VI.F. Timed Turns to Magnetic Compass Headings

References: Instrument Flying Handbook (FAA-H-8083-15)

Objectives	The student should develop knowledge of the elements related to magnetic compass errors and using a compass for heading information.
Key Elements	1. North Lags 2. South Leads 3. UNOS – Undershoot N, Overshoot S 4. ANDS – Accelerate N, Decelerate S
Elements	1. Magnetic Compass 2. Timed Turns
Schedule	1. Discuss Objectives 2. Review material 3. Development 4. Conclusion
Equipment	1. White board and markers 2. References
IP's Actions	1. Discuss lesson objectives 2. Present Lecture 3. Ask and Answer Questions 4. Assign homework
SP's Actions	1. Participate in discussion 2. Take notes 3. Ask and respond to questions
Completion Standards	The student understands how to compensate for errors in the compass and can competently make turns to various headings using the magnetic compass.

Instructors Notes:

Introduction:

Attention

Interesting fact or attention-grabbing story

Overview

Review Objectives and Elements/Key ideas

What

The magnetic compass is not as simple as a heading indicator when making turns. This lesson describes the operation of the magnetic compass and its innate errors as well as how to overcome them in flight.

Why

In the case you lost your gyro instruments (specifically the heading indicator) you would need to turn to the magnetic compass for heading information. It is very important you understand its operation so that you can competently navigate the aircraft.

How:

1. Magnetic Compass

A. Operation

i. Two small magnets attached to a metal float sealed inside a bowl of clear compass fluid

ii. A card is wrapped around the float and visible from the outside with a lubber line

a. Lubber Line: The reference line used in a magnetic compass or heading indicator

iii. The float/card has a steel pivot in the center riding inside a spring loaded, hard glass jewel cup

a. The jewel and pivot mount allow the float to rotate and tilt up to approximately 18°

iv. The magnets align with the Earth's magnetic field and direction is read opposite the lubber line

a. The pilot always sees the compass card from its backside (the card stays stationary and the pilot turns around it)

- For this reason, headings appear backward on the compass
- When flying N, E is shown left of the lubber line vs right in actuality

b. Technique: Don't turn toward the heading as displayed on the compass, instead move the desired heading to the lubber line

B. Errors

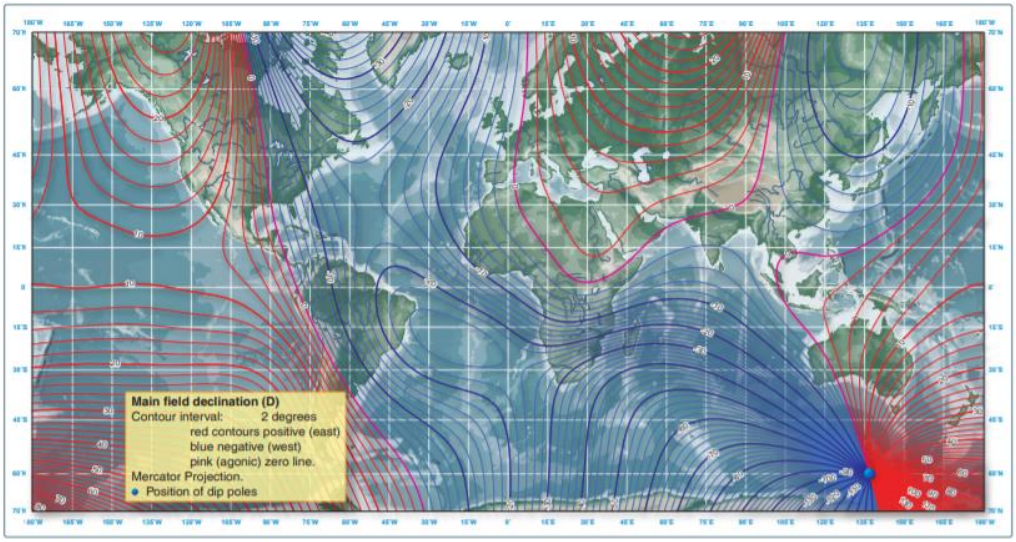
i. Variation

a. Caused by the difference in the locations of the magnetic and geographic north pole

- The magnetic north pole is not collocated with the geographic north pole
- They're approximately 1300 miles apart

b. Isogonic Lines: Lines used to connect points with the same magnetic variation

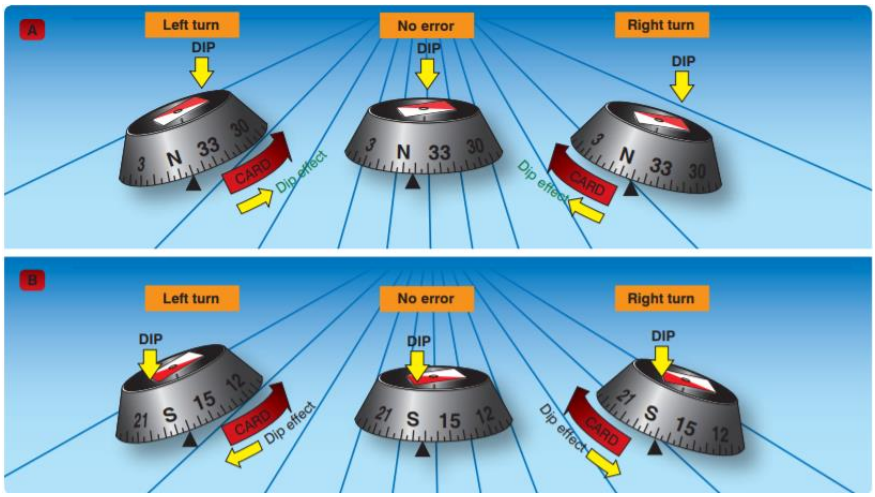
c. Agonic Line: The line along which the two poles are aligned, and there is no variation



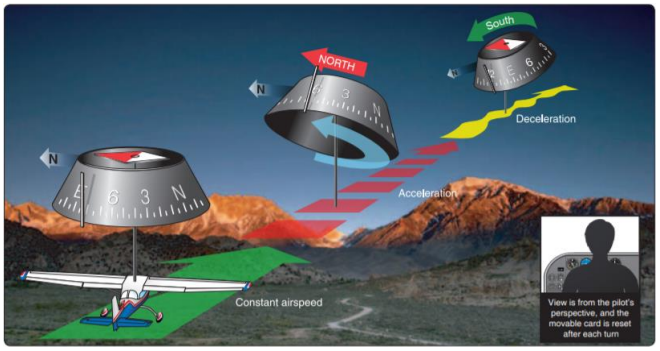
ii. Deviation
   a. Caused by local magnetic fields within the aircraft
      - Not affected by geographic location (like variation)
   b. Degrees of deviation is shown on a compass correction card
      - Different on each heading; can be minimized by "swinging the compass"
   c. Compensator units (magnets that compensate for deviation) can also help

iii. Finding the Compass Course – True Course corrected for Variation and Deviation
   a. True Course ± Variation = Magnetic Course; Magnetic Course ± Deviation = Compass Course
   b. Remember: East is Least, West is Best
      - East: Subtract variation from true course; West: Add variation to true course

iv. Dip Errors
   a. What's Going On
      - Lines of magnetic flux leave the Earth at the magnetic N pole/enter at magnetic S pole
         a At both poles the lines are perpendicular to the surface
         b Over the equator the lines are parallel to the surface
      - Magnets align with these fields and near the poles they dip/tilt the float and card
   b. Northerly and Southerly Turning Errors (basically, the compass pulls toward the North)
      - Starting a turn from a Southerly heading (turning to a Northerly direction):
         a Compass Leads – initially shows a more aggressive turn in the same direction
         b As the aircraft banks, the compass card tilts with it, and the magnetic field pulls the card in the direction of the turn (toward the North)
         c Undershoot Northerly headings to compensate (30°- N; 20°- 030/330; 10°- 060/300)
      - Starting a turn from a Northerly heading (turning to a Southerly direction):
         a Compass Lags – initially shows a turn in the opposite direction
         b As the aircraft banks the compass card tilts with it, and the magnetic field pulls the card opposite the direction of turn (back toward the North)
         c Overshoot Southerly headings to compensate (30°- S; 20°- 150/210; 10°- 120/240)
      - *Remember*: Undershoot North, Overshoot South (no compensation needed for E/W)
   c. Acceleration Error (only applicable on East and West headings)



- Due to the pendulous-type mounting, the aft end of the compass tilts up when accelerating and down when decelerating
- On an E or W heading, acceleration appears as a turn to the North, and deceleration indicates a turn toward the South
- *Remember*: ANDS – Accelerate North, Decelerate South

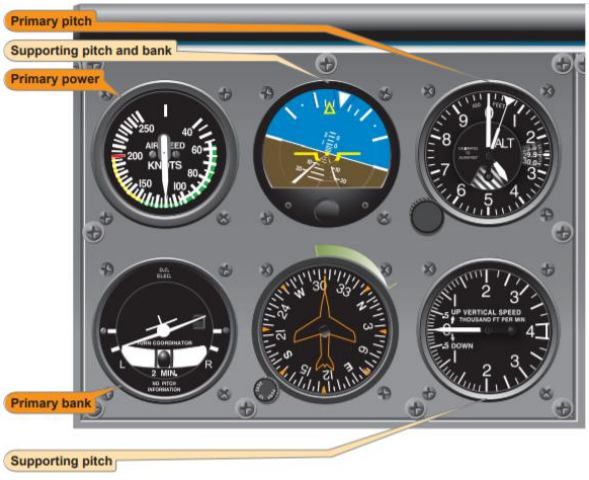


v. Oscillation Error
   a. A combination of all the other errors as well as the movement of the plane
      - It results in the compass card swinging back and forth around the heading being flown
   b. Use the average indication

2. Timed Turns

A. General
   i. Clock and turn coordinator are used to change heading a specific number of degrees in a given time
      a. Ex: In a standard rate turn, the plane turns 45° in 15 seconds, half standard = 45° in 30 seconds
   ii. Same control / crosscheck as a normal turn, except the clock replaces the heading indicator
   iii. Mini aircraft of the turn coordinator is primary for bank
   iv. Altimeter is primary for pitch
   v. Airspeed Indicator is primary for power

B. Turn Coordinator Calibration (depicted, right)
   i. Prior to performing timed turns, calibrate the turn coordinator to determine its accuracy
   ii. Note the heading, and establish a standard rate turn as the second hand of a clock passes a cardinal direction (12, 3, 6, 9)
   iii. Hold standard rate and note heading changes every 10 seconds (should be 30° of turn)
   iv. If the amount of turn is more or less than 30°, adjust bank to obtain standard rate
   v. Check the standard rate bank in both directions, use the corrected bank angle for all timed turns



C. Full Panel Timed Turn

i. Establish a standard rate turn on the turn coordinator as the second hand passes a cardinal point
   a. Trim as required
ii. Include the clock in the crosscheck in place of the heading indicator
iii. Crosscheck and adjust to maintain bank, airspeed, and altitude
   a. Heading / Attitude indicators can be crosschecked for additional situational awareness
iv. Begin the rollout when the required time has elapsed
   a. If the rate of roll-in and roll-out is the same, the time for the entry / recovery can be ignored
v. Check the heading indicator for turn accuracy

D. Partial Panel Timed Turn
i. Very similar to full panel, except the attitude indicator and heading indicator are inoperative
ii. Establish a standard rate turn on the turn coordinator as the second hand passes a cardinal point
   a. Trim as required
iii. Crosscheck and adjust to maintain bank, airspeed, and altitude
iv. Begin the rollout when the required time has elapsed
   a. Again, the time to roll-in and roll-out is not a factor if they're performed at the same rate
v. Check the magnetic compass at the completion of the turn, taking into account compass errors

Common Errors

- Incorrect calibration procedures
- Improper timing
- Uncoordinated use of the controls
- Improper trim control

Conclusion:

Brief review of the main points

PTS Requirements:

To determine that the applicant:

1. Exhibits instructional knowledge of timed turns to magnetic compass headings by describing-
   A. operating characteristics and errors of the magnetic compass.
   B. calibration of the miniature aircraft of the turn coordinator, both right and left, using full panel and the clock.
   C. procedures using full panel and partial panel performing compass turns to a specified heading.
2. Exhibits instructional knowledge of common errors related to timed turns to magnetic compass headings by describing-
   A. incorrect calibration procedures.
   B. improper timing.
   C. uncoordinated use of controls.
   D. improper trim control.
3. Demonstrates and simultaneously explains timed turns to magnetic compass headings from an instructional standpoint.
4. Analyzes and corrects simulated common errors related to timed turns to magnetic compass headings.

ACS Skills Standards

1. Maintain altitude ±100 feet during level flight, selected headings ±10°, airspeed ±10 knots, and bank angles ±5° during turns.
2. Use proper instrument cross-check and interpretation, and apply the appropriate pitch, bank, power, and trim corrections when applicable.