GROUND SCHOOL

NAVIGATION II

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GROUND SCHOOL

LECTURE TWO: NAVIGATION THEORY – PLANNING A FLIGHT

1. Map Preparation
2. Speeds
3. Master Planning
4. Using the CRP-1 or CRP-5 (the whizz-wheel)
5. Fuel Calculations
6. Planning Considerations

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GROUND SCHOOL

MAP PREPARATION: CHOOSING YOUR ROUTE

Always mark track lines in BLACK pen – it stands out best

As you can see from the route marked on the left, by drawing the lines all the way to your turning points you will obscure information that may help identify that turning point

Best to have the lines slightly short of turning points...

Hint! – remove permanent pen from your chart with the board pens we use (or methylated spirit or nail varnish remover)

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MAP PREPARATION: CHOOSING YOUR ROUTE

GROUND SCHOOL

At first it is best to avoid all controlled airspace, glider sites, instrument approaches, etc. until you have confidence on the RT

Pick turning points where there is a way of identifying the place!

Google maps is a great way of having a sneaky peek at what a turning point looks like

For example...

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MAP PREPARATION: CHOOSING YOUR ROUTE

GROUND SCHOOL

Disused airfields are always a popular choice for turning points but they may be obvious like this...

Oakley airfield in our local training area

Or...

Drayton St Leonard (a few miles west of Benson)

Here!

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LET'S GET PLANNING: INITIAL ROUTE & FLIGHT LOG (PLOG)

GROUND SCHOOL

Start with where you are going!

On a log you will be using in the aircraft it will be easier to leave a line between each leg but for now, we will use each line...

The route:

Henley (51°32'N 000°55'W) to Newbury racecourse (51°24'N 001°18'W) to Bembridge airfield on the Isle of Wight (50°41'N 001°07'W) and return to Henley (51°32'N 000°55'W)

FROM	TO	MSA	ALT	TAS	TRK°T	W/V	HDG°T	VAR	HDG°M	HDG°C	DIST	G/S	TIME
Henley	Newbury												
Newbury	Bembridge												
Bembridge	Henley												

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GROUND SCHOOL

CHART VIEW

Your chart should look something like this

Remember – track lines in BLACK and draw them slightly short of each turning point

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GROUND SCHOOL

LET'S GET PLANNING: INITIAL ROUTE & FLIGHT LOG (PLOG)

Now you have drawn on the track lines between the places as we have just discussed ...

... we can measure the **tracks** and **distances** of each of the legs

Get out your protractors and rulers

FROM	TO	MSA	ALT	TAS	TRK°T	W/V	HDG°T	VAR	HDG°M	HDG°C	DIST	G/S	TIME
Henley	Newbury												
Newbury	Bembridge												
Bembridge	Henley												

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GROUND SCHOOL

LET'S GET PLANNING: INITIAL ROUTE & FLIGHT LOG (PLOG)

TRACKS ...

Make sure you align the protractor with north towards the top of the chart!

Try to measure the direction in the middle of the leg

You may need to extend your track line on the chart if it is too short to be read easily

Put the tracks into the PLOG – always use three digits

Align the protractor with the vertical lines on the chart

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LET'S GET PLANNING: INITIAL ROUTE & FLIGHT LOG (PLOG)

GROUND SCHOOL

DISTANCES ...

Use the correct scale side of the ruler!
(1: 500 000)

Make sure you know where "0" is on your ruler – some rulers have 0 marked, and for others its just the end of the plastic

PLOG the distances

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LET'S GET PLANNING: INITIAL ROUTE & FLIGHT LOG (PLOG)

GROUND SCHOOL

Your PLOG should now look like this:

FROM	TO	MSA	ALT	TAS	TRK°T	W/V	HDG°T	VAR	HDG°M	HDG°C	DIST	G/S	TIME
Henley	Newbury				240						17		
Newbury	Bembridge				170						44		
Bembridge	Henley				008						52		

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LET'S GET PLANNING: INITIAL ROUTE & FLIGHT LOG (PLOG)

GROUND SCHOOL

Now we can do the MSA - 2 methods

1. Look along each leg 5 nm either side of track and find the highest obstacle. Add 1000 feet to this plus an extra 300 feet for an obstacle less than 300 feet high not shown on the chart.

2. Find the highest MEF (Maximum Elevation Figure) in each of the quadrants that the track runs through then add 1000 feet to this PLOG.

FROM	TO	MSA	ALT	TAS	TRK°T	W/V	HDG°T	VAR	HDG°M	HDG°C	DIST	G/S	TIME
Henley	Newbury	2300			240						17		
Newbury	Bembridge	2300			170						44		
Bembridge	Henley	2300			008						52		

Remember – you don't have to fly above the MSA if you are in VMC but if you get into cloud you MUST be above it

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GROUND SCHOOL

LET'S GET PLANNING: INITIAL ROUTE & FLIGHT LOG (PLOG)

Now PLOG the **variation** that applies to each leg – this may be a different amount on each leg so always check

Don't worry about ½ degrees!

FROM	TO	MSA	ALT	TAS	TRK°T	W/V	HDG°T	VAR	HDG°M	HDG°C	DIST	G/S	TIME
Henley	Newbury	2300			240			1W			17		
Newbury	Bembridge	2300			170			1W			44		
Bembridge	Henley	2300			008			1W			52		

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GROUND SCHOOL

SPEEDS

Now we need to figure out the altitude we will fly at and the speeds that we will use for our calculations ...

FROM	TO	MSA	ALT	TAS	TRK°T	W/V	HDG°T	VAR	HDG°M	HDG°C	DIST	G/S	TIME
Henley	Newbury	2300			240			1W			17		
Newbury	Bembridge	2300			170			1W			44		
Bembridge	Henley	2300			008			1W			52		

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GROUND SCHOOL

SPEEDS

Before you can begin with any time – distance – speed calculations for navigation you need to understand the different types of speeds and what they are used for.

Decide the speed you want to fly at – this will usually be the design cruise speed of your aircraft

Cessna 152 – 90 kts IAS

PA28 – 100 kts IAS

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GROUND SCHOOL

SPEEDS

Indicated Airspeed (IAS) ← What you will fly

INSTRUMENT ERROR

POSITION ERROR

Calibrated / Rectified Airspeed (CAS / RAS)

DENSITY ERROR

True Airspeed (TAS) ← What you need for your navigation calculations

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GROUND SCHOOL

SPEEDS

Indicated Airspeed (IAS)

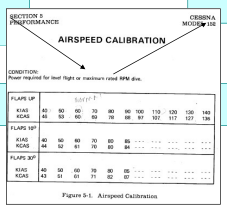
Calibrated / Rectified Airspeed (CAS / RAS)

True Airspeed (TAS)

90 kts (IAS)

88 kts (CAS / RAS)

True Airspeed (TAS)



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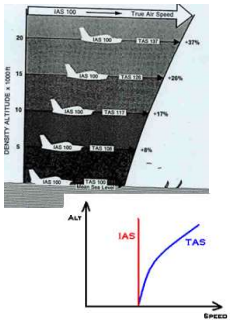
GROUND SCHOOL

SPEEDS



As the aircraft climbs (density decreases) IAS under-reads in relation to TAS

This can be worked out using the CRP 1/5 or on some airspeed indicators

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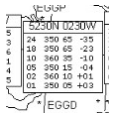
GROUND SCHOOL

SPEEDS

So we know that the RAS / CAS is 88 kts, what is the TAS?

We need to know the **altitude** we will be flying at and the **temperature** at that altitude for the flight



Use Metform 214 to find the temperature
(register at *www.metoffice.gov.uk/aviation/ga*)

If we want to fly at 3000 feet for this flight we can expect a temperature of about -1°C
(interpolation between +1˚C at 2000 ft and -4˚C at 5000 ft)

Time to get the whizz-wheel out!

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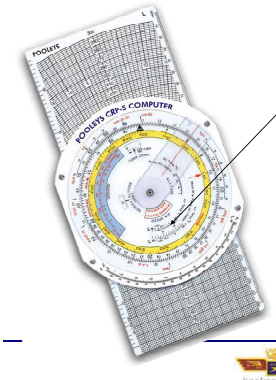
GROUND SCHOOL

SPEEDS



You need the colourful side...

In the airspeed window you need to line up 3000 feet against a temperature of -1°C

Now line read where 88 is on the inner scale (RAS) and the outer scale will read your TAS

Aaaggghhh! – photos coming up!

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GROUND SCHOOL

SPEEDS

Line up 3000 feet against -1°C

88 kts on **inner** (RAS) scale reads
90 kts on the **outer** (TAS) scale

Note: it doesn't always end up back where you started!!

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NEXT STEP

GROUND SCHOOL

Our flight log now looks like this...

FROM	TO	MSA	ALT	TAS	TRK°T	W/V	HDG°T	VAR	HDG°M	HDG°C	DIST	G/S	TIME
Henley	Newbury	2300	3000	90	240			1W			17		
Newbury	Bembridge	2300	3000	90	170			1W			44		
Bembridge	Henley	2300	3000	90	008			1W			52		

Time to get some wind information so that we can work out headings and groundspeeds, etc.

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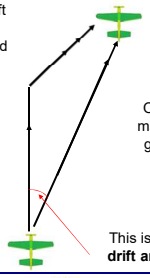
TRIANGLE OF VELOCITIES

GROUND SCHOOL

Wind blows the aircraft off course and also affects its groundspeed

Our aircraft is heading north at its cruise speed



Our aircraft's "track made good" over the ground will be very different

This is our **drift angle**

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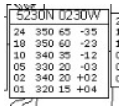
TRIANGLE OF VELOCITIES

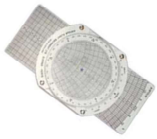
GROUND SCHOOL



Get the appropriate wind information from the Metform 214

For our calculations we will use 340° at 20 kts

First step is to input this information to the wind side of the flight computer



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HEADING & GROUNDSPEED

GROUND SCHOOL

There are three main methods of using the flight computer to gain heading and groundspeed information

Dot Down

Dot Up

"Winnie the Pooh"

We will look at the Dot Down method (you will need this for ATPL purposes) and the Winnie the Pooh method as it is the quickest for exam purposes

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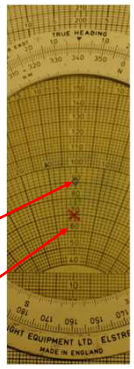
DOT DOWN

GROUND SCHOOL

Rotate the outside ring so that the wind direction is displayed at the top

Put the TAS you calculated under the centre dot by sliding the rectangular section

Mark down with a dot the wind speed



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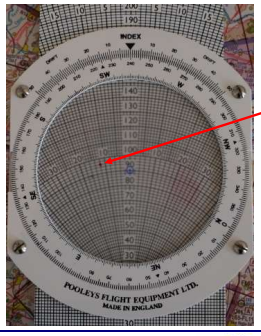
HEADING & GROUNDSPEED: DOT DOWN METHOD

GROUND SCHOOL



Rotate bezel until the desired track lies under the "true heading" mark

The dot will have moved out sideways

Count up the amount of sideways movement
(be careful – the scale changes from 1° per square to 2° per square)

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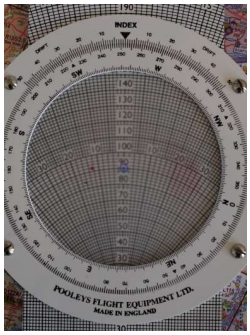
HEADING & GROUNDSPEED: DOT DOWN METHOD

GROUND SCHOOL



Rotate the bezel by that many degrees in the direction of the dot, i.e. move the **dot down**

Check the number of degrees out the dot is now

If the number has changed repeat the above steps

When the amount of drift no longer changes, read off the information

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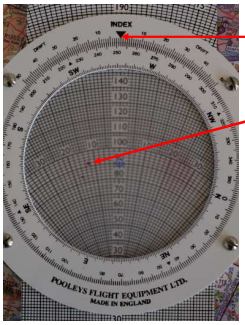
HEADING & GROUNDSPEED: DOT DOWN METHOD

GROUND SCHOOL



The "true heading" mark will show the true heading!

Read from the dot back to the centre to retrieve ground speed

PLOG <u>both:</u>

- true heading
- groundspeed

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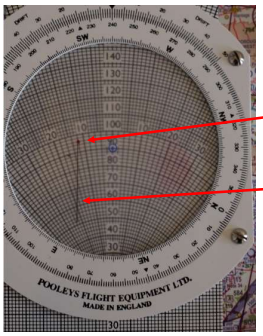
HEADING & GROUNDSPEED: WINNIE THE POOH METHOD

GROUND SCHOOL



Rotate bezel until the desired track lies under the "true heading" mark

The dot will have moved out sideways

Draw a vertical line straight down from the dot (use the vertical lines at the base to assist)

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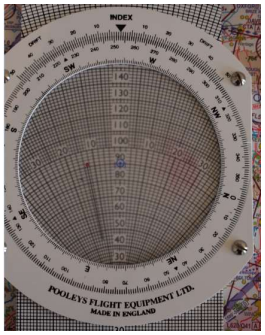
HEADING & GROUNDSPEED: WINNIE THE POOH METHOD

GROUND SCHOOL



Rotate the bezel until your vertical line is parallel with the slanted lines on the wind computer face

Read off true heading from index at top and groundspeed toward the centre

Input this information onto your PLOG

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HEADING & GROUNDSPEED

GROUND SCHOOL

FROM	TO	MSA	ALT	TAS	TRK°T	W/V	HDG°T	VAR	HDG°M	HDG°C	DIST	G/S	TIME
Henley	Newbury	2300	3000	90	240	340/20	252	1W			17	92	
Newbury	Bembridge	2300	3000	90	170	340/20	172	1W			44	110	
Bembridge	Henley	2300	3000	90	008	340/20	003	1W			52	72	

Nearly there! Apply **variation** to get magnetic heading and **deviation** (from aircraft deviation card) to get compass heading. Then we just need to calculate the time per leg.

N	30°	60°	E	120°	150°
001°	029°	060°	089°	120°	152°
S	210°	240°	W	300°	330°
181°	212°	240°	268°	301°	330°

Compass Correction Card

FROM	TO	MSA	ALT	TAS	TRK°T	W/V	HDG°T	VAR	HDG°M	HDG°C	DIST	G/S	TIME
Henley	Newbury	2300	3000	90	240	340/20	252	1W	253	252	17	92	
Newbury	Bembridge	2300	3000	90	170	340/20	172	1W	173	174	44	110	
Bembridge	Henley	2300	3000	90	008	340/20	003	1W	004	005	52	72	

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HEADING & GROUNDSPEED: TIME CALCULATION

GROUND SCHOOL

Some basic maths to start with...

Distance = Speed x Time

Speed = Distance ÷ Time

Time = Distance ÷ Speed

So you can use a calculator but you also need to know how to use the flight computer to gain this information

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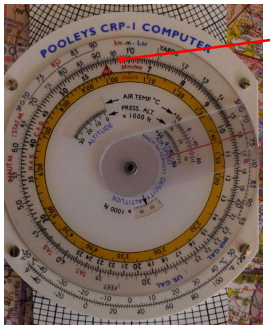
HEADING & GROUNDSPEED: TIME CALCULATION

GROUND SCHOOL



On the calculation side of the flight computer, set the ground speed under the "per hour" index

Read off the number of nautical miles to be flown on the outer scale against the number of minutes it will take on the inner scale

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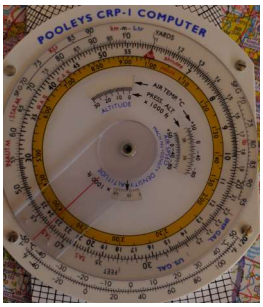
HEADING & GROUNDSPEED: TIME CALCULATION

GROUND SCHOOL



If your groundspeed is over 100 kts – just take off a zero – the flight computer doesn't have a decimal point

Rule of thumb –

Unless your speed is below 60 kts the number for your time will ALWAYS be a smaller number than the distance

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FLIGHT LOG

GROUND SCHOOL

Our PLOG is now completed!

FROM	TO	MSA	ALT	TAS	TRK°T	W/V	HDG°T	VAR	HDG°M	HDG°C	DIST	G/S	TIME
Henley	Newbury	2300	3000	90	240	340/20	252	1W	253	254	17	92	11
Newbury	Bembridge	2300	3000	90	170	340/20	172	1W	173	174	44	110	24
Bembridge	Henley	2300	3000	90	008	340/20	003	1W	004	003	52	72	43

For ease of use in the aircraft highlight the HDG (C) and Time columns

Well, apart from how much fuel it will take to fly the trip, communications frequencies, airfield information, NOTAMs, weather suitability, etc., etc.

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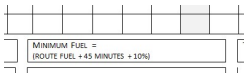
FUEL REQUIRED

GROUND SCHOOL



You will then need to make a fuel calculation for how much Avgas you should have with you

Different schools have different rules

Our total time from our PLOG was 78 minutes

Add 45 minutes contingency for diversion gives a total of 123 minutes

10% of this total is 12 minutes

A total of 135 minutes of fuel required

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TIME TO PRACTICE

GROUND SCHOOL

Time for a quick practice...

Start a new PLOG – here are your flight details

ROUTE

Stokenchurch Mast – Cranfield

Cranfield – Wellesbourne

(assume that the deviation is zero)

WEATHER

Cloud base 3300 feet

Wind 080/30

Temperature +20°

IAS 100 kts, RAS 95 kts

Scream if you get stuck...

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TIME TO PRACTICE

GROUND SCHOOL

You should end up with something like this...

FROM	TO	MSA	ALT	TAS	TRK°T	W/V	HDG°T	VAR	HDG°M	HDG°C	DIST	G/S	TIME
Stokenchurch	Cranfield	2200	2300	100	025	080/30	037	1W	038	040	27	81	20
Cranfield	Wellesbourne	2400	2300	100	281	080/30	286	1W	288	288	38	128	18

Total fuel needed = 38 minutes + 45 minutes = 83 minutes

+ 10% = 91 minutes

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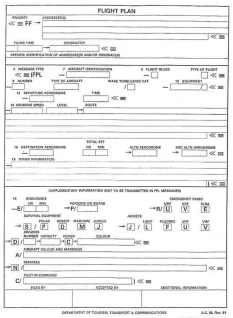
GROUND SCHOOL

FLIGHT PLAN



You will need to also fill in an ATC flight plan if your flight is:

- Outside the original FIR (Flight Information Region)
- More than 50 nm from the coast
- Over largely uninhabited or inhospitable area

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GROUND SCHOOL

Lecture complete

Any questions?

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