PRIVATE PILOT STUDY GUIDE

VFR Navigation

A complete guide to pilotage, dead reckoning, radio navigation, chart reading, and practical decision making for VFR cross country flight.

VFR NAVIGATION | PILOTAGE | DEAD RECKONING | SECTIONAL CHARTS | CROSS COUNTRY | GPS

WHY NAVIGATION MATTERS

VFR navigation is the backbone of private pilot training and one of the most tested areas on both the written exam and the checkride. Every time you leave the traffic pattern, you are expected to plan a route, track progress across the ground, use the chart fluently, and handle the unexpected without becoming dependent on a single device.

The FAA expects private pilot applicants to understand and demonstrate three methods of navigation: pilotage, dead reckoning, and radio or GPS navigation. The safe pilot integrates all three. Pilotage confirms what the airplane is actually passing over, dead reckoning predicts where the airplane should be, and radio or GPS navigation gives independent position confirmation.

THE THREE NAVIGATION TOOLS

PILOTAGE

Navigate by visible landmarks such as rivers, airports, towns, roads, and lakes. Choose features that are large, distinctive, and difficult to confuse at cruise altitude.

DEAD RECKONING

Compute position from a known starting point, true course, wind correction, true airspeed, elapsed time, and groundspeed. Then verify with the outside world.

RADIO AND GPS

Use VOR, GPS, and electronic flight bags as cross checks. A moving map is useful, but it does not replace chart awareness and basic navigation skill.

Instructor Standard

One matching landmark is only a clue. Two or three matching features together make a position fix. Train yourself to confirm location by shape, relative position, and timing.

Checkride Trap

If the GPS is covered, the flight should still make sense. Know your last checkpoint, your next checkpoint, your estimated time, and the approximate heading you are flying.

BUILDING A ROUTE

CHECKPOINT SELECTION

- Place the first checkpoint about 5 to 10 nautical miles from departure so you can establish track early and catch wind drift before it grows.
- Use large airports, prominent water bodies, towns at major road intersections, reservoirs, highway junctions, and railroad crossings that are easy to identify.
- Avoid small ponds, gravel roads, single towers, and features that repeat across the area. If you could confuse it at 120 knots in haze, pick another checkpoint.
- Select checkpoints every 10 to 20 nautical miles. Missing one checkpoint should not leave you without a useful reference for a long time.

PILOTAGE AND CHART READING

A sectional chart is the primary VFR navigation chart. Its scale is 1:500,000, which means one inch represents about 6.86 nautical miles. Sectionals are revised every 56 days. An expired chart is not automatically illegal under Part 91, but it is poor risk management because airspace, obstacles, services, and frequencies can change.

Use the sectional as a system, not as a picture. Airport color, airspace boundaries, obstacle symbols, MEF figures, contour lines, shaded relief, special use airspace, and VOR symbols all answer different navigation questions. The pilot who can read them quickly has more time to fly the airplane and scan for traffic.

CHART FEATURES THAT DRIVE DECISIONS

FEATURE	WHAT IT TELLS YOU	NAVIGATION USE
Airport color	Blue means an operating control tower. Magenta means no operating control tower.	Plan communications, airspace entry, and checkpoint identification.
MEF	Highest known terrain or obstacle in the chart quadrant, rounded upward with allowance.	Use as a terrain awareness floor, then add a real safety margin.
Obstacle symbol	MSL elevation is printed near the symbol. AGL height appears in parentheses.	Avoid mixing AGL and MSL when selecting cruise altitude.
Airspace boundary	Class B, C, D, E surface areas, and Mode C veil markings define entry requirements.	Plan altitudes and routes before the workload rises in flight.
SUA	Restricted, prohibited, warning, MOA, and alert areas each carry different risk and rules.	Route around restricted and prohibited areas unless authorized.

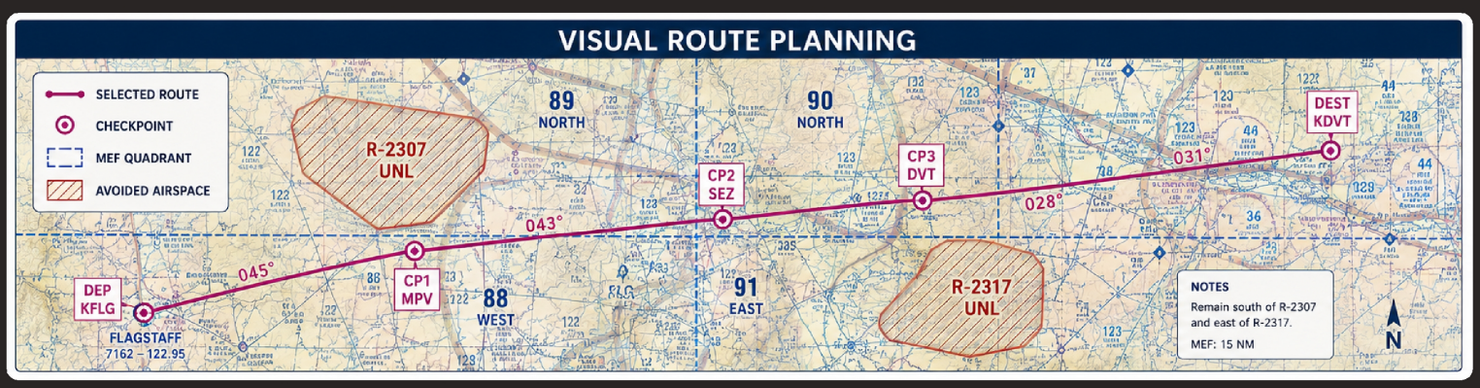
MEF Mistake

The MEF is MSL, and your altimeter reads MSL. Obstacle AGL numbers in parentheses are not altitudes to fly. Convert the entire problem into MSL before choosing a cruise altitude.

Chart Currency Oral

A strong answer says that VFR chart currency is not stated as a simple legal prohibition, then explains why using current chart data is the only professional choice.

VISUAL ROUTE PLANNING



Sectional style diagram showing a VFR cross country route with selected checkpoints, MEF quadrants, and avoided special use airspace.

REFERENCE SNAPSHOT

CHART REVISION CYCLES

- Sectional chart, 1:500,000 scale, revised every 56 days in most areas.
- Terminal Area Chart, 1:250,000 scale, revised every six months in most areas.
- World Aeronautical Charts were discontinued in 2015 and 2016.

AIRPORT SYMBOL MEMORY

- Blue airports have an operating control tower.
- Magenta airports do not have an operating control tower.
- Published airport data supports field elevation, runway length, lighting, fuel, and service decisions.

DEAD RECKONING AND HEADING MATH

Dead reckoning begins with true course measured from the sectional chart. Measure along a meridian near the midpoint of the leg because meridians converge toward the poles and the angle changes along long east or west routes. From that course, winds aloft and aircraft performance produce the heading to fly and the groundspeed to expect.

The products of dead reckoning are heading and groundspeed. Heading keeps you on the line. Groundspeed drives ETA and fuel burn. Those numbers are planned before flight, then corrected in flight when actual checkpoint times show the forecast wind was imperfect.

TRUE COURSE TO COMPASS HEADING

TC plus or minus WCA = TH
TH plus or minus VAR = MH
MH plus or minus DEV = CH

Compass heading is the number you actually fly. TC comes from the chart, WCA from the E6B, VAR from the chart, and DEV from the aircraft compass card.

VARIATION MEMORY AID

East is least
West is best

Subtract easterly variation from true heading. Add westerly variation to true heading. In much of the continental United States, variation is westerly.

Course Measurement Error

Students often measure true course at the departure airport or destination. Slide the plotter to a vertical longitude line near the midpoint of the leg before reading the course.

Compass Deviation

Deviation may be small, but it is real. Apply the compass correction card before flight so the planned compass heading matches the aircraft you are actually flying.

WIND AND GROUNDSPEED

WCA QUICK ESTIMATE

WCA = Crosswind / TAS x 60

Use the 60 to 1 idea as a sanity check. A 15 knot crosswind at 120 knots TAS gives about 7.5 degrees of correction.

GROUNDSPEED CHECK

GS = Distance / Time

Time must be in hours. If 20 nautical miles takes 12 minutes, GS is 100 knots. Use that to update remaining ETA and fuel.

WINDS ALOFT DECODING

ENTRY	MEANING	USE
2714	270 degrees true at 14 knots.	Use true wind direction with true course on the E6B.
9900	Light and variable, less than 5 knots.	Expect little wind correction, but still verify in flight.
731960	230 degrees true at 119 knots, temperature minus 60 Celsius.	For winds over 99 knots, add 50 to direction and subtract 100 from speed.
Interpolation	Use values between published altitudes.	If cruising between 3,000 and 6,000 feet, split the difference as appropriate.

CRUISE ALTITUDE AND THE NAVLOG

The navlog turns a planned route into cockpit work. It captures true course, wind correction angle, magnetic variation, compass deviation, heading, true airspeed, groundspeed, distance, estimated time, and fuel burn for each leg. Complete it before flight. In the airplane, your job is to compare the plan against actual time and position.

Use pencil. Record actual times over checkpoints, compare them to estimates, and update the remaining ETA and fuel plan. If the first leg takes longer than planned, do not carry the old estimate forward as though nothing changed.

VFR CRUISING ALTITUDES

MAGNETIC COURSE	ALTITUDE	EXAMPLES
0 to 179 degrees	Odd thousands MSL plus 500 feet.	3,500, 5,500, 7,500, 9,500.
180 to 359 degrees	Even thousands MSL plus 500 feet.	4,500, 6,500, 8,500, 10,500.
Below 3,000 feet AGL	No cruising altitude requirement from 91.159.	Use any safe and legal altitude.
At or above 18,000 feet MSL	Assigned by ATC.	Flight levels apply.

OEO WEE

Odd East Odd
West Even Even

The rule uses magnetic course and applies only when more than 3,000 feet above the surface in level cruising flight.

Altitude Trap

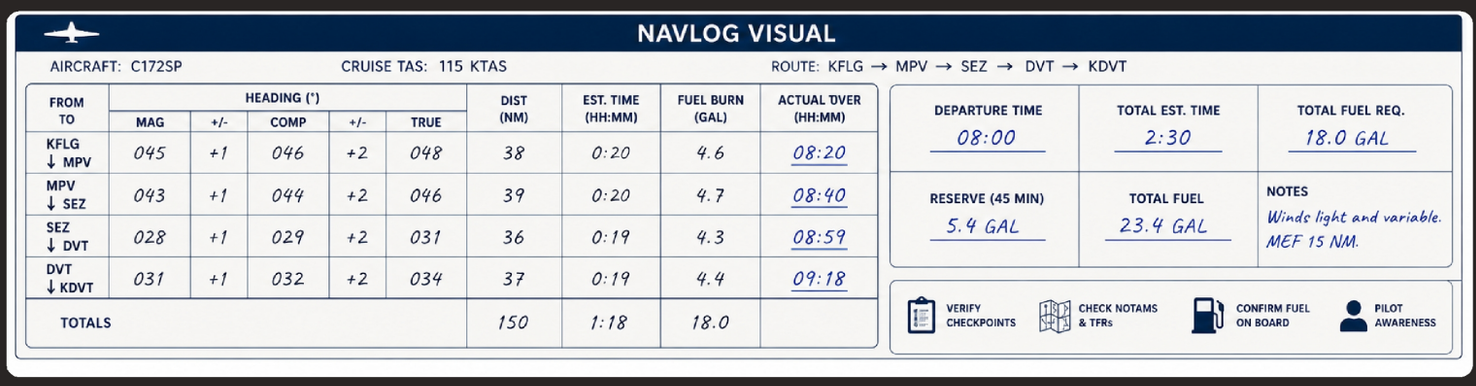
Do not select cruising altitude from true course. Convert true heading to magnetic, then apply the eastbound or westbound rule.

PLANNING ORDER OF OPERATIONS

CROSS COUNTRY WORKFLOW

- Select departure, checkpoints, destination, and any alternate options. Note airspace and terrain along the route.
- Measure true course for each leg at the midpoint meridian, then note MEFs and select a terrain safe altitude.
- Obtain winds aloft for the cruise altitude and time window, compute WCA and groundspeed, then convert to magnetic and compass headings.
- Calculate time and fuel for each leg, verify reserve fuel, check weight and balance, file a VFR flight plan if appropriate, then obtain a full weather brief.

NAVLOG VISUAL



Compact navlog diagram showing heading conversion fields, distance, estimated time, fuel burn, and actual checkpoint time entries.

In Flight Discipline

Never let more than about 10 minutes pass without a positive position fix. Look ahead for the next two checkpoints before you reach them.

Fuel Awareness

Fuel is time and options. Check fuel against the navlog at each checkpoint, especially when groundspeed is lower than planned.

RADIO NAVIGATION AND GPS

A VOR station broadcasts a signal that allows a NAV radio to identify the magnetic radial the aircraft is on. Tune the VOR, identify the station, center the CDI with a FROM indication, and the selected course is the radial from the station. Crossing two radials from two stations gives a VOR cross fix.

GPS is now the dominant navigation tool in general aviation, but it is a supplement to VFR navigation skill. Panel units, handheld receivers, and tablet apps can all fail through battery loss, database age, signal loss, overheating, glare, or pilot distraction. The outside world, the chart, and your dead reckoning plan remain part of the system.

VOR CROSS FIX TECHNIQUE

TWO INDEPENDENT LINES OF POSITION

- Tune and identify the first VOR. Center the CDI with a FROM indication, then note the radial and draw it outward from the station.
- Tune and identify the second VOR and repeat the same process. The intersection of the two radials is your position.
- The best geometry is close to 90 degrees from your position. Nearly parallel radials create a weak fix and can mislead you.

GPS Cross Check
If the moving map says you are over a lake and the windshield shows farmland, trust the airplane and investigate. GPS position must agree with pilotage.

RAIM And Databases
AIM guidance expects VFR pilots to integrate GPS with other methods. VFR databases are not required to be current, but outdated data near critical airspace is a poor choice.

KEY FREQUENCIES AND CODES

FREQUENCY	PURPOSE
122.2 MHz	Universal Flight Service frequency.
121.5 MHz	Emergency and guard frequency.
122.75 MHz	General aviation air to air.
122.8 MHz	Common CTAF at many uncontrolled airports, verify on chart.

CODE	MEANING
1200	VFR squawk when not assigned a code.
7500	Hijacking.
7600	Lost communications.
7700	Emergency.

EFB AND VFR WAYPOINTS

ELECTRONIC FLIGHT BAGS
ForeFlight, Garmin Pilot, and similar apps can display current charts, weather, and GPS position. They are accepted planning tools, but examiners may still ask you to demonstrate navigation without looking at the tablet.

VFR WAYPOINTS
Published VFR waypoints use five letter identifiers beginning with VP. They help position awareness near busy airspace and terrain, but they are not recognized by ATC for IFR flight plans.

Heads Down Risk
Program routes before engine start. Building waypoint chains after takeoff steals time from traffic scan, chart scan, and aircraft control.

VOR MON Note
The FAA has reduced the VOR network as GPS use has grown. Verify any VOR you plan to use through NOTAMs and current briefing sources.

DIVERSIONS AND LOST PROCEDURES

A diversion is a change of destination for weather, fuel, mechanical concerns, passenger needs, pilot fatigue, or examiner scenario. The ACS does not require perfect math for a nearby diversion. It requires a reasonable heading, distance, ETA, fuel estimate, communication plan, and decisive aircraft control.

If you become uncertain of position, do not wander. Hold a sensible heading, stabilize workload, and begin an organized process. The earlier you admit uncertainty, the easier it is to recover.

DIVERSION FLOW

- Identify the alternate on the chart and turn toward a reasonable estimated heading.
- Estimate distance with a plotter or the thumb rule, then compute ETA from known groundspeed.
- Estimate fuel required using known fuel burn and compare it to fuel remaining.
- Tell ATC if using flight following, then refine heading and timing once the airplane is stable.

5 CS

- Climb for better radio range, more visible terrain, and more time, while staying clear of clouds and airspace.
- Confess that you are uncertain and ask ATC or Flight Service for assistance.
- Communicate on the best available frequency, use 121.5 MHz if needed, and squawk 7700 if declaring an emergency.
- Conserve fuel with an efficient power setting while you sort out the situation.
- Comply with ATC instructions, but speak up immediately if a vector creates terrain, weather, or airspace risk.

THUMB RULE

One thumb width = about 10 NM

At arm length on a standard sectional. Use it for quick diversion distance, not precision navigation.

MEF BUFFER

MEF plus 1,000 feet

A practical comfort margin over unknown terrain. In mountainous terrain, many pilots use a larger margin.

CHECKRIDE QUESTIONS IN CONTEXT

HEADING CHAIN

Walk through true course, winds aloft, E6B wind correction, true heading, magnetic variation, compass deviation, and the compass heading you will fly.

MISSING CHECKPOINT

Hold heading, verify time, compare expected groundspeed, look for alternate landmarks, and start the 5 Cs if uncertainty remains.

MEF MEANING

State that MEF represents known terrain or obstacle height in the quadrant, rounded upward with allowance, but it is not a guaranteed safe altitude.

CRUISING ALTITUDE

Use magnetic course, apply 91.159 only when more than 3,000 feet AGL, and state the proper eastbound or westbound altitude group.

REGULATIONS THAT ANCHOR THE LESSON

REFERENCE	PLAIN ENGLISH	WHY IT MATTERS
14 CFR 91.103	Before flight, the PIC must know all available information appropriate to the flight.	Supports weather, fuel, alternates, route, and delay planning.
14 CFR 91.151	Day VFR requires destination fuel plus 30 minutes. Night VFR requires destination fuel plus 45 minutes.	Fuel reserve is a legal floor, not a best practice target.
14 CFR 91.159	VFR cruising altitude more than 3,000 feet above the surface is based on magnetic course.	Provides vertical separation between opposite direction traffic.
AIM 1 1 17	VFR pilots should integrate GPS with pilotage and dead reckoning.	GPS is an aid, not a replacement for navigation skill.
AIM 5 1 7	VFR flight plans are recommended for search and rescue support.	An open flight plan helps someone find you if the flight does not arrive.