Objectives	• Understand the elements related to navigation and flight planning
Elements	• Terms • Aeronautical Charts • Pilotage • Dead Reckoning • Radio Navigation • Whether Check • Using a Flight Log • Flight Planning • The Nav Log • GPS Navigation • Filing a Flight Plan • Diversion to an Alternate • Lost Procedures
Schedule	• Review lesson objectives • Review lesson material • Conclusion & Review
Equipment	• White Board / Markers • Aeronautical Charts • Navigation Log • Flight Computer
CFI Actions	• Present lesson • Use teaching aids • Ask/ answer questions
Student Actions	• Participate in discussion • Take notes • Ask / answer questions
Completion Standards	• The student can properly plan and execute a cross country flight to any chosen destination

Additional Notes: _____
_____
_____

CE = Common Error

Introduction

Overview

Review objectives / Elements

What

Navigation and flight planning is the process of planning and executing cross country flights

Why

The fundamentals of flight planning will make flight planning easier and more organized as well as provide procedures for situations that could arise on these flights

How

Terms

Navigation Terms

- True course -
- True Heading
- Magnetic Course
- Magnetic Heading
- Wind Correction Angle
- Compass Heading
- Magnetic Deviation
- Magnetic Variation

Atmospheric Terminology

- Standard Pressure
- Standard Temperature

Altitude Terminology

- Indicated Alt
- Pressure Alt
- Density Alt
- True Alt
- Absolute Alt

Airspeed Terminology

- Indicated (IAS)
- Calibrated (CAS)
- Equivalent (EAS)
- True (TAS)
- Groundspeed (GS)

Aeronautical Charts

- The roadmap for us VFR pilots
- Provides info that allows us to track position and increase safety
- Types of charts: Sectional Chart, Terminal Area chart (TAC), World aeronautical chart

Sectional Charts

- Provides information on topology, airspace, airways, and other terrain features useful to VFR navigation
- 1:500,000 Scale (1in = 6.86NM/8SM)
- Revised every 6 months

VFR Terminal Area charts

- Provides more detailed information on areas near congested class B airspace
- 1:250,000 Scale (1in = 3.43NM/4SM)
- Revised every 6 months

World aeronautical charts

- Provide a larger area than the traditional sectional chart allowing faster aircraft to navigate easier
- 1:1,000,000 Scale (1in = 13.7NM, 16SM)
- Lack some detail compared to sectional charts due to scale
- Revised annually

Importance of updated charts

- It is vitally important to check the publication date of the chart before use
    - Revisions may include radio frequencies, new obstructions, temporary or permanent closing of runways or airports, and other temporary or permanent hazards to flight
- Obsolete charts should NEVER be used for navigation

Pilotage, Dead Reckoning & Radio Navigation

Pilotage

- **Definition - Navigation by reference to landmarks or checkpoints**
- **A method of navigation that can be used on any course with adequate checkpoints, but is more commonly used with dead reckoning and VFR radio navigation**
    - It becomes difficult in areas lacking prominent landmarks or in low visibility
- **The checkpoints used should be prominent features common to the area of flight**
    - Choose checkpoints that can be readily identified by other features such as roads, rivers, railroad tracks, lakes, and power lines
        - Roads shown are usually the most traveled/easily visible from the sky
            - New roads and structures are constantly being built and may not be on the chart
- **If possible, select features that will make useful boundaries on each side of the course**
    - Keep from drifting too far off course be referring to and not crossing selected brackets
- **Never place complete reliance on any single checkpoint, choose ample checkpoints**

- If one is missed, look for the next one while maintaining the necessary heading
- Turn based on time if the checkpoint is not in sight, do not continue blindly

Dead Reckoning

- **Definition - Navigation solely by computations based on time, airspeed, distance, and direction**
  - The products derived from these, when adjusted by wind speed and velocity, are heading and ground speed (GS)
    - The predicted heading will guide the airplane along the intended path and the GS will establish the time to arrive at each checkpoint and destination
- **Except for flights over water, dead reckoning is usually used with pilotage**
  - Heading and GS is constantly monitored and corrected by pilotage as observed from checkpoints
  - Ideally, Radio navigation should be added so that a pilot uses all three forms of navigation
    - Start with dead reckoning and confirm with pilotage and radio navigation

Radio Navigation

- **Definition - Navigation by which a predetermined flight path is followed by using radio waves**
- **There are four radio navigation systems available: VOR, NDB, LORAN-C, GPS**
  - Aircraft equipment and preference will dictate which system to use
    - GPS and VOR are the most common
    - NDB and LORAN are almost non-existent

Pilotage, Dead Reckoning & Radio Navigation

- **Obtaining a preflight weather briefing is the first step to determine if the flight can be conducted safely**
- **FAR 91.103 requires familiarity with weather reports and forecasts for the flight**

Go / No – Go Decision

- **Good judgment is necessary in deciding whether to take the flight**
  - A dangerous condition could end badly
- **Weather factors must be considered in relation to the equipment to be flown**
  - Can the aircraft handle the flight?
    - Are any limitations exceeded
- **The following conditions may lead to a No-Go Decision**
  - T-Storms of any kind, especially embedded
  - Fast-moving fronts or squall lines
  - Moderate or greater turbulence
  - Icing
  - Fog, or other visual obscurations
  - Excessive wind

Physical / Mental condition

- **Sick, tired, upset, depressed – These factors can affect your ability to handle any problem**

- **IMSAFE checklist**

Recent Flight Experience

- **Don't go beyond your abilities or the airplane's abilities**
  - Example: Are you comfortable in MVFR if you haven't flown in a while?

Using A Flight Log

- **The navigation log will assist in planning and conducting the flight**
  - It prepares the information in a logical sequence allowing the pilot to track the progress of the flight
  - Necessary frequencies, waypoints, headings, etc. are in order and easy to find for the pilot's use

Flight Planning

Plotting a Course

- **First, draw the route**
- Draw a line (or lines depending on your course) from Point A to Point B
  - If the route is direct, the course will consist of a single straight line
  - If not, it will consist of 2 or more straight line segments
    - For example, a VOR station which is off the direct route but will make navigating easier
  - Always consider terrain, airspace, navigation capabilities, etc. when choosing the route
- Decide what altitude you will fly the trip it based on the direction of flight, terrain, fuel, etc.

Checkpoints

- **Recognizable points along your route of flight used to maintain your course**

Top of Climb (TOC)

- **First, map out your top of climb waypoint, this will provide a reference for the time, and distance using a climb power setting (increased fuel burn)**
  - Based on Rate of Climb info and desired cruising altitude calculate the distance to reach the top of climb
    - Rate of Climb can be calculated in the AFM (ex. 1,000 fpm)
    - **Altitude to climb:** Cruising altitude – Airport Elevation (ex. 6,500' -500' = 6,000' to climb)
    - 6,000' to climb at 1,000 fpm = 6 minutes of climbing
    - Use your groundspeed in the climb (TAS adjusted for wind) in order to find the distance it will take to climb to 6,500' MSL
      - Ex. If your GS is 90 knots in the climb, then it will take 9 NM to reach your altitude
        - 6 min/60 min = 1/10 of an hour of climbing
        - Every hour the aircraft travels 90 NM, therefore (90 NM/hr)(1/10 hr) = 9 NM
- **Label the TOC on your course 9 nm from the departure airport**
  - Attempt to find a checkpoint that corresponds with the TOC

Top of Descent (TOD)

- **Second, map out your top of descent waypoint, this will provide a point to start the descent into the terminal area of your destination**
  - Based on Rate of Descent info and cruising altitude
    - Rate of Descent is up to you (we'll use 1,000 fpm as an example)
    - Altitude to descend (Cruising Altitude – Airport Elevation)
      - Ex.6500'-1200'=5,300' to descend
        - Note: Rather than making the calculation based on descending to the airport elevation (the ground) it may be more beneficial to use pattern altitude instead
    - Time to descend: 5,300' to descend at 1000fpm
      - How many minutes will it take to descend 5,300' when you are descending at 1000fpm
        - 5,300/1,000 = 5.3 minutes
    - Distance to descend:
      - Using your ground speed calculate how far you will travel in 5.3 minutes
      - If Ground speed = 150 kts, then you need to start your descent 13-14 NM from the airport
        - 5.3 minutes/60 minutes = 0.088 hours (convert minutes to hours)
        - 0.088 hours * 150 kts / hr. = 13.25 NM
      - Plan to start the descent at about 14nm from the airport
      - We can use the 3/1 rule
        - AGL*3 in thousands of feet = distance to place TOD
      - Mark this point on the course
        - Find a visual checkpoint nearby this

Enroute

- Find additional checkpoints along the route the bridge the gap between the TOC and TOD
  - These will be used to ensure you maintain the desired route
  - Distance between checkpoints can vary based on the trip, terrain and personal minimums
    - A checkpoint every 10-25 miles is a good place to start
    - Don't overburden yourself
  - Checkpoints should be easy to locate points like large towns, lakes and rivers, or combinations of recognizable points like towns with an airport, or a network of highways or railroads, geographic features like mountain ranges are also helpful
- Record your TOC, TOD, and additional checkpoints on your Nav Log

Fuel Stops

- **Plane fuel stops based on personal comfort, and at a minimum, on regulatory requirements**
  - **FAR 91.151** requires that there be enough fuel on board the airplane to fly to the point of intended landing and, at normal cruise power, to fly for at least
    - 30 min during the day, or 45 min during the night
- **Plan accordingly!**

Overview & what if's

- **Once the course is drawn, survey the route of flight**
  - Look for available alternate airports along the route
  - Look at the terrain (mountains, swamps, water, etc.) that would have impact if an emergency landing were necessary
  - Mentally prepare for any type of emergency situation and the appropriate action to be taken
  - Also, ensure the route of flight does not penetrate any restricted (if in use) or prohibited areas

The Nav Log

- **Start by finding the True Airspeed for the trip and record it on your Nav Log**
  - Use the chart provided in the aircraft POH
- **Now that the course is drawn, and the checkpoints are marked, find the distance between each of the checkpoints by measuring the course on the map**
  - Input these distances in the Nav Log
- **Next, find the true course for each leg of the flight plan**
  - True Course (TC) – Direction of the line connecting two points drawn on the chart and measured clockwise in degrees from True North
    - North is always straight up when measuring true course
    - Use your plotter to find the True Course
- **Adjust True Course for wind in order to get True Heading**
  - On the back of the flight computer calculate the Wind Correction Angle and add/subtract it to/from the True Course in order to get your True Heading
    - Add West, subtract East corrections (East is least, West is best is a decent memory aid)
    - Also make a note of the Ground Speed for each leg of the flight on the Nav Log
- **Finally, adjust the True Heading in order to find Magnetic Heading**
  - Magnetic Heading - Magnetic variation is applied to True Heading
    - Using the isogonic lines on the sectional, add or subtract the necessary number of degrees in order to find the magnetic heading required to maintain your course
  - If necessary, get your Compass Heading by adjusting for Deviation with the correction card near the compass of your aircraft
- **At this point your Nav Log should have all of the checkpoints listed, each with a distance, a True Course, True Heading, Magnetic Heading, Compass Heading, as well as an altitude and Ground Speed**
- **Next is the Time and Distance Information**
  - Since you already have the Distance and Ground Speed between each point, calculate the estimated amount of time for each leg
    - Distance = Rate x Time, so Time = Distance/Rate (or Ground Speed)

- **Finally, use the Time for each leg in order to find the fuel burn for each leg**
  - Using the POH find your fuel burn for Climb, Cruise, and Descent
    - It will be shown in Gallons per hour
    - Convert your time for each leg into hours and then find the gallons burned per leg
      - ❖ This can be done using the flight computer or a calculator
- **All of this should be entered in the Navigation Log**

GPS Navigation

- **The GPS is an extremely useful tool, and should be used once the pilot is capable of competently navigating without it**
  - Great for situational awareness
    - **Don't get complacent with the GPS and lose situational awareness**, a GPS failure in this case could be hazardous
    - If the GPS fails, you must be able to safely continue along the route by means of pilotage and dead reckoning

Filing a Flight Plan

- **Not required but it is a good operating practice since the info can be used for search and rescue**
- **Filing can be done on the ground or in the air**
  - **On the ground: Call the FSS (1 800-WX BRIEF)**
- **After takeoff, contact the FSS by radio and give them the takeoff time to activate the flight plan**
  - Once filed, the flight plan will be held for an hour after the proposed departure time
- **Don't forget to close the flight plan!!!**
  - The FAA will begin a search 30 min after the scheduled arrival time if the flight plan is not closed

Diversion to an Alternate

- **There will probably come a time when you cannot make it to the planned destination**
  - This can result from weather, malfunctions, poor planning, fuel, pilot/passenger fatigue/illness, etc.
- **Before flight, check the route for suitable landing areas and for nav aids that can be used in a diversion**
  - Take advantage of all shortcuts/rule of thumb computations when computing course/speed/distance
- **Thumb technique to estimate distance**
  - Using the scale on your map, figure out approximately how far from the fingertip of your thumb (toward the knuckle) 10 NM is
  - In the case of a diversion use your thumb to quickly measure the number of 10 nm increments to the alternate airport

- This will provide a rough distance estimate for quicker, less stressful time and fuel calculations
- **Use a compass rose, airway or any other reference to determine the approximate new heading**
  - Choose an alternate shown on your sectional or use the 'Nearest' page in the GPS

diversion Procedure

- **Confirm your present position on the sectional chart**
- **Divert immediately toward the alternate using shortcuts/rule of thumb calculations (above)**
  - Completing all measuring, plotting, computations first may aggravate the situation
  - Once established on course, note the time
    - Use the winds aloft nearest the diversion point to calculate a heading and GS
      - Once determined, calculate a new arrival time and fuel consumption
      - Give priority to flying while dividing attention between navigation and planning
    - When determining an altitude, consider cloud heights, winds, terrain, etc.

Lost Procedures

Avoiding Becoming Lost

- **Always know where you are - Plan ahead, Know the next landmark/Anticipate Nav indications**
- **If the radio nav systems/visual observations do not confirm expectations, take corrective actions**
  - Use multiple landmarks to verify your position
    - If possible don't depend on one landmark

What to do if you become Lost

- **Don't Panic**

The Five C's

- **CLIMB – This will allow you to see more ground, increasing chances of spotting a landmark**
  - Improves radio reception, extends the transmitter range, and increases radar coverage
- **COMMUNICATE – use the frequencies on the chart, including RCO frequencies at VOR stations**
  - A controller can provide radar vectors
  - **Use 121.5 if the situation becomes threatening and squawk 7700**
- **CONFESS – Tell any ATC facility the situation**
- **COMPLY – Comply with any ATC suggestions**
- **CONSERVE – Reduce power/airspeed for max endurance or range (whichever is appropriate)**

PLUS

- **Check the heading indicator with the magnetic compass**
  - If there is an error, note the direction of error before resetting the heading indicator
    - This can help determine whether you are right or left of course
      - ❖ EX: if the compass indicates 10^{o} > than the heading indicator, you may be to the right of course
- **Use navigational radios (VOR/ADF) to attempt to plot your position in relation to two navaids**
  - GPS can also be used to determine location
- **If near a town the name of the town may be visible on a water tower**

Conclusion & Review

Review the Main Lesson Points

Cross country flight planning requires a lot of preflight work! It also helps to prevent getting lost and keeps us away from potentially dangerous or bad weather.

review

1. Terms used in navigation.
2. Features of aeronautical charts.
3. Importance of using the proper and current aeronautical charts.
4. Method of plotting a course, selection of fuel stops and alternates, and appropriate actions in the event of unforeseen situations.
5. Fundamentals of pilotage and dead reckoning.
6. Fundamentals of radio navigation.
7. Diversion to an alternate.
8. Lost procedures.
9. Computation of fuel consumption.
10. Importance of preparing and properly using a flight log.
11. Importance of a weather check and the use of good judgment in making a "go / no-go" decision.
12. Purpose of, and procedure used in, filing a flight plan.