

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 5

Distance, Speed, Time and Conversions

Everything the flight computer does with a rate — and why you still have to understand the arithmetic the box is hiding from you.

About this module

This module covers the **Navigation Computer** — Chapters 5 to 9 of the General Navigation syllabus. Earlier chapters, covering maps, projections and the basics of position and direction, sit elsewhere in the Ghost Aviator library. The numbering follows the DGCA syllabus, which is why this module opens at Chapter 5.

Every technique here is taught on the **ASA CX-3** flight computer and, where the CX-3 has no function, on a scientific calculator. Both are permitted in the DGCA examination. The old circular slide rule — the plastic disc with the rotating wind face — is not taught. The *physics* it computed has not changed, and that is what you are here to learn.

SIXTY SECONDS IN THE COCKPIT

You are 40 minutes into a night sector, cruising at 320 knots ground speed. ATC asks you to confirm your estimate for a reporting point 18 nautical miles ahead. You reach for the CX-3, type quickly, and the screen returns **3.5**.

Three and a half *what*? If you read that as 3.5 minutes you are right. If you read it as 3.5 *hours*, you have just told a controller you will arrive at a point you will actually pass in three minutes — and the next aircraft is being sequenced on your number.

The box did the arithmetic perfectly. The box cannot tell you whether the answer is sensible. **That job never left the flight deck.** This chapter is about doing it well.

1 • The ratio principle — what the box hides

Almost every problem in this chapter is the same problem wearing different clothes. Something happens at a steady **rate**, and you want to know how much of it happens in a given **time**.

A **rate** is simply a quantity per unit of time. Feet per minute. Nautical miles per hour. Kilograms per hour. Litres per hour. Once you see that they are all the same shape, the whole chapter collapses into one idea:

$$\text{quantity} = \text{rate} \times \text{time}$$

$$\text{and therefore } \text{rate} = \text{quantity} \div \text{time} \text{ and } \text{time} = \text{quantity} \div \text{rate}$$

Take a rate of climb of **700 feet per minute**. In 2 minutes you gain 1,400 feet. In 3 minutes, 2,100 feet. In 4 minutes, 2,800 feet. You are not doing a new calculation each time — you are reading off the same fixed proportion. That proportion is the rate.

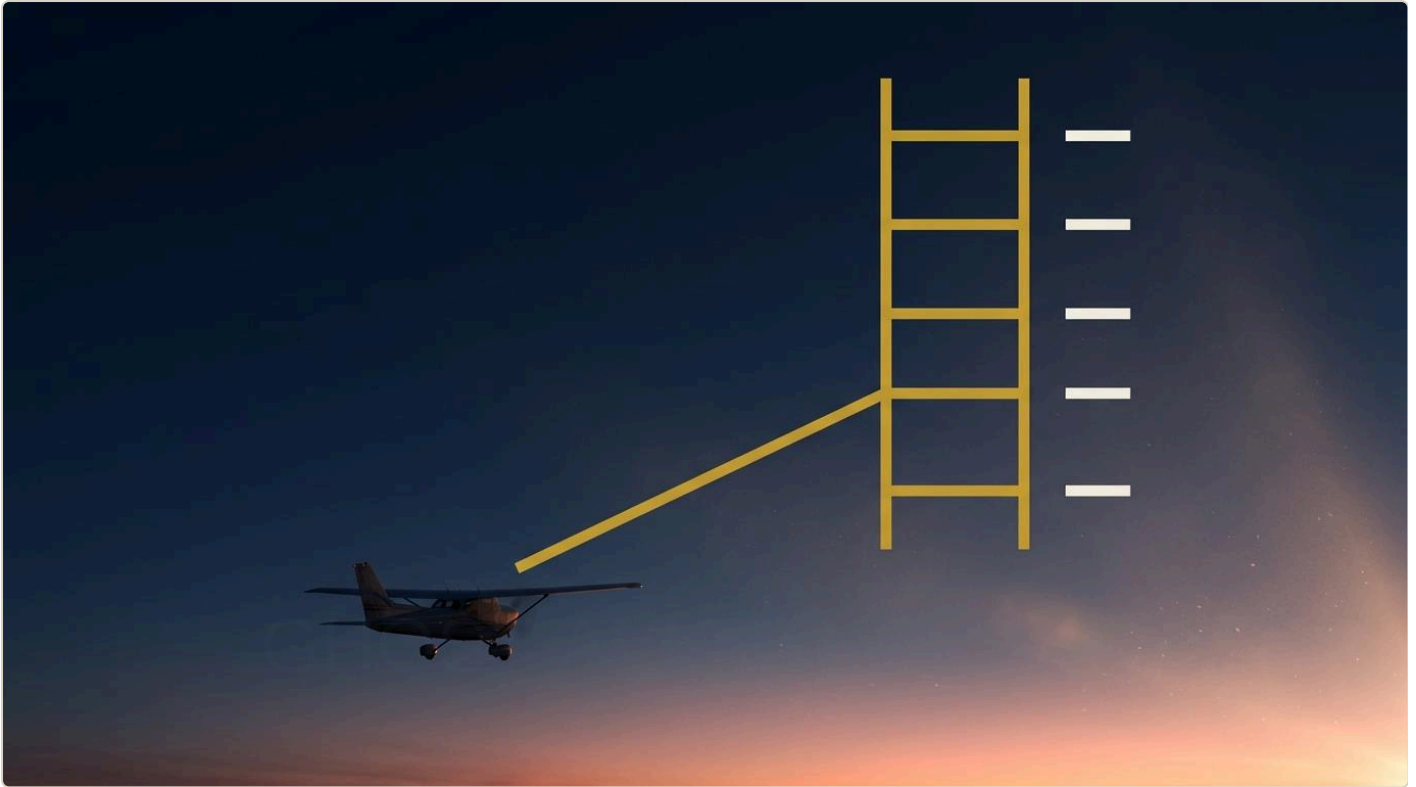


Figure 5.1 — A rate is a fixed proportion. Every minute at 700 fpm adds the same 700 feet. Doubling the time doubles the height gained.

■ equal height gained each minute □ equal steps of time

Per minute or per hour — the trap that used to be a scale

Here is where students lose marks, and it has nothing to do with which computer you own. Rates in aviation are quoted in two different time units, and they are mixed freely:

- **Per minute** — rate of climb and descent, almost always
- **Per hour** — fuel flow, ground speed, almost always

A fuel flow of 2,000 kg per hour is the same thing as 33.33 kg per minute. Same rate, different clothes. On the old disc there were two separate index marks to handle this, and choosing the wrong one was a classic way to be out by a factor of sixty.

What this means on the CX-3

The CX-3 removes the choice. Every duration field is a real duration — you enter `1:37:00` and the machine knows that is one hour and thirty-seven minutes. There is no index to select and no factor of sixty to get wrong.

But you still have to know roughly what the answer should be, because the CX-3 will just as happily return a wrong answer from a wrong input. The disc at least made you look at the arithmetic. The box does not.

What the examiner is really asking

When a question gives you a rate in one time unit and asks for an answer in another, it is not testing your typing. It is testing whether you noticed. Read the units in the question and the units in the answer options *before* you touch the keypad.

2 • Distance, speed and time

Three quantities, one relationship. Know any two and the third is fixed.

$$\text{Distance} = \text{Ground Speed} \times \text{Time}$$

Keep time in hours, or work in minutes and divide by 60. Mixing the two is the most common arithmetic error in this whole subject.

Note the words **ground speed**. Not airspeed. Distance over the ground is covered at the speed you are actually moving over the ground, and the wind is what makes those two different. That is Chapter 7's problem. For now, every speed in this chapter is a ground speed.

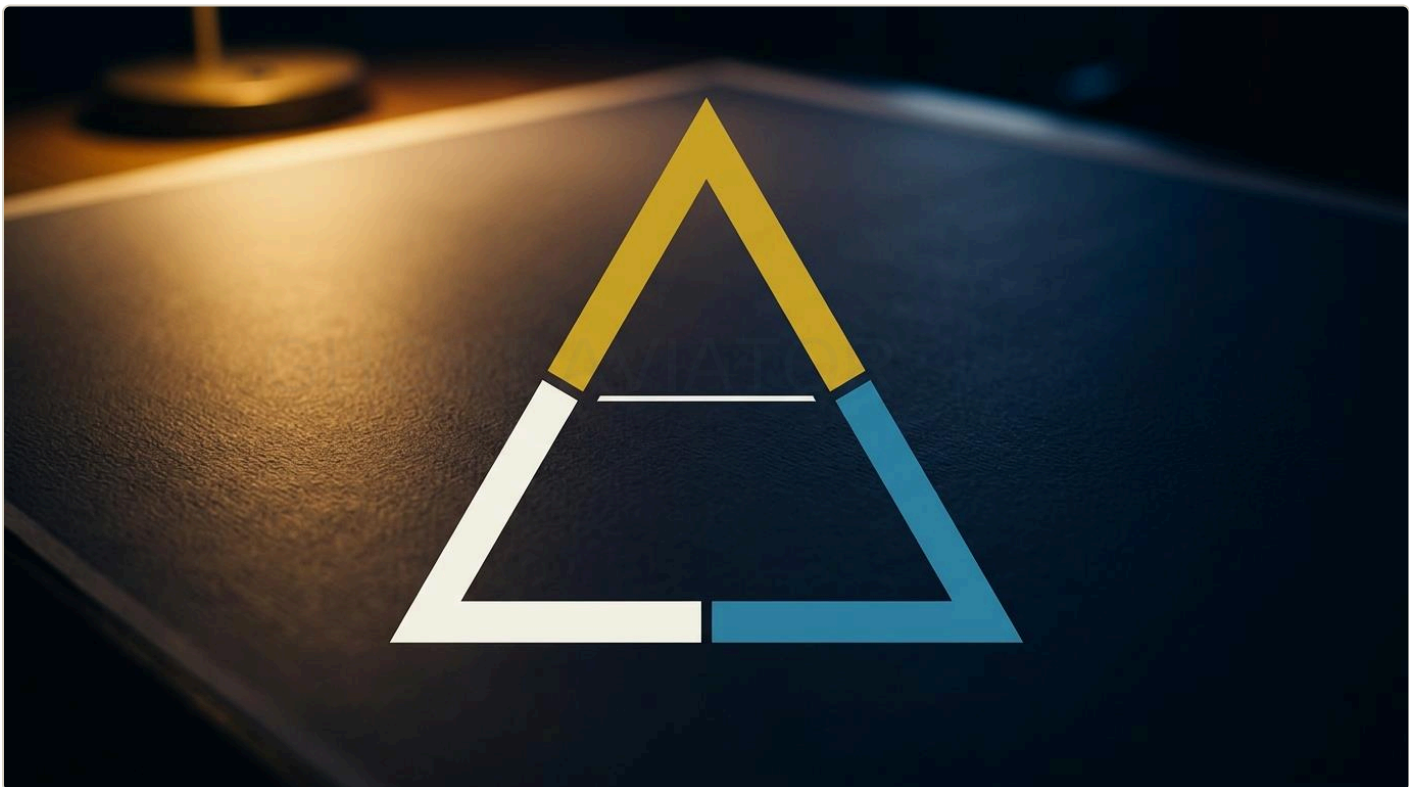


Figure 5.2 — The three-way relationship. Cover the quantity you want and the remaining two show you whether to multiply or divide.

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The CX-3 route

GROUND SPEED — DISTANCE, DURATION, SPEED

FLT → Ground Speed

Fields

Dist · Dur · GS

How it works

Enter any **two**, the third is calculated.

Duration format

Press **CONV UNIT** on **Dur** to switch between **HMS**, **HR**, **MIN** and **SEC**. Use the **:** key to separate hours, minutes and seconds.

Verified against the CX-3 User's Guide V1.3, page 10: 5 NM flown in 00:02:32 returns 118.42 KTS GS.

Worked example 1 — finding distance

Problem. How far do you travel in 48 minutes at a ground speed of 120 knots?

METHOD 1 — THE ARITHMETIC

$$\text{Dist} = \text{GS} \times (\text{min} \div 60) = 120 \times (48 \div 60) = \mathbf{96.00 \text{ NM}}$$

METHOD 2 — THE CX-3

1. Press **FLT**, scroll to **Ground Speed**, tap enter.
2. Scroll to **GS**. Press **1** **2** **0** and tap enter.
3. Scroll to **Dur**. Press **CONV UNIT** until **MIN** is displayed.
4. Press **4** **8** and tap enter.

Dist reads **96.00 NM**

Sanity check. 48 minutes is a bit over three quarters of an hour. Three quarters of 120 is 90. The answer should be somewhere near 90–100, and 96 is. If the screen had said 9.6 or 960 you would have caught it here.

Worked example 2 — finding ground speed

Problem. You have covered 90 NM over the ground in 30 minutes. What is your ground speed?

METHOD 1 — THE ARITHMETIC

$$\text{GS} = (\text{Dist} \div \text{min}) \times 60 = (90 \div 30) \times 60 = \mathbf{180.00 \text{ kt}}$$

METHOD 2 — THE CX-3

1. **FLT** → **Ground Speed**.
2. Dist : **9 0**, enter.
3. Dur : switch to **MIN**, press **3 0**, enter.

GS reads **180.00 KTS**

Sanity check. 30 minutes is half an hour, so the hourly figure is double the half-hourly one: $90 \times 2 = 180$. Exactly right.

Where students lose the mark — order of magnitude

On the old disc this example returned a bare **18**, and you had to decide for yourself whether it meant 18, 180 or 1,800 knots. At 18 knots you would fall out of the sky. At 1,800 knots you would pull the wings off. Only 180 is a real aeroplane.

The CX-3 gives you the decimal point, so this specific trap is gone. **The habit must not go with it.** A mistyped digit, a duration entered as hours when you meant minutes, a distance in kilometres when the field wanted nautical miles — every one of those produces a confident, precise, wrong number. The only thing standing between that number and your flight plan is you asking "*is that sensible?*"

GHOST AVIATOR

Worked example 3 — finding time

Problem. Your ground speed is 220 knots and you have 57 NM to run. How long will it take?

METHOD 1 — THE ARITHMETIC

$$\text{min} = (\text{Dist} \div \text{GS}) \times 60 = (57 \div 220) \times 60 = \mathbf{15.55 \text{ min}}$$

METHOD 2 — THE CX-3

1. **FLT** → **Ground Speed**.
2. **GS** : **2** **2** **0** , enter.
3. **Dist** : **5** **7** , enter.
4. Read **Dur** . Press **CONV UNIT** on it to see the answer as **MIN** .

Dur reads **15.5 MIN** (00:15:33 in HMS)

Sanity check. 57 NM is roughly a quarter of 220. A quarter of an hour is 15 minutes. The answer must be near 15, and it is.

3 · Time formats — minutes into hours and minutes

An answer of **142.6 minutes** is correct but useless on a flight plan. Nobody files an estimate in decimal minutes. You need 2 hours 22.6 minutes.

This used to be a scale of its own

The old disc carried an entire dedicated ring — the *yellow scale* — whose only job in life was converting minutes into hours and minutes. That is all it did. On the CX-3 it is a keypress.

TWO WAYS TO HANDLE TIME

The **:** **key**

Separates hours from minutes and minutes from seconds *on input*. 2 hours, 38 minutes, 45 seconds is entered as **2** **:** **38** **:** **45** and displays as **02:38:45** .

CONV UNIT **on a** **Dur** **field**

Cycles the display between **HMS** , **HR** , **MIN** and **SEC** . Use it to read an answer in whichever form the question wants.

The habit worth building

Enter durations in `HMS` whenever the question gives you hours and minutes. Do not convert 1 h 37 min to 97 minutes in your head first — that is an extra opportunity to make an error, and the machine does not need you to. Type `1 : 37 : 00` and move on.

4 • Ram rise — why the thermometer lies

Your aircraft measures outside air temperature with a probe stuck into a 320-knot airflow. That air does not arrive at the probe gently. It is brought violently to a stop, and stopping air heats it.

Two temperatures, and you must not confuse them

Static Air Temperature (SAT) — the true temperature of the air the aircraft is flying through, with no error introduced by the act of measuring it. Sometimes called OAT. **This is the temperature every performance calculation needs:** TAS from CAS and pressure altitude, TAS from Mach number, density altitude, all of it.

Total Air Temperature (TAT) — what the probe actually reads. It includes the heating caused by bringing the airflow to rest, so it is **always higher than SAT**.

The difference between them is the **ram rise**.

$$\text{Ram Rise} = \text{TAT} - \text{SAT}$$

A rough approximation, useful for a mental check:

$$\text{Ram Rise} \approx (\text{TAS} \div 100)^2 \quad \text{TAS in knots, answer in } ^\circ\text{C}$$

At 400 kt that gives about 16°C. At 500 kt, about 25°C. It runs slightly low — the flight computer's answer is the more accurate one.

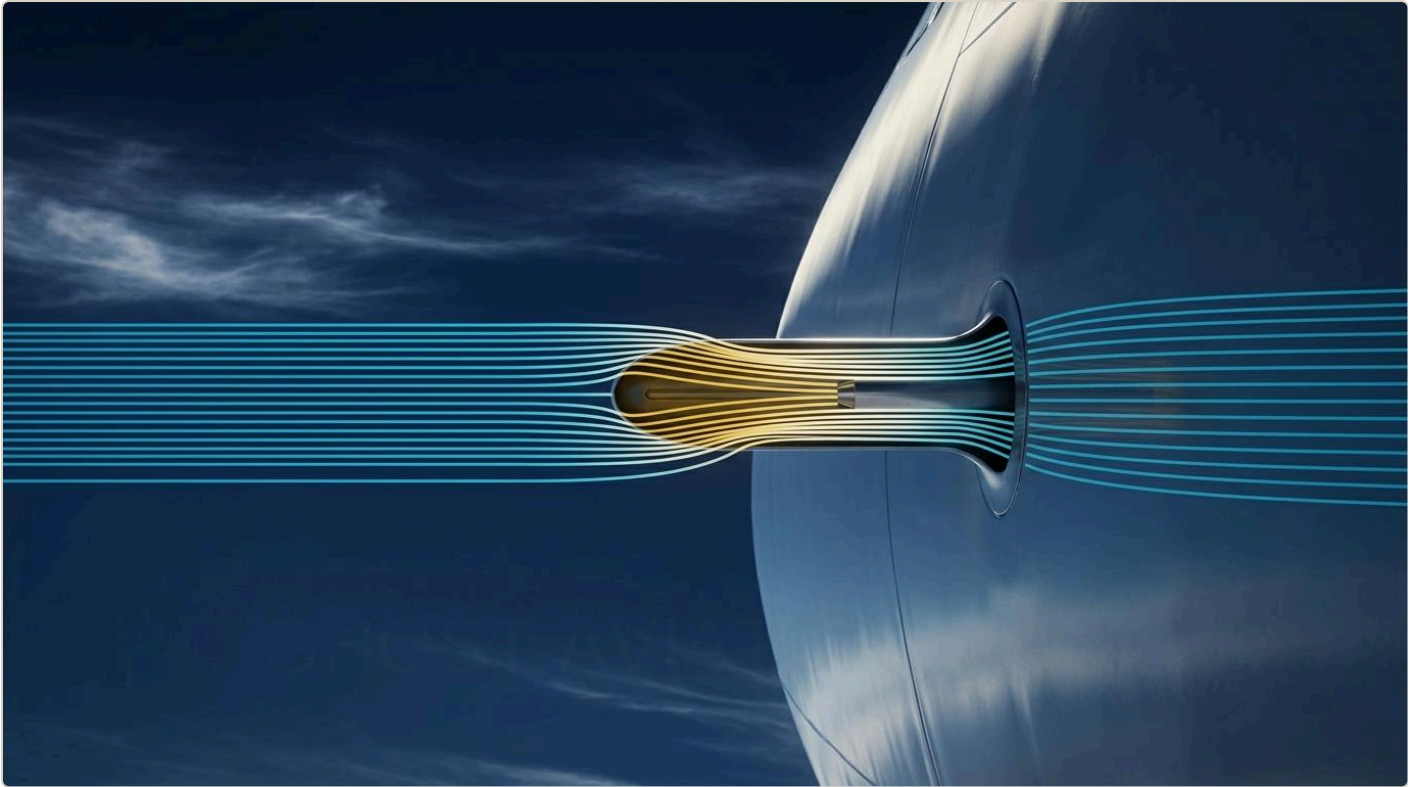


Figure 5.3 — Air brought to rest at the probe is heated. What the probe reads (TAT) is always warmer than the air the aircraft is actually flying through (SAT).

■ SAT — the air you are flying through ■ TAT — what the probe reads □ the difference is ram rise

This used to be a scale too

The disc carried a *blue scale* for reading ram rise. It is gone. The CX-3 handles the SAT↔TAT relationship inside the **Airspeed** function, in both directions.

AIRSPEED — THE TEMPERATURE PAIR

FLT → **Airspeed**

Planned TAS You give it **OAT** → it returns **TAT** (among others). Use this on the ground, planning.

Actual TAS You give it **TAT** → it returns **OAT**. Use this in flight, where the probe reading is what you have.

The K factor Lives in **SET** → **Aircraft Profile**. The Guide calls it "the instrument calibration factor of the airplane... used to calculate OAT from TAT (and vice-versa)". Default **1.0**.

Verified against the User's Guide V1.3, pages 5 and 9.

Worked in the head

TAS 400 knots, probe reading (TAT) -22°C . Ram rise is roughly $(400 \div 100)^2 = 16$, call it 17°C on the computer. So the real air temperature is 17°C colder than the probe says: $-22 - 17 = -39^{\circ}\text{C SAT}$.

Direction check: SAT is always the colder of the two. If your SAT came out warmer than your TAT, you added when you should have subtracted.

5 • Fuel

Fuel problems are distance-speed-time problems with the words changed. A fuel flow is a rate. A quantity of fuel is a "distance". The arithmetic is identical.

$$\text{Fuel used} = \text{Fuel flow} \times \text{Time}$$

FUEL — THREE WAYS TO USE ONE FUNCTION

FLT → Fuel

Fuel Burn Dur + Rate → Vol

Fuel Rate Wt + Dur → Rate

Endurance Vol + Rate → Dur

Volume or weight — the function does both

Fuel is quoted sometimes by volume (litres, gallons) and sometimes by mass (kilograms, pounds). The Fuel function carries **both** a vol field and a wt field, and the Rate field follows whichever you use — LPH and GPH for volume, LBS/HR and KG/HR for mass.

So a question in kilograms per hour needs no conversion and no workaround. Use the wt field.

Verified against the User's Guide V1.3, page 10: 1:14:38 at 9.5 U.S. GPH returns **11.82 U.S. GAL**; 9,500 LBS burned in 2:30 returns **3,800 LBS/HR**; 38 U.S. GAL at 9.5 U.S. GPH returns **3:59:59** endurance.

Worked example 4 — fuel used

Problem. Fuel consumption 2,300 kg/hour. Time to destination 1 hour 37 minutes. How much fuel will you use?

METHOD 1 — THE ARITHMETIC

$$\text{Fuel} = \text{Rate} \times \text{hours} = 2300 \times (97 \div 60) = \mathbf{3,718.3 \text{ kg}}$$

METHOD 2 — THE CX-3

1. **FLT** → **Fuel**.
2. Scroll to **Dur**, press **CONV UNIT** to get **HMS**.
3. Press **1** **:** **3** **7** **:** **0** **0** and tap enter.
4. Scroll to **Rate**, set units to **KG/HR**, press **2** **3** **0** **0**, enter.

Wt reads **3,718.3 kg**

Sanity check. 1 h 37 is a bit over one and a half hours. One and a half times 2,300 is 3,450. A little more than that is expected, and 3,718 fits.

A note on precision

Older textbooks give this answer as **3,720 kg**, read off a plastic disc. The exact figure is 3,718.33. The disc was being read by eye to three significant figures, which is about as well as it could be read.

This is worth noticing now, because you will meet it repeatedly in this chapter and the next four. **Where an exact calculation and an old answer key disagree by a fraction of a percent, the calculation is right.**

Worked example 5 — safe endurance

Problem. Fuel flow 130 imperial gallons per hour. You have 380 gallons above reserves. What is your safe endurance?

METHOD 1 — THE ARITHMETIC

$$\text{hours} = \text{Vol} \div \text{Rate} = 380 \div 130 = \mathbf{2.923\ h} = \mathbf{2\ h\ 55.4\ min}$$

METHOD 2 — THE CX-3

1. **FLT** → **Fuel**.
2. Vol : set units to imperial gallons, press **3** **8** **0**, enter.
3. Rate : press **1** **3** **0**, enter.
4. Read Dur .

Dur reads **02:55:23** (175.4 minutes)

Sanity check. $380 \div 130$ is just under 3. Just under 3 hours. Correct.

Safe endurance is not total endurance

Notice the words "above your reserves". Safe endurance is the flying time available from the fuel you are **allowed to burn** — not the fuel in the tanks. Reserves are not yours to plan with.

An examiner who gives you total fuel and a reserve figure in the same question is checking whether you subtracted before you divided. A pilot who forgets it lands with less than legal minima, or does not land at all.

Worked example 6 — finding the flow rate

Problem. You have used 3,700 litres in the last 1 hour 45 minutes. What is your fuel consumption rate?

METHOD 1 — THE ARITHMETIC

$$\text{Rate} = \text{Vol} \div \text{hours} = 3700 \div 1.75 = \mathbf{2,114.3 \text{ L/h}}$$

METHOD 2 — THE CX-3

1. **FLT** → **Fuel**.
2. Vol : set to litres, press **3** **7** **0** **0**, enter.
3. Dur : HMS , press **1** **:** **4** **5** **:** **0** **0**, enter.

Rate reads **2,114.3 litres/hour**

Sanity check. 1 h 45 is 1.75 hours. $3,700 \div 1.75$ is a bit over 2,000. Correct.

Watch the units in the question, not just the numbers

At least one widely-used textbook works this exact example and prints the answer as **2,110 kg/hour**. The question was asked in **litres**. Litres in, litres out — the answer is 2,114.3 **litres** per hour, and calling it kilograms silently assumes the fuel has a specific gravity of exactly 1.00, which no aviation fuel does.

Read the units. Then read them again in the answer options.

6 • Distance conversions

Three units of distance are in daily use, and you will meet all three.

Unit	What it is	Where you meet it
Nautical mile (NM)	One minute of latitude. 1,852 metres exactly.	Aviation and marine navigation. Your default.
Statute mile (SM)	1,609.344 metres exactly.	Visibility reports in some states, US road distances.
Kilometre (km)	1,000 metres.	Visibility, cloud base in metric states, most charts outside the US.

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$$1 \text{ NM} = 1.852 \text{ km} = 1.15078 \text{ SM}$$

A nautical mile is the longest of the three. If a conversion makes your nautical miles the biggest number, you have gone the wrong way.

The memory aid worth keeping

Equator to pole is 90 degrees of latitude, which is $90 \times 60 = 5,400$ **nautical miles**. That same distance is very close to **10,000 km** — which is how the metre was originally defined.

So **10,000 km** $\approx$ **5,400 NM**, and therefore **10 km** $\approx$ **5.4 NM**. That single pair will get you an order of magnitude on any distance conversion in the exam, with no calculator at all.

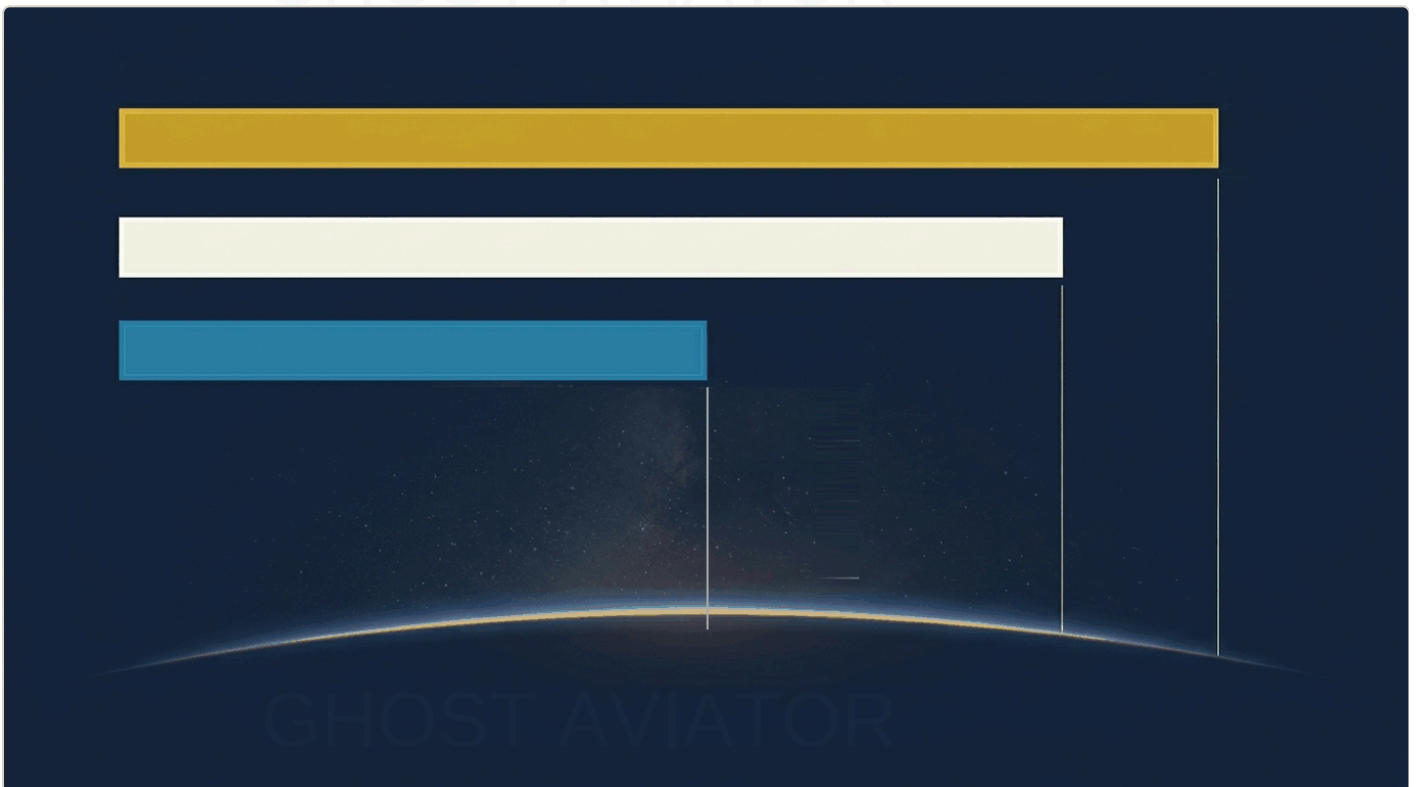


Figure 5.4 — Relative sizes. The nautical mile is the longest; the kilometre the shortest. Converting to a shorter unit always gives a bigger number.

■ 1 nautical mile ■ 1 statute mile ■ 1 kilometre

DISTANCE CONVERSION ON THE CX-3

Select any **Dist** field → press **CONV UNIT**

Tapping **CONV UNIT** cycles the value through **NM**, **KM**, **SM**, **FT** and **M**. The number converts as the label changes — you do not re-enter anything.

Verified against the User's Guide V1.3, page 7: 100 KM converts to **54 NM**.

Worked example 7. Convert 148 kilometres to nautical miles and statute miles.

1. Select a **Dist** field. Press **CONV UNIT** until **KM** shows.
2. Press **1** **4** **8** and tap enter.
3. Press **CONV UNIT** to step to **NM** — read **79.9 NM**.
4. Press **CONV UNIT** again to reach **SM** — read **92.0 SM**.

Sanity check. 148 km is about 15 lots of 10 km, and 10 km is 5.4 NM. $15 \times 5.4 = 81$. Close to 79.9. Good.

Yards — do not go hunting for one in the menu

Older question sets sometimes ask for yards. The Guide names the distance units the converter carries, and **“yard” does not appear anywhere in it**. Step through your own **Dist** unit list once, at home, so you know for certain — but do not spend exam seconds looking. A missing unit is not a reason to skip the topic; it is a reason to use the other instrument.

A yard is **exactly three feet**, so convert to feet on the CX-3 and divide by three on the calculator.

Worked example 7b. Convert 256 metres to feet and to yards.

METHOD 1 – THE ARITHMETIC

$$256 \times 3.28084 = \mathbf{839.9 \text{ ft}} \cdot 839.9 \div 3 = \mathbf{280.0 \text{ yd}}$$

METHOD 2 – THE CX-3

1. On a **Dist** field set to **M**, enter **2** **5** **6**.
2. **CONV UNIT** to **FT** – **839.9 FT**.
3. **CALC** : $839.9 \div 3 = \mathbf{280.0}$ yards.

Sanity check. A yard is a little short of a metre, so the yard figure must be slightly larger than the metre figure. $280 > 256$. Correct.

7 • Volume conversions

1 imperial gallon = 4.54609 litres • 1 US gallon = 3.785412 litres

and therefore 1 imperial gallon = 1.201 US gallons

The two facts to carry into the exam

There are about **4½ litres to an imperial gallon**, and **5 imperial gallons make about 6 US gallons**. The imperial gallon is the bigger one — which is why the same fuel load is a *larger number* of US gallons.

VOLUME CONVERSION ON THE CX-3

Select any **Vol** field → press **CONV UNIT**

Worked example 8. Convert 136 litres to imperial and US gallons.

1. On a Vol field, set units to litres and enter **1 3 6**.
2. **CONV UNIT** to imperial gallons — **29.9 imp.gal.**
3. **CONV UNIT** to US gallons — **35.9 US.gal.**

Sanity check. $136 \div 4.5$ is about 30 imperial gallons. US gallons are smaller so the number must be bigger: about 36. Both fit.

8 • Volume to weight — specific gravity

The concept

Fuel is loaded by **volume** — the bowser meter counts litres or gallons. The aeroplane cares about **mass**, because mass is what the wings must lift and what the tanks' structure must carry.

Specific gravity (SG), also called relative density, is simply how heavy a liquid is compared with water. And the whole topic collapses onto one fact:

1 litre of water = 1 kilogram

$$\text{so } \text{Mass (kg)} = \text{Volume (litres)} \times \text{SG}$$

If a fuel has an SG of 0.80, one litre of it weighs 0.80 kg. That is the entire idea. Aviation fuels run roughly 0.72 to 0.84, so they are all *lighter* than water — which gives you a permanent sanity check.

Why SG matters operationally, not just arithmetically

The energy in fuel — what actually turns into thrust and range — is tied to its **mass**, not its volume. Fill with a lower-SG fuel and you need a *greater volume* to carry the same energy.

200 litres at SG 0.80 is 160 kg. To carry that same 160 kg at SG 0.75 you would need about 213 litres. Same energy, more tank space. On a volume-limited aircraft that is a real payload problem, not a bookkeeping one.

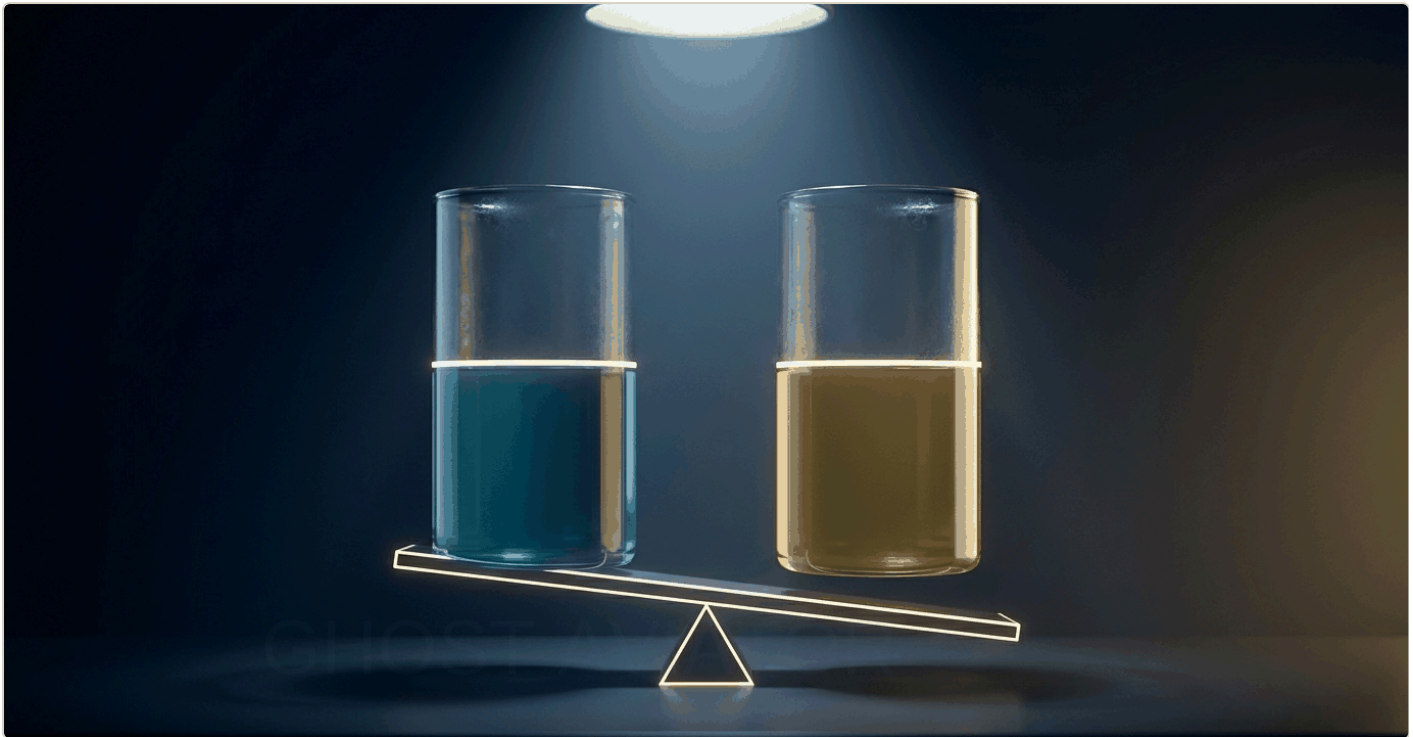


Figure 5.5 — Equal volumes, unequal mass. Specific gravity is the ratio between the two. Aviation fuel always sits below 1.00.

■ water ■ fuel — same volume, less mass

The CX-3 stops here — this is a real gap

The CX-3's unit conversion will happily convert volume to volume, and weight to weight. It will **not** convert volume to weight at an arbitrary SG.

The only fuel densities the machine knows are three fixed standards buried in the Weight & Balance section — **AvGas 6 lb/gal, Jet fuel 6.84 lb/gal, oil 7.5 lb/gal**. The exam will hand you SG values of .72, .78, .80, .81, .84. None of those are in the machine.

You will do this one on the scientific calculator. That is not a workaround — it is the correct professional method.

The method — three steps, always in this order

1. **Get to litres.** Whatever volume unit the question gives you, convert it to litres on the CX-3 with **CONV UNIT**.
2. **Multiply by SG.** On the scientific calculator. That gives you kilograms.
3. **Convert kilograms to whatever the answer wants.** Back on the CX-3 with **CONV UNIT** on a **Wt** field.

Going backwards — from a weight to a volume — is the same three steps in reverse: get to kilograms, divide by SG to get litres, convert to the volume unit required.

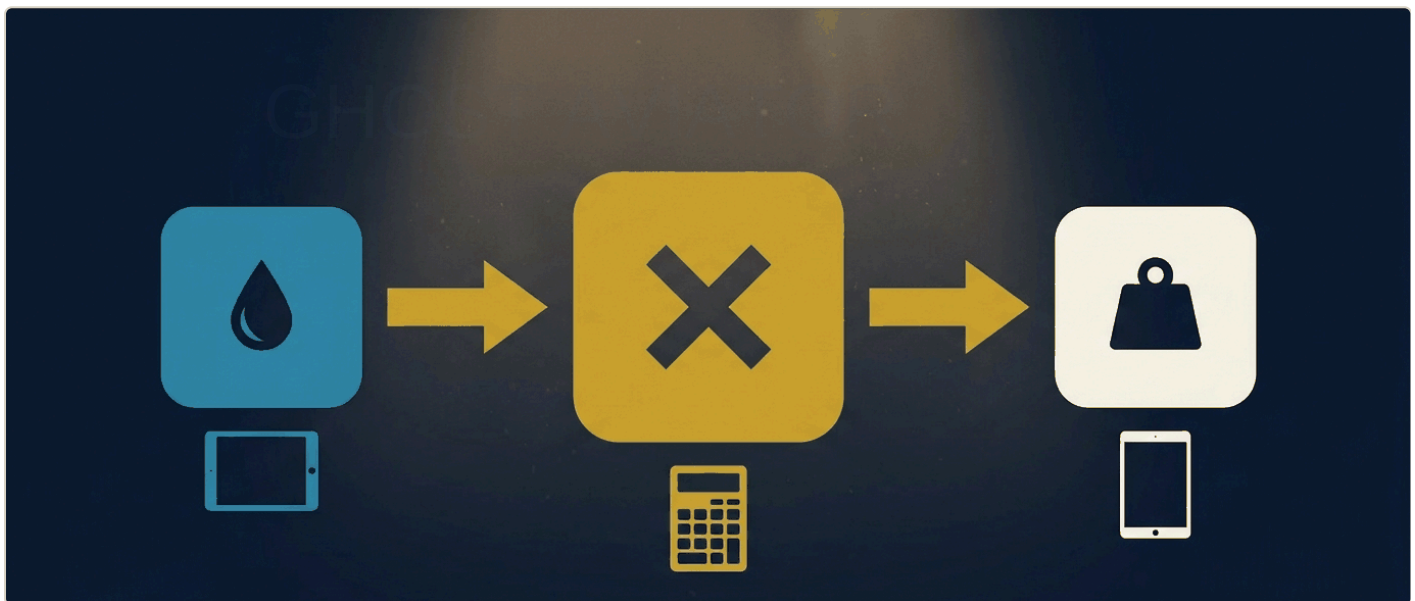


Figure 5.6 — The three-step method. The CX-3 does the outer two steps; the calculator does the middle one.

■ 1. get to litres — CX-3 ■ 2. $\times$ SG — calculator ■ 3. convert — CX-3

Worked example 9. Convert 300 US gallons at SG 0.80 to imperial gallons, litres, kilograms and pounds.

1. **To litres.** On a **Vol** field enter 300 US.gal. **CONV UNIT** to litres → **1,135.6 litres**.
2. **To imperial gallons.** **CONV UNIT** again → **249.8 imp.gal.**
3. **To kilograms.** Scientific calculator: $1,135.6 \times 0.80 = 908.5$ kg.
4. **To pounds.** Back on the CX-3, enter 908.5 on a **Wt** field in kg and **CONV UNIT** to lb → **2,003.0 lb.**

Sanity check. 1,135 litres of water would be 1,135 kg. Fuel at 0.8 is lighter, so somewhere near 900 kg. And 900 kg is a bit under 2,000 lb. Both fit.

Why your answer may differ from an older textbook by a little

Older answer keys convert to pounds using the imperial shorthand "**one imperial gallon of water weighs 10 pounds**". It is a beautiful rule and it is very slightly wrong: one imperial gallon of water is 4.54609 kg, which is **10.0224 lb**. The shorthand runs **0.22% low**.

On this example the shorthand gives 1,998 lb where the exact conversion gives 2,003 lb. On a few thousand pounds of fuel the gap grows to ten or more.

Use the exact conversion. It is what the CX-3 does, it is what your loadsheet does, and where the two disagree the exact one is right. Where an exam option matches the 10-pound shorthand within a few pounds, that is still the intended answer — the difference will not change which option you pick.

9 • Which route do I take?

The reference card below is a lookup table. This is the decision you actually make when a question is in front of you and you do not yet know what kind of problem it is.

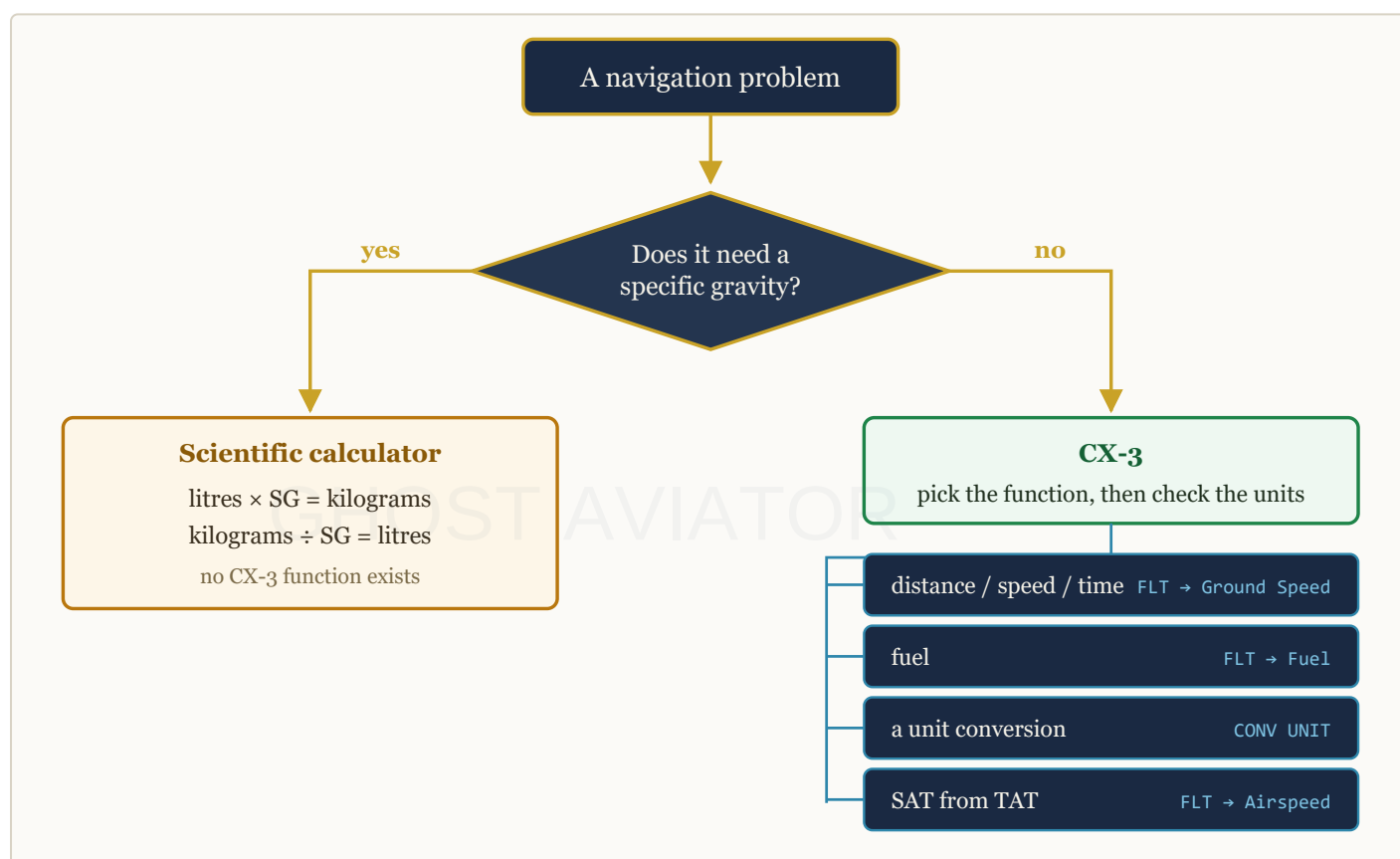


Figure 5.7 — One question splits the whole chapter. Specific gravity is the only thing here the CX-3 cannot do; everything else is a matter of choosing the right function and watching the units.

Why this one question

Every gap in this chapter reduces to specific gravity. If a problem does not involve SG, the CX-3 has a function for it and your only real job is picking the right one and checking the units. If it does involve SG, the machine cannot help and the calculator is not a fallback — it is the correct professional tool.

Questions

Work every row. The answers begin after the last table — do not read ahead.

Q1 • Ground speed, distance and time

#	Ground speed (kt)	Distance (NM)	Time (min)
1	230	33	
2	175	234	
3	182	510	
4	145		15
5	260		77
6	200		51
7		46.5	16.5
8		231	97
9		156	43
10	320		3.5

Q2 • Fuel flow, time and fuel used

#	Fuel flow	Time	Fuel used
1	140 litres/h	1 h 20 min	
2	2120 kg/h		570 kg
3		3 h 25 min	400 imp.gal
4	8.7 US.gal/h	2 h 15 min	
5	9800 lb/h	5 h 20 min	
6	165 kg/h		420 kg
7		1 h 47 min	1075 lb
8	295 US.gal/h	4 h 40 min	
9	160 litres/h	1 h 45 min	
10	260 imp.gal/h		1120 imp.gal

Q3 • Nautical miles, statute miles and kilometres

#	Nautical mile	Statute mile	Kilometre
1	88		
2		27	
3			87
4	141		
5		147	
6			310
7			10 000
8	433		

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Q4 • Metres and feet

#	Metres	Feet
1	1 000	
2		29
3	120	
4	356	

Q5 • Volume, specific gravity and weight

#	Litres	imp.gal	US.gal	SG	kg	lb
1	1000			.78		
2		420		.81		
3			800	.84		
4				.80	1000	
5				.72		2000

Answers

How these answers were produced

Every figure below was computed from the exact conversion constants (1 NM = 1.852 km, 1 NM = 1.15078 SM, 1 m = 3.28084 ft, 1 imp.gal = 4.54609 L, 1 US.gal = 3.785412 L, 1 kg = 2.20462 lb) and cross-checked against the CX-3's own worked examples.

Where an older answer key differs, it is noted on the row and explained. In every such case the difference comes from reading a plastic disc by eye, or from the 10-pound-per-imperial-gallon shorthand. **The exact value is the one to learn.**

A1 • Ground speed, distance and time

Method for every row: **FLT** → **Ground Speed**. Enter the two values you are given; read the third. Set **Dur** to **MIN** with **CONV UNIT** so the times match the table.

Row 1 in full. GS 230 kt, distance 33 NM, find time.

1. **FLT** → **Ground Speed**, tap enter.
2. GS : **2** **3** **0**, enter.
3. Dist : **3** **3**, enter.
4. Dur : **CONV UNIT** to **MIN**.

Reads **8.61 MIN**

33 NM at 230 kt — about a seventh of an hour, so about 8–9 minutes.

Row 4 in full. GS 145 kt, time 15 min, find distance.

1. **FLT** → **Ground Speed**.
2. GS : **1** **4** **5**, enter.
3. Dur : **CONV UNIT** to **MIN**, press **1** **5**, enter.

Dist reads **36.25 NM**

15 minutes is a quarter hour. A quarter of 145 is about 36. Correct.

Rows 2, 3, 5–10 use exactly the same three keystrokes — enter the two given values, read the third.

#	Ground speed (kt)	Distance (NM)	Time (min)	Note
1	230	33	8.6	
2	175	234	80.2	
3	182	510	168.1	
4	145	36.3	15	
5	260	333.7	77	
6	200	170.0	51	
7	169.1	46.5	16.5	
8	142.9	231	97	
9	217.7	156	43	
10	320	18.7	3.5	Some keys print 18.5

Row 10 — worth pausing on

320 knots for 3.5 minutes. 3.5 minutes is $3.5 \div 60$ of an hour, so $320 \times 3.5 \div 60 = \mathbf{18.67 \text{ NM}}$. Older answer keys print 18.5, which is a disc read a shade low.

This is the scenario from the top of the chapter. The number that matters is not the third significant figure — it is knowing that the answer is **eighteen point something nautical miles** and therefore about three and a half *minutes* away, not three and a half hours.

A2 • Fuel flow, time and fuel used

Method for every row: **FLT** → **Fuel**. Use the **vol** field for litres and gallons, the **wt** field for kilograms and pounds. Enter the two you have; read the third.

Row 1 in full. 140 litres/h for 1 h 20 min.

1. **FLT** → **Fuel**.
2. Dur : **CONV UNIT** to HMS , press **1** **:** **2** **0** **:** **0** **0** , enter.
3. Rate : set to LPH , press **1** **4** **0** , enter.

Vol reads **186.7 litres**

1 h 20 is $1\frac{1}{3}$ hours. 140×1.33 is about 187. Correct.

Row 2 in full. 2120 kg/h, 570 kg used, find time.

1. **FLT** → **Fuel**.
2. Wt : set to KG , press **5** **7** **0** , enter.
3. Rate : set to KG/HR , press **2** **1** **2** **0** , enter.

Dur reads **00:16:08** — 16.1 minutes

570 is roughly a quarter of 2120, and a quarter of an hour is 15 minutes. Correct.

Rows 3–10 are the same two entries and a read.

GHOST AVIATOR

#	Fuel flow	Time	Fuel used
1	140 litres/h	1 h 20 min	186.7 litres
2	2120 kg/h	16.1 min	570 kg
3	117.1 imp.gal/h	3 h 25 min	400 imp.gal
4	8.7 US.gal/h	2 h 15 min	19.6 US.gal
5	9800 lb/h	5 h 20 min	52 266.7 lb
6	165 kg/h	2 h 32.7 min	420 kg
7	602.8 lb/h	1 h 47 min	1075 lb
8	295 US.gal/h	4 h 40 min	1376.7 US.gal
9	160 litres/h	1 h 45 min	280.0 litres
10	260 imp.gal/h	4 h 18.5 min	1120 imp.gal

A3 • Nautical miles, statute miles and kilometres

Method for every row: enter the value you are given on a **Dist** field in its own unit, then tap **CONV UNIT** to step round to the other two. One entry, two reads.

Row 1 in full. 88 NM to SM and km.

1. On a **Dist** field, **CONV UNIT** until **NM**.
2. Press **8** **8**, enter.
3. **CONV UNIT** to **SM** — **101.3**.
4. **CONV UNIT** to **KM** — **163.0**.

88 NM is about 9 lots of 10 km-equivalent (5.4 NM each), so roughly 163 km. Correct.

#	Nautical mile	Statute mile	Kilometre	Note
1	88	101.3	163.0	
2	23.5	27	43.5	
3	47.0	54.1	87	
4	141	162.3	261.1	
5	127.7	147	236.6	
6	167.4	192.6	310	
7	5399.6	6213.7	10 000	The equator-to-pole pair
8	433	498.3	801.9	<i>Some keys print 499 / 805</i>

Row 7 is the memory aid, checked

10,000 km comes out at 5,399.6 NM — which is why "equator to pole = 5,400 NM = 10,000 km" works. It is accurate to better than one part in ten thousand. Carry it into the exam.

A4 • Metres and feet

Method: enter on a field in metres or feet, to the other.

#	Metres	Feet	Note
1	1 000	3280.8	
2	8.8	29	
3	120	393.7	
4	356	1168.0	<i>Some keys print 1166</i>

The one to memorise

1,000 metres = 3,281 feet. Or, more usefully in the cockpit, **1 metre ≈ 3.28 feet** and **300 metres ≈ 1,000 feet.** That last one converts a metric cloud base to something you can fly to without touching a calculator.

A5 • Volume, specific gravity and weight

Method for every row — the three steps from §8: get to litres on the CX-3, multiply or divide by SG on the scientific calculator, convert the result on the CX-3.

Row 1 in full. 1000 litres at SG .78.

1. **Already in litres.** Enter 1000 on a **Vol** field set to litres.
2. **CONV UNIT** to imperial gallons — **220.0**.
3. **CONV UNIT** to US gallons — **264.2**.
4. **Calculator:** $1000 \times 0.78 = 780 \text{ kg}$.
5. Enter 780 on a **Wt** field in kg, **CONV UNIT** to lb — **1719.6 lb**.

1000 litres of water is 1000 kg; fuel at .78 is lighter, so 780 kg. And 780 kg is a bit over 1700 lb.

Row 5 in full — working backwards. 2000 lb at SG .72.

1. Enter 2000 on a **Wt** field in lb. **CONV UNIT** to kg — **907.2 kg**.
2. **Calculator:** $907.2 \div 0.72 = 1260.0 \text{ litres}$. Divide, because you are going from mass back to volume.
3. Enter 1260 on a **Vol** field in litres, **CONV UNIT** round for **277.2 imp.gal** and **332.9 US.gal**.

The litre figure must be bigger than the kilogram figure, because fuel is lighter than water. $1260 > 907$. Correct. If yours came out smaller, you multiplied where you should have divided.

Rows 2, 3 and 4 follow the identical three steps.

#	Litres	imp.gal	US.gal	SG	kg	lb
1	1000	220.0	264.2	.78	780.0	1719.6
2	1909.4	420	504.4	.81	1546.6	3409.6
3	3028.3	666.1	800	.84	2543.8	5608.1
4	1250.0	275.0	330.2	.80	1000	2204.6
5	1260.0	277.2	332.9	.72	907.2	2000

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Why the pounds column may not match an older key

Older answer keys give 1716, 3402, 5600 and 2200 for the pounds in rows 1 to 4. Those come from the shorthand *one imperial gallon of water weighs 10 pounds*, which runs 0.22% light. The exact conversion — the one the CX-3 performs — gives the values in the table above.

The gap is a few pounds in a few thousand. It will not change which option you select in an exam. It *would* matter on a loadsheet, which is why the exact route is the one to build the habit on.

GHOST AVIATOR

GHOST AVIATOR

90-second speed drill

CX-3 in hand. Scientific calculator beside it. Set a 90-second timer. Ten answers. Go.

1. Ground speed 240 kt. How far in 25 minutes?
2. You cover 75 NM in 20 minutes. Ground speed?
3. Ground speed 180 kt, 63 NM to run. Time?
4. Express 197 minutes as hours and minutes.
5. Fuel flow 1,800 kg/h for 2 h 10 min. Fuel used?
6. You have 240 litres usable at 95 litres/h. Endurance?
7. Convert 250 km to nautical miles.
8. Convert 64 NM to statute miles.
9. 900 litres of fuel at SG 0.79. Mass in kilograms?
10. TAS 300 kt, probe reads -15°C . Approximate SAT?

ANSWERS

1. **FLT** → Ground Speed — **100.0 NM**
2. **FLT** → Ground Speed — **225.0 kt**
3. **FLT** → Ground Speed — **21.0 min**
4. **CONV UNIT** on **Dur** — **3 h 17 min**
5. **FLT** → Fuel — **3,900 kg**
6. **FLT** → Fuel — **2 h 31.6 min**
7. **CONV UNIT** on **Dist** — **135.0 NM**
8. **CONV UNIT** on **Dist** — **73.6 SM**
9. Calculator: 900×0.79 — **711 kg**
10. Ram rise $\approx (300 \div 100)^2 = 9^{\circ}\text{C}$, so SAT $\approx -24^{\circ}\text{C}$

Quick reference — CX-3 or calculator?

Photograph this page. It is the fastest route to every problem in this chapter.

Problem	Fastest route
Distance, ground speed or time — any two given	CX-3 · FLT → Ground Speed
Minutes into hours and minutes	CX-3 · CONV UNIT on Dur , or the : key on input
Fuel used, fuel flow or endurance — volume	CX-3 · FLT → Fuel, Vol field
Fuel used, fuel flow or endurance — mass	CX-3 · FLT → Fuel, Wt field
NM ↔ SM ↔ km ↔ m ↔ ft	CX-3 · CONV UNIT on any Dist field
litres ↔ imp.gal ↔ US.gal	CX-3 · CONV UNIT on any Vol field
kg ↔ lb	CX-3 · CONV UNIT on any Wt field
Volume → weight at a given SG	Calculator · litres × SG = kg. <i>No CX-3 function exists.</i>
Weight → volume at a given SG	Calculator · kg ÷ SG = litres. <i>No CX-3 function exists.</i>
SAT from TAT (ram rise)	CX-3 · FLT → Airspeed → Actual TAS. Mental check: (TAS÷100) ²

The five numbers to carry in your head

- **10 km ≈ 5.4 NM** — and 10,000 km = 5,400 NM, equator to pole
- **1 m ≈ 3.28 ft** — and 300 m ≈ 1,000 ft
- **1 imp.gal ≈ 4.5 litres**
- **5 imp.gal ≈ 6 US.gal**
- **1 litre of water = 1 kg** — the fact the whole SG topic rests on

Chapter 5 — Distance, Speed, Time and Conversions

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*Next: **Chapter 6 — TAS and Altitude Conversions**, where the temperature you just learned to correct becomes the input to every airspeed calculation you will ever make.*