

STUDY AID — PENDING INDEPENDENT AUDIT

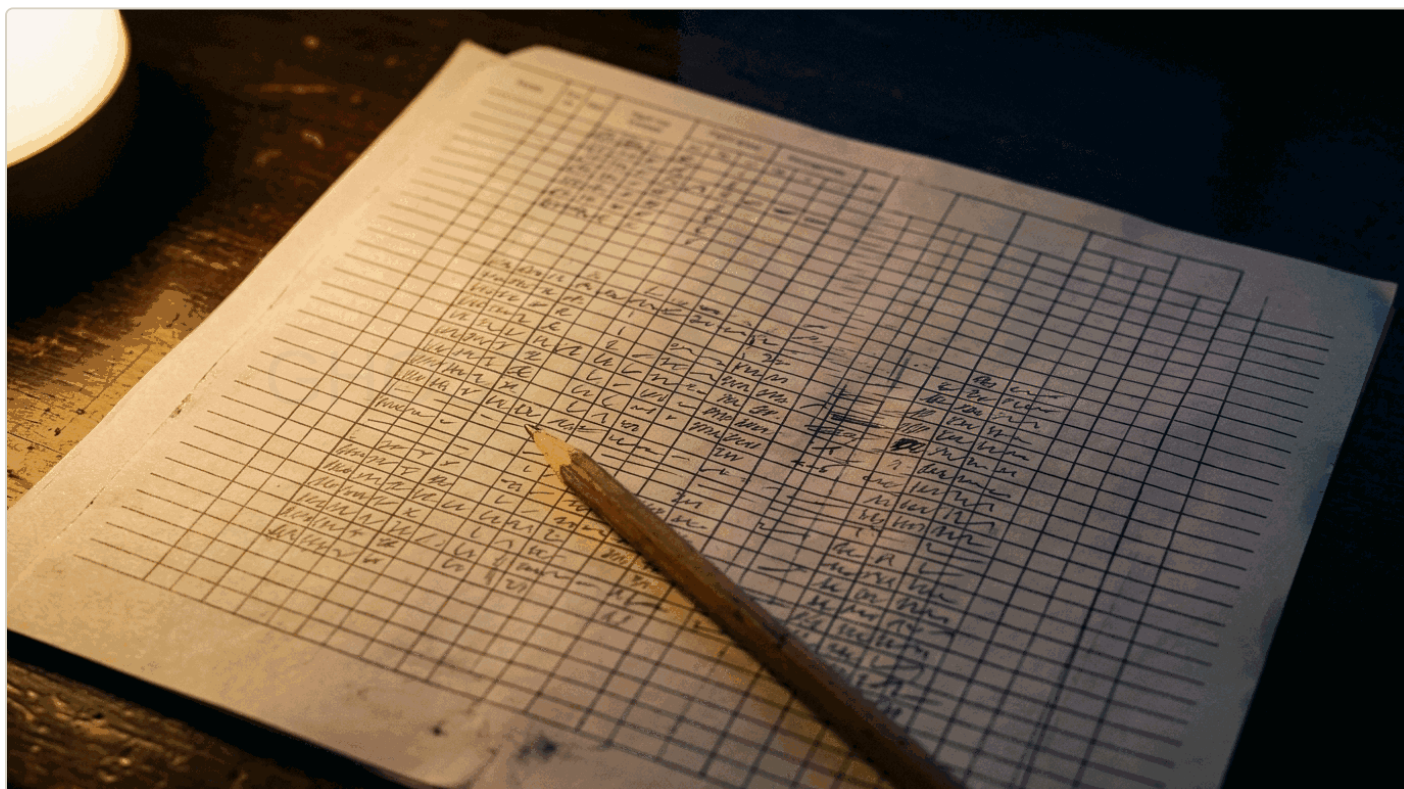
These notes are study aids for DGCA examination preparation. They are PENDING INDEPENDENT AUDIT and must not be used for operational flight planning. Always verify procedures against current AIPs, NOTAMs, and your operator's manuals.

GENERAL NAVIGATION • THE NAVIGATION COMPUTER

Chapter 8B

The Flight Plan and Wind Finding

Every chapter of this module has been one operation at a time. This is where they all run in a single row of a table — and where the computer stops being a calculator and becomes a flight planning tool.



Opening plate — One row per leg, and every column earned by a separate skill. By the end of this chapter you will be able to fill one from the left edge to the right without stopping.

Join live classes for guided practice and doubt clearing.

The chart is marked, the legs are measured, the forecast is in your hand. In front of you is a table with fourteen columns and seven rows, and every cell is empty except the ones you were given.

Nothing in that table is new to you. Column by column it is **Chapter 6** (a calibrated airspeed and a temperature become a true airspeed), then **Chapter 8A** (a track and a wind become a heading and a ground speed), then **this chapter** (a true heading becomes the number you will actually steer by), then **Chapter 5** (a distance and a ground speed become minutes).

The skill being tested is not any one of those. It is doing all four in order without losing your place. That is why the exercises at the end of this chapter are worked across the rows and never down the columns.

GHOST AVIATOR

1 • What a flight plan actually is

Strip the printing away and a flight plan row is a chain of five conversions. Each one hands its answer to the next, which is exactly why a mistake in the third column is invisible until the last one is wrong.

Step	You have	You want	What does it	Chapter
1	CAS, pressure altitude, OAT	TAS	FLT → Airspeed → Planned TAS	6
2	Track, TAS, W/V	Heading (T), GS	PLAN → Leg	8A
3	Heading (T), variation	Heading (M)	arithmetic, or the Var field	this one
4	Heading (M), deviation	Heading (C)	arithmetic, or the Dev field	this one
5	Distance, GS	Time	FLT → Ground Speed, or ETE	5

Why the whole module has been building to this

A student who can do steps 1, 2 and 5 in isolation and cannot fill in a flight plan row has not learned navigation. They have learned three party tricks.

The examination knows this, which is why the flight plan questions are worth disproportionate marks and why they are where candidates run out of time.

2 · Variation and deviation — and the sign trap that will get you

Steps 3 and 4 are the only genuinely new arithmetic in this chapter, and they are two lines. The danger is not the arithmetic. It is the sign.

The rule, and the mnemonic that has never let anyone down

Variation west, magnetic best.

Variation east, magnetic least.

So going from **true to magnetic**:

Magnetic = True + West variation

Magnetic = True - East variation

And deviation behaves identically, one step further along: Compass = Magnetic + West deviation .

Worked: true 095°, variation 5°W → magnetic 100°. Then deviation 1°W → compass 101°. West both times, so you add twice.

The trap: the book's plus sign and the CX-3's plus sign mean opposite things

Most rows in the exercises write variation in words — 5°W , 3°E — and there is no ambiguity. But some rows write it as a *signed number*, and there the two conventions you will meet are exact mirrors of each other.

	+ means	- means
The exercises in this chapter	East	West
The CX-3's Var field	West	East

Type the book's sign straight into the machine and you do not get the variation slightly wrong. You get it wrong by twice the variation — once for applying it backwards, once for the correction you needed and did not get. On a 34° variation, which appears in these exercises, that is 68°.

The CX-3's own words, from the User's Guide V1.3: "east is least, west is best: enter a positive number for a westerly variation and a negative number for an easterly variation." Its own worked example enters 17° East as 1 7 +/- → -17.

Read the machine's convention as the mnemonic made mechanical, not as a contradiction of it. It computes Magnetic = True + Var , so entering east as negative produces the subtraction the mnemonic describes. The arithmetic is the same rule you already know. What changes is only which key you press first.

Join live classes for guided practice and doubt clearing.

The safe habit, and it costs two seconds: never type a variation as a bare signed number. Say the word to yourself — "five *west*" — decide from the mnemonic whether the magnetic heading gets bigger or smaller, and only then decide what to press.

Deviation is smaller, which is exactly why it is missed

Variation runs to tens of degrees and demands attention. Deviation is usually one, two, three degrees, and a student who has fought through the variation quietly forgets it.

It is the last column before the number you actually fly. **An unapplied 3° deviation is 3° of track error for the whole leg** — five miles at the end of a hundred.

GHOST AVIATOR

3 · One leg, end to end

Here is a single row of Flight Plan 1, worked from the left edge to the right, with nothing skipped. Once you can do this one you can do all thirty.

- **Pressure altitude** — 2000 ft
- **OAT** — -10°C
- **CAS** — 160 kt
- **Track required** — 100°(T)
- **W/V** — 330/17
- **Variation** — 5°W · **Deviation** — 1°W
- **Distance** — 50 NM

GHOST AVIATOR

Worked example 8B.1. Fill the row. Find TAS, heading true, heading magnetic, heading compass, ground speed and time.

METHOD 1 — THE ARITHMETIC

five steps, in order, never skipping

1. TAS. Density ratio at 2000 ft and -10°C is 1.018, so

$$\text{TAS} = 160 \div \sqrt{1.018} = 158.6 \rightarrow \mathbf{159 \text{ kt}}$$

2. Heading and GS. Wind from 330 points toward 150. $\theta = 150 - 100 = 50^{\circ}$

$$\text{WCA} = \sin^{-1}(17 \cdot \sin 50 \div 159) = 4.7^{\circ}$$

$$\text{HDG} = 100 - 4.7 = 95.3 \rightarrow \mathbf{095^{\circ}(\text{T})}$$

$$\text{GS} = 159 \cdot \cos 4.7 + 17 \cdot \cos 50 = 169.4 \rightarrow$$

169 kt

3. Magnetic. Variation 5°West , so magnetic is *best* — bigger.

$$095 + 5 = \mathbf{100^{\circ}(\text{M})}$$

4. Compass. Deviation 1°West , same direction again.

$$100 + 1 = \mathbf{101^{\circ}(\text{C})}$$

5. Time. $50 \div 169.4 \times 60 = 17.7 \rightarrow \mathbf{18 \text{ min}}$

**159 kt · 095(T) · 100(M) · 101(C) ·
169 kt · 18 min**

METHOD 2 — THE CX-3

two menus, and the second one keeps the answer

1. **FLT** → Airspeed → **Planned TAS.**

Enter **CAS** 160, **OAT** -10 , **PAIt** 2000.

Read **TAS**.

2. **PLAN** → open leg 1.

3. **TCrs** 100 · **TAS** from step 1 · **WDir** 330 · **WSpd** 17.

4. **Var** — 5°West , and west is **positive** on this machine, so enter **5**, no sign key.

5. **Dev** — 1°West , same again: **1**.

6. **Dist** 50, and **Rate** if you want the fuel.

7. Read **GS**, **CHdg** and **ETE** straight off the leg.

CHdg 101 · GS 169 · ETE 18 min

Look at what the machine did there. Method 1 needed four separate calculations and two sign decisions. The **PLAN** leg took the same inputs and returned the compass heading directly — variation and deviation already inside it. **That is the first time in this module the electronic computer has saved you real work rather than just time, and it is why this chapter exists.**

Sanity check. The wind is from 330 on a track of 100 — behind your left shoulder. Behind, so ground speed beats TAS: 169 against 159, yes. On the left, so it drifts you right and you aim left: 095 is left of 100, yes. Both variation and deviation are west, so both headings climb: $095 \rightarrow 100 \rightarrow 101$, yes. If your compass heading had come out lower than your true heading with two westerly corrections, you applied them backwards.

4 • The PLAN menu — where it stops being a calculator

One leg is a fair fight between the formula and the machine. Seven legs is not.



Figure 8.12 — A trip is legs, and legs share almost everything. The aircraft does not change TAS between turning points; the variation barely moves; the fuel flow is a property of the engine, not of the leg. The machine knows this.

Global values — the feature that does the actual work

Four of the PLAN inputs are marked with a **blue circle icon**: TAS, Var, Dev and Rate. A blue circle means **this value repeats across every leg**. Enter it once and every leg has it.

So a seven-leg plan is not seven times the work. It is one aircraft set-up, then seven pairs of numbers — track and distance — and a wind for each.

Per-leg inputs are Dist, TCrs, TAS, WDir, WSpd, Var, Dev, Rate, Dep; per-leg outputs are GS, CHdg, ETE, Fuel. The Total Trip line returns total Dist, ETE, ETA and Fuel.

Total Trip — the number nobody calculates by hand twice

At the foot of the plan the machine totals the distance, the elapsed time, the fuel, and — given a departure time — the **ETA**.

Add a leg, change a wind, or accept a re-route, and every one of those totals moves on its own. Doing that by hand means re-adding four columns and it is exactly where a tired pilot makes an arithmetic error at one in the morning.

Set the departure in **UTC** and read the ETA in UTC. Mixing local and UTC inside one flight plan is a classic and expensive mistake, and the machine will not catch it for you — it has no idea which one you typed.

Set the aircraft up once, before the first leg

Under **SET** the CX-3 carries an **Aircraft Profile**. Put your TAS and your fuel flow in it and they are waiting for you every time.

The same menu carries **K**, the instrument calibration factor used to convert OAT to TAT and back, defaulting to 1.0. That is the electronic replacement for the E6B's blue scale, and unless your operator tells you otherwise, 1.0 is what you leave it at.

And the housekeeping one: clear the memory before an examination. The requirement is written into the Guide for FAA knowledge exams. Whether DGCA imposes the same is not something I can show you in writing, so treat clearing it as good practice rather than as a rule I have proved.

5 • Wind finding — the third job

Back to the table at the start of Chapter 8A. Row one was finding track. Row two was finding heading. **Row three is finding the wind**, and it is the only one where the answer is something nobody gave you.

Why bother, when the forecast is right there

A forecast wind covers a large area and is valid for several hours. It is an average of a region over a period, and it was written before you took off.

The wind you find in flight is the wind **at your level, in your part of the sky, over the last twenty minutes**. It is more recent and more local than anything you were handed on the ground, and every remaining leg of your plan is better for having it.

The situation

You are heading **060°(T)** at a TAS of **140 knots**, flying some planned track.

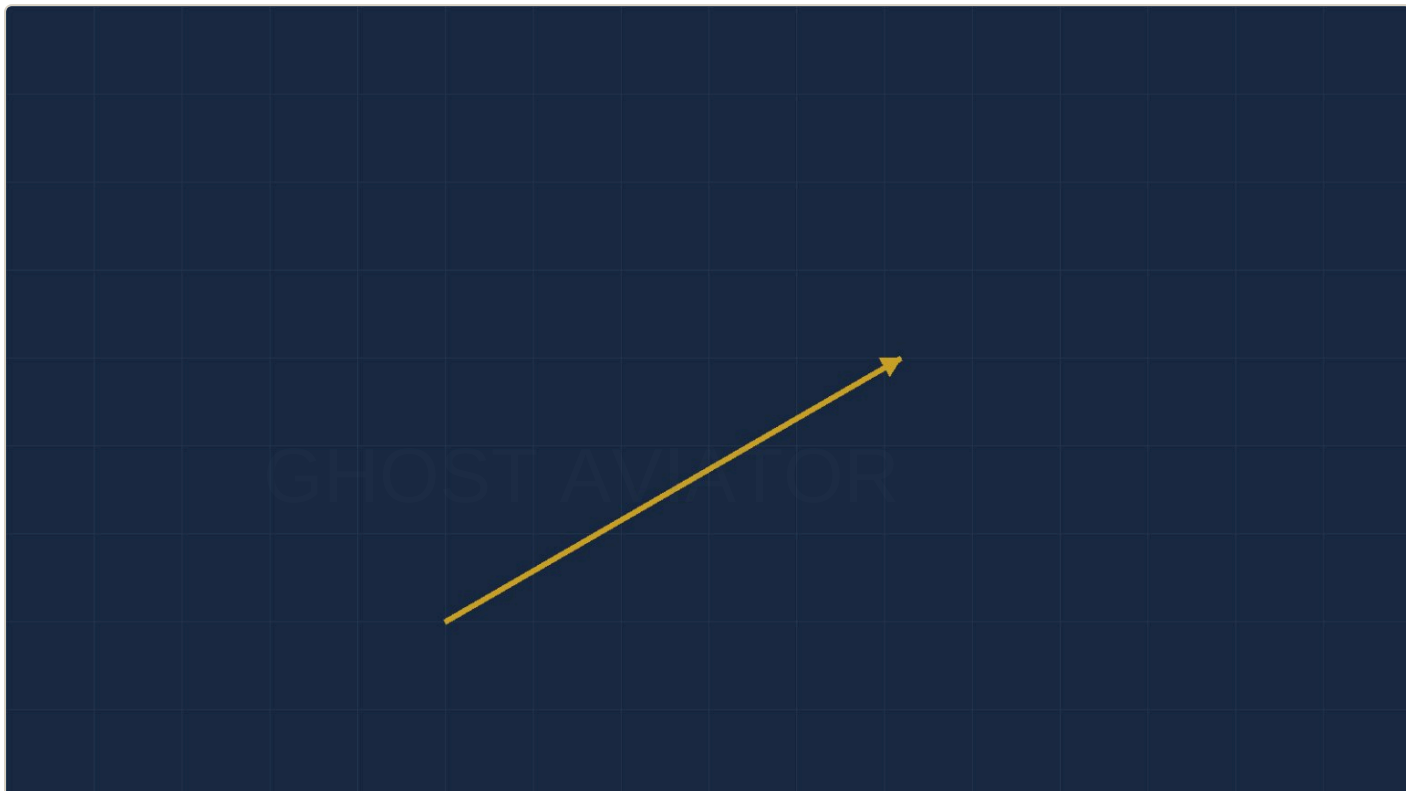


Figure 8.13 — This is all you have at the start: one vector, whose direction is your heading and whose length is your TAS. Everything else has to come from looking out of the window.

■ heading 060°(T), TAS 140 kt

You pass a known landmark at **A**. Twenty minutes later you get a fix at **B**. On the chart you measure the line from A to B: it runs **065°(T)** and it is **40 nautical miles** long.

Forty miles in twenty minutes is **120 knots** over the ground. And now you have four numbers, which is one more than you need:

- **Heading** — 060°(T)
- **TAS** — 140 kt
- **Track made good** — 065°(T)
- **Ground speed** — 120 kt



Figure 8.14 — Two sides of the triangle, measured rather than forecast. The gap between the two arrowheads is the wind, and it has been there all along.

■ air vector — heading 060, 140 kt ■ ground vector — track 065, 120 kt

The whole of wind finding, in one sentence

The wind is the vector that joins the tip of the air vector to the tip of the ground vector.

Nothing else. Draw where you were pointing, draw where you actually went, and the line closing the gap between the two arrowheads is the wind — pointing the way it blows, with a length equal to its speed.



Figure 8.15 — The triangle closes, and the closing side is the answer. Note where it starts and where it ends: **from the air vector's tip, to the ground vector's tip**. Draw it the other way round and you have the reciprocal, which is the single commonest error in this operation.

- air vector — one arrowhead ■ ground vector — two arrowheads
- the wind — three arrowheads, and it was the unknown

GHOST AVIATOR

Worked example 8B.2. Heading 060°(T), TAS 140 kt, track made good 065°(T), ground speed 120 kt. Find the W/V.

METHOD 1 — THE ARITHMETIC

subtract one vector from the other

1. Break the air vector into east and north parts:

$$E = 140 \cdot \sin 060 = 121.24$$

$$N = 140 \cdot \cos 060 = 70.00$$

2. Same for the ground vector:

$$E = 120 \cdot \sin 065 = 108.76$$

$$N = 120 \cdot \cos 065 = 50.71$$

3. Subtract, ground *minus* air. This is the step whose order decides everything:

$$E = 108.76 - 121.24 = -12.48$$

$$N = 50.71 - 70.00 = -19.29$$

4. Wind speed is the hypotenuse:

$$\sqrt{(12.48^2 + 19.29^2)} = 22.98$$

5. That vector points *toward*

$\text{atan2}(-12.48, -19.29) = 213^\circ$. A wind is named for where it comes *from*, so add 180.

W/V 033° / 23 kt

METHOD 2 — THE CX-3

and this time the function name is honest

1. **FLT** → **Wind Correction**.
2. **THdg** 060 · **TAS** 140 · **TCrs** 065 · **GS** 120.
3. Read **WDir**, **WSpd** and **WCA**.
4. Four inputs, three outputs, no sign decisions and nothing to draw. **This is the one wind job the CX-3 does better than you do.**

W/V 033° / 23 kt

Now the trap from Chapter 8A, seen from the other side. *The function called Wind Correction was the wrong tool for finding a heading. Here it is exactly right. Its name has always described what it takes, not what it gives you — and reading it that way makes the whole menu obvious.*

Sanity check. *You drifted from 060 to 065 — five degrees right — so the wind must be pushing from your left, somewhere north-westerly to northerly. 033 is north-north-east, which is on your left on a heading of 060. Yes.*

And your ground speed dropped from 140 to 120, so it must have a head component. A wind from 033 against a heading of 060 is 27° off the nose. Yes.

If you had computed 213° instead, you would have subtracted the vectors the wrong way round — and 213 is exactly the reciprocal of 033, which is how that error always announces itself.



Figure 8.16 — On a rotating computer the wind vector is swung down to the six o'clock position before it is read. That step has no mathematics in it at all — **it exists only so the number can be read accurately** off a scale.

■ the wind, moved only to be measured

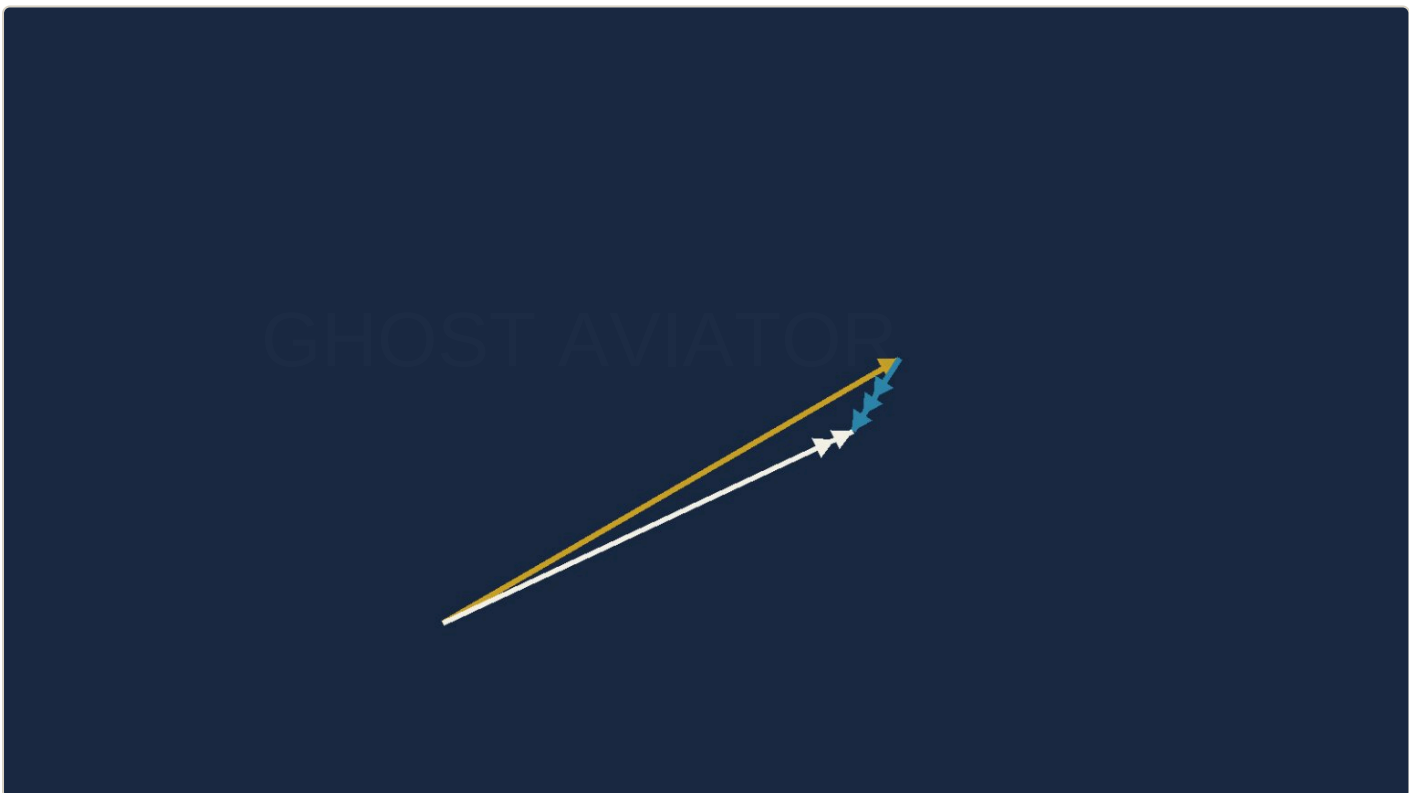


Figure 8.17 — W/V 033/23. This is the wind that has been acting on you for the last twenty minutes — not an area forecast, not an average, but the actual air you are flying in. Put it into the remaining legs of your plan.

Join live classes for guided practice and doubt clearing.

A one-degree difference you will meet in the answers

The arithmetic above gives 32.9° , which rounds to **033**. The published answer for this example is **034** — read off a rotating disc to the nearest degree.

Neither is wrong to any degree that matters here. But when you are choosing between exam options that sit a degree or two apart, **trust the arithmetic**. It is exact and it is reproducible, and the next section explains when even the arithmetic cannot help you.

6 · When the wind direction barely means anything

Here is something the source book does not tell you, and it will save you an argument with an answer key one day.

The wind is the *small difference* between two large vectors. When the wind is light and the aeroplane is fast, that difference is a short line joining the tips of two long ones — and the **direction** of a short line between two long ones is extremely sensitive to any error in either.

The rough size of it, and it is an upper bound not a law

Get your measured track wrong by **one degree**, and the wind direction you compute can move by up to roughly

$$\text{TAS} \div \text{wind speed degrees.}$$

Often it moves much less — it depends on the geometry — but that ratio is the worst case and it is worth carrying in your head.

A worked instance from the question set below. Row 29: heading 274, track 275, TAS 290, GS 270. The wind works out at about 21 knots, so $\text{TAS} \div \text{W}$ is roughly 14. And measured directly: one degree of track error swings the computed wind direction by **13.2°** .

And the opposite extreme. Row 37: TAS 460, GS 505, and a wind of about 149 knots. $\text{TAS} \div \text{W}$ is 3, and the measured swing is **1.5°** . A big wind pins its own direction down.

What to do with this, practically

Trust a found wind's SPEED more than its DIRECTION when the wind is light relative to your TAS. The speed comes out of a length, which is robust; the direction comes out of an angle between two nearly-parallel lines, which is not.

Do not chase a few degrees. If your answer and the key differ by three or four degrees on a light wind at high speed, neither of you is wrong — the data does not contain the answer to that precision.

Fly for longer before you fix. The fix at B is what sets your track accuracy. Twenty minutes gives a better wind than five, because the same half-mile of fix error is a smaller angle over a longer line. This is the practical reason wind finding is done over a decent run and not opportunistically.

GHOST AVIATOR

Questions — the flight plans

How to work these, and it is not optional advice

Work across the rows. One row at a time, left to right, finishing each before you start the next.

Doing it column by column — all the TAS values, then all the headings — is faster and it is worthless. It turns the exercise into typing, and it hides the one thing being trained: holding a five-step chain in your head without dropping a link.

The blank cells are **TAS**, **HDG(T)**, **HDG(M)**, **HDG(C)**, **GS** and **Time**. Everything else is given.

Flight Plan 1

GHOST AVIATOR

#	PA ft	OAT °C	CAS	TAS	Track °(T)	W/V	HDG °(T)	Var	HDG °(M)	Dev	HDG °(C)	GS	Dist NM	Time min
1	2000	-10	160		100	330/17		5°W		1°W			50	
2	4700	-2	170		227	300/10		3°E		2°E			112	
3	4000	-10	175		134	262/17		3°W		1°E			30	
4	2000	+2	170		157	110/12		6°W		2°W			38.5	
5	6000	-3	154		100	320/18		4°E		1°W			60	
6	5000	-15	150		050	110/45		8°W		2°E			13	
7	10000	-8	173		320	181/27		3°E		3°W			44	

Join live classes for guided practice and doubt clearing.

Flight Plan 2

#	PA ft	OAT °C	CAS	TAS	Track °(T)	W/V	HDG °(T)	Var	HDG °(M)	Dev	HDG °(C)	GS	Dist NM	Time min
1	5000	+5	170		070	230/25		5°W		1°E			86	
2	6500	-2	170		234	210/30		3°W		2°E			71	
3	6000	+2	174		240	210/22		4°W		1°E			57	
4	7500	+2	175		166	110/30		6°W		3°E			89	
5	8000	-2	174		190	245/36		4°E		1°W			60	
6	9000	-5	180		050	110/45		11°W		2°E			13	
7	12000	-11	184		324	190/47		3°E		2°E			50	

Flight Plan 3

Sixteen legs, and the altitudes climb. Watch legs 9 and 10 — there is a reason they are up there, and it is explained in the answers.

#	PA ft	OAT °C	CAS	TAS	Track °(T)	W/V	HDG °(T)	Var	HDG °(M)	Dev	HDG °(C)	GS	Dist NM	Time min
1	3000	+15	190		315	045/33		7°W		2°E			88	
2	9000	-10	205		324	335/21		6°E		1°W			105	
3	14000	+5	142		071	030/55		11°W		1°W			80	
4	4000	-10	132		300	190/25		8°E		3°E			332	
5	3500	-17	130		019	300/28		9°W		2°E			110	
6	7500	+0	160		342	130/40		3°E		1°W			92	
7	9500	+0	180		262	010/38		34°E		2°W			145	
8	7000	+15	159		021	265/32		16°W		4°W			112	
9	22500	-30	202		033	310/50		7°W		2°E			46	
10	28000	-55	194		162	210/20		14°W		3°E			1312	
11	2000	+4	148		228	280/20		10°W		2°E			84	
12	3000	+16	123		351	060/30		12°W		2°W			95	
13	5000	-5	166		043	123/46		9°E		1°W			62	
14	2500	+0	123		032	120/30		4°E		1°E			49	
15	3500	+8	96		162	140/40		9°W		1°W			130	
16	4000	-5	111		343	220/30		11°E		1°W			82	

Questions — wind finding

What you are given, and what you are finding

Each row gives you a **heading**, a **TAS**, the **track you actually made good** and your **ground speed**. One column is blank: the **W/V**.

All directions are degrees TRUE. Remember the direction of the subtraction — ground vector *minus* air vector — and remember that a wind is named for where it comes from, so the answer is the reciprocal of the vector you just computed.

#	HDG°(T)	W/V	Track made good°(T)	TAS	GS
1	209		219	150	134
2	270		266	180	202
3	223		224	206	246
4	069		079	138	124
5	299		293	125	120
6	167		162	202	190
7	213		231	85	80
8	014		005	200	218
9	330		348	90	90
10	179		168	196	226
11	098		100	310	338
12	091		080	440	435
13	050		055	398	415
14	351		340	393	405
15	288		292	434	462
16	276		281	335	316

Join live classes for guided practice and doubt clearing.

#	HDG°(T)	W/V	Track made good°(T)	TAS	GS
17	280		275	430	435
18	291		292	330	360
19	097		095	343	322

#	HDG°(T)	W/V	Track made good°(T)	TAS	GS
20	056		055	287	320
21	108		109	480	530
22	176		171	428	438
23	270		265	335	308
24	248		243	406	332
25	247		252	380	352
26	200		202	435	403
27	198		202	340	325
28	275		275	435	395
29	274		275	290	270
30	321		326	338	280
31	045		061	285	305
32	196		205	210	245
33	311		295	482	435
34	011		358	198	211
35	355		008	248	270
36	111		115	120	114
37	228		245	460	505
38	175		168	121	114

Join live classes for guided practice and doubt clearing.

Answers — the flight plans

Flight Plan 1

#	PA ft	OAT °C	CAS	TAS	Track °(T)	W/V	HDG °(T)	Var	HDG °(M)	Dev	HDG °(C)	GS	Dist NM	Time min
1	2000	-10	160	158	100	330/17	095	5°W	100	1°W	101	169	50	18
2	4700	-2	170	180	227	300/10	230	3°E	227	2°E	225	176	112	38
3	4000	-10	175	180	134	262/17	138	3°W	141	1°E	140	190	30	9
4	2000	+2	170	172	157	110/12	154	6°W	160	2°W	162	164	38.5	14
5	6000	-3	154	166	100	320/18	096	4°E	092	1°W	093	180	60	20
6	5000	-15	150	155	050	110/45	065	8°W	073	2°E	071	128	13	6
7	10000	-8	173	199	320	181/27	315	3°E	312	3°W	315	219	44	12

Flight Plan 2

#	PA ft	OAT °C	CAS	TAS	Track °(T)	W/V	HDG °(T)	Var	HDG °(M)	Dev	HDG °(C)	GS	Dist NM	Time min
1	5000	+5	170	183	070	230/25	073	5°W	078	1°E	077	206	86	25
2	6500	-2	170	186	234	210/30	230	3°W	233	2°E	231	158	71	27
3	6000	+2	174	190	240	210/22	237	4°W	241	1°E	240	170	57	20
4	7500	+2	175	196	166	110/30	159	6°W	165	3°E	162	178	89	30
5	8000	-2	174	195	190	245/36	199	4°E	195	1°W	196	172	60	21
6	9000	-5	180	205	050	110/45	061	11°W	072	2°E	070	178	13	4
7	12000	-11	184	219	324	190/47	315	3°E	312	2°E	310	249	50	12

CORRECTED — Flight Plan 2, leg 5. The published answer is wrong.

The leg: PA 8000 ft, OAT -2°C, CAS 174, track 190°(T), W/V 245/36, variation 4°E, deviation 1°W, distance 60 NM.

The TAS is not the problem. It works out at 195 by the compressible relation and 196 by the simple one, and the published 196 is perfectly defensible. Use *either* value and the heading still comes out at **199° (T)** and the ground speed at **172–173 knots**. The published heading and ground speed are wrong on their own terms, whichever TAS you feed them.

	Published	Correct
HDG°(T)	196	199
HDG°(M)	192	195
HDG°(C)	193	196
GS	180	172
Time	20	21

How I know it is wrong rather than merely different. Take the published heading of 196°(T), fly it at TAS 196 in a wind of 245/36, and the track you make good is **187°** — not the 190° the question requires. The published answer does not solve its own question.

Its ground speed fails the same test: with this wind, no heading that achieves a track of 190° produces 180 knots. The correct pair is 199°(T) and 172 knots, and those do reproduce track 190 exactly.

What it looks like it was. The row prints TAS 196 and HDG(T) 196 — the same number twice, in adjacent columns. The magnetic heading, the compass heading and the time are then all derived *correctly* from that wrong heading and that wrong ground speed: 196 – 4°E gives 192, 192 + 1°W gives 193, and 60 NM at 180 knots gives 20 minutes. Every one of those steps is right. That is the signature of a copied cell rather than an arithmetic mistake, and it is why the error survived proofreading: every check you could run *within* the row passes.

Flight Plan 3

#	PA ft	OAT °C	CAS	TAS	Track °(T)	W/V	HDG °(T)	Var	HDG °(M)	Dev	HDG °(C)	GS	Dist NM	Time min
1	3000	+15	190	200	315	045/33	324	7°W	331	2°E	329	198	88	27
2	9000	-10	205	231	324	335/21	325	6°E	319	1°W	320	210	105	30
3	14000	+5	142	181	071	030/55	060	11°W	071	1°W	072	136	80	35
4	4000	-10	132	136	300	190/25	290	8°E	282	3°E	279	142	332	140
5	3500	-17	130	131	019	300/28	007	9°W	016	2°E	014	122	110	54
6	7500	+0	160	179	342	130/40	349	3°E	346	1°W	347	211	92	26
7	9500	+0	180	208	262	010/38	272	34°E	238	2°W	240	217	145	40
8	7000	+15	159	181	021	265/32	012	16°W	028	4°W	032	192	112	35
9	22500	-30	202	284	033	310/50	023	7°W	030	2°E	028	274	46	10
10	28000	-55	194	290	162	210/20	165	14°W	179	3°E	176	276	1312	285
11	2000	+4	148	150	228	280/20	234	10°W	244	2°E	242	137	84	37
12	3000	+16	123	130	351	060/30	003	12°W	015	2°W	017	116	95	49
13	5000	-5	166	175	043	123/46	058	9°E	049	1°W	050	161	62	23
14	2500	+0	123	125	032	120/30	046	4°E	042	1°E	041	121	49	24
15	3500	+8	96	101	162	140/40	153	9°W	162	1°W	163	63	130	124
16	4000	-5	111	115	343	220/30	330	11°E	319	1°W	320	129	82	38

Join live classes for guided practice and doubt clearing.

Legs 9 and 10 — and an error of mine, not the book's

Leg 9 is 22,500 ft at -30°C , CAS 202. Leg 10 is 28,000 ft at -55°C , CAS 194. Everywhere else in these plans the simple density-ratio formula — $\text{TAS} = \text{CAS} \div \sqrt{\sigma}$ — reproduces the published TAS to within a knot.

On these two it does not. It gives 289 and 296 against the published 284 and 291 — about five knots high on both. My first reaction was that the book was wrong. It is not. **I was.**

Those two legs run at **Mach 0.47 and Mach 0.50**. The simple formula ignores compressibility, and above roughly Mach 0.45 that is no longer a rounding error. Work them through the compressible relation instead — dynamic pressure to Mach number to true airspeed — and you get **284.1** and **290.0**. The book is right to a knot.

This is Chapter 6 arriving in the middle of a flight plan, which is exactly why it was taught there. Every other leg in these three plans is below Mach 0.37, and there the two methods agree to within about a knot, which is the other half of the lesson: the correction is real, and it is only real where it is real.

The CX-3 handles this internally. Its Airspeed function solves the compressible relation and there is no separate correction step to apply — the words "compressibility" and "EAS" do not appear anywhere in its 24-page Guide, because on that machine there is nothing for you to do.

Answers — wind finding

#	HDG°(T)	W/V	Track made good°(T)	TAS	GS
1	209	157/29	219	150	134
2	270	057/26	266	180	202
3	223	049/40	224	206	246
4	069	015/27	079	138	124
5	299	005/14	293	125	120
6	167	219/21	162	202	190
7	213	143/26	231	85	80
8	014	128/37	005	200	218

Join live classes for guided practice and doubt clearing.

#	HDG°(T)	W/V	Track made good°(T)	TAS	GS
9	330	249/28	348	90	90
10	179	300/50	168	196	226
11	098	301/30	100	310	338
12	091	172/84	080	440	435
13	050	297/39	055	398	415
14	351	084/77	340	393	405
15	288	158/42	292	434	462
16	276	222/34	281	335	316
17	280	015/38	275	430	435
18	291	123/31	292	330	360
19	097	125/24	095	343	322

#	HDG°(T)	W/V	Track made good°(T)	TAS	GS
20	056	226/33	055	287	320
21	108	298/51	109	480	530
22	176	278/39	171	428	438
23	270	314/39	265	335	308
24	248	269/81	243	406	332
25	247	201/42	252	380	352
26	200	176/35	202	435	403
27	198	143/28	202	340	325
28	275	275/40	275	435	395
29	274	261/21	275	290	270
30	321	299/64	326	338	280

Join live classes for guided practice and doubt clearing.

#	HDG°(T)	W/V	Track made good°(T)	TAS	GS
31	045	309/84	061	285	305
32	196	066/50	205	210	245
33	311	013/136	295	482	435
34	011	110/48	358	198	211
35	355	251/63	008	248	270
36	111	059/10	115	120	114
37	228	129/149	245	460	505
38	175	236/16	168	121	114

CORRECTED — wind finding, row 35. One mistyped digit.

The row: heading 355°(T), TAS 248, track made good 008°(T), GS 270. **Published answer 262/62. It should be 251/63** — and the book almost certainly meant to print **252**.

The test that settles it. Take the published wind of 262/62 and fly it from the row's own heading of 355 at its own TAS of 248. You get a ground speed of **259 knots**. The row states 270. The published answer is eleven knots away from reproducing its own question.

Change the 6 to a 5 — **252/62** — and it gives track 008 and ground speed 269. That is a single transposed digit, and it lands the row back inside normal reading tolerance.

Note what this is not. Two other rows in this set — **26 and 29** — differ from my arithmetic by more than four degrees of wind direction, and neither is an error. They are the ill-conditioning of Section 6: fly their published winds forward from their own headings and they reproduce their own tracks and ground speeds. Row 29 in particular swings 13° of wind direction for one degree of track, which is exactly the case that section was written about. **Row 35 is the only row in the set whose published answer fails its own data.**

What I checked across this chapter, and what I did not

All 30 flight plan legs and all 38 wind finding rows were recomputed from first principles — compressible airspeed, full vector triangle, signed variation and deviation, and time from distance and ground speed.

Flight plans: 28 of 30 legs reproduce. Headings within a degree, ground speeds within two knots, times within half a minute.

Two legs fall outside that, and they are different in kind. Flight Plan 2 leg 5 is corrected above — it is a genuine error in the source. **Flight Plan 3 leg 10 is not an error**; it is the compressibility correction arriving in the totals. At Mach 0.50 the compressible TAS is 290 against the published 291, which carries about 3 knots into the ground speed and, over 1,312 nautical miles, four minutes into the elapsed time. Both are defensible — they come from different airspeed methods, and this is the one leg long enough and fast enough for that choice to become visible in the time column.

Wind finding: 35 of 38 rows agree to within four degrees of direction and four knots of speed. Of the three that do not, **rows 26 and 29 are not errors** — their published winds fly forward and reproduce their own tracks and ground speeds, and the disagreement is the ill-conditioning of Section 6. **Row 35 is a genuine source error**, corrected above.

What I could not settle. Whether the residual one- and two-knot differences are reading error or typesetting. They are consistent with reading an analogue scale and none of them changes an exam answer, but I have not proved the cause — only that they do not matter.

The chapter in seven lines

Take these into the exam

1. **A flight plan row is five conversions in a chain** — CAS to TAS, track to heading, true to magnetic, magnetic to compass, distance to time. Work across the row, never down the column.
2. **Variation west, magnetic best. Variation east, magnetic least.** Deviation behaves identically, one step further on.
3. **The CX-3's sign convention is the opposite of the book's.** On the machine, **+** is WEST. Say the word "west" or "east" out loud before you press anything.
4. **The wind is the vector from the air vector's tip to the ground vector's tip.** That order, always. Reverse it and you get the exact reciprocal, which is how the error announces itself.
5. **Wind finding is **FLT** → Wind Correction.** Heading and ground speed is **PLAN**. The names describe what each function *takes*, not what it gives.

Join live classes for guided practice and doubt clearing.

6. **A light wind at high speed has a badly determined direction** — up to about $TAS \div W$ degrees of swing per degree of track error. Trust its speed more than its direction, and do not argue over three degrees.
7. **Above about Mach 0.45 the simple TAS formula runs high.** Two legs in these exercises prove it. Below that, it is exact enough for anything.

Next — Chapter 9: multi-drift winds, where three drift readings on three headings pin down a wind that no single run can; and wind components, which carry the most operationally dangerous trap in this whole module — the CX-3's crosswind function demands a runway number and a magnetic wind, and the forecast in your hand is in true.

GHOST AVIATOR