2)

The rotatable disc of the computer is referred to as the INNER wheel (gray scale) and is primarily used for TIME. (Figure 4.3-3)

Figure 4.3-2 Outer Wheel

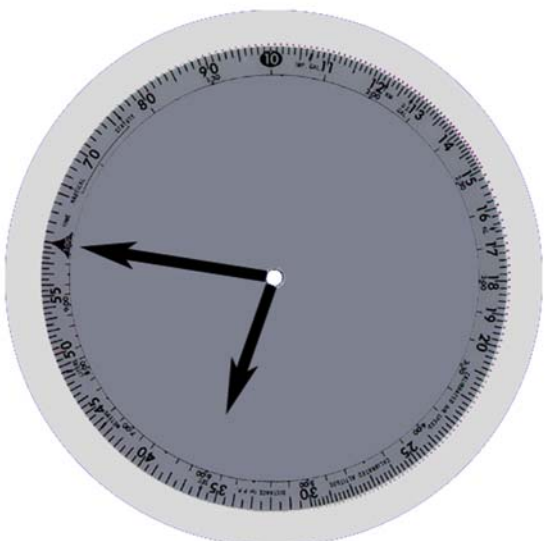


Figure 4.3-3 Inner Wheel

If the "**10**" indexes are lined up on the outer and inner wheels, you will notice that the two scales are identical. (Figure 4.3-4)

Figure 4.3-4 Outer/Inner Scales

Both scales are graduated with unequally spaced values printed from 10 to 90. The CR-3 uses a "floating decimal" (Figure 4.3-5) which allows the printed numbers to represent different values, depending on where the decimal point or succeeding zero is placed. For example, the number 21 may stand for .21, 2.1, 21, 210 or 2100. Not all numbers are printed on the scales, therefore, the values will have to be read accurately between the printed numbers.

Figure 4.3-5 Floating Decimal

Notice that there are 9 "tick marks" (Figure 4.3-6) between each whole number from 10 to 15. Since the tick marks make a total of ten divisions between the whole numbers, each tick mark represents a difference of one. Because of the floating decimal, the first mark to the right of ten could represent 10.1, 101, or 1010. There are 4 tick marks between each whole number from 15 to 30. In this case, each tick mark represents a difference of two, therefore the first unmarked value to the right of 15 could represent 15.2, 152, or 1520. There is a single tick mark between the whole numbers between 30 and 60 with each representing a difference of five. The first unmarked value after the 30 could represent 30.5, 305, or 3050.

Figure 4.3-6 Tick Marks

When it is necessary to read an unmarked value between two of the marked divisions, determine the values of the tick marks and interpolate. The value 151 would be found halfway between 15 and the first tick mark past 15. 307 would be slightly less than half way between the first mark past 30 and the next large mark.

RATE INDEX

This index will be used for most problems that involve time. Note that this mark is found where the 60 would normally be on the inner wheel. It is used for any problem where the unit of time being considered is an hour. (Figure 4.3-7)

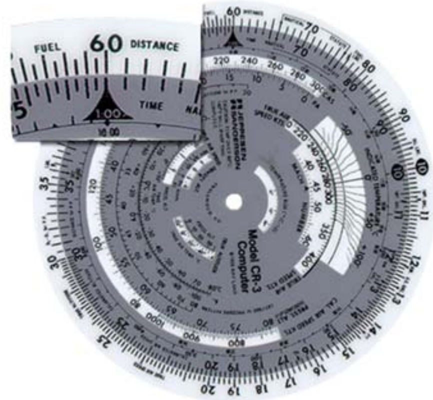


Figure 4.3-7 Rate Index

HIGH SPEED RATE INDEX

This index will be used for problems that involve short amounts of time (typically seconds). Note that this mark is found where the 36 is on the inner wheel (because 3600 sec equals 1 hour). It is used for any problem where the unit of time being considered is 1 to 2 minutes or less. (Figure 4.3-8)

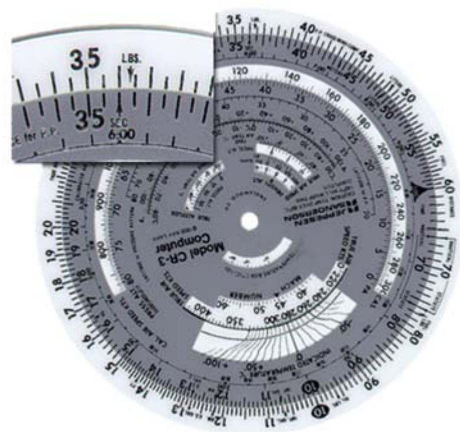


Figure 4.3-8 High Speed Rate Index

UNIT INDEX

This index is used for all mathematical functions (e.g. ratios) that do not involve time. It is found at the Ten position on both wheels. (Figure 4.3-9)

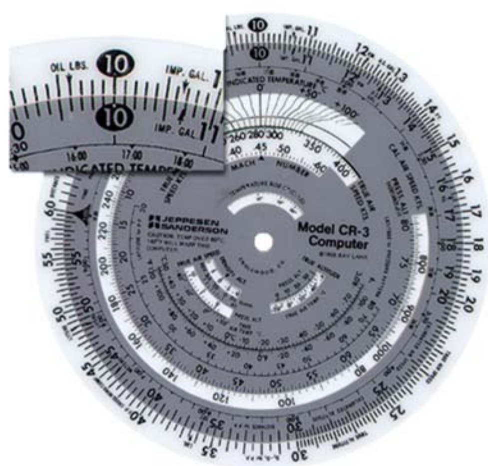


Figure 4.3-9 Unit Index

CURSOR HAIRLINE

The primary function of the cursor hairline is to input temperature into the CR-3 for calculating true Air Speed (see chapter 4). Its secondary purpose is to help with interpolation of any values derived from the inner and outer wheels.

<u>TIME</u>

MINUTES AND HOURS

Both the outer and inner scales are the same. The outer scale can be referred to as the DISTANCE scale and the inner scale called the TIME scale. In using the TIME scale, the large numbers near the edge of the inner scale usually represent minutes. The floating decimal concept still applies; for example the 15 value on the minute scale could represent 1.5, 15, or 150 minutes. Notice it DOES NOT, directly represent seconds. Note that the value of 60 minutes has a special meaning; it equals one hour. Because it is an often-used point it has been specially marked with a triangle, called the RATE INDEX. Realize this is 0.6, 6.0, or 60 MINUTES, NOT 1.

Beneath this scale is a smaller scale marked in hours. This scale directly reads hour values that correspond to the minute scale. For example 120 minutes = 2:00 hours and 1200 minutes = 20:00 hours. The hour circle converts this for us. Below the number 12 (Figure 4.3-10) the value 2:00 is found above the hour circle and 20:00 below the circle.

Figure 4.3-10 Minutes to Hours

The small marks between the hour values on the upper side of the hour circle represent ten-minute intervals. As an example, notice the value 15 (here 150 minutes) on the TIME (minutes) scale (figure 4.3-2) and directly below it is 2:30, or 2 hours and 30 minutes, on the hour scale. Notice the small mark to the right of the 2:30, directly below the number 16 (here 160 minutes). This represents the next ten-minute interval, or 2:40 (2 hours and 40 minutes). The value 168 on the minute scale will read 2:48, or 2 hours and 48 minutes on the hour scale.

SECONDS AND MINUTES

Seconds have the same relationship to minutes as minutes do to hours (60 seconds is one minute; 60 minutes is one hour). Since the numbers and relationships are the same, the same scales can be used to measure these values; just remember which units are being used. For instance, the TIME scale is assigned to read seconds, the hour circle will read minutes. Referencing the above example, with 150 minutes on the TIME scale, directly below it is 2:30, or 2 hours and 30 minutes, on the hour scale. If 150 seconds is on the TIME scale, directly below it is 2:30, or 2 minutes and 30 seconds, on the hour circle (which now reads minutes).

There is a special mark (the RATE INDEX □) for 60 minutes because it equates to one hour. Since one hour is an important value, a special mark denoting the second's equivalent to one hour is needed when the TIME scale represents seconds. Since there are 3600 seconds in one hour this special mark is at the "36". The very small arrow with "SEC" beneath it is referred to as the "seconds bug" or "high speed" index (figure 4.3-11). This "high speed" index is used when the large numbers on the TIME scale are to represent SECONDS (rather than minutes), and the inner hour circle is to represent minutes (rather than hours). <u>The "high speed" index is used in rate problems involving seconds as the time flown or to be flown.</u>

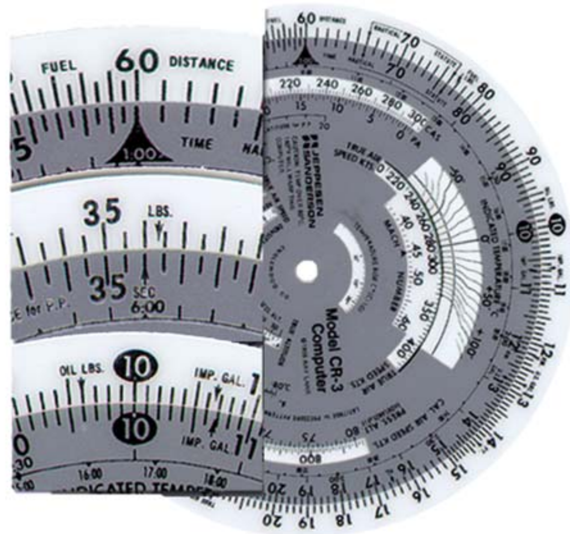


Figure 4.3-11 Indexes

CONVERSION OF HOURS, MINUTES, AND SECONDS

Using the minute can make conversion of minutes to hours, or vice versa, and hour scales on the TIME scale (inner wheel). The answers are read directly from either the minute or the hour scales.

EXAMPLE: Convert 3 hours and 10 minutes into total minutes.

Solution:

1. Find 3:10 on the hour circle (inner scale).

2. Above the 3:10 read "19" (or 190). (Figure 4.3-12)

Answer: 190 minutes

Conversions of minutes (and decimal minutes) to seconds, or vice versa, can be made by using the small "SEC" arrow and the rate index (□) which are located on the TIME scale, see

Figure 4.3-12 Hours to Minutes

Figure 4.3-13. Place the rate index (inner scale) under the number of minutes on the outer (white) scale and read the number of seconds opposite the "SEC" arrow on the same scale.

EXAMPLE: Convert 3.7 minutes to seconds.

Solution:

1. Place the rate index (on the inner scale) opposite 37 (which represents 3.7 minutes) on the outer scale.

2. On the DISTANCE (outer) scale, opposite the "SEC" arrow on the TIME (inner) scale, read the number of seconds (Figure 4.3-13).

Answer: 222 seconds. In addition, use the innermost scale on the time scale to convert to minutes and seconds. Look under 222 and read 3 minutes 42 seconds.

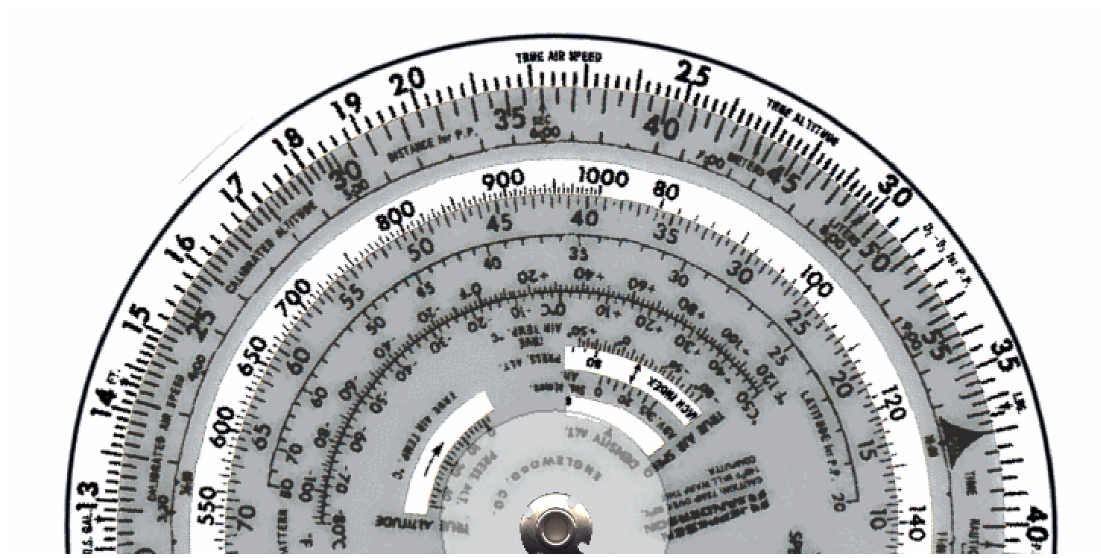


Figure 4.3-13 Minutes to Seconds

RATIOS

Ratios, or proportions, are the basis for the multiplication and division processes on the CR-3 computer and are used in solving problems of time, distance, speed, and fuel consumption/conversion. If any two of three components are known, the third component can be easily computed. One problem in solving a ratio for the unknown factor is determining the position of the decimal point. Since each value on the computer represents a multiple of ten, a rough estimate should be made of the answer in order to interpret where to place the decimal point. The DISTANCE and TIME scales are identical and designed in such a manner that when a ratio or fraction is set up on the scales, all other possible fractions of equal value are automatically set up. Distance will be placed, or read, on the DISTANCE (outer) scale, and time will likewise be placed, or read, on the TIME (inner) scale. Setting them up on the DISTANCE and TIME scales exactly as they would be written on a piece of paper solves ratios.

There are some important rules to remember when setting up ratio problems on the whiz wheel:

1. Units of measure in the numerators must be the same (i.e. nm or pounds).

2. Units of measure in the denominators must be the same (i.e. minutes or seconds).

3. The units are placed on the whiz wheel with numerator values on the outside and denominator values on the inner wheel. (Figure 4.3-14)

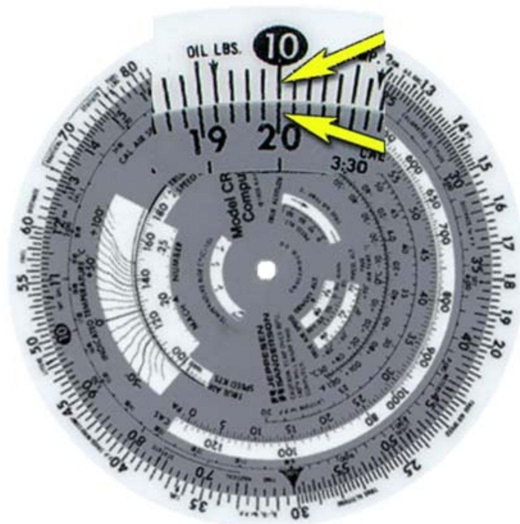


Figure 4.3-14 Ratio 1

EXAMPLE: In the following ratio, solve the unknown factor (X):

$$\frac{1}{2} = \frac{8}{X}$$

Solution: The unknown, X, can be found by transferring the ratio directly to the outer and inner scales as described below.

1. First, estimate the answer: Since 8 is about eight times 1, then "X" is about eight times larger than 2 or about 16.

2. Set up the CR-3 computer with 10 on the outer scale over 20 on the inner scale.

3. Next, find the factor 80 on the outer scale and read the value for "X" directly below on the inner scale. The number below 80 is 16. This could represent 1.6, 16, 160 or 1600.

Answer: Since you have "estimated" your answer to be approximately 16, you now read the value for "X" as 16. (Figure 4.3-15)

Remember that determining the correct position for the decimal point is a major challenge in solving a ratio for the unknown value. Always estimate the approximate answer before interpreting the computer.

Figure 4.3-15 Ratio 2

TIME - SPEED - DISTANCE

In aviation the unit of measurement for distance is usually the nautical mile, which is 6080 feet. Time is measured in hours, minutes and seconds. Speed is in nautical miles per hour or "knots." On the CR-3 computer, the time scale is on the moveable disk (inner scale) and is graduated in minutes. Since most TIME, SPEED, DISTANCE, and FUEL CONSUMPTION problems are expressed in units per hour, we will use the RATE INDEX.

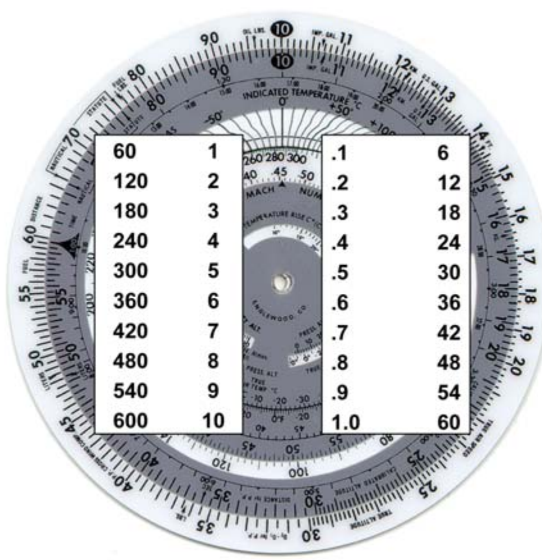
Time, speed, distance, and fuel consumption problems are simply ratios that deal with time (rates). The unknown values are found by transferring the known values of the ratio directly to the outer (DISTANCE) and inner (TIME) scales. Keep in mind that the RATE INDEX (□) represents 60 minutes and is used as the basis for what is happening per hour.

ESTIMATING TOOLS

Rule of 60

One tool used to estimate time/speed/distance problems is known as the rule of 60. Stated simply, aircraft ground speed divided by 60 equals the distance (nm) traveled in one minute. (Table 4.3-1)

For example at 60kts the aircraft travels one nm a minute, at 120kts it travels two nm's a minute, etc.



60	1	.1	6
120	2	.2	12
180	3	.3	18
240	4	.4	24
300	5	.5	30
360	6	.6	36
420	7	.7	42
480	8	.8	48
540	9	.9	54
600	10	1.0	60

Knots to NM/Min **Decimal Minute to Seconds**

Table 4.3-1 Knots to NM per Minute/Decimal Minutes to Seconds

Rule of 6

A related rule, the rule of 6 states that 1/10th of the aircraft's ground speed is the distance it will travel in six minutes.

For example, at 300kts the aircraft will travel 30nm in six minutes.

TIME

The time required to cover a specified distance at a given (known) speed can be expressed in the following formula:

$$\frac{\text{SPEED}}{\text{RATE INDEX}} = \frac{\text{DISTANCE}}{\text{TIME}}$$

When the known ground speed, or estimated ground speed, is placed over the RATE INDEX (60 minute mark) on the computer, any given distance on the outer (DISTANCE) scale will match with the correct time on the inner (TIME) scale. The distance flown, or the time it will take to fly a given distance in any given time, will be easily determined.

NOTE: It is often necessary to convert from decimal minutes to minutes and seconds (or vice-versa). Table 4.3-1 shows the conversion. This table also applies to decimal hours and minutes as well.

EXAMPLE:

How long will it take to fly 350 NM at a ground speed of 150 kts?

Solution:

1. Estimate the answer. In two hours, 300 nm will be flown (150 x 2); so, it will take slightly over 2 hours (120 minutes).

2. Set the ground speed of 150 knots over the RATE INDEX (60 minutes) on the TIME scale. (Figure 4.3-16)

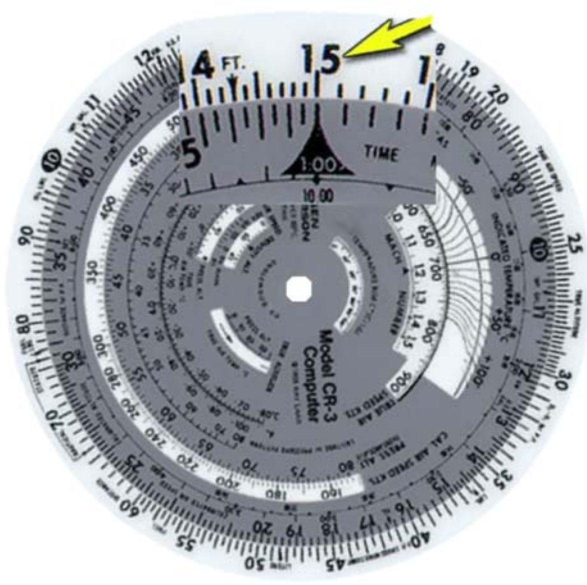


Figure 4.3-16 Time 1

3. On the outer (DISTANCE) scale, find the distance of 350 nautical miles (the 35).

4. Now read directly below 35 (350 NM). The time en route will be 140 minutes or 2 hours and 20 minutes (2 + 20). (Figure 4.3-17)

Answer: 2 hours and 20 minutes

Figure 4.3-17 Time 2

At times, it may be necessary to work small, or short, distances and times (low level/high speed navigation). The answer will be a short period of time, in minutes or minutes and seconds. The smaller index marked "SEC" (located at figure "36" on the inner, or TIME, scale) is referred to as the "seconds bug" or ”high speed index." The "high speed index" converts a 60-minute (one-hour) time period into 3600 seconds. When the "high speed index" is placed beneath the speed on the DISTANCE scale, any distance read on the DISTANCE scale will correspond to time in seconds on the TIME scale.

EXAMPLE:

Given: Ground speed . . . . . . 250 KTS
Distance to travel . . . . . . 5 NM

Find: Time to fly

Solution:

1. Estimate the answer. Convert 250 Kts to 4 NM/Min (round 250 to 240 and divide by 60). The time will be slightly over 1 minute.

2. Place the 250 KTS ground speed information on the DISTANCE scale directly above the "SEC" index (or high-speed index) on the TIME scale.

3. Opposite the 50 (representing 5 NM) on the DISTANCE scale, read the time to the station on the TIME scale. (Figure 4.3-18)

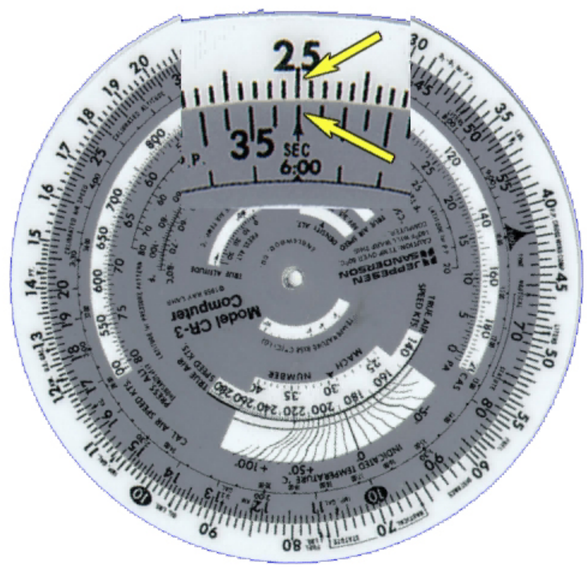


Figure 4.3-18 Time 3

Answer: 72 seconds, or 1 minute and 12 seconds (1:12). (Figure 4.3-19)

Figure 4.3-19 Time 4

SPEED

If time and distance are known, simply transfer the ratio, or proportion, information to the DISTANCE and TIME scales of the CR-3 computer and read the unknown factor of speed over the rate index. Use the same formula previously discussed:

$$\frac{\text{SPEED}}{\text{RATE INDEX}} = \frac{\text{DISTANCE}}{\text{TIME}}$$

EXAMPLE

Given: Distance covered. . . . . 30 NM
Time flown . . . . .11 min

Find: Ground Speed

Solution:

1. Estimate the answer. 11 goes into 60 approximately 6 times, so the speed is approximately 6 x 30 or 180 kts.

$$\frac{\text{Xnm}}{\text{60min}} = \frac{\text{30nm}}{\text{11min}}$$

2. Locate the distance (30 NM) on the outer (DISTANCE) scale and place the time flown (11 minutes) directly under the distance on the inner (TIME) scale. (Figure 4.3-20)

Figure 4.3-20 Speed 1

3. Locate the "RATE INDEX" (□) on the inner scale. (Figure 4.3-21)

4. Above the "RATE INDEX" read the ground speed. Because of the estimation of 180, the correct answer can easily be determined.

Figure 4.3-21 Speed 2

Answer: 164 KTS ground speed.

DISTANCE

Solutions to problems requiring a distance flown, or a distance to be flown, over a known period of time may be solved in a manner similar to solving problems of time. Again, it is a process of setting up a ratio using the DISTANCE and TIME scales and the basic SPEED, DISTANCE, TIME equation.

EXAMPLE

Given: Ground speed . . . . . . 240 KTS
Time flown . . . . 19 minutes

Find: Distance flown

Solution:

1. Estimate the answer. 60 goes into 240 4 times. 19 times 4 is approximately 80.

2. Set the RATE INDEX (□) on the inner (TIME) scale opposite the ground speed (240 KTS) on the outer (DISTANCE) scale. (Figure 4.3-22)

3. Look on the TIME scale over 19 minutes and read the distance directly above. (Figure 4.3-23)

Answer: 76 NM

Figure 4.3-22 Speed 3

Figure 4.3-23 Speed 4

FUEL CONSUMPTION

Solving problems of fuel consumption is similar to problems of speed, time, or distance. Both are rate problems. The only difference is that the unit that changes over a given amount of time is now fuel instead of distance. Again, it is a simple matter of setting up ratios on the computer and solving for the unknown factor. The outer scale is now used as the FUEL scale; and the solution is still a matter of transferring the ratio, or proportion, to the outer/inner scales of the computer and reading the unknown factor (fuel consumed or rate of consumption). Use the formula:

$$\frac{\text{FUEL FLOW}}{\text{RATE INDEX}} = \frac{\text{FUEL CONSUMED}}{\text{TIME}}$$

Since fuel is measured in pounds, the outer scale on the CR-3 becomes the FUEL (in pounds) scale while the inner scale remains the TIME scale.

Examples of fuel consumption problems follow.

EXAMPLE ONE: Finding amount of fuel consumed.

Given: Fuel consumption. . . . . 1000 pounds per hour
Time flown. .1 hour and 45 minutes
Find: Fuel consumed

Solution:

1. Estimate the answer. Since the total time is just under 2 hours the answer should be a little under 2000 (2 hr x 1000 # / hr), approximately 1800.

2. Place the RATE INDEX (□) located on the TIME (inner) scale under the 10 (1000 # / hr) on the FUEL (outer) scale. (Figure 4.3-24)

3. Convert 1 hour 45 minutes to 105 (60 + 45) on the TIME (inner) scale and read the amount of fuel consumed on the FUEL (outer) scale. (Figure 4.3-25)

Answer: 1750 pounds of fuel consumed

Figure 4.3-24 Fuel Consumption 1

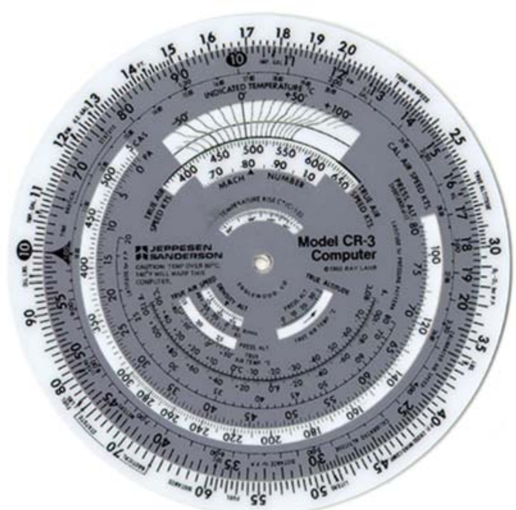


Figure 4.3-25 Fuel Consumption 2

EXAMPLE TWO: Finding fuel flow.

Given: Time flown . . . . 45 sec
Fuel consumed . . . 117 pounds
Find: Fuel flow.

Solution:

1. Estimate the answer. Since the time is less than a minute, it is logical to assume after a minute the fuel burned would be about 150 #, so a good estimate would be about 9000 #.

2. Find 11.7 (117 #) on the FUEL (outer) scale and place it over 45 seconds on the TIME (inner) scale. (Figure 4.3-26)

3. Opposite the High-Speed Rate Index (3600 sec) located on the TIME (inner) scale, read the amount of fuel consumed in one hour on the outer (FUEL) scale. (Figure 4.3-27)

Answer: 9350 pounds per hour.

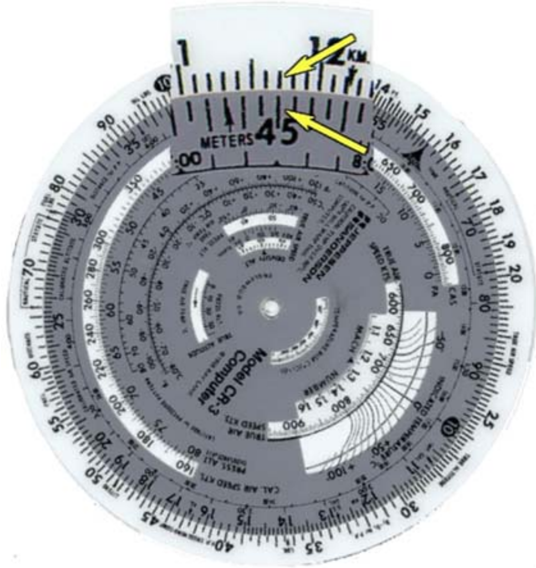


Figure 4.3-26 Fuel Flow 1

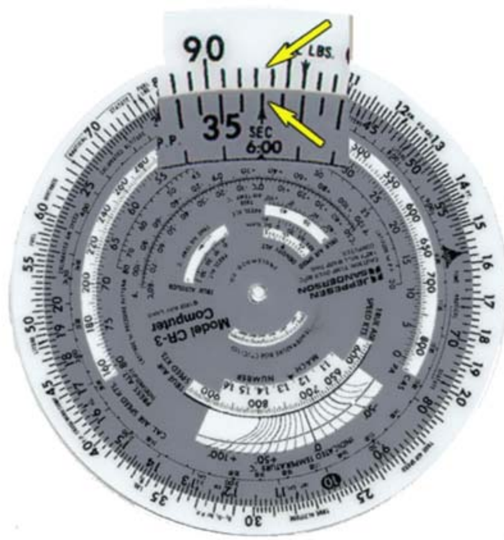


Figure 4.3-27 Fuel Flow 2

FUEL CONVERSION

Fuel is sold in gallons, but all fuel computations in the aircraft reference pounds. This is because it is important to know the total weight of the aircraft. Therefore, the conversion from gallons to pounds is a necessary skill in aviation. To convert gallons of fuel to pounds, the weight of a single gallon must be known. On a standard day, most aviation fuel weighs between 6.5 and 6.9 pounds per one gallon. This ratio of 6.X to 1 is used in the formula:

$$\frac{\text{FUEL WEIGHT}}{\text{1 GALLON}} = \frac{\text{TOTAL POUNDS}}{\text{TOTAL GALLONS}}$$

Note that the outer scale on the CR-3 remains the FUEL scale, and the inner scale now becomes the GALLONS scale.

It is important to remember that the 10 on the inner wheel represents 1-gallon. Since there is no time involved in this type of problem, DO NOT use the rate index! Also remember that there will always be more pounds than gallons.

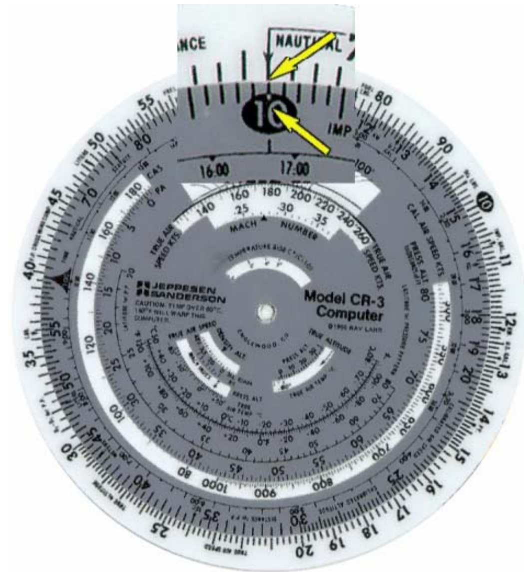


Figure 4.3-28 Fuel Conversion 1

EXAMPLE ONE: Finding total fuel weight.

Given: Total gallons . . . . 525 gallons
Fuel weight. . . . 6.6 lbs per gallon
Find: Total fuel weight.

Solution:

1. Estimate the answer. Round the fuel weight up to 7 pounds per gallon. Round the total gallons down to 500. 7 x 500 is 3500 (pounds).

2. Find 66 (6.6#) on the POUNDS (outer) scale and place it over 10 on the GALLONS (inner) scale. (Figure 4.3-28)

3. Find 525 (525 gallons) on the inner (gallons) scale and read the amount of total fuel weight on the outer (pounds) scale. (Figure 4.3-29)

Figure 4.3-29 Fuel Conversion 2

Answer: 3460 pounds of fuel.

Since mission requirements are based on pounds of fuel, the aircrew will need to convert pounds to gallons in order to request fuel for the aircraft. This is because fuel trucks can only reference gallons. Use the above formula, inserting the fuel weight on the outer wheel above the 10, and find the gallons needed below the pounds required.

EXAMPLE TWO: Finding gallons required.

Given: Total pounds . . . . . 6000 pounds
Fuel weight . . . . . . 6.4 pounds per gallon
Find: Total gallons required.

Solution:

1. Estimate the answer. Round the fuel weight down to 6 pounds per gallon. Divide 6000 by 6. Approximately 1000 gallons.

2. Find 64 (6.4#) on the POUNDS (outer) scale and place it over 10 on the GALLON (inner) scale. (Figure 4.3-30)

3. Find 60 (6000 pounds) on the POUNDS (outer) scale and read the amount of total gallons on the GALLONS (inner) scale. (Figure 4.3-31)

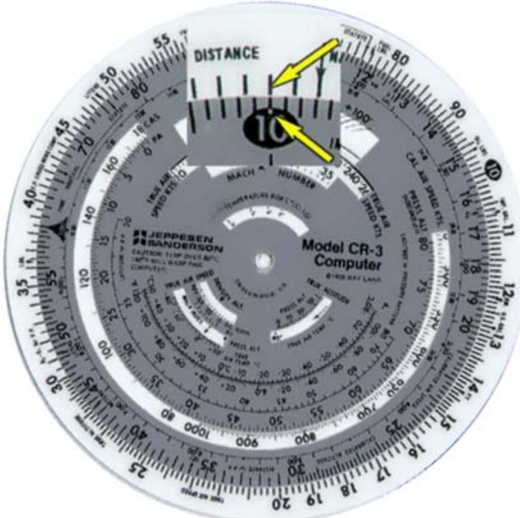


Figure 4.3-30 Fuel Conversion 3

Answer: 938 gallons of fuel.

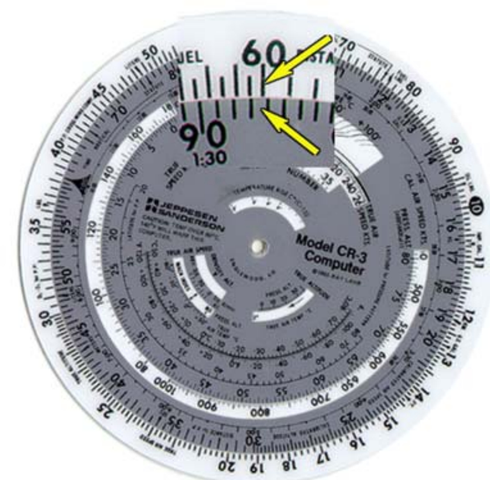


Figure 4.3-31 Fuel Conversion 4

EXAMPLE Three: Finding pounds consumed.

Given: Ground Speed . . . . 425 Knots
Fuel Flow . . . . .9000 lbs/hour
Distance Traveled . . . . 11 nm

Find: Total pounds consumed.

Solution:

1. Estimate the answer. At 7 nm/min it will take roughly 90 seconds to fly 11 nm. At a fuel flow of 9000 #/hour about 220 lbs of fuel will be burned.

2. Find 42.5 (425 Kts) on the DISTANCE (outer) scale and place it over 36 (3600 seconds) on the TIME (inner) scale. (Figure 4.3-32)

3. Find 11 (11 nm) on the DISTANCE (outer) scale and read the amount of total seconds on the TIME (inner) scale. 11nm will take 93 seconds of flight time. (Figure 4.3-33)

4. Find 90 (9000 #) on the POUNDS (outer) scale and place it over 36 (3600 seconds) on the TIME (inner) scale. (Figure 4.3-34)

5. Find 93 (93 seconds) on the TIME (inner) scale and read the amount of total pounds on the POUNDS (outer) scale. (Figure 4.3-35)

Answer: 232 pounds of fuel.

Figure 4.3-32 Fuel Conversion 5

Figure 4.3-33 Fuel Conversion 6

Figure 4.3-34 Fuel Conversion 7

Figure 4.3-35 Fuel Conversion 8

PRACTICE PROBLEMS

TIME

Find the TIME, given the SPEED and DISTANCE:

	DISTANCE (NM)	SPEED (knots)	ANSWERS (hr/min/sec)
1.	310	220	______
2.	45	430	______
3.	215	165	______
4.	125	545	______
5.	1500	330	______
6.	5	210	______
7.	2	415	______
8.	15	620	______
9.	435	145	______
10.	2600	360	______
11.	85	510	______
12.	560	405	______
13.	1.5	110	______
14.	95	225	______
15.	135	450	______
16.	1450	300	______
17.	850	185	______
18.	3	215	______
19.	90	640	______
20.	500	260	______
21.	117	415	______
22.	720	150	______
23.	510	380	______
24.	480	530	______
25.	3.5	650	______

26. How much time will it take a P-3 "Orion" aircraft to cover 230 nautical miles at a speed of 315 knots?

    a. 12 min
    b. 35 min
    c. 44 min
    d. 73 min

27. How much time will it take a T-1 to go 5 nautical miles at a speed of 420 knots?

    a. 72 sec
    b. 55 sec
    c. 43 sec
    d. 35 sec

28. Flying at 365 knots an aircraft would cover 2000 nautical miles in ________.

    a. 12 hrs
    b. 9 hrs 10 min
    c. 7 hrs 30 min
    d. 5 hrs 28 min

29. How much time would it take an aircraft to cover 215 nautical miles at 160 knots?

    a. 0 hrs 45 min
    b. 0 hrs 57 min
    c. 1 hr 5 min
    d. 1 hr 21 min

30. At a speed of 120 knots, a T-34 aircraft could cover 340 nautical miles in

    a. 17 minutes
    b. 1 hour, 8 minutes
    c. 2 hours, 50 minutes
    d. 3 hours, 30 minutes

SPEED

Find the SPEED, given the DISTANCE and TIME:

DISTANCE (NM)		TIME (hr+min+sec)	ANSWERS (knots)
1.	425	1+50+00	______
2.	300	2+00+00	______
3.	20	0+30+00	______
4.	600	2+30+00	______
5.	1200	4+00+00	______
6.	15	0+10+00	______
7.	285	0+50+00	______
8.	5	0+00+20	______
9.	1000	3+20+00	______
10.	22	0+15+00	______
11.	3	0+00+15	______
12.	300	1+00+00	______
13.	550	3+00+00	______
14.	3000	7+00+00	______
15.	300	0+45+00	______
16.	195	0+30+00	______
17.	1600	4+00+00	______
18.	5.5	0+00+45	______
19.	625	1+50+00	______
20.	60	0+20+00	______
21.	375	1+40+00	______
22.	98	0+19+00	______
23.	525	1+10+00	______
24.	200	1+40+00	______
25.	3	0+00+31	______

26. A T-34 “Mentor” aircraft travels 420 nautical miles in 2 hours 30 minutes. What is its speed?

    a. 160 knots
    b. 168 knots
    c. 280 knots
    d. 360 knots

27. If a T-39 "Sabreliner" traveled 184 nautical miles in 35 minutes, how fast was it flying?

    a. 525 knots
    b. 315 knots
    c. 114 knots
    d. 107 knots

28. In 23 seconds an F-15 "Eagle" covered 3.5 nautical miles. What was its speed?

    a. 236 knots
    b. 395 knots
    c. 546 knots
    d. 912 knots

29. If an S-3 "Viking" covered 375 nautical miles in 1 hour 30 minutes, how fast was it flying?

    a. 415 knots
    b. 250 knots
    c. 200 knots
    d. 174 knots

30. An F-14 "Tomcat" flying at ________ knots would cover 950 nautical miles in 1 hour 50 minutes.

    a. 380 knots
    b. 520 knots
    c. 865 knots
    d. 950 knots

DISTANCE

Find the DISTANCE, given the SPEED and TIME:

SPEED (knots)		TIME (hr+min+sec)	ANSWERS (NM)
1.	220	2+00+00	______
2.	175	1+30+00	______
3.	310	0+40+00	______
4.	420	0+45+00	______
5.	250	0+00+13	______
6.	195	7+00+00	______
7.	620	1+30+00	______
8.	725	1+40+00	______
9.	230	0+00+50	______
10.	385	2+30+00	______
11.	435	0+17+00	______
12.	150	0+37+00	______
13.	240	1+10+00	______
14.	400	0+00+45	______
15.	520	1+30+00	______
16.	210	0+50+00	______
17.	340	0+30+00	______
18.	175	0+22+00	______
19.	700	4+00+00	______
20.	210	1+50+00	______
21.	120	0+00+42	______
22.	625	2+00+00	______
23.	430	0+40+00	______
24.	195	0+00+37	______
25.	300	5+20+00	______

26. How far would an T-1 travel in 20 minutes if its speed was 360 knots?

   a. 12 NM
   b. 72 NM
   c. 102 NM
   d. 120 NM

27. At 210 knots, how far would an aircraft travel in 2 hours 20 minutes?

    a. 765 NM
    b. 490 NM
    c. 470 NM
    d. 294 NM

28. A T-34 “Mentor” aircraft traveling for 45 seconds at 210 knots would cover what distance?

    a. 2.6 NM
    b. 9.4 NM
    c. 12.4 NM
    d. 15.8 NM

29. An F-15 "Eagle" aircraft traveling at 420 knots would cover what distance in 1 hour 40 minutes?

    a. 700 NM
    b. 429 NM
    c. 352 NM
    d. 340 NM

30. What distance would an aircraft traveling at 320 knots cover in 4 hours 30 minutes?

    a. 2400 NM
    b. 2300 NM
    c. 1440 NM
    d. 810 NM

FUEL CONSUMPTION

	FUEL FLOW	TIME	FUEL QUANTITY
1.	1500 lbs	1+25	______ lbs
2.	175 lbs	0+17	______ lbs
3.	550 lbs	3+30	______ lbs
4.	2900 lbs	2+54	______ lbs
5.	______ lbs	1+15	2500 lbs
6.	270 lbs	______	3250 lbs
7.	1400 lbs	______	15000 lbs
8.	______ lbs	0+45	117 lbs
9.	1870 lbs	2+10	______ lbs
10.	770 lbs	______	2800 lbs
11.	______ lbs	6+30	25000 lbs
12.	325 lbs	4+27	______ lbs
13.	1660 lbs	5+50	______ lbs
14.	______ lbs	0+36	256 lbs
15.	425 lbs	______	250 lbs
16.	______ lbs	3+00	756 lbs
17.	1100 lbs	2+15	______ lbs
18.	4300 lbs	______	7500 lbs
19.	______ lbs	7+00	1250 lbs
20.	______ lbs	1+25	335 lbs
21.	655 lbs	4+45	______ lbs
22.	1750 lbs	10+30	______ lbs
23.	350 lbs	______	935 lbs
24.	______ lbs	3+35	1675 lbs
25.	______ lbs	0+53	850 lbs

26. An F-14 "Tomcat" aircraft is burning fuel at a rate of 5,000 lbs per hour. How many flight hours will the aircraft fly if it has 18,000 lbs onboard?

    a. 3 hours 10 minutes
    b. 3 hours 36 minutes
    c. 6 hours
    d. 2 hours 56 minutes

27. If an F-15 "Eagle" aircraft consumed 76,000 lbs of fuel in a 3 hour 30 minute flight, what was the rate of fuel consumed per hour?

    a. 270 lbs
    b. 2,170 gals
    c. 2,170 lbs
    d. 21,700 lbs

28. An A-6 "Intruder" aircraft burns 5000 lbs per hour. What will be the total fuel consumed if it flies for 2 hours 40 minutes?

    a. 1,400 lbs
    b. 130 lbs
    c. 1,360 lbs
    d. 13,300 lbs

29. An F/A-18 "Hornet" aircraft carries 12,000 lbs of fuel internally. What is the total time it can fly if it burns fuel at a rate of 4,250 lbs per hour?

    a. 2 hours 50 minutes
    b. 4 hours 40 minutes
    c. 1 hour 50 minutes
    d. 2 hours 05 minutes

30. A T-34 "Mentor" aircraft consumes 250 lbs per hour. What will be the fuel consumed if it flies for 2 hours 10 minutes?

    a. 500 lbs
    b. 540 lbs
    c. 325 lbs
    d. 253 lbs

FUEL CONVERSIONS

	Fuel Weight	Fuel (lbs.)	Fuel (gallons)
1.	6.4 #/g	2340#	_____ gal
2.	6.6 #/g	4200#	_____ gal
3.	6.8 #/g	_____#	2200 gal
4.	6.5 #/g	14000#	_____ gal
5.	6.6 #/g	_____#	640 gal
6.	6.5 #/g	_____#	1200 gal
7.	6.8 #/g	8750#	_____ gal
8.	6.5 #/g	_____#	3000 gal
9.	6.8 #/g	12600#	_____ gal
10.	6.5 #/g	_____#	860 gal

ASSIGNMENT SHEET

Airspeeds
Assignment Sheet No. 4.4.1A

INTRODUCTION

Aircraft operate in a dynamic environment. To ensure flight safety and accurate navigation solutions, aircrew must be familiar with the principles of pressure and altitude in order to understand and apply them to an accurate True Airspeed solution. As one of the four basic elements of DR, an understanding of airspeeds allows the aircrew to accurately maintain a DR plot.

LESSON TOPIC LEARNING OBJECTIVES

TERMINAL OBJECTIVE:
Partially supported by this lesson topic:

4.0 Upon completion of this unit of instruction, the student will demonstrate, per NAVAVSCOLSCOMINST 1610.7 series, knowledge of the fundamentals of air navigation skills necessary for pilot or naval flight officer training.

ENABLING OBJECTIVES:
Completely supported by this lesson topic:

4.25 Describe the effects that changes in density have on True Airspeed and mach airspeed.

4.26 Define Indicated Airspeed, Calibrated Airspeed, True Airspeed, and Ground Speed.

4.27 Determine True Airspeed and Mach Number using the CR-3 computer.

STUDY ASSIGNMENT

Study Information Sheet 4.4.1I and solve the practice problems at the end of the lesson topic.

INFORMATION SHEET

Airspeeds
Information Sheet No. 4.4.1I

INTRODUCTION

A clear understanding of the airspeed of an aircraft and how it relates to pressure and altitude is essential in order to effectively navigate. This chapter will explain the theory, principles, and techniques required to accurately calculate required airspeed.

REFERENCES

INFORMATION

ALTITUDE THEORY

Altitude is defined as height above a given reference. Altitude relates to the navigation problem because of the corresponding density changes with changes in altitude. These pressure and temperature changes at different altitudes affect True Airspeed, thereby influencing the DR plot.

All aircraft use a barometric altimeter to determine height. Some aircraft use additional types of altimeters, including encoding and radar altimeters that are specialized equipment used for mission requirements. The barometric altimeter is an aneroid barometer which converts pressure differences to a direct readout in feet.

Altimeter readings must include a reference in order to be useful. Altimeter readings for a barometric altimeter use the current barometric pressure at Mean Sea Level (MSL) as the reference. Prior to an aircraft's departure, the airfield tower controller tells the pilot the local altimeter setting, which is the barometric pressure at Mean Sea Level for the airfield. Airfields are normally higher than Mean Sea Level; and when the pilot sets the local altimeter setting in the Kollsman window of the aircraft's altimeter, the altimeter will indicate the airfield’s elevation above Mean Sea Level. For example, if the aircraft is in Denver, Colorado, the altimeter will indicate approximately 5,600 feet while the aircraft is still on the ground since the elevation at Denver is 5,600 feet MSL. The altitude shown on the altimeter is called **Indicated Altitude**.

Altimeters are subject to errors caused by installation, mechanical misalignment, positioning of the pressure-sensing ports on the aircraft, and age/wear. These errors are grouped into one category called **Instrument Error**. Instrument error is determined by noting the difference between known airfield elevation and Indicated Altitude (on altimeter) prior to takeoff when the current airfield altimeter setting is SET. For example, an aircraft altimeter showing an Indicated Altitude of 80 feet at NAS Pensacola, where the airfield elevation is 30 feet MSL, would have an instrument error of +50 feet. You cannot correct for instrument error; and for this reason, if the total altimeter error is in excess of 75 feet, the aircraft is considered unsafe for IFR flight. Indicated altitude corrected for instrument error is called **Calibrated Altitude**.

DENSITY

In order to calculate **True Altitude**, which is the height of the aircraft above Mean Sea Level (MSL), calibrated altitude must be corrected for density. The two major factors affecting air density are temperature and pressure.

TEMPERATURE

Outside Air Temperature (OAT) or Indicated Air Temperature (IAT) is measured with aircraft instruments. These temperatures may or may not be corrected for aircraft instrument error. Aircraft instruments are calibrated for standard lapse rates. An incorrect instrument indication will result if the temperature deviates from the standard.

For every 11^{o}C that the temperature varies from the standard lapse rate, the altimeter will be in error 4%. If the air is colder than the standard atmosphere, the aircraft will be lower than the altimeter indicates; if the air is warmer than standard, the aircraft will be higher than the altimeter indicates. For purposes of this course always assume a standard lapse rate.

Temperature’s effects on pressure and density translate directly to corresponding affects on TAS.

PRESSURE

When an aircraft flies from one place to another at a constant indicated altitude, it is flying along a surface of constant pressure. As the surface pressure varies, so do the heights of the pressure levels aloft. Figure 4.4-1 shows the path of an aircraft as it follows a constant pressure surface. As the surface pressure is reduced (all other conditions remaining the same), the whole column of air aloft is lowered, causing an aircraft flying at a particular pressure level to descend to a lower altitude.

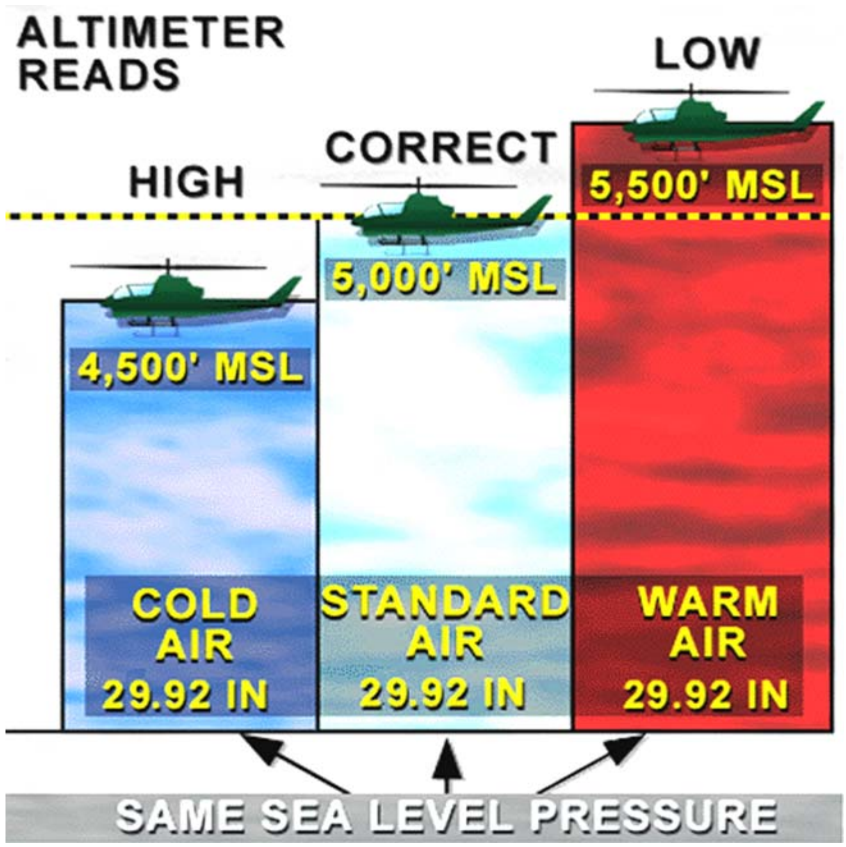


Figure 4.4-1 Path of Aircraft Following a Constant Pressure Surface

The current altimeter setting must be obtained by radio throughout the flight and it is imperative to receive an altimeter setting from the tower at your destination prior to landing. Without a current altimeter setting, a pilot flying toward an area where the pressure is decreasing would be at an MSL altitude lower than indicated. A change in pressure of 0.10 in-Hg will change the altimeter reading 100 feet. A basic rule for altimeter errors is, when flying from point to point and your flight takes you from

High pressure to Low pressure, your altimeter indicates
High but the aircraft is actually Lower

	P	P	ALT	A/C
RULE –	High	Low	High	Low

-or-

"High to Low LOOK OUT BELOW"

On the other hand, if you fail to reset your altimeter with a current altimeter setting and you are flying from a low-pressure area, then

Low pressure to High pressure, your altimeter indicates
Low but the aircraft is actually Higher

	P	P	ALT	A/C
RULE --	Low	High	Low	High

-or-

"Low to High PLENTY OF SKY"

STANDARD DAY

A "Standard Day" is defined as a barometric pressure of 29.92 inches of mercury (Hg) and the Outside Air Temperature (OAT) is +15 degrees centigrade at Mean Sea Level (MSL). As the aircraft increases in altitude, temperature and pressure should decrease. Theoretically, these decreases in pressure and temperature will occur at the "Standard Lapse Rate" (Figure 4.4-2), which is a temperature decrease of 2 degrees centigrade and pressure drop of 1" Hg for each 1,000 feet increase in altitude.

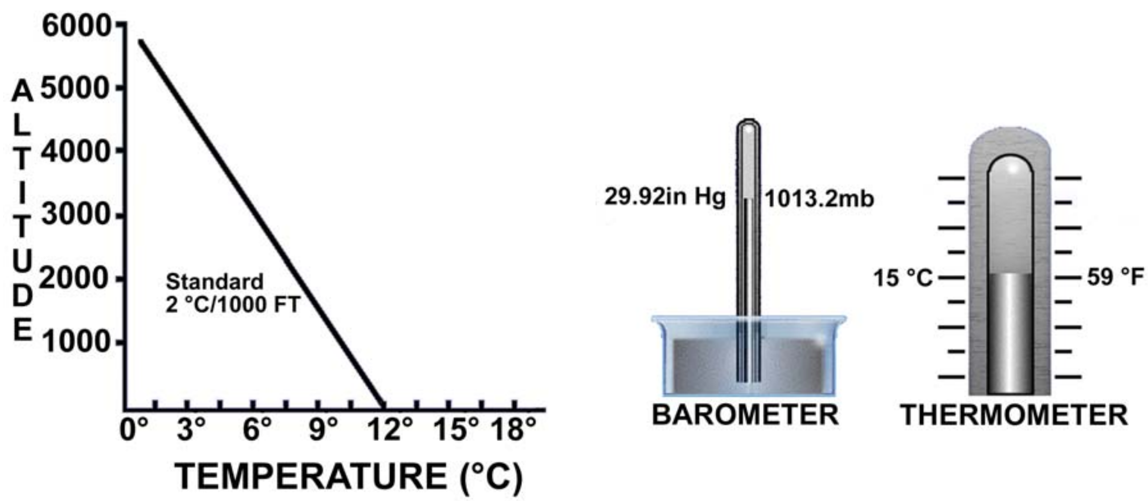


Figure 4.4-2 Standard Lapse Rate

On a Standard Day, the Calibrated Altitude and True Altitude will always be the same. Unfortunately, the Standard Day conditions and the Standard Lapse Rate rarely occur due to temperature inversions, high and low pressure fronts, and other weather occurrences. Atmospheric temperature and pressure vary continuously, and you must correct for these changes by using your CR-3 computer.

REVIEW OF ALTITUDE DEFINITIONS

Indicated altitude: (IA) is the altitude reading on the aircraft altimeter when it is set to the local area (nearest station) barometric pressure (altimeter setting).

Calibrated altitude: (CA) is indicated altitude corrected for instrument and installation errors.

Pressure altitude: (PA) is the calibrated altitude corrected for the difference between local atmospheric pressure and the standard datum plane, 29.92. Pressure altitude is the reference used to calculate True Airspeed.

True Altitude: (TA) is the actual height of the aircraft above Mean Sea Level (MSL). Found by correcting CA for density. TA is very important because terrain elevation on navigational charts is labeled in feet MSL.

Absolute Altitude: Actual height of the aircraft above the surface of the earth. Also known as altitude Above Ground Level (AGL).

Figure 4.4-3 shows a comparison of these altitudes.

AIRSPEED

Airspeed is defined as the speed of an aircraft relative to the air, or the earth's surface. Airspeed is obtained by means of a pitot-static system on the aircraft. Differences in pressure caused by the aircraft movement are measured by the system and displayed on a cockpit airspeed indicator.

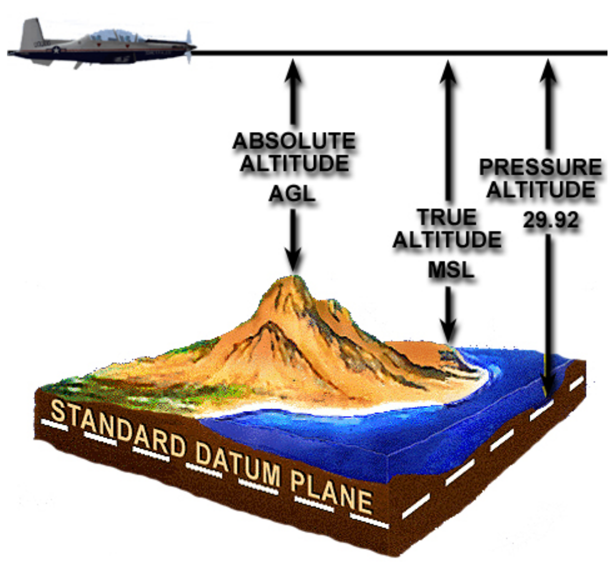


Figure 4.4-3 Altitudes

DEFINITIONS:

Indicated Airspeed: (IAS) is the airspeed read directly from the aircraft Airspeed Indicator.

Calibrated Airspeed: (CAS) is Indicated Airspeed corrected for instrument installation error. Airspeed indicator correction information is generally displayed on an airspeed calibration card placed in the aircraft cockpit. Calibrated airspeed data should be used in place of Indicated airspeed where possible.

True Airspeed: (TAS) is calibrated airspeed corrected for air density (pressure and temperature) and is the speed of the aircraft through the air mass.

Ground Speed: (GS) is the actual speed of the aircraft relative to the ground and is found by correcting TAS for head/tail wind.

TRUE AIRSPEED

True Airspeed (TAS) is the speed of the aircraft through the air mass and is not affected by wind speed or direction. The airspeed indicator in the cockpit gives IAS information which must be corrected for instrument error and density to determine TAS. (Figure 4.4-4)

To convert IAS to TAS, first determine Calibrated Airspeed (CAS). CAS is the result of IAS corrected for instrument error. This instrument error is recorded in the cockpit in the form of an Airspeed Calibration Card which gives what the airspeed indicator reads (IAS) and what it should read (CAS).

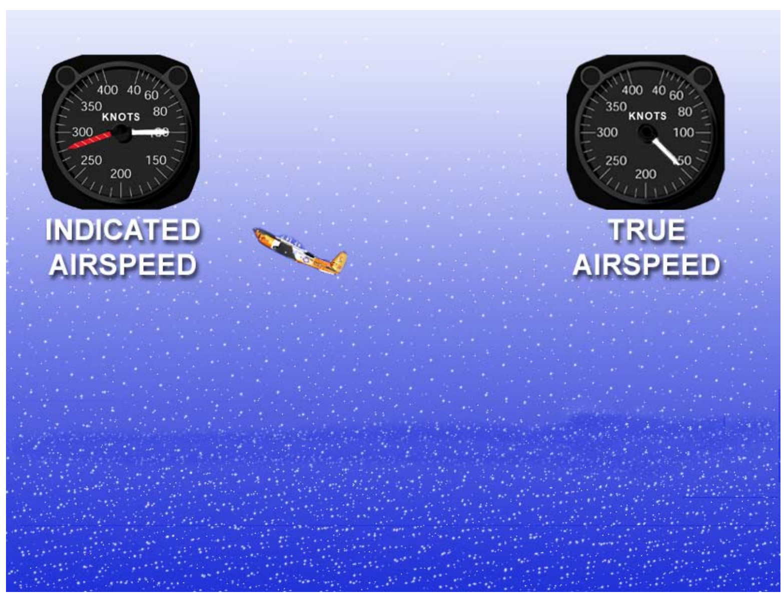


Figure 4.4-4 True Airspeed

For a given IAS ("X"), TAS will generally increase with an increase in altitude.

PRESSURE ALTITUDE

Pressure Altitude (PA) is the measurement of atmospheric pressure from the "Standard Datum Plane." To find Pressure Altitude, first determine the Calibrated Altitude. Calibrated Altitude is Indicated Altitude PLUS or MINUS instrument error. Example follows:

Indicated Alt	= 10,000 feet
Altimeter error	= 0 feet
Calibrated Alt	= 10,000 feet

Next, find the difference between the given altimeter setting and the Standard Datum Plane. If the local altimeter setting was 31.12" and the Standard Datum Plane is 29.92", the problem would look like this:

Local Altimeter	31.12"	
Standard Datum Plane	- 29.92"	
	1.20"	(pressure difference)

Then, change the pressure difference (1.20") to altitude (feet) using the standard lapse rate of 1" Hg (mercury) = 1,000 feet. A difference of 1.20" Hg would equal 1,200 feet.

Finally, you must either ADD or SUBTRACT the pressure difference (1,200 feet) from the Calibrated Altitude (10,000 feet). If the given altimeter setting is less than 29.92", you ADD. If the given altimeter is greater than 29.92", (like the above example) you SUBTRACT:

Calibrated Alt	10,000 feet
Pressure Difference	- 1,200 feet
Pressure Altitude	8,800 feet

NOTES:

1. To assist in determining whether to add or subtract the pressure difference, apply the term "LAGS" which stands for:
   - If the given altimeter setting is Less (than 29.92"), then ADD
   - If the given altimeter setting is Greater (than 29.92"), then SUBTRACT

L ess
A dd
G reater
S ubtract

2. While in flight, Pressure Altitude can be read right off the aircraft altimeter IF 29.92" is dialed into the Kollsman Window AND there is NO instrument error.

CALIBRATED AIRSPEED

Given an IAS, it will be necessary to calculate the CAS because it is a more accurate value to use when calculating the TAS. Looking at the instrument calibration card (Figure 4.4-5), an IAS of 255 knots equates to a TAS of 252 knots. Since there is not a 255 (IAS) available on the calibration card it is necessary to use the closest value of 253 (IAS). At 253 knots (IAS) the correction factor is –3 knots to arrive at a CAS of 250 knots. Therefore, the same correction factor, -3 knots, would be applied to an IAS of 255 to arrive at a CAS of 252. This would be an example of correcting for instrument error.

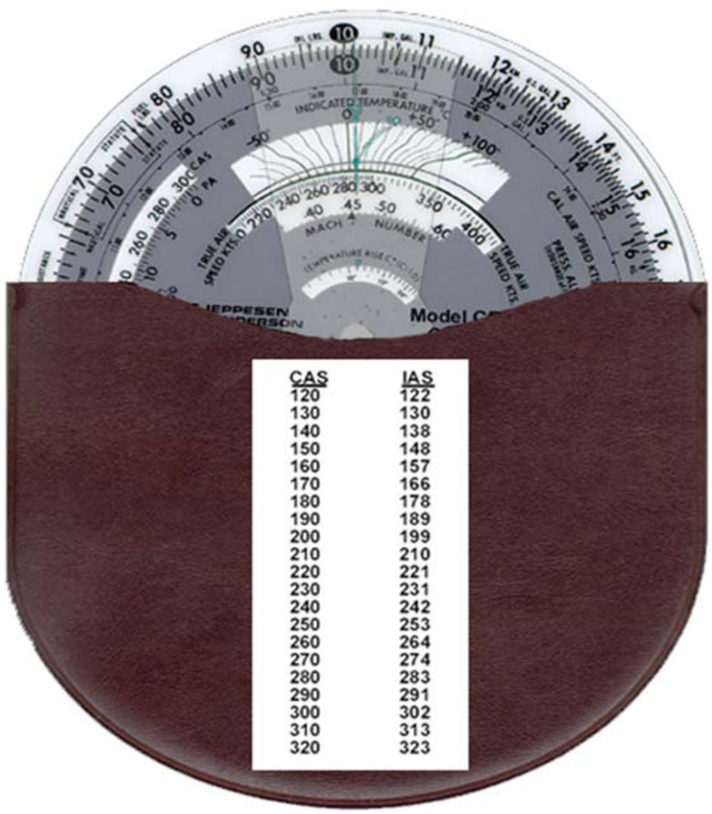
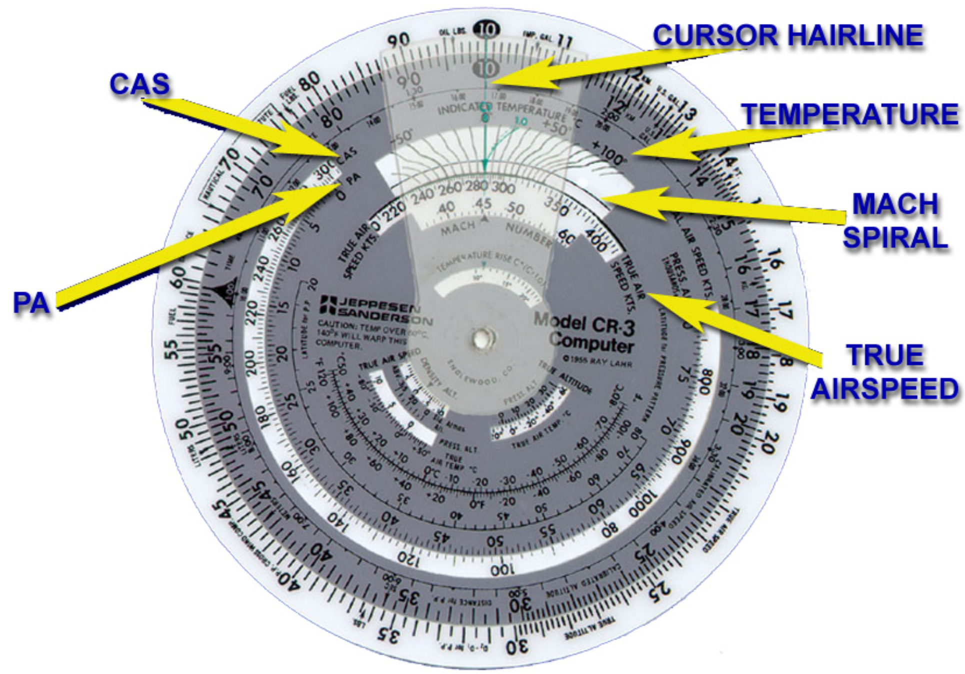


Figure 4.4-5 Airspeed Calibration Card

Once CAS is calculated, the TAS can be solved for using the CR3 navigation computer.



SOLVING FOR TRUE AIRSPEED

SITUATION: What is the TAS of an aircraft at 10,000’ CA, if its IAS is 255 kts and the OAT is -20° C.

1. Set the CAS from the problem (convert IAS to CAS) over the PA (which was calculated in the previous problem). Be careful, the scales increase in opposite directions! (i.e. 10000 is **RIGHT** of 15000) (Figure 4.4-6)

2. Go to the large window at 12 o’clock to input the temperature. Be extra careful to set the green hairline at the intersection of the MACH spiral (black line running left to right) and the temperature wiggley (black line running top to bottom) representing -20°. Now follow the green line down to the TAS scale and read the value, in this case, 272 kts. (Figure 4.4-7)

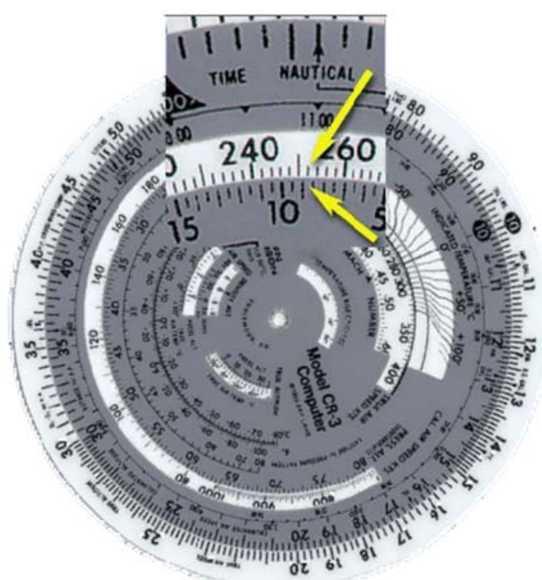


Figure 4.4-6 TAS 1 (CAS/PA)

MACH NUMBER

As an airplane flies, velocity and pressure changes create sound waves in the airflow around the airplane (Figure 4.4-8). Since these sound waves travel at the speed of sound, an airplane flying at subsonic airspeeds will travel slower than the sound waves and allow them to dissipate. However, as the airplane nears the speed of sound, these pressure waves pile up forming a wall of pressure, called a shock wave, which also travels at the speed of sound. As long as the airflow velocity on the airplane remains below the local speed of sound (LSOS), the airplane will not suffer the effects of compressibility. Therefore, it is appropriate to compare the two velocities. **Mach Number** (M) is the ratio of the airplane's True Airspeed to the local speed of sound.

$$M = \frac{TAS}{LSOS}$$

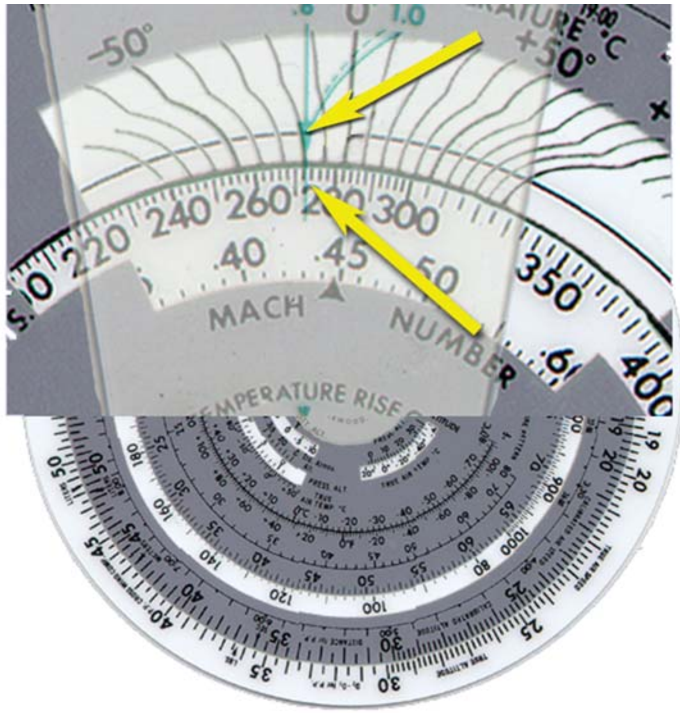


Figure 4.4-7 TAS 2 TEMP/TAS/MACH SPIRAL

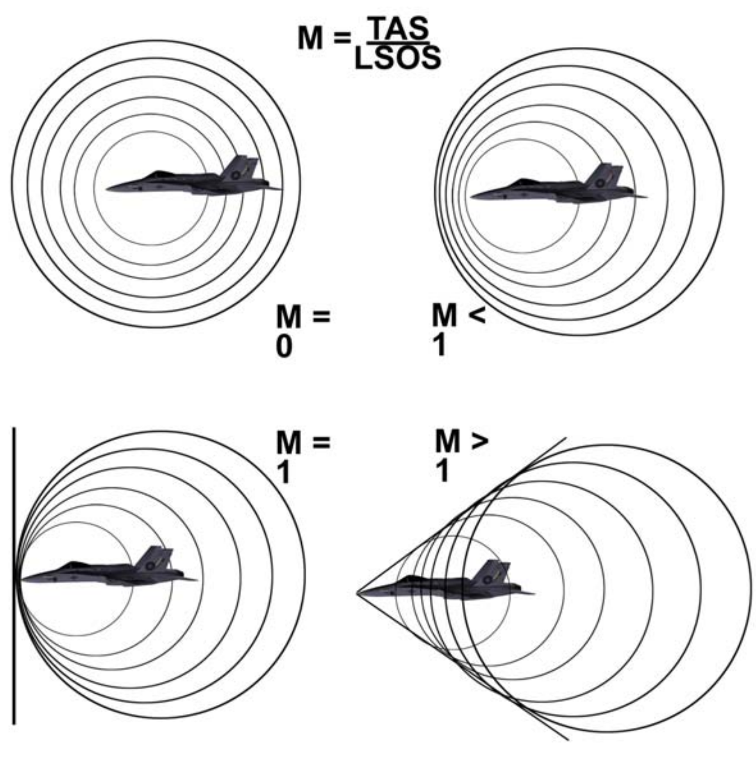


Figure 4.4-8 Mach Number

SOLVING FOR MACH AIRSPEED

SITUATION: What is the Mach Number of the same aircraft at 10,000' CA, IAS of 255 kts and the OAT still -20° C.

1. Set the CAS from the problem (remember to convert IAS to CAS if necessary) over the PA (which, again, may have to be calculated as in the previous problem). Remember, the scales increase in opposite directions! (Figure 4.4-9)

2. Go to the large window at 12 o'clock where TAS was found. Read the Mach Number directly under the TAS scale at the Mach Number index, in this case, .448 mach. Note that at a constant Mach Number the corresponding TAS is temperature dependent. (Figure 4.4-10)

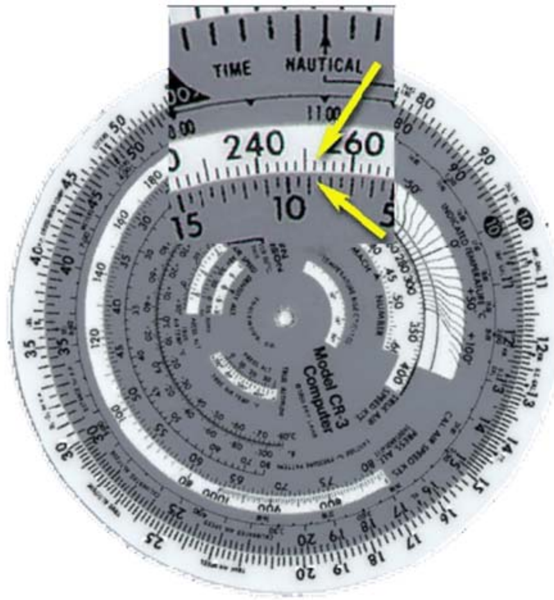


Figure 4.4-9 Mach 1

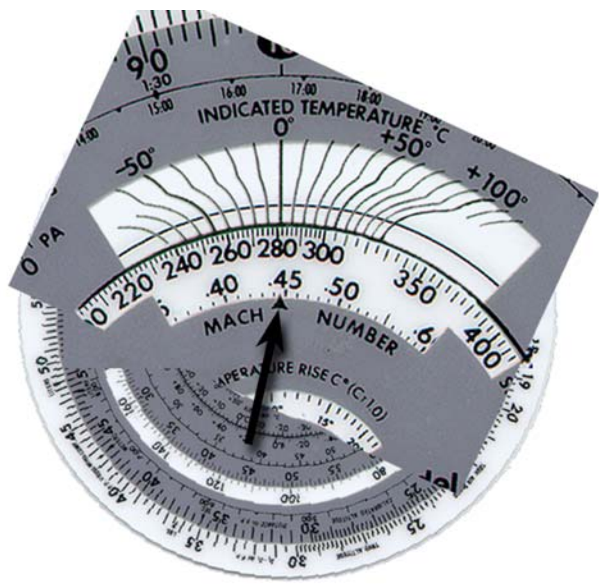


Figure 4.4-10 Mach 2

PRACTICE PROBLEMS

A. Using the CR-3 computer, fill in the missing parameters.

	CALT	ALTIM	TEMP	PALT	CAS	TAS
1	N/A	N/A	10	10000	177	
2	N/A	N/A	10	9000	177	
3	N/A	N/A	10	10240	160	
4	N/A	N/A	-12	19300	303	
5	N/A	N/A	14	5940	126	
6	N/A	N/A	-2	8320	151	
7	N/A	N/A	-10	10000	177	
8	N/A	N/A	0	10000	177	
9	N/A	N/A	-5	8500	137	
10	N/A	N/A	20	3720	219	
11	10000	29.92	10		177	
12	10000	30.92	10		177	
13	11000	30.68	10		160	
14	19500	30.12	-12		303	
15	6000	29.98	14		126	
16	8000	29.60	-2		151	
17	10000	29.92	-10		177	
18	10000	29.92	0		177	
19	8000	29.42	-5		137	
20	3500	29.70	20		219	
21	10000	28.92	10		177	
22	8000	30.20	-7		163	
23	7500	28.92	5		182	
24	12000	30.42	-5		180	
25	2750	29.90	10		180	
26	6000	30.92	-10		219	
27	8500	29.50	-15		203	
28	11500	29.92	20		298	
29	4550	27.92	-20		300	
30	14925	28.50	0			301
31	10500	30.42	5			322
32	1700	28.42	-5			283
33	8500	27.62	10			232
34	3000	28.92	-10			199
35	2380	29.02	-20			311
36	6300	28.02	0			308
37	5600	29.92	0			279
38	8000	29.82	15			290
39	7500	29.95	10			274

40	6800	30.15	-10			250
41	15000	28.95	-20		450	
42	14500	30.01	0		500	
43	8900	29.99	5		475	
44	6900	30.25	10		460	
45	6500	29.95	-25		355	
46	20000	29.92	-20		274	
47	15000	29.99	15		315	
48	1900	30.05	10		495	
49	18000	30.55	0		800	
50	30000	29.63	-5		500	

B. Solve the following problems using the given preflight information.

51. Calibrated altitude is 15,000 feet. OAT is -15 degrees C. Altimeter setting is 29.92 inches Hg. To maintain a TAS of 210 knots, what INDICATED airspeed must be flown?

a. 152 knots
b. 161 knots
c. 166 knots
d. 171 knots

52. An aircraft is flying at 200 knots CAS, pressure altitude 16,000 feet, and OAT is -10 degrees C. What is the TAS?

a. 245 knots
b. 253 knots
c. 262 knots
d. 270 knots

53. SITUATION: An aircraft's calibrated altitude is 15,000 feet, OAT is **-**15°C**,** and the altimeter setting is 29.92 inches Hg. What INDICATED airspeed must be flown to maintain 300 knots TAS?

a. 232 knots
b. 239 knots
c. 243 knots
d. 249 knots

54. SITUATION: An aircraft is flying at 162 knots CAS, 16,000 feet pressure altitude, and an OAT of -10° C. What is the TAS?

a. 124 knots
b. 157 knots
c. 167 knots
d. 207 knots

55. SITUATION: An aircraft's CAS is 120 knots, the altimeter indicates 15,000 feet (zero error), OAT is -30°C, and the pressure altitude is 14,500 feet. What is the aircraft's true airspeed?

a. 138 knots
b. 144 knots
c. 150 knots
d. 161 knots

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ASSIGNMENT SHEET

Preflight Winds
Assignment Sheet No. 4.5.1A

INTRODUCTION

This assignment introduces the CR-3 computer in solving preflight air navigation problems. Practice will be given in wind vector analysis to find True Heading and Ground Speed.

LESSON TOPIC LEARNING OBJECTIVES

TERMINAL OBJECTIVE:
Partially supported by this lesson topic:

4.0 Upon completion of this unit of instruction, the student will demonstrate, per NAVAVSCOLSCOMINST 1610.7 series, knowledge of the fundamentals of air navigation skills necessary for pilot or naval flight officer training.

ENABLING OBJECTIVES:
Completely supported by this lesson topic:

4.28 Identify the three vectors and their two components that make up the wind triangle.

4.29 Demonstrate the application of the wind side of the CR-3 computer in air navigation.

4.30 Determine the True Heading and crab angle necessary to fly a given True Course, using forecast winds and a given True Airspeed and predict the resultant Ground Speed.

STUDY ASSIGNMENT

Study Information Sheet 4.5.1I and solve the practice problems at the end of the lesson topic.

INFORMATION SHEET

Preflight Winds
Information Sheet No. 4.5.1I

INTRODUCTION

The path of an aircraft over the earth's surface is determined by two factors: (1) direction of the aircraft through the air mass and (2) direction of the air mass across the earth's surface. The motion of the air mass is called wind. This assignment will aid in understanding the effects of wind on an aircraft's flight path.

REFERENCES

INFORMATION

WIND THEORY

Wind is the movement of an air mass across the earth's surface. Its direction is expressed as the direction from which the wind blows in degrees true (i.e., the origin of the wind). For example, a 045° wind is a wind originating from the northeast and blowing toward the southwest. The wind's velocity is always given in nautical miles per hour (knots).

Winds are reported in one of two ways: TRUE winds and MAGNETIC winds. En route winds received from the forecaster are TRUE winds and are taken from the Winds-Aloft Charts and Teletype Winds-Aloft Forecasts. The surface winds received from Airport Traffic Control Towers and Approach/Departure Control are MAGNETIC winds that coincide with the magnetic direction of the runways.

The Wind Side of the CR-3 circular computer is designed to aid the Warrior-Navigator in the solution of wind problems. The Wind Side of the CR-3 can be used to solve for navigation problems with the use of Ground Speed, courses, and distances.

Think of the air mass as a large balloon. If an aircraft is inside the balloon, it may travel at any speed and in any direction. As long as the balloon does not move over the ground, the aircraft's motion (speed and direction) over the ground is the same as its motion inside the balloon. Once the balloon begins moving, however, the aircraft's motion over the ground is a combination of its motion inside the balloon and the motion of the balloon over the ground.

For example, Figure 4.5-1 shows a balloon with a width of 50 nm (mass of air) moving east at 50 knots. If an aircraft were flying eastward at 50 knots inside the balloon, at the end of one hour, it will have traveled a total of 100 nm toward the east.

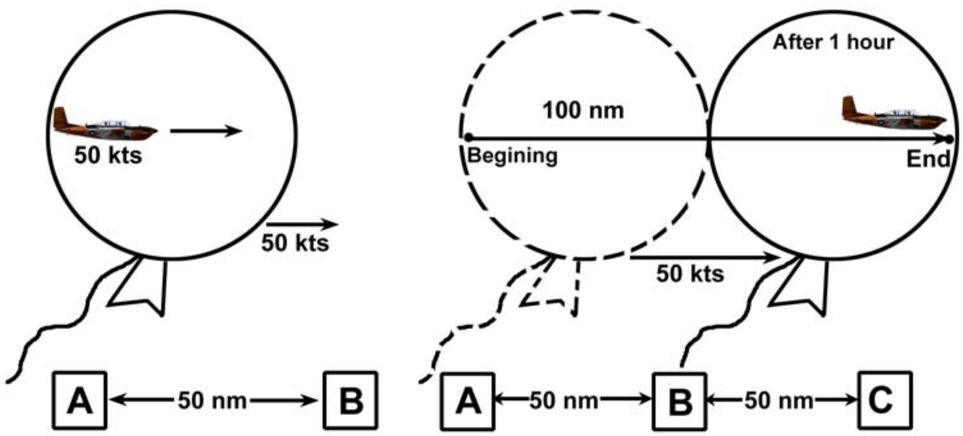

Figure 4.5-1

On the other hand, if an aircraft moves eastward at 50 knots while the balloon moves westward at 50 knots the aircraft will not move over the ground (Figure 4.5-2).

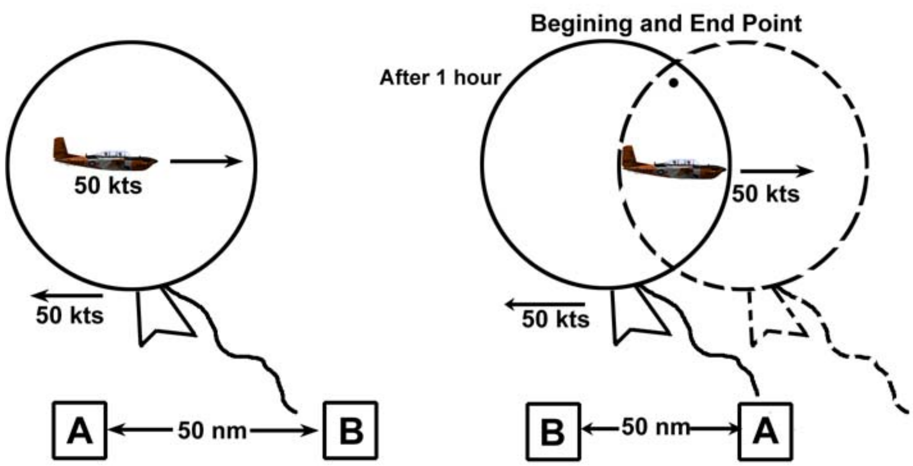

Figure 4.5-2

The aircraft will, however, travel from one side of the balloon to the other regardless of the fact that the balloon is moving westward at the same rate the aircraft is flying eastward.

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If the balloon moves in a direction other than the desired course (Figure 4.5-3), the aircraft's path over the ground will be the combination of the path of the balloon (air mass) and the path of the aircraft through that balloon (air mass) (Figure 4.5-4).

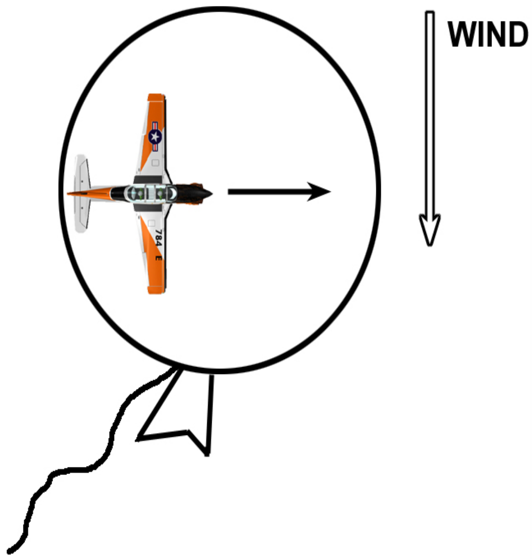

Figure 4.5-3

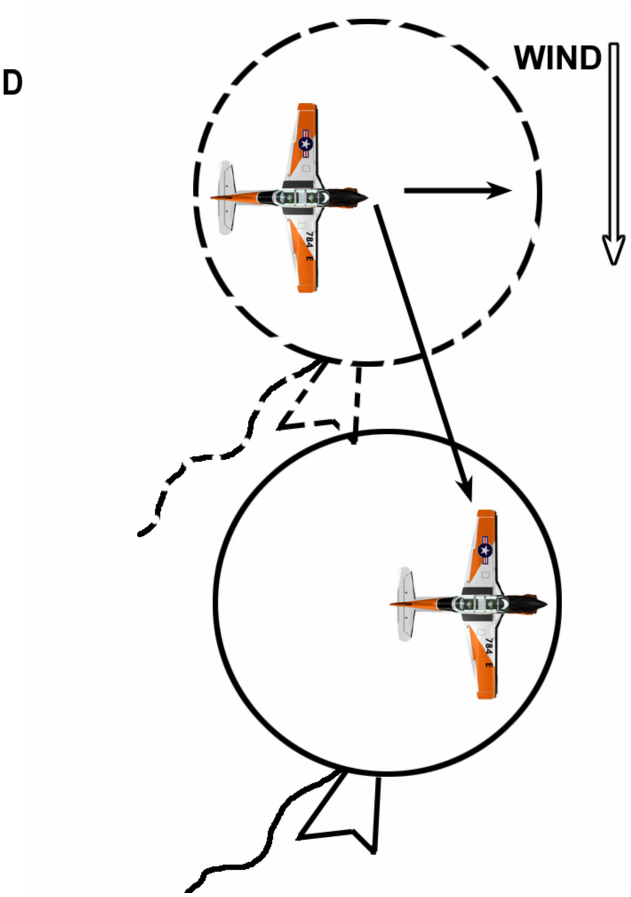

Figure 4.5-4

It is clear that when the movement of the air mass is parallel to the flight path, simple addition or subtraction of the wind can determine the speed over the ground. However, if the movement of the air mass is at an angle to the flight path, as it usually is, vector addition must be used to determine the movement over the ground.

VECTOR ANALYSIS AND THE WIND TRIANGLE

A vector possesses both direction and magnitude (or speed for our purpose). Vectors can represent wind movement and aircraft movement through the air and over the ground. Three vectors comprise the Wind Triangle or, as it is sometimes called, the Navigation Triangle. The three vectors of the Wind Triangle are the:

AIR VECTOR - the aircraft's direction and speed represented by True Heading (TH) and True Airspeed (TAS).

GROUND VECTOR - the aircraft's intended or actual flight path (True Course or Track) and Groundspeed (GS).

WIND VECTOR - the wind's Direction (DIR) and Velocity (VEL).

The **AIR VECTOR** (TH and TAS) is displayed as in Figure 4.5-5.

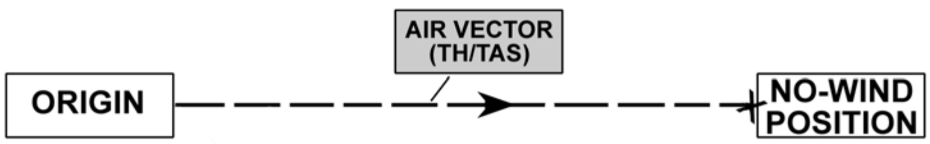

Figure 4.5-5

Adding the **WIND VECTOR** (Direction and Velocity) to the AIR Vector would look like figure 4.5-6.

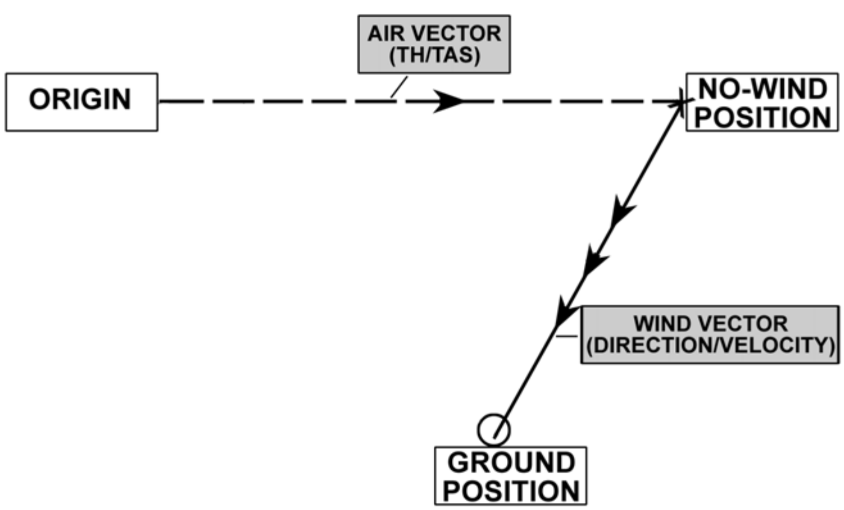

Figure 4.5-6

The resultant vector is the **GROUND VECTOR** that represents True Course or Track and Ground Speed. The result is the Wind Triangle (Figure 4.5-7).

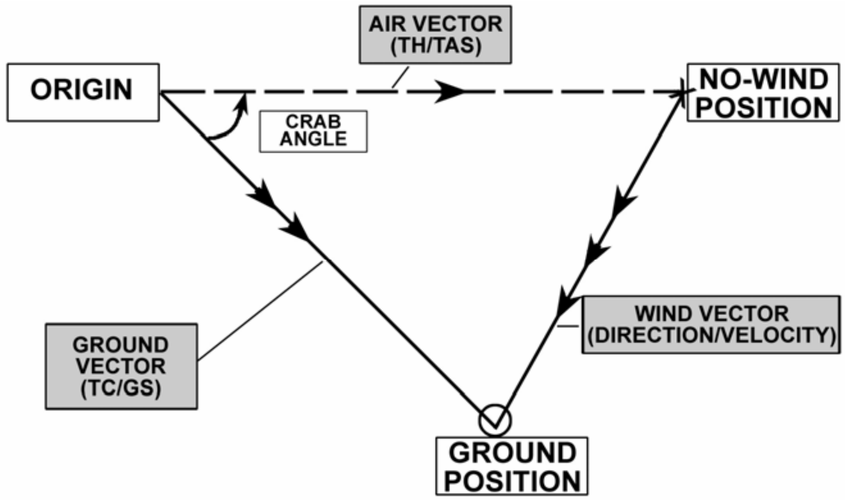

Figure 4.5-7

The direction of the ground vector is the aircraft's intended or actual path over the ground, and the magnitude is the aircraft's groundspeed. The tail of the ground vector is our origin, and the head is the aircraft's current or predicted ground position. On the Wind Triangle, the angle formed by the Air and Ground vectors is called crab angle. (Figure 4.5-7)

Drift angle is the difference between true heading and track measured either left or right of true heading. The aircraft will drift off-course to the left due to the northeasterly wind blowing from 030° at 30 knots (030/30). Instead of accepting this off-course drift, the aircraft must be turned into the wind to compensate for the right crosswind.

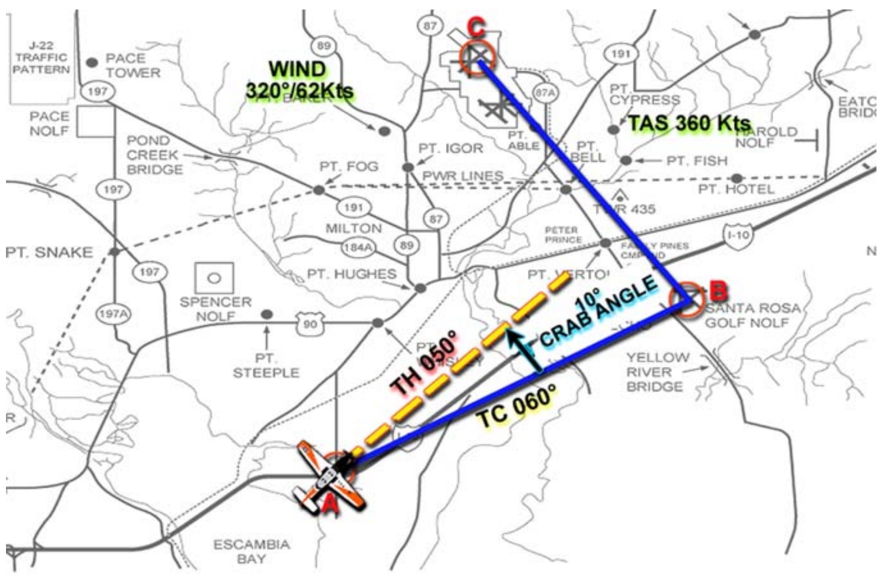

Figure 4.5-8 Crab Angle

Crab angle is the amount of correction an aircraft must be turned into the wind in order to maintain the desired course. It is equal in magnitude but opposite in direction, to the Drift Angle (Figure 4.5-8).

If given any two sides of the wind triangle, the third side can be found by using the CR-3 computer.

COMPONENTS OF THE CR-3 WIND SIDE

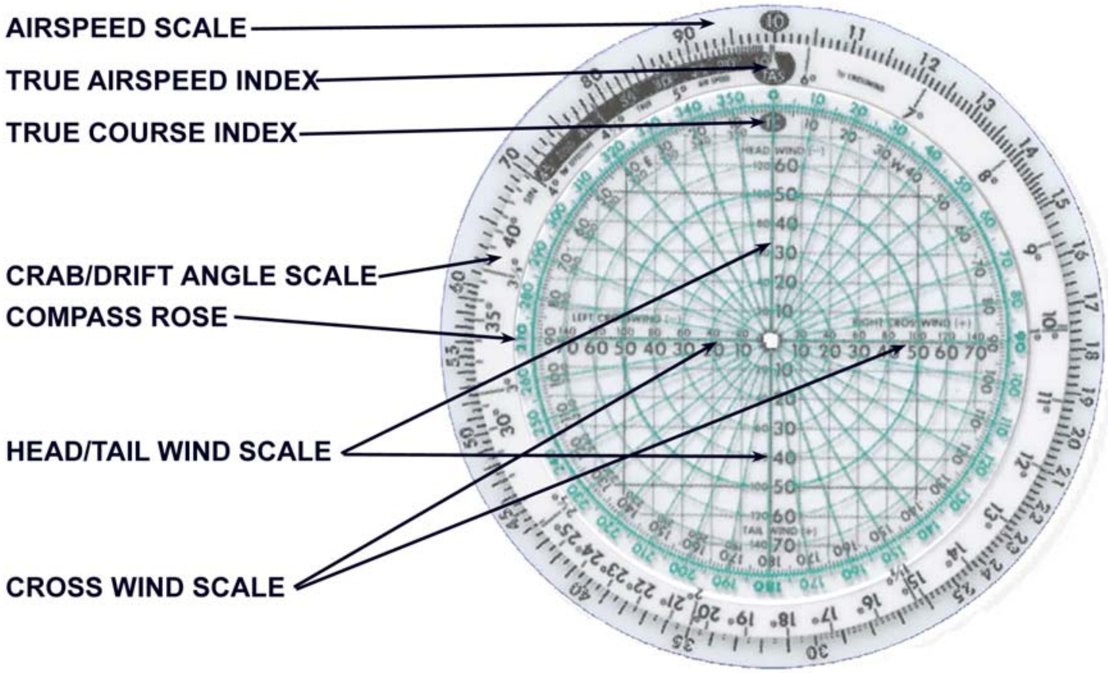

Figure 4.5-9 THE CR-3 AIR NAVIGATION COMPUTER (WIND SIDE COMPONENTS)

AIRSPEED SCALE

The outer most scale (Figure 4.5-9) represents True Airspeed (TAS) when initially setting up the problem, but also represents crosswind component values when computing crab/drift angles.

TRUE AIRSPEED INDEX

This index, located on the second disk (Figure 4.5-9), is where the TAS is applied to the problem. TAS is required to accurately compute the crab/drift angle.

TRUE COURSE INDEX

The True Course Index is used to input the True Course (TC) in a preflight wind calculation, or Track (TK) in an in-flight wind calculation (Figure 4.5-9). Remember that either of these directions can represent the direction of the Ground Vector (Figure 4.5-7).

CRAB AND DRIFT ANGLE SCALE

The numbers on the edge of the middle disc (Figure 4.5-9) are used for either CRAB or DRIFT angle, depending on the type of problem.

COMPASS ROSE

The Compass Rose is a standard 360 degree scale showing one-degree increments (Figure 4.5-9). This disk also includes range rings that correspond with the wind scales and direction lines that originate from the center.

COMPUTER WIND SCALES

There are two wind scales depicted on the horizontal and vertical lines that radiate from the center of the computer (Figure 4.5-9). These scales are printed in black. The large scale (which represents speeds from 0 to 80 knots) is used if the wind is less than 60 knots while the smaller scale (higher speeds, from 0 to 160) is used if the wind is greater than 60 knots. Once a desired scale is chosen, that same scale MUST be used throughout the entire problem. Care should be taken not to mix the two scales within the same problem.

10% RULE

If the crosswind component is 10% of the True Airspeed, the Crab Angle should be 6 degrees. This is a consistent relationship throughout the range of airspeeds that apply to tactical aviation. Therefore, as the crosswind component increases the corresponding crab angle will also.

For example, with a TAS of 150 and a crosswind of 30 kts the crab will equal 12 degrees (twice the 6 degrees from 10% of the TAS).

Summarizing;	If,	Crosswind	=	10% of TAS,
	Then,	Crab angle	=	6º

QUARTERING ANALYSIS

Given a True Course and a preflight wind, quartering analysis can be used to estimate what type of quartering wind the aircraft will experience (i.e. Right Head Wind). Once the quartering wind has been determined True Heading can be compared to True Course, and Ground Speed can be compared to True Airspeed (Figure 4.5-10)

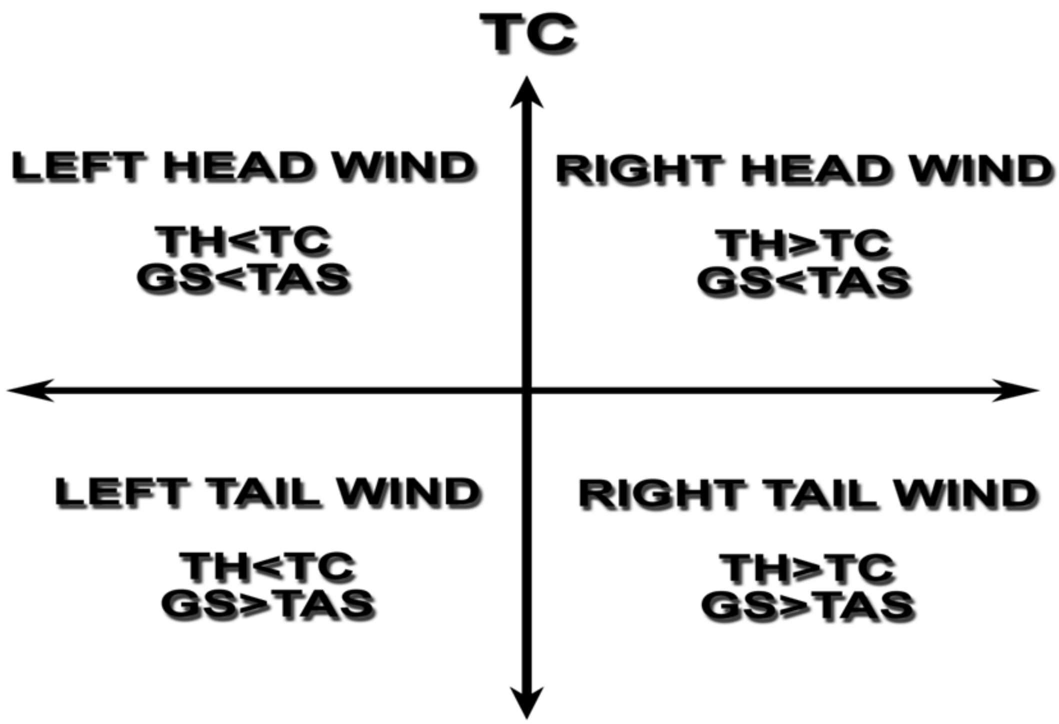

Figure 4.5-10 Quartering Analysis

A list of the steps to calculate predicted True Heading and Ground speed are:

(ESTIMATE!)
1. Plot the wind.
2. Set the TAS.
3. Set the TC.

(Confirm estimation.)

4. Note the crosswind component.
5. Note the headwind/tailwind component.
6. Apply headwind/tailwind. (ground speed)

(Estimate the crab angle using the 10% Rule)

7. Determine the crab angle.
8. Apply the crab angle. (True Heading)
9. **Verify the estimate!**

CALCULATING PREFLIGHT HEADINGS AND GROUNDSPEEDS

Things to remember: erase the wheel completely before starting each problem, take time to analyze the type of wind you have, and estimate its' effects.

SITUATION: Your mission requires you to fly a true course of 218° while maintaining 325 kts TAS. If the winds are forecasted to be from 100° at 40 kts, what TH and GS will you fly?

Estimate first! Sketch out the winds in relation to the desired TC. In this case, there is a Left Tailwind. This will produce the following: GS > TAS and TH < TC (Figure 4.5-11).

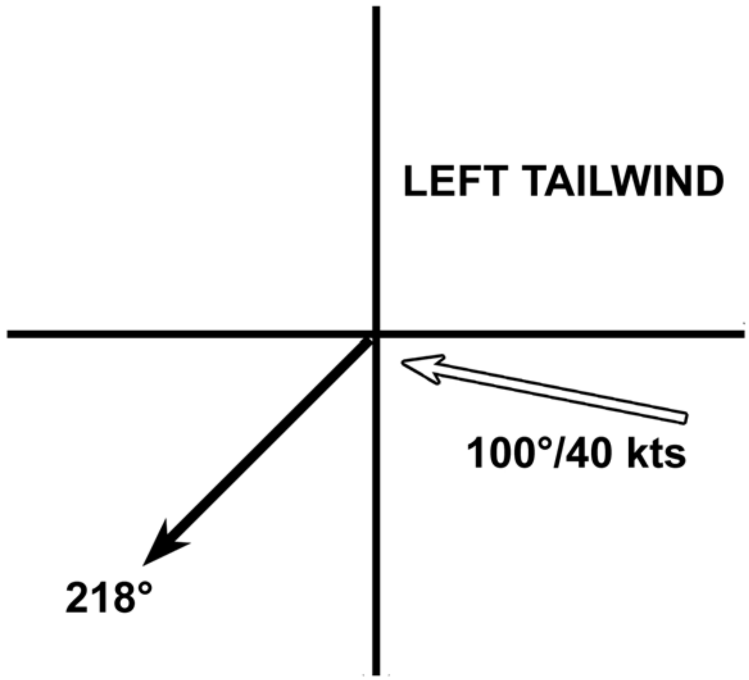

Figure 4.5-11 Preflight Wind Estimation

1. Plot the wind by setting the wind direction (100°) on the inner wheel on top of the TC arrow (Figure 4.5-12).

2. Choose the appropriate scale (lg. or sm.) and mark the velocity (40 kts) with a dot. Circle the dot to make it more visible (Figure 4.5-12).

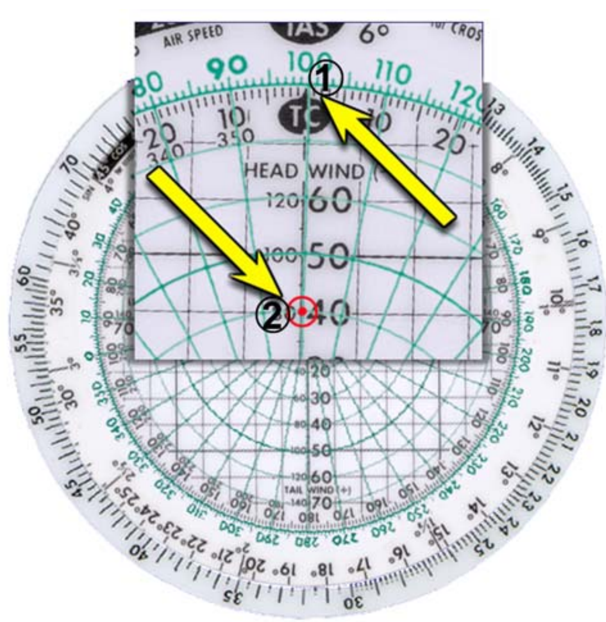

Figure 4.5-12 Preflight Wind Calculation 1

3. Set the TAS (325 kts) over the TAS index on the outer wheel (use floating decimal) (Figure 4.5-13).

Figure 4.5-13 Preflight Wind Calculation 2

4. Rotate the inner wheel to set the desired TC (218°) over the TC arrow. NOTE: at this point, check your estimate. Is it a left tailwind? If not, recheck the preceding steps (Figure 4.5-14).

Figure 4.5-14 Preflight Wind Calculation 3

5. Determine the Crosswind component by drawing a vertical line (up in this case) from the wind dot to the Crosswind scale. Read the velocity in knots (35 kts) remembering to use the same scale as step 2 (Figure 4.5-15).

Figure 4.5-15 Preflight Wind Calculation 4

6. Determine the HW/TW component in the same manner as step 5 (draw a horizontal line as shown in Figure 4.5-16) and add or subtract this value (19 kts TW) to the TAS as appropriate to calculate the GS of 344.

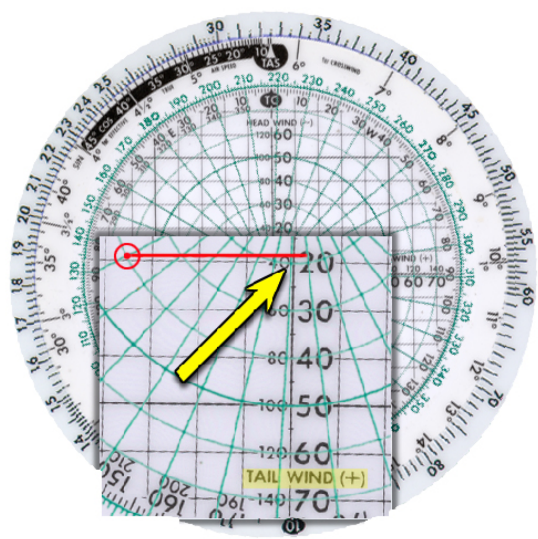

Figure 4.5-16 Preflight Wind Calculation 5

Estimate the crab angle using the 10% Rule

7. Take the Crosswind velocity from step 5 (35 kts), input it on the outer wheel (floating decimal), and read the Crab Angle under it on the middle wheel. (Apply the 10% rule below to verify it is a good value. In this case: 325 X 10% = 32.5, 32.5 kts ≈ 6°).

8. The actual crosswind value of 35 should produce a Crab Angle slightly greater than 6°. It does (6.2°, Figure 4.5-17), but always round to the nearest whole degree. Apply this CA to the TC (+ or -) to determine the TH. In this case, 218° minus 6° equals a TH of 212°.

9. **Verify** the **estimate!**

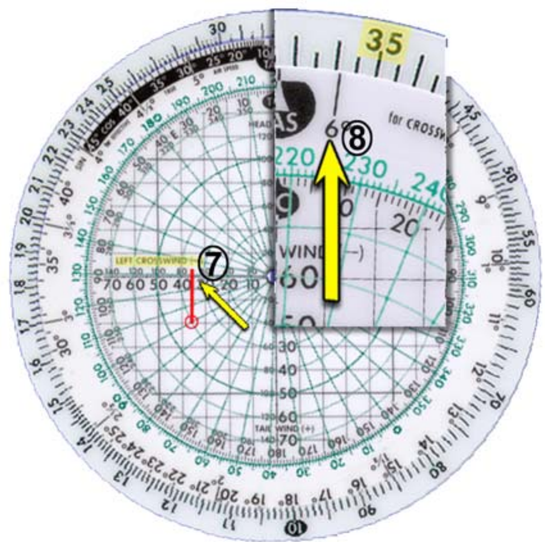

Figure 4.5-17 Preflight Wind Calculation 6

PRACTICE PROBLEMS

A. Using the given winds, determine the predicted TH needed to fly the desired TC and the resulting ground speed.

	TC	TAS	DIR KTS	X - W	C A	TH	H/ T	GS
1	218	325	100 \ 40					
2	299	164	340 \ 30					
3	110	280	330 \ 30					
4	045	350	180 \ 50					
5	040	400	080 \ 100					
6	010	170	210 \ 60					
7	250	330	210 \ 80					
8	292	164	340 \ 32					
9	176	150	220 \ 35					
10	190	220	010 \ 20					
11	325	150	120 \ 20					
12	188	234	030 \ 20					
13	040	135	270 \ 28					
14	054	186	360 \ 14					
15	253	136	290 \ 33					
16	300	175	010 \ 16					
17	252	170	198 \ 27					
18	127	192	320 \ 18					
19	136	204	040 \ 22					
20	115	114	310 \ 46					
21	087	192	050 \ 40					
22	294	325	170 \ 48					
23	334	100	310 \ 33					
24	246	165	180 \ 14					
25	232	231	250 \ 48					
26	265	320	030 \ 50					
27	218	257	110 \ 24					
28	279	145	310 \ 36					
29	065	410	210 \ 25					
30	265	253	330 \ 28					
31	024	230	160 \ 12					
32	250	460	010 \ 60					
33	115	300	045 \ 10					
34	105	200	125 \ 95					
35	148	150	330 \ 15					
36	135	115	125 \ 85					
37	127	800	315 \ 75					

	TC	TAS	DIR KTS	X- W	C A	TH	H/ T	GS
38	159	458	050 \ 20					
39	220	658	110 \ 65					
40	257	521	210 \ 30					
41	198	547	310 \ 55					
42	248	841	115 \ 45					
43	258	621	225 \ 50					
44	147	210	135 \ 45					
45	159	541	245 \ 35					
46	257	687	155 \ 60					
47	248	214	265 \ 25					
48	205	368	175 \ 70					
49	159	985	285 \ 15					
50	167	623	195 \ 80					

B. Solve the following problems using the given preflight information

1. The weatherman predicts winds at 25,000' to be 185/50 and at 30,000' to be 230/80. If your true course is 295°, what altitude should be flown to attain the greatest ground speed? ___________

2. The weather shop predicts winds to be 230/45 with OAT of -10°. You plan to fly a TC of 330° at an IAS of 186 kts. Your planned calibrated alt will be 15,000' using the local altimeter of 27.56. Find:

   CALIBRATED AIRSPEED ________
   TRUE AIRSPEED ________
   GROUND SPEED ________
   PRESSURE ALT ________
   CROSSWIND COMPONENT ________
   H/T WIND COMPONENT ________
   CRAB ANGLE ________
   TRUE HEADING ________

3. You are planning for your first cross-country flight. Your planned TAS is 300 kts and calibrated altitude is 30,000'. The forecaster is predicting winds to be 280°/22 kts with an OAT of -60°. The local altimeter will remain constant throughout the route at 29.35".

   a. What will your IAS be? ___________

   b. If the distance from point A to B on the flight is 349 nm and the measured TC is 345°, what time will you arrive at point B if you depart point A at 1315 GMT? ___________

4. As the clock strikes Midnight, and you are just wrapping up your planning for your first cross-country, the phone rings. It's your instructor and he wants to change the destination to San Diego because of the increased training value on the West coast (and the yearly migration of the Gray Whale is at its peak). You amend your indicated altitude now to 39,000' to try to make it in one leg. You are also going to fly a CAS of 190 kts. After letting the phone ring for ten minutes the duty forecaster rolls out of the rack to give you winds aloft of 320°/65 kts, an OAT of -75°, and altimeter remained 29.35". With a course of 275°T, will increasing your altitude help get you to San Diego any faster? _________ (Hint: Ground Speed...)

5. Weather west of the Rockies causes your cross-country to be canceled so you are rescheduled for a Friday afternoon AIRNAV. You rush home, get a twenty-minute power nap and grab the remote control. The weather channel predicts winds to be 290°/65 kts, with OAT of -45°. You plan to fly a TC of 335° at an IAS of 300kts. Your planned indicated alt will be 11,000' using the local altimeter of 28.56. Find:

CALIBRATED AIRSPEED	________
TRUE AIRSPEED	________
GROUND SPEED	________
PRESSURE ALT	________
CROSSWIND COMPONENT	________
H/T WIND COMPONENT	________
CRAB ANGLE	________
TRUE HEADING	________

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ASSIGNMENT SHEET

In Flight Winds
Assignment Sheet No. 4.6.1A

INTRODUCTION

The purpose of this assignment sheet is to aid the student in determining wind direction and velocity (the wind vector), given the True Heading and True Airspeed (the air vector), Track and Ground Speed (the ground vector).

LESSON TOPIC LEARNING OBJECTIVES

TERMINAL OBJECTIVE:
Partially supported by this lesson topic:

4.0 Upon completion of this unit of instruction, the student will demonstrate, per NAVAVSCOLSCOMINST 1610.7 series, knowledge of the fundamentals of air navigation skills necessary for pilot or naval flight officer training.

ENABLING OBJECTIVES:
Completely supported by this lesson topic:

4.31 Evaluate the effect of wind on the path of an aircraft over the ground.

4.32 Demonstrate the application of the wind side of the CR-3 computer in finding winds in flight.

4.33 Using the CR-3, solve for unknown values of wind direction and velocity given True Heading, True Airspeed, Track, and Ground Speed.

4.34 Determine a TACAN point-to-point course when given a TACAN radial and DME destination and starting point.

STUDY ASSIGNMENT

Study Information Sheet 4.6.1I and solve the practice problems at the end of the lesson topic.

INFORMATION SHEET

In Flight Winds
Information Sheet No. 4.6.1I

INTRODUCTION

While in flight, aircrew will periodically be required to fix the aircraft's position by visual or electronic means. Once fixed, Track (actual flight path) and Ground Speed (distance covered/time) can be determined. With the True Heading and True Airspeed, all the information necessary to compute actual in-flight wind direction and velocity is available.

REFERENCES

INFORMATION

<u>IN-FLIGHT WIND THEORY</u>

The actual winds encountered in flight will often differ from the forecast winds. In order to stay on the intended course, the Warrior-Navigator must be able to compute the actual winds aloft using the information gathered during the flight. After takeoff from the departure point and enroute to the destination, the aircraft position will periodically require fixing by either visual or electronic means, or both. Once a fix is determined, Track (TK) as well as the Ground Speed can be calculated. These values, combined with TH and TAS, can then be inputted into the CR-3 to determine actual in-flight winds (Figure 6.2-1).

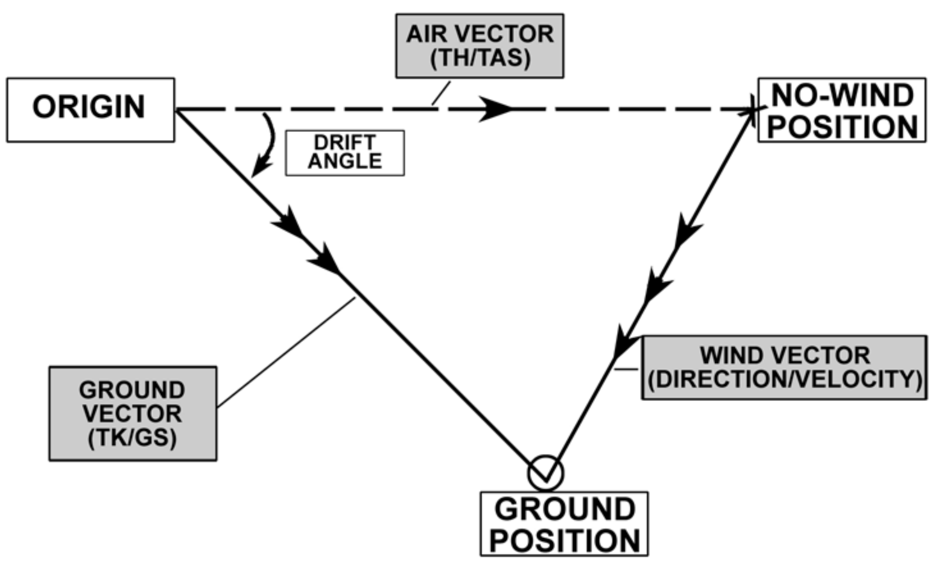

Figure 6.2-1 Wind Triangle

Consider the following scenario. Preflight planning for the leg from point A to point B produces a TC of 055ºT for a distance of 120 nm (Figure 4.6-2). The preflight wind calculation yields a TH of 052ºT and a predicted GS of 255 kts. Once in the air the aircrew sets a TH of 052ºT and a TAS of 250 kts and proceeds on his merry way. 15 minutes into the leg the aircrew fixes his position at point C in Figure 4.6-2. Using plotting skills learned in chapter 2, a track of 045ºT and a distance of 55 nm is measured. A quick time, speed, distance calculation reveals a ground speed of 220 knots.

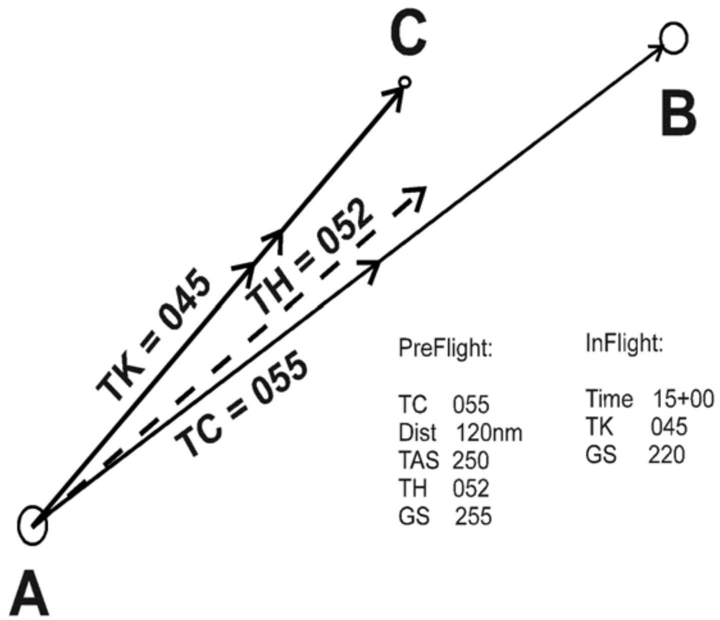

Figure 4.6-2 Wind Scenario (not to scale)

Since the Track (045ºT) and actual Ground Speed (220 kts) are different from the True Course (055ºT) and predicted Ground Speed (255 kts), it becomes evident that actual winds are different from the forecast winds. Now, there is enough information to construct two of the three vectors of the wind triangle, the Air and Ground vectors (Figure 4.6-3), and solve for the actual winds using the CR-3 computer.

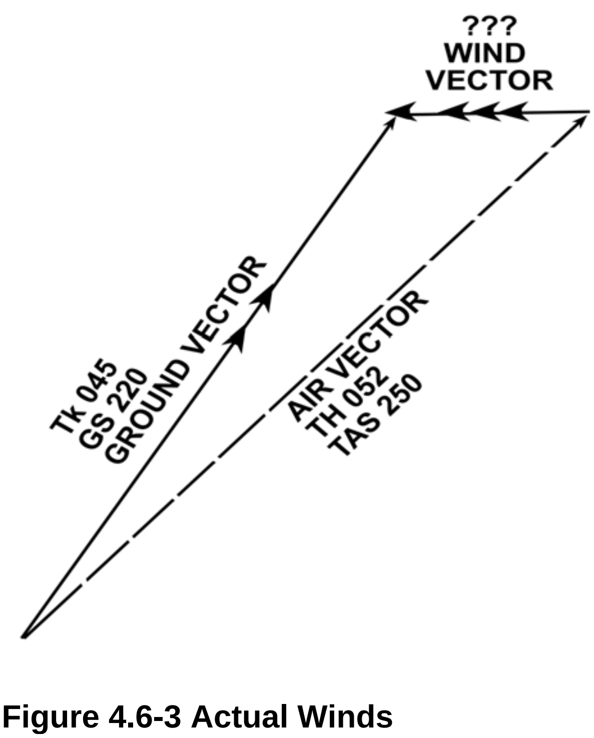

Figure 4.6-3 Actual Winds

CALCULATING IN-FLIGHT WINDS

To calculate in-flight winds, analyze the affect that the winds have already had and determine the direction of the wind from that analysis. As in chapter 5 preflight wind problems, remember to erase the wheel before starting each new problem.

SITUATION: The TH of your T-1 is 350° with a TAS of 150 kts. GS has been determined to be 160 kts, and the Track is 355°. What is the wind?

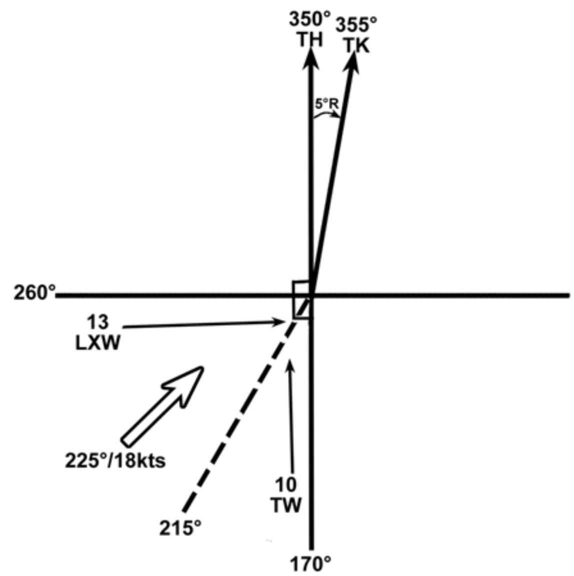

Figure 4.6-4 In-Flight Wind Estimation

ESTIMATE! First compare TAS to GS to determine HW/TW component: GS>TAS =TW. Now, compare TH to TK: TH<TK means a Right Drift, which is caused by a Left Crosswind. We know that we are experiencing a Left Tailwind. The 10% Rule states that at a TAS of 150 kts, 15 kts of crosswind will give us about 6º of drift. A drift angle of 5º would only require about 13 knots of crosswind. The inflight wind would be closer to the wing line at about 225º/18 knots (Figure 4.6-4).

1. Set TAS over TAS arrow (Figure 4.6-5).

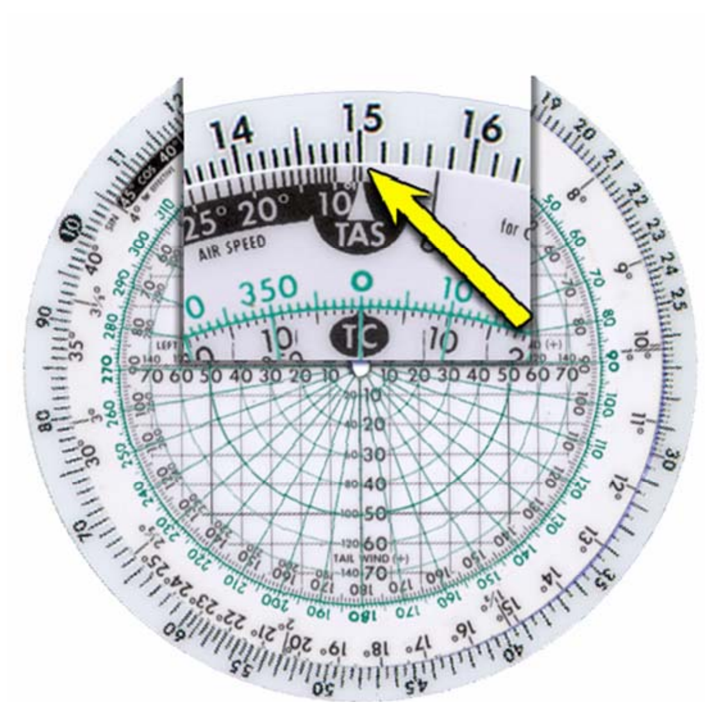

Figure 4.6-5 In-Flight Wind Calculation 1

2.	Set Track over TC arrow. Remember that TC <u>or</u> Track can represent the direction of the ground vector (Figure 4.6-6).

Figure 4.6-6 In-Flight Wind Calculation 2

3.	Use 10% rule to estimate crosswind and then input DA (5 degrees) on middle wheel (Figure 4.6-7).

4.	Read crosswind (13 kts) above DA (Figure 4.6-7). Round to the nearest whole knot.

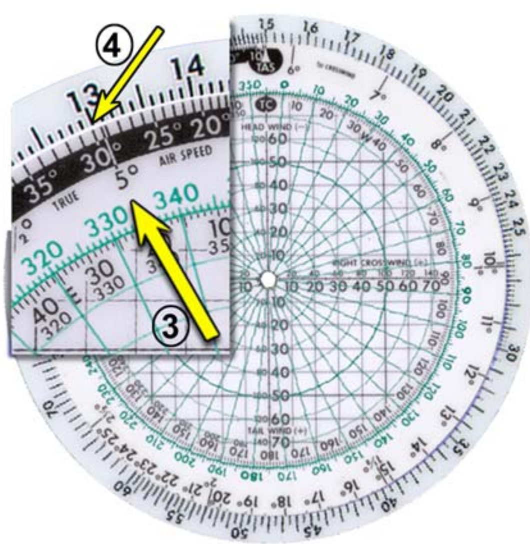

Figure 4.6-7 In-Flight Wind Calculation 3 & 4

5. Choose a scale and draw a vertical line representing the crosswind component (As per the estimate, to the left, because of the right drift) (Figures 4.6-8).

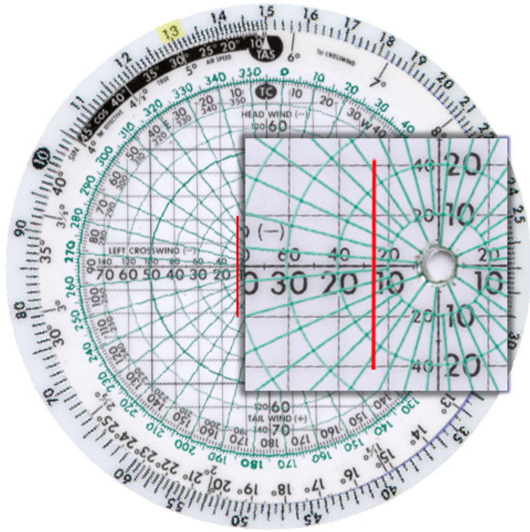

Figure 4.6-8 In-Flight Wind Calculation 5

6. Compare TAS to GS to obtain the HW/TW component (160 GS - 150 TAS = 10 kts TW, which also agrees with the estimate). Draw horizontal line along appropriate value (Figure 4.6-9).

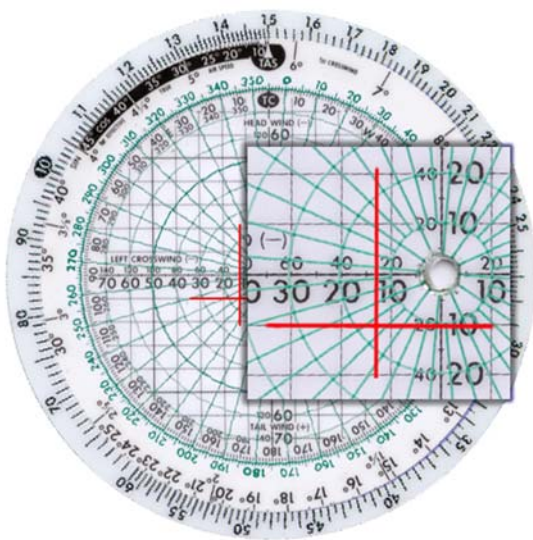

Figure 4.6-9 In-Flight Wind Calculation 6

7. Rotate the compass rose so that the intersection of the two lines is on the vertical scale (Headwind scale).

(Confirm Estimate!)

8. The direction of the wind is read on top of the TC arrow (228°). (Figure 4.6-10)

9. The magnitude is determined by using the same scale from steps 5 & 6, in this case 17 kts. (Figure 4.6-8, 4.6-9)

10. Verify the estimate.

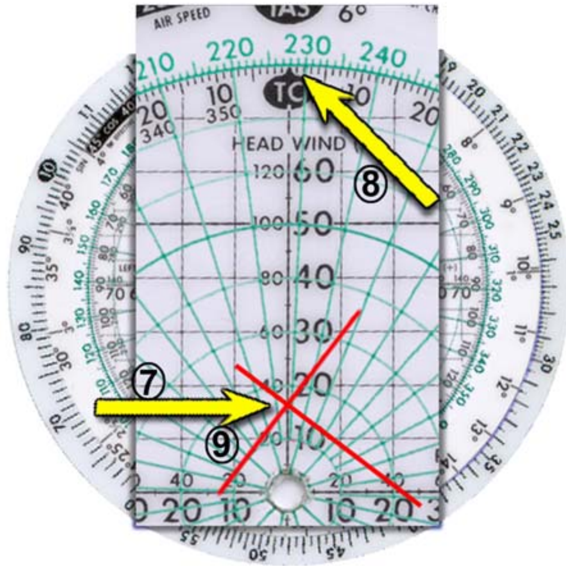

Figure 4.6-10 In-Flight Wind Calculation 7

SUMMARY OF STEPS NECESSARY TO SOLVE FOR THE WIND ARE:

(**ESTIMATE!)**

1. Set the TAS over the TAS index.
2. Set the TRACK over the TC index.
3. Input DA.
4. Read Crosswind.
5. Draw Crosswind.
6. Determine and draw Headwind/Tailwind component.
7. Rotate Intersection to 12 o'clock. (Confirm Estimate!)
8. Read Wind Direction.
9. Read Wind Velocity.
10. Verify the Estimate.

BDHI

Figure 4.6-11 BDHI

Recall in chapter 2 the information provided by the BDHI (Figure 4.6-11). A majority of an aircrew's navigation information will come from this instrument and will be the only type of electronic navigation available to the student aviator during the majority of training. It is imperative that the aircrew is able to build a picture, or an awareness, of where they are in flight using this instrument. In this course, only information provided by the #2 needle (thicker/double needle) will be covered. This will primarily be TACAN navigation.

TACAN POINT TO POINT NAVIGATION

An advantage to navigating with a TACAN is that an aircrew can navigate themselves directly from one TACAN radial/DME fix to another without first flying to the TACAN station. This is called POINT-TO-POINT NAVIGATION and can be accomplished with the CR-3 computer or with the BDHI.

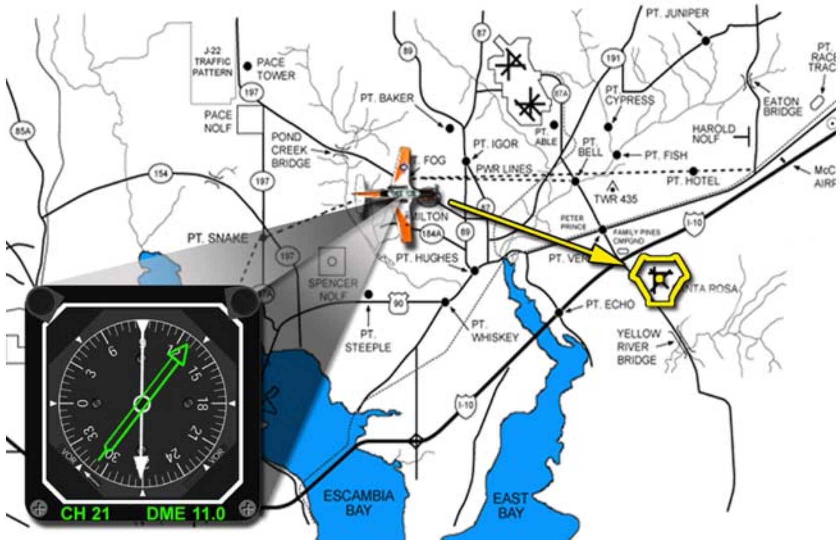

Figure 4.6-12 Tacan Point to Point 1

CR-3 POINT TO POINTS

When using the CR-3 computer to solve point-to-point navigation problems, visualize the wind side of the computer as a map with the center of the circular, green grid representing the TACAN station. The green numbers around the edge of the circular grid represent radials of the TACAN station. Each of the green concentric circles around the station represents range rings. The value assigned to each ring (distance) is printed on the Head/Tail/Crosswind lines. The following steps will utilize a present position of 307°/ 11 (307° radial at 11 DME) (Figure 4.6-12) and a destination of 180°/15.

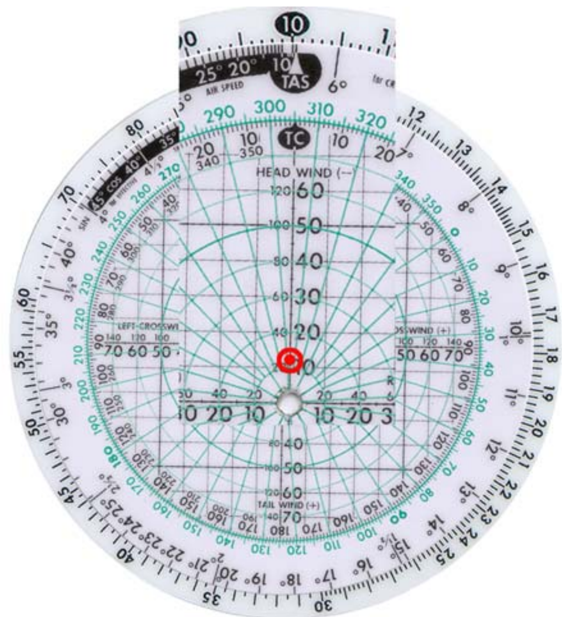

Figure 4.6-13 Tacan Point to Point 2

Once the radial and range have been determined for both the present position and the destination, merely plot each corresponding point on the wheel in a manner similar to plotting the wind in chapter 5 (Figures 4.6-13 & 4.6-14).

Now that the two points are plotted, and the computer is correctly oriented (with the black "TAS" and "TC" circles at the top), the direct course between the two fixes can be computed. To do this, first connect the two dots with a straight line. It's a good idea to mark the destination dot with a circle. This will help to avoid reading reciprocal courses.

Figure 4.6-14 Tacan Point to Point 3

The next step is to rotate the circular grid until the line connecting the two dots is vertical (parallel to the vertical grid lines). (Figure 4.6-15). Additionally, <u>the dot representing the destination must be above the dot representing the present position</u> (the arrow points up).

To find the direct course (no wind), read the number that is directly above the "TC" symbol at the top of the computer. That number (157) is the MAGNETIC course to the desired destination.

In effect, what was drawn is a point on a chart (green, circular grid) showing the present location and another point showing the destination. Then, a line was drawn connecting those two points; and the direction between the two points (the magnetic course) was determined.

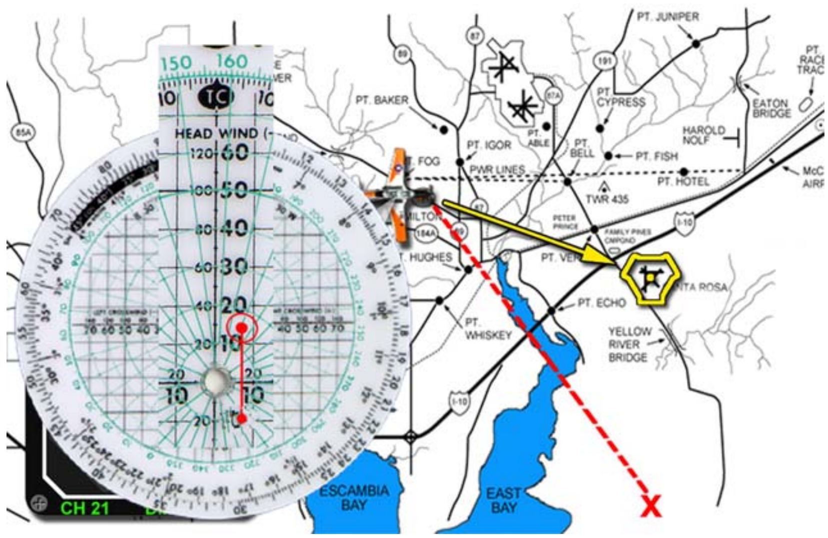

Figure 4.6-15 Tacan Point to Point 4

To determine the distance between the two points, utilize the Headwind/Tailwind scale as displayed on the CR-3. Read the appropriate displayed range <u>using the same scale</u> numbers used for plotting DME. The distance between the two points can now be found. In this case the distance is 24NM (2.4 squares at 10NM each). Therefore, if the aircrew flies a magnetic COURSE of 157 degrees for 24NM, they should arrive at the desired destination.

PRACTICE PROBLEMS

A. Given the following, determine the ***Drift Angle*** and ***In-flight Winds*** you are encountering:

	TH	TAS	TRK	GS	D A	X- W	H/ T	DIR	VEL
1	350	150	355	160					
2	091	200	100	180					
3	340	250	335	240					
4	186	130	195	150					
5	065	300	060	290					
6	305	400	314	340					
7	149	265	142	287					
8	275	324	281	284					
9	063	290	060	308					
10	208	445	201	495					
11	170	255	176	235					
12	171	450	168	418					
13	122	420	122	380					
14	160	340	158	342					
15	295	210	299	192					
16	011	300	008	322					
17	213	256	209	242					
18	248	280	240	285					
19	125	112	133	122					
20	225	358	228	365					
21	235	687	240	700					
22	105	250	113	220					
23	110	248	105	210					
24	115	257	106	265					
25	315	954	310	875					
26	225	568	229	550					
27	248	457	240	465					
28	167	851	175	825					
29	159	248	150	265					
30	128	210	135	205					
31	305	541	313	533					
32	248	620	250	600					
33	119	570	122	564					
34	106	541	109	535					
35	111	587	118	601					
36	210	248	215	268					
37	310	158	319	175					

	TH	TAS	TRK	GS	D A	X- W	H/ T	DIR	VEL
38	048	168	057	185					
39	150	164	158	175					
40	025	335	032	350					
41	358	125	003	133					
42	089	205	094	218					
43	148	695	140	705					
44	157	850	165	845					
45	248	450	250	435					
46	269	445	273	440					
47	258	205	266	213					

B. Apply the appropriate procedures for determining in-flight winds under the following conditions:

1. An H-3 is on a true heading of 085° and is experiencing 10° of right drift. The crew has determined the ground speed to be 125 kts. True air speed is determined to be 115 kts.

   a. What type of wind is the helicopter experiencing? ____________
   b. What is the actual wind being encountered? ____________

2. A P-3 is on a track of 175° and has traveled 125 nm since taking off 20 minutes ago. It has maintained a true heading of 185° and has flown at a constant TAS of 360 kts.

   a. What type of wind has it experienced? ____________
   b. What is the speed and direction on the winds encountered? ____________

3. Refer to the previous cross-country example (Nav-5, # 3): you maintained the desired TAS and altitude, and constant TH of 341°. Having determined your track as 346°, and arriving at point B at 1420 GMT, what were the actual winds encountered in flight? ___________

C. Given the following information, determine the *COURSE* and *DISTANCE* to be flown:

1. You are currently on the 210° radial at 30 DME. You are instructed to proceed to the 045° radial at 44 DME. What is the MC and distance to be flown? __________

2. You are instructed to proceed to the 332° radial at 84 DME. Currently, you are on the 010° radial at 13 DME. What is the MC and distance to be flown? __________

3. You have been cleared to proceed from your present position (refer to the BDHI on the right) to the 175° Radial at 28 nm. What is the MC and distance to be flown? __________

4. You have been cleared to proceed from your present position (refer to the BDHI on the right) to the 215° Radial at 44 nm. What is the MC and distance to be flown? __________

5. You have been cleared to proceed from your present position (refer to the BDHI on the right) to the 010° Radial at 55 nm. What is the MC and distance to be flown? __________

6. After completing a low-level flight on the VR-1355 on a heading of 256°, the aircrew tunes the TACAN to channel 85. In order to land back at Whidbey Island Naval Air Station and find that the #2 needle shows a bearing to the station of 251° and DME of 94 miles. Upon checking in with Approach control, they are informed to proceed to the holding fix (defined as the 020° radial at 15 DME). What is the magnetic course and distance from the current position to the holding fix?

7. On a heading of 087° southeast of Vance Air Force Base, an aircrew finds the #2 needle indicates a bearing to the Vance TACAN of 340° and that the DME is 53 miles. Vance approach instructs the crew to proceed to the initial approach fix (the Vance TACAN 170/15). What is the magnetic course and distance?

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ASSIGNMENT SHEET

Flight planning and Conduct
Assignment Sheet No. 4.7.1A

INTRODUCTION

The purpose of this assignment sheet is to aid the student in learning and understanding flight planning and conduct.

LESSON TOPIC LEARNING OBJECTIVES

TERMINAL OBJECTIVE:
Partially supported by this lesson topic:

4.0 Upon completion of this unit of instruction, the student will demonstrate, per NAVAVSCOLSCOMINST 1610.7 series, knowledge of the fundamentals of air navigation skills necessary for pilot or naval flight officer training.

ENABLING OBJECTIVES:
Completely supported by this lesson topic:

4.34 Demonstrate the methods of flight planning as they pertain to basic air navigation.

4.35 State the primary purpose of the jet log.

4.36 Demonstrate the techniques of time and fuel planning.

4.37 Determine the estimated time of arrival (ETA) at a destination when given an updated ground speed.

4.38 Determine the estimated fuel remaining (EFR) at the destination when given current fuel on board and a predicted fuel flow.

STUDY ASSIGNMENT

Study Information Sheet 4.7.1I and solve the practice problems at the end of the lesson topic.

INFORMATION SHEET

Flight Planning and Conduct
Information Sheet No. 4.7.1I

INTRODUCTION

Any successful military operation is a result of careful planning and coordination. This requires all participants in the operation to carefully plan each of their missions in order to execute the plan flawlessly and strive to be on target, on time. This chapter introduces methods that enable the aircrew to develop a basic flight plan incorporating elements from each preceding chapter.

REFERENCE

INFORMATION

FLIGHT PLANNING

FLIGHT PLANNING STEPS

Basic air navigation and flight planning, in general, follows four steps:

1. Measure True Courses and distances.
2. Use preflight winds to determine appropriate headings and Ground Speeds.
3. Using Ground Speed, compute an enroute time for each leg (ETE).
4. Using ETE and a given fuel flow, compute fuel consumption for each leg (Leg Fuel).

These steps incorporate everything that has been presented in this course so far and will enable the aircrew to arrive at their appointed place on time and with enough fuel. The result of these steps will be recorded on a card (called a Jet Log) to be referenced in flight.

JET LOGS

The primary purpose of the jet log is fuel management. The jet log also assists with enroute voice communications, navigation, and nav-aid identification. Other sections of the jet log provide the Warrior-Navigator with departure and destination airfield information. The jet log is about 5 X 7 inches in size, is designed to fit on a knee board, and gives the aviator instant access to important information. This is a single-source document, eliminating the need to reference other publications during critical phases of flight such as takeoffs and landings.

The jet log will be used by the student aviator to plan all T-34 instrument flights utilizing the enroute airways structure. The front and backsides of the jet log are shown in Figure 4.7-1. The various sections of the log will be introduced briefly in the following paragraphs.

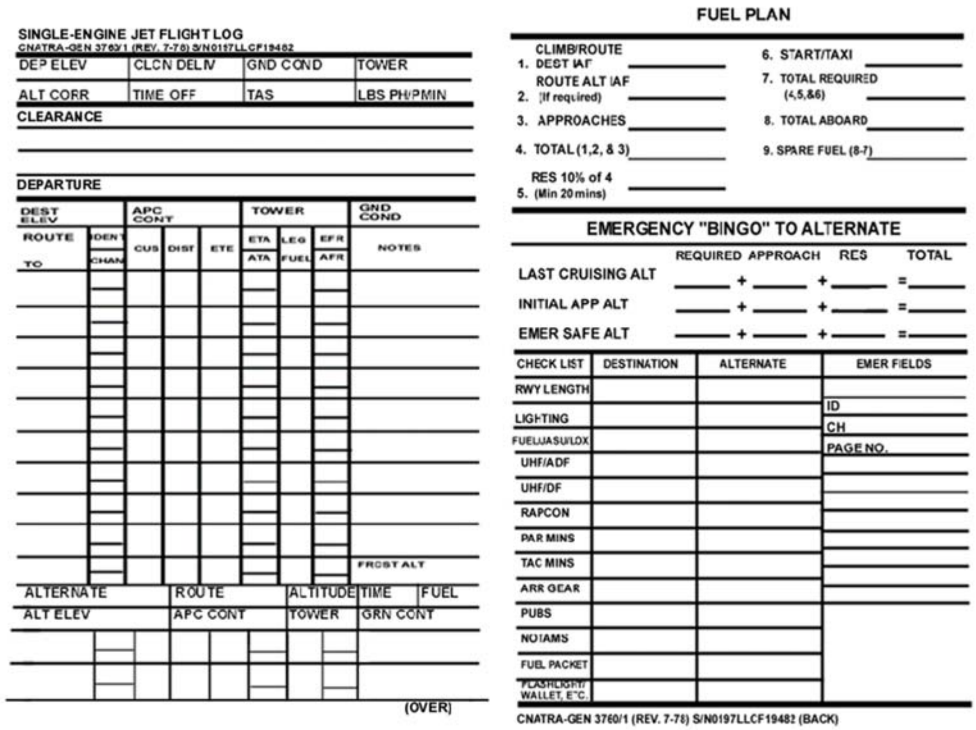

Figure 4.7-1 Jet Log

JET LOG FRONT

The departure section (Figure 4.7-2) contains blanks for information pertaining to the departure such as field elevation, communication frequencies, planned true airspeed, and planned fuel flow.

SINGLE ENGINE JET FLIGHT LOG CNATRA-GEN 3760.7 (REV. 7-1815/NOTPTLCF19492)			
DEP ELEV	CLNC DELAY	GND CONT	TOWER
ALT CORR	TIME OFF	TAS	LBS PH/PMIN

Figure 4.7-2 Departure Section

The clearance section (Figure 4.7-3) consists of space to copy the air traffic control (ATC) clearance which includes departure procedures, approved route of flight, altitude, and departure frequencies. This section is left blank during preflight planning and is filled in just prior to taxiing as the clearance is received over the radio.

CLEARANCE
DEPARTURE

Figure 4.7-3 Clearance Section

The destination section (Figure 4.7-4) contains blanks for information pertaining to the destination airfield such as airfield elevation and communication frequencies.

DEST ELEV	APC CONT	TOWER	GND CONT

Figure 4.7-4 Destination Section

ROUTE TO	IDENT / CHAN	CUS	DIST	ETE	ETA / ATA	LEG FUEL	EFR / AFR	NOTES
								FRCST ALT

Figure 4.7-5 Enroute Section

The en route section will be the only part of the jet log utilized in this course (Figure 4.7-5). It contains information about each leg along a route of flight. Starting from the left, there is space for information about the electronic nav-aids that will be used to define points along the route of flight. There are boxes for the magnetic course (CUS) and distance (DIST) for each leg of the flight. There are also columns for estimated time enroute (ETE), estimated time of arrival (ETA)/ actual time of arrival (ATA), leg fuel, and estimated fuel remaining (EFR)/ actual fuel remaining (AFR). The actual time of arrival and actual fuel remaining blocks are filled in during flight.

The alternate section (Figure 4.7-6) provides room for data necessary to safely divert to another field due to bad weather at the destination, fouled deck, etc.

FRCST ALT	ROUTE	ALT	TIME	FUEL
ALT ELEV	APC CONT	TOWER	GND CONT	

Figure 4.7-6 Alternate Section

JET LOG BACK

The fuel plan section (Figure 4.7-7) contains both a summary of the fuel required to complete the flight, including a reserve, and an emergency (Bingo) fuel to the alternate field at various flight profiles. Fuel consumption is unique to each individual aircraft and flight profile.

FUEL PLAN

1. CLIMB/ROUTE DEST IAF	______	6. START / TAXI	______
2. ROUTE ALT IAF (If required)	______	7. TOTAL REQ (4,5 & 6)	______
3. APPROACHES	______	8. TOTAL ABOARD	______
4. TOTALS (1,2, & 3)	______	9. SPARE FUEL (8-7)	______
5. RES 10% of 4 (Min 20 mins)	______		

EMERGENCY "BINGO" TO ALTERNATE

	REQUIRED		APPROACH		RES		TOTAL
LAST CRUISING ALT	______	+	______	+	______	=	______
INITIAL APP ALT	______	+	______	+	______	=	______
EMER SAFE ALT	______	+	______	+	______	=	______

Figure 4.7-7 Fuel Section

The checklist section (Figure 4.7-8) at the bottom of the card contains blanks for details about both the destination and alternate airfields. There are also a few blocks reminding the aircrew of items to check or bring along on the flight.

CHECK LIST	DESTINATION	ALTERNATE	EMERG FIELDS
RWY LENGTH			
LIGHTING			
FUEL/JASU/LOX			
UHF/ADF			
UHF/DF			
RAPCON			
PAR MINS			
TAC MINS			
APR GEAR			
PUBS			
NOTAMS			
FUEL PACKET			
FLASHLIGHT WALLET, ETC.			

Figure 4.7-8 Checklist Section

A sample completed jet flight log for a flight from NAS Jacksonville to NAS Whiting North is shown in Figure 4.7-9.

SINGLE ENGINE JET FLIGHT LOG
CNATRA-GEN 3760.7 (REV. 7-1815/NOTPTLCF19492)

DEP ELEV 30'	CLNC DELAY 268.7	GND CONT 336.4	TOWER 340.2
ALT CORR	TIME OFF	TAS 180 KTS	LBS PH/PMIN 250/4.2

CLEARANCE

DEPARTURE 372.0

DEST ELEV 22'	APC CONT 284.6	TOWER 355.8	GND CONT 336.4

ROUTE / TO	IDENT / CHAN	CUS	DIST	ETE	ETA / ATA	LEG FUEL	EFR / AFR	NOTES
CRESTVIEW	CEW / 119	S/D	69	0.30		79	706	5k JAX CENTER
V241 WIREGRASS	RRS / 53	073	71	0.24		100	606	
V7 TALLAHASSEE	TLH / 122	126	69	0.23		96	510	
V198 GREENVILLE	GEF / 27	088	31	0.10		24	486	
V198 TAYLOR	TAY / 76	091	64	0.21		51	435	
V198 MONIA INTXN	TAY / 76	096	26	0.09		22	413	JAX 114.5
D→ NIP	NIP / 49	130	25	0.08		19	394	NAS JACKSONVILLE
			355	2.05		391		
								FRCST ALT

FRCST ALT NAS CECIL FIELD NZC	ROUTE D→ NZC	ALT 4,000	TIME 0.04	FUEL 20
ALT ELEV 81	APC CONT JAX 284.6	TOWER 360.2	GND CONT 384.4	

Figure 4.7-9 Completed Sample Log

FLIGHT PLANNING EXAMPLE

As stated earlier, only the enroute section will be emphasized in this course. In the following example, a flight will be planned from Tyndall AFB (30° 04.2' N 085° 34.6' W) to Marianna Municipal (30° 50.1' N 085° 11.0' W) with an intermediate turn point over Blountstown Airfield (30° 27.0'N 085° 02.0' W). The preflight winds are 300/20, TAS=120kts, fuel flow=240pph and total starting fuel is 815 pounds. Takeoff time is 1400 Zulu.

STEP 1: MEASURE TRUE COURSES AND DISTANCES.

The first step in preflight planning is to measure the courses and the distances utilizing the procedures in chapter two. Doing this, a True Course to Blountstown from Tyndall is 051°T and from Blountstown to Marianna is 342°T. Figure 4.7-10 depicts a generalization of this route.

Figure 4.7-10 Course & Distance

Determine the distances and fill in the applicable blocks on the jet log as in Figure 4.7-11. Notice that any “given” information can be entered in the “notes” block for the starting point.

DEST ELEV		APC CONT			TOWER			GND COND
ROUTE TO	IDENT / CHAN	CUS	DIST	ETE	ETA / ATA	Leg Fuel	EFR / AFR	NOTES
TYNDALL							815#	TAS=120 FF=240PPH WINDS=300/20
BLOUNTSTOWN		051	36					
MARIANNA		342	25					

Figure 4.7-11 Step 1 Flight Planning

STEP 2: COMPUTING HEADING AND GROUNDSPEED

The next step is to use preflight winds to compute a True Heading from the True Course and the predicted ground speed for each leg. Using the procedures from chapter five, predicted heading and ground speed for the first leg are 042°T/127kts and for the second leg are 334°T/105kts.

The resulting heading and Ground Speed values can then be entered in the “notes” block to the far right of the jet log for reference during the flight (Figure 4.7-12).

DEST ELEV		APC CONT			TOWER			GND COND
ROUTE TO	IDENT / CHAN	CUS	DIST	ETE	ETA / ATA	Leg Fuel	EFR / AFR	NOTES
TYNDALL							815#	TAS=120 FF=240PPH WINDS=300/20
BLOUNTSTOWN		051	36					TH-042 GS=127
MARIANNA		342	25					TH=334 GS=105

Figure 4.7-12 Step 2 Flight Planning

STEP 3: COMPUTING ESTIMATED TIME ENROUTE (ETE)

Once a Ground Speed is determined, an estimated time enroute (ETE) can be calculated for each leg. This is the third step in preflight planning. The distance from Tyndall to Blountstown is 36NM and will be flown at a predicted Ground Speed of 127kts. Using the procedures from chapter three, an ETE of 17 minutes is calculated which can then be entered in the ETE block shown in Figure 4.7-13.

DEST ELEV		APC CONT			TOWER			GND COND
ROUTE TO	IDENT / CHAN	CUS	DIST	ETE	ETA / ATA	Leg Fuel	EFR / AFR	NOTES
TYNDALL							815#	TAS=120 FF=240PPH WINDS=300/20
BLOUNTSTOWN		051	36	17+00	1417+00			TH-042 GS=127
MARIANNA		342	25	14+18	1431+18			TH=334 GS=105

Figure 4.7-13 Step 3 Flight Planning

STEP 4: COMPUTING LEG FUEL AND ESTIMATED FUEL REMAINING (EFR)

The next step is to use the ETE just computed to find how much fuel will be used for each leg and the estimated fuel remaining (EFR) at the next point. The fuel flow for this problem is 240pph. Utilizing fuel computation procedures from chapter three, there will be 68# of fuel burned on the first leg. Subtract this leg fuel from the starting fuel (815#) to arrive at the estimated fuel remaining (EFR) over the next turn point, Blountstown. The results of these computations are entered in the appropriate jet log blocks as shown in Figure 4.7-14.

DEST ELEV		APC CONT			TOWER			GND COND
ROUTE TO	IDENT / CHAN	CUS	DIST	ETE	ETA / ATA	Leg Fuel	EFR / AFR	NOTES
TYNDALL							815#	TAS=120 FF=240PPH WINDS=300/20
BLOUNTSTOWN		051	36	17+00	1417+00	68#	747#	TH-042 GS=127
MARIANNA		342	25	14+18	1431+18	57#	690#	TH=334 GS=105

Figure 4.7-14 Step 4 Flight Planning

Each of the flight planning steps is repeated for the remaining legs and logged.

FLIGHT CONDUCT

IN-FLIGHT NAVIGATION

When the aircrew straps into the aircraft to execute their plan, the information on the jet log is nothing more than their best estimate as to what will happen. Aviation is a dynamic environment. Conditions or situations change rapidly and unexpectedly requiring the aircrew to adapt and rethink/recompute their plan continuously.

To the greatest extent possible, aircrew should strive to maintain their course as published or planned in order to maintain a safe and orderly flying environment. However, in this course, if the aircrew find themselves off course, merely compute a NEW course and heading to the turn point/destination using updated winds, and update the ETA and EFR.

FLIGHT CONDUCT (UPDATING) STEPS

Basic in-flight navigation follows four basic updating steps:

1. Plot fix and measure track/distance.
2. Measure updated true course/distance to next turn point.
3. Determine actual in-flight winds.
4. Apply new winds to remaining legs and update ETA and EFR.

FLIGHT CONDUCT EXAMPLE

Continuing with the flight planning example from Tyndall AFB to Marianna Municipal, enroute to Blountstown at an elapsed time of 5+05, the aircrew find themselves on the 205° radial from Marianna VORTAC (30° 47.2'N 085° 07.5'W) at a distance of 39NM. Fuel flow remains 240pph. Compute a new ETA and EFR at Blountstown.

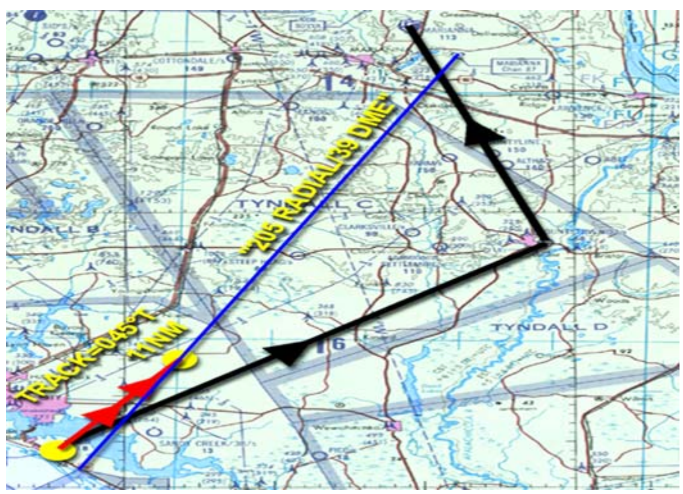

Figure 4.7-15 Track & Distance

STEP 1: PLOT FIX AND MEASURE TRACK/DISTANCE

The first step in this problem is to plot the given fix and measure the resulting track and distance flown. Plotting 205º/39 on the chart (don't forget to convert mag to true) and then measuring the line from Tyndall to this point yields a track of 045° TRUE and a distance of 11NM (Figure 4.7-15).

Fill in information as shown in Figure 4.7-16.

DEST ELEV		APC CONT			TOWER			GND COND
ROUTE TO	IDENT / CHAN	CUS	DIST	ETE	ETA / ATA	Leg Fuel	EFR / AFR	NOTES
MARIANNA 205/39		(TK) 045	11	5+05				
BLOUNTSTOWN								
MARIANNA								

Figure 4.7-16 Step 1 Flight Conduct

STEP 2: MEASURE UPDATED COURSE/ DISTANCE TO NEXT TURNPOINT

From the fix plotted in the first step, a new course line is drawn directly to the next turn point. Measuring this line yields a new True Course of 057º and a distance of 26 nm (Figure 4.7-17).

Figure 4.7-17 Track & New Course

Fill in information as shown in Figure 4.7-18.

DEST ELEV		APC CONT			TOWER			GND COND
ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	Leg Fuel	EFR AFR	NOTES
MARIANNA 205/39		(TK) 045	11	5+05				
BLOUNTSTOWN		057	26					
MARIANNA		342	25					

Figure 4.7-18 Step 2 Flight Conduct

STEP 3: DETERMINE ACTUAL WINDS

The True Heading for this leg was 042°T. Using this value, the Track of 045ºT, the TAS of 120, and the actual Ground Speed of 130 kts (using time and distance covered), actual winds of 254°/11 are computed.

Fill in information as shown in Figure 4.7-19.

DEST ELEV		APC CONT			TOWER			GND COND
ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	Leg Fuel	EFR AFR	NOTES
MARIANNA 205/39		(TK) 045	11	5+05				GS=130, TW=10, DA=3R LX-W=6,WNDS=254/11
BLOUNTSTOWN		057	26					
MARIANNA		342	25					

Figure 4.7-19 Step 3 Flight Conduct

STEP 4: APPLY NEW WINDS TO REMAINING LEGS AND UPDATE ETA AND EFR

The next step is to take these "new" winds and apply them to the new course to Blountstown (057°T) in order to determine a new True Heading and predicted Ground Speed. The True Heading is calculated to be 055ºT, and the Ground Speed is calculated to be 131kts.

With the new Ground Speed and remaining distance to Blountstown a new ETE can be calculated. Given this new ETE and the fuel flow, a new leg fuel is calculated. With the given fuel on board minus the calculated amount of fuel used up to this point (22#), a new EFR can be computed at Blountstown, just as in the preflight steps. In this case, the ETA will be 16+59 (11+54 ETE added to 5+05 elapsed time) with an EFR of 745.5# (815# start - 22# getting off course - 47.5# leg fuel).

Repeat these steps for the remaining legs to derive an ETA and EFR at the destination. The results are logged in the jetlog as in Figure 4.7-20.

DEST ELEV		APC CONT			TOWER			GND COND
ROUTE TO	IDENT / CHAN	CUS	DIST	ETE	ETA / ATA	Leg Fuel	EFR / AFR	NOTES
MARIANNA 205/39		(TK) 045	11	5+05	5+05	22	793#	GS=130, TW=10, DA=3R LX-W=6,WNDS=254/11
BLOUNTSTOWN		057	26	11+54	16+59	47.5	745.5	GS=131, TW=11 LXW=4, CA=2L, TH=055
MARIANNA		342	25	12+36	29+35	50.5	695#	GS=119, HW=1 LX-W=11, CA=5L,TH=337

Figure 4.7-20 Step 4 Flight Conduct

PRACTICE PROBLEMS

1. All of the following are basic air navigation flight planning steps except, _______.

    a. determine headings & ground speeds using preflight winds
    b. compute an ETE for each leg using ground speed
    c. use track to determine updated winds
    d. plot courses and measure distances

2. The primary purpose of a jet log is to provide the aviator with instant access to navigational information during critical phases of flight.

    a. TRUE
    b. FALSE

3. To plot a position on a Lambert Conformal chart when using TACAN radial/DME fix, ________ must be applied.

    a. magnetic variation
    b. instrument error
    c. deviation
    d. instrument variation

4. Using the practice chart, the jet log below, and the following preflight information, determine the EFR at Evadale.

    GIVEN: Route of Flight: Lake Charles, (30º 08.8'N, 093º 13.5'W) direct Jefferson, (29º 57.0'N, 094º 01.5'W) direct Evadale (30º 19.0'N, 094º 05.0'W). TAS is 190kts, fuel flow will be 120pph and Fuel on Board is 150lbs. Preflight winds are 080°/35.

DEST ELEV		APC CONT			TOWER			GND CONT
ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES

5. Eight minutes into the flight the aircrew fixes their position as the 080 Radial at 20 miles from the Beaumont VORTAC (Ch 92). What is the updated EFR over Evadale?

DEST ELEV		APC CONT			TOWER			GND CONT
ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES

6. Using the practice chart, the jet log below, and the following preflight information, determine the EFR at Beauregard.

GIVEN: Route of flight: Alexandria (31º 19.5’N, 092º 33.0’W) direct Natchitoches (31º 44.2’N, 093º 05.5’W) direct Beauregard (30º 50.0’N, 093º 20.0’W). TAS is 135, Fuel on Board is 200lbs with a fuel flow of 100pph. Preflight winds are 190°/45.

DEST ELEV		APC CONT			TOWER			GND CONT
ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES

7. Using the information given in question 6, the aircrew find themselves over Natchitoches at 0944Z. If they need to be overhead Beauregard at 1000Z, what GROUNDSPEED must they maintain enroute to Beauregard?

USE THE JETLOGS AT THE END OF THE CHAPTER AND THE CHART TO COMPLETE PROBLEMS 8 - 13.

8. Situation for Problem 8: Plan to depart from the carrier at 0200Z. Route of flight: Carrier (28º 05'N, 096º 25'W) direct MATAGORDA (28º 33'N, 096º 07W') direct PORT LAVACA (28º 39'N, 096º 41'W). CA is 2,000 ft, TAS is 160 kts. Fuel on board is 862 lbs, fuel flow will be 123 pph. The local altimeter is 30.42", temperature is +25ºC, and preflight winds are 130º/20 kts.

   a. Compute ETA and EFR at Port Lavaca.

   AT 0204Z, you are on the 173º radial, 31 DME of the Palacios VORTAC (28º 46'N, 096º 18'W).

   b. Plot your position, compute in-flight winds and update ETA and EFR at Port Lavaca.

9. Situation for Problem 9: You plan to depart from Huntsville at 1830Z. Route of flight is Huntsville (30º 45'N, 095º 35'W) direct Hearne (30º 53'N, 096º 37'W) direct Giddings Lee (30º 10'N, 096º 58'W). Planned flight altitude is 14,000 ft and the TAS is 260 kts. Forecast winds are 020º/30 kts with a temperature of -25ºC. The local altimeter is 29.42". Fuel at takeoff is 3,500 lbs with a fuel flow of 475pph.

   a. Compute ETA and EFR at Giddings Lee.

   At 1836Z, your BDHI shows a bearing to the College Station VORTAC (30º 35'N, 096º 25'W) of 247º at 21DME.

   b. Plot your position, compute in-flight winds and update your ETA and EFR at Giddings Lee.

10. <u>Situation for Problem 10</u>: Plan a flight to depart from Lockridge at 0200Z. Route of flight: Lockridge (31º 59'N. 095º 58'W) direct Cherokee Co. (31º 53N, 095º 13'W) direct Center (31º 50'N, 094º 09'W). CA is 10,000 ft. TAS 185 KTS. Forecast winds are 330º/ 25 kts and the temperature is -6ºC. The local altimeter is 30.92". Fuel on board is 1,200 lbs and fuel flow will be 245 pph.

   a. Compute ETA and EFR at Center.

   At 0204Z, your BDHI indicates a bearing to the Frankston VORTAC (32º 04'N, 095º 32'W) of 037º at 13 DME.

   b. Plot your position, compute in-flight winds and update ETA and EFR at Center.

11. <u>Situation for Problem 11</u>: Plan a flight to depart from Liberty at 0430Z. Route of flight: Liberty Airfield (30º 05.1'N. 094º 41.8'W) direct Livingston Airfield (30º 41.4’N, 095º 01.1’W) direct Navasota Airfield (30º 22.5'N, 096º 06.6'W). CA is 10,500 ft. TAS 175 KTS. Forecast winds are 130º/ 40 kts and the temperature is 16ºC. The local altimeter is 30.42". Fuel on board is 1,552 lbs and average fuel flow will be 131 pph.

   a. Compute ETA and EFR at Navasota.

   At 0438Z, your BDHI indicates a bearing to the Daisetta VORTAC (CH 116) of 145º at 16 DME.

   b. Plot your position, compute in-flight winds and update ETA and EFR at Navasota.

12. <u>Situation for Problem 12</u>: Plan a flight to depart from Angelina at 1430L. Route of flight: Angelina Airfield (31º 14.1'N. 094º 45.0'W) direct Cherokee Co. Airfield (31º 52.5’N, 095º 13.1’W) direct Carter Airfield (31º 34.0'N, 095º 46.0'W). TAS 148 KTS. Forecast winds are 358º/ 36 kts and the temperature is -26ºC. The local altimeter is 28.42". Fuel on board is 827 lbs and average fuel flow will be 110 pph.

   a. Compute ETA and EFR at Carter.

   At 1438L, your BDHI indicates you are on the Lufkin VORTAC (CH 58) 319 radial at 26.5 DME.

   b. Plot your position, compute in-flight winds and update ETA and EFR at Carter.

13. Situation for Problem 19: Plan a flight to depart from USS Lincoln at 1240L. Route of flight: Lincoln (29º 01.0'N. 092º 01.0'W) direct Williams Airfield (29º 42.8’N, 091º 20.6’W) direct Houma Terrebonne Airfield (29º 34.0'N, 090º 39.5'W). CAS 200 KTS, pressure altitude is 17,000’. Forecast winds are 158º/ 13 kts and the temperature is -75ºC. The local altimeter is 26.12". Fuel on board is 1100 lbs and average fuel flow will be 122 pph.

a. Compute ETA and EFR at Houma Terrebonne.

At 1249L, your BDHI indicates you are on the Tibby VORTAC (CH 57) 254 radial at 45 DME.

b. Plot your position, compute in-flight winds and update ETA and EFR at Houma Terrebonne.

ROUTE	IDENT	CUS	DIST	ETE	ETA	LEG	EFR	NOTES
TO	CHAN				ATA	FUEL	AFR	
								FRCST ALT

ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES
								FRCST ALT

ROUTE	IDENT	CUS	DIST	ETE	ETA	LEG	EFR	NOTES
TO	CHAN				ATA	FUEL	AFR	
								FRCST ALT

ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES
								FRCST ALT

ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES
								FRCST ALT

ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES
								FRCST ALT

APPENDIX 4.A

TOLERANCES

General

Final exam	80%
Pulling/Plotting Lat/Long	+/- 1 minute
Measure Direction	+/- 1 degree
Measuring Distance	+/- ½ nautical mile

CR 3

Front Side

Time	+/- one unit on logarithmic scale*****
Speeds	
Groundspeed	+/- one unit on logarithmic scale*****
True Airspeed	+/- 2 knots
Mach #	+/- .01
Distance	+/- one unit on logarithmic scale*****
Fuel Flow	+/- one unit on logarithmic scale*****
Fuel Quantity	+/- one unit on logarithmic scale*****

Back Side

Headwind/Tailwind Comp	If wind velocity < 70 knots +/- 3 knots If wind velocity ≥ 70 knots +/- 5 knots
Crosswind Components	If wind velocity < 70 knots +/- 3 knots If wind velocity ≥ 70 knots +/- 5 knots
In-flight Winds	If wind velocity < 70 knots +/- 3° and 3 knots If wind velocity ≥ 70 knots +/- 5° and 5 knots

Mission Planning/Jet Log EFR

Problem specific. Each problem takes into account each individual skill required to perform the task. Every skill has a tolerance, which creates a pyramid of possible answers. Using the pyramid enables us to ensure if you are within the tolerances for each individual skill. Maintaining this accuracy will allow you to be within the tolerances for the final EFR calculation!

*****+/- 1 unit on logarithmic scale is based on the distance per tick-mark on the 10 to 15 section of the CR-3. This equates to approximately +/- 1%.

PRACTICE PROBLEM ANSWERS

<u>CH1</u>

1. B
2. B
3. D
4. B
5. C
6. A
7. A
8. B
9. B
10. A

<u>CH2</u>

1. D
2. D
3 A
4. B
5. A
6. B
7. C
8. D
9. B
10. A
11. C
12. B
13. 28° 27.2’N, 091° 37.0’W
14. MC = 142°
    DIST = 14NM
15. 29° 37.0’N, 091° 39.2’W
16. 28° 07.9’N, 091° 09.0’W
17. 28° 15.8’N, 092° 06.8’W
18. MC = 356°
    DIST = 50.5NM
19. MC = 259°
    DIST = 61.5NM
20. 29° 22.5’N, 091° 23.2’W
    DIST = 40.6NM
    MC = 356°
21. MC = 190°
    DIST = 39NM
22. MC = 315°
    DIST = 30.5NM
23. MC = 173°
    DIST = 34NM
24. MC = 334°
    DIST = 70.6NM
25. 31° 15.6’N, 094° 07.7’W
    (BRIDGE)
26. 31° 31.5’N, 093° 48.0’W
    (BRIDGE)
27. 31° 32.8N, 095° 13.6’W
    (TOWN OF WECHES)
28. 31° 05.5’N, 092° 03.7’W
    (MARKSVILLE AIRFIELD)
29. 31° 43.0’N, 091° 32.5’W
    (TOWN OF CLAYTON)
30. 2220 LMT
31. 1830 LMT
32. 1010 GMT
33. 2252 GMT
34. 1712 LMT
35. 1115 GMT
36. 1110 LMT
37. 0215 LMT
38. 2030 LMT
39. 0120 GMT
40. 1200 LMT
41. YES! (1700 LMT)
42. 1335 LMT
43. 0600 LMT
44. 2200 LMT

CH3

TIME (hr+min+sec)		**SPEED** (KTS)		**DISTANCE** (NM)	
1.	1+24+48	1.	232	1.	440
2.	0+06+17	2.	150	2.	262
3.	1+18+00	3.	40	3.	207
4.	0+13+48	4.	240	4.	315
5.	4+32+00	5.	300	5.	.9
6.	0+01+26	6.	90	6.	1368
7.	0+00+17	7.	342	7.	930
8.	0+01+27	8.	900	8.	1210
9.	3+00+00	9.	300	9.	3.2
10.	7+14+00	10.	88	10.	962
11.	0+10+00	11.	720	11.	123
12.	1+23+00	12.	300	12.	93
13.	0+00+49	13.	184	13.	280
14.	0+25+24	14.	430	14.	5
15.	0+18+00	15.	400	15.	780
16.	4+50+00	16.	390	16.	175
17.	4+35+00	17.	400	17.	170
18.	0+00+50	18.	440	18.	64
19.	0+08+26	19.	340	19.	2800
20.	1+55+30	20.	180	20.	384
21.	0+16+54	21.	225	21.	1.4
22.	4+48+00	22.	309	22.	1250
23.	1+20+30	23.	450	23.	286
24.	0+55+00	24.	120	24.	2
25.	0+00+19	25.	348	25.	1610
26.	C	26.	B	26.	D
27.	C	27.	B	27.	B
28.	D	28.	C	28.	A
29.	D	29.	B	29.	A
30.	C	30.	B	30.	C

FUEL CONSUMPTION

1. 2124#
2. 49.5#
3. 1920#
4. 8400#
5. 2000PPH
6. 12+02
7. 10+42
8. 156PPH
9. 4050#
10. 3+38
11. 3850PPH
12. 1450#
13. 9700#
14. 427PPH
15. 0+35
16. 252PPH
17. 2475#
18. 1+45
19. 178PPH
20. 236PPH
21. 3120#
22. 18400#
23. 2+40
24. 465PPH
25. 960PPH
26. B
27. D
28. D
29. A
30. B

FUEL CONVERSION

1. 365 GAL
2. 638 GAL
3. 14980#
4. 2153 GAL
5. 4220#
6. 7800#
7. 1289 GAL
8. 19500#
9. 1855 GAL
10. 5590#

CH4

A.

	CALT	ALTIM	TEMP	PALT	CAS	TAS
1	N/A	N/A	10	10000	177	**208**
2	N/A	N/A	10	9000	177	**205**
3	N/A	N/A	10	10240	160	**190**
4	N/A	N/A	-12	19300	303	**396**
5	N/A	N/A	14	5940	126	**140**
6	N/A	N/A	-2	8320	151	**170**
7	N/A	N/A	-10	10000	177	**201**
8	N/A	N/A	0	10000	177	**205**
9	N/A	N/A	-5	8500	137	**154**
10	N/A	N/A	20	3720	219	**233**
11	10000	29.92	10	**10000**	177	**209**
12	10000	30.92	10	**9000**	177	**205**
13	11000	30.68	10	**10240**	160	**190**
14	19500	30.12	-12	**19300**	303	**396**
15	6000	29.98	14	**5940**	126	**140**
16	8000	29.60	-2	**8320**	151	**170**
17	10000	29.92	-10	**10000**	177	**201**
18	10000	29.92	0	**10000**	177	**204**
19	8000	29.42	-5	**8500**	137	**154**
20	3500	29.70	20	**3720**	219	**234**
21	10000	28.92	10	**11000**	177	**213**
22	8000	30.20	-7	**7720**	163	**179**
23	7500	28.92	5	**8500**	182	**207**
24	12000	30.42	-5	**11500**	180	**212**
25	2750	29.90	10	**2770**	180	**186**
26	6000	30.92	-10	**5000**	219	**226**
27	8500	29.50	-15	**8920**	203	**223**
28	11500	29.92	20	**11500**	298	**360**
29	4550	27.92	-20	**6550**	300	**309**
30	14925	28.50	0	**16345**	**233**	300
31	10500	30.42	5	**10000**	**280**	322
32	1700	28.42	-5	**3200**	**282**	283
33	8500	27.62	10	**10800**	**194**	232
34	3000	28.92	-10	**4000**	**195**	199
35	2380	29.02	-20	**3280**	**320**	311
36	6300	28.02	0	**8200**	**278**	306
37	5600	29.92	0	**5600**	**263**	278
38	8000	29.82	15	**8100**	**255**	290
39	7500	29.95	10	**7470**	**245**	274
40	6800	30.15	-10	**6570**	**235**	250
41	15000	28.95	-20	**15970**	450	**520**
42	14500	30.01	0	**14410**	500	**576**
43	8900	29.99	5	**8830**	475	**512**
44	6900	30.25	10	**6570**	460	**486**
45	6500	29.95	-25	**6470**	355	**358**
46	20000	29.92	-20	**20000**	274	**359**

	CALT	ALTIM	TEMP	PALT	CAS	TAS
47	15000	29.99	15	**14930**	315	**399**
48	1900	30.05	10	**1770**	495	**483**
49	18000	30.55	0	**17370**	800	**865**
50	30000	29.63	-5	**30290**	500	**716**

B.

51. **C**
52. **B**
53. **D**
54. **D**
55. **B**

CH5

	TC	TAS	DIR	KTS	X- W	C A	TH	H/ T	GS
1	218	325	100 \	40	**35 L**	**6 L**	**212**	**19 T**	**344**
2	299	164	340 \	30	**20 R**	**7 R**	**306**	**23 H**	**141**
3	110	280	330 \	30	**19 L**	**4 L**	**106**	**23 T**	**303**
4	045	350	180 \	50	**35 R**	**6 R**	**051**	**35 T**	**385**
5	040	400	080 \	100	**64 R**	**9 R**	**049**	**77 H**	**323**
6	010	170	210 \	60	**21 L**	**7 L**	**003**	**56 T**	**226**
7	250	330	210 \	80	**51 L**	**9 L**	**241**	**61 H**	**269**
8	292	164	340 \	32	**24 R**	**8 R**	**300**	**21 H**	**143**
9	176	150	220 \	35	**24 R**	**9 R**	**185**	**25 H**	**125**
10	190	220	010 \	20	**0 R**	**0 R**	**190**	**20 T**	**240**
11	325	150	120 \	20	**8 R**	**3 R**	**328**	**18 T**	**168**
12	188	234	030 \	20	**7 L**	**2 L**	**186**	**19 T**	**253**
13	040	135	270 \	28	**21 L**	**9 L**	**031**	**18 T**	**153**
14	054	186	360 \	14	**11 L**	**3 L**	**051**	**8 H**	**178**
15	253	136	290 \	33	**20 R**	**8 R**	**261**	**26 H**	**110**
16	300	175	010 \	16	**15 R**	**5 R**	**305**	**5 H**	**170**
17	252	170	198 \	27	**22 L**	**7 L**	**245**	**16 H**	**154**
18	127	192	320 \	18	**4 L**	**1 L**	**126**	**18 T**	**210**
19	136	204	040 \	22	**22 L**	**6 L**	**130**	**2 T**	**206**
20	115	114	310 \	46	**12 L**	**6 L**	**109**	**44 T**	**158**
21	087	192	050 \	40	**24 L**	**7 L**	**080**	**32 H**	**160**
22	294	325	170 \	48	**40 L**	**7 L**	**287**	**27 T**	**352**
23	334	100	310 \	33	**13 L**	**8 L**	**326**	**30 H**	**70**
24	246	165	180 \	14	**13 L**	**5 L**	**241**	**6 H**	**159**
25	232	231	250 \	48	**15 R**	**4 R**	**236**	**46 H**	**185**
26	265	320	030 \	50	**41 R**	**7 R**	**272**	**29 T**	**349**
27	218	257	110 \	24	**23 L**	**5 L**	**213**	**7 T**	**264**
28	279	145	310 \	36	**19 R**	**7 R**	**286**	**31 H**	**114**
29	065	410	210 \	25	**14 R**	**2 R**	**067**	**20 T**	**430**
30	265	253	330 \	28	**25 R**	**6 R**	**271**	**12 H**	**241**
31	024	230	160 \	12	**8 R**	**2 R**	**026**	**9 T**	**239**
32	250	460	010 \	60	**52 R**	**6 R**	**256**	**30 T**	**490**
33	115	300	045 \	10	**9 L**	**2 L**	**113**	**3 H**	**297**
34	105	200	125 \	95	**32 R**	**9 R**	**114**	**89 H**	**111**
35	148	150	330 \	15	**1 L**	**0 R**	**148**	**15 T**	**165**
36	135	115	125 \	85	**15 L**	**7 L**	**128**	**84 H**	**31**
37	127	800	315 \	75	**10 L**	**1 L**	**126**	**74 T**	**874**
38	159	458	050 \	20	**19 L**	**2 L**	**157**	**7 T**	**465**
39	220	658	110 \	65	**61 L**	**5 L**	**215**	**22 T**	**680**
40	257	521	210 \	30	**22 L**	**2 L**	**255**	**20 H**	**501**
41	198	547	310 \	55	**51 R**	**5 R**	**203**	**21 T**	**568**
42	248	841	115 \	45	**33 L**	**2 L**	**246**	**31 T**	**872**
43	258	621	225 \	50	**28 L**	**3 L**	**255**	**42 H**	**579**

	TC	TAS	DIR	KTS	X- W	C A	TH	H/ T	GS
44	147	210	135 \	45	**9 L**	**2 L**	**145**	**44 H**	**166**
45	159	541	245 \	35	**35 R**	**4 R**	**163**	**2 H**	**539**
46	257	687	155 \	60	**59 L**	**5 L**	**252**	**12 T**	**699**
47	248	214	265 \	25	**7 R**	**2 R**	**250**	**24 H**	**190**
48	205	368	175 \	70	**35 L**	**5 L**	**200**	**61 H**	**307**
49	159	985	285 \	15	**12 R**	**1 R**	**160**	**9 T**	**994**
50	167	623	195 \	80	**38 R**	**3 R**	**170**	**71 H**	**552**

B.

1. **25000**

2. CAS **187** TAS **242** GS **250**
PRESSURE ALT **17360** CROSS-WIND **45L**
H/T WIND **8T** CRAB **11L** TH **319**

3. A. **197**
B. **1427**

4. **Yes**. Your original plan, question #3, had you at 30,000' flying 300kts TAS. Spinning the winds (280°/22 kts) gives you 22 kts of headwind and a resultant ground speed of 278 kts on a course of 275°T.

After your instructor changed the plan you chose to go to 39,000', which gave you an OAT of -75° and winds at 320°/65 kts. A CAS of 190 kts at this altitude and temperature gives you a TAS of 337 kts. Spinning the winds gives you 45 kts of headwind resulting in a ground speed of 292 kts on a course of 275°T.

Therefore going higher, in this case, gets you to San Diego faster.

5. CAS **298** TAS **322** GS **276**
PRESSURE ALT **12360** CROSS-WIND **46L**
H/T WIND **46H** CRAB **8°L** TH **327°**

CH6

A.

	TH	TAS	TRK	GS	D A	X- W	H/ T	DIR	VEL
1	350	150	355	160	**5 R**	**13 L**	**10 T**	**229 **	**17**
2	091	200	100	180	**9 R**	**31 L**	**20 H**	**042 **	**37**
3	340	250	335	240	**5 L**	**22 R**	**10 H**	**040 **	**24**
4	186	130	195	150	**9 R**	**20 L**	**20 T**	**061 **	**28**
5	065	300	060	290	**5 L**	**26 R**	**10 H**	**128 **	**27**
6	305	400	314	340	**9 R**	**65 L**	**60 H**	**267 **	**88**
7	149	265	142	287	**7 L**	**32 R**	**22 T**	**266 **	**38**
8	275	324	281	284	**6 R**	**34 L**	**40 H**	**241 **	**52**
9	063	290	060	308	**3 L**	**15 R**	**18 T**	**200 **	**23**
10	208	445	201	495	**7 L**	**54 R**	**50 T**	**334 **	**74**
11	170	255	176	235	**6 R**	**27 L**	**20 H**	**123 **	**33**
12	171	450	168	418	**3 L**	**24 R**	**32 H**	**205 **	**39**
13	122	420	122	380	**0 R**	**0 L**	**40 H**	**122 **	**40**
14	160	340	158	342	**2 L**	**12 R**	**2 T**	**259 **	**12**
15	295	210	299	192	**4 R**	**15 L**	**18 H**	**260 **	**24**
16	011	300	008	322	**3 L**	**16 R**	**22 T**	**153 **	**27**
17	213	256	209	242	**4 L**	**18 R**	**14 H**	**262 **	**23**
18	248	280	240	285	**8 L**	**39 R**	**5 T**	**337 **	**39**
19	125	112	133	122	**8 R**	**16 L**	**10 T**	**010 **	**17**
20	225	358	228	365	**3 R**	**19 L**	**7 T**	**116 **	**20**
21	235	687	240	700	**5 R**	**60 L**	**13 T**	**137 **	**61**
22	105	250	113	220	**8 R**	**35 L**	**30 H**	**063 **	**46**
23	110	248	105	210	**5 L**	**22 R**	**38 H**	**135 **	**43**
24	115	257	106	265	**9 L**	**40 R**	**8 T**	**208 **	**41**
25	315	954	310	875	**5 L**	**83 R**	**79 H**	**357 **	**117**
26	225	568	229	550	**4 R**	**40 L**	**18 H**	**164 **	**44**
27	248	457	240	465	**8 L**	**64 R**	**8 T**	**337 **	**65**
28	167	851	175	825	**8 R**	**119 L**	**26 H**	**097 **	**121**
29	159	248	150	265	**9 L**	**39 R**	**17 T**	**262 **	**42**
30	128	210	135	205	**7 R**	**26 L**	**5 H**	**056 **	**26**
31	305	541	313	533	**8 R**	**75 L**	**8 H**	**225 **	**75**
32	248	620	250	600	**2 R**	**22 L**	**20 H**	**201 **	**30**
33	119	570	122	564	**3 R**	**30 L**	**6 H**	**042 **	**30**
34	106	541	109	535	**3 R**	**28 L**	**6 H**	**030 **	**29**
35	111	587	118	601	**7 R**	**71 L**	**14 T**	**017 **	**73**
36	210	248	215	268	**5 R**	**22 L**	**20 T**	**081 **	**30**
37	310	158	319	175	**9 R**	**25 L**	**17 T**	**195 **	**30**
38	048	168	057	185	**9 R**	**26 L**	**17 T**	**284 **	**30**
39	150	164	158	175	**8 R**	**23 L**	**11 T**	**042 **	**25**
40	025	335	032	350	**7 R**	**41 L**	**15 T**	**282 **	**43**
41	358	125	003	133	**5 R**	**11 L**	**8 T**	**235 **	**14**

	TH	TAS	TRK	GS	D A	X- W	H/ T	DIR VEL
42	089	205	094	218	**5 R**	**18 L**	**13 T**	**326 \ 23**
43	148	695	140	705	**8 L**	**96 R**	**10 T**	**235 \ 96**
44	157	850	165	845	**8 R**	**118 L**	**5 H**	**077 \ 118**
45	248	450	250	435	**2 R**	**16 L**	**15 H**	**203 \ 22**
46	269	445	273	440	**4 R**	**31 L**	**5 H**	**191 \ 31**
47	258	205	266	213	**8 R**	**29 L**	**8 T**	**160 \ 30**

B.

1. a. Left tail
   b. 338°/22kts

2. a. Right tail
   b. 278°/65kts

   3. 214°/33kts

C.

1. 039°M / 74nm

2. 326°M / 75nm

3. 147°M / 60nm

4. 239°M / 60nm

5. 349°M / 60nm

6. 259°M / 87nm

7. 335°M / 38nm

CH7

1. c.

2. b.

3. a.

4. 113#

DEST ELEV		APC CONT			TOWER			GND CNTL
ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES
Lake								FF=120 TAS=190
Charles					0+00		150#	WINDS=080/35
Jefferson		256	43	11.45	11+27	23#	127#	LX-W=3 CA=1L TH=255
				11+27				TW=34 GS=224
Evadale		353	22.5	7.2	18+39	14#	**113#**	RX-W=34 CA=10R TH=003
				7+12				HW=3 GS=188

5. Tracked 247ºT for 23.5 nm in 8 minutes yields in-flight winds of 305º / 27 kts. New EFR = 104#

DEST ELEV		APC CONT			TOWER			GND CNTL
ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES
Fix		247	23.5	8.0	8.0	16#		DA=7L GS=176 HW=14
BPT 080/20		(TK)		8+00	8+00		134#	RX-W=23 WINDS=305/27
Jefferson		265	20	7.1	15+06	14#	120#	RX-W=18 CA=6R TH=271
				7+06				HW=21 GS=169
Evadale		353	22.5	7.85	22+57	16#	**104#**	LX-W=20 CA=6L TH=347
				7+51				HW=18 GS=172

6. 115#

DEST ELEV		APC CONT			TOWER			GND CNTL
ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES
Alexandria								FF=100 TAS=135
					0+00		200#	WINDS=190/45
Natchitoches		312	38	14.5	14+30	23#	177#	LX-W=38 CA=16L TH=296
				14+30				TW=23 GS=158
Beauregard		194	56	37.4	51+54	62#	**115#**	LX-W=4 CA=2L TH=192
				37+24				HW=45 GS=90

7. 210 kts

8a.

DEST ELEV		APC CONT			TOWER			GND CNTL
ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES
USS Boat								FF=123pph TAS=160
					0200Z		862#	WINDS=130/20
Matagorda		029T		11.55	0211+24		839#	RX-W=20 CA=7R TH=036
			31.5	11+33		23#		TW=4 GS=164
Port		283T		10.1	**0221+30**		**818#**	LX-W=9 CA=3L TH=280
Lavaca			30	10+06		21#		TW=18 GS=178

8b.

DEST ELEV		APC CONT			TOWER			GND CNTL
ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES FF=123pph TAS=160
Fix		032	11.5	4.0	0204+00			GS=172 TW=12 DA=4L
PSX 173°/31		(TK)		4+00		8#	854#	RX-W=11 WINDS=170/16
		028T		7.0	0211+00		839.5#	RX-W=10 CA=4R TH=032
Matagorda			20	7+00		14.5#		TW=12 GS=172
		283T		10.8	**0221+48**		**817.5#**	LX-W=16 CA=6L TH=277
Port Lavaca			30	10+48		22#		TW=7 GS=167

9a.

DEST ELEV		APC CONT			TOWER			GND CNTL
ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES
Huntsville								FF=475pph TAS=260
					1830Z		3500#	WINDS=020/30
Hearne		277T		12.2	1842+12		3403#	RX-W=30 CA=7R TH=284
			54	12+12		97#		TW=5 GS=265
Giddings Lee		203T		9.5	**1851+42**		**3328#**	RX-W=2 CA=0 TH=203
			46	9+30		75#		TW=30 GS=290

9b.

DEST ELEV		APC CONT			TOWER 3500#			GND CNTL
ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES FF=475pph TAS=260
Fix		263T		6.0				GS=230 HW=30 DA=21L
CLL 067º/21		(TK)	23	6+00	1836Z	47.5#	3452.5#	RX-W=93 WINDS=335/97
		288T		9.85	1845+51		3374.5#	RX-W=70 CA=16R TH=304
Hearne			32	9+51		78#		HW=65 GS=195
		203T		8.5	**1854+21**		**3307#**	RX-W=72 CA=16R TH=219
Giddings Lee			46	8+30		67.5#		TW=65 GS=325

10a.

DEST ELEV		APC CONT			TOWER			GND CNTL
ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES
Lockridge								FF=245pph TAS=185
					0200Z		1200#	Winds=330/25
Cherokee Co.		101T		11.3	0211+18		1154#	LX-W=19 CA=6L TH=095
			38	11+18		46#		TW=17 GS=202
Center		093T		16.4	**0227+42**		**1087#**	LX-W=22 CA=7L TH=100
			54.5	16+24		67#		TW=14 GS=199

10b.

DEST ELEV		APC CONT			TOWER 1200#			GND CNTL
ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES FF=245pph TAS=185
Fix FZT 217º/13		110T (TK)	13.5	4.0 4+00	0204Z	16#	1183.5#	GS=202 TW=17 DA=15R LX-W=48 WINDS=002/51
Cherokee Co.		096T	25	7.95 7+57	0211+57	32.5#	1151#	LX-W=51 CA=16L TH=080 TW=4 GS=189
Center		093T	54.5	17.5 17+30	**0229+27**	71.5	**1079.5#**	LX-W=52 CA=16 TH=077 TW=2 GS=187

11a.

DEST ELEV		APC CONT			TOWER			GND CNTL
ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES
Liberty					0430Z		1552#	FF=131pph TAS=175 WINDS=130/40
Livingston		335T	40	11.4 11+25	0441+25	25	1527#	RX-W=17 CA=6R TH=341 TW=37 GS=212
Navasota		252T	59.5	18.5 18+30	**0459+55**	40	**1487#**	LX-W=34 CA=11L TH=241 TW=22 GS=197

11b.

DEST ELEV		APC CONT			TOWER			GND CNTL
ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES FF=131pph TAS=175
Fix DAS 325/16		344T (TK)	21	8.0 8+00	0438Z	17.5	1534.5#	GS=158 HW=17 DA=3R LX-W=9 WINDS=315/18
Livingston		326T	19.5	7.55 7+33	0445+33	16.5	1518#	LX-W=4 CA=0 TH=326 HW=18 GS=157
Navasota		252T	59.5	21.6 21+36	**0507+09**	47	**1471#**	RX-W=16 CA=5R TH=257 HW=8 GS=167

12a.

DEST ELEV		APC CONT			TOWER			GND CNTL
ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUE	EFR AFR	NOTES
Angelina								FF=110pph TAS=148
					1430L		827#	WINDS=358/36
Cherokee Co.		328T	45	23.2	1453+12	42.5	784.5#	RX-W=18 CA=7R TH=335
				23+12				HW=32 GS=116
Carter		237T	33.5	12.1	**1505+18**	22	**762.5#**	RX-W=31 CA=12R TH=249
				12+06				TW=19 GS=167

12b.

DEST ELEV		APC CONT			TOWER			GND CNTL
ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES FF=110pph TAS=148
Fix		321	22	8.0		14.5		GS=165 TW=17 DA=14L
LFK 319/26.5		(TK)		08+00	1438Z		812.5#	RX-W=36 WINDS=075/40
Cherokee Co.		334T	24	9.2	1447+12	17	795.5#	RX-W=39 CA=15R TH=349
				9+12				TW=8 GS=156
Carter		237T	34	11.0	**1458+12**	20	**775.5#**	LX-W=12 CA=5L TH=232
				11+00				TW=38 GS=186

13a.

DEST ELEV		APC CONT			TOWER			GND CNTL
ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES
USS Lincoln								FF=122pph TAS=223
					1240L		1100#	WINDS=158/13
Williams		040T	55	14.4	1254+24	29	1071#	RX-W=12 CA=3R TH=043
				14+24				TW=6 GS=229
Houma		104T	36.5	10.25	**1304+39**	21	**1050#**	RX-W=12 CA=3R TH=107
Terrebonne				10+15				HW=8 GS=215

13b.

DEST ELEV		APC CONT			TOWER			GND CNTL
ROUTE	IDENT	CUS	DIST	ETE	ETA	LEG	EFR	NOTES
TO	CHAN				ATA	FUEL	AFR	FF=122pph TAS=223
Fix		032	34.5	9.0		18		GS=230 TW=7 DA=11L
TBD 254/45		(TK)		9+00	1249L		1082#	RX-W=43 WINDS=130/43
Williams		053T	21.5	6.1	1255+03	12.5	1069.5#	RX-W=42 CA=11R TH=064
				6+03				HW=10 GS=213
Houma		104T	36.5	11.9	**1306+57**	24	**1045.5#**	RX-W=19 CA=5R TH=109
Terrebonne				11+54				HW=39 GS=184

APPENDIX 4.B

NAVIGATION PRACTICE EXAM

1. The three instruments essential for Dead Reckoning (DR) navigation are the compass, clock, and

   A. sextant.
   B. temperature gauge.
   C. altimeter.
   D. airspeed indicator.

2. What is the Local Mean Time (LMT) of arrival at Apalachicola (ZD -5) if an aircraft departs Waycross-Ware County at 1700 GMT with an estimated time enroute of 38 minutes?

   A. 1238 LMT
   B. 1738 LMT
   C. 1748 LMT
   D. 2238 LMT

3. The aircrew's primary instrument for determining direction in the aircraft is the

   A. wet compass.
   B. #2 needle.
   C. gyro indicator.
   D. remote gyro vertical compass card.

4. The secondary instruments used in DR navigation are the

   A. OAT and airspeed indicator.
   B. compass and airspeed indicator.
   C. altimeter and OAT.
   D. OAT and compass.

5. The tail of the #2 needle on a BDHI displays the magnetic

   A. heading to a VOR.
   B. bearing to a TACAN.
   C. heading to a TACAN.
   D. radial of a TACAN.

6. The actual path that an aircraft travels between two points is known as its

   A. course.
   B. track.
   C. drift.
   D. heading.

7. A true course is always

   A. the actual path the aircraft has flown over the ground.
   B. the same as the aircraft's true heading.
   C. the intended flight path of the aircraft.
   D. measured relative to the nose of the aircraft.

8. Isogonic lines connect points of equal

   A. elevation.
   B. deviation.
   C. variation.
   D. pressure.

9. What is the magnetic course from Groveton Trinity Airport (31º 05.0'N, 095º 09.5'W) to Cherokee Co. (31º 52.0'N, 095º 13.0'W)?

   A. 001º
   B. 081º
   C. 176º
   D. 351º

10. By definition, the following is/are (a) great circle(s):

   A. All parallels of latitude.
   B. Equator.
   C. Meridians.
   D. Both B and C

11. Using the BDHI to the right, what is the Lat/Long of the indicated position from the Lufkin VORTAC located approximately 31º 10.0'N, 094º 43.0'W?

A. 31° 11.0'N, 095° 02.5'W
B. 31° 14.2'N, 095° 02.5'W
C. 31° 05.5'N, 094° 23.5'W
D. 31° 11.7'N, 094° 51.0'W

12. If an aircraft is traveling at 650 knots, it will travel 1 NM in __________

A. 5.5 seconds.
B. 9.2 seconds.
C. 92 seconds.
D. .92 minutes.

13. How long can an aircraft fly with 121 GALLONS of fuel and a consumption rate of 160 pounds/hour? (Fuel density conversion factor is 6.2 pounds/gallon).

A. 0 hours 45 minutes
B. 2 hours 00 minutes
C. 3 hours 15 minutes
D. 4 hours 41 minutes

14. If a ground speed check indicates that an aircraft has flown 12 NM in 6 minutes, a flight of 2 hours and 34 minutes would cover a distance of

A. 308 NM.
B. 320 NM.
C. 470 NM.
D. 510 NM.

15. What is an aircraft's ground speed if it has flown 1 NM over the ground in 22 seconds?

A. 79 knots
B. 132 knots
C. 164 knots
D. 274 knots

16. What is the flight time available with a fuel supply of 1390 pounds and a consumption rate of 1200 pounds per hour?

    A. 1 hour 1 minute
    B. 1 hour 9 minutes
    C. 1 hour 17 minutes
    D. 1 hour 25 minutes

17. What is an aircraft's Mach number if it is flying at a pressure altitude of 15,000 feet, a CAS of 225 with an OAT of 40ºC?

    A. .45
    B. .48
    C. .50
    D. .52

18. What calibrated airspeed must they maintain if an aircrew desires to fly a TAS of 300 knots at a pressure altitude of 25,000 feet and an OAT of -25 degrees C?

    A. 180 knots
    B. 186 knots
    C. 204 knots
    D. 210 knots

19. What is the aircraft's Mach number if it is flying at a pressure altitude of 11,000 feet and a CAS of 800 knots?

    A. 1.38
    B. 1.43
    C. 1.46
    D. Need more information to determine Mach number

20. What is the aircraft's true airspeed if its CAS is 600 knots, the altimeter indicates 15,000 feet (zero error), the OAT is -30 degrees C, and the pressure altitude is 14,500 feet?

    A. 620 knots
    B. 626 knots
    C. 639 knots
    D. 700 knots

21. What is the pressure altitude if TAS is 170 knots, calibrated airspeed is 153 knots, and the OAT is -20 degrees C?

    A. 4,200 feet
    B. 5,600 feet
    C. 9,600 feet
    D. 11,200 feet

22. What is an aircraft's TAS if the altimeter indicates 32,000 feet (zero error), the IAS is 320 kts, the OAT is -60^{o}C, and the altimeter setting shows 30.92?

    A. 436
    B. 450
    C. 455
    D. 468

23. The air vector represents

    A. magnetic heading and true airspeed.
    B. true heading and ground speed.
    C. true heading and true airspeed.
    D. wind direction and velocity.

24. Wind direction and velocity at altitude are stated from

    A. a magnetic direction and speed in knots.
    B. a magnetic direction and speed in miles per hour.
    C. a true direction and speed in miles per hour.
    D. a true direction and speed in knots.

25. What TH and GS are predicted if an aircrew desires to fly a preflight TC of 206^{o} at a TAS of 470kts and the preflight winds are reported as 230/30?

    A. 190^{o}/443 kts
    B. 208^{o}/497 kts
    C. 208^{o}/443 kts
    D. 222^{o}/443 kts

26. What is the true heading and predicted ground speed of an aircraft if the wind is 151 degrees/47 knots, TAS is 120 knots, and the desired true course is 267 degrees?

A. 246 degrees/ 99 knots
B. 246 degrees/141 knots
C. 288 degrees/ 99 knots
D. 288 degrees/141 knots

27. While preflight planning for a true course of 285, an aviator is informed that the preflight winds are 107/40. How does the predicted TH and GS compare to the TC and TAS?

A. TH increases and GS increases
B. TH decreases and GS increases
C. TH increases and GS decreases
D. TH decreases and GS decreases

28. An aircrew desires to fly a true course of 290 degrees at a TAS of 192 knots. Winds are 050 degrees/40 knots. What true heading should be flown and what is the predicted ground speed?

A. 279 degrees/172 knots
B. 279 degrees/212 knots
C. 301 degrees/172 knots
D. 301 degrees/212 knots

29. Which of the following is a possible wind direction and velocity if an aviator finds their track has been 150 degrees after drifting right and noting that their groundspeed is less than their TAS?

A. 110 degrees/45 knots
B. 180 degrees/45 knots
C. 290 degrees/45 knots
D. 360 degrees/45 knots

30. What is the wind direction and velocity if, while flying on a true heading of 154 degrees at a TAS of 170 knots, an aircrew takes a fix and determines that the aircraft's track has been 144 degrees with a ground speed of 180 knots?

    A. 035 degrees/32 knots
    B. 249 degrees/10 knots
    C. 252 degrees/32 knots
    D. 252 degrees/46 knots

31. After determining that their groundspeed is greater than their TAS and that they have drifted right 33° to 333 degrees, the aircrew can estimate a possible wind direction of ___________.

    A. 010 degrees.
    B. 100 degrees.
    C. 195 degrees.
    D. 280 degrees.

32. What is the wind direction and velocity if an aircraft's track has been 103 degrees with a true heading of 091 degrees, groundspeed is 375, and TAS is 425?

    A. 043 degrees/ 50 knots
    B. 043 degrees/100 knots
    C. 095 degrees/ 50 knots
    D. 163 degrees/100 knots

33. Which of the following is a possible wind direction and velocity if the aircraft's track has been 214 degrees after drifting left 12 degrees and the groundspeed is greater than the TAS?

    A. 005 degrees/ 32 knots
    B. 097 degrees/ 24 knots
    C. 257 degrees/ 40 knots
    D. More information required to compute winds.

34. While enroute from Biggs AAF to MCAS Yuma, an aircrew determines that their groundspeed has been greater than their TAS and that they are drifting left. What general type of wind are they experiencing?

A. Left headwind
B. Right headwind
C. Left tailwind
D. Right tailwind

35. While enroute from Offut AFB to Patrick AFB, an aircrew determines that their groundspeed has been less than their TAS and that they are drifting left. What general type of wind are they experiencing?

A. Left headwind
B. Right headwind
C. Right tailwind
D. Left tailwind

36. An aircraft is flying with a true heading of 200 degrees and a TAS of 175 knots. 14 degrees of left drift is observed. What is the aircraft's track?

A. 186 degrees
B. 200 degrees
C. 214 degrees
D. More information required to determine aircraft's track

37. What course should be flown if an aircraft is currently on a magnetic heading of 275 degrees inbound to NAS Pensacola, the aircraft's TACAN shows it on the 064 degree radial at 60 DME, and approach control requests the aircraft proceed direct to the SANDY Intersection (310 degree radial at 50 DME)?

A. 095 degrees
B. 102 degrees
C. 275 degrees
D. 282 degrees

38. The jet log’s PRIMARY purpose is

A. to provide route navigation data.
B. for route timing.
C. for aircrew coordination.
D. for fuel management.

39. Using the figure to the right, what course and distance must be flown to proceed from the aircraft's present position direct to the 190 radial/25 DME?

A. 101 degrees/73 NM
B. 110 degrees/37 NM
C. 281 degrees/37 NM
D. 281 degrees/73 NM

40. All of the following are basic flight planning steps except

A. plot new course and distance using TACAN fix.
B. find heading and groundspeed using preflight winds.
C. compute leg fuel using ETE and fuel flow.
D. compute enroute time using groundspeed.

CONTINUED ON THE PRACTICAL EXERCISE

NAVIGATION PRACTICE EXAM

Practical Exercise

DIRECTIONS for questions 41 and 42: Use the appropriate area on your TPC chart and write your answers on the jet log sheet provided.

SITUATION FOR ITEM 41:
Route of flight: DeSoto airport (32º 04’N, 093º 46’W) direct Joyce airfield (31º 58’N, 092º 40’W) direct Hart airfield (31° 33’N, 093° 29’W).

TAS will be 190, with a current fuel on board of 1800 lbs and a fuel flow of 240pph. The preflight winds are 353/28.

41. What is the EFR overhead Hart airfield?

SITUATION FOR ITEM 42:
After 6 minutes and 42 seconds of flight, the aircraft is found to be directly overhead the 469’ tower located approximately 32º 05’N, 093º 13’W.

42. Following the planned route of flight, calculate the actual winds and compute the EFR overhead Hart airfield.

END OF PRACTICE EXAM

41.

ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES

42.

ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES

NAVIGATION PRACTICE EXAM ANSWER KEY

1.D	11.B	21.C	31.C
2.A	12.A	22.C	32.B
3.D	13.D	23.C	33.A
4.C	14.A	24.D	34.D
5.D	15.C	25.C	35.B
6.B	16.B	26.B	36.A
7.C	17.A	27.B	37.C
8.C	18.C	28.D	38.D
9.D	19.B	29.A	39.D
10.D	20.B	30.C	40.A

41.

DEST ELEV		APC CONT			TOWER			GND CNTL
ROUTE TO	IDENT / CHAN	CUS	DIST	ETE	ETA / ATA	LEG FUEL	EFR / AFR	NOTES
DeSoto								FF=240 TAS=190
							1800	WINDS=353/28
Joyce		096T	56.8	17.3	17+18	69#	1731	LX-W=28 CA=8L TH=088
				17+18				TW=7 GS=197
Hart		238T	49.2	14.6	31+54	58.3#	**1672.7**	RX-W=26 CA=8R TH=246
				14+36				TW=13 GS=203

42.

DEST ELEV		APC CONT			TOWER			GND CNTL
ROUTE TO	IDENT / CHAN	CUS	DIST	ETE	ETA / ATA	LEG FUEL	EFR / AFR	NOTES FF=240 TAS=190
Fix		090T	28	6.7		26.8#		GS=250 DA=2R LX-W=7
469’ Tower		(TK)		6+42	6+42		1773.2	TW=60 WINDS=276/61
Joyce		103T	29.3	7.0	13+42	28#	1745.2	RX-W=7 CA=2R TH=105
				7+00				TW=60 GS=250
Hart		238T	49.2	20.65	34+21	82.8#	**1662.4**	RX-W=37 CA=11R TH=249
				20+39				HW=47 GS=143

APPENDIX 4.C

Practice Jet Logs

ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES
								FRCST ALT

ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES
								FRCST ALT

ROUTE	IDENT	CUS	DIST	ETE	ETA	LEG	EFR	NOTES
TO	CHAN				ATA	FUEL	AFR	
								FRCST ALT

ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES
								FRCST ALT

ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES
								FRCST ALT

ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES
								FRCST ALT

ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES
								FRCST ALT

ROUTE TO	IDENT CHAN	CUS	DIST	ETE	ETA ATA	LEG FUEL	EFR AFR	NOTES
								FRCST ALT