Turns to Headings (Instrument)

Objective	
To ensure the applicant learns the purpose of and can exhibit a clear understanding of the turns to headings basic instrument maneuver and how to perform the maneuver properly.	
Purpose	
Although non-instrument rated pilots should never enter instrument conditions, weather changes rapidly and mistakes happen. This maneuver teaches the basic instrument flying skills necessary to survive an inadvertent encounter with below-VFR conditions, and introduces pilots to the instrument scan, the standard rate turn, and is the primary skill used in executing a 180 degree turn to escape the below-VFR conditions.	

Schedule	**Equipment**

• **Ground Lesson**: 15 minutes
• Initial
  ▪ **Flight 1**: 20 minutes - *Introduction to Maneuver*
  ▪ **Flight 2**: 20 minutes - *Improve Proficiency (Dual)*
• Pre-Checkride
  ▪ **Flight 3**: 10 minutes - *Demonstrate Proficiency*
• **Debrief**: 10 minutes (*per flight*)
	• Whiteboard / Markers (optional)
	• Foggles / Hood

Student Actions	**Instructor Actions**
• Ask any questions, receive study material for the next lesson. • Watch linked video. • Review listed references.	• Deliver the ground lesson (below). • Demonstrate the maneuver in flight. • Debrief after each flight.

Completion Standards

- **Ground**: Student can explain the purpose of the turns to headings instrument maneuver and how the various instruments are used to maintain control during the maneuver.
- **Flight**: Student can perform the maneuver to the applicable ACS standards.
  - Pilot establishes a standard rate turn at an appropriate airspeed solely by reference to instruments.
  - Pilot rolls out on the desired heading ±10°, maintains altitude ±200 feet, and airspeed ±10 knots.
  - Pilot divides attention between accurate, coordinated airplane control and instrument scan and cross-check.
  - See expanded Completion Standards below.

References

- alexaviation - “Instrument Flying Introduction”
    - YouTube - https://www.youtube.com/watch?v=aXjCk-ZBF1c
- FAA-H-8083-3B (Airplane Flying Handbook) - Chapter 3, Page 5-6 [Integrated Flight Instruction], Chapter 3, Page 6-9 [Straight and Level Flight], Chapter 3, Page 10-16 [Level Turns]
- FAA-H-8083-25B (Pilot’s Handbook of Aeronautical Knowledge) - Chapter 5, Page 22-23 [Forces in Turns], Chapter 8, Page 3-4 [Altimeter], Chapter 8, Page 8-9 [Airspeed Indicator], Chapter 8, Page 17-18 [Turn Coordinator], Chapter 8, Page 18-19 [Attitude Indicator]
- FAA-H-8083-15B (Instrument Flying Handbook) - Chapter 3, Page 2-5 [Sensory Systems for Orientation], Chapter 3, Page 5-7 [Illusions Leading to Spatial Disorientation], Chapter 5, Page 19-21 [Gyroscopic Instruments], Chapter 6, Page 4-8 [Attitude Instrument Flying/Primary and Supporting], Chapter 6, Page 10-13 [Instrument Cross-Check/Interpretation], Chapter 7, Page 20 [Turns to Predetermined Headings]
- FAA-S-ACS-6B (Private Pilot ACS) - Area VIII Task D
- FAA-S-8081-6D (CFI PTS) - Area XII Task D

Ground Lesson Outline

- Introduction to Basic Attitude Instrument Flying
    - Situations to Avoid
- Your Senses Cannot Be Trusted
    - The Vestibular System, Rely on the Flight Instruments
- The Flight Instruments
    - Pitch Instruments - Attitude Indicator, Altimeter, Vertical Speed Indicator, Airspeed Indicator
    - Bank Instruments - Attitude Indicator, Directional Gyro, Turn Coordinator
    - Power Instruments - Airspeed Indicator, Tachometer
- The Instrument Scan
    - Primary and Supporting Instruments, Scan Techniques, Cross-Check
    - Errors of Fixation of Omission
- Pitch + Power = Performance
    - Importance of Trim
- The Standard Rate Turn
    - Easy to Estimate - 180/1 min, 90/30s, 45/15s, etc.
- Phases of an Instrument Turn
    - Roll Into Turn
    - Steady Turn
    - Roll Out of Turn
- Maneuver Description - step-by-step
    - Altitude, airspeed, etc.
- Expanded Completion Standards

Common Errors

- **“Fixation,” “omission,” and “emphasis” errors during instrument cross-check.**
- Improper instrument interpretation.
- Improper control applications.
- Failure to establish proper pitch, bank, and power adjustments during altitude, bank, and airspeed corrections.
- **Improper entry or rollout procedure.**
- **Faulty trim procedure.**

Ground Lesson Content

- **Introduction to Basic Attitude Instrument Flying** - Although a Private Pilot certificate does not allow new pilots to fly in instrument conditions, situations might occur when pilots unexpectedly find themselves in these conditions: an inadvertent encounter with an unseen or misjudged cloud, deteriorating weather conditions, etc. In these conditions, pilots need a minimal amount of training to give them the tools to escape these situations. **The primary goal of Basic Attitude Instrument Flying at the Private Pilot level is to allow the pilot to make a 180 degree turn and return back to visual conditions.**
    - **Situations to Avoid** - Although it may seem obvious, **the number one way to avoid a dangerous situation as a non-instrument rated Private Pilot is to avoid continuing into situations where the weather is unknown, or rapidly changing**. Some situations that should be avoided:
        - Night VFR in the presence of low clouds
        - **Continued VFR flight in areas of low cloud ceiling or deteriorating conditions**

        - Early morning or early evening VFR flight when the temperature and dew point are very close together (creating a high risk of fog)
        - VFR flight above a solid cloud layer (How to get down?)
    - **Maintain Control** - The first skill pilots must develop in order to safely exit instrument conditions is the ability to **fly the airplane straight-and-level**. Although pilots may have very little trouble with this in visual conditions, this is an extremely challenging skill to master solely by reference to the flight instruments.
- **Your Senses Cannot Be Trusted** - The most challenging aspect of transitioning to flying on instruments is that pilots are accustomed to recognizing the sensations their body is experiencing during flight. Something *feels* like a turn, or *feels* like a climb. However, pilots must realize that human perception of orientation and motion is extremely limited when outside visual references are not present! The human body senses motion using something called the *vestibular system*. The vestibular system primarily senses accelerations in one

The Internal Ear

direction or another. It can generally sense rotation or movement, and with the aid of the other senses (primarily vision), the brain maintains a concept of the body's orientation and motion. However, **like a heading indicator which drifts over time, *without continual reinforcement from outside visual references*, the body's sense of "which way is up" or "which way am I going?" gradually drifts over time.**

- **Rely on the Flight Instruments** - **The only solution to maintaining control in instrument conditions is to *rely on the flight instruments.*** The flight instruments are not subject to the same errors as the vestibular system and provide a much more reliable, accurate representation of the aircraft attitude.

- **The Flight Instruments** - Most airplanes with conventional instruments (often informally called *steam gauges)* are equipped with a standard "*6 pack*" of flight instruments. These are, from left to right, top to bottom: the *airspeed indicator*, the *attitude indicator*, the *altimeter*, the *turn coordinator*, the *directional gyro*, and the *vertical speed indicator*. There is also, elsewhere on the instrument panel, a *tachometer*, which gives engine power indications. **These instruments give the pilot information about *pitch*, *bank*, and *power*.**

  - **Pitch Instruments** - The instruments which display pitch information are the attitude indicator, the altimeter, the airspeed indicator, and the vertical speed indicator.
    - **Attitude Indicator** - The attitude indicator is an instrument which uses a gyroscope and uses the property of gyros called *rigidity in space*. It is the *only instrument which provides a direct indication of aircraft attitude*. It is often called an *artificial horizon* because it acts very similarly to the natural horizon. **When flying on instruments, it is generally the most important instrument for maintaining straight and level flight.** It usually has markings for every 5 degrees of pitch. **Most standard instrument maneuvers will take place within +/- 10 degrees of pitch.** The attitude indicator is a self-correcting instrument, and as the gyroscope *precesses* (is affected by friction), it makes small corrections to remain upright.

- **Altimeter** - The altimeter provides pitch information because it displays the current altitude. An aircraft which is climbing has higher pitch, resulting in an increasing altimeter reading, and an aircraft which is descending has lower pitch.

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- **Airspeed Indicator** - The airspeed indicator provides pitch information because when pitch is *increasing*, the airspeed tends to *decrease*, and vice-versa. Additionally, if the airplane is flying at a known power setting, a slower than normal airspeed likely indicates a climb, and so on.

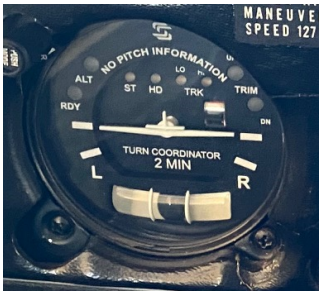
- **Vertical Speed Indicator** - The vertical speed indicator shows pitch information because it directly indicates the rate of climb or descent. (Indicated in hundreds of feet per minute) A climbing airplane has a higher pitch, and a descending airplane has a lower pitch.

- **Bank Instruments** - The instruments which display bank information are the attitude indicator, the directional gyro, and the turn coordinator.
  - **Attitude Indicator** - Because the attitude indicator shows the aircraft's attitude directly, the attitude indicator is also a bank instrument. **When flying on instruments, it is generally the most important instrument for maintaining straight and level flight.** It usually has markings for every 10 degrees of bank. Most standard instrument maneuvers will take place within +/- 15 degrees of bank. **Maintaining wings level is often the most important and challenging task when flying on instruments.**

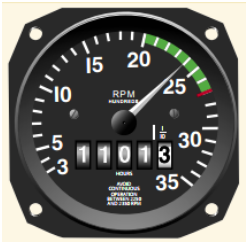
  - **Directional Gyro** - The directional gyro (or *DG*) is another gyro-based instrument which operates on the principle of rigidity in space. The directional gyro is set to track the magnetic compass, and displays the current airplane heading. Unlike the attitude indicator, the directional gyro is *not* a self-correcting instrument, and must be periodically reset by the pilot to match it to the magnetic compass. **The directional gyro provides a bank indication because an airplane which**

is banking is also changing heading. (The DG will be turning)

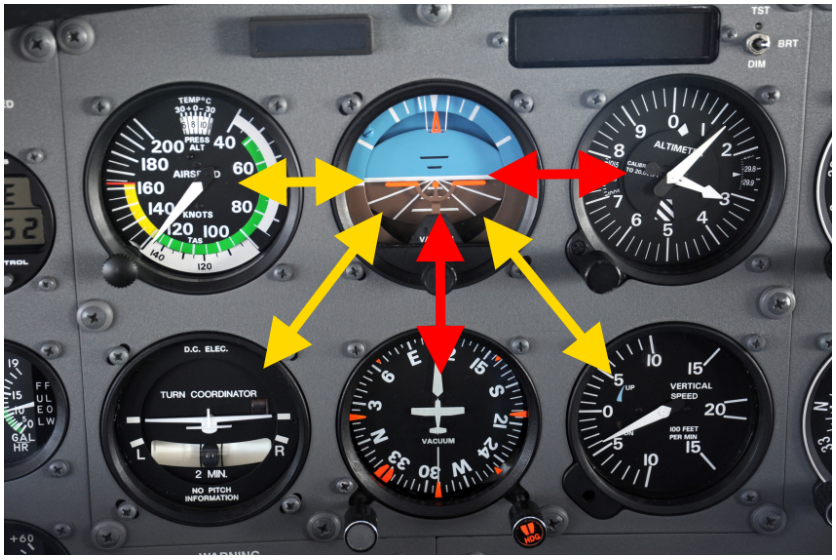
- **Turn Coordinator** - The turn coordinator is yet another gyroscopic instrument which also depends on rigidity in space and a property called *precession*. When the airplane turns, the gyroscope is turned with it, causing it to 'precess', meaning it applies a force in a different which can be measured. **The turn coordinator provides a bank indication because it shows the rate of turn. An airplane which is turning is also banked.** The angled marks on the indicator represent a rate of turn of 3 degrees per second. **When turning at this rate, the airplane will make a full 360 degree turn in 2 minutes. This is called a *standard rate turn*, and is used for all turns in instrument conditions.**



- **Power Instruments** - The instruments which display power information are the tachometer and the airspeed indicator.
  - **Airspeed Indicator** - The airspeed indicator gives an indication of power because, when the airplane is flying straight and level, or in a lightly-banked turn, the airspeed is primarily related to the engine power setting.
  - **Tachometer** - The tachometer gives a direct reading of the power being produced by the airplane engine. Pilots should be familiar with their airplane and the commonly-used power settings for level flight, climbs, descents, and turns.

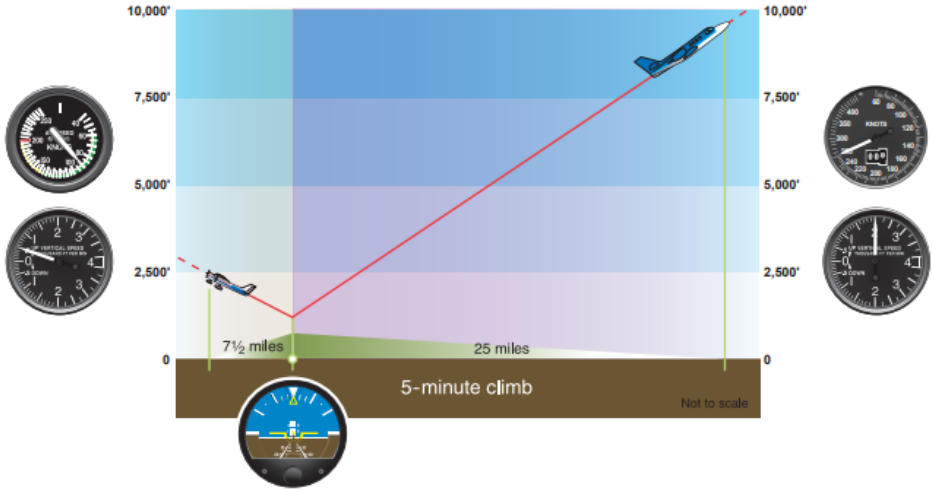


- **The Instrument Scan** - When attempting to maintain aircraft control using instruments, pilots cannot just haphazardly glance from one instrument to another. In order to maintain control of the airplane, the pitch, bank, and power instruments need to be scanned in a particular pattern in order to ensure that no single instrument gets ignored. Different maneuvers also require more or less emphasis on certain instruments. This scanning pattern is called the *instrument scan,* or instrument *cross check*.
  - **Primary and Secondary Instruments** - Depending on the maneuver, certain instruments provide more pertinent information. **In general, the *primary* instruments show the value that the pilot is trying to hold steady, while the *secondary (or supporting)* instruments show the progress of the maneuver.**
  - **Scan Techniques** - One of the most widely used instrument scanning patterns is the *radial scan*, which concentrates on the attitude indicator. The attitude indicator is the most important instrument for most maneuvers because it provides a direct indication of the airplane's attitude. The radial scan begins at the attitude indicator, and moves to a primary instrument, then back to the attitude indicator, and repeats, then moves on to the secondary instruments, and back to the attitude indicator, etc. **The primary instruments get scanned more often, and the attitude indicator is scanned in between every other instrument.** For example, for straight and level flight, the primary pitch (altimeter) and primary bank (directional gyro) get scanned more often. (Denoted by **red**)



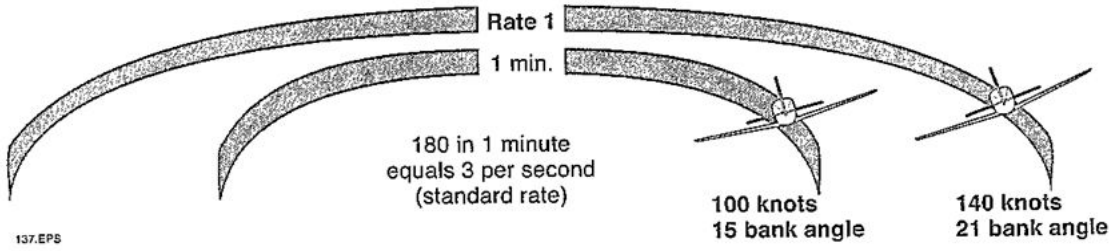
- **Cross Check** - Another name for an instrument scan is the *cross check*. **It is important that pilots evaluate the indications they are receiving from the flight instruments to ensure that they agree with what is expected!** For example, if the attitude indicator indicates a climb, but the aircraft is not climbing, the power setting may be incorrect, etc.
- **Errors of Fixation or Omission** - A very common error made by pilots when starting to fly on instruments is *fixation* on a particular instrument (usually the attitude indicator), or the *omission* of an instrument from their instrument scan. **It is crucial that all flight instruments be included in the scan.**
  - *For example*: A pilot who fixates on the attitude indicator when trying to maintain straight and level flight may not notice large deviations of heading or altitude. A pilot who never scans the airspeed indicator may be successfully maintaining straight and level flight, but an incorrect power setting may result in the airspeed decaying dangerously.

- **Pitch + Power = Performance** - There is a saying in instrument flying that “pitch + power = performance”. In general, a given pitch and power setting will produce a given airspeed and climb or descent rate. **It is important that pilots get to know their particular airplane. If 2,400 RPM is the normal cruise flight in an airplane, but the airplane is climbing, that is an important clue that the airplane may be pitched too steeply, or trimmed incorrectly.**



- **Importance of Trim** - Proper trim is *crucial* for successful flight on instruments. **The airplane should always be trimmed so that it can be flown hands-free or nearly hands-free**, which will free the pilot to momentarily concentrate on other tasks, such as executing a 180 degree turn to exit instrument conditions, communicating to ATC, or navigating. **Instrument flight maneuvers are more gentle than normal visual maneuvers to prevent pilot disorientation, so proper trim allows pilots to use lighter, more precise control pressures.**

- **The Standard Rate Turn** - Due to the risk of spatial disorientation, instrument flying maneuvers are typically much more subdued than visual maneuvers. In particular, **turns made in instrument conditions are deliberately made at a very gentle rate**. In order to standardize instrument flying procedures, a specific rate of turn has been developed called the *standard rate turn*.
  - **Easy to Estimate** - The standard rate turn is 3 degrees per second. This value was chosen because it allows simple mental calculations to be performed. For example, **a 180 degree turn takes exactly 1 minute at standard rate**, and a full 360 degree turn takes 2 minutes. Other common values are easy as well: 90 degrees of turn is 30 seconds, and 45 degrees of turn is 15 seconds.



A rate-one turn requires steeper bank at higher speed.

- **Phases of a Turn on Instruments** - There are 3 distinct stages of performing a turn using instrument references:
  - **Roll Into Turn** - Begin banking towards the direction of turn.
    - **Primary Instruments**
      - **Pitch** - Altimeter - *Altitude should remain steady.*
      - **Bank** - Attitude Indicator - *Establish a gentle bank and hold it.*
      - **Power** - Airspeed Indicator - *Airspeed should remain steady.*
    - **Supporting Instruments**
      - **Pitch** - Attitude Indicator, Vertical Speed Indicator - *Should remain at a steady pitch and indicate level flight.*
      - **Bank** - Attitude Indicator, Turn Coordinator - *Should begin to indicate a turn in the desired direction.*
      - **Power** - n/a

- **Steady Turn** - Add a bit of backpressure to compensate for the loss of vertical lift and adjust bank to maintain the rate of turn.
  - **Primary Instruments**
    - **Pitch** - Altimeter - *Altitude should remain steady.*
    - **Bank** - Turn Coordinator - *Should remain steady a standard rate turn.* ***Any corrections should be made by increasing or decreasing bank.***
    - **Power** - Airspeed Indicator - *Should remain steady.*
  - **Supporting Instruments**
    - **Pitch** - Attitude Indicator, Vertical Speed - *Should indicate a level pitch attitude, and level flight.*
    - **Bank** - Attitude Indicator, Directional Gyro - *Should indicate a bank and a turn in the desired direction.*
    - **Power** - n/a

- **Roll Out of Turn** - Begin to gently reduce bank **10-20 degrees before target heading** to avoid overshooting the turn. Re-establish level flight by using the attitude indicator to level the wings.
  - **Primary Instruments**
    - **Pitch** - Altimeter - *Altitude should remain steady.*
    - **Bank** - Directional Gyro - *Heading should remain steady.*
    - **Power** - Airspeed Indicator - *Airspeed should remain steady.*
  - **Supporting Instruments**
    - **Pitch** - Attitude Indicator, Vertical Speed - *Should indicate a level flight attitude.*
    - **Bank** - Attitude Indicator, Turn Coordinator - *Should remain steady, with wings level attitude.*
    - **Power** - n/a

Maneuver Description

- **Preparation** - Instructor or examiner will take control of the plane while the pilot puts on the foggles or hood.
- **Scan** - Begin the instrument scan/cross check and maintain controlled flight by continuously referencing the flight instruments.
- **Establish Turn** - Establish a standard rate turn at an appropriate level flight airspeed and power setting.
- **Airspeed** - Maintain a constant airspeed +/- 10 knots.
- **Altitude** - Maintain altitude, +/- 200 feet, by managing the pitch, power, and trim.
- **Heading** - Roll out on the heading specified by the instructor or examiner, +/- 10 degrees, by managing the bank.
- **Recovery** - Level-off and re-establish cruise flight at the altitude specified.
- **Stall Awareness and Coordination** - The stall indicator should never be heard during instrument flying maneuvers. Additionally, **proper coordination is essential**. A stall when in instrument conditions, particularly an uncoordinated stall, is unlikely to be recoverable.

- **Never attempt this maneuver solo!** - The instructor or examiner will act as what is called a *safety pilot*, and will be responsible for all visual traffic scanning, collision avoidance, etc.

Expanded Completion Standards

- The pilot can explain the purpose of the turns to headings instrument maneuver and how the various instruments are used to maintain control during the maneuver.
- The pilot can perform the maneuver to the following standards:
    - Pilot establishes a standard rate turn at an appropriate airspeed *solely by reference to instruments.*
    - Pilot rolls out on the desired heading **±10°, maintains altitude ±200 feet, and airspeed ±10 knots**.
    - Pilot divides attention between accurate, *coordinated airplane control* and instrument scan and cross-check.