Contents

AVI310101) Three-Digit Bearings

Exploring the Concept

Why Three-Digit Bearings?

Key Discovery

Picture this:

You are an air traffic controller at Sydney Approach. On your radar screen, 23 aircraft are converging toward the airport. Two of them — QF401 and VA218 — are closing in on the same airspace, 40 seconds from conflict. You need to turn QF401 **now**. Every second you spend thinking about which direction to say is a second those two aircraft get closer together.

In this moment, do you want a system that takes 3 mental steps to process, or 1?

In maths class, you may have seen **direction bearings** like N40°E or S25°W. Aviation does not use them. Here is why.

Direction bearing (e.g., N40°E) requires **3 mental steps**:

1. Identify the reference direction — is it North or South?
2. Identify the rotation direction — towards East or West?
3. Process the angle between them.

Three-digit bearing (e.g., 040°) requires just **1 step** after training:

- Fixed reference: always North.
- Fixed direction: always clockwise.
- One number to process.

Key Idea

A controller managing dozens of aircraft simultaneously cannot afford extra cognitive steps. One moment of confusion — mixing up "N25°W" with "N25°E" — could send an aircraft into the path of another.

Three-digit bearings eliminate this risk. There is only one reference (North), only one direction (clockwise), and only one number. With repeated training, a controller hears "two-seven-zero" and **instantly** visualises due West — no calculation, just pattern recognition.

Key Discovery

Why exactly three digits?

Imagine a pilot transmits the number "two-three" over radio. Is the heading 023°? Or is it the start of 235°, and the pilot hasn't finished speaking yet? You would have to **wait** to find out — but waiting costs time you don't have.

Now imagine the pilot says just "three". Is the heading 3°? Or 30°? Or 300°? There is no way to tell.

The three-digit rule eliminates this ambiguity completely:

- You always hear **exactly three digits**. No more, no less.
- After the third digit, the number is complete — no waiting.
- No need for words like "hundred" or "degrees" — just three digits, done.

3° becomes "zero-zero-three". 30° becomes "zero-three-zero". 300° becomes "three-zero-zero". Each one is instantly distinguishable.

The Three Rules

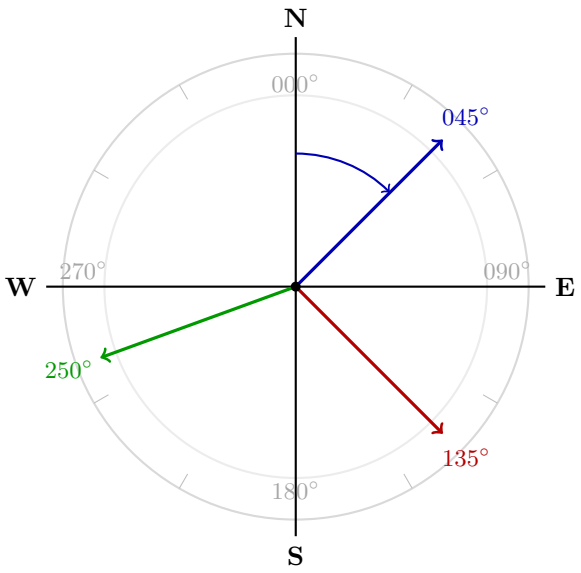
Key Idea

The Three Rules of Three-Digit Bearings:

1. Always measured from **North**.
2. Always measured **clockwise**.
3. Always written as **three digits** (045°, not 45°).

Cardinal directions:

$$\text{N} = 000° \text{ (or } 360°), \quad \text{E} = 090°, \quad \text{S} = 180°, \quad \text{W} = 270°$$



Intercardinal Directions:

Direction	Bearing
NE	045°
SE	135°
SW	225°
NW	315°

How to Read Bearings Aloud

Key Idea

In ICAO radio communication, bearings are spoken **digit by digit**:

- 320° → "three-two-zero"
- 045° → "zero-four-five"
- 270° → "two-seven-zero"
- 008° → "zero-zero-eight"

NEVER "three hundred twenty" or "forty-five". There's no time for multi-syllable number words when aircraft are converging.

Key Discovery

Real World: Every Syllable Counts

Two aircraft are converging. The controller has seconds to act:

"Qantas 401, turn left heading two-seven-zero, ***immediately****."*

The pilot hears 3 digits, instantly pictures due West, and begins the turn. Now imagine the controller had said "two hundred and seventy degrees" — that is **11 syllables instead of 3**. In the time it takes to say those extra 8 syllables, both aircraft have travelled another 2 km closer together.

This is not hypothetical. The 2002 Überlingen mid-air collision killed 71 people partly because of communication delays between controller and pilots. Speed of communication saves lives.

Quadrant Identification

Quick mental check — which quadrant is a bearing in?

Bearing Range	Quadrant
000°–090°	NE quadrant
090°–180°	SE quadrant
180°–270°	SW quadrant
270°–360°	NW quadrant

Example

Example 1) Convert these compass directions to three-digit bearings.

i) Due East

ii) South-West

iii) North-North-East (halfway between N and NE)

i) Due East = 090°

ii) South-West = 225°

iii) North-North-East is halfway between 000° and 045°, so ≈ 022° (or 023°).

Example 2) State which quadrant each bearing falls in, and give the nearest cardinal or intercardinal direction.

i) 148°

ii) 312°

iii) 073°

i) 148° is in the SE quadrant (090°–180°), nearest to S (180°).

ii) 312° is in the NW quadrant (270°–360°), nearest to NW (315°).

iii) 073° is in the NE quadrant (000°–090°), nearest to E (090°).

Example 3) Write how each bearing is spoken in ATC radio communication.

i) 195°

ii) 030°

iii) 270°

i) 195° → “one-nine-five”

ii) 030° → “zero-three-zero”

iii) 270° → “two-seven-zero”

Try It Yourself!

a. Convert to three-digit bearings.

i) North-West _____

ii) South-East _____

iii) Due North _____

iv) West-South-West (halfway between W and SW) _____

b. State the quadrant and nearest cardinal or intercardinal direction.

i) 205° _____

ii) 087° _____

iii) 338° _____

c. Write how each bearing is spoken aloud (ICAO phraseology).

i) 145° _____

ii) 006° _____

iii) 350° _____

AVI310102) Bearing FROM and TO

Exploring the Concept

The Reverse Bearing Problem

A controller says: "The bearing of the aircraft from the airport is 100°." This means if you stand at the airport and look toward the aircraft, you face 100° (slightly south of east).

But what if the **pilot** wants to fly back to the airport? The pilot needs the **bearing of the airport from the aircraft** — the reverse direction.

Key Idea

Bearing of A from B means: stand at B, face North, turn clockwise until you face A.

The bearing of A from B is **not** the same as the bearing of B from A. They point in opposite directions.

The Compass Cross Method

To find the reverse bearing, draw a **compass cross** (N–S–E–W lines) at **both** positions. Because all North lines are parallel, you can use the geometry of parallel lines to find the return bearing.

Key Discovery

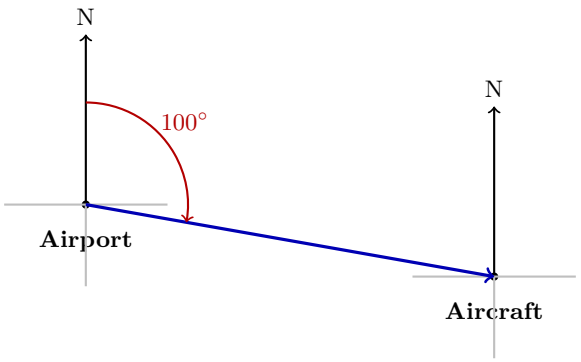
Why does this work?

All North lines across the Earth point in the same direction (toward the North Pole). This means the North line at the airport is **parallel** to the North line at the aircraft. The bearing line connecting the two points is a **transversal** cutting these parallel lines.

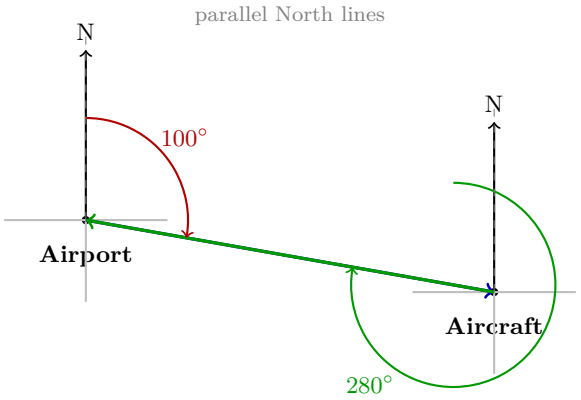
The co-interior angles (same-side interior angles) formed by a transversal cutting parallel lines add up to 180°. This is the geometric reason why the return bearing always differs by 180° from the forward bearing.

Worked Demonstration: The bearing of an aircraft from the airport is 100°. Find the bearing of the airport from the aircraft.

Step 1: Draw both positions with compass crosses.



Step 2: At the aircraft, draw the bearing line back toward the airport. Measure the angle clockwise from North.



Step 3: Read the answer. The bearing of the airport from the aircraft is **280°**.

Notice: $280° = 100° + 180°$. This is not a coincidence — it is a consequence of the co-interior angles formed by parallel North lines.

Important

Always draw the compass cross at both positions. Do not try to guess the return bearing mentally — draw it, measure from North clockwise, and verify. The +180° shortcut will be formalised in the next concept (Reciprocal Bearings).

Example

Example 1) The bearing of a ship from the lighthouse is 065°. Find the bearing of the lighthouse from the ship.

Draw compass crosses at both positions. The forward bearing is 065° (NE direction). At the ship, the return direction points SW.

From the ship's North line, measuring clockwise to the lighthouse: $065° + 180° = 245°$.

The bearing of the lighthouse from the ship is 245°.

Example 2) The bearing of Town B from Town A is 215°. Find the bearing of Town A from Town B.

Draw compass crosses at both towns. The forward bearing is 215° (SW direction). At Town B, the return direction points NE.

Since $215° \geq 180°$: $215° - 180° = 035°$.

The bearing of Town A from Town B is 035°.

Example 3) A rescue helicopter spots a stranded hiker. The bearing of the hiker from the helicopter's base is 310°. The helicopter flies to the hiker. What bearing should the pilot fly to return directly to base?

Draw compass crosses at the base and the hiker's position. The forward bearing (base to hiker) is 310° (NW direction). The return bearing (hiker to base) points SE.

$310° - 180° = 130°$.

The pilot should fly bearing 130° to return to base.

Try It Yourself!

a. The bearing of a plane from the control tower is 070°. Draw compass crosses at both positions and find the bearing of the control tower from the plane.

b. The bearing of City B from City A is 195°. Find the bearing of City A from City B by drawing compass crosses.

c. A pilot flies from airport X to airport Y on a bearing of 325°. What bearing should the pilot fly to return from Y to X?

d. The bearing of a lighthouse from a ship is 260°. What is the bearing of the ship from the lighthouse?

AVI310103) Reciprocal Bearings

Exploring the Concept

What is a Reciprocal Bearing?

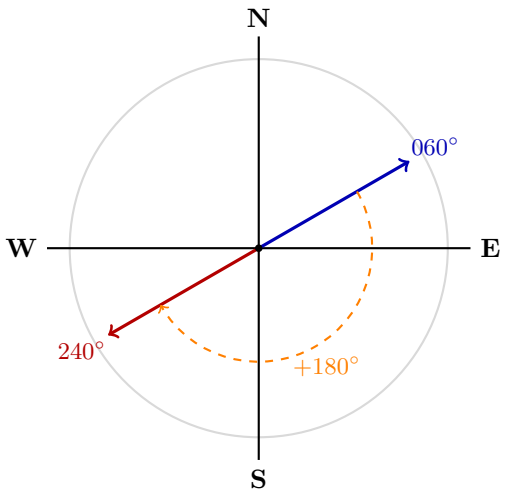
A reciprocal bearing is the **opposite direction** — the bearing you would be on if you turned exactly 180°.

Key Idea

The **reciprocal** of a bearing is found by adding or subtracting 180°:

- If bearing $< 180°$: reciprocal = bearing $+180°$
- If bearing $\geq 180°$: reciprocal = bearing $-180°$

Simple check: the reciprocal always differs from the original by exactly 180°.



Aviation Applications

Key Discovery

Bearing TO vs Bearing FROM

When a pilot reports their position relative to a navigation aid (like a VOR), there is an important distinction:

- **Bearing TO** the station: the bearing you would fly to reach it
- **Bearing FROM** the station: the direction away from the station toward you

These are always reciprocals of each other. If the bearing TO a VOR is 045°, then the bearing FROM that VOR is 225°.

VOR radials are defined as bearings FROM the station. If you are on the 090 radial, the station is to your west (bearing TO station = 270°).

Key Discovery

The 180° Turn

If you are flying heading 025° and ATC tells you to "turn 180" (a complete reversal), your new heading will be $025° + 180° = 205°$. Reciprocal bearings help you instantly know your return heading.

Example

Example 1) Find the reciprocal of 070°.

$070° < 180°$, so reciprocal $= 070° + 180° = 250°$.

Example 2) Find the reciprocal of 315°.

$315° \geq 180°$, so reciprocal $= 315° - 180° = 135°$.

Example 3) A pilot is flying heading 195°. ATC instructs "turn 180." What is the new heading?

Reciprocal of $195° = 195° - 180° = 015°$.

Example 4) An aircraft is on the 135 radial of a VOR. What bearing should the pilot fly to head directly toward the VOR?

A radial is a bearing FROM the station. The bearing TO the station is the reciprocal:

$135° < 180°$, so reciprocal $= 135° + 180° = 315°$.

Try It Yourself!

a. Find the reciprocal bearing.

i) 040° _____

ii) 265° _____

iii) 180° _____

iv) 355° _____

v) 090° _____

b. A pilot is flying heading 310°. What heading will they be on after a 180° turn?

c. An aircraft is on the 220 radial of a VOR.

i) What is the bearing FROM the VOR to the aircraft? _____

ii) What bearing should the pilot fly to head directly TO the VOR? _____

AVI310104) Why FROM/TO Is a Reciprocal

Exploring the Concept

One Line, Two Directions

In Concept 2, you drew compass crosses at two points and measured the bearing at each end. In Concept 3, you learned that reciprocal bearings are always 180° apart. Now let's see why these are **the same thing**.

Key Idea

The bearing line from A to B and the bearing line from B to A are **the same line** — the arrows just point in opposite directions.

This means the "bearing of B from A" and the "bearing of A from B" are **reciprocals**. They must differ by exactly 180°.

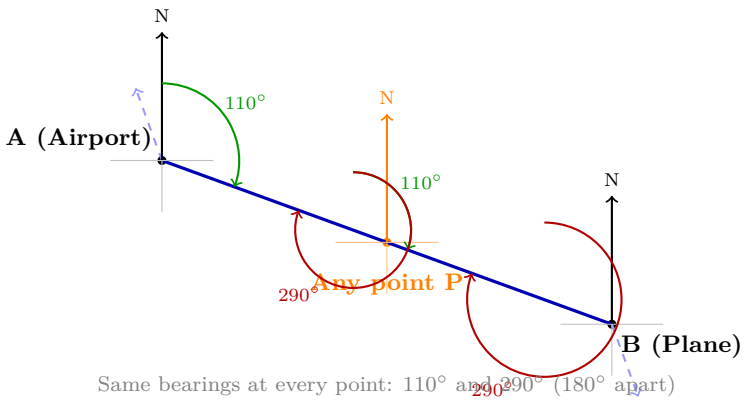
Pick Any Point on the Line

Key Discovery

Visual proof:

Draw any bearing line between two points. Now pick a **new point anywhere on that line** and draw a compass cross there. Measure the bearing in both directions from your new point.

You will always get the same two bearings — and they are always 180° apart. It does not matter **where** on the line you stand. The line itself has a fixed direction, and the opposite direction is always the reciprocal.



Same bearings at every point: 110° and 290° (180° apart)

Key Idea

The connection:

- "Bearing of B from A" and "bearing of A from B" are **opposite directions on the same line**.
- Opposite directions on the same line always differ by 180°.
- Therefore, "bearing of B from A" and "bearing of A from B" are always **reciprocals**.

The compass cross method (Concept 2) and the ±180° shortcut (Concept 3) are not two separate ideas — they are the **same idea** seen from two perspectives.

Important

The reciprocal shortcut (±180°) **works because** the North lines are parallel. Without parallel North lines, the co-interior angle argument breaks down. On very long distances, Earth's curvature means North lines converge toward the pole, and the difference is no longer exactly 180°. For the distances we work with, the flat-map assumption is perfectly accurate.

Example

Example 1) The bearing of a lighthouse from a ship is 065°. What is the bearing of the ship from the lighthouse?

These are opposite directions on the same line, so they are reciprocals:

$065° + 180° = 245°$.

The bearing of the ship from the lighthouse is 245°.

Example 2) A pilot flies from airport X to airport Y on a bearing of 310°. Without calculating, explain why the return bearing must be 130°.

The outbound and return paths are the same line, just opposite directions. Opposite directions on a line are reciprocals (180° apart).

$310° - 180° = 130°$.

No compass cross needed — the two bearings **must** be reciprocals because they lie on the same line.

Example 3) Imagine you are standing in the middle of a runway. The runway runs on a bearing of 070°/250°. Explain why every runway has two numbers that differ by 18.

A runway is a single straight line. Looking one way gives one bearing; looking the other way gives the reciprocal (180° apart).

Runway numbers are the bearing divided by 10 and rounded. So 070° → Runway 07, and 250° → Runway 25.

$25 - 07 = 18$. This is always true because $180 \div 10 = 18$.

Try It Yourself!

a. The bearing of Town B from Town A is 145°. Without drawing a compass cross, find the bearing of Town A from Town B. Explain your reasoning.

b. A helicopter flies from base to a rescue site on bearing 225°. What bearing does the pilot fly to return? Is this the reciprocal? Why?

c. A runway is labelled Runway 16/34. What are the two bearings of the runway? Verify they are reciprocals.

d. Draw a line between two points. Pick three different points on the line and draw a compass cross at each. Measure the bearing in both directions at each point. What do you notice?

AVI310105) Turn Direction — Which Way to Turn?

Exploring the Concept

Two Ways Around the Compass

Key Discovery

Picture this:

You are flying at heading 040° when ATC calls:

"QF401, turn heading two-seven-zero."

Should you turn left or right? You could turn either way and eventually reach 270° — but one way is much shorter than the other. In an emergency with aircraft converging, turning the wrong way wastes precious seconds.

On a compass, there are always **two ways** to get from any heading to any other heading:

- **Clockwise** (turning right)
- **Anticlockwise** (turning left)

The two arcs always add up to 360°. The shorter arc is always $\leq 180°$, and the longer arc is always $\geq 180°$.

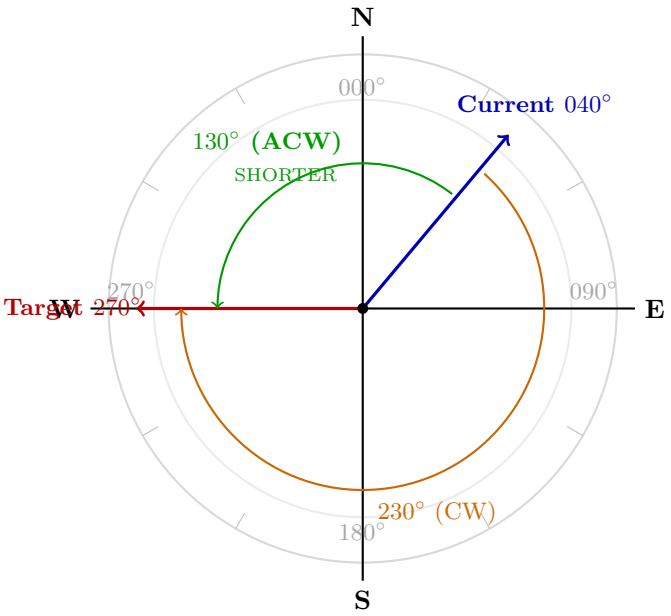
Key Idea

Turn Direction Rule:

1. Calculate the **clockwise difference**: target − current.
2. If the result is negative, add 360°.
3. If the result $\leq 180°$ → turn **RIGHT** (clockwise is the shorter path).
4. If the result $> 180°$ → turn **LEFT** (anticlockwise is the shorter path).

The number of degrees in the shorter turn is:

- If turning right: the clockwise difference itself.
- If turning left: 360° − clockwise difference.



From 040° *to* 270°*: clockwise is* 230°*, anticlockwise is* 130°*.*

Since 230° > 180°*, turning LEFT (anticlockwise) is shorter.*

Important

Special case: exactly 180°

If the clockwise difference is exactly 180°, both directions are equally long. In practice, ATC will always specify "turn left" or "turn right" so the pilot never has to decide — they simply follow the instruction.

Key Discovery

Why ATC always specifies turn direction

In real operations, ATC does not just say "turn heading two-seven-zero". They say "**turn left** heading two-seven-zero" or "**turn right** heading two-seven-zero". This removes all ambiguity — the pilot does not need to calculate which way is shorter; they just follow the instruction.

Why not let the pilot choose? Because ATC can see other traffic on radar. The shorter turn might send the aircraft toward another plane. ATC picks the direction that is both efficient **and** safe.

Example

Example 1) Current heading 040°, target heading 130°. Which direction gives the shorter turn?

Clockwise difference = 130° − 040° = 090°.

Since 090° ≤ 180°, the clockwise path is shorter.

→ Turn **RIGHT** by 090°.

Example 2) Current heading 320°, target heading 050°. Which direction gives the shorter turn?

Clockwise difference = $050° - 320° = -270°$.

This is negative, so add $360°$: $-270° + 360° = 090°$.

Since $090° \leq 180°$, the clockwise path is shorter.

→ Turn **RIGHT** by $090°$.

Note: This turn crosses North (360°/000°). The method works perfectly regardless — no special handling needed.

Example 3) Current heading 170°, target heading 350°. Which direction gives the shorter turn?

Clockwise difference = $350° - 170° = 180°$.

Since the difference is exactly 180°, both directions are equal — turning left or right requires the same amount of rotation.

→ **Either direction** works (180° each way). In practice, ATC will specify which way to turn.

Try It Yourself!

a. Current heading 090°, target heading 250°. Which way should you turn? How many degrees?

b. Current heading 310°, target heading 050°. Which way should you turn? How many degrees?

c. Current heading 200°, target heading 020°. Which way should you turn? How many degrees?

d. *(Challenge)* ATC says: "QF401, turn heading two-seven-zero." The pilot's current heading is 260°. Should they turn left or right? By how many degrees? Is this realistic in practice?

AVI3100 — Section 1 Review: Aviation Bearings

Question 1) *(AVI310101 — Three-Digit Bearings)*

An air traffic controller gives the instruction: "Turn right heading three-one-five." Write this heading as a number, and state which quadrant and nearest intercardinal direction it falls in.

315°. NW quadrant (270°–360°), nearest intercardinal direction: NW.

Question 2) *(AVI310101 — Three-Digit Bearings)*

A student writes the bearing of East as "90°." Is this correct? Explain what should be written instead and how it is spoken in radio communication.

The number is correct mathematically, but bearing convention requires three digits. It should be written as 090° and spoken as "zero-nine-zero."

Question 3) *(AVI310102 — Bearing FROM and TO)*

The bearing of a helicopter from the airport is 140°. By drawing a compass cross at the helicopter's position, find the bearing of the airport from the helicopter.

Draw a compass cross at the helicopter. The bearing FROM the airport TO the helicopter is 140° (SE direction). The reverse direction (from helicopter back to airport) points NW. Using co-interior angles with the parallel North lines: 140° + return angle from North = 360°... or simply, the bearing from the helicopter to the airport = 140° + 180° = 320°.

Question 4) *(AVI310102 — Bearing FROM and TO)*

Town B is on a bearing of 250° from Town A. Find the bearing of Town A from Town B.

Draw a compass cross at Town B. Town A is in the opposite direction: 250° − 180° = 070°. The bearing of Town A from Town B is 070°.

Question 5) *(AVI310103 — Reciprocal Bearings)*

An aircraft is on the 310 radial of a VOR. What bearing should the pilot fly to head directly toward the VOR?

The 310 radial means the bearing FROM the VOR is 310°. The reciprocal (bearing TO the VOR) = 310° − 180° = 130°.

Question 6) *(AVI310103 — Reciprocal Bearings)*

A pilot is flying heading 158° and receives the instruction to reverse course (turn 180°). What will the new heading be?

158° < 180°, so reciprocal = 158° + 180° = 338°.

Question 7) *(AVI310104 — Why FROM/TO Is a Reciprocal)*

A runway is labelled Runway 12/30. What are the two bearings of the runway? Verify that they are reciprocals.

Runway 12 faces 120° and Runway 30 faces 300°. Check: 300° − 120° = 180°. They are reciprocals because they are opposite directions on the same line (the runway).

Question 8) *(AVI310104 — Why FROM/TO Is a Reciprocal)*

Explain why the compass cross method (drawing parallel North lines) and the ±180° shortcut always give the same answer.

Both methods describe the same geometric fact: the bearing from A to B and from B to A are opposite directions on the same line. The co-interior angles formed by parallel North lines sum to 180°, which is exactly the ±180° shortcut.

Question 9) *(AVI310105 — Turn Direction)*

Current heading 280°, target heading 060°. Which way should you turn? How many degrees?

Clockwise difference $= 060° - 280° = -220°$. Add 360°: $-220° + 360° = 140°$. Since $140° \leq 180°$, the clockwise path is shorter. Turn **RIGHT** by 140°.

Question 10) *(AVI310105 — Turn Direction)*

A pilot is heading 350° and ATC instructs "turn left heading one-seven-zero." Is this the shorter turn or the longer turn? Show your calculation.

Clockwise difference $= 170° - 350° = -180°$. Add 360°: $-180° + 360° = 180°$. Both directions are equal (180° each way). ATC specified left, which is valid — neither direction is shorter.

AVI310101) Three-Digit Bearings — Homework

Question 1) Convert to three-digit bearings.

i) Due South

ii) North-East

iii) West-North-West (halfway between W and NW)

iv) South-South-East (halfway between S and SE)

v) Due West

Question 2) State the quadrant for each bearing and give the nearest cardinal direction.

i) 112°

ii) 267°

iii) 029°

iv) 193°

Question 3) Write the ICAO radio phraseology for each bearing.

i) 240°

ii) 015°

iii) 308°

iv) 090°

Question 4) A student pilot writes a heading as "45°" in their navigation log. The instructor marks it wrong. Explain why, and write the correct form.

AVI310102) Bearing FROM and TO — Homework

1. For each situation, draw compass crosses at both positions and find the return bearing.

i) The bearing of a yacht from the harbour is 045°. Find the bearing of the harbour from the yacht.

ii) The bearing of Town Q from Town P is 230°. Find the bearing of Town P from Town Q.

iii) The bearing of a plane from the radar station is 172°. Find the bearing of the radar station from the plane.

2. A search plane takes off from base and flies to a crash site on a bearing of 118°. After the rescue, the pilot needs to fly back to base. What bearing should the pilot fly?

3. The bearing of Lighthouse B from Lighthouse A is 295°. A ship at Lighthouse B wants to sail to Lighthouse A. What bearing should it follow?

4. A pilot radios: "I can see the airport on bearing two-four-zero." The controller needs to know the bearing of the aircraft from the airport. What is it?

5. Explain why the return bearing is always exactly 180° different from the forward bearing. Use the words "parallel" and "North lines" in your answer.

AVI310103) Reciprocal Bearings - Homework

Question 1) Find the reciprocal of each bearing.

i) 125°

ii) 298°

iii) 060°

iv) 210°

v) 345°

vi) 180°

Question 2) Complete the table.

Bearing	Reciprocal
055°	
	320°
170°	
	095°

Question 3) A Cessna 172 is flying heading 248°. The pilot decides to return to the departure airport by turning 180°. What is the new heading?

Question 4) An aircraft is on the 075 radial of Brisbane VOR.

i) What is the bearing FROM the VOR to the aircraft?

ii) What bearing must the pilot fly to head TO the VOR?

iii) If the pilot flies to the VOR and then continues past it, what radial will they now be on?

AVI310104) Why FROM/TO Is a Reciprocal — Homework

1. The bearing of an island from a harbour is 078°. Find the bearing of the harbour from the island. State whether you used the compass cross method or the reciprocal shortcut, and explain why both give the same answer.

2. A search aircraft flies from base on bearing 192° to reach a search area. After completing the search, the pilot needs to return to base.

i) What bearing should the pilot fly to return? _____

ii) Explain why this must be the reciprocal of 192°.

3. An airport has Runway 09/27.

i) What bearing does Runway 09 face? _____

ii) What bearing does Runway 27 face? _____

iii) Are these reciprocals? Verify with the ±180° rule.

4. *(Challenge)* Sydney Airport has Runway 16R/34L. Melbourne Airport has Runway 16/34. Do these runways face the same direction? Explain using bearings and reciprocals.

AVI310105) Turn Direction — Homework

Question 1) Current heading 150°, target heading 300°. Determine the turn direction and the number of degrees in the shorter turn. Show your working.

Question 2) Current heading 045°, target heading 315°. Determine the turn direction and the number of degrees in the shorter turn. Show your working.

Question 3) In ATC radio communication, the controller always says "turn **left** heading …" or "turn **right** heading …" rather than just "turn heading …". Explain why specifying the direction is important, even when the shorter turn seems obvious.

Question 4) *(Challenge)* Current heading 180°, target heading 000°. What is the clockwise difference? What is the anticlockwise difference? What is special about this case, and what would ATC do?

AVI310101) Three-Digit Bearings — Answers

a.

i) 315°

ii) 135°

iii) 000° (or 360°)

iv) 248° (or 247°)

b.

i) SW quadrant, nearest SW (225°)

ii) NE quadrant, nearest E (090°)

iii) NW quadrant, nearest N (000°/360°)

c.

i) “one-four-five”

ii) “zero-zero-six”

iii) “three-five-zero”

AVI310102) Bearing FROM and TO — Answers

a. The bearing of the control tower from the plane.

Forward bearing (tower to plane) = 070°. Since 070° < 180°:

Return bearing = 070° + 180° = 250°.

b. The bearing of City A from City B.

Forward bearing (A to B) = 195°. Since 195° ≥ 180°:

Return bearing = 195° − 180° = 015°.

c. Return bearing from Y to X.

Forward bearing = 325°. Since 325° ≥ 180°:

Return bearing = 325° − 180° = 145°.

d. Bearing of the ship from the lighthouse.

Forward bearing (ship to lighthouse) = 260°. Since 260° ≥ 180°:

Return bearing = 260° − 180° = 080°.

AVI310103) Reciprocal Bearings - Answers

a.

i) $040° + 180° = 220°$

ii) $265° - 180° = 085°$

iii) $180° + 180° = 360°$ (or $000°$)

iv) $355° - 180° = 175°$

v) $090° + 180° = 270°$

b. $310° - 180° = 130°$

c.

i) $220°$ (the radial IS the bearing from the VOR)

ii) $220° - 180° = 040°$

AVI310104) Why FROM/TO Is a Reciprocal — Answers

a. $145° + 180° = 325°$. The two bearings lie on the same line (opposite directions), so they must be reciprocals — always 180° apart.

b. $225° - 180° = 045°$. Yes, it is the reciprocal. The outbound and return paths are the same line, and opposite directions on a line are always reciprocals.

c. Runway 16 = 160°, Runway 34 = 340°. Check: $340° - 160° = 180°$ ✓. They are reciprocals (same line, opposite ends).

d. At every point, the bearings in both directions are the same two values (e.g., 110° and 290°), and they always differ by 180°. The position on the line does not matter — the line has a fixed direction.

AVI310105) Turn Direction — Answers

a. Clockwise difference = $250° - 090° = 160°$.

Since $160° \leq 180°$, the clockwise path is shorter.

→ Turn **RIGHT** by 160°.

b. Clockwise difference = $050° - 310° = -260°$.

Add 360°: $-260° + 360° = 100°$.

Since $100° \leq 180°$, the clockwise path is shorter.

→ Turn **RIGHT** by 100°.

c. Clockwise difference = $020° - 200° = -180°$.

Add 360°: $-180° + 360° = 180°$.

Since the difference is exactly 180°, both directions are equal. Either turn is 180°.

→ **Either direction** works. ATC would specify "turn left" or "turn right".

d. Clockwise difference = $270° - 260° = 010°$.

Since $010° \leq 180°$, the clockwise path is shorter.

→ Turn **RIGHT** by 010°.

Is this realistic? A 10° turn is extremely small — essentially a minor course correction. In practice, ATC would not normally issue a heading change this small as a "turn" instruction. They might instead say "fly heading two-seven-zero" without specifying left or right, since the adjustment is so minor that direction is obvious. Alternatively, ATC might not issue the instruction at all — small corrections are often handled by the autopilot or the pilot's own navigation.

AVI310101) Three-Digit Bearings — Homework Answers

Question 1)

i) 180°

ii) 045°

iii) 293° (or 292°)

iv) 157° (or 158°)

v) 270°

Question 2)

i) SE quadrant, nearest E (090°)

ii) SW quadrant, nearest W (270°)

iii) NE quadrant, nearest N (000°)

iv) SW quadrant, nearest S (180°)

Question 3)

i) “two-four-zero”

ii) “zero-one-five”

iii) “three-zero-eight”

iv) “zero-nine-zero”

Question 4) Bearings must always be written as three digits. The correct form is 045°. Writing “45°” is ambiguous and violates the standard convention. In radio communication it would be spoken as “zero-four-five.”

AVI310102) Bearing FROM and TO — Homework Answers

1.

i) $045° + 180° = 225°$. The bearing of the harbour from the yacht is 225°.

ii) $230° - 180° = 050°$. The bearing of Town P from Town Q is 050°.

iii) $172° + 180° = 352°$. The bearing of the radar station from the plane is 352°.

2. $118° + 180° = 298°$. The pilot should fly bearing 298° to return to base.

3. $295° - 180° = 115°$. The ship should follow bearing 115°.

4. The pilot sees the airport on 240°, so the bearing FROM the pilot TO the airport is 240°. The bearing FROM the airport TO the aircraft (what the controller needs) is the reverse: $240° - 180° = 060°$.

5. All North lines on the Earth are parallel (they all point toward the North Pole). The bearing line between two positions is a transversal cutting these parallel North lines. The co-interior angles formed on the same side add up to 180°. This means the forward bearing and the return bearing always differ by exactly 180°.

AVI310103) Reciprocal Bearings - Homework Answers

Question 1)

i) $125° + 180° = 305°$

ii) $298° - 180° = 118°$

iii) $060° + 180° = 240°$

iv) $210° - 180° = 030°$

v) $345° - 180° = 165°$

vi) $180° + 180° = 360°$ (or $000°$)

Question 2)

Bearing	Reciprocal
055°	235°
140°	320°
170°	350°
275°	095°

Question 3) $248° - 180° = 068°$

Question 4)

i) $075°$ (the radial is the bearing FROM the VOR)

ii) $075° + 180° = 255°$

iii) After passing through the VOR, the aircraft is now on the reciprocal radial = $075° + 180° = 255$ radial.

AVI310104) Why FROM/TO Is a Reciprocal — Homework Answers

1. 078° + 180° = 258°. Both methods give the same answer because the compass cross method shows the geometry (parallel North lines, co-interior angles), which always results in a 180° difference — exactly what the reciprocal shortcut says. They are the same idea.

2.

i) 192° − 180° = 012°

ii) The outbound path (base to search area) and the return path are the same line, opposite directions. Opposite directions on a straight line are reciprocals — always 180° apart.

3.

i) 090°

ii) 270°

iii) Yes. 270° − 090° = 180° ✓

4. Yes, they face the same direction. Runway 16 means bearing ≈ 160° and Runway 34 means bearing ≈ 340°. Both Sydney and Melbourne have 16/34, so both runways face approximately 160°/340°. The L/R suffix indicates left or right when there are parallel runways at the same airport — it does not change the bearing.

AVI310105) Turn Direction — Homework Answers

Question 1) Clockwise difference = $300° - 150° = 150°$.

Since $150° \leq 180°$, the clockwise path is shorter.

→ Turn **RIGHT** by 150°.

Question 2) Clockwise difference = $315° - 045° = 270°$.

Since $270° > 180°$, the anticlockwise path is shorter.

Anticlockwise turn = $360° - 270° = 090°$.

→ Turn **LEFT** by 090°.

Question 3) ATC specifies the direction because:

- The shorter turn is not always the safest turn — other aircraft may be in the way.
- ATC can see all traffic on radar and chooses the direction that avoids conflicts.
- Removing ambiguity saves time — the pilot does not need to calculate or decide, they just follow the instruction immediately.
- In an emergency, every second counts. A pilot turning the wrong way could move into the path of another aircraft.

Question 4) Clockwise difference = $000° - 180° = -180°$.

Add 360°: $-180° + 360° = 180°$.

Anticlockwise difference = $360° - 180° = 180°$.

Both turns are exactly 180° — neither direction is shorter. This is the special case where the current and target headings are exact reciprocals (opposite directions). ATC would specify "turn left heading zero-zero-zero" or "turn right heading zero-zero-zero" to remove ambiguity.

AVI3100 — Section 1 Review: Aviation Bearings — Answers

Question 1) 315°. NW quadrant (270°–360°), nearest intercardinal direction: NW.

Question 2) The number is correct mathematically, but bearing convention requires three digits. It should be written as 090° and spoken as "zero-nine-zero."

Question 3) Draw a compass cross at the helicopter. The bearing from the airport to the helicopter is 140° (SE). Using co-interior angles with parallel North lines, the return bearing = 140° + 180° = 320°.

Question 4) Draw a compass cross at Town B. The return direction is 250° − 180° = 070°.

Question 5) The 310 radial means the bearing FROM the VOR is 310°. The reciprocal (bearing TO the VOR) = 310° − 180° = 130°.

Question 6) 158° < 180°, so reciprocal = 158° + 180° = 338°.

Question 7) Runway 12 faces 120° and Runway 30 faces 300°. Check: 300° − 120° = 180°. They are reciprocals because they are opposite directions on the same line (the runway).

Question 8) Both methods describe the same geometric fact: the bearing from A to B and from B to A are opposite directions on the same line. The co-interior angles formed by parallel North lines sum to 180°, which is exactly the ±180° shortcut.

Question 9) Clockwise difference = 060° − 280° = −220°. Add 360°: 140°. Since 140° ≤ 180°, turn **RIGHT** by 140°.

Question 10) Clockwise difference = 170° − 350° = −180°. Add 360°: 180°. Both directions are equal (180° each way). ATC specified left, which is valid — neither direction is shorter.

